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The Geology of the Antamina Copper-Zinc Skarn Deposit, Peru

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Antamina, the world's largest known skarn deposit of copper and zinc, is located in the eastern part of the Western Cordillera of north Peru at 9° 32' south and 77° 03' west, at an altitude between 4,200 and 4,800 meters. The terrain comprises steep limestone peaks, glacial valleys and lakes, and deep canyons. It is 270 km north of Lima and 130 km east of the Pacific Ocean (Fig. 1). By road, it is about 500 km from Lima and takes nine to twelve hours to get there.

Copper is said to have been mined at Antamina in pre-Spanish times and the name means Copper Mine, derived from *anta* (copper in Quechua). The earliest records of small scale mining at Antamina date from the 1850s. The naturalist Antonio Raimondi visited the area in 1860 and recorded the presence of a small smelter producing lead and silver ingots. Attempts to leach copper were made in the early 1900s, and Northern Peru drilled eight holes in 1925.

The first significant exploration was not carried out until 1952 when the Cerro de Pasco Corporation acquired the property. They explored intermittently for 18 years and defined about 1 Mt at over 3% Cu. The project became part of Minero Peru in 1970 and a consortium was formed with the Romanian Government's mining agency Geomin. They explored for six years and developed a resource of 129 Mt at 1.6% Cu and 1.3% Zn and produced a full feasibility study for a 10,000 to 20,000 tpd operation. However financing was not available for a project of that size in Peru at that time.

Antamina was transferred to Centromin and privatized by public bidding on July 12, 1996. The bid was won by Rio Algom Ltd and Inmet Mining Corporation, in a 50:50 joint venture. The bid included $20M US cash, a commitment to spend $13.5M US over two years, and to invest $2.5 billion US over five years, with 30% of any unspent amount to be paid to the state at the end of the fifth year. The Compañia Minera Antamina S.A. was formed and the contract was signed on September 6, 1996.

The feasibility study took eighteen months and was completed by March 1998. This included 103,704 m of diamond drilling in 271 holes using up to 15 drills, 3,410 m of reverse circulation drilling, a 230 m drift for bulk sampling, and shipping of over 400 tonnes of metallurgical samples to Canada. This resulted in an almost four-fold increase of the known mineable reserves.

Inmet subsequently sold its interest in the project on July 13, 1998. The owners now are Rio Algom Ltd (37.5%), Noranda Inc. (37.5%) and Teck Corporation (25%). The Canadian consortium announced its decision to develop the project on September 16, 1998 and the investment period was extended to 45 months until June 6, 2002.

The geological resource is 990 Mt at 1.2% Cu, 1.0% Zn, 0.03% Mo and 13 g/t Ag. This is contained within a global resource of 1.5 billion tonnes which is open at depth on the limbs of the deposit. The deepest hole cut 722 metres grading 1.7% Cu and 1.35% Zn. An open pit was designed around the 760 Mt resource that is in the measured and indicated categories, giving a mineable reserve of 500 Mt at 1.2% Cu, 1.0% Zn, 0.03% Mo and 12 g/t Ag. The known reserves are sufficient for a 70,000 tpd operation for 20 years. The average stripping ratio is 2.7 to 1. The ore will be treated by flotation to produce 1.3 million tonnes of concentrate per year, which will be transported by pipeline to a new port at Huarmey. Antamina will be the third largest concentrate producer in the world, after Chuquicamata and Escondida. The annual metal produced will be 270,000 tonnes (600 Mlb) copper and 162,000 tonnes (360 Mlb) zinc. This will put Antamina in seventh place in world production, for copper and third place for zinc. Average cash costs per pound of copper are projected at $0.35, net of credits, well within the lowest-cost quartile of global production, and the total capital cost is estimated at $2.35 B.

Regional Geology

Antamina is hosted by Mesozoic carbonates that are within a fold and thrust belt in the eastern part of the Western Cordillera. Precambrian schists of the Marañon Complex outcrop further east in the Eastern Cordillera. The Mesozoic sedimentary rocks were deposited in the eastern half of an ensialic back arc basin related to eastward subduction, and were deformed in the Late Eocene. In the western part of the basin there is a thick sequence of submarine basic and intermediate volcanic rocks that host VMS deposits such as Tambo Grande. This half of the basin was closed in the mid-Cretaceous and the Coastal Batholith was intruded along the axis in the Late Cretaceous to Paleocene. The porphyry copper deposits of southern Peru - Cerro Verde, Toquepala, Cuajone and Quellaveco - are related to the final stages of batholith emplacement.

During the late Tertiary, subaerial volcanic rocks accumulated in the western part of the Western Cordillera, which are intruded by small, high-level stocks of Miocene age. In the Late Miocene, the Cordillera Blanca Batholith was emplaced to the west of Antamina. The rich ore deposits of the Western Cordillera Polymetallic Belt are related to Miocene magmatism, and include copper skarns such as Antamina, carbonate replacement deposits (e.g. Cerro de Pasco), porphyry copper deposits (e.g. Michiquillay), porphyry copper-gold deposits (e.g. Cerro Corona), epithermal silver-base metal deposits (e.g. Quiruvilca) and epithermal gold deposits such as Yanacocha and Pierina.

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MDD Goals and Objectives

The Mineral Deposits Division of the Geological Association of Canada is Canada's foremost society for promoting the study of mineral deposits by supporting local and national meetings, symposia, short courses and field trips. We sponsor the publication of research relating to ore deposits and metallogeny, and recognize the contributions of outstanding Canadian economic geologists by annually awarding the Duncan Derry and William Harvey Gross medals and the Julian Boldy Certificate.

Publication Schedule:

SUBMISSION DEADLINE	PUBLICATION DATE
December 15	January
March 15	April
June 15	July
September 15	October

Information for contributors:

The objective of this newsletter is primarily to provide a forum for members and other professionals to voice new ideas, describe interesting mineral occurrences or expound on deposit models. Articles on ore deposits, deposit models, news events, field trips, book reviews, conferences, reprints of presentations to companies, mining groups or conferences, or other material which may be of interest to the economic geology community are welcome. Manuscripts should be submitted by email in WP or WORD format. A printed version should be mailed or FAXed. Illustrations should be camera-ready (ideally as CDR digital files); photos should be of good quality. Short items dealing with news events or meetings can be submitted by FAX, postal mail or email. Contributions may be edited for clarity or brevity.

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Message from the Editors

The Gangue has moved from its temporary home in Ottawa into its new residence in Bathurst (east coast), the second move in as many years. After personally enjoying this newsletter for over 10 years, we extend our thanks to Brian Grant for his enthusiasm and commitment and also to Al Galley for not dropping the ball when searching (arm twisting!) for a new editor(s). We have "very big shoes" to fill because they provided editorial excellence (and stamina!) that nurtured **The Gangue**, and *MDD* for that matter, for many years. We are going to try hard to continue to build on that tradition.

As with any move, decisions are made regarding what goes and what gets left behind at curbside. We are looking at this move as an opportunity, figuratively speaking, to cobble the ore together, dump the waste and make some new discoveries. However, no matter how carefully the sorting and moving are done, something valuable always seems to go astray, at least temporarily. That's where you come in. Tell us if we unwittingly dump something from **The Gangue**, which you find to be useful or interesting. We (more than) welcome suggestions about new things you would like to see in future issues. Better yet, make submissions; after all, it is your newsletter! Please mail, fax or email your suggestions and (or) contributions to either of us at the coordinates below.

MDD is building a new website for information, business purposes, and linking to other key sites, i.e. to serve the membership better. It is hoped that this newsletter will be posted on the MDD's website in the not too distant future. Feedback on the website (www.northfacesoftware.com/MDD) and its future direction(s) is most welcome too.

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ANTAMINA con'd

Deposit Geology

Antamina is hosted by Cretaceous sedimentary rocks that comprise carbonates overlying a sandstone-shale-coal sequence. The regional strike is northwest. The skarn itself is hosted within the Late Cretaceous Celendin Formation (Coniacian - Santonian age) . This formation consists of calcareous siltstones that regionally are several hundred metres thick. This formation was structurally thickened to form a thrust duplex at Antamina, and was overthrust by massive limestones of the underlying Jumasha Formation (Albian - Turonian age). The steep thrust ramp is exposed in the lower part of the Antamina valley and erosional remnants of the imbricate zone are preserved on the ridges on both sides of the valley.

