Mineral Deposit Models

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Mineral Deposit Models

DENNIS P. COX and DONALD A. SINGER, Editors

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PREFACE

By Paul B. Barton

Conceptual models that describe the essential characteristics of groups of similar deposits have a long and useful role in geology. The first models were undoubtedly empirical attempts to extend previous experiences into future success. An example might be the seeking of additional gold nuggets in a stream in which one nugget had already been found, and the extension of that model to include other streams as well. Emphasis within the U.S. Geological Survey on the synthesis of mineral deposit models (as contrasted with a long line of descriptive and genetic studies of specific ore deposits) began with the collation by R. L. Erickson (1982) of 48 models. The 85 descriptive deposit models and 60 grade-tonnage models presented here are the culmination of a process that began in 1983 as part of the USGS-INGEOMINAS Cooperative Mineral Resource Assessment of Colombia (Hodges and others, 1984). Effective cooperation on this project required that U.S. and Colombian geologists agree on a classification of mineral deposits, and effective resource assessment of such a broad region required that grade-tonnage models be created for a large number of mineral deposit types. A concise one-page format for descriptive models was drawn up by Dennis Cox, Donald Singer, and Byron Berger, and Singer devised a graphical way of presenting grade and tonnage data. Sixty-five descriptive models (Cox, 1983a and b) and 37 grade-tonnage models (Singer and Mosier, 1983a and b) were applied to the Colombian project. Because interest in these models ranged far beyond the Colombian activity, it was decided to enlarge the number of models and to include other aspects of mineral deposit modeling. Our colleagues in the Geological Survey of Canada have preceded this effort by publishing a superb compilation of models of deposits important in Canada (Eckstrand, 1984). Not surprisingly, our models converge quite well, and in several cases we have drawn freely from the Canadian publication.

It is a well-known axiom in industry that any excuse for drilling may find ore; that is, successful exploration can be carried out even though it is founded upon an erroneous model. Examples include successful exploration based on supposed (but now proven erroneous) structural controls for volcanogenic massive sulfide deposits in eastern Canada and for carbonate-hosted zinc in east Tennessee. As the older ideas have been replaced, additional ore has been found with today's presumably more valid models.

Although models have been with us for centuries, until recently they have been almost universally incomplete when descriptive and unreasonably speculative when genetic. What is new today is that, although we must admit that all are incomplete in some degree, models can be put to rigorous tests that screen out many of our heretofore sacred dogmas of mineral formation. Examples are legion, but to cite a few: (1) fluid-inclusion studies have shown conclusively that the classic Mississippi Valley-type ores cannot have originated from either syngenetic processes or unmodified surface waters; (2) epithermal base- and precious-metal ores have been proved (by stable-isotope studies) to have formed through the action of meteoric waters constituting fossil geothermal systems; and (3) field and laboratory investigations clearly show that volcanogenic massive sulfides are the products of syngenetic, submarine, exhalative processes, not epigenetic replacement of sedimentary or volcanic rocks. Economic geology has evolved quietly from an "occult art" to a respectable science as the speculative models have been put to definitive tests.

Several fundamental problems that may have no immediate answers revolve around these questions: Is there a proper number of models? Must each deposit fit into one, and only one, pigeon-hole? Who decides (and when?) that a model is correct and reasonably complete? Is a model ever truly complete? How complete need a model be to be useful?

In preparing this compilation we had to decide whether to discuss only those deposits for which the data were nearly complete and the interpretations concordant, or whether to extend coverage to include many deposits of uncertain affiliation, whose characteristics were still subjects for major debate. This compilation errs on the side of scientific optimism; it includes as many deposit types as possible, even at the risk of lumping or splitting types incorrectly. Nevertheless, quite a few types of deposits have not been incorporated.

The organization of the models constitutes a classification of deposits. The arrangement used emphasizes easy access to the models by focusing on host-rock lithology and tectonic setting, the features most apparent to the geologist preparing a map. The system is nearly parallel to a genetic arrangement for syngenetic ores, but it diverges strongly for the epigenetic where it creates some strange juxtapositions of deposit types. Possible ambiguities are accommodated, at least in part, by using multiple entries in the master list in table 1.

In considering ways to make the model compilation as useful as possible, we have become concerned about ways to enhance the ability of the relatively inexperienced geoscientist to find the model(s) applicable to his or her observations. Therefore, we have included extensive tables of attributes in which the appropriate models are identified.

Our most important immediate goal is to provide assistance to those persons engaged in mineral resource assessment or exploration. An important secondary goal is to upgrade the quality of our model compilation by encouraging (or provoking?) input from those whose experience has not yet been captured in the existing models. Another target is to identify specific research needs whose study is particularly pertinent to the advance of the science. We have chosen to err on the side of redundancy at the expense of neatness, believing that our collective understanding is still too incomplete to rule out some alternative interpretations. Thus we almost certainly have set up as separate models some types that will ultimately be blended into one, and there surely are groupings established here that will subsequently be divided. We also recognize that significant gaps in coverage still exist. Even at this stage the model compilation is still experimental in several aspects and continues to evolve. The product in hand can be useful today. We anticipate future editions, versions, and revisions, and we encourage suggestions for future improvements.

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Mineral Deposit Models

Dennis P. Cox *and* Donald A. Singer, *Editors*

INTRODUCTION

By Dennis P. Cox, Paul B. Barton, and Donald A. Singer

The U.S. Geological Survey has a long and distinguished history in assessing the mineral resources of the public domain, and that role remains active today in programs designed to assess the mineral resources of the lands administered by the U.S. Bureau of Land Management and Forest Service, the Alaska Mineral Resource Assessment Program, and the Conterminous United States Mineral Assessment Program. The Survey has thus an immediate and constantly recurring need to upgrade and maintain the capability of its staff to identify and assess areas favorable for mineral deposits. One major step toward fulfilling this need is the assembly of a comprehensive group of mineral deposit models that enable any geologist to compare his or her observations with the collective knowledge and experience of a much wider group of geoscientists.

This report deals exclusively with nonfuel minerals (including uranium), for these show a commonality of geologic expressions that differ markedly from those of the areally much larger (and economically even more important) coal, oil, and gas deposits.

CITATION AND ACKNOWLEDGMENTS

This report has been assembled through the generous efforts of many persons. The authors of the individual models and many of the other sections are indicated. We all would appreciate it if the individual authors could be cited whenever practical rather than simply refering to the whole compilation.

Among the editors, Dennis Cox had the lead in soliciting the model authors and in assembling the brief models; Donald Singer played a similar role for all of the grade and tonnage models; and Paul Barton provided the attribute cross-indexes and carefully reviewed the overall package. The editors greatly appreciate the encouragement and suggestions from (in alphabetical order) Larry Bernstein, John H. DeYoung, Jr., Bob Earhart, Ralph Erickson, Fred Fisher, Bill Greenwood, Carroll Ann Hodges, Kate Johnson, Steve Ludington, Dick McCammon, Hal Morris, Rob Robinson, Don White, and many others. The editors were greatly helped by suggestions from geologists outside the USGS, particularly D. F. Sangster, R. V. Kirkham, and J. M. Franklin of the Geological Survey of Canada, and by Ryoichi Kouda, Takeo Sato, and Yukio Togashi of the Geological Survey of Japan. Among the many geologists from private industry who provided helpful information and suggestions were R. G. Blair, A. E. Soregaroli, E. I. Bloomstein, and G. E. McKelvey.

SOME FUNDAMENTAL DEFINITIONS

A "mineral occurrence" is a concentration of a mineral (usually, but not necessarily, considered in terms of some commodity, such as copper, barite or gold) that is considered valuable by someone somewhere, or that is of scientific or technical interest. In rare instances (such as titanium in a rutile-bearing black sand), the commodity might not even be concentrated above its average crustal abundance.

A "mineral deposit" is a mineral occurrence of sufficient size and grade that it might, under the most favorable of circumstances, be considered to have economic potential.

An "ore deposit" is a mineral deposit that has been tested and is known to be of sufficient size, grade, and accessibility to be producible to yield a profit. (In these days of controlled economies and integrated industries, the "profit" decision may be based on considerations that extend far beyond the mine itself, in some instances relating to the overall health of a national economy.)

On one hand, the field observations usually begin with "mineral occurrences" (or with clues to their existence) and progress with further study to "mineral deposits" and only rarely to "ore deposits," but we must present information that helps us deal with all classes of "mineral occurrences," not just "ore deposits." On the other hand, in terms of accessible information our sample is strongly biased toward "ore deposits," for it is only in them that sufficient exposure is available to develop a real knowledge of the overall character of the mineralization process. Some mineral occurrences are, therefore, unrecognized mineral deposits, while others are simply mineralized localities where ore-forming processes were so weak or incomplete that a deposit was not formed. Thus we summarize the state of knowledge regarding ore deposit models, and we call them "mineral deposit models" with the hope that what we have learned about large and high-grade metal concentrations will help us sort out all mineral occurrences to identify their true character and, we hope, to recognize which have potential to constitute ore deposits.

The attributes or properties of a mineral occurrence are, of course, those features exhibited by the occurrence. When applied to a model, these terms refer to those features possessed by the class of deposits represented by the model. It is useful to consider attributes on at least two scales: the first deals with local features that may be observed directly in the field (mineralogy, zonal patterns, local chemical haloes, and so on); the second is those features concerning the regional geologic setting and which must be interpreted from the local studies or may be inferred from global tectonic considerations (for instance, that the rock sequence under study represents a deep-water, back-arc rift environment, or that the area is underlain by anomalously radioactive high-silica rhyolite and granite). Two of the most prominent attributes, the commodities/geochemical patterns and the mineralogy, are cross-indexed to model types in Appendixes C and D, respectively.

To the greatest extent possible, models were constructed so as to be independent of site-specific attributes and therefore contain only those features which are transferable from one deposit to another. This goal is difficult to attain, because we do not always know which features are site specific.

The term "model" in an earth-science context elicits a wide variety of mental images, ranging from the physical duplication of the form of a subject, as in a scale model of the workings of a mine, to a unifying concept that explains or describes a complex phenomenon. In this context we shall apply only the latter usage. Therefore, let us propose a working definition of "model" in the context of mineral deposits, the overriding purpose being to communicate information that helps mankind find and evaluate mineral deposits. A mineral deposit model is the systematically arranged information describing the essential attributes (properties) of a class of mineral deposits. The model may be empirical (descriptive), in which instance the various attributes are recognized as essential even though their relationships are unknown; or it may be theoretical (genetic), in which instance the attributes are interrelated through some fundamental concept.

One factor favoring the genetic model over the simply descriptive is the sheer volume of descriptive information needed to represent the many features of complex deposits. If all such information were to be included, the number of models would escalate until it approached the total number of individual deposits considered. Thus we should no longer have models, but simply descriptions of individual deposits. Therefore, the compilers must use whatever sophisticated or rudimentary genetic concepts are at their disposal to distinguish the critical from the incidental attributes. It is commonly necessary to carry some possibly superficial attributes in order not to preclude some permissible but not necessarily favored, multiple working concepts.

The following example illustrates the problem. One of the commonly accepted attributes of the model for the carbonate-hosted lead-zinc deposits of the Mississippi Valley type is the presence of secondary dolomite. But do we know that this is essential? Suppose a deposit were found in limestone; would we reject its assignment to the Mississippi Valley class? Or could it be correct that the critical property is permeability and that the formation of dolomite either (1) enhances permeability (and thereby makes the ground more favorable), or (2) reflects pre-existing permeability that is exploited by both the dolomite and the ore? Perhaps the dolomite merely records a particular range of Ca/Mg ratio in the fluid which in turn is characteristic of the basinal brines that constitute the ore fluid. In any event, the dolomite is a powerful ore guide and belongs somewhere in the "final model."

CLASSIFICATION OF MODELS USED IN THIS COMPILATION

For the purpose at hand the classification scheme has two requirements: (1) it must be open so that new types of deposits can be added in the future, and (2) the user must be able to find easily the appropriate models to apply to the rock and tectonic environments being investigated.

Figure 1 maps out the four logic trees that constitute a broad lithotectonic classification; this system is similar to one developed by Page and others (1982c). The classification of deposits by the environment of formation of their host rocks is continued on a finer scale in table 1. This classification scheme is relatively straightforward for deposits formed essentially contemporaneously with their host rock. However, for epigenetic deposits a conflict arises between the lithotectonic environment of the formation of the host and the lithotectonic environment of the mineralization process. Therefore, for epigenetic deposits we have selected the most important aspect of the lithotectonic alternatives and classified the deposit accordingly. This procedure

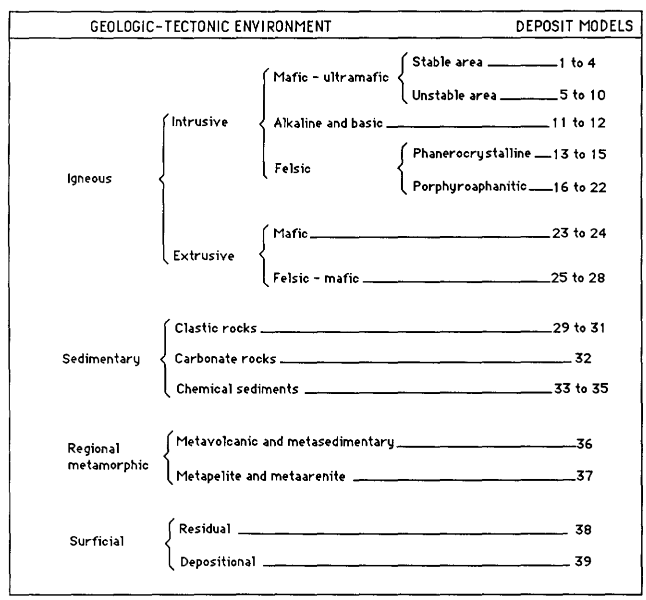


Figure 1. Tree diagram showing relationship of broad geologic-tectonic environments to models. These deposit models are classified on a finer scale in table 1.

Table 1. Classification of deposit models by lithologic-tectonic environment

[*indicates that model is not included in this bulletin]

Deposit environment	Model No.
Mafic and ultramafic intrusions	
A. Tectonically stable area; stratiform complexes	
Stratiform deposits	
Basal zone	
Stillwater Ni-Cu	1
Intermediate zone	
Bushveld chromitite	2a
Merensky Reef PGE	2b
Upper zone	
Bushveld Fe-Ti-V	3
Pipe-like deposits	
Cu-Ni pipes	4a*
PGE pipes	4b*
B. Tectonically unstable area	
Intrusions same age as volcanic rocks	
Rift environment	
Duluth Cu-Ni-PGE	5a
Noril'sk Cu-Ni-PGE	5b
Greenstone belt in which lowermost rocks of sequence contain ultramafic rocks	
Komatiitic Ni-Cu	6a
Dunitic Ni-Cu	6b
Intrusions emplaced during orogenesis	
Synorogenic in volcanic terrane	
Synorogenic-synvolcanic Ni-Cu	7a
Synorogenic intrusions in non-volcanic terrane	
Anorthosite-Ti	7b
Ophiolites	
Podiform chromite	8a
Major podiform chromite	8b
(Lateritic Ni)	(38a)
(Placer Au-PGE)	(39a)
Serpentine	
Limassol Forest Co-Ni	8c
Serpentine-hosted asbestos	8d
(Silica-carbonate Hg)	(27c)
(Low-sulfide Au-quartz vein)	(36a)
Cross-cutting intrusions (concentrically zoned)	
Alaskan PGE	9
(Placer PGE-Au)	(39b)
C. Alkaline intrusions in stable areas	
Carbonatite	10
Alkaline complexes	11*
Diamond pipes	12
Felsic intrusions	
D. Mainly phanerocrystalline textures	
Pegmatitic	
Be-Li pegmatites	13a*
Sn-Nb-Ta pegmatites	13b*
Granitic intrusions	
Wallrocks are calcareous	
W skarn	14a
Sn skarn	14b
Replacement Sn	14c

Table 1. Classification of deposit models by lithologic-tectonic environment --Continued

Deposit environment	Model No.
D. Mainly phanerocrystalline textures--Continued	
Granitic intrusions--Continued	
Other wallrocks	
W veins	15a
Sn veins	15b
Sn greisen	15c
(Low-sulfide Au-quartz vein)	(36a)
(Homestake Au)	(36b)
Anorthosite intrusions	
(Anorthosite Ti)	(7b)
E. Porphyroaphanitic intrusions present	
High-silica granites and rhyolites	
Climax Mo	16
(Fluorspar deposits)	(26b*)
Other felsic and mafic rocks including alkalic	
Porphyry Cu	17
Wallrocks are calcareous	
Deposits near contact	
Porphyry Cu, skarn-related	18a
Cu skarn	18b
Zn-Pb skarn	18c
Fe skarn	18d
Carbonate-hosted asbestos	18e
Deposits far from contact	
Polymetallic replacement	19a
Replacement Mn	19b
(Carbonate-hosted Au)	(26a)
Wallrocks are coeval volcanic rocks	
In granitic rocks in felsic volcanics	
Porphyry Sn	20a
Sn-polymetallic veins	20b
In calcalkalic or alkalic rocks	
Porphyry Cu-Au	20c
(Epithermal Mn)	(25g)
Wallrocks are older igneous and sedimentary rocks	
Deposits within intrusions	
Porphyry Cu-Mo	21a
Porphyry Mo, low-F	21b
Porphyry W	21c*
Deposits within wallrocks	
Volcanic hosted Cu-As-Sb	22a
Au-Ag-Te veins	22b
Polymetallic veins	22c
(Epithermal quartz-alunite Au)	(25e)
(Low-sulfide Au-quartz vein)	(36a)
Extrusive rocks	
F. Mafic extrusive rocks	
Continental or rifted craton	
Basaltic Cu	23
(Sediment-hosted Cu)	(30b)
Marine, including ophiolite-related	
Cyprus massive sulfide	24a
Besshi massive sulfide	24b
Volcanogenic Mn	24c
Blackbird Co-Cu	24d
(Komatiitic Ni-Cu)	(6a)

Table 1. Classification of deposit models by lithologic-tectonic environment --Continued

Deposit environment	Model No.
G. Felsic-mafic extrusive rocks	
Subaerial	
Deposits mainly within volcanic rocks	
Hot-spring Au-Ag	25a
Creede epithermal vein	25b
Comstock epithermal vein	25c
Sado epithermal vein	25d
Epithermal quartz-alunite Au	25e
Volcanogenic U	25f
Epithermal Mn	25g
Rhyolite-hosted Sn	25h
Volcanic-hosted magnetite	25i
(Sn polymetallic veins)	(20b)
Deposits in older calcareous rocks	
Carbonate-hosted Au-Ag	26a
Fluorspar deposits	26b*
Deposits in older clastic sedimentary rocks	
Hot-spring Hg	27a
Almaden Hg	27b
Silica-carbonate Hg	27c
Simple Sb	27d
Marine	
Kuroko massive sulfide	28a
Algoma Fe	28b
(Volcanogenic Mn)	(24c)
(Volcanogenic U)	(25f)
(Low-sulfide Au-quartz vein)	(36a)
(Homestake Au)	(36b)
(Volcanogenic U)	(25f)
Sedimentary rocks	
H. Clastic sedimentary rocks	
Conglomerate and sedimentary breccia	
Quartz pebble conglomerate Au-U	29a
Olympic Dam Cu-U-Au	29b
(Sandstone U)	(30c)
(Basaltic Cu)	(23)
Sandstone	
Sandstone-hosted Pb-Zn	30a
Sediment-hosted Cu	30b
Sandstone U	30c
(Basaltic Cu)	(23)
(Kipushi Cu-Pb-Zn)	(32c)
(Unconformity U-Au)	(37a)
Shale-siltstone	
Sedimentary exhalative Zn-Pb	31a
Bedded barite	31b
Emerald veins	31c
(Basaltic Cu)	(23)
(Carbonate-hosted Au-Ag)	(26a)
(Sediment-hosted Cu)	(30b)
I. Carbonate rocks	
No associated igneous rocks	
Southeast Missouri Pb-Zn	32a
Appalachian Zn	32b
Kipushi Cu-Pb-Zn	32c
(Replacement Sn)	(14c)

Table 1. Classification of deposit models by lithologic-tectonic environment --Continued

Deposit environment	Model No.
I. Carbonate rocks--Continued	
No associated igneous rocks--Continued	
(Sedimentary exhalative Zn-Pb)	(31a)
(Karst bauxite)	(38c)
Igneous heat sources present	
(Polymetallic replacement)	(19a)
(Replacement Mn)	(19b)
(Carbonate-hosted Au-Ag)	(26a)
(Fluorspar deposits)	(26b*)
J. Chemical sediments	
Oceanic	
Mn nodules	33a*
Mn crusts	33b*
Shelf	
Superior Fe	34a
Sedimentary Mn	34b
Phosphate, upwelling type	34c
Phosphate, warm-current type	34d
Restricted basin	
Marine evaporite	35a*
Playa evaporite	35b*
(Sedimentary exhalative Zn-Pb)	(31a)
(Sedimentary Mn)	(34b)
Regionally metamorphosed rocks	
K. Derived mainly from eugeosynclinal rocks	
Low-sulfide Au-quartz vein	36a
Homestake Au	36b
(Serpentine-hosted asbestos)	(8d)
(Gold on flat faults)	(37b)
L. Derived mainly from pelitic and other sedimentary rocks	
Unconformity U-Au	37a
Gold on flat faults	37b
Surficial and unconformity-related	
M. Residual	
Lateritic Ni	38a
Bauxite, laterite type	38b
Bauxite, karst type	38c
(Unconformity U-Au)	(37a)
N. Depositional	
Placer Au-PGE	39a
Placer PGE-Au	39b
Shoreline placer Ti	39c
Diamond placers	39d
Stream placer Sn	39e
(Quartz pebble conglomerate Au-U)	(29a)

inevitably introduces a substantial bias on the part of the classifier, thus we have followed a system of including, parenthetically, alternative classifications less favored by the compiler at the appropriate alternative points in the classification scheme.

MODEL NAMES

Each model has been assigned a name that is derived either from the special characteristics of the classes or from a type locality. The latter strategy was employed to avoid excessively long descriptive names. The use of type names derived from specific deposits does produce confusion in some readers, however, who may feel, for example, that a deposit that does not look "exactly" like Comstock cannot be represented by a "Comstock epithermal vein" model. This confusion may be minimized by realizing that most models are blends of attributes from a large number of deposits and that the names are only conveniences, not constrictions. The contributors to this report and the literature in general are not without disagreements regarding nomenclature (as well as genetic aspects and some facets of the groupings made here), but provision for alternative names is made in the model format under the heading of approximate synonyms.

DESCRIPTIVE MODELS

Because every mineral deposit, like every fingerprint, is different from every other in some finite way, models have to progress beyond the purely descriptive in order to represent more than single deposits. Deposits sharing a relatively wide variety and large number of attributes come to be characterized as a "type," and a model representing that type can evolve. As noted above, generally accepted genetic interpretations play a significant role in establishing model classes. Here we shall emphasize the more descriptive aspects of the deposits because our goal is to provide a basis for interpreting geologic observations rather than to provide interpretations in search of examples. The attributes listed are intended to be guides for resource assessment and for exploration, both in the planning stage and in the interpretation of findings.

The descriptive models have two parts. The first, the "Geological Environment," describes the environments in which the deposits are found; the second gives the identifying characteristics of the deposits. The headings "Rock Types" and "Textures" cover the favorable host rocks of deposits as well as source rocks believed to be responsible for hydrothermal fluids which may have introduced epigenetic deposits. "Age" refers to the age of the event responsible for the formation of the deposit. "Tectonic Setting" is concerned with major features or provinces (perhaps those that might be portrayed only at 1:1,000,000 or smaller scale), not ore control by structures that are local and often site-specific. "Associated Deposits" are listed as deposits whose presence might indicate suitable conditions for additional deposits of the type portrayed by the model.

The second part of the model, the "Deposit Description," provides the identifying characteristics of the deposits themselves, particularly emphasizing aspects by which the deposits might be recognized through their geochemical and geophysical anomalies. In most cases the descriptions also contain data useful in project planning for mineral assessment or exploration; this aspect is especially important where limited financial and manpower resources must be allocated to the more significant tasks.

GRADE-TONNAGE MODELS

Estimated pre-mining tonnages and grades from over 3,900 well-explored, well-characterized deposits were used to construct 60 grade-tonnage models. Where several different estimates were available for a deposit, the estimated tonnages associated with the lowest cutoff grades were used. Grades not available (always for by-products) were treated as zero. Except for a few instances, the data base is so large as to preclude specific references. Several published compilations of data were particularly useful sources for multiple deposit types (Canada Department of Energy, Mines and Resources, 1980; DeYoung and others, 1984; Krauss and others, 1984; Laughlin, 1984; Menzie and Mosier, 1985; Mosier and others, 1983; Mosier and others, in press; Singer and others, 1980; Yamada and others, 1980). The U.S. Geological Survey has a great deal of data available in the Mineral Resources Data System.

The grade-tonnage models are presented in graphical format to make it easy to compare deposit types and to display the data. All plots show either grade or tonnage on the horizontal axis, while the vertical axis is always the cumulative proportion of deposits. Plots of the same commodity or tonnages are presented on the same scale; a logarithmic scale is used for tonnage and most grades. Each dot represents an individual deposit (or, rarely, a district), cumulated in ascending grade or tonnage. Where a large number of deposits is plotted, individual digits represent the number of deposits. Smoothed curves are plotted through arrays of points, and intercepts for the 90th, 50th, and 10th percentiles are constructed. For tonnages and most grades, the smoothed curves represent percentiles of a lognormal distribution that has the same mean and standard deviation as the observed data; exceptions are plots where only a small percentage of deposits had reported grades and grade plots that are presented on an arithmetic scale, such as iron or manganese, for which the smoothed curve was fit by eye. Summary statistics by deposit type are provided in Appendix B. The number of deposits in each type is indicated at the upper right of each diagram. The deposits used to construct each model are listed with the model and cross-indexed to model types in Appendix E. Correlations among grades and between tonnage and each grade are indicated only when significant at the 1 percent level.

There are important limitations inherent in the data base used for all grade-tonnage models. Estimates of cutoff grades within individual deposit types can vary because of regional, national, or operator differences. All too commonly there is no mention of the actual cutoff grades or mining widths that are incorporated into published reserve figures; nevertheless, the grade-tonnage figures given do represent material that the company or the government believed might someday be economic to mine. Stratiform deposits of large areal extent, such as phosphate or sedimentary manganese, are special problems because of differences in opinion and practice regarding how closely drilled they must be to "prove" ore tonnages and regarding the thicknesses and depths of what may be considered for eventual mining. Effects of another source of variation, mining methods, are recognized in some of the placer models; typically, however, mining methods are fairly consistent within a deposit type. In a few instances, irregular cumulative frequency plots reflect mixing of economic and scientific data sources, such as in the plot of gold in porphyry copper deposits. In spite of the current difficulty of quantifying variation of grades and tonnages with respect to changes in cutoff grades or mining methods, the models presented here are believed to account for the main source of variation in grades and tonnages of mineral deposits--variation due to differences among types of deposits.

The question of whether one counts deposits within a cluster of related deposits as individuals or as a total will probably never be resolved to everyone's satisfaction. Some geostatisticians would separate each ore body (and then argue about whether two operations on the same body should be counted separately), whereas some economic geologists would lump everything from a single district (and then argue about district boundaries). For the most part the entities summarized are individual deposits, but in some instances such data are mixed with data representing entire districts. Because of these inconsistencies, some care is necessary in comparing grade-tonnage models between deposit types or in comparing this summary with those prepared using alternative methods.

Care is also warranted in interpreting the grade distributions for which data are missing; this concerns principally by-product grades. In some instances, such as the platinum-group element (PGE) contents in podiform chromite and the cobalt content of laterites, the fragmentary information given probably represents the entire class. In other instances, such as the lead content of Cyprus massive sulfide deposits, the missing grades probably represent values below the lowest reported grades. The grades derived from studies of trace elements in ores more probably represent the former situation rather than the latter.

Deposits strongly suspected to be small or very low grade are seldom sampled well enough to be characterized in terms of grade and tonnage, thus the sample of many deposit classes is truncated by economics. Nonetheless, probably 40 percent of the deposits used in these models are, in fact, non-economic today; and a perusal of the figures will discover examples of both small deposits and low-grade deposits.

Potential metal supply is dominated by the very few largest tonnage deposits, as shown by Singer and DeYoung (1980), who also pointed out that inverse correlations between grade and tonnage are surprisingly rare. Thus the fact that a deposit is large does not necessarily mean that it will prove to be of low grade. This means that most low-grade deposits are not likely to have huge resources and also that the omission of a few low-grade or small tonnage deposits will not seriously degrade the predictions of potential national supplies for most commodities. In contrast, the missing low-grade and small deposits suggest that the grade-tonnage models represent a biased sample of the large number of low-grade or small-tonnage occurrences and prospects found by exploration. This fact must be considered in cases where the number of undiscovered deposits is estimated. In order for the estimated number of deposits to be consistent with a grade-tonnage model, approximately half of the deposits estimated should have greater than the model's median tonnage or grade. Thus the probability that an untested prospect represents a significant deposit can too easily be overestimated.

OTHER TYPES OF MODELS AND THEIR INTERRELATIONSHIPS

The bulk of this report deals with descriptive mineral deposit models and their grade-tonnage counterparts, but there are other useful aspects which we wish to discuss even though we have not yet had the opportunity to develop or exploit them. They are the genetic, occurrence probability, and quantitative process models.

Many authors prefer to keep a clear distinction between descriptive and genetic models, apparently feeling that the descriptive models somehow represent "pure truth" whereas the genetic constitute a less objective philosophical position (or at least make the investigator "skate on thin ice"). It is altogether desirable to avoid confusing interpretation with fact; but it is well to remember, for example, that each time a field geoscientist extrapolates geology across a covered area he or she adds an element of "interpretation" to a "factual" map, and that this interpretation is not necessarily any more "real" (or "unreal") than, for example, an isotope geologist's conclusion that a given oxygen and hydrogen isotopic signature extracted from fluid inclusions points to a meteoric origin for the fluid. The point is that the whole of our professional knowledge rests on a broad continuum of interpretations; many of them are so commonly accepted that they are no longer questioned, but many others still evoke challenges. Thus we suggest that a combination descriptive-genetic model is not inconsistent with professional practice. The model begins as a description, but various aspects of the model become genetic as they acquire satisfactory genetic explanations. Eventually much of the model becomes genetic, as has happened, for example, with the Cyprus-type massive sulfide deposits or the sandstone uranium deposits of the Colorado Plateau.

As the attributes of a model become understood in a genetic sense, the descriptive model evolves to a genetic model:

1. Genetic models are compilations of the properties of a group of related deposits in which the reasons for certain attributes being favorable are identified. Descriptive models evolve into genetic models, and as such they become far more flexible and powerful.

We have presented the three model subtypes above as if they constituted a linear logical sequence leading toward the "final" model, but in fact there must be an iterative relationship among descriptive, genetic, and grade/tonnage models. The consequence of examining any of these three may be a reassessment of the groupings of deposits chosen to be represented by a model type and the redesignation of the attributes diagnostic for that type.

With a dominantly genetic model in hand, two more model types can be generated:

2. Occurrence probability models are models that predict the probability of a deposit (of a size and grade indicated by the appropriate grade-tonnage models) occurring within a given area. As with the descriptive and genetic models, probability models that are tied to lithic or structural geologic entities (that is, they are genetic) are far more focused; in fact, it is probably impossible to generate a useful probability model before the establishment of a genetic model. Accurate probability models are very difficult to construct because although the technical community has very complete data on mineral producers (mines), the data on non-producing mineral deposits (prospects and mineral shows) are much less well documented, a point also covered in the discussion of grade-tonnage models. Even more importantly, data on barren areas are sparse. We must extrapolate from a very fragmentary base toward a completely unseen target.

There is much to learn before the probability model can be made a dependable tool; yet the successful targeting of exploration programs by industry demonstrates that, at least on a qualitative basis, areas with better-than-average probabilities can be identified. It is worth noting, also, that mineral fuels are much more predictable and now can have realistic probability-of-occurrence values attached to specific volumes of sediments provided that the initial character and postdepositional histories of the sediments are well known. It is a distant but not unreasonable dream to anticipate that some day we shall approach that level of certainty for some types of nonfuel mineral deposits.

3. Quantitative process models are models that describe quantitatively some process related to mineral deposit formation; they are offshoots of the genetic model. Examples would be models of heat or fluid flow around a cooling pluton; rates of crystal growth as functions of supersaturation, impurities, and temperature; or sequences and amounts of minerals deposited from evaporating seawater.

All five of these model subtypes can be parts of the "final" model, and recycling of the model back to the original groupings stage helps refine the selection process. Figure 2 shows the flow of information that results in the generation of the models we have discussed.

Table 2 compares the five model subtypes with five distinct types of uses for the information. Note that persons engaged in research guidance and especially exploration and development have broad-ranging needs, whereas those dealing with the availability of minerals or of land-use allocation have less use for genetic or quantitative process models. Overall there is a need for a comprehensive array of mineral deposit models to meet these individual objectives.

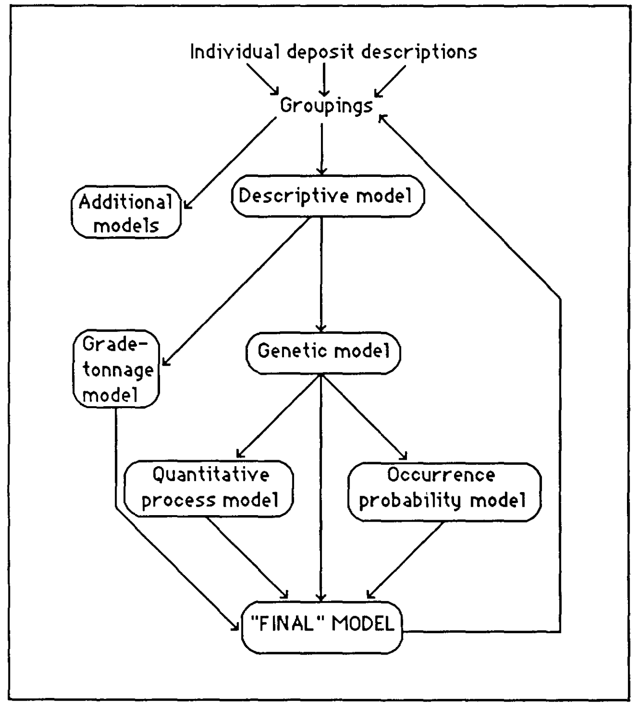


Figure 2. Flow sheet showing evolution of model types. Individual model subtypes are discussed in text. It is essential that such a structure represents the repetitive cycling of information leading to continual refinement of groupings of deposits that represent each model type.

MATURITY OF DESCRIPTIVE-GENETIC MODELS

The rate at which we gain understanding and the current levels of genetic knowledge vary considerably from one deposit type to another, as figures 3 and 4 show. Such types as placers and evaporites are well known genetically and the problems in their exploration and utilization concern local site-specific geologic issues rather than mineral genesis or the degree of maturation of the model. In contrast, others such as the Coeur d'Alene Ag-Pb-Zn veins, or the massive Zn-Mn-Fe oxide/silicate bodies at Franklin and Sterling Hill, or the Cu-U-Au at Olympic Dam, or the Cu-Zn-Pb-Ge ores of Kipushi and the Tsumeb pipe remain genetic enigmas despite, in the instances of the first two, extensive research spanning many years. Still others, such as the diamond-bearing kimberlite pipes, are geologically well understood regarding their origin yet very poorly understood in terms of the reasons for their existing at any particular site. Our rate of acquisition of information is very irregular, as the schematic diagram in figure 3 shows. The several scarps between plateaus in the knowledge curve for the marine phosphate model might mark, successively, the recognition that the phosphate was a chemical precipitate, that it occurred on continental shelves where upwelling of deep marine waters occurred, and that the upwelling regions were related to wind and current patterns that were tied to the global configuration of the continents and ocean basins. A

Table 2. Comparison of application of the five model subtypes by various users

[Level of use: Major, **X**; minor, X; minimal, x]

Uses	Subtypes of models				
	Grade/tonnage	Descriptive	Genetic	Probability of occurrence	Quantitative process
Exploration/development	**X**	**X**	**X**	X	X
Supply potential	**X**	x	x	**X**	x
Land use	**X**	X	x	**X**	x
Education	x	X	**X**	X	**X**
Research guidance	X	X	**X**	X	**X**

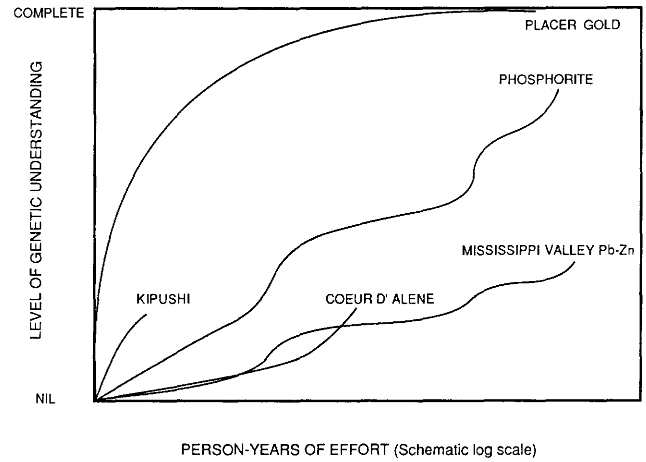


Figure 3. Schematic growth patterns for understanding of some typical genetic models. Individual curves discussed in text.

second example from the Mississippi Valley-type ores might involve scarps marking the recognition (from fluid-inclusion evidence) that the ores were deposited from warm (about 100 °C) highly saline solutions that could represent neither simple surface nor marine waters. A second scarp might be associated with the recognition that the deposits were integral parts of a regional hydrologic regime whose distribution and character was susceptible to interpretation.

Figures 3 and 4 bring out another point: some aspects of any model always remain to be determined, thus we never acquire a "complete" model. Indeed, the approach to "complete" understanding is asymptotic, and a lot of additional effort to clear up the "last" uncertainty in a nearly perfect model is probably unwarranted. But, as the examples in figure 3 show, new ideas and new technologies can provide the impetus for new spurts in knowledge for heretofore incomplete models.

Note that the horizontal axis in figure 3 is simply "years of effort" devoted to fundamental geologic investigation. The scale certainly needs to be exponential in order to fit the intensively studied and sparsely studied deposit types, but this figure is strictly schematic, there being no source of documentation for either coordinate. The figure also indicates that different deposit types may require different amounts of effort to achieve a similar level of genetic understanding.

Figure 4 shows a hypothetical growth curve along which different types of deposits have been schematically arrayed. Because some deposits (such as volcanogenic massive sulfides) are so much more difficult to understand than others (gold placers), the horizontal axis has been "normalized" by plotting a ratio of effort done to effort needed thereby permitting a smooth, although admittedly subjective and schematic, curve to be illustrated. As with figure 3, there is no documentation to support this diagram, although the general concept meets with agreement among most contributors to this volume.

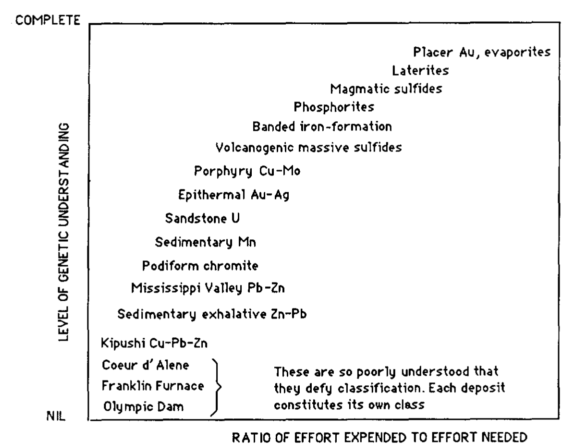


Figure 4. Comparison of relative levels of understanding of some important model types. Vertical coordinate same as for figure 3; but because difficulty of acquiring the genetic information differs so widely among model types, the horizontal coordinate is "normalized" as noted in text.

DESCRIPTIVE MODEL OF STILLWATER Ni-Cu

By Norman J Page

APPROXIMATE SYNONYM Stratiform mafic-ultramafic Ni-Cu.

DESCRIPTION Ni, Cu sulfides at base of large repetitively layered mafic-ultramafic intrusion. (see fig. 5).

GENERAL REFERENCES Geological Society of South Africa, Special Publication 1 (1969); Economic Geology, v. 77, no. 6 (1982) and v. 71, no. 7 (1976).

GEOLOGICAL ENVIRONMENT

Rock Types Layered intrusion contains norite, gabbro-norite, dunite, harzburgite, peridotite, pyroxenite, troctolite, anorthosite, and gabbro.

Textures Cumulate textures; layers with gradational proportions of euhedral crystals; locally with poikilitic matrix.

Age Range Generally Precambrian, but may be as young as Tertiary.

Depositional Environment Intruded into granitic gneiss or volcanic-sedimentary terrane.

Tectonic Setting(s) Cratonal, mostly in Precambrian shield areas.

Associated Deposit Types Bushveld Cr, Merensky Reef PGE, Bushveld Fe-Ti-U. PGE placers.

DEPOSIT DESCRIPTION

Mineralogy Pyrrhotite + chalcopyrite + pentlandite + cobalt sulfides, by-product platinum group metals (PGE).

Texture/Structure Locally massive; interstitial to silicates; disseminated.

Alteration None related to ore.

Ore Controls Basins in basal contact of intrusion with rapidly varying lithologies. Sulfides may intrude fractures in footwall country rock. Ingress of sulfur through fractures in footwall may be important ore control.

Weathering Gossan.

Geochemical Signature Cu, Ni, PGE, Co. High Mg; low Na, K, and P.

EXAMPLES

Stillwater Complex, USMT (Page, 1977)

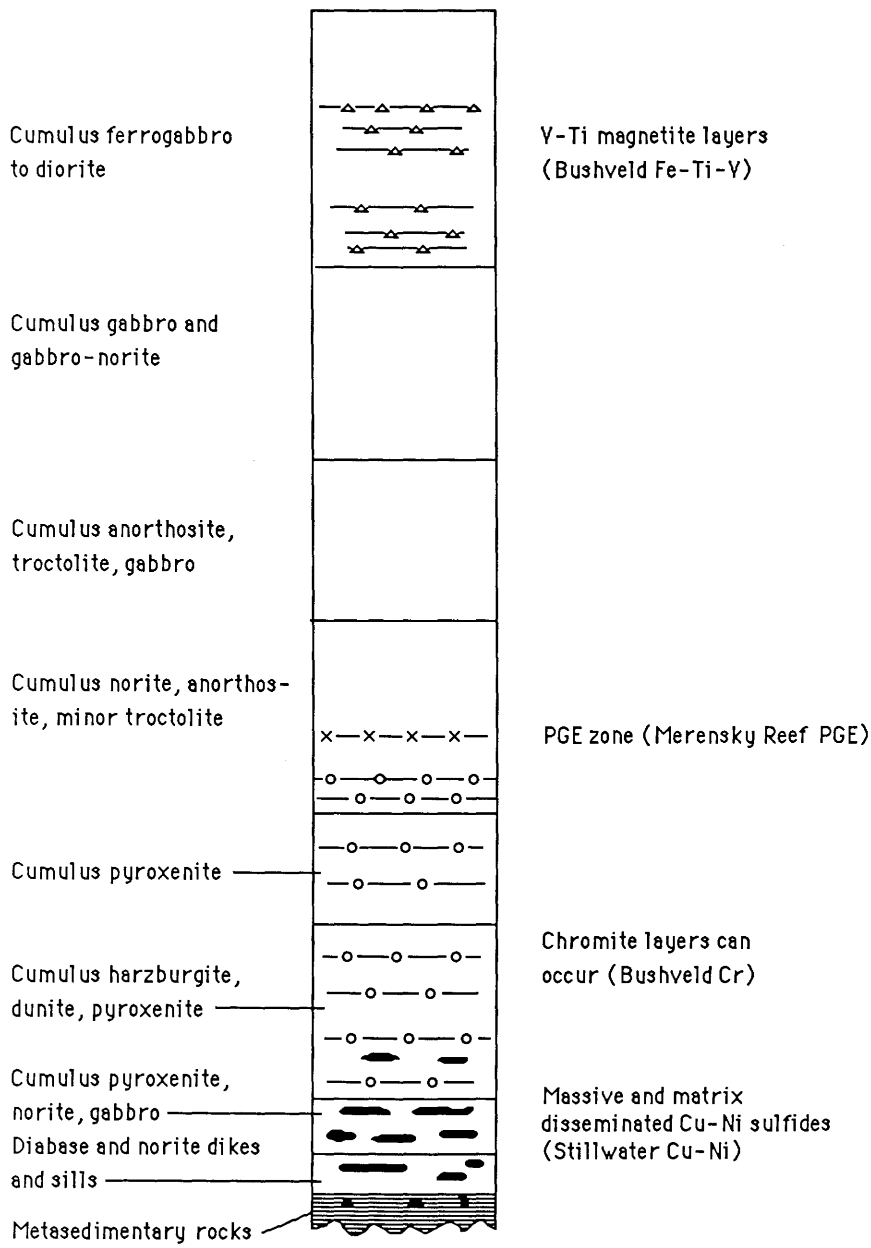


Figure 5. Diagram of typical mafic-ultramafic stratiform complex, 500 to 1,500 m thick, showing stratigraphic relations of rock units and mineral deposits. Deposit models shown in parentheses.

DESCRIPTIVE MODEL OF BUSHVELD Cr

By Norman J Page

SYNONYM Stratiform mafic-ultramafic Cr.

DESCRIPTION Layered chromitite in lower intermediate zone of large repetitively layered mafic-ultramafic intrusions (see fig. 5).

GEOLOGICAL ENVIRONMENT

Rock Types Intrusion may contain norite, gabbro-norite, dunite, harzburgite, peridotite, pyroxenite, troctolite, anorthosite, and gabbro.

Textures Cumulate textures; layers with gradational proportions of euhedral crystals; locally with poikilitic matrix.

Age Range Generally Precambrian, but may be as young as Tertiary.

Depositional Environment Intruded into granitic gneiss or into volcanic-sedimentary terrane.

Tectonic Setting(s) Cratonal, mostly in Precambrian shield areas.

Associated Deposit Types Stillwater-Ni-Cu, Merensky Reef PGE, and Bushveld Fe-Ti-V deposits. PGE placers.

DEPOSIT DESCRIPTION

Mineralogy Chromite ± ilmenite ± magnetite ± pyrrhotite ± pentlandite ± chalcopyrite ± PGE minerals (dominantly laurite, cooperite, and braggite).

Texture/Structure Massive to disseminated layers, cumulus texture.

Alteration None related to ore.

Ore Controls May be in dunite, orthopyroxenite, or anorthosite. Thickness of chromite increases in basinal depressions in layering.

Weathering Abundant blocks of chromitite in soil and alluvium.

Geochemical Signature Cr, PGE. High Mg; low Na, K, P.

EXAMPLES

Bushveld Complex, SAFR	(Cameron and Desborough, 1969)
Stillwater Complex, USMT	(Jackson, 1969)
Great Dyke, ZIMB	(Bichan, 1969)

DESCRIPTIVE MODEL OF MERENSKY REEF PGE

By Norman J Page

SYNONYM Stratiform mafic-ultramafic PGE.

DESCRIPTION Disseminated PGE-rich sulfides in olivine-rich rocks in anorthosite-gabbro zone of large layered intrusions (see fig. 5).

GEOLOGICAL ENVIRONMENT

Rock Types Norite, gabbro-norite, dunite, harzburgite, peridotite, pyroxenite, troctolite, anorthosite, and gabbro.

Textures Cumulate textures; layers with gradational proportions of euhedral crystals; locally with poikilitic matrix.

Age Range Generally Precambrian, but may be as young as Tertiary.

Depositional Environment Intruded into granitic gneiss or into volcanic-sedimentary terrane.

Tectonic Setting(s) Cratonal, mostly in Precambrian shield areas.

Associated Deposit Types Stillwater Ni-Cu, Bushveld Cr, and Bushveld Fe-Ti-V. PGE placers.

DEPOSIT DESCRIPTION

Mineralogy Pyrrhotite + chalcopyrite + pentlandite ± chromite ± graphite. PGE minerals are braggite, cooperite, kotulskite, vysotskite, sperrylite, moncheite, and alloys of platinum-group metals.

Texture/Structure Clots of massive sulfide and disseminated grains.

Alteration None related to ore.

Ore Controls In layers near first reappearance of olivine as a cumulate phase after thick accumulation of plagioclase pyroxene rocks. May be related to introduction of new magma. Locally associated with pipes of Fe-rich olivine.

Weathering Difficult to see ore zone on weathered surface, exploration requires extensive sampling and chemical analysis.

Geochemical Signature PGE, Cu, Ni, Cr, Ti. High Mg; low Na, K, P.

EXAMPLES

Bushveld Complex, SAFR	(Vermaak and Hendriks, 1976)
Stillwater Complex, USMT	(Todd and others, 1982)

DESCRIPTIVE MODEL OF BUSHVELD Fe-Ti-V

By Norman J Page

SYNONYM Stratiform mafic-ultramafic Fe-Ti-V.

DESCRIPTION Layers of Ti-V-rich magnetite in upper parts of large repetitively layered mafic-ultramafic intrusions (see fig. 5).

GEOLOGICAL ENVIRONMENT

Rock Types Norite, gabbro-norite, dunite, harzburgite, peridotite, pyroxenite, troctolite, anorthosite, and gabbro.

Textures Cumulate textures; layers with gradational proportions of euhedral crystals; locally with poikilitic matrix.

Age Range Generally Precambrian, but may be as young as Tertiary.

Depositional Environment Intruded into granitic gneiss or into volcanic-sedimentary terrane.

Tectonic Setting(s) Cratonal, mostly in Precambrian shield areas.

Associated Deposit Types Bushveld Cr, Stillwater Ni-Cu, and Merensky Reef PGE. PGE placers.

DEPOSIT DESCRIPTION

Mineralogy Vanadium-bearing magnetite ± ilmenite ± traces of sulfides.

Texture/Structure Massive magnetite-ilmenite, cumulus textures.

Ore Controls Layers near top of intrusion. Layers may be cut by pipes and veins rich in ilmenite.

Weathering Blocks of magnetite in soil and alluvium.

Geochemical Signature Fe, Ti, V.

EXAMPLES

Bushveld Complex, SAFR (Williams, 1969; Molyneux, 1969)

DESCRIPTIVE MODEL OF DULUTH Cu-Ni-PGE

By Norman J Page

DESCRIPTION Sporadically distributed massive to disseminated sulfides associated with basal portion of large layered intrusions in rift environments.

GENERAL REFERENCE Weiblen and Morey (1980).

GEOLOGICAL ENVIRONMENT

Rock Types Peridotite, harzburgite, pyroxenite, norite, augite, troctolite, anorthosite. Associated with pyritic shale, anhydrite, or recognizable source of sulfur to contaminate magma.

Textures Cumulus textures, locally diabasic or ophitic textures.

Age Range Precambrian to Tertiary(?).

Depositional Environment Intruded during rifting into metasedimentary (slate, argillite, graywacke) and metavolcanic rocks.

Tectonic Setting(s) Rift environment.

DEPOSIT DESCRIPTION

Mineralogy Pyrrhotite + pentlandite + chalcopyrite + cubanite ± PGE minerals ± graphite.

Texture/Structure Disseminated, matrix, and massive sulfides.

Alteration Locally sulfides may show evidence of hydrothermal remobilization.

Ore Controls Zone of active syn-intrusion faulting forming basins, in basal part of intrusion; source of external sulfur; source of silicic material to contaminate magma.

Geochemical Signature Ni/Cu approximately 1/3, Cu, Ni; PGE, Co, Ti; sulfur isotopes show non-magmatic sulfur.

EXAMPLES

Duluth Complex, USMN (Dunka Road deposits)	(Weiblen and Morey, 1980; Bonnichsen, 1972; Ripley, 1981)

DESCRIPTIVE MODEL OF NORIL'SK Cu-Ni-PGE

By Norman J Page

DESCRIPTION Massive to disseminated sulfides in small shallow mafic to ultramafic intrusives with an external source of sulfur.

GEOLOGICAL ENVIRONMENT

Rock Types Flood basalts, picritic intrusive rocks, picritic gabbro, norite, olivine gabbro, dolerite, intrusive and volcanic breccias. Associated with evaporites or some external source of sulfur.

Textures Ophitic, subophitic, gabbroic, cumulate.

Age Range Paleozoic.

Depositional Environment Magma has intruded through evaporites or pyritic shale, and formed sills in flood basalts during active faulting.

Tectonic Setting(s) Rift environment.

DEPOSIT DESCRIPTION

Mineralogy Pyrrhotite + pentlandite + chalcopyrite + cubanite + millerite + vallerite + pyrite + bornite + gersdorffite + sperrylite + PGE alloys + polarite + PGE tellurides, arsenides, and antimonides.

Texture/Structure Lenses, layers of massive, matrix, and disseminated sulfide.

Alteration None related to ore.

Ore Controls External source of sulfur; sulfides form persistent basal layers to intrusion and dike-like bodies into country rock; and form in fault-bounded depressions.

Geochemical Signature Ni/Cu = 1.5 to 0.5, Co/Ni = 1/16; Pt/(Pd/Ni) = 1/500

EXAMPLES

Noril'sk, USSR (Krauss and Schmidt, 1979)

DESCRIPTIVE MODEL OF KOMATIITIC Ni-Cu

By Norman J Page

DESCRIPTION Lenticular, irregular elongate to tabular, pipelike Ni-Cu sulfides associated with komatiitic volcanic extrusive rocks (see fig. 6).

GENERAL REFERENCE Arndt and Nisbet (1982).

GEOLOGICAL ENVIRONMENT

Rock Types Dunite, pyroxenite, peridotite, basalt, komatiites, komatiitic basalts. Rocks contain more than 15 percent and may approach 40 percent MgO.

Textures Bladed olivine or pyroxene with skeletal appearance in random or parallel orientations; spinifex textures, fracture or joint patterns that resemble pillows.

Age Range Archean or Proterozoic generally, but some may be Cretaceous or Tertiary.

Depositional Environment Mafic to felsic rock sequences with numerous volcanic events.

Tectonic Setting(s) Greenstone belts.

Associated Deposit Types Dunitic Ni.

DEPOSIT DESCRIPTION

Mineralogy Pyrite + pyrrhotite + chalcopyrite + pentlandite, by-product PGE.

Texture/Structure Sulfide contents vary from base to top of deposit. Base contains massive sulfide grading into net-textured or matrix sulfide into disseminated sulfide.

Alteration None related to ore.

Ore Controls In lowermost flows more than 10 m thick; in zones of increased spinifex development; and near feeder areas for the flows. Orebodies show evidence of active faulting at the time the flows were deposited and have thickening and thinning of flows along strike. Ore occurs in irregularities at bottom of flows. Unit contains greater than 1,000 ppm sulfur or is associated with sulfide-bearing chert and argillite. Shale or iron carbonate sequences occur below flows.

Weathering Develop gossans, laterites.

Geochemical Signature High Mg, Ni, Cu, Mg, PGE. Gossans contain 15 to 30 ppb Pd and 5 to 10 ppb Ir over known Ni-Cu deposits where Cu and Ni are leached out of the gossan.

EXAMPLES

Kambalda, AUWA	(Gresham and Loftus-Hills, 1981)
Damba, ZIMB	(Williams, 1979)
Langmuir, CNON	(Green and Naldrett, 1981)

GRADE AND TONNAGE MODEL OF KOMATIITIC Ni-Cu

By Donald A. Singer, Norman J Page, and W. David Menzie

COMMENTS Nickel grade is correlated with tonnage ($r = -0.47$) and with copper grade ($r = 0.59$, $n = 21$). Au, Ir, Pt, and Pd grades are based on reported analyses of samples from the deposits. See figs. 7-10.

DEPOSITS

Name	Country	Name	Country
Carnilya E.	AUWA	Munda	AUWA
Carnilya Hill	AUWA	Nepean	AUWA
Damba	ZIMB	Perseverance	ZIMB
Epoch	ZIMB	Rankin Inlet	CNNT
E. Scotia	AUWA	Redross	AUWA
Hitura	FNLD	Scotia	AUWA
Hunters Road	ZIMB	Selukwe	ZIMB
Kambalda	AUWA	Shangani	ZIMB
Kotalahti	FNLD	Sothman Twp.	CNON
Langmuir 1	CNON	Spargoville	AUWA
Langmuir 2	CNON	S. Windarra	AUWA
Marbridge	CNQU	Textmont	CNON
McWatters	CNON	Trojan	ZIMB
Miriam	AUWA	Wannaway	AUWA
Mt. Edwards	AUWA	Wigie 3	AUWA
Mt. Windarra	AUWA		

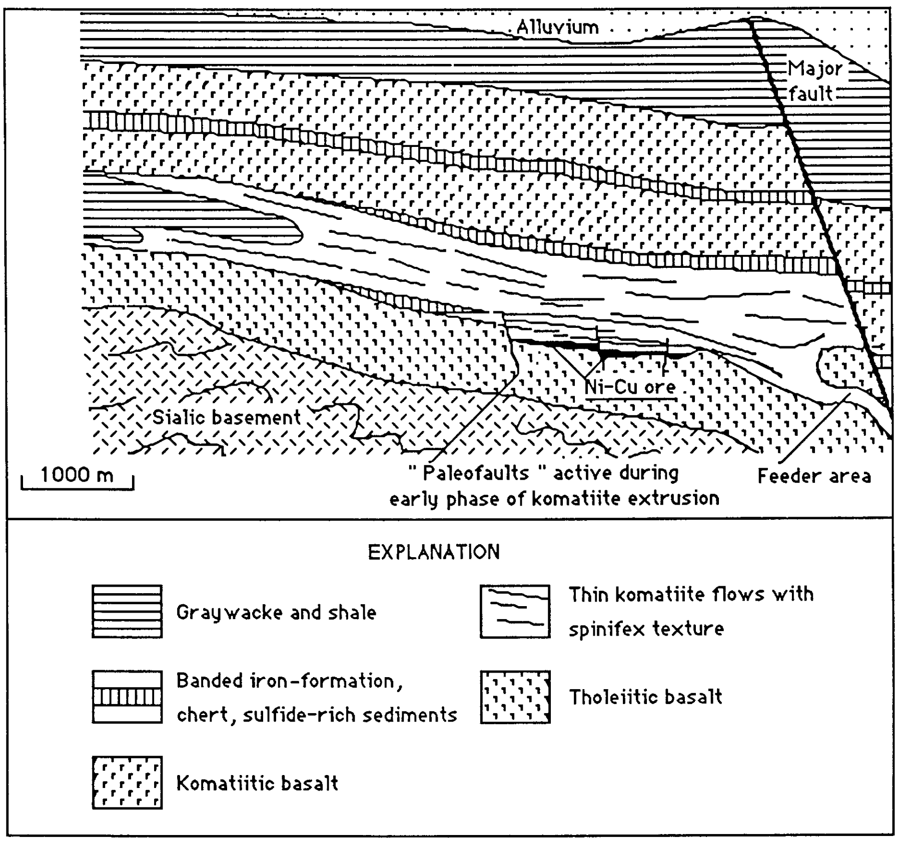


Figure 6. Cartoon cross section of typical komatiitic volcanic sedimentary sequence showing ore controls of komatiitic Ni-Cu deposits. Modified from Marston and others (1981).

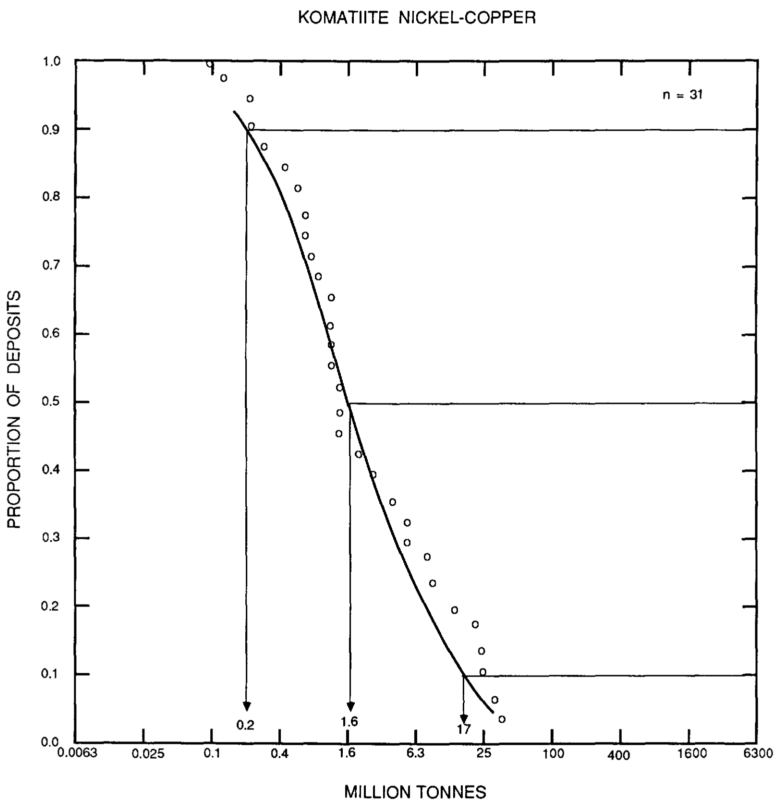


Figure 7. Tonnages of komatiitic Ni-Cu deposits.

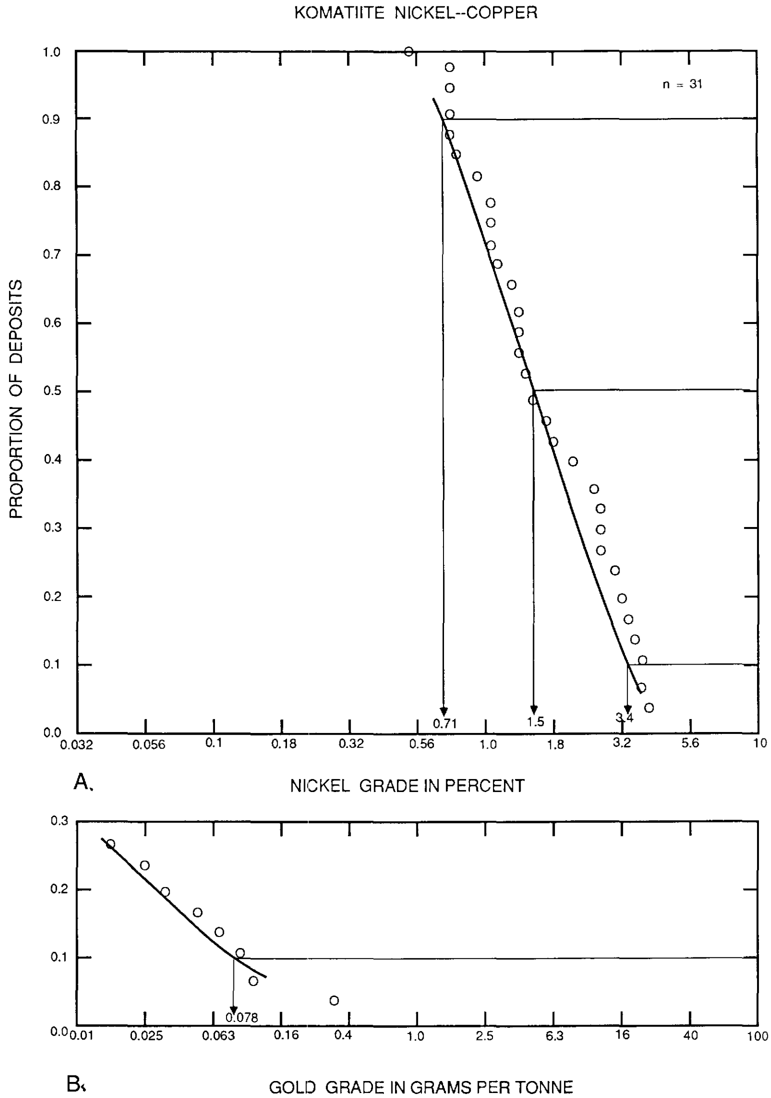


Figure 8. Nickel and gold grades of komatiitic Ni-Cu deposits. A, Nickel. B, Gold.

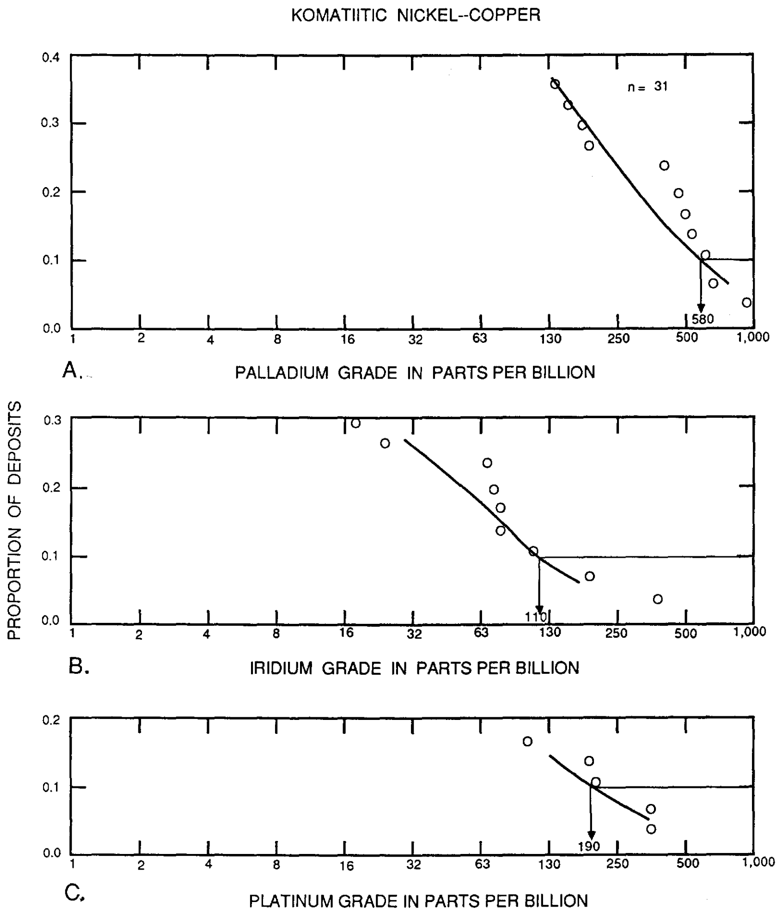


Figure 9. PGE grades of komatiitic Ni-Cu deposits. A, Palladium. B, Iridium. C, Platinum.

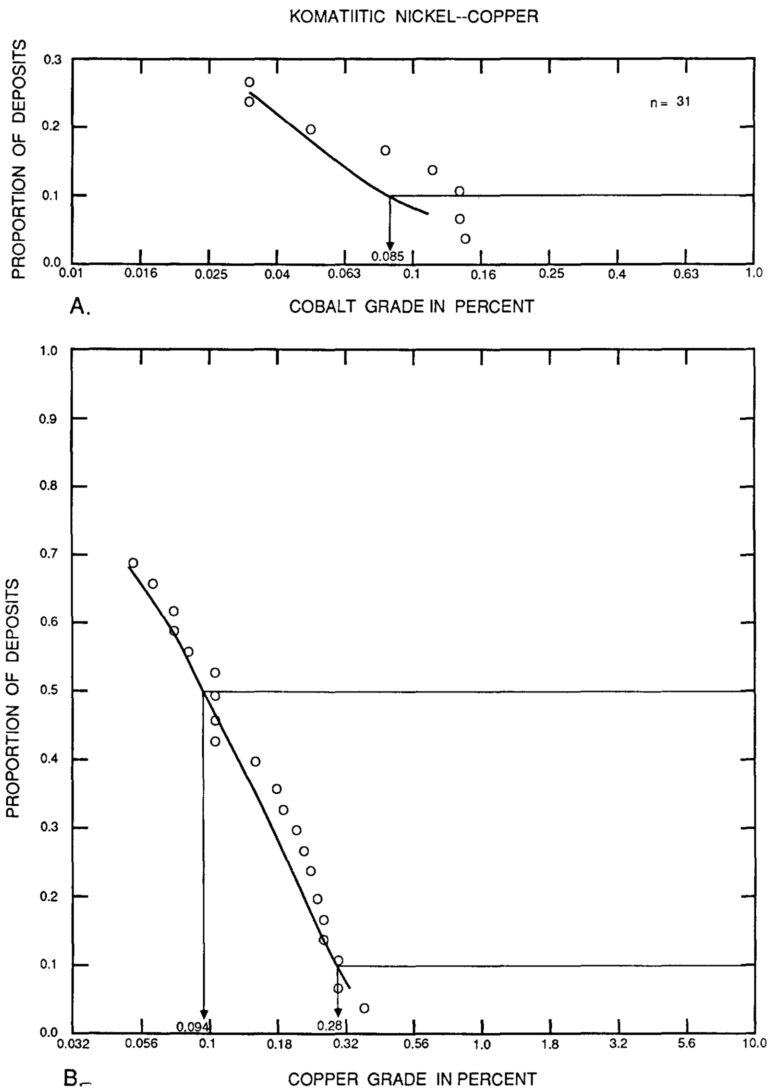


Figure 10. Base-metal grades among komatiitic Ni-Cu deposits. A, Cobalt. B, Copper.

DESCRIPTIVE MODEL OF DUNITIC Ni-Cu

By Norman J Page

DESCRIPTION Disseminated sulfide mineralization in intrusive dunites.

GENERAL REFERENCE Marston and others (1981); Ross and Travis (1981).

GEOLOGICAL ENVIRONMENT

Rock Types Dunite, olivine peridotite in subconcordant lenses 500-1,000 m long, 50-100 m thick.

Textures Dunite; coarse-grained (2-20 mm) subequant olivine (Fo_{87-95}) interlocked to give polygonal to mosaic texture; olivine peridotite; ovate olivine with intercumulus pyroxene, sulfide and oxide minerals.

Age Range Precambrian.

Depositional Environment Intruded into contacts between clastic sedimentary and felsic volcanic rocks and mafic to ultramafic volcanic rocks.

Tectonic Setting(s) Greenstone belts.

Associated Deposit Types Komatiitic Ni, synorogenic-synvolcanic-Ni talc-carbonate Ni-Au, layered sedimentary Ni.

DEPOSIT DESCRIPTION

Mineralogy High grade (1-9 percent Ni): pyrrhotite + pentlandite + magnetite + pyrite + chalcopyrite + chromite. Low grade (0.4-1 percent Ni): the same minerals ± millerite ± heazlewoodite ± godlevskite ± polydymite ± vaesite ± awaruite ± bravoite ± cobaltite ± nickeliferous linnaeite ± cubanite ± Fe-Ni arsenides.

Texture/Structure Lenticular shoots of massive, matrix, and breccia ores are fine to medium grained, also occurs as interstitial films. Olivine is commonly rounded when sulfide is present.

Alteration Prograde and retrograde serpentinization after deposition; usually metamorphosed.

Ore Controls Dunitic lenses close to major strike-slip faults and at high stratigraphic position in volcanic pile; most Ni-rich ores concentrated at one margin, perhaps at base of intrusion.

Weathering Lateritic zones may be enriched in PGE.

Geochemical Signature Ni, Cu, PGE, Cr, Co, Mg. Ni/Cu = 19-70+, Ni/Co=30-70. Massive sulfide ores 6-9 percent Ni, disseminated ores up to 3 percent Ni.

EXAMPLES

Agnew (Perseverance), AUWA	(Martin and Allchurch, 1975)
Mt. Keith, AUWA	(Burt and Sheppy, 1975)

GRADE AND TONNAGE MODEL OF DUNITIC Ni-Cu

By Donald A. Singer and Norman J Page

COMMENTS Nickel grade is correlated with tonnage ($r = -0.54$) and copper grade ($r = 0.84$, $n = 12$). Ir, Pd, Au, and Co grades are based on reported analyses of samples from the deposits. See fig. 11-14.

DEPOSITS

Name	Country	Name	Country
Agnew (Perserverance)	AUWA	Honeymoon Well	AUWA
Amax	CNMN	Manibridge	CNMN
Birch Tree	CNMN	Moak	CNMN
Black Swan	AUWA	Mt. Keith	AUWA
Bowden Lake	CNMN	Mystery Lake	CNMN
Bucko	CNMN	Pipe	CNMN
Discovery	CNMN	Six Mile	AUWA
Dumont	CNQU	Soab N.	CNMN
Forrestania Group	AUWA	Soab S.	CNMN
Geol. Reser. No. 34	CNMN	Thompson	CNMN
Hambone	CNMN	Weebo Bore	AUWA

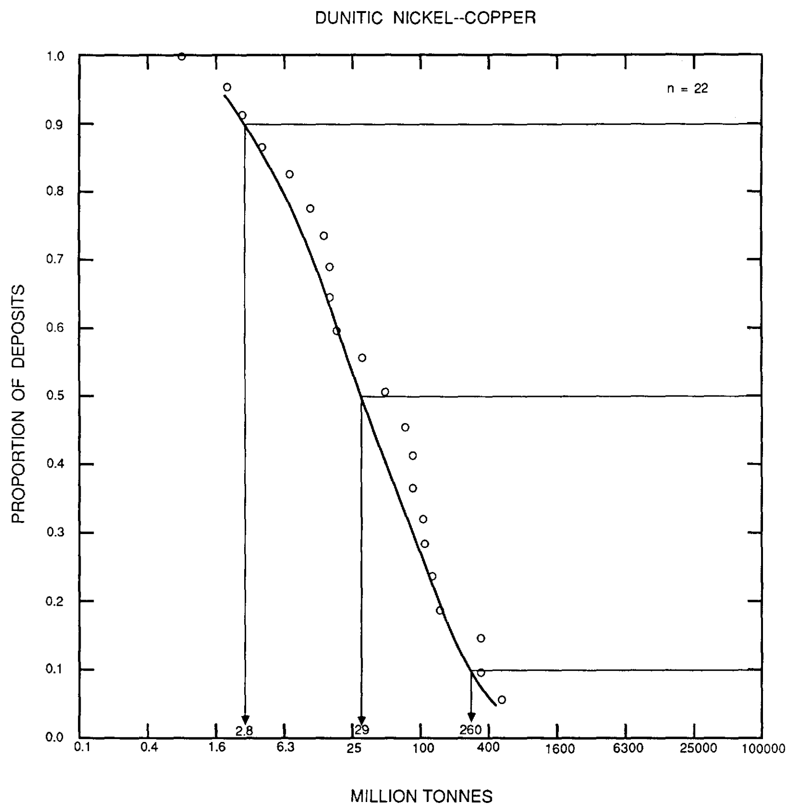


Figure 11. Tonnages of dunitic Ni-Cu deposits.

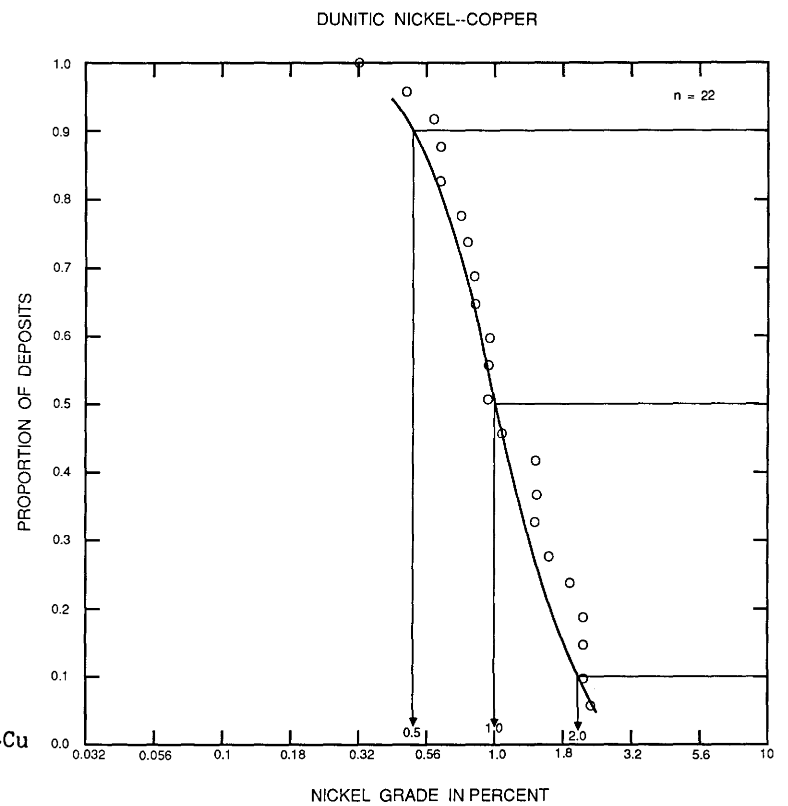


Figure 12. Nickel grades of dunitic Ni-Cu deposits.

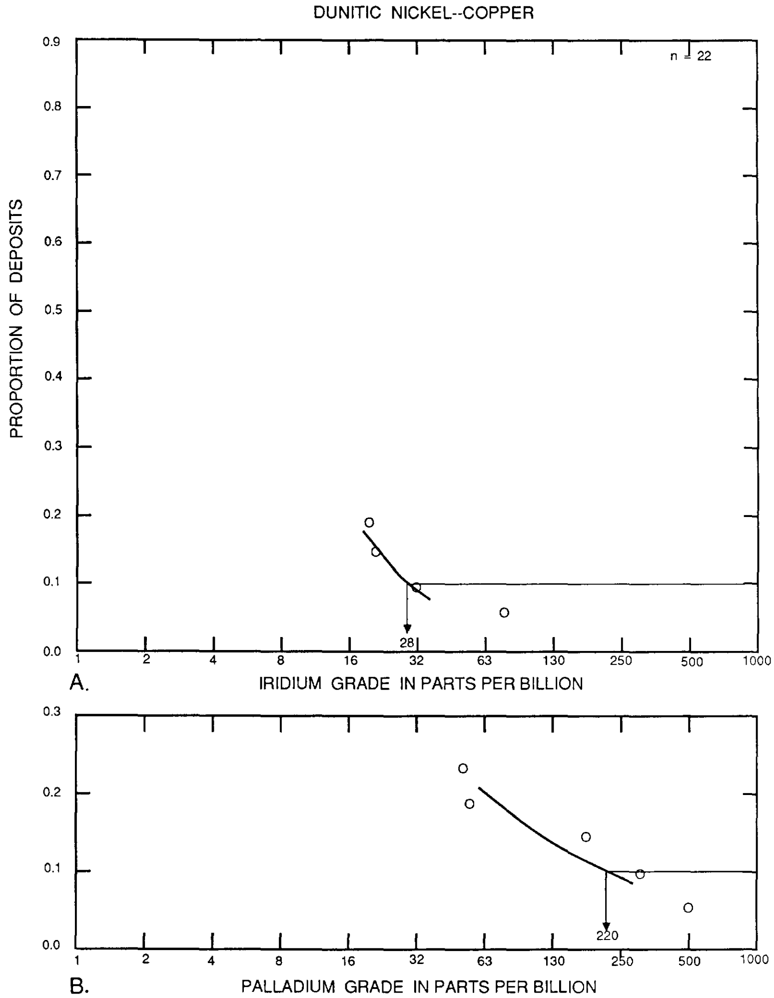


Figure 13. PGE grades of dunitic Ni-Cu deposits. A, Iridium. B, Palladium.

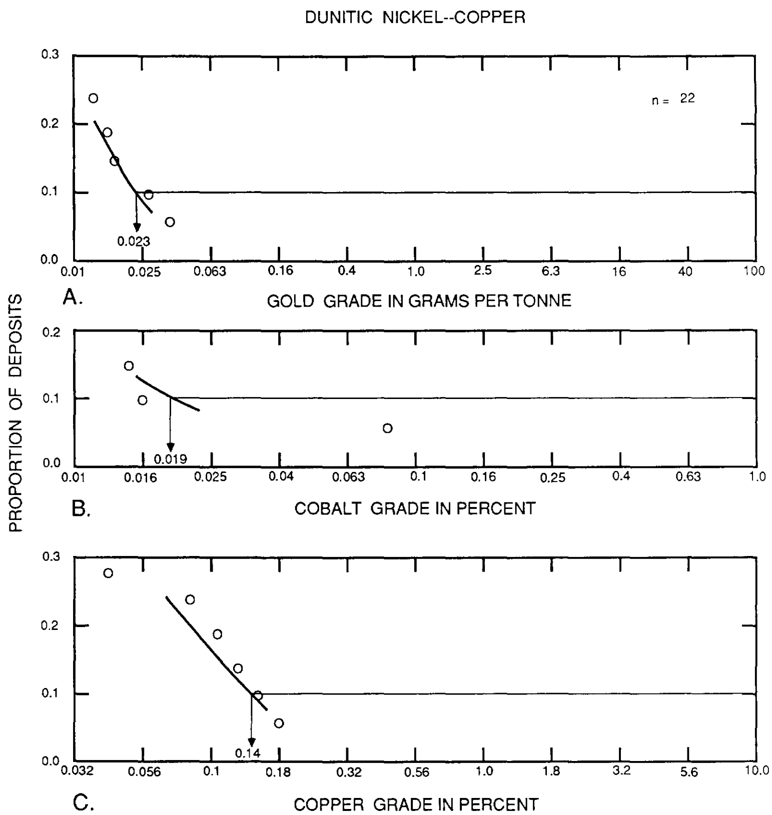


Figure 14. By-product grades of dunitic Ni-Cu deposits. A, Gold. B, Cobalt. C, Copper.

DESCRIPTIVE MODEL OF SYNOROGENIC-SYNVOLCANIC Ni-Cu

By Norman J Page

APPROXIMATE SYNONYMS Gabbroid class (Ross and Travis, 1981), gabbroid associated (Marston and others, 1981).

DESCRIPTION Massive lenses, matrix and disseminated sulfide in small to medium sized gabbroic intrusions in greenstone belts.

GEOLOGICAL ENVIRONMENT

Rock Types Norite, gabbro-norite, pyroxenite, peridotite, troctolite, and anorthosite forming layered or composite igneous complexes.

Textures Phase and cryptic layering sometimes present, rocks usually cumulates.

Age Range Archean to Tertiary, predominantly Archean and Proterozoic.

Depositional Environment Intruded synvolcanically or during orogenic development of a metamorphic terrane containing volcanic and sedimentary rocks.

Tectonic Setting(s) Metamorphic belts, greenstone belts, mobile belts.

Associated Deposit Types Komatiitic Ni-Cu, dunitic Ni-Cu, talc-carbonate Ni-Au (no model available).

DEPOSIT DESCRIPTION

Mineralogy Pyrrhotite + pentlandite + chalcopyrite ± pyrite ± Ti-magnetite ± Cr-magnetite ± graphite--by-product Co and PGE.

Texture/Structure Predominantly disseminated sulfides; commonly highly deformed and metamorphosed so primary textures and mineralogy have been altered. Deformation about the same age as the deposit.

Ore Control Sulfides commonly are in the more ultramafic parts of the complex and near the basal contacts of the intrusion.

Weathering Lateritic.

Geochemical Signature Ni, Cu, Co, PGE.

EXAMPLES

Sally Malay, AUWA	(Thornett, 1981)
Rana, NRWY	(Boyd and Mathiesen, 1979)
Moxie pluton, USMA	(Thompson and Naldrett, 1984)

GRADE AND TONNAGE MODEL OF SYNOROGENIC-SYNVOLCANIC Ni-Cu

By Donald A. Singer, Norman J Page, and W. David Menzie

COMMENTS Pd, Pt, Au, and Co grades are based on reported analyses of samples from the deposits. See figs. 15-18.

DEPOSITS

Name	Country	Name	Country
Bamble	NRWY	Funter Bay	USAK
Carr Boyd	AUWA	Gap	USPA
Empress	ZIMB	Giant Mascot	CNBC
Flaat	NRWY	Hosanger	NRWY

Kenbridge	CNON	Phoenix	BOTS
Kylmakoski	FNLD	Pikwe	BOTS
Lainijaur	SWDN	Renzy	CNQU
Lappuattnet	SWDN	Risliden	SWDN
Laukunkawges	FNLD	Selebi	BOTS
Lorraine	CNQU	Selebi N.	BOTS
Lynn Lake	CNMN	Selkirk	BOTS
Madziwa	ZIMB	Tekwane	BOTS
Makola	FNLD	Thierry	CNON
Mjodvattnet	SWDN	Vakkerlien	NRWY
Montcalm	CNON	Vammala	FNLD
Mt. Sholl	AUWA	Yakobi Island	USAK

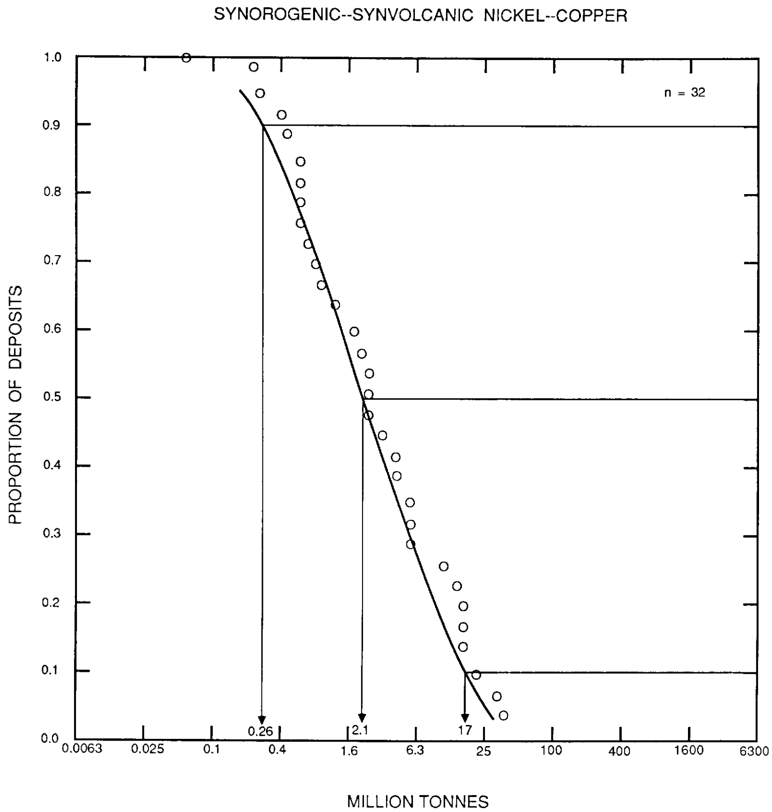


Figure 15. Tonnages of synorogenic-synvolcanic Ni-Cu deposits.

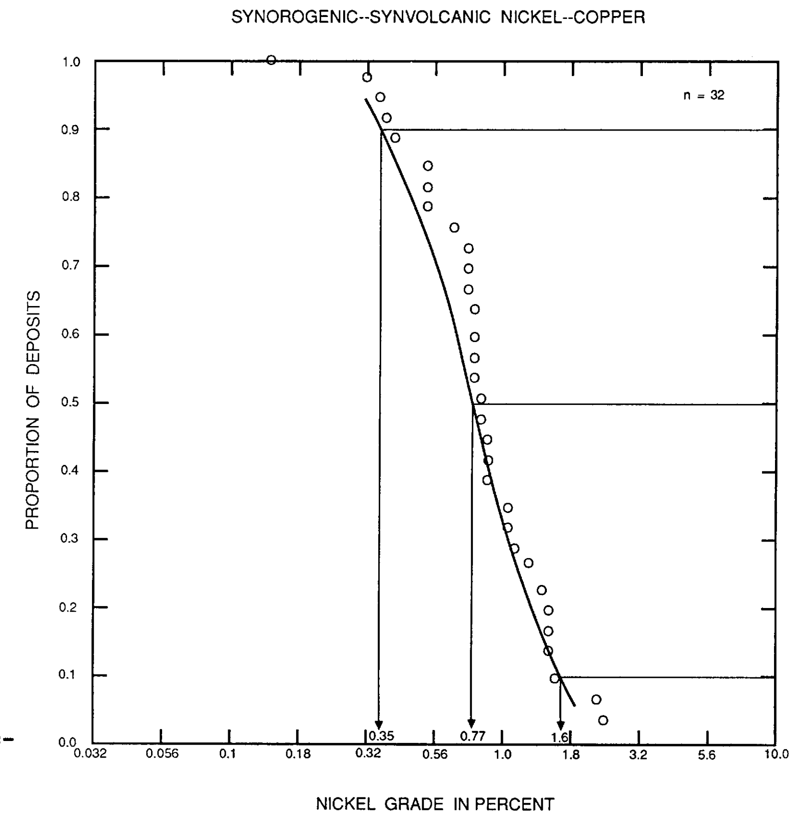


Figure 16. Nickel grades of synorogenic-synvolcanic Ni-Cu deposits.

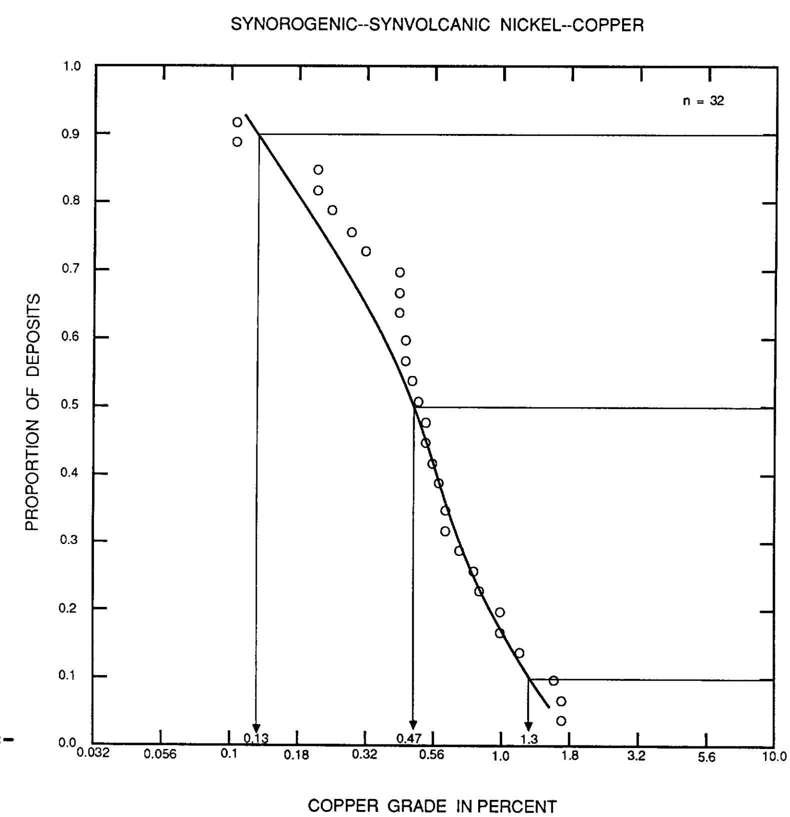


Figure 17. Copper grades of synorogenic-synvolcanic Ni-Cu deposits.

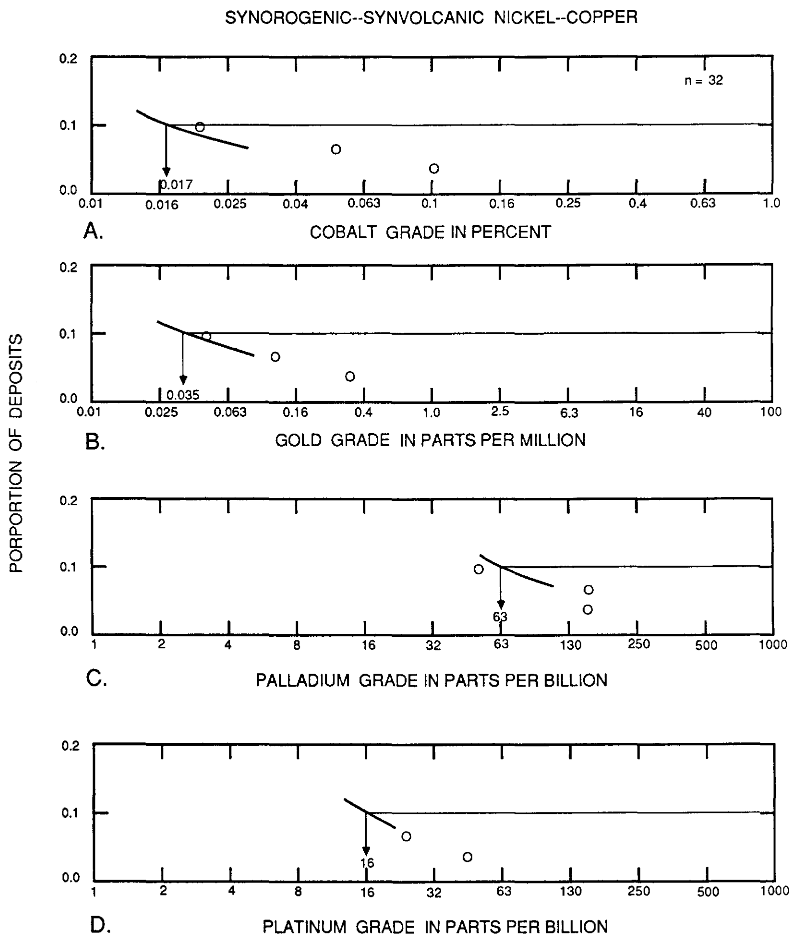


Figure 18. By-product grades of synorogenic-synvolcanic Ni-Cu deposits. A, Cobalt. B, Gold. C, Palladium. D, Platinum.

DESCRIPTIVE MODEL OF ANORTHOSITE Ti

By Eric R. Force

DESCRIPTION Ilmenite (and rutile) deposits in granulite metamorphic terranes intruded by anorthosite-ferrodiorite-clan plutons. Two subsets (1 and 2) distinguished below (see fig. 19).

GEOLOGICAL ENVIRONMENT

Rock Types (1) Andesine anorthosite massifs in granulite-facies country rocks (associated mineralization includes rutile if andesine is antiperthitic).
(2) Ferrodiorite-type intrusive rocks (gabbro, charnockite, jutunite) generally younger than anorthosite, with associated ilmenite ± apatite mineralization.

Textures Granulation in anorthosite, quartz platy and blue where present.

Age Range Most, and perhaps all, between 900 and 1,500 m.y. in age.

Depositional Environment Lower crust, intrusion under hot, dry conditions.

Tectonic Setting(s) Not well known.

Associated Deposit Types None known.

DEPOSIT DESCRIPTION

Mineralogy: (1) Ilmenite ± rutile
(2) Ilmenite ± apatite
Deposit value is much greater if intergrown magnetite and ulvospinel are absent.

Texture/Structure (1) Disseminations to veinlets along anorthosite margins, hosted by both impure anorthosite and adjacent country rock.
(2) Both concordant layers within or at base of ferrodiorite-clan sheets, and vein-like massive bodies in underlying structural units (especially anorthosite).

Alteration None related to ore.

Ore Controls (1) High-temperature metasomatism between Ti-Fe oxides-rich country rock, and anorthosite, coupled with unknown processes in anorthosite magma. Especially concentrated in swarms of anorthosite sills.
(2) Immiscible Ti, P liquid in ferrodioritic magma, forming both cumulate-like bodies and fracture fillings.

Weathering Residual enrichment may occur in weathering zone.

Geochemical and Geophysical Signature (2) High Ti, P, and Zr. Magnetic anomalies.

EXAMPLES

(1)	Roseland, USVA	(Herz and Force, 1984)
	Pluma Hidalgo, MXCO	(Paulson, 1964)
(2)	Roseland, USVA	(Herz and Force, 1984)
	Sanford Lake, USNY	(Gross, S. O., 1968)
	Laramie Range, USWY	(Eberle and Atkinson, 1983)

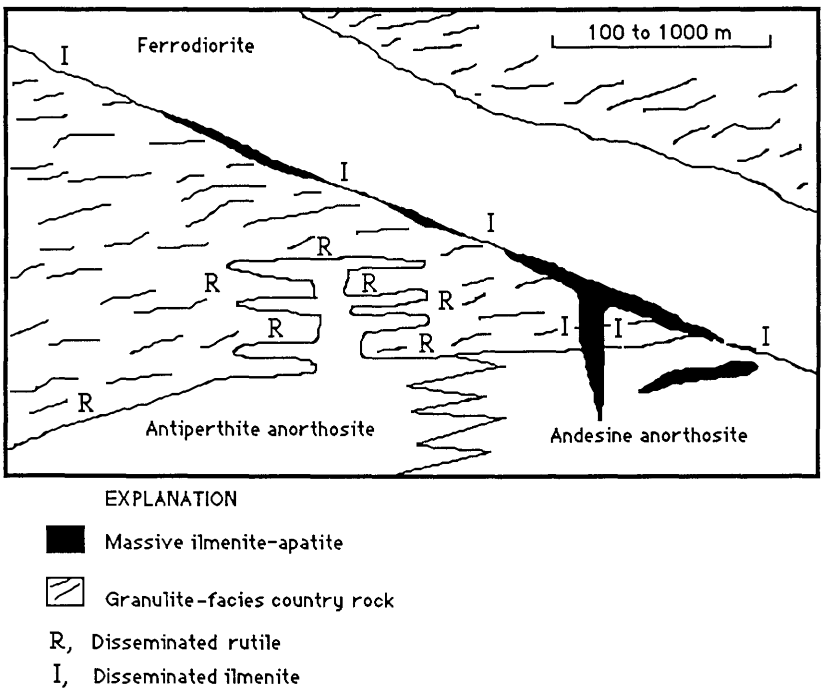


Figure 19. Cartoon cross section of a typical anorthosite ferrodiorite intrusion showing relation between different forms of Ti concentrations.

DESCRIPTIVE MODEL OF PODIFORM CHROMITE

By John P. Albers

APPROXIMATE SYNONYM Alpine type chromite (Thayer, 1964).

DESCRIPTION Podlike masses of chromitite in ultramafic parts of ophiolite complexes (see fig. 20).

GENERAL REFERENCE Dickey (1975).

GEOLOGICAL ENVIRONMENT

Rock Types Highly deformed dunite and harzburgite of ophiolite complexes; commonly serpentinized.

Textures Nodular, orbicular, gneissic, cumulate, pull-apart; most relict textures are modified or destroyed by flowage at magmatic temperatures.

Age Range Phanerozoic.

Depositional Environment Lower part of oceanic lithosphere.

Tectonic Setting(s) Magmatic cumulates in elongate magma pockets along spreading plate boundaries. Subsequently exposed in accreted terranes as part of ophiolite assemblage.

Associated Deposit Types Limassol Forest Co-Ni-S-As.

DEPOSIT DESCRIPTION

Mineralogy Chromite ± ferrichromite ± magnetite ± Ru-Os-Ir alloys ± laurite.

Texture/Structure Massive coarse-grained to finely disseminated.

Alteration None related to ore.

Ore Controls Restricted to dunite bodies in tectonized harzburgite or lower portions of ultramafic cumulate (see fig. 99).

Weathering Highly resistant to weathering and oxidation.

Geochemical Signature None recognized.

EXAMPLES

High Plateau, Del Norte Cty, USCA	(Wells and others, 1946)
Coto Mine, Luzon, PLPN	(LeBlanc and Violette, 1983)

GRADE AND TONNAGE MODEL OF MINOR PODIFORM CHROMITE

By Donald A. Singer and Norman J Page

DATA REFERENCES Singer and others (1980); Calkins and others (1978); Carlson and others (1985).

COMMENTS All deposits in this grade-tonnage compilation are from California and Oregon. The two largest tonnage deposits are actually districts rather than individual deposits. The majority of the grades represent shipping grades. Grades less than 35 percent typically represent in-place "ore". The mixture of shipping grades and in-place grades may explain the significant negative correlation (r = -0.25) between grade and tonnage. Rh, Ir, Ru, Pd, and Pt grades are based on reported analyses of samples from the deposits. Unreported PGE grades are probably similar to those presented here. Rhodium is correlated with chromite (r = 0.35, n = 69), platinum (r= 0.69, n = 31), iridium (r = 0.47, n = 35), ruthenium (r = 0.56, n = 28). Ruthenium is correlated with palladium (r = 0.72, n = 21) and iridium (r = 0.59, n = 29). See figs. 21-23.

DEPOSITS

Name	Country
Ace of Spades	USCA
Adobe Canyon Gp.	USCA
Ajax	USOR
Alice Mine	USCA
Allan (Johnson)	USCA
Alta Hill	USCA
Althouse	USOR
Alyce and Blue Jay	USCA
American Asbestos	USCA
Anti Axis	USCA
Apex (Del Norte Co.)	USCA
Apex (El Dorado Co.)	USCA
Applegate	USOR
Associated Chromite	USOR
Babcock	USOR
Babyfoot	USOR
Beat	USCA
Big Bear	USOR
Big Bend	USCA
Big Chief	USOR
Big Dipper (Robr)	USCA
Big Four	USOR
Big Pine Claim	USCA
Big Yank No. 1	USOR
Binder No. 1	USCA
Black Bart (Great Western)	USCA
Black Bart Claim (Avery)	USCA
Black Bart Group	USCA
Black Bear	USCA
Black Beauty	USOR
Black Boy	USOR
Black Chrome	USCA
Black Diamond	USOR
Black Diamond (Grey Eagle Gp.)	USCA
Black Hawk	USOR
Black Otter	USOR
Black Rock Chrome	USCA
Black Streak	USOR
Black Warrior	USOR
Blue Brush	USCA
Blue Creek Tunnel	USCA
Blue Sky (Lucky Strike)	USCA
Boiler Pit	USCA
Bonanza	USCA
Booker Lease	USCA
Bowden Prospect	USCA
Bowie Estate	USCA
Bowser	USOR
Bragdor	USCA
Briggs Creek	USOR
Brown Scratch	USOR
Bunker	USCA
Burned Cabin	USOR
Butler Claims	USCA
Butler, Estate Chrome, etc	USCA
Buttercup Chrome	USCA
Camden Mine	USCA
Campbell	USOR
Camptonville area	USCA
Castro Mine	USCA
Cattle Springs	USCA
Cavyell Horse C	USOR
Cavyell Horse Mountain	USOR
Cedar Creek	USOR
Celebration	USOR
Challange area	USCA
Chambers	USOR
Chicago	USCA
Christian Place	USCA
Chrome Camp	USCA
Chrome Gulch	USCA
Chrome Hill	USCA
Chrome King (Josephine Co.)	USOR
Chrome King (Jackson Co.)	USOR
Chrome No. 3	USOR
Chrome Ridge	USOR
Clara H	USCA
Clary and Langford	USCA
Cleopatra	USOR
Clover Leaf	USCA
Codd Prospect	USCA
Coggins	USCA
Collard Mine	USOR
Commander	USCA
Coon Mt. Nos. 1-3	USCA
Copper Creek (Low Divide)	USCA
Courtwright	USCA
Courtwright (Daggett)	USCA
Cow Creek Gp.	USCA
Crouch	USOR
Crown	USOR
Cyclone Gap	USCA
Cynthia	USOR
Daisy (Aldelabron)	USCA
Dark Star	USOR
Darrington	USCA
Deep Gorge Chrome	USOR
Delare Prospect	USOR
Detert	USCA
Diamond	USCA
Dickerson	USCA
Dickey and Drisbach	USCA
Dirty Face	USOR
Doe Flat	USCA
Don Pedro	USCA
Dorriss	USCA
Dozier	USCA
Dry Creek	USOR
Earl Smith	USCA
Early Sunrise	USOR
Edeline	USCA
Eden	USCA
Eggling and Williams	USCA
El Primero	USCA
Elder Claim	USCA
Elder Creek	USCA
Elder Creek Gp.	USCA
Elk Creek Claim	USCA
Elkhorn Chromite	USOR

Model 8a--Con.

Ellingwood	USCA
Ellis	USCA
Esterly Chrome	USOR
Esther and Phyllis	USCA
Fairview	USCA
Fiddler's Green	USCA
Fields and Stoker	USCA
Finan	USCA
Forest Queen	USCA
Foster	USOR
Four Point	USOR
Fourth of July	USCA
French Hill	USCA
Friday	USOR
Gallagher	USOR
Gardner Mine	USOR
Gas Canyon	USCA
Geach	USCA
Gibsonville	USCA
Gill (Gill Ranch)	USCA
Gillan	USCA
Gillis Prospect	USCA
Glory Ho	USOR
Golconda Fraction	USCA
Gold Bug Claim	USCA
Goncolda	USOR
Gray Boy	USOR
Gray Buck Gp.	USOR
Green (Americus)	USCA
Green Mine	USCA
Green Ridge	USCA
Green's Capco Leases	USCA
Griffin Chromite	USOR
Gunn Claims	USCA
Half Chrome	USCA
Hanscum	USOR
Happy Go Lucky	USCA
Harp and Sons Ranch	USCA
Hawks Rest View	USOR
Hayden and Hilt	USCA
Helemar	USCA
Hendricks No. 2	USCA
High Dome	USCA
High Plateau	USCA
Hill-Top Chrome	USCA
Hodge Ranch	USCA
Hoff	USCA
Holbrook and McGuire	USCA
Holseman (and others)	USCA
Holston (Vaughn)	USCA
Horseshoe	USCA
Horseshoe Chrome	USOR
Houser & Burges	USOR
Hudson (Fuller Claims)	USCA
I-Wonder	USCA
Illinois River	USOR
Independence	USOR
Irene Chromite	USOR
Iron King	USOR
Iron Mountain	USOR
Jack Forth	USCA
Jack Sprat Gp.	USCA
Jackson	USOR
Jim Bus	USOR
Johns	USOR
Josephine	USCA
Josephine No. 4	USOR
Judy (Hicks)	USCA
Julian	USCA
Kangaroo Court Mine	USCA
Kingsley	USOR
Kleinsorge Gp.	USCA
Kremmel and Froelich	USCA
Lacey	USCA
Lambert	USCA
Langley Chrome	USOR
Lassic Peak	USCA
Last Buck	USOR
Last Chance (Coos)	USOR
Last Chance (Josephine)	USOR
Laton	USCA
Letty	USCA
Liberty	USCA
Liberty Bond Claim	USCA
Linda Marie	USOR
Little Boy	USOR
Little Castle Creek	USCA
Little Hope	USCA
Little Rock Mine	USCA
Little Siberia	USOR
Lone Gravel	USCA
Long Ledge Gp.	USCA
Lost Lee	USOR
Lotty	USCA
Lucky Boy	USCA
Lucky Friday	USOR
Lucky Girl	USCA
Lucky Hunch	USOR
Lucky L. & R.	USOR
Lucky Nine Gp.	USOR
Lucky Star	USOR
Lucky Strike (Lake Co.)	USCA
Lucky Strike (S.L.O. Co.)	USCA
Lucky Strike (Curry Co.)	USOR
Lucky Strike	USOR
Mackay	USCA
Madeira	USCA
Madrid	USCA
Manchester	USCA
Maralls Capro Leases	USCA
Marks & Tompson	USOR
Mary Jane	USCA
Mary Walker	USOR
Maxwell	USCA
Mayflower	USCA
McCaleb's Sourdough	USOR
McCarty	USCA
McCormick	USCA
McGuffy Creek Gp.	USCA
McMurty	USCA
Meeker (Sonoma Chrome)	USCA
Merrifield	USCA
Mighty Joe	USOR
Milton	USCA
Mockingbird	USOR
Moffett Creek Gp.	USCA

Mohawk Claim	USOR
Moore	USCA
Moscatelli	USCA
Moscatelli No. 2	USCA
Mountain View	USCA
Mountain View Gp.	USCA
MuNaly	USCA
Mulcahy Prospect	USCA
Mule Creek	USCA
Mum and Alice June Claim	USCA
Murphy	USCA
Muzzleloader (Stevens No. 1)	USCA
New Hope	USCA
New Hope Claim	USOR
Newman	USCA
Nichelini Mine	USCA
Nickel Mountain	USOR
Nickel Ridge	USOR
No. 5	USCA
Noble Electric Co.	USCA
Norcross	USCA
North End, West End, Spotted Fawn	USCA
North Fork Chrome	USCA
North Star	USOR
North Star (Red Mtn)	USCA
Norway	USOR
Oak Ridge	USCA
Olive B.	USOR
Olsen	USCA
Onion Springs	USOR
Oregon Chrome	USOR
Oxford	USCA
P. U. P. (Zenith)	USCA
Paradise No. 1	USOR
Paradise No. 2	USOR
Park's Ranch	USCA
Parker	USCA
Parkeson	USCA
Pearsoll Peak	USOR
Peewan	USCA
Peg Leg (Lambert)	USCA
Pennington Butte	USOR
Perconi Ranch	USCA
Pillikin	USCA
Pine Mountain Claim	USCA
Pines	USOR
Pleasant No. 1 & 2	USOR
Poco Tiempo Quartz	USCA
Pony Shoe	USCA
Poodle Dog	USCA
Porter Property	USCA
Powers	USOR
Prater	USOR
Pyramid	USCA
Queen of May	USOR
Quigg	USCA
Rainbow	USOR
Rainy Day	USOR
Rancherie	USOR
Randall	USCA
Rattlesnake Mountain	USCA
Ray (Tip Top)	USOR
Ray Spring	USOR
Red Ledge	USCA
Red Mountain	USOR
Red Slide Gp.	USCA
Redskin	USCA
Richards	USCA
Richey, U.S. & S.J.	USCA
Robt. E.	USOR
Rock Creek	USOR
Rock Wren Mine	USCA
Rose Claim	USCA
Rosie Claim	USOR
Round Bottom	USCA
Roupe	USCA
Sad Sack	USOR
Saddle Chrome	USOR
Saint	USCA
Sally Ann	USOR
Salt Rock	USOR
Saturday Anne	USOR
Schmid	USOR
Seiad Creek (Mt. View)	USCA
September Morn	USCA
Sexton Mountain	USOR
Shade Chromite	USOR
Shafer Lease	USCA
Shamrock	USCA
Shelly	USCA
Sheppard Mine	USCA
Shotgun Creek	USCA
Silver Lease	USOR
Simmons	USCA
Simon	USCA
Sims	USCA
Six-Mile	USOR
Skyline Mine	USCA
Skyline No. 1	USCA
Skyline No. 2	USCA
Smith Geitsfield	USOR
Snakehead (Jumbo)	USCA
Snowy Ridge	USCA
Snowy Ridge	USOR
Snyder	USCA
Sour Dough	USOR
Sousa Ranch	USCA
Southern Pacific Property	USCA
Spot	USCA
Spring Hill	USCA
St. Patrick (Camp 8)	USCA
Stafford	USCA
Stark Bee	USCA
State School	USCA
Stevens-Miller	USOR
Stewart	USCA
Stone & Haskins	USOR
Store Gulch	USOR
Stray Dog	USOR
Sullivan and Kahl	USCA
Sunnyslope	USCA
Sunrise	USCA
Sunset (Fresno Co.)	USCA
Sunset (Placer Co.)	USCA

Sunshine	USCA	Unknown Name	USOR
Sutro Mine	USCA	Valen Prospect	USOR
Suzy Bell (Lucky Strike)	USCA	Valenti	USCA
Swayne	USCA	Victory No. 3	USCA
Sweetwater	USCA	Violet	USOR
Tangle Blue Divide	USCA	Vogelgesang	USCA
Tennessee Chrome	USOR	Wait	USCA
Tennessee Pass	USOR	Waite	USCA
Thompson Gp.	USOR	Walker	USCA
Tomkin	USCA	War Bond	USCA
Toujours Gai	USCA	War Eagle-Miller	USCA
Trinidad	USCA	Ward	USOR
Twin Cedars	USOR	Ward and Lyons	USCA
Twin Valley	USOR	Washout	USCA
Unnamed	USCA	Welch Prospect	USCA
Uncle Sam	USOR	West Chrome	USCA
Unknown Name	USOR	Western Magnesite	USCA
Unknown Name	USOR	White Bear	USCA
Unknown Name	USOR	White Cedar	USCA
Unknown Name	USOR	White Feather	USCA
Unknown Name	USOR	White Pine Mine	USCA
Unknown Name	USOR	Wild Cat Claim	USOR
Unknown Name	USOR	Wilder (Fish Creek)	USCA
Unknown Name	USOR	Windy Point	USOR
Unknown Name	USOR	Wolf Creek	USCA
Unknown Name	USOR	Wolf Creek area	USCA
Unknown Name	USOR	Wonder	USOR
Unknown Name	USOR	Wonder Gp.	USOR
Unknown Name	USOR	Yellow Pine	USCA
Unknown Name	USOR	Young	USOR
Unknown Name	USOR	Young's Mine	USOR
Unknown Name	USOR	Zerfirg Ranch	USCA
Unknown Name	USOR		

GRADE AND TONNAGE MODEL OF MAJOR PODIFORM CHROMITE

By Donald A. Singer, Norman J Page, and Bruce R. Lipin

DATA REFERENCES Page and others (1979), Page and others (1982b), Page and others (1984).

COMMENTS This model, number 8b, is provided as an alternative to the podiform chromite model, number 8a, based on California and Oregon deposits because of the significant difference in tonnage of the two groups. The two groups are geologically similar and share the same descriptive model. Rh, Ir, Ru, Pd, and Pt grades are based on reported analyses of samples from the deposits. Platinum grade is correlated with chromite grade ($r = 0.76$, $n = 12$) and iridium grade ($r = 0.71$, $n = 8$). Rhodium is correlated with iridium grade ($r = 0.88$, $n = 7$). See figs. 24-26.

DEPOSITS

Name	Country	Name	Country
Abdasht	IRAN	Bagin	TRKY
Akarca	TRKY	Bagirsakdire	TRKY
Akcabuk	TRKY	Balcicakiri	TRKY
Akkoya	TRKY	Batikef	TRKY
Alice Louise	NCAL	Bati-N. Yarma	TRKY
Alpha	NCAL	Bati-Taban	TRKY
Altindag	TRKY	Bati- W. Yarma	TRKY
Amores	CUBA	Bellacoscia	NCAL
Andizlik	TRKY	Bellevue	NCAL
Anna Madeleine	NCAL	Bereket	TRKY
Asagi Zorkum	TRKY	Bezkere-Bulurlii	TRKY
Aventura	CUBA	Bicir-Cakir	TRKY
Avsar	TRKY	Bicir-Gul	TRKY

Bonsecours	NCAL	Karatas-Kumocak	TRKY
Bozkonus	TRKY	Kartalkoyu	TRKY
Bozotluk-No. 551	TRKY	Kavakcali	TRKY
Bugugan	TRKY	Kavakdere	TRKY
Buyiik Gurleyen	TRKY	Kazadere-Kandil	TRKY
Buyiik Karamanli	TRKY	Kefdag-East	TRKY
Caledonia	CUBA	Kemikli Inbasi	TRKY
Camaguey	CUBA	Kilic-Kafasi 1	TRKY
Catak	TRKY	Kilic-Kafasi 2	TRKY
Catak-Koraalan	TRKY	Kiranocak	TRKY
Catolsinir I	TRKY	Koca	TRKY
Catolsinir II	TRKY	Komek	TRKY
Cenger	TRKY	Koycegiz-Curukcu	TRKY
Cenger-Adatepe	TRKY	Koycegiz-Kurardi	TRKY
Cenger-Demirk	TRKY	Koycegiz-Orta	TRKY
Cenger-Domuza	TRKY	Kuldoden	TRKY
Cezni	TRKY	Kundikan-Keluskdere	TRKY
Chagrin	NCAL	Kundikan-Kelusktepe	TRKY
Child Harold	NCAL	Kurudere	TRKY
Consolation	NCAL	Kuyuluk Isletmesi	TRKY
Cosan	TRKY	Kuzkavak	TRKY
Coto	PLPN	La Caridid	CUBA
Cromita	CUBA	Lagonoy	PLPN
Dagardi	TRKY	La Victoria	CUBA
Dagkuplu	TRKY	Lolita	CUBA
Danacik	TRKY	Marais Kiki	NCAL
Dcev 7	NCAL	Meululter	TRKY
Delta	CUBA	Middle Ore Body	PLPN
Demirli	TRKY	Mirandag Koru	TRKY
Dinagat	PLPN	Mirandag Mevki	TRKY
Dogu Ezan	TRKY	Morrachini	NCAL
Dogu Kef	TRKY	Musa Danisman	TRKY
Domuzburnu II	TRKY	Narciso	CUBA
Dovis	IRAN	Ni Te Ocutes	CUBA
East Ore Body	PLPN	Ochanocagi	TRKY
El Cid	CUBA	Ofelia	CUBA
Eldirek	TRKY	Orta Ezan	TRKY
Ermenis	TRKY	Otmanlar-Harpuzlu	TRKY
Fanrouche	NCAL	Otmanlar-Mesebuku	TRKY
Findikli	TRKY	Panamana-An	PLPN
Findikli #301	TRKY	P. B.	NCAL
Findikli #306-#307	TRKY	Pergini	TRKY
Findikli #326	TRKY	Potosi	CUBA
General Gallieni	NCAL	Ruff Claim No. 32	PLPN
Gerdag	TRKY	Saka	TRKY
Golalan	TRKY	Salur	TRKY
Gorunur	TRKY	Sarialan	TRKY
Govniikbelen	TRKY	Sarikaya	TRKY
Gr2h	NCAL	Saysin	TRKY
Guillermina	CUBA	Sekioren	TRKY
Gunlet-Uckopur	TRKY	Shahin	IRAN
Gunliik Basi	TRKY	Sicankale	TRKY
Herpit Yayla	TRKY	Sirac	TRKY
Ikisulu-Gercek	TRKY	Sofulu	TRKY
Jose	CUBA	Sogham	IRAN
Kagit Octu	TRKY	Sta. Cruz	PLPN
Kandira	TRKY	Stephane	NCAL
Kapin	TRKY	Suluiyeh	IRAN
Karaculha	TRKY	Sulu	TRKY
Karageban	TRKY	Suluk	TRKY
Karani	TRKY	Sutpinar	TRKY
Karaninar	TRKY	Suzanne	NCAL
Karasivri	TRKY	Tekneli	TRKY

Model 8b--Con.

Tepebasi	TRKY	West Ore Body	PLPN
Terlik	TRKY	Yanikara	TRKY
Tiebaghi	NCAL	Yaprakli	TRKY
Tilkim-Karanlik	TRKY	Yayca Boyna	TRKY
Togobomar	PLPN	Yilmaz Ocagi	TRKY
Tosin	TRKY	Yukari Zorkum	TRKY
Toparlar-Alacik	TRKY	Yunus Yayla	TRKY
Tuzlakaya	TRKY	Yurtlak	TRKY
Uckopru	TRKY	Zambales Ch	PLPN
Vieille Montagne 1	NCAL	Zimparalik	TRKY
Vieille Montagne 2	NCAL		

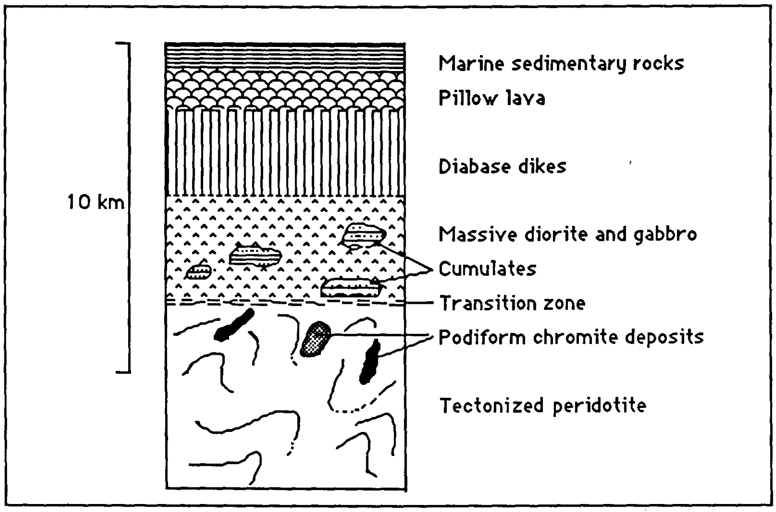


Figure 20. Cartoon cross section of a typical ophiolite sequence showing locations of podiform chromite deposits. From Dickey (1975).

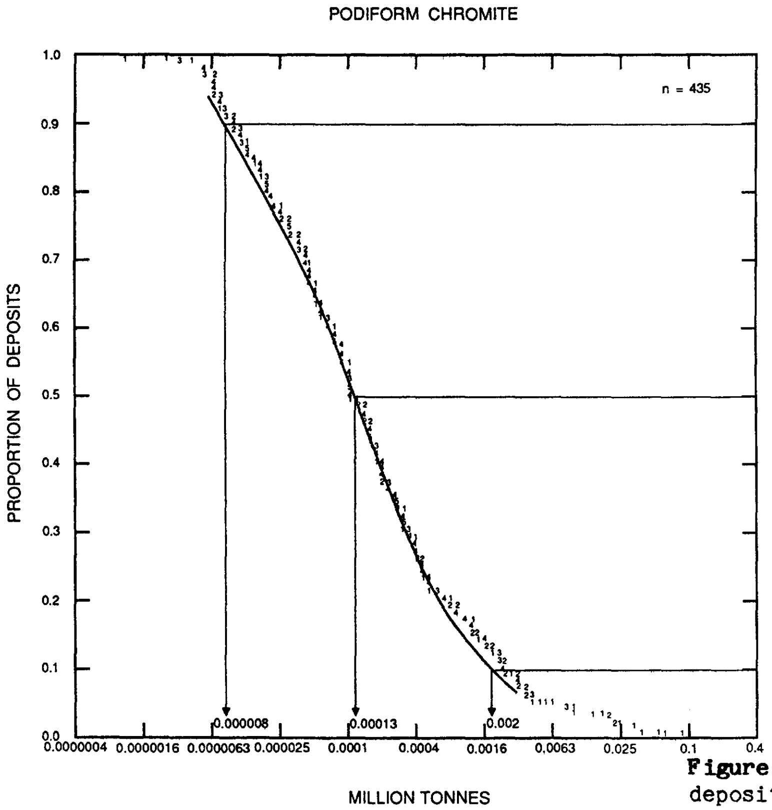


Figure 21. Tonnages of podiform chromite deposits from California and Oregon, U.S.A. Individual digits represent number of deposits.

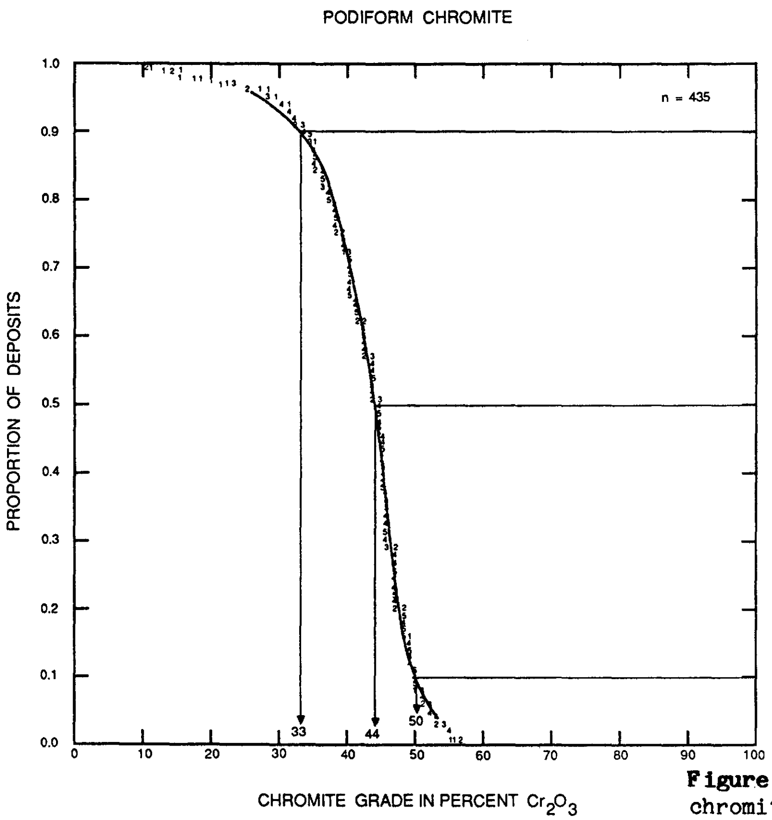


Figure 22. Chromite grades of podiform chromite deposits from California and Oregon, U.S.A. Individual digits represent number of deposits.

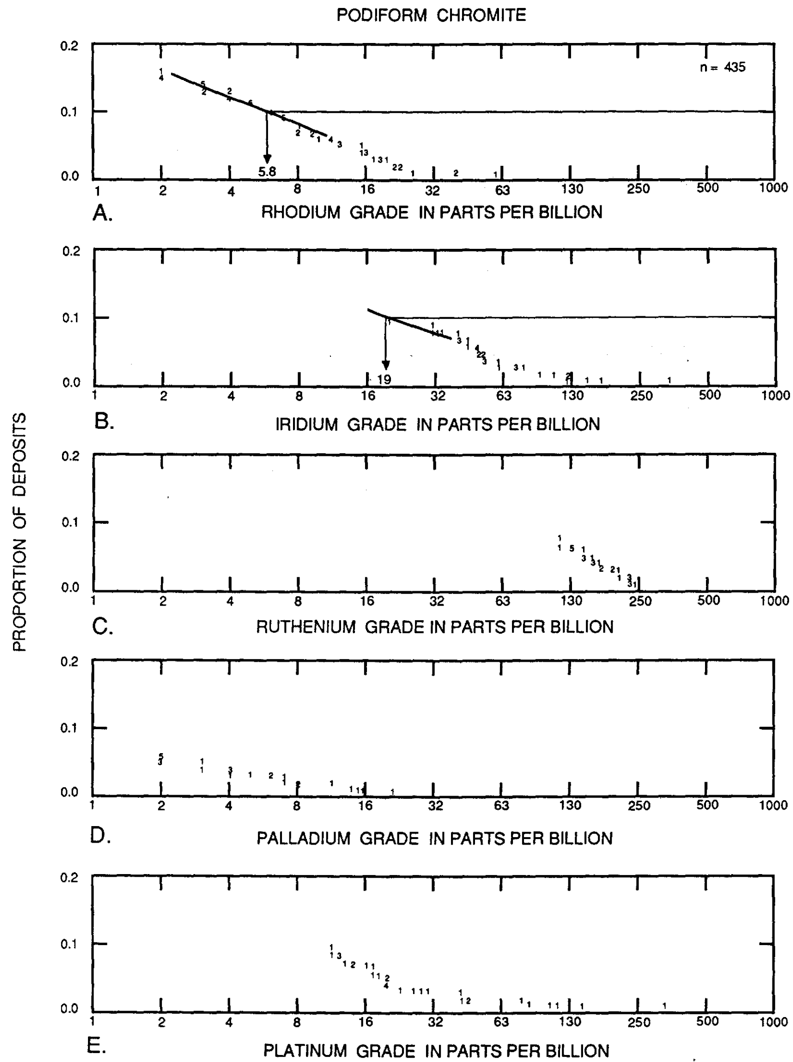


Figure 23. PGE grades of podiform chromite deposits from California and Oregon, U.S.A. A, Rhodium. B, Iridium. C, Ruthenium. D, Palladium. E, Platinum. Individual digits represent number of deposits.

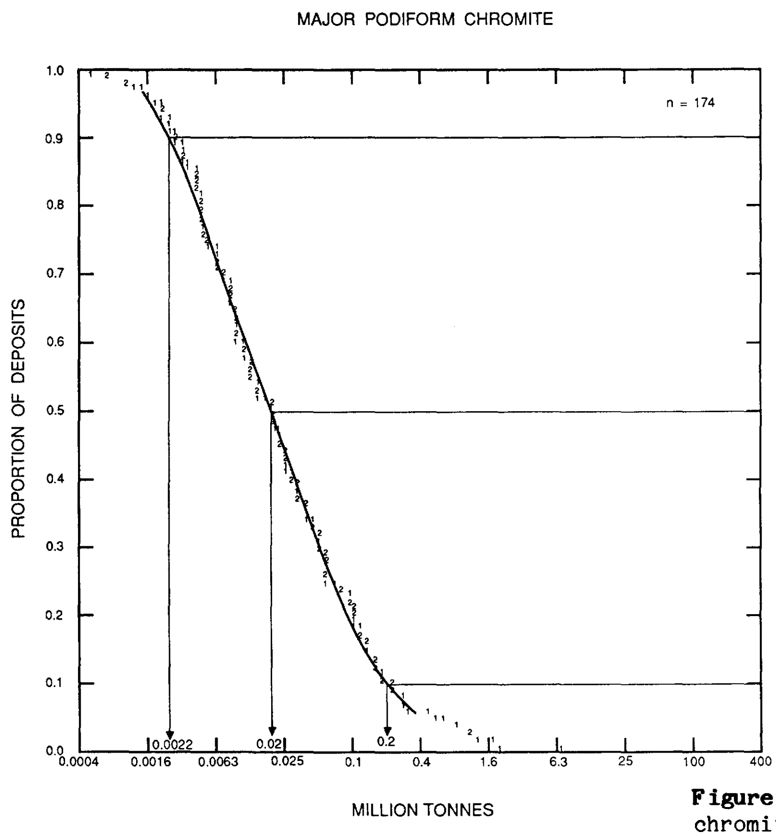


Figure 24. Tonnages of major podiform chromite deposits. Individual digits represent number of deposits.

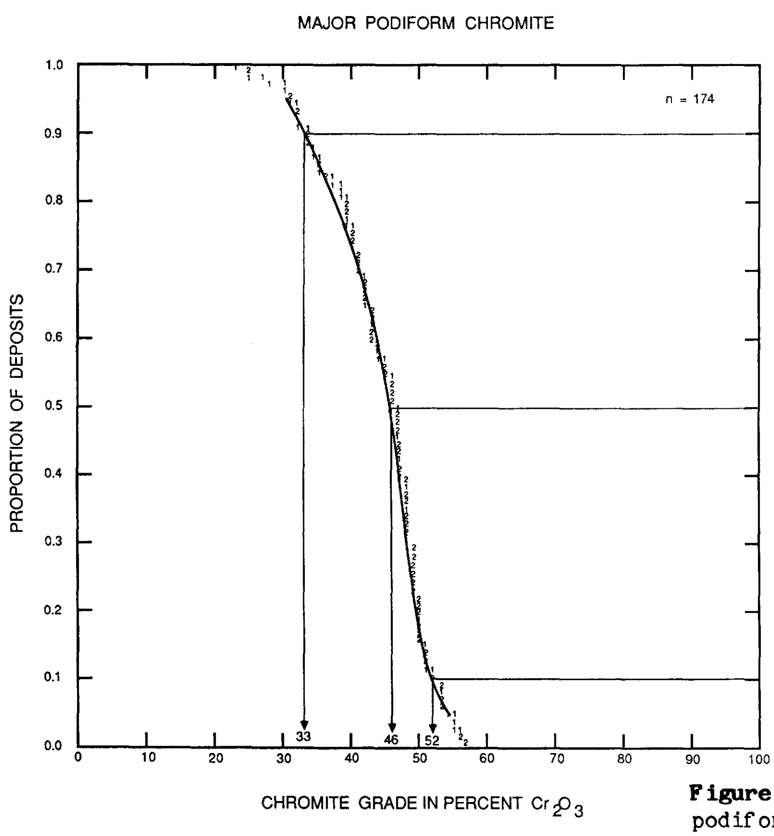


Figure 25. Chromite grades of major podiform chromite deposits. Individual digits represent number of deposits.

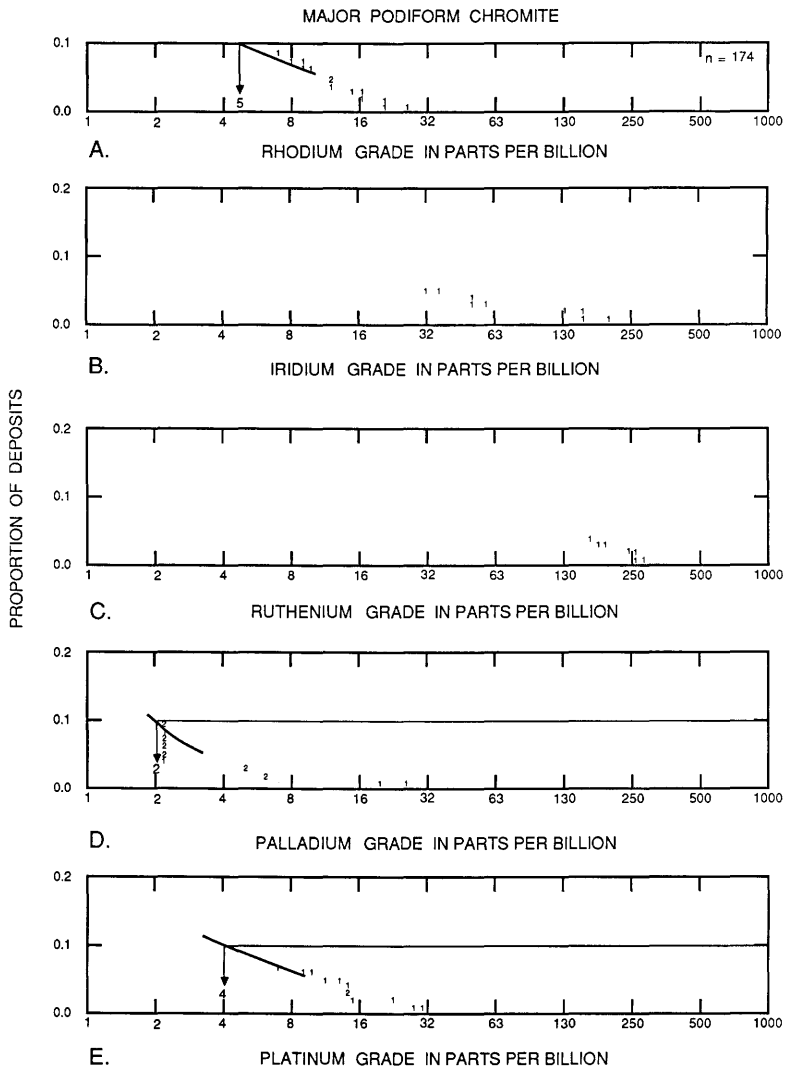


Figure 26. PGE grades of major podiform chromite deposits. A, Rhodium. B, Iridium. C, Ruthenium. D, Palladium. E, Platinum. Individual digits represent number of deposits.

DESCRIPTIVE MODEL OF LIMASSOL FOREST Co-Ni

By Norman J Page

DESCRIPTION Irregular veins, pods and lenses associated with serpentinized peridotite and dunite or nearby country rocks.

GEOLOGICAL ENVIRONMENT

Rock Types Highly serpentinized dunite, harzburgite, pyroxenite; quartz-carbonate rocks.

Textures Sheared.

Age Range Paleozoic and Mesozoic.

Depositional Environment Faults, fractures associated with serpentinized ultramafic rocks of an ophiolite.

Tectonic Setting(s) Unstable, accreted terranes, near plate boundaries.

Associated Deposit Types Podiform chromite, Ni-laterite, Co-Ni-Cu ophiolite sulfide.

DEPOSIT DESCRIPTION

Mineralogy: Pyrrhotite + pyrite ± pentlandite ± chalcopyrite ± vallerite ± loellingite ± niccolite ± maucherite ± skutterudite ± gersdorffite ± cobaltite ± magnetite ± chromite ± mackinawite ± pararammelsbergite.

Texture/Structure Irregular vein and fracture fillings.

Alteration Serpentinization and quartz-carbonate.

Ore Controls Serpentinized ultramafic rock, possible external source of arsenic (see fig. 99).

Geochemical Signature As, Co, Ni

EXAMPLES

Bou Azzer, MRCO	(LeBlanc, 1981; LeBlanc and Bilaud, 1982)
Limmasol Forest, CYPS	(Panayiotou, 1980)

DESCRIPTIVE MODEL OF SERPENTINE-HOSTED ASBESTOS

By Norman J Page

APPROXIMATE SYNONYM Quebec Type (Shride, 1973).

DESCRIPTION Chrysotile asbestos developed in stockworks in serpentinized ultramafic rocks.

GEOLOGICAL ENVIRONMENT

Rock Types Serpentinites, dunite, harzburgite, pyroxenite.

Textures Highly fractured and veined, serpentinized ultramafic rocks.

Age Range Paleozoic to Tertiary.

Depositional Environment Usually part of an ophiolite sequence. Later deformation and igneous intrusion may be important.

Tectonic Setting(s) Unstable accreted oceanic terranes.

Associated Deposit Types Podiform chromite.

DEPOSIT DESCRIPTION

Mineralogy Chrysotile asbestos ± magnetite ± brucite ± talc ± tremolite-actinolite.

Texture/Structure Stockworks of veins in serpentinized ultramafic rocks.

Alteration None associated with ore, but silica-carbonate, talc may be developed.

Ore Controls Two periods of serpentinization, an earlier pervasive one and a later period near the end of intense deformation accompanied by hydrothermal activity perhaps as a function of intrusion of acidic, igneous rocks highly dependent upon major faulting, and fracture development.

Geochemical signature None.

EXAMPLES:
Thetford-Black Lake, CNQU (Riordon, 1957)

GRADE AND TONNAGE MODEL OF SERPENTINE-HOSTED ASBESTOS

By Greta J. Orris

COMMENTS Long and short fibers are combined. Some literature did not specify if reported production was tons of fiber or tons of ore. In these cases, production was assumed to be tons of ore which may have led to underestimation of some deposit tonnages. See Figs. 27, 28.

DEPOSITS

Name	Country	Name	Country
Abitibi	CNQU	Lafayette	CNQU
Advocate	CNNF	Lake Asbestos	CNQU
Asbestos Hill	CNQU	Las Brisas	CLBA
Asbestos Island	CNQU	Lili	CNQU
Belvidere	USVT	McAdam	CNQU
Black Lake	CNQU	Midlothian	CNON
British Canadian	CNQU	Moladezhnoye	URRS
Caley	CNYT	Munro	CNON
Carey/East Broughton	CNQU	National	CNQU
Cana Brava	BRZL	Nicolet Asbestos	CNQU
Cassiar Mine	CNBC	Normandie/Penhale	CNQU
Clinton Creek	CNYT	Pontbriand	CNQU
Continental	CNQU	Qala-el-Nahl?	SUDN
Courvan Mine	CNQU	Reeves	CNON
Cranbourne	CNQU	Rex	CNYT
Daffodil	CNON	Roberge Lake	CNQU
Eagle	USAK	St. Adrien Mtn.	CNQU
Gilmont	CNQU	St. Cyr	CNQU
Golden Age	CNQU	Santiago Papalo	MXCO
Havelock Mine	SWAZ	Shihmien	CINA
Jefferson Lake	USCA	Steele Brook	CNQU
Jeffrey Lake	CNQU	Thetford Group	CNQU
Kinlock	SAFR	Windsor	CNQU
Kolubara-Azbest	YUGO	Woodsreef Mine	AUNS
Kudu Asbestos Mine	ZIMB	Zindani	GREC

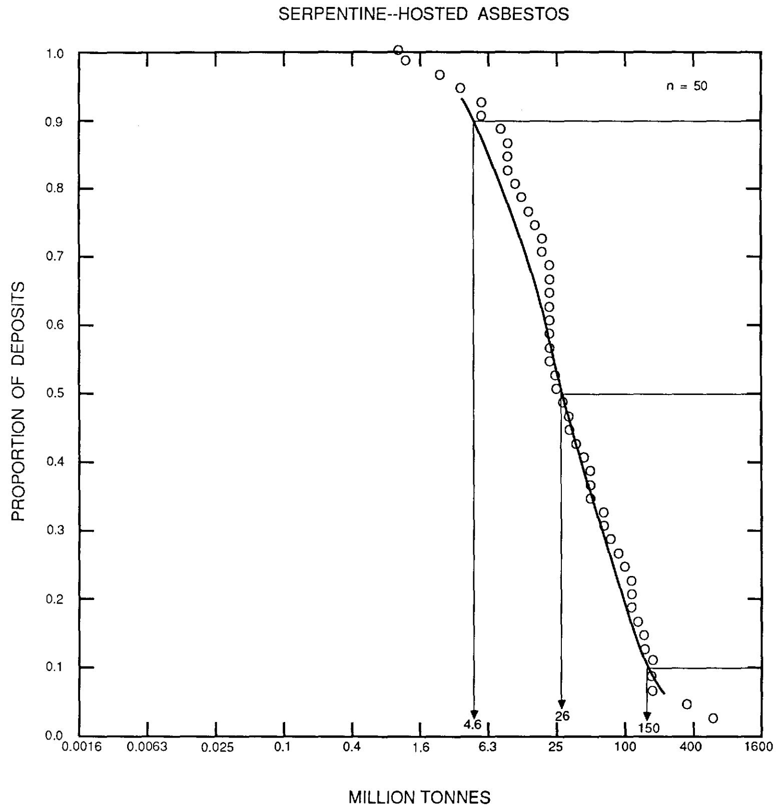


Figure 27. Tonnages of serpentine-hosted asbestos deposits.

