Late Jurassic Ammonites From the Western Sierra Nevada, California

GEOLOGICAL SURVEY PROFESSIONAL PAPER 374-D

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By RALPH W. IMLAY

SHORTER CONTRIBUTIONS TO GENERAL GEOLOGY

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Ammonites furnish correlations with Jurassic rocks elsewhere on the Pacific coast and with the standard European stages

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON : 1961

UNITED STATES DEPARTMENT OF THE INTERIOR

STEWART L. UDALL, *Secretary*

GEOLOGICAL SURVEY

Thomas B. Nolan, *Director*

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington 25, D.C.

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LATE JURASSIC AMMONITES FROM THE WESTERN SIERRA NEVADA, CALIFORNIA

By Ralph W. Imlay

ABSTRACT

The ammonites from the Jurassic strata in the western part of the Sierra Nevada represent the Callovian, Oxfordian, and the lower part of the Kimmeridgian stages of the Upper Jurassic. There is no faunal evidence for the presence of any older Jurassic rocks, although the lower and middle parts of the Cosumnes formation have not furnished any fossils and could be in part older than the Callovian. The upper part of the Cosumnes formation has furnished one fragmentary ammonite indicative of a Callovian age. The lower part of the overlying Logtown Ridge formation has furnished many ammonites of early to middle Callovian age not older than the European zone of *Sigaloceras calloviense*. Because the formations grade into each other, the part of the Cosumnes formation that contains the Callovian ammonite must be of early Callovian age older than that zone.

The early Callovian is definitely represented by the ammonites *Kepplerites* (*Seymourites*) and K. (*Gowericeras*) obtained near Colfax, Calif. These indicate an age slightly older than the ammonites in the lower part of the Logtown Ridge formation on the Cosumnes River. The late Callovian is represented by a large specimen of *Peltoceras* obtained near Indian Creek in Amador County, presumably from the Logtown Ridge formation.

There is no faunal record of the early Oxfordian in California. The late Oxfordian to early Kimmeridgian is represented by the ammonite *Idoceras* obtained near the top of the Logtown Ridge formation on the Cosumnes River. The late Oxfordian is represented in the Mariposa formation by species of *Perisphinctes* (*Dichotomosphinctes*) and *P.* (*Discosphinctes*) that are virtually identical with species in Mexico and Cuba. These ammonites show that the lower part of the Mariposa formation and similar slatey units are locally of the same approximate age as the upper part of the Logtown Ridge formation on the Cosumnes River.

The early Kimmeridgian is represented in the Mariposa formation by *Amoeboceras* (*Amoebites*) and probably by *Subdichotomoceras* in association with the pelecypod *Buchia concentrica* (Sowerby).

The late Oxfordian to early Kimmeridgian is represented in the Monte de Oro formation by an ammonite, *Perisphinctes* (*Dichotomosphinctes*) cf. *P. elisabethaeformis* Burckhardt, and by two crushed specimens of *Buchia* cf. *B. concentrica* (Sowerby).

The Mariposa and Monte de Oro formations have not furnished any fossils that are younger than the early Kimmeridgian. The same is true of the Galice formation of southwestern Oregon and northwestern California which is lithologically similar to the Mariposa and likewise is characterized by the presence of *Perisphinctes* (*Dichotomosphinctes*) and *Buchia concentrica* (Sowerby). As the Galice formation is overlain with pronounced angular unconformity by beds of middle to late Portlandian age (Riddle formation), the middle Kimmeridgian to early Portlandian time appears to be represented, at least in part, by the unconformity.

The affinities of the Callovian ammonites in the Sierra Nevada are mainly boreal as indicated by the presence of such ammonites as *Cadoceras, Paracadoceras, Pseudocadoceras, Kepplerites,* and *Gowericeras*. The affinities of the late Oxfordian ammonites are mostly with ammonites in Mexico and Cuba but partly with those in Alaska. The early Kimmeridgian ammonite *Amoeboceras* indicates boreal affinities as the genus is rare in the Tethyan region. These affinities indicate that the seas in California were connected freely northward with Alaska and southward with southern Mexico.

INTRODUCTION

This study of the Late Jurassic ammonites from the western part of the Sierra Nevada, Calif., is based mainly on collections made by field parties of the U.S. Geological Survey since 1884. It includes, also, 4 specimens from Leland Stanford Junior University furnished by Siemon Wm. Muller, 1 specimen from the University of California furnished by Wyatt Durham and Joseph H. Peck, Jr., and 1 specimen from the Museum of Comparative Zoology at Harvard furnished by Bernhard Kummel. It does not include any fossils from the Taylorsville, Downieville, or Sailors Canyon area in the eastern part of the western Sierra Nevada metamorphic belt.

The description of the ammonites is a byproduct of paleontological assistance to Lorin D. Clark, of the Geological Survey, in his comprehensive analytical studies of the geology of the western Sierra Nevada. The assistance mainly involved determining the age limits of the rock units that Clark had mapped. This appeared at first to be a difficult task because of the wretched preservation of most of the fossils. After a little study, however, it was found that some of the fossils belonged to well-known genera and species from Alaska, Mexico, and Cuba and that rather precise dating of the rock units was locally possible by comparisons with the faunal successions in those areas. Such faunal dating is useful in making correlations with Jurassic rocks elsewhere on the Pacific coast, in unraveling complex stratigraphic and structural problems, and in interpreting the history of Jurassic sedimentation in California.