The skarn covers an area of almost 3 km by 1 km and it has a known vertical extent of 1 km, but is still open at depth (Figs. 2 & 3). It is elongated in a northeast direction. The intrusions and skarn are controlled by the location of thrust faults that were reactivated as extensional structures in the lLte Miocene, i.e. at the time of intrusion and skarn formation.

A pre-skarn thrust fault separates two different structural domains within the deposit. Most of the mineralisation at Antamina is in the footwall. The drill sections show steeply dipping to vertical contacts between intrusive rocks, skarn and marble. These structures are interpreted to be steep, NE-trending lateral ramps and NW-striking, shallow to moderately dipping frontal ramps. In the hanging wall, as mapped in outcrop, the structural style is dominated by low- to moderately-dipping, bedding,-parallel thrust faults (flats) and NW-trending frontal ramps.

The deposit has a remarkably consistent zonation for its size. The skarn is dominantly garnet, with only minor diopside, and is then

The University of Toronto Student Chapter
of the Society of Economic Geologists
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by Floyd F. Sabins, *Remote Sensing Enterprises, Inc.*
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The course addresses the use of Landsat Thematic Mapper (TM), SPOT, Hyperspectral Systems and Radar imagery in mineral exploration. Ordering, processing and using images are discussed, and put into context using case histories and examples from Nevada, Chile, Australia, Indonesia and the Sudbury Basin. The course is geared towards exploration geologists, and focuses on the practical application of remote sensing to exploration. The presenters have considerable experience in remote sensing, and Floyd Sabins has over 40 years of industry experience.

***For further details contact*: Heather MacDonald - Tel: (416) 978-0657**
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zoned from brown garnet out to green garnet, then marblized limestone. Locally, there is a wollastonite-diopside zone on the outer margins of the skarn, which is best developed to the southwest edge. The metals are also zoned, with copper in the brown garnet and copper-zinc in the green garnet. Most importantly, over 90% of the skarn, is mineralized and contains significant amounts of copper with subordinate zinc, silver, and molybdenite.

The core intrusion actually comprises a series of quartz monzonite porphyry intrusions that can be divided into early, imiddle, and late phases. The intrusive complex has been dated at 9.8 Ma (McKee et al., 1979, Econ. Geol., v. 74, 928-930). These porphyries have phenocrysts of plagioclase, orthoclase, quartz, biotite and hornblende. The early or main phase forms a stock that is responsible for skarn genesis. The middle- and late- phases tend to form dikes and sills. The early and middle phases have biotite and orthoclase alteration and a quartz vein stockwork ;associated porphyry Cu-Mo mineralization grades about 0.2% Cu on average. Locally, there are areas of high-grade molybdenite (up to 0.1%). The late intrusions typically have K-feldspar megacrysts and very little alteration.

Most of the skarn is exoskarn and is dominated by massive garnet. Higher Cu grades in the intrusions are in endoskarn zones with red-brown garnet. An important feature of Antamina is that the roof of the intrusion is preserved. The intrusions that crop out are minor dikes, and skarn is preserved above the roof of the intrusion, which contributes greatly to the tonnage.

The garnets are zoned outwards on a deposit scale from brown to green. The green garnet zone is narrow at depth and widens at surface, suggesting that it originally wrapped over the roof of the intrusive complex. Both types are andradite-rich and show a similar composition and variation. The compositions vary from around grossular 30% - andradite 70% in cores to near 100% andradite in the rims. Aluminium and ferric iron vary antipathetically and account for almost all the variation. The red-brown endoskarn garnets are midway between grossular and andradite.

Diopside is present in minor amounts in the green garnet zone and has uniform composition. Wollastonite-diopside is developed locally at the outer margins, notably to the southwest, but accounts for less than 10% of the deposit. Beyond the skarn is a zone of marbleised limestone with veins and mantos of skarn.

Retrograde alteration of garnet skarn varies from fracture-controlled (including stockwork), pervasive, and breccia-related. Where pervasive it was logged as chlorite skarn and makes up less than 4% of the deposit. Likewise phyllic and argillic alteration of the intrusions is minor. Retrograde alteration is strongest in hydrothermal breccias that form vertical bodies and acted as important fluid pathways. Breccia formation began during late prograde skarn formation, and continued episodically through the retrograde phase.