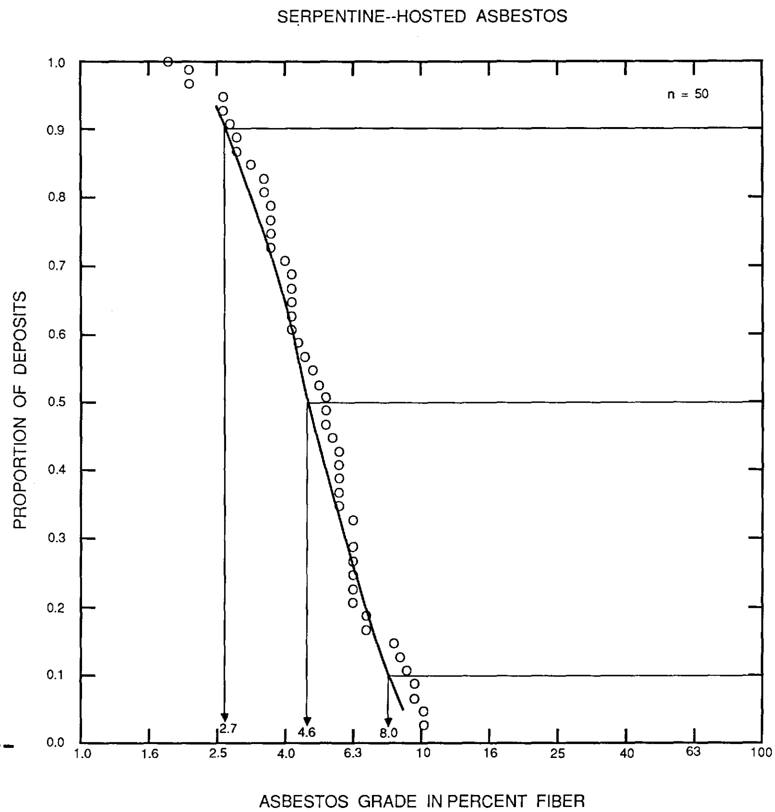


Figure 28. Asbestos grades of serpentine-hosted asbestos deposits.

DESCRIPTIVE MODEL OF ALASKAN PGE

By Norman J Page and Floyd Gray

APPROXIMATE SYNONYMS Zoned ultramafic Cr-Pt; Kachkanar-type (Cabri and Naldrett, 1984).

DESCRIPTION Crosscutting ultramafic to felsic intrusive rocks with approximately concentric zoning of rock types containing chromite, platinum, and Ti-V-magnetite (see fig. 29).

GEOLOGICAL ENVIRONMENT

Rock Types Dunite, wehrlite, harzburgite, pyroxenite, magnetite-hornblende pyroxenite, two-pyroxene gabbros, hornblende gabbro, hornblende clinopyroxenite, hornblende-magnetite clinopyroxenite, olivine gabbro, norite. Post-orogenic tonalite and diorite are commonly spatially related. Orthopyroxene-bearing rocks absent in Klamath Mountains.

Textures Cumulus textures, poikilitic, mush flow textures, lineated fabrics, layered.

Age Range Precambrian to late Mesozoic, most Paleozoic and Mesozoic.

Depositional Environment Deposits occur in layered ultramafic and mafic rocks that intrude into granodiorite, island arc or ophiolite terranes. Evidence indicates shallow levels of emplacement.

Tectonic Setting(s) Unstable tectonic areas.

Associated Deposit Types PGE placer deposits.

DEPOSIT DESCRIPTION

Mineralogy Assemblage 1: chromite + Pt-Fe alloys + Os-Ir alloys + platinum-iridium ± pentlandite ± pyrrhotite ± native gold ± PGE arsenides. Assemblage 2: Ti-V magnetite ± Pt-Fe alloys ± Os-Ir alloys ± cooperite ± bornite ± chalcopyrite.

Texture/Structure Assemblage 1: clots, pods, schlieren, wisps of chromite in dunite, clinopyroxenite, harzburgite. Assemblage 2: magnetite segregations, layers in wehrlite, pyroxenite, gabbro (see fig. 29).

Alteration None: post-mineralization serpentinization.

Ore Controls Appear to be restricted to specific rock types by magmatic processes.

Weathering Mechanical weathering produces placers; chemical weathering could produce laterites.

Geochemical Signature Cr, PGE, Ti, V, Cu, Ni, S, As. Assemblage 2 ores in Klamath Mountains are low in Cr and Ni.

EXAMPLES

Urals, USSR	(Duparc and Tikonovitch, 1920)
Duke Island, USAK	(Irvine, 1974)
Guseva-Gora, USSR	(Razin, 1976)
Tin Cup Peak, USOR	(Page and others, 1982a)

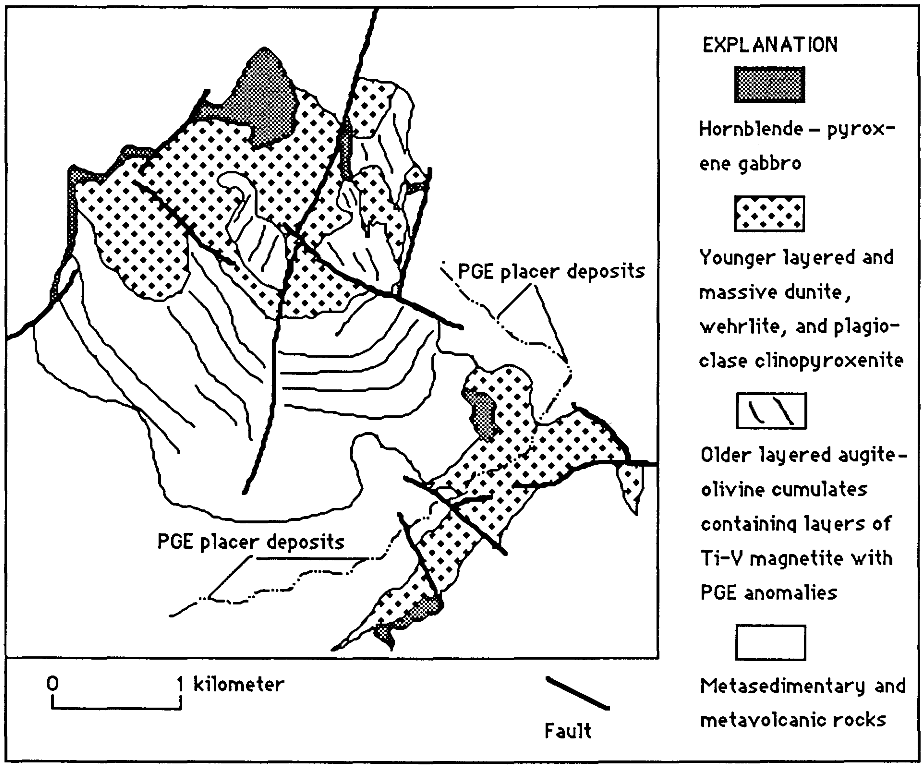


Figure 29. Generalized geologic map of zoned ultramafic complex at Lower Coon Mountain, Calif. (from Gray and Page, 1985). V-rich magnetite layers and anomalous PGE concentrations typical of Alaskan Cr-Pt deposits are associated with plutons of this type.

DESCRIPTIVE MODEL OF CARBONATITE DEPOSITS

By Donald A. Singer

APPROXIMATE SYNONYM Apatite-magnetite and rare earths in carbonatites.

DESCRIPTION Apatite-magnetite and rare-earth deposits and combinations of these in zoned complexes consisting of central plug of carbonatite or syenite breccia surrounded by ring dikes and cone sheets of alternating rock types.

GENERAL REFERENCE Tuttle and Gittins (1966).

GEOLOGICAL ENVIRONMENT

Rock Types Apatite-magnetite deposits tend to be in sovite (calcitic carbonatite); RE types tend to occur in ankerite carbonatite; most deposits have both. In general pyroxenite, nepheline and feldspathic pyroxenite, carbonatite, fenite, ijolite, dunite, picrite-porphyrites, gneiss and alkalic fenitized gneiss, and locally alkaline volcanics rocks.

Textures Hypidiomorphic-granular, poikiloblastic. Breccias abundant. Carbonatites show intrusive relations. Wallrocks fenitized.

Age Range Almost all known carbonatite complexes are intrusive into Precambrian shields, however, the carbonatites themselves may be much younger.

Depositional Environment Multiple stages of igneous, deuteric and metasomatic crystallization in carbonatite magma.

Tectonic Setting(s) Continental shields. Spatially related to fault lineaments such as East African rift system. Locally related to alkaline volcanism.

Associated Deposit Types None.

DEPOSIT DESCRIPTION

Mineralogy Apatite-magnetite-type: apatite, magnetite, pyrochlore ± columbite ± perovskite ± niocalite. RE-type: barite, strontianite ± siderite ± rhodochrosite ± ankerite ± bastnaesite ± chlorites ± parisite ± monagite ± breunnerite. General: calcite, dolomite, fluorite, pyrrhotite, ilmenite, molybdenite, chalcopyrite, pyrite, sphalerite, pyroxene, biotite, phlogopite, amphibole, spinel, ± galena, ± hematite, ± quartz, ± forsterite, ± serpentine, ± zircon ± sphene, ± anatase, ± rutile, ± brookite, ± fersmite.

Texture/Structure Disseminated and banded.

Alteration Fenitization (widespread alkali metasomatism of quartzo-feldspathic rock; mostly alkalic feldspar with some aegerine and subordinate alkali-hornblende and accessory sphene and apatite) near contact of carbonatite intrusion. Locally, chloritization.

Ore Controls Commonly restricted to carbonatite dikes, sills, breccias, sheets, veins, and large masses, but may occur in other rocks associated with the complex rocks.

Weathering May result in goethite-rich soil enriched in P, Nb, and RE.

Geochemical Signature Radiometric anomalies, magnetic anomalies, high gravity anomalies, Th, U, Ti, Zn, Nb, Y, Ce, Mo, Cu, V, P, Mn, S, La, Sm, Pb, Zr, Ba, Eu. High values of Be, B, Li, Sn, Ta, Hf, and W are rare.

EXAMPLES

Oka, CNQU	(Gold and others, 1966)
Iron Hill, USCO	(Temple and Grogan, 1965)
St. Honore, CNQU	(Dawson, 1974)
Gem Park, USCO	(Parker and Sharp, 1970)
Mountain Pass, USCA	(Olson and others, 1954)

GRADE AND TONNAGE MODEL OF CARBONATITE DEPOSITS

By Donald A. Singer

COMMENTS Locally these carbonatite complexes may contain economically interesting grades of uranium, thorium, titanium, iron, copper, vermiculite, zirconium or phosphorus; frequently, these other commodities are in different zones than the niobium-rich parts of the complex. See figs. 30, 31.

DEPOSITS

Name	Country	Name	Country
Araxa	BRZL	Mountain Pass	USCA
Bingo	ZIRE	Mrima Hill	KNYA
Dominion Gulf	CNON	Nemogos (Lackner Lake)	CNON
Catalao	BRZL	Oka CNQU	
Iron Hill	USCO	Salitre	BRZL
James Bay	CNON	Serra Negra	BRZL
Lueshe	ZIRE	Søve	NRWY
Mbeya	TNZN	Sukulu	UGND
Martison Lake	CNON	St. Honore (Soquem)	CNQU
Manitou Island	CNON	Tapira	BRZL

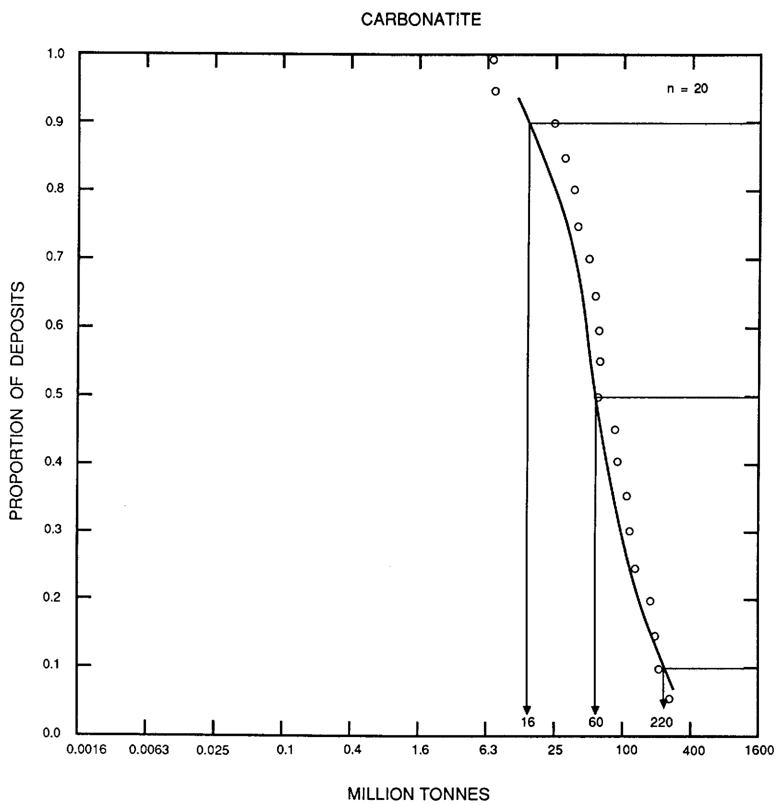


Figure 30. Tonnages of carbonatite deposits.

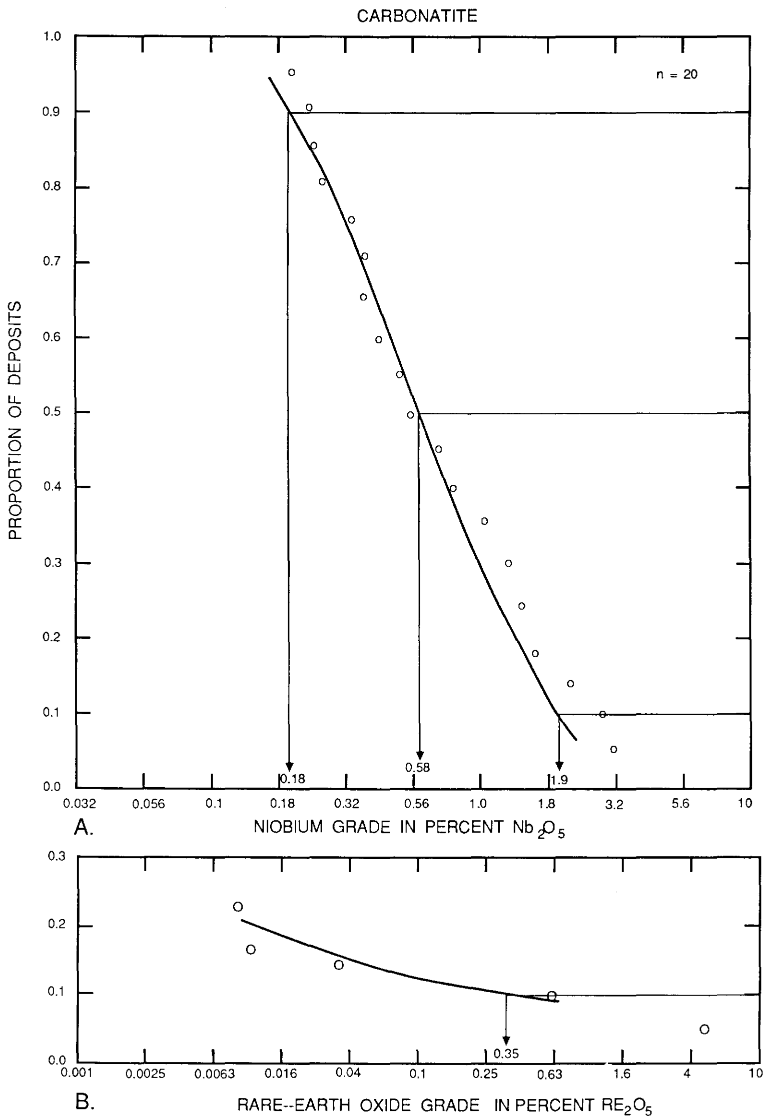


Figure 31. Grades of carbonatite deposits. A, Niobium. B, Rare-earth oxides.

DESCRIPTIVE MODEL OF DIAMOND PIPES

By Dennis P. Cox

DESCRIPTION Diamonds in kimberlite diatremes and other alkaline mafic rocks.

GENERAL REFERENCE Orlov (1973), Dawson (1980), Gold (1984).

GEOLOGICAL ENVIRONMENT

Rock Types Kimberlite diatremes. Olivine lamproite (K-rich Mg-lamprophyre) and leucite lamproite.

Textures Pipes: porphyritic igneous texture. Breccias with inclusions of many rocks from mantle, basement and overlying sequences. Lapilli tuff locally fills upper levels of diatreme.

Age Range Most productive pipes are 80-100, 250, and 1,000-1,100 m.y. in age.

Depositional Environment Pipes intruded from mantle source under high pressure but with rapid quenching.

Tectonic Setting(s) Most pipes intrude cratonal areas, stable since Early Proterozoic. Some intrude folded cover rocks that overlie deformed cratonal margins. Pipes are not correlated with orogenic events but occur in areas of epeirogenic warping or doming and along major basement fracture zones. Some pipes occur at intersections of regional zones of weakness visible in LANDSAT or SLAR.

Associated Deposit Types Diamond placers.

DEPOSIT DESCRIPTION

Mineralogy Diamond, bort or carbonado (polycrystalline generally dark colored), ballas (spherulitic polycrystalline), and amorphous carbonado.

Texture/Structure Diamonds are sparsely disseminated as phenocrysts or xenocrysts in breccia. Mined kimberlites yield from 0.1 to 0.6 ppm diamond.

Alteration Serpentinization resulting in "blue clay" zones. Silicification and carbonate alteration of country rock near pipe; rarely, alkalic metasomatism forming K-feldspar and Na-amphiboles.

Ore Controls Diamond distribution is irregular and restricted to kimberlite or lamproite pipes and upward-flaring crater zones. Productive pipes are rare and, at present, can only be identified by their diamond content.

Weathering Pipes weather rapidly to form topographic depressions.

Geochemical Signature Cr, Ti, Mn, Ni, Co, PGE, Ba. Anomalous Ni, Nb, and heavy minerals pyrope, garnet, phlogopite, and Mg-ilmenite indicate nearby pipes. Lamproite pipes lack ilmenite.

EXAMPLES

African deposits	(Sutherland, 1982)
Western Australia deposits	(Atkinson and others 1984)
Wyoming-Colorado	(Lincoln, 1983)

DESCRIPTIVE MODEL OF W SKARN DEPOSITS

By Dennis P. Cox

DESCRIPTION Scheelite in calc-silicate contact metasomatic rocks.

GENERAL REFERENCE Einaudi and Burt (1982), Einaudi and others (1981).

GEOLOGICAL ENVIRONMENT

Rock Types Tonalite, granodiorite, quartz monzonite; limestone.

Textures Granitic, granoblastic.

Age Range Mainly Mesozoic, but may be any age.

Depositional Environment Contacts and roof pendants of batholith and thermal aureoles of apical zones of stocks that intrude carbonate rocks.

Tectonic Setting(s) Orogenic belts. Syn-late orogenic.

Associated Deposit Types Sn-W skarns, Zn skarns.

DEPOSIT DESCRIPTION

Mineralogy Scheelite ± molybdenite ± pyrrhotite ± sphalerite ± chalcopyrite ± bornite ± arsenopyrite ± pyrite ± magnetite ± traces of wolframite, fluorite, cassiterite, and native bismuth.

Alteration Diopside-hedenbergite + grossular-andradite. Late stage spessartine + almandine. Outer barren wollastonite zone. Inner zone of massive quartz may be present.

Ore Controls Carbonate rocks in thermal aureoles of intrusions.

Geochemical Signature W, Mo, Zn, Cu, Sn, Bi, Be, As.

EXAMPLES

Pine Creek, USCA	(Newberry, 1982)
MacTung, CNBC	(Dick and Hodgson, 1982)
Strawberry, USCA	(Nokleberg, 1981)

GRADE AND TONNAGE MODEL OF W SKARN DEPOSITS

By W. David Menzie and Gail M. Jones

COMMENTS All mines associated with the contact zone of a particular intrusive with a favorable host rock were combined to form a single deposit. In the absence of detailed geologic information, mines within 10 km of each other were combined. See figs. 32, 33.

DEPOSITS

Name	Country	Name	Country
Bailey	CNYT	Lost Creek	USMT
Brejui	BRZL	Lucky Mike	CNBC
Cab	CNYT	Mactung	CNNT
Calvert (Red Button)	USMT	Maykhura	URTD
Cantung	CNNT	Milford area	USUT
Dublin Gulch (GSZ)	CNYT	Nevada-Massachusetts	USNV
Emerald-Dodger	CNBC	Nevada-Scheelite	USNV
Iron Mountain	USNM	Osgood Range	USNV
King Island	AUTS	Pine Creek	USCA

Model 14a--Con.

Quixaba	BRZL	Tyrny-Auz	URRS
Ray Gulch	CNYT	Uludag	TRKY
Sang Dong	SKOR	Victory	CNBC
Stormy Group	CNYT	Yellow Pine district	USID
Tem Piute district	USNV	Ysxjoberg	SWDN

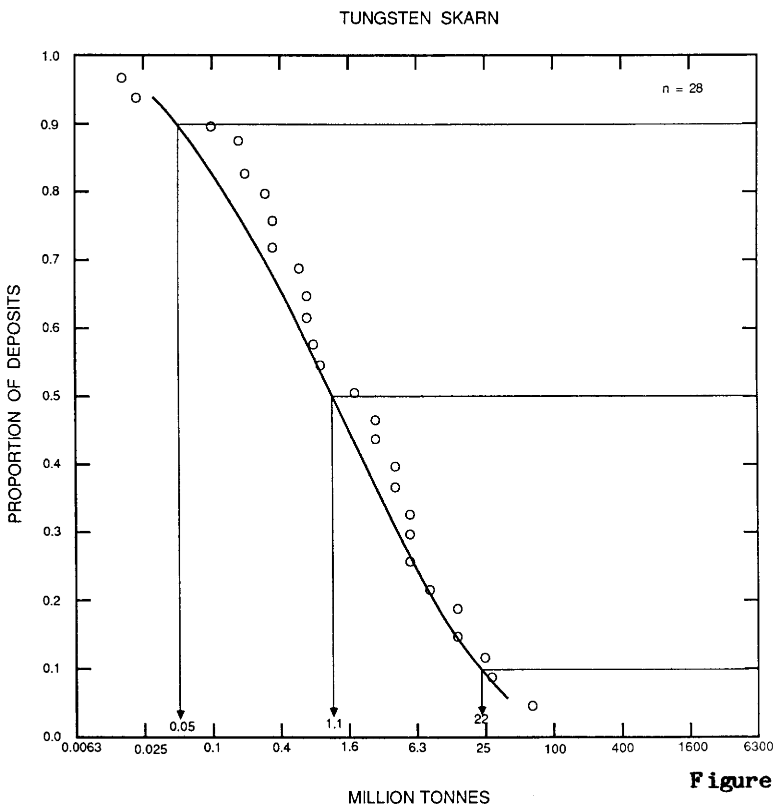


Figure 32. Tonnages of W skarn deposits.

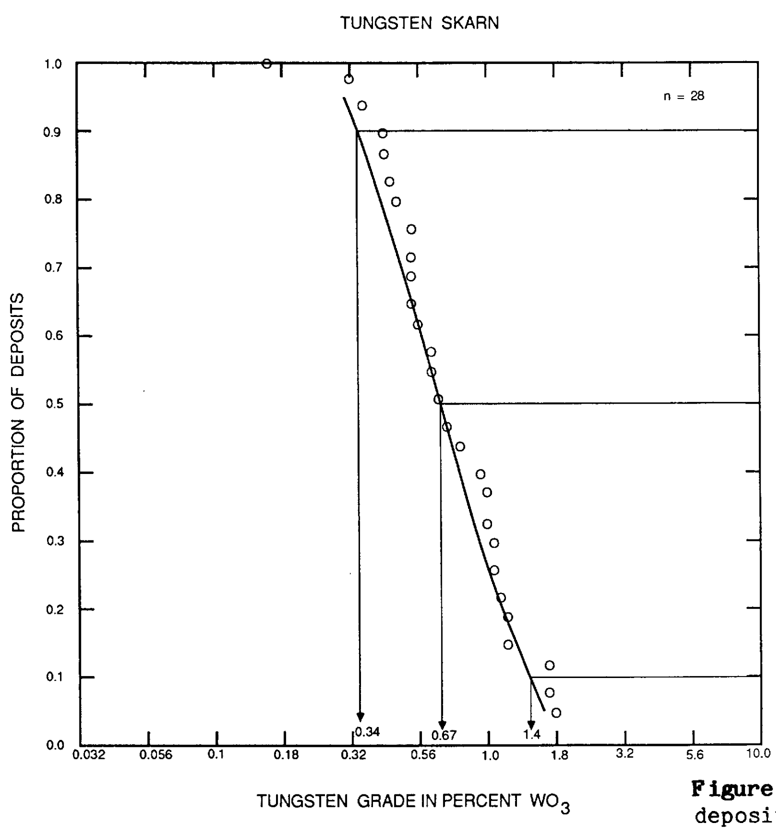


Figure 33. Tungsten grades of W skarn deposits.

Model 14b

DESCRIPTIVE MODEL OF Sn SKARN DEPOSITS

By Bruce L. Reed and Dennis P. Cox

DESCRIPTION Tin, tungsten, beryllium minerals in skarns, veins, stockworks and greisens near granite-limestone contacts (see fig. 34).

GENERAL REFERENCE Einaudi and Burt (1982), Einaudi and others (1981), Scherba (1970).

GEOLOGICAL ENVIRONMENT

Rock Types Leucocratic biotite and(or) muscovite granite, specialized phase or end members common, felsic dikes, carbonate rocks.

Textures Plutonic textures most common (granitic, seriate, fine-grained granitic). Also porphyritic-aphanitic; skarn is granoblastic to hornfelsic, banded skarn common.

Age Range Mainly Mesozoic, but may be any age.

Depositional Environment Epizonal(?) intrusive complexes in carbonate terrane.

Tectonic Setting(s) Granite emplacement generally late (post orogenic).

Associated Deposit Types W skarn, Sn greisen, and quartz-cassiterite-sulfide veins; at increasing distances from intrusive-carbonate contact Sn replacement and fissure lodes may develop (as at Renison Bell).

DEPOSIT DESCRIPTION

Mineralogy Cassiterite ± minor scheelite ± sphalerite ± chalcopyrite ± pyrrhotite ± magnetite ± pyrite ± arsenopyrite ± fluorite in skarn. Much Sn may be in silicate minerals and be metallurgically unavailable.

Texture/Structure Granoblastic skarn, wrigglite [chaotic laminar pattern of alternating light (fluorite) and dark (magnetite) lamellae], stockworks, breccia.

Alteration Greisenization (quartz-muscovite-topaz ± tourmaline, fluorite, cassiterite, sulfides) near granite margins and in cusps. Topaz tourmaline greisens. Idocrase + Mn-grossular-andradite ± Sn-andradite ± malayaite in skarn. Late-stage amphibole + mica + chlorite and mica + tourmaline + fluorite.

Ore Controls Mineralized skarns may or may not develop at intrusive contact with carbonate rocks; major skarn development up to 300 m from intrusion controlled by intrusion-related fractures; cross-cutting veins and felsic dikes.

Weathering Erosion of lodes may lead to deposition of tin placer deposits.

Geochemical Signature Sn, W, F, Be, Zn, Pb, Cu, Ag, Li, Rb, Cs, Re, B. Specialized granites characteristically have SiO_2 > 73 percent, K_2O > 4 percent and are depleted in CaO, TiO_2, MgO, and total Fe. They are enriched in Sn, F, Rb, Li, Be, W, Mo, Pb, B, Nb, Cs, U, Th, Hf, Ta, and most REE. They are depleted in Ni, Cu, Cr, Co, V, Sc, Sr, La, and Ba.

EXAMPLES

Lost River, USAK	(Dobson, 1982)
Moina, AUTS	(Kwak and Askins, 1981)
	(Scherba, 1970)

GRADE AND TONNAGE MODEL OF Sn SKARN DEPOSITS

By W. David Menzie and Bruce L. Reed

COMMENTS Normally a grade-tonnage model would not be built with so few deposits. However, this model is presented because tin skarn deposits are significantly different than replacement deposits in grades, tonnages, and other characteristics. Because of the small number of deposits plotted, the cumulative plot of discrete data points differes from the continuous lognormal curve. If the deposits had been plotted in descending order, the points would fall on the other side of the curve. Potential by-products from these deposits include tungsten, fluorite, beryllium, zinc, and gold. See figs. 35, 36.

DEPOSITS

Name	Country
Gilliam	AUQL
Lost River	USAK
Moina	AUTS
Pinnacles	AUQL

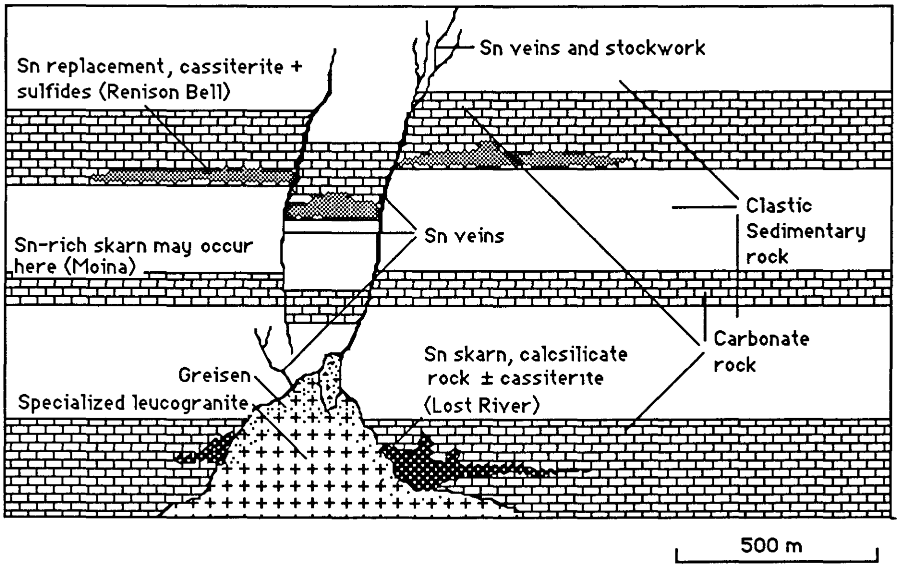


Figure 34. Cartoon cross section showing relation between Sn skarn, replacement Sn and Sn vein deposits, and granite intrusions.

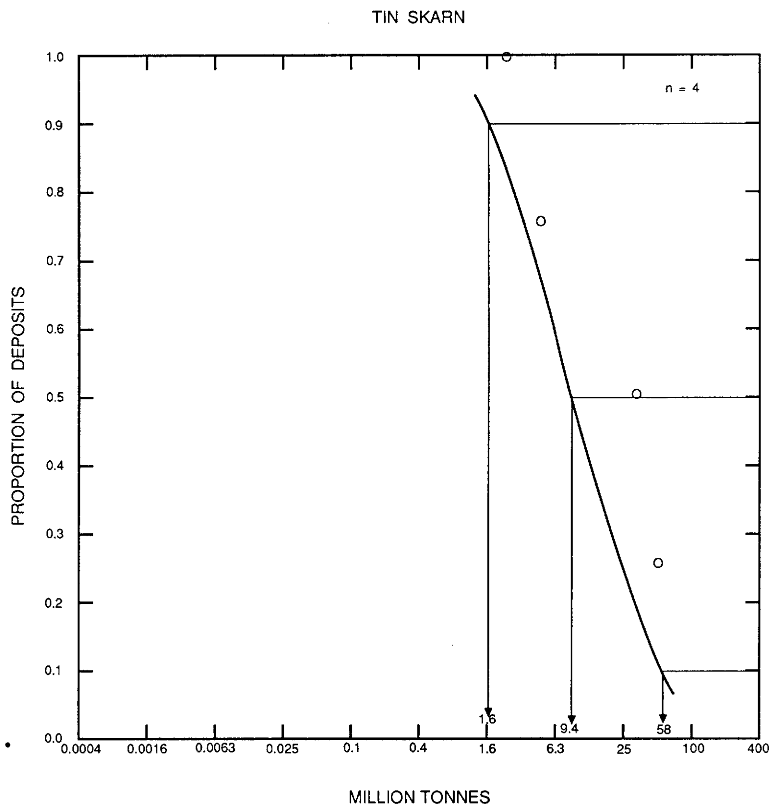


Figure 35. Tonnages of Sn skarn deposits.

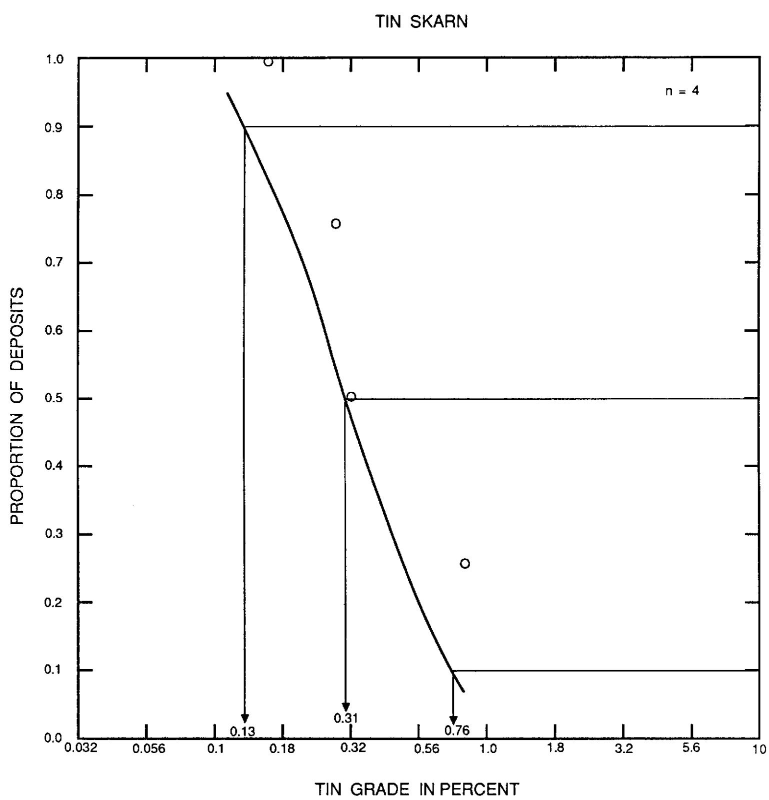


Figure 36. Tin grades of Sn skarn deposits.

DESCRIPTIVE MODEL OF REPLACEMENT Sn

By Bruce L. Reed

APPROXIMATE SYNONYM Exhalative Sn (Plimer, 1980; Hutchinson, 1979).

DESCRIPTION Stratabound cassiterite-sulfide (chiefly pyrrhotite) replacement of carbonate rocks and associated fissure lodes related to underlying granitoid complexes (see fig. 34).

GENERAL REFERENCE Patterson and others (1981).

GEOLOGICAL ENVIRONMENT

Rock Types Carbonate rocks (limestone or dolomite); granite, monzogranite, quartz porphyry dikes generally present; quartz-tourmaline rock; chert, pelitic and iron-rich sediments, and volcanic rocks may be present.

Textures Plutonic (equigranular, seriate, porphyritic).

Age Range Paleozoic and Mesozoic most common; other ages possible.

Depositional Environment Epizonal granitic complexes in terranes containing carbonate rocks. Note: the epigenetic replacement classification for these deposits has been questioned and an alternative exhalative synsedimentary origin followed by postdepositional metamorphic reworking hypothesis proposed (Hutchinson, 1979, 1982; Plimer, 1980; Lehmann and Schneider, 1981).

Tectonic Setting(s) Late orogenic to postorogenic passive emplacement of high-level granitoids in foldbelts containing carbonate rocks; alternatively, tin and associated metals were derived from submarine exhalative processes with subsequent reequilibration of sulfide and silicate minerals.

Associated Deposit Types Greisen-style mineralization, quartz-tourmaline-cassiterite veins, Sn-W-Mo stockworks, Sn-W skarn deposits close to intrusions.

DEPOSIT DESCRIPTION

Mineralogy Pyrrhotite + arsenopyrite + cassiterite + chalcopyrite (may be major) + ilmenite + fluorite; minor: pyrite, sphalerite, galena, stannite, tetrahdedrite, magnetite; late veins: sphalerite + galena + chalcopyrite + pyrite + fluorite.

Texture/Structure Vein stockwork ores, and massive ores with laminations following bedding in host rock, locally cut by stockwork veins, pyrrhotite may be recrystallized.

Alteration Greisenization (± cassiterite) near granite margins; sideritic alteration of dolomite near sulfide bodies; tourmalization of clastic sediments; proximity to intrusions may produce contact aureoles in host rocks.

Ore Controls Replacement of favorable carbonate units; fault-controlled fissure lodes common. Isolated replacement orebodies may lie above granitoid cupolas; faults provide channels for mineralizing fluids.

Geochemical Signature Sn, As, Cu, B, W, F, Li, Pb, Zn, Rb.

EXAMPLES

Renison Bell, AUTS	(Patterson and others, 1981)
Cleveland, AUTS	(Collins, 1981)
Mt. Bischoff, AUTS	(Groves and others, 1972)
Changpo-Tongkeng, CINA	(Liang and others, 1984)

GRADE AND TONNAGE MODEL OF REPLACEMENT Sn

By W. David Menzie and Bruce L. Reed

COMMENTS This model is built with deposits from Tasmania. Deposits of this type also occur in the Dachang and Geijui ore fields of the Peoples Republic of China. Potential by-products from this type of deposit include zinc, lead, and copper. See figs. 37, 38.

DEPOSITS

Name	Country
Cleveland	AUTS
Mount Bischoff	AUTS
Queen Hill	AUTS
Razorback	AUTS
Renison Bell	AUTS
St. Dizier	AUTS

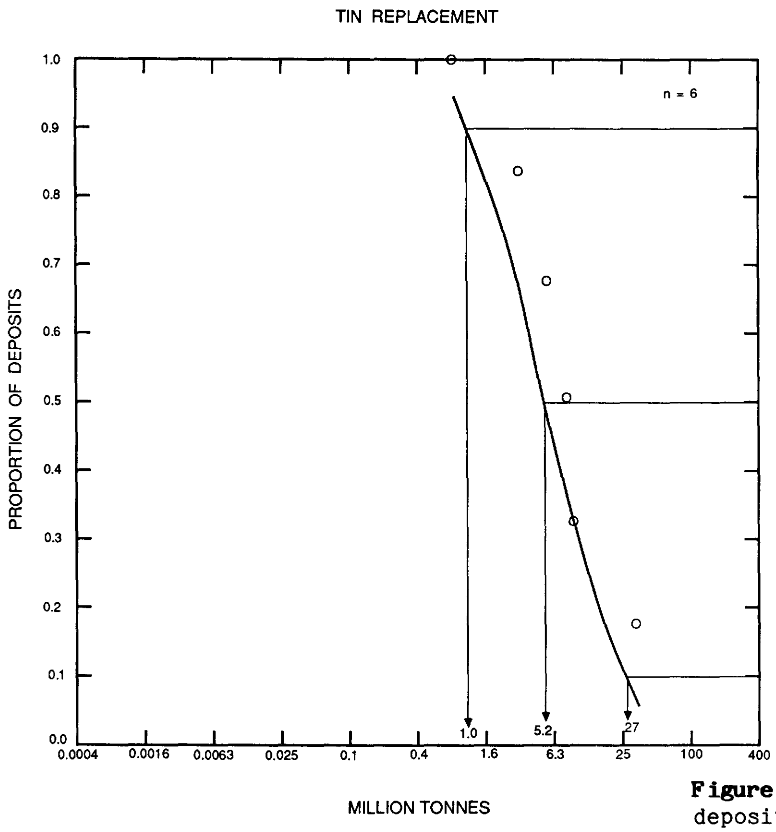


Figure 37. Tonnages of Sn replacement deposits.

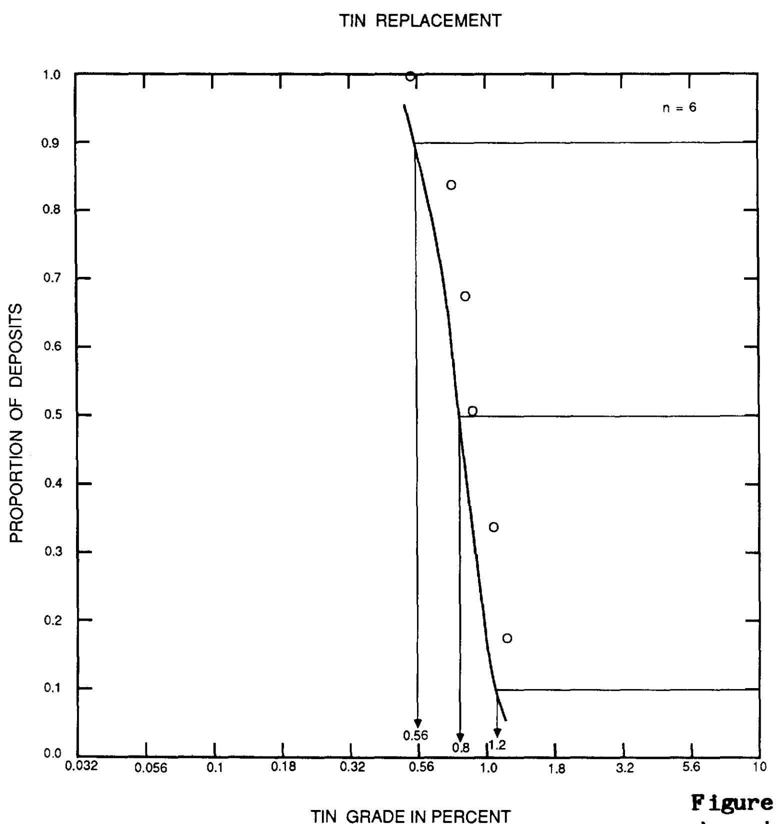


Figure 38. Tin grades of Sn replacement deposits.

DESCRIPTIVE MODEL OF W VEINS

By Dennis P. Cox and William C. Bagby

APPROXIMATE SYNONYM Quartz-wolframite veins (Kelly and Rye, 1979).

DESCRIPTION Wolframite, molybdenite, and minor base-metal sulfides in quartz veins (see fig. 39).

GEOLOGICAL ENVIRONMENT

Rock Types Monzogranite to granite stocks intruding sandstone, shale, and metamorphic equivalents.

Textures Phanerocrystalline igneous rocks, minor pegmatitic bodies, and porphyroaphanitic dikes.

Age Range Paleozoic to late Tertiary.

Depositional Environment Tensional fractures in epizonal granitic plutons and their wallrocks.

Tectonic Setting(s) Belts of granitic plutons derived from remelting of continental crust. Country rocks are metamorphosed to greenschist facies.

Associated Deposit Types Sn-W veins, pegmatites.

DEPOSIT DESCRIPTION

Mineralogy Wolframite, molybdenite, bismuthinite, pyrite, pyrrhotite, arsenopyrite, bornite, chalcopyrite, scheelite, cassiterite, beryl, fluorite; also at Pasto Bueno, tetrahedrite-tennantite, sphalerite, galena, and minor enargite.

Texture/Structure Massive quartz veins with minor vugs, parallel walls, local breccia.

Alteration Deepest zones, pervasive albitization; higher pervasive to vein-selvage pink K-feldspar replacement with minor disseminated REE minerals; upper zones, vein selvages of dark-gray muscovite or zinnwaldite (greisen). Chloritization. Widespread tourmaline alteration at Isla de Pinos.

Ore Controls Swarms of parallel veins cutting granitic rocks or sedimentary rocks near igneous contacts.

Weathering Wolframite persists in soils and stream sediments. Stolzite and tungstite may be weathering products.

Geochemical Signature W, Mo, Sn, Bi, As, Cu, Pb, Zn, Be, F.

EXAMPLES

Pasto Bueno, PERU	(Landis and Rye, 1974)
Xihuashan, CINA	(Hsu, 1943; Giuliani, 1985; and personal visit)
Isla de Pinos, CUBA	(Page and McAllister, 1944)
Hamme District, USNC	(Foose and others, 1980)
Round Mountain, USNV	(Shawe and others, 1984)
Chicote Grande, BLVA	(Personal visit)

GRADE AND TONNAGE MODEL OF W VEINS

By Gail M. Jones and W. David Menzie

COMMENTS Data are for vein systems rather than for individual veins or mines. Some data are based on past production only. Xihuashan is the sole deposit from the Peoples Republic of China. See figs. 40,41.

DEPOSITS

Name	Country	Name	Country
Carrock Fell	GRBR	Montredon	FRNC
Chicote Grande	BLVA	Needle Hill	HONG
Grey River	CNNF	Oakleigh Creek	AUTS
Hamme District	USNC	Panasqueria	PORT
Isla de Pinos	CUBA	Pasto Bueno	PERU
Josefina	AGTN	San Martin	AGTN
Kami	BLVA	Storeys Creek	AUTS
Los Condores	AGTN	Xihuashan	CINA

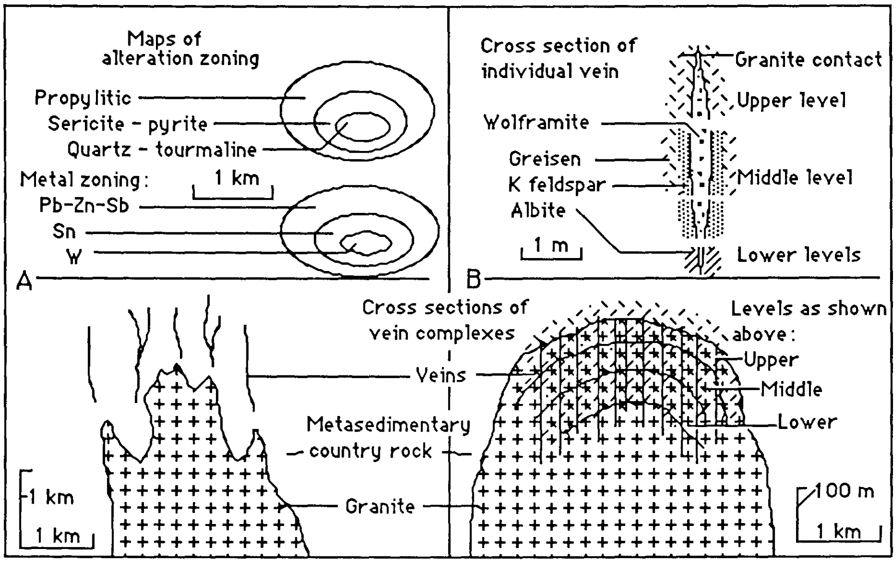


Figure 39. Maps and sections of W vein deposits illustrating mineral and alteration zoning. A, Chicote Grande deposit, Bolivia. B, Xihuashan, China.

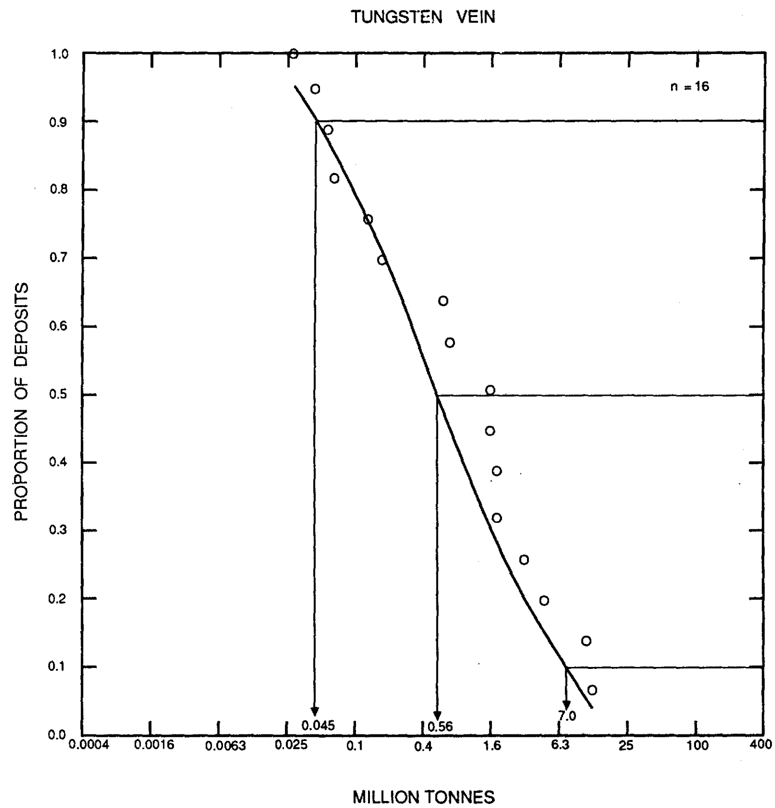


Figure 40. Tonnages of W vein deposits.

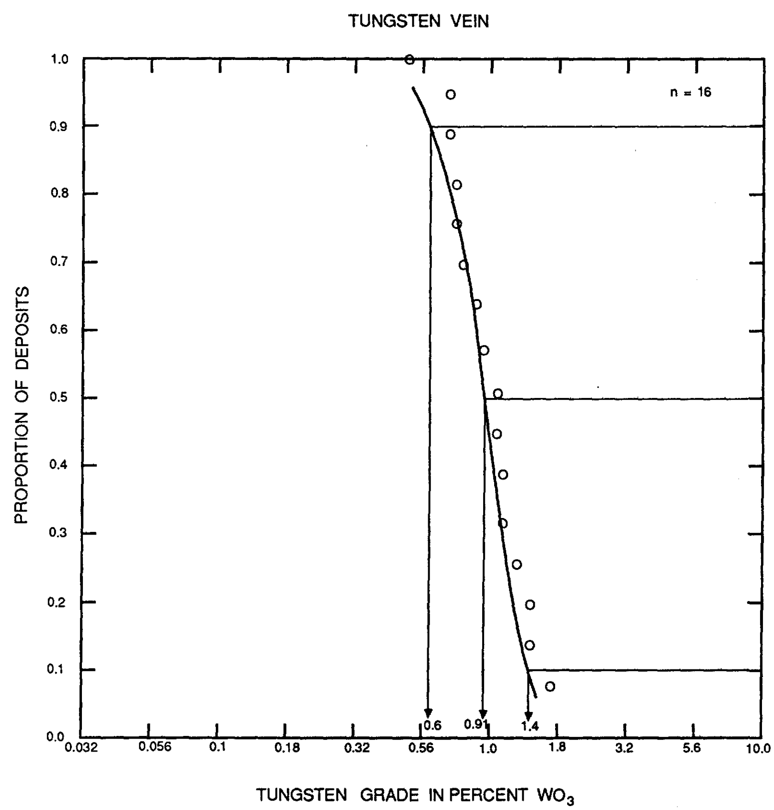


Figure 41. Tungsten grades of W vein deposits.

DESCRIPTIVE MODEL OF Sn VEINS

By Bruce L. Reed

APPROXIMATE SYNONYM Cornish type lodes.

DESCRIPTION Simple to complex quartz-cassiterite ± wolframite and base-metal sulfide fissure fillings or replacement lodes in ore near felsic plutonic rocks (see fig. 34).

GENERAL REFERENCE Hosking (1974), Taylor (1979).

GEOLOGICAL ENVIRONMENT

Rock Types Close spatial relation to multiphase granitoids; specialized biotite and(or) muscovite leucogranite common; pelitic sediments generally present.

Textures Common plutonic textures.

Age Range Paleozoic and Mesozoic most common; may be any age.

Depositional Environment Mesozonal to hypabyssal plutons; extrusive rocks generally absent; dikes and dike swarms common.

Tectonic Setting(s) Foldbelts and accreted margins with late orogenic to postorogenic granitoids which may, in part, be anatectic; regional fractures common.

Associated Deposit Types Sn greisen, Sn skarn, and replacement Sn deposits.

DEPOSIT DESCRIPTION

Mineralogy Extremely varied; cassiterite ± wolframite, arsenopyrite, molybdenite, hematite, scheelite, beryl, galena, chalcopyrite, sphalerite, stannite, bismuthinite; although variations and overlaps are ubiquitous, many deposits show an inner zone of cassiterite ± wolframite fringed with Pb, Zn, Cu, and Ag sulfide minerals.

Texture/Structure Variable; brecciated bands, filled fissures, replacement, open cavities.

Alteration Sericitization (greisen development) ± tourmalization common adjacent to veins and granite contacts; silicification, chloritization, hematization. An idealized zonal relation might consist of quartz-tourmaline-topaz, quartz-tourmaline-sericite, quartz-sericite-chlorite, quartz-chlorite, chlorite.

Ore Controls Economic concentrations of tin tend to occur within or above the apices of granitic cusps and ridges; localized controls include variations in vein structure, lithologic and structural changes, vein intersections, dikes, and cross-faults.

Weathering Cassiterite in stream gravels, placer tin deposits.

Geochemical Signature Sn, As, W, B are good pathfinder elements; elements characteristic of specialized granites (F, Rb, Be, Nb, Cs, U, Mo, REE, see model 14b).

EXAMPLES

Cornwall, GRBR	(Hosking, 1969)
Herberton, AUQL	(Blake, 1972)

GRADE AND TONNAGE MODEL OF Sn VEINS

By W. David Menzie and Bruce L. Reed

COMMENTS The grade-tonnage model for this deposit type is built with data from 43 deposits, or in some cases, districts. The imprecise definition of what constitutes a deposit has arisen here because many lodes were mined by a number of operators during the second half of the nineteenth century. Data for most deposits and districts consist of past production, although for some deposits, especially those still operating, reserves are included. Of the 43 deposits in the model, 27 are from Australia. These include most of the small tonnage deposits. This is thought to be an artifact of data reporting. For example, if data were available for many of the small deposits in Cornwall, the deposits would undoubtedly fall within the low tonnage part of the curve. See figs. 42, 43.

DEPOSITS

Name	Country	Name	Country
Aberfoyle	AUTS	Kelapa Kampit	INDO
Adventure Creek	AUQL	Killifreth	GRBR
Bakerville	AUQL	Krupka	CZCL
Basset	GRBR	Levant	GRBR
Bloodwood Creek	AUQL	Maranboy	AUNT
Brownsville	AUQL	Mawchi	BRMA
Carn Brea-Tincroft	GRBR	Mount Nolan Dist.	AUQL
Carocoles	BLVA	Mount Paynter	AUNS
Conrad Lodes	AUNW	Mount Wellington	GRBR
Coolgarra Dist.	AUQL	Mowbray Creek	AUQL
Dargo Range Dist.	AUQL	Nount Wells	AUNS
Dulcoath	GRBR	Nymbool Dist.	AUQL
Emu Creek	AUQL	Ottery Lode	AUNS
Emu Dist.	AUQL	Pahang	MLYS
Geevor	GRBR	Royal George	AUTS
Gleneindale Dist.	AUQL	Silver Valley	AUQL
Grenville	GRBR	South Crofty	GRBR
Gundie	AUNW	Stannary Hills	AUQL
Gurrumba Dist.	AUQL	Watsonville	AUQL
Hales Siding	AUQL	Wheal Jane	GRBR
Herberton	AUQL	Wheal Kitty-Penhalls	GRGB
Irvine Bank	AUQL		

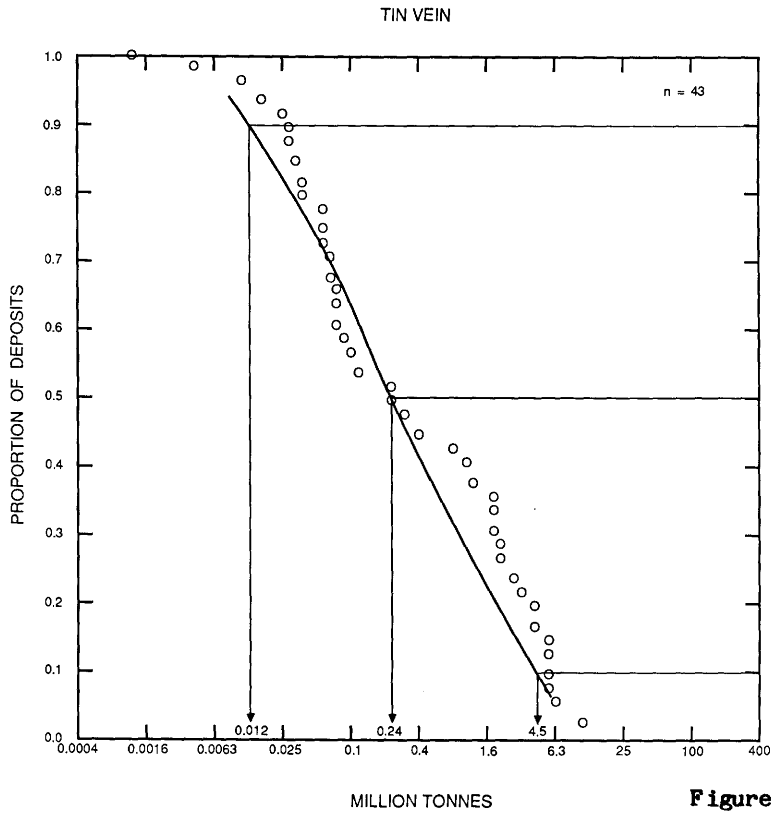


Figure 42. Tonnages of Sn vein deposits.

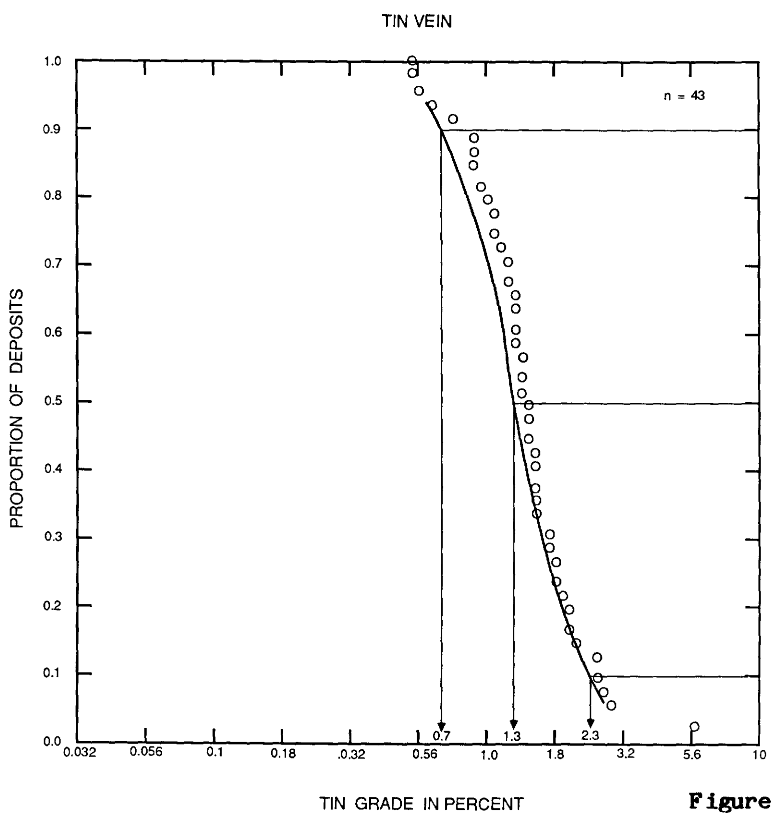


Figure 43. Tin grades of Sn vein deposits.

DESCRIPTIVE MODEL OF Sn GREISEN DEPOSITS

By Bruce L. Reed

DESCRIPTION Disseminated cassiterite, and cassiterite-bearing veinlets, stockworks, lenses, pipes, and breccia in greisenized granite (see fig. 44).

GENERAL REFERENCE Scherba (1970), Taylor (1979), Reed (1982), Tischendorf (1977).

GEOLOGICAL ENVIRONMENT

Rock Types Specialized biotite and(or) muscovite leucogranite (S-type); distinctive accessory minerals include topaz, fluorite, tourmaline, and beryl. Tin greisens are generally post-magmatic and associated with late fractionated melt.

Textures Common plutonic rock textures, miarolitic cavities may be common; generally nonfoliated; equigranular textures may be more evolved (Hudson and Arth, 1983); aplitic and porphyritic textures common.

Age Range May be any age; tin mineralization temporally related to later stages of granitoid emplacement.

Depositional Environment Mesozonal plutonic to deep volcanic environment.

Tectonic Setting(s) Foldbelts of thick sediments ± volcanic rocks deposited on stable cratonic shield; accreted margins; granitoids generally postdate major folding.

Associated Deposit Types Quartz-cassiterite sulfide lodes, quartz-cassiterite ± molybdenite stockworks, late complex tin-silver-sulfide veins.

DEPOSIT DESCRIPTION

Mineralogy General zonal development of cassiterite + molybdenite, cassiterite + molybdenite + arsenopyrite + beryl, wolframite + beryl + arsenopyrite + bismuthinite, Cu-Pb-Zn sulfide minerals + sulphostannates, quartz veins ± fluorite, calcite, pyrite.

Texture/Structure Exceedingly varied, the most common being disseminated cassiterite in massive greisen, and quartz veinlets and stockworks (in cupolas or in overlying wallrocks); less common are pipes, lenses, and tectonic breccia.

Alteration Incipient greisen (granite): muscovite ± chlorite, tourmaline, and fluorite. Greisenized granite: quartz-muscovite-topaz-fluorite, ± tourmaline (original texture of granites retained). Massive greisen: quartz-muscovite-topaz ± fluorite ± tourmaline (typically no original texture preserved). Tourmaline can be ubiquitous as disseminations, concentrated or diffuse clots, or late fracture fillings. Greisen may form in any wallrock environment, typical assemblages developed in aluminosilicates.

Ore Controls Greisen lodes located in or near cupolas and ridges developed on the roof or along margins of granitoids; faults and fractures may be important ore controls.

Weathering Granite may be "reddened" close to greisen veins. Although massive greisen may not be economic as lodes, rich placer deposits form by weathering and erosion.

Geochemical Signature Cassiterite, topaz, and tourmaline in streams that drain exposed tin-rich greisens. Specialized granites may have high contents of SiO (>73 percent) and K_2O (>4 percent), and are depleted in CaO, TiO_2, MgO, and total FeO. They are enriched in Sn, F, Rb, Li, Be, W, Mo, Pb, B, Nb, Cs, U, Th, Hf, Ta, and most REE, and impoverished in Ni, Cu, Cr, Co, V, Sc, Sr, La, and Ba.

EXAMPLES

Lost River, USAK	(Dobson, 1982; Sainsbury, 1964)
Anchor Mine, AUTS	(Groves and Taylor, 1973)
Erzgebirge, CZCL	(Janecka and Stemprok, 1967)

GRADE AND TONNAGE MODEL OF Sn GREISEN DEPOSITS

By W. David Menzie and Bruce L. Reed

COMMENTS See figs. 45, 46.

DEPOSITS

Name	Country	Name	Country
Altenberg	GRME	Coal Creek	USAK
Anchor	AUTS	E. Kempville	CNNS
Archer	AUTS	Hub	CZCL
Cinovec	CZCL	Potosi	BRZL
Cista	CZCL	Prebuz	CZCL

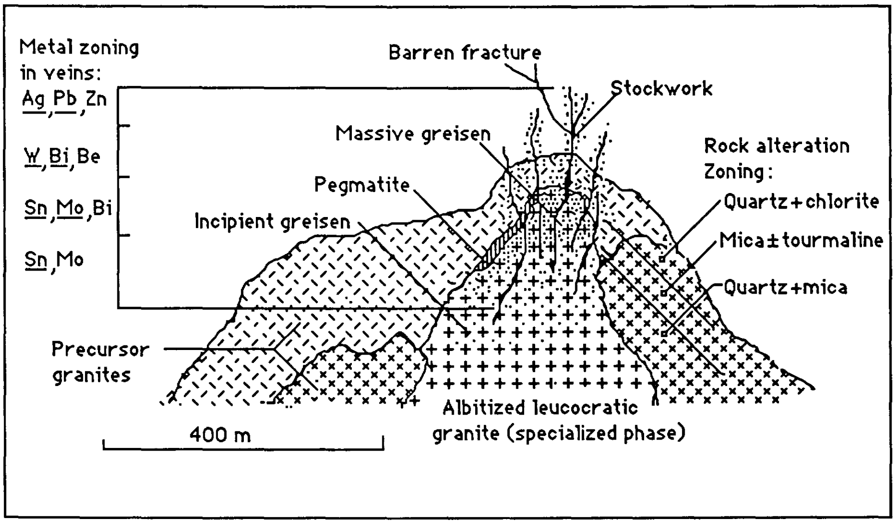


Figure 44. Cartoon cross section of a Sn greisen.

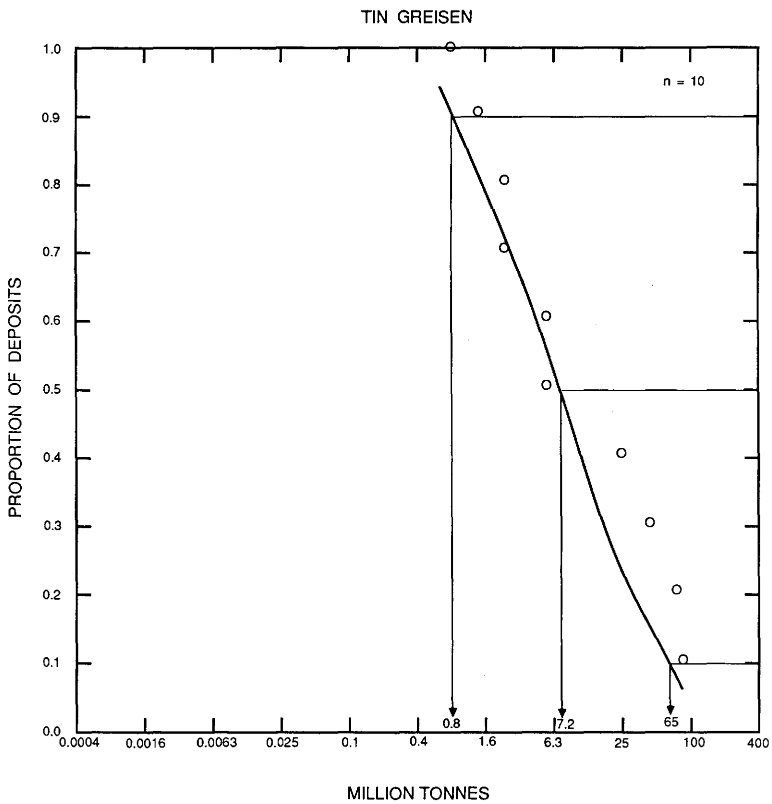


Figure 45. Tonnages of Sn greisen deposits.

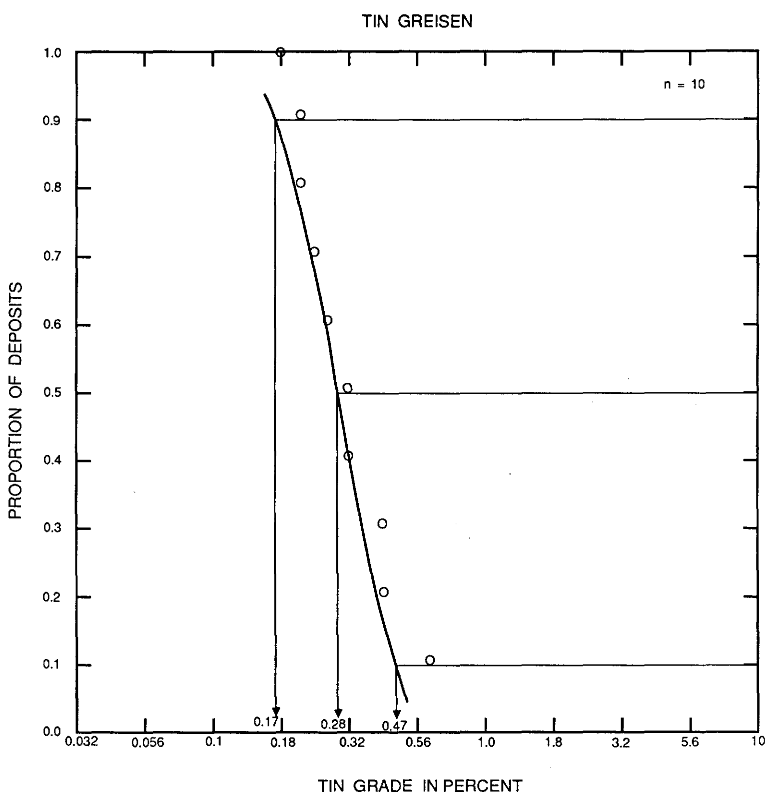


Figure 46. Tin grades of Sn greisen deposits.

DESCRIPTIVE MODEL OF CLIMAX Mo DEPOSITS

By Stephen D. Ludington

APPROXIMATE SYNONYM Granite molybdenite (Mutschler and others, 1981).

DESCRIPTION Stockwork of quartz and molybdenite associated with fluorite in granite porphyry (see fig. 47).

GENERAL REFERENCE White and others (1981).

GEOLOGICAL ENVIRONMENT

Rock Types Granite-rhyolite with >75 percent SiO_2. Rb, Y, Nb are high, Ba, Sr, Zr low. Stocks with radial dikes; small breccias common.

Textures Porphyry with fine- to medium-grained aplitic groundmass.

Age Range Examples are mainly mid-Tertiary.

Depositional Environment Multistage hypabyssal intrusions.

Tectonic Setting(s) Mainly extensional zones in cratons. May be related to subduction, but found far from continental margins in areas of thick crust, and late in the cycles.

Associated Deposit Types Ag-base-metal veins, fluorspar deposits. On the basis of similar geochemistry of associated rhyolite magmas, rhyolite-hosted Sn deposits may be a surface expression. Porphyry tungsten deposits, as at Mount Pleasant, Canada, may be W-rich Climax systems.

DEPOSIT DESCRIPTION

Mineralogy: Molybdenite + quartz ± fluorite ± K-feldspar ± pyrite ± wolframite ± cassiterite ± topaz.

Texture/Structure Predominantly in veinlets and fractures; minor disseminations.

Alteration Intense quartz and quartz + K-feldspar veining in ore zone. Upper phyllic and propylitic zones. Halo of rhodochrosite, rhodonite, spessartine garnet. Minor greisen veins below ore body.

Ore Controls Stockwork ore zone draped over small, <1 km^2 stocks. Multiple phases of intrusion and mineralization are highly favorable.

Weathering Yellow ferrimolybdite stains.

Geochemical Signature Mo, Sn, W and Rb anomalies close above ore zones. Pb, Zn, F, and U anomalies in wall rocks up to a few kilometers distant. Cu anomaly external to Mount Emmons deposit. In panned concentrates, Sn, W, Mo, and F may be important.

EXAMPLES

Redwell Basin, Winfield, Middle Mtn. Climax, Henderson, and Mt. Emmons, USCO	(White and others, 1981)
Pine Grove, USUT	(Abbott and Williams, 1981)
Mount Hope, USNV	(Westra, 1982b)
Big Ben, USMT	(Witkind, 1973)

GRADE AND TONNAGE MODEL OF CLIMAX Mo DEPOSITS

By Donald A. Singer, Ted G. Theodore, and Dan L. Mosier

COMMENTS See figs. 48, 49.

Model 16--Con.

DEPOSITS

Name	Country	Name	Country
Big Ben	USMT	Mount Hope	USNV
Climax	USCO	Pine Grove	USUT
Henderson	USCO	Questa-Goat Hill	USNM
Malmbjerg	GRLD	Redwell	USCO
Mount Emmons	USCO		

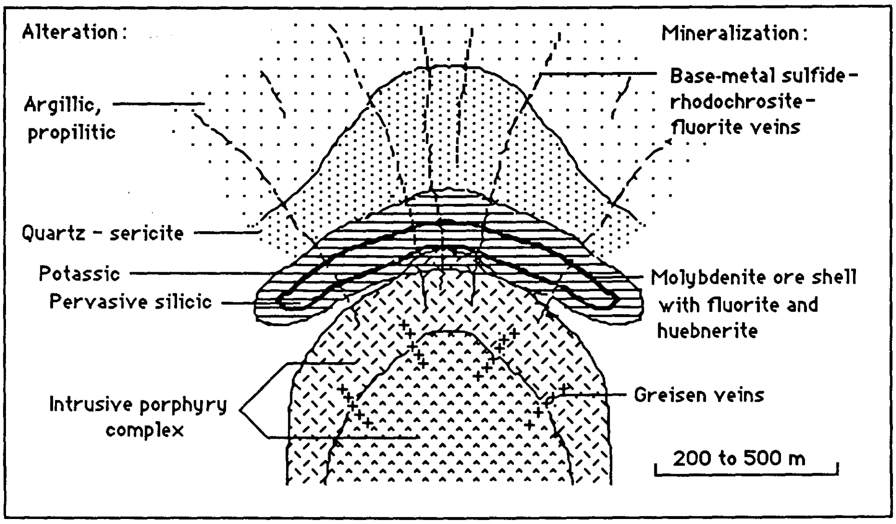


Figure 47. Cartoon cross section of Climax Mo deposit showing relationship of ore and alteration zoning to porphyry intrusions from Mutschler and others (1981). Cartoon represents a region about 1 km wide.

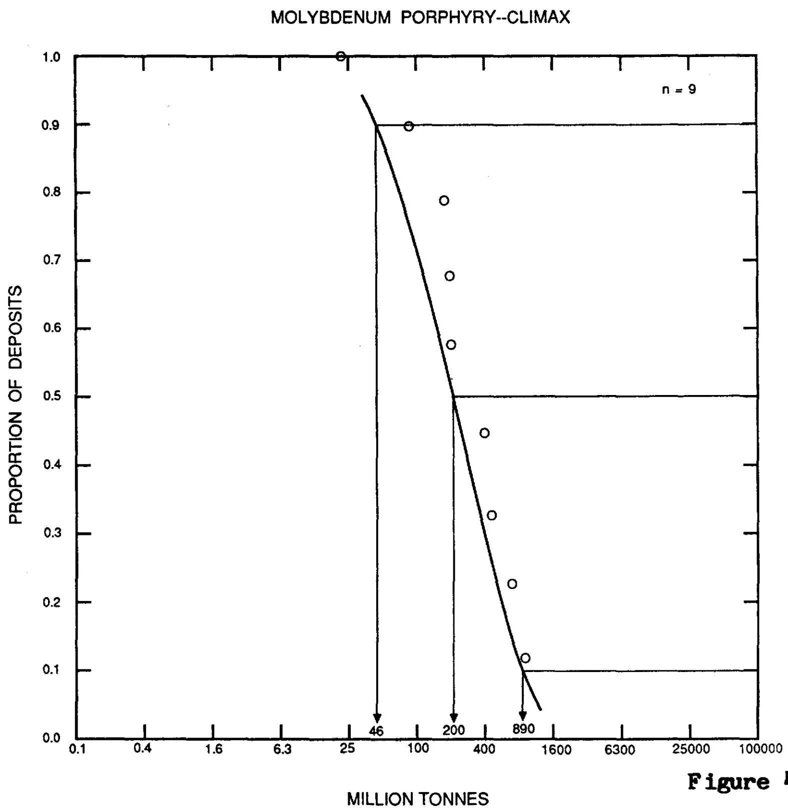


Figure 48. Tonnages of Climax Mo deposits.

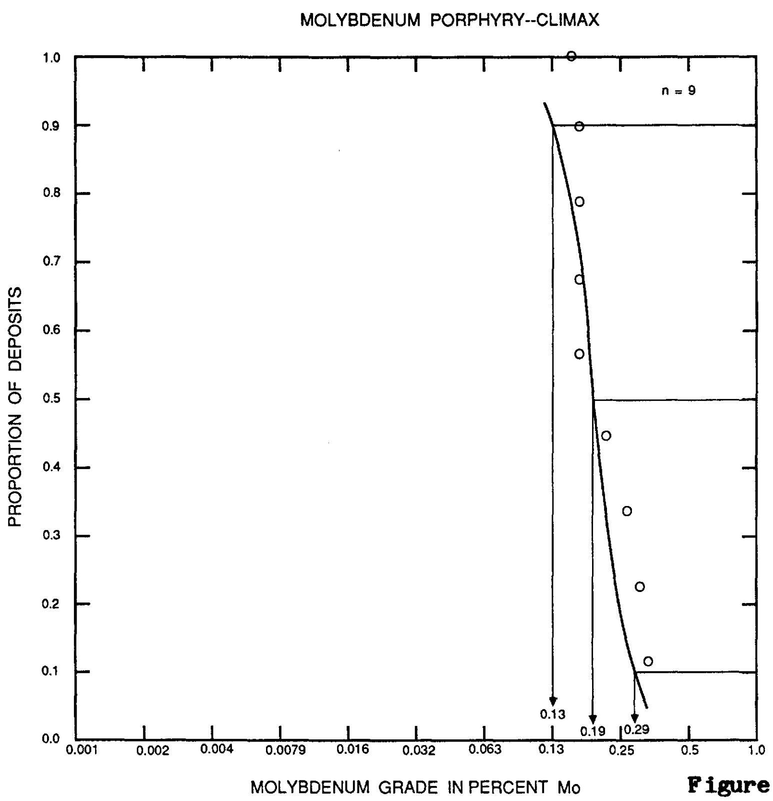


Figure 49. Molybdenum grades of Climax Mo deposits.

DESCRIPTIVE MODEL OF PORPHYRY Cu

By Dennis P. Cox

DESCRIPTION This generalized model includes various subtypes all of which contain chalcopyrite in stockwork veinlets in hydrothermally altered porphry and adjacent country rock (see fig. 50).

GENERAL REFERENCE Titley (1982).

GEOLOGICAL ENVIRONMENT

Rock Types Tonalite to monzogranite or syenitic porphyry intruding granitic, volcanic, calcareous sedimentary, and other rocks.

Textures Porphyry has closely spaced phenocrysts and microaplitic quartz-feldspar groundmass.

Age Range Mainly Mesozoic and Cenozoic, but may be any age.

Depositional Environment High-level intrusive rocks contemporaneous with abundant dikes, breccia pipes, faults. Also cupolas of batholiths.

Tectonic Setting(s) Rift zones contemporaneous with Andean or island-arc volcanism along convergent plate boundaries. Uplift and erosion to expose subvolcanic rocks.

Associated Deposit Types Base-metal skarn, epithermal veins, polymetallic replacement, volcanic hosted massive replacement. See also: Porphyry Cu-skarn related, porphyry Cu-Mo, and porphyry Cu-Au.

DEPOSIT DESCRIPTION

Mineralogy: Chalcopyrite + pyrite ± molybdenite; chalcopyrite + magnetite ± bornite ± Au; assemblages may be superposed. Quartz + K-feldspar + biotite ± anhydrite; quartz + sericite ± clay minerals. Late veins of enargite, tetrahedrite, galena, sphalerite, and barite in some deposits.

Texture/Structure Stockwork veinlets and disseminated sulfide grains.

Alteration From bottom, innermost zones outward: sodic-calcic, potassic, phyllic, and argillic to propylitic. High-alumina alteration in upper part of some deposits. See table 3. Propylitic or phyllic alteration may overprint early potassic assemblage.

Ore Controls Stockwork veins in porphyry, along porphyry contact, and in favorable country rocks such as carbonate rocks, mafic igneous rocks, and older granitic plutons.

Weathering Green and blue Cu carbonates and silicates in weathered outcrops, or where leaching is intense, barren outcrops remain after Cu is leached, transported downward, and deposited as secondary sulfides at water table or paleowater table. Fractures in leached outcrops are coated with hematitic limonite having bright red streak. Deposits of secondary sulfides contain chalcocite and other Cu_2S minerals replacing pyrite and chalcopyrite. Residual soils overlying deposits may contain anomalous amounts of rutile.

Geochemical Signature: Cu ± Mo ± Au ± Ag ± W ± B ± Sr center, Pb, Zn, Au, As, Sb, Se, Te, Mn, Co, Ba, and Rb outer. Locally Bi and Sn form most distal anomalies. High S in all zones. Some deposits have weak U anomalies.

EXAMPLES

Bingham, USUT	(Lanier and others, 1978)
San Manuel, USAZ	(Lowell and Guilbert, 1970)
El Salvador, CILE	(Gustafson and Hunt, 1975)

GRADE AND TONNAGE MODEL OF PORPHYRY Cu

By Donald A. Singer, Dan L. Mosier, and Dennis P. Cox

COMMENTS All porphyry copper deposits with available grades and tonnages were included in these plots in order to provide a model for cases where it is not possible to use the gold-rich or molybdenum-rich models. Parts of the porphyry copper deposits which could be considered skarn were included in these data. Gold grade is correlated with tonnage (r = -0.49, n = 81) and with molybdenum grade (r = -0.45, n = 55). See figs. 51-53.

DEPOSITS

Name	Country	Name	Country
Afton	CNBC	Copper Cities	USAZ
Ajax	CNBC	Copper Creek	USAZ
Ajo	USAZ	Copper Flat	USNM
Am	CNBC	Copper Mountain	CNBC
Amacan	PLPN	Cordon	PLPN
Andacolla	CILE	Cuajone	PERU
Ann	CNBC	Cubuagan	PLPN
Ann Mason	USNV	Dexing	CINA
Arie	PPNG	Dizon	PLPN
Atlas Carmen	PLPN	Dorothy	CNBC
Atlas Frank	PLPN	Dos Pobres	USAZ
Atlas Lutopan	PLPN	Eagle	CNBC
Axe	CNBC	El Abra	CILE
Aya Aya	PLPN	El Arco	MXCO
Bagdad	USAZ	El Pachon	AGTN
Basay	PLPN	El Salvador	CILE
Bear	USNV	El Soldado	CILE
Bell Copper	CNBC	El Teniente	CILE
Berg	CNBC	Elatsite	BULG
Bethlehem	CNBC	Ely	USNV
Big Onion	CNBC	Escondida	CILE
Bingham	USUT	Esperanza	CILE
Bisbee	USAZ	Exotica	CILE
Bluebird	USAZ	Fish Lake	CNBC
Bond Creek	USAK	Florence	USAZ
Boneng Lobo	PLPN	Frieda River	PPNG
Bozshchaku	URRS	Galaxy	CNBC
Brenda	CNBC	Galore Creek	CNBC
Brenmac	USWA	Gambier Island	CNBC
Butilad	PLPN	Gaspe	CNQU
Butte	USMT	Gibraltar	CNBC
Campanamah	AGTN	Glacier Peak	USWA
Cananea	MXCO	Granisle	CNBC
Canariaco	PERU	Hale-Mayabo	PLPN
Cariboo Bell	CNBC	Heddleston	USMT
Carpenter	USAZ	Helvetia	USAZ
Cash	CNYT	Highmont	CNBC
Casino	CNYT	Hinobaan	PLPN
Castle Dome	USAZ	Huckleberry	CNBC
Catface	CNBC	Ingerbelle	CNBC
Catheart	USMN	Inguaran	MXCO
Cerro Blanco	CILE	Ino-Capaya	PLPN
Cerro Colorado	CILE	Inspiration	USAZ
Cerro Colorado	PANA	Iron Mask	CNBC
Cerro Verde	PERU	Island Copper	CNBC
Chaucha	ECDR	Ithaca Peak	USAZ
Chuquicamata	CILE	June	CNBC
Coalstoun	AUQL	Kadzharan	URAM
Copper Basin	USAZ	Kalamaton	PLPN

Model 17--Con.

Kalamazoo-San Manuel	USAZ
Kalmakyr	URUZ
Kennon	PLPN
King-King	PLPN
Kirwin	USWY
Kounrad	URKZ
Krain	CNBC
Kwanika	CNBC
La Alumbrera	AGTN
La Caridad	MXCO
La Florida	MXCO
La Verde	MXCO
Lakeshore	USAZ
Lights Creek	USCA
Lornex	CNBC
Lorraine	CNBC
Los Bronces	CILE
Los Pelambres	CILE
Los Pilares	MXCO
Lumbay	PLPN
Luna-Bash	PLPN
MacArthur	USNV
Maggie	CNBC
Majdanpek	YUGO
Mamut	MDGS
Mantos Blancos	CILE
Mapula	PLPN
Marcopper	PLPN
Margaret	USWA
Marian	PLPN
Mazama	USWA
Metcalf	USAZ
Michiquillay	PERU
Middle Fork	USWA
Mineral Butte	USAZ
Misty	CNBC
Mocha	CILE
Mocoa	CLBA
Moniwa	BRMA
Morenci	USAZ
Morococha	PERU
Morrison	CNBC
Mountain Mines	PLPN
Mount Canninda	AUQL
Namosi East	FIJI
Namosi West	FIJI
North Fork	USWA
Ok	CNBC
Ok Tedi	PPNG
Orange Hill	USAK
Pampa Norte	CILE
Panguna	PPNG
Paramillos	AGTN
Parks	AUNS
Pashpap	PERU
Petaquilla	PANA
Philippine	PLPN
Pima-Mission	USAZ
Plurhinaler	THLD
Poison Mountain	CNBC
Potrerillos	CILE
Primer	CNBC
Quebrada Blanca	CILE
Quelleveco	PERU
Ray	USAZ
Recsk	HUNG
Red Chris	CNBC
Red Mountain	USAZ
Rio Blanco	CILE
Rio Vivi	PTRC
Sacaton (E-W)	USAZ
Safford (KCC)	USAZ
Saindak East	PKTN
Saindak North	PKTN
Saindak South	PKTN
Samar	PLPN
San Antonio	PLPN
San Fabian	PLPN
San Juan	USAZ
San Xavier	USAZ
Sanchez	USAZ
Santa Rita	USNM
Santo Nino	PLPN
Santo Tomas	MXCO
Santo Tomas	PLPN
Sar Cheshmeh	IRAN
Schaft Creek	CNBC
Sierra Gorda	CILE
Silver Bell	USAZ
Sipalay	PLPN
Star Mt.-Fubilan	PPNG
Star Mt.-Futik	PPNG
Star Mt.-Nong River	PPNG
Star Mt.-Olgal	PPNG
Sugarloaf Hill	CNBC
Tagpura	PLPN
Tanama	PTRC
Tawi-Tawi	PLPN
Taysan	PLPN
Toledo	PLPN
Toquepala	PERU
Trojan	CNBC
Twin Buttes	USAZ
Tyrone	USNM
Valley Copper	CNBC
Vekol	USAZ
Washington	MXCO
Yandera	PPNG
Yeoval	AUNS
Yerington	USNV

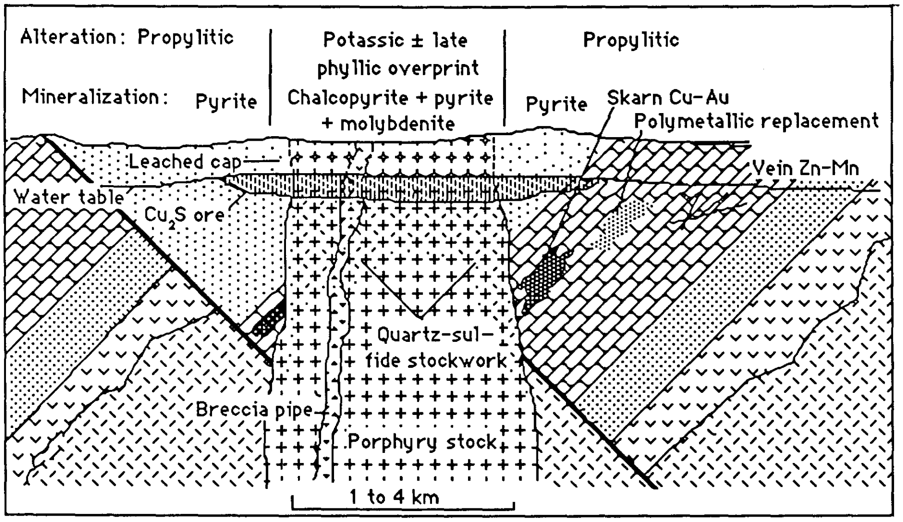


Figure 50. Cartoon cross section illustrating generalized model for porphyry Cu deposits showing relation of ore minerals, alteration zoning, supergene enrichment and associated skarn, replacement, and vein deposits.

Table 3. Types of hydrothermal alteration characteristic of porphyry copper and other deposit models

Type of alteration and synonyms	Original mineral	replaced by	Appearance
Potassic alteration (K-silicate)	plagioclase------- hornblende--------	K-feldspar fine-grained biotite + rutile + pyrite or magnetite. Anhydrite	Rocks look fresh but may have pinkish K-feldspar veinlets. and black biotite veinlets and clusters of fine biotite after mafic phenocrysts.
Sodic-calcic alteration (albitic)	K-feldspar-------- biotite-----------	oligoclase or albite actinolite + sphene	Rocks are hard and dull white. Biotite is absent. Veinlets of actinolite, epidote, and hematite have hard, white alteration haloes.
Phyllic alteration (quartz-sericite)	plagioclase------- hornblende and biotite-----------	sericite sericite + chlorite + rutile + pyrite	Rocks are soft and dull to lustrous white. Pyrite veinlets have distinct, soft translucent gray, sericite haloes. Tourmaline rosettes may be present.
Propylitic alteration	plagioclase------- hornblende and biotite-------	albite or oligoclase + epidote or calcite chlorite + rutile + magnetite or pyrite	Rocks are hard and dull greenish gray. Veinlets of pyrite or chlorite and epidote lack prominent alteration haloes.
Argillic alteration	plagioclase------- mafic minerals----	clay + sericite clay + sericite + chlorite + pyrite	Rocks are soft and white. Tongue will stick to clay-altered minerals.
High alumina (alsic, advanced argillic)	All original and earlier hydrothermal minerals converted to pyrophyllite, alunite, andalusite, corundum, and diaspore with variable amounts of clay and sericite.		Rocks are light colored and moderately soft.

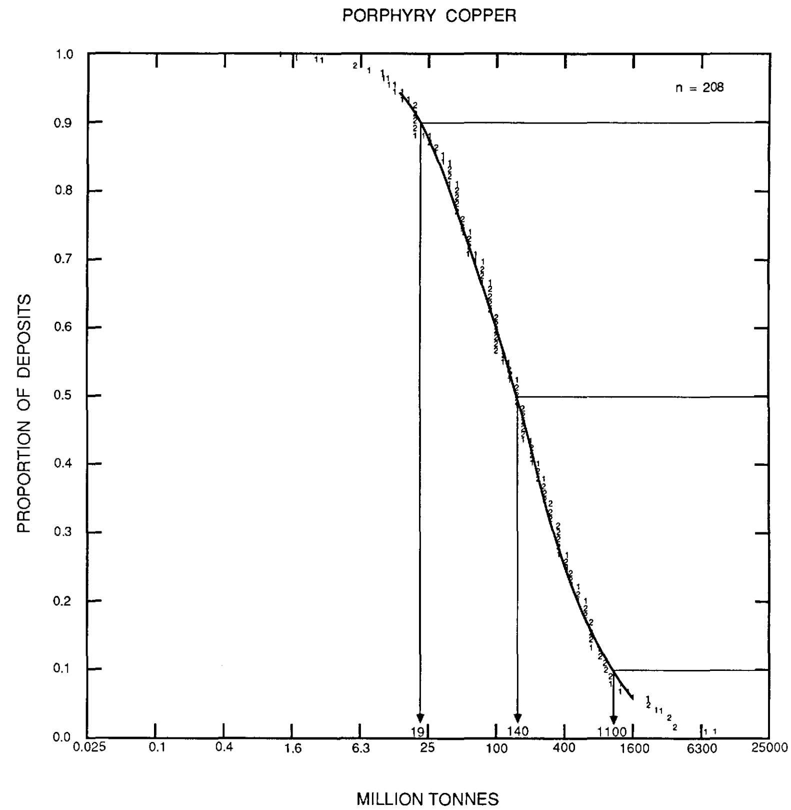


Figure 51. Tonnages of porphyry Cu deposits. Individual digits represent number of deposits.

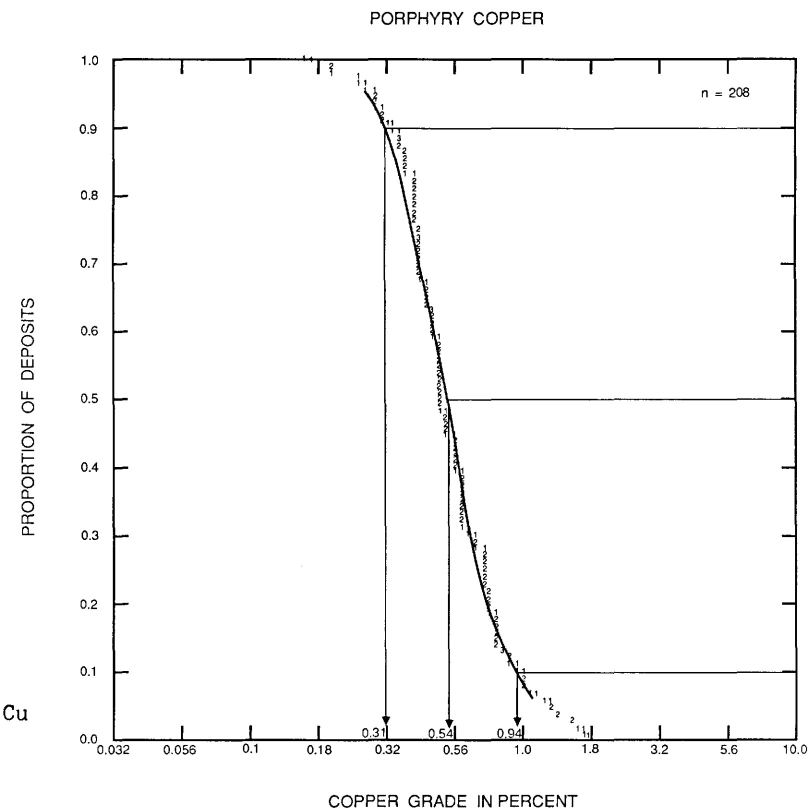


Figure 52. Copper grades of porphyry Cu deposits. Individual digits represent number of deposits.

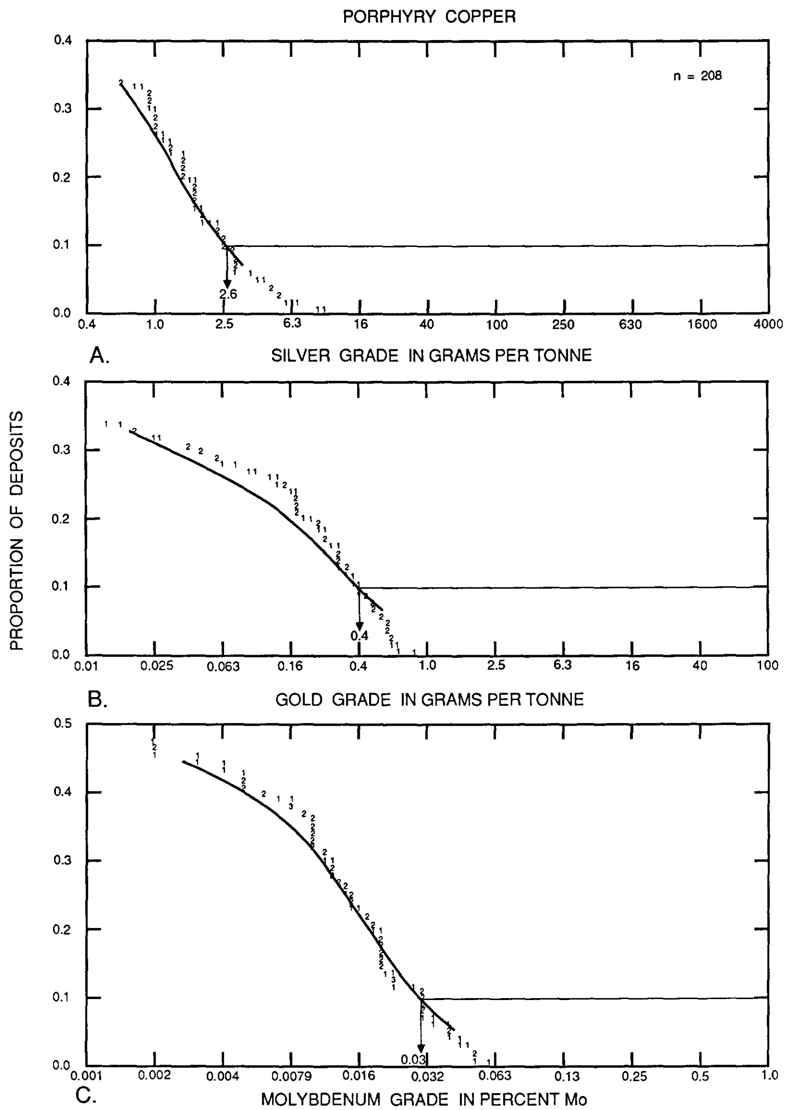


Figure 53. By-product grades of porphyry Cu deposits. A, Silver. B, Gold. C, Molybdenum. Individual digits represent number of deposits.

Model 18a

DESCRIPTIVE MODEL OF PORPHYRY Cu, SKARN-RELATED DEPOSITS

By Dennis P. Cox

DESCRIPTION Chalcopyrite in stockwork veinlets in hydrothermally altered intrusives and in skarn with extensive retrograde alteration (see fig. 50).

GENERAL REFERENCE Einaudi and others (1981), p. 341-354.

GEOLOGICAL ENVIRONMENT

Rock Types Tonalite to monzogranite intruding carbonate rocks or calcareous clastic rocks.

Textures Porphyry has microaplitic groundmass.

Age Range Mainly Mesozoic and Tertiary, but may be any age.

Depositional Environment Epizonal intrusion of granitic stocks into carbonate rocks. Intense fracturing.

Tectonic Setting(s) Andean-type volcanism and intrusion superimposed on older continental shelf carbonate terrane.

Associated Deposit Types Skarn copper, replacement Pb-Zn-Ag.

DEPOSIT DESCRIPTION

Mineralogy Chalcopyrite + pyrite + magnetite in inner garnet pyroxene zone; bornite + chalcopyrite ± sphalerite ± tennantite in outer wollastonite zone. Scheelite and traces of molybdenite and galena may be present. Hematite or pyrrhotite may be predominant.

Texture/Structure Fine granular calc-silicates and quartz sulfide veinlets.

Alteration Potassic alteration in pluton is associated with andradite and diopside in calcareous rocks. Farther from contact are zones of wollastonite or tremolite with minor garnet, idocrase, and clinopyroxene. These grade outward to marble. Phyllic alteration in pluton is associated with retrograde actinolite, chlorite, and clay in skarn.

Ore Controls Intense stockwork veining in igneous and skarn rocks contains most of the copper minerals. Cu commonly accompanies retrograde alteration.

Weathering Cu carbonates, silicates, Fe-rich gossan.

Geochemical Signature Cu, Mo, Pb, Zn, Au, Ag, W, Bi, Sn, As, Sb.

EXAMPLES

Ruth, (Ely), USNV	(Westra, 1982a)
Gaspe, CNQU	(Allcock, 1982)
Christmas, USAZ	(Koski and Cook, 1982)
Silver Bell, USAZ	(Graybeal, 1982)

GRADE AND TONNAGE MODEL OF PORPHYRY Cu, SKARN-RELATED DEPOSITS

By Donald A. Singer

DATA REFERENCES Einaudi and others (1981), Einaudi (1981).

COMMENTS Skarn copper deposits associated with porphyry copper deposits are included in this model. Tonnages and grades attributable to skarn were estimated for some deposits from estimated proportions of skarn provided by Einaudi and others (1981) and Einaudi (1981). See figs. 54-56.

DEPOSITS

Name	Country	Name	Country
Cananea (Capote)	MXCO	Gold Coast	PPNG
Carr Fork	USUT	Lakeshore	USAZ
Christmas	USAZ	Lyon	USNV
Continental	USNM	Pima-Mission	USAZ
Copper Basin (Battle Mt. D.)	USNV	Potrerillos	CILE
Copper Canyon	USNV	Recsk	HUNG
Craigmont	CNBC	Santa Rita	USNM
Ely	USNV	Silver Bell	USAZ
Gaspe (Needle Mountain)	CNQU	Twin Buttes	USAZ

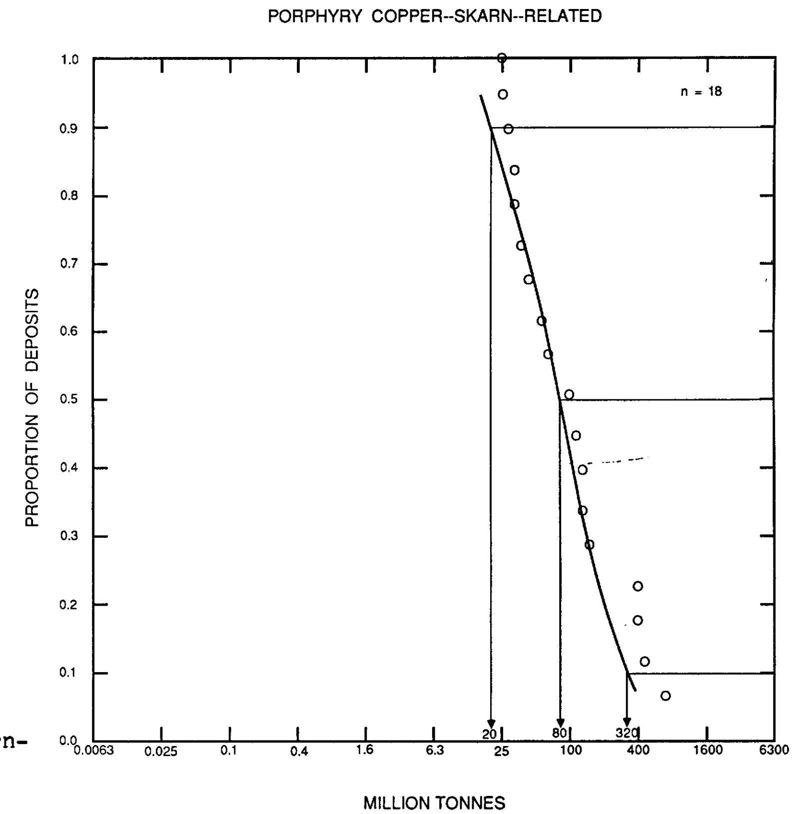


Figure 54. Tonnages of porphyry Cu-skarn-related deposits.

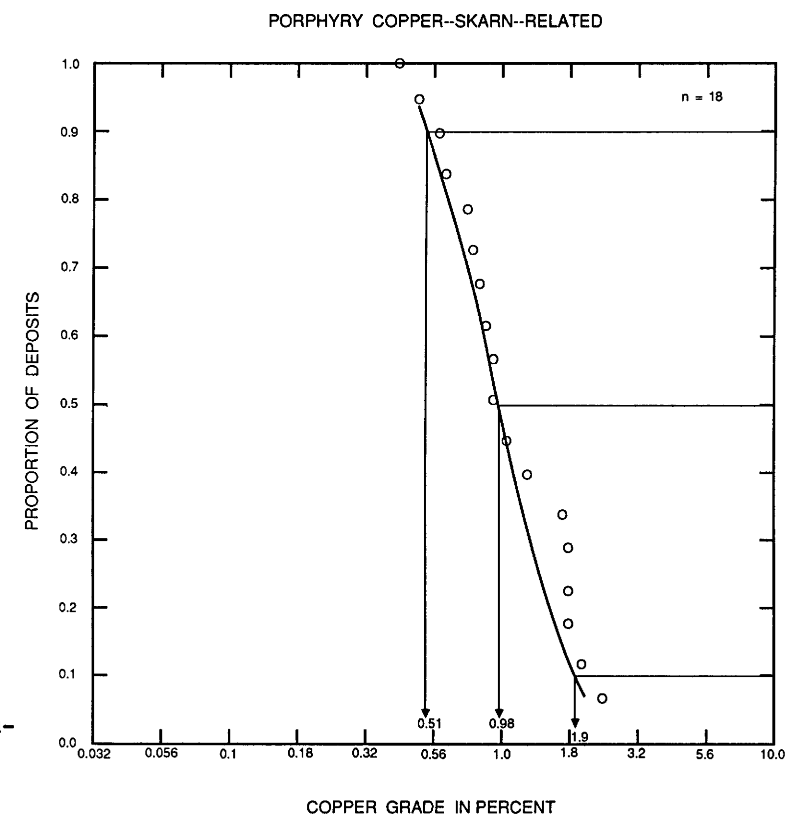


Figure 55. Copper grades of porphyry Cu-skarn-related deposits.

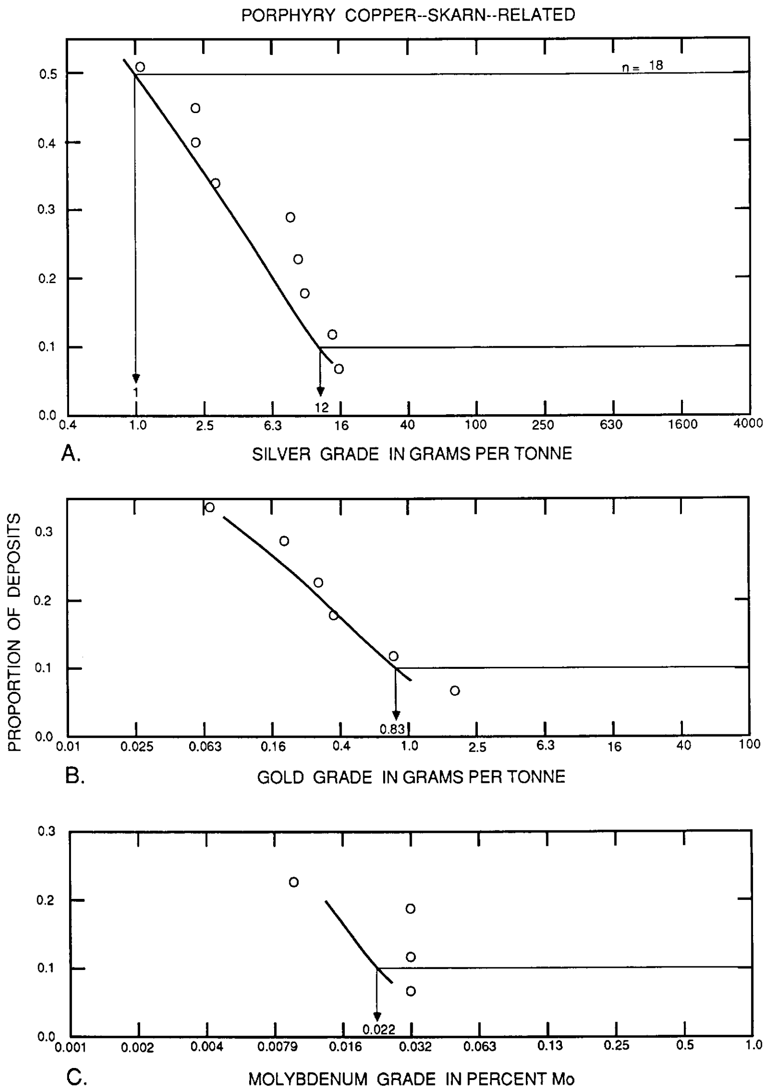


Figure 56. By-product grades of porphyry Cu-skarn-related deposits. A, Silver. B, Gold. C, Molybdenum.

DESCRIPTIVE MODEL OF Cu SKARN DEPOSITS

By Dennis P. Cox and Ted G. Theodore

DESCRIPTION Chalcopyrite in calc-silicate contact metasomatic rocks (see fig. 57).

GENERAL REFERENCES Einaudi and Burt (1982), Einaudi and others (1981).

GEOLOGICAL ENVIRONMENT

Rock Types Tonalite to monzogranite intruding carbonate rocks or calcareous clastic rocks.

Textures Granitic texture, porphyry, granoblastic to hornfelsic in sedimentary rocks.

Age Range Mainly Mesozoic, but may be any age.

Depositional Environment Miogeosynclinal sequences intruded by felsic plutons.

Tectonic Setting(s) Continental margin late orogenic magmatism.

Associated Deposit Types Porphyry Cu, zinc skarn, polymetallic replacement, Fe skarn.

DEPOSIT DESCRIPTION

Mineralogy Chalcopyrite + pyrite ± hematite ± magnetite ± bornite ± pyrrhotite. Also molybdenite, bismuthinite, sphalerite, galena, cosalite, arsenopyrite, enargite, tennantite, loellingite, cobaltite, and tetrahedrite may be present. Au and Ag may be important products.

Texture/Structure Coarse granoblastic with interstitial sulfides. Bladed pyroxenes are common.

Alteration Diopside + andradite center; wollastonite ± tremolite outer zone; marble peripheral zone. Igneous rocks may be altered to epidote + pyroxene + garnet (endoskarn). Retrograde alteration to actinolite, chlorite, and clays may be present.

Ore Controls Irregular or tabular ore bodies in carbonate rocks and calcareous rocks near igneous contacts or in xenoliths in igneous stocks. Breccia pipe, cutting skarn at Victoria, is host for ore. Associated igneous rocks are commonly barren.

Weathering Cu carbonates, silicates, Fe-rich gossan. Calc-silicate minerals in stream pebbles are a good guide to covered deposits.

Geochemical Signature Rock analyses may show Cu-Au-Ag-rich inner zones grading outward to Au-Ag zones with high Au:Ag ratio and outer Pb-Zn-Ag zone. Co-As-Sb-Bi may form anomalies in some skarn deposits. Magnetic anomalies.

EXAMPLES

Mason Valley, USNV	(Harris and Einaudi, 1982)
Victoria, USNV	(Atkinson and others, 1982)
Copper Canyon, USNV	(Blake and others, 1979)
Carr Fork, USUT	(Atkinson and Einaudi, 1978)

GRADE AND TONNAGE MODEL OF Cu SKARN DEPOSITS

By Gail M. Jones and W. David Menzie

COMMENTS Data used in this model were restricted to copper skarns associated with barren stocks as recommended by Einaudi and others (1981). Some of the data are from districts. See figs. 58-60

DEPOSITS

Name	Country	Name	Country
Agordo-Brosso	ITLY	Loei-Chiengkarn	THLD
Arctic Chief	CNYT	Ludwig	USNV
B. C.	CNBC	Mackey	USID
Benson Lake	CNBC	Malko Trnova	BULG
Best Chance	CNYT	Marble Bay	CNBC
Black Cub	CNYT	Mason Valley-Malachite	USNV
Blue Grouse	CNBC	McConnell	USNV
Bluestone	USNV	Meme	HATI
Caledonia	CNBC	Mina El Sapo	CLBA
Cassius	HATI	Mina Vieja	CLBA
Casting	USNV	Mother Lode-Sunset	CNBC
Cerro de Cobre	CLBA	Obira	JAPN
Chalcobamba	PERU	Oregon	CNBC
Coast Copper	CNBC	Oro Denoro (Ema)	CNBC
Cobriza	PERU	Phoenix	CNBC
Concepcion Del Oro	MXCO	Queen Victoria (Swift)	CNBC
Copper Queen	CNBC	Rosita	NCRG
Cornell	CNBC	San Pedro	USNM
Cowley Creek	CNYT	Sasca Montana	RMNA
Douglas Hill	USNV	Sasagatani	JAPN
Gem	CNYT	Snowshoe	USNM
Hiragane	JAPN	Strandzha	BULG
Hope	CNBC	Tasu-Wesfrob	CNBC
Iide	JAPN	Tintaya	PERU
Indian Chief	CNBC	Traversella	ITLY
Kamaishi	JAPN	Tsumo	JAPN
Kedbeg Copper	URRS	Vananda	CNBC
Keewenaw	CNYT	War Eagle	CNYT
Kodiak Cub	CNYT	Western Nevada	USNV
Lily (Ikeno)	CNBC	Wexford	CNBC
Little Chief	CNYT	Yreka	CNBC
Lucky Four	CNBC	Zip	CNBC

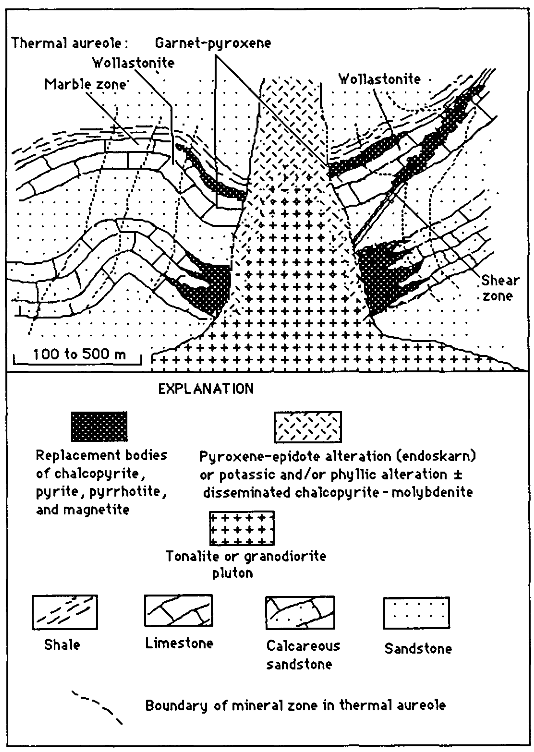


Figure 57. Cartoon cross section of Cu skarn deposit showing relationship between contact metamorphic zones, ore bodies, and igneous intrusion.

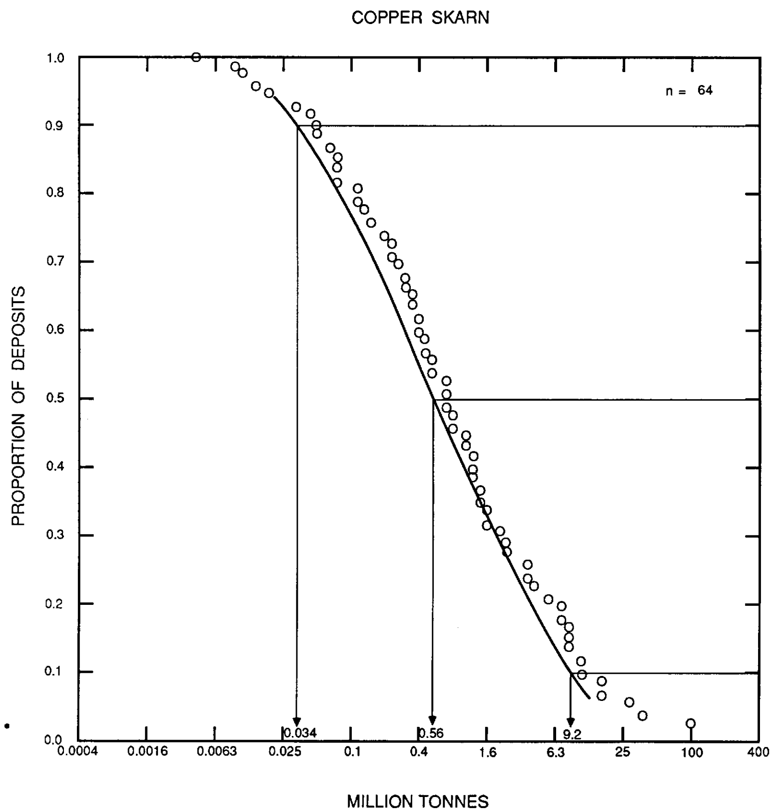


Figure 58. Tonnages of Cu skarn deposits.

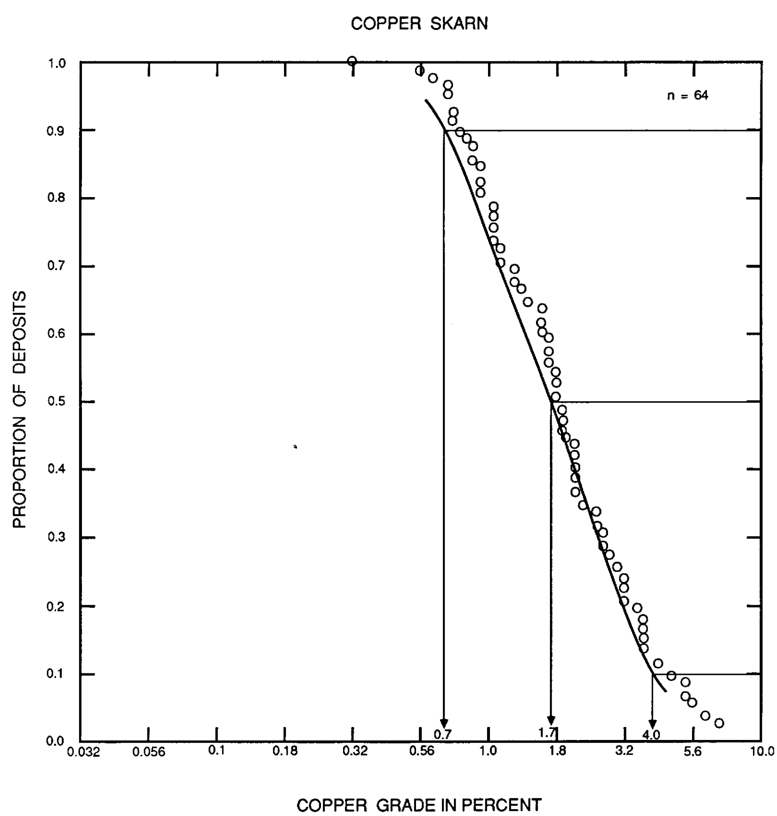


Figure 59. Copper grades of Cu skarn deposits.

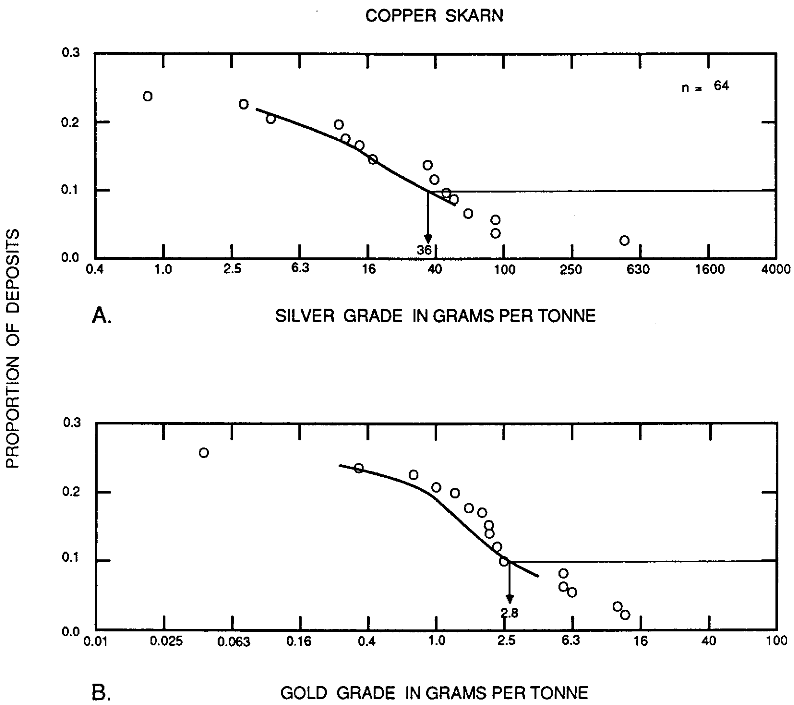


Figure 60. Precious-metal grades of Cu skarn deposits. A, Silver. B, Gold.

DESCRIPTIVE MODEL OF Zn-Pb SKARN DEPOSITS

By Dennis P. Cox

DESCRIPTION Sphalerite and galena in calc-silicate rocks.

GENERAL REFERENCES Einaudi and Burt (1982); Einaudi and others (1981).

GEOLOGICAL ENVIRONMENT

Rock Types Granodiorite to granite, diorite to syenite. Carbonate rocks, calcareous clastic rocks.

Textures Granitic to porphyritic; granoblastic to hornfelsic.

Age Range Mainly Mesozoic, but may be any age.

Depositional Environment Miogeoclinal sequences intruded by generally small bodies of igneous rock.

Tectonic Setting(s) Continental margin, late-orogenic magmatism.

Associated Deposit Types Copper skarn.

DEPOSIT DESCRIPTION

Mineralogy Sphalerite + galena ± pyrrhotite ± pyrite ± magnetite ± chalcopyrite ± bornite ± arsenopyrite ± scheelite ± bismuthinite ± stannite ± fluorite. Gold and silver do not form minerals.

Texture/Structure Granoblastic, sulfides massive to interstitial.

Alteration Mn-hedenbergite ± andradite ± grossular ± spessartine ± bustamite ± rhodonite. Late stage Mn-actinolite ± ilvaite ± chlorite ± dannemorite ± rhodochrosite.

Ore Controls Carbonate rocks especially at shale-limestone contacts. Deposit may be hundreds of meters from intrusive.

Weathering Gossan with strong Mn oxide stains.

Geochemical Signature Zn, Pb, Mn, Cu, Co, Au, Ag, As, W, Sn, F, possibly Be. Magnetic anomalies.

EXAMPLES

Ban Ban, AUQU (Ashley, 1980)
Hanover-Fierro district, USNM (Hernon and Jones, 1968)

GRADE AND TONNAGE MODEL OF Zn-Pb SKARN DEPOSITS

By Dan L. Mosier

COMMENTS Zinc grade is correlated with lead grade (r = 0.66, n = 30) and with copper (r = 0.61, n = 17). See figs. 61-65.

DEPOSITS

Name	Country	Name	Country
Aguilar	AGTN	El Mochito	HNDR
Ammeberg	SWDN	Falun	SWDN
Aravaipa	USAZ	Garpenberg Norra	SWDN
Black Hawk	USNM	Garpenberg Odal	SWDN
Dolores	MXCO	Groundhog	USNM

Kalvbacken	SWDN	Shuikoushan	CINA
Kennecott	USNM	Stollberg	SWDN
Langban	SWDN	Svardsio	SWDN
McDame Belle	CNBC	Tetyukhe	URRS
Meat Cove	CNNS	Tienpaoshan	CINA
Mount Hundere	CNYT	Uchucchacua	PERU
Nyseter	NRWY	Ulchin	SKOR
Parroquio-Magistral	MXCO	Washington Camp	USAZ
Rajabasa	INDS	Yanchiachangtze	CINA
Ryllshyttan	SWDN	Yeonhwa I	SKOR
Sala	SWDN	Yeonhwa II	SKOR
Saxberget	SWDN	Zip	CNBC

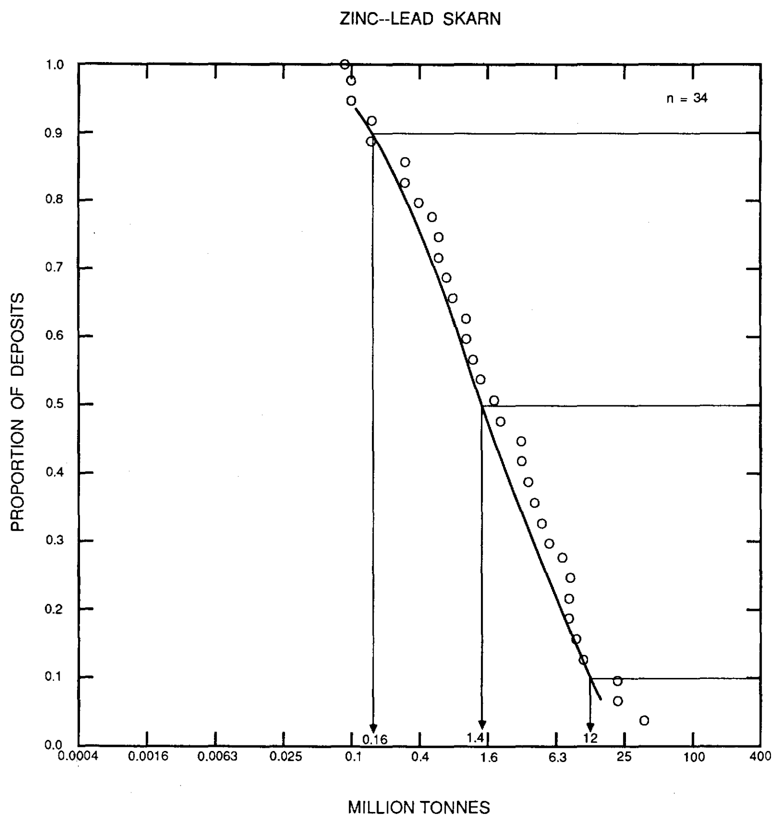


Figure 61. Tonnages of Zn-Pb skarn deposits.

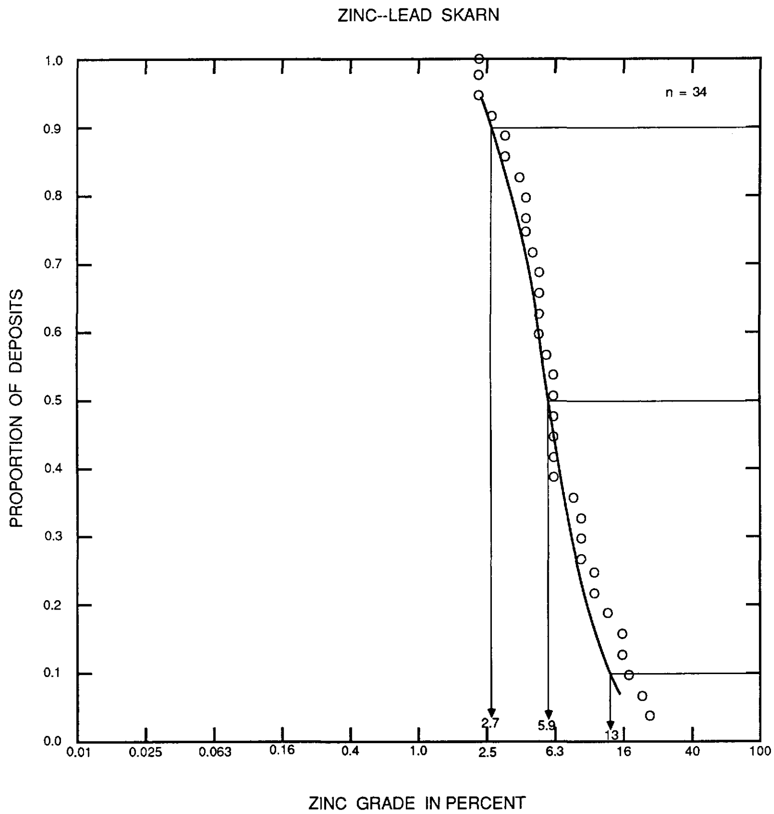


Figure 62. Zinc grades of Zn-Pb skarn deposits.

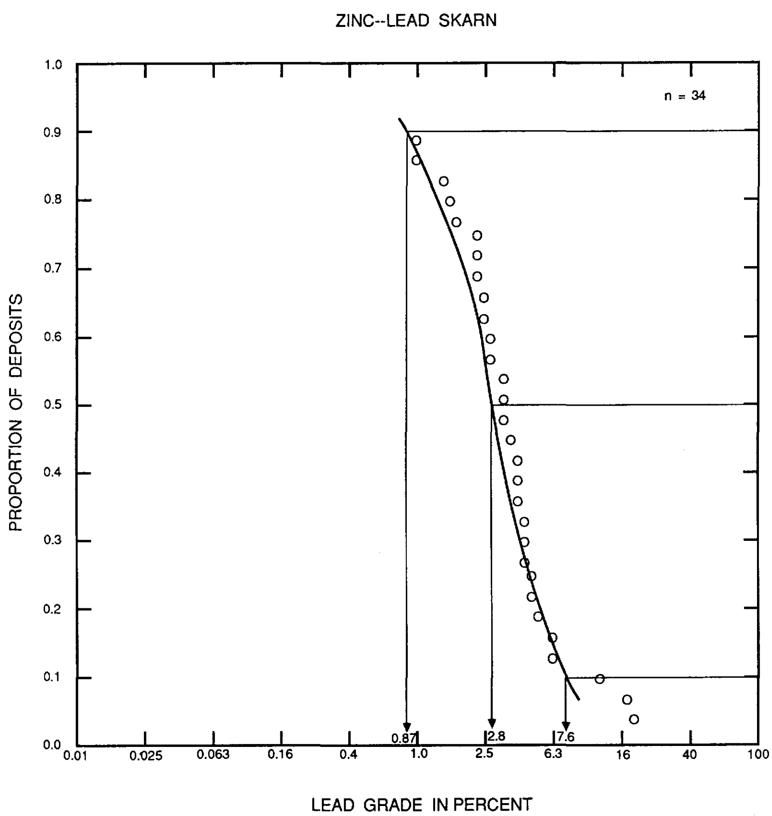


Figure 63. Lead grades of Zn-Pb skarn deposits.

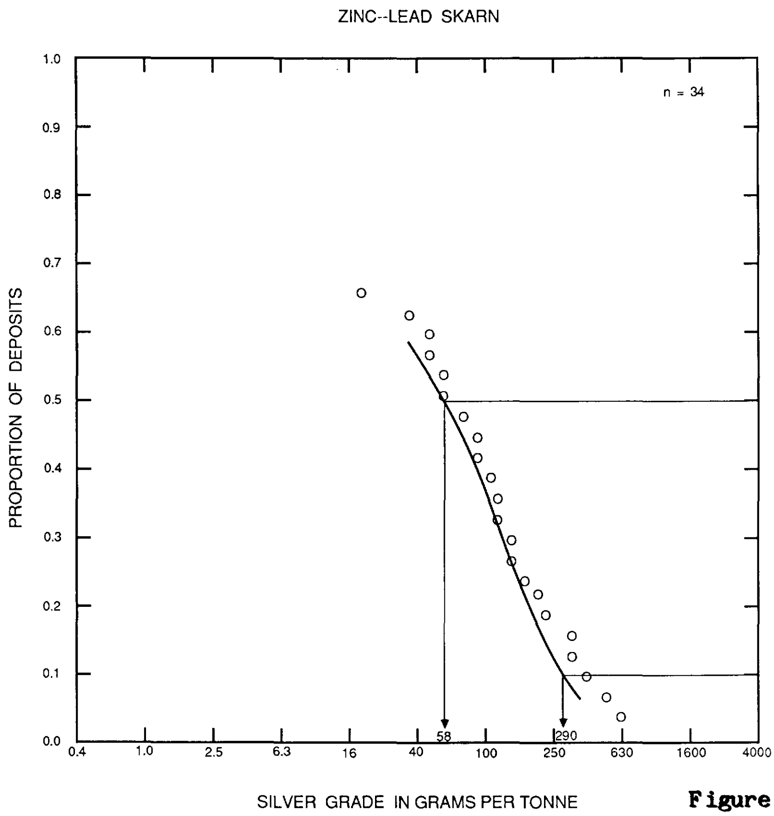


Figure 64. Silver grades of Zn-Pb skarn deposits.

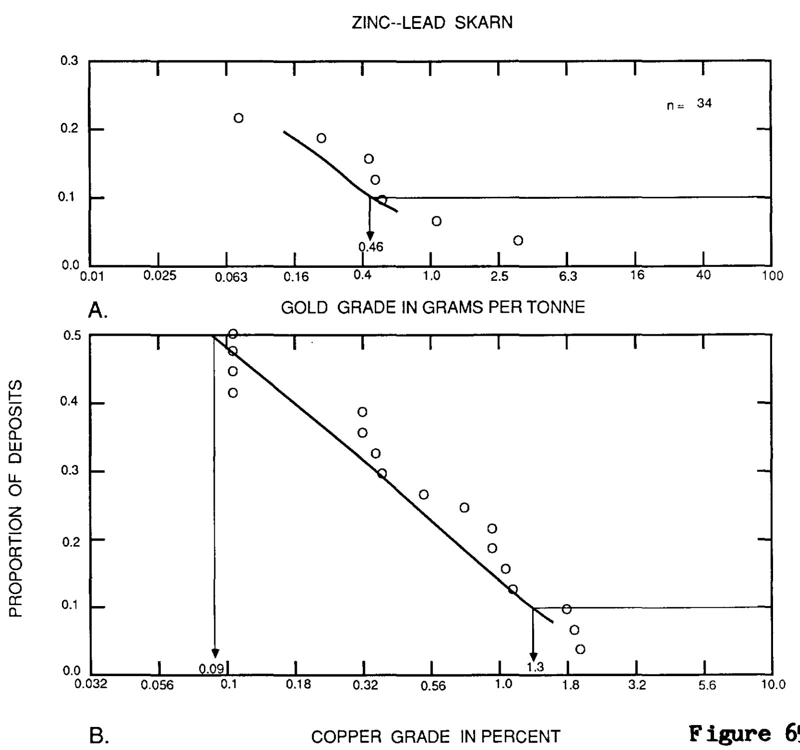


Figure 65. Metal grades of Zn-Pb skarn deposits. A, Gold. B, Copper.

DESCRIPTIVE MODEL OF Fe SKARN DEPOSITS

By Dennis P. Cox

DESCRIPTION Magnetite in calc-silicate contact metasomatic rocks.

GENERAL REFERENCES Einaudi and Burt (1982), Einaudi and others (1981).

GEOLOGICAL ENVIRONMENT

Rock Types Gabbro, diorite, diabase, syenite, tonalite, granodiorite, granite, and coeval volcanic rocks. Limestone and calcareous sedimentary rocks.

Textures Granitic texture in intrusive rocks; granoblastic to hornfelsic textures in sedimentary rocks.

Age Range Mainly Mesozoic and Tertiary, but may be any age.

Depositional Environment Contacts of intrusion and carbonate rocks or calcareous clastic rocks.

Tectonic Setting(s) Miogeosynclinal sequences intruded by felsic to mafic plutons. Oceanic island arc, Andean volcanic arc, and rifted continental margin.

DEPOSIT DESCRIPTION

Mineralogy Magnetite ± chalcopyrite ± Co-pyrite ± pyrite ± pyrrhotite. Rarely cassiterite in Fe skarns in Sn-granite terranes.

Texture/Structure Granoblastic with interstitial ore minerals.

Alteration Diopside-hedenbergite + grossular-andradite + epidote. Late stage amphibole ± chlorite ± ilvaite.

Ore Controls Carbonate rocks, calcareous rocks, igneous contacts and fracture zones near contacts. Fe skarn ores can also form in gabbroic host rocks near felsic plutons.

Weathering Magnetite generally crops out or forms abundant float.

Geochemical and Geophysical Signature Fe, Cu, Co, Au, possibly Sn. Strong magnetic anomaly.

EXAMPLES

Shinyama, JAPN	(Uchida and Iiyama, 1982)
Cornwall, USPA	(Lapham, 1968)
Iron Springs, USUT	(Mackin, 1968)

GRADE AND TONNAGE MODEL OF Fe SKARN DEPOSITS

By Dan L. Mosier and W. David Menzie

COMMENTS Some of the data represent districts. See figs. 66-67.

DEPOSITS

Name	Country	Name	Country
Adaevka central	URRS	Alagada	PORT
Adaevka north	URRS	Aleshinka	URRS
Adaevka south	URRS	Argonaut	CNBC
Agalteca	HNDR	Asvan	TRKY
Ain Mokra	ALGR	Auerbach	URUR
Ain Oudrer	ALGR	Ayazmant	TRKY
Akatani	JAPN	Baghain	IRAN

Baisoara	RMNA
Beck	USCA
Beni Douala	ALGR
Benkala	URRS
Bessemer	CNON
Bizmisen-Akusagi	TRKY
Blairton	CNON
Bolsherechensk	URRS
Bulacan	PLPN
Brynor	CNBC
Calabogie	CNON
Camiglia	ITLY
Capacmarca	PERU
Capitan	USNM
Carmen	CILE
Cave Canyon	USCA
Cehegin	SPAN
Chichibu	JAPN
Childs Mine	CNON
Colquemarca	PERU
Copper Flat	USNM
Cuchillo-Negro	USNM
Daiquiri	CUBA
Dammer Nissar	PKTN
Dannemora	SWDN
Dayton	USNV
Divrigi	TRKY
Dungun	MDGS
Dzama	URRS
Eagle Mountain	USCA
El Pedroso	SPAN
El Sol y La Luna	MXCO
El Volcan-Piedra Iman	MXCO
Eltay	URRS
Estyunin	URRS
Fierro-Hannover	USNM
Gallinas	USNM
Giresun	TRKY
Gora Magnitnaya	URRS
Gora Vysokaya	URRS
Hatillo	DMRP
Hierro Indio	AGTN
Huacravilca	PERU
Hualpai	CNBC
Huancabamba	PERU
Hull	CNQU
Imanccasa	PERU
Ino	JAPN
Iron Duke	CNBC
Iron Hat	USCA
Iron Mike	CNBC
Iron Mountain (Colfax Co.)	USNM
Iron Mountain (Sierra Co.)	USNM
Iron Springs	USUT
Jedway	CNBC
Jerez de los Caballeros	SPAN
Jib	CNBC
Jicarilla	USNM
Jones Camp	USNM
Juncos	CNBC
Kachar	URRS
Kalkan	TRKY
Kambaikhin central	URRS
Kambaikhin east	URRS
Kambaikhin north	URRS
Karamadazi	TRKY
Kaunisvaara-Masugnsbyn	SWDN
Kesikkopru	TRKY
Kozyrevka	URRS
Kroumovo	URRS
Kruglogorsk	URRS
Kurzhunkul	URRS
La Carmen	MXCO
La Laguna	DMRP
La Paloma	MXCO
La Piedra Iman	MXCO
Las Animas Cerro Prieto	MXCO
Las Truchas	MXCO
Larap-Calambayungan	PLPN
Lava Bed	USCA
Lebyazhka	URRS
Livitaca-Velille	PERU
Lomonosov	URRS
Maanshan	HONG
Mac	CNBC
Marbella	SPAN
Marmoraton	CNON
Martinovo	BULG
Maslovo	URRS
Mati	PLPN
Mogpog	PLPN
Monte Carmelo	NCRG
Munesada	JAPN
Nimpkish	CNBC
Novo Maslovo	URRS
Novo Peschansk	URRS
Ocna de Fier	RMNA
Old Dad Mountains	USCA
Orogrande	USNM
Osokino-Aleksandrovsk	URRS
Pambuhan Sur	PLPN
Pampachiri	PERU
Paracale	PLPN
Pena Colorada	MXCO
Perda Niedda	ITLY
Persberg	SWDN
Peschansk	URRS
Picila	MXCO
Piddig	PLPN
Plagia	GREC
Pokrovsk	URRS
Rankin	CNON
Recibimiento	MXCO
Rondoni	PERU
Rose	CNBC
Rudna Glava	YUGO
Sabana Grande	DMRP
Samli	TRKY
San Carlos	MXCO
San Juan de Chacna	PERU
San Leone	ITLY
Sankyo	JAPN
Santa Lucia	PERU
Santa Rita	USNM
Sarbay	URRS
Senor de Huarquisa	PERU

Model 18d--Con.

Severnoe I	URRS	Tepustete	MXCO
Severnoe II	URRS	Texada	CNBC
Severnoe III	URRS	Tovarnica	YUGO
Shagyrkul	URRS	Tsaitsukou	CINA
Shasta-California	USCA	Val Di Peio	ITLY
Shinyama	JAPN	Valuev	URRS
Silver Lakes	USCA	Vorontsovka	URRS
Sorka	URRS	Vulcan	USCA
Sosva	URRS	Vyhne	CZCL
South Sarbay	URRS	Wagasennin	JAPN
Takanokura	JAPN	Yellow Jacket	USNM
Tapairihua	PERU	Zanitza	MXCO
Techa	URRS	Zarikan	IRAN
Tecolote	USNM	Zeballos	CNBC

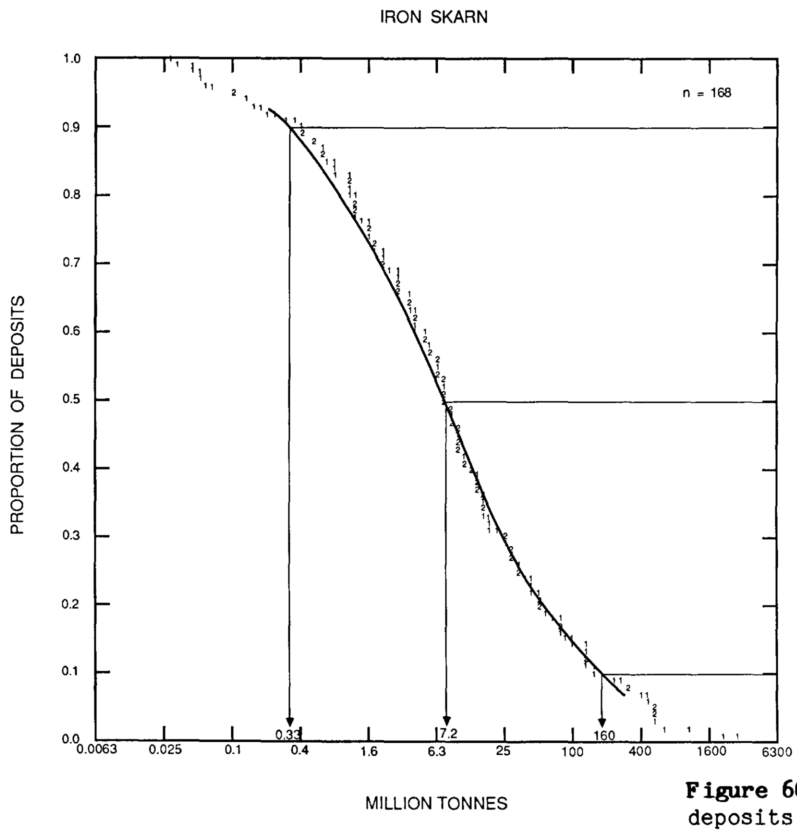


Figure 66. Tonnages of Fe skarn deposits. Individual digits represent number of deposits.