BIOLOGIC ANALYSIS

The Late Jurassic ammonite specimens from the western part of the Sierra Nevada that are available for study number about 200. Of these, 150 belong to the Cardioceratidae, 29 to the Perisphinctidae, and 13 to the Kosmoceratidae. Most genera and subgenera are represented by 1 to 4 specimens. Ammonites are actually more difficult to find in the area than these figures suggest, considering that 1 locality (Mesozoic loc. 27317) accounts for 120 specimens, and 3 localities (Mesozoic locs. 719, 901, and 27313) account for another 45 specimens. The biological distribution of the ammonites by subgenera, genera, subfamilies, and families is shown in table 1.

STRATIGRAPHIC SUMMARY

The fossils dealt with herein are from an irregular belt of metamorphosed Jurassic rocks, 10 to 25 miles in width, that crop out near the western base of the Sierra Nevada from Butte County on the north to western Madera County on the south. A number of formational names have been proposed for the rocks within this belt, but the validity of most of the names has not been firmly established.

For an isolated area of Jurassic rocks east of Oroville, in southeastern Butte County, the term Monte de Oro formation was proposed by Turner (1896, p. 548, 549). This formation consists mostly of dark carbonaceous clay slates similar to those of the Mariposa formation but includes some sandstone and conglomerate. It has furnished plant fossils, some marine pelecypods, and one ammonite.

For the main mass of Jurassic sedimentary rocks extending from the Colfax-Grass Valley area southward to Madera County, the term Mariposa slate was proposed by Becker (1885, p. 18–23). This term was restricted by J. P. Smith (1910, chart facing p. 217) to the slate and associated rocks in the metamorphic Gold Belt (mother lode) area that are characterized by the pelecypod *Buchia* (formerly called *Aucella*) and by the ammonite now referred to *Amoeboceras dubium* (Hyatt).

For the rocks in the southwestern part of the Colfax quadrangle that had been called Mariposa slate by Becker, Smith (1910, p. 217) proposed the term Colfax formation. These rocks, as described by Lindgren (1900), consist of interbedded shale, slate, sandstone, tuff, and conglomerate. He noted that most of the slate is not very fissile, which feature is a possible distinction from the slates of the Mariposa formation. In naming the Colfax formation, Smith appears to have been influenced by the lack of the pelecypod *Buchia* and by presence of *Ammonites colfaxi* Gabb, which he considered to be of Portlandian age.

Subsequently N. L. Taliaferro and his students made extensive studies of the Jurassic in the foothills of the Sierra Nevada from Eldorado County southward to Madera County. As a result of these studies the Mariposa slate was raised by Taliaferro (1933, p. 149) to the rank of a group and divided into the Mariposa slate above and the Indian Gulch agglomerates below.

Beneath the Mariposa group, Taliaferro recognized (1933, p. 149) some thousands of feet of Jurassic rocks that had previously been included partly in the Mariposa slate, partly in the Paleozoic Calaveras group, and partly in intrusive rocks of unknown age. For these older Jurassic rocks the term Amador group was proposed (Taliaferro, 1942, p. 89, 90). This group in the northern part of its known extent in Eldorado, Amador, and Calaveras Counties, as described by Taliaferro (1943, p. 282–284), is about 7,100 feet thick, rests uncomfortably on the Paleozoic, and consists of the Cosumnes formation below and the Logtown Ridge agglomerates at the top. Near the southern part of its extent, south of Calaveras County, the group is at least 14,000 feet thick, its base is not exposed, and it consists of five formations. On the Merced

TABLE 1.—*Ammonite genera and subgenera from Late Jurassic beds in the western Sierra Nevada, Calif.*

Family	Subfamily	Genus and subgenus	Number of specimens
Phylloceratidae	Phylloceratinae	*Phylloceras*	2
Oppeliidae	Taramelliceratinae	*Taramelliceras? (Proscaphites?)*	4
Kosmoceratidae		*Kepplerites (Seymourites)*	12
		(Gowericeras)	1
Cardioceratidae	Cadoceratinae	*Pseudocadoceras*	125
	Cardioceratinae	*Amoeboceras (Amoebites)*	25
Perisphinctidae	Pseudoperisphinctinae	*Grossouvria*	1
	Perisphinctinae	*Perisphinctes?*	1
		Perisphinctes (Discosphinctes)	14
		(Dichotomosphinctes)	1
		(Dichotomosphinctes?)	6
	Idoceratinae	*Idoceras*	1
		Idoceras?	1
	Virgatosphinctinae	*Subdichotomoceras?*	4
Asipidoceratidae	Peltoceratinae	*Peltoceras (Metapeltoceras?)*	1

River from oldest to youngest these formations include: (a) Lower volcanic rocks; (b) pillow basalt; (c) Hunter Valley chert; (d) Peñon Blanco volcanics; and (e) Agua Fria slate. Taliaferro correlated the Peñon Blanco agglomerate with the Logtown Ridge agglomerate and the Hunter Valley chert with part of the Cosumnes formation. Type localities for these formations were not designated.

During and after World War II, the Jurassic rocks in and near the Mother Lode area were studied by geologists of the U.S. Geological Survey. According to Lorin Clark (oral communication, October 1958), the five formations proposed by Taliaferro for the Merced River area are difficult to recognize with the exception of his Peñon Blanco volcanics. In contrast the Cosumnes and Logtown Ridge formations, particularly as exposed along and near the Cosumnes River, are definitely mappable units. The sequence along the Cosumnes River, described briefly by Heyl (1948, p. 15–17) and Lorin Clark (written communication, January 1960), may be summarized as follows:

Mariposa slate:

5. Mostly dark-blue-gray to black clay slate that weathers pale green to olive brown. Includes some siltstone, graywacke, conglomerate lenses, and locally volcanic rocks. Thickness unknown but evidently several thousand ft. Differs from the Cosumnes formation containing much less conglomerate.