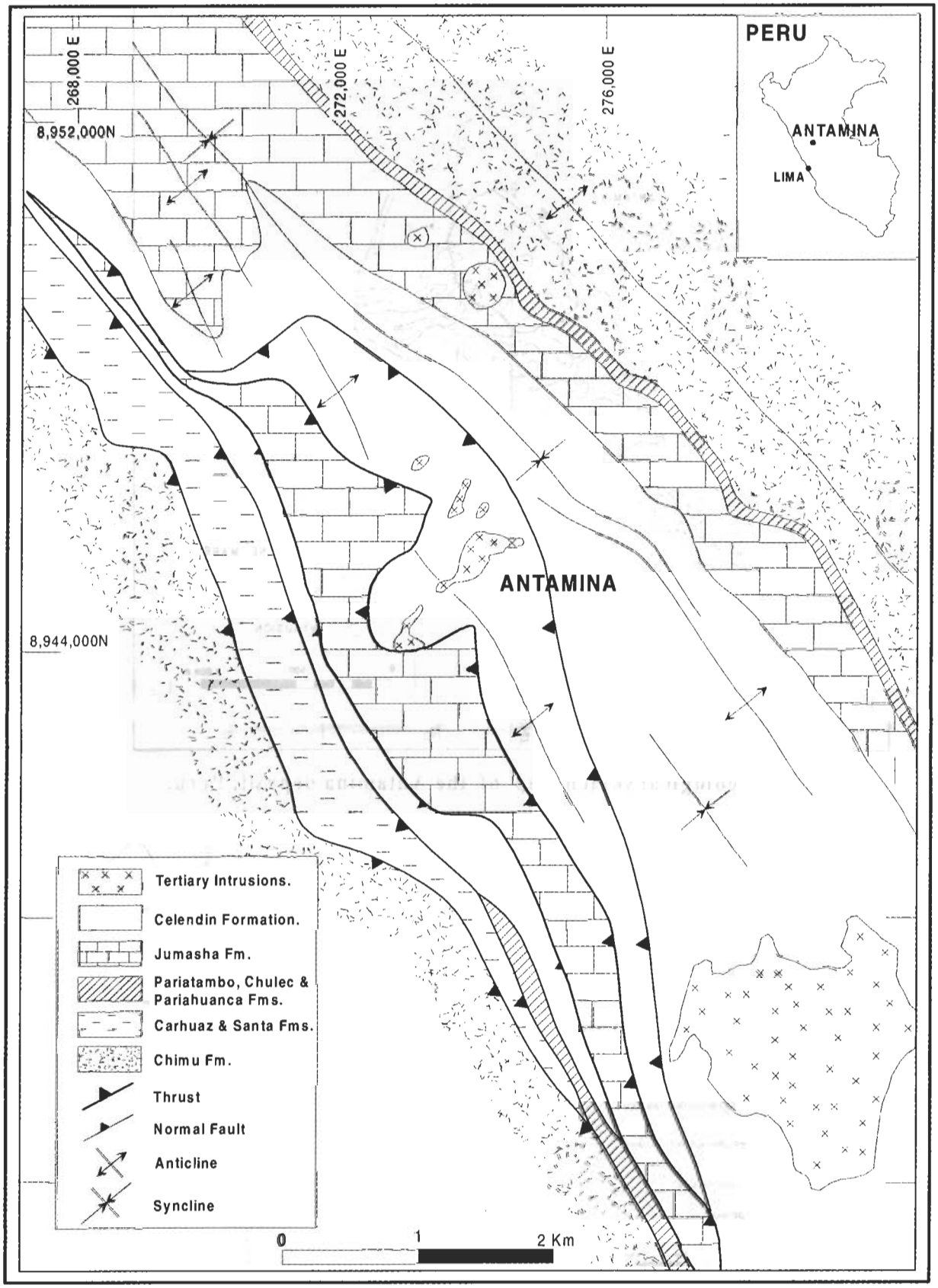

Figure 1. The geological setting of the Antamina Cu-Zn deposit, Peru

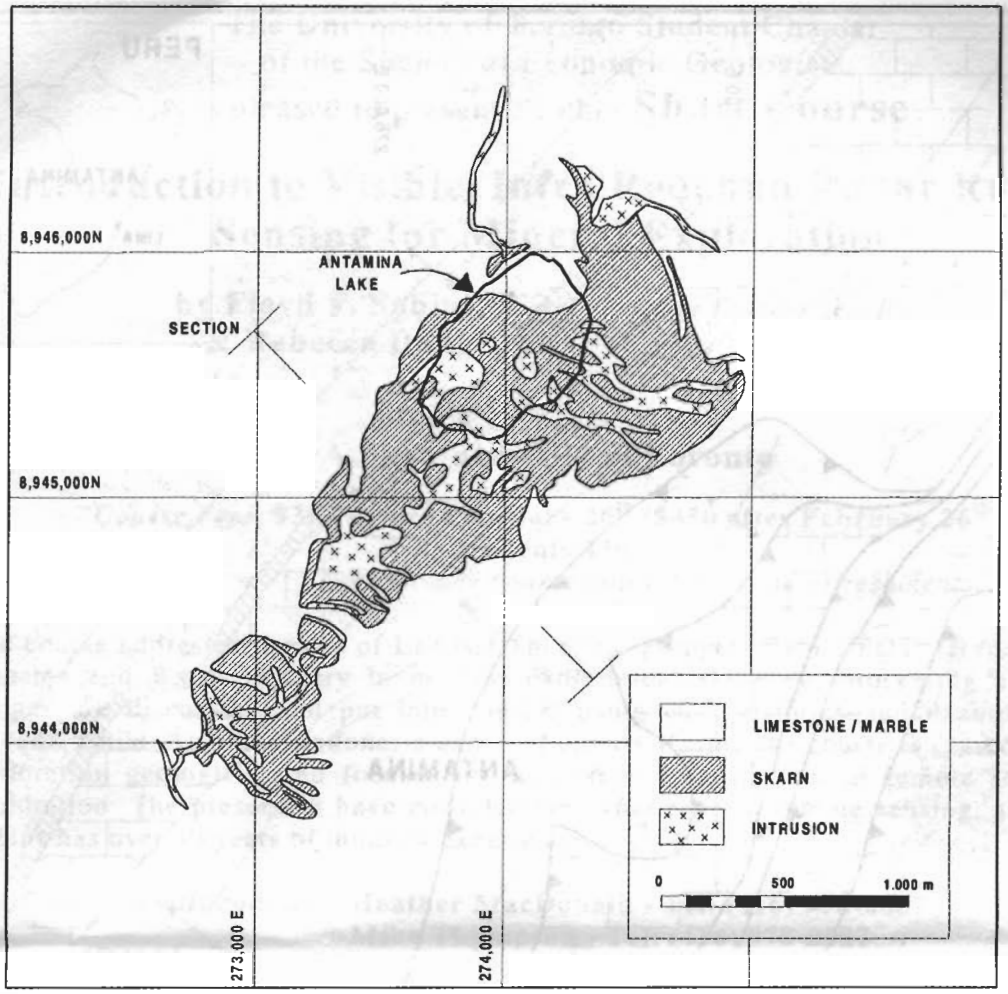

Figure 2. Geological sketch map of the Antamina deposit, Peru.

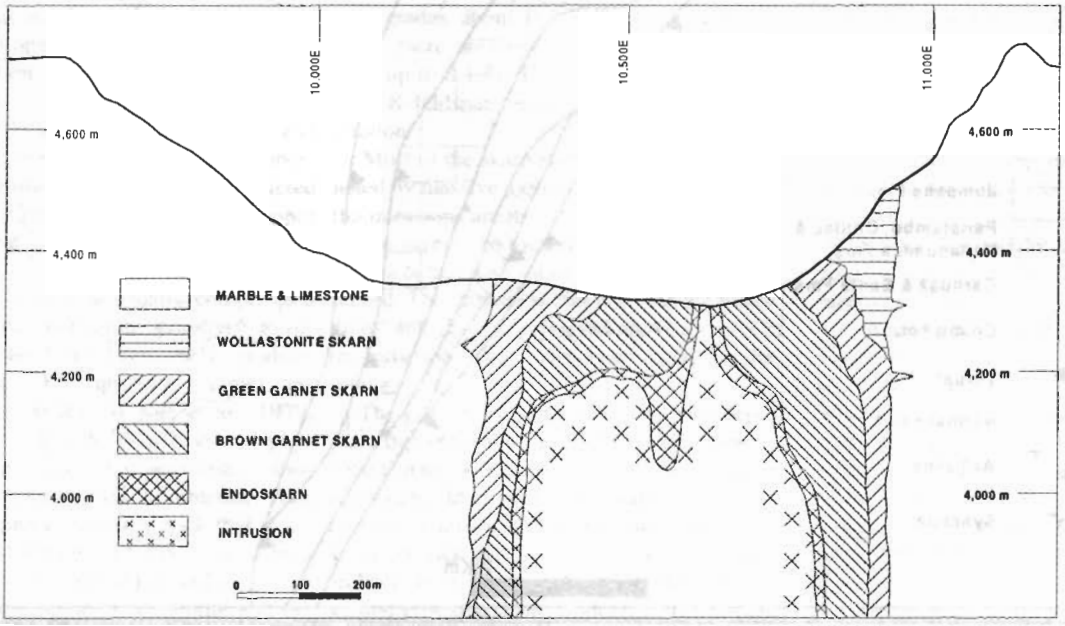

Figure 3. Cross section 20,200 N showing skarn zonation.

Retrograde skarn minerals include chlorite, epidote, actinolite, quartz, calcite, sericite, and clay.

The sulphides at Antamina are coarse grained and are easy to physically separate. The amount of iron sulphides is low. These features contribute to good Cu - Zn separation, high recoveries, and good grade concentrates. Sulphides are interstitial to garnet crystals, as well as in veinlets and semi-massive zones. Prograde and retrograde phases of mineralisation are recognised.

Pyrite and magnetite are ubiquitous; pyrrhotite is minor and there are magnetite pseudomorphs of early specular hematite.

Most of the copper is in chalcopyrite, which is ubiquitous. Zinc occurs throughout as sphalerite but averages only 0.2% in the brown garnet zone, which is not recoverable, and over 2% in the green garnet zone. The average grade of 1% is thus a bit misleading. Massive sulphide zones at the contact between skarn and limestone are common as are sulphide mantos and veins in the marble. The zinc zone averages 100 - 200 m wide at surface and narrows at depth.

Molybdenite is found in the early and middle intrusions and around them in the brown garnet skarn. It is also abundant in the wollastonite-diopside zone.

Silver is present throughout the system. It reports to the copper concentrate and appears to be in the chalcopyrite itself, with average grades of around 7 to 8 g/t in most of the deposit. The outer part of the Cu-Zn zone has higher Ag that is associated with galena, tennantite and bismuth sulphosalts.

Lead is present at low concentrations, usually less than 50 ppm, throughout the deposit. Like silver, Pb is highest in the outer zones.

The distribution of bismuth was studied in detail because of its undesirable tendency to report to the copper concentrate. It is present around the edges of the deposit in 40% of the mineralisation. It occurs mostly as aikinite ($PbCuBiS_3$), cosalite ($Pb_2Bi_2S_5$), and bismuthinite, which are coarse grained and can easily be separated from the chalcopyrite concentrates.

The wollastonite-diopside zone is a low-iron assemblage and contains bornite rather than chalcopyrite. The sphalerite contains almost no iron and the bismuth is in wittichenite (Cu_3BiS_3). This is intergrown with bornite and is not easy to separate. The only gold at Antamina is in this bornite zone, averaging 0.1 to 0.2 g/t.