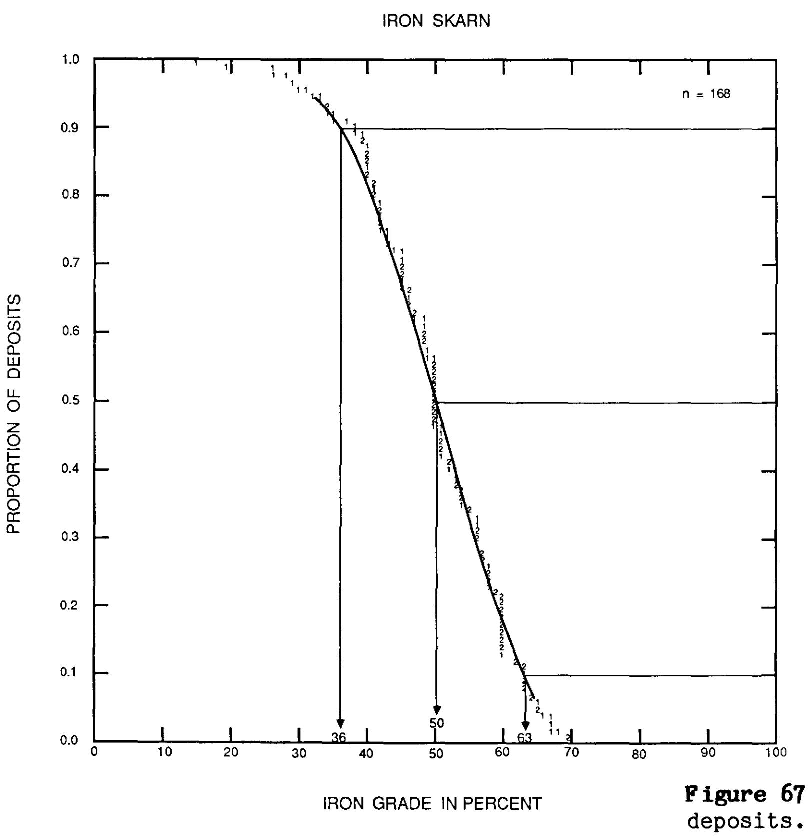


Figure 67. Iron grades of Fe skarn deposits. Individual digits represent number of deposits.

DESCRIPTIVE MODEL OF CARBONATE-HOSTED ASBESTOS

By Chester T. Wrucke and Andrew F. Shride

APPROXIMATE SYNONYM Arizona type (Shride, 1973).

DESCRIPTION Long-staple chrysotile asbestos in veins developed in tabular layers of serpentine that replaced silicated limestone adjacent to diabase sheets, sills, and dikes.

GENERAL REFERENCE Shride (1969).

GEOLOGIC ENVIRONMENT

Rock Types Serpentine, diabase, silicated limestone, cherty dolomite.

Textures Original bedding details of cherty dolomite preserved in fine-grained metamorphic limestone that includes nodular silicate masses partly to wholly replaced by serpentine.

Age Range Middle Proterozoic in Arizona, but may be of any age.

Depositional Environment Contact metamorphic aureole associated with injection of diabase magma into cherty dolomite.

Tectonic Setting Probably rifted or partly rifted continental terrane, as suggested by regionally voluminous alkalic olivine tholeiite diabase in nearshore marine and terrestrial strata.

Associated Deposit Types Contact-metamorphic magnetite. Talc deposits exist widely in similar physical settings.

DEPOSIT DESCRIPTION

Mineralogy Chrysotile asbestos, dense serpentine, magnetite, and calcite.

Texture/Structure Sharp-walled gash fracture and ribbon veins of cross-fiber chrysotile and calcite with occasional veins of dense chrysotile in massive serpentine. Veins mostly less than 0.3 cm wide but commonly 2-8 and rarely up to 25 cm.

Alteration Tremolite, diopside, and talc formed during prograde metamorphism were largely replaced by massive serpentine during retrograde metamorphism. Vein minerals were emplaced during late hydrothermal stage.

Ore Controls Favorable stratigraphic zones proximate (within 10 m) to diabase. Open folds formed on emplacement of the diabase were favorable sites for small-scale bedding and thrust faults which were repeatedly opened during metamorphism and mineralization.

EXAMPLES

Gila County, USAZ, Cuddappah district, INDA
southwestern USMT, Barberton-Caroline District, SAFR
Hopeh Province, CINA, near Kanye, BOTS (Sinclair, 1955)

DESCRIPTIVE MODEL OF POLYMETALLIC REPLACEMENT DEPOSITS

By Hal T. Morris

APPROXIMATE SYNONYM Manto deposits, many authors.

DESCRIPTION Hydrothermal, epigenetic, Ag, Pb, Zn, Cu minerals in massive lenses, pipes and veins in limestone, dolomite, or other soluble rock near igneous intrusions (see fig. 68).

GENERAL REFERENCE Jensen and Bateman (1981), p. 134-146.

GEOLOGICAL ENVIRONMENT

Rock Types Sedimentary rocks, chiefly limestone, dolomite, and shale, commonly overlain by volcanic rocks and intruded by porphyritic, calc-alkaline plutons.

Textures The textures of the replaced sedimentary rocks are not important; associated plutons typically are porphyritic.

Age Range Not important, but many are late Mesozoic to early Cenozoic.

Depositional Environment Carbonate host rocks that commonly occur in broad sedimentary basins, such as epicratonic miogeosynclines. Replacement by solutions emanating from volcanic centers and epizonal plutons. Calderas may be favorable.

Tectonic Setting(s) Most deposits occur in mobile belts that have undergone moderate deformation and have been intruded by small plutons.

Associated Deposit Types Base metal skarns, and porphyry copper deposits.

DEPOSIT DESCRIPTION

Mineralogy Zonal sequence outward: enargite + sphalerite + argentite + tetrahedrite + digenite ± chalcopyrite, rare bismuthinite; galena + sphalerite + argentite ± tetrahedrite ± proustite ± pyrargyrite, rare jamesonite, jordanite, bournonite, stephanite, and polybasite; outermost sphalerite + rhodochrosite (see fig. 68). Widespread quartz, pyrite, marcasite, barite. Locally, rare gold, sylvanite, and calaverite.

Texture/Structure Ranges from massive to highly vuggy and porous.

Alteration Limestone wallrocks are dolomitized and silicified (to form jasperoid); shale and igneous rocks are chloritized and commonly are argillized; where syngenetic iron oxide minerals are present, rocks are pyritized. Jasperoid near ore is coarser grained and contains traces of barite and pyrite.

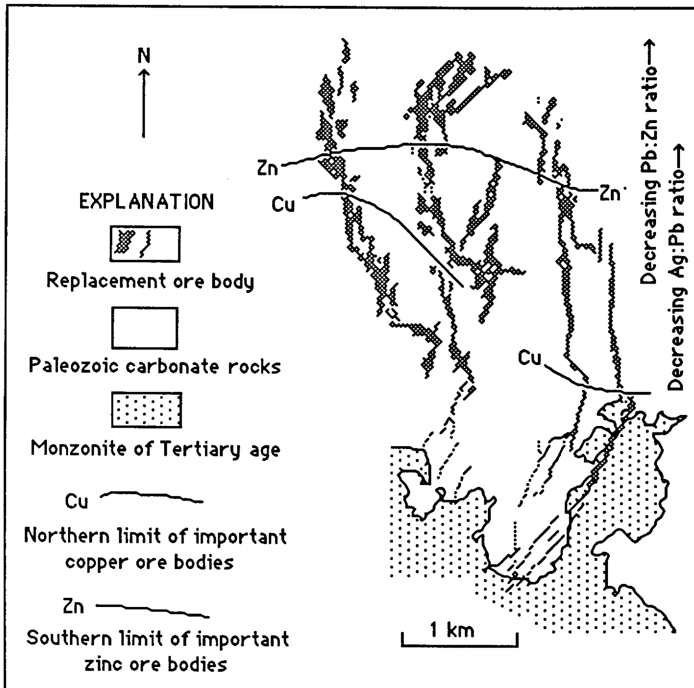
Ore Controls Tabular, podlike and pipelike ore bodies are localized by faults or vertical beds; ribbonlike or blanketlike ore bodies are localized by bedding-plane faults, by susceptible beds, or by preexisting solution channels, caverns, or cave rubble.

Weathering Commonly oxidized to ochreous masses containing cerrusite, anglesite, hemimorphite, and cerargyrite.

Geochemical Signature On a district-wide basis ore deposits commonly are zoned outward from a copper-rich central area through a wide lead-silver zone, to a zinc- and manganese-rich fringe. Locally Au, As, Sb, and Bi. Jasperoid related to ore can often be recognized by high Ba and trace Ag content.

Examples

East Tintic district, USUT	(Morris and Lovering, 1979)
Eureka district, USNV	(Nolan, 1962)
Manto deposit, MXCO	(Prescott, 1926)



Metals	Dominant mineralogy Ore	Gangue
Zn-Mn	Sphalerite + rhodochrosite	Fine-grained pyritic jasperoid
Pb-Ag	Galena + sphalerite + argentite + Ag sulfosalts ± tetrahedrite	Fine-grained jasperoid with barite crystals and quartz-lined vugs
Cu-Au	Enargite-famatinite + tennantite-tetrahedrite + sphalerite + argentite + digenite	Medium-grained jasperoid and coarse crystals of quartz and barite

Figure 68. Generalized map showing metal and mineral zoning in polymetallic replacement deposits in the Main Tintic district, Utah. Modified from Morris (1968).

GRADE AND TONNAGE MODEL OF POLYMETALLIC REPLACEMENT DEPOSITS

By Dan L. Mosier, Hal T. Morris, and Donald A. Singer

COMMENTS Carbonate-hosted replacement and transitional vein and other replacement deposits are included. Only districts with combined production and reserves of at least 100,000 tonnes are used. Tonnages for many districts, particularly in the U.S. are biased because only production data were available. The break in slope in the zinc grade plot at about 1 percent may be related to early difficulties of processing zinc oxides, and the consequent underreporting of zinc grades where estimates were based on production. Lead grade is correlated with silver ($r = 0.55$, $n = 45$). See figs. 69-74.

DEPOSITS

Name	Country	Name	Country
American Fork	USUT	Nakatatsu	JAPN
Atacocha	PERU	Mitate	JAPN
Bell	USNV	Naica	MXCO
Big Cottonwood-L.C.	USUT	New Calumet	CNQU
Blue Bell	CNBC	Olympias Chalkidiki	GREC
Bolkardag	TRKY	Ophir	USUT
Bristol (Jack Rabbit)	USNV	Park City	USUT
Cerro Gordo	USCA	Plomosas	MXCO
Chalchihuites	MXCO	Rush Valley	USUT
Charcas	MXCO	San Francisco	USUT
Cortez	USNV	Santa Eulalia	MXCO
Darwin	USCA	Santander	PERU
Drina	YUGO	Saua-Toranica	YUGO
East Tintic	USUT	Silva-Aysen	CILE
El Porvenir (Milpo)	PERU	Sombrerete	MXCO
Eureka	USNV	Spruce Mountain	USNV
Hunnan	CINA	Star	USUT
La Encantada	MXCO	Sumadisa	YUGO
La Reforma	MXCO	Tecopa	USCA
Lampazos	MXCO	Tintic	USUT
Laurium	GREC	Tombstone	USAZ
Liaoning	CINA	Trepca-Kopaonik	YUGO
Lone Mountain	USNV	Velardepa	MXCO
Magdalena	USNM	White Pine	USNV
Maria Christina	CILE	Yellow Pine	USNV
Mazapil	MXCO	Zimapan	MXCO

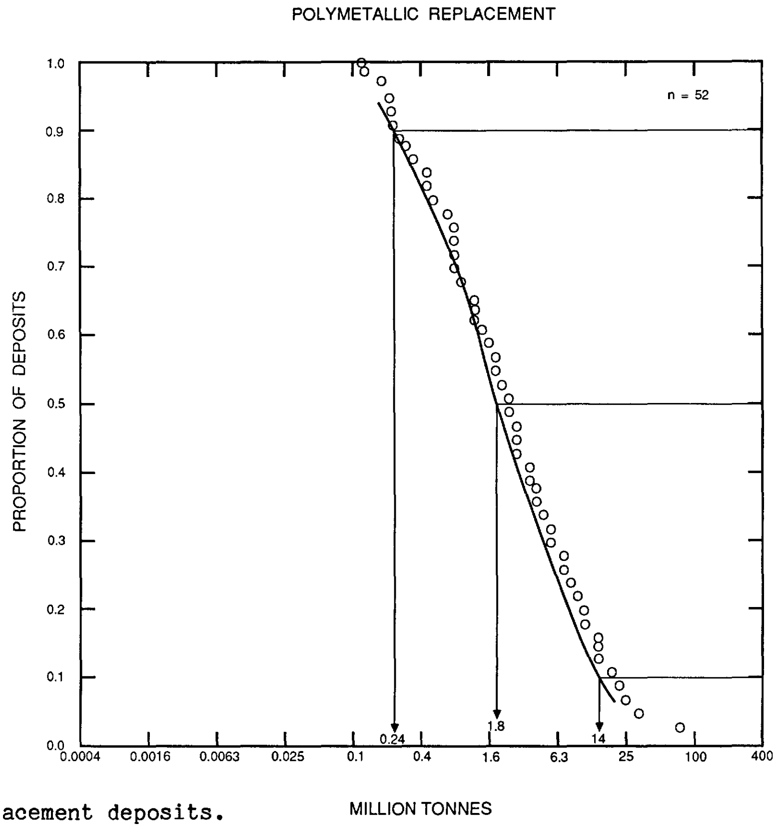


Figure 69. Tonnages of polymetallic replacement deposits.

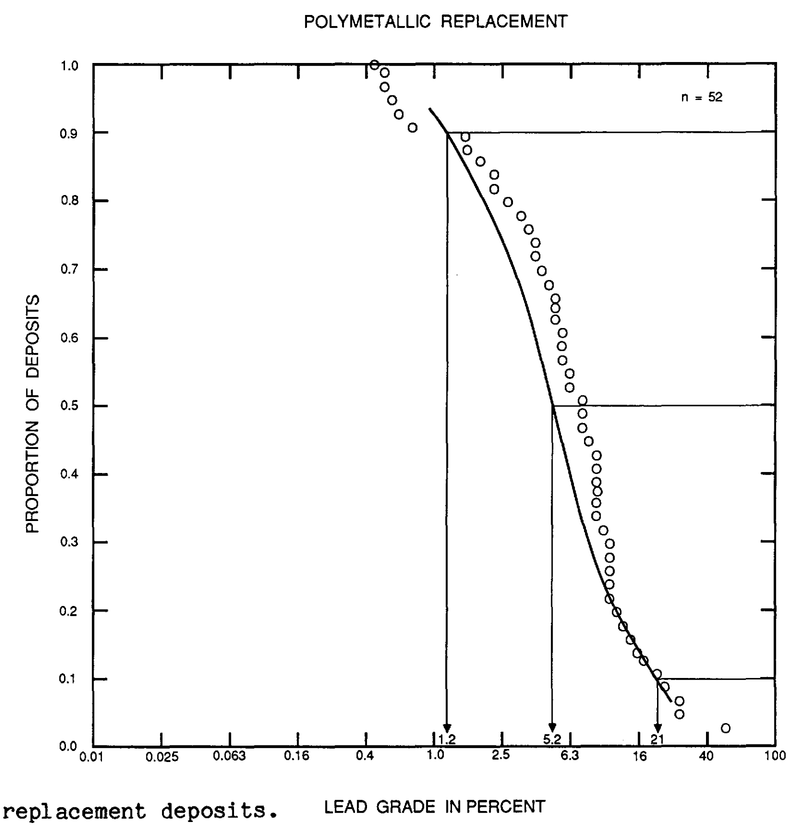


Figure 70. Lead grades of polymetallic replacement deposits.

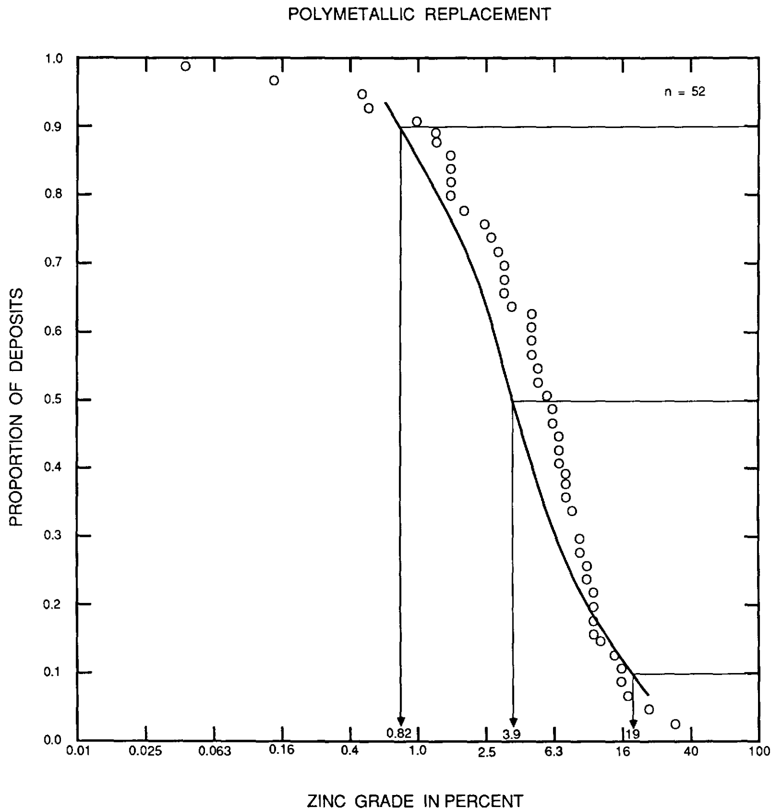


Figure 71. Zinc grades of polymetallic replacement deposits.

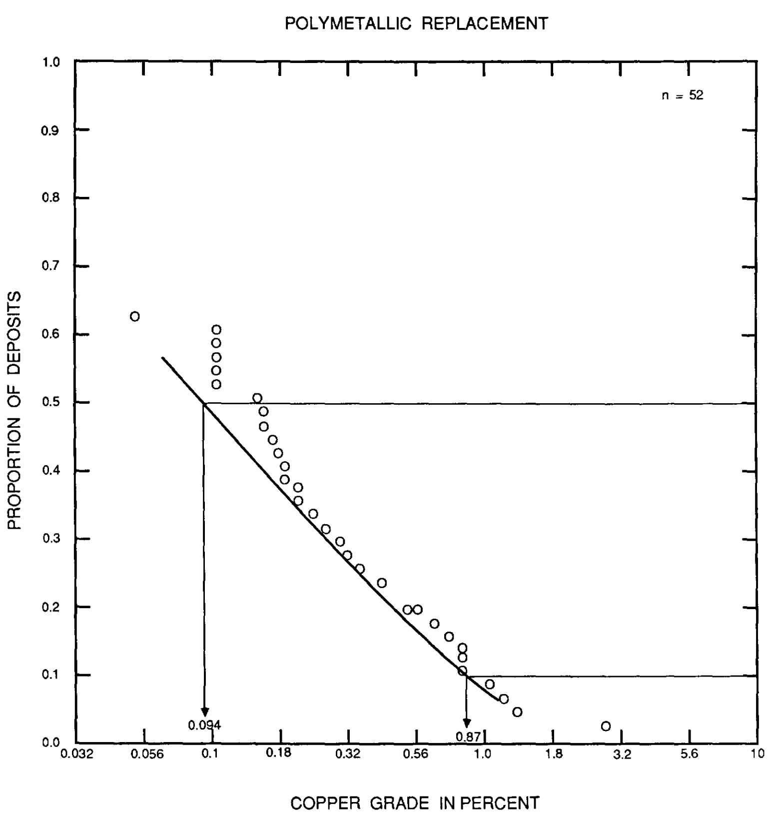


Figure 72. Copper grades of polymetallic replacement deposits.

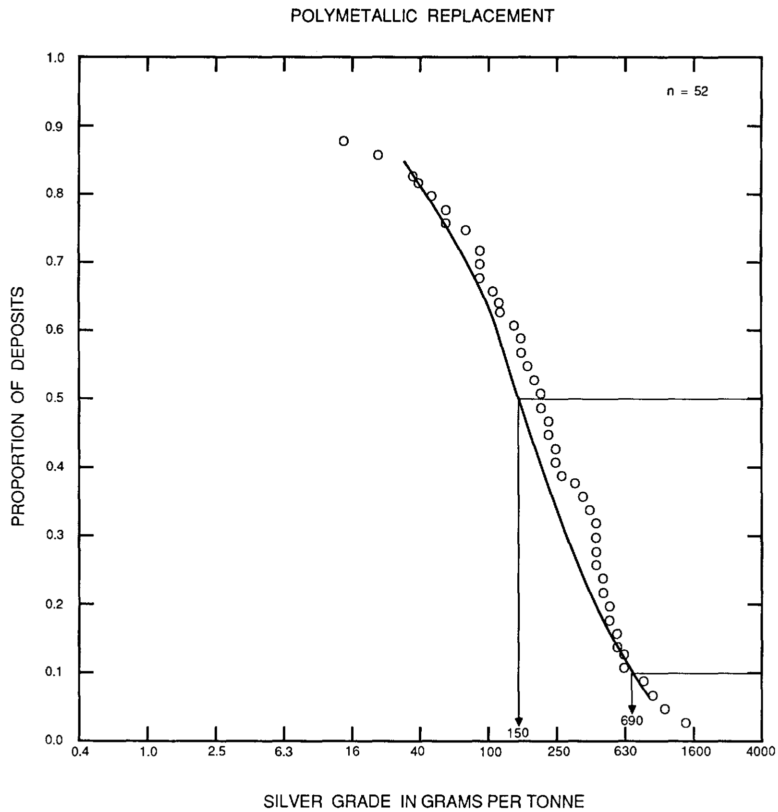


Figure 73. Silver grades of polymetallic replacement deposits.

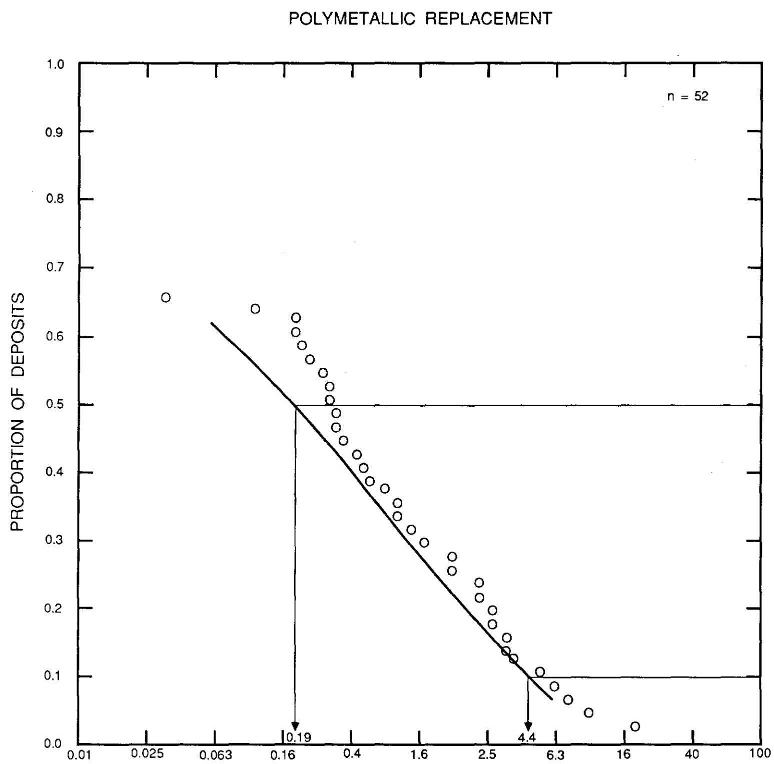


Figure 74. Gold grades of polymetallic replacement deposits.

DESCRIPTIVE MODEL OF REPLACEMENT Mn

By Dan L. Mosier

DESCRIPTION Manganese oxide minerals occur in epigenetic veins or cavity fillings in limestone, dolomite, or marble, which may be associated with intrusive complexes.

GEOLOGICAL ENVIRONMENT

Rock Types Limestone, dolomite, marble, and associated sedimentary rocks; granite and granodiorite plutons.

Age Range Mainly Paleozoic to Tertiary, but may be any age.

Depositional Environment Miogeosynclinal sequences intruded by small plutons.

Tectonic Setting(s) Orogenic belts, late orogenic magmatism.

Associated Deposit Types Polymetallic vein, polymetallic replacement, skarn Cu, skarn Zn, porphyry copper.

DEPOSIT DESCRIPTION

Mineralogy Rhodochrosite ± rhodonite + calcite + quartz ± barite ± fluorite ± jasper ± manganocalcite ± pyrite ± chalcopyrite ± galena ± sphalerite.

Texture/Structure Tabular veins, irregular open space fillings, lenticular pods, pipes, chimneys.

Ore Controls Fracture permeability in carbonate rocks. May be near intrusive contact.

Weathering Mn oxide minerals: psilomelane, pyrolusite, and wad form in the weathered zone and make up the richest parts of most deposits. Limonite and kaolinite.

Geochemical Signature Mn, Fe, P, Cu, Ag, Au, Pb, Zn.

EXAMPLES

Lake Valley, USNM	(Farnham, 1961)
Philipsburg, USMT	(Prinz, 1963)
Lammereck, ASTR	(Lechner and Plochinger, 1956)

GRADE AND TONNAGE MODEL OF REPLACEMENT Mn

By Dan L. Mosier

COMMENTS Copper grades are only available for some of the low tonnage deposits. See figs. 75-76.

DEPOSITS

Name	Country	Name	Country
Atlas	USAZ	Golden Gate	USAZ
Bear Mountain	USNM	Hendricks-Twilight	USAZ
Birchfield	USNM	Kahal de Brezina	ALGR
Blinman	AUSA	Kingston	USNM
Brachy	FRNC	Lake Valley	USNM
Chloride Flat	USNM	Lammereck	ASTR
Crown King	USAZ	Las Ambollas	FRNC
Cynthia	GREC	Las Cabesses	FRNC
Danville-Hanchette	USAZ	Lone Mountain	USNM
Detroit	USUT	Los Volcanes	MXCO
Dinamita	MXCO	Mammoth	USAZ
Djebel El Aziza	TUNS	Mercedes	CUBA
Essex and Steptoe	USNV	Philipsburg	USMT

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Poludnig-Hermagor	ASTR	Thuburnic	TUNS
Oregon	USAZ	Ulukoy	TRKY
Saligny	FRNC	Veitsch	ASTR
San Carlos	MXCO	Vorderen Strubberges	ASTR
Sattelberges	ASTR	Waterloo	USAZ
Summit-No. 4	USAZ		

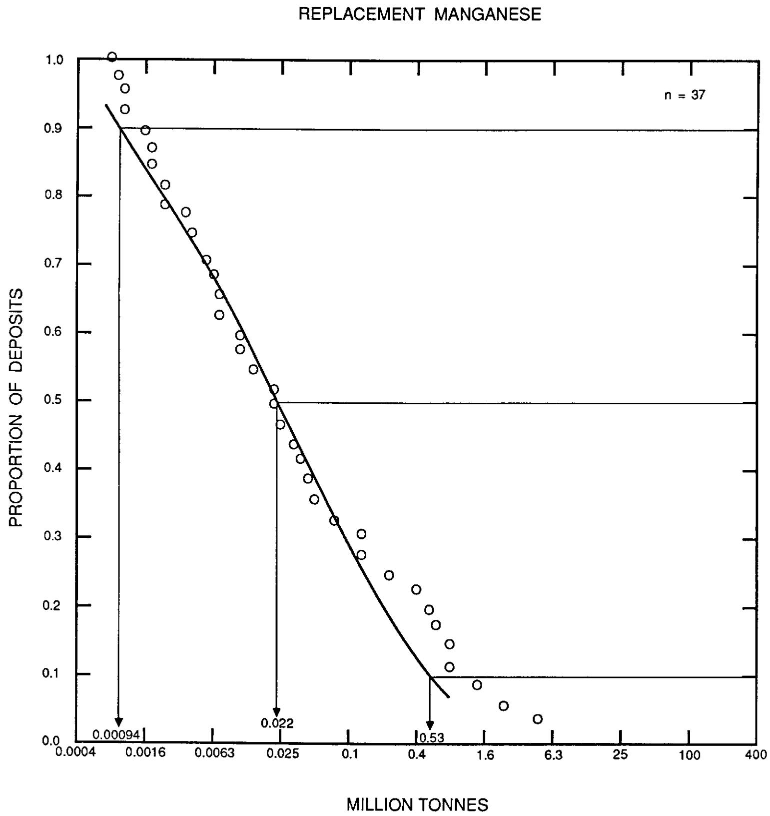

Figure 75. Tonnages of replacement Mn deposits.

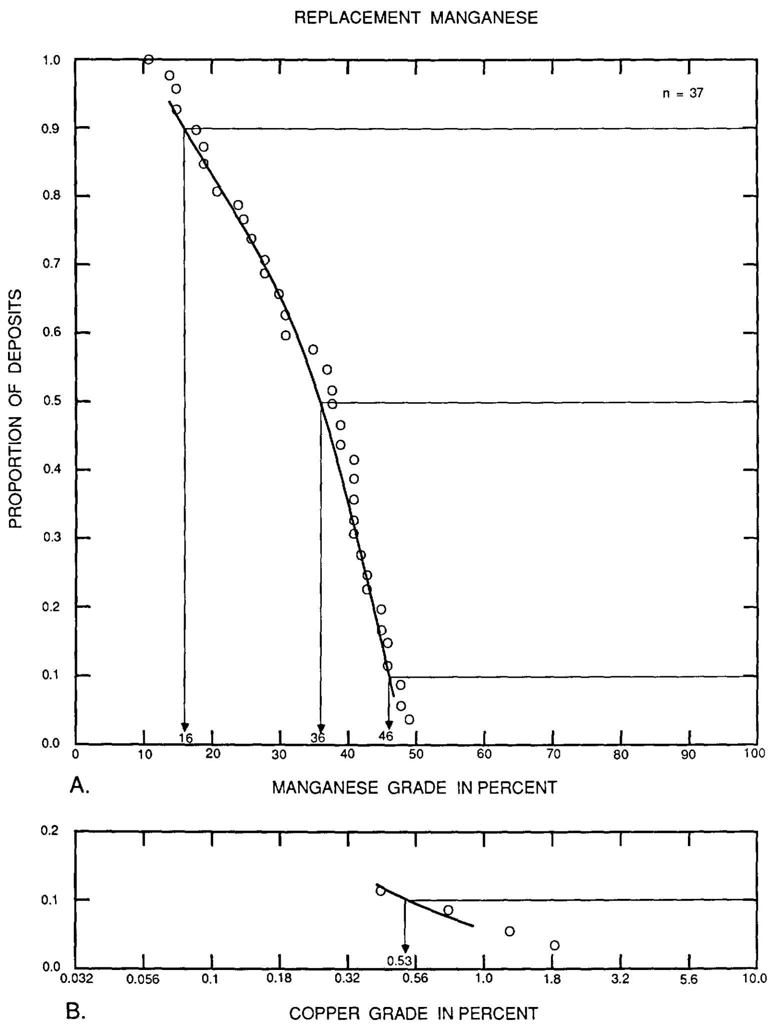

Figure 76. Manganese and copper grades of replacement Mn deposits.

DESCRIPTIVE MODEL OF PORPHYRY Sn

By Bruce L. Reed

APPROXIMATE SYNONYM Subvolcanic tin (Grant and others, 1977).

DESCRIPTION Subvolcanic intrusive complexes containing disseminated, veinlet- and breccia-controlled fine-grained cassiterite in quartz porphyry and adjacent rocks.

GENERAL REFERENCE Grant and others (1980).

GEOLOGICAL ENVIRONMENT

Rock Types Intermediate to acid quartz porphyry stocks (quartz-latite, dacite, rhyodacite) and cogenetic calc-alkaline pyroclastics and lavas (quartz-latite to rhyodacite).

Textures Intrusions most closely associated with mineralization are strongly altered and brecciated quartz porphyry.

Age Range May be any age. Classic Bolivian porphyry tin deposits are Miocene. Subvolcanic W-Mo-Sn deposits at Mount Pleasant, New Brunswick, are late Carboniferous.

Depositional Environment Subvolcanic stocks emplaced 1 to 3 km beneath or within vents of terrestrial strato-volcanoes.

Tectonic Setting(s) Paleozoic foldbelt cut by subduction-generated high-level stocks and cogenetic volcanic rocks.

Associated Deposit Types Sn veins and Sn polymetallic veins.

DEPOSIT DESCRIPTION

Mineralogy Cassiterite and quartz accompanied by sulfide minerals (chiefly pyrite) but including pyrrhotite, stannite, chalcopyrite, sphalerite, and arsenopyrite; late veins commonly carry complex sulfostannates and Ag minerals.

Texture/Structure Disseminations, veinlets, and fractures in igneous breccia and adjacent wallrock; stocks commonly funnel-shaped and 1-2 km^2.

Alteration Pervasive alteration and porphyry tin mineralization predates tin-silver veins; concentric zoning grades from a central quartz-tourmaline core (minor disseminated cassiterite), outward to sericite-tourmaline, sericite (closely related to disseminated cassiterite), and propylitic alteration; argillic alteration present in upper parts of some systems.

Ore Controls Porphyry mineralization is breccia controlled and centered on stocks emplaced in the inner, deeper regions of volcanoes; close relation between disseminated cassiterite and sericitic alteration; late fracture- controlled quartz-cassiterite and quartz-cassiterite-sulfide veins occur within or near the margins of intrusive centers.

Weathering Surface iron staining variable (pyrite); supergene enrichment unlikely; cassiterite may be concentrated in nearby placer deposits.

Geochemical Signature: Sn + B center; Sn, Ag, Pb, Zn, As, Sb, Cu, Ba in outer zone.

EXAMPLES

Chorolque, BLVA	(Grant and others, 1980)
Catavi (Salvadora stock, Llallagua), BLVA	(Sillitoe and others, 1975)

DESCRIPTIVE MODEL OF Sn-POLYMETALLIC VEINS

by Yukio Togashi (Geological Survey of Japan)

APPROXIMATE SYNONYMS Polymetallic xenothermal (Imai and others, 1978), Bolivian subvolcanic multistage.

DESCRIPTION Multistage Cu-Zn-Sn-Ag-bearing veins associated with felsic ignimbrites and subvolcanic intrusions.

GENERAL REFERENCES Nakamura and Hunahashi (1970), Grant and others (1977).

GEOLOGICAL ENVIRONMENT

Rock Types Rhyolitic tuff, welded tuff and tuff breccia. Rhyolitic to basaltic dikes. Sandstone, slate, chert, and basic tuff.

Textures Welded and airfall tuff. Porphyritic-aphanitic intrusives.

Age Range Late Cretaceous to Miocene in Japan, Miocene in Bolivia, but may be any age.

Depositional Environment Fissures in and around felsic ignimbrite.

Tectonic Setting(s) Continental margin. Syn-late orogenic.

Associated Deposit Types Polymetallic replacement, epithermal Ag veins, porphyry Sn.

DEPOSIT DESCRIPTION

Mineralogy Cassiterite, chalcopyrite, sphalerite, pyrrhotite, pyrite, galena, scheelite, wolframite, arsenopyrite, native bismuth, bismuthinite, argentite, native gold, magnetite, molybdenite, and complex sulfosalt minerals including teallite, frankeite, cylindrite, and stannite.

Texture/Structure Multistage composite veins with Sn, Cu, Zn, and Ag minerals occurring in the same vein.

Alteration Minor quartz-chlorite-sericite alteration close to veins. Tourmaline, fluorite, or siderite may be present.

Ore Controls Veins, breccia veins, and breccia pipes. Metal zoning sequence is Sn + W to Cu + Sn, Cu + Zn, Pb + Zn, Pb + Ag, Au + Ag from center to periphery, or from depths to shallow levels. Zones are commonly superimposed or "telescoped" to produce complex veins.

Weathering Limonitization. Cassiterite in soils and gossans.

Geochemical Signature Cu, Zn, Sn, Pb, W, Au, Ag, Bi, As.

EXAMPLES

Ashio, Akenobe, Ikuno, Kishu, JAPN	(Nakamura, 1970)
Potosi, BLVA	(Turneaure, 1971)

DESCRIPTIVE MODEL OF PORPHYRY Cu-Au

By Dennis P. Cox

DESCRIPTION Stockwork veinlets of chalcopyrite, bornite, and magnetite in porphyritic intrusions and coeval volcanic rocks. Ratio of Au (ppm) to Mo (percent) is greater than 30 (see fig. 77).

GENERAL REFERENCES Sillitoe (1979), Cox and Singer (in press).

GEOLOGICAL ENVIRONMENT

Rock Types Tonalite to monzogranite; dacite, andesite flows and tuffs coeval with intrusive rocks. Also syenite, monzonite, and coeval high-K, low-Ti volcanic rocks (shoshonites).

Textures Intrusive rocks are porphyritic with fine- to medium-grained aplitic groundmass.

Age Range Cretaceous to Quaternary.

Depositional Environment In porphyry intruding coeval volcanic rocks. Both involved and in large-scale breccia. Porphyry bodies may be dikes. Evidence for volcanic center; 1-2 km depth of emplacement.

Tectonic Setting(s) Island-arc volcanic setting, especially waning stage of volcanic cycle. Also continental margin rift-related volcanism.

Associated Deposit Types Porphyry Cu-Mo; gold placers.

DEPOSIT DESCRIPTION

Mineralogy Chalcopyrite ± bornite; traces of native gold, electrum, sylvanite, and hessite. Quartz + K-feldspar + biotite + magnetite ± chlorite ± actinolite ± anhydrite. Pyrite + sericite ± clay minerals ± calcite may occur in late-stage veinlets.

Texture/Structure Veinlets and disseminations.

Alteration Quartz ± magnetite ± biotite (chlorite) ± K-feldspar ± actinolite, ± anhydrite in interior of system. Outer propylitic zone. Late quartz + pyrite + white mica ± clay may overprint early feldspar-stable alteration.

Ore Controls Veinlets and fractures of quartz, sulfides, K-feldspar magnetite, biotite, or chlorite are closely spaced. Ore zone has a bell shape centered on the volcanic-intrusive center. Highest grade ore is commonly at the level at which the stock divides into branches.

Weathering Surface iron staining may be weak or absent if pyrite content is low in protore. Copper silicates and carbonates. Residual soils contain anomalous amounts of rutile.

Geochemical Signature Central Cu, Au, Ag; peripheral Mo. Peripheral Pb, Zn, Mn anomalies may be present if late sericite pyrite alteration is strong. Au (ppm):Mo (percent) 30 in ore zone. Au enriched in residual soil over ore body. System may have magnetic high over intrusion surrounded by magnetic low over pyrite halo.

EXAMPLES

Dos Pobres, USAZ	(Langton and Williams, 1982)
Copper Mountain, CNBC	(Fahrni and others, 1976)
Tanama, PTRC	(Cox, 1985)

GRADE AND TONNAGE MODEL OF PORPHYRY Cu-Au

By Donald A. Singer and Dennis P. Cox

COMMENTS See figs. 78-81.

DEPOSITS

Name	Country	Name	Country
Afton	CNBC	Mamut	MDGS
Amacan	PLPN	Mapula	PLPN
Atlas Lutopan	PLPN	Marcopper	PLPN
Basay	PLPN	Marian	PLPN
Bell Copper	CNBC	Mountain Mines	PLPN
Boneng Lobo	PLPN	Ok Tedi	PPNG
Cariboo Bell	CNBC	Panguana	PPNG
Copper Mountain	CNBC	Red Chris	CNBC
Cubuagan	PLPN	Rio Vivi	PTRC
Dizon	PLPN	Saindak South	PKTN
Dos Pobres	USAZ	San Antonio	PLPN
Fish Lake	CNBC	San Fabian	PLPN
Frieda River	PPNG	Santo Nino	PLPN
Galore Creek	CNBC	Santo Tomas	PLPN
Hinobaan	PLPN	Star Mt.-Fubilan	PPNG
Ingerbelle	CNBC	Star Mt.-Futik	PPNG
Kennon	PLPN	Tanama	PTRC
La Alumbrera	AGTN	Tawi-Tawi	PLPN
Lorraine	CNBC	Taysan	PLPN
Lumbay	PLPN	Toledo	PLPN

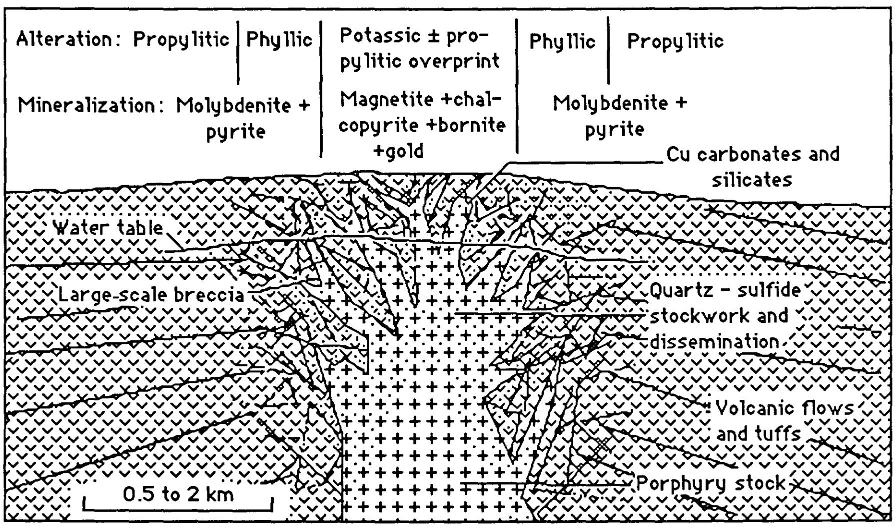

Figure 77. Cartoon cross section of porphyry Cu-Au deposit. Modified from Langton and Williams (1982).

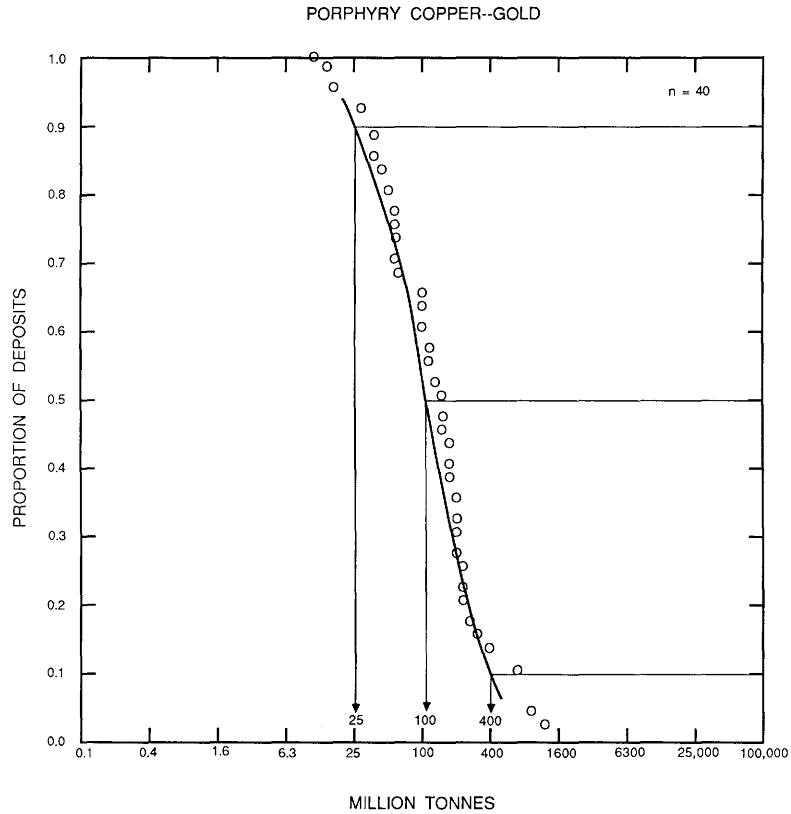

Figure 78. Tonnages of porphyry Cu-Au deposits.

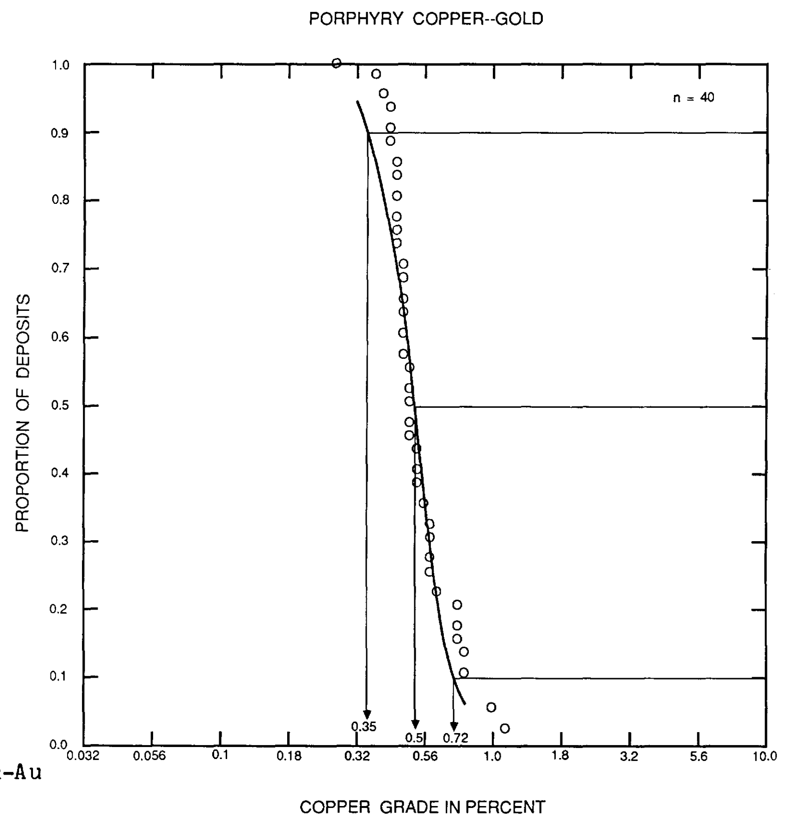

Figure 79. Copper grades of porphyry Cu-Au deposits.

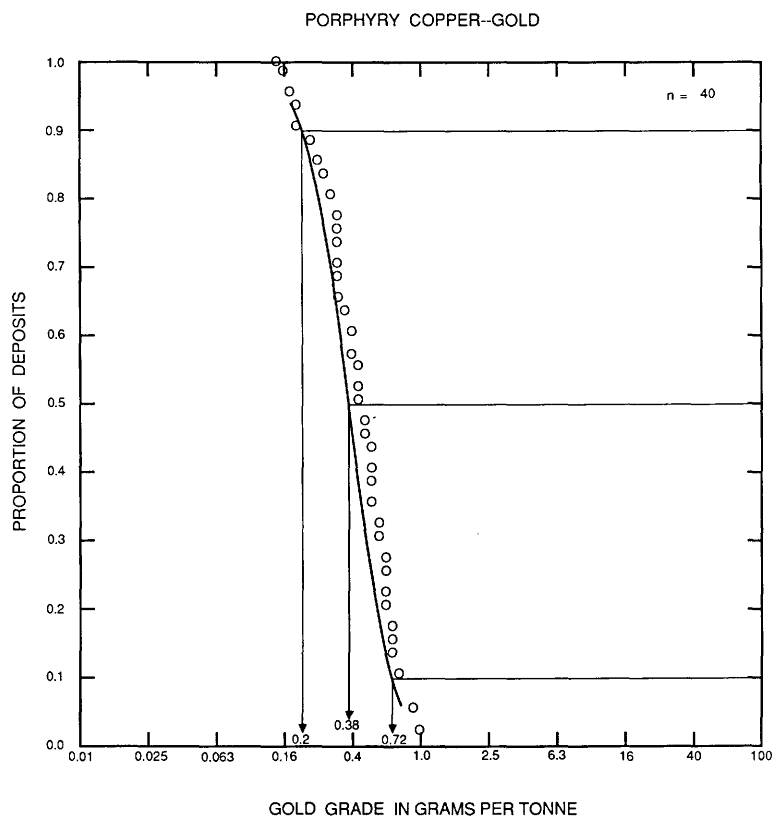

Figure 80. Gold grades of porphyry Cu-Au deposits.

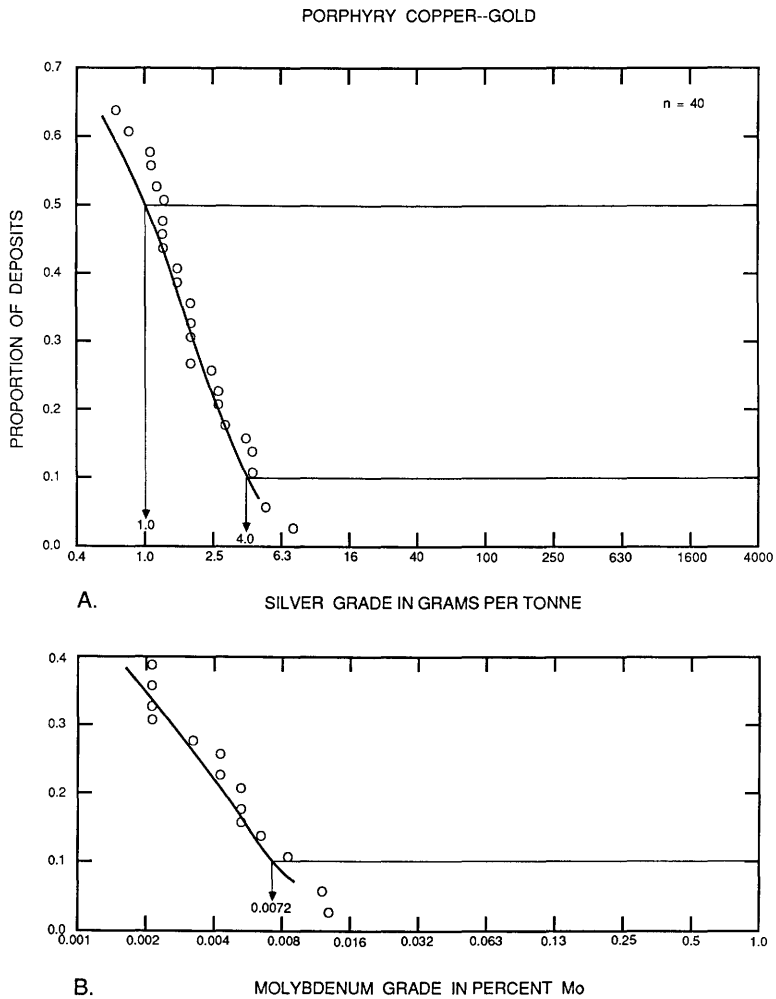

Figure 81. By-product grades of porphyry Cu-Au deposits. A, Silver. B, Molybdenum.

DESCRIPTIVE MODEL OF PORPHYRY Cu-Mo

By Dennis P. Cox

DESCRIPTION Stockwork veinlets of quartz, chalcopyrite, and molybdenite in or near a porphyritic intrusion. Ratio of Au (in ppm) to Mo (in percent) less than 3 (See fig. 82).

GENERAL REFERENCE Titley (1982).

GEOLOGICAL ENVIRONMENT

Rock Types Tonalite to monzogranite stocks and breccia pipes intrusive into batholithic, volcanic, or sedimentary rocks.

Textures Intrusions contemporaneous with ore commonly are porphyries with fine- to medium-grained aplitic groundmass. Porphyry texture may be restricted to small dikes in some deposits (Brenda).

Age Range Mainly Mesozoic to Tertiary, but can be any age.

Depositional Environment High-level intrusive porphyry contemporaneous with abundant dikes, faults, and breccia pipes. Cupolas of batholiths.

Tectonic Setting(s) Numerous faults in subduction-related volcanic plutonic arcs. Mainly along continental margins but also in oceanic convergent plate boundaries.

Associated Deposit Types Cu, Zn, or Fe skarns may be rich in gold, gold + base-metal sulfosalts in veins, gold placers. Volcanic-hosted massive replacement and polymetallic replacement.

DEPOSIT DESCRIPTION

Mineralogy Chalcopyrite + pyrite + molybdenite. Peripheral vein or replacement deposits with chalcopyrite + sphalerite + galena ± gold. Outermost zone may have veins of Cu-Ag-Sb-sulfides, barite, and gold.

Texture/Structure Veinlets and disseminations or massive replacement of favorable country rocks.

Alteration Quartz + K-feldspar + biotite (chlorite) ± anhydrite (potassic alteration) grading outward to propylitic. Late white mica + clay (phyllic) alteration may form capping or outer zone or may affect the entire deposit. High-alumina alteration assemblages may be present in upper levels of the system (see table 3).

Ore Controls Ore grade is, in general, positively correlated with spacing of veinlets and mineralized fractures. Country rocks favorable for mineralization are calcareous sediments; diabase, tonalite, or diorite.

Weathering Intense leaching of surface; wide areas of iron oxide stain. Fractures coated with hematitic limonite. Supergene copper as chalcocite may form blanket below leached zone. Residual soils may contain anomalous amounts of rutile.

Geochemical Signature Cu + Mo + Ag ± W ± B ± Sr center; Pb, Zn, Au, As, Sb, Se, Te, Mn, Co, Ba, and Rb in outer zone. Locally Bi and Sn form distal anomalies. High S in all zones. Ratio of Au (ppm): Mo (percent)$\leq$3. Magnetic low.

EXAMPLES

Brenda, CNBC	(Soregaroli and Whitford, 1976)
Sierrita Esperanza, USAZ	(West and Aiken, 1982)

GRADE AND TONNAGE MODEL OF PORPHYRY Cu-Mo

By Donald A. Singer, Dennis P. Cox, and Dan L. Mosier

COMMENTS These deposits are a subset of porphyry Cu-Mo deposits for which a Cu, Mo and Au grade were available. See figs. 83-87.

DEPOSITS

Name	Country	Name	Country
Berg	CNBC	Inspiration	USNM
Bethlehem	CNBC	Lornex	CNBC
Brenda	CNBC	Morenci	USAZ
Gambier Island	CNBC	Ray	USAZ
Gaspe	CNQU	Sierrita-Esperanza	USAZ
Gibraltar	CNBC	Tyrone	USNM
Highmont	CNBC	Twin Buttes	USAZ
Huckleberry	CNBC	Valley Copper	CNBC

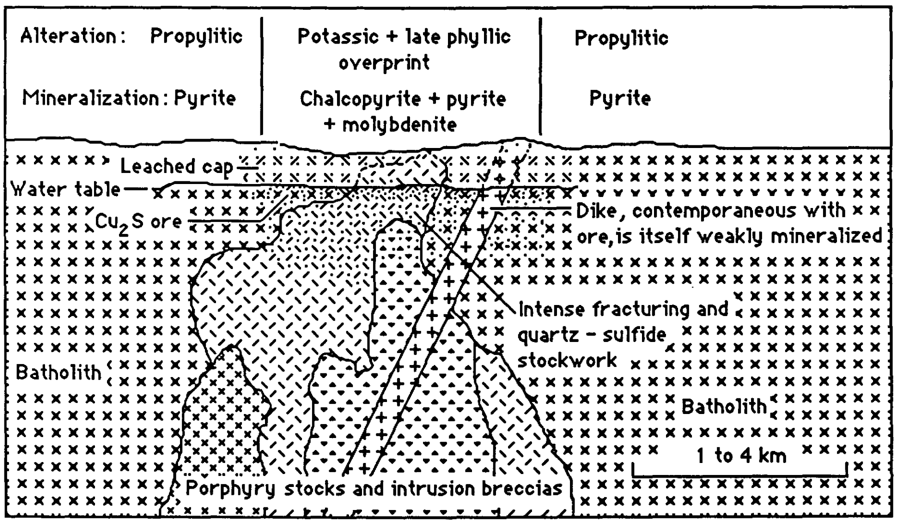

Figure 82. Cartoon cross section of porphyry Cu-Mo deposit showing relationship between mineral- and alteration-zoning and igneous intrusion.

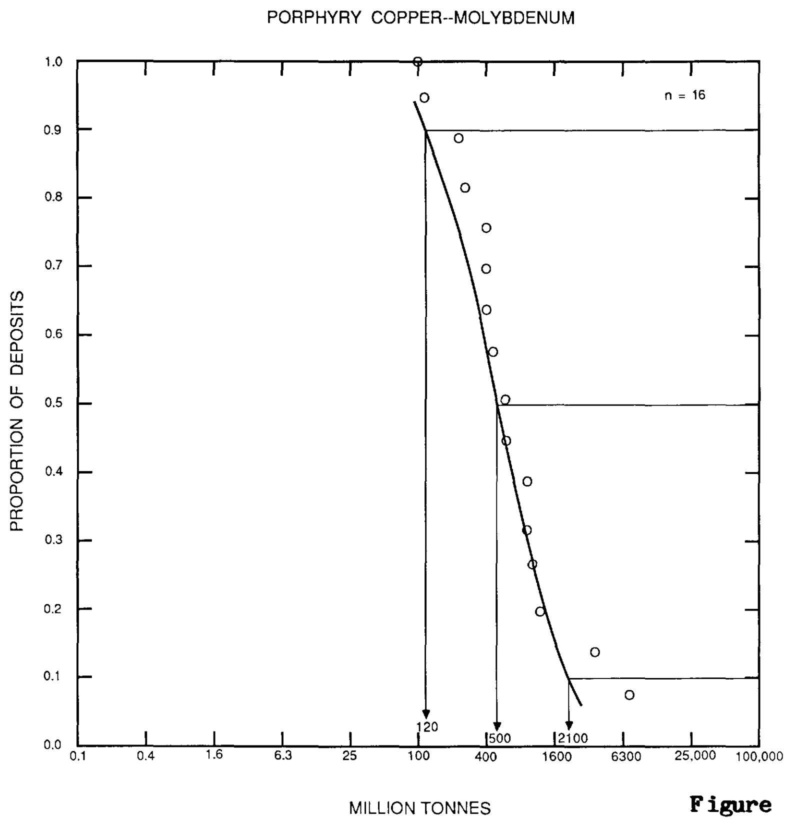

Figure 83. Tonnages of porphyry Cu-Mo deposits.

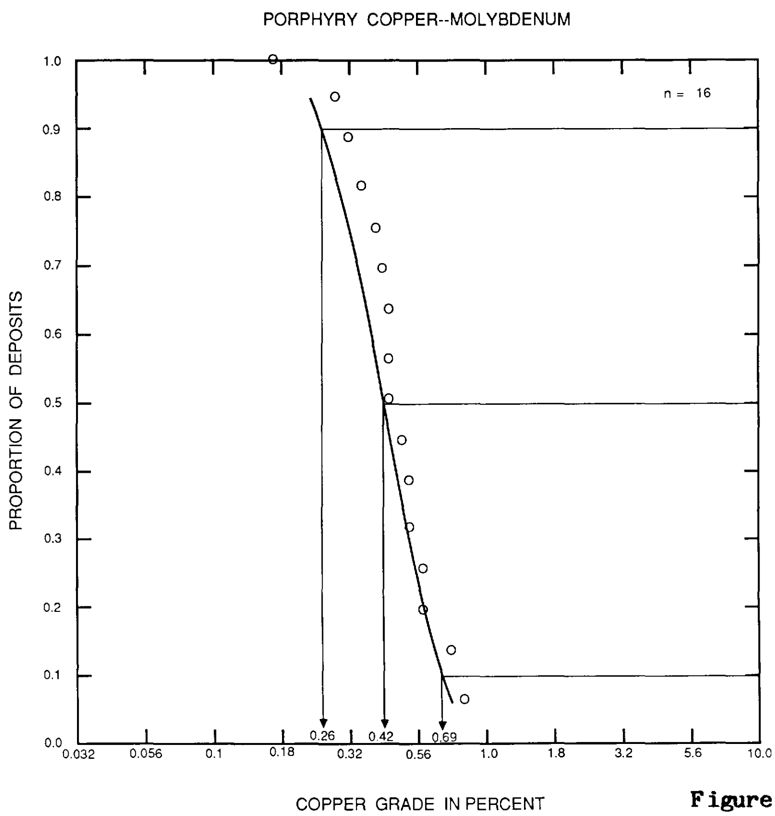

Figure 84. Copper grades of porphyry Cu-Mo deposits.

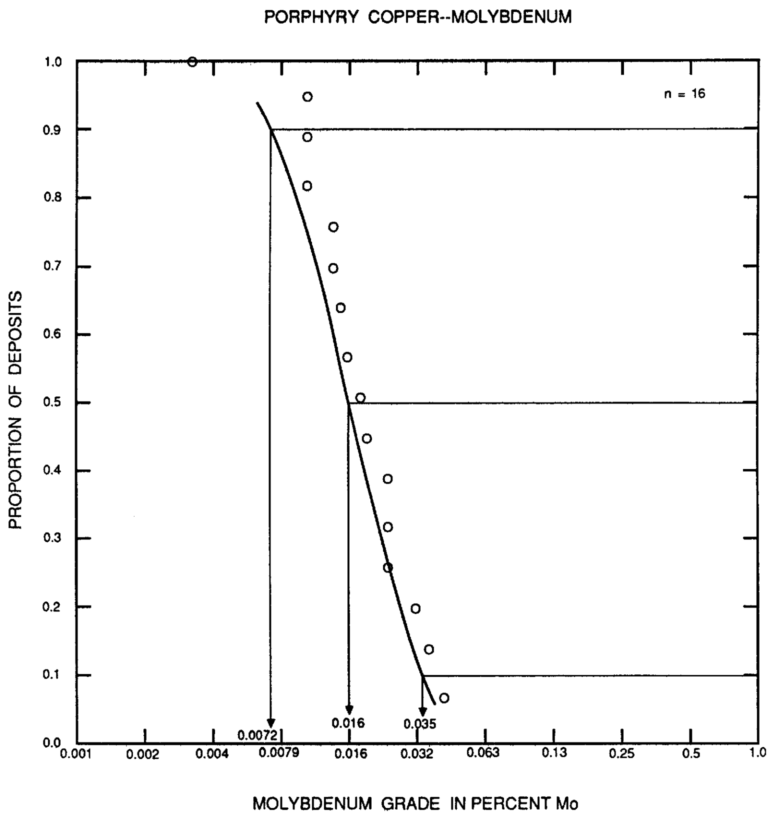

Figure 85. Molybdenum grades of porphyry Cu-Mo deposits.

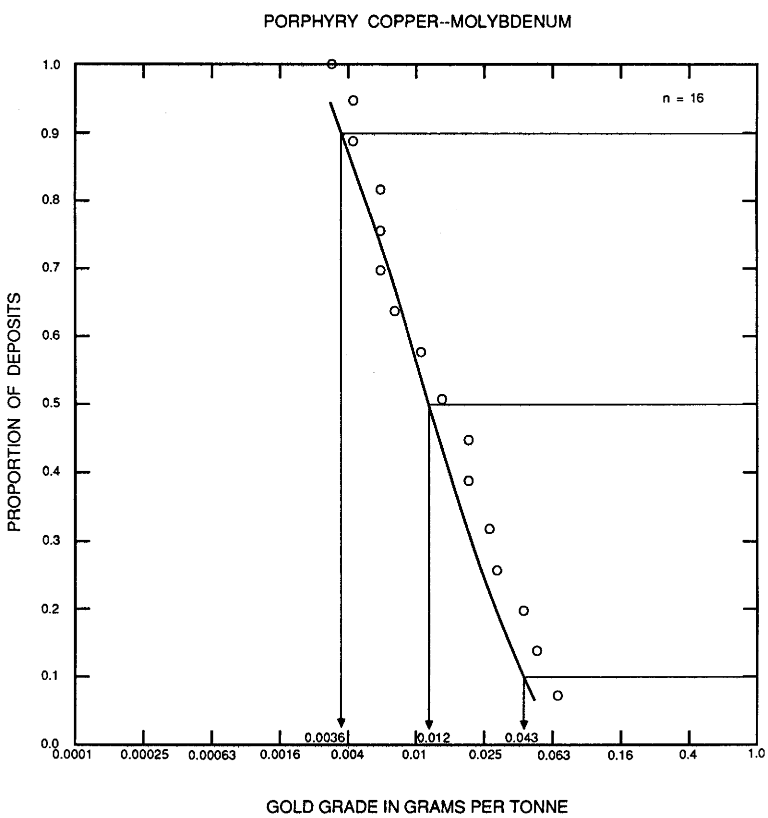

Figure 86. Gold grades of porphyry Cu-Mo deposits.

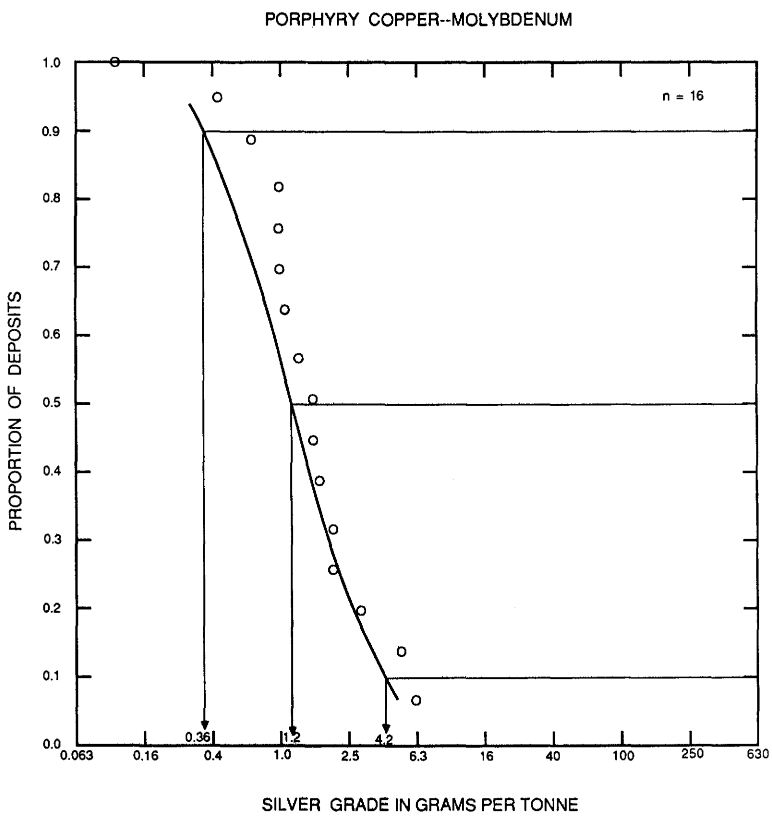

Figure 87. Silver grades of porphyry Cu-Mo deposits.

DESCRIPTIVE MODEL OF PORPHYRY Mo, LOW-F

By Ted G. Theodore

APPROXIMATE SYNONYM Calc-alkaline Mo stockwork (Westra and Keith, 1981).

DESCRIPTION Stockwork of quartz-molybdenite veinlets in felsic porphyry and in its nearby country rock.

GENERAL REFERENCE Westra and Keith (1981).

GEOLOGICAL ENVIRONMENT

Rock Types Tonalite, granodiorite, and monzogranite.

Textures Porphyry, fine aplitic groundmass.

Age Range Mesozoic and Tertiary.

Depositional Environment Orogenic belt with calcalkaline intrusive rocks.

Tectonic Setting(s) Numerous faults.

Associated Deposit Types Porphyry Cu-Mo, Cu skarn, volcanic hosted Cu-As-Sb.

DEPOSIT DESCRIPTION

Mineralogy Molybdenite + pyrite ± scheelite ± chalcopyrite ± argentian tetrahedrite. Quartz + K-feldspar + biotite ± calcite ± white mica and clays.

Texture/Structure Disseminated and in veinlets and fractures.

Alteration Potassic outward to propylitic. Phyllic and argillic overprint (see table 3).

Ore Controls Stockwork in felsic porphyry and in surrounding country rock.

Weathering Yellow ferrimolybdite after molybdenite. Secondary copper enrichment may form copper ores in some deposits.

Geochemical Signature Zoning outward and upward from Mo + Cu ± W to Cu + Au to Zn + Pb, + Au, + Ag. F may be present but in amounts less than 1,000 ppm.

EXAMPLES

Buckingham, USNV	(Blake and others, 1979)
USSR deposits	(Pavlova and Rundquist, 1980)

GRADE AND TONNAGE MODEL OF PORPHYRY Mo, LOW-F

By W. David Menzie and Ted G. Theodore

COMMENTS See figs. 88, 89.

DATA REFERENCE Theodore and Menzie (1983).

DEPOSITS

Name	Country	Name	Country
Anduramba	AUQL	Boss Mountain	CNBC
Adanac (Ruby Creek)	CNBC	Boswell River	CNYT
Ajax (Dak River)	CNBC	Buckingham	USNV
B. C. Moly	CNBC	Cannivan Gulch	USMT
Bell Molybdenum	CNBC	Carmi	CNBC

Creston	MXCO	Pitman (JB)	CNBC
Endako	CNBC	Quartz Hill	USAK
Gem	CNBC	Red Bird	CNBC
Glacier Gulch	CNBC	Red Mountain	CNYT
Hall	USNV	Serb Creek	CNBC
Haskin Mountain	CNBC	Setting Net Lake	CNON
Karen	CNBC	Storie	CNBC
Lucky Ship	CNBC	Sunshine Creek	CNBC
Machkatica	YUGO	Thompson Creek	USID
Mount Thomlinson	CNBC	Trout Lake	CNBC
Mount Tolman	USWA	UV Industries	USNV
Pine Nut	USNV		

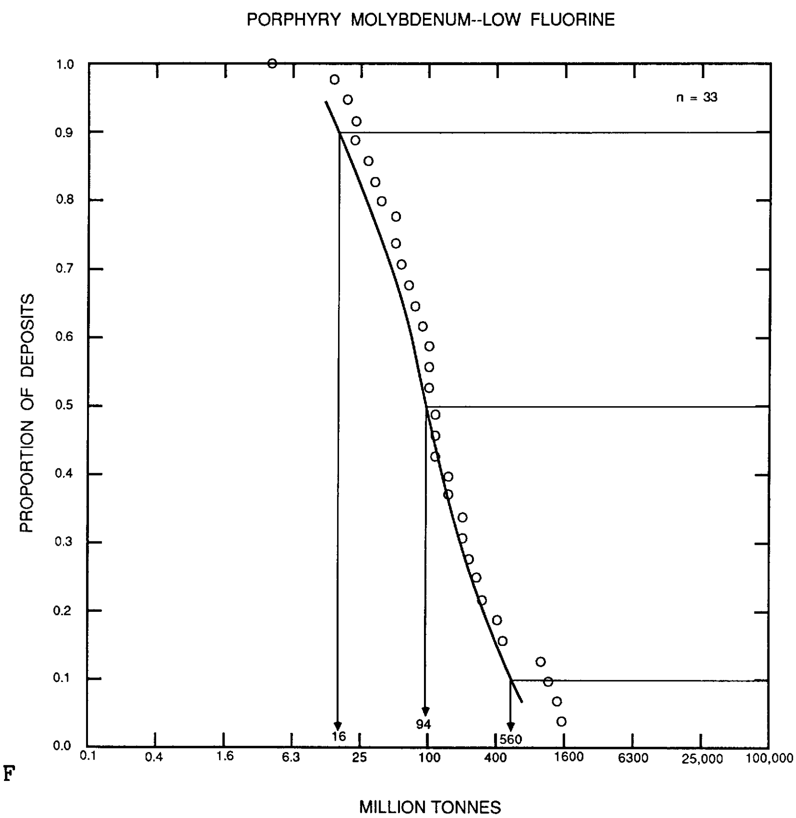

Figure 88. Tonnages of porphyry Mo-low F deposits.

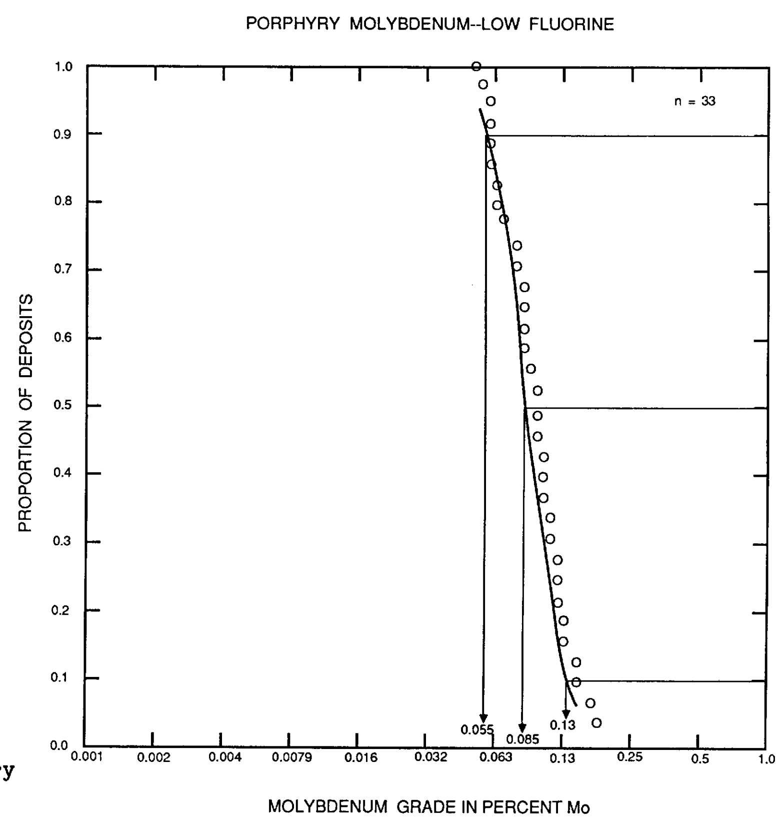

Figure 89. Molybdenum grades of porphyry Mo-low F deposits.

DESCRIPTIVE MODEL OF VOLCANIC-HOSTED Cu-As-Sb

By Dennis P. Cox

APPROXIMATE SYNONYM Enargite massive sulfide (Sillitoe, 1983)

DESCRIPTION Stratabound to pipelike massive copper sulfosalt deposits in volcanic flows, breccias, and tuffs near porphyry systems.

GENERAL REFERENCES Sillitoe (1983), Ashley (1982).

GEOLOGICAL ENVIRONMENT

Rock Types Andesite, dacite, flows, breccias, and tuffs.

Textures Fine grained, porphyritic, brecciated.

Age Range Mainly Tertiary.

Depositional Environment Volcanic terrane, uppermost levels of intrusive systems.

Tectonic Setting(s) Continental margins and island arcs.

Associated Deposit Types Porphyry Cu-Mo, porphyry Mo low-F.

DEPOSIT DESCRIPTION

Mineralogy All contain pyrite. In addition, enargite + luzonite + tennantite (Lepanto), enargite + covellite + chalcocite + bornite + chalcopyrite (Bor), enargite + luzonite + tetrahedrite (Resck), tetrahedrite + sphalerite + chalcopyrite + arsenopyrite (Sam Goosly). Most contain a few parts per million Au; Sam Goosly is Ag-rich.

Texture/Structure Massive ore, breccia filling, replacement of clasts by sulfides.

Alteration Chalcedony plus high-alumina assemblages containing alunite, pyrophyllite, diaspore, dickite, andalusite. Dumortierite, tourmaline, barite, and scorzalite may be present.

Ore Controls Tuff-breccias or breccia pipes are the channelways for ore solutions originating from younger porphyry copper systems. Known deposits are separated from typical porphyry type mineralization by 500 to 700 m.

Geochemical Signature As, Sb, Cu, Zn, Ag, Au, ± minor Sn (Lepanto), and W (Sam Goosly).

EXAMPLES

Lepanto, PLPN	(Gonzales, 1956)
Recsk, HUNG; Bor, YUGO	(Sillitoe, 1983)
Sam Goosly (Equity Silver), CNBC	(Cyr and others, 1984)

DESCRIPTIVE MODEL OF Au-Ag-Te VEINS

By Dennis P. Cox and William C. Bagby

DESCRIPTION Gold telluride minerals and fluorite in veins and breccia bodies related to hypabyssal or extrusive alkalic rocks.

GEOLOGICAL ENVIRONMENT

Rock Types Syenite, monzonite, or diorite; phonolite, monchiquite, and vogesite. Silica-undersaturated low-Ti basalts (shoshonites).

Textures Porphyro-aphanitic. Volcanic breccias and lapilli tuff.

Age Range Mainly Cretaceous and Tertiary, but could be any age.

Depositional Environment Volcanic centers, caldera rims, and caldera-fill breccias.

Tectonic Setting(s) Disrupted Precambrian craton with thin Phanerozoic cover. Also late shoshonitic stage of volcanism in island arcs.

Associated Deposit Types Polymetallic veins, polymetallic replacement deposits.

DEPOSIT DESCRIPTION

Mineralogy Calaverite, sylvanite, hessite, coloradoite, fine-grained pyrite, galena, sphalerite, tetrahedrite, and stibnite in veins of smokey quartz, calcite, purple fluorite, barite, celestite, roscoelite (V-mica), and adularia. Fluorite absent in Fiji deposit.

Texture/Structure Veins mainly carbonates and quartz. Ore minerals in clusters and locally in vug linings. Breccia-filling textures in some deposits.

Alteration Propylitic, dominated by carbonates (particularly dolomite) and pyrite. Sericite introduced in wallrocks. Silicification is rare.

Ore Controls Rich breccia ores in central zone of caldera. Veins on steep radial fractures and on faults gently inclined toward caldera. Veins may follow porphyry dikes. Replacement ore bodies may form where veins cut limestone, organic-rich argillaceous limestone being especially favorable.

Weathering Tellurides easily destroyed by weathering. Resulting "flour" gold may not be retained in placer deposits. Some tellurium redeposited as green oxides (emmonsite). Supergene enrichment, depositing native Au, occurs in some deposits.

Geochemical Signature Au, Ag, Te, Cu, Pb, Zn, Sb, Hg, F, Ba, PGE.

EXAMPLES

Cripple Creek, USCO	(Loughlin and Koschman, 1935; Lindgren and Ransome, 1906)
Gold Hill, USCO	(Kelly and Goddard, 1969)
LaPlata district, USCO	(Eckel, 1949)
Zortman-Landusky (Little Rockies district), USMT	(Corry, 1933)
North Mocassin-Warm Springs district), USMT	(Blixt, 1933)
Emperor mine, Tavua, FIJI	(Colley, 1976)

DESCRIPTIVE MODEL OF POLYMETALLIC VEINS

By Dennis P. Cox

APPROXIMATE SYNONYM Felsic intrusion-associated Ag-Pb-Zn veins (Sangster, 1984).

DESCRIPTION Quartz-carbonate veins with Au and Ag associated with base metal sulfides related to hypabyssal intrusions in sedimentary and metamorphic terranes.

GEOLOGICAL ENVIRONMENT

Rock Types Calcalkaline to alkaline, diorite to granodiorite, monzonite to monzogranite in small intrusions and dike swarms in sedimentary and metamorphic rocks. Subvolcanic intrusions, necks, dikes, plugs of andesite to rhyolite composition.

Textures Fine- to medium-grained equigranular, and porphyroaphanitic.

Age Range Most are Mesozoic and Cenozoic, but may be any age.

Depositional Environment Near-surface fractures and breccias within thermal aureol of clusters of small intrusions. In some cases peripheral to porphyry systems.

Tectonic Setting(s) Continental margin and island arc volcanic-plutonic belts. Especially zones of local domal uplift.

Associated Deposit Types Porphyry Cu-Mo, porphyry Mo low-F, polymetallic replacement. Placer Au.

DEPOSIT DESCRIPTION

Mineralogy Native Au and electrum with pyrite + sphalerite ± chalcopyrite ± galena ± arsenopyrite ± tetrahedrite-tennantite ± Ag sulfosalts ± argentite ± hematite in veins of quartz + chlorite + calcite ± dolomite ± ankerite ± siderite ± rhodochrosite ± barite ± fluorite ± chalcedony ± adularia.

Texture/Structure Complex, multiphase veins with comb structure, crustification, and colloform textures. Textures may vary from vuggy to compact within mineralized system.

Alteration Generally wide propylitic zones and narrow sericitic and argillic zones. Silicification of carbonate rocks to form jasperoid.

Ore Controls Areas of high permeability: intrusive contacts, fault intersections, and breccia veins and pipes. Replacement ore bodies may form where structures intersect carbonate rocks.

Weathering Minor gossans and Mn-oxide stains. Zn and Pb carbonates and Pb sulfate. Abundant quartz chips in soil. Placer gold concentrations in soils and stream sediments. Supergene enrichment produces high-grade native and horn silver ores in veins where calcite is not abundant.

Geochemical Signature Zn, Cu, Pb, As, Au, Ag, Mn, Ba. Anomalies zoned from Cu-Au outward to Zn-Pb-Ag to Mn at periphery.

EXAMPLES

St. Anthony (Mammoth), USAZ	(Creasey, 1950)
Wallapai District, USAZ	(Thomas, 1949)
Marysville District, USMT	(Knopf, 1913)
Misima I., PPNG	(Williamson and Rogerson, 1983)
Slocan District, CNBC	(Cairnes, 1934)

GRADE AND TONNAGE MODEL OF POLYMETALLIC VEINS

By James D. Bliss and Dennis P. Cox

COMMENTS The data used to generate grade and tonnage models for polymetallic veins reflect considerable complexity in the geology and economic conditions under which deposits are produced or evaluated. This model represents a first attempt to resolve these complexities. Four important factors may affect the adequacy of this model.

1. Zinc grades are subject to considerable uncertainty because smelters have in the past penalized producers for ore containing zinc which in turn caused mine operators to avoid zinc-bearing ore in their mining and milling. Zinc grades are likely underestimated. Irregular behavior in the zinc-grade model may be due to these factors.

2. Polymetallic veins of two types appear to exist--a base-metal polymetallic vein worked primarily for a base metal or metals and silver and a gold-silver polymetallic vein with copper, lead, and zinc production likely in less than half the deposits. Grade and tonnage models are presented for the base-metal polymetallic veins. Grade and tonnge models are not presented for the gold-silver polymetallic veins because preliminary data are inadequate. In our data, districts in which both types occur generally have six times as many base-metal polymetallic veins as gold-silver polymetallic veins.

3. The Slocan Mining District, British Columbia, Canada, contributed nearly 60 percent of the deposit data for the base-metal polymetallic veins, and this may bias the models in ways not identified.

4. Deposits are defined as all workings within 1 km of each other and having a minimum of 100 tonnes of ore. A few deposits are for districts with workings of unknown spacing. See figs. 90-94.

Name	Country	Name	Country
Albert Lea Group	USAZ	Mammoth-St. Anthony	USAZ
Altoona-Elkhor-Mercury	CNBC	Marietta	USMT
Amazon	USMT	Mineral Park	USAZ
Antoine	CNBC	Minniehaha	CNBC
Arlington	CNBC	Molly Gibson	CNBC
Badger	USAZ	Monitor	CNBC
Baltic and Revenue	USCO	Montezuma	CNBC
Baltimore	USMT	Mountain Chief and vicinity	CNBC
Bell	CNBC	Mountain Con	CNBC
Bell and California	USCO	Noonday	CNBC
Bell Boy-Niles-Towsley	USMT	North Cerbat (Golconda)	USAZ
Big Four	USMT	Northern Bell-Jackson	CNBC
Bosum	CNBC	Payne Group	CNBC
Bullion	USCO	Pennsylvania	USCO
C.O.D.	USAZ	Queen Bess and vicinity	CNBC
California-Hartney-Marion	CNBC	Rambler-Cariboo	CNBC
Carnation-Jennie Lind	CNBC	Rio	CNBC
Central Cerbat District	USAZ	Robert Emmet	USMT
Champion-New London	USAZ	Santiago-Commonwealth-Centennial	USCO
Chlorite District	USAZ	Scraton-Pontiac-Sunset	CNBC
Comstock	CNBC	Silversmith-Richmond-Ruth-Hope	CNBC
Cork-Province	CNBC	Slocan-Sovereign	CNBC
Dardanelles	CNBC	Soho	CNBC
Defiance	USAZ	Standard and vicinity	CNBC
Eva May	USMT	Stockton	USAZ
Fisher Maiden Group	CNBC	Sunshine-Corinth	CNBC
Flint-Martin	CNBC	Surprise-Noble Five and vicinity	CNBC
Galena Farm and vicinity	CNBC	Treasure Hill	USAZ
Gray Eagle	USMT	Tybo	USNV
Idaho-Alamo Group	CNBC	Union	USNV
Idaho-Alamo-Silver Bell	CNBC	Utica	CNBC
Ivanhoe-Canadian	CNBC	Vancouver Group	CNBC
Keno Hill-Galena Hill	CNYT	Von Roi-Hewitt-A.U.	CNBC
King Solomon	USMT	Wellington	CNBC
Leadsmith	CNBC	Wintrop	CNBC
Legal Tender	USMT	Wonderful-Elkhorn	CNBC
Little Nell	USMT		
Liverpool	USMT		
Majestic-Sapphire	CNBC		

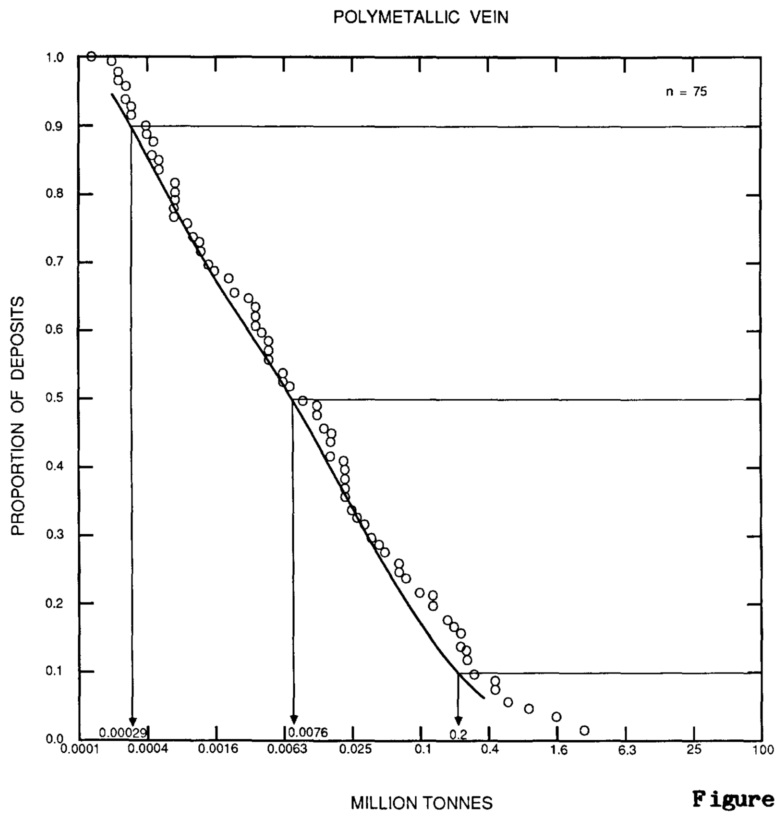

Figure 90. Tonnages of polymetallic vein deposits.

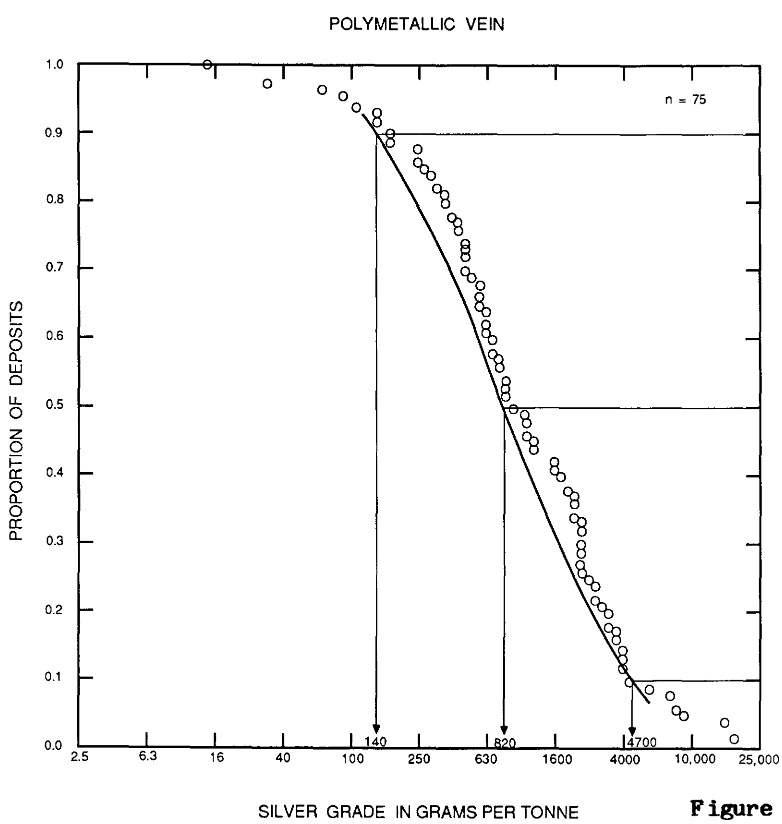

Figure 91. Silver grades of polymetallic vein deposits.

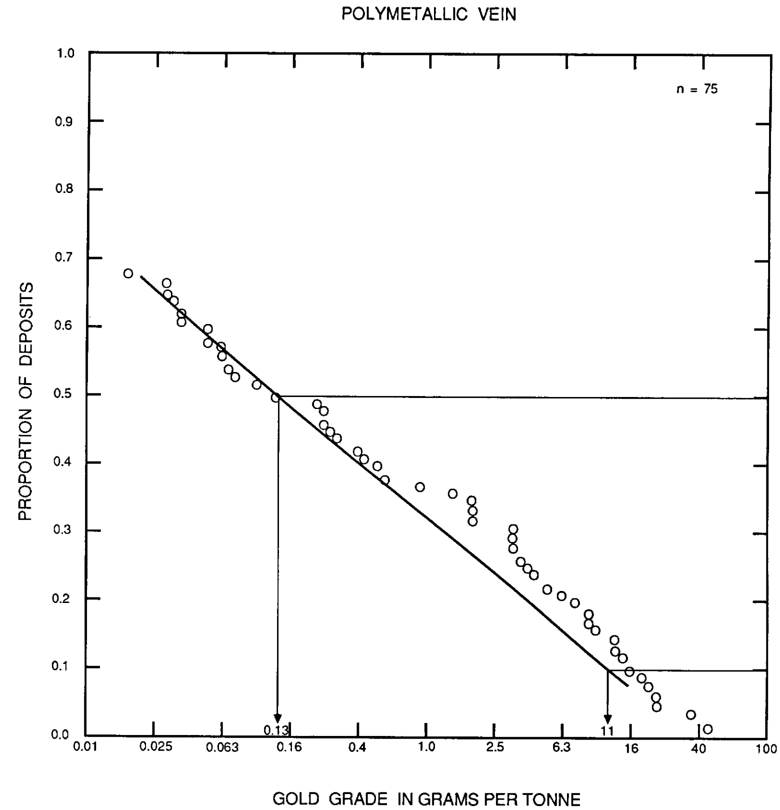

Figure 92. Gold grades of polymetallic vein deposits.

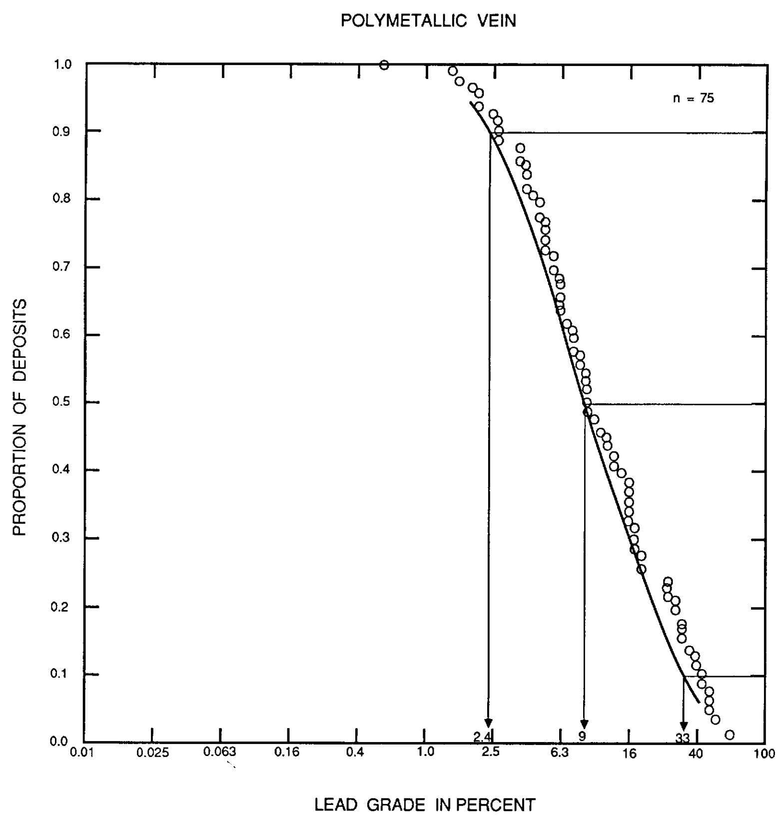

Figure 93. Lead grades of polymetallic vein deposits.

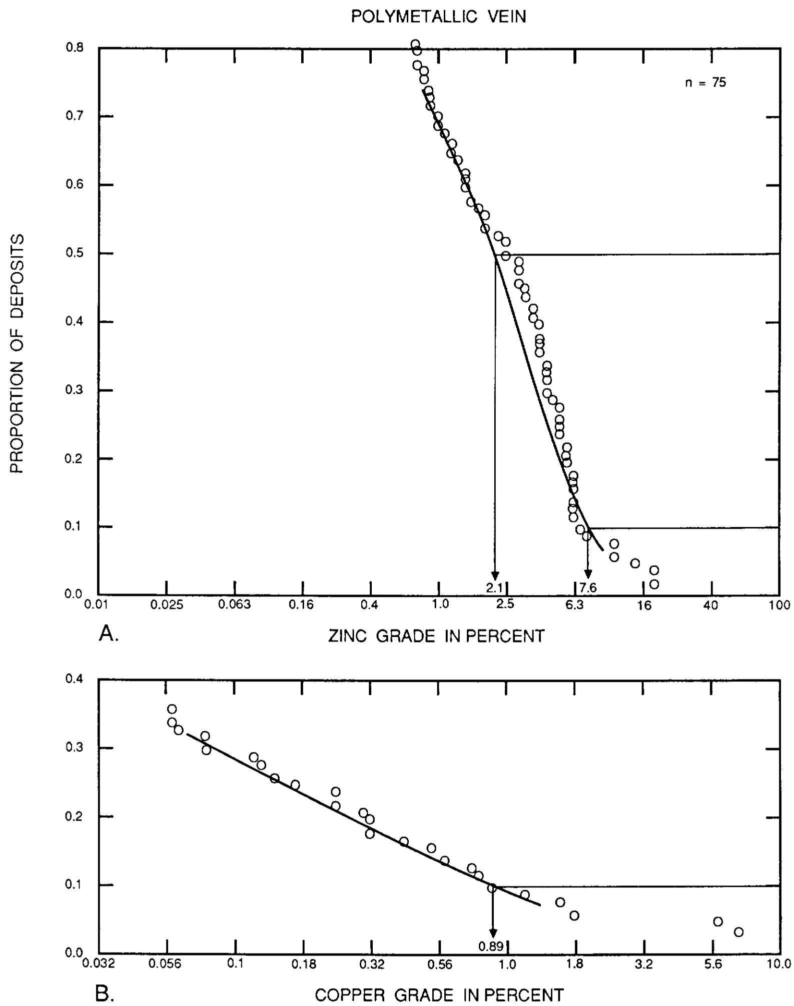

Figure 94. Zinc and copper grades of polymetallic vein deposits. A, Zinc. B, Copper.

DESCRIPTIVE MODEL OF BASALTIC Cu

By Dennis P. Cox

APPROXIMATE SYNONYM Volcanic redbed Cu (Kirkham, 1984).

DESCRIPTION A diverse group including disseminated native copper and copper sulfides in the upper parts of thick sequences of subaerial basalt, and copper sulfides in overlying sedimentary beds.

GENERAL REFERENCE Kirkham (1984).

GEOLOGICAL ENVIRONMENT

Rock Types Subaerial to shallow marine basalt flows, breccias and tuffs, red-bed sandstone, tuffaceous sandstone, conglomerate. Younger tidal facies limestone and black shale.

Textures Amygdules, flow-top breccias in lava. Laminated algal carbonate rocks. Sediments with high original porosity.

Age Range Proterozoic, Triassic and Jurassic, and Tertiary deposits known.

Depositional Environment Copper-rich (100-200 ppm) basalt interlayered with red clastic beds and overlain by mixed shallow marine and continental deposits formed near paleo-equator.

Tectonic Setting(s) Intracontinental rift, continental margin rift. Regional low-grade metamorphism may mobilize copper in some districts. Deposits are characteristic of the Triassic part of Wrangellia terrane in Alaska.

Associated Deposit Types Sediment-hosted copper. Volcanogenic Mn at Boleo, Mexico.

DEPOSIT DESCRIPTION

Mineralogy Native copper, native silver in flows and coarse clastic beds. Chalcocite and other Cu_2S minerals and locally bornite and chalcopyrite are concentrated in overlying shale and carbonate rocks. Fine-grained pyrite is common but not abundant with copper sulfide minerals.

Texture/Structure Flow-top breccia and amygdule fillings in basalt. Fine grains in matrix and along shaley parting in clastics. Massive replacement of carbonates at Kennicott. Finely varved chalcopyrite sediment at Denali.

Alteration Calcite-zeolite + epidote + K-feldspar. Red coloration due to fine hematite.

Ore Controls Flow-top breccias, amygdules, fractures in basalt; organic shale, limestone in overlying sequence. Limestone is tidal, algal, with stromatolite fossils. Synsedimentary faulting may be important.

Weathering Widely dispersed copper nuggets in streams draining basalts.

Geochemical Signature Cu-Ag-Zn-Cd. Co at Boleo, Mexico. Cu:Zn ratio is very high. Au anomalously low.

EXAMPLES

Keweenaw, USMI	(White, 1968)
Calumet, USMI	(Ensign and others, 1968)
Kennicott, USAK	(Bateman and McLaughlin, 1920)
Denali, USAK	(Seraphim, 1975)
Boleo, MXCO	(Wilson, 1955)
Buena Esperanza, CILE	(Ruiz, 1965)
Redstone, CNNT	(Ruelle, 1982)
Sustut, CNBC	(Harper, 1977)

DESCRIPTIVE MODEL OF CYPRUS MASSIVE SULFIDE

By Donald A. Singer

APPROXIMATE SYNONYM Cupreous pyrite.

DESCRIPTION Massive pyrite, chalcopyrite, and sphalerite in pillow basalts (see figs. 95, 96).

GENERAL REFERENCE Franklin, and others (1981).

GEOLOGICAL ENVIRONMENT

Rock Types Ophiolite assemblage: tectonized dunite and harzburgite, gabbro, sheeted diabase dikes, pillow basalts, and fine-grained metasedimentary rocks such as chert and phyllite (fig. 95).

Textures Diabase dikes, pillow basalts, and in some cases brecciated basalt.

Age Range Archean(?) to Tertiary--majority are Ordovician or Cretaceous.

Depositional Environment Submarine hot spring along axial grabens in oceanic or back-arc spreading ridges. Hot springs related to submarine volcanoes producing seamounts (fig. 96).

Tectonic Setting(s) Ophiolites. May be adjacent to steep normal faults.

Associated Deposit Types Mn and Fe-rich cherts regionally.

DEPOSIT DESCRIPTION

Mineralogy Massive: pyrite + chalcopyrite + sphalerite ± marcasite ± pyrrhotite. Stringer (stockwork): pyrite + pyrrhotite, minor chalcopyrite and sphalerite (cobalt, gold, and silver present in minor amounts).

Texture/Structure Massive sulfides (>60 percent sulfides) with underlying sulfide stockwork or stringer zone. Sulfides brecciated and recemented. Rarely preserved fossil worm tubes.

Alteration Stringer zone--feldspar destruction, abundant quartz and chalcedony, abundant chlorite, some illite and calcite. Some deposits overlain by ochre (Mn-poor, Fe-rich bedded sediment containing goethite, maghemite, and quartz).

Ore Controls Pillow basalt or mafic volcanic breccia, diabase dikes below; ores rarely localized in sediments above pillows. May be local faulting.

Weathering Massive limonite gossans. Gold in stream sediments.

Geochemical Signature General loss of Ca and Na and introduction and redistribution of Mn and Fe in the stringer zone.

EXAMPLES

Cyprus deposits, CYPS	(Constantinou and Govett, 1973)
Oxec, GUAT	(Petersen and Zantop, 1980)
York Harbour, CNNF	(Duke and Hutchinson, 1974)
Turner-Albright, USOR	(Koski and Derkey, 1981)

GRADE AND TONNAGE MODEL OF CYPRUS MASSIVE SULFIDE

By Donald A. Singer and Dan L. Mosier

DATA REFERENCE Mosier and others (1983).

COMMENTS Massive sulfide deposits from Mosier and others (1983) which had only mafic or ultramafic rocks immediately above through 500 m below, and had either pillow basalt or diabase dikes in the sequence were included in these plots. See figs. 97-99.

Model 24a--Con.

DEPOSITS

Name	Country	Name	Country
Aarja	OMAN	Lasail	OMAN
Agrokipia	CYPS	Limni	CYPS
Ambelikou	CYPS	Little Bay	CNNF
Ana Yatak-Ergani	TRKY	Lokken	NRWY
Apliki	CYPS	Lorraine	PLPN
Arinteiro	SPAN	Mathiati North	CYPS
Bama	SPAN	Mavrovouni	CYPS
Barlo	PLPN	Mousoulos-Kalavasos	CYPS
Bayda	OMAN	Ny Sulitjelma	NRWY
Betts Cove	CNNF	Oxec	GUAT
Big Mike	USNV	Peravasa	CYPS
Bonanza	CNBC	Platies	CYPS
Bongbongan	PLPN	Rendall-Jackson	CNNF
Carawison	PLPN	Rua Cove	USAK
Carmel	PLPN	Sha	CYPS
Colchester	CNNF	Siirt Madenkoy	TRKY
Fornas	SPAN	Skorovass	NRWY
Hand Camp	CNNF	Skouriotissa	CYPS
Huntingdon	CNQU	Svano	NRWY
Kapedhes	CYPS	Tilt Cove	CNNF
Kokkinoyia	CYPS	Troulli	CYPS
Kokkinopezoula	CYPS	Turner-Albright	USOR
Kure (Asikoy)	TRKY	Whalesback-Little Deer	CNNF
Kure (Bakibaba)	TRKY	York Harbour	CNNF
Kynousa	CYPS		

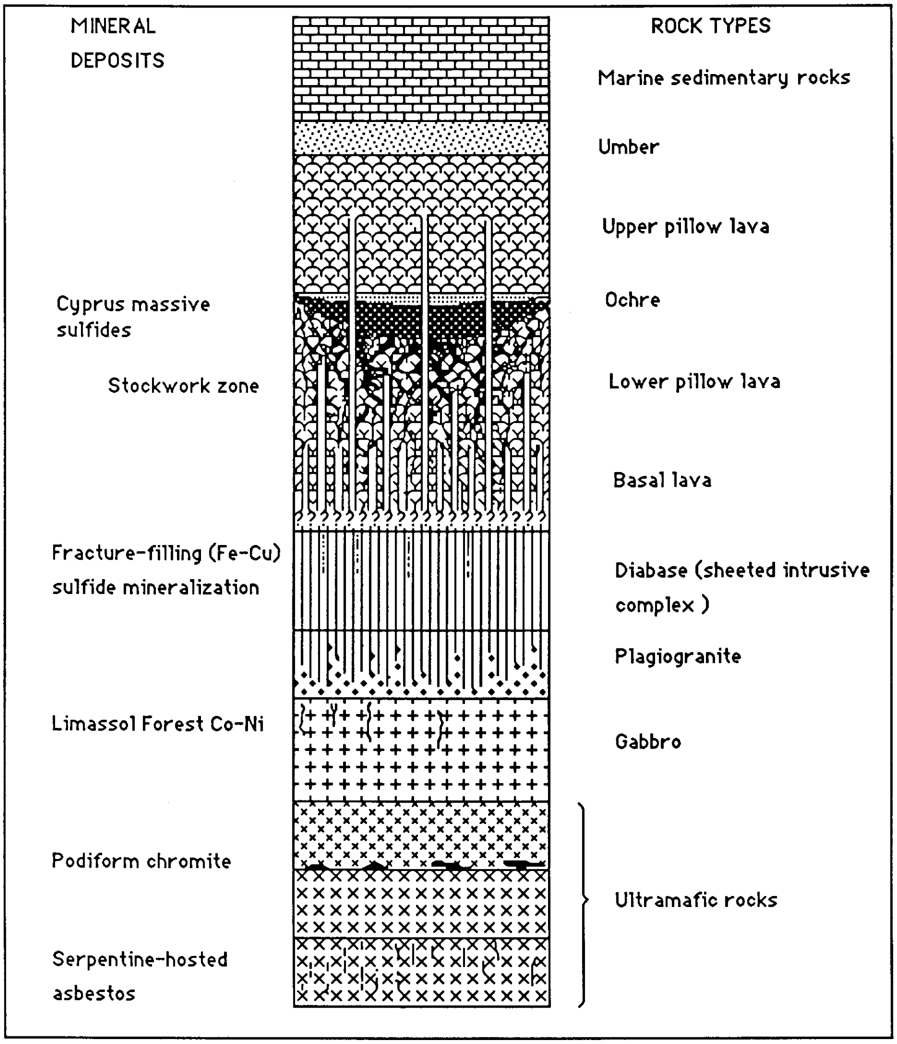

Figure 95. Generalized stratigraphic column through the Troodos ophiolite showing Cyprus massive sulfides and other deposit types and their asssociated rock types. Modified from Constantinou(1980).

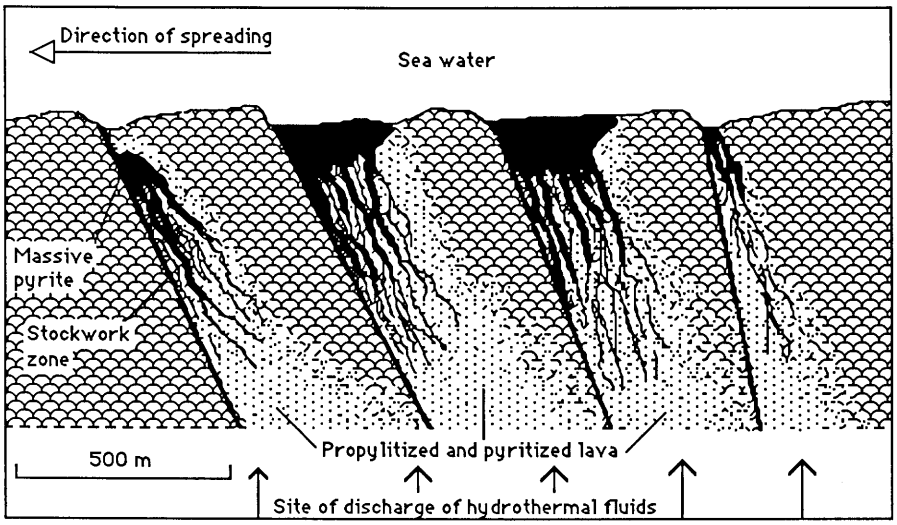

Figure 96. Cross section through the Kalavos district, Cyprus, showing relationship of massive sulfide deposits to faults and alteration zones. Section is drawn normal to the spreading axis and represents a time period prior to deposition of a thick sequence of pillow lavas and sedimentary rocks. Modified from Adamides (1980).

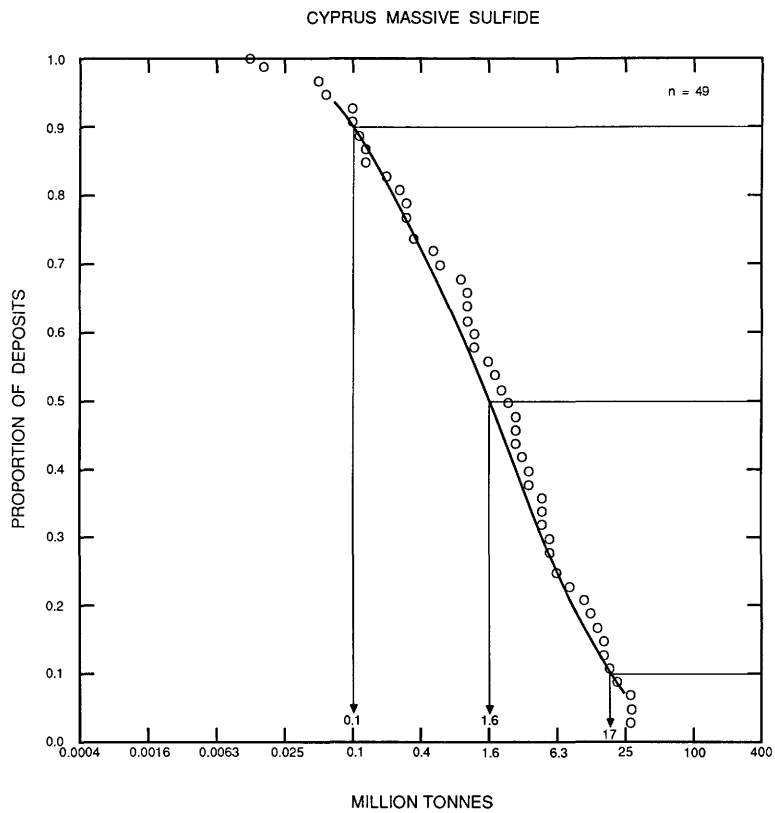

Figure 97. Tonnages of Cyprus massive sulfide deposits.

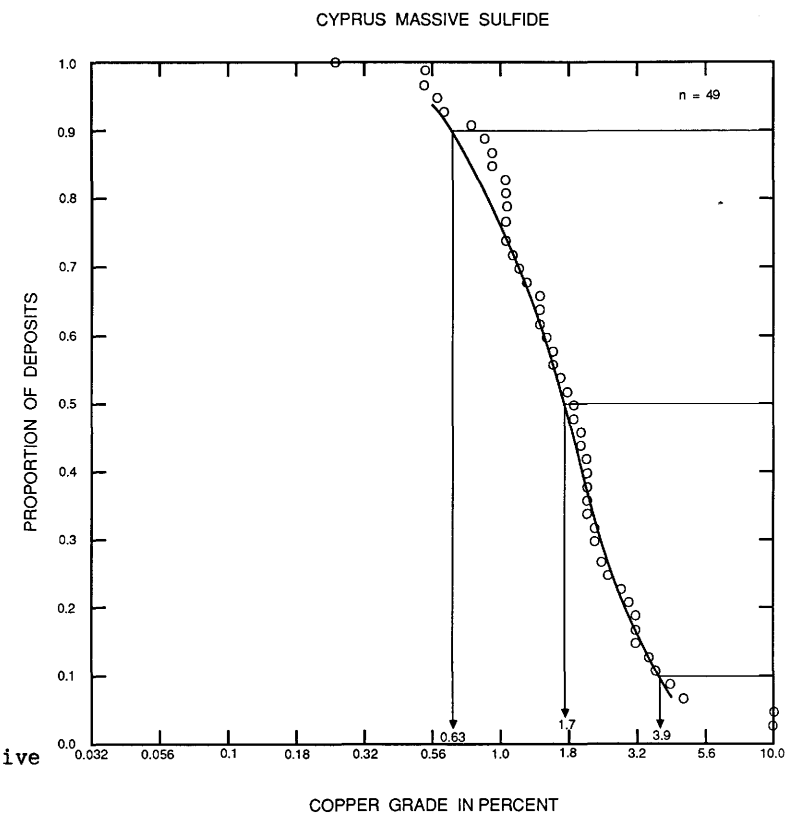

Figure 98. Copper grades of Cyprus massive sulfide deposits.

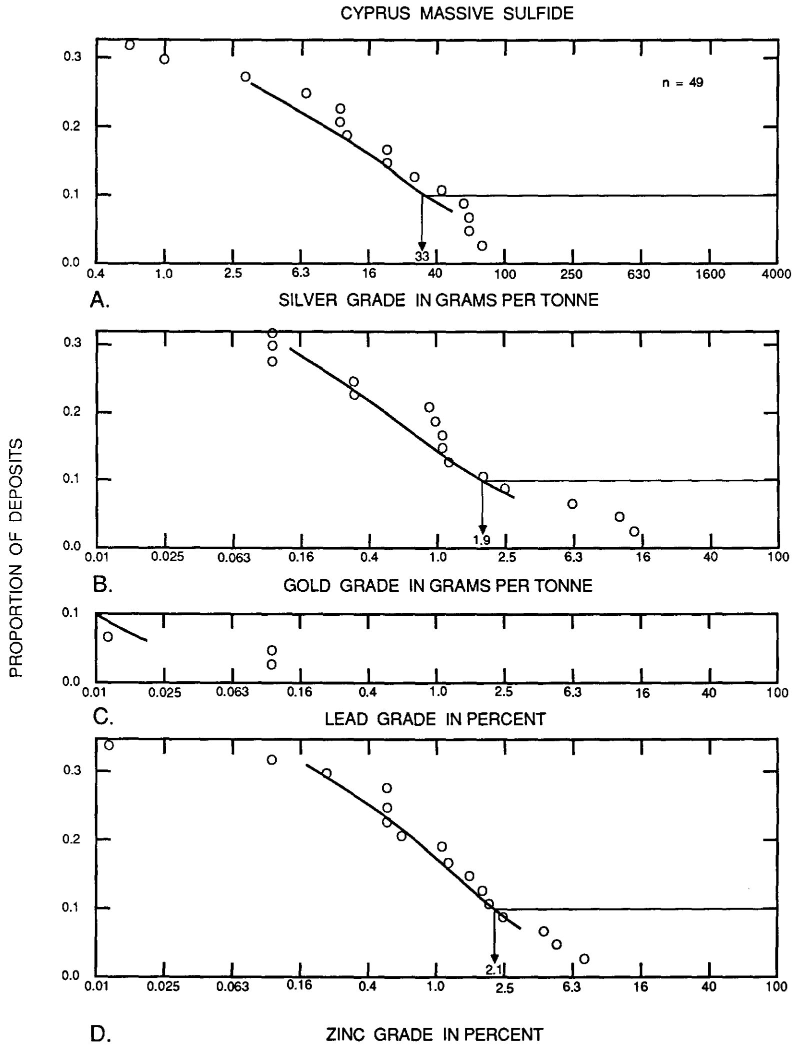

Figure 99. By-product grades of Cyprus massive sulfide deposits. A, Silver. B, Gold. C, Lead. D, Zinc.

DESCRIPTIVE MODEL OF BESSHI MASSIVE SULFIDE

By Dennis P. Cox

APPROXIMATE SYNONYM Besshi type, Kieslager.

DESCRIPTION Thin, sheetlike bodies of massive to well-laminated pyrite, pyrrhotite, and chalcopyrite within thinly laminated clastic sediments and mafic tuffs.

GENERAL REFERENCES Klau and Large (1980), Fox (1984).

GEOLOGICAL ENVIRONMENT

Rock Types Clastic terrigenous sedimentary rocks and tholeiitic to andesitic tuff and breccia. Locally, black shale, oxide-facies iron formation, and red chert.

Textures Thinly laminated clastic rocks. All known examples are in strongly deformed metamorphic terrane. Rocks are quartzose and mafic schist.

Age Range Mainly Paleozoic and Mesozoic.

Depositional Environment Uncertain. Possibly deposition by submarine hot springs related to basaltic volcanism. Ores may be localized within permeable sediments and fractured volcanic rocks in anoxic marine basins.

Tectonic Setting(s) Uncertain. Possibly rifted basin in island arc or back arc. Possibly spreading ridge underlying terrigenous sediment at continental slope.

Associated Deposit Types None known.

DEPOSIT DESCRIPTION

Mineralogy Pyrite + pyrrhotite + chalcopyrite + sphalerite ± magnetite ± valleriite ± galena ± bornite ± tetrahedrite ± cobaltite ± cubanite ± stannite ± molybdenite. Quartz, carbonate, albite, white mica, chlorite, amphibole, and tourmaline.

Texture/Structure Fine-grained, massive to thinly laminated ore with colloform and framboidal pyrite. Breccia or stringer ore. Cross-cutting veins contain chalcopyrite, pyrite, calcite or galena, sphalerite, calcite.

Alteration Difficult to recognize because of metamorphism. Chloritization of adjacent rocks is noted in some deposits.

Ore Controls Uncertain. Deposits are thin, but laterally extensive and tend to cluster in en echelon pattern.

Weathering Gossan.

Geochemical Signature Cu, Zn, Co, Ag, Ni, Cr, Co/Ni >1.0, Au up to 4 ppm, Ag up to 60 ppm.

EXAMPLES

Besshi, JAPN	(Kanehira and Tatsumi, 1970)
Motoyasu, JAPN	(Yui, 1983)
Kieslager, ASTR	(Derkman and Klemm, 1977)
Raul, PERU	(Ripley and Ohmoto, 1977)

GRADE AND TONNAGE MODEL OF BESSHI MASSIVE SULFIDE

By Donald A. Singer

DATA REFERENCE Yamada and others (1980).

COMMENTS Only deposits from Japan containing more than 10,000 tonnes are included. See figs. 100-102.

DEPOSITS

Name	Country	Name	Country
Akinokawa (Onishi)	JAPN	Motoyasu	JAPN
Asakawa	JAPN	Nakayama	JAPN
Besshi	JAPN	Nanogawa	JAPN
Choja	JAPN	Naruyasu	JAPN
Chushiro	JAPN	Nii	JAPN
Ehime	JAPN	Nishinokawa	JAPN
Higashiyame	JAPN	Noji	JAPN
Hirabaya	JAPN	Nonowaki	JAPN
Hirota	JAPN	Okuki	JAPN
Hitachi	JAPN	Omine	JAPN
Imade & Ouchi	JAPN	Ryuo	JAPN
Imori	JAPN	Sazare	JAPN
Iyo	JAPN	Shiiba, Takaragi	JAPN
Izushi	JAPN	Shimokawa	JAPN
Kamegamori	JAPN	Shimokawa (Kouchi)	JAPN
Kanayama	JAPN	Shinga	JAPN
Kotsu	JAPN	Shirataki	JAPN
Kune	JAPN	Takaura	JAPN
Machimi	JAPN	Terano	JAPN
Makimine, Hibira	JAPN	Yanahara	JAPN
Minawa	JAPN	Yoshimoto	JAPN
Miyawa	JAPN	Yuryo	JAPN

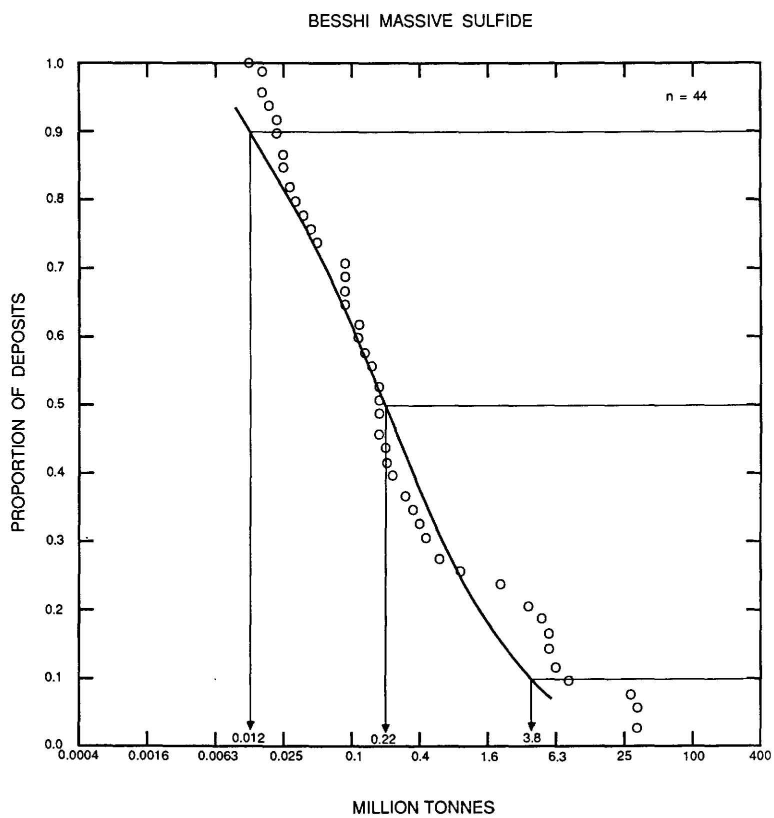

Figure 100. Tonnages of Besshi massive sulfide deposits.

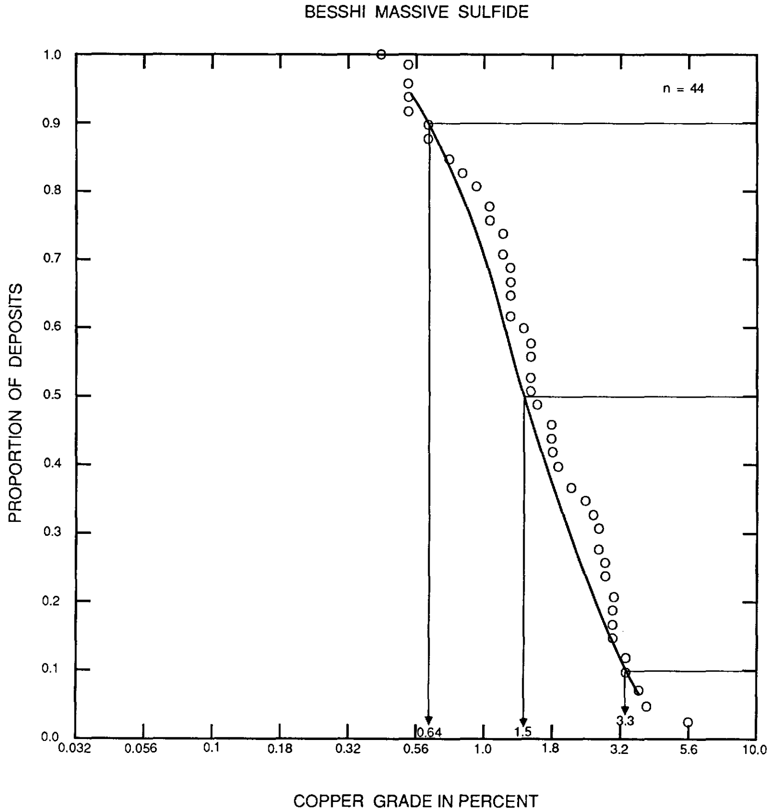

Figure 101. Copper grades of Besshi massive sulfide deposits.

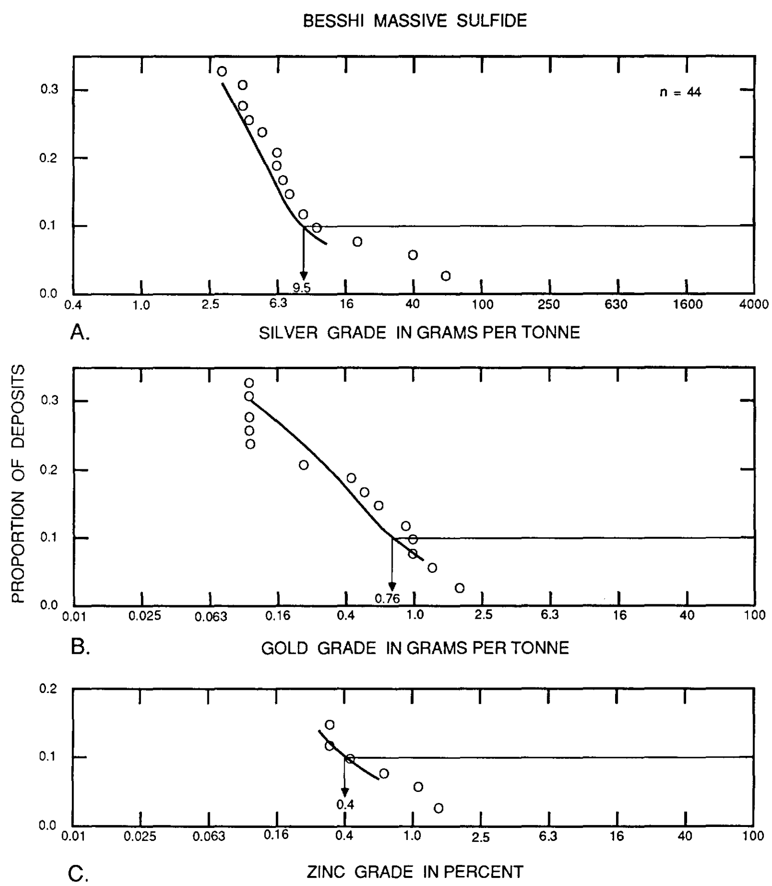

Figure 102. By-product grades of Besshi massive sulfide deposits. A, Silver. B, Gold. C, Zinc.

DESCRIPTIVE MODEL OF VOLCANOGENIC Mn

By Randolph A. Koski

APPROXIMATE SYNONYM Volcanogenic-sedimentary (Roy, 1981)

DESCRIPTION Lenses and stratiform bodies of manganese oxide, carbonate, and silicate in volcanic-sedimentary sequences. Genesis related to volcanic (volcanogenic) processes.

GENERAL REFERENCE Roy (1981).

GEOLOGICAL ENVIRONMENT

Rock Types Chert, shale, graywacke, tuff, basalt; chert, jasper, basalt (ophiolite); basalt, andesite, rhyolite (island-arc); basalt, limestone; conglomerate, sandstone, tuff, gypsum.

Age Range Cambrian to Pliocene.

Depositional Environment Sea-floor hot spring, generally deep water; some shallow water marine; some may be enclosed basin.

Tectonic Setting(s) Oceanic ridge, marginal basin, island arc, young rifted basin; all can be considered eugeosynclinal.

Associated Deposit Types Kuroko massive sulfide deposits.

DEPOSIT DESCRIPTION

Mineralogy Rhodochrosite, Mn-calcite, braunite, hausmannite, bementite, neotocite, alleghenyite, spessartine, rhodonite, Mn-opal, manganite, pyrolusite, coronadite, cryptomelane, hollandite, todorokite, amorphous MnO_2.

Texture/Structure Fine-grained massive crystalline aggregates, botryoidal, colloform in bedded and lensoid masses.

Alteration Spilitic or greenschist-facies alteration of associated mafic lavas, silicification, hematitization.

Ore Controls Sufficient structure and porosity to permit subsea-floor hydrothermal circulation and sea-floor venting; redox boundary at seafloor-seawater interface around hot spring; supergene enrichment to upgrade Mn content.

Weathering Strong development of secondary Mn oxides (todorokite, birnessite, pyrolusite, amorphous MnO_2) at the surface and along fractures.

Geochemical Signature Although Mn is only moderately mobile and relatively abundant in most rocks, Mn minerals may incorporate many other trace elements such as Zn, Pb, Cu, and Ba.

Examples

Olympic Peninsula, USWA	(Park, 1942, 1946; Sorem and Gunn, 1967)
Franciscan type, USCA, USOR	(Taliaferro and Hudson, 1943; Crerar and others, 1982; Snyder 1978; Kuypers and Denyer, 1979)

GRADE AND TONNAGE MODEL OF VOLCANOGENIC Mn

By Dan L. Mosier

COMMENTS Tonnage is correlated with manganese grade (r = -0.32) and with phosphorus grade (r = -0.94, n = 8). See figs. 103-104.

Model 24c--Con.

DEPOSITS

Name	Country	Name	Country
Abuhemsin (Abiulya)	TRKY	Korucular	TRKY
Abundancia	TRKY	La Calanesa	SPAN
Akcakilise Topkirazlar	TRKY	Ladd	USCA
Akoluuk	TRKY	Lagnokaha	UVOL
Akseki Gokceovacik	TRKY	Lasbela	PKTN
Antonio	CUBA	La Unica	CUBA
Augusto Luis and others	CUBA	Laverton-Mt. Lucky	AUWA
Avispa	CUBA	Liberty	USCA
Black Diablo	USNV	Lucia (Generosa)	CUBA
Blue Jay	USCA	Lucifer	MXCO
Boston Group	CUBA	Magdalena	CUBA
Briseida Group and others	CUBA	Manacas Group	CUBA
Buckeye	USCA	Manuel	CUBA
Bueycito	CUBA	Montenegro-Adriana	CUBA
Buritirama	BRZL	Mrima	KNYA
Cadiz	CUBA	Pirki	TRKY
Castillode Palanco	SPAN	Piskala	TRKY
Cavdarli-Komurluk	TRKY	Ponupo	CUBA
Cayirli Koy	TRKY	Ponupo de Manacal	CUBA
Charco Redondo-Casualidad	CUBA	Pozo Prieto	CUBA
Crescent	USWA	Progreso	CUBA
Cubenas	CUBA	Quarzazate	MRCO
Cubuklu Koyu	TRKY	Quinto	CUBA
Cummings	USCA	Raymond	NCAL
Curiol-Playa Real-Pavones	CORI	Rhiw	GRBR
Danisment	TRKY	Sabanilla	CUBA
Dassoumble	IVCO	Santa Rosa	CUBA
Djebel Guettara	ALGR	Sapalskoe	URRS
Durnovskoe	URRS	Sereno	BRZL
El Cuervo	SPAN	Sigua	CUBA
Esperancita	CUBA	Soloviejo	SPAN
Estrella-Sopresa	CUBA	South Thomas	USCA
Fabian	USCA	Taratana	CUBA
Faucogney	FRNC	Taritipan	INDS
Foster Mountain	USCA	Thatcher Creek	USCA
Glib en Nam	MRCO	Thomas	USCA
Gloria-Elvira-Polaris	CUBA	Tiere	UVOL
Gocek Koyu	TRKY	Tiouine	MRCO
Gran Piedra	CUBA	Tokoro	JAPN
Guanaba Group	CUBA	Topkirozlar	TRKY
Gunbasi (Akcakese)	TRKY	Toscana (Cerchiara)	ITLY
Hyatt No. 1	PANA	Tutunculer	TRKY
Idikel	MRCO	Valle de Maganeso	CUBA
Jo7	NCAL	Welch	USCA
Jutinicu	CUBA	Woody Woody	AUWA
Komurluk Koyunun	TRKY	Yeya	CUBA

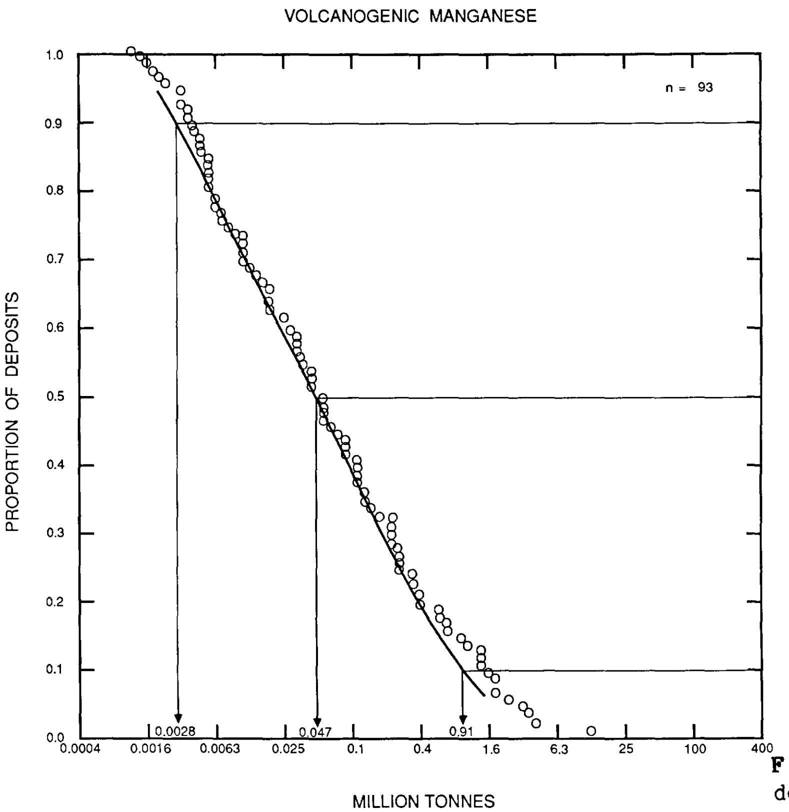

Figure 103. Tonnages of volcanogenic Mn deposits.

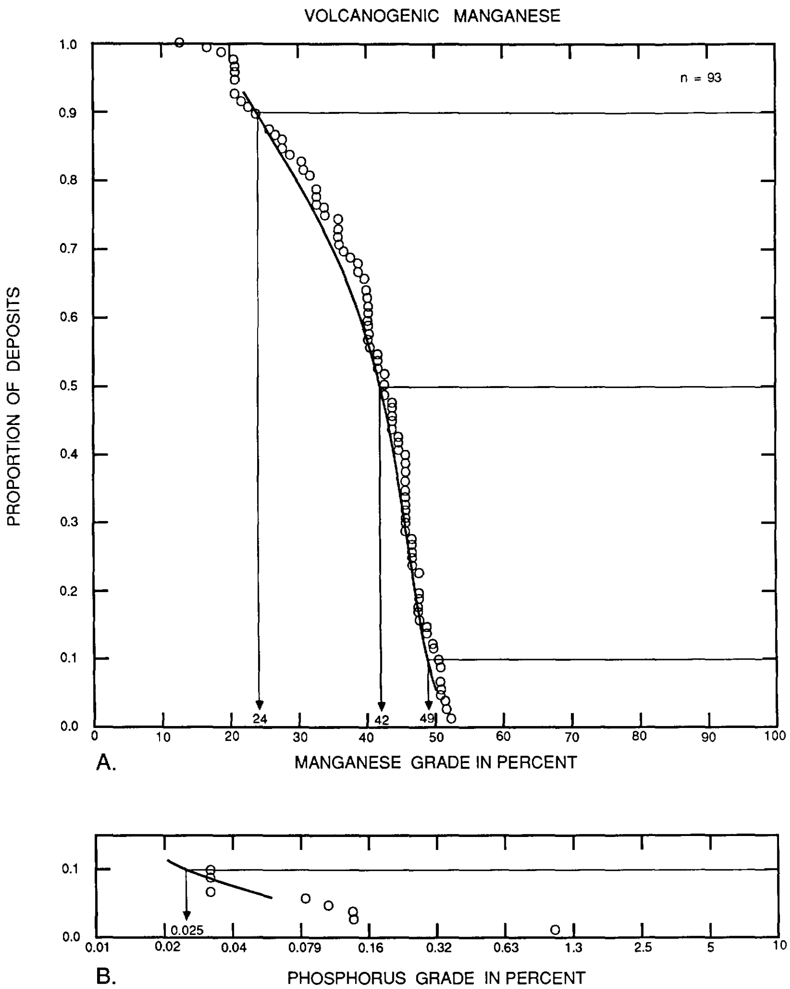

Figure 104. Metal grades of volcanogenic Mn deposits. A, Manganese. B, Phosphorus.

DESCRIPTIVE MODEL OF BLACKBIRD Co-Cu

By Robert L. Earhart

DESCRIPTION Massive and disseminated pyrite, pyrrhotite, arsenopyrite, cobaltite, chalcopyrite, and magnetite in stratabound lenses, stringers, and in quartz-tourmaline breccia pipes.

GENERAL REFERENCES Bennett (1977), Hughes (1983).

GEOLOGICAL ENVIRONMENT

Rock Types Fine-grained metasedimentary rocks (argillite, siltite, and quartzite), mafic metatuff, and magnetite-pyrite iron formation. Metasedimentary rocks may have large volcanic rock component.

Textures Fine-grained, thin-bedded turbidite sequences, graded beds, mafic dikes.

Age Range The Blackbird example is Proterozoic, but deposits could be of any age.

Depositional Environment Marine turbidite deposition with basaltic pyroclastic activity and submarine hot springs.

Tectonic Setting(s) Failed rift along continental margin.

Similar or Associated Deposit Types Besshi-type massive sulfide (?).

DEPOSIT DESCRIPTION

Mineralogy Cobaltite, chalcopyrite, pyrite, pyrrhotite, arsenopyrite, and magnetite. Gold and silver are locally present in tourmaline breccia pipes. Breccias contain pyrite-arsenopyrite-pyrrhotite and minor chalcopyrite-cobaltite.

Texture/Structure Fine to fairly coarse sulfides and sulfarsenides in lenses and stringers, locally with cataclastic texture along shear zones. Pyrite locally has colloform structure.

Alteration Silicification and intense chloritization.

Ore Controls Ore commonly occupies disrupted beds, regional distribution of ore closely follows distribution of mafic tuff and (or) iron-formation. Lenses may form at several stratigraphic horizons separated by barren metasedimentary rocks. Relationship between stratabound and breccia pipe mineralization is not understood.

Weathering Forms prominent gossans where sulfide and sulfarsenide-rich rocks crop out.

Geochemical Signature Enriched in Fe, As, B, Co, Cu, Au, Ag, Mn. May be depleted in Ca, Na. Rare-earth and trace-element distribution poorly known.

EXAMPLES Blackbird, USID (Bennett, 1977)

DESCRIPTIVE MODEL OF HOT-SPRING Au-Ag

By Byron R. Berger

DESCRIPTION Fine-grained silica and quartz in silicified breccia with gold, pyrite, and Sb and As sulfides (see fig. 105).

GENERAL REFERENCE Berger (1985).

GEOLOGICAL ENVIRONMENT

Rock Types Rhyolite.

Textures Porphyritic, brecciated.

Age Range Mainly Tertiary and Quaternary.

Depositional Environment Subaerial rhyolitic volcanic centers, rhyolite domes, and shallow parts of related geothermal systems.

Tectonic Setting(s) Through-going fracture systems related to volcanism above subduction zones, rifted continental margins. Leaky transform faults.

Associated Deposit Types Epithermal quartz veins, hot-spring Hg, placer Au.

DEPOSIT DESCRIPTION

Mineralogy Native gold + pyrite + stibnite + realgar; or arsenopyrite ± sphalerite ± chalcopyrite ± fluorite; or native gold + Ag-selenide or tellurides + pyrite.

Texture/Structure Crustified banded veins, stockworks, breccias (cemented with silica or uncemented). Sulfides may be very fine grained and disseminated in silicified rock.

Alteration Top of bottom of system: chalcedonic sinter, massive silicification, stockworks and veins of quartz + adularia and breccia cemented with quartz, quartz + chlorite. Veins generally chalcedonic, some opal. Some deposits have alunite and pyrophyllite. Ammonium feldspar (buddingtonite) may be present.

Ore Controls Through-going fracture systems, brecciated cores of intrusive domes; cemented breccias important carrier of ore.

Weathering Bleached country rock, yellow limonites with jarosite and fine-grained alunite, hematite, goethite.

Geochemical Signature Au + As + Sb + Hg + Tl higher in system, increasing Ag with depth, decreasing As + Sb + Tl + Hg with depth. Locally, NH_4, W.

EXAMPLES

McLaughlin, USCA	(Averitt, 1945 and Becker, 1888)
Round Mountain, USNV	(Tingley and Berger, 1985)
Delamar, USID	(Lindgren, 1900)

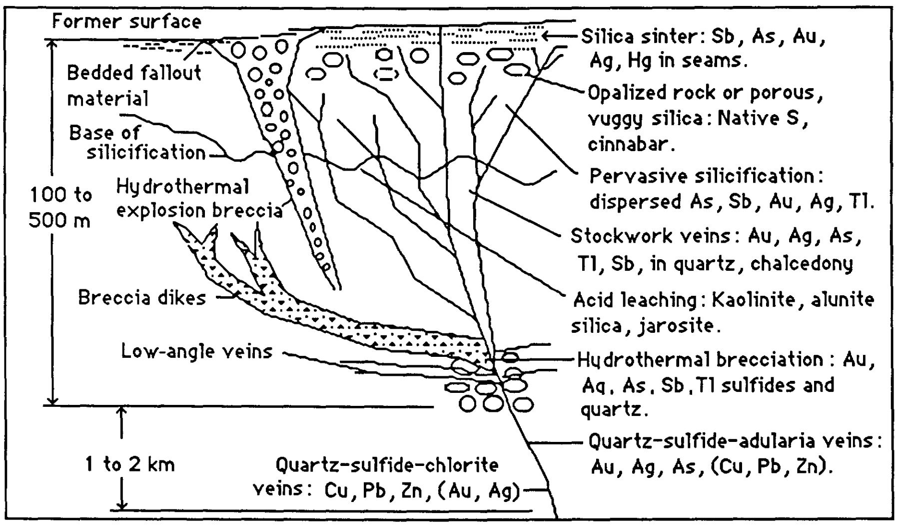

Figure 105. Cartoon cross section of hot-spring Au-Ag deposit.

DESCRIPTIVE MODEL OF CREEDE EPITHERMAL VEINS

By Dan L. Mosier, Takeo Sato, Norman J Page, Donald A. Singer, and Byron R. Berger

APPROXIMATE SYNONYM Epithermal gold (quartz-adularia) alkali-chloride-type, polymetallic veins (see fig. 106).

DESCRIPTION Galena, sphalerite, chalcopyrite, sulfosalts, ± tellurides ± gold in quartz-carbonate veins hosted by felsic to intermediate volcanics. Older miogeosynclinal evaporites or rocks with trapped seawater are associated with these deposits.

GENERAL REFERENCES Buchanan (1980), Boyle (1979).

GEOLOGICAL ENVIRONMENT

Rock Types Host rocks are andesite, dacite, quartz latite, rhyodacite, rhyolite, and associated sedimentary rocks. Mineralization related to calc-alkaline or bimodal volcanism.

Textures Porphyritic.

Age Range Mainly Tertiary (most are 29-4 m.y.).

Depositional Environment Bimodal and calc-alkaline volcanism. Deposits related to sources of saline fluids in prevolcanic basement such as evaporites or rocks with entrapped seawater.

Tectonic Setting(s) Through-going fractures systems; major normal faults, fractures related to doming, ring fracture zones, joints associated with calderas. Underlying or nearby older rocks of continental shelf with evaporite basins, or island arcs that are rapidly uplifted.

Associated Deposit Types Placer gold, epithermal quartz alunite Au, polymetallic replacement.