Logtown Ridge formation of Taliaferro:

4. Mostly tuffs, andesitic agglomerates, and volcanic breccia. Includes two units of pillow lava. Thickness several thousand ft. *Idoceras* cf. *I. planula* (Heyl) *in* Zeiten, described herein, is reported to have been found near the top of the formation.

Cosumnes formation of Taliaferro:

3. Thin-bedded green gray and black tuff, in part slatey; some hundreds of ft. thick. Contains *Pseudocadoceras grewingki* (Pompeckj) (Mesozoic locs. 24710, 27317) in abundance about 600–700 ft above base.
2. Graywacke and dark clay slate. *Pseudocadoceras* ? sp. (Mesozoic loc. 22175) was found about 500 ft below top. Thickness unknown.
1. Conglomerate and sandstone in alternating units. Contains debris of underlying Paleozoic Calaveras formation. Thickness unknown.

Calaveras formation.

The combined thickness of the Logtown Ridge formation and the Cosumnes formation along the Cosumnes River is indicated by Heyl to be between 7,000 and 8,000 feet. The Cosumnes formation is reported to be about 3,600 feet thick and the Logtown Ridge formation about 4,300 feet thick by Lorin Clark (written communication, January 1960). However the 700 feet or more of thin-bedded tuff that Heyl placed at the top of the Cosumnes formation (unit 3 above) are transitional into the Logtown Ridge formation and, for convenience in mapping, are now placed in that formation by Clark (oral communication, October 1958). As mapped by Clark, the Logtown Ridge formation consists entirely of volcanic rocks, and the Cosumnes formation consists of interbedded sedimentary and volcanic rocks.

The sequence of the Logtown Ridge formation and Cosumnes formation exposed along the Cosumnes River is particularly interesting because the outcrops are nearly continuous, the formational boundaries are well exposed, there appear to be no great structural complications, and ammonites have been found at three places whose relative stratigraphic positions can be determined. As a result, the Logtown Ridge formation and the upper part of the Cosumnes formation along the Cosumnes River are dated fairly closely.

These conditions contrast with those found generally throughout the belt of Jurassic rocks under discussion. According to Lorin Clark (written communication, Nov. 16, 1959)

> the stratigraphy of the Jurassic in the western Sierra Nevada is extremely complicated. Volcanic formations intertongue with sedimentary formations, and both change thickness and character markedly within distances of 20 miles or less.

Such lithologic changes within short distances imply that formational boundaries do not remain time planes for many miles. These changes, in conjunction with the repetition of apparently identical rocks at different parts of the Jurassic sequence, probably explain why most of the fossil collections from the belt of Jurassic rocks have not been closely located stratigraphically.

AGES AND CORRELATIONS

COSUMNES FORMATION

The Cosumnes formation at its type locality on the Cosumnes River is at least in part of Callovian age because it grades upward into the Logtown Ridge formation whose basal beds have furnished many specimens of the Callovian ammonite *Pseudocadoceras* (figs. 1, 2). The only ammonite from the Cosumnes formation proper is a crushed specimen obtained about 500 feet below the top of the formation on the Cosumnes River. This specimen (see pl. 2, fig. 23) was at one time compared by Imlay (1952, p. 975) with the Callovian genus *Grossouvria*, but its coiling is too involute for that genus, and it is now referred tentatively to *Pseudocadoceras* on the basis of coiling and rib pattern. The specimen is of some significance because it suggests that the upper part of the Cosumnes formation is not older than Callovian.