The deposit was unroofed by Quaternary glaciation, with the result that there is no significant oxidation or enrichment. Sulphides with partial oxidation crop out, and all of the reserves are sulphide. There are two moraines. The first is limestone rich and pyritic, and is overlain by a younger, softer limonitic moraine that eroded the interglacial oxidation.

Antamina is a calcic copper skarn related to a subeconomic, calc-alkaline, porphyry copper-molybdenum deposit. It is an oxidised, garnet-rich skarn, and the garnet and pyroxene chemistry and zonation are typical of copper skarns. The outer zinc zone is very well developed with economic grades. While copper skarns commonly have minor sphalerite in the outer zone, it is normally low grade. Retrograde alteration is notably minor, in contrast to the strong retrograde alteration typical of most skarns. This may help to explain the homogeneity of the deposit and the preservation of the zinc zone. The localised outer zone with the low-iron assemblage of wollastonite-bornite is typical of copper skarns. However the diopside and elevated Au and Bi present in parts of this outer zone are features similar to distal, reduced gold skarns.

ACKNOWLEDGEMENTS

The work presented here is the result of a tremendous amount of work by a joint Rio Algom and Inmet team and I would like to thank everybody that contributed. Particular thanks are due to John Kapusta, Ian Pirie, Frank Balint, Leo Hathaway, Brian Brodsky, Alex Ascencios, Rainer Lehne, Manuel Pacheco and José Salas. I would also like to thank Richard Sillitoe, Keith Glover and David Love. Permission to publish was granted by Rio Algom, Noranda, Teck and Inmet.

1998 Julian Boldy Award Winners

The Bold Award is presented by the Mineral Deposits Division to the author(s) of the paper(s) presented at the annual GAC meeting that are judged to best describe significant and pragmatic advances in mineral deposit research or exploration. The winning papers are more than excellent technical writing; they are also elegantly and concisely presented.

At the recent meeting in Quebec City, there were two MDD-sponsored Special Sessions organized by Benoit Dube; Ore Deposits in Mafic and Ultramafic Rocks, organized by S.-J. Barnes and Mineralized Hydrothermal Skarn Systems, organized by D. Lentz & G. Lynch. The three recipients are listed in alphabetical order by presenter's name.

1) **Lang, James, R., Baker, T.** *(MDRU, Univ. of BC, Vancouver, BC)* & **Lewis, P.D.** *(Lewis Geoscience Services, Surrey, BC).*
Intrusive, Stratigraphic, Geochemical and Structural Controls on Skarn and Massive Sulphide Manto and Chimney Ores in the La Negra and Zimapan Districts, Central Mexico

2) **Allen, John** *(John Allen & Associated Ltd., Auckland, New Zealand)* & **Tania Aslund** *(PT Freeport, Jakarta, Indonesia)*
The Wabu Gold Skarn, Irian Jaya, Indonesia

3) ***Redwood, Stewart D.*** *(INMET Mining Corp., Lima, Peru)*
The Geology of the Antamina Copper-Zinc Skarn Deposit, Peru

Following the Boldy tradition, expanded abstracts of each paper appear in an issue of *The GANGUE* Newsletter (the first two in the October, 1998 issue (No. 59) and the third in this issue of *The Gangue*) for the benefit of those unable to attend the meeting. Each author received a wall certificate, a book plate and a small cash prize. On behalf of MDD, we extend our gratitude to those who assisted in judging the papers presented in Quebec City.

Diamonds and Metals: Recent Contributions of Commercial Activities and Marine Research to the Development of High Value Terrestrial and Marine Deposits. *The 29th Annual Conference of the Underwater Mining Institute*

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Introduction

The conference was held on October 22-23, 1998 at the Days Inn in Toronto, attracting nearly 100 registrants from 14 countries including a significant contingent from South Africa. The conference was opened by **Charles Morgan** of the Marine Minerals Technology Center, University of Hawaii, Hawaii and **Steven Scott** of the University of Toronto, Ontario. There were 30 presentations spread over two days focusing on the technical and economic aspects of the development of mineral deposits on the seabed with comparisons made to analogous equivalents on land. **Richard Garnett** of Valrik Enterprises Inc., Oakville, Ontario organized and chaired the first day technical session that was mostly on diamonds while Steven Scott and **Richard Moore** of Falconbridge Limited, Toronto organized and co-chaired the second day technical session on base and precious metals.

This was the first time that the UMI had focused on the mining of alluvial diamonds on the seabed. Based on the talks and discussions, it was clear from the beginning that the presenters from this established industry, mostly engineers and businesspersons, brought a needed "hardheaded" perspective of underwater mining to the rest of the participants. In contrast, the presentations on the mineability of seafloor sulphide deposits showed that, technically and economically, these types of ventures are still very much in their infancy. Studying these deposits, however, has provided lessons for geologists involved in the exploration and mining of base and precious metal orebodies on land.

Diamonds

Richard Garnett opened the diamond session providing an up to date summary of the offshore diamond mining industry focusing on the activities off the coast of southwestern Africa where there are presently 800 km of continuous mining. His introduction set the rigorous technical and economic tone of the day. The high level of technical focus was borne out by specific talks by **Stefan Schwank** of Bauer Spezialtiefbau Gmbh, Germany on the use of underwater trench cutting for sampling and by **Anthony Wakefield**, Consulting Engineer, England, on jet pumps used for the transportation of rock slurries. **Tony van der Steen** of Paragon International, Netherlands outlined the factors determining the design and choice of different seabed mining systems.

Luc Rombouts of Terraconsult BVBA, Belgium discussed sampling methods used for the estimation of alluvial diamond reserves. Areas of high grade material tend to be overestimated while those of low grade material tend to be underestimated; a problem not unknown to land-based mine geologists. An update of the status of the diamond market was provided at this time. It was noted that prices of good quality diamonds, especially between 0.1-1.0 caret size, have dropped considerably in price since June and that most offshore production is of gem quality within that size fraction.

Most of the rest of the talks of the day were by operators of seafloor exploration and mining ventures which varied in scale from the use of a dugout canoe to multi-million dollar scale mechanized programs. **Michael Gibb** of Marine Mining Inc., Toronto provided an example of the former outlining their grassroots exploration program for alluvial gold and diamonds off the coast of Ghana. It was reported the recovery of samples of crystalline gold coated on detrital particles. This disputes the interpretation that crystalline gold in paleo-placer deposits indicates a late epithermal mineralizing process. **Ian Corbett** of DeBeers Marine, South Africa presented the example of the latter. A rare glimpse was provided into the massive exploration and mining effort off the Namibian coast which is maintaining DeBeers as the technical and economic leaders in the industry. Presently, the mining of diamonds is at a maximum depth of 140 metres with stripping off of up to 4 metres of overburden. Exploration is occurring to a maximum depth of 400 metres.

Dan Johnson of Diamond Fields International, Vancouver, British Columbia outlined their aggressive exploration program off shore the Namibian. The program has progressed to the mine development stage with a envisioned potential production of 500,000 carats a day. **Ian Selby** of Coastal Geosciences, United Kingdom discussed the preliminary exploration program conducted by RTZ/CRA off the northern coast of Australia during the early 1990s. The program met with limited success and no follow-up exploration has been conducted since 1993.

Two talks on alluvial diamond production were of particular interest to the participants. **John Gurney** of Benguela Concessions, South Africa outlined some of the geological factors controlling the grade and size of the deposits along the turbulent seacoast of southwestern Africa. It was stated that the best diamond deposits are in gravels situated on the continental slope. The differences between sampling and production grades of deposits was discussed noting that the actual grade can be higher than the estimated grade because the diamonds tend to concentrate more towards the bottom of gravel pockets. The economic benefits of this discovery can only be achieved with a well thought out mining program maximizing

ore recovery rather than the rate of production. Some information on the economics of ocean diamond mining was shared. A high grade deposit with a grade of 1 carat/metre^2 can provide a good profit, however, an economic cut-off grade of 0.1 carat/metre^2 is needed for a mining operation to be truly successful in the long term. Generally, a production of 6,000 carats/month is required by a mining vessel in order to maintain a profitable operation. **Andre Louw** of Ocean Diamond Mining Holdings, South Africa also emphasized the importance of maximizing diamond recovery by "surgically removing payable ore from waste" on the seafloor. A detailed understanding of the geology of the gravel beds and seafloor bedrock is an important tool for defining mineable reserves and a knowledge of the geology of the alluvial orebodies on the adjacent shorelines has been very helpful in achieving this. Side-scan sonar and remotely operated vehicles are tools for increasing mining efficiency to be more commonly used in the future. Although successful low grade mining operations are needed for long term success, the initial profitable recovery of high grade pockets is crucial to small companies in order to quickly pay back capital costs and maintain investor confidence.