DEPOSIT DESCRIPTION

Mineralogy Galena + sphalerite + chalcopyrite + copper sulfosalts + silver sulfosalts ± gold ± tellurides ± bornite ± arsenopyrite. Gangue minerals are quartz + chlorite ± calcite + pyrite + rhodochrosite + barite ± fluorite ± siderite ± ankerite ± sericite ± adularia ± kaolinite. Specularite and alunite may be present.

Texture/Structure Banded veins, open space filling, lamellar quartz, stockworks, colloform textures.

Alteration Top to bottom: quartz ± kaolinite + montmorillonite ± zeolites ± barite ± calcite; quartz + illite; quartz + adularia ± illite; quartz + chlorite; presence of adularia is variable.

Ore Controls Through-going or anastomosing fracture systems. High-grade shoots where vein changes strike or dip and at intersections of veins. Hanging-wall fractures are particularly favorable.

Weathering Bleached country rock, goethite, jarosite, alunite--supergene processes often important factor in increasing grade of deposit.

Geochemical Signature Higher in system Au + As + Sb + Hg; Au + Ag + Pb + Zn + Cu; Ag + Pb + Zn, Cu + Pb + Zn. Base metals generally higher grade in deposits with silver. W + Bi may be present.

EXAMPLES

Creede, USCO	(Steven and Eaton, 1975; Barton and others, 1977)
Pachuca, MXCO	(Geyne and others, 1963)
Toyoha, JAPN	(Yajima and Ohta, 1979)

GRADE AND TONNAGE MODEL OF CREEDE EPITHERMAL VEINS

By Dan L. Mosier, Takeo Sato, and Donald A. Singer

COMMENTS Gold grade is correlated with zinc grade (r = -0.52, n = 22). See figs. 107-112.

DEPOSITS

Name	Country	Name	Country
Animas	USCO	Nogal	USNM
Bonanza	USCO	Oe	JAPN
Casapalca	PERU	Ogane	JAPN
Chavin	PERU	Ophir	USCO
Coco Mina	NCGA	Pachuca-Real del Monte	MXCO
Colqui	PERU	Red Mountain	USCO
Creede	USCO	Rio Pallanga	PERU
El Tigre	MXCO	Sai	JAPN
Eureka	USCO	Sneffels	USCO
Hosokura	JAPN	Telluride	USCO
Kata	PERU	Toyoha	JAPN
Lake City	USCO	Uruachic	MXCO
Los Mantiales	AGTN	Yatani	JAPN
Madrigal	PERU		

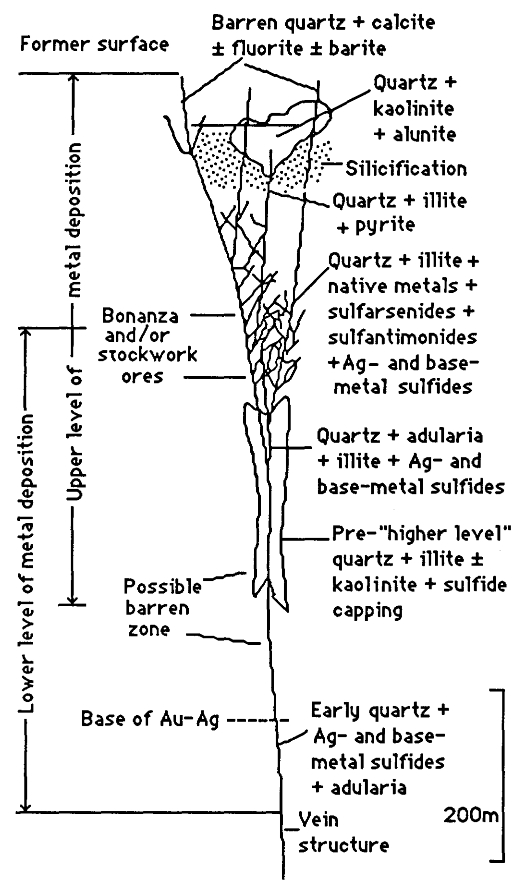

Figure 106. Cartoon cross section of typical Creede-type epithermal vein deposit.

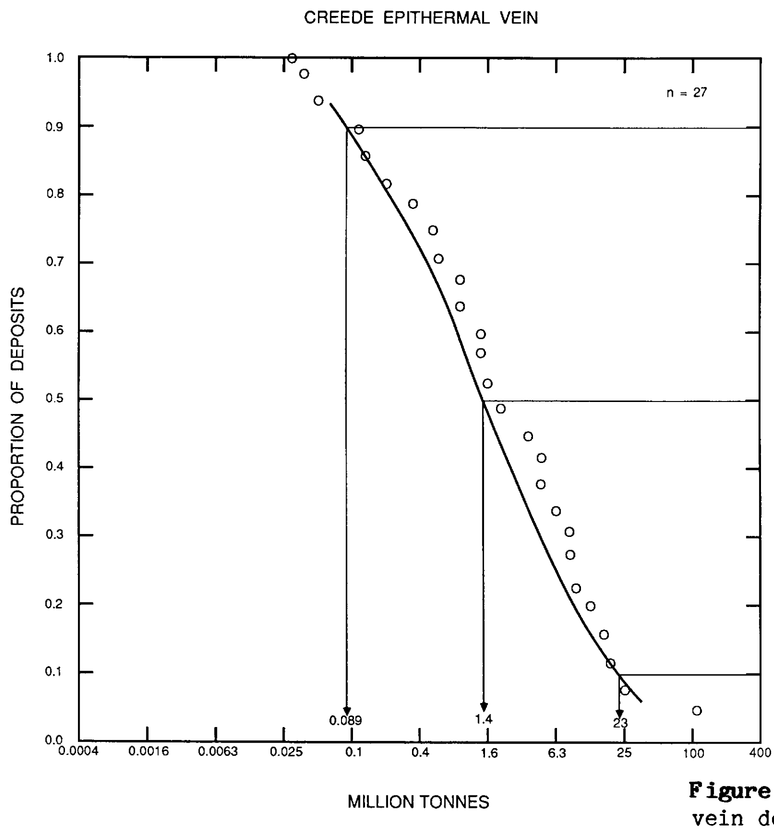

Figure 107. Tonnages of Creede epithermal vein deposits.

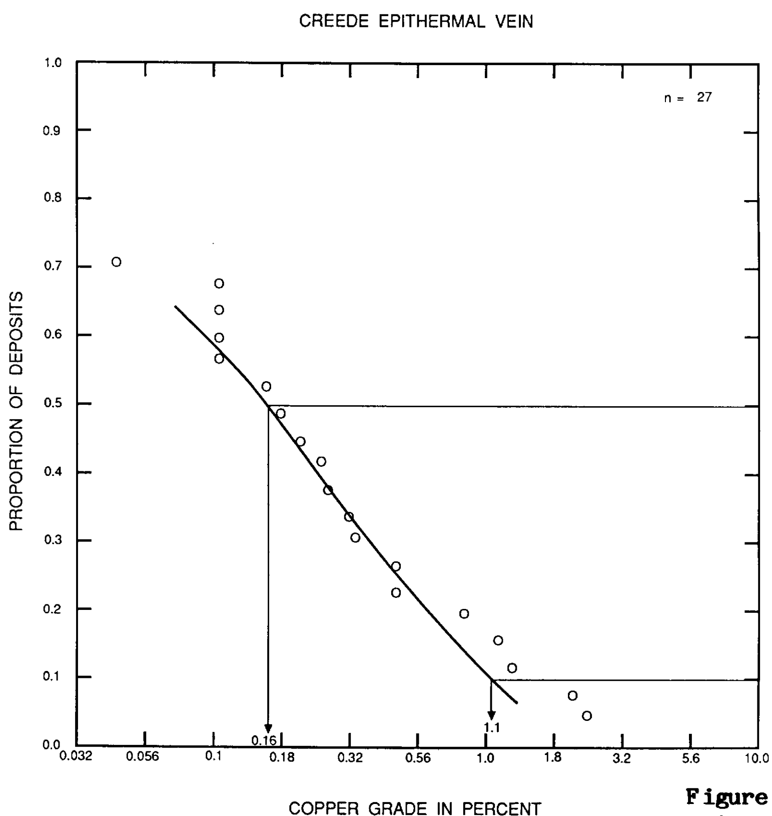

Figure 108. Copper grades of Creede epithermal vein deposits.

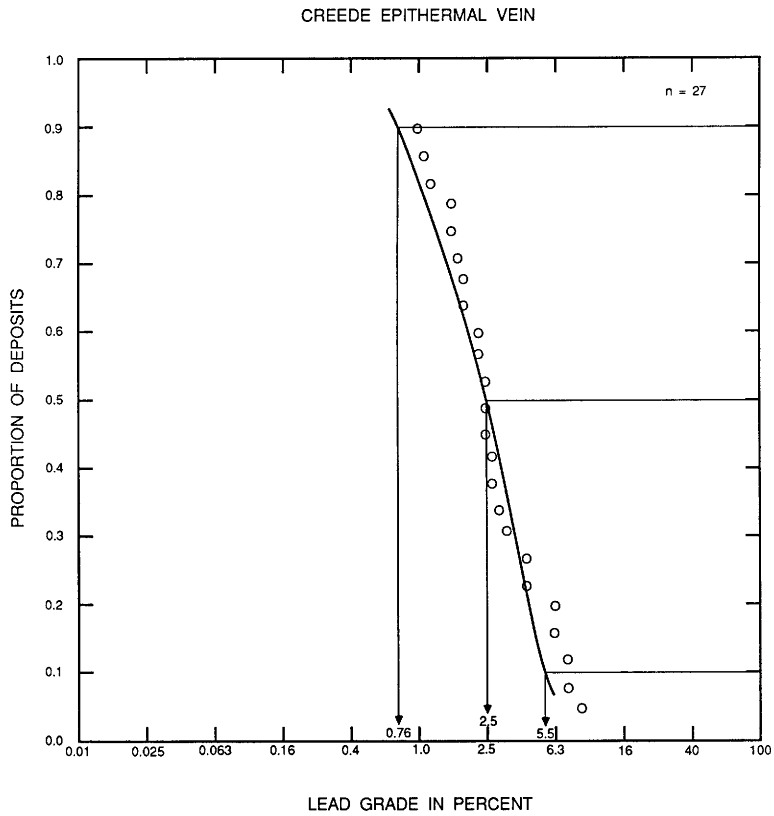

Figure 109. Lead grades of Creede epithermal vein deposits.

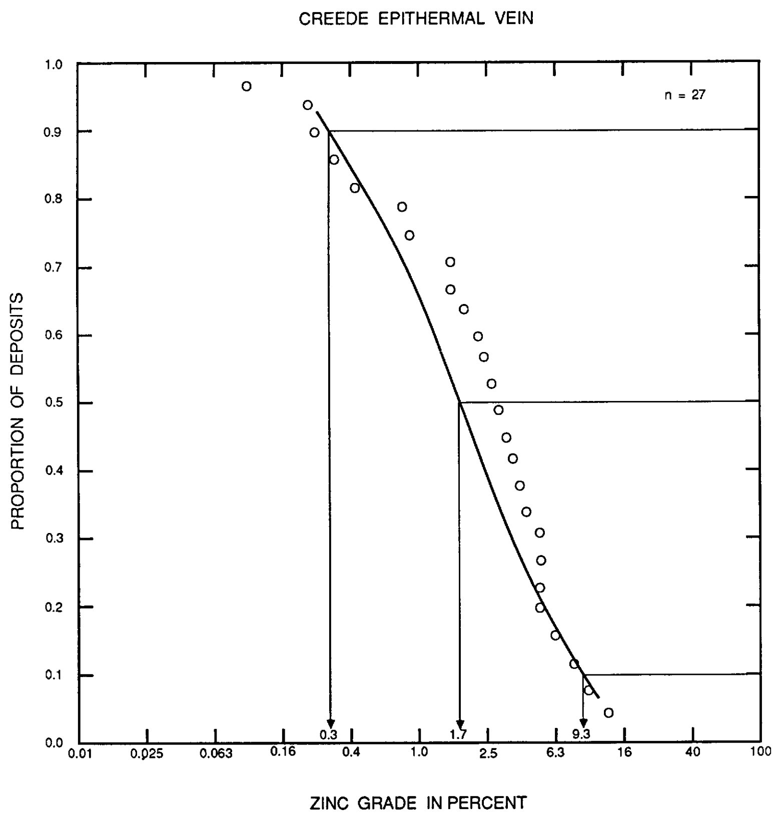

Figure 110. Zinc grades of Creede epithermal vein deposits.

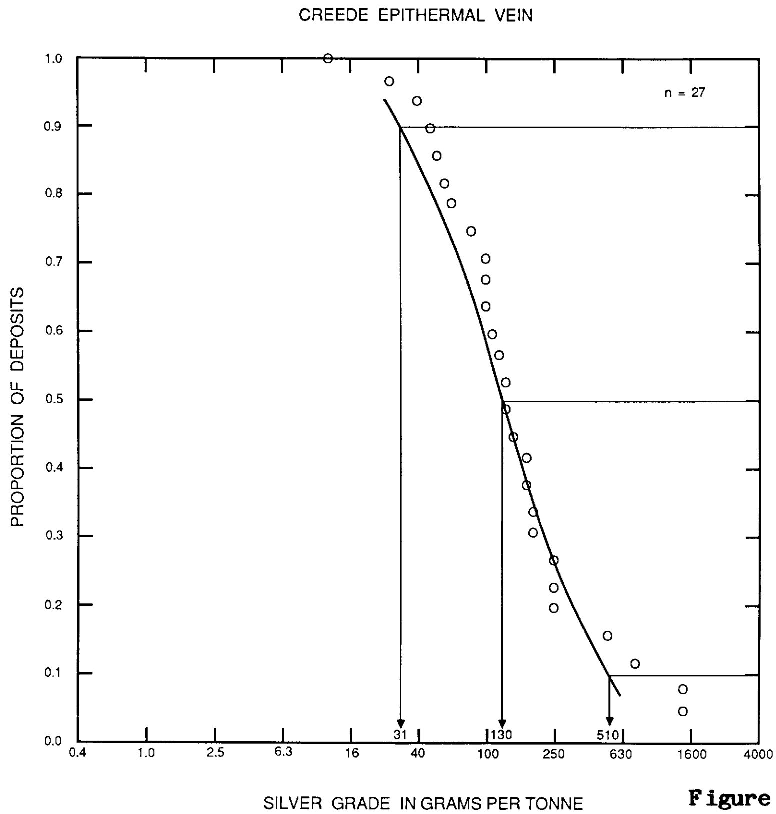

Figure 111. Silver grades of Creede epithermal vein deposits.

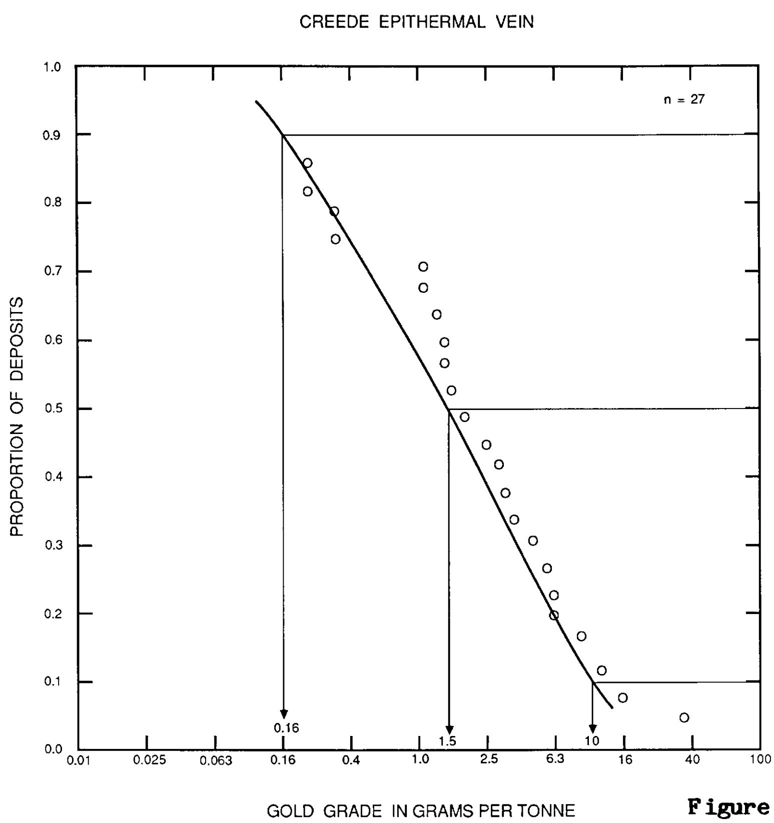

Figure 112. Gold grades of Creede epithermal vein deposits.

DESCRIPTIVE MODEL OF COMSTOCK EPITHERMAL VEINS

By Dan L. Mosier, Donald A. Singer, and Byron R. Berger

APPROXIMATE SYNONYM Epithermal gold (quartz-adularia) alkali-chloride type.

DESCRIPTION Gold, electrum, silver sulfosalts, and argentite in vuggy quartz-adularia veins hosted by felsic to intermediate volcanic rocks that overlie predominantly clastic sedimentary rocks, and their metamorphic equivalents (see fig. 106).

GENERAL REFERENCES Buchanan (1980), Boyle (1979).

GEOLOGICAL ENVIRONMENT

Rock Types Host rocks are andesite, dacite, quartz latite, rhyodacite, rhyolite; and associated sedimentary rocks. Mineralization related to calc-alkaline or bimodal volcanism.

Textures Porphyritic.

Age Range Mainly Tertiary (most are 40-3.7 m.y.).

Depositional Environment Calc-alkaline and bimodal volcanism and associated intrusive activity over basement rocks composed of clastic sedimentary rocks and their metamorphic equivalents. Volcanic-related geothermal systems lack access to saline fluids from basement sources.

Tectonic Setting(s) Through-going fracture systems, major normal faults, fractures related to doming, ring fracture zones, joints.

Associated Deposit Types Placer gold and epithermal quartz-alunite Au.

DEPOSIT DESCRIPTION

Mineralogy Argentite + gold or electrum ± silver sulfosalts ± naumannite. Galena, sphalerite, chalcopyrite, tellurides, hematite, and arsenopyrite are moderate to sparse. Gangue minerals are quartz + pyrite ± adularia ± calcite ± sericite ± chlorite. Barite, fluorite, rhodochrosite, kaolinite, and montmorillonite are moderate to sparse. Ore minerals constitute only a few percent of vein.

Texture/Structure Banded veins, open space filling, lamellar quartz, stockwork.

Alteration From top to bottom of system: quartz + kaolinite + montmorillonite ± zeolite ± barite ± calcite; quartz + illite; quartz + adularia ± illite; quartz + chlorite; presence of adularia is variable.

Ore Controls Through-going anastomosing fracture systems, centers of intrusive activity. Hanging wall more favorable.

Weathering Bleached country rock, limonite, jarosite, goethite, alunite, hematite, argillization with kaolinite.

Geochemical Signature Higher in system Au + As + Sb + Hg or Au + As + Cu; Au + Ag + Pb + Cu; also Te and W.

EXAMPLES

Comstock, USNV	(Becker, 1882)
Guanajuato, MXCO	(Buchanan, 1980; Wandke and Martinez, 1928)

GRADE AND TONNAGE MODEL OF COMSTOCK EPITHERMAL VEINS

By Dan L. Mosier, Donald A. Singer, and Byron R. Berger

COMMENTS See figs. 113-116.

DEPOSITS

Name	Country	Name	Country
Aurora	USNV	Ohguchi	JAPN
Bodie	USCA	Ohito	JAPN
Bovard	USNV	Olinghouse	USNV
Calico	USCA	Orient	USWA
Calistoga	USCA	Patterson	USCA
Comstock	USNV	Republic	USWA
Divide	USNV	Rosario	HNDR
Dolores	MXCO	Sand Springs	USNV
El Rincon	MXCO	Searchlight	USNV
Fairview	USNV	Seikoshi	JAPN
Fuke	JAPN	Seven Trough	USNV
Gold Mountain	USUT	Sheep Tank	USAZ
Guanacevi	MXCO	Silver City	USNV
Guanajuato	MXCO	Taio	JAPN
Hostotipaquilla	MXCO	Tayoltita	MXCO
Katherine	USAZ	Toi	JAPN
Kushikino-Arakawa	JAPN	Tonopah	USNV
Mochikoshi	JAPN	Tuscarora	USAZ
Mogollon	USNM	Weaver	USAZ
Nawaji	JAPN	Yugashima	JAPN
Oatman	USAZ		

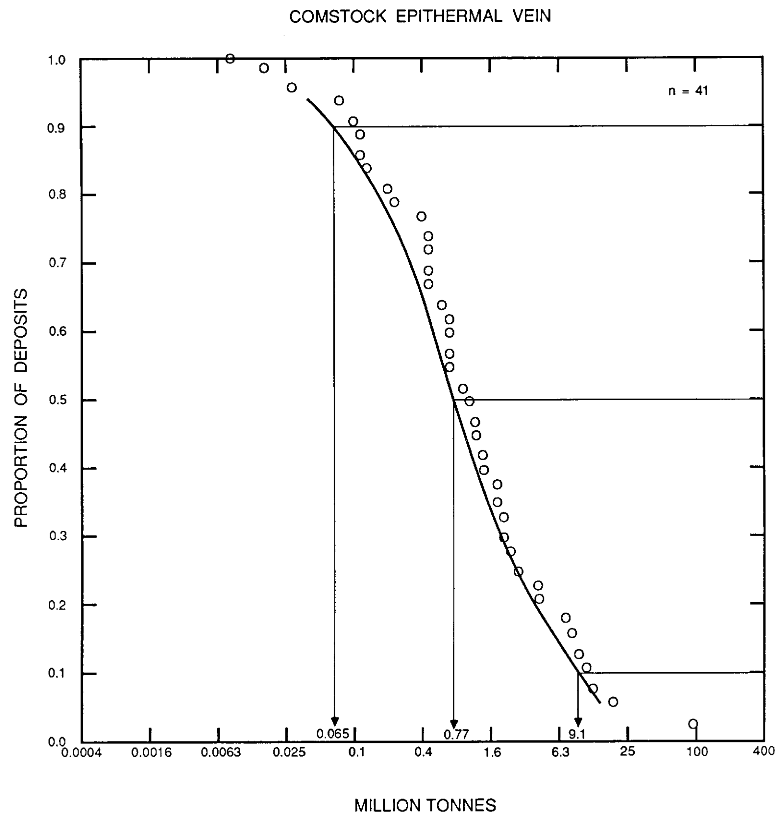

Figure 113. Tonnages of Comstock epithermal vein deposits.

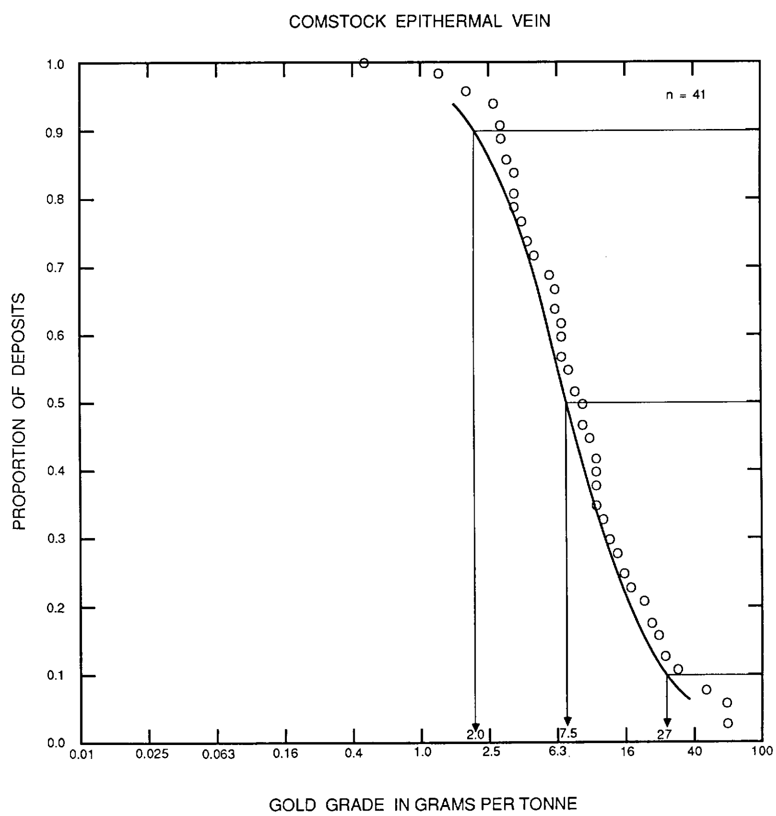

Figure 114. Gold grades of Comstock epithermal vein deposits.

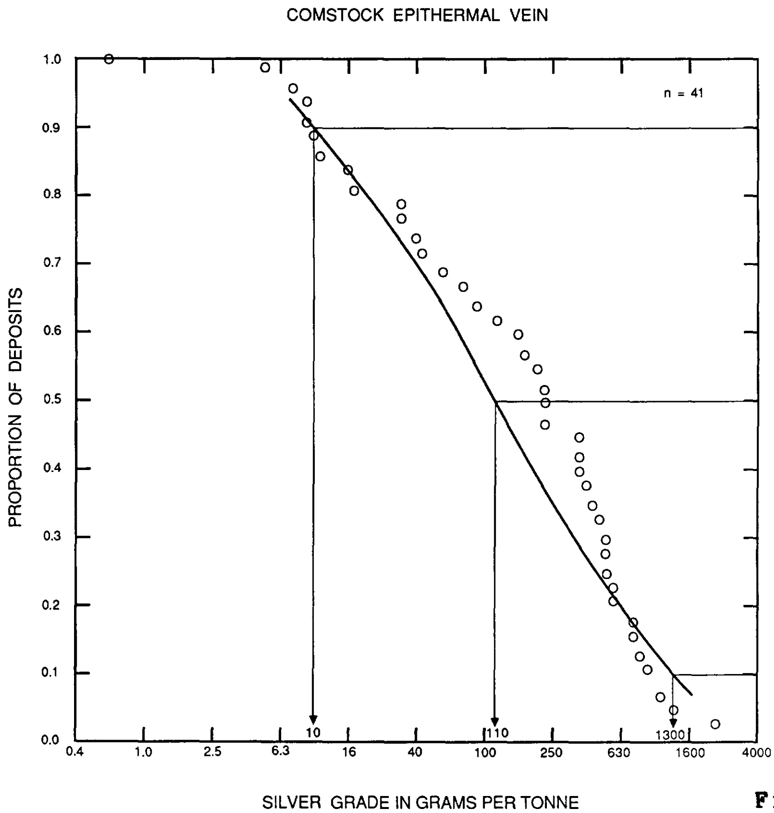

Figure 115. Silver grades of Comstock epithermal vein deposits.

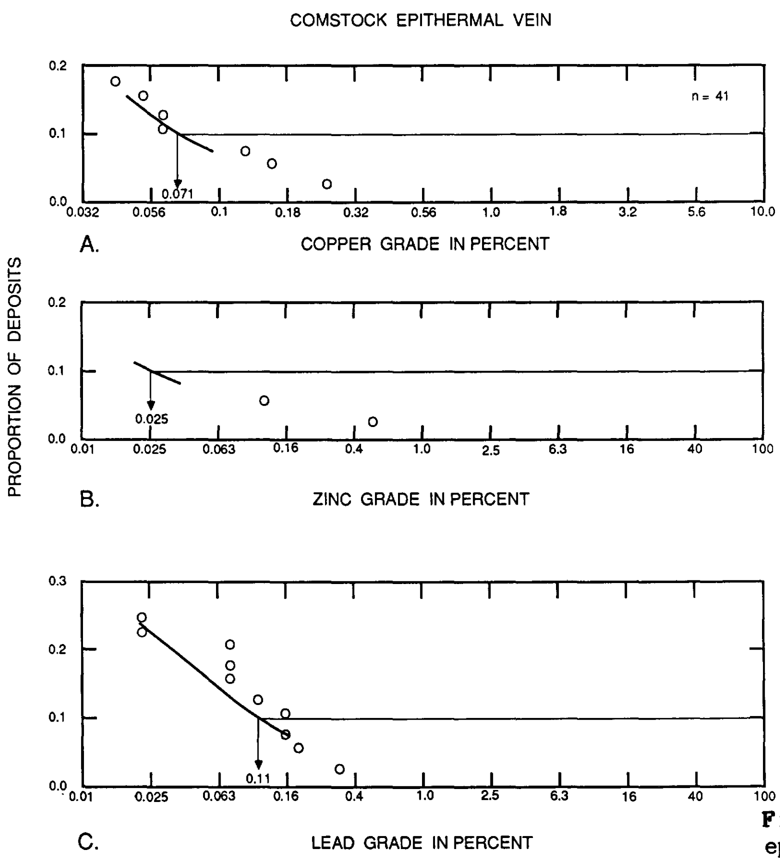

Figure 116. By-product grades of Comstock epithermal vein deposits. A, Copper. B, Zinc. C, Lead.

DESCRIPTIVE MODEL OF SADO EPITHERMAL VEINS

By Dan L. Mosier, Bruce R. Berger, and Donald A. Singer

DESCRIPTION Gold, chalcopyrite, sulfosalts, and argentite in vuggy veins hosted by felsic to intermediate volcanic rocks that overlie older volcanic sequences or igneous intrusions (see fig. 106).

GENERAL REFERENCE Boyle (1979).

GEOLOGICAL ENVIRONMENT

Rock Types Host rocks are andesite, dacite, quartz latite, rhyodacite, rhyolite, and associated sedimentary rocks. Mineralization related to calc-alkaline or bimodal volcanism.

Textures Porphyritic.

Age Range Mainly Tertiary (most are 38-5 m.y.).

Depositional Environment Calc-alkaline and bimodal volcanism and associated intrusive activity over basement rocks composed of thick, older volcanic sequences or igneous intrusives (batholiths). Volcanic-related geothermal systems lack access to saline fluids from basement sources.

Tectonic Setting(s) Through-going fracture systems, major normal faults, fractures related to doming, ring fracture zones, joints.

Associated Deposit Types Placer gold and quartz-alunite Au.

DEPOSIT DESCRIPTION

Mineralogy Gold ± argentite + electrum + chalcopyrite. Sulfosalts and tellurides are moderate, galena and sphalerite are sparse. Gangue minerals are quartz ± pyrite ± adularia ± calcite. Chalcedony, adularia, kaolinite, rhodochrosite, chlorite, sericite, and barite are moderate to sparse.

Texture/Structure Banded veins, open space filling, lamellar quartz, stockwork, breccia pipes.

Alteration Silicification zoned by quartz + kaolinite + montmorillonite ± alunite; may have pervasive propylitic alteration of chlorite + calcite.

Ore Controls Through-going fracture systems; major normal faults, fractures related to doming, ring fractures, joints.

Weathering Bleached country rock, limonite, hematite, goethite, jarosite, alunite; argillization with kaolinite.

Geochemical Signature: Au + Ag; Au + Ag + Cu.

EXAMPLES

Takeno, JAPN	(Soeda and Watanabe, 1981)

GRADE AND TONNAGE MODEL OF SADO EPITHERMAL VEINS

By Dan L. Mosier and Takeo Sato

COMMENTS The two lowest gold grades were not plotted because it is suspected that their reported grades are in error. See figs. 117-119.

DEPOSITS

Name	Country	Name	Country
Bajo	JAPN	La Libertad	MXCO
Benten	JAPN	Mamuro	JAPN
Bruner	USNV	Mizobe	JAPN
Chitose	JAPN	Nagamatsu	JAPN
Guadalupe and Calvo	MXCO	Sado	JAPN
Hayden Hill	USCA	Sanei	JAPN
High Grade	USCA	Takahata	JAPN
Innai	JAPN	Takatama	JAPN
Kawasaki	JAPN	Takeno	JAPN
Koyama	JAPN	Winters	USCA

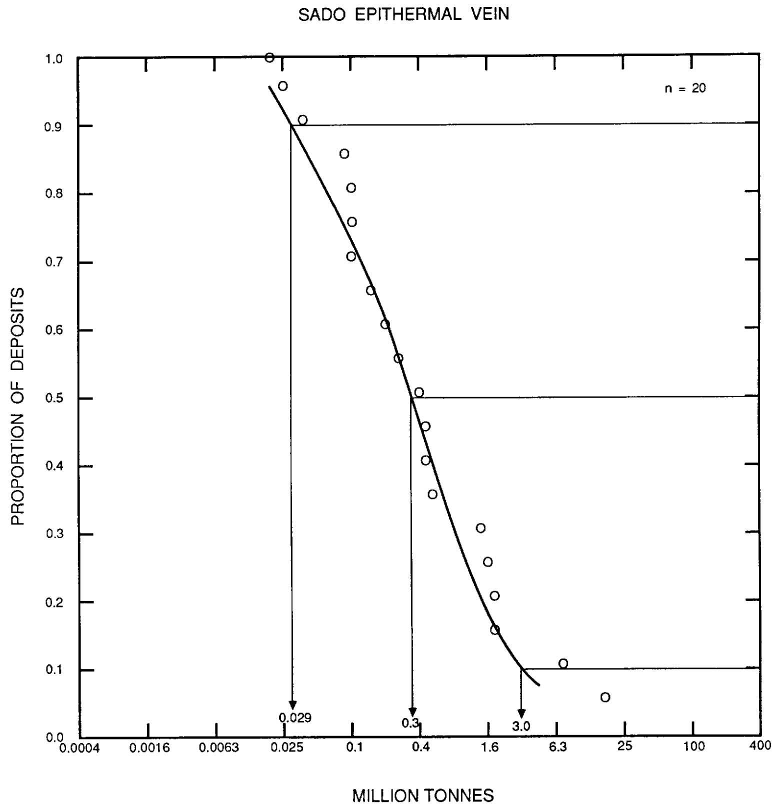

Figure 117. Tonnages of Sado epithermal vein deposits.

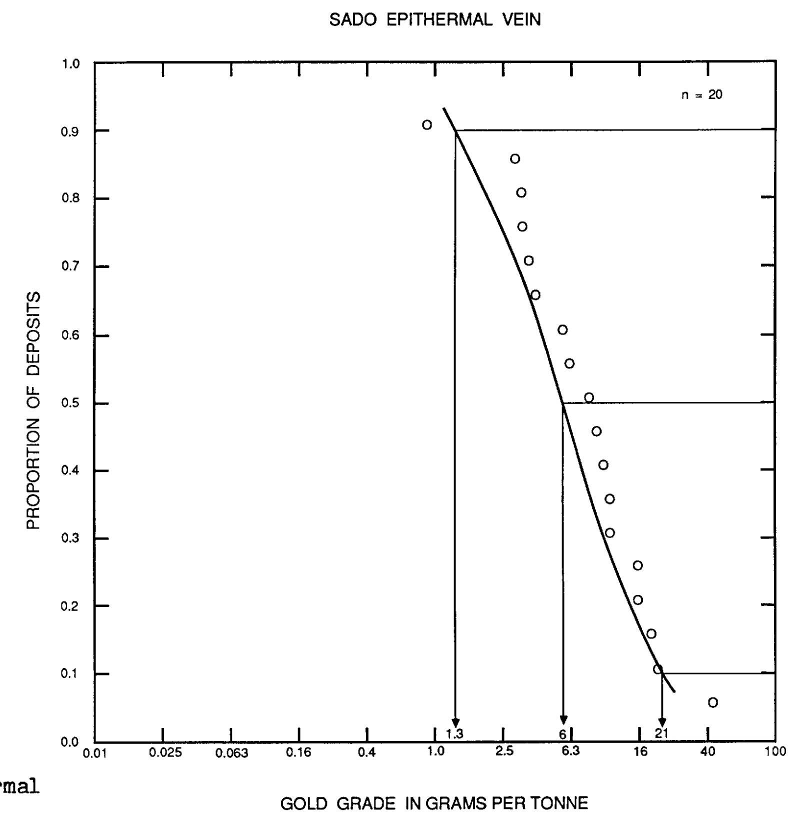

Figure 118. Gold grades of Sado epithermal vein deposits.

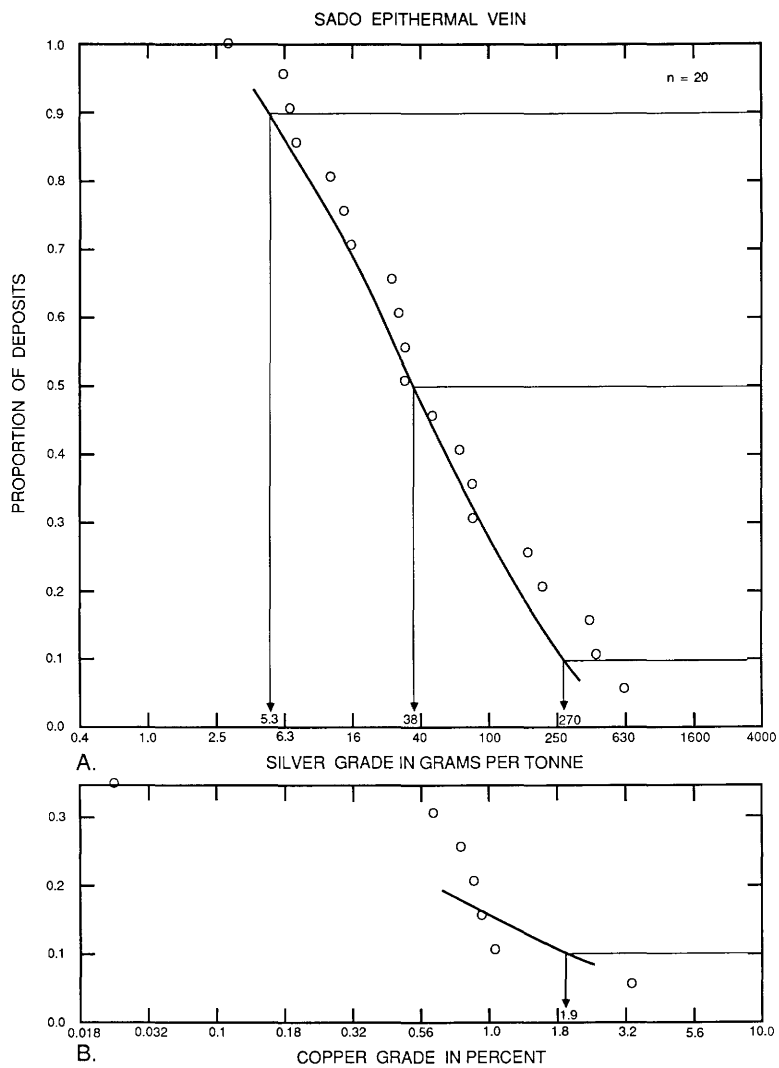

Figure 119. By-product grades of Sado epithermal vein deposits. A, Silver. B, Copper.

DESCRIPTIVE MODEL OF EPITHERMAL QUARTZ-ALUNITE Au

By Byron R. Berger

APPROXIMATE SYNONYM Acid-sulfate, or enargite gold (Ashley, 1982).

DESCRIPTION Gold, pyrite, and enargite in vuggy veins and breccias in zones of high-alumina alteration related to felsic volcanism.

GENERAL REFERENCE Ashley (1982).

GEOLOGICAL ENVIRONMENT

Rock Types Volcanic: dacite, quartz latite, rhyodacite, rhyolite. Hypabyssal intrusions or domes.

Textures Porphyritic.

Age Range Generally Tertiary, but can be any age.

Depositional Environment Within the volcanic edifice, ring fracture zones of calderas, or areas of igneous activity with sedimentary evaporites in basement.

Tectonic Setting(s) Through-going fracture systems: keystone graben structures, ring fracture zones, normal faults, fractures related to doming, joint sets.

Associated Deposit Types Porphyry copper, polymetallic replacement, volcanic hosted Cu-As-Sb. Pyrophyllite, hydrothermal clay, and alunite deposits.

DEPOSIT DESCRIPTION

Mineralogy Native gold + enargite + pyrite + silver-bearing sulfosalts ± chalcopyrite ± bornite ± precious-metal tellurides ± galena ± sphalerite ± huebnerite. May have hypogene oxidation phase with chalcocite + covellite ± luzonite with late-stage native sulfur.

Texture/Structure Veins, breccia pipes, pods, dikes; replacement veins often porous, and vuggy, with comb structure, and crustified banding.

Alteration Highest temperature assemblage: quartz + alunite + pyrophyllite may be early stage with pervasive alteration of host rock and veins of these minerals; this zone may contain corundum, diaspore, andalusite, or zunyite. Zoned around quartz-alunite is quartz + alunite + kaolinite + montmorillonite; pervasive propylitic alteration (chlorite + calcite) depends on extent of early alunitization. Ammonium-bearing clays may be present.

Ore Controls Through-going fractures, centers of intrusive activity. Upper and peripheral parts of porphyry copper systems.

Weathering Abundant yellow limonite, jarosite, goethite, white argillization with kaolinite, fine-grained white alunite veins, hematite.

Geochemical Signature Higher in system: Au + As + Cu; increasing base metals at depth. Also Te and (at El Indio) W.

EXAMPLES

Goldfield, USNV	(Ransome, 1909)
Kasuga mine, JAPN	(Taneda and Mukaiyama, 1970)
El Indio, CILE	(Walthier and others, 1982)
Summitville, USCO	(Perkins and Nieman, 1983)
Iwato, JAPN	(Saito and Sato, 1978)

GRADE AND TONNAGE MODEL OF EPITHERMAL QUARTZ-ALUNITE Au

By Dan L. Mosier and W. David Menzie

COMMENTS See figs. 120-123.

DEPOSITS

Name	Country
Chinkuashih	TIWN
El Indio	CILE
Goldfield	USNV
Iwato	JAPN
Kasuga	JAPN
Masonic	USCA
Mohave	USCA
Stedman	USCA

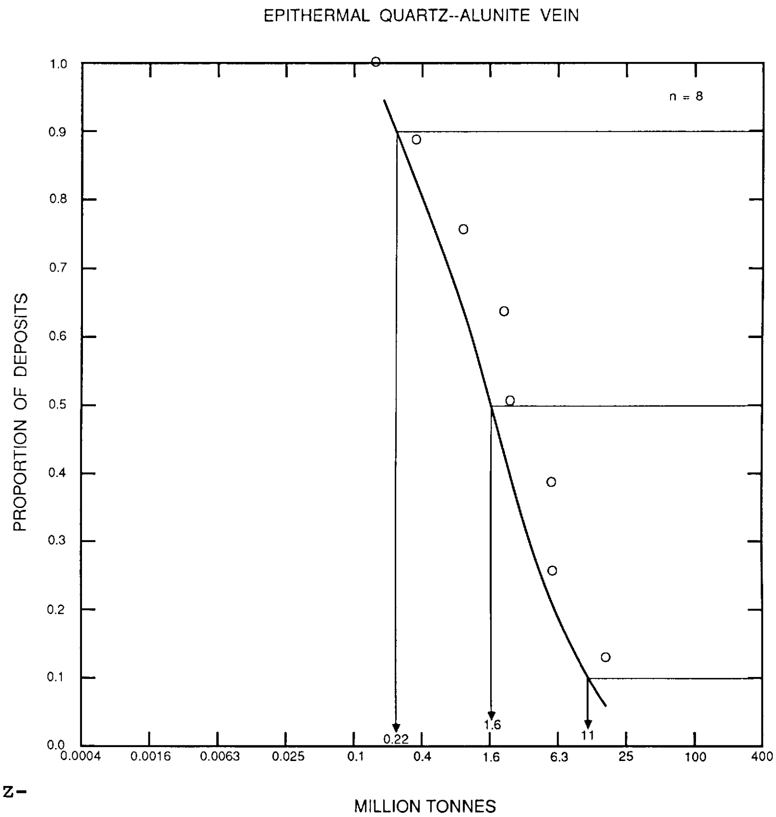

Figure 120. Tonnages of epithermal quartz-alunite vein deposits.

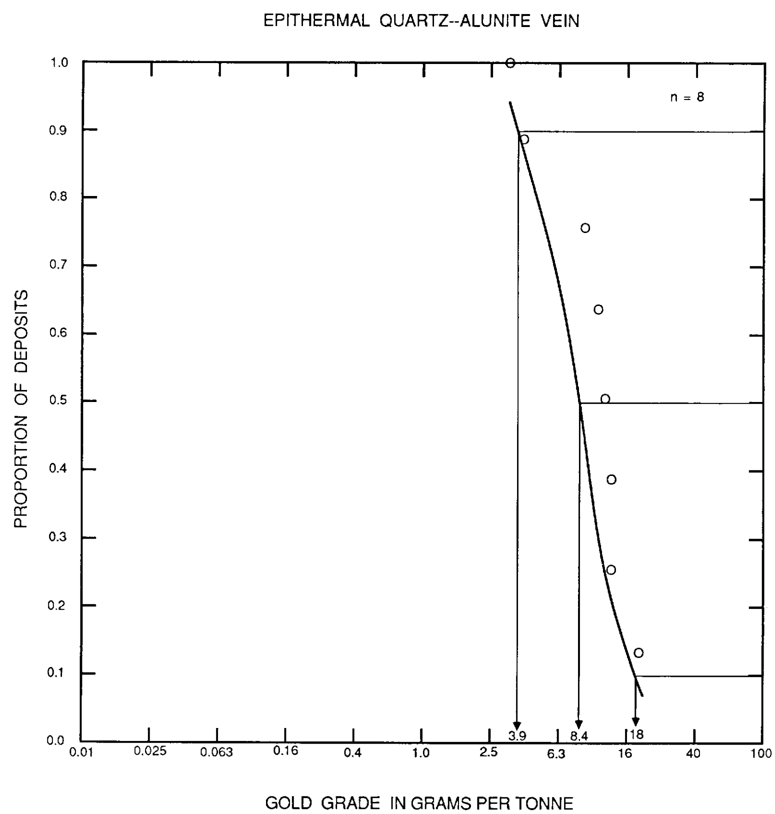

Figure 121. Gold grades of epithermal quartz-alunite vein deposits.

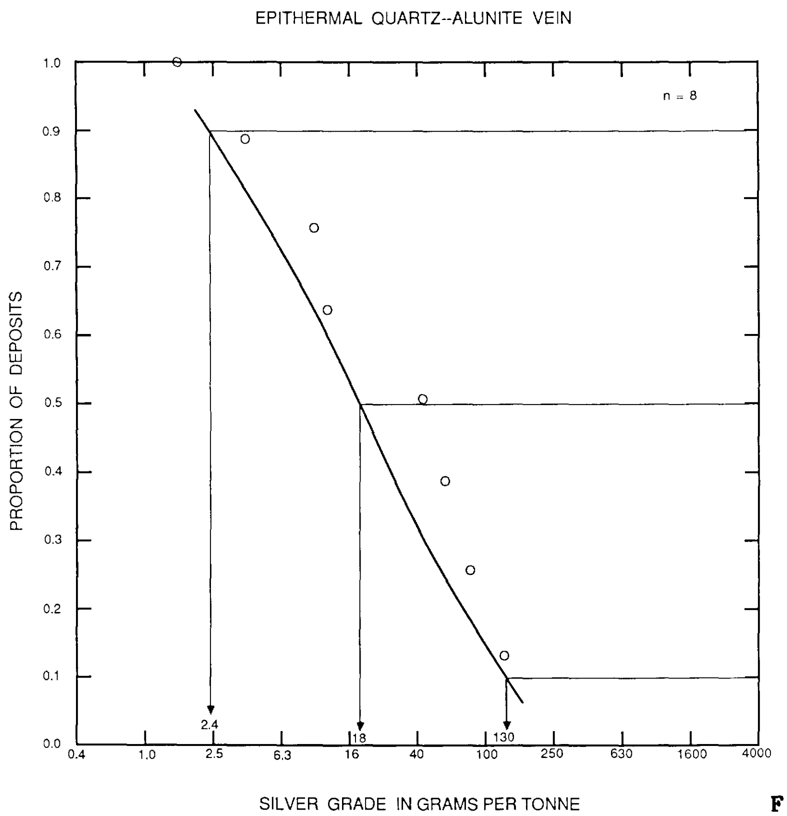

Figure 122. Silver grades of epithermal quartz-alunite vein deposits.

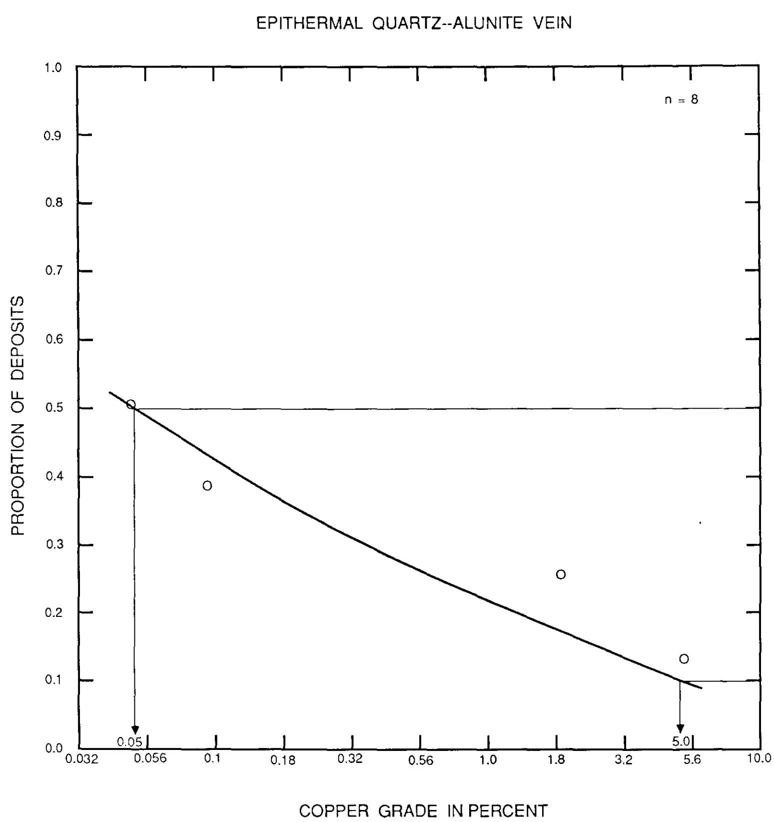

Figure 123. Copper grades of epithermal quartz-alunite vein deposits.

Model 25f

DESCRIPTIVE MODEL OF VOLCANOGENIC U

By William C. Bagby

DESCRIPTION Uranium mineralization in epithermal veins composed of quartz, fluorite, and iron, arsenic, and molybdenum sulfides.

GENERAL REFERENCE Nash (1981).

GEOLOGICAL ENVIRONMENT

Rock Types High-silica alkali rhyolite and potash trachytes. Peralkaline and peraluminous rhyolite host ore.

Textures Porphyritic to aphyric vesicular flows and shallow intrusive rocks.

Age Range Precambrian to Tertiary.

Depositional Environment Subaerial to subaqueous volcanic complexes. Near-surface environment, association with shallow intrusive rocks is important.

Tectonic Setting(s) Continental rifts and associated calderas.

Associated Deposit Types Roll-front uranium in volcaniclastic sediments. Fluorite deposits.

DEPOSIT DESCRIPTION

Mineralogy Coffinite, uraninite, brannerite are most common uranium minerals. Other minerals include pyrite, realgar/orpiment, leucoxene, molybdenite, fluorite, quartz, adularia, and barite. Gold is present in some deposits. Deposits associated with alkaline complexes may contain bastnaesite.

Texture/Structure Open-space filling in breccias. Uraninite commonly encapsulated in silica.

Alteration Kaolinite, montmorillonite, and alunite are common. Silicification, accompanied by adularia, affects wallrocks spatially most closely associated with ore.

Ore Controls Through-going fractures and breccias formed along the margins of shallow intrusives. Vugs in surface flows are of minor importance.

Weathering Near-surface oxidation produces jordisite and a variety of secondary uranium minerals. Supergene uranium enrichment is generally not important.

Geochemical Signature Li and Hg are zoned away from the ore. High anomalous As, Sb, F, Mo ± W occur near and with the ore. Mo is deep, Hg is shallow. REE may be highly anomalous. Anomalously radioactive.

EXAMPLES

Marysvale, USUT	(Kerr and others, 1957)
Aurora prospect, USOR	(Roper and Wallace, 1981)
Rexspar, CNBC	(Joubin and James, 1956)

GRADE AND TONNAGE MODEL OF VOLCANOGENIC U

By Dan L. Mosier

COMMENTS Only deposits with reported sizes greater than 1,000 tonnes are included. See figs. 124, 125.

DEPOSITS

Name	Country	Name	Country
Aurora	USOR	Los Puertos	MXCO
Ben Lomond	AUQL	Lucky Lass	USOR
Bretz	USOR	Macusani	PERU
Buckhorn	USNV	Moonlight	USNV
Coteje	BLVA	Nopal III	MXCO
El Mezquite	MXCO	Novazza	ITLY
El Nopal (Nopal I)	MXCO	Osamu Utsumi	BRZL
Henry district	USUT	Petersen Mtn.	USCA
La Bajada	USNM	Rexspar	CNBC
Laguna Colorado	AGTN	White King	USOR
Laguna del Cuervo	MXCO		

Model 25f--Con.

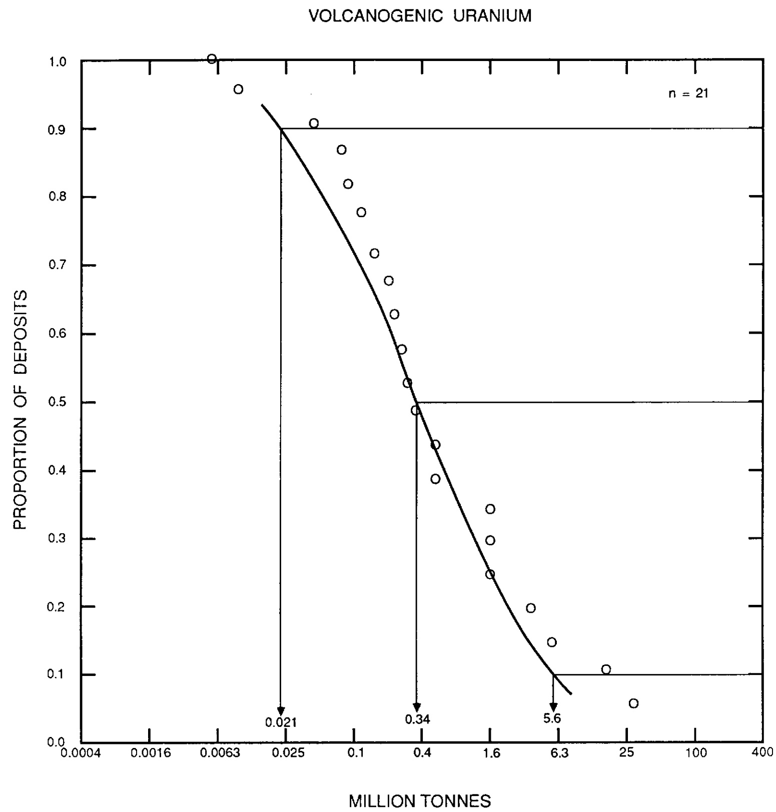

Figure 124. Tonnages of volcanogenic U deposits.

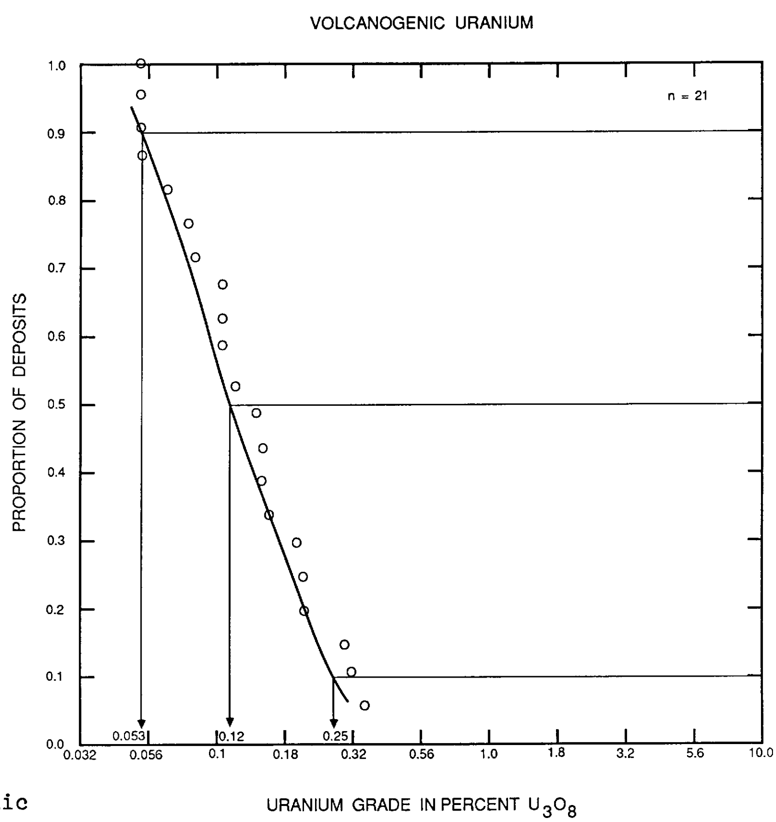

Figure 125. Uranium grades of volcanogenic U deposits.

DESCRIPTIVE MODEL OF EPITHERMAL Mn

By Dan L. Mosier

DESCRIPTION Manganese mineralization in epithermal veins filling faults and fractures in subaerial volcanic rocks.

GEOLOGICAL ENVIRONMENT

Rock Types Flows, tuffs, breccias, and agglomerates of rhyolitic, dacitic, andesitic or basaltic composition.

Age Range Tertiary.

Depositional Environment Volcanic centers.

Tectonic Setting(s) Through-going fracture systems.

Associated Deposit Types Epithermal gold-silver.

DEPOSIT DESCRIPTION

Mineralogy Rhodochrosite, manganocalcite, calcite, quartz, chalcedony, barite, zeolites.

Texture/Structure Veins, bunches, stringers, nodular masses, disseminations.

Alteration Kaolinitization.

Ore Controls Through-going faults and fractures; brecciated volcanic rocks.

Weathering Oxidization zone contains abundant manganese oxides, psilomelane, pyrolusite, braunite, wad, manganite, cryptomelane, hollandite, coronadite, and Fe oxides.

Geochemical Signature Mn, Fe, P(Pb, Ag, Au, Cu). At Talamantes W is important.

EXAMPLES

Talamantes, MXCO	(Rocha and Wilson, 1948)
Gloryana, USNM	(Farnham, 1961)
Sardegna, ITLY	(Burckhardt and Falini, 1956)

GRADE AND TONNAGE MODEL OF EPITHERMAL Mn

By Dan L. Mosier

COMMENTS See figs. 126-127.

DEPOSITS

Name	Country	Name	Country
Abra Negra	MXCO	Murguia	MXCO
Armour Group	USAZ	Nacozari	MXCO
Atenguillo	MXCO	Niggerhead	USNM
Black Crow-San Juan	USNM	Oviachic 1&2	MXCO
California Group	USAZ	Phillips Lease	USNM
Casa de Janos	MXCO	Pito Real	MXCO
Casas Grandes	MXCO	Red Hill-Red Hill Ext.	USNM
Ciudad Obregon	MXCO	St. Pietro	ITLY
Cliff Roy	USNM	San Bernardo	MXCO
Estacion Llanos	MXCO	San Miguel El Alto	MXCO
Gloryana	USNM	Santa Ana	MXCO
Griffith	USNM	Sardegna	ITLY
Hatton	USAZ	Satevo	MXCO
J.M. Meadows Group	USAZ	Selimiye	TRKY
JVB Claim	USNM	Shag Rock	CNBC
Karangnunggal	INDS	Sierra de El Alto	MXCO
Karatas	TRKY	Sierra de Enmedio	MXCO
Kliripan	INDS	Sierra Los Organos	MXCO
Lajas	MXCO	Soto	MXCO
La Leona	MXCO	Talamantes	MXCO
La Noria	MXCO	Terrenates	MXCO
Las Varas-La Vaca	MXCO	Thurston & Hardy	USAZ
Los Borregos	MXCO	Topock	USAZ
Los Volcanes	MXCO	Turfullar	TRKY
M and M Group	USNM	U.S. Group	USAZ
Manganese Chief	USNM	Viterbo-Roma	ITLY
Manganese Development	USAZ	West Niggerhead	USNM
Matamoros	MXCO	Yahualica	MXCO
Mezcala	MXCO	Zacate-Cerro Chino	MXCO
Montosa	MXCO		

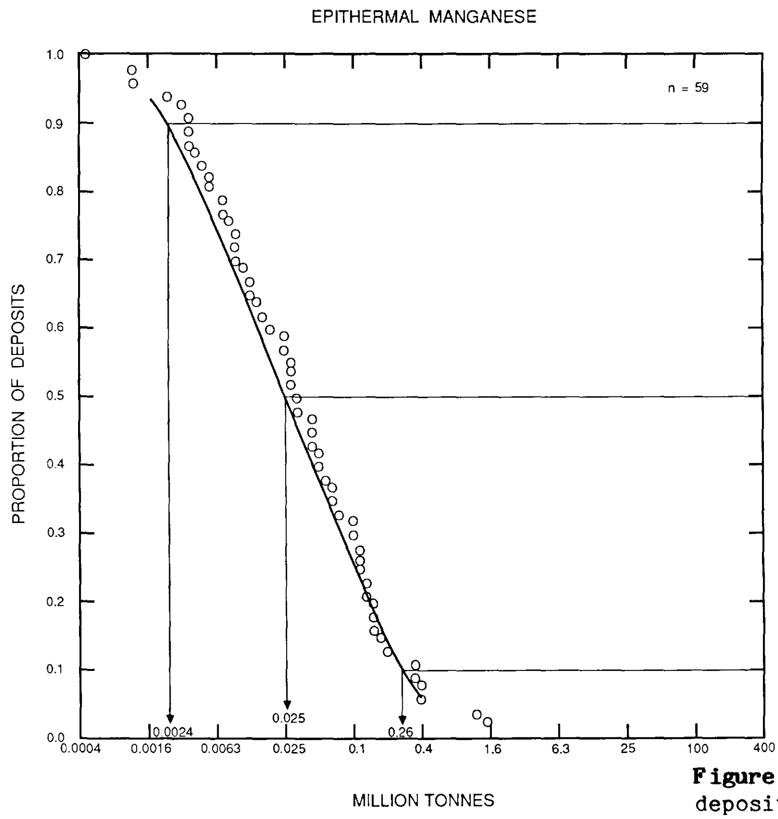

Figure 126. Tonnages of epithermal Mn deposits.

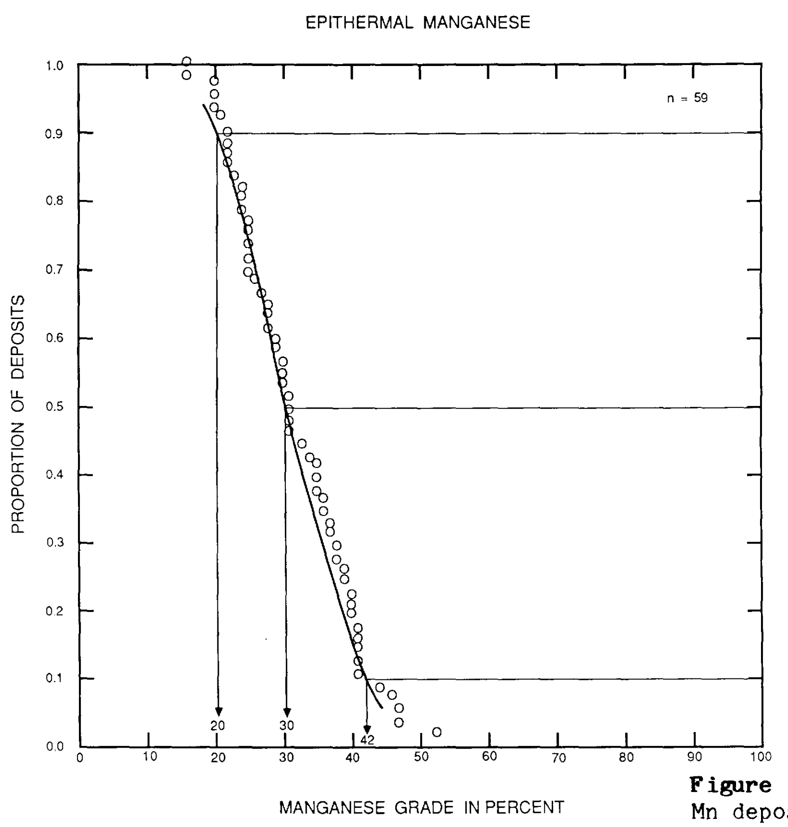

Figure 127. Manganese grades of epithermal Mn deposits.

Model 25h

DESCRIPTIVE MODEL OF RHYOLITE-HOSTED Sn

By Bruce L. Reed, Wendell Duffield, Stephen D. Ludington, Charles H. Maxwell, and Donald H. Richter

APPROXIMATE SYNONYM Mexican-type.

DESCRIPTION Cassiterite and wood tin in discontinuous veinlets in rhyolite flow-dome complexes and derivative placers (see fig. 128).

GENERAL REFERENCES Lee-Moreno (1980), Huspeni and others (1984).

GEOLOGICAL ENVIRONMENT

Rock Types Alkali-feldspar rhyolite with SiO_2 >75 percent; includes topaz rhyolites of Burt and others (1982) and Christiansen and others (1983). Distinctive accessory minerals may include topaz, fluorite, bixbyite, pseudobrookite, and beryl. Petrochemical signature similar to Climax Mo.

Textures Crystal-poor (5 percent) to crystal-rich (50 percent) rhyolite with quartz and sanidine phenocrysts; rare fayalite, biotite, or hornblende may be present.

Age Range Tertiary; chiefly Oligocene and Miocene.

Depositional Environment Rhyolite flow-dome complexes and related pyroclastic and epiclastic rocks.

Tectonic Setting(s) Silicic volcanic fields, generally in areas of thick continental crust.

Associated Deposit Types None are known, but based on geochemical similarity of associated magmas, these may be a surface expression of Climax Mo.

DEPOSIT DESCRIPTION

Mineralogy Cassiterite (including wood tin) plus hematite (characteristically specularite) ± cristobalite, fluorite, tridymite, opal, chalcedony, beudantite, mimetite, adularia, durangite, and zeolite minerals.

Texture/Structure Most commonly as 0.1- to 10-cm-wide discontinuous veins and veinlets whose other dimensions seldom exceed 75 m. These veins and veinlets may be clustered in zones of somewhat greater dimension. Cassiterite also occurs as disseminations in the matrix of rhyolite flows or fault breccias. These two types of deposits are part of a continuum.

Alteration May be absent; tin may or may not occur in large areas of vapor-phase alteration (tridymite, sanidine, hematite, ± pseudobrookite); alteration directly associated with mineralization may include cristobalite, fluorite, smectite, kaolinite, and other clay minerals.

Ore Controls Deposits are generally in the fractured and brecciated outer parts of flow-dome complexes where permeability is high.

Weathering Weathering is generally minor, but a translucent red-orange clay mineral (smectite) is present in most deposits.

Geochemical Signature Dispersion of associated elements (Sn, Fe, Be, Li, F, As, Sb, Pb, Zn, Bi, REE) in rock is minimal. Best exploration guide is presence of high concentrations of tin (>1,000 ppm) in pan concentrate samples. Cassiterite in stream sediments is usually restricted to within 2-3 km of tin deposits.

Examples

Black Range, USNM	(Fries, 1940; Lufkin, 1972)
Mexico deposits	(Foshag and Fries, 1942; Smith and others, 1950; Ypma and Simons, 1969; Pan, 1974; Lee-Moreno, 1980)

GRADE AND TONNAGE MODEL OF RHYOLITE-HOSTED Sn

By Donald A. Singer and Dan L. Mosier

COMMENTS See figs. 129-130.

DATA REFERENCES Bracho (1960, 1961).

COMMENTS Grade and tonnage estimates were based on reserves. Tonnage is significantly correlated with tin grades (r = 0.36).

DEPOSITS

Name	Country	Name	Country
Arguilillas	MXCO	El Picacho	MXCO
Amigos	MXCO	El Pleito	MXCO
Arrieros #2	MXCO	El Polvillo	MXCO
Arrieros #3	MXCO	El Profesor	MXCO
Arrieros #4	MXCO	El Romadizo	MXCO
Arroyo Durango	MXCO	El Santo Nino	MXCO
Castrita	MXCO	El Socavon #4	MXCO
Catas de las Vacas	MXCO	El Socavon #5	MXCO
Catas el Durango	MXCO	El Socavon #6	MXCO
Cerro Blanco	MXCO	El Socavon #7	MXCO
Cerro Grande	MXCO	El Socavon #8	MXCO
Cerro Prieto, La Quemada, La Colocion	MXCO	El Tarango	MXCO
Chavarria	MXCO	El Venado	MXCO
Cordon Estaneros	MXCO	El Zanzon	MXCO
Don Teodoro	MXCO	Galvan	MXCO
El Abra	MXCO	Gavilancillos	MXCO
El Atascadero	MXCO	Grupos 1 & 2-Vendo W	MXCO
El Baluarte	MXCO	Grupos 3 & 4	MXCO
El Barroso	MXCO	Guadalupe	MXCO
El Borrego #1	MXCO	Hierbaniz	MXCO
El Borrego #2	MXCO	La Chapeteada	MXCO
El Calabrote	MXCO	La Chililla	MXCO
El Capulin	MXCO	La Chinche	MXCO
El Coloradillo	MXCO	La Chorrera	MXCO
El Corral	MXCO	La Cinta Corrida	MXCO
El Cristal	MXCO	La Cocona	MXCO
El Dorado	MXCO	La Desparramada	MXCO
El Duraznillo	MXCO	La Escondida	MXCO
El Durazno (El Aguila)	MXCO	La Esperanza (El Aguila)	MXCO
El Durazno (Juan Aldama)	MXCO	La Esperanza (La Ochoa)	MXCO
El Encino	MXCO	La Esperanza (Los Angeles)	MXCO
El Gotera	MXCO	La Estrella	MXCO
El Huacal	MXCO	La Guera	MXCO
El Indio, El Plieto, Tadeo, San Antonio	MXCO	La Hormiga	MXCO
El Ladrillo	MXCO	La Huacalona	MXCO
El Mamey	MXCO	La Leona	MXCO
El Naranjo, Buena Suerte	MXCO	La Loba	MXCO
El Noladero	MXCO	La Liendre	MXCO
El Nopal (Juan Aldama)	MXCO	La Mula	MXCO
El Nopal (La Ochoa)	MXCO	La Polvosa	MXCO
El Penasco	MXCO	La Puntilla	MXCO
El Perdido	MXCO	Las Aguilas	MXCO
		Las Amarillas	MXCO
		Las Calaveras	MXCO
		Las Flores	MXCO
		Las Fundiciones	MXCO
		Las Marias	MXCO
		Las Pegazones	MXCO

Las Perlitas	MXCO	Mina del Aire	MXCO
Las Tablas	MXCO	Mina Dura	MXCO
La Triste	MXCO	Palo Colorado	MXCO
La Venadita	MXCO	Panchillo	MXCO
La Vibora	MXCO	Plan de Tecolotes	MXCO
La Victoria	MXCO	Potrero del Molino	MXCO
La Vieja-El Agua	MXCO	San Francisco	MXCO
Leoncitos	MXCO	San Humberto	MXCO
Loreto	MXCO	San Juanera	MXCO
Los Angeles	MXCO	San Rafael	MXCO
Los Arrieros	MXCO	San Ruperto	MXCO
Los Caballos	MXCO	Santa Efigenia	MXCO
Los Campamentos #1	MXCO	Santa Gertrudis	MXCO
Los Campamentos #2	MXCO	Santa Leonor	MXCO
Los Campamentos #3	MXCO	Santa Lucia	MXCO
Los Cuatillos	MXCO	Socorro-Guadalupe	MXCO
Los Garcia	MXCO	Sombreretillo	MXCO
Los Lobos	MXCO	Soto	MXCO
Los Pinacates	MXCO	Tecolotes	MXCO
Manga de Lopez	MXCO	Tolano	MXCO
Manzanillas	MXCO	Veta Blanca	MXCO
Metal Negro	MXCO		

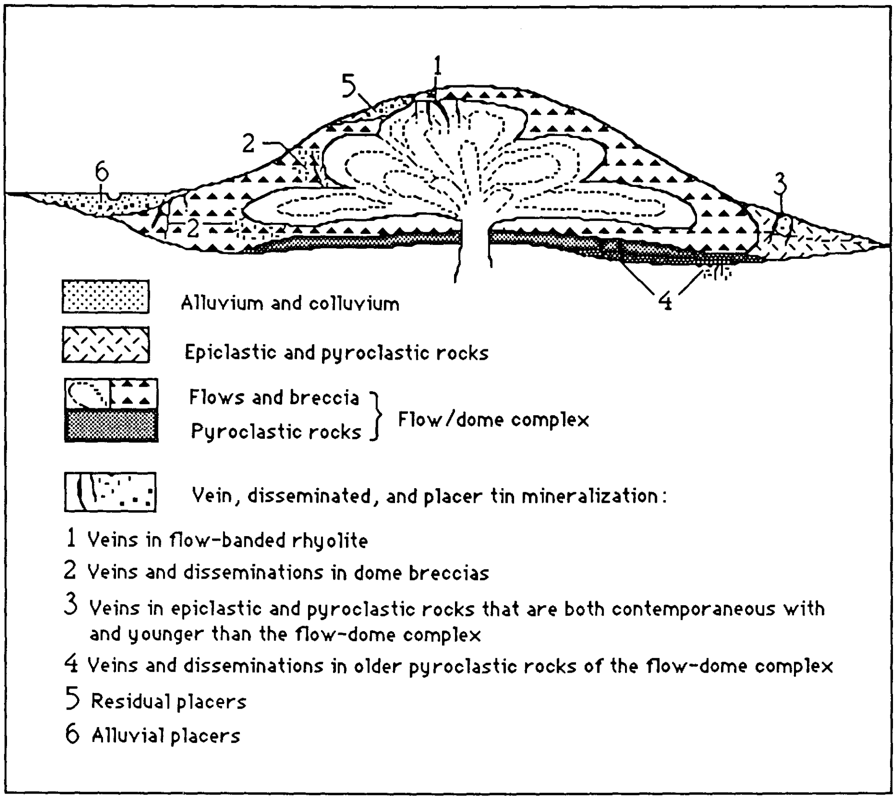

Figure 128. Cartoon cross section of rhyolite-hosted Sn deposit showing relationship of cassiterite concentrations to rhyolite dome.

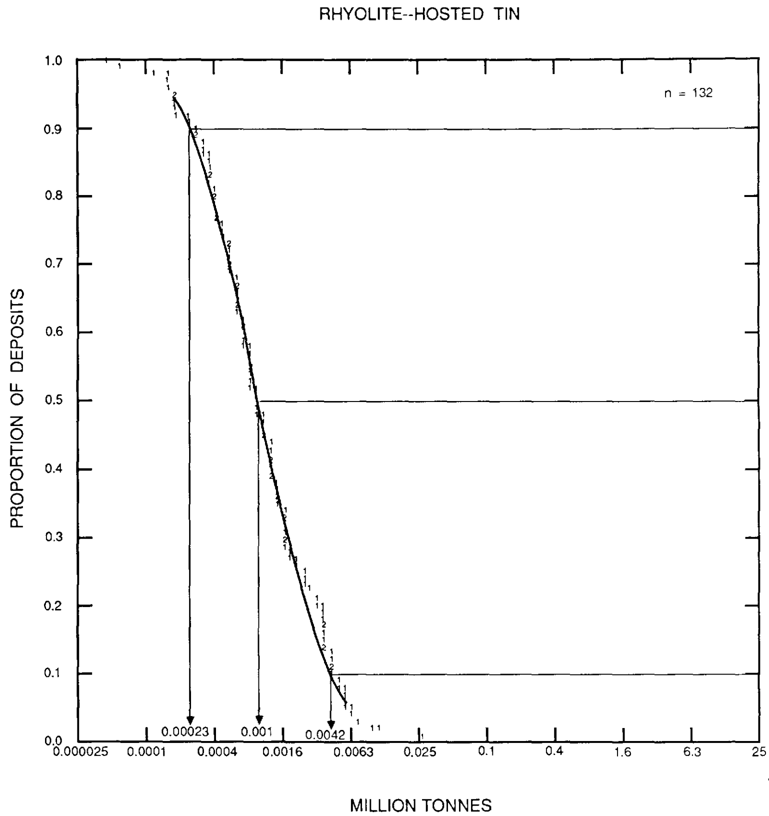

Figure 129. Tonnages of rhyolite-hosted Sn deposits. Individual digits represent number of deposits.

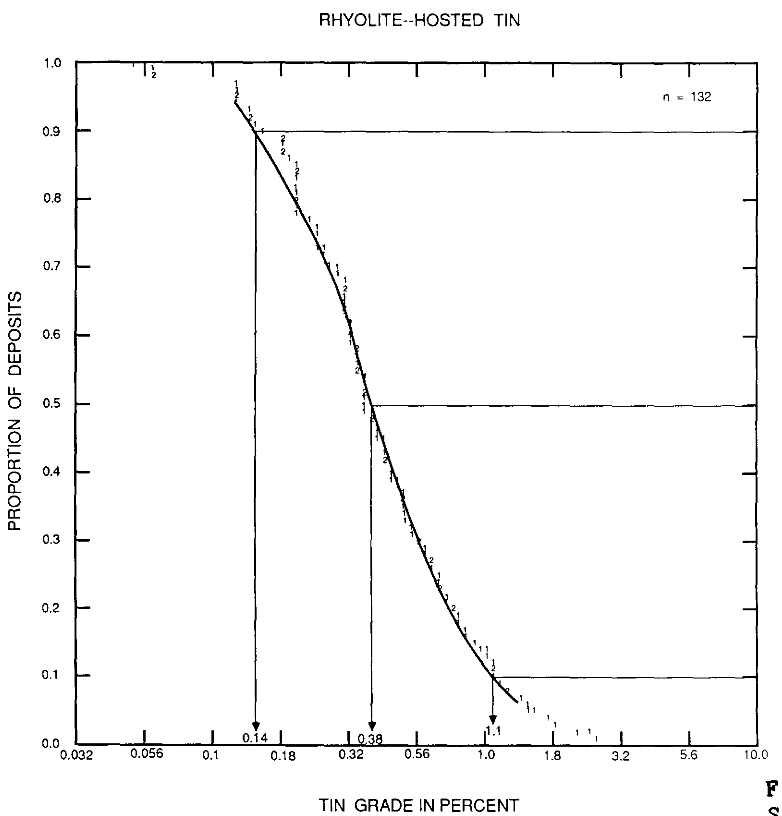

Figure 130. Tin grades of rhyolite-hosted Sn deposits. Individual digits represent number of deposits.

DESCRIPTIVE MODEL OF VOLCANIC-HOSTED MAGNETITE

By Dennis P. Cox

APPROXIMATE SYNONYM Porphyrite iron, Kiruna iron.

DESCRIPTION Massive concordant and discordant magnetite ore bodies in intermediate to alkalic volcanic rocks with actinolite or diopside alteration.

GEOLOGICAL ENVIRONMENT

Rock Types Andesitic to trachytic flows and subvolcanic intrusions, also at Kiruna, quartz porphyry, syenite porphyry, monzonite, and diorite.

Textures Porphyroaphanitic to fine- to medium-grained equigranular. Flows may be amygdaloidal.

Age Range Mesozoic to Holocene in circum-Pacific area. In Sweden and Missouri, 1,300-1,500 m.y.

Depositional Environment Continental volcanic rocks and clastic sediments intruded by subvolcanic intermediate plutons.

Tectonic Setting(s) Continental margin, subduction-related volcanic terrane. Especially with high-K volcanic rocks, possibly related to waning stages of volcanism.

Associated Deposit Types Sedimentary Fe in associated clastic rocks, apatite-magnetite deposits, hematite in quartz-sericite alteration, possible disseminated Au.

DEPOSIT DESCRIPTION

Mineralogy Magnetite + apatite. Rarely pyrite, chalcopyrite, chalcocite, and covellite. Ti is in sphene.

Texture/Structure Fine, granoblastic, skarn type textures.

Alteration Actinolite or diopside, andradite, biotite, quartz, albite, andesine, K-feldspar, sodic scapolite, epidote; carbonates, and locally, tourmaline, sphene, chlorite, barite, fluorite, kaolin, or sericite.

Ore Controls Magnetite in massive replacement, breccia filling and stockwork veins. Orebodies may be stratabound, concordant to intrusive contacts or in cross-cutting veins. Possibly related to cupolas of deeper plutons.

Geochemical and Geophysical Signature Fe, P, V, and minor Ba, F, Bi, Cu, Co; strong magnetic anomalies.

EXAMPLES

Kirunavaara, Sweden	(Frietsch 1982, 1978)
El Romeral, Chile	(Bookstrom, 1977)
Middle-Lower Yangtze Valley, CINA	(Research Group of Porphyrite Iron Ore, 1977)

GRADE AND TONNAGE MODEL OF VOLCANIC-HOSTED MAGNETITE

By Dan L. Mosier

COMMENTS Only deposits with abundant apatite are included. See figs. 131-133.

DEPOSITS

Name	Country	Name	Country
Arnold Hill	USNY	Cerro de Mercado	MXCO
Benson	USNY	Chador-Malu	IRAN

Chahehgaz	IRAN	Los Vasitos	MXCO
Choghart	IRAN	Luossauaara	SWDN
Ekstromberg	SWDN	Malmberget	SWDN
El Algarrobo	CILE	Minarets	USCA
El Dorado	CILE	Mineville-Port Henry	USNY
El Encino	MXCO	Modarelli	USNV
EL Romeral	CILE	Nakerivaara	SWDN
Grangesberg	SWDN	Northern Anomaly	IRAN
Gruvberget	SWDN	Painirova	SWDN
Guadalupe & Solis	MXCO	Pea Ridge	USMO
Hercules	MXCO	Ringwood	USNJ
Idkerberget	SWDN	Saghand	IRAN
Infiernillo	CILE	Savage River	AUTS
Joinville	BRZL	Se Chakhum	IRAN
Kiirunavaara	SWDN	Sterling Lake	USNY
La Grulla	MXCO	Tjarrojakka	SWDN
La Perla-La Negra	MXCO	Unnamed	MXCO
Leveaniemi	SWDN		

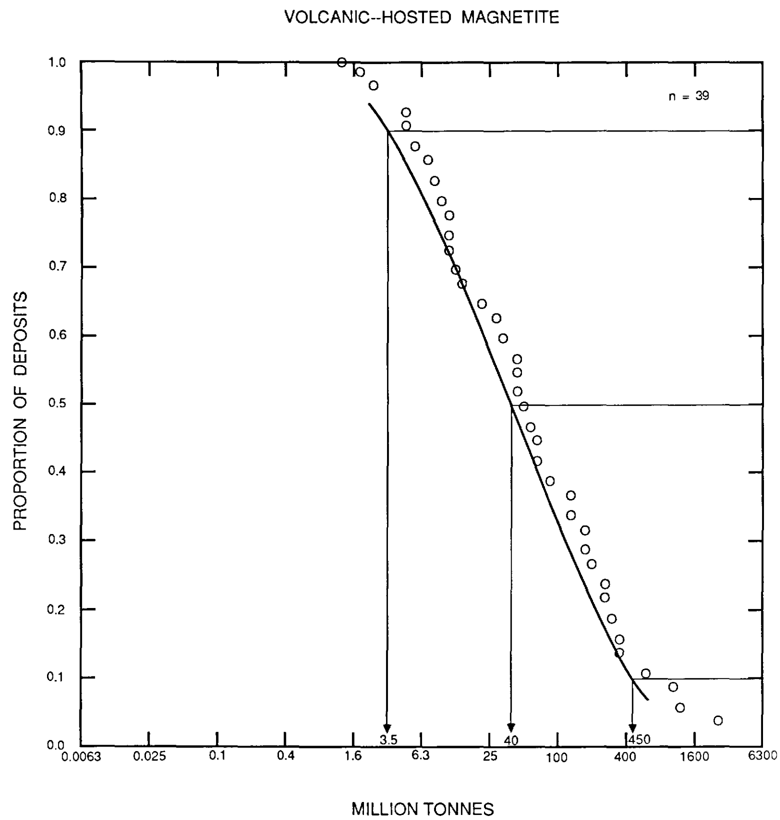

Figure 131. Tonnages of volcanic-hosted magnetite deposits.

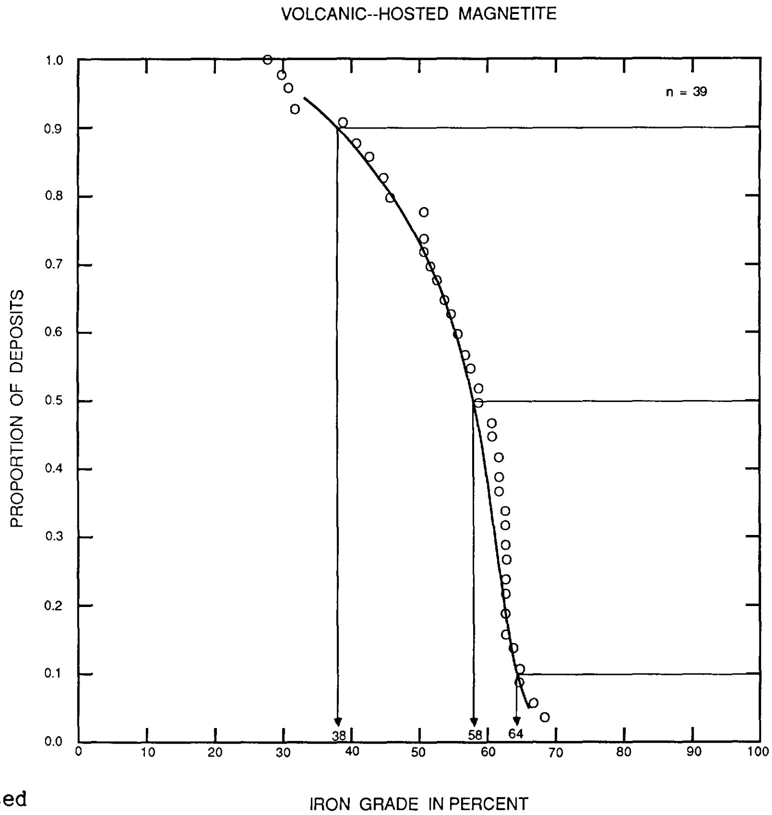

Figure 132. Iron grades of volcanic-hosted magnetite deposits.

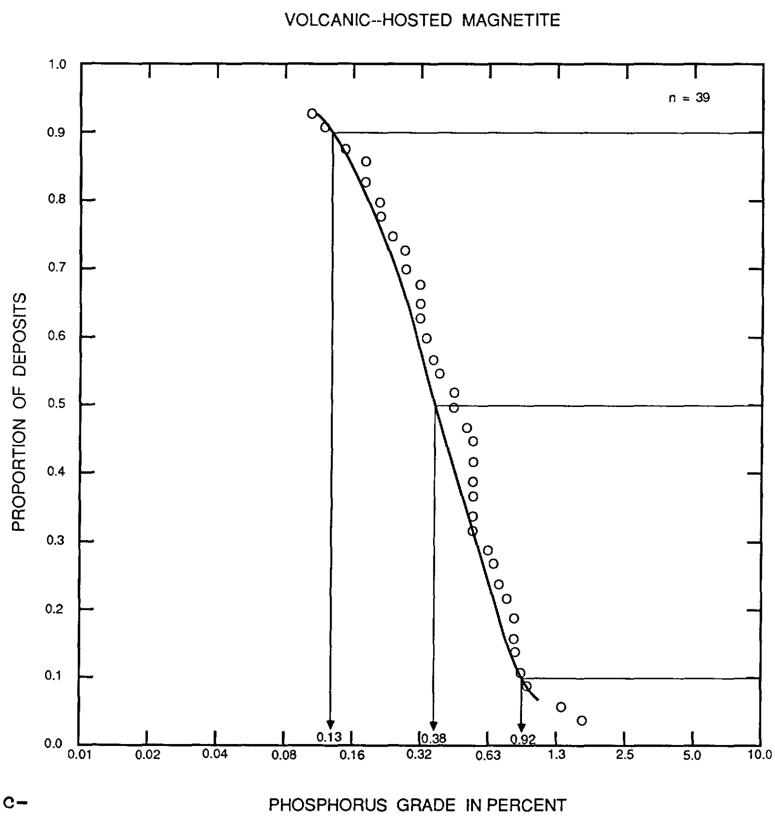

Figure 133. Phosphorus grades of volcanic-hosted magnetite deposits.

DESCRIPTIVE MODEL OF CARBONATE-HOSTED Au-Ag

By Byron R. Berger

APPROXIMATE SYNONYM Carlin-type or invisible gold.

DESCRIPTION Very fine grained gold and sulfides disseminated in carbonaceous calcareous rocks and associated jasperoids.

GENERAL REFERENCE Tooker (1985).

GEOLOGICAL ENVIRONMENT

Rock Types Host rocks: thin-bedded silty or argillaceous carbonaceous limestone or dolomite, commonly with carbonaceous shale. Intrusive rocks: felsic dikes.

Textures Dikes are generally porphyritic.

Age Range Mainly Tertiary, but can be any age.

Depositional Environment Best host rocks formed as carbonate turbidites in somewhat anoxic environments. Deposits formed where these are intruded by igneous rocks under nonmarine conditions.

Tectonic Setting(s) High-angle normal fault zones related to continental margin rifting.

Associated Deposit Types W-Mo skarn, porphyry Mo, placer Au, stibnite-barite veins.

DEPOSIT DESCRIPTION

Mineralogy Native gold (very fine grained) + pyrite + realgar + orpiment ± arsenopyrite ± cinnabar ± fluorite ± barite ± stibnite. Quartz, calcite, carbonaceous matter.

Texture/Structure Silica replacement of carbonate. Generally less than 1 percent fine-grained sulfides.

Alteration Unoxidized ore: jasperoid + quartz + illite + kaolinite + calcite. Abundant amorphous carbon locally appears to be introduced. Hypogene oxidized ore: kaolinite + montmorillonite + illite + jarosite + alunite. Ammonium clays may be present.

Ore Controls Selective replacement of carbonaceous carbonate rocks adjacent to and along high-angle faults, or regional thrust faults or bedding.

Weathering Light-red, gray, and (or) tan oxides, light-brown to reddish-brown iron-oxide-stained jasperoid.

Geochemical Signature: Au + As + Hg + W ± Mo; As + Hg + Sb + Tl ± F (this stage superimposed on preceding); NH_3 important in some deposits.

EXAMPLES

Carlin, USNV	(Radtke and others, 1980)
Getchell, USNV	(Joralemon, 1951)
Mercur, USUT	(Gilluly, 1932)

GRADE AND TONNAGE MODEL OF CARBONATE-HOSTED Au-Ag

By William C. Bagby, W. David Menzie, Dan L. Mosier, and Donald A. Singer

COMMENTS See figs. 134-135

Model 26a--Con.

DEPOSITS

Name	Country	Name	Country
Alligator Ridge	USNV	Jerritt Canyon	USNV
Atlanta	USNV	Maggie Creek	USNV
Blue Star	USNV	Mercur	USUT
Carlin	USNV	Northumberland	USNV
Cortez	USNV	Pinson	USNV
Dee	USNV	Preble	USNV
Emigrant Springs #1	USNV	Rain	USNV
Emigrant Springs #2	USNV	Relief Canyon	USNV
Florida Canyon	USNV	Roberts Mtns. Dist.	USNV
Getchell	USNV	Santa Fe	USNV
Giltedge	USMT	Standard	USNV
Gold Bar	USNV	Toiyabe	USNV
Gold Acres	USNV	Tolman	USID
Gold Quarry	USNV	Tonkin Springs	USNV
Horse Canyon	USNV	Windfall	USNV

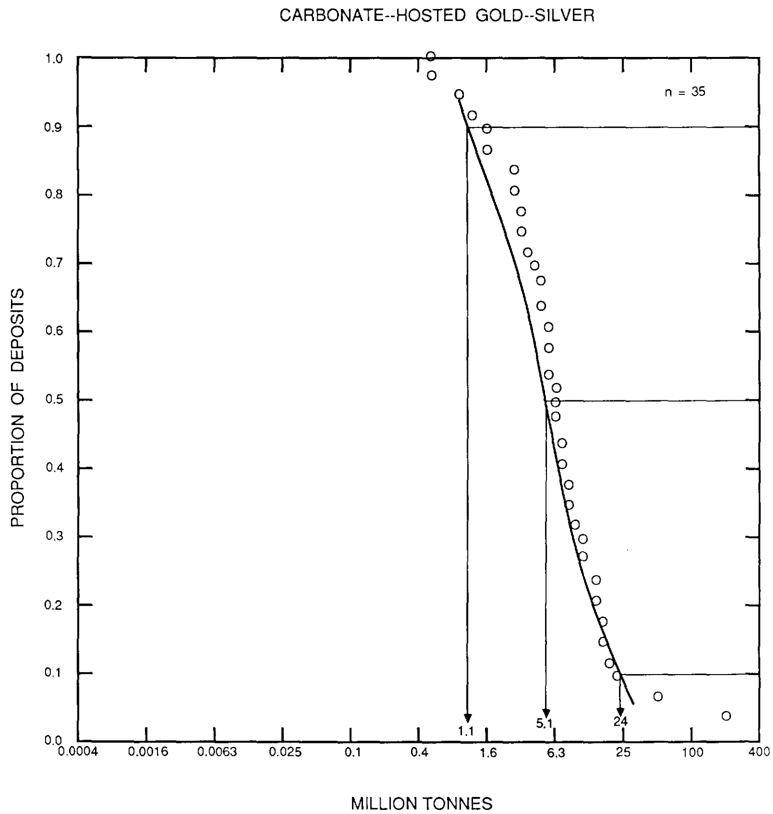

Figure 134. Tonnages of carbonate-hosted Au-Ag deposits.

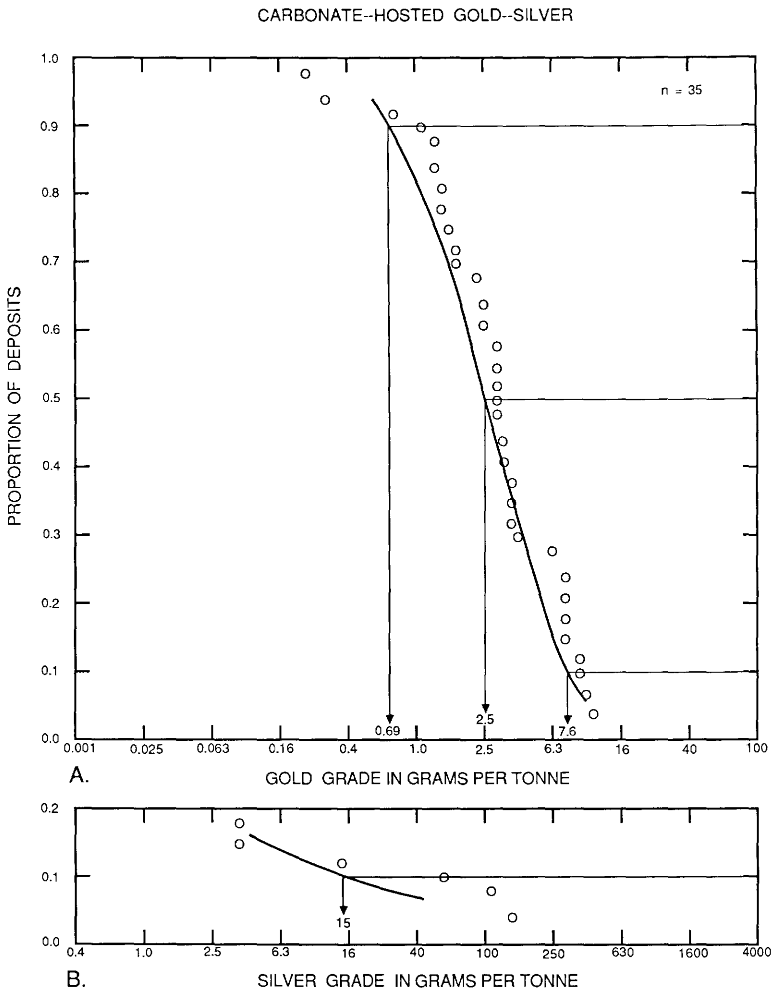

Figure 135. Precious-metal grades of carbonate-hosted Au-Ag deposits. A, Gold. B, Silver.

DESCRIPTIVE MODEL OF HOT-SPRING Hg

By James J. Rytuba

APPROXIMATE SYNONYM Sulphur Bank type of White (1981) or sulfurous type of Bailey and Phoenix (1944).

DESCRIPTION Cinnabar and pyrite disseminated in siliceous sinter superjacent to graywacke, shale, andesite, and basalt flows and diabase dikes.

GEOLOGICAL ENVIRONMENT

Rock Types Siliceous sinter, andesite-basalt flows, diabase dikes, andesitic tuffs, and tuff breccia.

Age Range Tertiary.

Depositional Environment Near paleo ground-water table in areas of fossil hot-spring system.

Tectonic Setting(s) Continental margin rifting associated with small volume mafic to intermediate volcanism.

Associated Deposit Types Hot-spring Au.

DEPOSIT DESCRIPTION

Mineralogy Cinnabar + native Hg + minor marcasite.

Texture/Structure Disseminated and coatings on fractures in hot-spring sinter.

Alteration Above paleo ground-water table, kaolinite-alunite-Fe oxides, native sulfur; below paleo ground-water table, pyrite, zeolites, potassium feldspar, chlorite, and quartz. Opal deposited at the paleo water table.

Ore Controls Paleo ground-water table within hot-spring systems developed along high-angle faults.

Geochemical Signature Hg + As + Sb ± Au.

EXAMPLES

Sulfur bank, USCA (White and Roberson, 1962)

GRADE AND TONNAGE MODEL OF HOT-SPRING Hg

By James J. Rytuba

COMMENTS See figs. 136, 137.

DEPOSITS

Name	Country	Name	Country
B and B	USNV	Idaho Almaden	USID
Baldwin	USNV	Mahattan	USCA
Bretz	USOR	McDermitt	USNV
Butte	USNV	Nevada Sulphur co.	USNV
Coleman	USNV	Opalite	USOR
Cordero	USNV	Rim Rock and Homestake	USNV
F and L Mine	USNV	Silver Cloud	USNV
Glass Butte	USOR	Steamboat Springs	USNV
Goldbanks	USNV	Sulphur Bank	USCA
Governor	USNV	Walibu	USCA

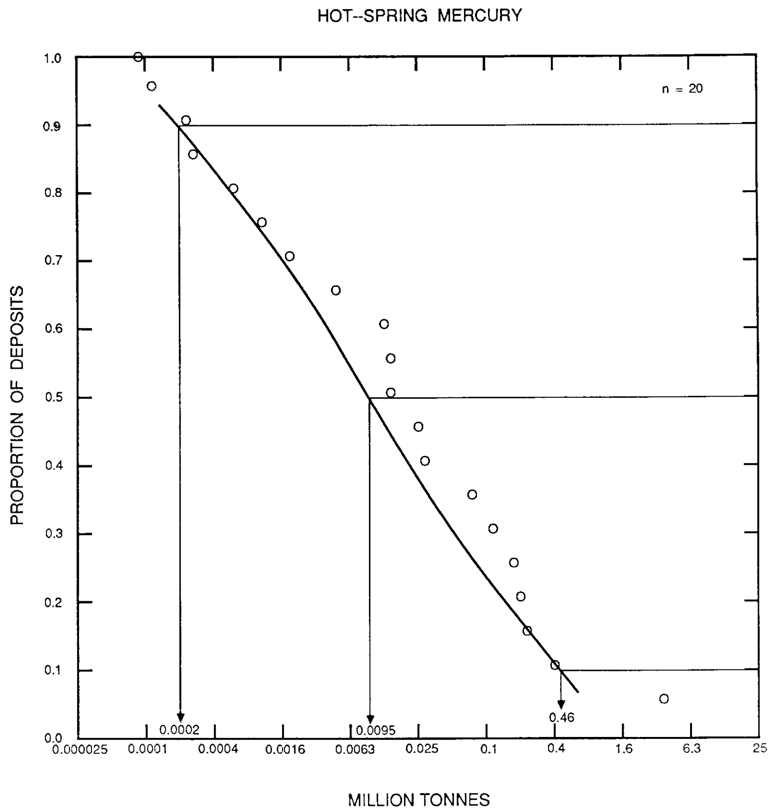

Figure 136. Tonnages of hot-spring Hg deposits.

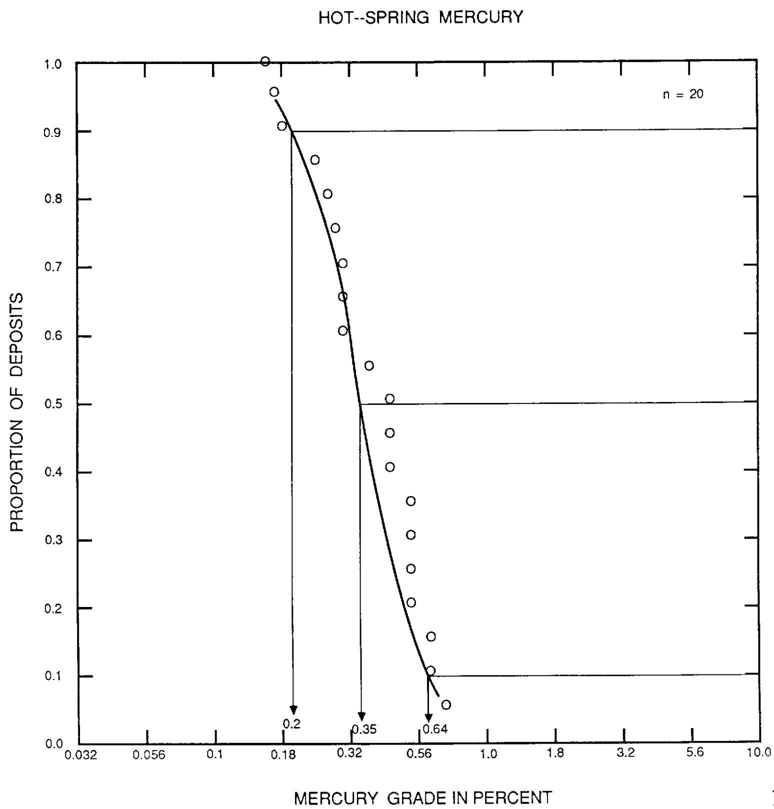

Figure 137. Mercury grades of hot-spring Hg deposits.

Model 27b

DESCRIPTIVE MODEL OF ALMADEN Hg

By James J. Rytuba

APPROXIMATE SYNONYM Almaden type.

DESCRIPTION Stratabound disseminated cinnabar and native mercury in volcaniclastic sedimentary rocks.

GENERAL REFERENCE Saupe (1973).

GEOLOGICAL ENVIRONMENT

Rock Types Unmetamorphosed shale, graywacke, calcareous graywacke, andesitic lava and tuff, andesite dikes. Volcanic vent breccia.

Age Range Almaden is Silurian, but deposits may be any age.

Depositional Environment Permeable sedimentary rocks, andesite dikes possibly near volcanic center.

Tectonic Setting(s) Volcanic centers along major deep-seated fault zone. Absence of regional metamorphism or plutonism following mineralization.

Associated Deposit Types Stibnite veins.

DEPOSIT DESCRIPTION

Mineralogy Cinnabar ± native mercury + pyrite + calcite + quartz.

Texture/Structure Disseminated.

Ore Controls Mineralized zone follows major fault, highest grade ore in calcareous graywacke.

Geochemical Signature Hg, As, Sb.

EXAMPLES

Almaden, SPAN	(Saupe, 1973)
Santa Barbara, PERU	(Berry and Singewald, 1922)
Nueva Esperanza, CLBA	(Lozano and others, 1977)

DESCRIPTIVE MODEL OF SILICA-CARBONATE Hg

By James J. Rytuba

APPROXIMATE SYNONYM New Almaden type.

DESCRIPTION Cinnabar at contact of serpentine and siltstone-graywacke above subduction-related thrust.

GENERAL REFERENCE Bailey (1964).

GEOLOGICAL ENVIRONMENT

Rock Types Serpentine, siltstone-graywacke.

Age Range Tertiary.

Depositional Environment Serpentinized intrusive rocks (sills and dikes) into siltstone, and graywacke and siltstone, fractures in altered serpentine.

Tectonic Setting(s) Deposits occur in accreted terrane above subduction-related thrust fault.

Associated Deposit Types Stibnite veins.

DEPOSIT DESCRIPTION

Mineralogy Cinnabar, native Hg, other minor sulfides: pyrite, stibnite, chalcopyrite, sphalerite, galena, and bornite.

Texture/Structure Replacement and minor veins.

Alteration Replacement of serpentine by quartz and dolomite and minor hydrocarbons to form "silica-carbonate" rock.

Ore Controls Contact of serpentine with siltstone especially where contact forms antiform. Ore primarily in silica-carbonate rock.

Geochemical Signature Unknown, probably Hg + Sb + Cu + Zn.

EXAMPLES

New Almaden, USCA (Bailey, 1964)

GRADE AND TONNAGE MODEL OF SILICA-CARBONATE Hg

By James J. Rytuba and Simon M. Cargill

COMMENTS (See figs. 138, 139)

DEPOSITS

Name	Country	Name	Country
Abbott	USCA	Helen	USCA
Aetna	USCA	Keystone	USCA
Bella Oak	USCA	Knoxville	USCA
Chicago	USCA	La Joya	USCA
Contact	USCA	La Libertad	USCA
Corona	USCA	Lion Den	USCA
Culver Bear	USCA	Mirabel	USCA
Dewey's	USCA	Mt. Diablo	USCA
Esperanza	USCA	New Almaden	USCA
Great Eastern-Mt. Jackson	USCA	Patriquin	USCA
Harrison	USCA	Polar Star	USCA

Model 27c--Con.

Red Elephant	USCA	Socrates	USCA
Red Rick	USCA	Twin Peaks	USCA
Reed	USCA	Wall Street	USCA

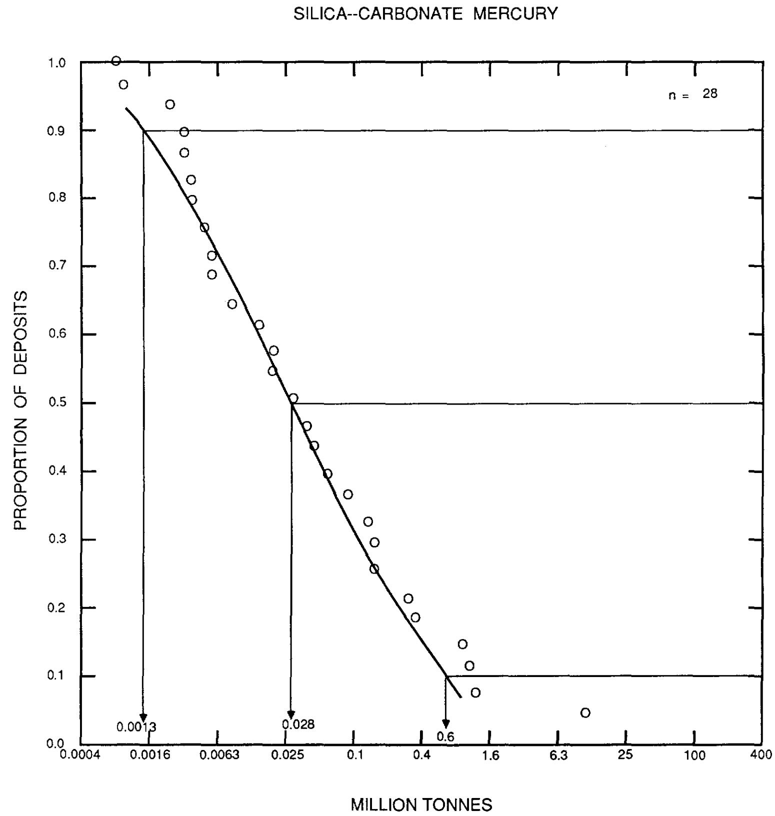

Figure 138. Tonnages of silica-carbonate Hg deposits.

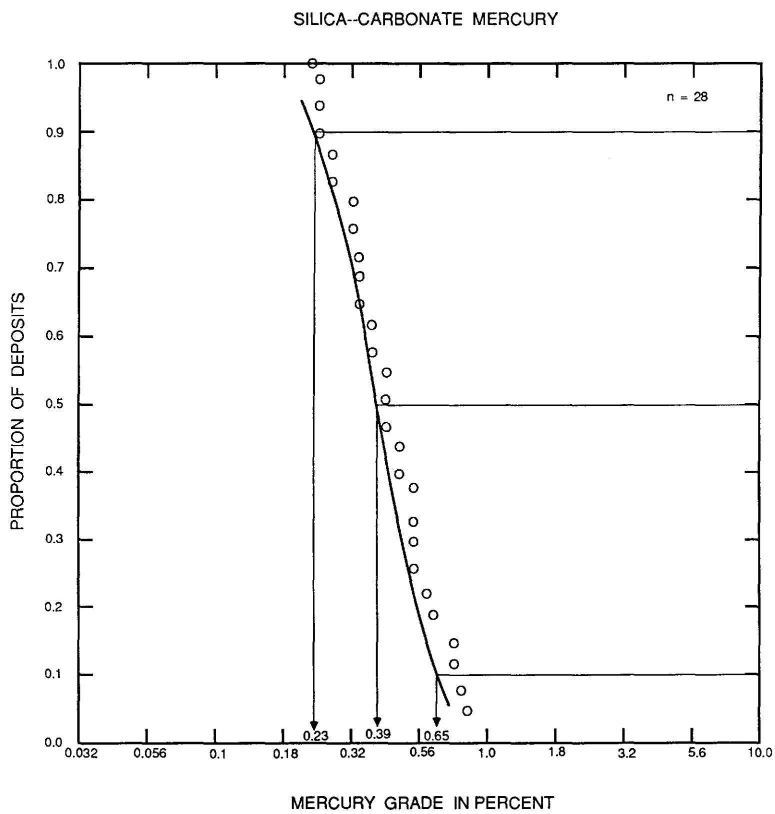

Figure 139. Mercury grades of silica-carbonate Hg deposits.

DESCRIPTIVE MODEL OF SIMPLE Sb DEPOSITS

By James D. Bliss and Greta J. Orris

APPROXIMATE SYNONYM Deposits of quartz-stibnite ore (Smirnov and others, 1983).

DESCRIPTION Stibnite veins, pods, and disseminations in or adjacent to brecciated or sheared fault zones.

GENERAL REFERENCES White (1962), Miller (1973).

GEOLOGICAL ENVIRONMENT

Rock Types One or more of the following lithologies is found associated with over half of the deposits: limestone, shale (commonly calcareous), sandstone, and quartzite. Deposits are also found with a wide variety of other lithologies including slate, rhyolitic flows and tuffs, argillite, granodiorite, granite, phyllite, siltstone, quartz mica and chloritic schists, gneiss, quartz porphyry, chert, diabase, conglomerate, andesite, gabbro, diorite, and basalt.

Textures Not diagnostic.

Age Range Known deposits are Paleozoic to Tertiary.

Depositional Environment Faults and shear zones.

Tectonic Setting(s) Any orogenic area.

Associated Deposit Types Stibnite-bearing veins, pods, and disseminations containing base metal sulfides ± cinnabar ± silver ± gold ± scheelite that are mined primarily for lead, gold, silver, zinc, or tungsten; low-sulfide Au-quartz veins; epithermal gold and gold-silver deposits; hot-springs gold; carbonate-hosted gold; tin-tungsten veins; hot-springs and disseminated mercury, gold-silver placers; infrequently with polymetallic veins and tungsten skarns.

DEPOSIT DESCRIPTION

Mineralogy Stibnite + quartz ± pyrite ± calcite; minor other sulfides frequently less than 1 percent of deposit and included ± arsenopyrite ± sphalerite ± tetrahedrite ± chalcopyrite ± scheelite ± free gold; minor minerals only occasionally found include native antimony, marcasite, calaverite, berthierite, argentite, pyrargyrite, chalcocite, wolframite, richardite, galena, jamesonite; at least a third (and possibly more) of the deposits contain gold or silver. Uncommon gangue minerals include chalcedony, opal (usually identified to be β-cristobalite by X-ray), siderite, fluorite, barite, and graphite.

Texture/Structure Vein deposits contain stibnite in pods, lenses, kidney forms, pockets (locally); may be massive or occur as streaks, grains, and bladed aggregates in sheared or brecciated zones with quartz and calcite. Disseminated deposits contain streaks or grains of stibnite in host rock with or without stibnite vein deposits.

Alteration Silicification, sericitization, and argillization; minor chloritization; serpentinization when deposit in mafic, ultramafic rocks.

Ore Controls Fissures and shear zones with breccia usually associated with faults; some replacement in surrounding lithologies; infrequent open-space filling in porous sediments and replacement in limestone. Deposition occurs at shallow to intermediate depth.

Weathering Yellow to reddish kermesite and white cerrantite or stibiconite (Sb oxides) may be useful in exploration; residual soils directly above deposits are enriched in antimony.

Geochemical Signature Sb ± Fe ± As ± Au ± Ag; Hg ± W ± Pb ± Zn may be useful in specific cases.

EXAMPLES

Amphoe Phra Saeng, THLD	(Gardner, 1967)
Caracota, BLVA	(U.S. Geological Survey Mineral Resources Data System)

Coimadai Antimony Mine, AUVT	(Fisher, 1952)
Last Chance, USNV	(Lawrence, 1963)
Lake George, CNNB	(Scratch and others, 1984)

GRADE AND TONNAGE MODEL OF SIMPLE Sb DEPOSITS

By James D. Bliss and Greta J. Orris

COMMENTS Grade and tonnage have been modeled separately for vein-dominated and disseminated simple antimony deposits. The vein-dominated deposits' grades and tonnages in this model reflect hand-sorting of the ore. A grade-tonnage model for deposits containing disseminated antimony, number 27e, follows this model. At least 15 percent of the simple antimony veins are accompanied by disseminated antimony mineralization. See figs. 140-142.

DEPOSITS

Name	Country	Name	Country
Amphoe Phra Saeong	THLD	Gribble	USNV
Antimonial	USNV	Happy Return	USNV
Antimony Canyon	USUT	Hard Luck	USNV
Antimony King I	USNV	Hermada	USID
Antimony King II	USNV	Hollywood	USNV
Antimony Lode	USNV	Hoyt	USNV
Antimony Mines	USMT	Huai Nai Khao	THLD
Antimony Ridge	USID	I.H.X.	USNV
Apex Antimony	USNV	Ichinokawa	JAPN
Black Warrior	USNV	Idaho	USID
Bloody Canyon	USNV	Jay Bird	USOR
Blue Dick	USNV	Jerritt Canyon	USNV
Blue Jay	USOR	Johnson-Heizer	USNV
Blue Nose	USNV	Last Chance	USNV
Blue Ribbon	USNV	Lithia	USNV
Bradley	USNV	Lofthouse	USNV
Bray-Beulah	USNV	Lowry	USNV
Burns Basin	USNV	Lucky Knock	USWA
Cervantite	USNV	Merrimac	USNV
Choates	USNV	Milton Canyon	USNV
Cia Minera Norcro	HNDR	Mizpah	USNV
Coasano	USAK	Mugi	JAPN
Coeur d'Alene	USID	Neardie	AUQL
Coimadai	AUVT	Nevada King	USNV
Conyarigi	TRKY	Nieves	MXCO
Costerfield	AUVT	Ore Drag	USNV
Cottonwood	USNV	Page	USNV
Darwin	USNV	Panther	USNV
Desert	USCA	Prunty	USNV
Doi Pha Khan	THLD	Scrafford	USAK
Donatelli	USNV	Snowdrift	USNV
Drumm	USNV	St. George	AUQL
Dry Canyon	USNV	Stewart May	USAR
Eaton	USNV	Stibnite	USAK
Elalmis	TRKY	Sutherland	USNV
Electric	USNV	Thompson Falls	USMT
Enterprise	USNV	Upper Bellingen	AUNS
Four-of-July	USID	Volcanic Peak	USNV
Fujinokawa	JAPN	W.P.	USNV
Green Antimony	USNV	Wall Canyon	USNV
Grey Eagle	USOR		

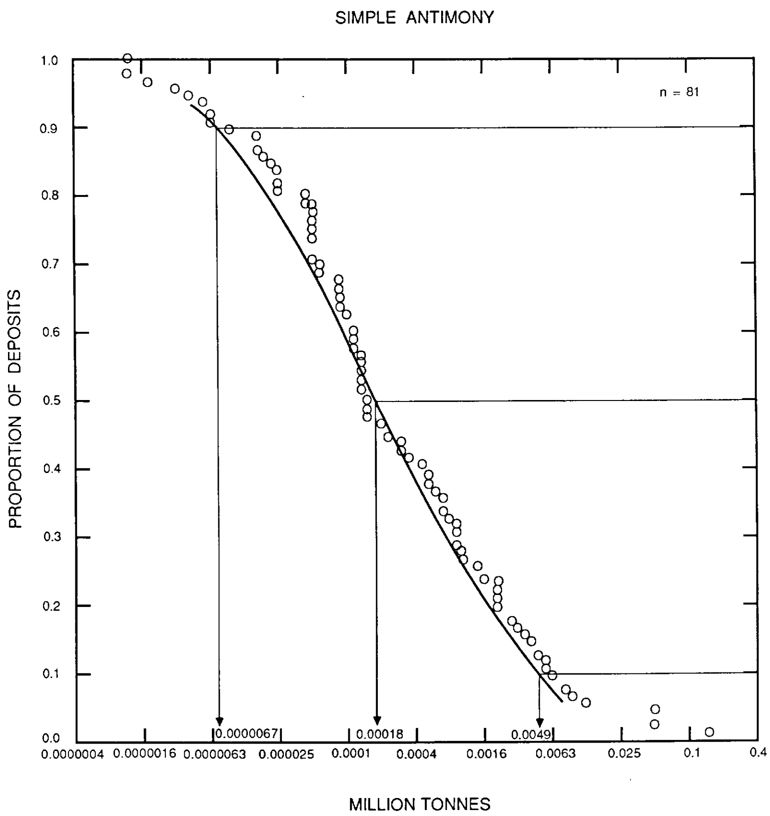

Figure 140. Tonnages of simple Sb deposits.

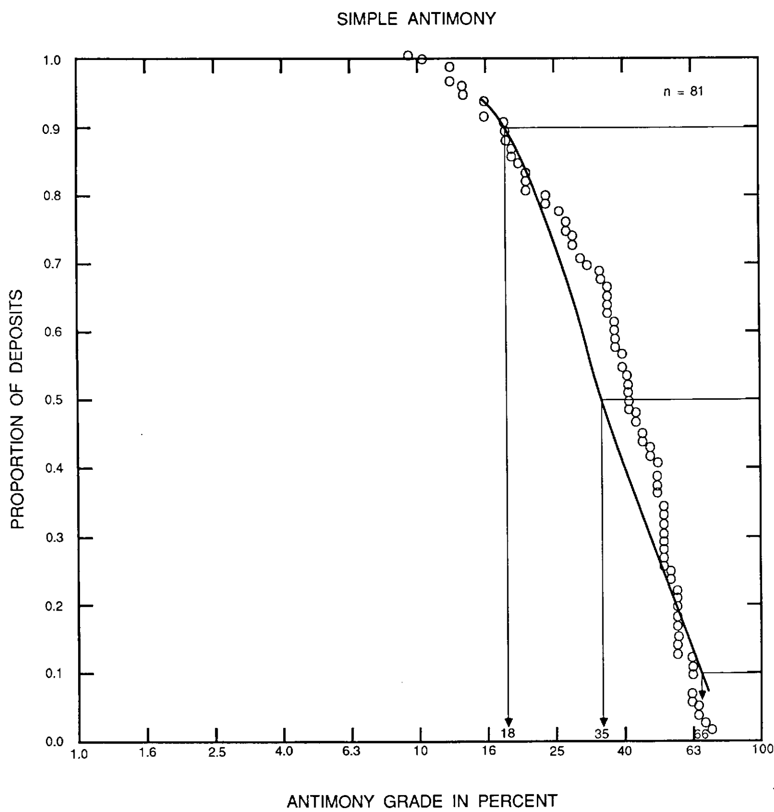

Figure 141. Antimony grades of simple Sb deposits.

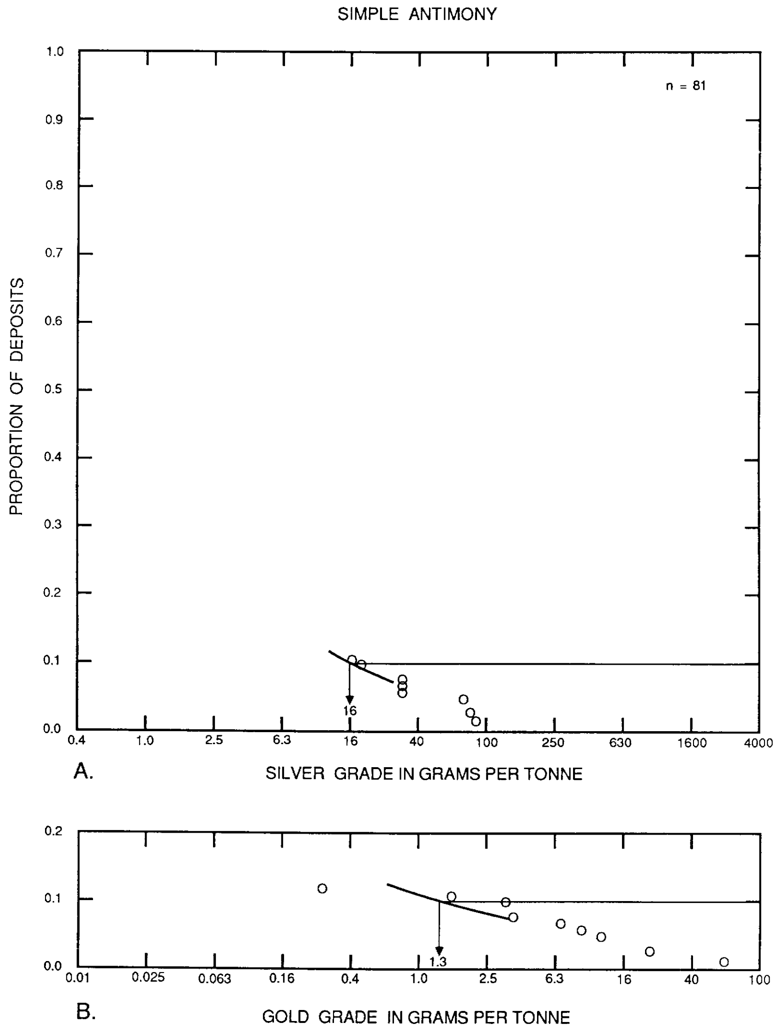

Figure 142. Precious-metal grades of simple Sb deposits. A, Silver. B, Gold.

GRADE AND TONNAGE MODEL OF DISSEMINATED Sb DEPOSITS

By James D. Bliss and Greta J. Orris

COMMENTS Disseminated simple antimony deposits, model 27e, is presented as an alternative to model 27d because of major differences in grade between the two groups. The two groups are similar geologically and share the same descriptive model. See figs. 143, 144.

DEPOSITS

Name	Country	Name	Country
Buyuk Yenice	TRKY	La Cruz	MXCO
Camlica Koyee	TRKY	Lake George	CNNB
Caracota	BLVA	Madeni	TRKY
Dagardi	TRKY	Mitchell River	AUQL
Demirkapi	USNV	Montezuma	USNV
Derekoy	TRKY	Orendere	TRKY
Dudas	USNV	Quien-Sabe	USCA
Emirli	TRKY	San Emigdio	USCA
Eskdale	AUQL	Tasdibi	TRKY
Espiritu Santo	BLVA	West Gore	CNNS
Goynuk	TRKY	Wildrose Canyon	USCA
Kucuk Yenice	TRKY		

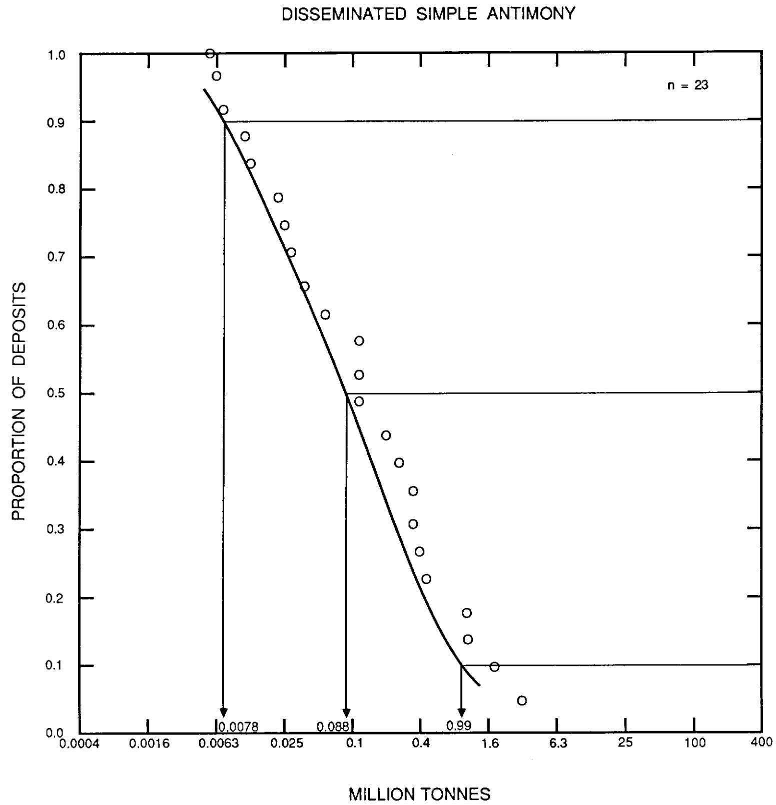

Figure 143. Tonnages of disseminated simple Sb deposits.

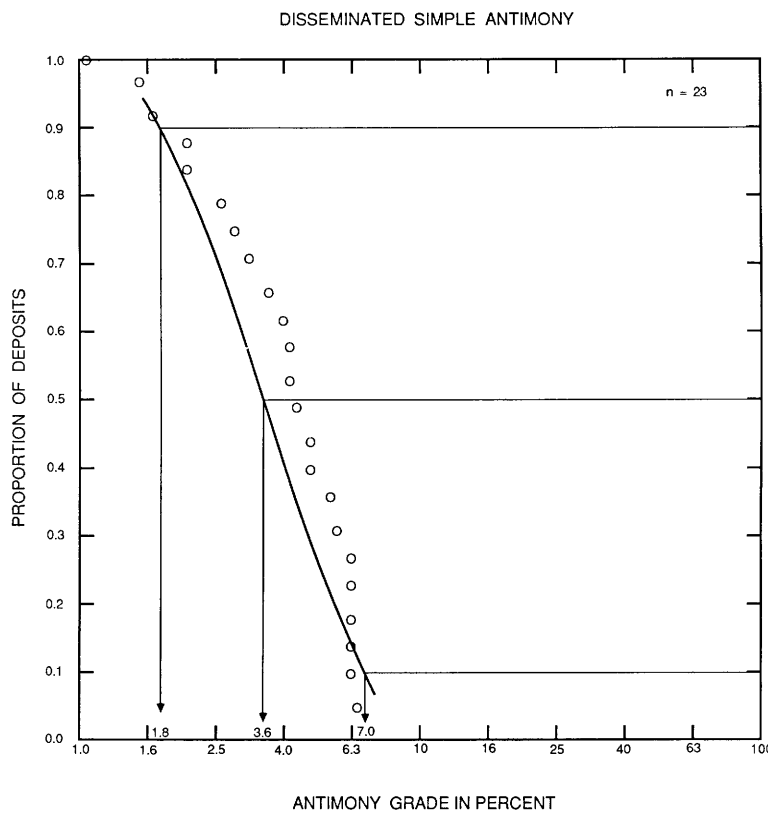

Figure 144. Antimony grades of disseminated simple Sb deposits.

DESCRIPTIVE MODEL OF KUROKO MASSIVE SULFIDE

By Donald A. Singer

APPROXIMATE SYNONYM Noranda type, volcanogenic massive sulfide, felsic to intermediate volcanic type.

DESCRIPTION Copper- and zinc-bearing massive sulfide deposits in marine volcanic rocks of intermediate to felsic composition (see fig. 145).

GENERAL REFERENCES Ishihara (1974), Franklin and others (1981), Hutchinson and others (1982), Ohmoto and Skinner (1983).

GEOLOGICAL ENVIRONMENT

Rock Types Marine rhyolite, dacite, and subordinate basalt and associated sediments, principally organic-rich mudstone or shale. Pyritic, siliceous shale. Some basalt.

Textures Flows, tuffs, pyroclastics, breccias, bedded sediment, and in some cases felsic domes.

Age Range Archean through Cenozoic.

Depositional Environment Hot springs related to marine volcanism, probably with anoxic marine conditions. Lead-rich deposits associated with abundant fine-grained volcanogenic sediments.

Tectonic Setting(s) Island arc. Local extensional tectonic activity, faults, or fractures. Archean greenstone belt.

Associated Deposit Types Epithermal quartz-adularia veins in Japan are regionally associated but younger than kuroko deposits. Volcanogenic Mn, Algoma Fe.

DEPOSIT DESCRIPTION

Mineralogy Upper stratiform massive zone (black ore)--pyrite + sphalerite + chalcopyrite ± pyrrhotite ± galena ± barite ± tetrahedrite - tennantite ± bornite; lower stratiform massive zone (yellow ore)--pyrite + chalcopyrite ± sphalerite ± pyrrhotite ± magnetite; stringer (stockwork) zone--pyrite + chalcopyrite (gold and silver). Gahnite in metamorphosed deposits. Gypsum/anhydrite present in some deposits.

Texture/Structure Massive (>60 percent sulfides); in some cases, an underlying zone of ore stockwork, stringers or disseminated sulfides or sulfide-matrix breccia. Also slumped and redeposited ore with graded bedding.

Alteration Adjacent to and blanketing massive sulfide in some deposits--zeolites, montmorillonite (and chlorite?); stringer (stockwork) zone--silica, chlorite, and sericite; below stringer--chlorite and albite. Cordierite and anthophyllite in footwall of metamorphosed deposits, graphitic schist in hanging wall.

Ore Controls Toward the more felsic top of volcanic or volcanic-sedimentary sequence. Near center of felsic volcanism. May be locally brecciated or have felsic dome nearby. Pyritic siliceous rock (exhalite) may mark horizon at which deposits occur. Proximity to deposits may be indicated by sulfide clasts in volcanic breccias. Some deposits may be gravity-transported and deposited in paleo depressions in the seafloor. In Japan, best deposits have mudstone in hanging wall.

Weathering Yellow, red, and brown gossans. Gahnite in stream sediments near some deposits.

Geochemical Signature Gossan may be high in Pb and typically Au is present. Adjacent to deposit--enriched in Mg and Zn, depleted in Na. Within deposits--Cu, Zn, Pb, Ba, As, Ag, Au, Se, Sn, Bi, Fe.

EXAMPLES

Kidd Creek, CNON	(Walker and others, 1975)
Mt. Lyell, AUTS	(Corbett, 1981)
Brittania, CNBC	(Payne and others, 1980)
Buchans, CNNF	(Swanson and others, 1981)

GRADE AND TONNAGE MODEL OF KUROKO MASSIVE SULFIDE

By Donald A. Singer and Dan L. Mosier

DATA REFERENCE Mosier and others (1983).

COMMENTS Includes all deposits listed by Mosier and others (1983) that are associated with felsic or intermediate volcanic rocks. Tonnage is correlated with copper grade (r = -0.17) and with gold grade (r = -0.19, n = 238). Zinc grade is correlated with lead grade (r = 0.55, n = 184) and with silver grade (r = 0.52, n = 249). Lead grade is correlated with silver (r = 0.55, n = 153) and with gold grade (r = 0.34, n = 124). Gold and silver grades are correlated (r = 0.39, n = 227). See figs. 146-149.

DEPOSITS

Name	Country	Name	Country
Abeshiro (Sakura)	JAPN	Bell Allard	CNQU
Adak-Lindskold	SWDN	Bell Channel	CNQU
Afterthought	USCA	Bidjovagge (A)	NRWY
Aijala	FNLD	Bidjovagge (B)	NRWY
Akarsen	TRKY	Bidjovagge (C)	NRWY
Akkoy	TRKY	Bidjovagge (D)	NRWY
Akulla Vastra	SWDN	Big Bend	USCA
Albert	CNQU	Big Hill	USME
Aldermac	CNQU	Binghampton	USAZ
Allard River	CNQU	Birch Lake	CNSK
Almagrera-Lapilla	SPAN	Bjorkasen	NRWY
Amulet A	CNQU	Bjurfors	SWDN
Amulet F	CNQU	Bjurliden	SWDN
Anayatak-Cakmakkaya	TRKY	Bjurtrask	SWDN
Anderson Lake	CNMN	Blue Ledge	USCA
Angelo	AUWA	Blue Moon	USCA
Anne	NRWY	Bodennec	FRNC
Antler	USAZ	Boliden	SWDN
Arctic	USAK	Bossmo	NRWY
Armstrong (A)	CNNB	Britannia	CNBC
As Safra	SAAR	Bruce	USAZ
Asen-east	SWDN	Brunswick No. 12	CNNB
Asen-west	SWDN	Brunswich No. 6	CNNB
Ash Shizm	SAAR	Buchans (LS-Roth.)	CNNF
Austin Brook	CNNB	Buchans (McLean)	CNNF
Avoca	IRLD	Buchans (OB-Orient.)	CNNF
Aznacollar	SPAN	Bully Hill-Rising St.	USCA
Bagacay	PLPN	Bursi	NRWY
Bailadores	VNZL	Campanario	SPAN
Balaklala	USCA	Canadian Jamieson	CNON
Bald Mountain	USME	Canoe Landing	CNNB
Bandgan	PKTN	Captain	CNNB
Barrett	USME	Captains Flat	AUNS
Barrington Lake	CNMN	Caribou	CNNB
Barvallee-Mogador	CNQU	Carpio	SPAN
Baskoy	TRKY	Castillo Buitron	SPAN
Bathurst-Norsemines	CNNT	Castro Verde	PORT
Bawdin	BRMA	CC	CNBC
Beatson	USAK	Centennial	CNMN
Bedford Hill	CNQU	Chestatee	USGA

Chester	CNNB	Gjersvik	NRWY
Chisel Lake	CNMN	Golden Grove	AUWA
Clinton	CNQU	Goodenough	CNMN
Conception	SPAN	Gray Eagle	USCA
Conigo	CNQU	Green Coast	CNON
Copper Crown	CNBC	Greens Creek	USAK
Copper George	AUWA	Gullbridge	CNNF
Copper Hill	USCA	Hacan	TRKY
Corbet	CNQU	Half Mile Lake (SG)	CNMN
Coronation	CNSK	Halliwell	CNQU
Crandon	USWI	Hanaoka (Doy.-Tsut.)	JAPN
Cronin	CNBC	Hanaoka (Mats.-Sha.)	JAPN
Cueva de la Mora	SPAN	Hanawa (Aket.-Osak.)	JAPN
Cupra D'Estrie	CNQU	Hanson Lake	CNSK
Cuprus	CNMN	Harkoy	TRKY
Davis	USMA	Heath Steele (A-C-D)	CNNB
Deer Isle	USME	Heath Steele (B)	CNNB
Delbridge	CNQU	Heath Steele (E-F)	CNNB
Despina	CNQU	Hercules	AUTN
Detour	CNQU	Herrerias	SPAN
Devils Elbow	CNNB	Hersjo	NRWY
Dickstone	CNMN	High Lake	CNNT
Don Jon	CNMN	Hixbar	PLPN
Double Ed	CNBC	Hoidal	NRWY
Dumagami	CNQU	Hood River	CNNT
Dumont Bourlamque	CNQU	Horne-Quemont	CNQU
Dunraine	CNQU	Hunter	CNQU
Duthie	CNBC	HW	CNBC
Dyce Siding	CNMN	Hyers Island	CNMN
Early Bird	USCA	Iron Dyke	USOR
East Sullivan	CNQU	Iron King	USAZ
Ego	CNON	Iron Mountain	USCA
Embury Lake	CNMN	Irsahan	TRKY
Emerson	USME	Iso-Magusi-New Insco	CNQU
Empire Le Tac	CNQU	Israil	TRKY
Errington	CNON	Iwami east	JAPN
Estacao	CNON	Iwami west	JAPN
Eulaminna	AUWA	Izok Lake	CNNT
Eustis	CNQU	Jabal Sayid	SAAR
F Group	CNON	Jakobsbakken	NRWY
Farewell Lake	CNMN	Jameland	CNON
Filon Sur-Esperanza	SPAN	Jerome	USAZ
Fjeldgruve	NRWY	Joanne	CNMN
FL & DH	CNMN	Joliet	CNQU
Flambeau	USWI	Josselin	CNQU
Flexar	CNSK	Joutel	CNQU
Flin Flon	CNMN	Kalkanli	TRKY
Fonnfjell	NRWY	Kam Kotia	CNON
Fox	CNMN	Kamitkita (Kominosawa)	JAPN
Freddie Wells	AUNS	Kankberg	SWDN
Fretais	PORT	Kedtrask	SWDN
Frotet Lake	CNQU	Kelly-Desmond	CNQU
Fukazawa	JAPN	Key Anacon	CNNB
Furuhaugen	NRWY	Keystone	USCA
Furutobe-Ainai	JAPN	Ketstone-Union	USCA
Gamle Folldal	NRWY	Khans Creek	AUNS
Garon Lake	CNQU	Khnaiguiyah	SAAR
Gaviao	PORT	Kidd Creek	CNON
Gelvenakko	SWDN	Killingdal	NRWY
George Copper	CNBC	Kimheden	SWDN
Ghost Lake	CNMN	Kittelgruvan	SWDN
Giken-Charlotta	NRWY	Kizilkaya	TRKY
Girilambone	AUNS	Koff Zone	CNMN

Model 28a--Con.