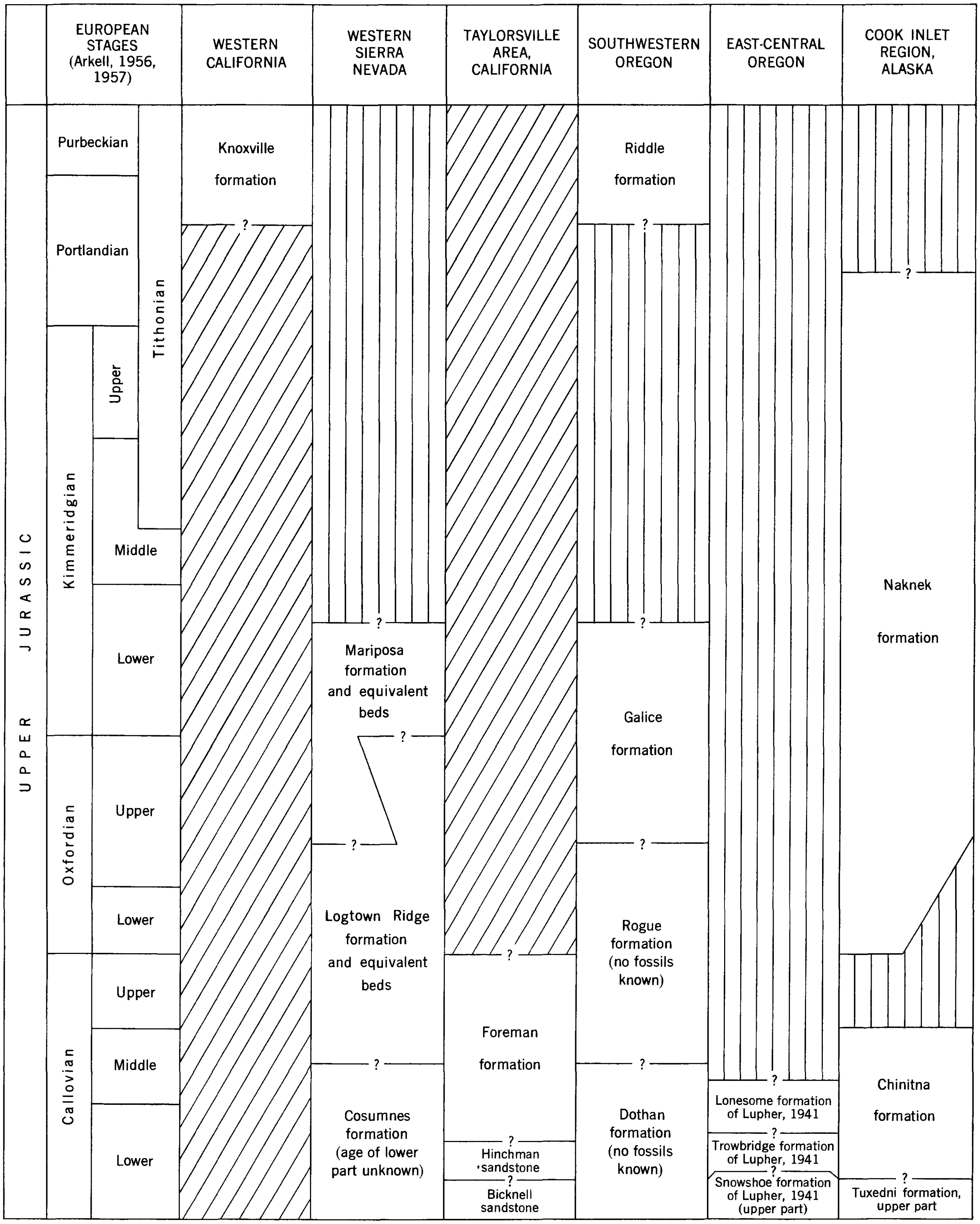

FIGURE 1.—Correlation of the Late Jurassic formation in the Pacific coast region.

	European stages (Arkell, 1946, 1956, 1957)			Standard zones in northwest Europe (Arkell, 1946, 1951, 1956; Callomon, 1955)	Characteristic fossils in the Western Interior region (Imlay, 1953)	Characteristic fossils in the Alaska Peninsula and Cook Inlet regions (Imlay, 1953)	Characteristic fossils in northwestern Washington	Characteristic fossils in California and Oregon	Characteristic fossils in Mexico (Imlay, 1943, 1952; Erben, 1957)
Upper Jurassic	Purbeckian		Tithonian		No fossil evidence	No fossil evidence	Buchia piochii	Buchia piochii: *Buchia fischeriana substeueroceras, Protacanthodiscus,* and *Proniceras*	*Substeueroceras* and *Proniceras*; *Micracanthoceras* and *Hildoglochiceras*
	Portlandian			*Titanites giganteus*		? *Buchia piochii*		*Kossmatia dilleri* and *Durangites*	*Kossmatia* and *Durangites*
				Glaucolithites gorei	? *Vetulonaia* spp. and *Gyraulus veternus*			? No fossil evidence	*Aulacosphinctoides, Virgatosphinctes,* and *Subplanites*
				Zaraiskites albani		? *Buchia rugosa* and *Buchia mosquensis*	? *Buchia rugosa* and *Buchia mosquensis*		
	Kimmeridgian	Upper		*Pavlovia pallasiodes*					? *Mazapilites*
				Pavlovia rotunda					
				Pectinatites pectinatus					
		Middle		*Subplanites wheatleyensis*					
				Subplanites spp.					
				Gravesia gigas					*Hybonoticeras* cf. *H. beckeri*
				Gravesia gravesiana					
		Lower		*Aulacostephanus pseudomutabilis*		*Buchia concentrica* and *Buchia spitiensis*	? No fossil evidence		*Idoceras durangense* and *Glochiceras fialar*
				Rasenia mutabilis		*Amoeboceras (Prionodoceras) spiniferum*		Buchia concentrica: *Amoeboceras (Amoebites) dubium* and *Subdichotomoceras?*	Group of *Idoceras balderum*
				Rasenia cymodoce					
				Pictonia baylei					? Group of *Sutneria platynota*
	Oxfordian	Upper		*Ringsteadia pseudocordata*	? *Buchia concentrica* in northwestern Montana			*Discosphinctes virgulatiformis* and *Dichotomosphinctes muhlbachi*	*Discosphinctes carribeanus* and *Ochetoceras canaliculatum*
				Decipia decipiens					
				Perisphinctes cautisnigrae					*Dichotomosphinctes durangensis*
				Perisphinctes plicatilis	*Cardioceras* spp.	*Cardioceras distans*		? No fossil evidence	?
		Lower		*Cardioceras cordatum*	*Cardioceras* spp.				
				Quenstedtoceras mariae	*Cardioceras cordiforme*; *Quenstedtoceras collieri*	? *Cardioceras martini*			? *Creniceras renggeri* and *Peltoceras (Parapeltoceras)*
	Callovian	Upper		*Quenstedtoceras lamberti*	No fossil evidence			*Peltoceras (Metapeltoceras?)*	? *Peltoceras* spp.
				Peltoceras athleta					
		Middle		*Erymnoceras coronatum*		*Pseudocadoceras*; *Cadoceras*		? *Pseudocadoceras grewingki*	? *Erymnoceras mixtecorum*
				Kosmoceras jason					
		Lower		*Sigaloceras calloviense*	*Kepplerites mclearni*; *Kepplerites tychonis*; *Gowericeras subitum*; *Gowericeras costidensum*	*Seymourites*; *Lilloettia*; *Paracadoceras* and *Gowericeras*		? *Kepplerites (Gowericeras), Lilloettia, Choffatia,* and *Xenocephalites*	? *Reineckeia neogaea*; ? *Eurycephalites* and *Xenocephalites*
				Macrocephalites macrocephalus	*Arcticoceras codyense*	*Xenocephalites* and *Kheraiceras*		? *Kepplerites* and *Choffatia*	