Richard Garnett closed the session with an excellent summary on seafloor mining which summarized the long and steep learning curve underwater alluvial mining has undergone to reach this point of success. The factors controlling exploration and production were reviewed with comparisons made to alluvial gold mining operations off the coast of Alaska. The need to economically recover the lowest possible grade was emphasized because as the cut-off grade increases the ore reserves become more fragmented. As well, the difference between resources and reserves was emphasized noting that the presence of resources has no relation to economic feasibility. Many of the comments and conclusions by Richard Garnett, Andre Louw and John Gurney, perhaps not surprisingly, are consistent with the experiences of land-based mining geologists and engineers but represented a new perspective to the ocean scientists present in the room. The session concluded with a cautionary warning of the expected technical and economic challenges to those proposing seafloor sulphide and manganese nodule mining ventures. However, what was perhaps left unsaid was that the success of the underwater diamond mining industry today shows that these hurdles can be overcome and bodes well for the future economic recovery of other resources from the seafloor.

Metals

The technical session was mostly an update to the 1993 UMI meeting held in Estes Park, Colorado entitled "Gold and Massive Sulphides in the Oceans: Lessons for Land and Sea Exploration". The participants, as in 1993, consisted of a mixture of marine scientists and exploration and mining industry types. Steve Scott opened the session with an update on seafloor sulphide deposits and their similarities and differences to the volcanogenic and sedex-type massive sulphide deposits being mined on land.

Marine geologists, many of whom had participated in the 93 meeting, provided new information on their exploration projects on the ocean floor. **Yves Fouquet** of IFREMER, France reported on the recent activities of the Ocean Drilling Program (ODP) on the Trans Atlantic Grothermal (TAG) deposit on the Mid Atlantic Ridge and Middle Valley deposit in the northeastern Pacific Ocean. The results allowed for the first time a third dimension view of these deposits and demonstrated the first order importance of zone refining and other subsurface hydrothermal processes resulting in the considerable leaching or enriching of base metals in relation to pyrite-rich bodies and thus the formation or obliteration of an orebody. At the sedimented Middle Valley, stacked zones of mineralization including a deep copper-rich body were intersected by drilling. The site may represent an actively forming modern analogue to sedex and possibly Besshi-type deposits. **Raymond Binns** of CSIRO, Australia reported on the felsic volcanic hosted gold and base metal rich seafloor sulphide deposits in the eastern Manus Basin, Papua New Guinea. Sixty samples analysed to date average 15 g/t Au. It was suggested that the sulphides may be underlain by subhalative or intrusive-related deposits. Deep drilling of the area by the ODP will be undertaken in 2000. The area has recently been covered by an exploration lease operated by Nautilus Mining Inc., Australia. **Roger Moss** of the University of Toronto reported on precious metal content in seafloor hydrothermal deposits noting the importance of silver and gold enriched zinc sulphides within both fore- and back-arc environments.

Mark Hannington of the Geological Survey of Canada, Ottawa reported on the exploration for shallow gold-rich seafloor deposits associated with spreading ridges around Iceland and along the Bonin Arc in the South Pacific. These areas range in depths from approximately 200-1000 metres, shallower than most seafloor sulphide deposits (2,000-3,500 metres) but deeper than the seafloor diamond orebodies. It was suggested that the area around White Island, north of the North Island of New Zealand, is a centre of considerable shallow water, magmatic, hydrothermal activity containing significant gold occurrences. **Peter Herzig** of the Institut fur Mineralogie, Freiberg, Germany discussed the recent discovery of shallow marine gold mineralization on a seamount 10 km south of the giant Lihir orebody (40 million ounces). The geology and mineralization are similar to that in the Lihir mine with recovered samples to date averaging 18 g/t Au, but the top of the seamount is at 1100 metres depth. The orebody is located within a volcanic caldera at the waterline of Lihir Island so the challenges encountered in the mine's development serve as an important guide to those ready to venture further out into the marine environment. **Alexander Malahoff** of the University of Hawaii, Honolulu described a spectacular caldera collapse in the Loihi submarine volcano and the formation of voluminous hydrothermal bacterial mats and copper and zinc mineralization. It was noted that the bac-

teria may have industrial applications and thus be considered a potential economic resource. It was interesting that the volcanic activity resulted in the release of a considerable discharge of metal contaminants into the marine environment which did not seem to be a concern to either the scientists or the local seafloor inhabitants.

Some geologists with both ocean- and land-based experience presented talks with a land-based focus. **Jan Peter** of the Geological Survey of Canada, Ottawa discussed the possibility that iron-silica exhalites and their anomalous Pb, Zn, Cu, As, Hg, Sn, and Ba signatures in the Pb-Zn-Cu Bathurst Mining Camp are the result of a paleo-plume fallout. This is possible if the plume is heavier than the surrounding seawater which would minimize dilution of the metal signatures. It was noted that the capriciousness of these anomalies as vectors to ore may be a function of variable hydrothermal activity and changeable ocean currents resulting in a "smearing" of the metal anomalies over a large area. However, the multiple-origin of silica in the exhalites, both as a hydrothermal contributant and detrital and biogenic dilutant, may also have a role in blurring the impact of the anomalies. **Kaihui Yang** and Steven Scott of the University of Toronto presented a poster on the discovery of high concentrations of metals in CO_2-rich fluids trapped in felsic volcanic rocks hosting sulphide deposits in the eastern Manus Basin and in footwall rocks to the 120^+ million tonne Brunswick #12 massive sulphide orebody. **Jim Franklin** of Franklin Geosciences, Ottawa reviewed the knowledge obtained from seafloor deposits with respect to the better understanding of their land-based analogues. It was pointed out that the study of seafloor sulphides has demonstrated the importance to the formation of massive sulphide orebodies of subvolcanic intrusions, a high permeability of subsurface rocks and a magmatic source of the mineralizing fluids.

A number of representatives from the mining industry gave presentations. **David Burrows** of Inco Technical Services Ltd., Toronto and **Gerald Riverin** of Inmet Mining Corporation, Rouyn-Noranda, Quebec each gave the industry perspective on the contribution of seafloor deposit research to land-based mining and exploration. Both representatives and to a lesser extent Jim Franklin expressed some disappointment of what little we have learned from the seafloor with respect to generating new tools for the exploration and development of new orebodies. Indeed, in many ways the benefit has been mostly in the other direction; for example the study of land-based deposits, especially in the third dimension, has provided considerable aid in understanding the seafloor analogues. Gerald Riverin emphasized the importance of being able to plot features on a map for data to be useful in exploration. David Burrows suggested that perhaps the greatest contribution of seafloor research may be the eventual direct exploitation of the resources, especially as larger and higher grade deposits are located. **Steven Juras** of MRDI Canada, Vancouver discussed the successful use of stratigraphic models in the exploration for ore while mine geologist for the Boliden-Westmin Myra Falls massive sulphide mine. The description of the preservation of the stacked deposits at Myra Falls including the deep copper-rich HW orebody, not dissimilar to that described at Middle Valley by Yves Fouquet, is an important lesson for both land- and sea-based explorers. At the end of the day, **Richard Hutchinson** of Golden, Colorado summarized the two days of presentations; many of the comments are included in this report.

Other Topics

In addition to the talks given on diamonds and metals, **Charity Lee** of the Deepsea Resources Research Center, Korea gave an overview of their deep seabed mining exploration program including Korea's continuing examination of Clarion-Clipperton zone in the central Pacific Ocean as a prospective mining area for manganese nodules. **S. Rajendran** of the Cochin University of Science and Technology, India provided information on placer deposits of India. Steven Scott in his capacity as the President of the Canadian Scientific Submersible Facility, Sydney, B.C. made a presentation on the ROPOS remotely operated vehicle as a tool for seafloor exploration.