Koprubasi	TRKY
Kosaka (Motoyama)	JAPN
Kosaka (Uch.-Uwa.)	JAPN
Kostere	TRKY
Kristineberg	SWDN
Kunitomi (3-4-6)	JAPN
Kunitomi (7-8)	JAPN
Kunitomi (1-5-1N-Fud.)	JAPN
Kurosawa	JAPN
Kutcho Creek	CNBC
Kutlular	TRKY
Kuvarshan	TRKY
La Joya	SPAN
La Torrera	SPAN
La Zarza	SPAN
Lagunazo	SPAN
Lahanos	SPAN
Lake Dufault	CNQU
Lancha	SPAN
Langdal	SWDN
Langsele	SWDN
Lenora-Twin J	CNBC
Levi	SWDN
Lingwick	CNQU
Lomero Poyatos	SPAN
Lost Lake	CNMN
Lousal	PORT
Louvem	CNQU
Lyndhurst	CNQU
Lynx	CNQU
Lyon Lake	CNON
MacBride Lake	CNMN
Madenkoy	TRKY
Malaiba	PLPN
Mamie	CNBC
Mammoth	USCA
Mandy	CNMN
Mankayan	PLPN
Marcos	PLPN
Mattabi	CNON
Mattagami Lake	CNQU
McMaster	CNNB
Metsamonttu	FNLD
Mic Mac	CNQU
Milan	USNH
Millenbach	CNQU
Mobrun	CNQU
Mofjell	NRWY
Moinho	PORT
Mokoman Lake	CNSK
Moleon Lake	CNQU
Monpas	CNQU
Mons Cupri	AUWA
Mordey	CNON
Mos	NRWY
Moskogaissa	NRWY
Moulton Hill	CNQU
Mount Bulga	AUNS
Mount Chalmers	AUQL
Mount Lyell	AUTS
Mount Morgan	AUQL
Mount Mulcahy	AUWA
Murgul	TRKY
Murray Brook	CNNB
Myra Falls-Lynx	CNBC
Nasliden	SWDN
Nepisiguit	CNNB
New Bay Pond	CNNF
New Hosco	CNQU
Newton	USCA
Nine Mile Brook	CNNB
Nordre Gjetryggen	NRWY
Norita	CNQU
Normetal	CNQU
North Boundary	CNNB
North Keystone	USCA
North Star	CNMN
Northair	CNBC
Nuqrah	SAAR
Old Waite	CNQU
Orange Point	USAK
Orchan	CNQU
Orijarvi	FNLD
Osbourne Lake	CNMN
Oshio	JAPN
Ostra Hogkulla	SWDN
Pabineau River	CNNB
Paronen	FNLD
Parys Mountain	GRBR
Pater	CNON
Paymogo	SPAN
Pecos	USNM
Pelican	USWI
Penn	USCA
Penobscot	USME
Perrunal	SPAN
Phelps Dodge	CNQU
Pilleys Island	CNNF
Pine Bay	CNMN
Piray	PLPN
Point Leamington	CNNF
Poirier	CNQU
Port Aux Moines	FRCN
Pot Lake	CNMN
Price	CNBC
Pyhasalmi	FNLD
Que River	AUTS
Radiore E	CNQU
Rail Lake	CNMN
Rakkejaur	SWDN
Rambler-Ming	CNNF
Ramsey	CNSK
Ravliden	SWDN
Ravlidmyran	SWDN
Rosebery-Read	AUTS
Red Wing	CNBC
Reed Lake	CNMN
Renstrom	SWDN
Rieppe	NRWY
Rio Tinto	SPAN
Rocky Turn	CNNB
Rod	CNMN
Rodhammeren	NRWY
Rodkleiv	NRWY
Romanera	SPAN
Romerito	SPAN

Rostvangen	NRWY
Rudtjebacken	SWDN
Ruttan	CNMN
Sabetjok	NRWY
Sagmo	NRWY
Sain Bel	FRNC
San Antonio	SPAN
San Domingos	PORT
San Guillermo-Sierra	SPAN
San Mateo	PLPN
San Pedro	SPAN
San Platon	SPAN
San Telmo	SPAN
Santa Rosa	SPAN
Schist Lake	CNMN
Selco-Scott	CNQU
Shasta King	USCA
Shunsby	CNON
Sierrecilla	SPAN
Silver Queen	CNBC
Skaide	NRWY
Solbec	CNQU
Sotiel	SPAN
Sourdough Bay	CNMN
South Dufault	CNQU
South Rusty Hill	CNQU
Spenceville	USCA
Spruce Point	CNMN
Stall Lake	CNMN
Stekenjokk	SWDN
Stirling	CNNS
Stowell	USCA
Stralak	CNON
Stratmat	CNNB
Sturgeon Lake	CNON
Suffield	CNQU
Sulat	PLPN
Sun	CNMN
Sunshine	CNBC
Susu Lake	CNNT
Sutro	USCA
Tache Lake	CNQU
Taisho (Nishimata)	JAPN
Takijug Lake	CNNT
Taknar I	IRAN
Taknar II	IRAN
Tapley	USME
Tashiro	JAPN
Taslica	TRKY
Teahan	CNNB
Tedi	CNBC
Terra Nova	CNNF
Teutonic Bore	AUWA
Texas	CNNB
Third Portage	CNNB
Tjokkola	SWDN
Tomogonops	CNNB
Trininty	CNQU
Trout Bay	CNON
Tsuchihata (Hatabira)	JAPN
Tsuchihata (Honniozaw.)	JAPN
Tsuchihata (Shiratsuc.)	JAPN
Tsuchihata (Uenono-Ok.)	JAPN
Tsuchihata (Washinosu)	JAPN
Tulk's Pond	CNNF
Tulsequah	CNBC
Tunca	TRKY
Tverrfjellet	NRWY
Uchi	CNON
Udden	SWDN
Undu	FIJI
Vaddas	NRWY
Vamp	CNMN
Vauze	CNQU
Vermillion	CNON
Vigsnes	NRWY
Viscaria	SWDN
Waden Bay	CNSK
Waite East	CNQU
Wallaroo	AUWA
Wedge	CNNB
Weedon	CNQU
Weiss	TRKY
Westarm	CNMN
Whim Creek	AUWA
White Lake	CNMN
Whundo	AUWA
Wildcat	PLPN
Willecho	CNON
Wim	CNMN
Windy	CNBC
Woodlawn	AUQL
Yava	CNNT
Yoichi	JAPN
Yokota (Motoyama-Hama.)	JAPN
Yoshino (Hisaka)	JAPN
Yoshino (Main)	JAPN
Z	CNMN

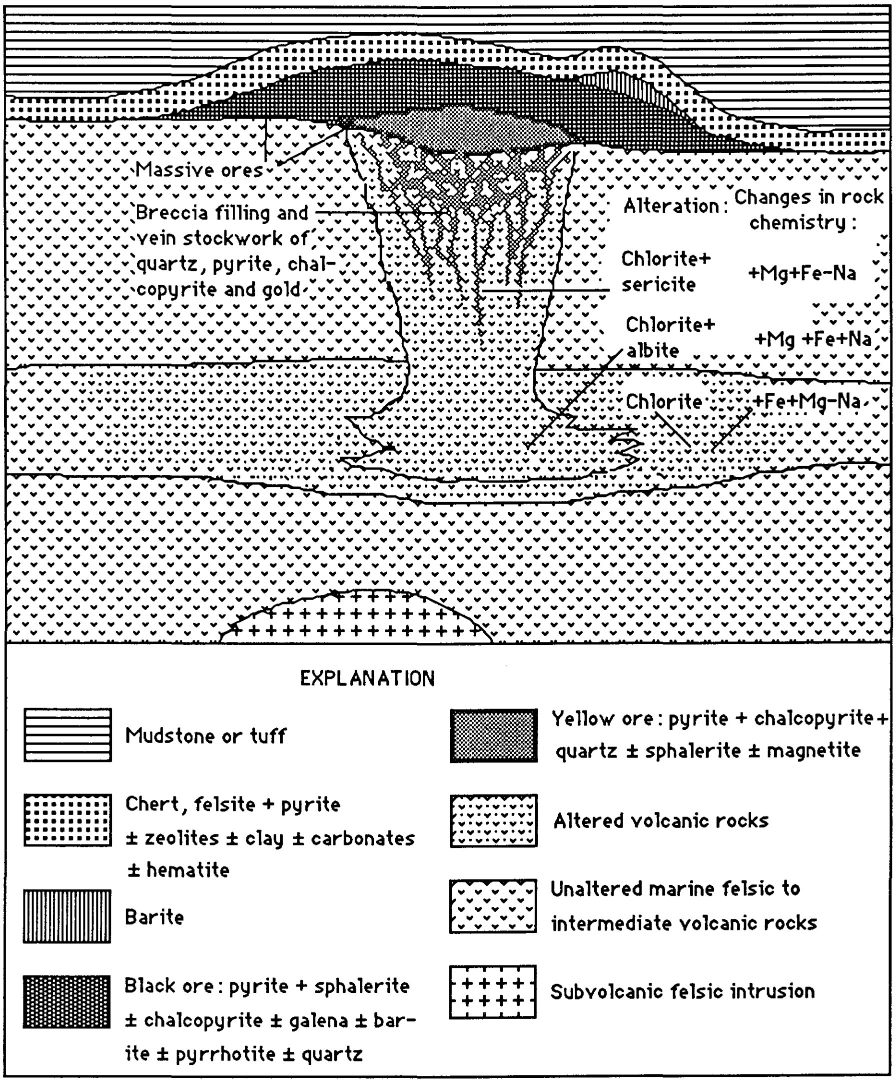

Figure 145. Cartoon cross section of kuroko massive sulfide deposit. Modified from Franklin and others (1981).

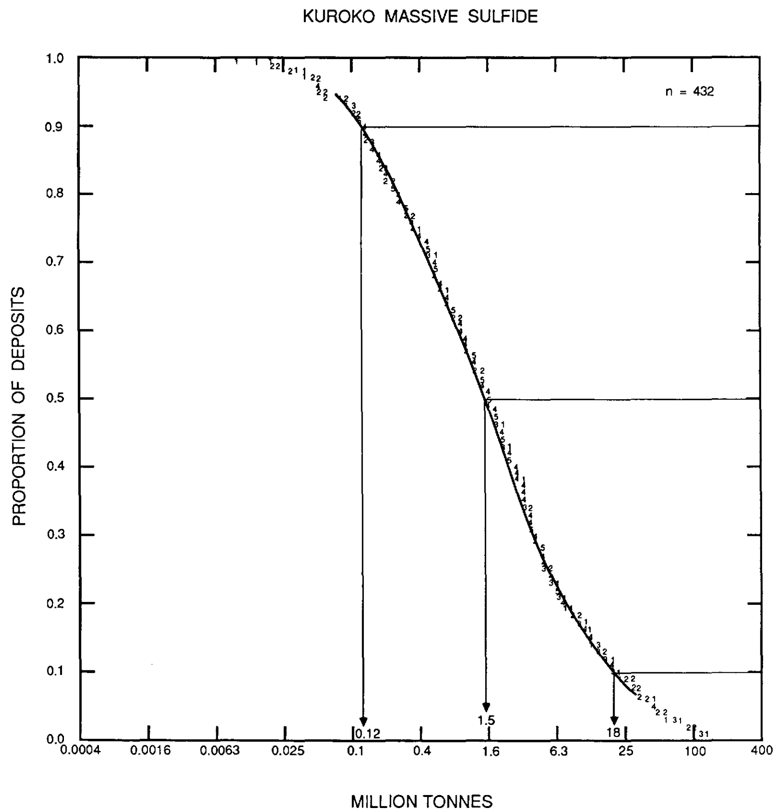

Figure 146. Tonnages of kuroko massive sulfide deposits. Individual digits represent number of deposits.

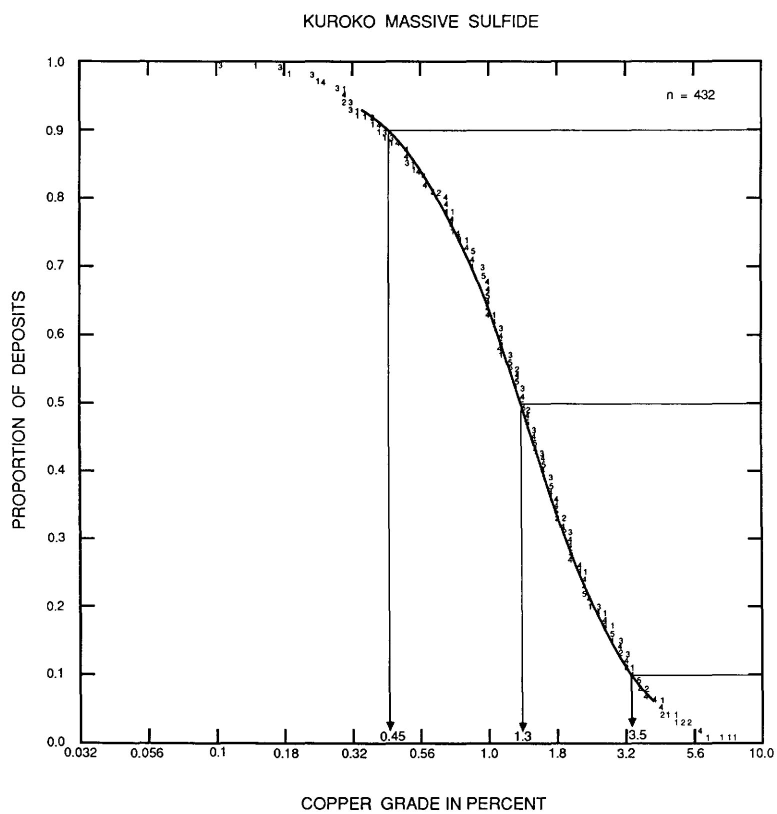

Figure 147. Copper grades of kuroko massive sulfide deposits. Individual digits represent number of deposits.

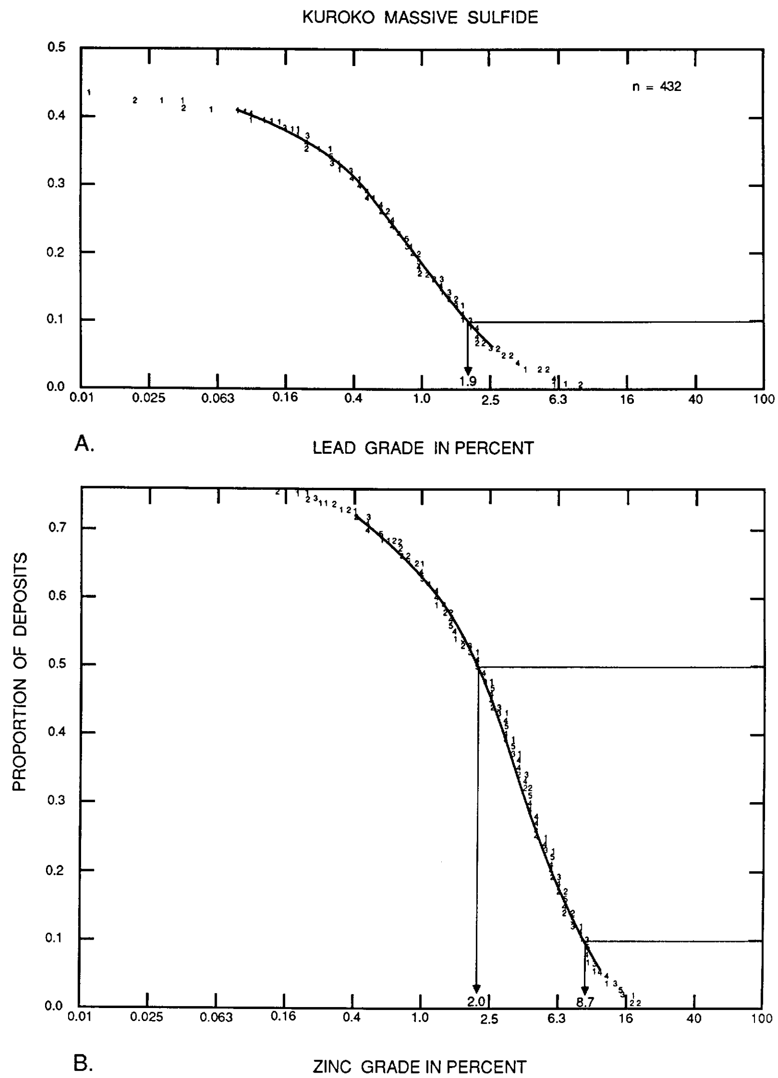

Figure 148. Lead-zinc grades of kuroko massive sulfide deposits. A, Lead. B, Zinc. Individual digits represent number of deposits.

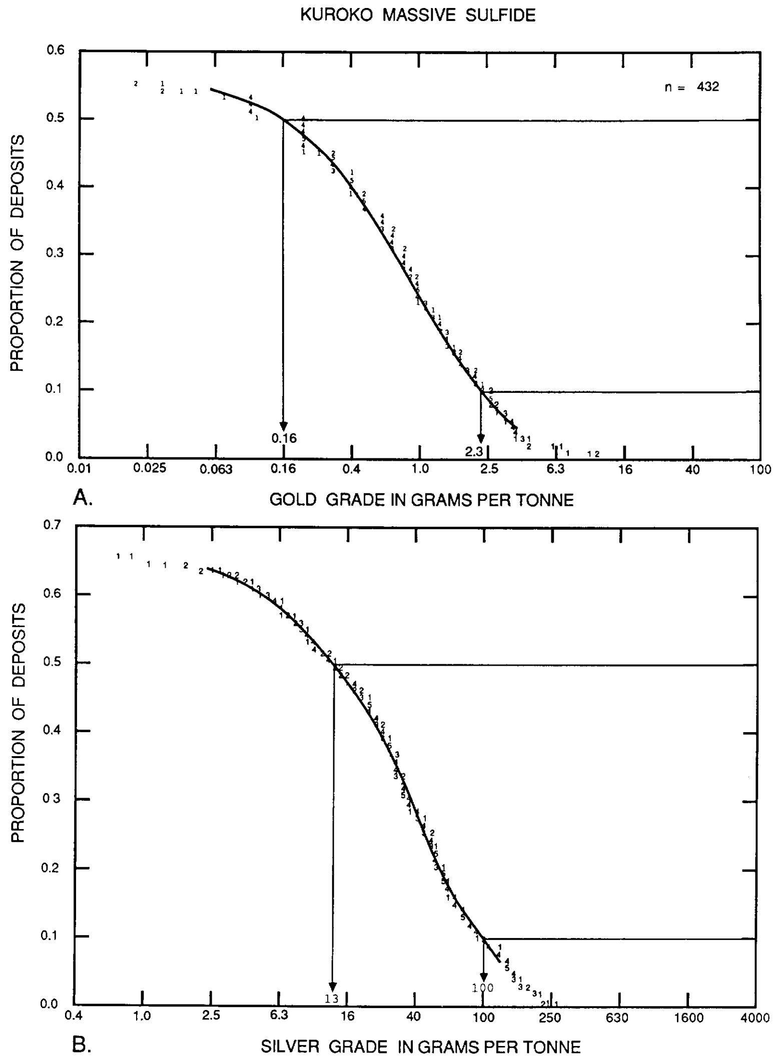

Figure 149. Precious-metal grades of kuroko massive sulfide deposits. A, Gold. B, Silver. Individual digits represent number of deposits.

DESCRIPTIVE MODEL OF ALGOMA Fe

By William F. Cannon

APPROXIMATE SYNONYM Volcanogenic iron-formation.

DESCRIPTION Beds of banded iron-rich rock typically in volcanic-sedimentary sequences formed in tectonically active oceanic regions. (The grade-tonnage model for Algoma Fe is included under Superior Fe).

GENERAL REFERENCE Goodwin (1973).

GEOLOGICAL ENVIRONMENT

Rock Types Mafic to felsic submarine volcanic rocks and deep-water clastic and volcaniclastic sediments.

Textures Pillowed greenstones, intermediate to felsic tuffs and agglomerates, poorly sorted clastic sediments.

Age Range Mostly Archean.

Depositional Environment Volcano-sedimentary basins (greenstone belts of Precambrian shields) generally with rapid turbidite sedimentation and thick volcanic accumulations.

Tectonic Setting(s) Tectonically active submarine volcanic belts, most commonly preserved in Precambrian shields.

Associated Deposit Types Kuroko massive sulfides and Homestake Au deposits.

DEPOSIT DESCRIPTION

Mineralogy Magnetite, hematite, siderite. Interlayered fine-grained quartz.

Texture/Structure Banded on centimeter scale with chert beds interlayered with Fe-rich beds.

Alteration No syngenetic alteration, but commonly metamorphosed to varying degrees and weathered.

Ore Controls Local controls within general volcano-sedimentary setting are not well established. Sub-basin with low sediment and volcanic input is probably key factor.

Weathering Conversion of iron minerals to Fe-hydroxides; leaching of silica. Intense weathering can form high-grade supergene ores.

Geophysical Signature Magnetic anomalies.

Examples

Vermillion iron-formation, USMN James (1983)

DESCRIPTIVE MODEL OF QUARTZ PEBBLE CONGLOMERATE Au-U

By Dennis P. Cox

DESCRIPTION Placer Au, U, and PGE in ancient conglomerate.

GENERAL REFERENCES Pretorius (1981), Minter (1982).

GEOLOGICAL ENVIRONMENT

Rock Types Oligomictic mature conglomerate beds in thick sequence of less mature conglomerate and sandstone deposited on Archean granite-greenstone. Basal volcanic rocks locally. Thick sedimentary sequences underlying Superior type iron-formation.

Textures Well-rounded, well-packed pebbles of vein quartz, chert and pyrite. Bimodal clast-size distribution with well-sorted pebbles and well-sorted matrix. Matrix is quartz, mica, chlorite, pyrite, and fuchsite. Granite clasts are absent.

Age Range Major deposits are Archean to Early Proterozoic (3,100-2,200 m.y.), Tarkwa is 1,900 m.y.

Depositional Environment Very thick onlapping sedimentary deposits in elongate epicontinental basins or half-grabens. Middle and basal reaches of alluvial fans deposited on steeper side of basins. Reducing atmosphere believed to be necessary to preserve detrital pyrite and uraninite.

Tectonic Setting(s) Slow subsidence of Archean craton. Later moderate uplift and erosion to remove Phanerozoic strata and retain Early Proterozoic rocks.

Associated Deposit Types Recent gold placer deposits. Low-sulfide gold quartz veins and Homestake Au in basement rocks. Superior Fe in overlying sequences.

DEPOSIT DESCRIPTION

Mineralogy Quartz, gold, pyrite, uraninite, brannerite, zircon, chromite, monazite, leucoxene, osmium-iridium alloys, isoferro platinum and sperrylite. By-product Ag. Middle Proterozoic (Tarkwa) and Phanerozoic occurrences have only traces of pyrite and no uraninite.

Texture/Structure Pyrite may occur as rounded grains, and concentrically layered concretions. Gold is in small angular grains, 0.005 to 0.1 mm in diameter.

Ore Controls Braided stream channels in broad unconformity surfaces in alluvial fans. Trough-cross bedding, current- or wave-winnowed bedding surfaces. Gold concentrated at base of mature conglomerate beds deposited on an erosion surface. Carbonaceous layers resembling algal mats deposited at low-energy base of fan contain U and fine Au.

Weathering Residual gold in weathering zone.

Geochemical Signature Au, U, PGE; anomalous radioactivity.

EXAMPLES

Witwatersrand, SAFR	(Pretorius, 1981; Feather, 1976)
Elliot Lake, CNON	(Roscoe, 1969)
Jacobina, BRZL	(Gross, W., 1968; Cox, 1967)
Tarkwa, GHNA	(Sestini, 1973)

Model 29b

DESCRIPTIVE MODEL OF OLYMPIC DAM Cu-U-Au

By Dennis P. Cox

DESCRIPTION Hematite, bornite, and other minerals in sedimentary breccia filling grabens in granitic basement.

GENERAL REFERENCE Roberts and Hudson (1983).

GEOLOGICAL ENVIRONMENT

Rock Types Proterozoic alkali granite with red K-feldspar, brecciated and forming clasts in matrix-rich breccia. Felsic volcanic breccia and tuff. Hematite iron-formation.

Textures Granophyric intergrowth in granite. Breccias grade from clast-supported in interior of basin to matrix-supported in central iron-rich part.

Age Range The only example is 1,500 m.y. old.

Depositional Environment Proterozoic granite basement broken by a deep, narrow graben filled by rapidly deposited breccia, iron-formation, and minor felsic volcanic rocks.

Tectonic Setting(s) Narrow graben transcurrent to broad arch. Local gravity high caused by dense iron-formation. Trace of graben can be detected in post-ore cover rocks as photo lineaments.

Associated Deposit Types Sediment-hosted copper deposits, iron-formation.

DEPOSIT DESCRIPTION

Mineralogy Stratabound hematite + bornite + chalcopyrite; transgressive hematite + chalcocite + bornite with fluorite, barite, and minor carrollite, cobaltite, native silver, coffinite, brannerite, bastnaesite, and florencite.

Texture/Structure Ore minerals in breccia matrix and in veins. Pisolitic siderite-fluorite-chlorite in stratabound ore.

Alteration Hematite-chlorite and sericite-quartz, also carbonates, fluorite, barite, rutile, and rare anhydrite, tourmaline, and magnetite. Intense chlorite alteration of granite below ore bodies. K-feldspar replaced by chlorite.

Ore Controls Stratiform ore in matrix polymictic-breccia containing clasts of granite, pisolitic rock, hematite, and sulfides. Transgressive ore in fractures parallel to long axis of graben.

Weathering Type example not exposed.

Geochemical and Geophysical Signature Cu + U + Co + Au + Ag + light REE + F + Ba. Dispersion pattern not known. Cu associated with hematite. Co associated with lower pyrite-rich zone. U-REE associated with Cu but Cu not always with U-REE. Au highest in late chalcocite ore. Pb, Zn very low.

Radioactivity would be detectable if exposed or shallow. Magnetic high of unknown origin.

EXAMPLES

Olympic Dam, AUSA (Roberts and Hudson, 1983)

DESCRIPTIVE MODEL OF SANDSTONE-HOSTED Pb-Zn

By Joseph A. Briskey

DESCRIPTION Stratabound to stratiform galena and sphalerite in multiple, thin, sheetlike ore bodies in arenaceous sedimentary rocks.

GENERAL REFERENCES Bjørlykke and Sangster (1981), Briskey (1982).

GEOLOGICAL ENVIRONMENT

Rock Types Continental, terrigenous, and marine quartzitic and arkosic sandstone, conglomerate, grit, and siltstone. Local evaporates.

Textures Bedding, crossbedding, paleochannels, liquification structures, and intraformational slump breccias. Quartz and subordinate calcite cement.

Age Range Proterozoic to Cretaceous host rocks.

Depositional Environment Host rocks deposited in combined continental and marine environments including piedmont, fluvial, lagoonal-lacustrine, lagoonal-deltaic, lagoonal-beach, and tidal channel-sand bar environments. Commonly succeeded by marine transgressions.

Tectonic Setting(s) Deep weathering and regional peneplanation during stable tectonic conditions, accompanied by marine platform or piedmont sedimentation associated with at least some orogenic uplift. Sialic basement, mainly "granites" or granitic gneisses.

Associated Deposit Types Sediment-hosted Cu.

DEPOSIT DESCRIPTION

Mineralogy Fine- to medium-crystalline galena with sporadic smaller amounts of sphalerite, pyrite, barite, and fluorite. Minor chalcopyrite, marcasite, pyrrhotite, tetrahedrite-tennantite, chalcocite, freibergite, bournonite, jamesonite, bornite, linnaeite, bravoite, and millerite. Quartz and calcite are usual gangue minerals, and organic debris occurs in some deposits.

Texture/Structure Clots of galena 0.5 to several centimeters in diameter; disseminations 0.1-1 mm in diameter; locally massive. Ore and gangue minerals are intergranular. Galena bands locally highlight crossbedding, and other sedimentary structures in sandstone. Laisvall has crosscutting curvilinear features resembling roll fronts.

Alteration "Sericite" (white mica?) reported in some deposits; but may only be recrystallized sedimentary illite.

Ore Controls Intergranular porosity. Ore may be massive where localized by porous sedimentary structures (above), impermeable barriers, faults, joints, and fractures. Within or immediately above paleochannels, or less commonly, paleoridges.

Weathering Surface oxidation of galena to cerussite, minor anglesite and pyromorphite, chalcopyrite to malachite, azurite, covellite, and chalcocite and (or) sphalerite to smithsonite, hemimorphite, hydrozincite, and goslarite.

Geochemical Signature: Anomalous amounts of Pb and Zn in host rocks and derivative soils; Ba, F, and Ag are enriched in lowermost parts of some deposits. Zinc tends to increase upward in the deposits. Sialic basement may contain anomalous lead concentrations. Background in sandstone: Pb = 7 ppm; Zn = 16 ppm.

EXAMPLES

Laisvall, SWDN	(Rickard and others, 1979)
Vassbo and Guttusjo, SWDN	(Christofferson and others, 1979)
Largentiere, FRNC	(Samama, 1976; Michaud, 1980)
Zeida-Bou Mia, MRCO	(Schmitt and Thiry, 1977)
Bou-Sellam, MRCO	(Caia, 1976)

Yava (Salmon R.), CNNS (Hornbrook, 1967; Scott, 1980a, b)
George Lake, CNSK (Karup-Møller and Brummer, 1970; Sangster and Kirkham, 1974)
Mechernich-Maubach, GRMY (Bjørlykke and Sangster, 1981)

GRADE AND TONNAGE MODEL OF SANDSTONE-HOSTED Pb-Zn

By Dan L. Mosier

COMMENTS Silver grades tend to be reported for the larger deposits only. See figs. 150-153

DEPOSITS

Name	Country	Name	Country
Belokany-Laura	URRS	Mechernich	GRMY
Bou Mia	MRCO	Oberpfalz	GRMY
Boylen	CNQU	Osen	NRWY
George Lake	CNSK	Sagliden	SWDN
Guttusjon	SWDN	Shertingdal	NRWY
Laisvall	SWDN	Smithfield	CNNS
Largentiere	FRNC	Tregioivo	ITLY
Lovstrand	SWDN	Vassbo	SWDN
Maiva	SWDN	Yava (Silvermine)	CNNS
Maubach	GRMY	Zeida	MRCO

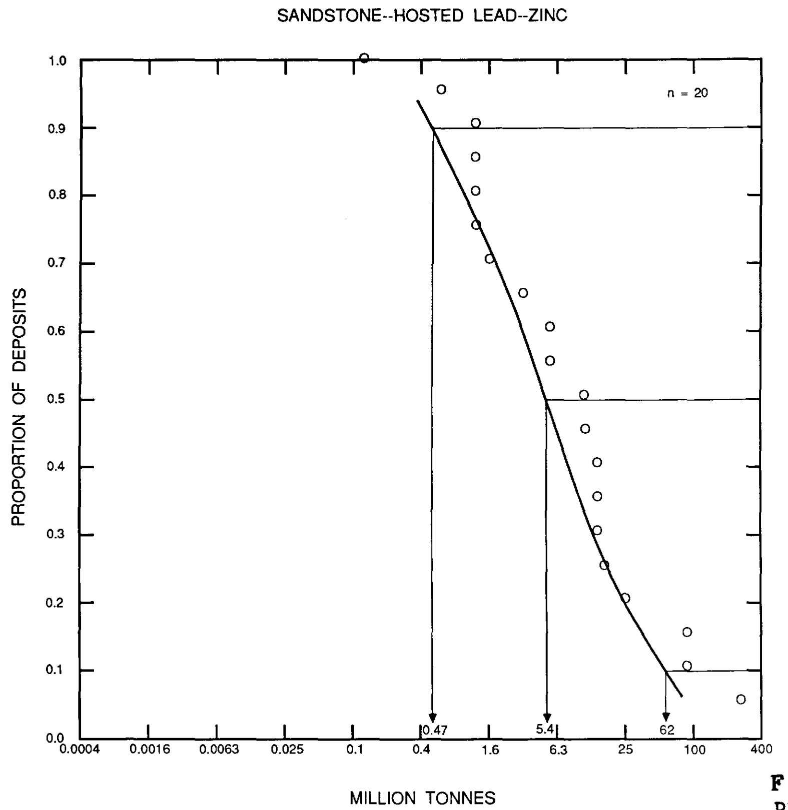

Figure 150. Tonnages of sandstone-hosted Pb-Zn deposits.

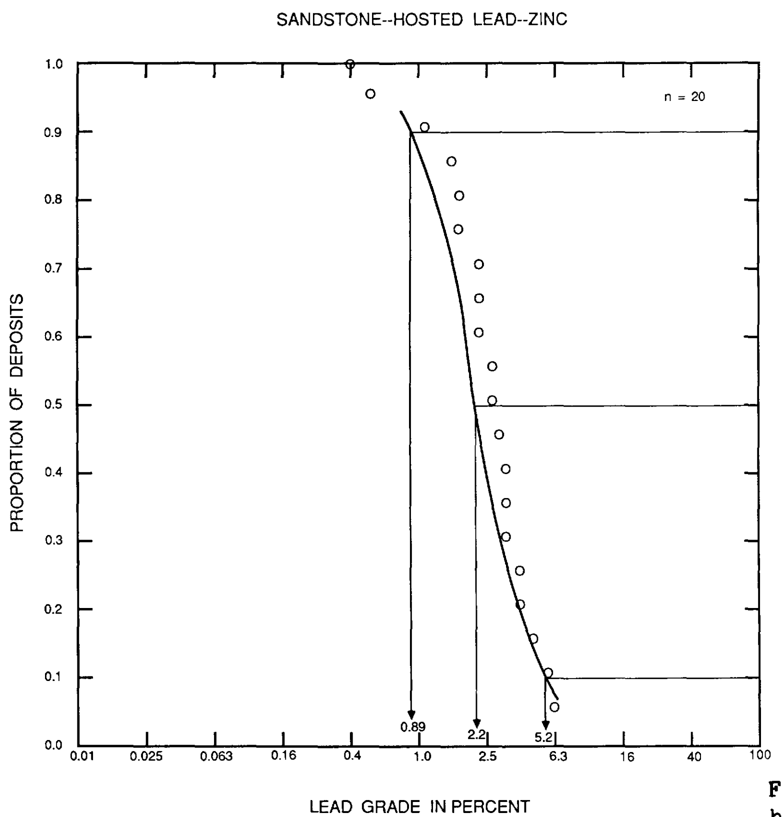

Figure 151. Lead grades of sandstone-hosted Pb-Zn deposits.

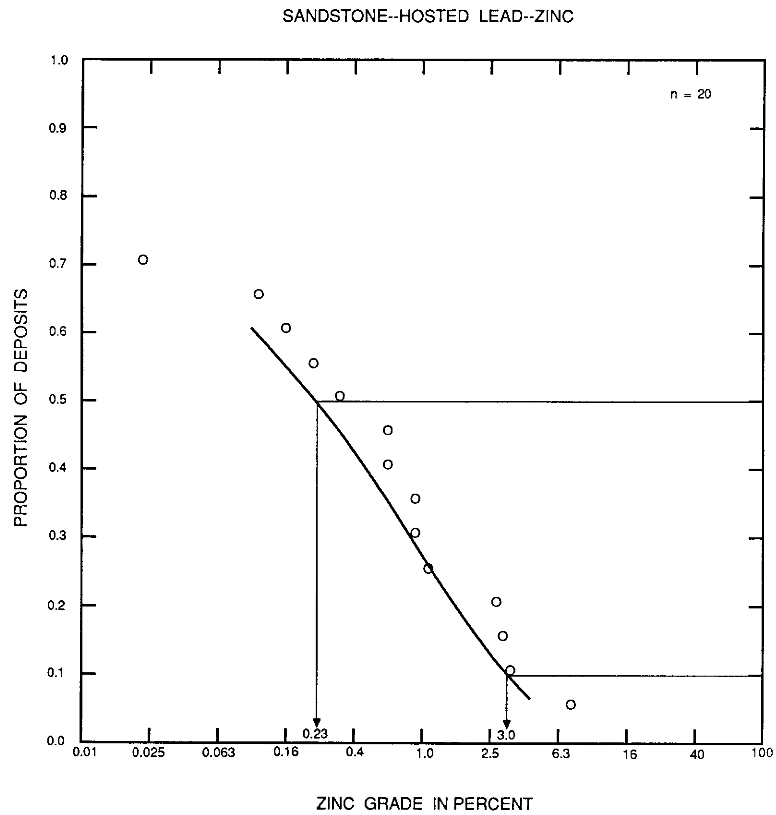

Figure 152. Zinc grades of sandstone-hosted Pb-Zn deposits.

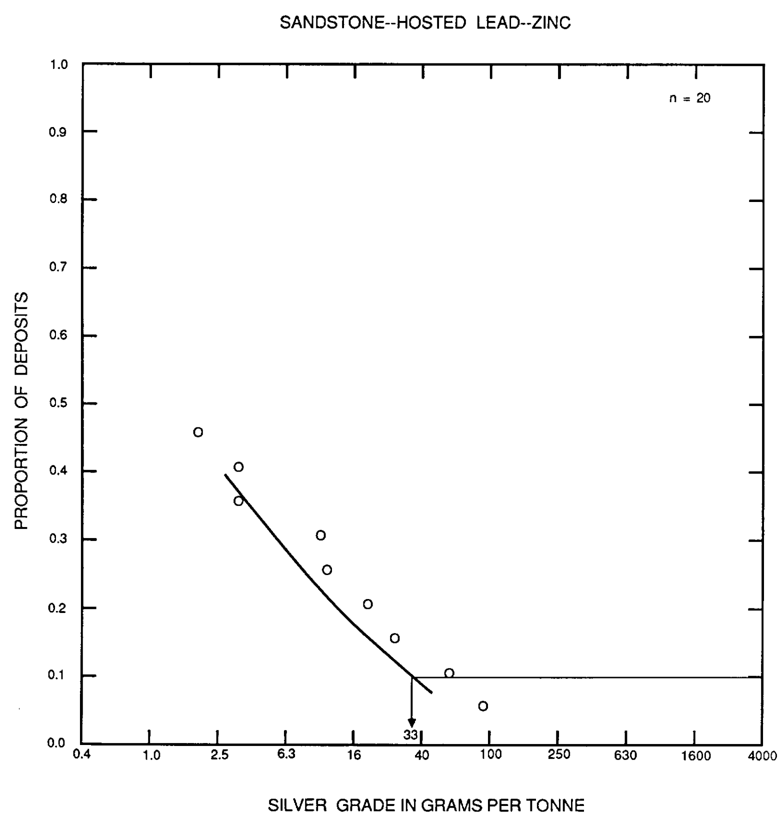

Figure 153. Silver grades of sandstone-hosted Pb-Zn deposits.

DESCRIPTIVE MODEL OF SEDIMENT-HOSTED Cu

By Dennis P. Cox

APPROXIMATE SYNONYM Sandstone Cu, includes Cu-shale (Lindsey, 1982).

DESCRIPTION Stratabound, disseminated copper sulfides in reduced beds of red-bed sequences.

GENERAL REFERENCES Tourtelot and Vine (1976), Gustafson and Williams (1981).

GEOLOGICAL ENVIRONMENT

Rock Types Red-bed sequence containing green or gray shale, siltstone, and sandstone. Thinly laminated carbonate and evaporite beds. Local channel conglomerate. Some deposits in thinly laminated silty dolomite.

Textures Algal mat structures, mudcracks, crossbedding and scour-and-fill structures. Fossil wood in channels.

Age Range Middle Proterozoic and Permian and early Mesozoic. Other Phanerozoic ages possible.

Depositional Environment Epicontinental shallow-marine basin near paleo-equator. Sabkhas. High evaporation rate. Sediments highly permeable.

Tectonic Setting(s) Intracontinental rift or aulacogen--failed arm of triple junction of plate spreading. Passive continental margin. Major growth faults.

Associated Deposit Types Halite, sylvite, gypsum, anhydrite. Sandstone uranium, basalt copper, and Kipushi Cu-Pb-Zn.

DEPOSIT DESCRIPTION

Mineralogy Chalcocite and other Cu_2S minerals + pyrite ± bornite ± native silver. Cu_2S replacement of early fine-grained pyrite is common. Deposits may be zoned with centers of chalcocite ± bornite, rims of chalcopyrite, and peripheral galena + sphalerite. Some deposits contain carrollite and Co-pyrite and Ge minerals.

Texture/Structure Fine disseminated, stratabound, locally stratiform. Framboidal or colloform pyrite. Cu minerals replace pyrite and cluster around carbonaceous clots or fragments.

Alteration Green, white, or gray (reduced) color in red beds. Regionally metamorphosed red beds may have purple color.

Ore Controls Reducing low-pH environment such as fossil wood, algal mat. Abundant biogenic sulfur. Pyritic sediments. Petroleum in paleoaquifers. High permeability of footwall sediments is critical. Boundaries between oxidized and reduced sediments.

Weathering Surface exposures may be completely leached. Secondary chalcocite enrichment down dip is common.

Geochemical Signature Cu, Ag, Pb, Zn (Mo, V, U) (Co, Ge). Au is low. Weak radioactivity in some deposits.

EXAMPLES

Kupferschiefer, GRMY	(Wedepohl, 1971)
White Pine, USMI	(Brown, 1971)
Western Montana (Belt), USMT	(Harrison 1972, 1982)
Kamoto, ZIRE	(Bartholome and others, 1976)

GRADE AND TONNAGE MODEL OF SEDIMENT-HOSTED Cu

By Dan L. Mosier, Donald A. Singer, and Dennis P. Cox

COMMENTS Tonnages are probably underestimated for deposits in Zambia and Zaire due to poor reporting. The extent to which mineralization exists between mines in Zambia and Zaire is not considered. Estimates for the deposits in Russia probably represent districts. See figs. 154-156

DEPOSITS

Name	Country	Name	Country
Alaska	ZIMB	Mangum	USOK
Baluba	ZMBA	Mansfeld	GRMY
Big Horn (Yarrow Ck)	CNAL	Matchless	NAMB
Burra	AUSA	Matchless West	NAMB
Bwana Mkubwa	ZMBA	Mokambo	ZMBA
Cattle Grid	AUSA	Mt. Gunson	AUSA
Chacarilla	BLVA	Mt. Oxide	AUQL
Chambiashi	ZMBA	Mufulira	ZMBA
Chibuluma	ZMBA	Musoshi	ZIRE
Chibuluma West	ZMBA	Musonoi	ZIRE
Chingola-Nchanga	ZMBA	Nacimiento	USNM
Chongwe	ZMBA	Norah	ZIMB
Corocoro	BLVA	Oamite	NAMB
Creta	USOK	Pintada-Stauber	USNM
Crowell Area	USTX	Presque Isle	USMI
Dikulume-Mashamba	ZIRE	Roan Antelope (Luanshya)	ZMBA
Dzhezhkazgan (Magakyan)	URRS	Rokana (Nkana)	ZMBA
Gwai River	ZIMB	Ruwe (Mutoshi)	ZIRE
Kalengwa	ZMBA	Shackleton	ZIMB
Kalushi (Kalulushi)	ZMBA	Silverside	ZIMB
Kamoto	ZIRE	Snowstorm	USMT
Kanmantoo	AUSA	Spar Lake (Troy)	USMT
Kansanshi	ZMBA	Tenke-Fungurume	ZIRE
Kapunda	AUSA	Tshinsenda (Kinsenda)	ZIRE
Kilembe	UGND	Udokan	URRS
Konkola (Bancroft)	ZMBA	White Pine	USMI
Lena	URRS		
Lubin (Legnica-Glogow)	PLND		
Lumwana	ZMBA		
Mammoth (Gunpowder)	AUQL		
Mangula (Miriam)	ZIMB		

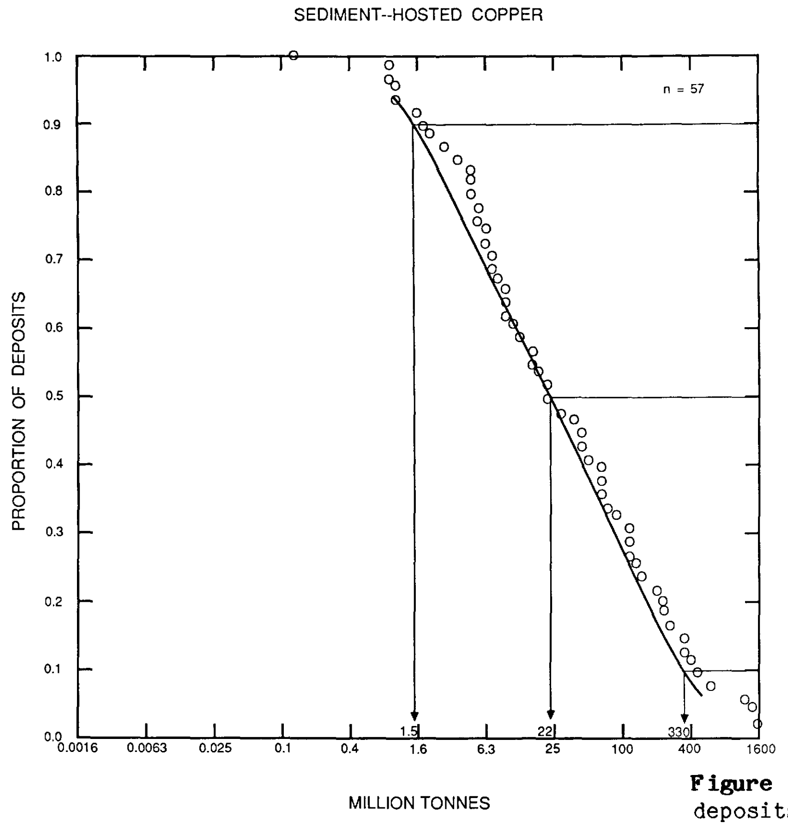

Figure 154. Tonnages of sediment-hosted Cu deposits.

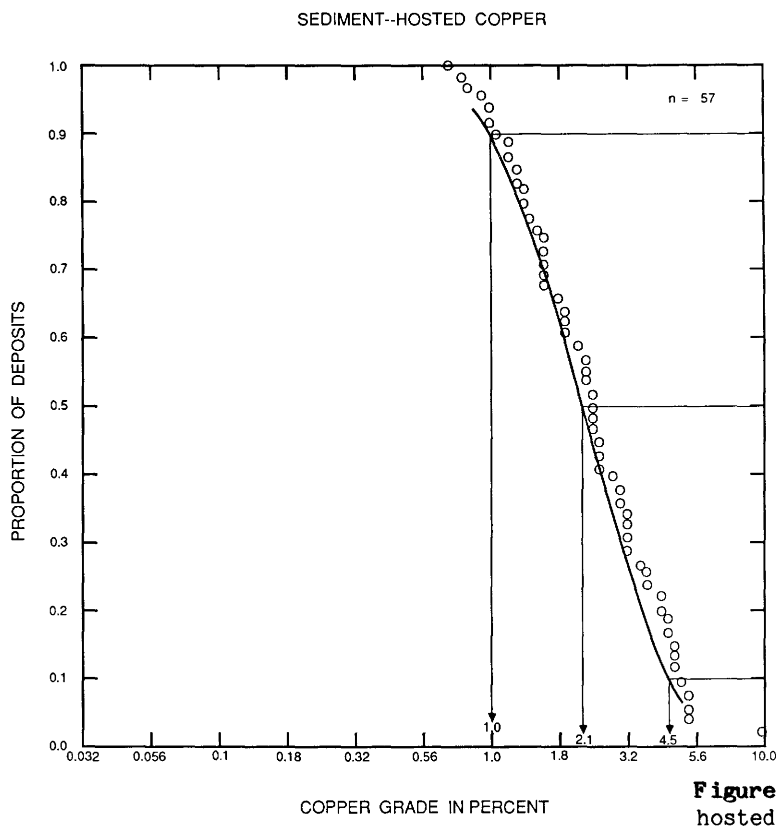

Figure 155. Copper grades of sediment-hosted Cu deposits.

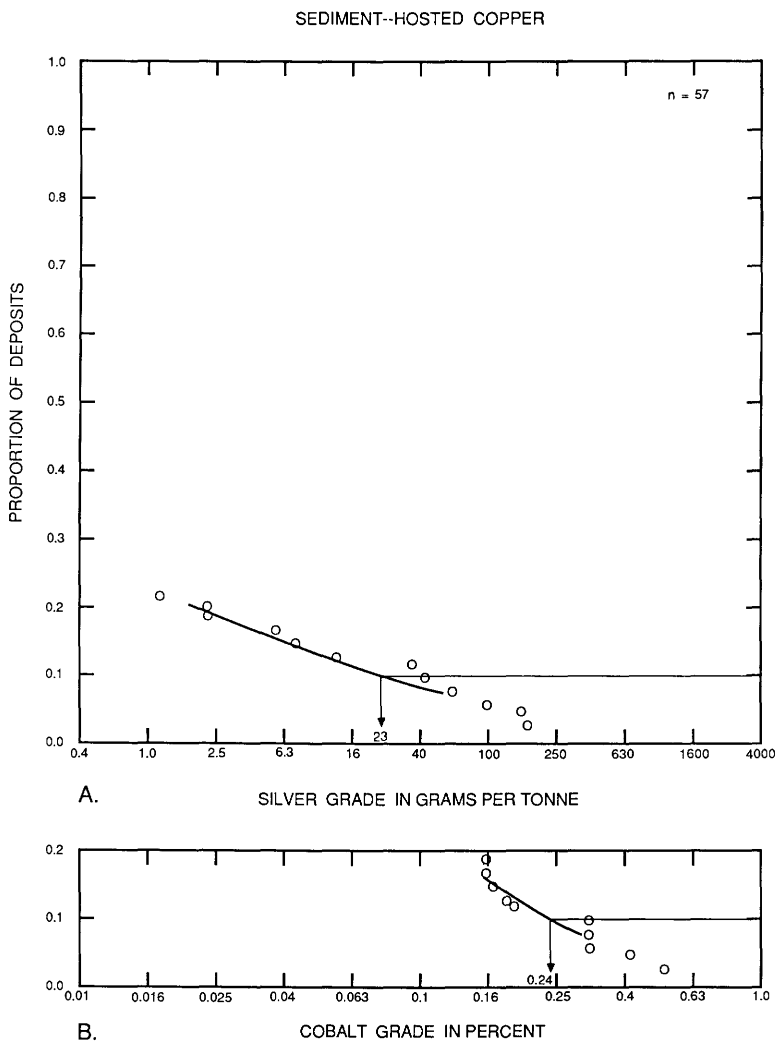

Figure 156. By-product grades of sediment-hosted Cu deposits. A, silver. B, Cobalt.

DESCRIPTIVE MODEL OF SANDSTONE U

By Christine E. Turner-Peterson and Carroll A. Hodges

APPROXIMATE SYNONYMS Tabular U ore, roll front U.

DESCRIPTION Microcrystalline uranium oxides and silicates deposited during diagenesis in localized reduced environments within fine- to medium-grained sandstone beds; some uranium oxides also deposited during redistribution by ground water at interface between oxidized and reduced ground (see fig. 157).

GENERAL REFERENCE Turner-Peterson and Fishman (1986), Granger and Warren (1969).

GEOLOGICAL ENVIRONMENT

Rock Types Host rocks are feldspathic or tuffaceous sandstone. Pyroclastic material is felsic in composition. Mudstone or shale commonly above and/or below sandstones hosting diagenetic ores (see fig. 157A).

Textures Permeable--medium to coarse grained; highly permeable at time of mineralization, subsequently restricted by cementation and alteration.

Age Range Most deposits are Devonian and younger. Secondary roll-front deposits mainly Tertiary.

Depositional Environment Continental-basin margins, fluvial channels, braided stream deposits, stable coastal plain. Contemporaneous felsic volcanism or eroding felsic plutons are sources of U. In tabular ore, source rocks for ore-related fluids are commonly in overlying or underlying mud-flat facies sediments.

Tectonic Setting(s) Stable platform or foreland-interior basin, shelf margin; adjacent major uplifts provide favorable topographic conditions.

Associated Deposit Types Sediment-hosted V may be intimately associated with U. Sediment-hosted Cu may be in similar host rocks and may contain U.

DEPOSIT DESCRIPTION

Mineralogy Uraninite, coffinite, pyrite in organic-rich horizons. Chlorite common.

Texture/Structure Stratabound deposits. Tabular U--intimately admixed with pore-filling humin in tabular lenses suspended within reduced sandstone (fig. 157A). Replacement of wood and other carbonaceous material. Roll front U--in crescentic lens that cuts across bedding, at interface between oxidized and reduced ground (fig. 157B).

Alteration Tabular--Humic acid mineralizing fluids leach iron from detrital magnetite-ilmenite leaving relict TiO_2 minerals in diagenetic ores. Roll front--Oxidized iron minerals in rock updip, reduced iron minerals in rock downdip from redox interface.

Ore Controls Permeability. Tabular--Humin or carbonaceous material the main concentrator of U. Roll front--S species, "sour" gas, FeS_2. Bedding sequences with low dips; felsic plutons or felsic tuffaceous sediments adjacent to or above host rock are favorable source for U. Regional redox interface marks locus of ore deposition.

Weathering Oxidation of primary uraninite or coffinite to a variety of minerals, notably yellow carnotite as bloom in V-rich ores.

Geochemical and Geophysical Signature U, V, Mo, Se, locally Cu, Ag. Anomalous radioactivity from daughter products of U. Low magnetic susceptibility in and near tabular ores.

EXAMPLES

Colorado Plateau	(Fischer, 1974)
Grants, USNM	(Turner-Peterson and Fishman, 1986)
Texas Gulf Coast	(Reynolds and Goldhaber, 1983)
USWY	(Granger and Warren, 1969)

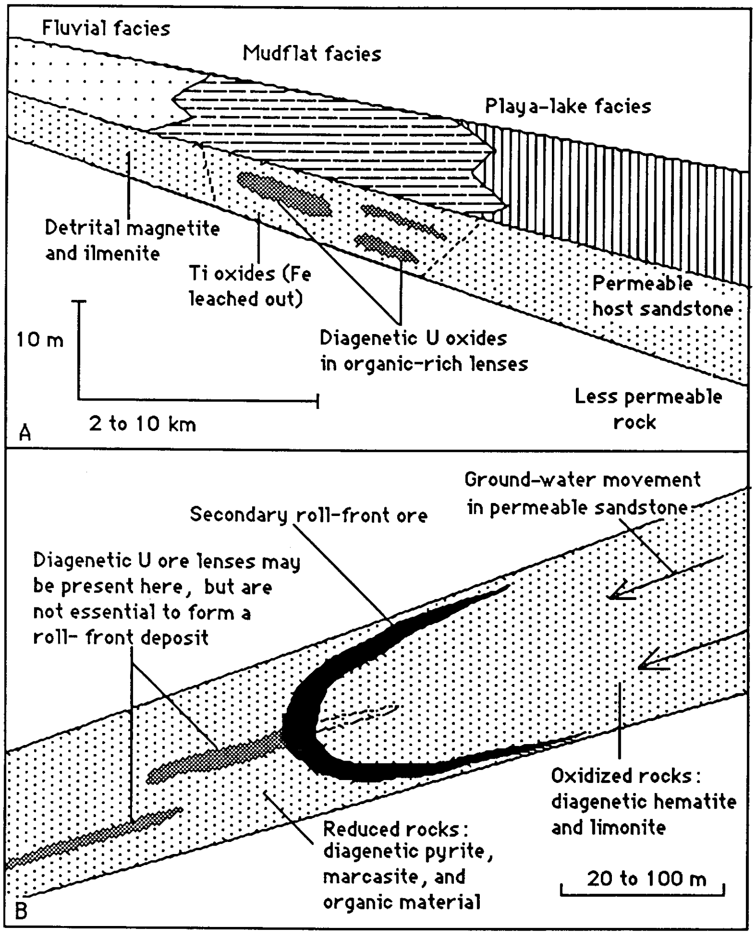

Figure 157. Cartoon sections showing: A, Diagenetic mineralization (from Turner-Peterson and Fishman, 1986); B, roll-front mineralization in sandstone U deposits (from Nash and others, 1981).

DESCRIPTIVE MODEL OF SEDIMENTARY EXHALATIVE Zn-Pb

By Joseph A. Briskey

APPROXIMATE SYNONYMS Shale-hosted Zn-Pb; sediment-hosted massive sulfide Zn-Pb.

DESCRIPTION Stratiform basinal accumulations of sulfide and sulfate minerals interbedded with euxinic marine sediments form sheet- or lens-like tabular ore bodies up to a few tens of meters thick, and may be distributed through a stratigraphic interval over 1,000 m (see fig. 158).

GENERAL REFERENCES Large (1980, 1981, 1983).

GEOLOGICAL ENVIRONMENT

Rock Types Euxinic marine sedimentary rocks including: black (dark) shale, siltstone, sandstone, chert, dolostone, micritic limestone, and turbidites. Local evaporitic sections in contemporaneous shelf facies. Volcanic rocks, commonly of bimodal composition, are present locally in the sedimentary basin. Tuffites are the most common. Slump breccias, fan conglomerates, and similar deposits, as well as facies and thickness changes, are commonly associated with synsedimentary faults.

Textures Contrasting sedimentary thicknesses and facies changes across hinge zones. Slump breccias and conglomerates near synsedimentary faults.

Age Range Known deposits are Middle Proterozoic (1,700-1,400 m.y.); Cambrian to Carboniferous (530-300 m.y.).

Depositional Environment Marine epicratonic embayments and intracratonic basins, with smaller local restricted basins (second- and third-order basins).

Tectonic Setting(s) Epicratonic embayments and intracratonic basins are associated with hinge zones controlled by synsedimentary faults, typically forming half-grabens. Within these grabens (first-order basins), penecontemporaneous vertical tectonism forms smaller basins (second-order basins) and associated rises. Smaller third-order basins (tens of kilometers) within the second-order basins (10^2-10^5 km) are the morphological traps from the stratiform sulfides.

Associated Deposit Types Bedded barite deposits.

DEPOSIT DESCRIPTION

Mineralogy Pyrite, pyrrhotite, sphalerite, galena, sporadic barite and chalcopyrite, and minor to trace amounts of marcasite, arsenopyrite, bismuthinite, molybdenite, enargite, millerite, freibergite, cobaltite, cassiterite, valleriite, and melnikovite.

Texture/Structure Finely crystalline and disseminated, monomineralic sulfide laminae are typical. Metamorphosed examples are coarsely crystalline and massive.

Alteration Stockwork and disseminated sulfide and alteration (silicification, tourmalization, carbonate depletion, albitization, chloritization, dolomitization) minerals possibly representing the feeder zone of these deposits commonly present beneath or adjacent to the stratiform deposits. Some deposits have no reported alteration. Celsian, Ba-muscovite, and ammonium clay minerals may be present.

Ore Controls Within larger fault-controlled basins, small local basins form the morphological traps that contain the stratiform sulfide and sulfate minerals. The faults are synsedimentary and serve as feeders for the stratiform deposits. Euxinic facies.

Weathering Surface oxidation may form large gossans containing abundant carbonates, sulfates, and silicates of lead, zinc, and copper.

Geochemical Signature Metal zoning includes lateral Cu-Pb-Zn-Ba sequence extending outward from feeder zone; or a vertical Cu-Zn-Pb-Ba sequence extending upward. NH_3 anomalies may be present. Exhalative chert interbedded with stratiform sulfide and sulfate minerals; peripheral hematite-chert formations. Local (within 2 km) Zn, Pb, and Mn haloes. Highest expected background in black shales: Pb = 500 ppm; Zn = 1,300 ppm; Cu = 750 ppm; Ba = 1,300 ppm; in carbonates: Pb = 9 ppm; Zn = 20; Cu = 4 pmm; Ba = 10.

EXAMPLES

Sullivan mine, CNBC	(Hamilton and others, 1982)
Meggen mine, GRMY	(Krebs, 1981)
Navan, Silvermines, Tynagh, IRLD	(Boyce and others, 1983; Taylor, 1984)

GRADE AND TONNAGE MODEL OF SEDIMENTARY EXHALATIVE Zn-Pb

By W. David Menzie and Dan L. Mosier

COMMENTS Deposits in this model include most commonly identified deposits of this type. Nevertheless, examination of the distribution of silver grade suggests the presence of two subtypes. Lead grades are significantly correlated with silver grades (r = 0.77, n = 39). See figs. 159-163.

DEPOSITS

Name	Country	Name	Country
Balmat	USNY	McArthur	AUNT
Baroi	INDA	Meggen	GRMY
Big Syncline	SAFR	Mineral King	CNBC
Black Mtn.	SAFR	Mount Isa	AUQL
Broken Hill	SAFR	Navan	IRLD
Broken Hill	AUNT	Rajpura-Daiba	INDA
Cirque	CNBC	Rammelsberg	GRMY
Dugald River	AUQL	Rampura-Agucha	INDA
Duncan Lake	CNBC	Red Dog	USAK
Dy	CNYT	Reeves MacDonald	CNBC
Faro	CNYT	Rosh Pinah	NAMB
Fx	CNBC	Silvermines	IRLD
Grum	CNYT	Squirrel Hills	AUQL
HB	CNBC	Sullivan	CNBC
Hilton	AUQL	Swim Lake	CNYT
Homestake	CNBC	Tom	CNYT
Howards Pass	CNYT	Tynagh	IRLD
Jersey Emerald	CNBC	Vangorda	CNYT
King Fissure	CNBC	Woodcutters	AUNT
Lady Loretta	AUQL	Wigwam	CNBC
MacMillan	CNYT	Zawar	INDA
Matt Berry	CNYT	Zawarmala	INDA

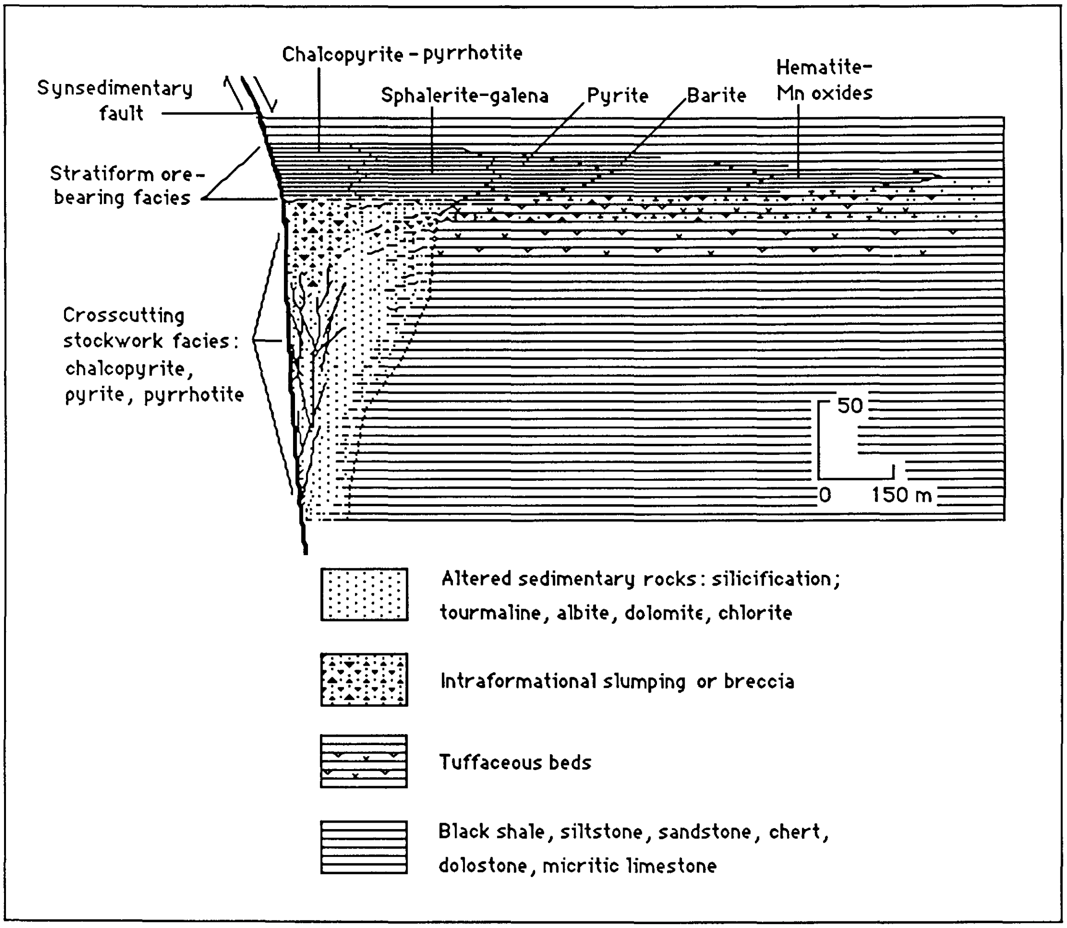

Figure 158. Cartoon cross section showing mineral zoning in sedimentary exhalative Zn-Pb deposits (modified from Large, 1980).

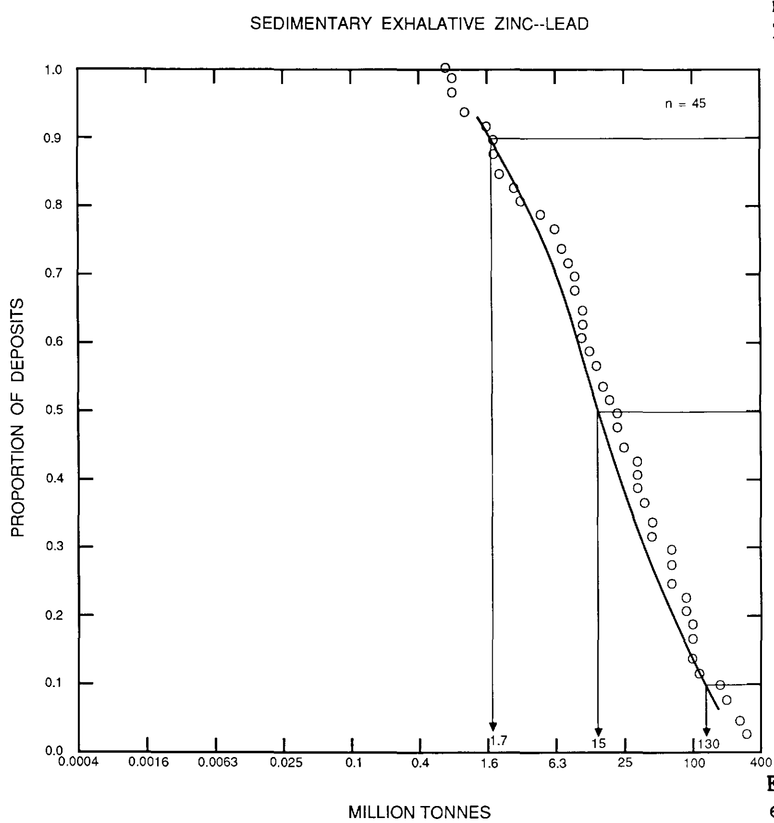

Figure 159. Tonnages of sedimentary exhalative Zn-Pb deposits.

Model 31a--Con.

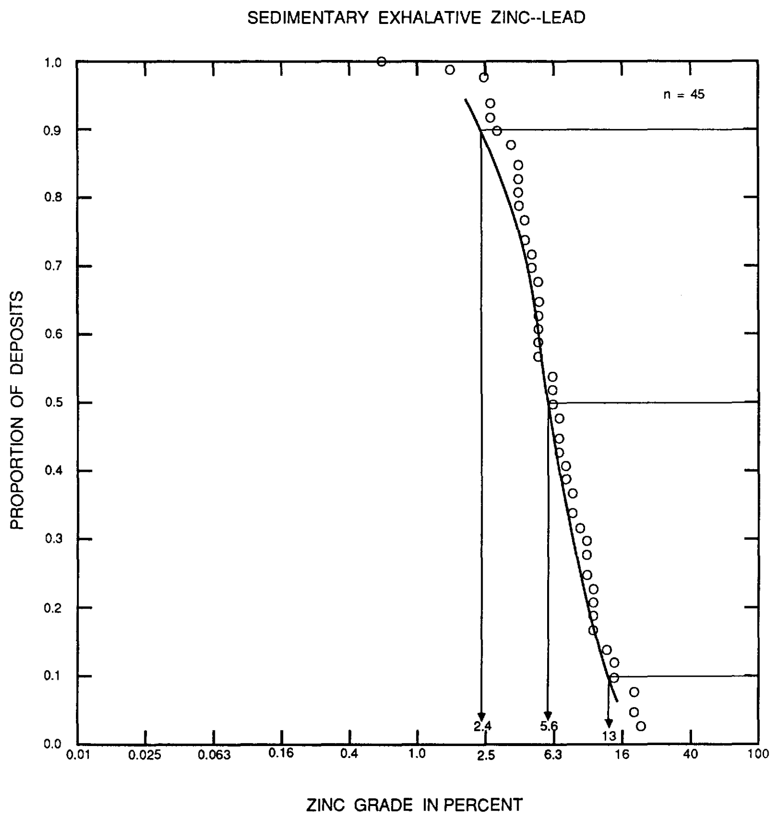

Figure 160. Zinc grades of sedimentary exhalative Zn-Pb deposits.

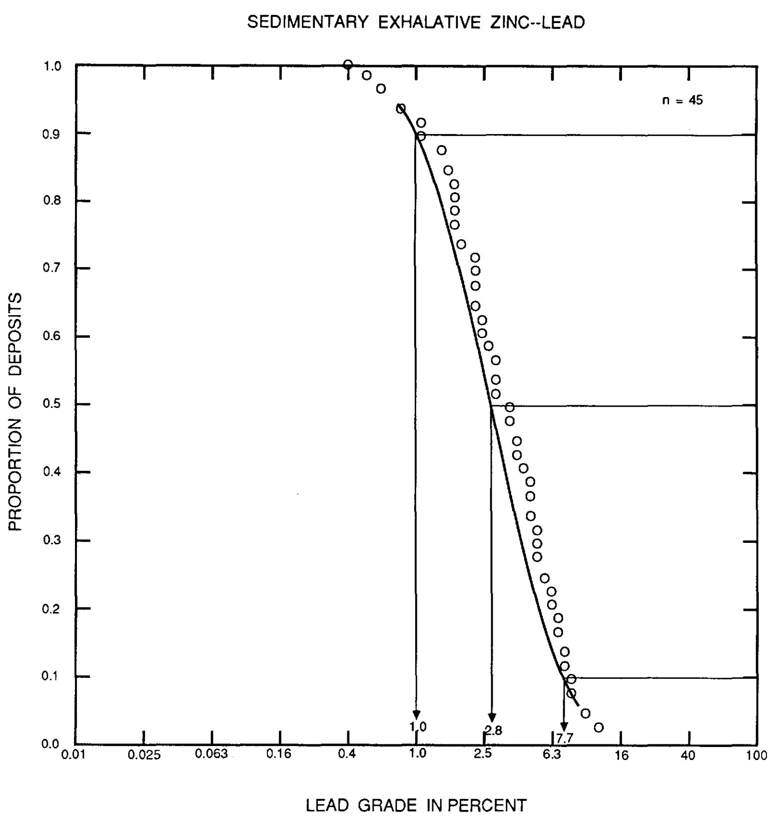

Figure 161. Lead grades of sedimentary exhalative Zn-Pb deposits.

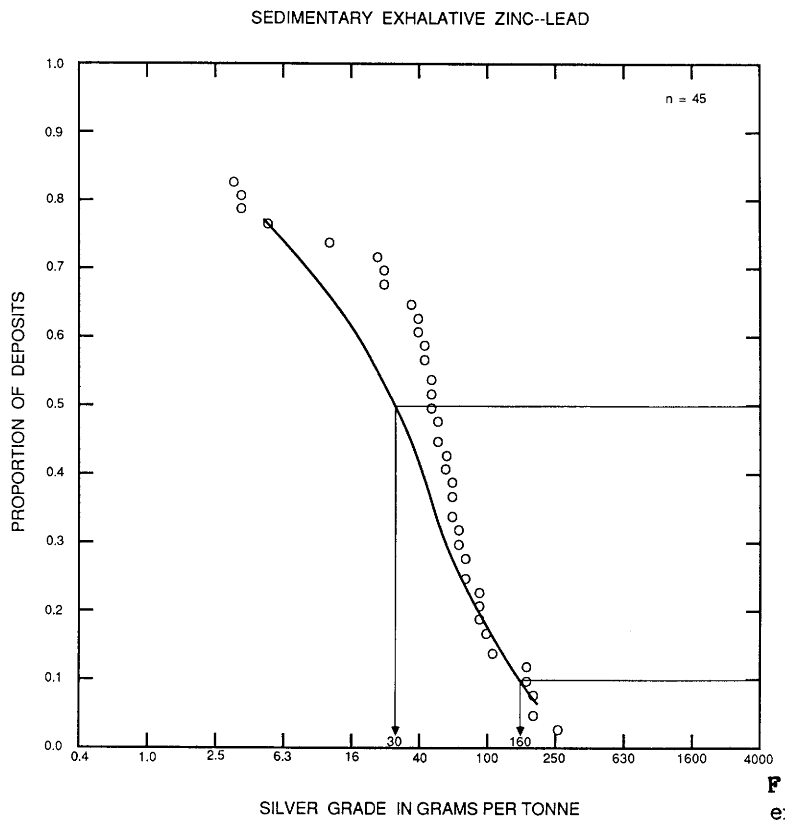

Figure 162. Silver grades of sedimentary exhalative Zn-Pb deposits.

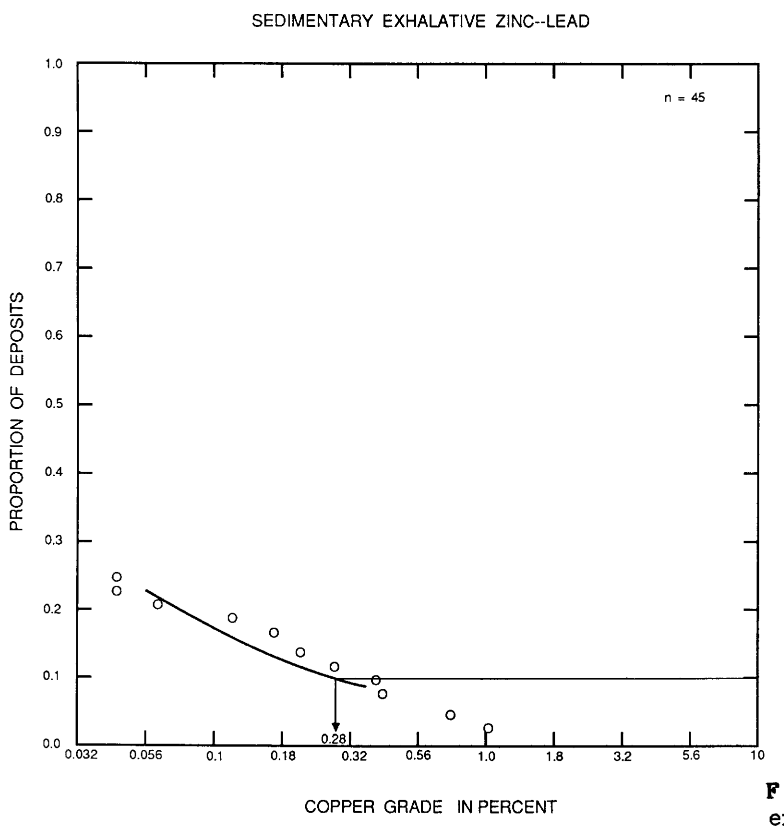

Figure 163. Copper grades of sedimentary exhalative Zn-Pb deposits.

DESCRIPTIVE MODEL OF BEDDED BARITE

By Greta J. Orris

APPROXIMATE SYNONYM Stratiform barite.

DESCRIPTION Stratiform deposits of barite interbedded with dark-colored cherty and calcareous sedimentary rocks.

GEOLOGICAL ENVIRONMENT

Rock Types Generally dark-colored chert, shale, mudstone, limestone or dolostone. Also with quartzite, argillite, and greenstone.

Age Range Proterozoic and Paleozoic.

Depositional Environment Epicratonic marine basins or embayments (often with smaller local restricted basins).

Tectonic Setting(s) Some deposits associated with hinge zones controlled by synsedimentary faults.

Associated Deposit Types Sedimentary exhalative Zn-Pb (see fig. 158).

DEPOSIT DESCRIPTION

Mineralogy Barite ± minor witherite ± minor pyrite, galena, or sphalerite. Barite typically contains several percent organic matter plus some H_2S in fluid inclusions.

Texture/Structure Stratiform, commonly lensoid to poddy; ore laminated to massive with associated layers of barite nodules or rosettes; barite may exhibit primary sedimentary features. Small country rock inclusions may show partial replacement by barite.

Alteration Secondary barite veining; weak to moderate sericitization has been reported in or near some deposits in Nevada.

Ore Controls Deposits are localized in second- and third-order basins.

Weathering Indistinct, generally resembling limestone or dolostone; occasionally weathered-out rosettes or nodules.

Geochemical Signature Ba; where peripheral to sediment-hosted Zn-Pb, may have lateral (Cu)-Pb-Zn-Ba zoning or regional manganese haloes. High organic C content.

EXAMPLES

Meggen, GRMY	(Krebs, 1981)
Magnet Cove, USAR	(Scull, 1958)
Northumberland, USNV	(Shawe and others, 1969)

GRADE AND TONNAGE MODEL OF BEDDED BARITE

By Greta J. Orris

COMMENTS See figs. 164-165.

DEPOSITS

Name	Country	Name	Country
Ballynoe	IRLD	Brookfield	CNNS
Barite Mtn.	CNYT	Castle Island	USAK
Barite (Mouse)	CNYT	Cathy (Walt)	CNYT
Barite Valley	SAFR	Cirque Barite	CNBC
Baw Hin Khao	THLD	Greystone	USNV

Gurranda	AUNS	Mountain Springs	USNV
Kempfield	AUNS	Nimiuktuk	USAK
Khuzdar	PKTN	Rammelsberg Barite	GRMY
Magnet Cove	USAR	Snake Mountain	USNV
Mangampetta N.	INDA	Tea	CNYT
Mangampetta S.	INDA	Uribe	USWA
Meggen Barite	GRMY	Weedaroo	AUSA
Mel Barite	CNYT		

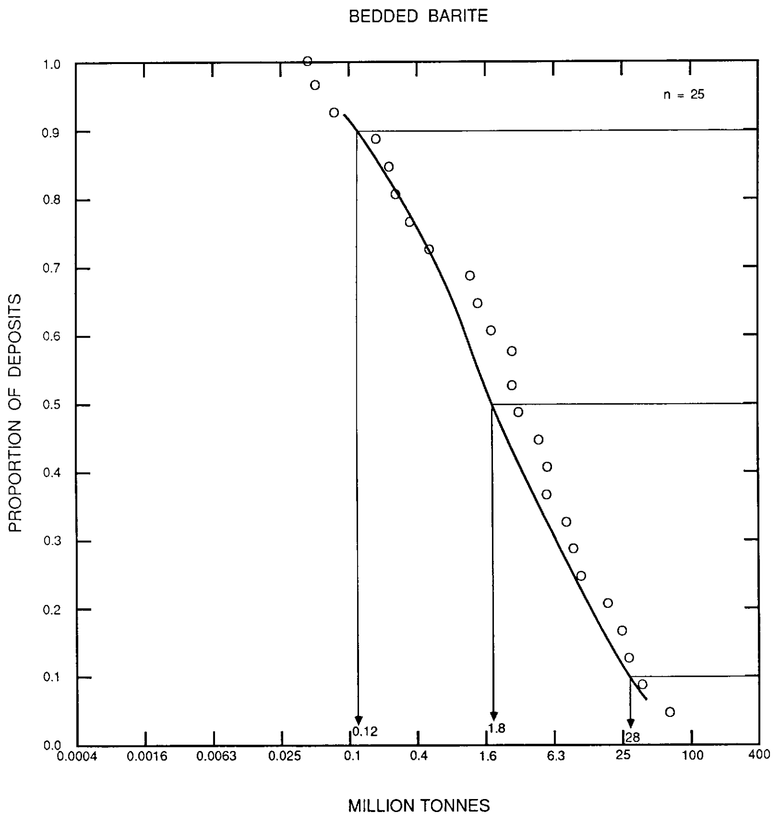

Figure 164. Tonnages of bedded barite deposits.

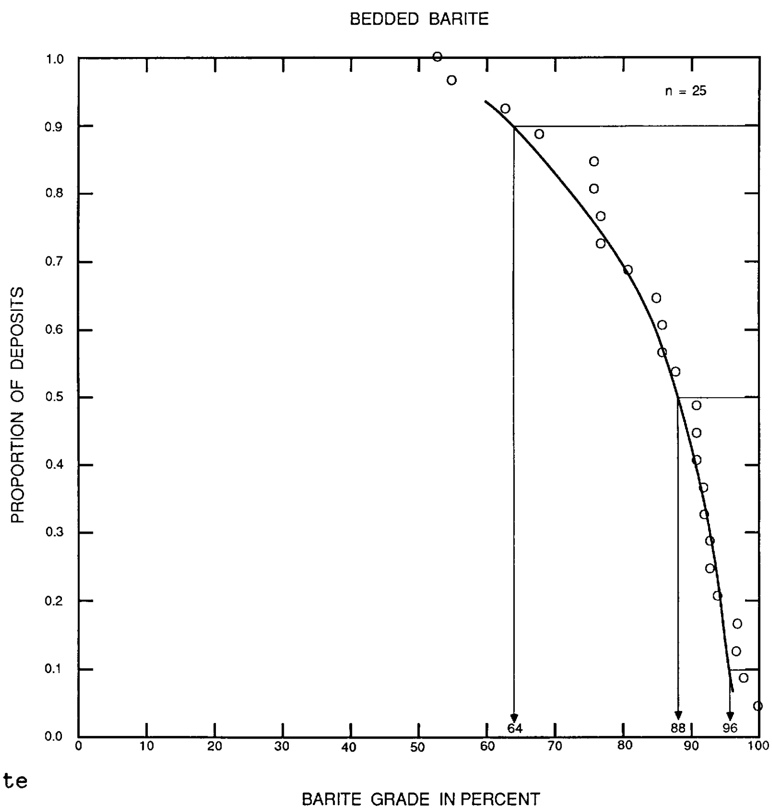

Figure 165. Barite grades of bedded barite deposits.

DESCRIPTIVE MODEL OF EMERALD VEINS

By Dennis P. Cox

DESCRIPTION Emerald in plagioclase-dolomite veins in black shale.

GENERAL REFERENCES Sinkankas (1981), p. 338-358, 407-435.

GEOLOGICAL ENVIRONMENT

Rock Types Black shale, claystone, siltstone, locally calcareous. Minor sandstone, limestone, conglomerate, and evaporites. Locally coarse dolomite breccia filled by carbonates and oligoclase.

Textures Diabasic dikes present but not prominent.

Age Range Cretaceous and Tertiary.

Depositional Environment Thick epicontinental anoxic marine shale. Evaporites may have provided saline solutions.

Tectonic Setting(s) Major faults. Minor intrusions may have provided heat sources for fluid circulation.

Associated Deposit Types May be associated with Pb-Zn deposits on a regional scale.

DEPOSIT DESCRIPTION

dineralogy Emerald + greenish beryl + oligoclase + dolomite + calcite + pyrite + fluorite + rutile + quartz. Apatite, parisite, and REE dolomite reported from Muzo.

Texture/Structure Crustified banding, vuggy, coarsely crystalline.

Alteration Shale altered to black hornfels, fossils replaced by oligoclase. Dolomitization.

Ore Controls Major fault at intersections of minor cross faults, sharp-walled veins, and tabular breccia bodies. Veins locally confined to sedimentary strata that overlie or underlie ferruginous beds.

Weathering Plagioclase weathers to pockets of kaolinite.

Geochemical Signature In veins: high Be, Na, Mg; low Li, Ba, K, Mo, Pb relative to shale outside of mineralized areas. At Muzo, REE in veins, Cu in underlying beds.

EXAMPLES

Gachala district, CLBA	(Escovar, 1979)
Muzo district, CLBA	(Sinkankas, 1981)

DESCRIPTIVE MODEL OF SOUTHEAST MISSOURI Pb-Zn

By Joseph A. Briskey

SYNONYMS Carbonate-hosted Pb-Zn; Mississippi Valley type.

DESCRIPTION Stratabound, carbonate-hosted deposits of galena, sphalerite, and chalcopyrite in rocks having primary and secondary porosity, commonly related to reefs on paleotopographic highs (see fig. 166). (For grade-tonnage model see Appalachian Zn deposit model.)

GENERAL REFERENCES Snyder and Gerdemann (1968), Thacker and Anderson (1977).

GEOLOGICAL ENVIRONMENT

Rock Types Dolomite; locally ore bodies also occur in sandstone, conglomerate, and calcareous shales.

Textures Calcarenites are most common lithology. Tidalites, stromatolite finger reefs, reef breccias, slump breccias; oolites, crossbedding, micrites.

Age Range Known deposits are in Cambrian to Lower Ordovician strata.

Depositional Environment Host rocks are shallow-water marine carbonates, with prominent facies control by reefs growing on flanks of paleotopographic basement highs. Deposits commonly occur at margins of clastic basins.

Tectonic Setting(s) Stable cratonic platform.

Associated Deposit Types Precambrian volcanic-hosted magnetite; Ba-Pb deposits occur higher in the Cambrian section.

DEPOSIT DESCRIPTION

Mineralogy Galena, sphalerite, chalcopyrite, pyrite, marcasite. Minor siegenite, bornite, tennantite, barite, bravoite, digenite, covellite, arsenopyrite, fletcherite, adularia, pyrrhotite, magnetite, millerite, polydymite, vaesite, djurleite, chalcocite, anilite, and enargite in order of abundance. Dolomite and minor quartz.

Texture/Structure Early fine-grained replacement; main stage coarse-grained replacement and vuggy or colloform open space filling. Hypogene leaching of galena is common.

Alteration Regional dolomitization; latter brown, ferroan, and bitumen-rich dolomite; extensive carbonate dissolution and development of residual shale; mixed-layer illite-chlorite altered to 2M muscovite; dickite and kaolinite in vugs; very minor adularia.

Ore Controls Open-space filling and replacement, most commonly at the interface between gray and tan dolomite, but also in traps at any interface between permeable and impermeable units. Any porous units may host ore: sandstone pinchouts; dissolution collapse breccias; faults; permeable reefs; slump, reef, and fault breccias; coarsely crystalline dolostone.

Geochemical Signature Regional anomalous amounts of Pb, Zn, Cu, Mo, Ag, Co, and Ni in insoluble residues. Zoning is roughly Cu ($\pm$ Ni $\pm$ Co)-Pb-Zn-iron sulfide going up section; ores contain about 30 ppm Ag; inconsistent lateral separation of metal zones. Background for carbonates: Pb = 9 ppm; Zn = 20; Cu = 4.

EXAMPLES

Viburnum subdistrict, USMO (Economic Geology 1977; Heyl, 1982)

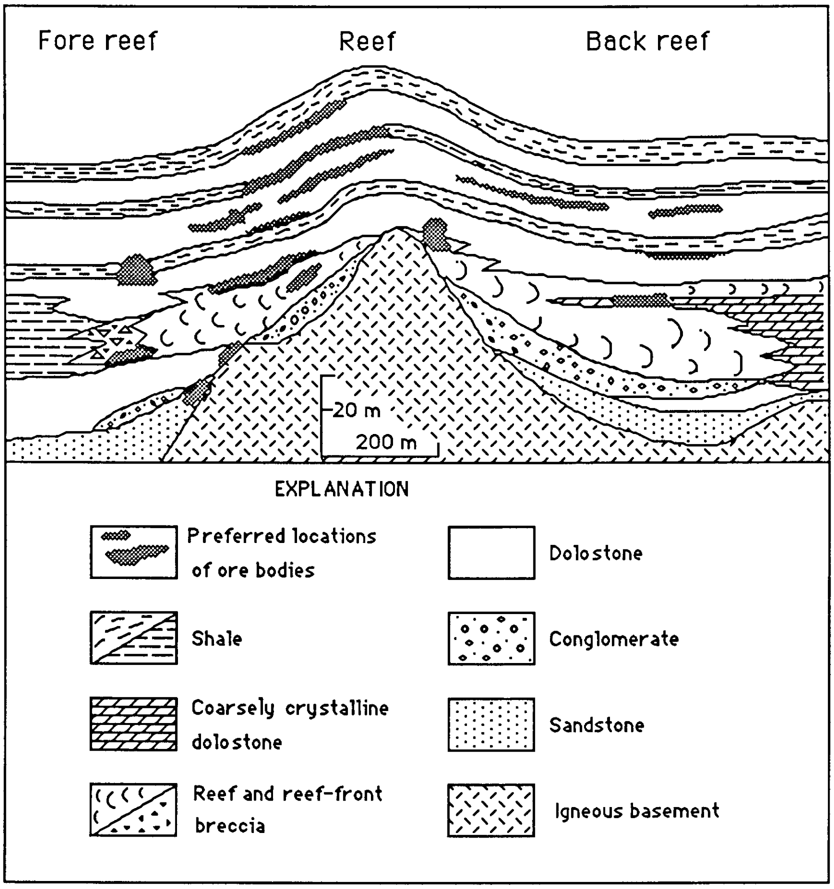

Figure 166. Cartoon cross section of a southeast Missouri Pb-Zn deposit (modified from Evans, 1977).

DESCRIPTIVE MODEL OF APPALACHIAN Zn

By Joseph A. Briskey

SYNONYMS Carbonate-hosted Zn; Mississippi Valley type.

DESCRIPTION Stratabound deposits of sphalerite and minor galena in primary and secondary voids in favorable beds or horizons in thick platform dolostone and limestone (see fig. 167).

GENERAL REFERENCE Hoagland (1976).

GEOLOGICAL ENVIRONMENT

Rock Types Dolostone and limestone.

Textures Subtidal, intratidal, and supratidal textures with high porosity are common, especially in the dolostones; limestones are commonly micritic, some with birdseye textures.

Age Range Appalachian deposits occur in rocks of Cambrian to Middle Ordovician age. Other deposits are in rocks as old as Proterozoic and as young as Triassic.

Depositional Environment Shallow-water, tidal and subtidal marine environments.

Tectonic Setting(s) Stable continental shelf.

Associated Deposit Types Stratabound carbonate-hosted deposits of barite-fluorite-sphalerite.

DEPOSIT DESCRIPTION

Mineralogy Sphalerite, with variable but subordinate pyrite and minor marcasite, and with minor barite, fluorite, gypsum, and anhydrite. Galena is usually absent or rare, but may be abundant locally.

Texture/Structure Mainly open space filling of coarse to medium crystalline sphalerite and pinkish dolomite. Sphalerite commonly displays banding. Locally, fine sphalerite in finely varved dolomite composes the breccia matrix.

Alteration Extensive finely crystalline dolostone occurs regionally and coarse crystalline dolomite is more common nearer to ore bodies. Silicification is typically closely associated with ore bodies. Extensive limestone dissolution and development of residual shale.

Ore Controls Ore occurs within dissolution collapse breccias that occur (1) throughout readily soluble limestone beds, or (2) in paleo-aquifer solution channels controlled by fractures or folds in limestone. Breccias commonly have domal cross sections above limestone aquifers that have been thinned by solution.

Weathering Zinc silicate and carbonate ores form in the zone of weathering and oxidation.

Geochemical Signature Readily detectable zinc anomalies in residual soils and in stream sediments. Primary zinc haloes in carbonate rocks near ore are not large enough to assist in exploration. Background in carbonate rocks: Zn = 20 ppm; Pb = 9 ppm.

EXAMPLES

Mascot-Jefferson City district, USTN	(Crawford and Hoagland, 1968; McCormick and others, 1971; Fulweiler and McDougal, 1971)
Copper Ridge district, USTN	(Hill and others, 1971)

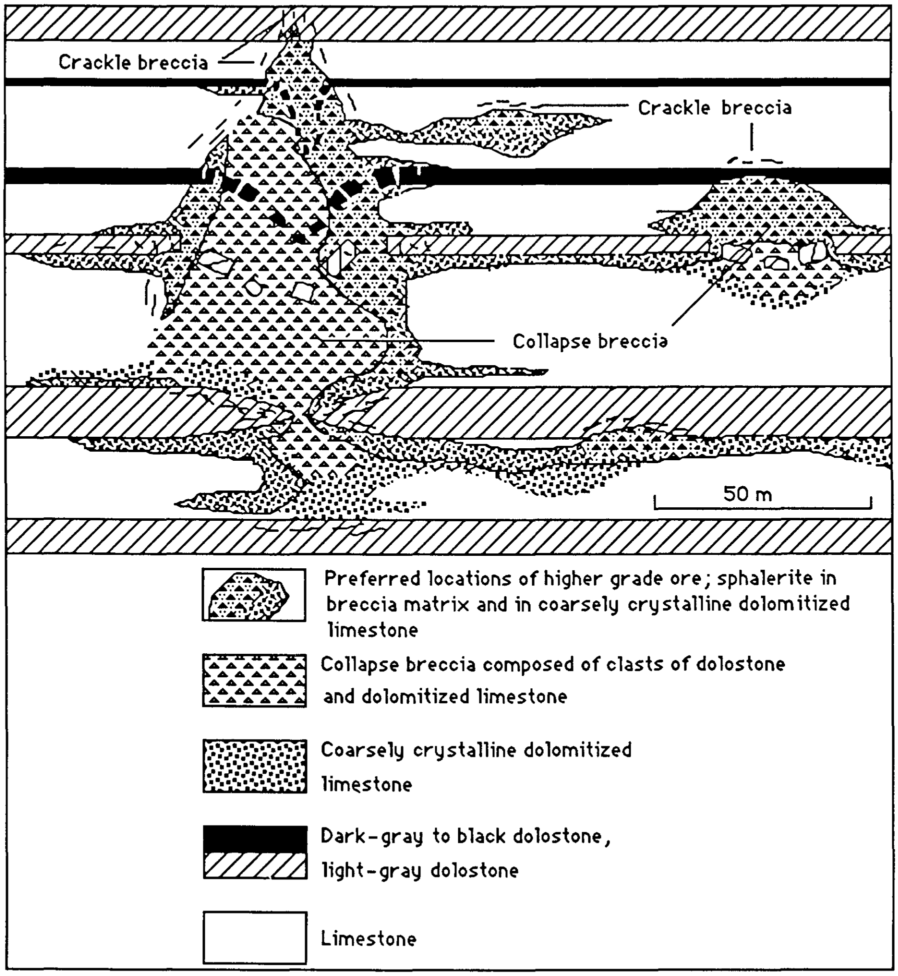

Figure 167. Cartoon cross section showing relationship of zinc ore to collapse breccia and dolomitized limestone in the Mascott-Jefferson City district, Tennessee. Modified from Armstrong and Lawrence (1983).

GRADE AND TONNAGE MODEL OF SOUTHEAST MISSOURI Pb-Zn AND APPALACHIAN Zn DEPOSITS

By Dan L. Mosier and Joseph A. Briskey

COMMENTS The models for stratabound carbonate-hosted Pb-Zn deposits, and for stratabound carbonate-hosted Zn deposits, are treated as end members that, in a general way, define a larger class of geologically complex stratabound carbonate-hosted deposits containing variable proportions of Pb or Zn. Grade-tonnage estimates were made for districts only, because of difficulties in defining the limits of an individual deposit within these typically large regionally mineralized systems. Numerous small districts containing less than about a million tonnes of ore are not included in this compilation, mainly because of the paucity of reliable data about reserves and past production, but also because they are outside the scope of this investigation. Lead grade is correlated with silver grade ($r = 0.87$, $n = 10$). See figs. 168-171.

DEPOSITS

Name	Country	Name	Country
Alpine-Lafatsch	ASTR-ITLY-YUGO	Nanisivik	CNNT
Austinville	USVA	Newfoundland Zinc	CNNF
Central Missouri	USMO	North Arkansas-Ozark	USAR
Central Tennessee	USTN	Pine Point	CNNT
East Tennessee	USTN	Polaris-Eclipse	CNNT
Friedensville	USPA	Robb Lake	CNBC
Gayna R.-Godlin L.	CNNT	Southeast Missouri	USMO
Kentucky-Illinois	USKN	Tri State	USMO-USOK
Metalline	USWA	Upper Mississippi Valley	USWI
Monarch-Kicking Horse	CNBC	Upper Silesia	PLND

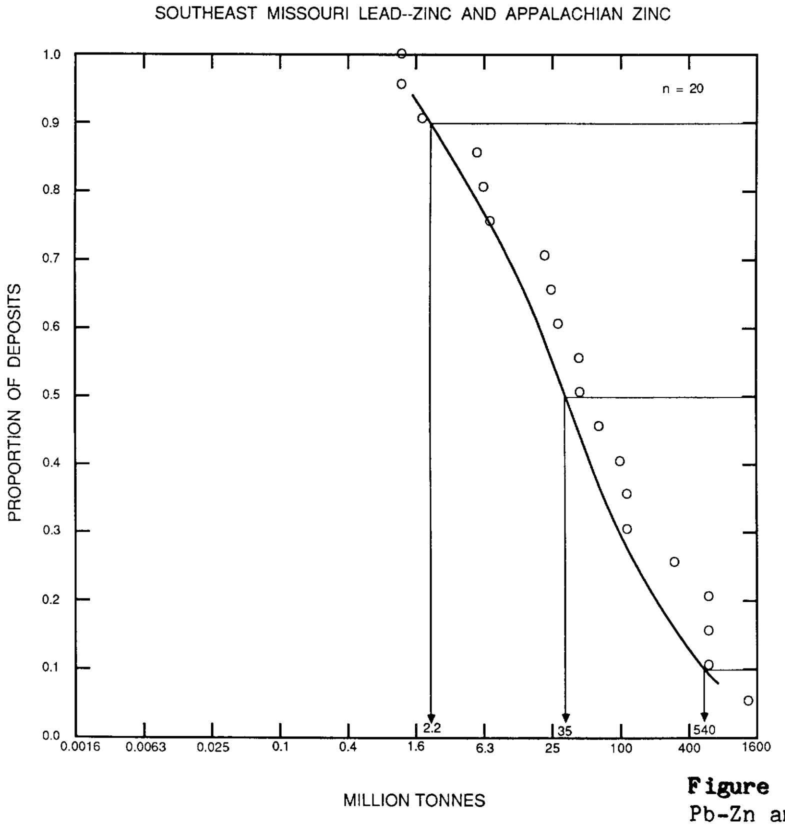

Figure 168. Tonnages of southeast Missouri Pb-Zn and Appalachian Zn deposits.

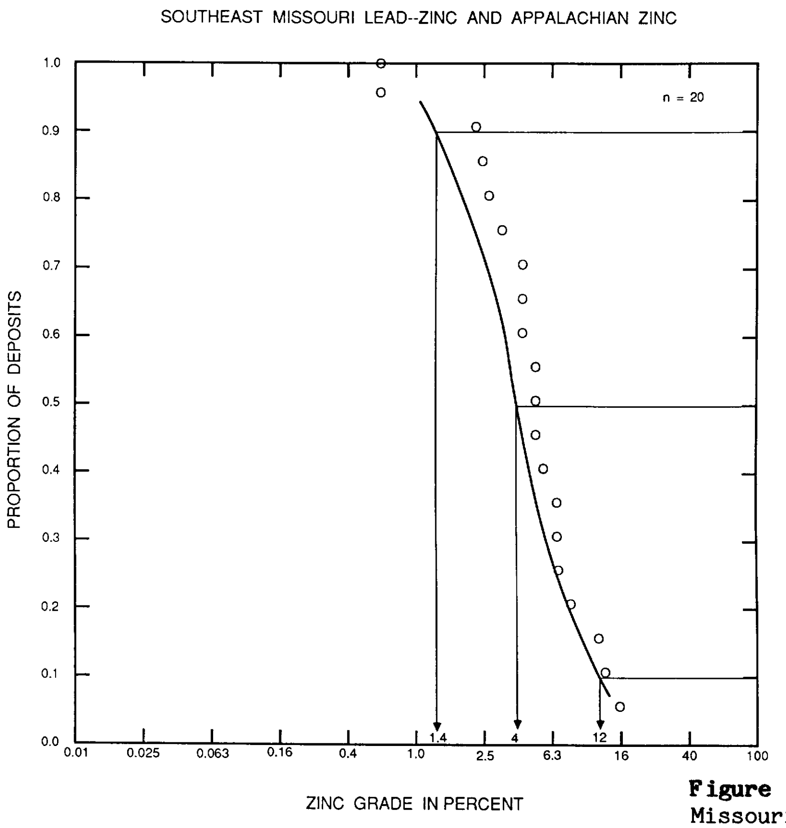

Figure 169. Zinc grades of southeast Missouri Pb-Zn and Appalachian Zn deposits.

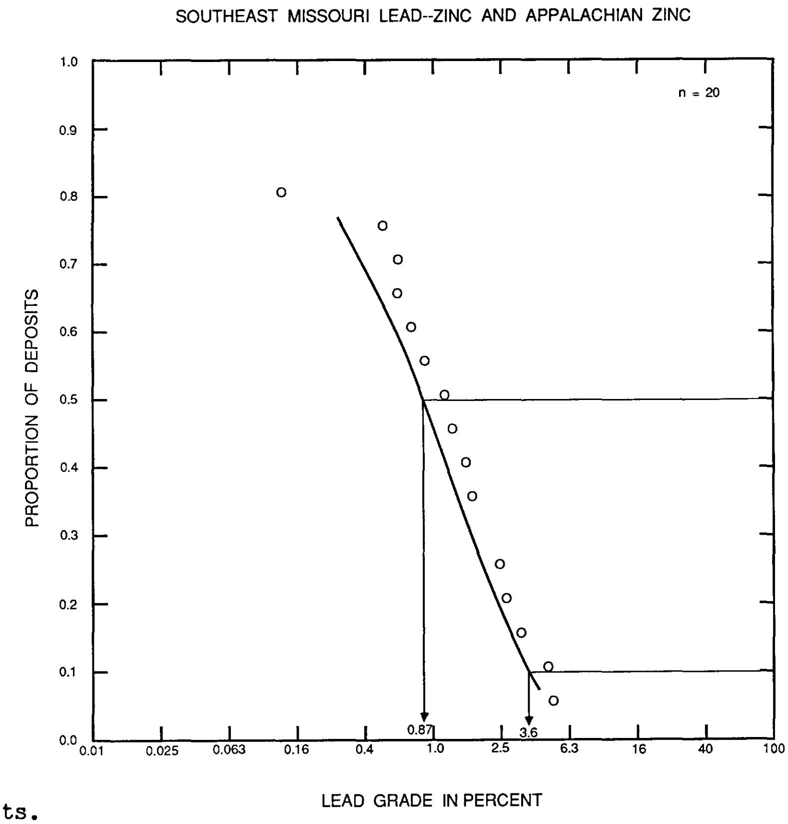

Figure 170. Lead grades of southeast Missouri Pb-Zn and Appalachian Zn deposits.

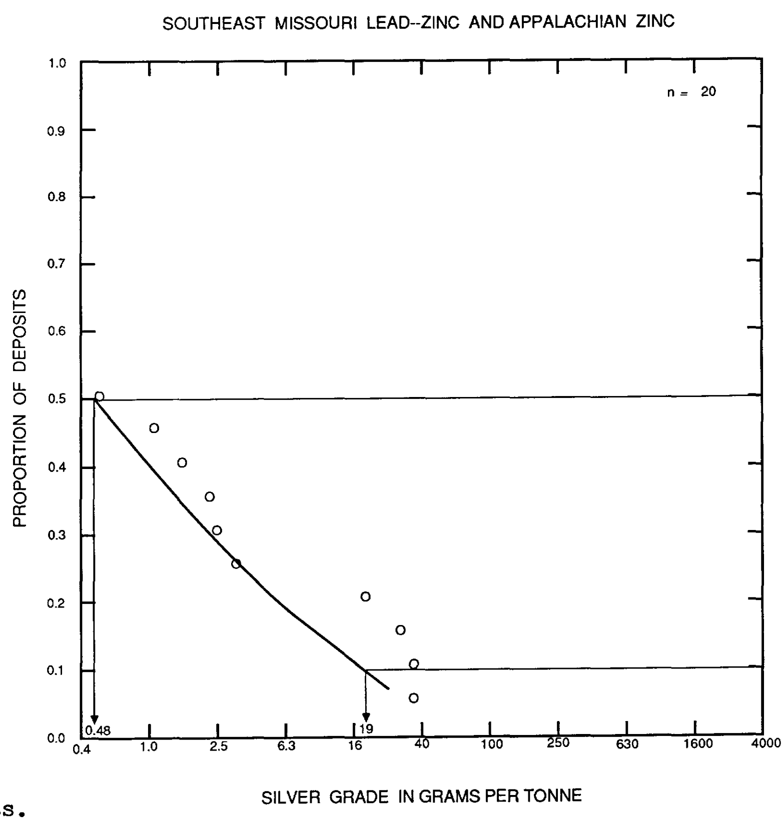

Figure 171. Silver grades of southeast Missouri Pb-Zn and Appalachian Zn deposits.

DESCRIPTIVE MODEL OF KIPUSHI Cu-Pb-Zn

By Dennis P. Cox and Lawrence R. Bernstein

DESCRIPTION Massive base-metal sulfides and As-sulfosalts in dolomite breccias characterized by minor Co, Ge, Ga, U, and V.

GEOLOGICAL ENVIRONMENT

Rock Types Dolomite, shale. No rocks of unequivocal igneous origin are related to ore formation. [The pseudoaplite at Tsumeb is herein assumed to be a metasedimentary rock following H. D. LeRoex (1955, unpublished report).]

Textures Fine-grained massive and carbonaceous, laminated, stromatolitic dolomites.

Age Range Unknown; host rocks are Proterozoic in Africa, Devonian in Alaska, Pennsylvanian in Utah.

Depositional Environment High fluid flow along tabular or pipe-like fault- or karst (?)-breccia zones.

Tectonic Setting(s) Continental platform or shelf terrane with continental or passive margin rifting. Ore formation at Tsumeb and Ruby Creek predates folding.

Associated Deposit Types Sedimentary copper, U-veins, barite veins. Sedimentary exhalative Pb-Zn may be a lateral facies.

DEPOSIT DESCRIPTION

Mineralogy Ruby Creek: pyrite, bornite, chalcocite, chalcopyrite, carrollite, sphalerite, tennantite. Tsumeb: galena, sphalerite, bornite, tennantite, enargite. Kipushi: sphalerite, bornite, chalcopyrite, carrollite, chalcocite, tennantite, pyrite. Less abundant minerals in these deposits are linnaeite, Co-pyrite, germanite, renierite, gallite, tungstenite, molybdenite, and native Bi. Bituminuous matter in vugs. At Apex mine, marcasite.

Texture/Structure Massive replacement, breccia filling, or stockwork. Replacement textures of pyrite after marcasite at Ruby Creek and Apex.

Alteration Dolomitization, sideritization, and silicification may be related to mineralization. Early pyrite or arsenopyrite as breccia filling or dissemination.

Ore Controls Abundant diagenetic pyrite or other source of S acts as precipitant of base metals in zones of high porosity and fluid flow. Bitumens indicate reducing environment at site of ore deposition.

Weathering Malachite-azurite, black Co-oxide, or pink Co-arsenate. Oxidation at Tsumeb has produced large crystals of many rare minerals. Oxidized Ge-Ga ore at Apex consists of iron oxides and jarosite; Ge and Ga minerals are not observed.

Geochemical and Geophysical Signature Cu, Zn, Pb, As, Co, Ag, Ge, Ga, Mo, W, Sn, Bi, U and V. Metal ratios: high Cu/Fe and locally high Cu/S in interior zones; high Co/Ni, As/Sb and Ag/Au. May be weakly radioactive.

EXAMPLES

Ruby Creek, ASAK	(Runnels, 1969)
Tsumeb, NAMB	(Sohnge, 1961); Wilson (1977)
Kipushi, ZIRE	(Intiomale and Oosterbosch, 1974)
Apex Mine, USUT	(Bernstein, 1986)

DESCRIPTIVE MODEL OF SUPERIOR Fe

By William F. Cannon

DESCRIPTION Banded iron-rich sedimentary rock, generally of great lateral extent, typically layered on centimeter scale with siliceous (chert) beds interlayered with iron-rich beds.

GENERAL REFERENCE James (1954).

GEOLOGICAL ENVIRONMENT

Rock Types Commonly interlayered with quartzite, shale, dolomite.

Textures Iron-formations and host rocks commonly contain sedimentary textures typical of shallow-water deposition in tectonically stable regions.

Age Range Mostly Early Proterozoic (2.0±0.2 b.y.). Less commonly Middle and Late Proterozoic.

Depositional Environment Stable, shallow-water marine environment, commonly on stable continental shelf or intracratonic basin.

Tectonic Setting(s) Now commonly preserved in forelands of Proterozoic orogenic belts.

Associated Deposit Types Sedimentary manganese deposits may occur stratigraphically near or be interbedded with iron-formations.

DEPOSIT DESCRIPTION

Mineralogy Hematite, magnetite, siderite, fine-grained quartz.

Texture/Structure Nearly always banded at centimeter scale; very fine grained where not metamorphosed.

Alteration None related to ore deposition. Commonly metamorphosed to varying degrees or weathered and enriched by supergene processes.

Ore Controls No primary controls of local importance. Supergene ores may be localized by irregularities in present or paleo erosion surface.

Weathering Alteration of original iron mineral to Fe-hydroxides and hematite. Silica partly to totally leached. End product of weathering is high-grade supergene ore.

Geophysical Signature Magnetic anomalies.

EXAMPLES
Mesabi Range, USMN (James, 1983)

GRADE AND TONNAGE MODEL OF SUPERIOR Fe AND ALGOMA Fe DEPOSITS

By Dan L. Mosier and Donald A. Singer

COMMENTS Archean and Proterozoic deposits (Algoma and Superior types) are both included because they are not significantly different in tonnage or grades. See figs. 172-174

DEPOSITS

Name	Country	Name	Country
Altamira-Frontera	VNZL	Bellary	INDA
Amapa	BRZL	Bicholim	INDA
An-shan	CINA	Burnt Hill-Knob Lake	CNQU
Bahia	BRZL	Cerro Bolivar	VNZL
Bailadila	INDA	Chityal and others	INDA

Cuyuna	USMN	Moose Mountain	CNON
Dhalli-Rajhara	INDA	Mount Gibson	AUWA
El Pao	VNZL	Mount Gould	AUWA
Fiskefjord	NRWY	Mount Hale	AUWA
Fort Apache	USAZ	Mount Philip	AUQL
Fort Gourand	MAUR	Musan	NKOR
Gogebic	USMN	Mutum	BLVA
Gorumahisani and others	INDA	Noamundi-Joda-Gua etc.	INDA
Goulais	CNON	Norberg	SWDN
Guntur	INDA	Pa-pan-ling	CINA
Isua	GRLD	Pen-chi-hu	CINA
Iron Monarch-Iron Knob	AUSA	Piacoa	VNZL
Jussaari	FNLD	Porkonen	FNLD
Kanjamalai and others	INDA	Rowghat	INDA
Kemmangundi and others	INDA	Sangalwara	INDA
Koolyanobbing	AUWA	Santa Barbara	VNZL
Krivoi-Rog	URRS	Serria do Carajas	BRZL
Kudremukh and others	INDA	Sirigao	INDA
Kung-changling	CINA	Ssu-chia-ying	CINA
Kusalpur	INDA	Stripa-Striberg	SWDN
Labrador Quebec	CNQU	Sydvananger	NRWY
Lohara and others	INDA	Tallering Peak	AUWA
Los Castillos	VNZL	Thabazimbi	SAFR
Maria Luisa	VNZL	Tonkolili	SRLN
Marquette	USMN	Vermilion	USMN
Mato Grosso	BRZL	Vestpolltind	NRWY
Menominee	USMN	Weld Range-Wilgie Mia	AUWA
Mesabi	USMN		
Minas Gerais	BRZL		

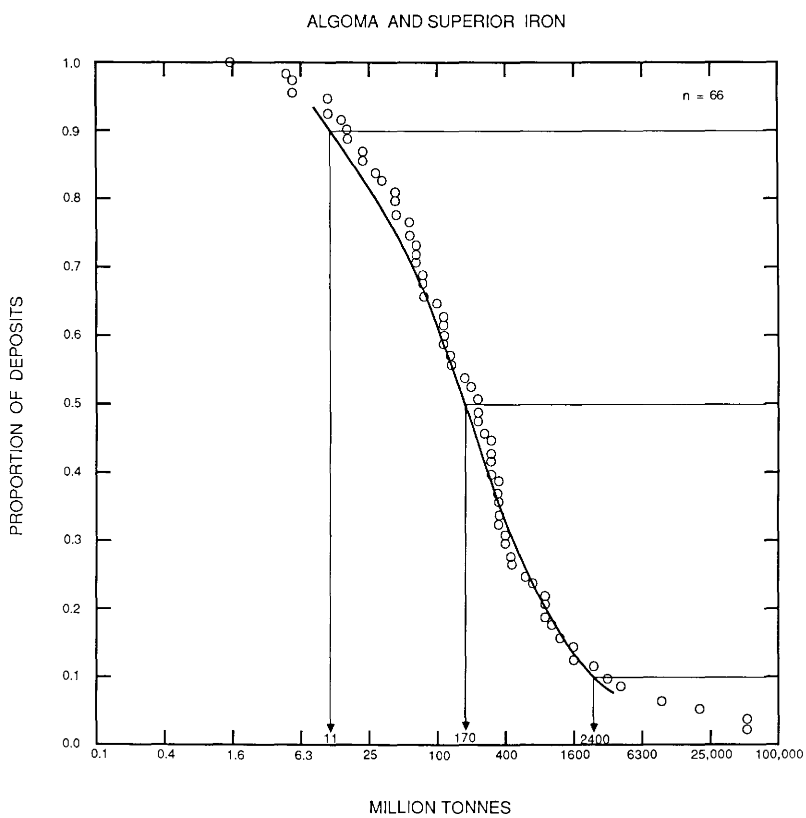

Figure 172. Tonnages of Algoma Fe and Superior Fe deposits.

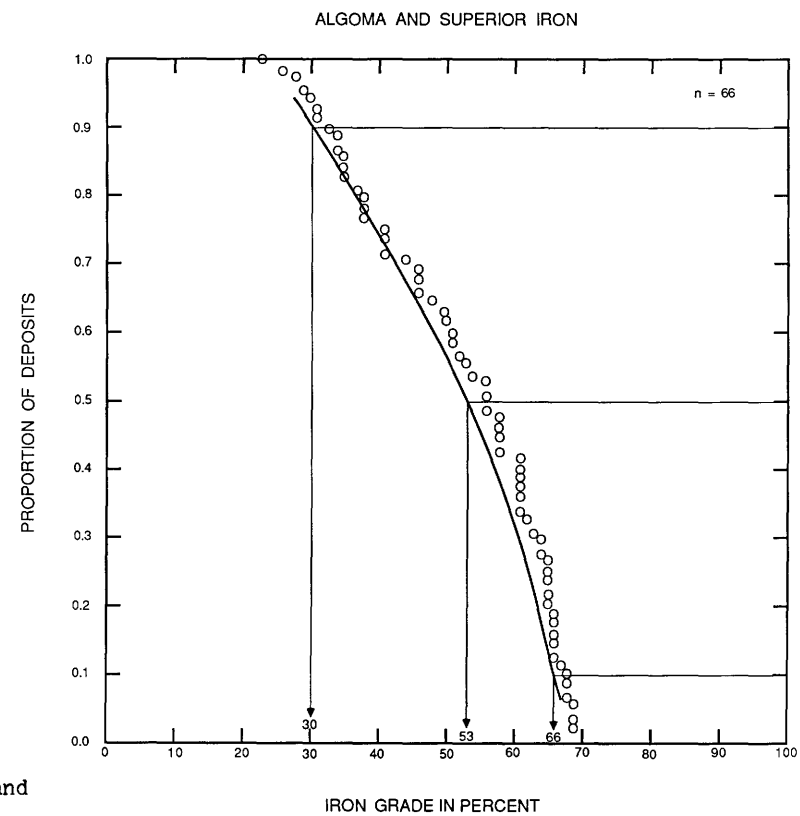

Figure 173. Iron grades of Algoma Fe and Superior Fe deposits.

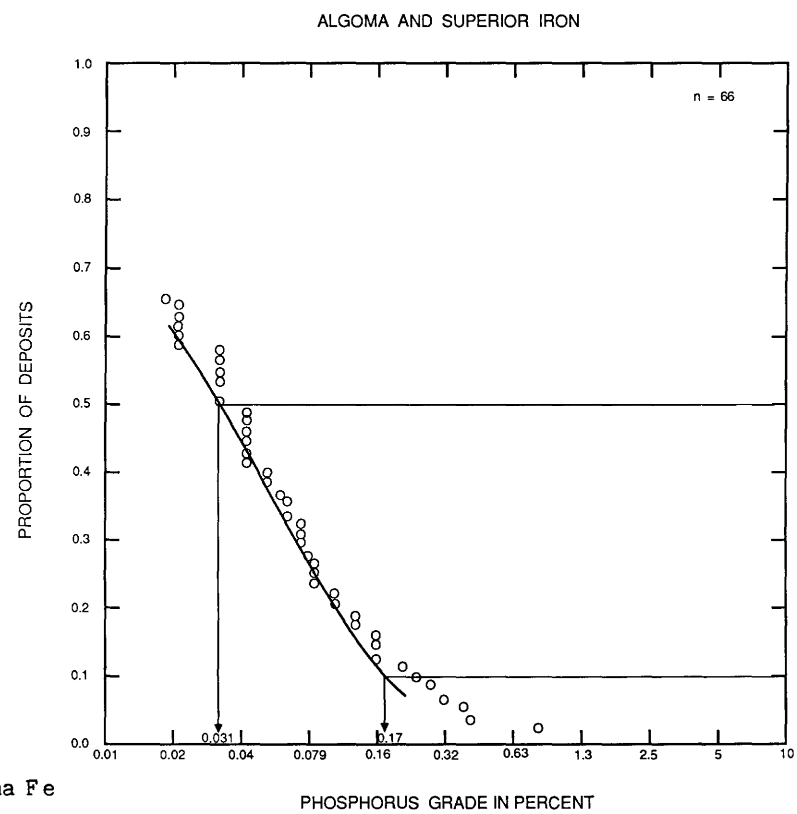

Figure 174. Phosphorus grades of Algoma Fe and Superior Fe deposits.

DESCRIPTIVE MODEL OF SEDIMENTARY Mn

By William F. Cannon and Eric R. Force

APPROXIMATE SYNONYM Bathtub-ring Mn.

DESCRIPTION Shallow marine (non-volcanogenic) sedimentary Mn deposits formed around rims of anoxic basins during transgression (see fig. 175).

GENERAL REFERENCE Cannon and Force (1983).

GEOLOGICAL ENVIRONMENT

Rock Types Shallow marine sediments, most commonly carbonates, clay, and glauconitic sand, commonly with shellbeds, in transgressive sequences associated with anoxic basins.

Age Range Mostly in "anoxic events," narrow time periods within the early Paleozoic, Jurassic, and mid-Cretaceous, but may be in rocks of any age associated with anoxic basins.

Depositional Environment Shallow (50-300 m) marine, commonly in sheltered sites around paleo-islands. Most deposits overlie oxidized substrates, but basinward, carbonate deposits may be in chemically reduced settings.

Tectonic Setting(s) Stable cratonic interior basin or margin.

Associated Deposit Types Locally, sedimentary phosporites, sediment-hosted Cu.

DEPOSIT DESCRIPTION

Mineralogy A variety of Mn carbonates (mostly basinward) and oxides (mostly landward).

Texture/Structure Commonly as oolites, pisolites, laminae, and shell replacements.

Alteration Supergene alteration to high-grade ore is common.

Ore Controls Oxidation-reduction interface (involves age, paleobasin reconstruction, paleodepth of site) and lack of clastic dilution.

Weathering Mn carbonates may weather to brown, nondescript rock. Black secondary oxides are common.

Geochemical Signature None known.

EXAMPLES

Molango (Jurassic), MXCO	(Tavera and Alexandri, 1972)
Nikopol (Oligocene), USSR	(Sapozhnikov, 1970)
Groote Eyland (Cretaceous), AUTN	(Frakes and Bolton, 1984)

GRADE AND TONNAGE MODEL OF SEDIMENTARY Mn

By Dan L. Mosier

DATA REFERENCES Most data from DeYoung and others (1984).

COMMENTS Because available grade and tonnage estimates represent mines from, in some cases, very extensive deposits and because the numbers are calculated at differing cutoff grades, the endowment of these deposits is undoubtedly much larger than indicated in these figures. See figs. 176-177.

DEPOSITS

Name	Country	Name	Country
Akviran	TRKY	Matese-Ciociaria	ITLY
Andhra Pradesh	INDA	Molango	MXCO
Ansongo	MALI	Morro da Mina	BRZL
Azul-Carajas	BRZL	Naniango	UVOL
Bolske-Tokmak	URRS	Nikolaevskoe	URRS
Chiatura	URRS	Nikopol	URRS
Chiwefwe	ZIMB	Nizne-Udinskaja	URRS
Groote Eylandt	AUNT	Otjosondu	SAFR
Gujarat	INDA	Ravensthorpe	AUWA
Horseshoe	AUWA	Seiba	URRS
Hsiangtan	CINA	Shimoga (Karnatoka)	INDA
Imini	MRCO	Timna	ISRL
Istranca	TRKY	Uracum	BRZL
Kalahari	SAFR	Urkut	HUNG
Kamenskoe	URRS	Usinsk	URRS
Kaochiao	CINA	Varna	BULG
Madhya Pradesh	INDA	Wafangtzu	CINA
Manuel Killigrews	CNNF		

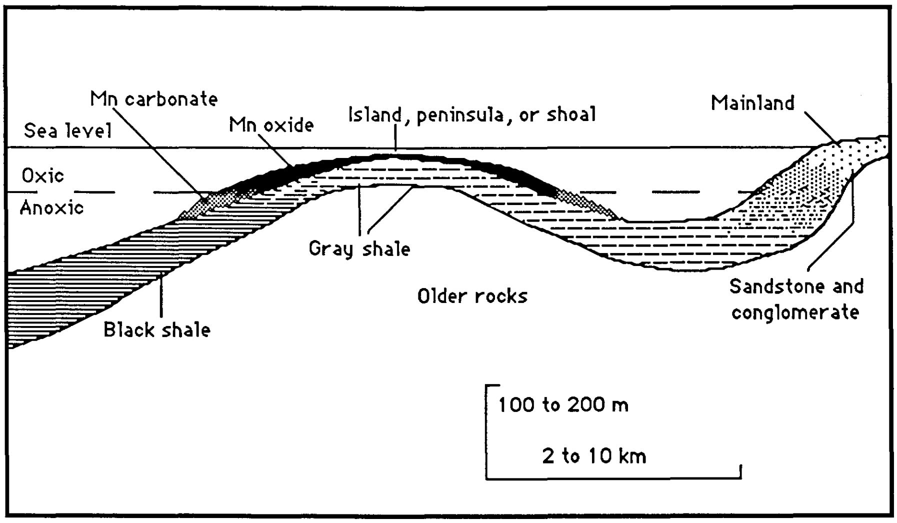

Figure 175. Cartoon cross section showing relation of sedimentary facies to sedimentary Mn deposits.

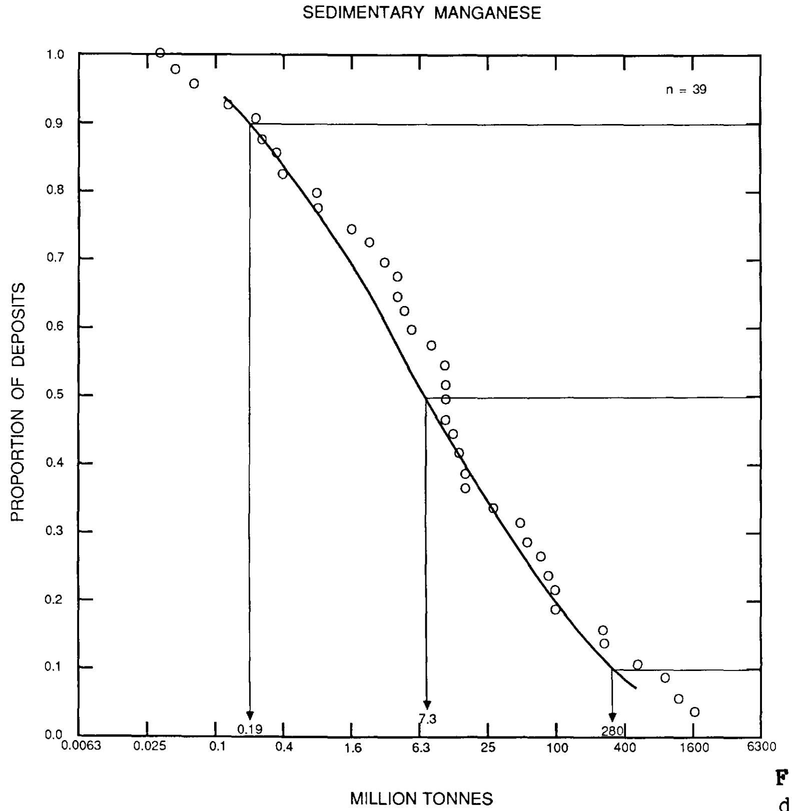

Figure 176. Tonnages of sedimentary Mn deposits.

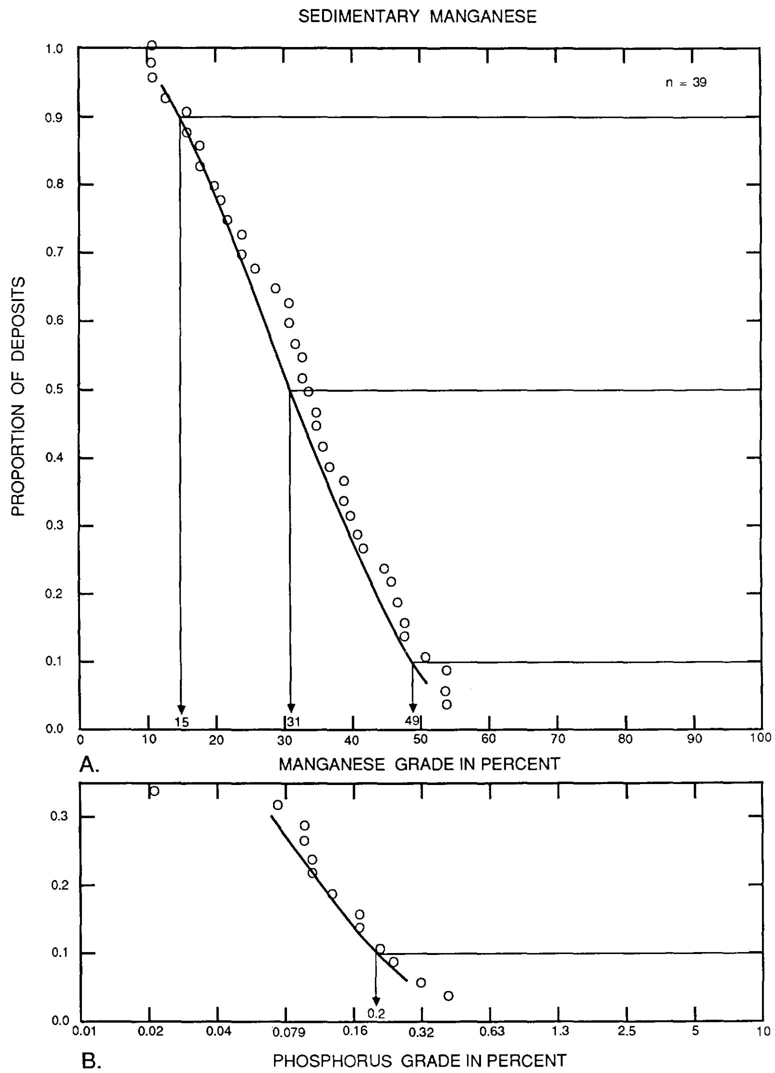

Figure 177. Metal grades of sedimentary Mn deposits. A, Manganese. B, Phosphorus.

Model 34c

DESCRIPTIVE MODEL OF UPWELLING TYPE PHOSPHATE DEPOSITS

By Dan L. Mosier

DESCRIPTION Phosphorite sediments form a major stratigraphic unit within a sequence of marine sediments in upwelling areas in basins with good connection to the open sea.

GENERAL REFERENCES Slansky (1980), Sheldon (1964).

GEOLOGICAL ENVIRONMENT

Rock Types Phosphorite, marl, shale, chert, limestone, dolomite, and volcanic materials.

Age Range Precambrian through Miocene.

Depositional Environment Marine sedimentary basins with good connection to the open sea and upwelling, areas highly productive of plankton. Deposition occurs mostly in warm latitudes, mostly between the 40th parallels.

Tectonic Setting(s) Intra-plate shelf, platform, miogeosynclines, and eugeosynclines.

Associated Deposit Types Sedimentary manganese.

DEPOSIT DESCRIPTION

Mineralogy Apatite + fluorapatite + dolomite + calcite + quartz + clays (montmorillonite or illite) ± halite ± gypsum ± iron oxides ± siderite ± pyrite ± carnotite.

Texture/Structure Pellets, nodules, phosphatized shell and bone material.

Alteration None related to ore.

Ore Controls Basins, or parts of basins, favorable for the accumulation of organic rich sediments and for their evolution into phosphorites. Individual beds may be a meter thick or more and may extend over hundreds of square kilometers.

Weathering Limonite and goethite.

Geochemical Signature P, N, F, C, and U. Anomalously radioactive.

EXAMPLES

Southeast, USID	(Gulbrandsen and Krier, 1980)
Meskala, MRCO	(British Sulphur Corp. Ltd., 1980)
Stra Quertane, TUNS	(British Sulphur Corp. Ltd., 1980)

GRADE AND TONNAGE MODEL OF UPWELLING TYPE PHOSPHATE DEPOSITS

By Dan L. Mosier

COMMENTS See figs. 178-179.

DATA REFERENCE Krauss and others (1984).

DEPOSITS

Name	Country	Name	Country
Abu Tartur	EGPT	Mdilla	TUNS
Akashat	IRAQ	Meskala	MRCO
Aktyubinsk	URRS	Metalaoui	TUNS
Al-Hasa/Oatrana	JRDN	Montana	USMT
Arad	ISRL	Moulares	TUNS
Beersheva	ISRL	Mrata	TUNS
Bu Craa	MRCO	Mzaita	ALGR
Brooks Range	USAK	Nahal-Zin	ISRL
Chilisai	URRS	New Cuyama	USCA
Djebel Onk	ALGR	Oronta	ISRL
D-Tree	AUQL	Oulad-Abdoun	MRCO
Duchess	AUQL	Patos de Minas	BRZL
Eastern A&B	SYRA	Qusseir	EGPT
El Hamrawein	EGPT	Redeyef	TUNS
Ganntour	MRCO	Ruseifa	JRDN
Hahotoe	TOGO	Safagar	EGPT
Haikou	CINA	San Juan de la Costa	MXCO
Hubsugul	MNGL	Sechura	PERU
Idfu-Qena	EGPT	Sehib	TUNS
Kalaa Khasba	TUNS	S.E. Idaho	USID
Kara Tau	URRS	Shediyah	JRDN
Khneifiss	SYRA	Sherrin Creek	AUQL
Kondonakasi	ANGL	Stra Quertane	TUNS
Kun Ming	CINA	Taiba	SNGL
Lady Annie	AUQL	Thamar-Kotra	INDA
Lee Creek	USNC	Thies	SNGL
Le Kouif	ALGR	Uinta Mtns	USUT
Lily Creek	AUQL	Vernal	USUT
Makhtesh	USRL	Warm Springs	USMT
Mazidagi	TRKY	Wyoming	USWY

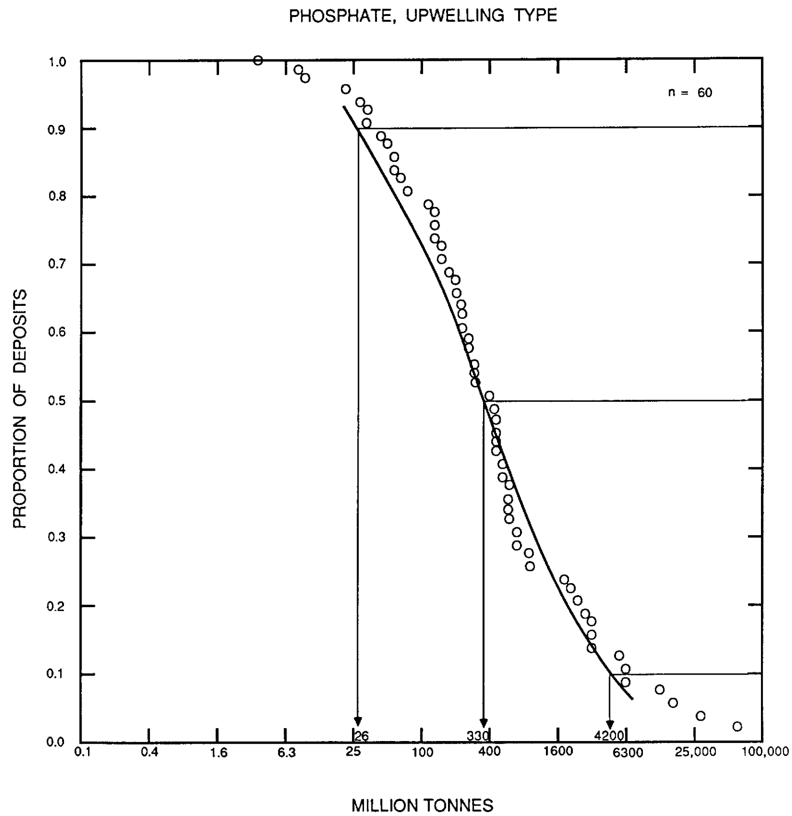

Figure 178. Tonnages of upwelling-type phosphate deposits.

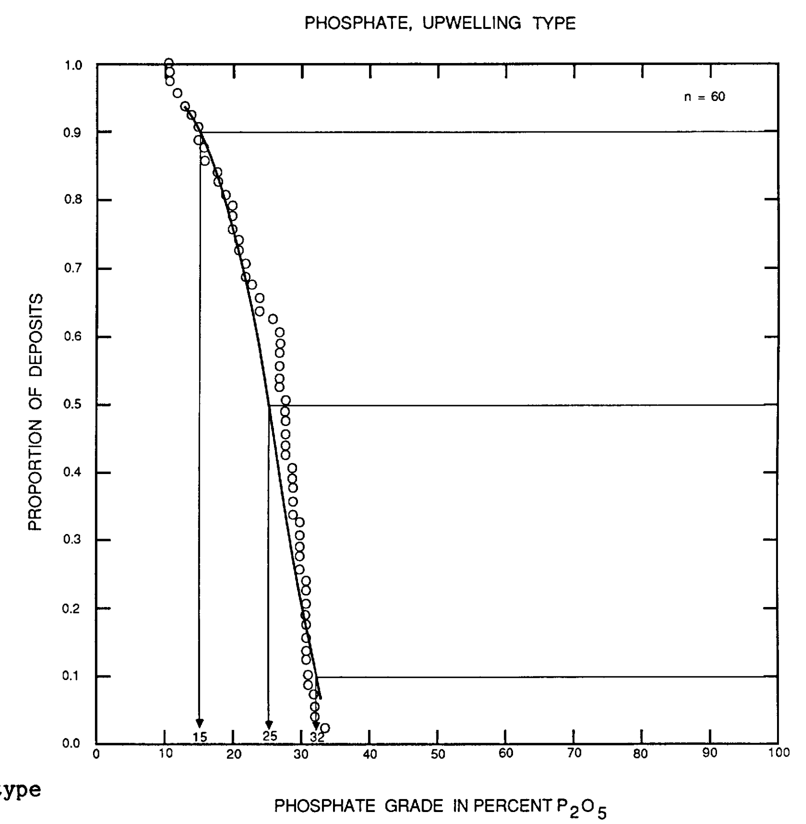

Figure 179. P_2O_5 grades of upwelling-type phosphate deposits.

DESCRIPTIVE MODEL OF WARM-CURRENT TYPE PHOSPHATE DEPOSITS

By Dan L. Mosier

DESCRIPTION Phosphorites formed in warm currents along the eastern coasts of continents; consist of phosphatic limestone or sandstone.

GENERAL REFERENCES Cathcart and Gulbrandsen (1973), Sheldon (1964).

GEOLOGICAL ENVIRONMENT

Rock Types Phosphatic limestone and sandstone; chert and diatomaceous material may be present.

Age Range Early Cretaceous through Pliocene.

Depositional Environment Basins of structural lows on the flanks of rising domes, at the mouths of rivers and estuaries. Deposition occurs in warm latitudes, mostly between the 40th parallels. Deposits are formed by dynamic upwelling or by the cool countercurrent associated with warm density current.

Tectonic Setting(s) Continental shelf; may be associated with eugeosynclinal rocks.

DEPOSIT DESCRIPTION

Mineralogy Fluorapatite + quartz + dolomite + montmorillonite + kaolinite + calcite ± wavellite ± crandallite ± illite ± clinoptilolite ± palygorskite ± smectite ± collophane.

Texture/Structure Phosphatic pellets and fossil fragments with a carbonate matrix.

Ore Controls Stratigraphic phosphatic horizons within embayments and estuarine environments in proximity to the open sea. Basins on flanks of structural highs (domes, arches, anticlines) are important controls for phosphate deposition.

Weathering Goethite.

Geochemical Signature P, C, U, N, F. Anomalously radioactive.

EXAMPLES

Paulista, BRZL	(British Sulphur Corp. Ltd. 1980)
East, north, and south Florida, USFL	
Offshore Savannah, USGA	(Zellars-Williams Inc., 1978)

GRADE AND TONNAGE MODEL OF WARM-CURRENT TYPE PHOSPHATE DEPOSITS

By Dan L. Mosier

DATA REFERENCE Krauss and others, (1984).

COMMENTS About half of the deposits are actually districts. Grades have been adjusted to reflect in-place grades rather than commonly reported concentrate grades. See figs. 180-181.

DEPOSITS

Name	Country	Name	Country
Big Four	USFL	Haynsworth	USFL
Bonny Lake	USFL	Kingsford	USFL
Clear Springs	USFL	Lonesome	USFL
East Florida	USFL	Noralyn-Phosphoria	USFL
Fort Green	USFL	North Florida	USFL
Hard Rock	USFL	North Carolina	USNC

Model 34d--Con.

Northeast Florida	USFL	Rockland	USFL
Offshore Savannah	USGA	Savannah River	USGA
Paulista	BRZL	South Florida	USFL

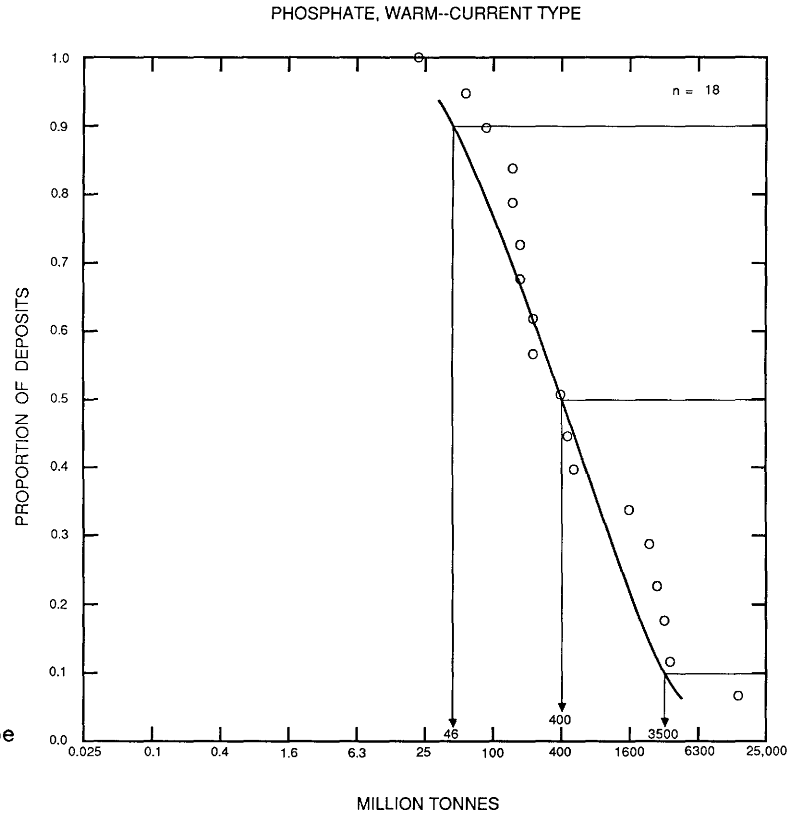

Figure 180. Tonnages of warm-current type phosphate deposits.

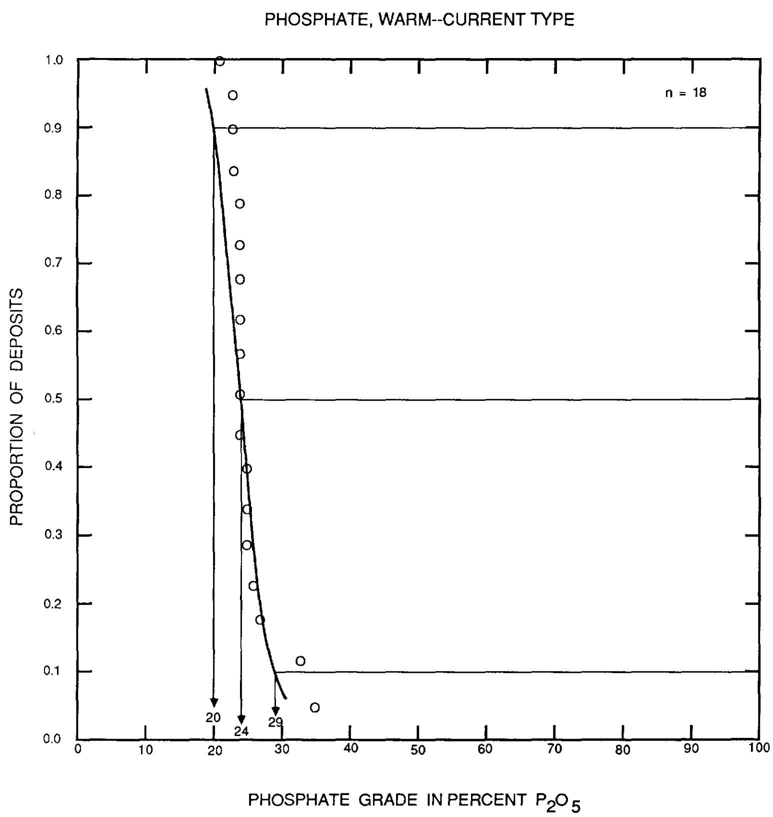

Figure 181. P_2O_5 grades of warm-current type phosphate deposits.

DESCRIPTIVE MODEL OF LOW-SULFIDE Au-QUARTZ VEINS

By Byron R. Berger

APPROXIMATE SYNONYMS Mesothermal quartz veins, Mother Lode veins.

DESCRIPTION Gold in massive persistent quartz veins mainly in regionally metamorphosed volcanic rocks and volcanic sediments.

GEOLOGICAL ENVIRONMENT

Rock Types Greenstone belts; oceanic metasediments: regionally metamorphosed volcanic rocks, graywacke, chert, shale, and quartzite. Alpine gabbro and serpentine. Late granitic batholiths.

Age Range Precambrian to Tertiary.

Depositional Environment Continental margin mobile belts, accreted margins. Veins are generally post-metamorphic and locally cut granitic rocks.

Tectonic Setting(s) Fault and joint systems produced by regional compression.

Associated Deposit Types Placer Au-PGE, kuroko massive sulfide, Homestake gold.

DEPOSIT DESCRIPTION

Mineralogy Quartz + native gold + pyrite + galena + sphalerite + chalcopyrite + arsenopyrite ± pyrrhotite. Locally tellurides ± scheelite ± bismuth ± tetrahedrite ± stibnite ± molybdenite ± fluorite. Productive quartz is grayish or bluish in many instances because of fine-grained sulfides. Carbonates of Ca, Mg, and Fe abundant.

Texture/Structure Saddle reefs, ribbon quartz, open-space filling textures commonly destroyed by vein deformation.

Alteration Quartz + siderite and (or) ankerite + albite in veins with halo of carbonate alteration. Chromian mica + dolomite and talc + siderite in areas of ultramafic rocks. Sericite and disseminated arsenopyrite + rutile in granitic rocks.

Ore Controls Veins are persistent along regional high-angle faults, joint sets. Best deposits overall in areas with greenstone. High-grade ore shoots locally at metasediment-serpentine contacts. Disseminated ore bodies where veins cut granitic rocks.

Weathering Abundant quartz chips in soil. Gold may be recovered from soil by panning.

Geochemical Signature Arsenic best pathfinder in general; Ag, Pb, Zn, Cu.