FIGURE 2. Correlation of the Late Jurassic faunas in the Pacific coast region.

LOGTOWN RIDGE FORMATION

The Logtown Ridge formation at its type locality on the Cosumnes River ranges in age from Callovian to late Oxfordian, or early Kimmeridgian. Evidence for a Callovian age consists of the presence of the ammonite *Pseudocadoceras* in the basal 600 feet of the formation. This genus in Europe ranges from the basal part of the zone of *Sigaloceras calloviense* into the zone of *Peltoceras athleta* (Callomon, 1955, p. 255), and is absent from the highest and lowest parts of the Callovian stage. A similar range is indicated in southwest Alaska where *Pseudocadoceras* occurs only in the upper two-thirds of the Chinitna formation associated with other ammonites that are correlated with the *Erymoceras coronatum*, *Kosmoceras jason*, and the upper part of the *Sigaloceras calloviense* zones of Europe (Imlay, 1953b, p. 48–54). Significantly, *Pseudocadoceras* is absent in the lower 1,000 feet of the Chinitna formation (Imlay, 1953b, p. 51–53) and in the upper 800 to 1,500 feet of the underlying Bowser member of the Tuxedni formation, although these parts have furnished early Callovian ammonites. This absence of *Pseudocadoceras* in the lower part of the Alaskan Callovian is comparable to its absence in the *Macrocephalites macrocephalus* zone at the base of the European Callovian. It follows, therefore, that the presence of *Pseudocadoceras* in the lower part of the Logtown Ridge formation in California shows not only that the lower part is Callovian but that it is younger than the earliest Callovian of Europe and Alaska (figs. 1, 2).

Further evidence concerning the age of the lower part of the Logtown Ridge formation is furnished by the particular species of *Pseudocadoceras* that are present. These include *P. grewingki* (Pompeckj) and probably, also, *P. crassicostatum* (Imlay, 1953b, p. 94, pl. 49, figs. 19, 20, 22–24). Of these species, *P. grewingki* (Pompeckj) in Alaska is the longer ranging, but its lowest occurrence is in beds that are correlated with the upper part of the *Sigaloceras calloviense* zone. *P. crassicostatum* Imlay has been found only in the upper part of the range of *P. grewingki* (Pompeckj) in beds that are correlated with the *Kosmoceras jason* and *Erymoceras coronatum* zones of Europe (Imlay, 1953b, p. 51–53). By comparisons with Alaska, therefore, the species of *Pseudocadoceras* that are present in the lower part of the Logtown Ridge formation suggest a middle rather than an early Callovian age.

The upper part of the Logtown Ridge formation is dated as latest Oxfordian or early Kimmeridgian by the presence of the ammonite *Idoceras* aff. *I. planula* (Heyl) *in* Zeiten. This species belongs to a group of species that in Mexico has been found only in the early Kimmeridgian (Burckhardt, 1912, p. 102; 1930, p. 64; Imlay, 1939, p. 21). In Europe, however, the group occurs also in beds of latest Oxfordian age (Wegele, 1929, p. 76–78; Arkell, 1956, p. 114, 115) at the top of the zone of *Epipeltoceras bimammatum*. A late Oxfordian age for the upper part of the Logtown Ridge formation is favored by the resemblance of the specimen of *Idoceras* present to a species in the late Oxfordian of Europe and to the fact that the apparently stratigraphically higher Mariposa formation in Calaveras, Mariposa, and Eldorado Counties has furnished ammonites that likewise are as old as late Oxfordian. It is possible, of course, that beds that are mapped as the Mariposa formation in one county are the lateral equivalents of beds mapped as the Logtown Ridge formation in another county.

Dating the upper part of the Logtown Ridge formation on the Cosumnes River as latest Oxfordian to early Kimmeridgian, based on the ammonite *Idoceras*, appears to be contradicted by the presence of a large specimen of *Peltoceras* of late Callovian age, described herein, from the Mariposa formation on nearby Big Indian Creek. It is questioned, however, whether *Peltoceras* actually was collected from the Mariposa formation or whether it came from some beds within the Logtown Ridge formation. When the *Peltoceras* was discovered in 1914, the term Logtown Ridge had not been defined, and it seems probable that any beds from Amador County that furnished Jurassic ammonites would have been referred to the Mariposa formation. Furthermore, the Logtown Ridge formation is exposed immediately west of Indian Creek and would seem to be a more likely source for a large ammonite than the relatively softer slates of the overlying Mariposa formation. A stratigraphic position for *Peltoceras* near the middle of the Logtown Ridge formation appears likely, provided that the specimen of *Idoceras* was actually obtained from the upper part of that formation, as is indicated by the matrix of the specimen.