Conclusions

The conference organization was excellent thanks to workers in both Hawaii and Toronto especially **Karynne Chong Morgan**, Administrative Officer of the Marine Minerals Technology Center and **Helen Lasthiotakis** of the Canadian ODP Secretariat at the University of Toronto. The chosen topics were a great success because they brought not only representatives of academia and industry together but also workers at different timelines in the pursuits of their underwater endeavours. Those studying seafloor sulphides deposits are working in a fundamentally different environment in comparison to those working on the diamoniferous seabed, considerably deeper and more thermally active, nevertheless the experiences in the latter will be invaluable in the future exploitation of precious and base metals on the seafloor.

It appears that every type of modern massive sulphide deposit has now been discovered either formed or being formed on the seafloor including both sedex and

- If you pay attention to things that don't fit, you are more likely to make discoveries than if you try to find things that do fit. --- *Beveridge, Frontiers Of Scientific Knowledge: Harvard University Press, Cambridge, Massachusetts, 501 p.*

Quote courtesy of L.G. Collins

volcanogenic types. One possible exception are the more distal Irish-Type Pb-Zn-Ag carbonate-hosted sulphide deposits. Their discovery will probably require drilling because, based on the results of land-based research to date, these deposits form by diagenic replacement beneath the seabed surface. Future efforts in seafloor research should encourage the participation of the mining industry and investors by focusing on the direct exploitation of resources rather than gathering information applicable to the land-based exploration. This can be done in the following areas:

- Study and delineation of precious metal deposits hosted in shallow water (<100 metres depth) with the purpose of testing their viability for commercial exploitation. Gold bearing, hydothermally active areas discussed during the conference include offshore to White Island, New Zealand and Lihir Island, Papua New Guinea. Also of interest are the extensions into the water of known ancient lode gold camps such as along strike southwest of the Ashanti Gold Belt offshore Ghana, West Africa.
- Exploration by drilling of favourable shallow, sediment-hosted, "briney", basins in order to search for giant polymetallic deposits. The Red Sea has been shown to host such an environment and to contain voluminous sulphides. Other candidates for additional exploration are the Black and Caspian Seas, or possibly the shallow northern end of the Gulf of California, Mexico in the area of the Salton Sea. The well documented Pb-Zn-Cu-Ag sulphide deposits of Guaymas Basin, at the central part of the gulf, are associted with carbonate exhalites.

The conference was a great success because the participants clearly benefited from the interaction with those in different fields of enterprise whom they would normally never meet. If the sulphide ventures can progress with similar success as with the diamonds, the title of the 49th Annual Conference of the Underwater Mining Institute will be "Marine Mining of Hydrothermal Polymetallic Ores: Now an Established Industry".

Editor's Note: This conference was financially supported by MDD.

Confucius: "In his leisure hours the master relaxed his manner and wore a cheerful countenance".

Australian Mineral Foundation
International Study Tours

by Mike Porter

Many of the world's greatest, classic and best known ore deposits are located in Canada. Consequently, Canadian mines have been conspicuous on the itinerary of three of the six International Study Tours that AMF International has run over the last two years.

These tours are part of a further education program aimed at practising professionals within the mining and exploration industry, throughout the world. The specific aim has been to allow geoscientists in this industry to advance their knowledge of the geology of ore deposits.

Rather than providing lectures in a remote institution, the strategy has been to go to the best examples of the particular ore type under consideration, wherever they may be, touch them, and talk to the people that know them the best - the geologists who work on and around the deposits.

The Tours To Date

The tours run to date have been:

Archipelago '97 - which visited 12 of the great porphyry related Cu and Au deposits of the South-east Asian Archipelago, in Papua New Guinea, the Philippines and Indonesia. These included the giant Grasberg, Ok Tedi, Batu Hijau, Lepanto-Far Southeast, Porgera and Lihir mines.

Archaean Gold '97 - which took in 15 classic gold and related ore deposits in North America and Africa. The tour started at Lupin in the Arctic of Canada, and included the great mines with which we are all familiar in Canada and South Africa, before ending at Renco within the Limpopo Mobile Belt, in the tropics of Zimbabwe.

OzGold '97 - that went to 12 major and representative gold deposits across Australia, from the Archaean lodes of Western Australia, through the Proterozoic orebodies of northern and central Australia, to the younger Phanerozoic mines of the eastern and southern states.

Cordillera '98 - that visited 15 of the classic porphyry related copper and gold mines in the Cordillera of the Americas in Chile, Argentina, the US and Canada. These included such orebodies as El Teniente, Los Bronces, El Indio-Tambo, Chuquicamata, Escondida, Alumbrera, Mission, San Manuel, Bingham Canyon, Highland Valley and Afton/Ajax.

Zinc '98 - that included 15 of the great zinc bearing ore deposits of Europe and North America, such as Reocin, Navan, Neves Corvo, Sullivan, Red Dog, Faro, Howards Pass, Flin Flon, Kidd Creek, Brunswick #12 and Crandon.

EpiGold '98 - a workshop and tour on the evaluation of epithermal gold deposits in the tropics, which included visits to gold projects in Indonesia. This was a tour for non-technical professionals, provided on request, and exclusively for an international group.

Treasurers Report
Mineral Deposits Division
Geological Association of Canada
January 20, 1999

The Mineral Deposits Division experienced a strong financial year, with publication sales continuing to produce healthy income. The attached Summary of Income & Expenses has been prepared prior to the preparation of audited financial statements, which will include year-end adjustments and accurate interest calculations and distributions.

Sales of three of the earliest publications on Highland Valley, Yellowknife and Newfoundland VMS deposits had declined to only a handful each year, even at reduced prices, and the remaining inventory was given to local geoscience groups. A glance at the attached documents shows that these never did return their investments although their sales are considered acceptable. Sales of all publications published by MDD since 1992 continue strong. The Alteration Atlas sold out its first printing of 2000 copies and a similar number were reprinted in 1998. The other current MDD publications also sold out during the last year or two and are now reprinted by GAC in small batches with a process called Docutech Style. About $1750 has been invested in a draft Canadian geology/mining poster but further work has been deferred until a partner is found and a marketing plan can be developed.

The healthy balance sheet allowed MDD to increase its funding for conferences in cases where the executive deemed that the support would benefit the general membership. In 1998, this included travel support for the skarn sessions at the AGM in Quebec City and for the Underwater Mining Institute conference in Toronto in October, as well as refundable seed money for the VMS Short Course scheduled for Vancouver in January, 1999 (cosponsored with MDRU).

The Division's surplus funds are invested in government insured bonds and short term certificates with maturity dates up to November, 2001 and interest rates between 4.0 and 6.1%.

Robert J Cathro
Treasurer

Members of the North American sediment-hosted module of the Zinc'98 AMF International Study Tour in the field near Sullivan, BC. From left to right: Carl Hehnke (Kennecott Ex.), Terry Lees (Pasminco Ex., back), Simon Tear (Rio Tinto Ex., front), Steve Coombes (Kennecott Ex.), Stuart Mills (Minorco BV), Pat Mackenzie (Rio Tinto Ex.), front), Terry Ballinger (North Ltd., back), Sam Wiggett (Billiton SA Ltd.), Simon Booth (Normandy Mining Ltd., back), Steve Andrews (Rio Tinto Ex.), front), Bob Beeson (North Ltd., back), Craig Leitch (AMF Consultant), Andrew Allan (North Ltd.), Mark Saxon (Pasminco Ex.), Terry Middleton (Hearald Res.), Sally Dibben (Pasminco Ex.), Tim Craske (WMC Res.).