EXAMPLES

Grass Valley, USCA	(Lindgren, 1896)
Mother Lode, USCA	(Knopf, 1929)
Ballarat Goldfield, Victoria, AUVT	(Baragwanath, 1953)
Goldfields of Nova Scotia, CNNS	(Malcolm, 1929)

GRADE AND TONNAGE MODEL OF LOW-SULFIDE Au-QUARTZ VEINS

By James D. Bliss

COMMENTS All mines within 1.6 km were combined and only deposits containing more than 99 tonnes are included. Gold grade is correlated with tonnage (r = -0.30) and with silver grade (r = 0.45, n = 39). See figs. 182-183.

Model 36a--Con.

DEPOSITS

Name	Country	Name	Country
Al	AUVT	Colfax	USCA
Achilles	NZLD	Colombo	USCA
Alabama Shoot	AUVT	Comet	USAK
Alex Hill-Mad Kiss	GUYN	Confidence	USCA
Alice	USCA	Coulterville	USCA
Alleghany East	USCA	Coulterville South	USCA
Alleghany West	USCA	Country Harbour	CNNS
Alto	USCA	Cove District	USCA
Amador City	USCA	Cow Bay	CNNS
American Bar	USCA	Cox, Bolyan & Loberg	USAK
Ample	CNBC	Cranberry Hill	CNNS
Angels-Carson	USCA	Dalesford	AUVT
Argo	USCA	Damascus	USCA
Argus Hill	AUVT	Defender	USCA
Ashland	USOR	Delta	USCA
Atlas	USCA	Demarest	USCA
Bagby	USCA	Dinero	USCA
Bagby Valley	USCA	Dominion Consolidated	NZLD
Ballarat	AUVT	Dorothea	USOR
Barrandum	USCA	Eagle Bluff-River Bend	USCA
Bear Valley	USCA	Eagle Shawmut	USCA
Bear Valley South	USCA	Early-Sweetwater	USCA
Beaver Dam	CNNS	East Rawdon	CNNS
Belden	USCA	Eclipse No. 1	USCA
Bendigo	AUVT	Ecum Secum	CNNS
Bendigo	NZLD	El Dorado	USCA
Berry Creek	USCA	El Portal	USCA
Bethanga	AUVT	Eliza-Schroeder	USCA
Big Oak Flat	USCA	Empire-Lone Star	USCA
Birthday-William Fancy	AUVT	Enterprise	USCA
Black Bear	USCA	Esmeralda	USCA
Black Boy	USCA	Ester Dome SE	USAK
Blackstone	USCA	Experimental	USCA
Blockhouse	CNNS	Felicianna	USCA
Blue Lead	USAK	Fifteen-mile Brook	CNNS
Blue Mountain	USCA	Fifteen-mile Stream	CNNS
Bonanza	NZLD	Fifty-five	USCA
Bondurant	USCA	Fine Gold	USCA
Braden	USOR	Finney	USCA
Bralorne-Pioneer	CNBC	Five Pines	USCA
Broken Hills	USCA	Forbestown	USCA
Brookfield	CNNS	Ford	USCA
Buller-Mokihinui	NZLD	Forest Hill	CNNS
Caledonia	AUVT	Four Hells Mine	USCA
Canyon Creek-East Fork	USCA	Fourth Crossing	USCA
Caribou	CNNS	Francis Ormand	AUVT
Caribou-Aurum	CNBC	Franklin	USCA
Carleton	CNNS	French	USCA
Carolin	CNBC	French Gulch	USCA
Cassilis	AUVT	Fryer's Creek	AUVT
Central	USCA	Gabriels Gully	NZLD
Central Rawdon	CNNS	Galice North	USOR
Chewton	AUVT	Gabretta	USCA
Chichagof	USAK	Gabrinus	USCA
Cleary Hill	USAK	Gem	USCA
Clunes Goldfield	AUVT	Gem Olive	USCA
Coarsegold	USCA	German Bar	USCA
Cobol	USAK	Giant King	USCA
Cochrane Hill	CNNS	Gibralter	USCA

Gladstone	USCA
Glencoe-Woodhouse	USCA
Globe-Ralston	USCA
Gold Bug	USCA
Gold Point	USCA
Gold Reef	USCA
Gold River	USCA
Gold Chariot	USCA
Golden Eagle	USCA
Golden Jubilee	USCA
Golden-El Dorado	USCA
Goldenville	CNNS
Grand Victory	USCA
Granite Hill	USOR
Granite King	USCA
Grant	USAK
Grass Valley	USCA
Green Excelsior	USCA
Greenback	USOR
Gwynne	USCA
Hall Creek	CNBC
Ham & Birney	USCA
Harriet	CNBC
Harrigan Cove	CNNS
Hathaway	USCA
Hazel	USCA
Hedley Camp	CNBC
Henry Ford	USAK
Herman	USCA
Hi-Yu	USAK
Hillgrove	AUNS
Hirst-Chichagof	USAK
Homestake-McCarty	USAK
Hornitos	USCA
Horseshoe I	USCA
Hunter Valley	USCA
Iconoclast	USCA
Indian Path Mine	CNNS
Invincible Lode	NZLD
Isaac's Harbour	CNNS
Jabal Guyan	SAAR
Jamestown	USCA
Joe Walker	USCA
Jubilee	NZLD
Jubilee-New Jubilee	AUVT
Julian-Banner	USCA
K.C.	USCA
Kelsey	USCA
Kelsey North	USCA
Kemptville	CNNS
Killag	CNNS
Kinsley	USCA
Kinsley North	USCA
Kotchkar Mines	USSR
Lake Catcha	CNNS
Lamphear	USCA
Lawrencetown	CNNS
Leipsigate	CNNS
Leviathan	AUVT
Liberty	USCA
Little Squaw	USAK
Locarno	USCA
Loch Fyne	AUVT
Lone Mary	USCA
Long Tunnel	AUVT
Lord Nelson	AUVT
Lucky Bart	USOR
Lucky Shot-War Baby	USAK
Lyell Goldfield	NZLD
Mabel	USAK
Malden North	AUVT
Mammoth	USCA
Mariners	AUVT
Mariposa	USCA
Maude & Yellow Girl	AUVT
Midas	USCA
Mikado	USAK
Miller Lake	CNNS
Minto	CNBC
Mizpah	USAK
Mohawk-Dome View	USAK
Mokelumne	USCA
Molega	CNNS
Montaque	CNNS
Moore's Flat	USCA
Moose River	CNNS
Moosehead	CNNS
Mooseland	CNNS
Mormon Bar	USCA
Morning Star	AUVT
Morris Ravine	USCA
Mount Bullion	USCA
Mount Gaines	USCA
Mount Pleasant	USCA
Mount Shasta	USCA
Mount Uniacke	CNNS
Mount Vernon	USCA
Mountain King	USCA
Nalden South	AUVT
Nashville	USCA
National	USCA
new Bendigo	AUVT
New Era-Rowe	AUVT
Nimrod	AUVT
North Murphy	USCA
North Star	USAK
Nuggetty	AUVT
O'Connors	AUVT
Old Diggings	USCA
Oldham	CNNS
Ophir	USCA
Oregon Bell	USOR
Oriential	AUVT
Oro Grande-Buena Vista	USCA
Oturehua Field	NZLD
Ovens	CNNS
Oya	JAPN
Paloma-Gwin	USCA
Paparoa Range	NZLD
Patrick	USCA
Penryn	USCA
Phoenix	USCA
Pipestem	CNBC
Placerville	USCA
Pleasant River	CNNS
Porto Rico	CNBC

Pyramid	USCA
R.R. Flat South	USCA
Rainbow	USOR
Rainbow	USCA
Ranch	USCA
Ravenswood	NZLD
Reefton Goldfield	NZLD
Reicher Trost	PLND
Renfrew	CNNS
Rich	USCA
Rich Gulch	USCA
Rich Gulch (Virgilia)	USCA
Rindge No. 1	USCA
Robert E	USOR
Robertson	USOR
Rose of Denmark	AUVT
Rosethistle & Shamrock	AUVT
Royal Mountain King	USCA
Ryan	USCA
Ryan Group	USAK
S. Branch Stweiacke	CNNS
Sailor's Gully	AUVT
Salmon River	CNNS
Salsigne	FRNC
Sambas	AUVT
Sandford	USAK
Scott Bar	USCA
Seal Harbour	CNNS
Second Relief	CNBC
Sesson Mine	USCA
Sheep Ranch	USCA
Shenandoah Mine	USCA
Sliger	USCA
Soo	USAK
Soulsbyville	USCA
South Uniacke	CNNS
Spring Gully	AUVT
Stonewall	USCA
Sultan	AUVT
Surf Inlet	CNBC
Sutter Creek	USCA
Sylvanite	USOR
Tangier	CNNS
Taylor	USCA
Tipperary Mine	NZLD
Toombou	AUVT
Treadwell Mines	USAK
Truscott	USCA
Uncle Sam	USCA
Upper Seal Harbour	CNNS
Valley View	USCA
Vogler's Cove	CNNS
Ward	CNBC
Warrington	USCA
Washington	USCA
Wattle Gully	AUVT
Waverley	CNNS
Wayside	CNBC
West Gore	CNNS
West Jacksonville	USCA
Westland	NZLD
Whiteburn	CNNS
Whitlock East	USCA
Whitlock West	USCA
Wilshire-Bishop	USCA
Wine Harbour	CNNS
Yankee Hill	USCA
Zeila	USCA

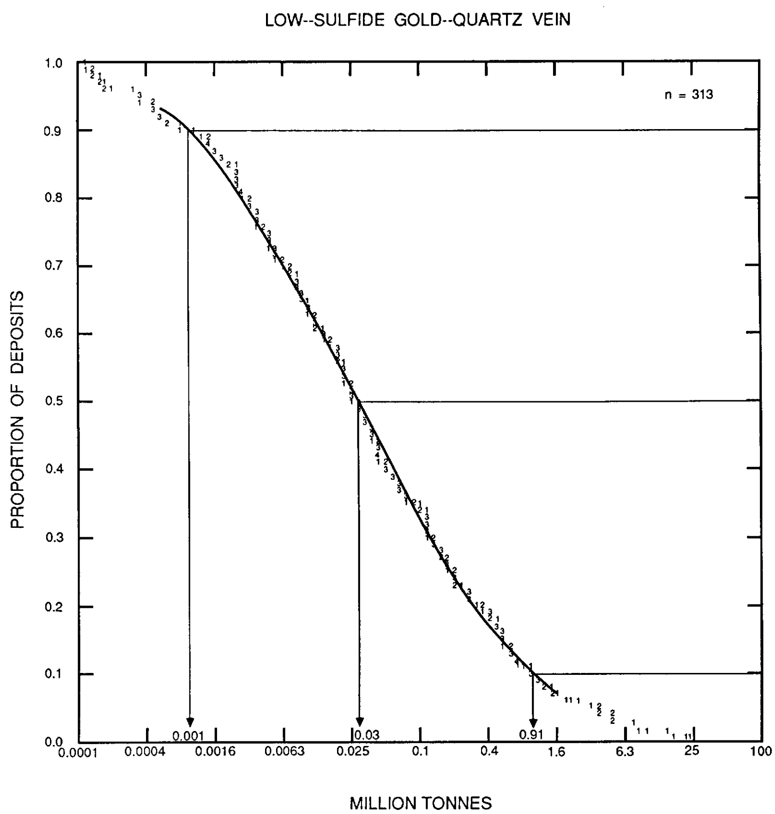

Figure 182. Tonnages of low-sulfide Au-quartz vein deposits.

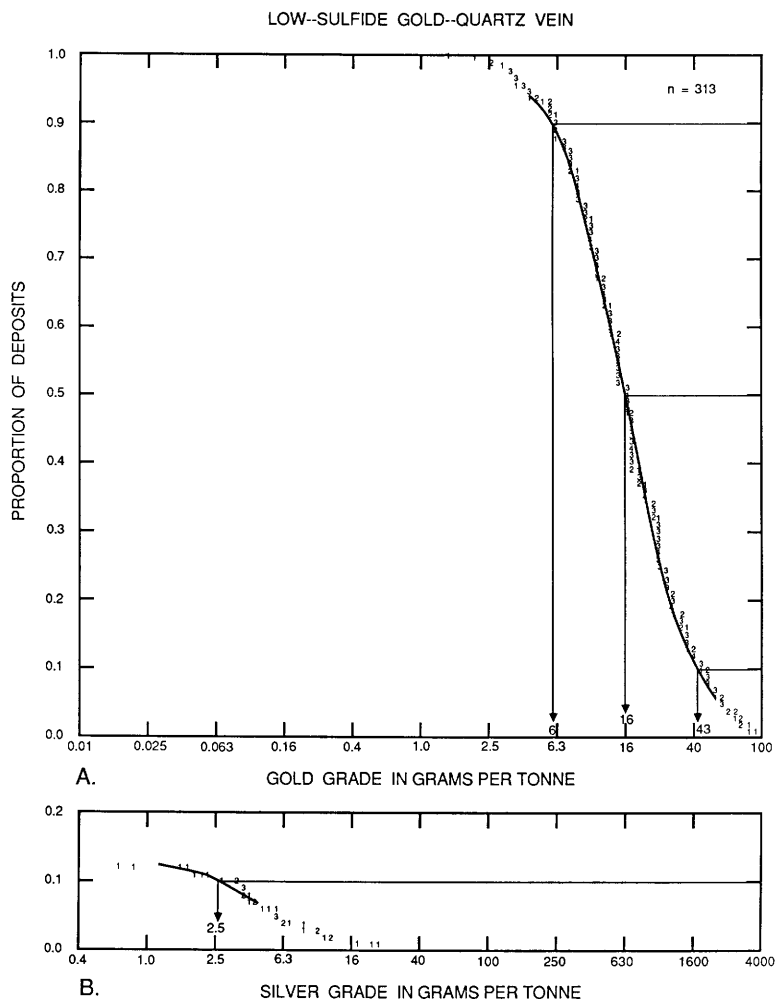

Figure 183. Precious-metal grades of low-sulfide Au-quartz vein deposits. A, Gold. B, Silver.

DESCRIPTIVE MODEL OF HOMESTAKE Au

By Byron R. Berger

APPROXIMATE SYNONYMS Volcanogenic gold, iron-formation-hosted Au, Archean lode gold.

DESCRIPTION Stratabound to stratiform gold deposits in iron-rich chemical sediments in Archean metavolcanic terrane.

GENERAL REFERENCES Ridler (1970), Hutchinson (1976), Philips and others (1984), Fripp (1976), Colvine and others (1984).

GEOLOGICAL ENVIRONMENT

Rock Types Regionally metamorphosed mafic and felsic metavolcanic rocks, komatiites, and volcaniclastic sediments interlayered with banded iron-formation. Intruded by felsic plutonic rocks and locally by quartz porphyry, and syenite porphyry.

Age Range Mainly Archean.

Depositional Environment Controversial: submarine hot-spring activity related to volcanism, or later hydrothermal activity related to intrusive rocks.

Tectonic Setting(s) Archean greenstone belts. Commonly near regional division or "break" between predominantly metavolcanic and predominantly metasedimentary rocks. Greenschist-facies metamorphism.

Associated Deposit Types Kuroko massive sulfide deposits, Algoma Fe, low-sulfide gold-quartz veins.

DEPOSIT DESCRIPTION

Mineralogy Native gold + pyrite + pyrrhotite ± arsenopyrite ± magnetite ± sphalerite ± chalcopyrite. May contain minor tetrahedrite + scheelite + wolframite + molybdenite ± fluorite ± stibnite. Realgar at Hemlo deposit. Some deposits show zoning from proximal pyrrhotite ± magnetite to distal arsenopyrite.

Texture/Structure Narrow thinly laminated beds, veins, or lenses, overlying stringers (stockworks).

Alteration Host rocks contain quartz + siderite and (or) ankerite + tourmaline + chlorite + magnetite in mafic volcanic terranes. Chromian mica and chlorite particularly around veins and stockworks. Banded oxide-facies iron-formation replaced by pyrite or pyrrhotite.

Ore Controls Bedded ores in Fe-rich siliceous or carbonate-rich chemical sediments with vein and stockworks in feeder zones to these sediments, often interlayered with flow rocks. Beds may be cut by condordant or sharply discordant quartz-carbonate veins with gold.

Weathering Gossans from oxide and carbonate iron-formation.

Geochemical Signature Au + Fe + As + B + Sb (+ platinum-group metals in mafic volcanic terranes). Bi, Hg, and minor Cu-Pb-Zn-Ag-Mo.

EXAMPLES

Homestake, USSD	(Rye and Rye, 1974)
Passagem, BRZL	(Fleisher and Routhier, 1973)
Dome Mine, CNON	(Fryer and others, 1979)
Agnico Eagle, CNQB	(Barnett and others, 1982)
Vubachikwe, ZIMB	(Fripp, 1976)

GRADE AND TONNAGE MODEL OF HOMESTAKE Au

By Dan L. Mosier

COMMENTS Deposits were combined when they occur within 1.6 km of each other. Grades and tonnages were not found to be significantly different for deposits associated with different host rocks. See figs. 184-186

DEPOSITS

Name	Country	Name	Country
Agassiz	CNMN	Gurney	CNMN
Albino	CNON	Hard Rock-McLeod-Cockshutt	CNON
Ankerite-Aunor-Delnite	CNON	Hasaga-Howey	CNON
Arrowhead	CNQU	Hollinger and others	CNON
Ashley	CNON	Homestake	USSD
Bankfield-Tombill	CNON	Hutti	INDA
Barbara-Surprise	AUWA	Ida H.	AUWA
Barber-Larder	CNON	Island Lake	CNMN
Barberton	SAFR	Jason	CNON
Barry Hollinger	CNON	Jerome	CNON
Bellevue	AUWA	Kerr Addison	CNON
Bidgood-Moffatt-Hall	CNON	Kiabakari	TNZN
Big Bell	AUWA	Kilo-Moto	CNGO
Black Range-Oroya	AUWA	Kolar	INDA
Bob	ZIMB	Laguerre	CNON
Bonnievale	AUWA	Lancefield	AUWA
Bouscadillac and others	CNON	Lapa Cadillac	CNQU
Broulan and others	CNON	Leitch-Sand River	CNON
Buffalo Red Lake	CNON	Lingman	CNON
Burbanks	AUWA	Little Long Lac	CNON
Calder-Bousquet	CNQU	Madsen	CNON
Campbell Red Lake-Dickenson	CNON	Magnet Cons.	CNON
Carshaw-Tommy Burns	CNON	Marble Bar	AUWA
Cathroy Larder	CNON	Martin-Bird	CNON
Central Manitoba	CNMN	Matachewan Cons. & others	CNON
Central Patricia	CNON	Matona-Stairs	CNON
Cheminis-Fernland-Omega	CNON	McFinley	CNON
Chesterville	CNON	McMarmac	CNON
Connemara	ZIMB	McWatters	CNQU
Coolgardie	AUWA	Menzies	AUWA
Copperhead	AUWA	Minto-Tyranite	CNON
Cosmopolitan	AUWA	Morris-Kirkland	CNON
Cullaton Lake	CNNT	Morro Velho	BRZL
Davidson	CNON	Mt. Magnet	AUWA
Day Dawn-Main Line	AUWA	Mt. Morgans	AUWA
De Santis	CNON	Naybob	CNON
Dome-Paymaster-Preston	CNON	Nobles Nob	AUWA
Edna May	AUWA	Norseman-Dundas	AUWA
Emu-Great Eastern	AUWA	Orpit	CNON
Fraser's	AUWA	Paddy's Flat	AUWA
Fuller-Tisdale	CNON	Palmer's Find	AUWA
Geita	TNZN	Passagem	BRZL
Gimlet-Slippery	AUWA	Pickle Crow	CNON
Gladstome-Sand Queen	AUWA	Queenston	CNON
God's Lake	CNMN	Raposos	BRZL
Gold Eagle-McKenzie	CNON	Red Crest	CNON
Gold Hawk	CNON	Red Lake Gold Shore	CNON
Gold Hill	CNON	Ross	CNON
Golden Ridge	AUWA	Rouyn Merger	CNQU
Gongo Socco	BRZL	Sanshaw	CNON

Shamva-Cymric Gp.	ZIMB	Uchi	CNON
Son of Gwalia	AUWA	Upper Beaver	CNON
Stadacona	CNQU	Upper Canada	CNON
Starratt-Olsen	CNON	Wasa Lake	CNQU
Talmora Longlac	CNON	White Feather	AUWA
Thompson Bousquet	CNQU	Wilmar and others	CNON
Timoni	AUWA	Wiluna-Moonlight	AUWA
Triton	AUWA	Youanmi	AUWA

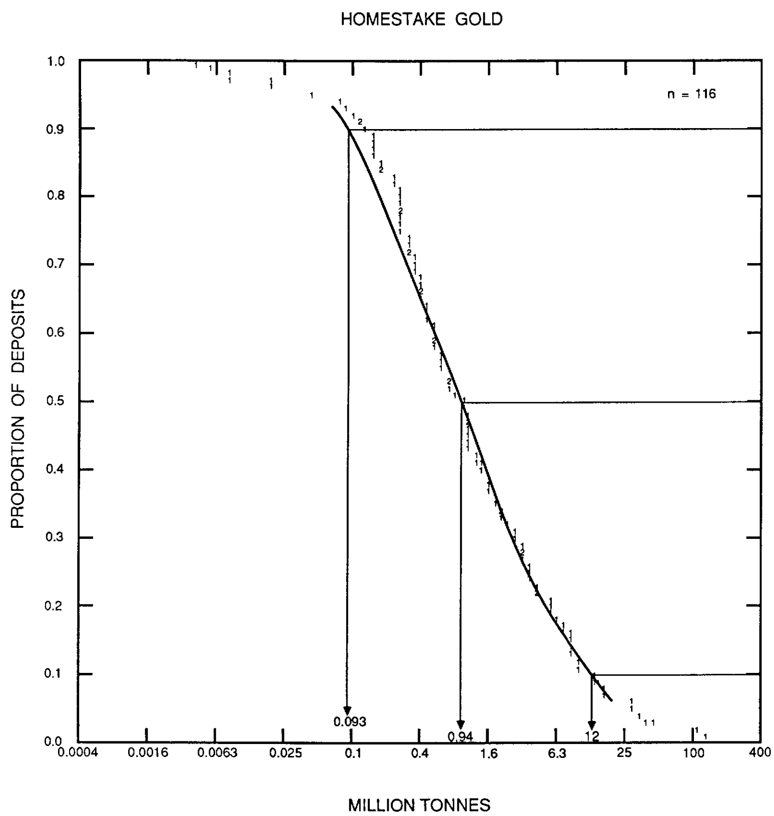

Figure 184. Tonnages of Homestake Au deposits.

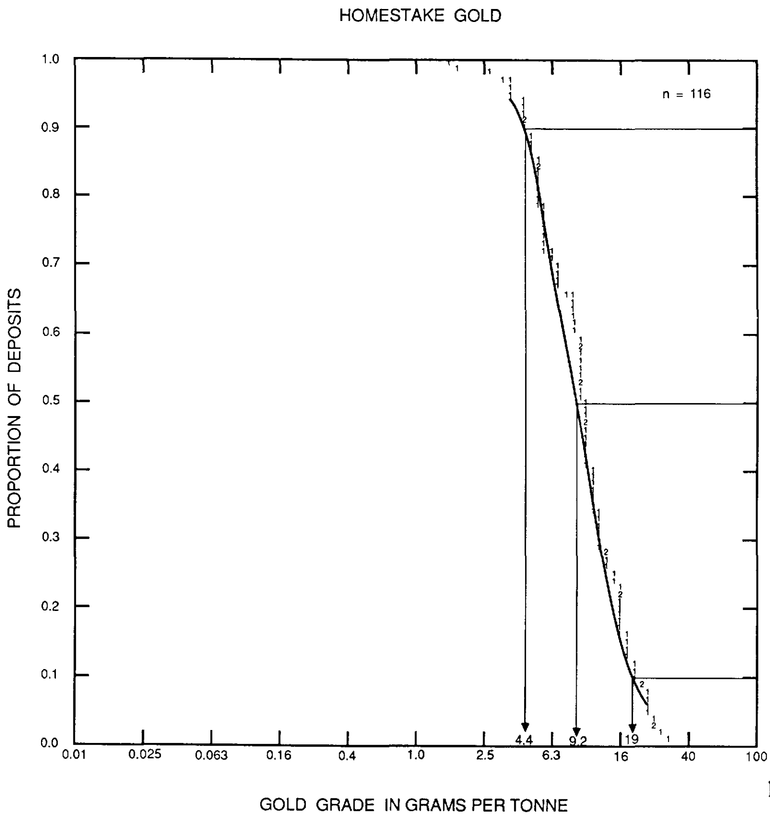

Figure 185. Gold grades of Homestake Au deposits.

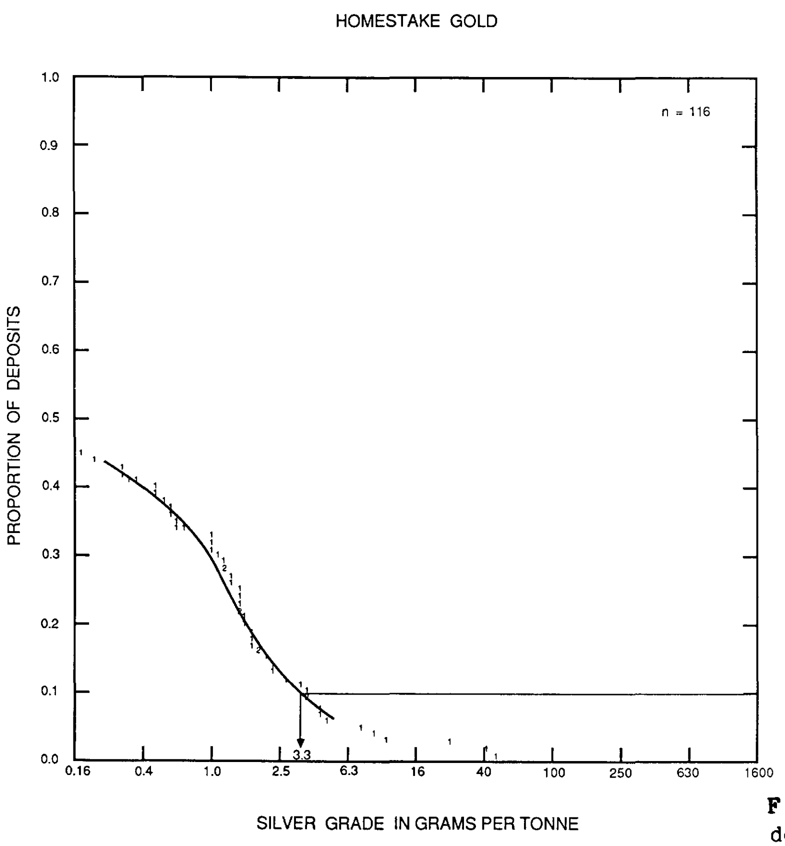

Figure 186. Silver grades of Homestake Au deposits.

DESCRIPTIVE MODEL OF UNCONFORMITY U-Au

By Richard I. Grauch and Dan L. Mosier

APPROXIMATE SYNONYM Veinlike type U (Dahlkamp and Adams, 1981).

DESCRIPTION Uranium mineralization occurs as fracture- and breccia-filling in metapelites, metapsammites and quartz arenites located below, above, or across an unconformity separating Early and Middle Proterozoic rocks.

GENERAL REFERENCE Nash and others (1981).

GEOLOGICAL ENVIRONMENT

Rock Types Regionally metamorphosed carbonaceous pelites, psammites, carbonate rocks. Younger unmetamorphosed quartz arenites.

Textures Metamorphic foliation and later brecciation.

Age Range In rocks of Early and Middle Proterozoic age (1,800-1,200 m.y.), affected by Proterozoic regional metamorphism.

Depositional Environment Host rocks are sedimentary shelf deposits and overlying continental sandstone. Deposits result from complex processes including regional metamorphism, weathering and supergene enrichment related to Proterozoic unconformity, and later remobilization and enrichment beneath cover of younger strata.

Tectonic Setting(s) Intracratonic sedimentary basins on the flanks of Archean domes. Tectonically stable since Middle Proterozoic.

Associated Deposit Types Gold- and nickel-rich uranium deposits may occur but are poorly understood and no models are available.

DEPOSIT DESCRIPTION

Mineralogy Pitchblende + uraninite ± coffinite ± pyrite ± chalcopyrite ± galena ± sphalerite ± arsenopyrite ± niccolite. Chlorite + quartz + calcite + dolomite + hematite + siderite + sericite. Locally late quartz-chlorite veins contain native gold or silver, uraninite, galena, and tellurides of Bi, Ni, Pb and Pd. Latest quartz-calcite veins contain pyrite, chalcopyrite, and bituminous matter.

Texture/Structure Breccia filling, veins, and disseminations. Coarse euhedral uraninite and fine colloform pitchblende. Latest quartz-calcite veins show open-space fillings, colloform texture.

Alteration Multistage chloritization is dominant. Local sericitization, dolomitization, hematitization, kaolinitization. Incipient and vuggy vein-type silicification occur throughout the alteration envelope. Alteration envelope is variably enriched in Mg, P, REE, and a variety of metals. Alkali elements are depleted.

Ore Controls Fracture porosity controlled ore distribution in the metamorphites and to a limited extent in the overlying quartz arenite. The unconformity acted as a major disruption in the flow of ore-forming fluids but did not necessarily act as a locus of ore formation.

Weathering Secondary U minerals uranyl-phosphate, metatorbernite, autunite, uranophane, gummite, sklodowskite.

Geochemical and Geophysical Signature Increase in U, Mg, P and locally in Ni, Cu, Pb, Zn, Co, As; decrease in SiO_2. Locally Au, associated with Ag, Te, Ni, Pd, Re, Mo, Hg, REE, Y and Rb. Anomalous radioactivity. Graphitic schists in some deposits are strong electromagnetic conductors.

EXAMPLES

Rabbit Lake, CNSK	(Hoeve and Sibbald, 1978)
Cluff Lake, CNSK	(Laine, 1985)

Key Lake, CNSK	(Dahlkamp, 1978)
Jabiluka, AUNT	(Binns and others, 1980, Grauch, 1984)
Ranger, AUNT	(Eupene, 1979)

GRADE AND TONNAGE MODEL OF UNCONFORMITY U-Au

By Dan L. Mosier

COMMENTS Deposits are defined by a separation of 100 m stratigraphically and along strike. Sufficient number of Au grades were not available to construct a plot. See figs. 187, 188.

DEPOSITS

Name	Country	Name	Country
Cluff Lake-Claude	CNSK	McClean Lake	CNSK
Cluff Lake D	CNSK	Maurice Bay	CNSK
Cluff Lake N	CNSK	Midwest Lake	CNSK
Cluff Lake OP	CNSK	Mount Burton (Rum Jungle)	AUNT
Cluff Lake R	CNSK	Mount Finch (Rum Jungle)	AUNT
Cluff Bay A	CNSK	Nabarlek	AUNT
Cluff Bay B	CNSK	Palette	AUNT
Dawn Lake	CNSK	Rabbit Lake	CNSK
Dyson's (Rum Jungle)	AUNT	Ranger No. 1	AUNT
El Sherana	AUNT	Ranger No. 3	AUNT
El Sherana West	AUNT	Rockhole-Teages	AUNT
Fond-du-Lac	CNON	Rum Jungle Creek South	AUNT
Jabiluka I	AUNT	Scinto 5	AUNT
Jabiluka II	AUNT	Skull	AUNT
Key Lake (Deilmann)	CNSK	Sleisbeck	AUNT
Key Lake (Gaertner)	CNSK	Stewart Island	CNSK
Koolpin Creek	AUNT	West Bear	CNSK
Koongarra	AUNT	White's (Rum Jungle)	AUNT

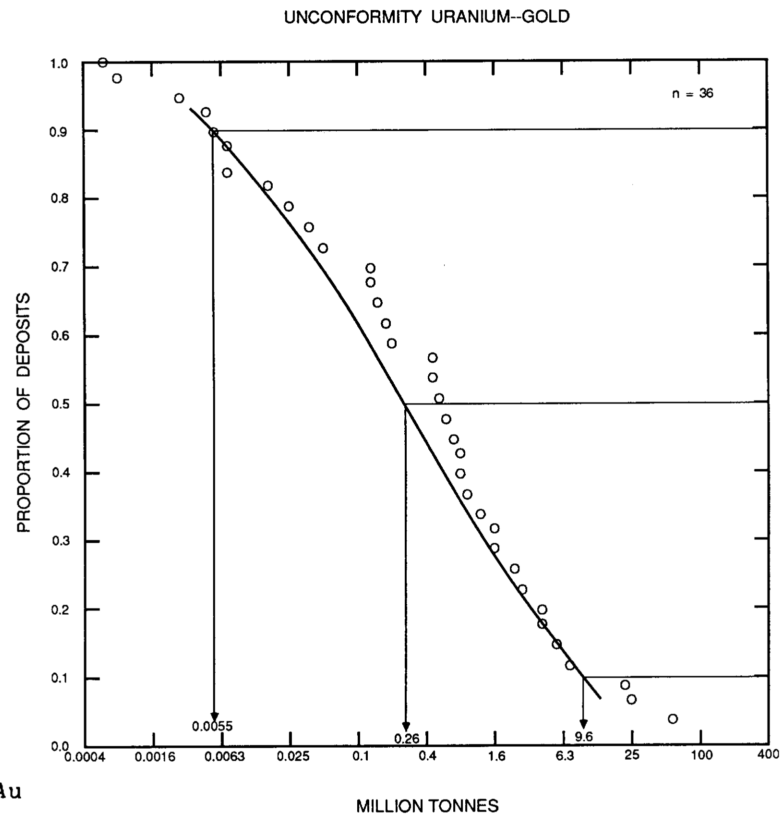

Figure 187. Tonnages of unconformity U-Au deposits.

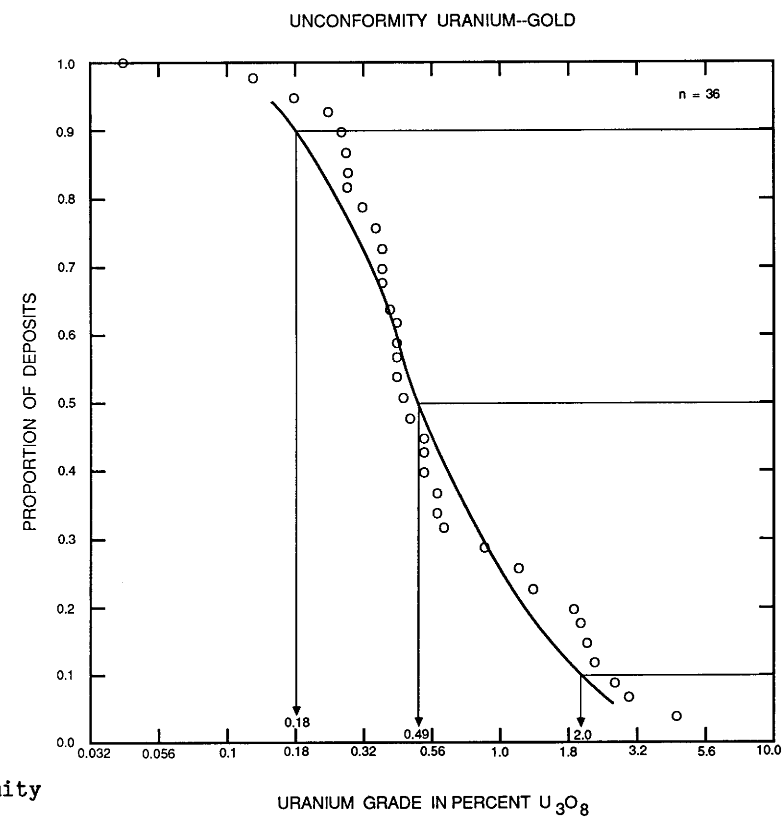

Figure 188. Uranium grades of unconformity U-Au deposits.

DESCRIPTIVE MODEL OF GOLD ON FLAT FAULTS

By Bruce A. Bouley*

DESCRIPTION Disseminated gold in breccia along low-angle faults

GENERAL REFERENCE Wilkins (1984).

GEOLOGICAL ENVIRONMENT

Rock Types Breccia derived from granitic rocks, gneiss, schist, mylonite and unmetamorphosed sedimentary and volcanic rocks. Rhyolitic dikes and plugs.

Textures Chaotic jumble of rock and vein material.

Age Range Unknown. Examples in southern California and southwestern Arizona are mainly Mesozoic and Tertiary.

Depositional Environment Permeable zones: source of heat and fluids unknown.

Tectonic Setting(s) Low-angle faults in crystalline and volcanic terrane. Including detachment faults related to some metamorphic core complexes and thrust faults related to earlier compressives regimes.

Associated Deposit Types Epithermal quartz adularia veins in hanging-wall rocks of some districts.

DEPOSIT DESCRIPTION

Mineralogy Gold, hematite, chalcopyrite, minor bornite, barite, and fluorite.

Texture/Structure Micrometer-size gold and specular hematite in stockwork veining and brecciated rock.

Alteration Hematite, quartz, and chlorite. Silicification. Carbonate minerals.

Ore Controls Intensely brecciated zones along low-angle faults. Steep normal faults in hanging wall. Sheeted veins.

Weathering Most ore is in oxidized zone because of lower cost of recovery. Mn oxides.

Geochemical Signature Au, Cu, Fe, F, Ba. Very low level anomalies in Ag, As, Hg, and W.

EXAMPLES:

Picacho, USCA	(Van Nort and Harris, 1984)
Copper Penny and Swansea, USAZ	(Wilkins and Heidrick, 1982)

* Present address: Callahan Mining Corp., 6245 North 24th Street, Phoenix, AZ 85016.

DESCRIPTIVE MODEL OF LATERITIC Ni

By Donald A. Singer

DESCRIPTION Nickel-rich, in situ lateritic weathering products developed from dunites and peridotites. Ni-rich iron oxides are most common. Some deposits are predominantly Ni silicates.

GENERAL REFERENCE Evans and others (1979).

GEOLOGICAL ENVIRONMENT

Rock Types Ultramafic rocks, particularily peridotite, dunite, and serpentinized peridotite.

Age Range Precambrian to Tertiary source rocks, typically Cenozoic weathering.

Depositional Environment Relatively high rates of chemical weathering (warm-humid climates) and relatively low rates of physical erosion.

Tectonic Setting(s) Convergent margins where ophiolites have been emplaced. Uplift is required to expose ultramafics to weathering.

Associated Deposit Types Podiform chromite, PGE placers, serpentine-hosted asbestos.

DEPOSIT DESCRIPTION

Mineralogy Garnierite, poorly defined hydrous silicates, quartz, and goethite. Goethite commonly contains much Ni.

Texture/Structure Red-brown pisolitic soils, silica-rich boxworks.

Alteration Zoned--from top: (1) Red, yellow, and brown limonitic soils; (2) saprolites--continuous transition from soft saprolite below limonite zone, hard saprolite and saprolitized peridotite, to fresh peridotite. Boxwork of chalcedony and garnierite occurs near bedrock-weathered rock.

Ore Controls Upper limonite zone containing 0.5-2 percent Ni in iron-oxides; lower saprolite and boxwork zone typically contains 2-4 percent Ni in hydrous silicates. The oxide and silicate ores are end members and most mineralization contains some of both.

Weathering The profile from red-brown pisolitic soil down to saprolite represents the products of chemically weathered ultramafic rocks.

Geochemical Signature Enriched in Ni, Co, Cr; depleted in MgO relative to fresh peridotite (less than 40 percent MgO).

EXAMPLES

Poro, NCAL	(Troly and others, 1979)
Cerro Matoso, CLBA	(Gomez and others, 1979)
Nickel Mountain, USOR	(Chace and others, 1969)
Greenvale, AUQL	(Burger, 1979)

GRADE AND TONNAGE MODEL OF LATERITIC Ni

By Donald A. Singer

COMMENTS Higher grades are typically associated with the silicate type. Numerous low-grade (less than 1 percent Ni) and low-tonnage deposits are not included. Nickel grade is correlated with tonnage (r = -0.31). See figs. 189, 190.

DEPOSITS

Name	Country	Name	Country
Ambatory	MDGS	Moa Bay	CUBA
Analumay	MDGS	Moorsom	PLPN
Barro Alto	BRZL	Moramanga	MDGS
Berong	PLPN	Morro de Engenho	BRZL
Bhimatangar	INDA	Mwaytung	BRMA
Blue Ridge	PLPN	Nepoui	NCAL
Br. Solomon Is.	SLMN	New Frontier	PLPN
Buka	PLPN	Niquelandia	BRZL
Cabo Rojo	PTRC	Nonoc	PLPN
Cerro Matoso	CLBA	Obi	INDS
Claude Hills	AUSA	Ora Banda	AUWA
Cyclops	INDS	Orsk	URRS
Dinagat Is.	PLPN	Pujada Pen.	PLPN
Euboea	GREC	Pomalea	INDS
Exmibal	GUAT	Poro	NCAL
Falconbridge	DMRP	Poum	NCAL
Gag Is.	INDS	Pratapolis	BRZL
Golesh Mt.	YUGO	Prony	NCAL
Golos	YUGO	Ramona-Loma	CUBA
Goro	NCAL	Riddle	USOR
Greenvale	AUQL	Rio Tuba	PLPN
Hagios Ioannis	GREC	Sablayon	PLPN
Halmahera	INDS	Sao Joaodo Piaui	BRZL
Ipaneme	BRZL	Santa Cruz	PLPN
Jacupuenga	BRZL	Saruabi	INDA
Kaliapani	INDA	S.E. Kalimantan	INDS
Kansa	INDA	Sidamo	ETHP
Kauadarci	YUGO	Simlipal	INDA
Laguney	PLPN	Soroako	INDS
Lake Joanina	GREC	Sukinda	INDA
Leviso R.	CUBA	Suriagao	PLPN
Loma de Hierro	VNZL	Taco Bay	CUBA
Long Point	PLPN	Thio	NCAL
Marlborough	AUQL	Tiebaghi	NCAL
Masinloc	PLPN	Wingelinna-Daisy	AUWA
Mayari	CUBA		

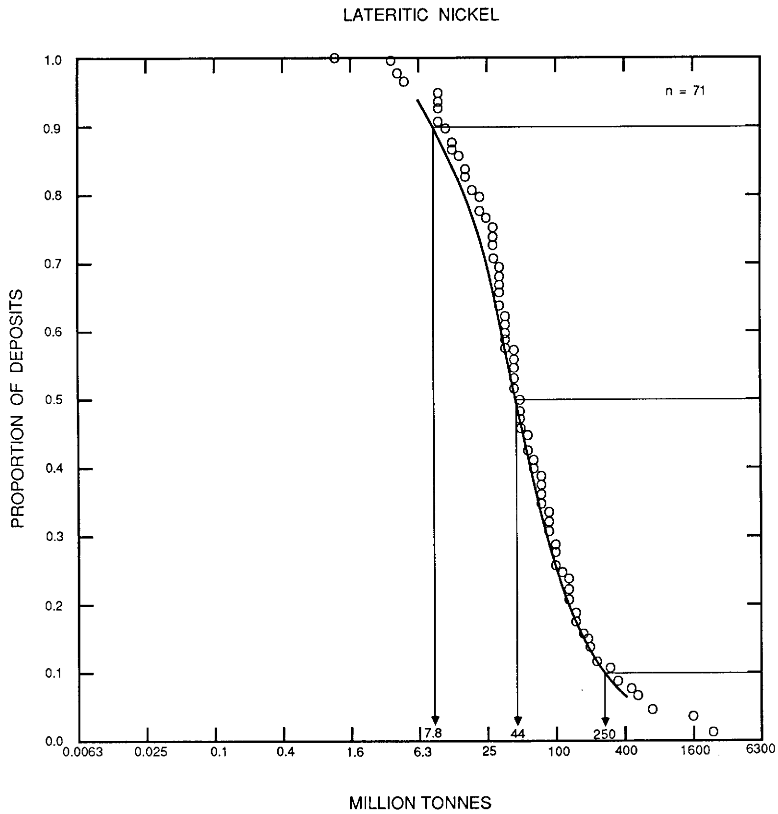

Figure 189. Tonnages of lateritic Ni deposits.

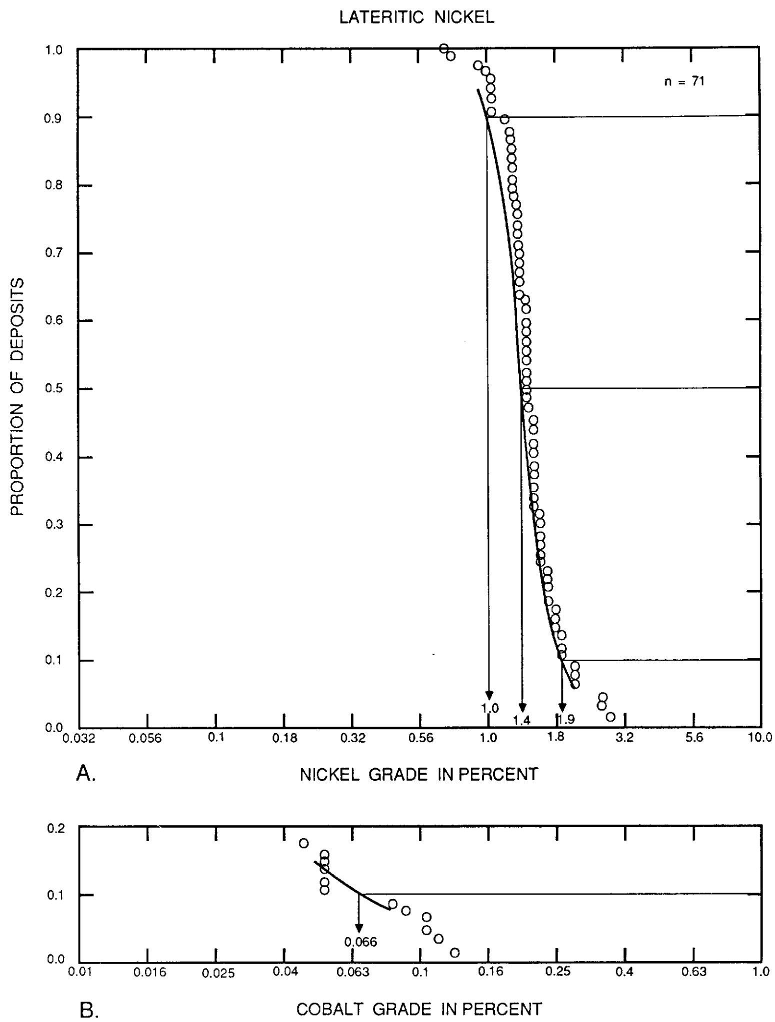

Figure 190. Metal grades of lateritic Ni deposits. A, Nickel. B, Cobalt.

DESCRIPTIVE MODEL OF LATERITE TYPE BAUXITE DEPOSITS

By Sam H. Patterson

APPROXIMATE SYNONYM Aluminum ore (Patterson, 1967).

DESCRIPTION Weathered residual material in subsoil formed on any rock containing aluminum.

GENERAL REFERENCE Patterson (1984).

GEOLOGICAL ENVIRONMENT

Rock Types Weathered rock formed on aluminous silicate rocks.

Textures Pisolitic, massive, nodular, earthy.

Age Range Mainly Cenozoic, one Cretaceous deposit known.

Depositional Environment Surficial weathering on well-drained plateaus in region with warm to hot and wet climates. Locally deposits in poorly drained areas low in Fe due to its removal by organic complexing.

Tectonic Setting(s) Typically occurs on plateaus in tectonically stable areas.

Associated Deposit Types Overlain by thin "A" horizon soil, underlain by saprolite (parent rock in intermediate stages of weathering).

DEPOSIT DESCRIPTION

Mineralogy Mainly gibbsite and mixture of gibbsite and boehmite; gangue minerals hematite, goethite, anatase, locally quartz.

Texture/Structure Pisolitic, massive, earthy, nodular.

Alteration Aluminous rocks are altered by weathering to bauxite.

Ore Controls Thoroughly weathered rock, commonly erosional boundaries of old plateau remnants.

Weathering Intensive weathering required to form bauxite. Bauxite continues to form in present weathering environment in most deposits.

Geochemical Signature: Al, Ga.

EXAMPLES
Australia, Brazil, Guinea
examples are reviewed in Patterson (1967)

GRADE AND TONNAGE MODEL OF LATERITE TYPE BAUXITE DEPOSITS

By Dan L. Mosier

REFERENCES Patterson (1967) and numerous other papers.

COMMENTS A district has been defined as a deposit or a group of deposits in which each deposit is not separated by more than 20 km from an adjacent deposit. Using this rule, most district names in the published literature have been retained; however, some previously regarded districts have been divided into two or more districts, which therefore are named after the largest deposit in that district or a local place name. See figs. 191, 192.

DEPOSITS

Name	Country	Name	Country
Affoh	GHNA	Khushab (Sargohda)	PKTN
Almeirim	BRZL	Kibi	GHNA
Alumen	MZMB	Kolaba-Ratnagiri	INDA
Analavory	MDGS	Kolhapur	INDA
Anantagiri	INDA	Koro Plateau	CHAD
Asafo	GHNA	Kutch	INDA
Aurukum	AUQL	Los Pijiguaos	VNZL
Awaso	GHNA	Maikala Range	INDA
Ayekoye	GNEA	Mainpat	INDA
Bihar	INDA	Manantenina	MDGS
Bakhuis Mountains	SRNM	Manus Island	PPNG
Balea-Sitaouma	MALI	Marangaka	MDGS
Bamboutos	CMRN	Marchinbar Island	AUNT
Bangam	CMRN	Mariana	BRZL
Barao de Cocais-Caete	BRZL	Mazagao	BRZL
Barra do Pirai	BRZL	Mimoso do Sul	BRZL
Bhavnagar	INDA	Minim-Martap	CMRN
Bilaspur	INDA	Mitchell Plateau	AUWA
Bintan Island	INDS	Mlanje Mountain	MLWI
Blue Mountains-Oko Mountains	GUYN	Moengo	SRNM
Boe	GNBS	Mogi das Cruzes	BRZL
Bom Repouso-Cambui	BRZL	Mokanji Hills	SRLN
Boolarra	AUVT	Monghyr	INDA
Caldas	BRZL	Moss Vale	AUNS
Cape Bougainville	AUWA	Mount Ejuanema-Nsisreso	AUNS
Caroline Islands	CARL	Mount Saddleback	AUWA
Cataguases	BRZL	Myalla	AUNT
Champagne (Oakwood)	AUNS	Nassau Mountains	SRNM
Chintapalli-Gurtedu	INDA	Nhamunda	BRZL
Chittering	AUWA	Nilgiri Hills	INDA
Croker Island	AUNT	North Weipa	AUQL
D'Analamaitso	MDGS	Northern Ireland	IRLD
D'Ankazobe	MDGS	Nuria	VNZL
Dabola	GNEA	NW Group	GUYN
Debele (Kindia)	GNEA	Nyinahin	GHNA
Del Park-Huntly	AUWA	Ourem	BRZL
Descoberto	BRZL	Ouse	AUTS
Divinolandia de Minas	BRZL	Palni Hills	INDA
East Maui	USHI	Paragominas	BRZL
Emmaville	AUNS	Paranam	SRNM
Fenoarivo	MDGS	Parish	AUNS
Fongo Tongo	CMRN	Pocos de Caldas-Aguas de Prata	BRZL
Fria-Kimbo	GNEA	Ramunia-Telok Ramunia	MLYS
Gambe	BRZL	Ranchi-Palamau	INDA
Gove	AUNT	St. Leonards	AUTS
Hampton	AUQL	Salem Hills	USOR
Iles de Los	GNEA	Saline-Pulaski	USAR
Intendencia de Arauca	CLBA	Sambalpur	INDA
Irituia	BRZL	Sangaredi	GNEA
Itanhandu-Resende	BRZL	Santa Barbara	BRZL
Jamirapat-Khuria	INDA	Sao Domingos do Capim	BRZL
Jamnagar (Saurashtra)	INDA	Sao Paulo	BRZL
Jarrahdale	AUWA	Shevaroy Hills	INDA
Kalahandi-Koraput	INDA	South Weipa	AUQL
Kauai	USHI	Tamborine Mountain	AUQL
Kaw Mountains	FRGN	Tougue	GNEA
Kerikeri	NZLD	Trombetas	BRZL
Kheda (Kaira)	INDA	Turtle Head	AUQL

Upata	VNZL	Wenlock River	AUQL
Valle del General	CORI	West Maui	USHI
Weipa-Andoom-Pera Head	AUQL	Weza	SAFR

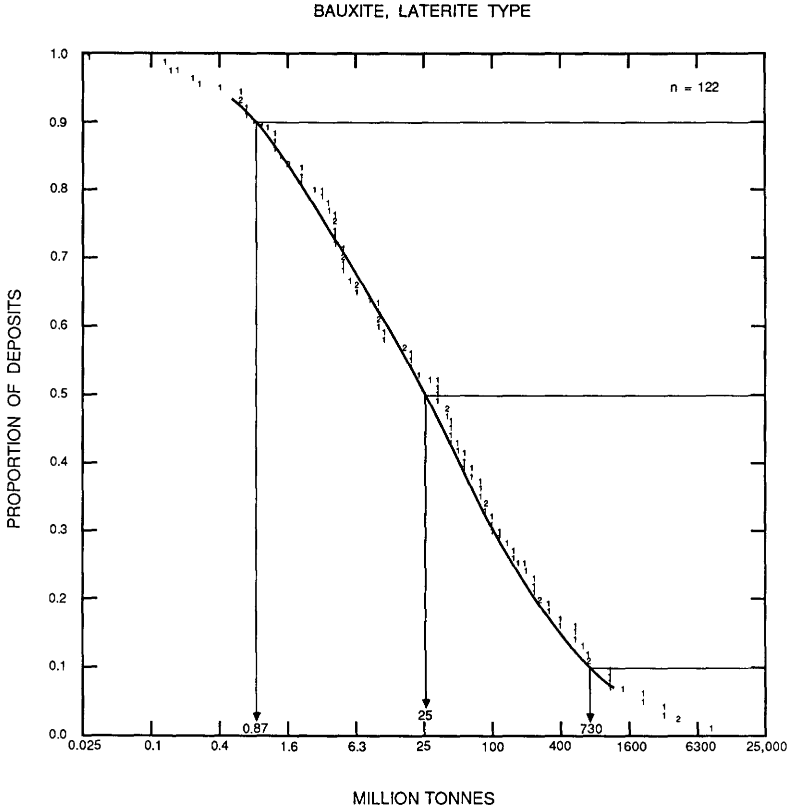

Figure 191. Tonnages of laterite-type bauxite deposits. Individual digits represent number of deposits.

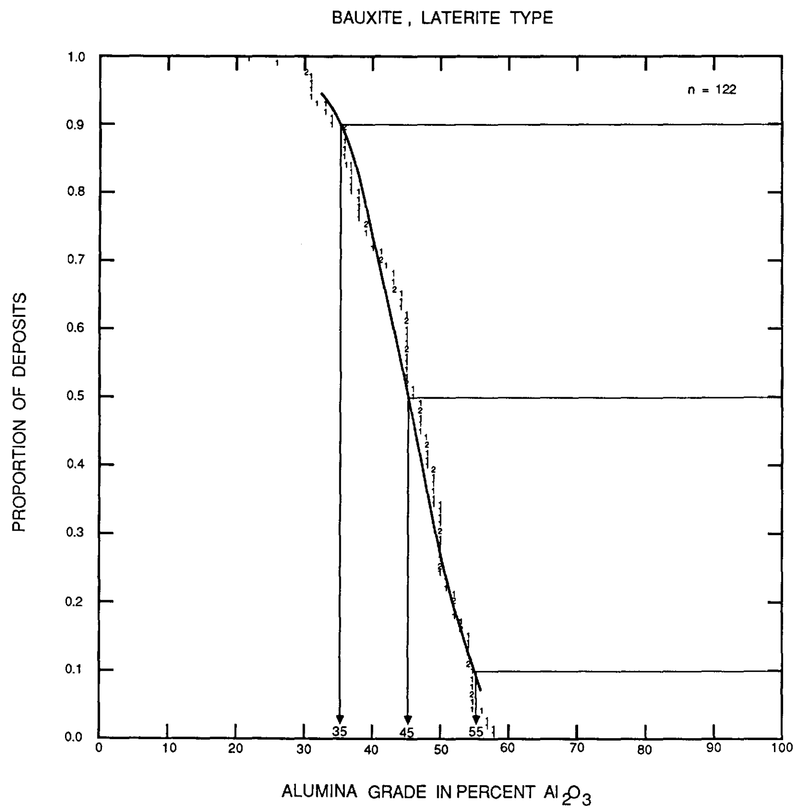

Figure 192. Alumina grades of laterite-type bauxite deposits. Individual digits represent number of deposits.

DESCRIPTIVE MODEL OF KARST TYPE BAUXITE DEPOSITS

By Sam H. Patterson

APPROXIMATE SYNONYM Aluminum ore (Bardossy, 1982).

DESCRIPTION Weathered residual and transported materials.

GENERAL REFERENCE Bardossy (1982).

GEOLOGICAL ENVIRONMENT

Rock Types Residual and transported material on carbonate rocks. Transported material may be felsic volcanic ash from a distant source or any aluminous sediments washed into the basin of deposition.

Textures Pisolitic, nodular, massive, earthy.

Age Range Paleozoic to Cenozoic.

Depositional Environment Surficial weathering mainly in wet tropical area.

Tectonic Setting(s) Stable land areas allowing time for weathering and protected from erosion.

Associated Deposit Types Limestone, dolomite, and shale; some are associated with minor coal and are low in Fe due to organic complexing and removal of Fe during formation.

DEPOSIT DESCRIPTION

Mineralogy Mainly gibbsite in Quaternary deposits in tropical areas. Gibbsite and boehmite mixed in older Cenozoic deposits, boehmite in Mesozoic deposits and in Paleozoic deposits; gangue minerals hematite, goethite, anatase, kaolin minerals, minor quartz.

Texture/Structure Pisolitic, massive, nodular.

Alteration Formation of bauxite is itself a form of alteration of aluminous sediments.

Ore Controls Deposits tend to be concentrated in depressions on karst surfaces.

Weathering Intense weathering required to form bauxite. Bauxite continues to form in the present weathering environment in most deposits.

Geochemical Signature Al, Ga.

EXAMPLE European and Jamaican examples are reviewed in Bardossy (1982).

GRADE AND TONNAGE MODEL OF KARST TYPE BAUXITE DEPOSITS

By Dan L. Mosier

COMMENTS See figs. 193, 194.

DEPOSITS

Name	Country	Name	Country
Abruzzi	ITLY	Camarasa-Oliana	SPAN
Aceitillar	DMRP	Campania	ITLY
Adana-Saimbeyli	TRKY	Clarendon Plateau	JMCA
Akeski	TRKY	Drnis-Obrovac	YUGO
Beceite-Fuendesplada	SPAN	Fenyoto	HUNG
		Gant	HUNG
Bulbula	IRAN	Halimba	HUNG

Imotski-Mostar	YUGO	Padurea Craiului	RMNA
Islahiye	TRKY	Parnassus-Helikon	GREC
Iszkaszentgyorgy	HUNG	Payas	TRKY
Jajce	YUGO	Punch	INDA
LangSen	VTNM	Rochelois Plat.	HATI
Maggotty	JMCA	San Giovanni Rotondo	ITLY
Manchester Plat.	JMCA	Seydisehr	TRKY
Megara-Eleusis	GREC	Sohodol-Cimpeni	RMNA
Muzaffarabad	PKTN	Spinazzola	ITLY
Nagyegyhaza	HUNG	St. Ann Plateau	JMCA
N.C. Puerto Rico	PTRC	Unterlaussa	ASTR
N.E. Alabama	USAL	Vlasenica	YUGO
Niksicka Zupa	YUGO	Zonguldak	TRKY
N.W. Georgia	USGA		
Nyirad	HUNG		

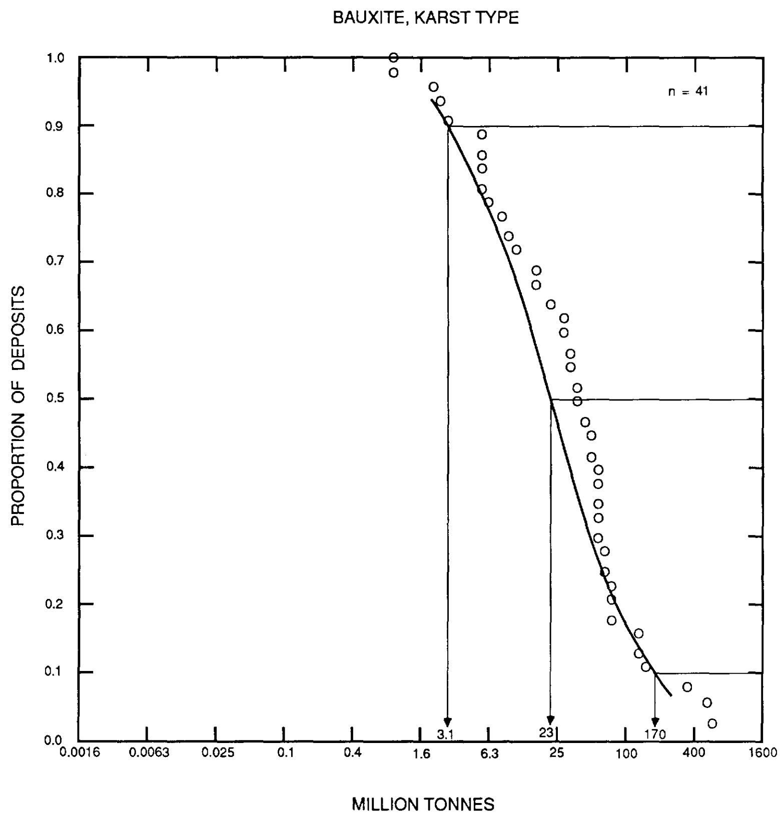

Figure 193. Tonnages of karst-type bauxite deposits.

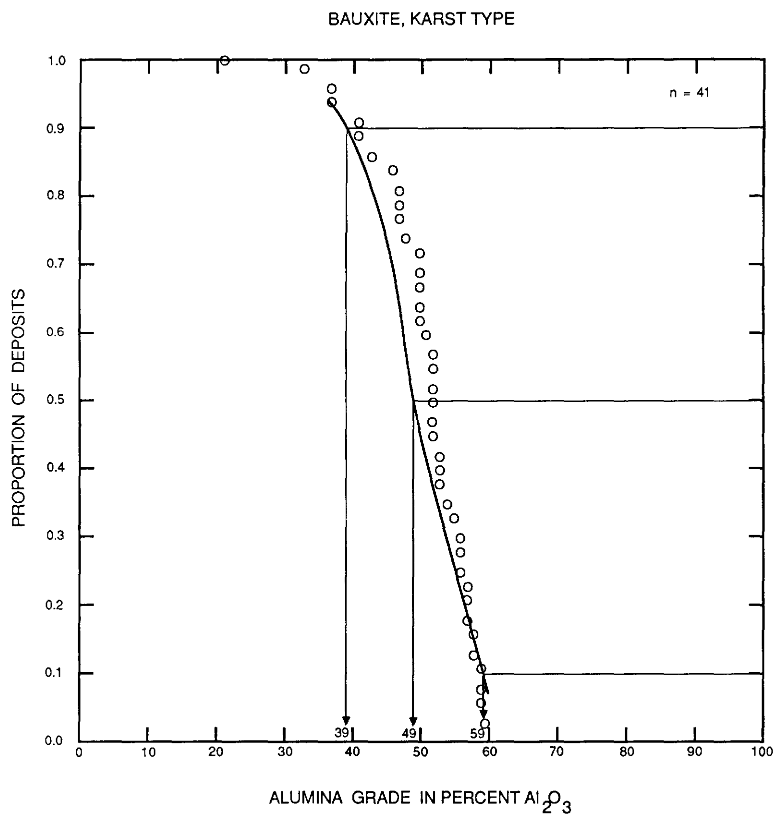

Figure 194. Alumina grades of karst-type bauxite deposits.

DESCRIPTIVE MODEL OF PLACER Au-PGE

By Warren E. Yeend

DESCRIPTION Elemental gold and platinum-group alloys in grains and (rarely) nuggets in gravel, sand, silt, and clay, and their consolidated equivalents, in alluvial, beach, eolian, and (rarely) glacial deposits (see fig. 195).

GENERAL REFERENCES Boyle (1979), Wells (1973), Lindgren (1911).

GEOLOGICAL ENVIRONMENT

Rock Types Alluvial gravel and conglomerate with white quartz clasts. Sand and sandstone of secondary importance.

Textures Coarse clastic.

Age Range Cenozoic. Older deposits may have been formed but their preservation is unlikely.

Depositional Environment High-energy alluvial where gradients flatten and river velocities lessen, as at the inside of meanders, below rapids and falls, beneath boulders, and in vegetation mats. Winnowing action of surf caused Au concentrations in raised, present, and submerged beaches.

Tectonic Setting(s) Tertiary conglomerates along major fault zones, shield areas where erosion has proceeded for a long time producing multicycle sediments; high-level terrace gravels.

Associated Deposit Types Black sands (magnetite, ilmenite, chromite); yellow sands (zircon, monazite). Au placers commonly derive from various Au vein-type deposits as well as porphyry copper, Cu skarn, and polymetallic replacement deposits.

DEPOSIT DESCRIPTION

Mineralogy Au, platinum-iron alloys, osmium-iridium alloys; gold commonly with attached quartz, magnetite, or ilmenite.

Texture/Structure Flattened, rounded edges, flaky, flour gold extremely fine grained flakes; very rarely equidimensional nuggets.

Ore Controls Highest Au values at base of gravel deposits in various gold "traps" such as natural riffles in floor of river or stream, fractured bedrock, slate, schist, phyllite, dikes, bedding planes, all structures trending transverse to direction of water flow. Au concentrations also occur within gravel deposits above clay layers that constrain the downward migration of Au particles.

Geochemical Signature Anomalous high amounts of Ag, As, Hg, Sb, Cu, Fe, S, and heavy minerals magnetite, chromite, ilmenite, hematite, pyrite, zircon, garnet, rutile. Au nuggets have decreasing Ag content with distance from source.

EXAMPLES

Sierra Nevada, USCA	(Lindgren, 1911; Yeend, 1974)
Victoria, AUVT	(Knight, 1975)

GRADE AND TONNAGE MODEL OF PLACER Au-PGE

By Greta J. Orris and James D. Bliss

REFERENCE Orris and Bliss (1985).

COMMENTS Placers used for this model are predominantly Quaternary in age and alluvial in nature. Many of the placer deposits contain a mix of depositional environments and energy level--deposits along minor tributaries have been worked with deposits downstream on a higher order stream, bench (or terrace) gravels have been mined with more recent deposits on valley floor. Some of the placers included in this model were formed by complex glacial-fluvial processes. Deposits not included in this model are those primarily cataloged as desert placers, pre-Tertiary or Tertiary age placers, beach placers, eolian placers, residual placers, eluvial placers, and gravel-plain deposits. These types, however, may be minor components of those deposits selected to be included. In most cases, the grade and tonnage figures are for districts or for placer operations within one mile (1.6 km) of one another. For some placers, early production figures were missing due to poor records of early gold rush work. In most cases, reserve figures (if a reserve is known) are not available. Some tonnage figures were estimated from approximate size of workings. Some grades were based on very limited information and in some cases extrapolated from information on manpower figures, type of equipment used, and estimates of the total contained gold produced.

Cutoff grades are dependent on the mining methods used to exploit placers. Methods of placer mining included in this model are as diverse as the depositional environment. These methods include panning, sluicing, hydraulic mining, and dredging. Draglines were used to mine some placers. Cut-off grades are also dependent on the value of gold during the period, or periods, of operation.

Some placer deposits were excluded due to grade or tonnage figures not compatible with the majority of placers found in the model. Placers exploited through drift mining exhibit grades that are too large and tonnages that are too small to be included in this model. Similarly, the large regional placers formed at the junction of mountainous areas and an adjacent plain or valley were excluded because they can be mined with large-volume dredges which are economic at grades not viable under other conditions. Both grades and tonnages of these placers are incompatible with this model.

Placer sizes were initially recorded in terms of cubic meters and the grades recorded as grams per cubic meter. In order to conform to other deposit models herein, deposit volume and grades have been converted to metric tons and grams per metric ton using 2.0 metric tons per cubic meter--the average density of wet sand and gravel. Gold grade is correlated with tonnage ($r = -0.35$) and with silver grade ($r = 0.66$, $n = 16$). See figs. 196, 197.

DEPOSITS

Name	Country	Name	Country
Adelong Creek	AUNS	Humbug Creek	USOR
Alma (Mills) Placer	USCO	Hundred Dollar Gulch	USID
Araluen Valley	AUNS	Iowa Gulch	USCO
Bannack	USMT	Jembaicumbene Creek	AUNS
Big Badja River	AUNS	Jordan Creek	USID
Blue River	USCO	Lamb Creek	USID
Boulder River	USMT	Llano de Oro	USOR
Bullrun Placer	USOR	Lowe Placer	USCO
Buxton Creek	CNBC	Lower Beaver Creek	USCO
Camanche	USCA	Lowland Creek	USMT
Cobweb Diggings	AUNS	Lynx Creek	USAZ
Copper Basin	USAZ	Missouri Creek	USCO
Corduroy Creek	USID	Mitchell Creek	USMT
Crooked Creek	USID	Nugget Creek (South Fork)	USID
Cullengoral	AUNS	Ophir	USMT
Deep Gravel	USOR	Pactolus	USCO
Dixie Placer	USOR	Picuris	USNM
El Dorado	USMT	Pioneer	USMT
Elkhorn Creek	USMT	Prickly Pear Creek	USMT
Elliston	USMT	Rio Challana	BLVA
Fall Creek	USID	Rio Chimate	BLVA
Foots Creek	USOR	Rio Tuichi (upper reach)	BLVA
Forest Creek	USOR	Rio Yolosano	BLVA
French Gulch	USCO	Rio Yuyo	BLVA
George Prezel	USID	Sand Creek	USID
Georgia Gulch	USCO	Schissler Creek	USID
Gold Run (Summit Co.)	USCO	Snowstorm area	USCO
Gold Run (Boulder Co.)	USCO	Sterling Creek	USOR
Golden Rule	USID	Sumpter Bar	USOR
Green River	USUT	Swan River	USCO
Horse Praire	USMT	T93-R77W Placer	USCO

Vermilion River	USMT	Wombat Creek	AUNS
Wellington	AUNS		

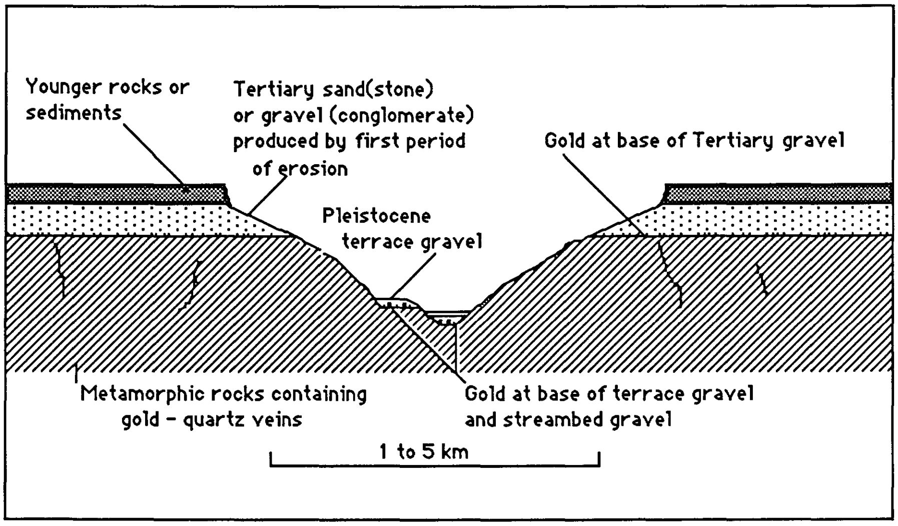

Figure 195. Cartoon cross section showing three stages of heavy mineral concentrations typical of placer Au-PGE deposits.

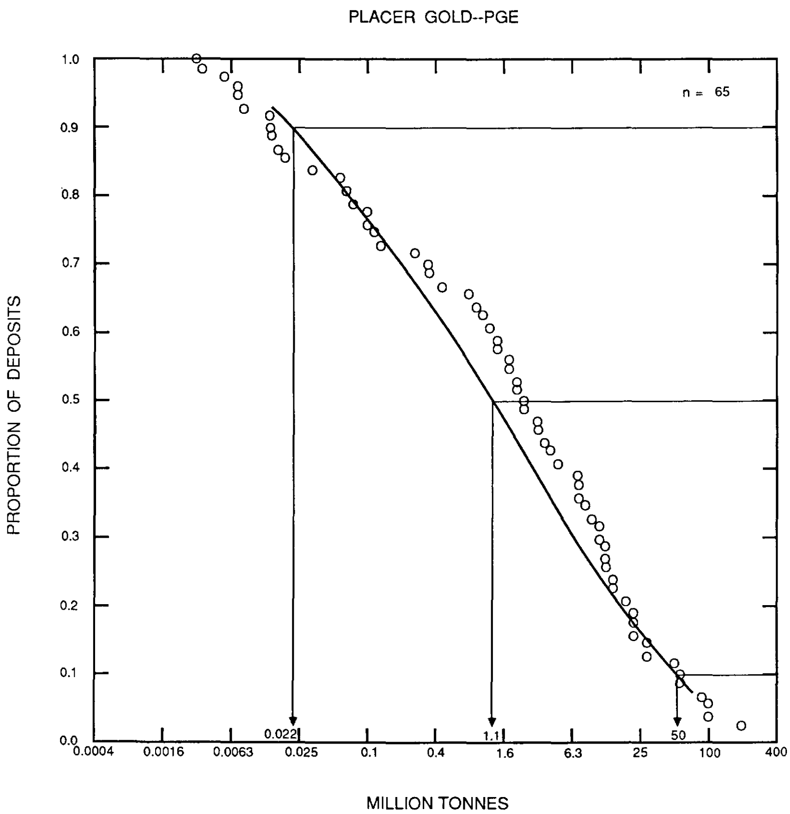

Figure 196. Tonnages of placer Au-PGE deposits. Individual digits represent number of deposits.

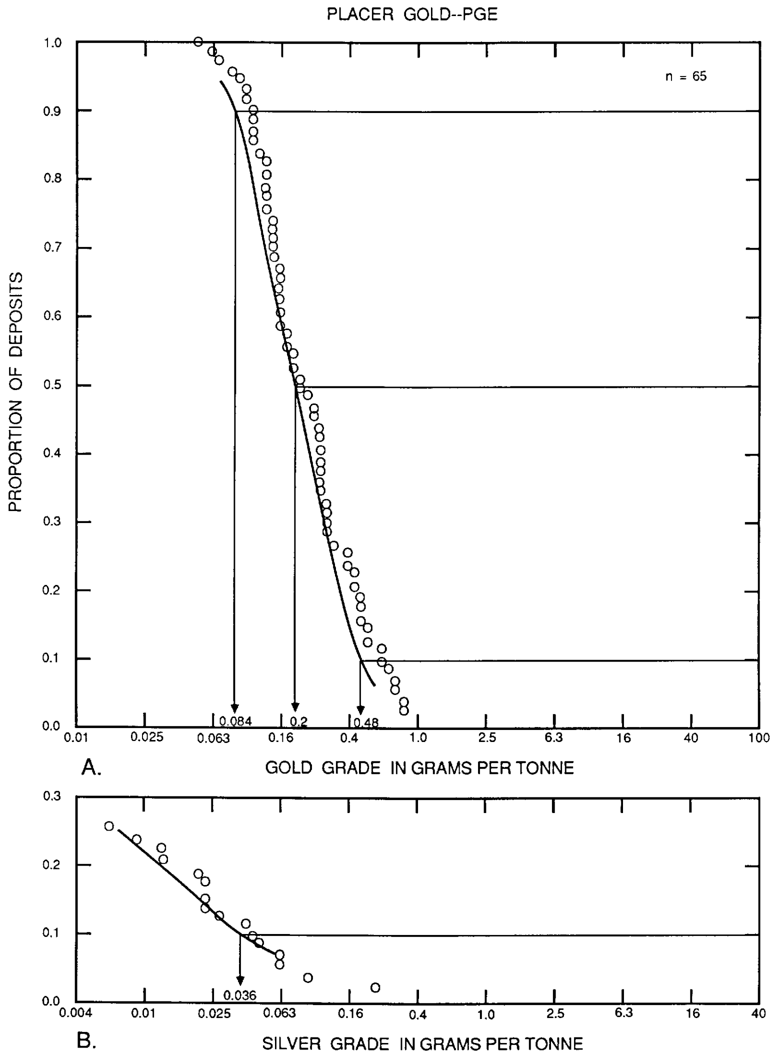

Figure 197. Precious-metal grades of placer Au-PGE deposits. A, Gold. B, Silver.

DESCRIPTIVE MODEL OF PLACER PGE-Au

By Warren E. Yeend and Norman J Page

DESCRIPTION Platinum-group alloys and elemental gold in grains and (rarely) nuggets in gravel, sand, silt, and clay, and their consolidated equivalents, in alluvial, beach, eolian, and (rarely) glacial deposits derived from ultramafic sources.

GENERAL REFERENCES Boyle (1979), Wells (1973), Lindgren (1911), Mertie (1969).

GEOLOGICAL ENVIRONMENT

Rock Types Alluvial gravel and conglomerate and heavy minerals indicative of ultramafic sources and low-grade metamorphic terrane. Sand and sandstone of secondary importance.

Textures Coarse to fine clastic.

Age Range Tertiary to Holocene. Older deposits may have been formed but their preservation is unlikely.

Depositional Environment Marine (near shore), rivers and streams (medium to low gradient), desert (eolian) sand dunes, in-situ weathering.

Tectonic Setting(s) Paleozoic to Mesozoic accreted terranes, Tertiary conglomerates along major fault zones; low terrace deposits; high-level terrace gravels.

Associated Deposit Types Alaskan PGE deposits.

DEPOSIT DESCRIPTION

Mineralogy Platinum-iron alloys (isoferroplatinum with rarer ferroanplatinum, tetraferroplatinum, and tulameenite), platinum-iridium, gold, osmium-iridium alloys; magnetite, chromite, or ilmenite.

Texture/Structure Flattened, rounded edges, flaky, flour-sized alloys and gold; very rarely equidimensional nuggets.

Ore Controls Highest Au values at base of gravel deposits or on argillaceous to clayey beds within gravel sequence; metal alloys concentrated in "traps" such as natural riffles in floor of river or stream, fractured bedrock, slate, schist, phyllite, dikes, bedding planes, and in structures trending transverse to direction of water flow. For PGE, predominantly zoned "Alaskan" type ultramafic complexes and minor ophiolites as source rocks; streams or rivers usually head in regions of ultramafic rocks.

Geochemical Signature Anomalously high amounts of Ag, As, Hg, Sb, Cu, Fe, S, Cr.

EXAMPLES

Urals, USSR	(Duparc and Tikonovitch, 1920; Mertie, 1969)
Goodnews Bay District, USAK	(Mertie, 1969)
Choco, CLBA	(Mertie, 1969)
Tulameen District, CNBC	(O'Neill and Gunning, 1934)

GRADE AND TONNAGE MODEL OF PLACER PGE-Au

By Donald A. Singer and Norman J Page

DATA REFERENCE Calkins and others, 1978.

COMMENTS All deposits used for the model are from the Urals of USSR. The platinum grade plot suggests three populations. Many of the deposits with grades less then 1,000 ppb Pt were probably mined by dredges, whereas the majority of deposits were mined by conventional placering methods. Some of the very high grades may represent reporting errors such as grades for a high-grade portion of a deposit being reported as representative of the total deposit. Probably because of the effects of combining deposits mined by two technologies, tonnage is correlated with platinum grade (r = -0.42) and with gold grade (r = -0.54, n = 23). Platinum grade is correlated with gold grade (r = 0.58, n = 23), with osmium grade (r = 0.89, n = 21), with iridium grade (r = 0.98, n = 10), and with palladium grade (r = 0.99, n = 13). Osmium grade is correlated with iridium grade (r=0.97, n=9) and with palladium grade (r = 0.89, n = 12). Iridium grade is correlated with palladium grade (r = 0.97, n = 9). Other correlations were not significant with the available number of samples. See figs. 198-200.

DEPOSITS

Name	Country	Name	Country
Aleksandrovskii Log	URRS	Malaia Prostokischenka	URRS
Alexii-Olginsky Log	URRS	Malaia Sosnowka	URRS
Anianowsky Lojok	URRS	Malomalsky-Priisk	URRS
Arkhangelskii Log	URRS	Malot Pokap	URRS
Besimianni Log	URRS	Martian R.	URRS
Bielgorsky Log	URRS	Melnitschnaia	URRS
Bobrowka River	URRS	Molitchowka	URRS
Bolshaya Choumika R.	URRS	Morphine-Log	URRS
Bolshaya Kamenouchka	URRS	Niasman R.	URRS
Bolshaya Ossokina R.	URRS	Nikolai-Tschoudotworsky	URRS
Bolshaya Prostokischenka	URRS	Novoi-Log	URRS
Bolshaya Sosnovka	URRS	Obodranny-Lojok	USSR
Bolshoi Pokap R.	URRS	Panowka	URRS
Bolshoi Sakciam	URRS	Patchek	URRS
Boyandinskaia	URRS	Pestchanka R.	URRS
Ejowka	URRS	Phedinan R.-Triok	URRS
Gloubokia 1	URRS	Podbornaia	URRS
Gloubokia 2	URRS	Podmoskowoi-Log	URRS
Illinsky Log	URRS	Popowsky-Lojok	URRS
Ivov R.	URRS	Popretschne-Log	URRS
Jerusalimsky-Priisk	URRS	Roublewik R.	URRS
Jourawlik R.	URRS	Sirkov Log	URRS
Judinsky-Lojok	URRS	Small unnamed-Weressowy	URRS
Kamenka	URRS	Solovyevskii Log	URRS
Kamenka R.	URRS	Soukhoi Log	URRS
Kisslaia-Peruonatchainik	URRS	Srednia-Prostokischenka	URRS
Kitlim, Severniy R.	URRS	Stepanoff-Log	URRS
Korobowsky Lojok	URRS	Syssim R.	URRS
Kossia R.	URRS	Tilai R.	URRS
Kossoi-Log	URRS	Toura R.	URRS
Kossorgskii Log	URRS	Trudny-Log	URRS
Krutoi Log	URRS	Tsauch R.	URRS
Lobwa R.	URRS	Tschachewitaia	URRS
Log No. 1-Propretschnoi	URRS	Tschch R.	URRS
Log No. 2-Suftlii Bor	URRS	Unnamed creek-B. Sosnowka	URRS
Log No. 3-Suftlii Bor	URRS	Verkho-Tourie	URRS
Log No. 6-Suftlii Bor	URRS	Wyssim R.	URRS
Log No. 7-Suftlii Bor	URRS	Yermakof-Log	URRS
Logwinska	URRS	Zaetzeff, R.	URRS
Lojok at Bisserskaya	URRS	Zemlianoi-Mostik Log	URRS
Lojok No. 1&2 Omoutnaia	URRS		
Main Valley of Kisslaia	URRS		
Malaia Koswa R.	URRS		

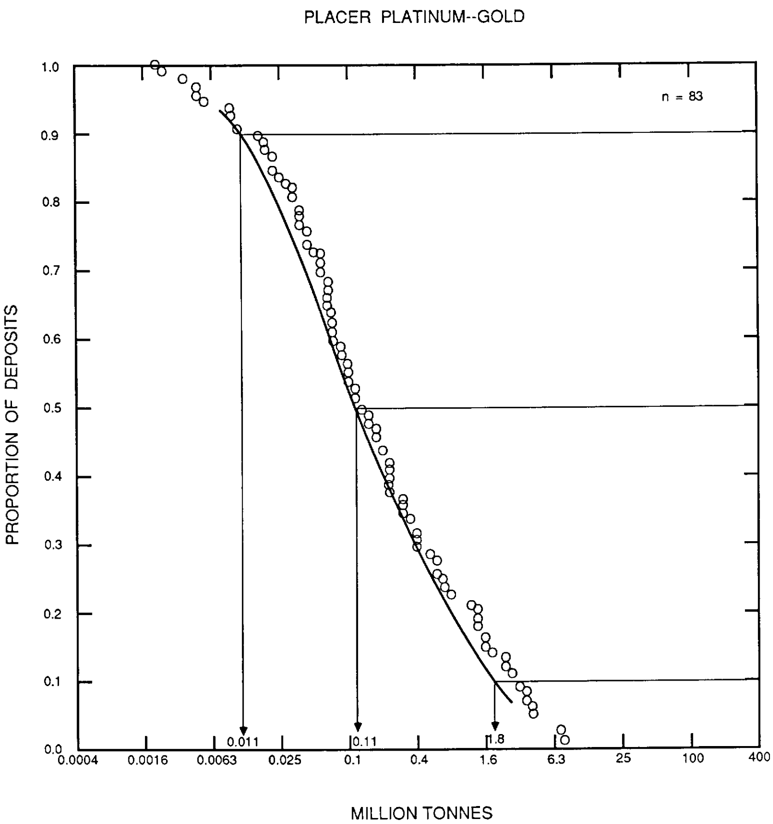

Figure 198. Tonnages of placer PGE-Au deposits.

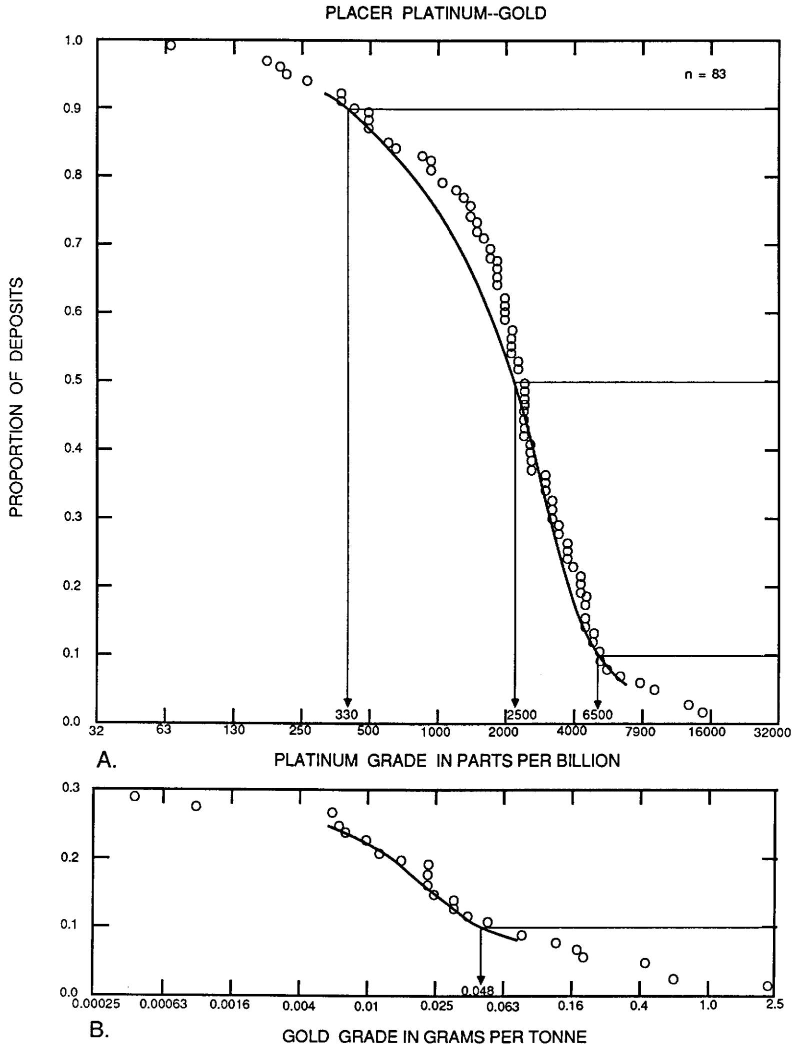

Figure 199. Precious-metal grades of placer PGE-Au deposits. A, Platinum. B, Gold.

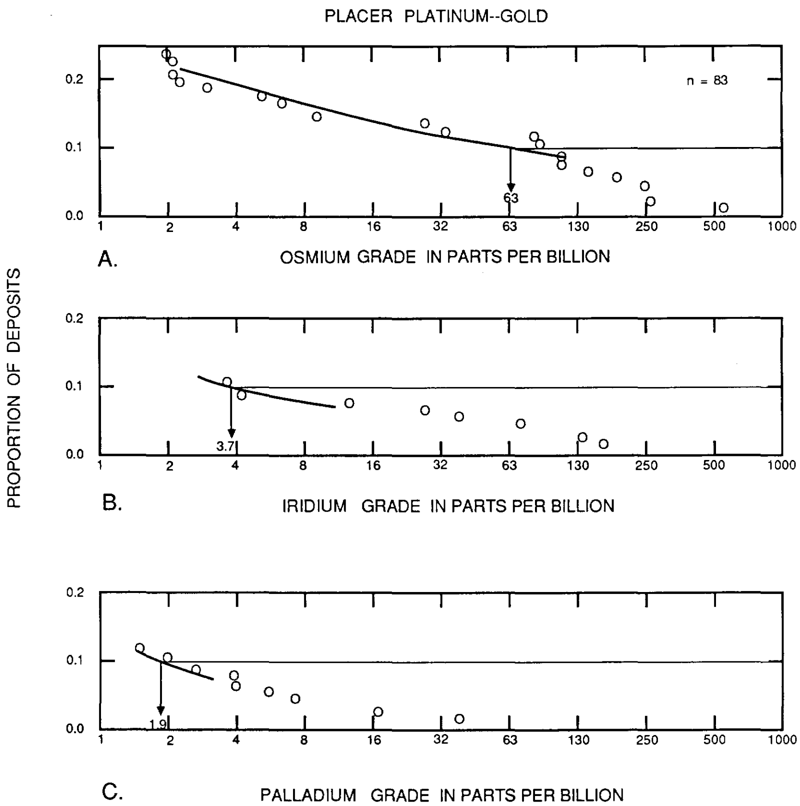

Figure 200. Other PGE grades of placer PGE-Au deposits. A, Osmium. B, Iridium. C, Palladium.

DESCRIPTIVE MODEL OF SHORELINE PLACER Ti

By Eric R. Force

DESCRIPTION Ilmenite and other heavy minerals concentrated by beach processes and enriched by weathering.

GENERAL REFERENCE Force (1976).

GEOLOGICAL ENVIRONMENT

Rock Types Well-sorted medium- to fine-grained sand in dune, beach, and inlet deposits commonly overlying shallow marine deposits.

Age Range Commonly Miocene to Holocene, but may be any age.

Depositional Environment Stable coastal region receiving sediment from deeply weathered metamorphic terranes of sillimanite or higher grade.

Tectonic Setting(s) Margin of craton. Crustal stablity during deposition and preservation of deposits.

DEPOSIT DESCRIPTION

Mineralogy Altered (low Fe) ilmenite ± rutile ± zircon. Trace of monazite, magnetite, and pyroxene; amphibole rare or absent. Quartz greatly exceeds feldspar.

Texture/Structure Elongate "shoestring" ore bodies parallel to coastal dunes and beaches.

Ore Controls High-grade metamorphic source; stable coastline with efficient sorting and winnowing; weathering of beach deposits.

Weathering Leaching of Fe from ilmenite and destruction of labile heavy minerals results in residual enrichment of deposits.

Geochemical and Geophysical Signature High Ti, Zr, REE, Th and U. Gamma radiometric anomalies resulting from monazite content. Induced-polarization anomalies from ilmenite.

EXAMPLES

Green Cove Springs, USFL	(Pirkle and others, 1974)
Trail Ridge, USFL	(Pirkle and Yoho, 1970)
Lakehurst, USNJ	(Markiewicz, 1969)
Eneabba, AUWA	(Lissiman and Oxenford, 1973)

GRADE AND TONNAGE MODEL OF SHORELINE PLACER Ti

By Emil D. Attanasi and John H. DeYoung, Jr.

COMMENTS Grade and tonnage estimates represent mining units rather than individual lenses. Grades are represented as percent TiO_2 from rutile, ilmenite, leucoxene, percent ZrO_2 from zircon, and percent rare-earth oxides from monazite. Zircon is correlated with rutile ($r = 0.49$, $n = 50$), ilmenite ($r = 0.58$, $n = 52$), leucoxene ($r = 0.55$, $n = 24$), and monazite ($r = 0.55$, $n = 29$). Ilmenite is correlated with leucoxene ($r = 0.66$, $n = 24$) and with monazite ($r = 0.66$, $n = 29$). See figs. 201-205.

DEPOSITS

Name	Country	Name	Country
Agnes Waters	AUQL	Boulougne-Folkston	USFL
Barrytown	NZLD	Bridge Hill Ridge	AUNS
Birchfield	NZLD	Brunswick-Altamaha	USGA
Bothaville-Wolmaransstad	SAFR	Camaratuba	BRZL
		Capel Shoreline	AUWA

Carolina	SAFR	Munbinea Shoreland	AUWA
Charleston-B	USSC	Munmorah	AUNS
Charleston-C	USSC	Muriwai	NZLD
Charleston-I	USSC	N.L. Industries (Aurora)	USNC
Charleston-K	USSC	N. Stradbroke Island	AUQL
Charleston-L	USSC	Natchez Trace State Park	USTN
Charleston-N	USSC	North Camden (Keer-McGee)	USTN
Cumberland Island	USGA	Oak Grove (Ethyl)	USTN
Curtis Island	AUQL	Orissa (Chatrapur)	INDA
East Rosetta	EGPT	Poerua River	NZLD
Eneabba Shoreline	AUWA	Pulmoddai	SRIL
Evans Head-Wooli area	AUNS	Quilon (Chavara)	INDA
Fraser Island	AUQL	Richards Bay	SAFR
Gingin Shoreline	AUWA	Ross	NZLD
Gladstone Mainland	AUQL	Scott River	AUWA
Green Cove Springs	USFL	Ship Island	USMS
Highland-Trail Ridge	USFL	Silica Mine	USTN
Hilton Head Island	USSC	Stockton Bight	AUNS
Hokitika North	NZLD	Tuncurry-Tomago area	AUNS
Hokitika South	NZLD	Waiho River	NZLD
Inskip Point (Cooloola area)	AUQL	Waroona Shoreline	AUWA
Jacksonville Area	USFL	Westport	NZLD
Karamea	NZLD	Yoganup Shoreline	AUWA
Lakehurst (Glidden)	USNJ	Yulee	USFL
Manavalakurichi	INDA		
Manchester (Asarco)	USNJ		
Moreton Island	AUQL		

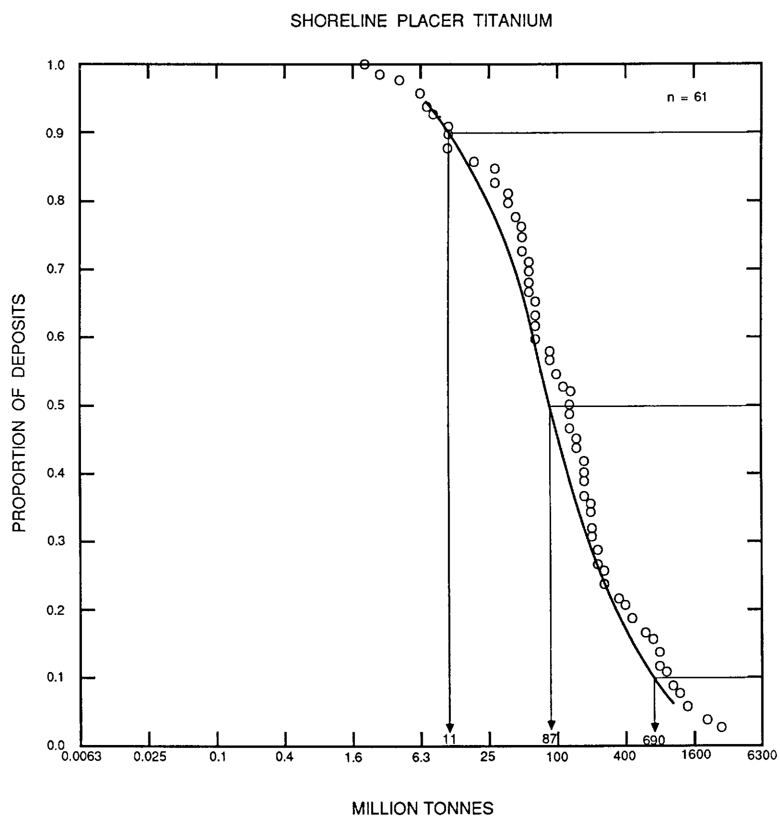

Figure 201. Tonnages of shoreline placer Ti deposits.

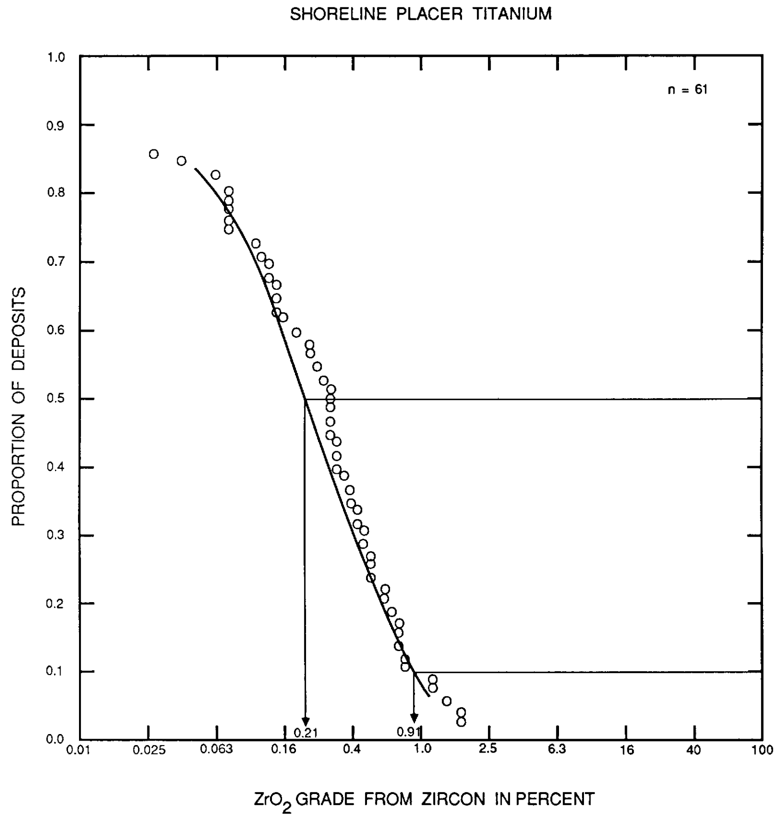

Figure 202. ZrO_2 grades from zircon in shoreline placer Ti deposits.

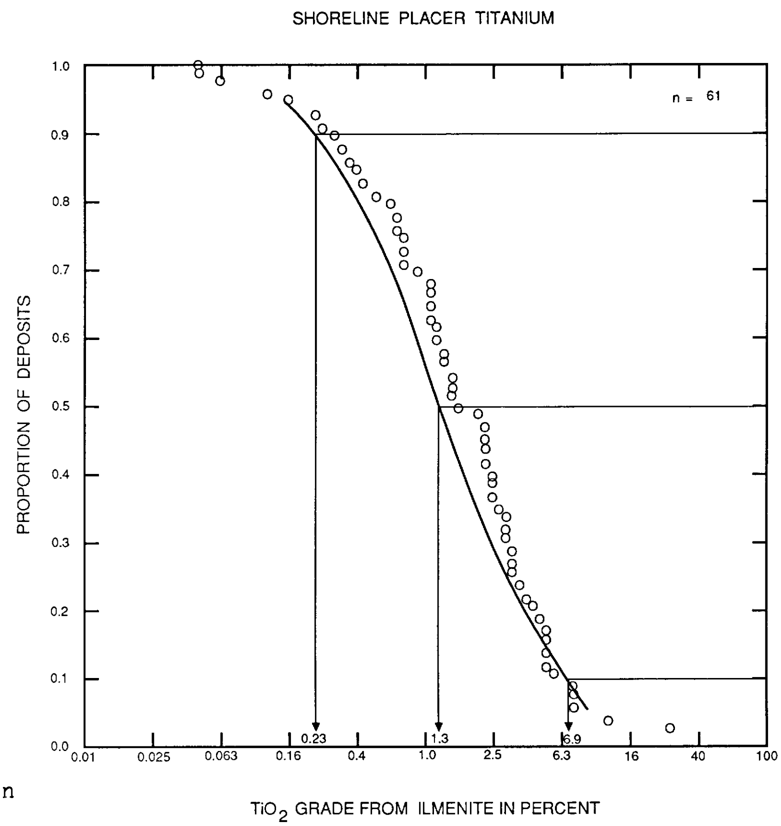

Figure 203. TiO_2 grades from ilmenite in shoreline placer Ti deposits.

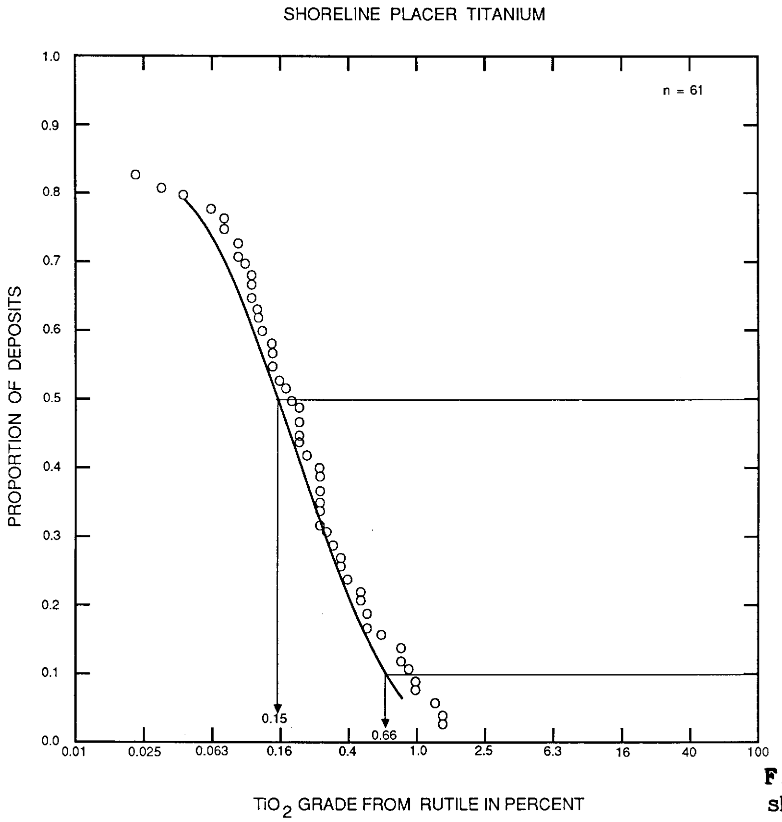

Figure 204. TiO_2 grades from rutile in shoreline placer Ti deposits.

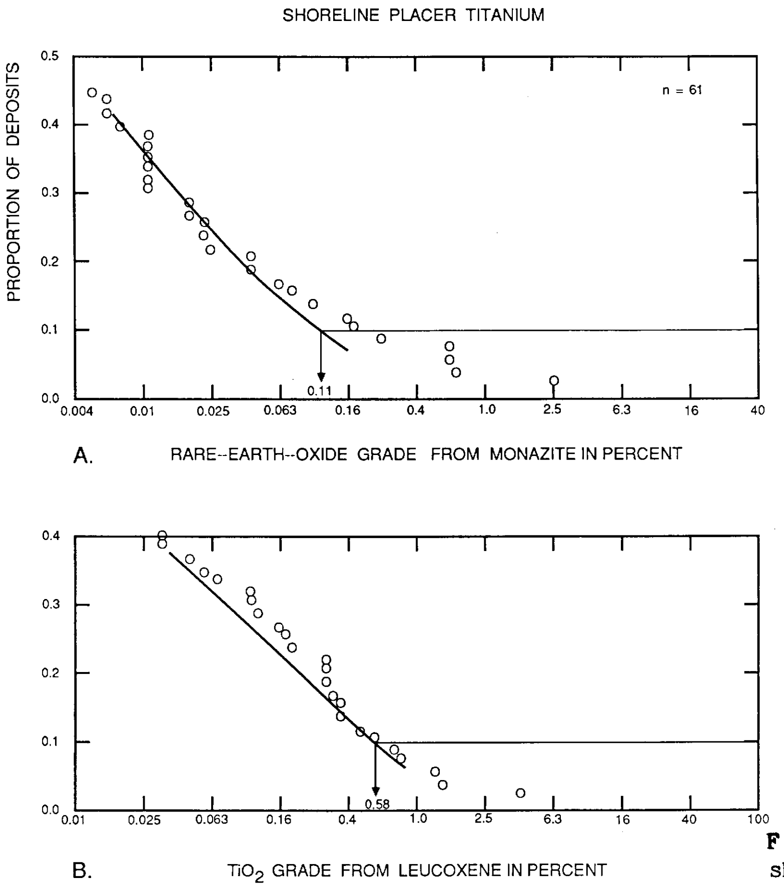

Figure 205. Other metal grades of shoreline placer Ti deposits. A, REE oxide from monazite. B, TiO_2 from leucoxene.

DESCRIPTIVE MODEL OF DIAMOND PLACERS

By Dennis P. Cox

DESCRIPTION Diamonds in alluvial and beach sediments and in sandstone and conglomerate.

GENERAL REFERENCES Orlov (1973), Lampietti and Sutherland (1978).

GEOLOGICAL ENVIRONMENT

Rock Types Sand and gravel alluvial and beach deposits. Conglomerate beds may contain paleoplacers.

Textures Coarse clastic.

Age Range Tertiary and Quaternary.

Depositional Environment Streams draining areas of kimberlite pipes or diamond concentrations in sedimentary or metamorphic rocks. Alluvial diamond deposits may be 1,000 km from source. It is possible that some diamonds may have been derived from Archean greenstone belts.

Tectonic Setting(s) Stable craton.

Associated Deposit Types Diamond pipes.

DEPOSIT DESCRIPTION

Mineralogy Diamond, bort or carbonado (polycrystalline, generally dark colored), ballas (spherulitic, polycrystalline and amorphous carbonado).

Texture/Structure Diamonds derived from ancient placers in sedimentary rock commonly retain sand grains cemented to grooves or indentations in the crystal.

Ore Controls Diamonds are concentrated in low-energy parts of stream systems with other heavy minerals. Diamonds decrease in size and increase in quality (fewer polycrystalline types) with distance from their source.

Geochemical Signature Cr, Ti, Mn, Ni, Co, PGE, Ba. Anomalous Ni and Nb together with the heavy minerals pyrope, Mg-ilmenite, and phlogopite indicate nearby kimberlite pipes.

EXAMPLES

African deposits	(Sutherland, 1982)
Venezuelan deposits	(Fairbairn, 1971; Reid and Bisque, 1975)

DESCRIPTIVE MODEL OF ALLUVIAL PLACER Sn

By Bruce L. Reed

DESCRIPTION Cassiterite and associated heavy minerals in silt- to cobble-size nuggets concentrated by the hydraulics of running water in modern and fossil streambeds.

GENERAL REFERENCES Hosking (1974), Taylor (1979), Sainsbury and Reed (1973).

GEOLOGICAL ENVIRONMENT

Rock Types Alluvial sand, gravel, and conglomerate indicative of rock types that host lode tin deposits.

Textures Fine to very coarse clastic.

Age Range Commonly late Tertiary to Holocene, but may be any age.

Depositional Environment Generally moderate to high-level alluvial, where stream gradients lie within the critical range for deposition of cassiterite (for instance, where stream velocity is sufficient to result in good gravity separation but not enough so the channel is swept clean). Stream placers may occur as offshore placers where they occupy submerged valleys or strandlines.

Tectonic Setting(s) Alluvial deposits derived from Paleozoic to Cenozoic accreted terranes or stable cratonic foldbelts that contain highly evolved granitoid plutons or their extrusive equivalents (see Model 14b, geochemical signature). Tectonic stability during deposition and preservation of alluvial deposits.

Associated Deposit Types Alluvial gravels may contain by-product ilmenite, zircon, monazite, and, where derived from cassiterite-bearing pegmatites, columbite-tantalite. Economic placers are generally within a few (<8) kilometers of the primary sources. Any type of cassiterite-bearing tin deposit may be a source. The size and grade of the exposed source frequently has little relation to that of the adjacent alluvial deposit.

DEPOSIT DESCRIPTION

Mineralogy Cassiterite; varying amounts of magnetite, ilmenite, zircon, monazite, allanite, xenotime, tourmaline, columbite, garnet, rutile, and topaz may be common heavy resistates.

Texture/Structure Cassiterite becomes progressively coarser as the source is approached; euhedral crystals indicate close proximity to primary source. Where a marine shoreline intersects or transgresses a stream valley containing alluvial cassiterite the shoreline placers normally have a large length-to-width ratio.

Ore Controls Cassiterite tends to concentrate at the base of stream gravels and in traps such as natural riffles, potholes, and bedrock structures transverse to the direction of water flow. The richest placers lie virtually over the primary source. Streams that flow parallel to the margin of a tin-bearing granite are particularly favorable for placer tin accumulation.

Geochemical Signature Anomalously high amounts of Sn, As, B, F, W, Be, W, Cu, Pb, Zn. Panned concentrate samples are the most reliable method for detection of alluvial cassiterite.

EXAMPLES

Southeast Asian tin fields	(Hosking, 1974) (Newell, 1971) (Simatupang and others, 1974) (Westerveld, 1937

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Appendix A. Locality Abbreviations

AGTN	Argentina
ALGR	Algeria
ANGL	Angola
ASTR	Austria
AUNS	Australia, New South Wales
AUNT	Australia, N. Territory
AUQL	Australia, Queensland
AUSA	Australia, South Australia
AUTS	Australia, Tasmania
AUVT	Australia, Victoria
AUWA	Australia, Western Australia
BLVA	Bolivia
BOTS	Botswana
BRMA	Burma
BRZL	Brazil
BULG	Bulgaria
CARL	Caroline Islands
CHAD	Chad
CILE	Chile
CINA	China
CLBA	Colombia
CMRN	Cameroon
CNAL	Canada, Alberta
CNBC	Canada, British Columbia
CNGO	Congo
CNMN	Canada, Manitoba
CNNB	Canada, New Brunswick
CNNF	Canada, Newfoundland
CNNS	Canada, Nova Scotia
CNNT	Canada, Northwest Territories
CNON	Canada, Ontario
CNQU	Canada, Quebec
CNSK	Canada, Saskatchewan
CNYT	Canada, Yukon Territory
CORI	Costa Rica
CUBA	Cuba
CYPS	Cyprus
CZCL	Czechoslovakia
DMRP	Dominican Republic
ECDR	Ecuador
EGPT	Egypt
ELSA	El Salvador
ETHP	Ethiopia
FIJI	Fiji
FNLD	Finland
FRNC	France
GHNA	Ghana
GNBS	Guinea-Bissau
GNEA	Guinea
GRBR	Great Britain
GREC	Greece
GRLD	Greenland
GRME	East Germany
GRMY	West Germany
GUAT	Guatemala
GUYN	Guyana
HATI	Haiti
HNDR	Honduras
HONG	Hong Kong
HUNG	Hungary
INDA	India
INDS	Indonesia
IRAN	Iran
IRAQ	Iraq
IRLD	Ireland
ISRL	Israel
ITLY	Italy
IVCO	Ivory Coast
JAPN	Japan
JMCA	Jamaica
JRDN	Jordan
KNYA	Kenya
MALI	Mali
MAUR	Mauritania
MDGS	Madagascar (Malagasy Rep.)
MLWI	Malawi
MLYS	Malaysia
MNGL	Mongolia
MRCO	Morocco
MXCO	Mexico
MZMB	Mozambique
NAMB	Namibia
NCAL	New Caledonia
NCRG	Nicaragua
NKOR	North Korea
NRWY	Norway
NZLD	New Zealand
OMAN	Oman
PANA	Panama
PERU	Peru
PKTN	Pakistan
PLND	Poland
PLPN	Philippines
PORT	Portugal
PPNG	Papua New Guinea
PTRC	Puerto Rico
RMNA	Romania
SAAR	Saudi Arabia
SAFR	South Africa
SKOR	South Korea
SLMN	Solomon Islands
SNGL	Senegal
SPAN	Spain
SRIL	Sri Lanka
SRLN	Sierra Leon
SRNM	Surinam
SUDN	Sudan
SWAF	SW Africa
SWAZ	Swaziland
SWDN	Sweden
SYRA	Syria
THLD	Thailand
TIWN	Taiwan
TNZN	Tanzania
TOGO	Togo
TRKY	Turkey
TUNS	Tunisia
UGND	Uganda
UVOL	Upper Volta (Burkina Fasso)
URAM	USSR, Armenia
URKZ	USSR, Kazakhstan
URRS	USSR, Russian Rep.
URTD	USSR, Tadzhikistan
URUZ	USSR, Uzbekistan
USAK	US, Alaska
USAR	US, Arkansas
USAZ	US, Arizona
USCA	US, California

USCO	US, Colorado
USFL	US, Florida
USGA	US, Georgia
USHI	US, Hawaii
USID	US, Idaho
USKY	US, Kentucky
USMA	US, Massachusetts
USME	US, Maine
USMI	US, Michigan
USMN	US, Minnesota
USMO	US, Missouri
USMT	US, Montana
USNC	US, North Carolina
USND	US, North Dakota
USNJ	US, New Jersey
USNM	US, New Mexico
USNV	US, Nevada
USNY	US, New York
USOK	US, Oklahoma
USOR	US, Oregon
USPA	US, Pennsylvania
USTN	US, Tennessee
USTX	US, Texas
USUT	US, Utah
USVA	US, Virginia
USVT	US, Vermont
USWA	US, Washington
USWI	US, Wisconsin
USWY	US, Wyoming
VNZL	Venezuela
VTNM	Vietnam
YUGO	Yugoslavia
ZIMB	Zimbabwe
ZIRE	Zaire
ZMBA	Zambia

Appendix B. Summary statistics of grade-tonnage models by Donald A. Singer
[Logarithms (base 10) except Al_2O_3, Fe, Cr_2O_3, fiber, Mn, and P_2O_5, which are percent. S. D., standard deviation]

	Komatiitic Ni-Cu			Dunitic Ni-Cu			Synorogenic-synvolcanic Ni-Cu		
Deposit type	Mean	S.D.	Number of deposits	Mean	S.D.	Number of deposits	Mean	S.D.	Number of deposits
Tonnage (metric)	6.235	0.7266	31	7.451	0.7664	22	6.300	0.6996	32
RE_2O_5 (pct)	--	--	--	--	--	--	--	--	--
Monazite (pct REO)	--	--	--	--	--	--	--	--	--
U_3O_8 (pct)	--	--	--	--	--	--	--	--	--
Zircon (pct ZrO_2)	--	--	--	--	--	--	--	--	--
Nb_2O_5 (pct)	--	--	--	--	--	--	--	--	--
Fiber (pct)	--	--	--	--	--	--	--	--	--
Barite (pct)	--	--	--	--	--	--	--	--	--
Al_2O_3 (pct)	--	--	--	--	--	--	--	--	--
P (pct)	--	--	--	--	--	--	--	--	--
P_2O_5 (pct)	--	--	--	--	--	--	--	--	--
Ilmenite (pct TiO_2)	--	--	--	--	--	--	--	--	--
Rutile (pct TiO_2)	--	--	--	--	--	--	--	--	--
Leucocite (pct TiO_2)	--	--	--	--	--	--	--	--	--
Cr_2O_3 (pct)	--	--	--	--	--	--	--	--	--
Mn (pct)	--	--	--	--	--	--	--	--	--
Fe (pct)	--	--	--	--	--	--	--	--	--
Co (pct)	-1.250	.3608	8	-1.592	.4286	3	-1.333	.3506	3
Ni (pct)	.1790	.2600	31	-.0048	.2337	22	-.1175	.2580	32
Cu (pct)	-.8450	.2548	21	-1.415	.4886	12	-.3170	.3101	29
Mo (pct)	--	--	--	--	--	--	--	--	--
WO_3 (pct)	--	--	--	--	--	--	--	--	--
Pd (ppb)	-.4703	.2898	11	-.8564	.4467	5	-1.005	.2799	3
Pt (ppb)	-.6967	.2213	5	--	--	--	-1.508	.1849	2
Rh (ppb)	--	--	--	--	--	--	--	--	--
Ir (ppb)	-1.145	.4086	9	-1.822	.7000	5	--	--	--
Ru (ppb)	--	--	--	--	--	--	--	--	--
Os (ppb)	--	--	--	--	--	--	--	--	--
Ag (g/t)	--	--	--	--	--	--	--	--	--
Au (g/t)	-1.443	.5335	10	-1.722	.1830	5	-.9408	.4151	3
Zn (pct)	--	--	--	--	--	--	--	--	--
Hg (pct)	--	--	--	--	--	--	--	--	--
Sn (pct)	--	--	--	--	--	--	--	--	--
Pb (pct)	--	--	--	--	--	--	--	--	--
Sb (pct)	--	--	--	--	--	--	--	--	--

	Minor podiform Cr			Major podiform Cr			Serpentine-hosted asbestos		
Deposit type	Mean	S.D.	Number of deposits	Mean	S.D.	Number of deposits	Mean	S.D.	Number of deposits
Tonnage (metric)	2.112	0.9292	435	4.321	0.7598	174	7.419	0.5874	50
RE_2O_5 (pct)	--	--	--	--	--	--	--	--	--
Monazite (pct REO)	--	--	--	--	--	--	--	--	--
U_3O_8 (pct)	--	--	--	--	--	--	--	--	--
Zircon (pct ZrO_2)	--	--	--	--	--	--	--	--	--
Nb_2O_5 (pct)	--	--	--	--	--	--	--	--	--
Fiber (pct)	--	--	--	--	--	--	.6618	.1859	50
Barite (pct)	--	--	--	--	--	--	--	--	--
Al_2O_3 (pct)	--	--	--	--	--	--	--	--	--
P (pct)	--	--	--	--	--	--	--	--	--
P_2O_5 (pct)	--	--	--	--	--	--	--	--	--
Ilmenite (pct TiO_2)	--	--	--	--	--	--	--	--	--
Rutile (pct TiO_2)	--	--	--	--	--	--	--	--	--
Leucocite (pct TiO_2)	--	--	--	--	--	--	--	--	--
Cr_2O_3 (pct)	42.13	7.775	435	44.03	7.291	174	--	--	--
Mn (pct)	--	--	--	--	--	--	--	--	--
Fe (pct)	--	--	--	--	--	--	--	--	--
Co (pct)	--	--	--	--	--	--	--	--	--
Ni (pct)	--	--	--	--	--	--	--	--	--
Cu (pct)	--	--	--	--	--	--	--	--	--
Mo (pct)	--	--	--	--	--	--	--	--	--
WO_3 (pct)	--	--	--	--	--	--	--	--	--
Pd (ppb)	.6723	.4671	31	.5411	.3694	16	--	--	--
Pt (ppb)	1.489	.4564	33	1.156	.1948	12	--	--	--
Rh (ppb)	.9088	.3940	69	1.116	.1683	14	--	--	--
Ir (ppb)	1.815	.3126	38	1.894	.3003	9	--	--	--
Ru (ppb)	2.278	.2217	29	2.344	.0763	7	--	--	--
Os (ppb)	--	--	--	--	--	--	--	--	--
Ag (g/t)	--	--	--	--	--	--	--	--	--
Au (g/t)	--	--	--	--	--	--	--	--	--
Zn (pct)	--	--	--	--	--	--	--	--	--
Hg (pct)	--	--	--	--	--	--	--	--	--
Sn (pct)	--	--	--	--	--	--	--	--	--
Pb (pct)	--	--	--	--	--	--	--	--	--
Sb (pct)	--	--	--	--	--	--	--	--	--

Appendix B. Summary statistics of grade-tonnage models--Continued

Deposit type	Carbonatite			W skarn			Sn skarn		
	Mean	S.D.	Number of deposits	Mean	S.D.	Number of deposits	Mean	S.D.	Number of deposits
Tonnage (metric)	7.777	0.4414	20	6.016	1.025	28	6.774	0.6178	4
RE_2O_5 (pct)	-1.013	1.207	5	--	--	--	--	--	--
Monazite (pct REO)	--	--	--	--	--	--	--	--	--
U_3O_8 (pct)	--	--	--	--	--	--	--	--	--
Zircon (pct ZrO_2)	--	--	--	--	--	--	--	--	--
Nb_2O_5 (pct)	-.1951	.3562	20	--	--	--	--	--	--
Fiber (pct)	--	--	--	--	--	--	--	--	--
Barite (pct)	--	--	--	--	--	--	--	--	--
Al_2O_3 (pct)	--	--	--	--	--	--	--	--	--
P (pct)	--	--	--	--	--	--	--	--	--
P_2O_5 (pct)	--	--	--	--	--	--	--	--	--
Ilmenite (pct TiO_2)	--	--	--	--	--	--	--	--	--
Rutile (pct TiO_2)	--	--	--	--	--	--	--	--	--
Leucocite (pct TiO_2)	--	--	--	--	--	--	--	--	--
Cr_2O_3 (pct)	--	--	--	--	--	--	--	--	--
Mn (pct)	--	--	--	--	--	--	--	--	--
Fe (pct)	--	--	--	--	--	--	--	--	--
Co (pct)	--	--	--	--	--	--	--	--	--
Ni (pct)	--	--	--	--	--	--	--	--	--
Cu (pct)	--	--	--	--	--	--	--	--	--
Mo (pct)	--	--	--	--	--	--	--	--	--
WO_3 (pct)	--	--	--	-.1826	.2430	28	--	--	--
Pd (ppb)	--	--	--	--	--	--	--	--	--
Pt (ppb)	--	--	--	--	--	--	--	--	--
Rh (ppb)	--	--	--	--	--	--	--	--	--
Ir (ppb)	--	--	--	--	--	--	--	--	--
Ru (ppb)	--	--	--	--	--	--	--	--	--
Os (ppb)	--	--	--	--	--	--	--	--	--
Ag (g/t)	--	--	--	--	--	--	--	--	--
Au (g/t)	--	--	--	--	--	--	--	--	--
Zn (pct)	--	--	--	--	--	--	--	--	--
Hg (pct)	--	--	--	--	--	--	--	--	--
Sn (pct)	--	--	--	--	--	--	-.5031	.3014	4
Pb (pct)	--	--	--	--	--	--	--	--	--
Sb (pct)	--	--	--	--	--	--	--	--	--

Deposit type	Replacement Sn			W vein			Sn vein		
	Mean	S.D.	Number of deposits	Mean	S.D.	Number of deposits	Mean	S.D.	Number of deposits
Tonnage (metric)	6.720	0.5493	6	5.748	0.8574	16	5.374	1.000	43
RE_2O_5 (pct)	--	--	--	--	--	--	--	--	--
Monazite (pct REO)	--	--	--	--	--	--	--	--	--
U_3O_8 (pct)	--	--	--	--	--	--	--	--	--
Zircon (pct ZrO_2)	--	--	--	--	--	--	--	--	--
Nb_2O_5 (pct)	--	--	--	--	--	--	--	--	--
Fiber (pct)	--	--	--	--	--	--	--	--	--
Barite (pct)	--	--	--	--	--	--	--	--	--
Al_2O_3 (pct)	--	--	--	--	--	--	--	--	--
P (pct)	--	--	--	--	--	--	--	--	--
P_2O_5 (pct)	--	--	--	--	--	--	--	--	--
Ilmenite (pct TiO_2)	--	--	--	--	--	--	--	--	--
Rutile (pct TiO_2)	--	--	--	--	--	--	--	--	--
Leucocite (pct TiO_2)	--	--	--	--	--	--	--	--	--
Cr_2O_3 (pct)	--	--	--	--	--	--	--	--	--
Mn (pct)	--	--	--	--	--	--	--	--	--
Fe (pct)	--	--	--	--	--	--	--	--	--
Co (pct)	--	--	--	--	--	--	--	--	--
Ni (pct)	--	--	--	--	--	--	--	--	--
Cu (pct)	--	--	--	--	--	--	--	--	--
Mo (pct)	--	--	--	--	--	--	--	--	--
WO_3 (pct)	--	--	--	-.0400	.1408	16	--	--	--
Pd (ppb)	--	--	--	--	--	--	--	--	--
Pt (ppb)	--	--	--	--	--	--	--	--	--
Rh (ppb)	--	--	--	--	--	--	--	--	--
Ir (ppb)	--	--	--	--	--	--	--	--	--
Ru (ppb)	--	--	--	--	--	--	--	--	--
Os (ppb)	--	--	--	--	--	--	--	--	--
Ag (g/t)	--	--	--	--	--	--	--	--	--
Au (g/t)	--	--	--	--	--	--	--	--	--
Zn (pct)	--	--	--	--	--	--	--	--	--
Hg (pct)	--	--	--	--	--	--	--	--	--
Sn (pct)	-.0965	.1265	6	--	--	--	.1038	.2028	43
Pb (pct)	--	--	--	--	--	--	--	--	--
Sb (pct)	--	--	--	--	--	--	--	--	--

Deposit type	Sn greisen Mean	Sn greisen S.D.	Sn greisen Number of deposits	Climax Mo Mean	Climax Mo S.D.	Climax Mo Number of deposits	Porphyry copper Mean	Porphyry copper S.D.	Porphyry copper Number of deposits
Tonnage (metric)	6.8572	0.7449	10	8.305	0.5020	9	8.159	0.6864	208
RE_2O_5 (pct)	--	--	--	--	--	--	--	--	--
Monazite (pct REO)	--	--	--	--	--	--	--	--	--
U_3O_8 (pct)	--	--	--	--	--	--	--	--	--
Zircon (pct ZrO_2)	--	--	--	--	--	--	--	--	--
Nb_2O_5 (pct)	--	--	--	--	--	--	--	--	--
Fiber (pct)	--	--	--	--	--	--	--	--	--
Barite (pct)	--	--	--	--	--	--	--	--	--
Al_2O_3 (pct)	--	--	--	--	--	--	--	--	--
P (pct)	--	--	--	--	--	--	--	--	--
P_2O_5 (pct)	--	--	--	--	--	--	--	--	--
Ilmenite (pct TiO_2) ...	--	--	--	--	--	--	--	--	--
Rutile (pct TiO_2)	--	--	--	--	--	--	--	--	--
Leucocite (pct TiO_2) ..	--	--	--	--	--	--	--	--	--
Cr_2O_3 (pct)	--	--	--	--	--	--	--	--	--
Mn (pct)	--	--	--	--	--	--	--	--	--
Fe (pct)	--	--	--	--	--	--	--	--	--
Co (pct)	--	--	--	--	--	--	--	--	--
Ni (pct)	--	--	--	--	--	--	--	--	--
Cu (pct)	--	--	--	--	--	--	-.2690	.1900	208
Mo (pct)	--	--	--	-.7171	.1363	9	-1.907	.4343	103
WO_3 (pct)	--	--	--	--	--	--	--	--	--
Pd (ppb)	--	--	--	--	--	--	--	--	--
Pt (ppb)	--	--	--	--	--	--	--	--	--
Rh (ppb)	--	--	--	--	--	--	--	--	--
Ir (ppb)	--	--	--	--	--	--	--	--	--
Ru (ppb)	--	--	--	--	--	--	--	--	--
Os (ppb)	--	--	--	--	--	--	--	--	--
Ag (g/t)	--	--	--	--	--	--	.2180	.3646	76
Au (g/t)	--	--	--	--	--	--	-.9077	.7012	81
Zn (pct)	--	--	--	--	--	--	--	--	--
Hg (pct)	--	--	--	--	--	--	--	--	--
Sn (pct)	-.5491	.1707	10	--	--	--	--	--	--
Pb (pct)	--	--	--	--	--	--	--	--	--
Sb (pct)	--	--	--	--	--	--	--	--	--

Deposit type	Porphyry Cu, skarn-related Mean	Porphyry Cu, skarn-related S.D.	Porphyry Cu, skarn-related Number of deposits	Cu skarn Mean	Cu skarn S.D.	Cu skarn Number of deposits	Zn-Pb skarn Mean	Zn-Pb skarn S.D.	Zn-Pb skarn Number of deposits
Tonnage (metric)	7.901	0.4726	18	5.747	0.9505	64	6.151	0.7302	34
RE_2O_5 (pct)	--	--	--	--	--	--	--	--	--
Monazite (pct REO)	--	--	--	--	--	--	--	--	--
U_3O_8 (pct)	--	--	--	--	--	--	--	--	--
Zircon (pct ZrO_2)	--	--	--	--	--	--	--	--	--
Nb_2O_5 (pct)	--	--	--	--	--	--	--	--	--
Fiber (pct)	--	--	--	--	--	--	--	--	--
Barite (pct)	--	--	--	--	--	--	--	--	--
Al_2O_3 (pct)	--	--	--	--	--	--	--	--	--
P (pct)	--	--	--	--	--	--	--	--	--
P_2O_5 (pct)	--	--	--	--	--	--	--	--	--
Ilmenite (pct TiO_2) ...	--	--	--	--	--	--	--	--	--
Rutile (pct TiO_2)	--	--	--	--	--	--	--	--	--
Leucocite (pct TiO_2) ..	--	--	--	--	--	--	--	--	--
Cr_2O_3 (pct)	--	--	--	--	--	--	--	--	--
Mn (pct)	--	--	--	--	--	--	--	--	--
Fe (pct)	--	--	--	--	--	--	--	--	--
Co (pct)	--	--	--	--	--	--	--	--	--
Ni (pct)	--	--	--	--	--	--	--	--	--
Cu (pct)	-.0081	.2211	18	.2266	.2880	64	-.3377	.4585	17
Mo (pct)	-1.657	.2591	4	--	--	--	--	--	--
WO_3 (pct)	--	--	--	--	--	--	--	--	--
Pd (ppb)	--	--	--	--	--	--	--	--	--
Pt (ppb)	--	--	--	--	--	--	--	--	--
Rh (ppb)	--	--	--	--	--	--	--	--	--
Ir (ppb)	--	--	--	--	--	--	--	--	--
Ru (ppb)	--	--	--	--	--	--	--	--	--
Os (ppb)	--	--	--	--	--	--	--	--	--
Ag (g/t)	.6798	.4185	9	1.331	.6955	15	2.059	.3908	22
Au (g/t)	-.4829	.5020	6	.2496	.6107	16	-.3489	.5134	7
Zn (pct)	--	--	--	--	--	--	.7719	.2709	34
Hg (pct)	--	--	--	--	--	--	--	--	--
Sn (pct)	--	--	--	--	--	--	--	--	--
Pb (pct)	--	--	--	--	--	--	.5076	.3053	30
Sb (pct)	--	--	--	--	--	--	--	--	--

Appendix B. Summary statistics of grade-tonnage models--Continued

Deposit type	Fe skarn			Polymetallic replacement			Replacement Mn		
	Mean	S.D.	Number of deposits	Mean	S.D.	Number of deposits	Mean	S.D.	Number of deposits
Tonnage (metric)	6.858	1.041	168	6.261	0.6884	52	4.348	1.073	37
RE_2O_5 (pct)	--	--	--	--	--	--	--	--	--
Monazite (pct REO)	--	--	--	--	--	--	--	--	--
U_3O_8 (pct)	--	--	--	--	--	--	--	--	--
Zircon (pct ZrO_2)	--	--	--	--	--	--	--	--	--
Nb_2O_5 (pct)	--	--	--	--	--	--	--	--	--
Fiber (pct)	--	--	--	--	--	--	--	--	--
Barite (pct)	--	--	--	--	--	--	--	--	--
Al_2O_3 (pct)	--	--	--	--	--	--	--	--	--
P (pct)	--	--	--	--	--	--	-1.481	.4493	3
P_2O_5 (pct)	--	--	--	--	--	--	--	--	--
Ilmenite (pct TiO_2) ...	--	--	--	--	--	--	--	--	--
Rutile (pct TiO_2)	--	--	--	--	--	--	--	--	--
Leucocite (pct TiO_2) ..	--	--	--	--	--	--	--	--	--
Cr_2O_3 (pct)	--	--	--	--	--	--	--	--	--
Mn (pct)	--	--	--	--	--	--	32.54	11.28	37
Fe (pct)	49.61	10.28	168	--	--	--	--	--	--
Co (pct)	--	--	--	--	--	--	--	--	--
Ni (pct)	--	--	--	--	--	--	--	--	--
Cu (pct)	--	--	--	-.6327	.5121	35	-.0546	.2839	4
Mo (pct)	--	--	--	--	--	--	--	--	--
WO_3 (pct)	--	--	--	--	--	--	--	--	--
Pd (ppb)	--	--	--	--	--	--	--	--	--
Pt (ppb)	--	--	--	--	--	--	--	--	--
Rh (ppb)	--	--	--	--	--	--	--	--	--
Ir (ppb)	--	--	--	--	--	--	--	--	--
Ru (ppb)	--	--	--	--	--	--	--	--	--
Os (ppb)	--	--	--	--	--	--	--	--	--
Ag (g/t)	--	--	--	2.286	.4599	45	--	--	--
Au (g/t)	--	--	--	-.1462	.7319	35	--	--	--
Zn (pct)	--	--	--	.5937	.5361	51	--	--	--
Hg (pct)	--	--	--	--	--	--	--	--	--
Sn (pct)	--	--	--	--	--	--	--	--	--
Pb (pct)	--	--	--	.7041	.4749	52	--	--	--
Sb (pct)	--	--	--	--	--	--	--	--	--

Deposit type	Porphyry Cu-Au			Porphyry Cu-Mo			Porphyry Mo, low-F		
	Mean	S.D.	Number of deposits	Mean	S.D.	Number of deposits	Mean	S.D.	Number of deposits
Tonnage (metric)	8.005	0.4746	40	8.706	0.4831	16	7.974	0.6053	33
RE_2O_5 (pct)	--	--	--	--	--	--	--	--	--
Monazite (pct REO)	--	--	--	--	--	--	--	--	--
U_3O_8 (pct)	--	--	--	--	--	--	--	--	--
Zircon (pct ZrO_2)	--	--	--	--	--	--	--	--	--
Nb_2O_5 (pct)	--	--	--	--	--	--	--	--	--
Fiber (pct)	--	--	--	--	--	--	--	--	--
Barite (pct)	--	--	--	--	--	--	--	--	--
Al_2O_3 (pct)	--	--	--	--	--	--	--	--	--
P (pct)	--	--	--	--	--	--	--	--	--
P_2O_5 (pct)	--	--	--	--	--	--	--	--	--
Ilmenite (pct TiO_2) ...	--	--	--	--	--	--	--	--	--
Rutile (pct TiO_2)	--	--	--	--	--	--	--	--	--
Leucocite (pct TiO_2) ..	--	--	--	--	--	--	--	--	--
Cr_2O_3 (pct)	--	--	--	--	--	--	--	--	--
Mn (pct)	--	--	--	--	--	--	--	--	--
Fe (pct)	--	--	--	--	--	--	--	--	--
Co (pct)	--	--	--	--	--	--	--	--	--
Ni (pct)	--	--	--	--	--	--	--	--	--
Cu (pct)	-.2968	.1205	40	-.3777	.1679	16	--	--	--
Mo (pct)	-2.516	.3681	20	-1.802	.2683	16	-1.070	.1459	33
WO_3 (pct)	--	--	--	--	--	--	--	--	--
Pd (ppb)	--	--	--	--	--	--	--	--	--
Pt (ppb)	--	--	--	--	--	--	--	--	--
Rh (ppb)	--	--	--	--	--	--	--	--	--
Ir (ppb)	--	--	--	--	--	--	--	--	--
Ru (ppb)	--	--	--	--	--	--	--	--	--
Os (ppb)	--	--	--	--	--	--	--	--	--
Ag (g/t)	.2012	.3720	27	.0852	.4162	16	--	--	--
Au (g/t)	-.4178	.2138	40	-1.908	.4189	16	--	--	--
Zn (pct)	--	--	--	--	--	--	--	--	--
Hg (pct)	--	--	--	--	--	--	--	--	--
Sn (pct)	--	--	--	--	--	--	--	--	--
Pb (pct)	--	--	--	--	--	--	--	--	--
Sb (pct)	--	--	--	--	--	--	--	--	--

Deposit type	Polymetallic vein Mean	Polymetallic vein S.D.	Polymetallic vein Number of deposits	Cyprus massive sulfide Mean	Cyprus massive sulfide S.D.	Cyprus massive sulfide Number of deposits	Besshi massive sulfide Mean	Besshi massive sulfide S.D.	Besshi massive sulfide Number of deposits
Tonnage (metric)	3.880	1.109	75	6.105	0.8765	49	5.339	0.9701	44
RE_2O_5 (pct)	--	--	--	--	--	--	--	--	--
Monazite (pct REO)	--	--	--	--	--	--	--	--	--
U_3O_8 (pct)	--	--	--	--	--	--	--	--	--
Zircon (pct ZrO_2)	--	--	--	--	--	--	--	--	--
Nb_2O_5 (pct)	--	--	--	--	--	--	--	--	--
Fiber (pct)	--	--	--	--	--	--	--	--	--
Barite (pct)	--	--	--	--	--	--	--	--	--
Al_2O_3 (pct)	--	--	--	--	--	--	--	--	--
P (pct)	--	--	--	--	--	--	--	--	--
P_2O_5 (pct)	--	--	--	--	--	--	--	--	--
Ilmenite (pct TiO_2)	--	--	--	--	--	--	--	--	--
Rutile (pct TiO_2)	--	--	--	--	--	--	--	--	--
Leucocite (pct TiO_2)	--	--	--	--	--	--	--	--	--
Cr_2O_3 (pct)	--	--	--	--	--	--	--	--	--
Mn (pct)	--	--	--	--	--	--	--	--	--
Fe (pct)	--	--	--	--	--	--	--	--	--
Co (pct)	--	--	--	--	--	--	--	--	--
Ni (pct)	--	--	--	--	--	--	--	--	--
Cu (pct)	-.7169	.8378	33	.2040	.3068	49	.1633	.2798	44
Mo (pct)	--	--	--	--	--	--	--	--	--
WO_3 (pct)	--	--	--	--	--	--	--	--	--
Pd (ppb)	--	--	--	--	--	--	--	--	--
Pt (ppb)	--	--	--	--	--	--	--	--	--
Rh (ppb)	--	--	--	--	--	--	--	--	--
Ir (ppb)	--	--	--	--	--	--	--	--	--
Ru (ppb)	--	--	--	--	--	--	--	--	--
Os (ppb)	--	--	--	--	--	--	--	--	--
Ag (g/t)	2.938	.5935	74	1.109	.6457	15	.8956	.3838	14
Au (g/t)	-.2088	1.166	54	-.0417	.6893	15	-.4650	.4697	14
Zn (pct)	.4439	.3718	60	-.1021	.7085	16	-.2506	.2755	6
Hg (pct)	--	--	--	--	--	--	--	--	--
Sn (pct)	--	--	--	--	--	--	--	--	--
Pb (pct)	.9529	.4426	75	-1.333	.5774	3	--	--	--
Sb (pct)	--	--	--	--	--	--	--	--	--

Deposit type	Volcanogenic Mn Mean	Volcanogenic Mn S.D.	Volcanogenic Mn Number of deposits	Creede epithermal vein Mean	Creede epithermal vein S.D.	Creede epithermal vein Number of deposits	Comstock epithermal vein Mean	Comstock epithermal vein S.D.	Comstock epithermal vein Number of deposits
Tonnage (metric)	4.674	0.9607	93	6.151	0.9382	27	5.884	0.8379	41
RE_2O_5 (pct)	--	--	--	--	--	--	--	--	--
Monazite (pct REO)	--	--	--	--	--	--	--	--	--
U_3O_8 (pct)	--	--	--	--	--	--	--	--	--
Zircon (pct ZrO_2)	--	--	--	--	--	--	--	--	--
Nb_2O_5 (pct)	--	--	--	--	--	--	--	--	--
Fiber (pct)	--	--	--	--	--	--	--	--	--
Barite (pct)	--	--	--	--	--	--	--	--	--
Al_2O_3 (pct)	--	--	--	--	--	--	--	--	--
P (pct)	-1.055	.5115	8	--	--	--	--	--	--
P_2O_5 (pct)	--	--	--	--	--	--	--	--	--
Ilmenite (pct TiO_2)	--	--	--	--	--	--	--	--	--
Rutile (pct TiO_2)	--	--	--	--	--	--	--	--	--
Leucocite (pct TiO_2)	--	--	--	--	--	--	--	--	--
Cr_2O_3 (pct)	--	--	--	--	--	--	--	--	--
Mn (pct)	38.80	9.723	93	--	--	--	--	--	--
Fe (pct)	--	--	--	--	--	--	--	--	--
Co (pct)	--	--	--	--	--	--	--	--	--
Ni (pct)	--	--	--	--	--	--	--	--	--
Cu (pct)	--	--	--	.5254	.4843	19	-1.816	.7955	18
Mo (pct)	--	--	--	--	--	--	--	--	--
WO_3 (pct)	--	--	--	--	--	--	--	--	--
Pd (ppb)	--	--	--	--	--	--	--	--	--
Pt (ppb)	--	--	--	--	--	--	--	--	--
Rh (ppb)	--	--	--	--	--	--	--	--	--
Ir (ppb)	--	--	--	--	--	--	--	--	--
Ru (ppb)	--	--	--	--	--	--	--	--	--
Os (ppb)	--	--	--	--	--	--	--	--	--
Ag (g/t)	--	--	--	2.099	.4766	27	2.060	.8156	41
Au (g/t)	--	--	--	.3265	.5874	23	.8726	.4410	41
Zn (pct)	--	--	--	.2744	.5545	26	-1.594	1.702	3
Hg (pct)	--	--	--	--	--	--	--	--	--
Sn (pct)	--	--	--	--	--	--	--	--	--
Pb (pct)	--	--	--	.4057	.2740	24	-1.870	.9817	19
Sb (pct)	--	--	--	--	--	--	--	--	--