COLFAX FORMATION OF SMITH, 1910

The Colfax formation of Smith crops out near Colfax in the southwestern part of the Colfax quadrangle, Placer County, and has furnished several ammonites of Callovian age. These include, in particular, *Ammonites colfaxi* Gabb, which Smith (1910, chart facing p. 217) considered to be of Portlandian age but which is herein identified with the Callovian genus *Grossouvria*. This dating is upheld by the presence of *Kepplerites lorinclarki* Imlay, n. sp., and *K.* (*Gowericeras*) *lindgreni* (Hyatt) from other localities near Colfax.

In Europe *Kepplerites* and its subgenus *Gowericeras* range through the lower two-thirds of the early Callovian zone of *Sigaloceras calloviense* (Callomon, 1955,

p. 255) except for two possible occurrences of *Kepplerites* in the zone of *Macrocephalites macrocephalus* (Arkell, 1953, p. 117, 119; 1956, p. 120). The subgenus *Seymourites* in the Boreal region and in the western interior of North America has a similar range (Spath, 1932, p. 138, 139, 145, 146; Imlay, 1953a, p. 7, 8, 17, 18). In the Cook Inlet region, Alaska, *Seymourites* occurs rarely in the lower part of the range of *Pseudocadoceras* in beds that are correlated with the *Kosmoceras jason* and the upper part of the *Sigaloceras calloviense* zones of Europe. *Gowericeras* likewise occurs rarely with *Pseudocadoceras* in beds that are correlated with the upper part of the *Sigaloceras calloviense* zone. Both subgenera are more common, however, below the range of *Pseudocadoceras* (Imlay, 1953b, p. 50, 52) in the basal part of the Chinitna formation which is correlated with the lower part of the *Sigaloceras calloviense* zone.

By comparisons, the occurrences of *Kepplerites* and *Gowericeras* in the Colfax formation of Smith near Colfax, Calif., might be as young as the *Pseudocadoceras* beds at the base of the Logtown Ridge formation, but most probably are somewhat older and equivalent to some part of the Cosumnes formation. In particular, the resemblance of *Kepplerites* (*Gowericeras*) *lindgreni* (Hyatt) to *K.* (*Gowericeras*) sp. from Alaska (Imlay, 1953b, p. 100, pl. 53, figs. 6, 7, 10), favors a correlation with the basal part of the Chinitna formation well below the range of *Pseudocadoceras*. Similarly, the greater resemblance of *Kepplerites lorinclarki* Imlay, n. sp., to species of *Kepplerites* from the basal Callovian of Europe (Buckman, 1922, pls. 286, 289a, b; Arkell, 1954, p. 118, and 1956, p. 120) than to any described North American species of *Kepplerites* suggests a very early Callovian age, perhaps corresponding to the *Macrocephalites macrocephalus* zone of Europe.

MARIPOSA FORMATION

The Mariposa formation proper and similar slatey beds, extending from Eldorado County southward to Madera County, have furnished the pelecypod *Buchia* at many places. The specimens of *Buchia* present have all been referred by Imlay (1959, p. 157) to *B. concentrica* (Sowerby), which in Eurasia ranges from the upper Oxfordian zone of *Perisphinctes cautisnigrae* to the lower Kimmeridgian zone of *Aulacostephanus pseudomutabilis*.

A similar age for the Mariposa formation is shown by some of the ammonites that are associated with *Buchia*. These are listed by localities as follows:

Taramelliceras? (*Proscaphites*?) *denticulatum* (Hyatt) Mesozoic loc. 901.
Amoeboceras (*Amoebites*) *dubium* (Hyatt) Mesozoic loc. 719.
Perisphinctes (*Discosphinctes*) *virgulatiformis* Hyatt Mesozoic loc. 901.
P. (*Dichotomosphinctes*) cf. *P. muhlbachi* Hyatt Mesozoic loc. 901.
Subdichotomoceras? aff. *S. filiplex* (Quenstedt) Mesozoic locs. 902, 903, 904.

Other ammonites from the Mariposa formation, not associated with *Buchia*, are:

Perisphinctes (*Dichotomosphinctes*) *muhlbachi* Hyatt, Mesozoic loc. 27517.
P. (*Dichotomosphinctes*) cf. *P. muhlbachi* Hyatt, Mesozoic loc. 27460.
P. (*Dichotomosphinctes*?) spp. Mesozoic locs. 490, 24317.

Concerning the Eurasian ranges of these ammonites, *Taramelliceras* ranges through the Oxfordian and Kimmeridgian, and the subgenus *Proscaphites* is typically Oxfordian (Arkell, 1957, p. L 280–281). *Amoeboceras* ranges through the upper Oxfordian and the lower Kimmeridgian. The subgenus *Amoebites* is known only from the lower Kimmeridgian (Arkell, 1957, p. L 306–307; Spath, 1935, p. 30–36). *Dichotomosphinctes* ranges through the Oxfordian (Arkell, 1957, p. L 322) and occurs rarely in the lower Kimmeridgian (Arkell, 1937, p. 61). *Discosphinctes* in central and southern Europe ranges through the zones of *Gregoryceras transversarium* and *Epipeltoceras bimammatum* of the upper Oxfordian (Arkell, 1937, p. XLVII, p. 61) and appears to be transitional to *Lithacoceras* of the lower and middle Kimmeridgian (Arkell, 1937, p. LII). *Subdichotomoceras* ranges through the Kimmeridgian (Arkell, 1957, p. L 328), but is most characteristic of the lower and middle Kimmeridgian.