MINERAL DEPOSITS DIVISION
GEOLOGICAL ASSOCIATION OF CANADA

SUMMARY OF INCOME & EXPENSES
FOR THE YEAR ENDED DECEMBER 31, 1998

GENERAL ACCOUNT

	1998	1997
INCOME		
Interest (estimate)	$4,500	$3,000
Membership Fees	9,291	8,809
Publication Sales (net from GAC)	36,470	54,459
Donations - Spanish Publication	200	-
- Field Trips	-	257
Short Course	-	5,673
	50,461	72,198
EXPENSES		
Accounting	571	473
Advertising	129	-
Convention - AGM	2,147	525
- Other	3,500	-
Newsletter (Gangue)	6,035	4,500
Office & Bank	269	359
Publication	35,883	4,842
Field Trips (loss)	4,462	3,429
	52,996	14,128
NET SURPLUS (LOSS)	(2,535)	58,070
Operating Surplus - Beginning of year	96,279	76,099
OPERATING SURPLUS - End of year	93,744	96,279

COMMEMORATIVE *ECONOMIC GEOLOGY SESSION* FOR DR. BRUCE NESBITT

GAC-MAC Annual Meeting

Sudbury, 26-28 May 1999

Economic Geology Session GS3

Submissions were invited for participation in a session of Economic Geology (GS3) talks dedicated to the memory of Bruce Nesbitt (1951-1998) who passed away after an accident in August. Friends, colleagues, and researchers who have worked in the broad range of fields of geology that Bruce influenced in his scientific career were encouraged to submit abstracts for this session. Please note that this session does not appear in the First Circular distributed for the meeting.

For further information, please contact;

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Jeremy Richards, *Co-chair*
Jeremy.Richards@ualberta.ca

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ENDOWMENT ACCOUNTS

DERRY ACCOUNT

Balance, December 31, 1997	253
Donation - Derry Family	1,500
Expenses	29
Interest Income (estimate)	100
Balance, December 31, 1998	1,824

GROSS ACCOUNT

Balance, December 31, 1997	40,399
Award	2,000
Expenses	29
Interest Income (estimate)	2,000
Balance, December 31, 1998	40,370

BOLDY ACCOUNT

Balance, December 31, 1997	7,766
Awards	400
Interest Income (estimate)	390
Balance, December 31, 1998	7,756

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ANNUAL PUBLICATION EXPENSES & INCOME

YEAR	EXPENSES*	INCOME>
1984-89	$42,937	$25,446
1990	-	5,482
1991	11,529	2,896
1992	-	1,439
1993	15,835	6,268
1994	10,204	8,919
1995	11,156	11,051
1996	34,364	18,729
1997	4,842	54,459
1998	35,883	36,470
TOTAL	166,750	171,159

* - includes minor refunds, advertising and administration costs
> - net of sales commissions to GAC and taxes.

FINANCIAL RESULTS FOR EACH PUBLICATION

YEAR	PUBLICATION	EXPENSE	NET SALES	% RETURN
1985	Highland Valley, BC	$10,358	$3,724	36.0
1985	Hemlo, ON	11,229	16,552	147.4
1987	Yellowknife, NWT	5,949	4,084	68.7
1988	Newfoundland VMS	15,401	12,874	83.6
1991	Greenstone Gold (NUNA #2)	11,529*	-	n/a
1993	Mid-Continent Diamonds	6,006	11,478	191.1
	Ore Deposit Models 11 (GAC Reprint Series #6)	10,000*	-	n/a
1994	Alteration Processes " (Short Course Notes #11)	11,715	22,741	194.1
1995	Mineral Deposit Modeling (GAC Special paper #40)	10,000*	-	n/a
	(Unallocated sales in 1995)	-	2,364	
1996	Trace-Element Geochem " (Short Course Notes #12)	8,694	11,845	136.2
	Alteration Atlas (reprinted in 1998)	59,255	91,687	154.7
1998	Unallocated expenses	1,316	-	
Total		161,452	177,349	109.8
	(excluding grants)	129,923	177,349	136.5

* - outright grant to GAC " - 50% MDD / 50% GAC

Top: The Archean Gold'97 International Study Tour group on the Heritage Outcrop at Hemlo with Ontario Geological Survey (OGS) staff. Standing: Roberty Simango (Rio Tinto Zimbabwe), Andrew Radonjic (Centaur Mining & Ex.), Paul Mazzoni (WMC Ex.), Dave Kershaw (Avgold, South Africa), Kevin Seymour (Delta Gold), Greg Edwards (Normandy Ex.), Dennis Gee (MIM Exploration), Mark Smyk (OGS); Kneeling: Lance Govey (Normandy Ex.), Michael Smith (NorthFlinders), Bernie Schnieders (OGS).

Bottom: Members of the volcanic hosted module of the Zinc'98 International Study Tour group in the field at the Brunswick No. 6 VMS deposit with a Noranda Mining staff member and a few "good looking" New Brunswick Dept. of Natural Resources & Energy (NBDNRE) staff. From the left: Sam Wiggett (Billiton, South Africa), Dave Lentz (kneeling, NBDNRE), Barry Murphy (Pasminco Ex.), Terry Ballinger (North Ltd.), Steve McCutcheon (kneeling, NBDNRE), Simon Booth (Normandy Mining), Angela Lorrigan (Pasminco Ex.), Pierre Bernard (Noranda Mining), Owen Parfrey (Pasminco Ex.).

Seminars, Workshops and Experts

The mine and project visits are supported on tour by seminars and workshops presented by international and local experts, as well as regional briefings and geological reconnaissance.

These put the tour deposits into a context and framework, while describing and comparing other important deposits not to be visited.

Sometimes seminars are run in conjunction with local bodies. One example was European overview seminar in Dublin for the Zinc '98 tour with the Irish Association for Economic Geology. It attracted over 120 geologists from Ireland and elsewhere in Europe and provided a wide base for discussion, exchange of experience and networking.

Commonly renowned experts are also contracted to accompany sections of the tour.

Content and Attendance

These tours have become increasingly international, not only in the range of deposits visited, but in the participants who attend.

Now, it is usual for the tour group to be composed of geologists based or working in countries not only in the Australasian and South-east Asian region, but also from southern Asia, Africa, Europe, North and South America.

This diversity contributes to the value of the tours, with geologists from varied backgrounds and experience travelling together, seeing ore deposits through different eyes and with varying viewpoints, to discuss, exchange experience and cross pollinate ideas.

The great majority of tour members have been from mining and exploration companies, with a few from government geological surveys. All have been funded by their employers. They range from promising juniors, to middle level and senior geologist, to exploration managers. Some are on tour as a reward for exemplary work.

They tend to come from the more progressive organisations who see a benefit and competitive advantage in developing their staff. Those geologists are then better equipped to recognise both the subtleties, and the wide range of possibilities of ore occurrence in their day to day exploration and property evaluation work.

Organisation

The tours are designed for maximum impact in the minimum time. Never-theless, the itineraries, while concentrated and compact, have essential rest days to avoid fatigue and saturation.

The tours are from 9 to 35 days in duration. The longer of these, are divided into logical modules of 7 to 12 days, which may be taken individually. This allows for a limit to the time company staff are absent from important projects, while providing a tight focus on that part of the tour they perceive to be essential.

All of the planning, costing and tedious organisational detail of the tours are carried out by AMF International. All the participants have to do is get to the starting point with their field and travel gear, and to read the comprehensive preparatory literature compiled and pre-delivered by the **AMF** International.

The meticulous preparation by **AMF** International permits costs to be kept to a minimum, while removing all of the hassle and allowing the participants to focus on the main goal - learning from some of the greatest ore deposits of the world.

The tours however, would not be possible without the generosity and hospitality of the mines and organisations visited. AMF International is deeply grateful in particular to the Canadian mining industry and to the National and Provincial geological surveys for their cooperation.

What is AMF International ?

AMF International is that part of the *Australian Mineral Foundation* (**AMF**) responsible for international activities.

The **AMF** is the premier provider of information, education and training services to the Australian minerals and petroleum industry, aimed principally at practising professionals. It is a not-for-profit foundation established and funded by the industry over 25 years ago, specifically for that purpose.

As the Australian mining industry has become increasingly more international and inter-woven with the world industry, so the **AMF** has become more international to serve it's constituency.

It's courses and conferences are available to, and are increasingly utilised by, companies throughout the world.

The Opportunity

While many of the world's greatest, classic and best known ore deposits are located in Canada, there are also many others spread around the other continents from which we can all learn.