Appendix B. Summary statistics of grade-tonnage models--Continued

Deposit type	Sado epithermal vein Mean	Sado epithermal vein S.D.	Sado epithermal vein Number of deposits	Epithermal quartz-alunite Au Mean	Epithermal quartz-alunite Au S.D.	Epithermal quartz-alunite Au Number of deposits	Volcanogenic U Mean	Volcanogenic U S.D.	Volcanogenic U Number of deposits
Tonnage (metric)	5.472	0.7876	20	6.199	0.6663	8	5.535	0.9451	21
RE_2O_5 (pct)	--	--	--	--	--	--	--	--	--
Monazite (pct REO)	--	--	--	--	--	--	--	--	--
U_3O_8 (pct)	--	--	--	--	--	--	-.9353	.2656	21
Zircon (pct ZrO_2)	--	--	--	--	--	--	--	--	--
Nb_2O_5 (pct)	--	--	--	--	--	--	--	--	--
Fiber (pct)	--	--	--	--	--	--	--	--	--
Barite (pct)	--	--	--	--	--	--	--	--	--
Al_2O_3 (pct)	--	--	--	--	--	--	--	--	--
P (pct)	--	--	--	--	--	--	--	--	--
P_2O_5 (pct)	--	--	--	--	--	--	--	--	--
Ilmenite (pct TiO_2) ...	--	--	--	--	--	--	--	--	--
Rutile (pct TiO_2)	--	--	--	--	--	--	--	--	--
Leucocite (pct TiO_2) ..	--	--	--	--	--	--	--	--	--
Cr_2O_3 (pct)	--	--	--	--	--	--	--	--	--
Mn (pct)	--	--	--	--	--	--	--	--	--
Fe (pct)	--	--	--	--	--	--	--	--	--
Co (pct)	--	--	--	--	--	--	--	--	--
Ni (pct)	--	--	--	--	--	--	--	--	--
Cu (pct)	-.7200	1.153	9	-.6255	1.045	5	--	--	--
Mo (pct)	--	--	--	--	--	--	--	--	--
WO_3 (pct)	--	--	--	--	--	--	--	--	--
Pd (ppb)	--	--	--	--	--	--	--	--	--
Pt (ppb)	--	--	--	--	--	--	--	--	--
Rh (ppb)	--	--	--	--	--	--	--	--	--
Ir (ppb)	--	--	--	--	--	--	--	--	--
Ru (ppb)	--	--	--	--	--	--	--	--	--
Os (ppb)	--	--	--	--	--	--	--	--	--
Ag (g/t)	1.579	.6647	20	1.251	.6788	8	--	--	--
Au (g/t)	.8363	.4007	18	.8927	.2341	8	--	--	--
Zn (pct)	-.602	--	1	--	--	--	--	--	--
Hg (pct)	--	--	--	--	--	--	--	--	--
Sn (pct)	--	--	--	--	--	--	--	--	--
Pb (pct)	-2.372	.2129	2	--	--	--	--	--	--
Sb (pct)	--	--	--	--	--	--	--	--	--

Deposit type	Epithermal Mn Mean	Epithermal Mn S.D.	Epithermal Mn Number of deposits	Rhyolite-hosted Sn Mean	Rhyolite-hosted Sn S.D.	Rhyolite-hosted Sn Number of deposits	Volcanic-hosted magnetite Mean	Volcanic-hosted magnetite S.D.	Volcanic-hosted magnetite Number of deposits
Tonnage (metric)	4.372	0.8246	59	2.992	0.4937	132	7.602	0.8222	39
RE_2O_5 (pct)	--	--	--	--	--	--	--	--	--
Monazite (pct REO)	--	--	--	--	--	--	--	--	--
U_3O_8 (pct)	--	--	--	--	--	--	--	--	--
Zircon (pct ZrO_2)	--	--	--	--	--	--	--	--	--
Nb_2O_5 (pct)	--	--	--	--	--	--	--	--	--
Fiber (pct)	--	--	--	--	--	--	--	--	--
Barite (pct)	--	--	--	--	--	--	--	--	--
Al_2O_3 (pct)	--	--	--	--	--	--	--	--	--
P (pct)	--	--	--	--	--	--	-0.3979	.2874	36
P_2O_5 (pct)	--	--	--	--	--	--	--	--	--
Ilmenite (pct TiO_2) ...	--	--	--	--	--	--	--	--	--
Rutile (pct TiO_2)	--	--	--	--	--	--	--	--	--
Leucocite (pct TiO_2) ..	--	--	--	--	--	--	--	--	--
Cr_2O_3 (pct)	--	--	--	--	--	--	--	--	--
Mn (pct)	30.59	8.538	59	--	--	--	--	--	--
Fe (pct)	--	--	--	--	--	--	53.72	11.08	39
Co (pct)	--	--	--	--	--	--	--	--	--
Ni (pct)	--	--	--	--	--	--	--	--	--
Cu (pct)	--	--	--	--	--	--	--	--	--
Mo (pct)	--	--	--	--	--	--	--	--	--
WO_3 (pct)	--	--	--	--	--	--	--	--	--
Pd (ppb)	--	--	--	--	--	--	--	--	--
Pt (ppb)	--	--	--	--	--	--	--	--	--
Rh (ppb)	--	--	--	--	--	--	--	--	--
Ir (ppb)	--	--	--	--	--	--	--	--	--
Ru (ppb)	--	--	--	--	--	--	--	--	--
Os (ppb)	--	--	--	--	--	--	--	--	--
Ag (g/t)	--	--	--	--	--	--	--	--	--
Au (g/t)	--	--	--	--	--	--	--	--	--
Zn (pct)	--	--	--	--	--	--	--	--	--
Hg (pct)	--	--	--	--	--	--	--	--	--
Sn (pct)	--	--	--	-.4130	.3352	132	--	--	--
Pb (pct)	--	--	--	--	--	--	--	--	--
Sb (pct)	--	--	--	--	--	--	--	--	--

Appendix B. Summary statistics of grade-tonnage models--Continued

Deposit type	Carbonate-hosted Au-Ag			Hot-spring Hg			Silica-carbonate Hg		
	Mean	S.D.	Number of deposits	Mean	S.D.	Number of deposits	Mean	S.D.	Number of deposits
Tonnage (metric)	6.706	0.5202	35	3.978	1.312	20	4.448	1.038	28
RE_2O_5 (pct)	--	--	--	--	--	--	--	--	--
Monazite (pct REO)	--	--	--	--	--	--	--	--	--
U_3O_8 (pct)	--	--	--	--	--	--	--	--	--
Zircon (pct ZrO_2)	--	--	--	--	--	--	--	--	--
Nb_2O_5 (pct)	--	--	--	--	--	--	--	--	--
Fiber (pct)	--	--	--	--	--	--	--	--	--
Barite (pct)	--	--	--	--	--	--	--	--	--
Al_2O_3 (pct)	--	--	--	--	--	--	--	--	--
P (pct)	--	--	--	--	--	--	--	--	--
P_2O_5 (pct)	--	--	--	--	--	--	--	--	--
Ilmenite (pct TiO_2) ...	--	--	--	--	--	--	--	--	--
Rutile (pct TiO_2)	--	--	--	--	--	--	--	--	--
Leucocite (pct TiO_2) ..	--	--	--	--	--	--	--	--	--
Cr_2O_3 (pct)	--	--	--	--	--	--	--	--	--
Mn (pct)	--	--	--	--	--	--	--	--	--
Fe (pct)	--	--	--	--	--	--	--	--	--
Co (pct)	--	--	--	--	--	--	--	--	--
Ni (pct)	--	--	--	--	--	--	--	--	--
Cu (pct)	--	--	--	--	--	--	--	--	--
Mo (pct)	--	--	--	--	--	--	--	--	--
WO_3 (pct)	--	--	--	--	--	--	--	--	--
Pd (ppb)	--	--	--	--	--	--	--	--	--
Pt (ppb)	--	--	--	--	--	--	--	--	--
Rh (ppb)	--	--	--	--	--	--	--	--	--
Ir (ppb)	--	--	--	--	--	--	--	--	--
Ru (ppb)	--	--	--	--	--	--	--	--	--
Os (ppb)	--	--	--	--	--	--	--	--	--
Ag (g/t)	1.340	.7148	5	--	--	--	--	--	--
Au (g/t)	.4106	.3914	34	--	--	--	--	--	--
Zn (pct)	--	--	--	--	--	--	--	--	--
Hg (pct)	--	--	--	-.4622	.2002	20	-.4070	.1738	28
Sn (pct)	--	--	--	--	--	--	--	--	--
Pb (pct)	--	--	--	--	--	--	--	--	--
Sb (pct)	--	--	--	--	--	--	--	--	--

Deposit type	Sb veins			Disseminated Sb			Kuroko massive sulfide		
	Mean	S.D.	Number of deposits	Mean	S.D.	Number of deposits	Mean	S.D.	Number of deposits
Tonnage (metric)	2.256	1.117	81	4.943	0.8211	23	6.175	0.8495	432
RE_2O_5 (pct)	--	--	--	--	--	--	--	--	--
Monazite (pct REO)	--	--	--	--	--	--	--	--	--
U_3O_8 (pct)	--	--	--	--	--	--	--	--	--
Zircon (pct ZrO_2)	--	--	--	--	--	--	--	--	--
Nb_2O_5 (pct)	--	--	--	--	--	--	--	--	--
Fiber (pct)	--	--	--	--	--	--	--	--	--
Barite (pct)	--	--	--	--	--	--	--	--	--
Al_2O_3 (pct)	--	--	--	--	--	--	--	--	--
P (pct)	--	--	--	--	--	--	--	--	--
P_2O_5 (pct)	--	--	--	--	--	--	--	--	--
Ilmenite (pct TiO_2) ...	--	--	--	--	--	--	--	--	--
Rutile (pct TiO_2)	--	--	--	--	--	--	--	--	--
Leucocite (pct TiO_2) ..	--	--	--	--	--	--	--	--	--
Cr_2O_3 (pct)	--	--	--	--	--	--	--	--	--
Mn (pct)	--	--	--	--	--	--	--	--	--
Fe (pct)	--	--	--	--	--	--	--	--	--
Co (pct)	--	--	--	--	--	--	--	--	--
Ni (pct)	--	--	--	--	--	--	--	--	--
Cu (pct)	--	--	--	--	--	--	.0999	.3493	432
Mo (pct)	--	--	--	--	--	--	--	--	--
WO_3 (pct)	--	--	--	--	--	--	--	--	--
Pd (ppb)	--	--	--	--	--	--	--	--	--
Pt (ppb)	--	--	--	--	--	--	--	--	--
Rh (ppb)	--	--	--	--	--	--	--	--	--
Ir (ppb)	--	--	--	--	--	--	--	--	--
Ru (ppb)	--	--	--	--	--	--	--	--	--
Os (ppb)	--	--	--	--	--	--	--	--	--
Ag (g/t)	1.561	.2851	8	.0792	--	1	1.459	.5133	284
Au (g/t)	.7111	.6872	9	-.5278	1.172	2	-.1080	.5281	238
Zn (pct)	--	--	--	--	--	--	.4482	.4626	330
Hg (pct)	--	--	--	--	--	--	--	--	--
Sn (pct)	--	--	--	--	--	--	--	--	--
Pb (pct)	--	--	--	--	--	--	-.1269	.5506	184
Sb (pct)	1.540	.2200	81	.5505	.2308	23	--	--	--

Deposit type	Algoma Fe and Superior Fe Mean	S.D.	Number of deposits	Sandstone-hosted Pb-Zn Mean	S.D.	Number of deposits	Sediment-hosted Cu Mean	S.D.	Number of deposits
Tonnage (metric)	8.218	0.9105	66	6.729	0.8268	20	7.341	0.9186	57
RE_2O_5 (pct)	--	--	--	--	--	--	--	--	--
Monazite (pct REO)	--	--	--	--	--	--	--	--	--
U_3O_8 (pct)	--	--	--	--	--	--	--	--	--
Zircon (pct ZrO_2)	--	--	--	--	--	--	--	--	--
Nb_2O_5 (pct)	--	--	--	--	--	--	--	--	--
Fiber (pct)	--	--	--	--	--	--	--	--	--
Barite (pct)	--	--	--	--	--	--	--	--	--
Al_2O_3 (pct)	--	--	--	--	--	--	--	--	--
P (pct)	-1.256	.4853	47	--	--	--	--	--	--
P_2O_5 (pct)	--	--	--	--	--	--	--	--	--
Ilmenite (pct TiO_2)	--	--	--	--	--	--	--	--	--
Rutile (pct TiO_2)	--	--	--	--	--	--	--	--	--
Leucocite (pct TiO_2)	--	--	--	--	--	--	--	--	--
Cr_2O_3 (pct)	--	--	--	--	--	--	--	--	--
Mn (pct)	--	--	--	--	--	--	--	--	--
Fe (pct)	50.83	13.65	66	--	--	--	--	--	--
Co (pct)	--	--	--	--	--	--	-.6226	.1919	10
Ni (pct)	--	--	--	--	--	--	--	--	--
Cu (pct)	--	--	--	--	--	--	.3317	.2540	57
Mo (pct)	--	--	--	--	--	--	--	--	--
WO_3 (pct)	--	--	--	--	--	--	--	--	--
Pd (ppb)	--	--	--	--	--	--	--	--	--
Pt (ppb)	--	--	--	--	--	--	--	--	--
Rh (ppb)	--	--	--	--	--	--	--	--	--
Ir (ppb)	--	--	--	--	--	--	--	--	--
Ru (ppb)	--	--	--	--	--	--	--	--	--
Os (ppb)	--	--	--	--	--	--	--	--	--
Ag (g/t)	--	--	--	1.050	.5824	9	1.208	.7646	12
Au (g/t)	--	--	--	--	--	--	--	--	--
Zn (pct)	--	--	--	-.2320	.6769	14	--	--	--
Hg (pct)	--	--	--	--	--	--	--	--	--
Sn (pct)	--	--	--	--	--	--	--	--	--
Pb (pct)	--	--	--	.3332	.3011	20	--	--	--
Sb (pct)	--	--	--	--	--	--	--	--	--

Deposit type	Sedimentary exhalative Zn-Pb Mean	S.D.	Number of deposits	Bedded barite Mean	S.D.	Number of deposits	Southeast Missouri Pb-Zn and Appalachian Zn Mean	S.D.	Number of deposits
Tonnage (metric)	7.167	0.7315	45	6.259	0.9271	25	7.542	0.9299	20
RE_2O_5 (pct)	--	--	--	--	--	--	--	--	--
Monazite (pct REO)	--	--	--	--	--	--	--	--	--
U_3O_8 (pct)	--	--	--	--	--	--	--	--	--
Zircon (pct ZrO_2)	--	--	--	--	--	--	--	--	--
Nb_2O_5 (pct)	--	--	--	--	--	--	--	--	--
Fiber (pct)	--	--	--	--	--	--	--	--	--
Barite (pct)	--	--	--	83.02	13.00	25	--	--	--
Al_2O_3 (pct)	--	--	--	--	--	--	--	--	--
P (pct)	--	--	--	--	--	--	--	--	--
P_2O_5 (pct)	--	--	--	--	--	--	--	--	--
Ilmenite (pct TiO_2)	--	--	--	--	--	--	--	--	--
Rutile (pct TiO_2)	--	--	--	--	--	--	--	--	--
Leucocite (pct TiO_2)	--	--	--	--	--	--	--	--	--
Cr_2O_3 (pct)	--	--	--	--	--	--	--	--	--
Mn (pct)	--	--	--	--	--	--	--	--	--
Fe (pct)	--	--	--	--	--	--	--	--	--
Co (pct)	--	--	--	--	--	--	--	--	--
Ni (pct)	--	--	--	--	--	--	--	--	--
Cu (pct)	-.7273	.4797	11	--	--	--	--	--	--
Mo (pct)	--	--	--	--	--	--	--	--	--
WO_3 (pct)	--	--	--	--	--	--	--	--	--
Pd (ppb)	--	--	--	--	--	--	--	--	--
Pt (ppb)	--	--	--	--	--	--	--	--	--
Rh (ppb)	--	--	--	--	--	--	--	--	--
Ir (ppb)	--	--	--	--	--	--	--	--	--
Ru (ppb)	--	--	--	--	--	--	--	--	--
Os (ppb)	--	--	--	--	--	--	--	--	--
Ag (g/t)	1.6367	.4705	37	--	--	--	.6693	.6917	10
Au (g/t)	--	--	--	--	--	--	--	--	--
Zn (pct)	.7519	.2908	45	--	--	--	.6079	.3623	20
Hg (pct)	--	--	--	--	--	--	--	--	--
Sn (pct)	--	--	--	--	--	--	--	--	--
Pb (pct)	.4443	.3443	45	--	--	--	.0893	.4068	16
Sb (pct)	--	--	--	--	--	--	--	--	--

Deposit type	Sedimentary Mn Mean	Sedimentary Mn S.D.	Sedimentary Mn Number of deposits	Phosphate, upwelling Mean	Phosphate, upwelling S.D.	Phosphate, upwelling Number of deposits	Phosphate, warm current Mean	Phosphate, warm current S.D.	Phosphate, warm current Number of deposits
Tonnage (metric)	6.862	1.240	39	8.520	0.8611	60	8.603	0.7360	18
RE_2O_5 (pct)	--	--	--	--	--	--	--	--	--
Monazite (pct REO)	--	--	--	--	--	--	--	--	--
U_3O_8 (pct)	--	--	--	--	--	--	--	--	--
Zircon (pct ZrO_2)	--	--	--	--	--	--	--	--	--
Nb_2O_5 (pct)	--	--	--	--	--	--	--	--	--
Fiber (pct)	--	--	--	--	--	--	--	--	--
Barite (pct)	--	--	--	--	--	--	--	--	--
Al_2O_3 (pct)	--	--	--	--	--	--	--	--	--
P (pct)	-.9034	.3273	13	--	--	--	--	--	--
P_2O_5 (pct)	--	--	--	23.96	6.604	60	24.16	3.402	18
Ilmenite (pct TiO_2)	--	--	--	--	--	--	--	--	--
Rutile (pct TiO_2)	--	--	--	--	--	--	--	--	--
Leucocite (pct TiO_2)	--	--	--	--	--	--	--	--	--
Cr_2O_3 (pct)	--	--	--	--	--	--	--	--	--
Mn (pct)	31.38	13.05	39	--	--	--	--	--	--
Fe (pct)	--	--	--	--	--	--	--	--	--
Co (pct)	--	--	--	--	--	--	--	--	--
Ni (pct)	--	--	--	--	--	--	--	--	--
Cu (pct)	--	--	--	--	--	--	--	--	--
Mo (pct)	--	--	--	--	--	--	--	--	--
WO_3 (pct)	--	--	--	--	--	--	--	--	--
Pd (ppb)	--	--	--	--	--	--	--	--	--
Pt (ppb)	--	--	--	--	--	--	--	--	--
Rh (ppb)	--	--	--	--	--	--	--	--	--
Ir (ppb)	--	--	--	--	--	--	--	--	--
Ru (ppb)	--	--	--	--	--	--	--	--	--
Os (ppb)	--	--	--	--	--	--	--	--	--
Ag (g/t)	--	--	--	--	--	--	--	--	--
Au (g/t)	--	--	--	--	--	--	--	--	--
Zn (pct)	--	--	--	--	--	--	--	--	--
Hg (pct)	--	--	--	--	--	--	--	--	--
Sn (pct)	--	--	--	--	--	--	--	--	--
Pb (pct)	--	--	--	--	--	--	--	--	--
Sb (pct)	--	--	--	--	--	--	--	--	--

Deposit type	Low-sulfide Au-quartz veins Mean	Low-sulfide Au-quartz veins S.D.	Low-sulfide Au-quartz veins Number of deposits	Homestake Au Mean	Homestake Au S.D.	Homestake Au Number of deposits	Unconformity U-Au Mean	Unconformity U-Au S.D.	Unconformity U-Au Number of deposits
Tonnage (metric)	4.470	1.163	313	5.974	0.8592	116	5.356	1.274	36
RE_2O_5 (pct)	--	--	--	--	--	--	--	--	--
Monazite (pct REO)	--	--	--	--	--	--	--	--	--
U_3O_8 (pct)	--	--	--	--	--	--	-.2816	.4167	36
Zircon (pct ZrO_2)	--	--	--	--	--	--	--	--	--
Nb_2O_5 (pct)	--	--	--	--	--	--	--	--	--
Fiber (pct)	--	--	--	--	--	--	--	--	--
Barite (pct)	--	--	--	--	--	--	--	--	--
Al_2O_3 (pct)	--	--	--	--	--	--	--	--	--
P (pct)	--	--	--	--	--	--	--	--	--
P_2O_5 (pct)	--	--	--	--	--	--	--	--	--
Ilmenite (pct TiO_2)	--	--	--	--	--	--	--	--	--
Rutile (pct TiO_2)	--	--	--	--	--	--	--	--	--
Leucocite (pct TiO_2)	--	--	--	--	--	--	--	--	--
Cr_2O_3 (pct)	--	--	--	--	--	--	--	--	--
Mn (pct)	--	--	--	--	--	--	--	--	--
Fe (pct)	--	--	--	--	--	--	--	--	--
Co (pct)	--	--	--	--	--	--	--	--	--
Ni (pct)	--	--	--	--	--	--	--	--	--
Cu (pct)	--	--	--	--	--	--	--	--	--
Mo (pct)	--	--	--	--	--	--	--	--	--
WO_3 (pct)	--	--	--	--	--	--	--	--	--
Pd (ppb)	--	--	--	--	--	--	--	--	--
Pt (ppb)	--	--	--	--	--	--	--	--	--
Rh (ppb)	--	--	--	--	--	--	--	--	--
Ir (ppb)	--	--	--	--	--	--	--	--	--
Ru (ppb)	--	--	--	--	--	--	--	--	--
Os (ppb)	--	--	--	--	--	--	--	--	--
Ag (g/t)	.6961	.3563	39	.2093	.5234	52	--	--	--
Au (g/t)	1.203	.3327	313	.9647	.2518	116	--	--	--
Zn (pct)	--	--	--	--	--	--	--	--	--
Hg (pct)	--	--	--	--	--	--	--	--	--
Sn (pct)	--	--	--	--	--	--	--	--	--
Pb (pct)	--	--	--	--	--	--	--	--	--
Sb (pct)	--	--	--	--	--	--	--	--	--

Deposit type	Lateritic Ni			Laterite bauxite			Karst bauxite		
	Mean	S.D.	Number of deposits	Mean	S.D.	Number of deposits	Mean	S.D.	Number of deposits
Tonnage (metric)	7.645	0.5864	71	7.401	1.142	122	7.366	0.6811	41
RE_2O_5 (pct)	--	--	--	--	--	--	--	--	--
Monazite (pct REO)	--	--	--	--	--	--	--	--	--
U_3O_8 (pct)	--	--	--	--	--	--	--	--	--
Zircon (pct ZrO_2)	--	--	--	--	--	--	--	--	--
Nb_2O_5 (pct)	--	--	--	--	--	--	--	--	--
Fiber (pct)	--	--	--	--	--	--	--	--	--
Barite (pct)	--	--	--	--	--	--	--	--	--
Al_2O_3 (pct)	--	--	--	44.97	7.747	122	49.18	7.930	41
P (pct)	--	--	--	--	--	--	--	--	--
P_2O_5 (pct)	--	--	--	--	--	--	--	--	--
Ilmenite (pct TiO_2) ...	--	--	--	--	--	--	--	--	--
Rutile (pct TiO_2).....	--	--	--	--	--	--	--	--	--
Leucocite (pct TiO_2) ..	--	--	--	--	--	--	--	--	--
Cr_2O_3 (pct)	--	--	--	--	--	--	--	--	--
Mn (pct)	--	--	--	--	--	--	--	--	--
Fe (pct)	--	--	--	--	--	--	--	--	--
Co (pct)	-1.159	.1665	12	--	--	--	--	--	--
Ni (pct)	.1346	.1043	71	--	--	--	--	--	--
Cu (pct)	--	--	--	--	--	--	--	--	--
Mo (pct)	--	--	--	--	--	--	--	--	--
WO_3 (pct)	--	--	--	--	--	--	--	--	--
Pd (ppb)	--	--	--	--	--	--	--	--	--
Pt (ppb)	--	--	--	--	--	--	--	--	--
Rh (ppb)	--	--	--	--	--	--	--	--	--
Ir (ppb)	--	--	--	--	--	--	--	--	--
Ru (ppb)	--	--	--	--	--	--	--	--	--
Os (ppb)	--	--	--	--	--	--	--	--	--
Ag (g/t)	--	--	--	--	--	--	--	--	--
Au (g/t)	--	--	--	--	--	--	--	--	--
Zn (pct)	--	--	--	--	--	--	--	--	--
Hg (pct)	--	--	--	--	--	--	--	--	--
Sn (pct)	--	--	--	--	--	--	--	--	--
Pb (pct)	--	--	--	--	--	--	--	--	--
Sb (pct)	--	--	--	--	--	--	--	--	--

Deposit type	Placer Au-PGE			Placer PGE-Au			Shoreline placer Ti		
	Mean	S.D.	Number of deposits	Mean	S.D.	Number of deposits	Mean	S.D.	Number of deposits
Tonnage (metric)	6.030	1.312	65	5.112	0.8548	83	7.942	0.7014	61
RE_2O_5 (pct)	--	--	--	--	--	--	--	--	--
Monazite (pct REO)	--	--	--	--	--	--	-1.5262	.8190	29
U_3O_8 (pct)	--	--	--	--	--	--	--	--	--
Zircon (pct ZrO_2)	--	--	--	--	--	--	-.5703	.4221	52
Nb_2O_5 (pct)	--	--	--	--	--	--	--	--	--
Fiber (pct)	--	--	--	--	--	--	--	--	--
Barite (pct)	--	--	--	--	--	--	--	--	--
Al_2O_3 (pct)	--	--	--	--	--	--	--	--	--
P (pct)	--	--	--	--	--	--	--	--	--
P_2O_5 (pct)	--	--	--	--	--	--	--	--	--
Ilmenite (pct TiO_2) ...	--	--	--	--	--	--	.1026	.5755	61
Rutile (pct TiO_2).....	--	--	--	--	--	--	-.6723	.4220	50
Leucocite (pct TiO_2) ..	--	--	--	--	--	--	-.6469	.5439	24
Cr_2O_3 (pct)	--	--	--	--	--	--	--	--	--
Mn (pct)	--	--	--	--	--	--	--	--	--
Fe (pct)	--	--	--	--	--	--	--	--	--
Co (pct)	--	--	--	--	--	--	--	--	--
Ni (pct)	--	--	--	--	--	--	--	--	--
Cu (pct)	--	--	--	--	--	--	--	--	--
Mo (pct)	--	--	--	--	--	--	--	--	--
WO_3 (pct)	--	--	--	--	--	--	--	--	--
Pd (ppb)	--	--	--	-2.825	.9818	13	--	--	--
Pt (ppb)	--	--	--	.2010	.5701	83	--	--	--
Rh (ppb)	--	--	--	--	--	--	--	--	--
Ir (ppb)	--	--	--	-2.077	1.193	10	--	--	--
Ru (ppb)	--	--	--	--	--	--	--	--	--
Os (ppb)	--	--	--	-1.805	1.068	21	--	--	--
Ag (g/t)	-1.571	.3954	16	--	--	--	--	--	--
Au (g/t)	-.6983	.2928	65	-1.531	.8495	23	--	--	--
Zn (pct)	--	--	--	--	--	--	--	--	--
Hg (pct)	--	--	--	--	--	--	--	--	--
Sn (pct)	--	--	--	--	--	--	--	--	--
Pb (pct)	--	--	--	--	--	--	--	--	--
Sb (pct)	--	--	--	--	--	--	--	--	--

Appendix C. Commodity/Geochemical Index by Paul B. Barton

This file shows economic (or potentially economic) commodities as primary products or by-products; it also indicates geochemical anomalies. These represent the elements present anywhere in the deposit, not solely in haloes distinct from ore. The listing covers only those deposits for which models are present elsewhere in this compilation. Figure 206 is a graphical presentation of some of the information in the following table. It provides an overview of the distribution of the elements among deposit types.

In an effort to represent the commonness or rarity of features, numbers are assigned. Universally present products/anomalies rate a +5 (shown simply as "5") grading down through 0 to -5 (shown as "(-5)") in a system similar to PROSPECTOR. The "0" value will seldom, if ever, be shown as it is the "don't know" (or "don't care") default. Note that negative numbers for "Primary" or "By-product" are not used, although they might be applied to indicate serious deleterious elements, such as phosphorus in iron ores. In almost all instances at present, these values will be guesses based on experience, not hard data; however, we do urge the compilation of data to make such assignments possible eventually. It is our intent to have the "1", "2", "3", "4", and "5" scores correspond respectively to the 0-10, 10-30, 30-70, 70-90, and 90-100 percent frequency relationship between the element and the deposit type. Obviously such statistical approaches are meaningless for deposit types having few representatives, such as emerald veins (31c), but the value can still be useful as an estimate of the compiler's opinion regarding the probable generality of the observation. The abbreviated suffixes "(prox.)" and "(dist.)" indicate respectively proximal (or nearer source) and distal (or farther from the source). For more complex relations please refer back to the models.

Figure 206 shows only the presence of an element at some unspecified anomalous level, either proximally or distally with respect to the deposit. The elements are grouped in such a way that the distinction between those of granitic and mafic associations can be easily made. The elements of high mobility in hydrothermal environments form a distinct grouping on the right side of the matrix.

It should be obvious from examination of the table and figure below that the presence of a given element seldom, if ever, "proves" the existence of an ore deposit. Anomalous amounts of some elements such as copper, gold, iron, and zinc are so common in so many settings that their presence tells very little about the possible character of the host deposit. Their presence is encouraging, however, and indicates that additional studies may be warranted.

Element	Primary	By-product	Geochemical anomaly	Deposit type and model number
Ag			3	Sn skarn (14b)
		3	4(dist.)	porphyry Cu (17)
		3	5	porphyry Cu, skarn-related (18a)
		4	5	Cu skarn (18b)
		4	5	Zn-Pb skarn (18c)
		5(dist.)	4	polymetallic replacement (19a)
			4	replacement Mn (19b)
			4(dist.)	porphyry Sn (20a)
	3	3	5	Sn-polymetallic veins (20b)
		4	5(prox.)	porphyry Cu-Au (20c)
		4	5(dist.)	porphyry Cu-Mo (21a)
			5(dist.)	porphyry Mo, low-F (21b)
	3	5	5	volcanic-hosted Cu-As-Sb (22a)
	2	5	5	Au-Ag-Te veins (22b)
	4	2	5	polymetallic veins (22c)
		3	4	basaltic Cu (23)
		3	4	Cyprus massive sulfide (24a)
		3	5	Besshi massive sulfide (24b)
		2	3	Blackbird Co-Cu (24d)
	3	4	5(prox.)	hot-spring Au-Ag (25a)

Model Number	Deposit Type	Li	Na	K	Rb	Cs	Be	B	REE	U	Th	Zr	Nb	Ta	Mg	Ca	Sr	Ba	Al	Ga	P	Ti	V	Cr	Mn	Fe
"1"	Stillwater Ni-Cu														•											
"2a"	Bushveld Cr														•									•		
"2b"	Merensky Reef PGE														•							•		•		
"3"	Bushveld Fe-Ti-V														•							•	•			•
"5a"	Duluth Cu-Ni-PGE																					•				
"5b"	Noril'sk Cu-Ni-PGE																									
"6a"	Komatiitic Ni-Cu														•											
"6b"	Dunitic Ni-Cu														•											
"7a"	Synorogenic-Synvolcanic Ni-Cu																									
"7b"	Anorthosite Ti											•									•	•	•			•
"8a & 8b"	Podiform chromite														•									•		
"8c"	Limassol Forest Co-Ni																									
"8d"	Serpentine-hosted asbestos														•											
"9"	Alaskan Cr-Pt														•							•	•	•		•
"10"	Carbonatite	•					•	•	•	•	•	•	•	•		•	•	•			•	•			•	
"12"	Diamond pipes			•									•		•			•				•		•	•	
"14a"	W skarn				•		•																			
"14b"	Sn skarn	•			•	•	•	•	•	•	•		•	•												
"14c"	Replacement Sn	•			•			•																		
"15a"	W veins	•					•	•																		
"15b"	Sn veins	•			•	•	•	•	•	•	•		•	•												
"15c"	Sn greisen	•			•	•	•	•	•	•	•		•	•												
"16"	Climax Mo			•	•	•				o			•	•											o	
"17"	Porphyry Cu			•	o			•																	o	
"18a"	Porphyry Cu, skarn-related																								o	
"18b"	Cu skarn																								o	•
"18c"	Zn-Pb skarn						•																		•	
"18d"	Fe skarn																									•
"18e"	Carbonate-hosted asbestos														•											
"19a"	Polymetallic replacement																	•							o	
"19b"	Replacement Mn																								•	
"20a"	Porphyry Sn							•										o								
"20b"	Sn-polymetallic vein							•																		
"20c"	Porphyry Cu-Au																								o	
"21a"	Porphyry Cu-Mo			•	o			•																	o	
"21b"	Porphyry Mo, low-F			•	o																					
"22a"	Volcanic-hosted Cu-As-Sb							•											•		•					
"22b"	Au-Ag-Te veins																•	•								
"22c"	Polymetallic veins																	•								
"23"	Basaltic Cu																									
"24a"	Cyprus massive sulfide																								o	
"24b"	Besshi massive sulfide																									
"24c"	Volcanogenic Mn																	•							•	
"24d"	Blackbird Co-Cu							•																	•	•
"25a"	Hot-spring Au-Ag																									
"25b"	Creede epithermal vein																	•							•	
"25c"	Comstock epithermal vein																									
"25d"	Sado epithermal vein																									
"25e"	Epithermal quartz-alunite Au																		•							
"25f"	Volcanogenic U	o							•	•																
"25g"	Epithermal Mn																				•				•	
"25h"	Rhyolite-hosted Sn	•					•		•																	
"25i"	Volcanic-hosted magnetite																	•			•		•			•
"26a"	Carbonate-hosted Au-Ag																	•								
"27a"	Hot-spring Hg																									
"27b"	Almaden Hg																									
"27c"	Silica-carbonate Hg																									
"27d"	Sb veins																									
"28a"	Kuroko massive sulfide														•			•								•
"28b"	Algoma Fe																									•
"29a"	Quartz pebble conglomerate Au-U									•		•														
"29b"	Olympic Dam Cu-U-Au								•	•								•								•
"30a"	Sandstone-hosted Pb-Zn																	•								
"30b"	Sediment-hosted Cu									•													•			
"30c"	Sandstone U									•													•			
"31a"	Sedimentary exhalative Zn-Pb																	•							o	•
"31b"	Bedded barite																	•								
"31c"	Emerald vein	•	•				•		•						•											
"32a"	Southeast Missouri Pb-Zn														•			o								
"32b"	Appalachian Zn														•			•								
"32c"	Kipushi Cu-Pb-Zn									•					•					•			•			
"34a"	Superior Fe																								•	•
"34b"	Sedimentary manganese																								•	
"34c"	Phosphate, upwelling type								•	•											•					
"34d"	Phosphate, warm current type								•	•											•					
"36a"	Low sulfide Au-quartz vein																									
"36b"	Homestake Au							•																		
"37a"	Unconformity U-Au				•				•	•					•						•					
"37b"	Gold on flat faults																	•								•
"38a"	Lateritic Ni																							•		
"38b"	Bauxite, laterite type																		•	•						
"38c"	Bauxite, karst type																		•	•						
"39a"	Placer Au-PGE																									•
"39b"	Placer PGE-Au																							•		•
"39c"	Shoreline placer Ti								•	•	•	•										•				•
"39d"	Diamond placer												•		•			•						•	•	
"39e"	Alluvial placer Sn	•					•	•																		
		Li	Na	K	Rb	Cs	Be	B	REE	U	Th	Zr	Nb	Ta	Mg	Ca	Sr	Ba	Al	Ga	P	Ti	V	Cr	Mn	Fe

Figure 206. Matrix diagram showing deposit models and their geochemical signature. Closed and open circles indicate that the element is anomalous proximally or distally to the deposit respectively.

Model Number	Deposit Type	Co	Ni	Cu	Mo	W	Re	PGE	Ag	Au	Zn	Cd	Hg	Tl	Ge	Sn	Pb	As	Sb	Bi	Te	Se	S	F	Br	C	NH3
"1"	Stillwater Ni-Cu	•	•	•				•																			
"2a"	Bushveld Cr							•																			
"2b"	Merensky Reef PGE		•	•				•																			
"3"	Bushveld Fe-Ti-V																										
"5a"	Duluth Cu-Ni-PGE	•	•	•				•																			
"5b"	Noril'sk Cu-Ni-PGE	•	•	•				•																			
"6a"	Komatiitic Ni-Cu	•	•	•				•		•																	
"6b"	Dunitic Ni-Cu	•	•	•				•																			
"7a"	Synorogenic-Synvolcanic Ni-Cu	•	•	•				•																			
"7b"	Anorthosite Ti																										
"8a & 8b"	Podiform chromite							•																			
"8c"	Limassol Forest Co-Ni	•	•					•		•								•									
"8d"	Serpentine-hosted asbestos																										
"9"	Alaskan Cr-Pt		•	•				•										•									
"10"	Carbonatite			•	•	•											•							•			
"12"	Diamond pipes	•	•					•																		•	
"14a"	W skarn			•	•	•					•					•		•		•				•			
"14b"	Sn skarn			•		•			•		•					•	•							•			
"14c"	Replacement Sn			•		•					•					•	•	•						•			
"15a"	W veins			•	•	•					•					•	•	•		•				•			
"15b"	Sn veins					•										•		•						•			
"15c"	Sn greisen				•											•		•		•				•			
"16"	Climax Mo			o	•	•	•				o					•	o							•			
"17"	Porphyry Cu			•	•	•			•	•	o					o	o	o	o	o	o	o					
"18a"	Porphyry Cu, skarn-related			•	•	•			•	•	o						o	o	o								
"18b"	Cu skarn	•		•	•				•	•	o						o	o	o	•							
"18c"	Zn-Pb skarn	•		•		•			•	•	•					•	•	•		•				•			
"18d"	Fe skarn	•		•												•											
"18e"	Carbonate-hosted asbestos																										
"19a"	Polymetallic replacement			•					•	•	•						•	•	•	•	•						
"19b"	Replacement Mn			•					•	•	•						•							•			
"20a"	Porphyry Sn			o					•	•	o					•	o	•	o								
"20b"	Sn-polymetallic vein			•		•			o	o	•					•	•	•	•					•			
"20c"	Porphyry Cu-Au			•	o				•	•	o						o										
"21a"	Porphyry Cu-Mo			•	•	•	•		o	o	o						o	o	o	o	o						
"21b"	Porphyry Mo, low-F			•	•	•			o	o	o						o							•			
"22a"	Volcanic-hosted Cu-As-Sb			•					•	•	•						•	•	•	•			•				
"22b"	Au-Ag-Te veins			•				•	•	•				•			•		•		•			•			
"22c"	Polymetallic veins			•					•	•	•						•	•	•	•	•			•			
"23"	Basaltic Cu	•		•					•																		
"24a"	Cyprus massive sulfide	•		•					•	•	•												•				
"24b"	Besshi massive sulfide	•	•	•					•	•	•												•				
"24c"	Volcanogenic Mn			•							•																
"24d"	Blackbird Co-Cu	•		•					•	•								•									
"25a"	Hot-spring Au-Ag								•	•			o	•				•	•								•
"25b"	Creede epithermal vein			•		•			•	•	•		•				•	•	•	•							
"25c"	Comstock epithermal vein			•		•			•	•			•				•	•	•		•						
"25d"	Sado epithermal vein			•					•	•							•	•	•		•						
"25e"	Epithermal quartz-alunite Au			•		•			•	•	•						•	•	•		•		•				
"25f"	Volcanogenic U				•	•							o					•	•					•			
"25g"	Epithermal Mn			•		•			•	•							•										
"25h"	Rhyolite-hosted Sn										•					•	•	•	•	•				•			
"25i"	Volcanic-hosted magnetite			•																•				•			
"26a"	Carbonate-hosted Au-Ag				•	•			•	•			•	•				•	•					•		•	•
"27a"	Hot-spring Hg									•			•					•	•								
"27b"	Almaden Hg												•					•	•								
"27c"	Silica-carbonate Hg			•							•		•						•								
"27d"	Sb veins					•			•	•	•		•				•	•	•								
"28a"	Kuroko massive sulfide			•					•	•	•					•	•	•	•	•		•	•				
"28b"	Algoma Fe																										
"29a"	Quartz pebble conglomerate Au-U							•		•																	
"29b"	Olympic Dam Cu-U-Au	•		•					•	•														•			
"30a"	Sandstone-hosted Pb-Zn										•						•							•		•	
"30b"	Sediment-hosted Cu	•		•	•				•		•				•											•	
"30c"	Sandstone U			•	•																	•				•	
"31a"	Sedimentary exhalative Zn-Pb			•	•				•	•	•					•	•	•	•				•			•	•
"31b"	Bedded barite										•															•	
"31c"	Emerald vein																							•			
"32a"	Southeast Missouri Pb-Zn	•	•	•	•				•		•	•					•							•	•	•	
"32b"	Appalachian Zn										•	•					•							o			
"32c"	Kipushi Cu-Pb-Zn	•		•	•	•			•		•				•	•	•	•		•						•	
"34a"	Superior Fe																										
"34b"	Sedimentary manganese																										
"34c"	Phosphate, upwelling type																							•		•	•
"34d"	Phosphate, warm current type																							•		•	•
"36a"	Low sulfide Au-quartz vein			•					•	•	•						•	•									
"36b"	Homestake Au	•		•	•			•	•	•	•		•				•	•	•	•							
"37a"	Unconformity U-Au	•	•	•	•		•	•	•	•	•		•					•			•						
"37b"	Gold on flat faults			•						•														•			
"38a"	Lateritic Ni	•	•																								
"38b"	Bauxite, laterite type									•																	
"38c"	Bauxite, karst type																										
"39a"	Placer Au-PGE			•					•	•	•		•					•	•								
"39b"	Placer PGE-Au	•	•	•					•	•	•		•					•	•								
"39c"	Shoreline placer Ti																										
"39d"	Diamond placer	•	•					•																		•	
"39e"	Alluvial placer Sn			•		•					•					•	•	•						•			
		Co	Ni	Cu	Mo	W	Re	PGE	Ag	Au	Zn	Cd	Hg	Tl	Ge	Sn	Pb	As	Sb	Bi	Te	Se	S	F	Br	C	NH3

Figure 206. Continued.

Element	Primary	By-product	Geochemical anomaly	Deposit type and model number
Ag (cont.)	4	2	5	Creede epithermal vein (25b)
	4	3	5	Comstock epithermal vein (25c)
	3	4	5	Sado epithermal vein (25d)
		2	3	epithermal quartz-alunite Au (25e)
			3	epithermal Mn (25g)
		2		carbonate-hosted Au-Ag (26a)
		1	3	simple Sb (27d)
	1	4	5	kuroko massive sulfide (28a)
		2	5	Olympic Dam Cu-U-Au (29b)
		3	4	sandstone-hosted Pb-Zn (30a)
	2	5	5	sediment-hosted Cu (30b)
		4	5	sedimentary exhalative Zn-Pb (31a)
		4	4	southeast Missouri Pb-Zn (32a)
		3	5	Kipushi Cu-Pb-Zn (32c)
		5	5	low-sulfide Au-quartz veins (36a)
		3	3	Homestake Au (36b)
		3	5	placer Au-PGE (39a)
		1	4	placer PGE-Au (39b)
			3	unconformity U-Au (37a)
			3	gold on flat faults (37b)
Al			5	volcanic-hosted Cu-As-Sb (22a)
			5	epithermal quartz-alunite Au (25e)
	5		5	bauxite, laterite type (38b)
	5		5	bauxite, karst type (38c)
			4	unconformity U-Au (37a)
As			5	Limassol Forest Co-Ni (8c)
			4	Alaskan PGE (9)
			4	W skarn (14a)
			5	replacement Sn (14c)
			3	W veins (15a)
			4	Sn veins (15b)
			4	Sn greisen (15c)
			3(dist.)	porphyry Cu (17)
			2(dist.)	Cu skarn (18b)
			4	Zn-Pb skarn (18c)
			3	polymetallic replacement (19a)
			4(dist.)	porphyry Sn (20a)
			4	Sn-polymetallic veins (20b)
			5(dist.)	porphyry Cu-Mo (21a)
	2		5	volcanic-hosted Cu-As-Sb (22a)
			4	polymetallic veins (22c)
			5	Blackbird Co-Cu (24d)
			4(dist.)	hot-spring Au-Ag (25a)
			4	Creede epithermal vein (25b)
			4	Comstock epithermal vein (25c)
			5	epithermal quartz-alunite Au (25e)
			4	Sado epithermal vein (25d)
			4(prox.)	volcanogenic U (25f)
			3	rhyolite-hosted Sn (25h)
			5	carbonate-hosted Au (26a)
			5	hot-spring Hg (27a)
			4	Almaden Hg (27b)
			5	simple Sb (27d)
			4	kuroko massive sulfide (28a)
			4	Homestake Au (28c)
			3	sedimentary exhalative Zn-Pb (31a)
			5	Kipushi Cu-Pb-Zn (32c)
			5	low-sulfide Au-quartz veins (36a)
			5	Homestake Au (36b)

Element	Primary	By-product	Geochemical anomaly	Deposit type and model number
As (cont.)			4	unconformity U-Au (37a)
			1	gold on flat faults (37b)
			4	placer Au-PGE (39a)
			4	placer PGE-Au (39b)
Au		2	3	komatiitic Ni-Cu (6a)
		4	5	porphyry Cu (17)
		3	4	porphyry Cu, skarn-related (18a)
		4	4	Cu skarn (18b)
		4	4	Zn-Pb skarn (18c)
	1	5	5(prox.)	porphyry Cu-Au (20c)
		3	5(dist.)	porphyry Cu-Mo (21a)
		3	4	Fe skarn (18d)
	1	3	4	polymetallic replacement (19a)
			4	replacement Mn (19b)
		3	4	Sn-polymetallic veins (20b)
			4(dist.)	porphyry Mo, low-F (21b)
		4	4	volcanic-hosted Cu-As-Sb (22a)
	5		5	Au-Ag-Te veins (22b)
	2	4	5(prox.)	polymetallic veins (22c)
			(-3)	basaltic Cu (23)
	2	4	5	Cyprus massive sulfide (24a)
	1	3	4	Besshi massive sulfide (24b)
		2	3	Blackbird Co-Cu (24d)
	4	2	5	hot-spring Au-Ag (25a)
	2	4	4	Creede epithermal vein (25b)
	4	3	5	Comstock epithermal vein (25c)
	4	3	5	Sado epithermal vein (25d)
	5		5	epithermal quartz-alunite Au (25e)
			3	epithermal Mn (25g)
	5		5	carbonate-hosted Au (26a)
		1	3	hot-spring Hg (27a)
		1	3	simple Sb (27d)
		3	5	kuroko massive sulfide (28a)
	5		5	Homestake Au (28c)
	4	2	5	quartz pebble conglomerate Au-U (29a)
		3	5	Olympic Dam Cu-U-Au (29b)
	5		5	low-sulfide Au-quartz veins (36a)
	5		5	Homestake Au (36b)
		3	5	unconformity U-Au (37a)
			5	gold on flat faults (37b)
	5	1	5	placer Au-PGE (39a)
		1	4	placer PGE-Au (39b)
B			1	carbonatite (10)
			5	Sn skarn (14b)
			4	replacement Sn (14c)
			2	W veins (15a)
			4	Sn veins (15b)
			4	Sn greisen (15c)
			3	porphyry copper (17)
			4(prox.)	porphyry Sn (20a)
			3	Blackbird Co-Cu (24d)
			3	kuroko massive sulfide (28a)
			3	sedimentary exhalative Zn-Pb (31a)
			4	Homestake Au (36b)
Ba	1		4	carbonatite (10)
			3	diamond pipes (12)
			3	polymetallic replacement (19a)
			4(dist.)	porphyry Sn (20a)

Element	Primary	By-product	Geochemical anomaly	Deposit type and model number
Ba (cont.)			3	Au-Ag-Te veins (22b)
			4(dist.)	polymetallic veins (22c)
			3	volcanogenic Mn (24c)
			4	Creede epithermal vein (25b)
			3	volcanic-hosted magnetite (25i)
			3	carbonate-hosted Au (26a)-Ag
		1	3	kuroko massive sulfide (28a)
			3	Olympic Dam Cu-U-Au (29b)
			3	sandstone-hosted Pb-Zn (30a)
			4(dist.)	sedimentary exhalative Zn-Pb (31a)
	5		5	bedded barite (31b)
			3(dist.)	southeast Missouri Pb-Zn (32a)
			3	Appalachian Zn (32b)
			3	gold on flat faults (37b)
			3	diamond placers (39d)
Be			1	carbonatite (10)
			5	W skarn (14a)
		1	4	Sn skarn (14b)
			3	W veins (15a)
			3	Sn greisen (15c)
			2	Zn-Pb skarn (18c)
			4	rhyolite-hosted Sn (25h)
	5		5	emerald veins (31c)
Bi			4	W skarn (14a)
		1	5	W veins (15a)
			3	Sn greisen (15c)
			2	porphyry Cu (17)
			2	Cu skarn (18b)
			3	Zn-Pb skarn (18c)
			3	polymetallic replacement (19a)
		2	4	Sn-polymetallic veins (20b)
			2	Creede epithermal vein (25b)
			3	rhyolite-hosted Sn (25h)
			3	volcanic-hosted magnetite (25i)
			2	kuroko massive sulfide (28a)
			3	Kipushi Cu-Pb-Zn (32c)
			3	Homestake Au (36b)
			3	unconformity U-Au (37a)
Br		2	5	marine potash
			3	southeast Missouri Pb-Zn (32a)
C (diamond)				
	5			diamond pipes (12)
	5			diamond placers (39d)
C (organic)				
			5	carbonate-hosted Au (26a)
			5	sandstone U (30c)
			4	sedimentary exhalative Zn-Pb (31a)
			4	quartz pebble conglomerate Au-U (29a)
			3	southeast Missouri Pb-Zn (32a)
			4	phosphate, upwelling type (34c)
			3	phosphate, warm-current type (34d)
			3	unconformity U-Au (37a)
Ca			(-4)	kuroko massive sulfide (28a)
			(-4)	Cyprus massive sulfide (24a)
			(-5)	southeast Missouri Pb-Zn (32a)

Element	Primary	By-product	Geochemical anomaly	Deposit type and model number
Ca (cont.)			(-5)	Appalachian Zn (32b)
			(-3)	Blackbird Co-Cu (24d)
			3	unconformity U (37a)
Cd		4		southeast Missouri Pb-Zn (32a)
		4		Appalachian Zn (32b)
Co		3	5	Stillwater Ni-Cu (1)
			4	Duluth Cu-Ni-PGE (5a)
		3	5	Noril'sk Cu-Ni-PGE (5b)
		2	3	komatiitic Ni-Cu (6a)
		2	5	dunitic Ni (6b)
		1	5	synorogenic-synvolcanic Ni-Cu (7a)
	5		5	Limassol Forest Co-Ni (8c)
			4	diamond pipes (12)
			2	Cu skarn (18b)
			3	Zn-Pb skarn (18c)
		1	2	Fe skarn (18d)
			1	basaltic Cu (23)
			3	Cyprus massive sulfide (24a)
			4	Besshi massive sulfide (24b)
	5		5	Blackbird Co-Cu (24d)
			3	Olympic Dam Cu-U-Au (29b)
	1	1	2	sediment-hosted Cu (30b)
			2	sedimentary exhalative Zn-Pb (31a)
		2	4	southeast Missouri Pb-Zn (32a)
		4	3	Kipushi Cu-Pb-Zn (32c)
		3	5	lateritic Ni (38a)
			3	Homestake Au (36b)
			4	unconformity U (37a)
			3	diamond placers (39d)
Cr	5		5	Bushveld Cr (2a)
			5	Merensky Reef PGE (2b)
			5	dunitic Ni (6b)
	5		5	podiform Cr (8a)
	2	1	5	Alaskan PGE (9)
			5	diamond pipes (12)
			3	Besshi massive sulfide (24b)
		1	5	lateritic Ni (38a)
			5	placer PGE-Au (39b)
			3	diamond placers (39d)
Cs			4	Sn skarn (14b)
			4	Climax Mo (16)
Cu	1	4	5	Stillwater Ni-Cu (1)
		1	5	Merensky Reef PGE (2b)
		3	5	Duluth Cu-Ni-PGE (5a)
	1	4	5	Noril'sk Cu-Ni-PGE (5b)
		3	5	komatiitic Ni-Cu (6a)
			4	dunitic Ni (6b)
		3	5	synorogenic-synvolcanic Ni-Cu (7a)
		1	5	Alaskan PGE (9)
	1		3	carbonatite (10)
		1	4	W skarn (14a)
		1	4	Sn skarn (14b)
		2	5	replacement Sn (14c)
			3	W veins (15a)
			4(prox.)	Climax Mo (16)
	5		5(prox.)	porphyry Cu (17)

Appendix C. Commodity/Geochemical Index--Continued

Element	Primary	By-product	Geochemical anomaly	Deposit type and model number
Cu (cont.)	5		5	porphyry Cu, skarn-related (18a)
	5		5(prox.)	Cu skarn (18b)
		4	5	Zn-Pb skarn (18c)
		1	4	Fe skarn (18d)
	3	4	5(prox.)	polymetallic replacement (19a)
			4	replacement Mn (19b)
			4(dist.)	porphyry Sn (20a)
	3	2	5	Sn-polymetallic veins (20b)
	5		5(prox.)	porphyry Cu-Au (20c)
	5		5(prox.)	porphyry Cu-Mo (21a)
			5(prox.)	porphyry Mo, low-F (21b)
	5		5	volcanic-hosted Cu-As-Sb (22a)
			4	Au-Ag-Te veins (22b)
	2	4	5(prox.)	polymetallic veins (22c)
	5		5	basaltic Cu (23)
	5		5	Cyprus massive sulfide (24a)
	5		5	Besshi massive sulfide (24b)
			3	volcanogenic Mn (24c)
		3	5	Blackbird Co-Cu (24d)
		3	5	Creede epithermal vein (25b)
		3	5	Comstock epithermal vein (25c)
		3	5	Sado epithermal vein (25d)
		3	5	epithermal quartz-alunite Au (25e)
			3	epithermal Mn (25g)
			3	volcanic-hosted magnetite (25i)
			3	silica-carbonate Hg (27c)
	5		5	kuroko massive sulfide (28a)
	5		5	Olympic Dam Cu-U-Au (29b)
	5		5	sediment-hosted Cu (30b)
		1	4	sandstone U (30c)
		1	5(prox.)	sedimentary exhalative Zn-Pb (31a)
		2	5	southeast Missouri Pb-Zn (32a)
	4	2	5	Kipushi Cu-Pb-Zn (32c)
			4	low-sulfide Au-quartz veins (36a)
			4	Homestake Au (36b)
			4	unconformity U (37a)
			5	gold on flat faults (37b)
			3	placer Au-PGE (39a)
			3	placer PGE-Au (39b)
F			2	carbonatite (10)
			2	W skarn (14a)
		1	4	Sn skarn (14b)
			5	replacement Sn (14c)
			4	W veins (15a)
			5	Sn greisen (15c)
			5	Climax Mo (16)
			3	Zn-Pb skarn (18c)
			3	porphyry Mo, low-F (21b)
			5	Au-Ag-Te veins (22b)
			5(prox.)	volcanogenic U (25f)
			4	rhyolite-hosted Sn (25h)
			3	volcanic-hosted magnetite (25i)
			2	carbonate-hosted Au (26a)
			3	Olympic Dam Cu-U-Au (29b)
			3	sandstone-hosted Pb-Zn (30a)
			2	southeast Missouri Pb-Zn (32a)
			3(dist.)	Appalachian Zn (32b)
		3	5	phosphate, upwelling type (34c)
		3	5	phosphate, warm current type (34d)
			4	gold on flat faults 37b

Element	Primary	By-product	Geochemical anomaly	Deposit type and model number
Fe			5	many, including:
		3	5	Bushveld Fe-Ti-V (3)
			5	anorthosite Ti (7b)
			1	carbonatite (10)
	5		5	Fe skarn (18d)
		1	5	Cyprus massive sulfide (24a)
	5		5	volcanic-hosted magnetite (25i)
	1	1	5	kuroko massive sulfide (28a)
			5	Olympic Dam Cu-U-Au (29b)
	5		5	Algoma Fe (28b)
			3	sedimentary exhalative Zn-Pb (31a)
	5		5	Superior Fe (34a)
			4	gold on flat faults (37b)
			4	placer Au-PGE (39a)
			4	placer PGE-Au (39b)
			4	shoreline placer Ti (39c)
Ga		3	3	Kipushi Cu-Pb-Zn (32c)
		3	5	bauxite, laterite type (38b)
		3	5	bauxite, karst type (38c)
Ge		2	4	sediment-hosted Cu (30b)
		2	3	Kipushi Cu-Pb-Zn (32c)
Hg	1		5	carbonate-hosted Au-Ag (26a)
			4	Au-Ag-Te veins (22b)
	1		4(dist.)	hot-spring Au-Ag (25a)
			2	Creede epithermal vein (25b)
			3	Comstock epithermal vein (25c)
			4(dist.)	volcanogenic U (25f)
			4	carbonate-hosted Au (26a)
	5		5	hot-spring Hg (27a)
	5		5	Almaden Hg (27b)
	5		5	silica-carbonate Hg (27c)
			4	simple Sb (27d)
			3	Homestake Au (36b)
			3	placer Au-PGE (39a)
			3	placer PGE-Au (39b)
Ir (see PGE)				
K			(-4)	Stillwater Ni-Cu (1)
			(-5)	Bushveld Cr (2a)
			(-5)	Merensky Reef PGE (2b)
			4	diamond pipes (12)
			(-3)	emerald veins (31c)
			4	unconformity U (37a)
Li			2	carbonatite (10)
			4	Sn skarn (14b)
			5	replacement Sn (14c)
			4(dist.)	volcanogenic U (25f)
			4	rhyolite-hosted Sn (25h)
			(-3)	emerald veins (31c)
Mg			5	Stillwater Ni-Cu (1)
			5	Bushveld Cr (2a)
			5	Merensky Reef PGE (2b)
			5	komatiitic Ni-Cu-(6b)
			5	dunitic Ni (6b)
			3	kuroko massive sulfide (28a)

Element	Primary	By-product	Geochemical anomaly	Deposit type and model number
Mg (cont.)			3	dolomitic Cu-Co
			5	southeast Missouri Pb-Zn (32a)
			5	Appalachian Zn (32b)
			4	emerald veins (31c)
Mn			3	carbonatite (10)
			4	diamond pipes (12)
			4(dist.)	porphyry Cu (17)
			5	Zn-Pb skarn (18c)
			4(dist.)	polymetallic replacement (19a)
	5		5	replacement Mn (19b)
			4(dist.)	porphyry Cu-Au (20c)
			4(dist.)	porphyry Cu-Mo (21a)
			5(dist.)	polymetallic veins (22c)
			4(dist.)	Cyprus massive sulfide (24a)
	5		5	volcanogenic Mn (24c)
			4	Blackbird Co-Cu (24d)
			3	Creede epithermal vein (25b)
	5		5	epithermal Mn (25g)
			4(dist.)	sedimentary exhalative Zn-Pb (31a)
	5		5	sedimentary Mn (34b)
			4	unconformity U (37a)
			4	diamond placers (39d)
Mo			4	carbonatite (10)
		2	5	W skarn (14a)
		2	5	W veins (15a)
		1	5	Sn greisen (15c)
		5	5(prox.)	Climax Mo (16)
		3	5(prox.)	porphyry Cu (17)
		2	5	porphyry Cu, skarn-related (18a)
		1	4	Cu skarn (18b)
		1	5(dist.)	porphyry Cu-Au (20c)
		4	5(prox.)	porphyry Cu-Mo (21a)
	5		5(prox.)	porphyry Mo, low-F (21b)
			5(prox.)	volcanogenic U (25f)
			2	carbonate-hosted Au (26a)
			3	sediment-hosted Cu (30b)
			4	sandstone U (30c)
			2	sedimentary exhalative Zn-Pb (31a)
			(-3)	emerald veins (31c)
			4	southeast Missouri Pb-Zn (32a)
			3	Kipushi Cu-Pb-Zn (32c)
			2	Homestake Au (36b)
			2	unconformity U-Au (37a)
N (as NH_4^+)			3	carbonate-hosted Au (26a)
			3	sedimentary exhalative Zn-Pb (31a)
			3	phosphate, upwelling type (34c)
			3	phosphate, warm-current type (34d)
Na			(-4)	Stillwater Ni-Cu (1)
			(-5)	Bushveld Cr (2a)
			(-5)	Merensky Reef PGE (2b)
			(-3)	Blackbird Co-Cu (24d)
Nb			(-4)	kuroko massive sulfide (28a)
			(-5)	Cyprus massive sulfide (24a)
			5	emerald veins (31c)
	4	1	4	carbonatite (10)
			4	diamond pipes (12)

Element	Primary	By-product	Geochemical anomaly	Deposit type and model number
Nb (cont.)			3	Climax Mo (16)
			4	diamond placers (39d)
Ni	4	1	5	Stillwater Ni-Cu (1)
		2	5	Merensky Reef PGE (2b)
	4	1	5	Duluth Cu-Ni-PGE (5a)
	4	1	5	Noril'sk Cu-Ni-PGE (5b)
	5		5	komatiitic Ni-Cu-(6a)
	5		5	dunitic Ni (6b)
	5		5	synorogenic-synvolcanic Ni-Cu (7a)
	1	3	5	Limassol Forest Co-Ni (8c)
	1	3	5	Alaskan PGE (9)
			5	diamond pipes (12)
			3	Besshi massive sulfide (24b)
		1	4	southeast Missouri Pb-Zn (32a)
			5	unconformity U (37a)
	5		5	lateritic Ni (38a)
			4	diamond placers (39d)
Os (see PGE)				
P	1	1	5	carbonatite (10)
			(-4)	Stillwater Ni-Cu (1)
			(-5)	Bushveld Cr (2a)
			(-5)	Merensky Reef PGE (2b)
			5	anorthosite-Ti (7b)
			4	replacement Mn (19b)
			4	epithermal Mn (25g)
		2	5	volcanic-hosted magnetite (25i)
	5		5	phosphate, upwelling type (34c)
	5		5	phosphate, warm-current type (34d)
Pb			3	carbonatite (10)
			3	Sn skarn (14b)
			4	replacement Sn (14c)
			3	W veins (15a)
			4(dist.)	Climax Mo (16)
			4(dist.)	porphyry Cu (17)
			3	porphyry Cu, skarn-related (18a)
		1	4(dist.)	Cu skarn (18b)
	2	4	5	Zn-Pb skarn (18c)
	4	2	5(dist.)	polymetallic replacement (19a)
			4	replacement Mn (19b)
			4(dist.)	porphyry Sn (20a)
		2	4	Sn-polymetallic veins (20b)
			4(dist.)	porphyry Cu-Au (20c)
			4(dist.)	porphyry Cu-Mo (21a)
			4(dist.)	porphyry Mo, low-F (21b)
			4	Au-Ag-Te veins (22b)
	3	2	5	polymetallic veins (22c)
		4	5	Creede epithermal vein (25b)
		4	5	Comstock epithermal vein (25c)
		3	3(prox.)	epithermal quartz-alunite Au (25e)
			4	epithermal Mn (25g)
			3	rhyolite-hosted Sn (25h)
			3	simple Sb (27d)
	1	3	5	kuroko massive sulfide (28a)
	5		5	sandstone-hosted Pb-Zn (30a)
			3	sediment-hosted Cu (30b)
	4		5	sedimentary exhalative Zn-Pb (31a)
			(-3)	emerald veins (31c)

Element	Primary	By-product	Geochemical anomaly	Deposit type and model number
Pb (cont.)	5		5	southeast Missouri Pb-Zn (32a)
		2	3	Appalachian Zn (32b)
	3	3	5	Kipushi Cu-Pb-Zn (32c)
			4	low-sulfide Au-quartz veins (36a)
			4	Homestake Au (36b)
			4	unconformity U-Au (37a)
Pd (see PGE)				
Pt (incl. all PGE)				
		4	5	Stillwater Ni-Cu (1)
		4	5	Bushveld Cr (2a)
		5	5	Merensky Reef PGE (2b)
		4	5	Duluth Cu-Ni-PGE (5a)
		4	5	Noril'sk Cu-Ni-PGE (5b)
		3	5	komatiitic Ni-Cu(6a)
		2	5	dunitic Ni (6b)
		1	4	synorogenic-synvolcanic Ni-Cu (7a)
			5	podiform Cr (8a)
	1	3	5	Alaskan PGE (9)
			5	diamond pipes (12)
		1	2	Au-Ag-Te veins (22b)
			2	Homestake Au (28c)
		2	4	quartz pebble conglomerate Au-U (29a)
	1	1	3	placer Au-PGE (39a)
	5		5	placer PGE-Au (39b)
			4	diamond placers (39d)
Rare Earths				
	2	2	5	carbonatite (10)
		1	3	W veins (15a)
			3	volcanogenic U (25f)
			2	rhyolite-hosted Sn (25h)
			3	Olympic Dam Cu-U-Au (29b)
			5	emerald veins (31c)
		1	4	phosphate, upwelling type (34c)
		1	4	phosphate, warm-current type (34d)
			3	unconformity U-Au (37a)
		2	5	shoreline placer Ti (39c)
Rb			5	Sn skarn (14b)
			5	replacement Sn (14c)
			4	Climax Mo (16)
			3(dist.)	porphyry Cu (17)
			4(dist.)	porphyry Cu-Mo (21a)
			3	unconformity U-Au (37a)
Re			4	Sn skarn (14b)
			5	Climax Mo (16)
			5	Porphyry Mo, low-F (21b)
			3	Unconformity U-Au (37a)
Rh (see PGE)				
Ru (see PGE)				
S	1	2	5	kuroko massive sulfide (28a)
	1	2	5	Cyprus massive sulfide (24a)
Sb			3(dist.)	porphyry Cu (17)
			3	polymetallic replacement (19a)

Appendix C. Commodity/Geochemical Index--Continued

Element	Primary	By-product	Geochemical anomaly	Deposit type and model number
Sb (cont.)			4(dist.)	porphyry Sn (20a)
			4(dist.)	porphyry Cu-Mo (21a)
		3	3	volcanic-hosted Cu-As-Sb (22a)
			4	Au-Ag-Te veins (22b)
			4(dist.)	hot-spring Au-Ag (25a)
			4	Creede epithermal vein (25b)
			4	Comstock epithermal vein (25c)
			4	volcanogenic U (25f)
			3	rhyolite-hosted Sn (25h)
			4	carbonate-hosted Au (26a)
		1	5	hot spring Hg (27a)
			4	Almaden Hg (27b)
			4	silica-carbonate Hg (27c)
	5		5	simple Sb (27d)
			4	kuroko massive sulfide (28a)
			2	sedimentary exhalative Zn-Pb (31a)
			4	Homestake Au (36a)
			2	placer Au-PGE (39a)
			2	placer PGE-Au (39b)
Se			3	porphyry Cu (17)
			2	kuroko massive sulfide (28a)
			5	sandstone U (30c)
Si			5	almost all epigenetic deposits
Sn			1	carbonatite (10)
			5	W skarn (14a)
	3	3	5	Sn skarn (14b)
	5		5	replacement Sn (14c)
		2	5	W veins (15a)
	5		5	Sn veins (15b)
	5		5	Sn greisen (15c)
		2	5(prox.)	Climax Mo (16)
			3(dist.)	porphyry Cu (17)
			3	Zn-Pb skarn (18c)
			1	Fe skarn (18d)
	5		5	porphyry Sn (20a)
	5		5	Sn-polymetallic veins (20b)
			2	volcanic-hosted Cu-As-Sb (22a)
	5		5	rhyolite-hosted Sn (25h)
			4	kuroko massive sulfide (28a)
		1	2	sedimentary exhalative Zn-Pb (31a)
			3	Kipushi Cu-Pb-Zn (32c)
Sr			3	carbonatite (10)
			3	Au-Ag-Te veins (22b)
Ta			1	carbonatite (10)
			3	Climax Mo (16)
Te			4(dist.)	porphyry Cu (17)
			4(dist.)	porphyry Cu-Mo (21a)
			3	polymetallic replacement (19a)
			5	Au-Ag-Te veins (22b)
			3	Comstock epithermal vein (25c)
Te (cont.)			3	Sado epithermal vein (25d)
			3	epithermal quartz-alunite Au (25e)
			3	unconformity U-Au (37a)
Th			5	carbonatite (10)

Element	Primary	By-product	Geochemical anomaly	Deposit type and model number
Th (cont.)		2	5	shoreline placer Ti (39c)
Ti			4	Merensky Reef PGE (2b)
			5	Bushveld Fe-Ti-V (3)
			4	Duluth Cu-Ni-PGE (5a)
	5		5	anorthosite-Ti (7b)
			4	Alaskan PGE (9)
			4	carbonatite (10)
			5	diamond pipes (12)
	5		5	shoreline placer Ti (39c)
			5	diamond placers (39d)
Tl			4(dist.)	hot-spring Au-Ag (25a)
			4	carbonate-hosted Au (26a)
U		1	5	carbonatite (10)
			3(dist.)	Climax Mo (16)
	1	4	4	quartz pebble conglomerate Au-U (29a)
		3	4	Olympic Dam Cu-U-Au (29b)
			2	sediment-hosted Cu (30b)
	5		5	sandstone U (30c)
			2	Kipushi Cu-Pb-Zn (32c)
		2	5	phosphate, upwelling type (34c)
		2	5	phosphate, warm-current type (34d)
	5		5	unconformity U (37a)
		1	5	shoreline placer Ti (39c)
V	3		5	Bushveld Fe-Ti-V (3)
		1	5	anorthosite-Ti (7b)
			4	Alaskan PGE (9)
		1	4	volcanic-hosted magnetite (25i)
			2	sediment-hosted Cu (30b)
	1	4	5	sandstone U (30c)
			3	Kipushi Cu-Pb-Zn (32c)
W			1	carbonatite (10)
	5		5	W skarn (14a)
	5		5	Sn skarn (14b)
		1	4	replacement Sn (14c)
	5		5	W veins (15a)
		2	5	Sn veins (15b)
		1	5(prox.)	Climax Mo (16)
			3(prox.)	porphyry Cu (17)
			2	porphyry Cu, skarn-related (18a)
		1	3	Zn-Pb skarn (18c)
		2	4	Sn-polymetallic veins (20b)
			4(prox.)	porphyry Cu-Mo (21a)
		1	5(prox.)	porphyry Mo, low-F (21b)
			2	Creede epithermal vein (25b)
			2	Comstock epithermal vein (25c)
			1	epithermal quartz-alunite Au (25e)
			2	volcanogenic U (25f)
		1	3	epithermal Mn (25g)
			4	carbonate-hosted Au (26a)
			4	simple Sb (27d)
			3	Kipushi Cu-Pb-Zn (32c)
Zn		1	4	W skarn (14a)
		1	4	Sn skarn (14b)
			4	replacement Sn (14c)
		1	3	W veins (15a)

Element	Primary	By-product	Geochemical anomaly	Deposit type and model number
Zn (cont.)			3(dist.)	Climax Mo (16)
			4(dist.)	porphyry Cu (17)
			3	porphyry Cu, skarn-related (18a)
		2	4(dist.)	Cu skarn (18b)
	5		5	Zn-Pb skarn (18c)
	4	1	5(dist.)	polymetallic replacement (19a)
			4	replacement Mn (19b)
			4(dist.)	porphyry Sn (20a)
	2	3	5	Sn-polymetallic veins (20b)
			4(dist.)	porphyry Cu-Au (20c)
			4(dist.)	porphyry Cu-Mo (21a)
			3(dist.)	porphyry Mo, low-F (21b)
			4	volcanic-hosted Cu-As-Sb (22a)
			3	Au-Ag-Te veins (22b)
	2	2	4(dist.)	polymetallic veins (22c)
			3	basaltic Cu (23)
		3	5	Cyprus massive sulfide (24a)
		2	5	Besshi massive sulfide (24b)
			3	volcanogenic Mn (24c)
		3	5	Creede epithermal vein (25b)
		2	4(prox.)	epithermal quartz-alunite Au (25e)
			3	rhyolite-hosted Sn (25h)
			3	silica-carbonate Hg (27c)
			3	simple Sb (27d)
	5		5	kuroko massive sulfide (28a)
	1	3	5	sandstone-hosted Pb-Zn (30a)
			3	sediment-hosted Cu (30b)
	5		5	sedimentary exhalative Zn-Pb (31a)
	5		5	southeast Missouri Pb-Zn (32a)
	5		5	Appalachian Zn (32b)
	4	1	5	Kipushi Cu-Pb-Zn (32c)
			3	low-sulfide Au-quartz veins (36a)
			4	Homestake Au (36b)
			3	unconformity U (37a)
Zr			4	anorthosite-Ti (7b)
	1	1	4	carbonatite (10)
		3	5	shoreline placer Ti (39c)

Appendix D. Mineralogical Index by Paul B. Barton

The mineralogy of the deposits is indicated in six categories describing the mode of occurrence of the mineral. Each category, which constitutes a column, is labeled as follows: "Ore mineral" (the mineral is commonly the source of the metal or other valuable product of the deposit), "Gangue mineral" (the mineral has no value but is closely associated in time and space with the ore minerals), "Host rock mineral" and "Associated rock mineral" (the mineral is characteristic of the rocks in which the deposit is found or with which it is genetically associated), "Alteration mineral" (the mineral is produced in rocks near the deposit by hydrothermal processes related to ore deposition or transport), and "Weathering mineral" (the mineral is produced by weathering or supergene enrichment).

An "ore" mineral is so designated if it is a mineral which under reasonable circumstances might be used to provide a concentrate of a valuable substance. Thus traces of bismuthinite are "ores", as are pyrite or arsenopyrite crystals that carry gold, and so is pyrite in sufficient abundance that it might be used as a source of sulfur. But accessory pyrite without economic values is "gangue" because neither iron nor sulfur would normally be produced from it; multiple entries for some minerals are expected. The "host" category is necessarily incomplete inasmuch as variations in host lithology are not necessarily critical parts of the model; for example a vein could cut a pegmatite containing minerals such as beryl or spodumene, neither of which would be very informative if added to the "host" minerals list.

Numerical values are given as a measure of the degree to which a mineral is present in the deposit of the type considered; the numbers are NOT the amount of mineral, but its universality anywhere in the deposit among all deposits of that class. The values "1", "2", "3", "4", and "5" correspond respectively to 0-10, 10-30, 30-70, 70-90, and 90-100 percent and, until definitive documentation for a given model type is available, will usually be no better than guesses based on experience. The numbers are modified by a letter suffix to give a qualitative estimate of the abundance of the mineral: "m" indicates a major component, which we define as 10 volume percent; "t" indicates traces, which we define as 1 volume percent; intermediate values are given no designation. Detail on the spatial distribution of minerals resides in the models themselves.

Mineral	Ore mineral	Gangue mineral	Host rock mineral	Associated rock mineral	Alteration mineral	Weathering mineral	Deposit type and model number
Adularia		4					Au-Ag-Te veins (22b)
(also see		3					polymetallic veins (22c)
feldspar)		4					hot-spring Au-Ag (25a)
		3			3		Creede epithermal vein (25b)
		3			3		Comstock epithermal vein (25c)
		3					Sado epithermal vein (25d)
		3			4		volcanogenic U (25f)
		4					rhyolite-hosted Sn (25h)
					4		hot-spring Hg (27a)
		2t					southeast Missouri Pb-Zn (32a)
Albite					4m		W veins (15a)
(also see					3		porphyry Cu (17)
feldspar)			4				Besshi massive sulfide (24b)
					4		volcanic-hosted magnetite (25i)
					3		kuroko massive sulfide (28a)
					3		sedimentary exhalative Zn-Pb (31a)
		4					emerald veins (31c)
		4					low-sulfide Au-quartz veins (36a)

Mineral	Ore min-eral	Gangue min-eral	Host rock min-eral	Assoc-iated rock min-eral	Alter-ation min-eral	Weath-ering min-eral	Deposit type and model number
Alleghenyite							
		2					volcanogenic Mn (24c)
Al oxides and hydroxides							
	5m					5m	bauxite, laterite type (38b)
	5m					5m	bauxite, karst type (38c)
Alunite							Alunite is a common result of the oxidation of sulfides in Al-bearing carbonate-poor rocks.
					3		porphyry Cu (17)
					4		volcanic-hosted Cu-As-Sb (22a)
		3					hot-spring Au-Ag (25a)
		2					Creede epithermal vein (25b)
					3		Sado epithermal vein (25d)
		3			5		epithermal quartz-alunite Au (25e)
					4		volcanogenic U (25f)
			4				hot-spring Hg (27a)
Amphibole							Amphibole is a common late-stage alteration in skarns of all types.
Mn-rich		4			4		Zn-Pb skarn (18c)
actinolite		3			3		porphyry Cu (17)
(includes		3			4		porphyry Cu, skarn-related (18a)
tremolite)		3			3		Cu skarn (18b)
					4		Zn-Pb skarn (18c)
		4				4	porphyry Cu-Au (20c)
			4				Besshi massive sulfide (24b)
					4		volcanic-hosted magnetite (25i)
			3				serpentine-hosted asbestos (8d)
anthophyllite				3	3		kuroko massive sulfide (28a)
cummingtonite			3m	3m			Homestake Au (28c)
Anatase			4			4	bauxite, laterite type (38b)
			4			4	bauxite, karst type (38c)
Andalusite						2	porphyry Cu (17)
					2		porphyry Cu-Mo (21a)
					4		volcanic-hosted Cu-As-Sb (22a)
					3		epithermal quartz-alunite Au (25e)
Anhydrite				3m			Duluth Cu-Ni-PGE (5a)
				3m			Noril'sk Cu-Ni-PGE (5b)
		3			3		porphyry Cu (17)
		3			4		porphyry Cu-Au (20c)
		3			3		porphyry Cu-Mo (21a)
		2					Cyprus massive sulfide (24a)
		2m	1m	2m	2		kuroko massive sulfide (28a)
		2					Olympic Dam Cu-U-Au (29b)
		2					Appalachian Zn (32b)

Mineral	Ore mineral	Gangue mineral	Host rock mineral	Associated rock mineral	Alteration mineral	Weathering mineral	Deposit type and model number
Apatite apatite, (includes fluor-francolite, collophane)							
		3					anorthosite-Ti (7b)
	1m	4					carbonatite (10)
		5					volcanic-hosted magnetite (25i)
	5m						phosphate, upwelling type (34c)
	5m						phosphate, warm-current type (34d)
Antimony (native)	2t						simple Sb (27d)
Argentite							
						5	Argentite is a common product of the supergene enrichment of silver ores.
	3t						polymetallic replacement (19a)
	3t						Sn-polymetallic veins (20b)
	3t						polymetallic veins (22c)
	3t						Creede epithermal vein (25b)
	5t						Comstock epithermal vein (25c)
	4t						Sado epithermal vein (25d)
	2t						simple Sb (27d)
Arsenates							
		3					rhyolite-hosted Sn (25h)
Arsenides	4t	2					Merensky Reef PGE (2b)
	3	3					Noril'sk Cu-Ni-PGE (5b)
	1t	3t					dunitic Ni (6b)
	4	4					Limassol Forest Co-Ni (8c)
	3t						Alaskan PGE (9)
		2					Cu skarn (18b)
Arsenopyrite							
		4t					W skarn (14a)
		3					Sn skarn (14b)
		4					replacement Sn (14c)
		5					W veins (15a)
		4					Sn veins (15b)
		5					Sn greisen (15c)
		3					Cu skarn (18b)
		3t					Zn-Pb skarn (18c)
		3					porphyry Sn (20a)
		4					Sn-polymetallic veins (20b)
		2					volcanic-hosted Cu-As-Sb (22a)
		3					polymetallic veins (22c)
		5					Blackbird Co-Cu (24d)
		3					hot-spring Au-Ag (25a)
		2					Creede epithermal vein (25b)
		2					Comstock epithermal vein (25c)
		3t					carbonate-hosted Au (26a)
		3t					simple Sb (27d)
		3t					sedimentary exhalative Zn-Pb (31a)
		1t					southeast Missouri Pb-Zn (32a)

Mineral	Ore mineral	Gangue mineral	Host rock mineral	Associated rock mineral	Alteration mineral	Weathering mineral	Deposit type and model number
Arsenopyrite (cont.)		2					Kipushi Cu-Pb-Zn (32c)
		4					low-sulfide Au-quartz veins (36a)
		4					Homestake Au (36b)
		3					unconformity U (37a)
Asbestos (see chrysotile)							
Ba-silicates		4					sedimentary exhalative Zn-Pb (31a)
Barite		4					carbonatite (10)
		4					polymetallic replacement (19a)
		3					replacement Mn (19b)
		3					volcanic-hosted Cu-As-Sb (22a)
		3					Au-Ag-Te veins (22b)
		3					polymetallic veins (22c)
		4m					Creede epithermal vein (25b)
		4					Comstock epithermal vein (25c)
		3					Sado epithermal vein (25d)
		3					volcanogenic U (25f)
		5					epithermal Mn (25g)
		3					volcanic-hosted magnetite (25i)
		3					carbonate-hosted Au (26a)
		2					simple Sb (27d)
	1m	3m		1m			kuroko massive sulfide (28a)
		4			4		Olympic Dam Cu-U-Au (29b)
		3					sandstone-hosted Pb-Zn (30a)
	1m	3		3m			sedimentary exhalative Zn-Pb (31a)
	5m						bedded barite (31b)
		3					southeast Missouri Pb-Zn (32a)
		3					Appalachian Zn (32b)
		2					gold on flat faults (37b)
Berthierite							
	2t						simple Sb (27d)
Beryl		3					W veins (15a)
		3t					Sn veins (15b)
		4					Sn greisen (15c)
	5t						emerald veins (31c)
Biotite							
							Biotite is a common mineral in igneous and metamorphic rocks.
		4					carbonatite (10)
					4		low-sulfide Au-quartz veins (15d)
		3			4		porphyry Cu (17)
					3		porphyry Cu, skarn-related (18a)
		3			5		porphyry Cu-Au (20c)
		4			4		porphyry Cu-Mo (21a)
		4			4		porphyry Mo, low-F (21b)
					4		volcanic-hosted magnetite (25i)

Mineral	Ore mineral	Gangue mineral	Host rock mineral	Associated rock mineral	Alteration mineral	Weathering mineral	Deposit type and model number
Bismuth							
	3t						W skarn (14a)
	4t						Sn-polymetallic veins (20b)
	2t						Kipushi Cu-Pb-Zn (32c)
	3t						low-sulfide Au-quartz veins (36a)
Bismuthinite							
	4t						W veins (15a)
	3t						Sn veins (15b)
	4t						Sn greisen (15c)
	3t						Cu skarn (18b)
	3t						Zn-Pb skarn (18c)
	2t						polymetallic replacement (19a)
	4t						Sn-polymetallic veins (20b)
	2t						sedimentary exhalative Zn-Pb (31a)
Boehmite							
	4m						bauxite, karst type (38c)
Bornite							
							Bornite may be a supergene, as well as hypogene, copper mineral.
	3						Noril'sk Cu-Ni-PGE (5b)
	3t						Alaskan PGE (9)
	3t						W skarn (14a)
	3t						W veins (15a)
	2						porphyry Cu (17)
	3						porphyry Cu, skarn-related (18a)
	3						Cu skarn (18b)
	3						Zn-Pb skarn (18c)
	4						porphyry Cu-Au (20c)
	3						volcanic-hosted Cu-As-Sb (22a)
	3						basaltic Cu (23)
	2						Besshi massive sulfide (24b)
	2						Creede epithermal vein (25b)
	3						epithermal quartz-alunite Au (25e)
	3t						silica-carbonate Hg (27c)
	3						kuroko massive sulfide (28a)
	5						Olympic Dam Cu-U-Au (29b)
	3t						sandstone-hosted Pb-Zn (30a)
	4						sediment-hosted Cu (30b)
	2t						sandstone U (30c)
	2						southeast Missouri Pb-Zn (32a)
	5						Kipushi Cu-Pb-Zn (32c)
	2t						gold on flat faults (37b)
Brannerite							
	4t						volcanogenic U (25f)
	4t						quartz pebble conglomerate Au-U (29a)
	4t						Olympic Dam Cu-U-Au (29b)
Bravoite							
	2t						sandstone-hosted Pb-Zn (30a)
	2t						southeast Missouri Pb-Zn (32a)
Brucite							
		3					serpentine-hosted asbestos (8d)

Mineral	Ore mineral	Gangue mineral	Host rock mineral	Associated rock mineral	Alteration mineral	Weathering mineral	Deposit type and model number
Buddingtonite							
		3			3		hot-spring Au-Ag (25a)
Calaverite (see tellurides)							
Carbonates (see specific carbonates below)							Carbonates are very common gangue and host-rock minerals in a wide variety of ores.
					5m		Limassol Forest Co-Ni (8c)
		5m					carbonatite (10)
					5m		W skarn (14a)
				5m			Sn Skarn (14b)
		5m	5m				replacement Sn (14c)
			5m				porphyry Cu, skarn-related (18a)
			5m				Cu skarn (18b)
			5m				Zn-Pb skarn (18c)
			5m				Fe skarn (18d)
			5m				polymetallic replacement (19a)
		5m	5m				replacement Mn (19b)
		5			5		Au-Ag-Te veins (22b)
		4			3		polymetallic veins (22c)
		4			3		basaltic Cu (23)
			3				Besshi massive sulfide (24b)
	4						volcanogenic Mn (24c)
		4m					Creede epithermal vein (25b)
		4					Comstock epithermal vein (25c)
		3			3		Sado epithermal vein (25d)
	5	4					epithermal Mn (25g)
			5				carbonate-hosted Au (26a)
					3		volcanic-hosted magnetite (25i)
			3m	3m			silica-carbonate Hg (27c)
					4		Olympic Dam Cu-U-Au (29b)
			5m				Kipushi Cu-Pb-Zn (32c)
ankerite							
		3					carbonatite (10)
		3					polymetallic veins (22c)
		3					low-sulfide Au-quartz veins (36a)
			3m	3m			Homestake Au (36b)
calcite							
		4m					carbonatite (10)
		3m					Sn greisen (15c)
					2		porphyry Cu (17)
		4	4				replacement Mn (19b)
		4					Au-Ag-Te veins (22b)
		3			3		polymetallic veins (22c)
		4			3		basaltic Cu (23)
					2		Cyprus massive sulfide (24a)
		3					Creede epithermal vein (25b)
		4					Comstock epithermal vein (25c)
		3			3		Sado epithermal vein (25d)
					2		epithermal quartz-alunite Au (25e)
		4					epithermal Mn (25g)
		4					Almaden Hg (27b)
		4					simple Sb (27d)

Mineral	Ore mineral	Gangue mineral	Host rock mineral	Associated rock mineral	Alteration mineral	Weathering mineral	Deposit type and model number
calcite		3					emerald veins (31c)
(cont.)		4					sandstone-hosted Pb-Zn (30a)
		4m					phosphate, upwelling type (34c)
		4					phosphate, warm-current type (34d)
		4					unconformity U (38d)
dolomite							
		4m					carbonatite (10)
		4	3		4m		polymetallic replacement (19a)
			3m				replacement Mn (19b)
		4			4		Au-Ag-Te veins (22b)
		2					polymetallic veins (22c)
					5		silica-carbonate Hg (27c)
					3		sedimentary exhalative Zn-Pb (31a)
		5			5		emerald veins (31c)
		5			5m		southeast Missouri Pb-Zn (32a)
		5m	5m		5m		Appalachian Zn (32b)
		4			4m		Kipushi Cu-Pb-Zn (32c)
				5			Superior Fe (34a)
		4m					phosphate, upwelling type (34c)
		4m					phosphate, warm-current type (34d)
		4			4		unconformity U (37b)
rhodochrosite							
		2					carbonatite (10)
		3			3		Climax Mo (16)
		3					Zn-Pb skarn (18c)
		3					polymetallic replacement (19a)
	5m						replacement Mn (19b)
		3					polymetallic veins (22c)
	4m						volcanogenic Mn (24c)
		4					Creede epithermal vein (25b)
		3					Comstock epithermal vein (25c)
		3					Sado epithermal vein (25d)
	5m						epithermal Mn (25g)
	3m						sedimentary Mn (34b)
siderite							
					4m		replacement Sn (14c)
					3		Sn-polymetallic veins (20b)
		3					carbonatite (10)
		3					polymetallic veins (22c)
		3					Creede epithermal vein (25b)
		2t					simple Sb (27d)
	3m						Algoma Fe (28b)
		3			3		Kipushi Cu-Pb-Zn (32c)
	3m						Superior Fe (34a)
		3					phosphate, upwelling type (34c)
		3					low-sulfide Au-quartz veins (36a)
			3m	3m			Homestake Au (36b)
		3					unconformity U (37a)
Carnotite							
						5	sandstone U (30c)
						3t	phosphate, upwelling type (34c)

Appendix D. Mineralogical Index--Continued

Mineral	Ore mineral	Gangue mineral	Host rock mineral	Associated rock mineral	Alteration mineral	Weathering mineral	Deposit type and model number
Carrollite							
	3t						Limassol Forest Co-Ni (8c)
	3t						Olympic Dam Cu-U-Au (29b)
	3t						sediment-hosted Cu (30b)
	4t						Kipushi Cu-Pb-Zn (32c)
Cassiterite							
	3t						W skarn (14a)
	5						Sn skarn (14b)
	5						replacement Sn (14c)
	4t						W veins (15a)
	5						Sn veins (15b)
	5						Sn greisen (15c)
	3t						Climax Mo (16)
	1t						Fe skarn (18d)
	5						porphyry Sn (20a)
	5						Sn-polymetallic veins (20b)
	5						rhyolite-hosted Sn (25h)
	1t						sedimentary exhalative Zn-Pb (31a)
Celestite							
		3					Au-Ag-Te veins (22b)
Chalcedony (includes opal)							
		4					replacement Mn (19b)
		5			5		volcanic-hosted Cu-As-Sb (22a)
		3					polymetallic veins (22c)
		5					Cyprus massive sulfide (24a)
		5m					hot-spring Au-Ag (25a)
		5m					Creede epithermal vein (25b)
		4m					Comstock epithermal vein (25c)
		4m					Sado epithermal vein (25d)
		3					epithermal quartz-alunite Au (25e)
		4m					volcanogenic U (25f)
		5					epithermal Mn (25g)
		5					rhyolite-hosted Sn (25h)
		5					hot-spring Hg (27a)
					4		silica-carbonate Hg (27c)
		2					simple Sb (27d)
Chalcocite and related Cu_xS phases							
						5	Chalcocite and related Cu_xS minerals are extremely common as supergene alterations of copper-bearing sulfides and as supergene replacements of chalcopyrite and, to a lesser extent, other primary sulfides.
	3						volcanic-hosted Cu-As-Sb (22a)
	4						basaltic Cu (23)
	2t						volcanic-hosted magnetite (25i)
	1t						simple Sb (27d)
	5						Olympic Dam Cu-U-Au (29b)

Mineral	Ore mineral	Gangue mineral	Host rock mineral	Associated rock mineral	Alteration mineral	Weathering mineral	Deposit type and model number
Chalcocite and related Cu_xS phases (cont.)							
	2t						sandstone-hosted Pb-Zn (30a)
	4					4	sediment-hosted Cu (30b)
	2						southeast Missouri Pb-Zn (32a)
	4						Kipushi Cu-Pb-Zn (32c)
Chalcopyrite							
	5						Stillwater Ni-Cu (1)
	5t						Bushveld Cr (2a)
	5t						Merensky Reef PGE (2b)
	5						Duluth Cu-Ni-PGE (5a)
	5						Noril'sk Cu-Ni-PGE (5b)
	5						komatiitic Ni-Cu (6a)
	5t						dunitic Ni (6b)
	5						synorogenic-synvolcanic Ni-Cu (7a)
	4t						Limassol Forest Co-Ni (8c)
	3t						Alaskan PGE (9)
	5t						carbonatite (10)
	4t						W skarn (14a)
	3t						Sn skarn (14b)
	4t						replacement Sn (14c)
	5t						W veins (15a)
	4t						Sn veins (15b)
	4t						Sn greisen (15c)
	5						porphyry Cu (17)
	5						porphyry Cu, skarn-related (18a)
	5						Cu skarn (18b)
	4						Zn-Pb skarn (18c)
	4t						Fe skarn (18d)
	4t						polymetallic replacement (19a)
	3t						replacement Mn (19b)
	4t						porphyry Sn (20a)
	5						Sn-polymetallic veins (20b)
	5						porphyry Cu-Au (20c)
	5						porphyry Cu-Mo (21a)
	3t						porphyry Mo, low-F (21b)
	4						volcanic-hosted Cu-As-Sb (22a)
	4						polymetallic veins (22c)
	4						basaltic Cu (23)
	5						Cyprus massive sulfide (24a)
	5						Besshi massive sulfide (24b)
	5						Blackbird Co-Cu (24d)
	3t						hot-spring Au-Ag (25a)
	5						Creede epithermal vein (25b)
	4t						Comstock epithermal vein (25c)
	5t						Sado epithermal vein (25d)
	4						epithermal quartz-alunite Au (25e)
	3						volcanic-hosted magnetite (25i)
	4t						silica-carbonate Hg (27c)
	3t						simple Sb (27d)
	5						kuroko massive sulfide (28a)
	5						Olympic Dam Cu-U-Au (29b)
	4t						sandstone-hosted Pb-Zn (30a)
	4						sediment-hosted Cu (30b)
	3t						sandstone U (30c)

Mineral	Ore mineral	Gangue mineral	Host rock mineral	Associated rock mineral	Alteration mineral	Weathering mineral	Deposit type and model number
Chalcopyrite (cont.)							
	4t						sedimentary exhalative Zn-Pb (31a)
	4t						southeast Missouri Pb-Zn (32a)
	4						Kipushi Cu-Pb-Zn (32c)
	4t						low-sulfide Au-quartz veins (36a)
	3t						Homestake Au (36b)
	4t						unconformity U (37a)
	4t						gold on flat faults (37b)
Chert							
				4m			Cyprus massive sulfide (24a)
				4m			volcanogenic Mn (24c)
			4m	1m			kuroko massive sulfide (28a)
		5m	5m	5m			Algoma Fe (28b)
		4m	4m	4m			sedimentary exhalative Zn-Pb (31a)
		5m	5m				Superior Fe (34a)
			5m	5m			Homestake Au (36b)
Chlorite							
		3			3		Sn skarn (14b)
					4m		W veins (15a)
					4m		Sn veins (15b)
					3m		Sn greisen (15c)
		2			4		porphyry Cu (17)
					3		porphyry Cu, skarn-related (18a)
				4			Cu skarn (18b)
					3		Zn-Pb skarn (18c)
		4			4		Fe skarn (18d)
					2		polymetallic replacement (19a)
					3		porphyry Sn (20a)
					4		Sn-polymetallic veins (20b)
					4		porphyry Cu-Mo (21a)
					4		porphyry Mo, low-F (21b)
		4			4		polymetallic veins (22c)
		3			5m		Cyprus massive sulfide (24a)
			5				Besshi massive sulfide (24b)
					5m		Blackbird Co-Cu (24d)
					3		hot-spring Au-Ag (25a)
		4			4		Creede epithermal vein (25b)
		3			4		Comstock epithermal vein (25c)
		3			4		Sado epithermal vein (25d)
					3		epithermal quartz-alunite Au (25e)
					4		hot-spring Hg (27a)
					3		simple Sb (27d)
				3	4		kuroko massive sulfide (28a)
		3			5		Olympic Dam Cu-U-Au (29b)
					5		sediment-hosted Cu (30b)
					4		sedimentary exhalative Zn-Pb (31a)
		3			3		low-sulfide Au-quartz veins (36a)
		4	4	4			Homestake Au (36b)
		5			5m		unconformity U (37a)
					5m		gold on flat faults (37b)
Chromite							
	5m			3t			Bushveld Cr (2a)
	3			3t			Merensky Reef PGE (2b)
		4		5			dunitic Ni (6b)
	5m			5			podiform Cr (8a)

Mineral	Ore mineral	Gangue mineral	Host rock mineral	Associated rock mineral	Alteration mineral	Weathering mineral	Deposit type and model number
Chromite (cont.)			3	3			Limassol Forest Co-Ni (8c)
	5m			5			Alaskan PGE (9)
		4					diamond pipes (12)
		4					placer PGE-Au (39b)
Chrysotile							
	5						serpentine-hosted asbestos (8d)
	5						carbonate-hosted asbestos (18e)
Cinnabar							
	3t						carbonate-hosted Au (26a)
	5						hot-spring Hg (27a)
	5						Almaden Hg (27b)
	5						silica-carbonate Hg (27c)
Clays (see specific clays below)							Clays are very common minerals in soils and sedimentary rocks as well as in altered rocks associated with ores.
					4		porphyry Cu (17)
					3		porphyry Cu, skarn-related (18a)
					3		Cu skarn (18b)
					3		polymetallic replacement (19a)
					3		porphyry Sn (20a)
					5		porphyry Cu-Au (20c)
					4		porphyry Cu-Mo (21a)
					4		Mo porphyry, low-F (21b)
					5		volcanic-hosted Cu-As-Sb (22a)
					4		polymetallic veins (22c)
					5		Creede epithermal vein (25b)
		3			5		Comstock epithermal vein (25c)
		3			5		Sado epithermal vein (25d)
					5		epithermal quartz-alunite Au (25e)
					5		volcanogenic U (25f)
					3		rhyolite-hosted Sn (25h)
					5		carbonate-hosted Au (26a)
					4		simple Sb (27d)
		5m					phosphate, upwelling type (34c)
		5m					phosphate, warm-current type (34d)
ammonium-bearing					3		epithermal quartz-alunite Au (25e)
					3		carbonate-hosted Au (26a)
					3		sedimentary exhalative Zn-Pb (31a)
illite							
					4		Cyprus massive sulfide (24a)
					4		Creede epithermal vein (25b)
					5		Comstock epithermal vein (25c)
					4		carbonate-hosted Au (26a)
kaolinite and dickite							
						5m	Kaolinite is commonly formed through the reaction of sulfuric acid derived from oxidizing sulfides with felsic rocks.

Mineral	Ore mineral	Gangue mineral	Host rock mineral	Associated rock mineral	Alteration mineral	Weathering mineral	Deposit type and model number
kaolinite and dickite (cont.)							
					4	4	porphyry Cu (17)
					5		porphyry Cu-Au (20c)
					5		porphyry Cu-Mo (21a)
					5		volcanic-hosted Cu-As-Sb (22a)
					3		Comstock epithermal vein (25c)
		3			4		Sado epithermal vein (25d)
					5		epithermal quartz-alunite Au (25e)
					5		volcanogenic U (25f)
					5		epithermal Mn (25g)
					3		rhyolite-hosted Sn (25h)
					2		volcanic-hosted magnetite (25i)
					4		carbonate-hosted Au (32a)
				5			hot-spring Hg (27a)
		4t					southeast Missouri Pb-Zn (32a)
					3		unconformity U (37a)
montmorillonite (smectite)							
					4		Creede epithermal vein (25b)
					4		Comstock epithermal vein (25c)
					4		Sado epithermal vein (25d)
					3		epithermal quartz-alunite Au (25e)
					4		volcanogenic U (25f)
					3		rhyolite-hosted Sn (25h)
					3		carbonate-hosted Au (26a)
					2		kuroko massive sulfide (28a)
sericite							
					4		porphyry Sn (20a)
					4		Sn-polymetallic veins (20b)
					4		porphyry Cu-Mo (21a)
					4		Au-Ag-Te veins (22b)
					5		polymetallic veins (22c)
					4		Besshi massive sulfide (24b)
					4		Creede epithermal vein (25b)
					4		Comstock epithermal vein (25c)
					4		Sado epithermal vein (25d)
					3		volcanic-hosted magnetite (25i)
					4		simple Sb (27d)
					3		kuroko massive sulfide (28a)
					5		Olympic Dam Cu-U-Au (29b)
					3t		sandstone-hosted Pb-Zn (30a)
					4		unconformity U (38d)
Co-bearing arsenides, sulfides and sulfarsenides							
	3t						Stillwater Ni-Cu (1)
	2t						dunitic Ni (6b)
	4t						Limassol Forest Co-Ni (8c)
	2						Cu skarn (18b)
	2						Fe skarn (18d)
	2t						Besshi massive sulfide (24b)

Mineral	Ore mineral	Gangue mineral	Host rock mineral	Associated rock mineral	Alteration mineral	Weathering mineral	Deposit type and model number
Co-bearing arsenides, sulfides and sulfarsenides (cont.)							
	5						Blackbird Co-Cu (24d)
	4t						Olympic Dam Cu-U-Au (29b)
	3						sediment-hosted Cu (30b)
	2t						sedimentary exhalative Zn-Pb (31a)
	2t						southeast Missouri Pb-Zn (32a)
	4t						Kipushi Cu-Pb-Zn (32c)
Coffinite							
	5t						volcanogenic U (25f)
	4t						Olympic Dam Cu-U-Au (29b)
	5t						sandstone U (30c)
	4t						unconformity U (38d)
Copper (native)							
						3	Native copper is a common mineral in oxidized copper ores; it also occurs as a trace deuteric mineral in some mafic rocks.
	4						basaltic Cu (23)
	3t						sediment-hosted Cu (30b)
Cordierite							
				2	2		kuroko massive sulfide (28a)
Corundum							
					1t		porphyry Cu (17)
					2t		epithermal quartz-alunite Au (25e)
Covellite							
							Covellite is a very common supergene mineral in oxidized copper ores.
	3						volcanic-hosted Cu-As-Sb (22a)
	4						epithermal quartz-alunite Au (25e)
	2						volcanic-hosted magnetite (25i)
	2t						southeast Missouri Pb-Zn (32a)
Cubanite							
	4						Duluth Cu-Ni-PGE (5a)
	4						Noril'sk Cu-Ni-PGE (5b)
	2						dunitic Ni (6b)
	3t						Cyprus massive sulfide (24a)
	3t						Besshi massive sulfide (24b)
Diamond							
	5tt						diamond pipes (12)
	5tt						diamond placers (39d)
Diaspore							
	2				2		porphyry Cu (17)
					3		volcanic-hosted Cu-As-Sb (22a)
					3		epithermal quartz-alunite Au (25e)
Diopside (see pyroxenes)							

Mineral	Ore mineral	Gangue mineral	Host rock mineral	Associated rock mineral	Alteration mineral	Weathering mineral	Deposit type and model number
Dumortierite							
					3		volcanic-hosted Cu-As-Sb (22a)
Enargite-luzonite							
	2t						W veins (15a)
	2t						Cu skarn (18b)
	3						polymetallic replacement (19a)
	5						volcanic-hosted Cu-As-Sb (22a)
	5						epithermal quartz-alunite Au (25e)
	1t						sedimentary exhalative Zn-Pb (31a)
	1t						southeast Missouri Pb-Zn (32a)
	2						Kipushi Cu-Pb-Zn (32c)
Epidote							
		3t			3		porphyry Cu (17)
					3		Cu skarn (18b)
		4			4		Fe skarn (18d)
		4					basaltic Cu (23)
					4		volcanic-hosted magnetite (25i)
Ferrimolybdite							
						4t	Ferrimolybdite is a common oxidation product in Mo-bearing ores.
Fletcherite (see sulfospinels)							
Fluorite							
		4					carbonatite (10)
		4t					W skarn (14a)
		4					Sn skarn (14b)
		5					replacement Sn (14c)
		4					W veins (15a)
		4			3		Sn greisen (15c)
		5			3		Climax Mo (16)
		2					Zn-Pb skarn (18c)
		3					replacement Mn (19b)
		3			3		Sn-polymetallic veins (20b)
		4					Au-Ag-Te veins (22b)
		4					polymetallic veins (22c)
		3					hot-spring Au-Ag (25a)
		3					Creede epithermal vein (25b)
		4					Comstock epithermal vein (25c)
		4					volcanogenic U (25f)
		3			3		rhyolite-hosted Sn (25h)
					2		volcanic-hosted magnetite (25i)
		3					carbonate-hosted Au (26a)
		2					simple Sb (27d)
		4t			4t		Olympic Dam Cu-U-Au (29b)
		3t					sandstone-hosted Pb-Zn (30a)
		5					emerald veins (31c)
		2t					Appalachian Zn (32b)
		3t					low-sulfide Au-quartz veins (36a)
		2t					Homestake Au (36b)
		3t					gold on flat faults (37b)

Mineral	Ore mineral	Gangue mineral	Host rock mineral	Associated rock mineral	Alteration mineral	Weathering mineral	Deposit type and model number
Ga minerals							
	2t						Kipushi Cu-Pb-Zn (32c)
Gahnite							
					3		kuroko massive sulfide (28a)
Galena							
	3t						carbonatite (10)
	2						replacement Sn (14c)
	2t						W veins (15a)
	3t						Sn veins (15b)
	3t						Sn greisen (15c)
	2t						porphyry Cu, skarn-related (18a)
	3t						Cu skarn (18b)
	5						Zn-Pb skarn (18c)
	4						polymetallic replacement (19a)
	2t						replacement Mn (19b)
	4t						Sn-polymetallic veins (20b)
	2						porphyry Cu-Mo (21a)
	4						Au-Ag-Te veins (22b)
	4						polymetallic veins (22c)
	3t						Besshi massive sulfide (24b)
	5						Creede epithermal vein (25b)
	4						Comstock epithermal vein (25c)
	4t						Sado epithermal vein (25d)
	4t						epithermal quartz-alunite Au (25e)
	4t						silica-carbonate Hg (27c)
	2t						simple Sb (27d)
	4						kuroko massive sulfide (28a)
	5						sandstone-hosted Pb-Zn (30a)
	2t						sediment-hosted Cu (30b)
	2t						sandstone U (30c)
	5						sedimentary exhalative Zn-Pb (31a)
	3t						bedded barite (31b)
	5						southeast Missouri Pb-Zn (32a)
	2t						Appalachian Zn (32b)
	3						Kipushi Cu-Pb-Zn (32c)
	4t						low-sulfide Au-quartz veins (36a)
	4t						unconformity U-Au (37a)
Garnet							
							Garnet is a common mineral in most skarns, in some regionally metamorphosed rocks, and in some igneous rocks.
almandine							
		3			3		W skarn (14a)
andradite							
		3m			4m		W skarn (14a)
					4m		Cu skarn (18b)
					4		volcanic-hosted magnetite (25i)
(Sn-bearing)							
					3		Sn skarn (14b)
and.-gros.-spess.					4		Zn-Pb skarn (18c)

Mineral	Ore mineral	Gangue mineral	Host rock mineral	Associated rock mineral	Alteration mineral	Weathering mineral	Deposit type and model number
Garnet (cont.)							
grossular-andradite		3m			5m		W skarn (14a)
					3		porphyry Cu, skarn-related (18a)
					4		Zn-Pb skarn (18c)
					5		Fe skarn (18d)
pyrope							
			5				diamond pipes (12)
			4				diamond placers (39d)
spessartine							
					3		Climax Mo (16)
					4		Zn-Pb skarn (18c)
					3		W skarn (14a)
		3					volcanogenic Mn (24c)
uvarovite							
			3				podiform Cr (8a)
Garnierite							
	5					5	lateritic Ni (38a)
Ge minerals							
	2t						sediment-hosted Cu (30b)
	5t						Kipushi Cu-Pb-Zn (32c)
Gold							
	3t						Alaskan PGE (9)
	4t						porphyry Cu (17)
	2t						polymetallic replacement (19a)
	4t						Sn-polymetallic veins (20b)
	5t						porphyry Cu-Au (20c)
	4t						porphyry Cu-Mo (21a)
	4t						volcanic-hosted Cu-As-Sb (22a)
	5t						polymetallic veins (22c)
	4t						Cyprus massive sulfide (24a)
	5t						hot-spring Au-Ag (25a)
	4t						Creede epithermal vein (25b)
	5t						Comstock epithermal vein (25c)
	5t						Sado epithermal vein (25d)
	5t						epithermal quartz-alunite Au (25e)
	3t						volcanogenic U (25f)
	5t						carbonate-hosted Au (26a)
	3t						simple Sb (27d)
	4t						kuroko massive sulfide (28a)
	5t						quartz pebble conglomerate Au-U (29a)
	4t						Olympic Dam Cu-U-Au (29b)
	5t						low-sulfide Au-quartz veins (36a)
	5t						Homestake Au (36b)
	3t						unconformity U-Au (37a)
	5t						gold on flat faults (37b)
	5t						placer Au-PGE (39a)
	4t						placer PGE-Au (39b)
Graphite							
	3t			3t			Merensky reef PGE (2b)
	3			3			Duluth Cu-Ni-PGE (5a)

Mineral	Ore mineral	Gangue mineral	Host rock mineral	Associated rock mineral	Alteration mineral	Weathering mineral	Deposit type and model number
Graphite (cont.)							
	3			3			synorogenic-synvolcanic Ni-Cu (7a)
	2						simple Sb (27d)
				4			kuroko massive sulfide (28a)
Greenockite							
						4t	Greenockite is a common trace mineral developed in the early stages of oxidation of cadmium-bearing sphalerite. Greenockite is rare as a primary mineral.
	2t						sediment-hosted Cu (30b)
Gypsum							
	2t						Appalachian Zn (32b)
	3						phosphate, upwelling type (34c)
			2	2			kuroko massive sulfide (28a)
Halite							
	3						Halite occurs as a daughter mineral in fluid inclusions from many porphyry copper and molybdenum deposits and from a few other deposits.
Hematite							
						5	Hematite is a common weathering product of iron minerals.
		3					Carbonatite (10)
		4			3		Sn veins (15b)
		3					porphyry Cu, skarn-related (18a)
		3					Cu skarn (18b)
		3					polymetallic veins (22c)
					3		basaltic Cu (23)
					3		volcanogenic Mn (24c)
		3					Creede epithermal vein (25b)
		4			2		Comstock epithermal vein (25c)
		5					rhyolite-hosted Sn (25h)
		1t		3			kuroko massive sulfide (28a)
	4m					5m	Algoma Fe (28b)
		5			5		Olympic Dam Cu-U-Au (29b)
				4			sediment-hosted Cu (30b)
				4			sandstone U (30c)
	5m					5m	Superior Fe (34a)
		3			3		unconformity U (37a)
		5					gold on flat faults (37b)
Hematite/Goethite							
						4	Hematite and goethite are common weathering products of iron-bearing sulfides. They are often grouped under the blanket term "limonite."
		4					carbonate-hosted Au (26a)
				5			hot-spring Hg (27a)
		4					phosphate, upwelling type (34c)
in ochre			4		4		Cyprus massive sulfide (24a)

Appendix D. Mineralogical Index--Continued

Mineral	Ore mineral	Gangue mineral	Host rock mineral	Associated rock mineral	Alteration mineral	Weathering mineral	Deposit type and model number
Idocrase					3		Sn skarn (14b)
					2		porphyry Cu, skarn-related (18a)
Illite (see clays)							
Ilmenite							Ilmenite is a common accessory mineral in igneous and metamorphic rocks.
		3		4			Bushveld Cr (2a)
	1	4		5			Bushveld Fe-Ti-V (3)
	5m						anorthosite-Ti (7b)
			5				diamond pipes (12)
		3					replacement Sn (14c)
		4					placer Au-PGE (39a)
		4					placer PGE-Au (39b)
	5						shoreline placer Ti (39c)
		4					diamond placers (39d)
Ilvaite					3		Zn-Pb skarn (18c)
					3		Fe skarn (18d)
Jarosite						4	Jarosite is a common product of the supergene oxidation of iron sulfides.
					4		carbonate-hosted Au (26a)
Jasperoid (includes silicification in carbonate rocks)							Jasperoid here refers to massive silica replacement of pre-existing (usually carbonate) rock.
					5		polymetallic replacement (19a)
					3		polymetallic veins (22c)
					5m		hot-spring Au-Ag (25a)
					5m		silica-carbonate Hg (27c)
					5m		carbonate-hosted Au (26a)
					3m		sedimentary exhalative Zn-Pb (31a)
					3m		southeast Missouri Pb-Zn (32a)
					4m		Appalachian Zn (32b)
					3m		Kipushi Cu-Pb-Zn (32c)
Kaolinite (see clays)							
K-feldspar (also see adularia)							Potassium feldspar is a common mineral in most types of felsic igneous, metamorphic and sedimentary rocks. Several lower temperature hydrothermal deposits contain the adularia variety (separate listing).
		3			4m		W veins (15a)
		4m			5m		Climax Mo (16)
		3			4		porphyry Cu (17)
		2			3		porphyry Cu, skarn-related (18a)
		3			4		porphyry Cu-Au (20c)
		4			4		porphyry Cu-Mo (21a)
		4			4		porphyry Mo, low-F (21b)
		3					basaltic Cu (23)
					4		volcanic-hosted magnetite (25i)

Mineral	Ore mineral	Gangue mineral	Host rock mineral	Associated rock mineral	Alteration mineral	Weathering mineral	Deposit type and model number
Leucoxene		3					volcanogenic U (25f)
Linneaite (also see sulfospinels)							
	2t						dunitic Ni (6b)
	3t						sandstone-hosted Pb-Zn (30a)
	3t						Kipushi Cu-Pb-Zn (32c)
Luzonite (see enargite-luzonite)							
Magnetite							
							Magnetite is a common accessory mineral in many types of rocks.
		4		4			Bushveld Cr (2a)
	5m			5			Bushveld Fe-Ti-V (3)
		4		5			dunitic Ni (6b)
		3		4			synorogenic-synvolcanic Ni-Cu (7a)
	5						anorthosite-Ti (7b)
		3		3			podiform Cr (8a)
		3		4			Limassol Forest Co-Ni (8c)
		4					serpentine-hosted asbestos (8d)
	3m		3	4			Alaskan PGE (9)
	4m						carbonatite (10)
		3		3			W skarn (14a)
		3					Sn skarn (14b)
		3					replacement Sn (14c)
		3			2		porphyry Cu (17)
		3			3		porphyry Cu, skarn-related (18a)
		4					Cu skarn (18b)
		3					Zn-Pb skarn (18c)
	5m						Fe skarn (18d)
		3					Sn-polymetallic veins (20b)
		4			4		porphyry Cu-Au (20c)
		4					Besshi massive sulfide (24b)
		5					Blackbird Co-Cu (24d)
	5m						volcanic-hosted magnetite (25i)
		3		2			kuroko massive sulfide (28a)
	5m						Algoma Fe (28b)
					2		Olympic Dam Cu-U-Au (29b)
		2t					southeast Missouri Pb-Zn (32a)
	5m						Superior Fe (34a)
		4	4	4			Homestake Au (36b)
		5					placer Au-PGE (39a)
		5					placer PGE-Au (39b)
Ti-rich							
	5m						Bushveld Fe-Ti-V (3)
	5m						anorthosite Ti (7b)
	4m						Alaskan PGE (9)
V-rich							
	5m						Bushveld Fe-Ti-V (3)
	4m						Alaskan PGE (9)
Malayaite							
	2t				2		Sn skarn (14b)

Mineral	Ore mineral	Gangue mineral	Host rock mineral	Associated rock mineral	Alteration mineral	Weathering mineral	Deposit type and model number
Marcasite							
						4	Marcasite is common as an incipient stage in the oxidation of pyrrhotite.
		4					polymetallic replacement (19a)
		2					Cyprus massive sulfide (24a)
		5					hot-spring Hg (27a)
		2t					simple Sb (27d)
		3t					sandstone-hosted Pb-Zn (30a)
		3					sandstone U (30c)
		4t					sedimentary exhalative Zn-Pb (31a)
		4					southeast Missouri Pb-Zn (32a)
		4t					Appalachian Zn (32b)
		2					Kipushi Cu-Pb-Zn (32c)
Melnikovite							
		2t					sedimentary exhalative Zn-Pb (31a)
Mercury (native)							
	4t						hot-spring Hg (27a)
	4t						Almaden Hg (27b)
	4t						silica-carbonate Hg (27c)
Millerite							
	3t						Noril'sk Cu-Ni-PGE (5b)
	2t						sandstone-hosted Pb-Zn (30a)
	2t						sedimentary exhalative Zn-Pb (31a)
	2t						southeast Missouri Pb-Zn (32a)
Mn oxides and silicates							
							These are common oxidation products of manganese-bearing ores.
						5m	replacement Mn (19b)
				3			Cyprus massive sulfide (24a)
	5m						volcanogenic Mn (24c)
	4m					5m	sedimentary Mn (34b)
Molybdenite							
	4t						carbonatite (10)
	4t						W skarn (14a)
	5t						W veins (15a)
	4t						Sn veins (15b)
	5t						Sn greisen (15c)
	5						Climax Mo (16)
	4						porphyry Cu (17)
	3t						porphyry Cu, skarn-related (18a)
	3t						Cu skarn (18b)
	3t						Sn-polymetallic veins (20b)
	5t						porphyry Cu-Mo (21a)
	5t						porphyry Mo, low-F (21b)
	4t						volcanogenic U (25f)
	2t						sandstone U (30c)
	2t						sedimentary exhalative Zn-Pb (31a)
	2t						Kipushi Cu-Pb-Zn (32c)
	2t						low-sulfide Au-quartz veins (36a)
	3t						Homestake Au (36b)

Mineral	Ore mineral	Gangue mineral	Host rock mineral	Associated rock mineral	Alteration mineral	Weathering mineral	Deposit type and model number
Muscovite							Muscovite is a common mineral in igneous and metamorphic rocks. It also occurs as in some felsic skarns, in veins, and as the fine-grained, wallrock alteration known as sericite (see clays).
		4m		5	5m		Sn skarn (14b)
		4		4	4		replacement Sn (14c)
		3			5m		W veins (15a)
		4m			5m		Sn veins (15b)
		2			5m		Sn greisen (15c)
					4m		Climax Mo (16)
		2m			3m		porphyry Cu (17)
					4		porphyry Cu, skarn-related (18a)
					3		southeast Missouri Pb-Zn (32a)
Cr-rich							
					3		low-sulfide Au-quartz veins (36a)
					3		Homestake Au (36b)
V-rich							
		3					Au-Ag-Te veins (22b)
					4		sandstone U (30c)
Ni silicates							
	5					5	lateritic Ni (38a)
Ni sulfides, arsenides, and sulfarsenides (see also pentlandite)							
	5						dunitic Ni (6b)
	5						Limassol Forest Co-Ni (8c)
	3t						sandstone-hosted Pb-Zn (30a)
	4t						southeast Missouri Pb-Zn (32a)
	3t						unconformity U (37a)
Niobium minerals							
	4						carbonatite (10)
Olivine							
			4m				Olivine is a common mineral in mafic igneous rocks (including those associated with models 1 through 12).
Organic matter							Organic matter is found in many sedimentary and a few metamorphic rocks. The ore types noted here are those for which some relationship is probable.
		5			5		carbonate-hosted Au (26a)
		5					silica-carbonate Hg (27c)
				3			kuroko massive sulfide (28a)
			4				quartz pebble conglomerate Au-U (29a)

Mineral	Ore mineral	Gangue mineral	Host rock mineral	Associated rock mineral	Alteration mineral	Weathering mineral	Deposit type and model number
Organic matter							
		4t	4t				sandstone-hosted Pb-Zn (30a)
			4				sediment-hosted Cu (30b)
			5				sandstone U (30c)
			4	4			sedimentary exhalative Zn-Pb (31a)
		3	2				southeast Missouri Pb-Zn (32a)
		4t	4				Kipushi Cu-Pb-Zn (32c)
		2t					unconformity U-Au (37a)
Orpiment							
		3					volcanogenic U (25f)
		5					carbonate-hosted Au (26a)
Pentlandite							
	5						Stillwater Ni-Cu (1)
	4t						Bushveld Cr (2a)
	5t						Merensky Reef PGE (2b)
	5						Duluth Cu-Ni-PGE (5a)
	5						Noril'sk Cu-Ni-PGE (5b)
	5						komatiitic Ni-Cu (6a)
	5						dunitic Ni (6b)
	5						synorogenic-synvolcanic Ni-Cu (7a)
	3						Limassol Forest Co-Ni (8c)
	2t						Alaskan PGE (9)
PGE minerals							
	5t						Stillwater Ni-Cu (1)
	4t						Bushveld Cr (2a)
	5t						Merensky Reef PGE (2b)
	5t						Duluth Cu-Ni-PGE (5a)
	5t						Noril'sk Cu-Ni-PGE (5b)
	4t						komatiitic Ni-Cu (6a)
	3t						podiform Cr (8a)
	5t						Alaskan PGE (9)
	4t						quartz pebble conglomerate Au-U (29a)
	2t						placer Au-PGE (39a)
	5t						placer PGE-Au (39b)
Phlogopite							
			4				carbonatite (10)
			5				diamond pipes (12)
		4					diamond placers (39d)
Phosphates							
	1m	5					carbonatite (10)
	5m					5m	phosphate, upwelling type (34c)
	5m					5m	phosphate, warm-current type (34d)
Plagioclase (also see albite)							
			4m		1		Plagioclase feldspar is a common mineral in igneous and metamorphic rocks associated with deposit types 1 through 10.
		5			5		emerald veins (31c)

Mineral	Ore mineral	Gangue mineral	Host rock mineral	Associated rock mineral	Alteration mineral	Weathering mineral	Deposit type and model number
Pyrite							
							Pyrite is a very common and abundant mineral in many ore deposits and as the product of sulfidic alteration of Fe-bearing wallrocks.
				4			Duluth Cu-Ni-PGE (5a)
		3		4			Noril'sk Cu-Ni-PGE (5b)
		4					komatiitic Ni-Cu (6a)
		4					dunitic Ni (6b)
		3					synorogenic-synvolcanic Ni-Cu (7a)
		4					Limassol Forest Co-Ni (8c)
		4					carbonatite (10)
		3			4		W skarn (14a)
		4			3		Sn skarn (14b)
		3					replacement Sn (14c)
		4			4		W veins (15a)
		5					Sn veins (15b)
		4					Sn greisen (15c)
		4					Climax Mo (16)
		5			4		porphyry Cu (17)
		4			2		porphyry Cu, skarn-related (18a)
		5					Cu skarn (18b)
		4					Zn-Pb skarn (18c)
		4					Fe skarn (18d)
		5			3		polymetallic replacement (19a)
		4					replacement Mn (19b)
		5					porphyry Sn (20a)
		5					Sn-polymetallic veins (20b)
					3		porphyry Cu-Au (20c)
		5			5		porphyry Cu-Mo (21a)
		5			5		porphyry Mo, low-F (21b)
		5			5		volcanic-hosted Cu-As-Sb (22a)
		5			5		Au-Ag-Te veins (22b)
		5			5		polymetallic veins (22c)
			3				basaltic Cu (23)
	1m	5m					Cyprus massive sulfide (24a)
		5m					Besshi massive sulfide (24b)
		5					Blackbird Co-Cu (24d)
		5					hot-spring Au-Ag (25a)
		5			5		Creede epithermal vein (25b)
		5			5		Comstock epithermal vein (25c)
		4					Sado epithermal vein (25d)
		5			5		epithermal quartz-alunite Au (25e)
		5					volcanogenic U (25f)
		2					volcanic-hosted magnetite (25i)
		5					carbonate-hosted Au (26a)
		5					hot-spring Hg (27a)
		5					silica-carbonate Hg (27c)
		4					simple Sb (27d)
		5m			5		kuroko massive sulfide (28a)
			4				quartz pebble conglomerate Au-U (29a)
		4t					sandstone-hosted Pb-Zn (30a)
		4					sediment-hosted Cu (30b)
		5					sandstone U (30c)
		4m					sedimentary exhalative Zn-Pb (31a)
		3t					bedded barite (31b)
		5					emerald veins (31c)
		5					southeast Missouri Pb-Zn (32a)

Mineral	Ore mineral	Gangue mineral	Host rock mineral	Associated rock mineral	Alteration mineral	Weathering mineral	Deposit type and model number
Pyrite (cont.)							
		4					Appalachian Zn (32b)
		5					Kipushi Cu-Pb-Zn (32c)
		4t					phosphate, upwelling type (34c)
		5					low-sulfide Au-quartz veins (36a)
		5					Homestake Au (36b)
		3					unconformity U (37a)
Pyrophyllite							
					2		porphyry Cu (17)
					2		porphyry Cu-Mo (21a)
					3		volcanic-hosted Cu-As-Sb (22a)
					2		hot-spring Au-Ag (25a)
					4		epithermal quartz-alunite Au (25e)
Pyroxene							
							Pyroxene is a common rock-forming mineral in mafic igneous rocks and in metamorphic rocks associated with some deposit types 1 through 10.
		4					carbonatite (10)
					5		Cu skarn (18b)
					5		Zn-Pb skarn (18c)
					5m		Fe skarn (18d)
		2					shoreline placer Ti (39c)
diopside							
			4				diamond pipes (12)
		4m			5m		W skarn (14a)
					3		porphyry Cu, skarn-related (18a)
					4m		Cu skarn (18b)
					5m		Fe skarn (18d)
					4		volcanic-hosted magnetite (25i)
hedenbergite							
		4m			5m		W skarn (14a)
					5m		Fe skarn (18d)
					5		Zn-Pb skarn (18c)
Mn-rich							
		2			4		Zn-Pb skarn (18c)
Pyrrhotite							
		5m					Stillwater Ni-Cu (1)
		5t					Bushveld Cr (2a)
		5					Merensky Reef PGE (2b)
		3t					Bushveld Fe-Ti-V (3)
		5m		3			Duluth Cu-Ni-PGE (5a)
		5m		3			Noril'sk Cu-Ni-PGE (5b)
		5m					komatiitic Ni-Cu (6a)
		5m					dunitic Ni (6b)
		5					synorogenic-synvolcanic Ni-Cu (7a)
		5					Limassol Forest Co-Ni (8c)
		3					Alaskan PGE (9)
		4					carbonatite (10)
		4					W skarn (14a)
		4					Sn skarn (14b)
		4m					replacement Sn (14c)

Appendix D. Mineralogical Index--Continued

Mineral	Ore mineral	Gangue mineral	Host rock mineral	Associated rock mineral	Alteration mineral	Weathering mineral	Deposit type and model number
Pyrrhotite (cont.)							
		3					W veins (15a)
		3					porphyry Cu, skarn-related (18a)
		3					Cu skarn (18b)
		4					Zn-Pb skarn (18c)
		4					Fe skarn (18d)
		1					polymetallic replacement (19a)
		3					porphyry Sn (20a)
		5					Sn-polymetallic veins (20b)
		3m					Cyprus massive sulfide (24a)
	1m	4m					Besshi massive sulfide (24b)
		5					Blackbird Co-Cu (24d)
		3m					kuroko massive sulfide (28a)
		2t					sandstone-hosted Pb-Zn (30a)
		3m					sedimentary exhalative Zn-Pb (31a)
		1t					southeast Missouri Pb-Zn (32a)
		3					low-sulfide Au-quartz veins (36a)
		4					Homestake Au (36b)
Quartz							
		4m	4m	4m	3m	3m	Quartz is almost universal in hydrothermal ores and a common and abundant constituent of most rocks.
Rare earth-bearing minerals							
	4						carbonatite (10)
					3t		W veins (15a)
		2t					volcanogenic U (25f)
	5t						Olympic Dam Cu-U-Au (29b)
		5t					emerald veins (31c)
	3						shoreline placer Ti (39c)
Realgar							
		4					hot-spring Au-Ag (25a)
		3t					volcanogenic U (25f)
		5					carbonate-hosted Au (26a)
		1t					Homestake Au (36b)
Rhodonite							
					3		Climax Mo (16)
	3						replacement Mn (19b)
					3		Zn-Pb skarn (18c)
	4						volcanogenic Mn (24c)
Rutile							
	2						anorthosite Ti (7b)
		2					carbonatite (10)
					4t		porphyry Cu (17)
					4t		porphyry Cu-Mo (21a)
					4t		Olympic Dam Cu-U-Au (29b)
		5t					emerald veins (31c)
	4						shoreline placer Ti (39c)
Scapolite							
					3		volcanic-hosted magnetite (25i)

Mineral	Ore mineral	Gangue mineral	Host rock mineral	Associated rock mineral	Alteration mineral	Weathering mineral	Deposit type and model number
Scheelite							
	5						W skarn (14a)
	4t						Sn skarn (14b)
	4t						W veins (15a)
	3t						Sn veins (15b)
	2t						porphyry Cu, skarn-related (18a)
	2t						Zn-Pb skarn (18c)
	3t						Sn-polymetallic veins (20b)
	4t						porphyry Mo, low-F (21b)
	3t						simple Sb (27d)
	3t						low-sulfide Au-quartz veins (36a)
	3t						Homestake Au (36b)
Selenides							
	2t						hot-spring Au-Ag (25a)
	3t						Comstock epithermal vein (25c)
	2t						sandstone U (30c)
Serpentine							
			4m	4m			Serpentine minerals are the common products of the low-temperature metamorphism of ultramafic and mafic rocks.
					5m		serpentine-hosted asbestos (8d)
		3					carbonatite (10)
			5m				diamond pipes (12)
					5m		carbonate-hosted asbestos (18e)
			5m				silica-carbonate Hg (27c)
					2		simple Sb (27d)
Silver (native)							
							Native silver is a common weathering product of silver-bearing sulfide ores.
	4t						basaltic Cu (23)
	2t					3t	Creede epithermal vein (25b)
	4t						Olympic Dam Cu-U-Au (29b)
	4t						sediment-hosted Cu (30b)
Silver sulfides and sulfosalts							
	4t					4t	Argentite and a wide variety of silver sulfosalts are common products of the oxidation and supergene enrichment of silver-bearing sulfide ores.
	1t						porphyry Cu-Mo (21a)
	4t						porphyry Mo, low-F (21b)
	4t						polymetallic veins (22c)
	5t						Creede epithermal vein (25b)
	4t						Comstock epithermal vein (25c)
	5t						Sado epithermal vein (25d)
	5t						epithermal quartz-alunite Au (25e)
	2t						simple Sb (27d)
	4t						kuroko massive sulfide (28a)
	2t						sandstone-hosted Pb-Zn (30a)
	3t						sedimentary exhalative Zn-Pb (31a)

Mineral	Ore mineral	Gangue mineral	Host rock mineral	Associated rock mineral	Alteration mineral	Weathering mineral	Deposit type and model number
Spessartite see Garnet							
Sphalerite							
	4t						carbonatite (10)
	4t						W skarn (14a)
	4t						Sn skarn (14b)
	3t						replacement Sn (14c)
	4t						W veins (15a)
	3t						Sn veins (15b)
	3t						Sn greisen (15c)
	3						porphyry Cu, skarn-related (18a)
	4						Cu skarn (18b)
	5						Zn-Pb skarn (18c)
	5						polymetallic replacement (19a)
	3t						replacement Mn (19b)
	4						porphyry Sn (20a)
	5						Sn-polymetallic veins (20b)
	3						porphyry Cu-Mo (21a)
	3						volcanic-hosted Cu-As-Sb (22a)
	3						Au-Ag-Te veins (22b)
	5						polymetallic veins (22c)
	3t						basaltic Cu (23)
	4						Cyprus massive sulfide (24a)
	5						Besshi massive sulfide (24b)
	4t						hot-spring Au-Ag (25a)
	5						Creede epithermal vein (25b)
	4						Comstock epithermal vein (25c)
	4t						Sado epithermal vein (25d)
	4t						epithermal quartz-alunite Au (25e)
	4t						silica-carbonate Hg (27c)
	3t						simple Sb (27d)
	5						kuroko massive sulfide (28a)
	5						sandstone-hosted Pb-Zn (30a)
	3t						sediment-hosted Cu (30b)
	2t						sandstone U (30c)
	5m						sedimentary exhalative Zn-Pb (31a)
	3t						bedded barite (31b)
	5						southeast Missouri Pb-Zn (32a)
	5						Appalachian Zn (32b)
	4						Kipushi Cu-Pb-Zn (32c)
	3						Homestake Au (36b)
	3t						unconformity U-Au (37a)
Sphene							
		3					carbonatite (10)
					2t		porphyry Cu (17)
		5t					volcanic-hosted magnetite (25i)
Spinel							
		4					carbonatite (10)
Stannite							
	3t						replacement Sn (14c)
	4t						Sn veins (15b)
	2t						Zn-Pb skarn (18c)
	4t						porphyry Sn (20a)
	4t						Sn polymetallic veins (20b)

Mineral	Ore mineral	Gangue mineral	Host rock mineral	Associated rock mineral	Alteration mineral	Weathering mineral	Deposit type and model number
Stibnite							
	3						Au-Ag-Te veins (22b)
	3t						hot-spring Au-Ag (25a)
	2t						Creede epithermal vein (25b)
	3t						carbonate-hosted Au (26a)
	4t						silica-carbonate Hg (27c)
	5						simple Sb (27d)
	2t						Homestake Au (36b)
Strontianite							
	3						carbonatite (10)
Sulfosalts							
							The term "sulfosalts" is here used to represent all of the minerals that combine silver or base metal sulfides with As- Sb- or Bi-sulfides; enargite-luzonite and tetrahedrite-tennantite fall within this broad usage, but the Fe, Co and Ni sulfarsenides and sulfantimonides do not.
	4t						replacement Sn (14c)
	4t						W veins (15a)
	3t						Sn greisen (15c)
	3t						porphyry Cu, skarn-related (18a)
	4t						Cu skarn (18b)
	5t						polymetallic replacement (19a)
	4t						Sn-polymetallic veins (20b)
	3t						porphyry Cu-Mo (21a)
	3t						porphyry Mo, low-F (21b)
	5						volcanic-hosted Cu-As-Sb (22a)
	4t						Au-Ag-Te veins (22b)
	4t						polymetallic veins (22c)
	3t						Besshi massive sulfide (24b)
	5t						Creede epithermal vein (25b)
	5t						Comstock epithermal vein (25c)
	5t						Sado epithermal vein (25d)
	5t						epithermal quartz-alunite Au (25e)
	4t						simple Sb (27d)
	5t						kuroko massive sulfide (28a)
	4t						sandstone-hosted Pb-Zn (30a)
	4t						sedimentary exhalative Zn-Pb (31a)
	1t						southeast Missouri Pb-Zn (32a)
	5						Kipushi Cu-Pb-Zn (32c)
	3t						Homestake Au (36b)
	3t						unconformity U (37a)
Sulfospinels (also see carrollite, linneaite)							
	2t						dunitic Ni (6b)
	3t						Olympic Dam Cu-U-Au (29b)
	3t						sandstone-hosted Pb-Zn (30a)
	3t						sediment-hosted Cu (30b)
	2t						southeast Missouri Pb-Zn (32a)
	3t						Kipushi Cu-Pb-Zn (32c)

Mineral	Ore mineral	Gangue mineral	Host rock mineral	Associated rock mineral	Alteration mineral	Weathering mineral	Deposit type and model number
Sulfur (native)							
						2t	Native sulfur is sometimes found as an intermediate stage in the oxidation of sulfide ores.
	2	3			2		epithermal quartz-alunite Au (25e)
		4					hot-spring Hg (27a)
Sylvanite (see tellurides)							
Talc							
		3					serpentine-hosted asbestos (8d)
Tantalum minerals							
	3t						carbonatite (10)
Tellurides							
	5t						Au-Ag-Te veins (22b)
	3t						hot-spring Au-Ag (25a)
	3t						Creede epithermal vein (25b)
	3t						Comstock epithermal vein (25c)
	4t						Sado epithermal vein (25d)
	2t						simple Sb (27d)
	3t						low-sulfide Au-quartz veins (36a)
	2t						unconformity U-Au (37a)
	2t						polymetallic replacement (19a)
	2t						porphyry Cu-Au (20c)
	5t						Au-Ag-Te veins (22b)
	4t						hot-spring Au-Ag (25a)
	3t						Comstock epithermal vein (25c)
	4t						Sado epithermal vein (25d)
	3t						epithermal quartz-alunite Au (25e)
	2t						simple Sb (27d)
Tennantite-tetrahedrite							
	3t						replacement Sn (14c)
	3t						W veins (15a)
	3t						porphyry Cu, skarn-related (18a)
	4t						Cu skarn (18b)
	4						polymetallic replacement (19a)
	3t						porphyry Cu-Mo (21a)
	4t						porphyry Mo, low-F (21b)
	4						volcanic-hosted Cu-As-Sb (22a)
	4						Au-Ag-Te veins (22b)
	4						polymetallic veins (22c)
	3t						Besshi massive sulfide (24b)
	5t						Creede epithermal vein (25b)
	4t						Sado epithermal vein (25d)
	3t						simple Sb (27d)
	4t						kuroko massive sulfide (28a)
	3t						sandstone-hosted Pb-Zn (30a)
	3t						sedimentary exhalative Zn-Pb (31a)
	2t						southeast Missouri Pb-Zn (32a)
	5						Kipushi Cu-Pb-Zn (32c)
	3t						Homestake Au (36b)

Mineral	Ore mineral	Gangue mineral	Host rock mineral	Associated rock mineral	Alteration mineral	Weathering mineral	Deposit type and model number
Topaz							
	4						Sn skarn (14b)
	3			3			replacement Sn (14c)
	2				3		Sn veins (15b)
					4		Sn greisen (15c)
	3						Climax Mo (16)
Tourmaline							
		4					Sn skarn (14b)
		3		3			replacement Sn (14c)
		3			3		W veins (15a)
		4			4		Sn veins (15b)
		4m			4m		Sn greisen (15c)
		2			2		porphyry Cu (17)
		4			3		porphyry Sn (20a)
		4					Sn-polymetallic veins (20b)
		3			3		volcanic-hosted Cu-As-Sb (22a)
			3				Besshi massive sulfide (24b)
		5					Blackbird Co-Cu (24d)
					3		volcanic-hosted magnetite (25i)
				3			kuroko massive sulfide (28a)
					2		Olympic Dam Cu-U-Au (29b)
				3			sedimentary exhalative Zn-Pb (31a)
		3	3	3			Homestake Au (36b)
Tungstenite							
	2t						Kipushi Cu-Pb-Zn (32c)
Ulvospinel							
	3						anorthosite-Ti (7b)
Uraninite							
crystalline							
	4t						quartz pebble conglomerate Au-U (29a)
	5t						unconformity U (37a)
pitchblende							
	5t						volcanogenic U (25f)
	5t						sandstone U (30c)
	5t						unconformity U (37a)
V-oxides							
	4t					4t	sandstone U (30c)
Valleriite							
	3t						Noril'sk Cu-Ni-PGE (5b)
	2t						Besshi massive sulfide (24b)
	2t						sedimentary exhalative Zn-Pb (31a)
Vanadates							
						4	sandstone U (30c)
Witherite							
		3t					bedded barite (31b)

Mineral	Ore mineral	Gangue mineral	Host rock mineral	Associated rock mineral	Alteration mineral	Weathering mineral	Deposit type and model number
Wolframite							
	3t						W skarn (14a)
	5						W veins (15a)
	4						Sn veins (15b)
	3						Sn greisen (15c)
	3t						Climax Mo (16)
	4						Sn-polymetallic veins (20b)
	3t						epithermal quartz-alunite Au (25e)
	2t						simple Sb (27d)
	2t						Homestake Au (36b)
Wollastonite							
					4m		W skarn (14a)
					4		porphyry Cu, skarn-related (18a)
					4		Cu skarn (18b)
Zeolites							
		4			4		basaltic Cu (23)
		5					epithermal Mn (25g)
		4					rhyolite-hosted Sn (25h)
					4		hot-spring Hg (27a)
				2			kuroko massive sulfide (28a)
		3					phosphate, warm-current type (34d)
Zinnwaldite							
		2t			2		W veins (15a)
Zircon							
		3t					anorthosite Ti (7b)
		3t					carbonatite (10)
	4t						shoreline placer Ti (39c)
Zunyite							
					3		epithermal quartz-alunite Au (25e)