Judging from the ranges of these ammonite genera, the Mariposa formation might be equivalent to the entire Oxfordian and Kimmeridgian stages of Europe. However, the association of certain ammonites with other ammonites, or with *Buchia concentrica* (Sowerby) indicates that only the late Oxfordian and the early Kimmeridgian are represented by fossils in the Mariposa formation.

Thus the late Oxfordian is represented by the faunule at USGS Mesozoic locality 901, which contains *Perisphinctes* (*Discosphinctes*) *virgulatiformis* Hyatt, *P.* (*Dichotomosphinctes*) cf. *P. muhlbachi* Hyatt, *Taramelliceras*? (*Proscaphites*?) *denticulatum* (Hyatt), and *Buchia concentrica* (Sowerby). Of these, the presence of *Buchia* is evidence of an age not older than late Oxfordian, both *Dichotomosphinctes* and *Proscaphites* are much more likely to be Oxfordian than Kimmeridgian in age, and *Discosphinctes* is typical of the late Oxfordian. Furthermore, the perisphinctid ammonites present are closely similar to species in the late Oxfordian of Cuba and Mexico. *P.* (*Discosphinctes*) *virgulatiformis* (Hyatt) is nearly identical with *Perisphinctes* (*Discosphinctes*) *carribeanus* Jaworski from the late Oxfordian of Cuba (Jaworski, 1940, p. 109, pl. 3, figs. 1, 2; pl. 4, fig. 5; pl. 7, fig. 6) and Mexico

(Burckhardt, 1912, p. 35, pl. 7, figs. 4-14). *P.* (*Dichotomosphinctes*) *muhlbachi* Hyatt greatly resembles *P.* (*Dichotomosphinctes*) *durangensis* Burckhardt (1912, p. 16, pl. 3, figs. 1, 2) from Mexico.

The early Kimmeridgian is equally strongly represented by the subgenus *Amoebites* at USGS Mesozoic locality 719 judging by the range of that ammonite in Eurasia and Greenland. It is probably represented also by the ammonites referred to the Kimmeridgian genus *Subdichotomoceras* from USGS Mesozoic localities 902, 903, and 904 as those ammonites are associated with *Buchia concentrica* (Sowerby) of late Oxfordian to early Kimmeridgian age.

None of the fossil collections from the Mariposa formation afford any evidence of an age younger than the early Kimmeridgian. An age as old as early Oxfordian is possible for those collections containing *Perisphinctes* (*Dichotomosphinctes*) *mühlbachi* Hyatt at USGS Mesozoic locality 27517 and comparable ammonites at USGS Mesozoic localities 490, 24317, and 27460 that are not associated with *Buchia.* Such an age seems unlikely, however, considering that the ammonites in question are closely similar to *P.* (*Dichotomosphinctes*) *durangensis* Burckhardt from the upper Oxfordian of Mexico.

Fossils other than *Buchia* and the ammonites listed above are scarce in the Mariposa formation. They are poorly preserved and have not been studied carefully and probably would not be useful in dating the formation. Such fossils include *"Belemnites" pacificus* Gabb (USGS Mesozoic locs. 490, 901, 903, 904, 1982, 25638), *Avicula*? sp. (USGS Mesozoic loc. 901; see Hyatt, 1894, p. 429), *Entolium*? *aurarium* (Meek) (USGS Mesozoic locs. 904, 1983), *Entolium*? sp. (USGS Mesozoic loc. 18937), *Nucula*? sp. (USGS Mesozoic loc. 18937), *Lima*? sp. (USGS Mesozoic locs. 27398, 27459), *Cerithium*? sp. (USGS Mesozoic loc. 901), and *Turbo*? sp. (USGS Mesozoic loc. 901).

In summation, the Mariposa formation, if dated on the basis of ammonites and the pelecypod *Buchia,* is of late Oxfordian and early Kimmeridgian age. The evidence shows that some of the beds are locally as old or perhaps slightly older than the upper part of the Logtown Ridge formation on the Cosumnes River.

Conceivably some of the Mariposa formation that has not furnished fossils could be younger than early Kimmeridgian. This seems unlikely, however, considering that the Geological Survey geologists have found *Buchia concentrica* (Sowerby) at 16 localities and that the collections in the museums in California contain this species from many other localities, but nowhere in the western part of the Sierra Nevada has a specimen of the younger *Buchia rugosa* (Fischer) been discovered.

Similarly in the Galice formation in southwestern Oregon, which formation is lithologically and faunally similar to the Mariposa formation, *Buchia concentrica* (Fischer) has been found at 18 localities, but not a single specimen of *Buchia rugosa* (Fischer) has been found. This contrasts with the abundance of *Buchia rugosa* (Fischer) from northwestern Washington northward into northern Alaska. Furthermore, in southwestern Oregon, the Galice formation is overlain with angular unconformity by the Riddle formation that contains ammonites and *Buchia piochii* (Gabb) of Portlandian-late Tithonian ages (Imlay and others, 1959, p. 2780). The time represented by the unconformity seems to correspond with the middle and upper Kimmeridgian and perhaps the early Portlandian, which is the time represented in Alaska and the Arctic region by *Buchia rugosa* (Fischer). It seems, therefore, that failure to find this species of *Buchia* in southwestern Oregon and in Claifornia is related to diastrophism and not to an unfavorable environment or to insufficient collecting.