These study tours provide an opportunity for geologists from around the world to come together and do just that.

What Next ?

The planned 1999 tours include **Oz-Tour '99** visiting a selection of the major base and precious metal deposits of Australia in May, and **Pacific Gold '99** going to the major gold deposits around the Pacific in September-October.

Contact **AMF** International in Adelaide, South Australia, for more details; Phone: +61 8 8379 0444, Fax: +61 8 8379 4634, email: education@amf.com.au, attention Mike Porter, David Pollard or Donna Biddick.

Visit the "International Study Tours" option of the **AMF** web site on http://www.amf.com.au/amf for detail on these tours as they are developed.

In addition this web site option contains overviews and review articles on past tours to gain a better flavour of what is offered, as well as literature collections for each tour.

** Mike Porter (Consultant) has designed, organised, photographed (3 photos here) and led the* **AMF** *International Study Tours.*

email: mporter@amf.com.au
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SUDBURY'99
GEOLOGICAL ASSOCIATION OF CANADA
Short Courses

• **SC1** Dynamic processes in magmatic ore deposits and their application in mineral exploration.
R.R. Keays (Laurentian U), C.M. Lesher (Mineral Exploration Research Centre, Laurentian U) and P.C. Lightfoot (INCO Ltd.) **(May 24-25);** Sponsors: Society of Economic Geologists and GAC Mineral Deposits Division

This two-day short course is aimed at geologists wishing to acquire an update on advances in the application of research to exploration for magmatic ore deposits, especially Ni-Cu-PGE sulphide deposits. The emphasis will be on the processes responsible for the formation of giant ore deposits (e.g., fluid dynamics, chemical dynamics and thermodynamics in lava channels, feeder sills and magma chambers) and how an understanding of these processes can be used in exploration. These concepts will be illustrated with examples from Voisey's Bay, Sudbury, Noril'sk, Kambalda/Perseverance, Raglan and Pechenga. Confirmed speakers include: D. Baines (U of Toronto); D.A. Williams (U of Alabama); S.-J. Barnes (U du Québec à Chicoutimi); C.M. Lesher (Laurentian U); P.C. Lightfoot (INCO Ltd.); A.J. Naldrett (U of Toronto); E.M. Ripley (Indiana U); S.J. Barnes (CSIRO-Perth); R.R. Keays (Laurentian U); A.H. Green (Falconbridge Ltd.); C. Farrow (INCO Ltd); E.A. Mathez (American Museum of Natural History); Discussion (led by A.J. Naldrett).
Attendees to this short course may also be interested in symposia SY3 and SY4, and field trips A1 and B1.

• **SC2** Physical volcanology: felsic volcanic processes, deposits and mineralization.
J. Stix (U of Montreal), R. Morton (U of Minnesota at Duluth), H.L. Gibson (Laurentian U) and W. Mueller (U du Québec à Chicoutimi) **(May 24-25)**

This course should be of interest to exploration geologists, as well as students and researchers, as both a review and a more detailed presentation of material often not available in an undergraduate course. The two-day course will cover volcanic processes important in volcanic systems, and deposits formed in felsic dominated volcanic systems, with some emphasis on the processes and deposits relating to a variety of styles of mineralization. The course is divided into a series of morning lectures followed by afternoon labs. Lectures on the volcanic processes during the first day will cover the theory and classification, relating to the formation of pyroclastic rocks, flows and domes, calderas, and volcaniclastic rocks. The afternoon will be spent in labs examining samples suites from a variety of areas displaying the variability of the different features presented in the lectures. The suites will include hand sample and thin section examples of features to allow a development of an appreciation of the microscopic textures associated with the macroscopic textures and features. Lectures on the second day will present examples of the volcanic deposits formed by the different processes as well as a discussion of problems potentially encountered during mapping and interpretation. The labs on the second day will present sample suites from the areas discussed in the lectures.
Attendees to this short course may also be interested in field trip B11.

• **SC3** Geophysics in mineral exploration: fundamentals and case histories.
C. Lowe, M.D. Thomas (Geological Survey of Canada) and W.A. Morris (McMaster U)

This one-day short course for non-specialists will review the geophysical characteristics and associated rock physical properties of mineral deposit types that include volcanogenic massive sulphides, nickel, gold and diamonds. The application of gravity, electromagnetic, magnetic and seismic geophysical techniques in the exploration of these deposits will be examined from a theoretical perspective and also from a practical standpoint using case histories. The advantages offered by recent advances in exploration technology will be highlighted for each method. A short general discussion is planned at the end of the course. A comprehensive set of short course notes will be available for participants.

Sudbury '99 one-day workshop
Geophysics in Mineral Exploration: Fundamentals and Case Histories

Sponsored by the Geophysics Division of the Geological Association of Canada

This one day course will examine the geophysical characteristics of different mineral deposit types, including volcanogenic massive sulphide, nickel, gold and diamond deposits. It will include discussion of the applications of gravity, electromagnetic, magnetic and seismic geophysical techniques in mineral exploration. For each method, recent advances and case histories will be highlighted. Course presenters come from industry and academia. More details and information on a related special session are posted on the GAC web site (http://www.laurentian.ca/www/geology/gacmac99.htm)

MEETINGS, WORKSHOPS, & FIELDTRIPS

1999

- March 1-3 – **SEG Annual Meeting with the Society for Mining, Metallurgy and Exploration (SME)**, Denver, CO (USA). Contact Don Taylor at Tel: (303) 235-4414; Fax: (303) 235-4435; email: taylor.don.dr@bhp.com.au

- March 14-17 – **Prospectors & Developers Association of Canada Annual Convention**, Metro Toronto Convention Centre, Toronto, ON Canada; Contact: PDA at Tel: (416) 362-1969; Fax: (416) 362-0101; email: info@pdac.ca

- April 11-16 – **19th International Geochemical Exploration Symposium.** Hotel Vancouver, Vancouver, BC. Contact: Venue West Conference Services Ltd., Tel: 604-681-5226; FAX: 604-681-2503; email: congress@venuewest.com; website: www.aeg.org

- May 2–5 – **CIM'99 Calgary 101st Annual General Meeting.** Contact: Tel: (514) 939-2710, ext. 304; Fax: (514) 939-2714; email: cmurphy@cim.net.

- May 26 - 28 – **Sudbury'99 - Geological Association of Canada/Mineralogical Association of Canada, Joint Annual Meeting**, Sudbury, ON. Contact P. Copper at Tel: (705) 675-1151; Fax: (705) 675-4898; email: gacmac99@nickel.laurentian.ca; website: www.laurentian.ca/www/geology/gacmac99.htm

- August 22-25, **Society for Geology Applied to Mineral Deposits (SGA) 5th Biennial IAGOD Conference. "Mineral Deposits: Processes to Processing".** Contact Chris J. Stanley at Tel: 44-171-938-9361; Fax: 44-171-938-9268, email: cjs@nhm.ac.uk; website: www.nhm.ac.uk/minerals/course/sga.htm.

- September 19-21 – **North Atlantic Minerals Symposium,** Trinity College, Dublin, Ireland. Contact Baxter Kean at Tel: (709) 729-5946; bfk@zeppo.geosurv.gov.nf.ca.

- October 25-28 – **Geological Society of America Annual Meeting, Denver, CO (USA)**. Contact GSA at Tel: (800) 472-1988; email: meetings@geosociety.org

- November 3-5 – **International Symposium on Geochemical and Mineralogical Tracers in Mining Exploration,** Santiago, Chile. Contact Brian Townley at email: btownley@tamarugo.cec.uchile.cl.

Please submit your events to Dave Lentz at email: dlentz@gov.nb.ca

QUOTES

- *In the field of observation, chance favors only the prepared mind. --- R. Vallery- Radot*
- *If you are always meticulously careful and everything is planned, you can only see what you expect to see. And if you do see what you expect to see, it is not worth doing the experiment. --- Robert Scott Root-Bernstein*
- *No one can challenge existing belief systems, habits of work, and power structures and expect to be welcomed by the scientific community with open arms. --- Robert Scott Root-Bernstein*

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