Appendix E. Index of Deposits

Name	Country	Model No
Aarja	OMAN	24a
Abbott	USCA	27c
Abdasht	IRAN	8a
Aberfoyle	AUTS	15b
Abeshiro (Sakura)	JAPN	28a
Abitibi	CNQU	8d
Abra Negra	MXCO	25g
Abruzzi	ITLY	38c
Abu Tartur	EGPT	34c
Abuhemsin (Abiulya)	TRKY	24c
Abundancia	TRKY	24c
Ace of Spades	USCA	8a
Aceitillar	DMRP	38c
Achilles	NZLD	36a
Adaevka	URRS	18d
Adak-Lindskold	SWDN	28a
Adana-Saimbeyli	TRKY	38c
Adanac (Ruby Creek)	CNBC	21b
Adelong Creek	AUNS	39a
Adobe Canyon	USCA	8a
Adventure Creek	AUQL	15b
Advocate	CNNF	8d
Aetna	USCA	27c
Affoh	GHNA	38b
Afterthought	USCA	28a
Afton	CNBC	20c
Agalteca	HNDR	18d
Agassiz	CNMN	36b
Agnes Waters	AUQL	39c
Agnew (Perseverance)	AUWA	6b
Agnico Eagle	CNQU	36b
Agordo-Brosso	ITLY	18b
Agrokipia	CYPS	24a
Aguilar	AGTN	18c
Aijala	FNLD	28a
Ain Mokra	ALGR	18d
Ain Oudrer	ALGR	18d
Ajax (Monte Carlo)	CNBC	17
Ajax	USOR	8a
Ajax (Dak River)	CNBC	21b
Ajo	USAZ	17
Akarca	TRKY	8a
Akarsen	TRKY	28a
Akashat	IRAQ	34c
Akatani	JAPN	18d
Akcabuk	TRKY	8a
Akcakilise Topkirazlar	TRKY	24c
Akenobe	JAPN	20b
Akeski	TRKY	38c
Akinokawa (Onishi)	JAPN	24b
Akkoy	TRKY	28a
Akkoya	TRKY	8a
Akoluuk	TRKY	24c
Akseki Gokceovacik	TRKY	24c
Aktyubinsk	URRS	34c
Akulla Vastra	SWDN	28a
Akviran	TRKY	34b
Al	AUVT	36a
Al-Hasa/Oatrana	JRDN	34c
Alabama bauxite	USAL	38c
Alabama Shoot	AUVT	36a
Alagada	PORT	18d
Alaska	ZIMB	30b
Albert	CNQU	28a
Albert Lea Group	USAZ	22c
Albino	CNON	36b
Aldermac	CNQU	28a
Aleksandrovskii Log	URRS	39b
Aleshinka	URRS	18d
Alex Hill-Mad Kiss	GUYN	36a
Alexii-Olginsky Log	URRS	39b
Alice	USCA	36a
Alice Louise	NCAL	8a
Alice Mine	USCA	8a
Allan (Johnson)	USCA	8a
Allard River	CNQU	28a
Alleghany	USCA	36a
Alligator Ridge	USNV	26a
Alma (Mills) Placer	USCO	39a
Almaden	SPAN	27b
Almagrera-Lapilla	SPAN	28a
Almeirim	BRZL	38b
Alpha	NCAL	8a
Alpine-Lafatsch	ASTR-ITLY-YUGO	32a,32b
Alta Hill	USCA	8a
Altamira-Frontera	VNZL	34a,28b
Altenberg	GRME	15c
Althouse	USOR	8a
Altindag	TRKY	8a
Alto	USCA	36a
Altoona-Elkhor-Mercury	CNBC	22c
Alumen	MZMB	38b
Alyce and Blue Jay	USCA	8a
Am	CNBC	17
Amacan	PLPN	17
Amador City	USCA	36a
Amapa	BRZL	34a,28b
Amax	CNMN	6b
Amazon	USMT	22c
Ambatory	MDGS	38a
Ambelikou	CYPS	24a
American Asbestos	USCA	8a
American Bar	USCA	36a
American Fork	USUT	19a
Amigos	MXCO	25h
Ammeberg	SWDN	18c
Amores	CUBA	8a
Amphoe Phra Saeong	THLD	27d
Ample	CNBC	36a
Amulet	CNQU	28a
An-shan	CINA	34a,28b
Ana Yatak-Ergani	TRKY	24a
Analavory	MDGS	38b
Analumay	MDGS	38a
Anantagiri	INDA	38b
Anayatak-Cakmakkaya	TRKY	28a
Anchor	AUTS	15c
Andacolla	CILE	17
Anderson Lake	CNMN	28a
Andhra Pradesh	INDA	34b
Andizlik	TRKY	8a
Anduramba	AUQL	21b
Angelo	AUWA	28a

Name	Country	Model No
Angels-Carson	USCA	36a
Anianowsky Lojok	URRS	39b
Animas	USCO	25b
Ankerite-Aunor-Delnite	CNON	36b
Ann	CNBC	17
Ann Mason	USNV	17
Anna Madeleine	NCAL	8a
Anne	NRWY	28a
Ansongo	MALI	34b
Anti Axis	USCA	8a
Antimonial	USNV	27d
Antimony Canyon	USUT	27d
Antimony King	USNV	27d
Antimony Lode	USNV	27d
Antimony Mines	USMT	27d
Antimony Ridge	USID	27d
Antler	USAZ	28a
Antoine	CNBC	22c
Antonio	CUBA	24c
Apex (Del Norte Co.)	USCA	8a
Apex (El Dorado Co.)	USCA	8a
Apex Antimony	USNV	27d
Apex Mines	USUT	32c
Apliki	CYPS	24a
Applegate	USOR	8a
Arad	ISRL	34c
Araluen Valley	AUNS	39a
Aravaipa	USAZ	18c
Araxa	BRZL	10
Archer	AUTS	15c
Arctic	USAK	28a
Arctic Chief	CNYT	18b
Argo	USCA	36a
Argonaut	CNBC	18d
Arguilillas	MXCO	25h
Argus Hill	AUVT	36a
Arie	PPNG	17
Arinteiro	SPAN	24a
Arkhangelskii Log	URRS	39b
Arlington	CNBC	22c
Armour Group	USAZ	25g
Armstrong (A)	CNNB	28a
Arnold Hill	USNY	25i
Arrieros	MXCO	25h
Arrowhead	CNQU	36b
Arroyo Durango	MXCO	25h
As Safra	SAAR	28a
Asafo	GHNA	38b
Asagi Zorkum	TRKY	8a
Asakawa	JAPN	24b
Asbestos Hill	CNQU	8d
Asbestos Island	CNQU	8d
Asen	SWDN	28a
Ash Shizm	SAAR	28a
Ashio	JAPN	20b
Ashland	USOR	36a
Ashley	CNON	36b
Associated Chromite	USOR	8a
Asvan	TRKY	18d
Atacocha	PERU	19a
Atenguillo	MXCO	25g
Atlanta	USNV	26a
Atlas	PLPN	20c
Atlas	USAZ	19b
Atlas	USCA	36a
Auerbach	URUR	18d
Augusto Luis & others	CUBA	24c
Aurora	USNV	25c
Aurora	USOR	25f
Aurukum	AUQL	38b
Austin Brook	CNNB	28a
Austinville	USVA	32a,32b
Aventura	CUBA	8a
Avispa	CUBA	24c
Avoca	IRLD	28a
Avsar	TRKY	8a
Awaso	GHNA	38b
Axe	CNBC	17
Aya Aya	PLPN	17
Ayazmant	TRKY	18d
Ayekoye	GNEA	38b
Aznacollar	SPAN	28a
Azul-Carajas	BRZL	34b
B and B	USNV	27a
B. C.	CNBC	18b
B. C. Moly	CNBC	21b
Babcock	USOR	8a
Babyfoot	USOR	8a
Badger	USAZ	22c
Bagacay	PLPN	28a
Bagby	USCA	36a
Bagby Valley	USCA	36a
Bagdad	USAZ	17
Baghain	IRAN	18d
Bagin	TRKY	8a
Bagirsakdire	TRKY	8a
Bailadila	INDA	34a,28b
Bailadores	VNZL	28a
Bailey	CNYT	14a
Baisoara	RMNA	18d
Bajo	JAPN	25d
Bakerville	AUQL	15b
Bakhuis Mountains	SRNM	38b
Balaklala	USCA	28a
Balcicakiri	TRKY	8a
Bald Mountain	USME	28a
Baldwin	USNV	27a
Balea-Sitaouma	MALI	38b
Ballarat	AUVT	36a
Ballynoe	IRLD	31b
Balmat	USNY	31a
Baltic and Revenue	USCO	22c
Baltimore	USMT	22c
Baluba	ZMBA	30b
Bama	SPAN	24a
Bamble	NRWY	7a
Bamboutos	CMRN	38b
Ban Ban	AUQU	18c
Bandgan	PKTN	28a
Bangam	CMRN	38b
Bankfield-Tombill	CNON	36b
Bannack	USMT	39a
Barao de Cocais-Caete	BRZL	38b
Barbara-Surprise	AUWA	36b
Barber-Larder	CNON	36b
Barberton	SAFR	36b
Barite (Mouse)	CNYT	31b
Barite Mtn.	CNYT	31b

Name	Country	Model No	Name	Country	Model No
Barite Valley	SAFR	31b	Bethlehem	CNBC	21a
Barlo	PLPN	24a	Betts Cove	CNNF	24a
Baroi	INDA	31a	Bezkere-Bulurlii	TRKY	8a
Barra do Pirai	BRZL	38b	Bhavnagar	INDA	38b
Barrandum	USCA	36a	Bhimatangar	INDA	38a
Barrett	USME	28a	Bicholim	INDA	34a,28b
Barrington Lake	CNMN	28a	Bicir-Cakir	TRKY	8a
Barro Alto	BRZL	38a	Bicir-Gul	TRKY	8a
Barry Hollinger	CNON	36b	Bidgood-Modfatt-Hall	CNON	36b
Barrytown	NZLD	39c	Bidjovagge	NRWY	28a
Barvallee-Mogador	CNQU	28a	Bielgorsky Log	URRS	39b
Basay	PLPN	17	Big Badja River	AUNS	39a
Baskoy	TRKY	28a	Big Bear	USOR	8a
Basset	GRBR	15b	Big Bell	AUWA	36b
Bathurst-Norsemines	CNNT	28a	Big Ben	USMT	16
Bati	TRKY	8a	Big Bend	USCA	28a
Bati-Taban	TRKY	8a	Big Bend	USCA	8a
Batikef	TRKY	8a	Big Chief	USOR	8a
Baw Hin Khao	THLD	31b	Big Cottonwood	USUT	19a
Bawdin	BRMA	28a	Big Dipper	USCA	8a
Bayda	OMAN	24a	Big Four	USFL	34d
Bear	USNV	17	Big Four	USMT	22c
Bear Mountain	USNM	19b	Big Four	USOR	8a
Bear Valley	USCA	36a	Big Hill	USME	28a
Beat	USCA	8a	Big Horn (Yarrow Ck)	CNAL	30b
Beatson	USAK	28a	Big Mike	USNV	24a
Beaver Dam	CNNS	36a	Big Oak Flat	USCA	36a
Beceite-Fuendesplada	SPAN	38c	Big Onion	CNBC	17
Beck	USCA	18d	Big Pine Claim	USCA	8a
Bedford Hill	CNQU	28a	Big Syncline	SAFR	31a
Beersheva	ISRL	34c	Big Yank No. 1	USOR	8a
Belden	USCA	36a	Bihar	INDA	38b
Bell	CNBC	22c	Bilaspur	INDA	38b
Bell	USNV	19a	Binder No. 1	USCA	8a
Bell Allard	CNQU	28a	Bingham	USUT	17
Bell Boy-Niles-Towsley	USMT	22c	Binghampton	USAZ	28a
Bell Channel	CNQU	28a	Bingo	ZIRE	10
Bell Copper	CNBC	20c	Bintan Island	INDS	38b
Bell Molybdenum	CNBC	21b	Birch Lake	CNSK	28a
Bell and California	USCO	22c	Birch Tree	CNMN	6b
Bella Oak	USCA	27c	Birchfield	NZLD	39c
Bellacoscia	NCAL	8a	Birchfield	USNM	19b
Bellary	INDA	34a,28b	Birthday-William Fancy	AUVT	36a
Bellevue	AUWA	36b	Bisbee	USAZ	17
Bellevue	NCAL	8a	Bizmisen-Akusagi	TRKY	18d
Belokany-Laura	URRS	30a	Bjorkasen	NRWY	28a
Belvidere	USVT	8d	Bjurfors	SWDN	28a
Ben Lomond	AUQL	25f	Bjurliden	SWDN	28a
Bendigo	AUVT	36a	Bjurtrask	SWDN	28a
Bendigo	NZLD	36a	Black Bart (Great Western)	USCA	8a
Beni Douala	ALGR	18d	Black Bart Claim (Avery)	USCA	8a
Benkala	URRS	18d	Black Bart Group	USCA	8a
Benson	USNY	25i	Black Bear	USCA	36a
Benson Lake	CNBC	18b	Black Bear	USCA	8a
Benten	JAPN	25d	Black Beauty	USOR	8a
Bereket	TRKY	8a	Black Boy	USCA	36a
Berg	CNBC	21a	Black Boy	USOR	8a
Berong	PLPN	38a	Black Chrome	USCA	8a
Berry Creek	USCA	36a	Black Crow-San Juan	USNM	25g
Besimianni Log	URRS	39b	Black Cub	CNYT	18b
Bessemer	CNON	18d	Black Diablo	USNV	24c
Besshi	JAPN	24b	Black Diamond	USOR	8a
Best Chance	CNYT	18b	Black Diamond (Grey Eagle Gp.)	USCA	8a
Bethanga	AUVT	36a	Black Hawk	USNM	18c

Name	Country	Model No
Black Hawk	USOR	8a
Black Lake	CNQU	8d
Black Mtn.	SAFR	31a
Black Otter	USOR	8a
Black Range	USNM	25h
Black Range-Oroya	AUWA	36b
Black Rock Chrome	USCA	8a
Black Streak	USOR	8a
Black Swan	AUWA	6b
Black Warrior	USNV	27d
Black Warrior	USOR	8a
Blackbird	USID	24d
Blackstone	USCA	36a
Blairton	CNON	18d
Blind River	CNON	29a
Blinman	AUSA	19b
Blockhouse	CNNS	36a
Bloodwood Creek	AUQL	15b
Bloody Canyon	USNV	27d
Blue Bell	CNBC	19a
Blue Brush	USCA	8a
Blue Creek Tunnel	USCA	8a
Blue Dick	USNV	27d
Blue Grouse	CNBC	18b
Blue Jay	USCA	24c
Blue Jay	USOR	27d
Blue Lead	USAK	36a
Blue Ledge	USCA	28a
Blue Moon	USCA	28a
Blue Mountain	USCA	36a
Blue Mountains-Oko Mountains	GUYN	38b
Blue Nose	USNV	27d
Blue Ribbon	USNV	27d
Blue Ridge	PLPN	38a
Blue River	USCO	39a
Blue Sky (Lucky Strike)	USCA	8a
Blue Star	USNV	26a
Bluebird	USAZ	17
Bluestone	USNV	18b
Bob	ZIMB	36b
Bobrowka River	URRS	39b
Bodennec	FRNC	28a
Bodie	USCA	25c
Boe	GNBS	38b
Boiler Pit	USCA	8a
Boleo	MXCO	23
Boliden	SWDN	28a
Bolkardag	TRKY	19a
Bolshaya Choumika R.	URRS	39b
Bolshaya Kamenouchka	URRS	39b
Bolshaya Ossokina R.	URRS	39b
Bolshaya Prostokischenka	URRS	39b
Bolshaya Sosnovka	URRS	39b
Bolsherechensk	URRS	18d
Bolshoi Pokap R.	URRS	39b
Bolshoi Sakciam	URRS	39b
Bolske-Tokmak	URRS	34b
Bom Repouso-Cambui	BRZL	38b
Bonanza	NZLD	36a
Bonanza	USCA	8a
Bonanza	USCO	25b
Bonanza	CNBC	24a
Bond Creek	USAK	17
Bondurant	USCA	36a
Boneng Lobo	PLPN	20c
Bongbongan	PLPN	24a
Bonnievale	AUWA	36b
Bonny Lake	USFL	34d
Bonsecours	NCAL	8a
Booker Lease	USCA	8a
Boolarra	AUVT	38b
Bor	YUGO	22a
Boss Mountain	CNBC	21b
Bossmo	NRWY	28a
Boston Group	CUBA	24c
Bosum	CNBC	22c
Boswell River	CNYT	21b
Bothaville-Wolmaransstad	SAFR	39c
Bou Azzer	MRCO	8c
Bou Mia	MRCO	30a
Bou Sellam	MRCO	30a
Boulder River	USMT	39a
Boulougne-Folkston	USFL	39c
Bouscadillac and others	CNON	36b
Bovard	USNV	25c
Bowden Lake	CNMN	6b
Bowden Prospect	USCA	8a
Bowie Estate	USCA	8a
Bowser	USOR	8a
Boyandinskaia	URRS	39b
Boylen	CNQU	30a
Bozkonus	TRKY	8a
Bozotluk-No. 551	TRKY	8a
Bozshchaku	URRS	17
Br. Solomon Is.	SLMN	38a
Brachy	FRNC	19b
Braden	USOR	36a
Bradley	USNV	27d
Bragdor	USCA	8a
Bralorne-Pioneer	CNBC	36a
Bray-Beulah	USNV	27d
Brejui	BRZL	14a
Brenda	CNBC	21a
Brenmac	USWA	17
Bretz	USOR	25f
Bretz	USOR	27a
Bridge Hill Ridge	AUNS	39c
Briggs Creek	USOR	8a
Briseida Group & others	CUBA	24c
Bristol (Jack Rabbit)	USNV	19a
Britannia	CNBC	28a
British Canadian	CNQU	8d
Broken Hill	AUNT	31a
Broken Hill	SAFR	31a
Broken Hills	USCA	36a
Brookfield	CNNS	31b
Brookfield	CNNS	36a
Broulan and others	CNON	36b
Brown Scratch	USOR	8a
Brownsville	AUQL	15b
Bruce	USAZ	28a
Bruner	USNV	25d
Brunswich	CNNB	28a
Brunswick-Altamaha	USGA	39c
Brynor	CNBC	18d
Bu Craa	MRCO	34c
Buchans	CNNF	28a
Buckeye	USCA	24c

Name	Country	Model No
Buckhorn	USNV	25f
Buckingham	USNV	21b
Bucko	CNMN	6b
Buena Esperanza	CILE	23
Bueycito	CUBA	24c
Buffalo Red Lake	CNON	36b
Bugugan	TRKY	8a
Buka	PLPN	38a
Bulacan	PLPN	18d
Bulbula	IRAN	38c
Buller-Mokihinui	NZLD	36a
Bullion	USCO	22c
Bullrun Placer	USOR	39a
Bully Hill	USCA	28a
Bunker	USCA	8a
Burbanks	AUWA	36b
Buritirama	BRZL	24c
Burned Cabin	USOR	8a
Burns Basin	USNV	27d
Burnt Hill-Knob Lake	CNQU	34a,28b
Burra	AUSA	30b
Bursi	NRWY	28a
Bushveld	SAFR	2a,2b,3
Butilad	PLPN	17
Butler Claims	USCA	8a
Butler, Estate Chrome	USCA	8a
Butte	USMT	17
Butte	USNV	27a
Buttercup Chrome	USCA	8a
Buxton Creek	CNBC	39a
Buyiik Gurleyen	TRKY	8a
Buyiik Karamanli	TRKY	8a
Buyuk Yenice	TRKY	27d
Bwana Mkubwa	ZMBA	30b
C.O.D.	USAZ	22c
CC	CNBC	28a
Cab	CNYT	14a
Cabo Rojo	PTRC	38a
Cadiz	CUBA	24c
Calabogie	CNON	18d
Caldas	BRZL	38b
Calder-Bousquet	CNQU	36b
Caledonia	AUVT	36a
Caledonia	CNBC	18b
Caledonia	CUBA	8a
Caley	CNYT	8d
Calico	USCA	25c
California Group	USAZ	25g
California-Hartney-Marion	CNBC	22c
Calistoga	USCA	25c
Calumet	USMI	23
Calvert (Red Button)	USMT	14a
Camaguey	CUBA	8a
Camanche	USCA	39a
Camarasa-Oliana	SPAN	38c
Camaratuba	BRZL	39c
Camden Mine	USCA	8a
Camiglia	ITLY	18d
Camlica Koyee	TRKY	27d
Campanamah	AGTN	17
Campanario	SPAN	28a
Campania	ITLY	38c
Campbell	USOR	8a
Campbell Red Lake-Dickenson	CNON	36b
Camptonville area	USCA	8a
Cana Brava	BRZL	8d
Canadian Jamieson	CNON	28a
Cananea	MXCO	17
Cananea (Capote)	MXCO	18a
Canariaco	PERU	17
Cannivan Gulch	USMT	21b
Canoe Landing	CNNB	28a
Cantung	CNNT	14a
Canyon Creek-East Fork	USCA	36a
Capacmarca	PERU	18d
Cape Bougainville	AUWA	38b
Capel Shoreline	AUWA	39c
Capitan	USNM	18d
Captain	CNNB	28a
Captains Flat	AUNS	28a
Caracota	BLVA	27d
Carawison	PLPN	24a
Carey/East Broughton	CNQU	8d
Cariboo Bell	CNBC	20c
Caribou	CNNB	28a
Caribou	CNNS	36a
Caribou-Aurum	CNBC	36a
Carleton	CNNS	36a
Carlin	USNV	26a
Carmel	PLPN	24a
Carmen	CILE	18d
Carmi	CNBC	21b
Carn Brea-Tincroft	GRBR	15b
Carnation-Jennie Lind	CNBC	22c
Carnilya E.	AUWA	6a
Carnilya Hill	AUWA	6a
Carocoles	BLVA	15b
Carolin	CNBC	36a
Carolina	SAFR	39c
Caroline Islands	CARL	38b
Carpenter	USAZ	17
Carpio	SPAN	28a
Carr Boyd	AUWA	7a
Carr Fork	USUT	18b
Carrock Fell	GRBR	15a
Carshaw-Tommy Burns	CNON	36b
Casa de Janos	MXCO	25g
Casapalca	PERU	25b
Casas Grandes	MXCO	25g
Cash	CNYT	17
Casino	CNYT	17
Cassiar Mine	CNBC	8d
Cassilis	AUVT	36a
Cassius	HATI	18b
Castillo Buitron	SPAN	28a
Castillode Palanco	SPAN	24c
Casting	USNV	18b
Castle Dome	USAZ	17
Castle Island	USAK	31b
Castrita	MXCO	25h
Castro Mine	USCA	8a
Castro Verde	PORT	28a
Cataguases	BRZL	38b
Catak	TRKY	8a
Catak-Koraalan	TRKY	8a
Catalao	BRZL	10
Catas de las Vacas	MXCO	25h
Catas el Durango	MXCO	25h

Name	Country	Model No
Catavi	BLVA	20a
Catface	CNBC	17
Catheart	USMN	17
Cathroy Larder	CNON	36b
Cathy (Walt)	CNYT	31b
Catolsinir	TRKY	8a
Cattle Grid	AUSA	30b
Cattle Springs	USCA	8a
Cavdarli-Komurluk	TRKY	24c
Cave Canyon	USCA	18d
Cavyell Horse Mountain	USOR	8a
Cayirli Koy	TRKY	24c
Cedar Creek	USOR	8a
Cehegin	SPAN	18d
Celebration	USOR	8a
Cenger	TRKY	8a
Cenger-Adatepe	TRKY	8a
Cenger-Demirk	TRKY	8a
Cenger-Domuza	TRKY	8a
Centennial	CNMN	28a
Central	USCA	36a
Central Cerbat District	USAZ	22c
Central Manitoba	CNMN	36b
Central Patricia	CNON	36b
Central Rawdon	CNNS	36a
Central Tennessee	USTN	32a,32b
Cerro Blanco	MXCO	25h
Cerro Bolivar	VNZL	34a,28b
Cerro Colorado	CILE	17
Cerro Colorado	PANA	17
Cerro Gordo	USCA	19a
Cerro Grande	MXCO	25h
Cerro Matoso	CLBA	38a
Cerro Prieto	MXCO	25h
Cerro Verde	PERU	17
Cerro de Cobre	CLBA	18b
Cerro de Mercado	MXCO	25i
Cervantite	USNV	27d
Cezni	TRKY	8a
Chacarilla	BLVA	30b
Chador-Malu	IRAN	25i
Chagrin	NCAL	8a
Chahehgaz	IRAN	25i
Chalchihuites	MXCO	19a
Chalcobamba	PERU	18b
Challange area	USCA	8a
Chambers	USOR	8a
Chambiashi	ZMBA	30b
Champagne (Oakwood)	UNS	38b
Champion-New London	USAZ	22c
Chang Po-Tongkeng	CINA	14c
Charcas	MXCO	19a
Charco Redondo-Casualidad	CUBA	24c
Charleston placers	USSC	39c
Chaucha	ECDR	17
Chavarria	MXCO	25h
Chavin	PERU	25b
Cheminis-Fernland-Omega	CNON	36b
Chestatee	USGA	28a
Chester	CNNB	28a
Chesterville	CNON	36b
Chewton	AUVT	36a
Chiatura	URRS	34b
Chibuluma	ZMBA	30b
Chibuluma West	ZMBA	30b
Chicago	USCA	27c
Chicago	USCA	8a
Chichagof	USAK	36a
Chichibu	JAPN	18d
Chicote Grande	BLVA	15a
Child Harold	NCAL	8a
Childs Mine	CNON	18d
Chilisai	URRS	34c
Chingola-Nchanga	ZMBA	30b
Chinkuashih	TIWN	25e
Chintapalli-Gurtedu	INDA	38b
Chisel Lake	CNMN	28a
Chitose	JAPN	25d
Chittering	AUWA	38b
Chityal and others	INDA	34a,28b
Chiwefwe	ZIMB	34b
Chloride Flat	USNM	19b
Chloride District	USAZ	22c
Choates	USNV	27d
Choghart	IRAN	25i
Choja	JAPN	24b
Chongwe	ZMBA	30b
Chorolque	BLVA	20a
Christain Place	USCA	8a
Christmas	USAZ	18a
Chrome Camp	USCA	8a
Chrome Gulch	USCA	8a
Chrome Hill	USCA	8a
Chrome King (Josephine Co.)	USOR	8a
Chrome King (Jackson Co.)	USOR	8a
Chrome No. 3	USOR	8a
Chrome Ridge	USOR	8a
Chuquicamata	CILE	17
Chushiro	JAPN	24b
Cia Minera Norcro	HNDR	27d
Cinovec	CZCL	15c
Cirque	CNBC	31a
Cirque Barite	CNBC	31b
Cista	CZCL	15c
Ciudad Obregon	MXCO	25g
Clara H	USCA	8a
Clarendon Plateau	JMCA	38c
Clary and Langford	USCA	8a
Claude Hills	AUSA	38a
Clear Springs	USFL	34d
Cleary Hill	USAK	36a
Cleopatra	USOR	8a
Cleveland	AUTS	14c
Cliff Roy	USNM	25g
Climax	USCO	16
Clinton	CNQU	28a
Clinton Creek	CNYT	8d
Clover Leaf	USCA	8a
Cluff Lake	CNSK	38d
Clunes Goldfield	AUVT	36a
Coal Creek	USAK	15c
Coalstoun	AUQL	17
Coarsegold	USCA	36a
Coasano	USAK	27d
Coast Copper	CNBC	18b
Cobol	USAK	36a
Cobriza	PERU	18b
Cobweb Diggings	AUNS	39a

Name	Country	Model No
Cochrane Hill	CNNS	36a
Coco Mina	NCGA	25b
Codd Prospect	USCA	8a
Coeur d'Alene	USID	27d
Coggins	USCA	8a
Coimadai	AUVT	27d
Colchester	CNNF	24a
Coleman	USNV	27a
Colfax	USCA	36a
Collard Mine	USOR	8a
Colombo	USCA	36a
Colquemarca	PERU	18d
Colqui	PERU	25b
Comet	USAK	36a
Commander	USCA	8a
Comstock	CNBC	22c
Comstock	USNV	25c
Concepcion Del Oro	MXCO	18b
Conception	SPAN	28a
Confidence	USCA	36a
Conigo	CNQU	28a
Connemara	ZIMB	36b
Conrad Lodes	AUNW	15b
Consolation	NCAL	8a
Contact	USCA	27c
Continental	CNQU	8d
Continental	USNM	18a
Conyarigi	TRKY	27d
Coolgardie	AUWA	36b
Coolgarra Dist.	AUQL	15b
Coon Mt. Nos. 1-3	USCA	8a
Copper Basin	USAZ	17
Copper Basin	USNV	18a
Copper Canyon	USNV	18b
Copper Cities	USAZ	17
Copper Creek	USAZ	17
Copper Creek (Low Divide)	USCA	8a
Copper Crown	CNBC	28a
Copper Flat	USNM	18d
Copper George	AUWA	28a
Copper Hill	USCA	28a
Copper Mountain	CNBC	17
Copper Mountain	CNBC	20c
Copper Penny	USAZ	37b
Copper Queen	CNBC	18b
Copper Ridge	USTN	32b
Copperhead	AUWA	36b
Corbet	CNQU	28a
Cordero	USNV	27a
Cordon	PLPN	17
Cordon Estaneros	MXCO	25h
Corduroy Creek	USID	39a
Cork-Province	CNBC	22c
Cornell	CNBC	18b
Cornwall	USPA	18d
Cornwall Sn	GRBR	15b
Corocoro	BLVA	30b
Corona	USCA	27c
Coronation	CNSK	28a
Cortez	USNV	19a
Cortez	USNV	26a
Cosan	TRKY	8a
Cosmopolitan	AUWA	36b
Costerfield	AUVT	27d

Name	Country	Model No
Coteje	BLVA	25f
Coto	PLPN	8a
Cottonwood	USNV	27d
Coulterville	USCA	36a
Country Harbour	CNNS	36a
Courtwright	USCA	8a
Courtwright (Daggett)	USCA	8a
Courvan Mine	CNQU	8d
Cove District	USCA	36a
Cow Bay	CNNS	36a
Cow Creek Gp.	USCA	8a
Cowley Creek	CNYT	18b
Cox, Bolyan & Loberg	USAK	36a
Craigmont	CNBC	18a
Cranberry Hill	CNNS	36a
Cranbourne	CNQU	8d
Crandon	USWI	28a
Creede	USCO	25b
Crescent	USWA	24c
Creston	MXCO	21b
Creta	USOK	30b
Cripple Creek	USCO	22b
Croker Island	AUNT	38b
Cromita	CUBA	8a
Cronin	CNBC	28a
Crooked Creek	USID	39a
Crouch	USOR	8a
Crowell Area	USTX	30b
Crown	USOR	8a
Crown King	USAZ	19b
Cuajone	PERU	17
Cubenas	CUBA	24c
Cubuagan	PLPN	17
Cubuagan	PLPN	20c
Cubuklu Koyu	TRKY	24c
Cuchillo-Negro	USNM	18d
Cueva de la Mora	SPAN	28a
Cullaton Lake	CNNT	36b
Cullengoral	AUNS	39a
Culver Bear	USCA	27c
Cumberland Island	USGA	39c
Cummings	USCA	24c
Cupra D'Estrie	CNQU	28a
Cuprus	CNMN	28a
Curiol-Playa Real-Pavones	CORI	24c
Curtis Island	AUQL	39c
Cuyuna	USMN	34a,28b
Cyclone Gap	USCA	8a
Cyclops	INDS	38a
Cynthia	GREC	19b
Cynthia	USOR	8a
D'Analamaitso	MDGS	38b
D'Ankazobe	MDGS	38b
D-Tree	AUQL	34c
Dabola	GNEA	38b
Daffodil	CNON	8d
Dagardi	TRKY	27d
Dagardi	TRKY	8a
Dagkuplu	TRKY	8a
Daiquiri	CUBA	18d
Daisy (Aldelabron)	USCA	8a
Dalesford	AUVT	36a
Damascus	USCA	36a
Damba	ZIMB	6a

Name	Country	Model No	Name	Country	Model No
Dammer Nissar	PKTN	18d	Djebel Guettara	ALGR	24c
Danacik	TRKY	8a	Djebel Onk	ALGR	34c
Danisment	TRKY	24c	Doe Flat	USCA	8a
Dannemora	SWDN	18d	Dogu Ezan	TRKY	8a
Danville-Hanchette	USAZ	19b	Dogu Kef	TRKY	8a
Dardanelles	CNBC	22c	Doi Pha Khan	THLD	27d
Dargo Range Dist.	AUQL	15b	Dolores	MXCO	18c
Dark Star	USOR	8a	Dolores	MXCO	25c
Darrington	USCA	8a	Dome-Paymaster-Preston	CNON	36b
Darwin	USCA	19a	Dominion Consolidated	NZLD	36a
Darwin	USNV	27d	Dominion Gulf	CNON	10
Dassoumble	IVCO	24c	Domuzburnu II	TRKY	8a
Davidson	CNON	36b	Don Jon	CNMN	28a
Davis	USMA	28a	Don Pedro	USCA	8a
Dawn Lake	CNSK	38d	Don Teodoro	MXCO	25h
Day Dawn-Main Line	AUWA	36b	Donatelli	USNV	27d
Dayton	USNV	18d	Dorothea	USOR	36a
Dcev 7	NCAL	8a	Dorothy	CNBC	17
De Santis	CNON	36b	Dorriss	USCA	8a
Debele (Kindia)	GNEA	38b	Dos Pobres	USAZ	20c
Dee	USNV	26a	Double Ed	CNBC	28a
Deep Gorge Chrome	USOR	8a	Douglas Hill	USNV	18b
Deep Gravel	USOR	39a	Dovis	IRAN	8a
Deer Isle	USME	28a	Dozier	USCA	8a
Defender	USCA	36a	Drina	YUGO	19a
Defiance	USAZ	22c	Drnis-Obrovac	YUGO	38c
Del Park-Huntly	AUWA	38b	Drumm	USNV	27d
Delamar	USID	25a	Dry Canyon	USNV	27d
Delare Prospect	USOR	8a	Dry Creek	USOR	8a
Delbridge	CNQU	28a	Dublin Gulch (GSZ)	CNYT	14a
Delta	CUBA	8a	Duchess	AUQL	34c
Delta	USCA	36a	Dudas	USNV	27d
Demarest	USCA	36a	Dugald River	AUQL	31a
Demirkapi	USNV	27d	Duke Island	USAK	9
Demirli	TRKY	8a	Dulcoath	GRBR	15b
Denali Copper	USAK	23	Duluth Complex	USMN	5a
Derekoy	TRKY	27d	Dumagami	CNQU	28a
Descoberto	BRZL	38b	Dumont	CNQU	6b
Desert	USCA	27d	Dumont Bourlamque	CNQU	28a
Despina	CNQU	28a	Duncan Lake	CNBC	31a
Detert	USCA	8a	Dungun	MDGS	18d
Detour	CNQU	28a	Dunraine	CNQU	28a
Detroit	USUT	19b	Durnovskoe	URRS	24c
Devils Elbow	CNNB	28a	Duthie	CNBC	28a
Dewey's	USCA	27c	Dy	CNYT	31a
Dexing	CINA	17	Dyce Siding	CNMN	28a
Dhalli-Rajhara	INDA	34a,28b	Dyson's (Rum Jungle)	AUNT	38d
Diamond	USCA	8a	Dzama	URRS	18d
Dickerson	USCA	8a	Dzhezhkazgan (Magakyan)	URRS	30b
Dickey and Drisbach	USCA	8a	E. Kempville	CNNS	15c
Dickstone	CNMN	28a	E. Scotia	AUWA	6a
Dikulume-Mashamba	ZIRE	30b	Eagle	CNBC	17
Dinagat	PLPN	8a	Eagle	USAK	8d
Dinagat Is.	PLPN	38a	Eagle Bluff-River Bend	USCA	36a
Dinamita	MXCO	19b	Eagle Mountain	USCA	18d
Dinero	USCA	36a	Eagle Shawmut	USCA	36a
Dirty Face	USOR	8a	Earl Smith	USCA	8a
Discovery	CNMN	6b	Early Bird	USCA	28a
Divide	USNV	25c	Early Sunrise	USOR	8a
Divinolandia de Minas	BRZL	38b	Early-Sweetwater	USCA	36a
Divrigi	TRKY	18d	East Florida (Deseret Ranch)	USFL	34d
Dixie Placer	USOR	39a	East Maui	USHI	38b
Dizon	PLPN	20c	East Ore Body	PLPN	8a
Djebel El Aziza	TUNS	19b	East Rawdon	CNNS	36a

Name	Country	Model No	Name	Country	Model No
East Rosetta	EGPT	39c	El Porvenir (Milpo)	PERU	19a
East Sullivan	CNQU	28a	El Primero	USCA	8a
East Tennessee	USTN	32a,32b	El Profesor	MXCO	25h
East Tintic	USUT	19a	El Rincon	MXCO	25c
Eastern A&B	SYRA	34c	El Romadizo	MXCO	25h
Eaton	USNV	27d	El Romeral	CILE	25i
Eclipse No. 1	USCA	36a	El Salvador	CILE	17
Ecum Secum	CNNS	36a	El Santo Nino	MXCO	25h
Edeline	USCA	8a	El Sherana	AUNT	38d
Eden	USCA	8a	El Sherana West	AUNT	38d
Edna May	AUWA	36b	El Socavon	MXCO	25h
Eggling and Williams	USCA	8a	El Sol y La Luna	MXCO	18d
Ego	CNON	28a	El Soldado	CILE	17
Ehime	JAPN	24b	El Tarango	MXCO	25h
Ejowka	URRS	39b	El Teniente	CILE	17
Ekstromberg	SWDN	25i	El Tigre	MXCO	25b
El Abra	CILE	17	El Venado	MXCO	25h
El Abra	MXCO	25h	El Volcan-Piedra Iman	MXCO	18d
El Algarrobo	CILE	25i	El Zanzon	MXCO	25h
El Arco	MXCO	17	Elalmis	TRKY	27d
El Atascadero	MXCO	25h	Elatsite	BULG	17
El Baluarte	MXCO	25h	Elder Claim	USCA	8a
El Barroso	MXCO	25h	Elder Creek	USCA	8a
El Borrego #1	MXCO	25h	Eldirek	TRKY	8a
El Borrego #2	MXCO	25h	Electric	USNV	27d
El Calabrote	MXCO	25h	Eliza-Schroeder	USCA	36a
El Capulin	MXCO	25h	Elk Creek Claim	USCA	8a
El Cid	CUBA	8a	Elkhorn Chromite	USOR	8a
El Coloradillo	MXCO	25h	Elkhorn Creek	USMT	39a
El Corral	MXCO	25h	Ellingwood	USCA	8a
El Cristal	MXCO	25h	Elliot Lake	CNON	29a
El Cuervo	SPAN	24c	Ellis	USCA	8a
El Dorado	CILE	25i	Elliston	USMT	39a
El Dorado	MXCO	25h	Eltay	URRS	18d
El Dorado	USCA	36a	Ely	USNV	18a
El Dorado	USMT	39a	Embury Lake	CNMN	28a
El Duraznillo	MXCO	25h	Emerald-Dodger	CNBC	14a
El Durazno	MXCO	25h	Emerson	USME	28a
El Encino (La Ochoa)	MXCO	25h	Emigrant Springs	USNV	26a
El Encino (Jalisco)	MXCO	25i	Emirli	TRKY	27d
El Gotera	MXCO	25h	Emmaville	AUNS	38b
El Hamrawein	EGPT	34c	Empire Le Tac	CNQU	28a
El Huacal	MXCO	25h	Empire-Lone Star	USCA	36a
El Indio	CILE	25e	Emporer Mine	FIJI	22b
El Indio, Tadeo, San Antonio	MXCO	25h	Empress	ZIMB	7a
El Ladrillo	MXCO	25h	Emu Creek	AUQL	15b
El Mamey	MXCO	25h	Emu Dist.	AUQL	15b
El Mezquite	MXCO	25f	Emu-Great Eastern	AUWA	36b
El Mochito	HNDR	18c	Endako	CNBC	21b
El Naranjo, Buena Suerte	MXCO	25h	Eneabba Shoreline	AUWA	39c
El Noladero	MXCO	25h	Enterprise	USCA	36a
El Nopal (Juan Aldama)	MXCO	25h	Enterprise	USNV	27d
El Nopal (La Ochoa)	MXCO	25h	Epoch	ZIMB	6a
El Nopal (Nopal I and III)	MXCO	25f	Equity Silver	CNBC	22a
El Pachon	AGTN	17	Ermenis	TRKY	8a
El Pao	VNZL	34a,28b	Errington	CNON	28a
El Pedroso	SPAN	18d	Erzegebirge	CZCL	15c
El Penasco	MXCO	25h	Escondida	CILE	17
El Perdido	MXCO	25h	Eskdale	AUQL	27d
El Picacho	MXCO	25h	Esmeralda	USCA	36a
El Pleito	MXCO	25h	Esperancita	CUBA	24c
El Polvillo	MXCO	25h	Esperanza	CILE	17
El Portal	USCA	36a	Esperanza	USCA	27c
			Espiritu Santo	BLVA	27d

Name	Country	Model No	Name	Country	Model No
Essex and Steptoe	USNV	19b	Forest Creek	USOR	39a
Estacao	CNON	28a	Forest Hill	CNNS	36a
Estacion Llanos	MXCO	25g	Forest Queen	USCA	8a
Ester Dome SE	USAK	36a	Fornas	SPAN	24a
Esterly Chrome	USOR	8a	Forrestania Group	AUWA	6b
Esther and Phyllis	USCA	8a	Fort Apache	USAZ	34a,28b
Estrella-Sopresa	CUBA	24c	Fort Gourand	MAUR	34a,28b
Estyunin	URRS	18d	Fort Green	USFL	34d
Euboea	GREC	38a	Foster	USOR	8a
Eulaminna	AUWA	28a	Foster Mountain	USCA	24c
Eureka	USCO	25b	Four Hells Mine	USCA	36a
Eureka	USNV	19a	Four Point	USOR	8a
Eustis	CNQU	28a	Four-of-July	USID	27d
Eva May	USMT	22c	Fourth Crossing	USCA	36a
Evans Head-Wooli area	AUNS	39c	Fourth of July	USCA	8a
Exmibal	GUAT	38a	Fox	CNMN	28a
Exotica	CILE	17	Francis Ormand	AUVT	36a
Experimental	USCA	36a	Franklin	USCA	36a
F Group	CNON	28a	Fraser Island	AUQL	39c
F and L Mine	USNV	27a	Fraser's	AUWA	36b
FL & DH	CNMN	28a	Freddie Wells	AUNS	28a
Fabian	USCA	24c	French	USCA	36a
Fairview	USCA	8a	French Gulch	USCA	36a
Fairview	USNV	25c	French Gulch	USCO	39a
Falconbridge	DMRP	38a	French Hill	USCA	8a
Fall Creek	USID	39a	Fretais	PORT	28a
Falun	SWDN	18c	Fria-Kimbo	GNEA	38b
Fanrouche	NCAL	8a	Friday	USOR	8a
Farewell Lake	CNMN	28a	Frieda River	PPNG	20c
Faro	CNYT	31a	Friedensville	USPA	32a,32b
Faucogney	FRNC	24c	Frotet Lake	CNQU	28a
Felicianna	USCA	36a	Fryer's Creek	AUVT	36a
Fenoarivo	MDGS	38b	Fujinokawa	JAPN	27d
Fenyoto	HUNG	38c	Fukazawa	JAPN	28a
Fiddler's Green	USCA	8a	Fuke	JAPN	25c
Fields and Stoker	USCA	8a	Fuller-Tisdale	CNON	36b
Fierro	USNM	18c	Funter Bay	USAK	7a
Fierro-Hannover	USNM	18d	Furuhaugen	NRWY	28a
Fifteen-mile Brook	CNNS	36a	Furutobe-Ainai	JAPN	28a
Fifteen-mile Stream	CNNS	36a	Fx	CNBC	31a
Fifty-five	USCA	36a	Gabretta	USCA	36a
Filon Sur-Esperanza	SPAN	28a	Gabriels Gully	NZLD	36a
Finan	USCA	8a	Gabrinus	USCA	36a
Findikli	TRKY	8a	Gachala	CLBA	31c
Fine Gold	USCA	36a	Gag Is.	INDS	38a
Finney	USCA	36a	Galaxy	CNBC	17
Fish Lake	CNBC	20c	Galena Farm and vicinity	CNBC	22c
Fisher Maiden Group	CNBC	22c	Galice North	USOR	36a
Fiskefjord	NRWY	34a,28b	Gallagher	USOR	8a
Five Pines	USCA	36a	Gallinas	USNM	18d
Fjeldgruve	NRWY	28a	Galore Creek	CNBC	20c
Flaat	NRWY	7a	Galvan	MXCO	25h
Flambeau	USWI	28a	Gambe	BRZL	38b
Flexar	CNSK	28a	Gambier Island	CNBC	21a
Flin Flon	CNMN	28a	Gamle Folldal	NRWY	28a
Flint-Martin	CNBC	22c	Ganntour	MRCO	34c
Florence	USAZ	17	Gant	HUNG	38c
Florida Canyon	USNV	26a	Gap	USPA	7a
Fond-du-Lac	CNON	38d	Gardner Mine	USOR	8a
Fongo Tongo	CMRN	38b	Garon Lake	CNQU	28a
Fonnfjell	NRWY	28a	Garpenberg Norra	SWDN	18c
Foots Creek	USOR	39a	Garpenberg Odal	SWDN	18c
Forbestown	USCA	36a	Gas Canyon	USCA	8a
Ford	USCA	36a	Gaspe	CNQU	21a

Name	Country	Model No
Gaspe (Needle Mountain)	CNQU	18a
Gaviao	PORT	28a
Gavilancillos	MXCO	25h
Gayna R.-Godlin L.	CNNT	32a,32b
Geach	USCA	8a
Geevor	GRBR	15b
Geita	TNZN	36b
Gelvenakko	SWDN	28a
Gem	CNYT	18b
Gem	USCA	36a
Gem	CNBC	21b
Gem Olive	USCA	36a
Gem Park	USCO	10
General Gallieni	NCAL	8a
Geol. Reser. No. 34	CNMN	6b
George Copper	CNBC	28a
George Lake	CNSK	30a
George Prezel	USID	39a
Georgia bauxite	USCO	8c
Gerdag	TRKY	8a
German Bar	USCA	36a
Getchell	USNV	26a
Ghost Lake	CNMN	28a
Giant King	USCA	36a
Giant Mascot	CNBC	7a
Gibraltar	CNBC	21a
Gibralter	USCA	36a
Gibsonville	USCA	8a
Giken-Charlotta	NRWY	28a
Gill (Gill Ranch)	USCA	8a
Gillan	USCA	8a
Gilliam	AUQL	14b
Gillis Prospect	USCA	8a
Gilmont	CNQU	8d
Giltedge	USMT	26a
Gimlet-Slippery	AUWA	36b
Gingin Shoreline	AUWA	39c
Giresun	TRKY	18d
Girilambone	AUNS	28a
Gjersvik	NRWY	28a
Glacier Gulch	CNBC	21b
Glacier Peak	USWA	17
Gladstome-Sand Queen	AUWA	36b
Gladstone	USCA	36a
Gladstone Mainland	AUQL	39c
Glass Butte	USOR	27a
Glencoe-Woodhouse	USCA	36a
Gleneindale Dist.	AUQL	15b
Glib en Nam	MRCO	24c
Globe-Ralston	USCA	36a
Gloria-Elvira-Polaris	CUBA	24c
Glory Ho	USOR	8a
Gloryana	USNM	25g
Gloubokia	URRS	39b
Gocek Koyu	TRKY	24c
God's Lake	CNMN	36b
Gogebic	USMN	34a,28b
Golalan	TRKY	8a
Golconda Fraction	USCA	8a
Gold Acres	USNV	26a
Gold Bar	USNV	26a
Gold Bug	USCA	36a
Gold Bug Claim	USCA	8a
Gold Chariot	USCA	36a
Gold Coast	PPNG	18a
Gold Eagle-McKenzie	CNON	36b
Gold Hawk	CNON	36b
Gold Hill	CNON	36b
Gold Hill	USCO	22b
Gold Mountain	USUT	25c
Gold Point	USCA	36a
Gold Quarry	USNV	26a
Gold Reef	USCA	36a
Gold River	USCA	36a
Gold Run (Boulder Co.)	USCO	39a
Gold Run (Summit Co.)	USCO	39a
Goldbanks	USNV	27a
Golden Age	CNQU	8d
Golden Eagle	USCA	36a
Golden Gate	USAZ	19b
Golden Grove	AUWA	28a
Golden Jubilee	USCA	36a
Golden Ridge	AUWA	36b
Golden Rule	USID	39a
Golden-El Dorado	USCA	36a
Goldenville	CNNS	36a
Goldfield	USNV	25e
Golesh Mt.	YUGO	38a
Golos	YUGO	38a
Goncolda	USOR	8a
Gongo Socco	BRZL	36b
Goodenough	CNMN	28a
Goodnews Bay	USAK	39b
Gora Magnitnaya	URRS	18d
Gora Vysokaya	URRS	18d
Goro	NCAL	38a
Gorumahisani and others	INDA	34a,28b
Gorunur	TRKY	8a
Goulais	CNON	34a,28b
Gove	AUNT	38b
Governor	USNV	27a
Govniikbelen	TRKY	8a
Goynuk	TRKY	27d
Gr2h	NCAL	8a
Gran Piedra	CUBA	24c
Grand Victory	USCA	36a
Grangesberg	SWDN	25i
Granisle	CNBC	17
Granite Hill	USOR	36a
Granite King	USCA	36a
Grant	USAK	36a
Grants	USNM	30c
Grass Valley	USCA	36a
Gray Boy	USOR	8a
Gray Buck Gp.	USOR	8a
Gray Eagle	USCA	28a
Gray Eagle	USMT	22c
Great Dyke	ZIMB	2a
Great Eastern-Mt. Jackson	USCA	27c
Green (Americus)	USCA	8a
Green Antimony	USNV	27d
Green Coast	CNON	28a
Green Cove Springs	USFL	39c
Green Excelsior	USCA	36a
Green Mine	USCA	8a
Green Ridge	USCA	8a
Green River	USUT	39a
Green's Capco Leases	USCA	8a

Name	Country	Model No
Greenback	USOR	36a
Greens Creek	USAK	28a
Greenvale	AUQL	38a
Grenville	GRBR	15b
Grey Eagle	USOR	27d
Grey River	CNNF	15a
Greystone	USNV	31b
Gribble	USNV	27d
Griffin Chromite	USOR	8a
Griffith	USNM	25g
Groote Eylandt	AUNT	34b
Groundhog	USNM	18c
Grum	CNYT	31a
Gruvberget	SWDN	25i
Guadalupe	MXCO	25h
Guadalupe & Calvo	MXCO	25d
Guadalupe & Solis	MXCO	25i
Guanaba Group	CUBA	24c
Guanacevi	MXCO	25c
Guanajuato	MXCO	25c
Guillermina	CUBA	8a
Gujarat	INDA	34b
Gullbridge	CNNF	28a
Gunbasi (Akcakese)	TRKY	24c
Gundie	AUNW	15b
Gunlet-Uckopur	TRKY	8a
Gunliik Basi	TRKY	8a
Gunn Claims	USCA	8a
Guntur	INDA	34a,28b
Gurney	CNMN	36b
Gurranda	AUNS	31b
Gurrumba Dist.	AUQL	15b
Guseva Gora	USSR	9
Guttusjon	SWDN	30a
Gwai River	ZIMB	30b
Gwynne	USCA	36a
HB	CNBC	31a
HW	CNBC	28a
Hacan	TRKY	28a
Hagios Ioannis	GREC	38a
Hahotoe	TOGO	34c
Haikou	CINA	34c
Hale-Mayabo	PLPN	17
Hales Siding	AUQL	15b
Half Chrome	USCA	8a
Half Mile Lake (SG)	CNMN	28a
Halimba	HUNG	38c
Hall	USNV	21b
Hall Creek	CNBC	36a
Halliwell	CNQU	28a
Halmahera	INDS	38a
Ham & Birney	USCA	36a
Hambone	CNMN	6b
Hamme District	USNC	15a
Hampton	AUQL	38b
Hanaoka (Doy.-Tsut.)	JAPN	28a
Hanaoka (Mats.-Sha.)	JAPN	28a
Hanawa (Aket.-Osak.)	JAPN	28a
Hand Camp	CNNF	24a
Hanover	USNM	18c
Hanscum	USOR	8a
Hanson Lake	CNSK	28a
Happy Go Lucky	USCA	8a
Happy Return	USNV	27d
Hard Luck	USNV	27d
Hard Rock	USFL	34d
Hard Rock-McLeod-Cockshutt	CNON	36b
Harkoy	TRKY	28a
Harp and Sons Ranch	USCA	8a
Harriet	CNBC	36a
Harrigan Cove	CNNS	36a
Harrison	USCA	27c
Hasaga-Howey	CNON	36b
Haskin Mountain	CNBC	21b
Hathaway	USCA	36a
Hatillo	DMRP	18d
Hatton	USAZ	25g
Havelock Mine	SWAZ	8d
Hawks Rest View	USOR	8a
Hayden Hill	USCA	25d
Hayden and Hilt	USCA	8a
Haynsworth	USFL	34d
Hazel	USCA	36a
Heath Steele	CNNB	28a
Heddleston	USMT	17
Hedley Camp	CNBC	36a
Helemar	USCA	8a
Helen	USCA	27c
Helvetia	USAZ	17
Henderson	USCO	16
Hendricks No. 2	USCA	8a
Hendricks-Twilight	USAZ	19b
Henry Ford	USAK	36a
Henry district	USUT	25f
Herberton	AUQL	15b
Hercules	AUTN	28a
Hercules	MXCO	25i
Hermada	USID	27d
Herman	USCA	36a
Herpit Yayla	TRKY	8a
Herrerias	SPAN	28a
Hersjo	NRWY	28a
Hi-Yu	USAK	36a
Hierbaniz	MXCO	25h
Hierro Indio	AGTN	18d
Higashiyame	JAPN	24b
High Dome	USCA	8a
High Grade	USCA	25d
High Lake	CNNT	28a
High Plateau	USCA	8a
Highland-Trail Ridge	USFL	39c
Highmont	CNBC	21a
Hill-Top Chrome	USCA	8a
Hillgrove	AUNS	36a
Hilton	AUQL	31a
Hilton Head Island	USSC	39c
Hinobaan	PLPN	20c
Hirabaya	JAPN	24b
Hiragane	JAPN	18b
Hirota	JAPN	24b
Hirst-Chichagof	USAK	36a
Hitachi	JAPN	24b
Hitura	FNLD	6a
Hixbar	PLPN	28a
Hodge Ranch	USCA	8a
Hoff	USCA	8a
Hoidal	NRWY	28a
Hokitika North	NZLD	39c

Name	Country	Model No
Hokitika South	NZLD	39c
Holbrook and McGuire	USCA	8a
Hollinger and others	CNON	36b
Hollywood	USNV	27d
Holseman (and others)	USCA	8a
Holston (Vaughn)	USCA	8a
Homestake	CNBC	31a
Homestake	USSD	36b
Homestake-McCarty	USAK	36a
Honeymoon Well	AUWA	6b
Hood River	CNNT	28a
Hope	CNBC	18b
Horne-Quemont	CNQU	28a
Hornitos	USCA	36a
Horse Canyon	USNV	26a
Horse Praire	USMT	39a
Horseshoe	AUWA	34b
Horseshoe	USCA	8a
Horseshoe Chrome	USOR	8a
Horseshoe I	USCA	36a
Hosanger	NRWY	7a
Hosokura	JAPN	25b
Hostotipaquilla	MXCO	25c
Houser & Burges	USOR	8a
Howards Pass	CNYT	31a
Hoyt	USNV	27d
Hsiangtan	CINA	34b
Huacravilca	PERU	18d
Huai Nai Khao	THLD	27d
Hualpai	CNBC	18d
Huancabamba	PERU	18d
Hub	CZCL	15c
Hubsugul	MNGL	34c
Huckleberry	CNBC	21a
Hudson (Fuller Claims)	USCA	8a
Hull	CNQU	18d
Humbug Creek	USOR	39a
Hundred Dollar Gulch	USID	39a
Hunnan	CINA	19a
Hunter	CNQU	28a
Hunter Valley	USCA	36a
Hunters Road	ZIMB	6a
Huntingdon	CNQU	24a
Hutti	INDA	36b
Hyatt No. 1	PANA	24c
Hyers Island	CNMN	28a
I-Wonder	USCA	8a
I.H.X.	USNV	27d
Ichinokawa	JAPN	27d
Iconoclast	USCA	36a
Ida H.	AUWA	36b
Idaho	USID	27d
Idaho Almaden	USID	27a
Idaho-Alamo Group	CNBC	22c
Idaho-Alamo-Silver Bell	CNBC	22c
Idaho phosphate	USID	34c
Idfu-Qena	EGPT	34c
Idikel	MRCO	24c
Idkerberget	SWDN	25i
Iide	JAPN	18b
Ikisulu-Gercek	TRKY	8a
Ilave	CUBA	24c
Iles de Los	GNEA	38b
Illinois River	USOR	8a

Name	Country	Model No
Illinsky Log	URRS	39b
Imade & Ouchi	JAPN	24b
Imanccasa	PERU	18d
Imini	MRCO	34b
Imori	JAPN	24b
Imotski-Mostar	YUGO	38c
Independence	USOR	8a
Indian Chief	CNBC	18b
Indian Path Mine	CNNS	36a
Infiernillo	CILE	25i
Ingerbelle	CNBC	20c
Inguaran	MXCO	17
Innai	JAPN	25d
Ino	JAPN	18d
Ino-Capaya	PLPN	17
Inskip Point	AUQL	39c
Inspiration	USAZ	21a
Intendencia de Arauca	CLBA	38b
Invincible Lode	NZLD	36a
Iowa Gulch	USCO	39a
Ipaneme	BRZL	38a
Irene Chromite	USOR	8a
Irituia	BRZL	38b
Iron Duke	CNBC	18d
Iron Dyke	USOR	28a
Iron Hat	USCA	18d
Iron Hill	USCO	10
Iron King	USAZ	28a
Iron King	USOR	8a
Iron Mask	CNBC	17
Iron Mike	CNBC	18d
Iron Monarch-Iron Knob	AUSA	34a,28b
Iron Mountain	USCA	28a
Iron Mountain	USNM	14a
Iron Mountain	USOR	8a
Iron Mountain	USNM	18d
Iron Springs	USUT	18d
Irsahan	TRKY	28a
Irvine Bank	AUQL	15b
Isaac's Harbour	CNNS	36a
Isla de Pinos	CUBA	15a
Islahiye	TRKY	38c
Island Copper	CNBC	17
Island Lake	CNMN	36b
Iso-Magusi-New Insco	CNQU	28a
Israil	TRKY	28a
Istranca	TRKY	34b
Isua	GRLD	34a,28b
Iszkaszentgyorgy	HUNG	38c
Itanhandu-Resende	BRZL	38b
Ithaca Peak	USAZ	17
Ivanhoe-Canadian	CNBC	22c
Ivov R.	URRS	39b
Iwami	JAPN	28a
Iwato	JAPN	25e
Iyo	JAPN	24b
Izok Lake	CNNT	28a
Izushi	JAPN	24b
J.M. Meadows Group	USAZ	25g
JVB Claim	USNM	25g
Jabal Guyan	SAAR	36a
Jabal Sayid	SAAR	28a
Jabiluka	AUNT	38d
Jack Forth	USCA	8a

Name	Country	Model No
Jack Sprat Gp.	USCA	8a
Jackson	USOR	8a
Jacksonville Area	USFL	39c
Jacobina	BRZL	29a
Jacupuenga	BRZL	38a
Jajce	YUGO	38c
Jakobsbakken	NRWY	28a
Jameland	CNON	28a
James Bay	CNON	10
Jamestown	USCA	36a
Jamirapat-Khuria	INDA	38b
Jamnagar (Saurashtra)	INDA	38b
Jarrahdale	AUWA	38b
Jason	CNON	36b
Jay Bird	USOR	27d
Jedway	CNBC	18d
Jefferson City	USTN	32b
Jefferson Lake	USCA	8d
Jeffrey Lake	CNQU	8d
Jembaicumbene Creek	AUNS	39a
Jerez de los Caballeros	SPAN	18d
Jerome	CNON	36b
Jerome	USAZ	28a
Jerritt Canyon	USNV	26a,27d
Jersey Emerald	CNBC	31a
Jerusalimsky-Priisk	URRS	39b
Jib	CNBC	18d
Jicarilla	USNM	18d
Jim Bus	USOR	8a
Jo7	NCAL	24c
Joanne	CNMN	28a
Joe Walker	USCA	36a
Johns	USOR	8a
Johnson-Heizer	USNV	27d
Joinville	BRZL	25i
Joliet	CNQU	28a
Jones Camp	USNM	18d
Jordan Creek	USID	39a
Jose	CUBA	8a
Josefina	AGTN	15a
Josephine	USCA	8a
Josephine No. 4	USOR	8a
Josselin	CNQU	28a
Jourawlik R.	URRS	39b
Joutel	CNQU	28a
Jubilee	NZLD	36a
Jubilee-New Jubilee	AUVT	36a
Judinsky-Lojok	URRS	39b
Judy (Hicks)	USCA	8a
Julian	USCA	8a
Julian-Banner	USCA	36a
Juncos	CNBC	18d
June	CNBC	17
Jussaari	FNLD	34a,28b
Jutinicu	CUBA	24c
K.C.	USCA	36a
Kachar	URRS	18d
Kadzharan	URAM	17
Kagit Octu	TRKY	8a
Kahal de Brezina	ALGR	19b
Kalaa Khasba	TUNS	34c
Kalahandi-Koraput	INDA	38b
Kalahari	SAFR	34b
Kalamaton	PLPN	17
Kalamazoo-San Manuel	USAZ	17
Kalengwa	ZMBA	30b
Kaliapani	INDA	38a
Kalimantan Ni	INDS	38a
Kalkan	TRKY	18d
Kalkanli	TRKY	28a
Kalmakyr	URUZ	17
Kalushi (Kalulushi)	ZMBA	30b
Kalvbacken	SWDN	18c
Kam Kotia	CNON	28a
Kamaishi	JAPN	18b
Kambaikhin central	URRS	18d
Kambaikhin east	URRS	18d
Kambaikhin north	URRS	18d
Kambalda	AUWA	6a
Kamegamori	JAPN	24b
Kamenka	URRS	39b
Kamenka R.	URRS	39b
Kamenskoe	URRS	34b
Kami	BLVA	15a
Kamitkita (Kominosawa)	JAPN	28a
Kamoto	ZIRE	30b
Kansanshi	ZMBA	30b
Kanayama	JAPN	24b
Kandira	TRKY	8a
Kangaroo Court Mine	USCA	8a
Kanjamalai	INDA	34a,28b
Kankberg	SWDN	28a
Kanmantoo	AUSA	30b
Kansa	INDA	38a
Kanye	BOTS	18e
Kaochiao	CINA	34b
Kapedhes	CYPS	24a
Kapin	TRKY	8a
Kapunda	AUSA	30b
Kara Tau	URRS	34c
Karaculha	TRKY	8a
Karageban	TRKY	8a
Karamadazi	TRKY	18d
Karamea	NZLD	39c
Karangnunggal	INDS	25g
Karani	TRKY	8a
Karaninar	TRKY	8a
Karasivri	TRKY	8a
Karatas	TRKY	25g
Karatas-Kumocak	TRKY	8a
Karen	CNBC	21b
Kartalkoyu	TRKY	8a
Kasuga	JAPN	25e
Kata	PERU	25b
Katherine	USAZ	25c
Kauai	USHI	38b
Kaunisvaara-Masugnsbyn	SWDN	18d
Kavadarci	YUGO	38a
Kavakcali	TRKY	8a
Kavakdere	TRKY	8a
Kaw Mountains	FRGN	38b
Kawasaki	JAPN	25d
Kazadere-Kandil	TRKY	8a
Kedbeg Copper	URRS	18b
Kedtrask	SWDN	28a
Keewenaw	CNYT	18b
Kefdag-East	TRKY	8a
Kelapa Kampit	INDO	15b

Name	Country	Model No
Kelly-Desmond	CNQU	28a
Kelsey	USCA	36a
Kelsey North	USCA	36a
Kemikli Inbasi	TRKY	8a
Kemmangundi and others	INDA	34a,28b
Kempfield	AUNS	31b
Kemptville	CNNS	36a
Kenbridge	CNON	7a
Kennecott	USNM	18c
Kennon	PLPN	20c
Keno Hill-Galena Hill	CNYT	22c
Kentucky-Illinois	USKN	32a,32b
Kerikeri	NZLD	38b
Kerr Addison	CNON	36b
Kesikkopru	TRKY	18d
Ketstone-Union	USCA	28a
Keweenaw	USMI	23
Key Anacon	CNNB	28a
Key Lake (Deilmann, Gaertner)	CNSK	38d
Keystone	USCA	27c
Keystone	USCA	28a
Khans Creek	AUNS	28a
Kheda (Kaira)	INDA	38b
Khnaiguiyah	SAAR	28a
Khneifiss	SYRA	34c
Khushab (Sargohda)	PKTN	38b
Khuzdar	PKTN	31b
Kiabakari	TNZN	36b
Kibi	GHNA	38b
Kidd Creek	CNON	28a
Kieslager	ASTR	24b
Kiirunavaara	SWDN	25i
Kilembe	UGND	30b
Kilic-Kafasi 1	TRKY	8a
Kilic-Kafasi 2	TRKY	8a
Killag	CNNS	36a
Killifreth	GRBR	15b
Killingdal	NRWY	28a
Kilo-Moto	CNGO	36b
Kimheden	SWDN	28a
King Fissure	CNBC	31a
King Island	AUTS	14a
King Solomon	USMT	22c
King-King	PLPN	17
Kingsford	USFL	34d
Kingsley	USOR	8a
Kingston	USNM	19b
Kinlock	SAFR	8d
Kinsley	USCA	36a
Kinsley North	USCA	36a
Kipushi	ZIRE	32c
Kiranocak	TRKY	8a
Kirwin	USWY	17
Kishu	JAPN	20b
Kisslaia-Peruonatchainik	URRS	39b
Kitlim, Severniy R.	URRS	39b
Kittelgruvan	SWDN	28a
Kizilkaya	TRKY	28a
Kleinsorge Gp.	USCA	8a
Kliripan	INDS	25g
Knoxville	USCA	27c
Koca	TRKY	8a
Kodiak Cub	CNYT	18b
Koff Zone	CNMN	28a

Name	Country	Model No
Kokkinopezoula	CYPS	24a
Kokkinoyia	CYPS	24a
Kolaba-Ratnagiri	INDA	38b
Kolar	INDA	36b
Kolhapur	INDA	38b
Kolubara-Azbest	YUGO	8d
Komek	TRKY	8a
Komurluk Koyunun	TRKY	24c
Kondonakasi	ANGL	34c
Konkola (Bancroft)	ZMBA	30b
Koolpin Creek	AUNT	38d
Koolyanobbing	AUWA	34a,28b
Koongarra	AUNT	38d
Koprubasi	TRKY	28a
Koro Plateau	CHAD	38b
Korobowsky Lojok	URRS	39b
Korucular	TRKY	24c
Kosaka (Motoyama)	JAPN	28a
Kosaka (Uch.-Uwa.)	JAPN	28a
Kossia R.	URRS	39b
Kossoi-Log	URRS	39b
Kossorgskii Log	URRS	39b
Kostere	TRKY	28a
Kotalahti	FNLD	6a
Kotchkar Mines	USSR	36a
Kotsu	JAPN	24b
Kounrad	URKZ	17
Koyama	JAPN	25d
Koycegiz-Curukcu	TRKY	8a
Koycegiz-Kurardi	TRKY	8a
Koycegiz-Orta	TRKY	8a
Kozyrevka	URRS	18d
Krain	CNBC	17
Kremmel and Froelich	USCA	8a
Kristineberg	SWDN	28a
Krivoi-Rog	URRS	34a,28b
Kroumovo	URRS	18d
Kruglogorsk	URRS	18d
Krupka	CZCL	15b
Krutoi Log	URRS	39b
Kucuk Yenice	TRKY	27d
Kudremukh and others	INDA	34a,28b
Kudu Asbestos Mine	ZIMB	8d
Kuldoden	TRKY	8a
Kun Ming	CINA	34c
Kundikan-Keluskdere	TRKY	8a
Kundikan-Kelusktepe	TRKY	8a
Kune	JAPN	24b
Kung-changling	CINA	34a,28b
Kunitomi	JAPN	28a
Kupferschiefer	GRMY	30b
Kure (Asikoy, Bakibaba)	TRKY	24a
Kurosawa	JAPN	28a
Kurudere	TRKY	8a
Kurzhunkul	URRS	18d
Kusalpur	INDA	34a,28b
Kushikino-Arakawa	JAPN	25c
Kutch	INDA	38b
Kutcho Creek	CNBC	28a
Kutlular	TRKY	28a
Kuvarshan	TRKY	28a
Kuyuluk Isletmesi	TRKY	8a
Kuzkavak	TRKY	8a
Kwanika	CNBC	17

Name	Country	Model No
Kylmakoski	FNLD	7a
Kynousa	CYPS	24a
La Alumbrera	AGTN	20c
La Bajada	USNM	25f
La Calanesa	SPAN	24c
La Caridad	MXCO	17
La Caridad	CUBA	8a
La Carmen	MXCO	18d
La Chapeteada	MXCO	25h
La Chililla	MXCO	25h
La Chinche	MXCO	25h
La Chorrera	MXCO	25h
La Cinta Corrida	MXCO	25h
La Cocona	MXCO	25h
La Colocion	MXCO	25h
La Cruz	MXCO	27d
La Desparramada	MXCO	25h
La Encantada	MXCO	19a
La Escondida	MXCO	25h
La Esperanza	MXCO	25h
La Estrella	MXCO	25h
La Florida	MXCO	17
La Grulla	MXCO	25i
La Guera	MXCO	25h
La Hormiga	MXCO	25h
La Huacalona	MXCO	25h
La Joya	SPAN	28a
La Joya	USCA	27c
La Laguna	DMRP	18d
La Leona	MXCO	25h
La Leona (Sonora)	MXCO	25g
La Libertad	MXCO	25d
La Libertad	USCA	27c
La Liendre	MXCO	25h
La Loba	MXCO	25h
La Mula	MXCO	25h
La Noria	MXCO	25g
La Paloma	MXCO	18d
La Perla-La Negra	MXCO	25i
La Piedra Iman	MXCO	18d
La Plata District	USCO	22b
La Polvosa	MXCO	25h
La Puntilla	MXCO	25h
La Quemada	MXCO	25h
La Reforma	MXCO	19a
La Torrera	SPAN	28a
La Triste	MXCO	25h
La Unica	CUBA	24c
La Venadita	MXCO	25h
La Verde	MXCO	17
La Vibora	MXCO	25h
La Victoria	CUBA	8a
La Victoria	MXCO	25h
La Vieja-El Agua	MXCO	25h
La Zarza	SPAN	28a
Lacey	USCA	8a
Lackner Lake	CNON	10
Ladd	USCA	24c
Lady Annie	AUQL	34c
Lady Loretta	AUQL	31a
Lafayette	CNQU	8d
Lagnokaha	UVOL	24c
Lagonoy	PLPN	8a
Laguerre	CNON	36b

Name	Country	Model No
Laguna Colorado	AGTN	25f
Laguna del Cuervo	MXCO	25f
Lagunazo	SPAN	28a
Laguney	PLPN	38a
Lahanos	SPAN	28a
Lainijaur	SWDN	7a
Laisvall	SWDN	30a
Lajas	MXCO	25g
Lake Asbestos	CNQU	8d
Lake Catcha	CNNS	36a
Lake City	USCO	25b
Lake Dufault	CNQU	28a
Lake George	CNNB	27d
Lake Joanina	GREC	38a
Lake Valley	USNM	19b
Lakehurst (Glidden)	USNJ	39c
Lakeshore	USAZ	18a
Lamb Creek	USID	39a
Lambert	USCA	8a
Lammereck	ASTR	19b
Lampazos	MXCO	19a
Lamphear	USCA	36a
Lancefield	AUWA	36b
Lancha	SPAN	28a
LangSen	VTNM	38c
Langban	SWDN	18c
Langdal	SWDN	28a
Langley Chrome	USOR	8a
Langmuir 2	CNON	6a
Langmuir 1	CNON	6a
Langsele	SWDN	28a
Lapa Cadillac	CNQU	36b
Lappuattnet	SWDN	7a
Laramie Range	USWY	7b
Larap-Calambayungan	PLPN	18d
Largentiere	FRNC	30a
Las Aguilas	MXCO	25h
Las Amarillas	MXCO	25h
Las Ambollas	FRNC	19b
Las Animas Cerro Prieto	MXCO	18d
Las Brisas	CLBA	8d
Las Cabesses	FRNC	19b
Las Calaveras	MXCO	25h
Las Flores	MXCO	25h
Las Fundiciones	MXCO	25h
Las Marias	MXCO	25h
Las Pegazones	MXCO	25h
Las Perlitas	MXCO	25h
Las Tablas	MXCO	25h
Las Truchas	MXCO	18d
Las Varas-La Vaca	MXCO	25g
Lasail	OMAN	24a
Lasbela	PKTN	24c
Lassic Peak	USCA	8a
Last Buck	USOR	8a
Last Chance	USNV	27d
Last Chance	USOR	8a
Laton	USCA	8a
Laukunkawges	FNLD	7a
Laurium	GREC	19a
Lava Bed	USCA	18d
Laverton-Mt. Lucky	AUWA	24c
Lawrencetown	CNNS	36a
Le Kouif	ALGR	34c

Name	Country	Model No	Name	Country	Model No
Leadsmith	CNBC	22c	Lonesome	USFL	34d
Lebyazhka	URRS	18d	Long Ledge Gp.	USCA	8a
Lee Creek	USNC	34c	Long Point	PLPN	38a
Legal Tender	USMT	22c	Long Tunnel	AUVT	36a
Leipsigate	CNNS	36a	Lord Nelson	AUVT	36a
Leitch-Sand River	CNON	36b	Loreto	MXCO	25h
Lena	URRS	30b	Lornex	CNBC	21a
Lenora-Twin J	CNBC	28a	Lorraine	CNBC	20c
Leoncitos	MXCO	25h	Lorraine	CNQU	7a
Lepanto	PLPN	22a	Lorraine	PLPN	24a
Letty	USCA	8a	Los Angeles	MXCO	25h
Levant	GRBR	15b	Los Arrieros	MXCO	25h
Leveaniemi	SWDN	25i	Los Borregos	MXCO	25g
Levi	SWDN	28a	Los Bronces	CILE	17
Leviathan	AUVT	36a	Los Caballos	MXCO	25h
Leviso R.	CUBA	38a	Los Campamentos	MXCO	25h
Liaoning	CINA	19a	Los Castillos	VNZL	34a,28b
Liberty (Stanislaw Co.)	USCA	24c	Los Condores	AGTN	15a
Liberty (Siskyou Co.)	USCA	36a	Los Cuatillos	MXCO	25h
Liberty (Calaveras Co.)	USCA	8a	Los Garcia	MXCO	25h
Liberty Bond Claim	USCA	8a	Los Lobos	MXCO	25h
Lights Creek	USCA	17	Los Mantiales	AGTN	25b
Lili	CNQU	8d	Los Pelambres	CILE	17
Lily (Ikeno)	CNBC	18b	Los Pijiguaos	VNZL	38b
Lily Creek	AUQL	34c	Los Pilares	MXCO	17
Limasol Forest	CYPS	8c	Los Pinacates	MXCO	25h
Limni	CYPS	24a	Los Puertos	MXCO	25f
Linda Marie	USOR	8a	Los Vasitos	MXCO	25i
Lingman	CNON	36b	Los Volcanes	MXCO	19b
Lingwick	CNQU	28a	Los Volcanes	MXCO	25g
Lion Den	USCA	27c	Lost Creek	USMT	14a
Lithia	USNV	27d	Lost Lake	CNMN	28a
Little Bay	CNNF	24a	Lost Lee	USOR	8a
Little Boy	USOR	8a	Lost River	USAK	14b,15c
Little Castle Creek	USCA	8a	Lotty	USCA	8a
Little Chief	CNYT	18b	Lousal	PORT	28a
Little Hope	USCA	8a	Louvem	CNQU	28a
Little Long Lac	CNON	36b	Lovstrand	SWDN	30a
Little Nell	USMT	22c	Lowe Placer	USCO	39a
Little Rock Mine	USCA	8a	Lower Beaver Creek	USCO	39a
Little Siberia	USOR	8a	Lowland Creek	USMT	39a
Little Squaw	USAK	36a	Lowry	USNV	27d
Liverpool	USMT	22c	Lubin (Legnica-Glogow)	PLND	30b
Livitaca-Velille	PERU	18d	Lucia (Generosa)	CUBA	24c
Llallagua	BLVA	20a	Lucifer	MXCO	24c
Llano de Oro	USOR	39a	Lucky Bart	USOR	36a
Lobwa R.	URRS	39b	Lucky Boy	USCA	8a
Locarno	USCA	36a	Lucky Four	CNBC	18b
Loch Fyne	AUVT	36a	Lucky Friday	USOR	8a
Loei-Chiengkarn	THLD	18b	Lucky Girl	USCA	8a
Lofthouse	USNV	27d	Lucky Hunch	USOR	8a
Logwinska	URRS	39b	Lucky Knock	USWA	27d
Lohara and others	INDA	34a,28b	Lucky L. & R.	USOR	8a
Lojok No. 1&2 Omoutnaia	URRS	39b	Lucky Lass	USOR	25f
Lojok at Bisserskaya	URRS	39b	Lucky Mike	CNBC	14a
Lokken	NRWY	24a	Lucky Nine Gp.	USOR	8a
Lolita	CUBA	8a	Lucky Ship	CNBC	21b
Loma de Hierro	VNZL	38a	Lucky Shot-War Baby	USAK	36a
Lomero Poyatos	SPAN	28a	Lucky Star	USOR	8a
Lomonosov	URRS	18d	Lucky Strike	USCA	8a
Lone Gravel	USCA	8a	Lucky Strike	USOR	8a
Lone Mary	USCA	36a	Lueshe	ZIRE	10
Lone Mountain	USNM	19b	Lumbay	PLPN	20c
Lone Mountain	USNV	19a	Lumwana	ZNBA	30b

Name	Country	Model No
Luna-Bash	PLPN	17
Luossauaara	SWDN	25i
Lyell Goldfield	NZLD	36a
Lyndhurst	CNQU	28a
Lynn Lake	CNMN	7a
Lynx	CNQU	28a
Lynx Creek	USAZ	39a
Lyon	USNV	18a
Lyon Lake	CNON	28a
M and M Group	USNM	25g
Maanshan	HONG	18d
Mabel	USAK	36a
Mac	CNBC	18d
MacArthur	USNV	17
MacBride Lake	CNMN	28a
MacMillan	CNYT	31a
Machimi	JAPN	24b
Machkatica	YUGO	21b
Mackay	USCA	8a
Mackey	USID	18b
Mactung	CNNT	14a
Macusani	PERU	25f
Madeira	USCA	8a
Madeni	TRKY	27d
Madenkoy	TRKY	28a
Madhya Pradesh	INDA	34b
Madrid	USCA	8a
Madrigal	PERU	25b
Madsen	CNON	36b
Madziwa	ZIMB	7a
Magdalena	CUBA	24c
Magdalena	USNM	19a
Maggie	CNBC	17
Maggie Creek	USNV	26a
Maggotty	JMCA	38c
Magnet Cons.	CNON	36b
Magnet Cove	USAR	31b
Maikala Range	INDA	38b
Main Valley of Kisslaia	URRS	39b
Mainpat	INDA	38b
Maiva	SWDN	30a
Majdanpek	YUGO	17
Majestic-Sapphire	CNBC	22c
Makhtesh	USRL	34c
Makimine, Hibira	JAPN	24b
Makola	FNLD	7a
Malaia Koswa R.	URRS	39b
Malaia Prostokischenka	URRS	39b
Malaia Sosnowka	URRS	39b
Malaiba	PLPN	28a
Malden North	AUVT	36a
Malko Trnova	BULG	18b
Malmberget	SWDN	25i
Malmbjerg	GRLD	16
Malomalsky-Priisk	URRS	39b
Malot Pokap	URRS	39b
Mamie	CNBC	28a
Mammoth	USAZ	19b
Mammoth (Kern Co.)	USCA	28a
Mammoth (Shasta Co.)	USCA	36a
Mammoth (Gunpowder)	AUQL	30b
Mammoth-St. Anthony	USAZ	22c
Mamuro	JAPN	25d
Mamut	MDGS	20c
Manacas Group	CUBA	24c
Manantenina	MDGS	38b
Manavalakurichi	INDA	39c
Manchester	USCA	8a
Manchester (Asarco)	USNJ	39c
Manchester Plat.	JMCA	38c
Mandy	CNMN	28a
Manga de Lopez	MXCO	25h
Mangampetta N.	INDA	31b
Mangampetta S.	INDA	31b
Manganese Chief	USNM	25g
Manganese Development	USAZ	25g
Mangula (Miriam)	ZIMB	30b
Mangum	USOK	30b
Manhattan	USCA	27a
Manibridge	CNMN	6b
Manitou Island	CNON	10
Mankayan	PLPN	28a
Mansfeld	GRMY	30b
Mantos Blancos	CILE	17
Manuel	CUBA	24c
Manuel Killigrews	CNNF	34b
Manus Island	PPNG	38b
Manzanillas	MXCO	25h
Mapula	PLPN	20c
Marais Kiki	NCAL	8a
Maralls Capro Leases	USCA	8a
Maranboy	AUNT	15b
Marangaka	MDGS	38b
Marbella	SPAN	18d
Marble Bar	AUWA	36b
Marble Bay	CNBC	18b
Marbridge	CNQU	6a
Marchinbar Island	AUNT	38b
Marcopper	PLPN	20c
Marcos	PLPN	28a
Margaret	USWA	17
Maria Christina	CILE	19a
Maria Luisa	VNZL	34a,28b
Marian	PLPN	20c
Mariana	BRZL	38b
Marietta	USMT	22c
Mariners	AUVT	36a
Mariposa	USCA	36a
Marks & Tompson	USOR	8a
Marlborough	AUQL	38a
Marmoraton	CNON	18d
Marquette	USMN	34a,28b
Martian R.	URRS	39b
Martin-Bird	CNON	36b
Martinovo	BULG	18d
Martison Lake	CNON	10
Mary Jane	USCA	8a
Mary Walker	USOR	8a
Marysvale	USUT	25f
Marysville District	USMT	22c
Mascot	USTN	32b
Masinloc	PLPN	38a
Maslovo	URRS	18d
Mason Valley-Malachite	USNV	18b
Masonic	USCA	25e
Matachewan Cons. & others	CNON	36b
Matamoros	MXCO	25g
Matchless	NAMB	30b

Name	Country	Model No
Matchless West	NAMB	30b
Matese-Ciociaria	ITLY	34b
Mathiati North	CYPS	24a
Mati	PLPN	18d
Matona-Stairs	CNON	36b
Matt Berry	CNYT	31a
Mattabi	CNON	28a
Mattagami Lake	CNQU	28a
Maubach	GRMY	30a
Maude & Yellow Girl	AUVT	36a
Maurice Bay	CNSK	38d
Mavrovouni	CYPS	24a
Mawchi	BRMA	15b
Maxwell	USCA	8a
Mayari	CUBA	38a
Mayflower	USCA	8a
Maykhura	URTD	14a
Mazagao	BRZL	38b
Mazama	USWA	17
Mazapil	MXCO	19a
Mazidagi	TRKY	34c
Mbeya	TNZN	10
McAdam	CNQU	8d
McArthur	AUNT	31a
McCaleb's Sourdough	USOR	8a
McCarty	USCA	8a
McClean Lake	CNSK	38d
McConnell	CNBC	18b
McCormick	USCA	8a
McDame Belle	CNBC	18c
McDermitt	USNV	27a
McFinley	CNON	36b
McGlaughlin	USCA	25a
McGuffy Creek Gp.	USCA	8a
McMarmac	CNON	36b
McMaster	CNNB	28a
McMurty	USCA	8a
McWatters	CNON	6a
McWatters	CNQU	36b
Mdilla	TUNS	34c
Meat Cove	CNNS	18c
Mechernich	GRMY	30a
Meeker (Sonoma Chrome)	USCA	8a
Megara-Eleusis	GREC	38c
Meggen	GRMY	31a
Meggen Barite	GRMY	31b
Mel Barite	CNYT	31b
Melnitschnaia	URRS	39b
Meme	HATI	18b
Menominee	USMN	34a,28b
Menzies	AUWA	36b
Mercedes	CUBA	19b
Mercur	USUT	26a
Merrifield	USCA	8a
Merrimac	USNV	27d
Mesabi	USMN	34a,28b
Meskala	MRCO	34c
Metal Negro	MXCO	25h
Metalline	USWA	32a,32b
Metcalf	USAZ	17
Metlaoui	TUNS	34c
Metsamonttu	FNLD	28a
Meululter	TRKY	8a
Mezcala	MXCO	25g

Name	Country	Model No
Mic Mac	CNQU	28a
Michiquillay	PERU	17
Midas	USCA	36a
Middle Fork	USWA	17
Middle Ore Body	PLPN	8a
Midlothian	CNON	8d
Midwest Lake	CNSK	38d
Mighty Joe	USOR	8a
Mikado	USAK	36a
Milan	USNH	28a
Milford area	USUT	14a
Millenbach	CNQU	28a
Miller Lake	CNNS	36a
Milton	USCA	8a
Milton Canyon	USNV	27d
Mimoso do Sul	BRZL	38b
Mina Dura	MXCO	25h
Mina El Sapo	CLBA	18b
Mina Vieja	CLBA	18b
Mina del Aire	MXCO	25h
Minarets	USCA	25i
Minas Gerais	BRZL	34a,28b
Minawa	JAPN	24b
Mineral Butte	USAZ	17
Mineral King	CNBC	31a
Mineral Park	USAZ	22c
Mineville-Port Henry	USNY	25i
Minim-Martap	CMRN	38b
Minniehaha	CNBC	22c
Minto	CNBC	36a
Minto-Tyranite	CNON	36b
Mirabel	USCA	27c
Mirandag Koru	TRKY	8a
Mirandag Mevki	TRKY	8a
Miriam	AUWA	6a
Misima Island	PPNG	22c
Missouri Creek	USCO	39a
Mistry	CNBC	17
Mitate	JAPN	19a
Mitchell Creek	USMT	39a
Mitchell Plateau	AUWA	38b
Mitchell River	AUQL	27d
Miyawa	JAPN	24b
Mizobe	JAPN	25d
Mizpah	USAK	36a
Mizpah	USNV	27d
Mjodvattnet	SWDN	7a
Mlanje Mountain	MLWI	38b
Moa Bay	CUBA	38a
Moak	CNMN	6b
Mobrun	CNQU	28a
Mocha	CILE	17
Mochikoshi	JAPN	25c
Mockingbird	USOR	8a
Mocoa	CLBA	17
Modarelli	USNV	25i
Moengo	SRNM	38b
Moffett Creek Gp.	USCA	8a
Mofjell	NRWY	28a
Mogi das Cruzes	BRZL	38b
Mogollon	USNM	25c
Mogpog	PLPN	18d
Mohave	USCA	25e
Mohawk Claim	USOR	8a

Name	Country	Model No
Mohawk-Dome View	USAK	36a
Moina	AUTS	14b
Moinho	PORT	28a
Mokambo	ZMBA	30b
Mokanji Hills	SRLN	38b
Mokelumne	USCA	36a
Mokoman Lake	CNSK	28a
Moladezhnoye	URRS	8d
Molango	MXCO	34b
Molega	CNNS	36a
Moleon Lake	CNQU	28a
Molitchowka	URRS	39b
Molly Gibson	CNBC	22c
Monarch-Kicking Horse	CNBC	32a,32b
Monghyr	INDA	38b
Monitor	CNBC	22c
Moniwa	BRMA	17
Monpas	CNQU	28a
Mons Cupri	AUWA	28a
Montana	USMT	34c
Montaque	CNNS	36a
Montcalm	CNON	7a
Monte Carmelo	NCRG	18d
Montenegro-Adriana	CUBA	24c
Montezuma	CNBC	22c
Montezuma	USNV	27d
Montosa	MXCO	25g
Montredon	FRNC	15a
Moonlight	USNV	25f
Moore	USCA	8a
Moore's Flat	USCA	36a
Moorsom	PLPN	38a
Moose Mountain	CNON	34a,28b
Moose River	CNNS	36a
Moosehead	CNNS	36a
Mooseland	CNNS	36a
Moramanga	MDGS	38a
Mordey	CNON	28a
Morenci	USAZ	21a
Moreton Island	AUQL	39c
Mormon Bar	USCA	36a
Morning Star	AUVT	36a
Morococha	PERU	17
Morphine-Log	URRS	39b
Morrachini	NCAL	8a
Morris Ravine	USCA	36a
Morris-Kirkland	CNON	36b
Morrison	CNBC	17
Morro Velho	BRZL	36b
Morro da Mina	BRZL	34b
Morro de Engenho	BRZL	38a
Mos	NRWY	28a
Moscatelli	USCA	8a
Moscatelli No. 2	USCA	8a
Moskogaissa	NRWY	28a
Moss Vale	AUNS	38b
Mother Lode	USCA	36a,39a
Mother Lode-Sunset	CNBC	18b
Motoyasu	JAPN	24b
Moulares	TUNS	34c
Moulton Hill	CNQU	28a
Mount Bischoff	AUTS	14c
Mount Bulga	AUNS	28a
Mount Bullion	USCA	36a
Mount Burton (Rum Jungle)	AUNT	38d
Mount Canninda	AUQL	17
Mount Chalmers	AUQL	28a
Mount Ejuanema-Nsisreso	AUNS	38b
Mount Emmons	USCO	16
Mount Finch (Rum Jungle)	AUNT	38d
Mount Gaines	USCA	36a
Mount Gibson	AUWA	34a,28b
Mount Gould	AUWA	34a,28b
Mount Hale	AUWA	34a,28b
Mount Hope	USNV	16
Mount Hundere	CNYT	18c
Mount Isa	AUQL	31a
Mount Lyell	AUTS	28a
Mount Morgan	AUQL	28a
Mount Mulcahy	AUWA	28a
Mount Nolan Dist.	AUQL	15b
Mount Paynter	AUNS	15b
Mount Philip	AUQL	34a,28b
Mount Pleasant	USCA	36a
Mount Saddleback	AUWA	38b
Mount Shasta	USCA	36a
Mount Thomlinson	CNBC	21b
Mount Tolman	USWA	21b
Mount Uniacke	CNNS	36a
Mount Vernon	USCA	36a
Mount Wellington	GRBR	15b
Mountain Chief and vicinity	CNBC	22c
Mountain Con	CNBC	22c
Mountain King	USCA	36a
Mountain Mines	PLPN	20c
Mountain Pass	USCA	10
Mountain Springs	USNV	31b
Mountain View	USCA	8a
Mountain View Gp.	USCA	8a
Mousoulos-Kalavasos	CYPS	24a
Mowbray Creek	AUQL	15b
Moxie Pluton	USMA	7a
Mrata	TUNS	34c
Mrima	KNYA	24c
Mrima Hill	KNYA	10
Mt. Diablo	USCA	27c
Mt. Edwards	AUWA	6a
Mt. Gunson	AUSA	30b
Mt. Keith	AUWA	6b
Mt. Magnet	AUWA	36b
Mt. Morgans	AUWA	36b
Mt. Oxide	AUQL	30b
Mt. Sholl	AUWA	7a
Mt. Windarra	AUWA	6a
MuNaly	USCA	8a
Mufulira	ZMBA	30b
Mugi	JAPN	27d
Mulcahy Prospect	USCA	8a
Mule Creek	USCA	8a
Mum and Alice June Claim	USCA	8a
Munbinea Shoreland	AUWA	39c
Munda	AUWA	6a
Munesada	JAPN	18d
Munmorah	AUNS	39c
Munro	CNON	8d
Murguia	MXCO	25g
Murgul	TRKY	28a
Muriwai	NZLD	39c

Name	Country	Model No
Murphy	USCA	8a
Murray Brook	CNNB	28a
Musa Danisman	TRKY	8a
Musan	NKOR	34a,28b
Musonoi	ZIRE	30b
Musoshi	ZIRE	30b
Mutum	BLVA	34a,28b
Muzaffarabad	PKTN	38c
Muzo	CLBA	31c
Muzzleloader (Stevens No. 1)	USCA	8a
Mwaytung	BRMA	38a
Myalla	AUNT	38b
Myra Falls-Lynx	CNBC	28a
Mystery Lake	CNMN	6b
Mzaita	ALGR	34c
N. Stradbroke Island	AUQL	39c
N.L. Industries (Aurora)	USNC	39c
NW Group	GUYN	38b
Nabarlek	AUNT	38d
Nacimiento	USNM	30b
Nacozari	MXCO	25g
Nagamatsu	JAPN	25d
Nagyegyhaza	HUNG	38c
Nahal-Zin	ISRL	34c
Naica	MXCO	19a
Nakatatsu	JAPN	19a
Nakayama	JAPN	24b
Nakerivaara	SWDN	25i
Nalden South	AUVT	36a
Namosi	FIJI	17
Naniango	UVOL	34b
Nanisivik	CNNT	32a,32b
Nanogawa	JAPN	24b
Narciso	CUBA	8a
Naruyasu	JAPN	24b
Nashville	USCA	36a
Nasliden	SWDN	28a
Nassau Mountains	SRNM	38b
Natchez Trace State	USTN	39c
National	CNQU	8d
National	USCA	36a
Navan	IRLD	31a
Nawaji	JAPN	25c
Naybob	CNON	36b
Neardie	AUQL	27d
Needle Hill	HONG	15a
Needle Mountain	CNCQ	18a
Nemogos	CNON	10
Nepean	AUWA	6a
Nepisiguit	CNNB	28a
Nepoui	NCAL	38a
Nevada King	USNV	27d
Nevada Sulphur co.	USNV	27a
Nevada-Massachusetts	USNV	14a
Nevada-Scheelite	USNV	14a
New Almaden	USCA	27c
New Bay Pond	CNNF	28a
New Bendigo	AUVT	36a
New Calumet	CNQU	19a
New Cuyama	USCA	34c
New Era-Rowe	AUVT	36a
New Frontier	PLPN	38a
New Hope	USCA	8a
New Hope Claim	USOR	8a
New Hosco	CNQU	28a
Newfoundland Zinc	CNNF	32a,32b
Newman	USCA	8a
Newton	USCA	28a
Nhamunda	BRZL	38b
Ni Te Ocutes	CUBA	8a
Niasman R.	URRS	39b
Nichelini Mine	USCA	8a
Nickel Mountain	USOR	38a
Nickel Mountain	USOR	8a
Nickel Ridge	USOR	8a
Nicolet Asbestos	CNQU	8d
Nieves	MXCO	27d
Niggerhead	USNM	25g
Nii	JAPN	24b
Nikolaevskoe	URRS	34b
Nikolai-Tschoudotworsky	URRS	39b
Nikopol	URRS	34b
Niksicka Zupa	YUGO	38c
Nilgiri Hills	INDA	38b
Nimiuktuk	USAK	31b
Nimpkish	CNBC	18d
Nimrod	AUVT	36a
Nine Mile Brook	CNNB	28a
Niquelandia	BRZL	38a
Nishinokawa	JAPN	24b
Nizne-Udinskaja	URRS	34b
Noamundi-Joda-Gua etc.	INDA	34a,28b
Noble Electric Co.	USCA	8a
Nobles Nob	AUWA	36b
Nogal	USNM	25b
Noji	JAPN	24b
Nonoc	PLPN	38a
Nonowaki	JAPN	24b
Noonday	CNBC	22c
Norah	ZIMB	30b
Noralyn-Phosphoria	USFL	34d
Norberg	SWDN	34a,28b
Norcross	USCA	8a
Nordre Gjetryggen	NRWY	28a
Noril'sk	USSR	5b
Norita	CNQU	28a
Normandie/Penhale	CNQU	8d
Normetal	CNQU	28a
Norseman-Dundas	AUWA	36b
North Arkansas-Ozark	USAR	32a,32b
North Boundary	CNNB	28a
North Camden (Keer-McGee)	USTN	39c
North Carolina phospate	USNC	34d
North Cerbat (Golconda)	USAZ	22c
North End, West End,Spotted Fawn		USCA8a
North Florida phosphate	USFL	34d
North Fork	USWA	17
North Fork Chrome	USCA	8a
North Keystone	USCA	28a
North Mocassin	USMT	22b
North Murphy	USCA	36a
North Star	CNMN	28a
North Star	USAK	36a
North Star	USOR	8a
North Star (Red Mtn)	USCA	8a
North Weipa	AUQL	38b
Northair	CNBC	28a
Northeast Florida	USFL	34d

Name	Country	Model No
Northern Anomaly	IRAN	25i
Northern Bell-Jackson	CNBC	22c
Northern Ireland	IRLD	38b
Northumberland	USNV	26a
Northumberland barite	USNV	31b
Norway	USOR	8a
Nount Wells	AUNS	15b
Novazza	ITLY	25f
Novo Maslovo	URRS	18d
Novo Peschansk	URRS	18d
Novoi-Log	URRS	39b
Nueva Esperanza	CLBA	27b
Nugget Creek (South Fork)	USID	39a
Nuggetty	AUVT	36a
Nuqrah	SAAR	28a
Nuria	VNZL	38b
Ny Sulitjelma	NRWY	24a
Nyinahin	GHNA	38b
Nyirad	HUNG	38c
Nymbool Dist.	AUQL	15b
Nyseter	NRWY	18c
O'Connors	AUVT	36a
Oak Grove (Ethyl)	USTN	39c
Oak Ridge	USCA	8a
Oakleigh Creek	AUTS	15a
Oamite	NAMB	30b
Oatman	USAZ	25c
Oberpfalz	GRMY	30a
Obi	INDS	38a
Obira	JAPN	18b
Obodranny-Lojok	USSR	39b
Ochanocagi	TRKY	8a
Ocna de Fier	RMNA	18d
Oe	JAPN	25b
Ofelia	CUBA	8a
Offshore	USGA	34d
Ogane	JAPN	25b
Ohguchi	JAPN	25c
Ohito	JAPN	25c
Ok	CNBC	17
Ok Tedi	PPNG	20c
Oka	CNQU	10
Okuki	JAPN	24b
Old Dad Mountains	USCA	18d
Old Diggings	USCA	36a
Old Waite	CNQU	28a
Oldham	CNNS	36a
Olinghouse	USNV	25c
Olive B.	USOR	8a
Olsen	USCA	8a
Olympias Chalkidiki	GREC	19a
Olympic Dam	AUSA	29b
Omine	JAPN	24b
Onion Springs	USOR	8a
Opalite	USOR	27a
Ophir	USCA	36a
Ophir	USCO	25b
Ophir	USMT	39a
Ophir	USUT	19a
Ora Banda	AUWA	38a
Orange Hill	USAK	17
Orange Point	USAK	28a
Orchan	CNQU	28a
Ore Drag	USNV	27d
Oregon	CNBC	18b
Oregon	USAZ	19b
Oregon Bell	USOR	36a
Oregon Chrome	USOR	8a
Orendere	TRKY	27d
Orient	USWA	25c
Oriential	AUVT	36a
Orijarvi	FNLD	28a
Orissa (Chatrapur)	INDA	39c
Oro Denoro (Ema)	CNBC	18b
Oro Grande-Buena Vista	USCA	36a
Orogrande	USNM	18d
Oronta	ISRL	34c
Orpit	CNON	36b
Orsk	URRS	38a
Orta Ezan	TRKY	8a
Osamu Utsumi	BRZL	25f
Osbourne Lake	CNMN	28a
Osen	NRWY	30a
Osgood Range	USNV	14a
Oshio	JAPN	28a
Osokino-Aleksandrovsk	URRS	18d
Ostra Hogkulla	SWDN	28a
Otjosondu	SAFR	34b
Otmanlar-Harpuzlu	TRKY	8a
Otmanlar-Mesebuku	TRKY	8a
Ottery Lode	AUNS	15b
Oturehua Field	NZLD	36a
Oulad-Abdoun	MRCO	34c
Ourem	BRZL	38b
Ouse	AUTS	38b
Ovens	CNNS	36a
Oviachic 1&2	MXCO	25g
Oxec	GUAT	24a
Oxford	USCA	8a
Oya	JAPN	36a
P. B.	NCAL	8a
P. U. P. (Zenith)	USCA	8a
Pa-pan-ling	CINA	34a,28b
Pabineau River	CNNB	28a
Pachuca-Real del Monte	MXCO	25b
Pactolus	USCO	39a
Paddy's Flat	AUWA	36b
Padurea Craiului	RMNA	38c
Page	USNV	27d
Pahang	MLYS	15b
Painirova	SWDN	25i
Palette	AUNT	38d
Palmer's Find	AUWA	36b
Palni Hills	INDA	38b
Palo Colorado	MXCO	25h
Paloma-Gwin	USCA	36a
Pambuhan Sur	PLPN	18d
Pampa Norte	CILE	17
Pampachiri	PERU	18d
Panamana-An	PLPN	8a
Panasqueria	PORT	15a
Panchillo	MXCO	25h
Panguana	PPNG	20c
Panguna	PPNG	17
Panowka	URRS	39b
Panther	USNV	27d
Paparoa Range	NZLD	36a
Paracale	PLPN	18d

Name	Country	Model No	Name	Country	Model No
Paradise	USOR	8a	Picuris	USNM	39a
Paragominas	BRZL	38b	Piddig	PLPN	18d
Paramillos	AGTN	17	Pikwe	BOTS	7a
Paranam	SRNM	38b	Pilleys Island	CNNF	28a
Parish	AUNS	38b	Pillikin	USCA	8a
Park	USTN	39c	Pima-Mission	USAZ	18a
Park City	USUT	19a	Pine Bay	CNMN	28a
Park's Ranch	USCA	8a	Pine Creek	USCA	14a
Parker	USCA	8a	Pine Grove	USUT	16
Parkeson	USCA	8a	Pine Mountain Claim	USCA	8a
Parks	AUNS	17	Pine Nut	USNV	21b
Parnassus-Helikon	GREC	38c	Pine Point	CNNT	32a,32b
Paronen	FNLD	28a	Pines	USOR	8a
Parroquio-Magistral	MXCO	18c	Pinnacles	AUQL	14b
Parys Mountain	GRBR	28a	Pinson	USNV	26a
Pashpap	PERU	17	Pintada-Stauber	USNM	30b
Passagem	BRZL	36b	Pioneer	USMT	39a
Pasto Bueno	PERU	15a	Pipe	CNMN	6b
Pasuquin	PLPN	28a	Pipestem	CNBC	36a
Patchek	URRS	39b	Piray	PLPN	28a
Pater	CNON	28a	Pirki	TRKY	24c
Patos de Minas	BRZL	34c	Piskala	TRKY	24c
Patrick	USCA	36a	Pitman (JB)	CNBC	21b
Patriquin	USCA	27c	Pito Real	MXCO	25g
Patterson	USCA	25c	Placerville	USCA	36a
Paulista	BRZL	34d	Plagia	GREC	18d
Payas	TRKY	38c	Plan de Tecolotes	MXCO	25h
Paymogo	SPAN	28a	Platies	CYPS	24a
Payne Group	CNBC	22c	Pleasant No. 1 & 2	USOR	8a
Pea Ridge	USMO	25i	Pleasant River	CNNS	36a
Pearsoll Peak	USOR	8a	Plomosas	MXCO	19a
Pecos	USNM	28a	Pluma Hidalgo	MXCO	7b
Peewan	USCA	8a	Plurhinaler	THLD	17
Peg Leg (Lambert)	USCA	8a	Poco Tiempo Quartz	USCA	8a
Pelican	USWI	28a	Pocos de Caldas	BRZL	38b
Pen-chi-hu	CINA	34a,28b	Podbornaia	URRS	39b
Pena Colorada	MXCO	18d	Podmoskowoi-Log	URRS	39b
Penn	USCA	28a	Poerua River	NZLD	39c
Pennington Butte	USOR	8a	Point Leamington	CNNF	28a
Pennsylvania	USCO	22c	Poirier	CNQU	28a
Penobscot	USME	28a	Poison Mountain	CNBC	17
Penryn	USCA	36a	Pokrovsk	URRS	18d
Peravasa	CYPS	24a	Polar Star	USCA	27c
Perconi Ranch	USCA	8a	Polaris-Eclipse	CNNT	32a,32b
Perda Niedda	ITLY	18d	Poludnig-Hermagor	ASTR	19b
Pergini	TRKY	8a	Pomalea	INDS	38a
Perrunal	SPAN	28a	Pontbriand	CNQU	8d
Persberg	SWDN	18d	Ponupo	CUBA	24c
Perseverance	ZIMB	6a	Ponupo de Manacal	CUBA	24c
Peschansk	URRS	18d	Pony Shoe	USCA	8a
Pestchanka R.	URRS	39b	Poodle Dog	USCA	8a
Petaquilla	PANA	17	Popowsky-Lojok	URRS	39b
Petersen Mtn.	USCA	25f	Popretschne-Log	URRS	39b
Phedinan R.-Triok	URRS	39b	Porkonen	FNLD	34a,28b
Phelps Dodge	CNQU	28a	Poro	NCAL	38a
Philipsburg	USMT	19b	Port Aux Moines	FRCN	28a
Phillips Lease	USNM	25g	Porter Property	USCA	8a
Phoenix	BOTS	7a	Porto Rico	CNBC	36a
Phoenix	CNBC	18b	Pot Lake	CNMN	28a
Phoenix	USCA	36a	Potosi	BLVA	20b
Piacoa	VNZL	34a,28b	Potosi	BRZL	15c
Picacho	USCA	37b	Potosi	CUBA	8a
Picila	MXCO	18d	Potrerillos	CILE	18a
Pickle Crow	CNON	36b	Potrero del Molino	MXCO	25h

Name	Country	Model No	Name	Country	Model No
Poum	NCAL	38a	Randall	USCA	8a
Powers	USOR	8a	Ranger	AUNT	38d
Pozo Prieto	CUBA	24c	Rankin	CNON	18d
Pratapolis	BRZL	38a	Rankin Inlet	CNNT	6a
Prater	USOR	8a	Raposos	BRZL	36b
Preble	USNV	26a	Rattlesnake Mountain	USCA	8a
Prebuz	CZCL	15c	Raul	PERU	24b
Presque Isle	USMI	30b	Ravensthorpe	AUWA	34b
Price	CNBC	28a	Ravenswood	NZLD	36a
Prickly Pear Creek	USMT	39a	Ravliden	SWDN	28a
Primer	CNBC	17	Ravlidmyran	SWDN	28a
Progreso	CUBA	24c	Ray	USAZ	21a
Prony	NCAL	38a	Ray (Tip Top)	USOR	8a
Propretschnoi	URRS	39b	Ray Gulch	CNYT	14a
Prunty	USNV	27d	Ray Spring	USOR	8a
Puerto Rico bauxite	PTRC	38c	Raymond	NCAL	24c
Pujada Pen	PLPN	38a	Razorback	AUTS	14c
Pulmoddai	SRIL	39c	Recibimiento	MXCO	18d
Punch	INDA	38c	Recsk	HUNG	18a 22a
Pyhasalmi	FNLD	28a	Red Bird	CNBC	21b
Pyramid (Mariposa Co.)	USCA	36a	Red Chris	CNBC	20c
Pyramid (Humboldt Co.)	USCA	8a	Red Crest	CNON	36b
Qala-el-Nahl	SUDN	8d	Red Dog	USAK	31a
Quartz Hill	USAK	21b	Red Elephant	USCA	27c
Quarzazate	MRCO	24c	Red Hill-Red Hill Ext.	USNM	25g
Que River	AUTS	28a	Red Lake Gold Shore	CNON	36b
Quebrada Blanca	CILE	17	Red Ledge	USCA	8a
Queen Bess and vicinity	CNBC	22c	Red Mountain	USAZ	17
Queen Hill	AUTS	14c	Red Mountain	USCO	25b
Queen Victoria (Swift)	CNBC	18b	Red Mountain	USOR	8a
Queen of May	USOR	8a	Red Mountain	CNYT	21b
Queenston	CNON	36b	Red Rick	USCA	27c
Quelleveco	PERU	17	Red Slide Gp.	USCA	8a
Questa-Goat Hill	USNM	16	Red Wing	CNBC	28a
Quien-Sabe	USCA	27d	Redeyef	TUNS	34c
Quigg	USCA	8a	Redross	AUWA	6a
Quilon (Chavara)	INDA	39c	Redskin	USCA	8a
Quinto	CUBA	24c	Redstone	CNNT	23
Quixaba	BRZL	14a	Redwell	USCO	16
Qusseir	EGPT	34c	Reed	USCA	27c
R.R. Flat South	USCA	36a	Reed Lake	CNMN	28a
Rabbit Lake	CNSK	38d	Reefton Goldfield	NZLD	36a
Radiore E	CNQU	28a	Reeves	CNON	8d
Rail Lake	CNMN	28a	Reeves MacDonald	CNBC	31a
Rain	USNV	26a	Reicher Trost	PLND	36a
Rainbow	USCA	36a	Relief Canyon	USNV	26a
Rainbow	USOR	36a	Rendall-Jackson	CNNF	24a
Rainbow	USOR	8a	Renfrew	CNNS	36a
Rainy Day	USOR	8a	Renison Bell	AUTS	14c
Rajabasa	INDS	18c	Renstrom	SWDN	28a
Rajpura-Daiba	INDA	31a	Renzy	CNQU	7a
Rakkejaur	SWDN	28a	Republic	USWA	25c
Rambler-Cariboo	CNBC	22c	Rex	CNYT	8d
Rambler-Ming	CNNF	28a	Rexspar	CNBC	25f
Rammelsberg	GRMY	31a	Rhiw	GRBR	24c
Rammelsberg Barite	GRMY	31b	Rich	USCA	36a
Ramona-Loma	CUBA	38a	Rich Gulch	USCA	36a
Rampura-Agucha	INDA	31a	Rich Gulch (Virgilia)	USCA	36a
Ramsey	CNSK	28a	Richards	USCA	8a
Ramunia-Telok Ramunia	MLYS	38b	Richards Bay	SAFR	39c
Rana	NRWY	7a	Richey, U.S. & S.J.	USCA	8a
Ranch	USCA	36a	Riddle	USOR	38a
Rancherie	USOR	8a	Rieppe	NRWY	28a
Ranchi-Palamau	INDA	38b	Rim Rock and Homestake	USNV	27a

Name	Country	Model No
Rindge No. 1	USCA	36a
Ringwood	USNJ	25i
Rio	CNBC	22c
Rio Blanco	CILE	17
Rio Challana	BLVA	39a
Rio Chimate	BLVA	39a
Rio Pallanga	PERU	25b
Rio Tinto	SPAN	28a
Rio Tuba	PLPN	38a
Rio Tuichi (upper reach)	BLVA	39a
Rio Vivi	PTRC	20c
Rio Yolosano	BLVA	39a
Rio Yuyo	BLVA	39a
Risliden	SWDN	7a
Roan Antelope (Luanshya)	ZMBA	30b
Robb Lake	CNBC	32a,32b
Roberge Lake	CNQU	8d
Robert E	USOR	36a
Robert Emmet	USMT	22c
Roberts Mtns. Dist.	USNV	26a
Robertson	USOR	36a
Robt. E.	USOR	8a
Rochelois Plat.	HATI	38c
Rock Creek	USOR	8a
Rock Wren Mine	USCA	8a
Rockhole-Teages	AUNT	38d
Rockland	USFL	34d
Rocky Turn	CNNB	28a
Rod	CNMN	28a
Rodhammeren	NRWY	28a
Rodkleiv	NRWY	28a
Rokana (Nkana)	ZMBA	30b
Romanera	SPAN	28a
Romerito	SPAN	28a
Rondoni	PERU	18d
Rosario	HNDR	25c
Rose	CNBC	18d
Rose Claim	USCA	8a
Rose of Denmark	AUVT	36a
Rosebery-Read	AUTS	28a
Roseland	USVA	7b
Rosethistle & Shamrock	AUVT	36a
Rosh Pinah	NAMB	31a
Rosie Claim	USOR	8a
Rosita	NCRG	18b
Ross	CNON	36b
Ross	NZLD	39c
Rostvangen	NRWY	28a
Roublewik R.	URRS	39b
Round Bottom	USCA	8a
Round Mountain Au	USNV	25a
Round Mountain W	USNV	15a
Roupe	USCA	8a
Rouyn Merger	CNQU	36b
Rowghat	INDA	34a,28b
Royal George	AUTS	15b
Royal Mountain King	USCA	36a
Rua Cove	USAK	24a
Ruby Creek	USAK	32c
Rudna Glava	YUGO	18d
Rudtjebacken	SWDN	28a
Ruff Claim No. 32	PLPN	8a
Rum Jungle Creek South	AUNT	38d
Ruseifa	JRDN	34c
Rush Valley	USUT	19a
Ruth	USNV	18a
Ruttan	CNMN	28a
Ruwe (Mutoshi)	ZIRE	30b
Ryan	USCA	36a
Ryan Group	USAK	36a
Ryllshyttan	SWDN	18c
Ryuo	JAPN	24b
Sabana Grande	DMRP	18d
Sabanilla	CUBA	24c
Sabetjok	NRWY	28a
Sablayon	PLPN	38a
Sacaton	USAZ	17
Sad Sack	USOR	8a
Saddle Chrome	USOR	8a
Sado	JAPN	25d
Safagar	EGPT	34c
Safford (KCC)	USAZ	17
Saghand	IRAN	25i
Sagliden	SWDN	30a
Sagmo	NRWY	28a
Sai	JAPN	25b
Sailor's Gully	AUVT	36a
Sain Bel	FRNC	28a
Saindak	PKTN	17
Saindak South	PKTN	20c
Saint	USCA	8a
Saka	TRKY	8a
Sala	SWDN	18c
Salem Hills	USOR	38b
Saligny	FRNC	19b
Saline-Pulaski	USAR	38b
Salitre	BRZL	10
Sally Ann	USOR	8a
Sally Malay	AUWA	7a
Salmon River	CNNS	36a
Salsigne	FRNC	36a
Salt Rock	USOR	8a
Salur	TRKY	8a
Sam Goosly	CNBC	22a
Samar	PLPN	17
Sambalpur	INDA	38b
Sambas	AUVT	36a
Samli	TRKY	18d
San Antonio	PLPN	20c
San Antonio	SPAN	28a
San Bernardo	MXCO	25g
San Carlos	MXCO	18d
San Domingos	PORT	28a
San Emigdio	USCA	27d
San Fabian	PLPN	20c
San Francisco	MXCO	25h
San Francisco	USUT	19a
San Giovanni Rotondo	ITLY	38c
San Guillermo-Sierra	SPAN	28a
San Humberto	MXCO	25h
San Juan	USAZ	17
San Juan de Chacna	PERU	18d
San Juan de la Costa	MXCO	34c
San Juanera	MXCO	25h
San Leone	ITLY	18d
San Manuel	USAZ	17
San Martin	AGTN	15a
San Mateo	PLPN	28a

Name	Country	Model No	Name	Country	Model No
San Miguel El Alto	MXCO	25g	Schissler Creek	USID	39a
San Pedro	SPAN	28a	Schist Lake	CNMN	28a
San Pedro	USNM	18b	Schmid	USOR	8a
San Platon	SPAN	28a	Scinto 5	AUNT	38d
San Rafael	MXCO	25h	Scotia	AUWA	6a
San Ruperto	MXCO	25h	Scott Bar	USCA	36a
San Telmo	SPAN	28a	Scott River	AUWA	39c
San Xavier	USAZ	17	Scrafford	USAK	27d
Sanchez	USAZ	17	Scraton-Pontiac-Sunset	CNBC	22c
Sand Creek	SID	39a	Se Chakhum	IRAN	25i
Sand Springs	USNV	25c	Seal Harbour	CNNS	36a
Sandford	USAK	36a	Searchlight	USNV	25c
Sanei	JAPN	25d	Sechura	PERU	34c
Sanford Lake	USNY	7b	Second Relief	CNBC	36a
Sang Dong	SKOR	14a	Sehib	TUNS	34c
Sangalwara	INDA	34a,28b	Seiad Creek (Mt. View)	USCA	8a
Sangaredi	GNEA	38b	Seiba	URRS	34b
Sankyo	JAPN	18d	Seikoshi	JAPN	25c
Sanshaw	CNON	36b	Sekioren	TRKY	8a
Santa Ana	MXCO	25g	Selco-Scott	CNQU	28a
Santa Barbara	BRZL	38b	Selebi	BOTS	7a
Santa Barbara	VNZL	34a,28b	Selimiye	TRKY	25g
Santa Barbara	PERU	27b	Selkirk	BOTS	7a
Santa Efigenia	MXCO	25h	Selukwe	ZIMB	6a
Santa Eulalia	MXCO	19a	Senor de Huarquisa	PERU	18d
Santa Fe	USNV	26a	September Morn	USCA	8a
Santa Gertrudis	MXCO	25h	Serb Creek	CNBC	21b
Santa Leonor	MXCO	25h	Sereno	BRZL	24c
Santa Lucia	MXCO	25h	Serra Negra	BRZL	10
Santa Lucia	PERU	18d	Serria do Carajas	BRZL	34a,28b
Santa Rita	USNM	18a	Sesson Mine	USCA	36a
Santa Rosa	CUBA	24c	Setting Net Lake	CNON	21b
Santa Rosa	SPAN	28a	Seven Trough	USNV	25c
Santander	PERU	19a	Severnoe	URRS	18d
Santiago Papalo	MXCO	8d	Sexton Mountain	USOR	8a
Santiago-Commonwealth-			Seydisehr	TRKY	38c
Centennial	USCO	22c	Sha	CYPS	24a
Santo Nino	PLPN	20c	Shackleton	ZIMB	30b
Santo Tomas	MXCO	17	Shade Chromite	USOR	8a
Santo Tomas	PLPN	20c	Shafer Lease	USCA	8a
Sao Domingos do Capim	BRZL	38b	Shag Rock	CNBC	25g
Sao Joao do Piaui	BRZL	38a	Shagyrkul	URRS	18d
Sao Paulo	BRZL	38b	Shahin	IRAN	8a
Santa Cruz	PLPN	38a	Shamrock	USCA	8a
Sapalskoe	URRS	24c	Shamva-Cymric Gp.	ZIMB	36b
Sar Cheshmeh	IRAN	17	Shangani	ZIMB	6a
Sarbay	URRS	18d	Shasta King	USCA	28a
Sardegna	ITLY	25g	Shasta-California	USCA	18d
Sarialan	TRKY	8a	Shediyah	JRDN	34c
Sarikaya	TRKY	8a	Sheep Ranch	USCA	36a
Saruabi	INDA	38a	Sheep Tank	USAZ	25c
Sasagatani	JAPN	18b	Shelly	USCA	8a
Sasca Montana	RMNA	18b	Shenandoah Mine	USCA	36a
Satevo	MXCO	25g	Sheppard Mine	USCA	8a
Sattelberges	ASTR	19b	Sherrin Creek	AUQL	34c
Saturday Anne	USOR	8a	Shertingdal	NRWY	30a
Saua-Toranica	YUGO	19a	Shevaroy Hills	INDA	38b
Savage River	AUTS	25i	Shihmien	CINA	8d
Savannah	USGA	34d	Shiiba, Takaragi	JAPN	24b
Savannah River	USGA	34d	Shimoga (Karnatoka)	INDA	34b
Saxberget	SWDN	18c	Shimokawa	JAPN	24b
Saysin	TRKY	8a	Shimokawa (Kouchi)	JAPN	24b
Sazare	JAPN	24b	Shinga	JAPN	24b
Schaft Creek	CNBC	17	Shinyama	JAPN	18d

Name	Country	Model No	Name	Country	Model No
Ship Island	USMS	39c	Soho	CNBC	22c
Shirataki	JAPN	24b	Sohodol-Cimpeni	RMNA	38c
Shotgun Creek	USCA	8a	Solbec	CNQU	28a
Shuikoushan	CINA	18c	Soloviejo	SPAN	24c
Shunsby	CNON	28a	Solovyevskii Log	URRS	39b
Sicankale	TRKY	8a	Sombrerete	MXCO	19a
Sidamo	ETHP	38a	Sombreretillo	MXCO	25h
Sierra Gorda	CILE	17	Son of Gwalia	AUWA	36b
Sierra Los Organos	MXCO	25g	Soo	USAK	36a
Sierra de El Alto	MXCO	25g	Soquem	CNQU	10
Sierra de Enmedio	MXCO	25g	Sorka	URRS	18d
Sierrecilla	SPAN	28a	Soroako	INDS	38a
Sierrita-Esperanza	USAZ	21a	Sosnowka	URRS	39b
Sigua	CUBA	24c	Sosva	URRS	18d
Siirt Madenkoy	TRKY	24a	Sothman Twp.	CNON	6a
Silica Mine	USTN	39c	Sotiel	SPAN	28a
Silva-Aysen	CILE	19a	Soto	MXCO	25h
Silver Bell	USAZ	18a	Soto (Chihuahua)	MXCO	25g
Silver City	USNV	25c	Soukhoi Log	URRS	39b
Silver Cloud	USNV	27a	Soulsbyville	USCA	36a
Silver Lakes	USCA	18d	Sour Dough	USOR	8a
Silver Lease	USOR	8a	Sourdough Bay	CNMN	28a
Silver Queen	CNBC	28a	Sousa Ranch	USCA	8a
Silver Valley	AUQL	15b	South Crofty	GRBR	15b
Silvermines	IRLD	31a	South Dufault	CNQU	28a
Silverside	ZIMB	30b	South Florida phosphate	USFL	34d
Silversmith-Richmond-			South Rusty Hill	CNQU	28a
Ruth-Hope	CNBC	22c	South Sarbay	URRS	18d
Simlipal	INDA	38a	South Thomas	USCA	24c
Simmons	USCA	8a	South Uniacke	CNNS	36a
Simon	USCA	8a	South Weipa	AUQL	38b
Sims	USCA	8a	Spar Lake (Troy)	USMT	30b
Sipalay	PLPN	17	Spargoville	AUWA	6a
Sirac	TRKY	8a	Spenceville	USCA	28a
Sirigao	INDA	34a,28b	Spinazzola	ITLY	38c
Sirkov Log	URRS	39b	Spot	USCA	8a
Six Mile	AUWA	6b	Spring Gully	AUVT	36a
Six-Mile	USOR	8a	Spring Hill	USCA	8a
Skaide	NRWY	28a	Spruce Mountain	USNV	19a
Skorovass	NRWY	24a	Spruce Point	CNMN	28a
Skouriotissa	CYPS	24a	Squirrel Hills	AUQL	31a
Skull	AUNT	38d	Srednia-Prostokischenka	URRS	39b
Skyline Mine	USCA	8a	Ssu-chia-ying	CINA	34a,28b
Sleisbeck	AUNT	38d	St. Adrien Mtn.	CNQU	8d
Sliger	USCA	36a	St. Ann Plat.	JMCA	38c
Slocan-Sovereign	CNBC	22c	St. Anthony	USAZ	22cSt.
Smith Geitsfield	USOR	8a	Cyr	CNQU	8d
Smithfield	CNNS	30a	St. Dizier	AUTS	14c
Snake Mountain	USNV	31b	St. George	AUQL	27d
Snakehead (Jumbo)	USCA	8a	St. Honore	CNQU	10
Sneffels	USCO	25b	St. Leonards	AUTS	38b
Snowdrift	USNV	27d	St. Patrick (Camp 8)	USCA	8a
Snowshoe	USNM	18b	St. Pietro	ITLY	25g
Snowstorm	USMT	30b	Sta. Cruz	PLPN	8a
Snowstorm area	USCO	39a	Stadacona	CNQU	36b
Snowy Ridge	USCA	8a	Stafford	USCA	8a
Snowy Ridge	USOR	8a	Stall Lake	CNMN	28a
Snyder	USCA	8a	Standard	USNV	26a
Søve	NRWY	10	Standard and vicinity	CNBC	22c
Soab	CNMN	6b	Stannary Hills	AUQL	15b
Socorro-Guadalupe	MXCO	25h	Star	USUT	19a
Socrates	USCA	27c	Star Mt.-Fubilan	PPNG	20c
Sofulu	TRKY	8a	Star Mt.-Futik	PPNG	20c
Sogham	IRAN	8a	Star Mt.-Nong River	PPNG	17

Name	Country	Model No	Name	Country	Model No
Star Mt.-Olgal	PPNG	17	Surprise-Noble Five and vicinity	CNBC	22c
Stark Bee	USCA	8a	Sustut	CNBC	23
Starratt-Olsen	CNON	36b	Susu Lake	CNNT	28a
State School	USCA	8a	Sutherland	USNV	27d
Steamboat Springs	USNV	27a	Sutpinar	TRKY	8a
Stedman	USCA	25e	Sutro	USCA	28a
Steele Brook	CNQU	8d	Sutro Mine	USCA	8a
Stekenjokk	SWDN	28a	Sutter Creek	USCA	36a
Stepanoff-Log	URRS	39b	Suzanne	NCAL	8a
Stephane	NCAL	8a	Suzy Bell (Lucky Strike)	USCA	8a
Sterling Creek	USOR	39a	Svano	NRWY	24a
Sterling Lake	USNY	25i	Svardsio	SWDN	18c
Stevens-Miller	USOR	8a	Swan River	USCO	39a
Stewart	USCA	8a	Swansea	USAZ	37b
Stewart Island	CNSK	38d	Swayne	USCA	8a
Stewart May	USAR	27d	Sweetwater	USCA	8a
Stibnite	USAK	27d	Swim Lake	CNYT	31a
Stillwater	USMT	1,2a,2b	Sydvananger	NRWY	34a,28b
Stirling	CNNS	28a	Sylvanite	USOR	36a
Stockton	USAZ	22c	Syssim R.	URRS	39b
Stockton Bight	AUNS	39c	Tache Lake	CNQU	28a
Stollberg	SWDN	18c	Taco Bay	CUBA	38a
Stone & Haskins	USOR	8a	Tagpura	PLPN	17
Stonewall	USCA	36a	Taiba	SNGL	34c
Store Gulch	USOR	8a	Taio	JAPN	25c
Storeys Creek	AUTS	15a	Taisho (Nishimata)	JAPN	28a
Storie	CNBC	21b	Takahata	JAPN	25d
Stormy Group	CNYT	14a	Takanokura	JAPN	18d
Stowell	USCA	28a	Takatama	JAPN	25d
Stra Quertane	TUNS	34c	Takaura	JAPN	24b
Stralak	CNON	28a	Takeno	JAPN	25d
Strandzha	BULG	18b	Takijug Lake	CNNT	28a
Stratmat	CNNB	28a	Taknar	IRAN	28a
Strawberry	USCA	14a	Talamantes	MXCO	25g
Stray Dog	USOR	8a	Tallering Peak	AUWA	34a,28b
Stripa-Striberg	SWDN	34a,28b	Talmora Longlac	CNON	36b
Sturgeon Lake	CNON	28a	Tamborine Mountain	AUQL	38b
Suffield	CNQU	28a	Tanama	PTRC	20c
Suftlii Bor	URRS	39b	Tangier	CNNS	36a
Sugarloaf Hill	CNBC	17	Tangle Blue Divide	USCA	8a
Sukinda	INDA	38a	Tapairihua	PERU	18d
Sukulu	UGND	10	Tapira	BRZL	10
Sulat	PLPN	28a	Tapley	USME	28a
Sullivan	CNBC	31a	Taratana	CUBA	24c
Sullivan and Kahl	USCA	8a	Taritipan	INDS	24c
Sulphur Bank	USCA	27a	Tarkwa	GHNA	29a
Sultan	AUVT	36a	Tasdibi	TRKY	27d
Sulu	TRKY	8a	Tashiro	JAPN	28a
Suluiyeh	IRAN	8a	Taslica	TRKY	28a
Suluk	TRKY	8a	Tasu-Wesfrob	CNBC	18b
Sumadisa	YUGO	19a	Tawi-Tawi	PLPN	20c
Summit	USAZ	19b	Taylor	USCA	36a
Summitville	USCO	25e	Tayoltita	MXCO	25c
Sumpter Bar	USOR	39a	Taysan	PLPN	20c
Sun	CNMN	28a	Tea	CNYT	31b
Sunnyslope	USCA	8a	Teahan	CNNB	28a
Sunrise	USCA	8a	Techa	URRS	18d
Sunset	USCA	8a	Tecolote	USNM	18d
Sunshine	CNBC	28a	Tecolotes	MXCO	25h
Sunshine	USCA	8a	Tecopa	USCA	19a
Sunshine Creek	CNBC	21b	Tedi	CNBC	28a
Sunshine-Corinth	CNBC	22c	Tekneli	TRKY	8a
Surf Inlet	CNBC	36a	Tekwane	BOTS	7a
Surigao	PLPN	38a			

Name	Country	Model No
Telluride	USCO	25b
Tem Piute district	USNV	14a
Tenke-Fungurume	ZIRE	30b
Tennessee Chrome	USOR	8a
Tennessee Pass	USOR	8a
Tepebasi	TRKY	8a
Tepustete	MXCO	18d
Terano	JAPN	24b
Terlik	TRKY	8a
Terra Nova	CNNF	28a
Terrenates	MXCO	25g
Tetyukhe	URRS	18c
Teutonic Bore	AUWA	28a
Texada	CNBC	18d
Texas	CNNB	28a
Textmont	CNON	6a
Thabazimbi	SAFR	34a,28b
Thamar-Kotra	INDA	34c
Thatcher Creek	USCA	24c
Thetford Group	CNQU	8d
Thierry	CNON	7a
Thies	SNGL	34c
Thio	NCAL	38a
Third Portage	CNNB	28a
Thomas	USCA	24c
Thompson	CNMN	6b
Thompson Bousquet	CNQU	36b
Thompson Creek	USID	21b
Thompson Falls	USMT	27d
Thompson Gp.	USOR	8a
Thuburnic	TUNS	19b
Thurston & Hardy	USAZ	25g
Tiebaghi Ni	NCAL	38a
Tiebaghi Cr	NCAL	8a
Tienpaoshan	CINA	18c
Tiere	UVOL	24c
Tilai R.	URRS	39b
Tilkim-Karanlik	TRKY	8a
Tilt Cove	CNNF	24a
Timna	ISRL	34b
Timoni	AUWA	36b
Tin Cup Peak	USOR	10
Tintaya	PERU	18b
Tintic	USUT	19a
Tiouine	MRCO	24c
Tipperary Mine	NZLD	36a
Tjarrojakka	SWDN	25i
Tjokkola	SWDN	28a
Togobomar	PLPN	8a
Toi	JAPN	25c
Toiyabe	USNV	26a
Tokoro	JAPN	24c
Tolano	MXCO	25h
Toledo	PLPN	20c
Tolman	USID	26a
Tom	CNYT	31a
Tombstone	USAZ	19a
Tomkin	USCA	8a
Tomogonops	CNNB	28a
Tonkin Springs	USNV	26a
Tonkolili	SRLN	34a,28b
Tonopah	USNV	25c
Toombou	AUVT	36a
Toparlar-Alacik	TRKY	8a

Name	Country	Model No
Topkirozlar	TRKY	24c
Topock	USAZ	25g
Toquepala	PERU	17
Toscana (Cerchiara)	ITLY	24c
Tosin	TRKY	8a
Tougue	GNEA	38b
Toujours Gai	USCA	8a
Toura R.	URRS	39b
Tovarnica	YUGO	18d
Toyoha	JAPN	25b
Trail Ridge	USFL	39c
Traversella	ITLY	18b
Treadwell Mines	USAK	36a
Treasure Hill	USAZ	22c
Tregioivo	ITLY	30a
Trepca-Kopaonik	YUGO	19a
Tri State	USMO-USOK	32a,32b
Trinidad	USCA	8a
Trininty	CNQU	28a
Triton	AUWA	36b
Trojan	CNBC	17
Trojan	ZIMB	6a
Trombetas	BRZL	38b
Troulli	CYPS	24a
Trout Bay	CNON	28a
Trout Lake	CNBC	21b
Trudny-Log	URRS	39b
Truscott	USCA	36a
Tsaitsukou	CINA	18d
Tsauch R.	URRS	39b
Tschachewitaia	URRS	39b
Tschch R.	URRS	39b
Tshinsenda	ZIRE	30b
Tsuchihata	JAPN	28a
Tsumeb	NAMB	32c
Tsumo	JAPN	18b
Tulameen	CNBC	39b
Tulk's Pond	CNNF	28a
Tulsequah	CNBC	28a
Tunca	TRKY	28a
Tuncurry-Tomago area	AUNS	39c
Turfullar	TRKY	25g
Turner-Albright	USOR	24a
Turtle Head	AUQL	38b
Tuscarora	USNV	25c
Tutunculer	TRKY	24c
Tuzlakaya	TRKY	8a
Tverrfjellet	NRWY	28a
Twin Buttes	USAZ	18a,21a
Twin Cedars	USOR	8a
Twin Peaks	USCA	27c
Twin Valley	USOR	8a
Tynagh	IRLD	31a
Tybo	USNV	22c
Tyrny-Auz	URRS	14a
Tyrone	USNM	21a
U.S. Group	USAZ	25g
UV Industries	USNV	21b
Uchi	CNON	28a
Uchi	CNON	36b
Uchucchacua	PERU	18c
Uckopru	TRKY	8a
Udden	SWDN	28a
Udokan	URRS	30b

Name	Country	Model No
Uinta Mtns.	USUT	34c
Ulchin	SKOR	18c
Uludag	TRKY	14a
Ulukoy	TRKY	19b
Uncle Sam	USCA	36a
Uncle Sam	USOR	8a
Undu	FIJI	28a
Union	USNV	22c
Unterlaussa	ASTR	38c
Upata	VNZL	38b
Upper Beaver	CNON	36b
Upper Bellingen	AUNS	27d
Upper Canada	CNON	36b
Upper Mississippi Valley	USWI	32a,32b
Upper Seal Harbour	CNNS	36a
Upper Silesia	PLND	32a,32b
Uracum	BRZL	34b
Uribe	USWA	31b
Urkut	HUNG	34b
Uruachic	MXCO	25b
Usinsk	URRS	34b
Utica	CNBC	22c
Vaddas	NRWY	28a
Vakkerlien	NRWY	7a
Val Di Peio	ITLY	18d
Valen Prospect	USOR	8a
Valenti	USCA	8a
Valle de Manganeso	CUBA	24c
Valle del General	CORI	38b
Valley Copper	CNBC	21a
Valley View	USCA	36a
Valuev	URRS	18d
Vammala	FNLD	7a
Vamp	CNMN	28a
Vananda	CNBC	18b
Vancouver Group	CNBC	22c
Vangorda	CNYT	31a
Varna	BULG	34b
Vassbo	SWDN	30a
Vauze	CNQU	28a
Veitsch	ASTR	19b
Vekol	USAZ	17
Velardepa	MXCO	19a
Verkho-Tourie	URRS	39b
Vermilion	USMN	34a,28b
Vermilion River	USMT	39a
Vermillion	CNON	28a
Vernal	USUT	34c
Vestpolltind	NRWY	34a,28b
Veta Blanca	MXCO	25h
Viburnum	USMO	32a
Victoria	USNV	18b
Victory	CNBC	14a
Victory No. 3	USCA	8a
Vieille Montagne	NCAL	8a
Vigsnes	NRWY	28a
Violet	USOR	8a
Viscaria	SWDN	28a
Viterbo-Roma	ITLY	25g
Vlasenica	YUGO	38c
Vogelgesang	USCA	8a
Vogler's Cove	CNNS	36a
Volcanic Peak	USNV	27d
Von Roi-Hewitt	CNBC	22c

Name	Country	Model No
Vorderen Strubberges	ASTR	19b
Vorontsovka	URRS	18d
Vubachikwe	ZIMB	36b
Vulcan	USCA	18d
Vyhne	CZCL	18d
W.P.	USNV	27d
Waden Bay	CNSK	28a
Wafangtzu	CINA	34b
Wagasennin	JAPN	18d
Waiho River	NZLD	39c
Wait (Amador Co.)	USCA	8a
Waite (Nevada Co.)	USCA	8a
Waite East	CNQU	28a
Walibu	USCA	27a
Walker	USCA	8a
Wall Canyon	USNV	27d
Wall Street	USCA	27c
Wallapai District	USAZ	22c
Wallaroo	AUWA	28a
Wannaway	AUWA	6a
War Bond	USCA	8a
War Eagle	CNYT	18b
War Eagle-Miller	USCA	8a
Ward	CNBC	36a
Ward	USOR	8a
Ward and Lyons	USCA	8a
Warm Springs, North Mocassin	USMT	22b
Warm Springs	USMT	34c
Waroona Shoreline	AUWA	39c
Warrington	USCA	36a
Wasa Lake	CNQU	36b
Washington	MXCO	17
Washington	USCA	36a
Washington Camp	USAZ	18c
Washout	USCA	8a
Waterloo	USAZ	19b
Watsonville	AUQL	15b
Wattle Gully	AUVT	36a
Waverley	CNNS	36a
Wayside	CNBC	36a
Weaver	USAZ	25c
Wedge	CNNB	28a
Weebo Bore	AUWA	6b
Weedaroo	AUSA	31b
Weedon	CNQU	28a
Weipa-Andoom-Pera Head	AUQL	38b
Weiss	TRKY	28a
Welch	USCA	24c
Welch Prospect	USCA	8a
Weld Range-Wilgie Mia	AUWA	34a,28b
Wellington	AUNS	39a
Wellington	CNBC	22c
Wenlock River	AUQL	38b
West Bear	CNSK	38d
West Chrome	USCA	8a
West Gore	CNNS	27d
West Jacksonville	USCA	36a
West Maui	USHI	38b
West Niggerhead	USNM	25g
West Ore Body	PLPN	8a
Westarm	CNMN	28a
Western Magnesite	USCA	8a
Western Nevada	USNV	18b
Westland	NZLD	36a

Name	Country	Model No
Westport	NZLD	39c
Wexford	CNBC	18b
Weza	SAFR	38b
Whalesback-Little Deer	CNNF	24a
Wheal Jane	GRBR	15b
Wheal Kitty-Penhalls	GRGB	15b
Whim Creek	AUWA	28a
White Bear	USCA	8a
White Cedar	USCA	8a
White Feather	AUWA	36b
White Feather	USCA	8a
White King	USOR	25f
White Lake	CNMN	28a
White Pine	USMI	30b
White Pine	USNV	19a
White Pine Mine	USCA	8a
White's (Rum Jungle)	AUNT	38d
Whiteburn	CNNS	36a
Whitlock	USCA	34d
Whundo	AUWA	28a
Wigie 3	AUWA	6a
Wigwam	CNBC	31a
Wild Cat Claim	USOR	8a
Wildcat	PLPN	28a
Wilder (Fish Creek)	USCA	8a
Wildrose Canyon	USCA	27d
Willecho	CNON	28a
Wilmar and others	CNON	36b
Wilshire-Bishop	USCA	36a
Wiluna-Moonlight	AUWA	36b
Wim	CNMN	28a
Windarra	AUWA	6a
Windfall	USNV	26a
Windsor	CNQU	8d
Windy	CNBC	28a
Windy Point	USOR	8a
Wine Harbour	CNNS	36a
Wingelinna-Daisy	AUWA	38a
Winters	USCA	25d
Wintrop	CNBC	22c
Witswatersrand	SAFR	29a
Wolf Creek	USCA	8a
Wolf Creek area	USCA	8a
Wombat Creek	AUNS	39a
Wonder	USOR	8a
Wonder Gp.	USOR	8a
Wonderful-Elkhorn	CNBC	22c
Woodcutters	AUNT	31a
Woodlawn	AUQL	28a
Woodsreef Mine	AUNS	8d
Woody Woody	AUWA	24c
Wyoming	USWY	34c
Wyssim R.	URRS	39b
Xihuashan	CINA	15a
Yahualica	MXCO	25g
Yakobi Island	USAK	7a
Yanahara	JAPN	24b
Yanchiachangtze	CINA	18c
Yandera	PPNG	17
Yanikara	TRKY	8a
Yankee Hill	USCA	36a
Yaprakli	TRKY	8a
Yatani	JAPN	25b
Yava	CNNT	28a

Name	Country	Model No
Yava (Silvermine)	CNNS	30a
Yayca Boyna	TRKY	8a
Yellow Jacket	USNM	18d
Yellow Pine	USCA	8a
Yellow Pine	USNV	19a
Yellow Pine district	USID	14a
Yeonhwa	SKOR	18c
Yeoval	AUNS	17
Yerington	USNV	17
Yermakof-Log	URRS	39b
Yeya	CUBA	24c
Yilmaz Ocagi	TRKY	8a
Yoganup Shoreline	AUWA	39c
Yoichi	JAPN	28a
Yokota (Motoyama-Hama.)	JAPN	28a
York Harbour	CNNF	24a
Yoshimoto	JAPN	24b
Yoshino (Hisaka)	JAPN	28a
Yoshino (Main)	JAPN	28a
Youanmi	AUWA	36b
Young	USOR	8a
Young's Mine	USOR	8a
Yreka	CNBC	18b
Ysxjoberg	SWDN	14a
Yugashima	JAPN	25c
Yukari Zorkum	TRKY	8a
Yulee	USFL	39c
Yunus Yayla	TRKY	8a
Yurtlak	TRKY	8a
Yuryo	JAPN	24b
Z	CNMN	28a
Zacate-Cerro Chino	MXCO	25g
Zaetzeff, R.	URRS	39b
Zambales Ch	PLPN	8a
Zanitza	MXCO	18d
Zarikan	IRAN	18d
Zawar	INDA	31a
Zawarmala	INDA	31a
Zeballos	CNBC	18d
Zeida	MRCO	30a
Zeila	USCA	36a
Zemlianoi-Mostik Log	URRS	39b
Zerfirg Ranch	USCA	8a
Zimapan	MXCO	19a
Zimparalik	TRKY	8a
Zindani	GREC	8d
Zip	CNBC	18b,18c
Zonguldak	TRKY	38c
Zortman Landusky	USMT	22b

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