MONTE DE ORO FORMATION

The Monte de Oro formation (Turner, 1896, p. 548, 549) contains mollusks of late Oxfordian age to early Kimmeridgian age (figs. 1, 2). The evidence consists mostly of one fairly well preserved specimen of the ammonite *Perisphinctes* (*Dichotomosphinctes*) (see pl. 4, figs. 4, 7) that is similar to *P.* (*Dichotomosphinctes*) *elisabethaeformis* Burckhardt (1912, p. 31, pl. 6, figs. 1-5) from the late Oxfordian of Mexico and of two crushed specimens of *Buchia* (see pl. 5, figs. 7, 8) that bear very fine radial striae and probably belong to *Buchia concentrica* (Sowerby).

The specimens of *Buchia* were obtained along the western side of some plant-bearing beds on the north bank of the Feather River from 3 to 4 miles northeast of Oroville (USGS Mesozoic loc. 4801). With them occur the pelecypods *Ostrea, Modiolus, Trigonia, Meleagrinella, Lima, Chlamys*?, *Tancredia,* a gastropod, belemnites, and plant fossils. Most of the molluscan genera are represented by only a few specimens, but *Meleagrinella* occurs in abundance.

The association of *Buchia* with *Meleagrinella* is interesting as *Meleagrinella* became scarce after the appearance of *Buchia* (Imlay, 1959, p. 156) in the late Oxfordian. The fact that *Meleagrinella* is represented by many specimens and that *Buchia* is represented by only two specimens suggests, therefore, that the beds containing these genera represent the time during which *Buchia* first appeared as a distinct genus. It is possible, however, that the relative abundance of the two genera is related to environmental conditions.

In contrast to the evidence afforded by the mollusks, the flora in the Monte de Oro formation has furnished a correlation with the Bajocian of Europe (Ward, 1900, p. 340–377; Fontaine, 1905, p. 48–145; Knowlton, 1910, p. 39, 43, 44). Furthermore, some plant-bearing beds in Douglas County, Oreg. that contain the same plant species have been referred also to the Bajocian (Knowlton, 1910, p. 33–64). These beds in Douglas County, Oreg., all occur, however, within sequences that contain *Buchia piochii* (Gabb) (Diller, 1908a, p. 376–383; Imlay and others, 1959, p. 2781), a fossil that is characteristic of the latest Jurassic (Portlandian-Tithonian) (Imlay, 1959, p. 159). Because of this association in Oregon, the comparable plant-bearing beds in the Monte de Oro formation near Oroville were at one time referred also to the Portlandian (McKee and others, 1956, p. 3). However, the discovery of *Buchia* cf. *B. concentrica* (Sowerby) within the same beds as the plants near Oroville and of *Dichotomosphinctes* in associated beds shows that the Monte de Oro formation is considerably older; that is, late Oxfordian to early Kimmeridgian. Therefore, on the basis of the mollusks, the plant species in question range from late Oxfordian to Portlandian, inclusive, and are much younger than the Bajocian.

A middle Late Jurassic age for the Monte de Oro formation is not out of harmony with the plant evidence because many species of plants have long ranges. Also, such an age means that the Monte de Oro formation is correlative, at least in part, with the Mariposa slate farther south, which correlation fits very well with present knowledge concerning the Jurassic paleogeography of California. A Portlandian age for the Monte de Oro formation does not fit because beds of that age are not known anywhere on the east sides of the Sacramento and San Joaquin Valleys.

COMPARISONS WITH OTHER FAUNAS

TAYLORSVILLE AREA, CALIFORNIA

Beds of Callovian age are represented near Taylorsville by the Hinchman tuff, Bicknell sandstone, and Foreman formations of Diller (1892, p. 370–394) on Mount Jura; by the North Ridge formation of Crickmay (1933b, p. 896, 901) on Mount Jura; and by the Kettle formation of Diller (1908b, p. 84) near Hosselkus Creek east of Mount Jura. In the Hinchman tuff and Bicknell sandstone occur corals and mollusks that Hyatt (*in* Diller, 1908b, p. 49–52) and Crickmay (1933b, p. 901) considered to be of Callovian age. In the North Ridge formation of Crickmay, which overlies the Hinchman tuff, was found the ammonite *Choffatia hyatti* (Crickmay) (1933b, p. 901, 913, 914, pl. 32, fig. 3, pl. 33) that Arkell (1956, p. 554) said resembled European species from the *Macrocephalites macrocephalus* zone. From the lower part of the overlying Foreman formation, was obtained *Reineckeia* (*Reineckeites*) *dilleri* (Crickmay) (1933b, p. 902, 914, pl. 32, fig. 2, pl. 34, figs. 1–5). Fragments of the same subgenus occur likewise in a collection from the Foreman formation made by Diller (1908b, p. 56, USGS Mesozoic loc. 3143). From talus near the middle of the Foreman formation, Vernon McMath, University of Oregon, collected specimens of *Pseudocadoceras* (identified by Imlay). These ammonites show that the lower and middle parts of the Foreman formation are of Callovian age not older than the European zone of *Sigaloceras calloviense* or younger than the zone of *Peltoceras athleta*.

From the Kettle meta-andesite near Hosselkus Creek, Vernon McMath and the writer obtained specimens of *Pseudocadoceras schmidti* (Pompeckj), *P.* cf. *P. grewingki* (Pompeckj), and *Choffatia* sp. (USGS Mesozoic loc. 26784). Some hundreds of feet higher stratigraphically were obtained *Cadoceras* sp. juv., *Xenocephalites*? sp., *Paracadoceras*? sp., and *Pseudocadoceras* cf. *P. grewingki* (Pompeckj) (USGS Mesozoic locs. 26785, 26786). These ammonites indicate an early middle Callovian age comparable with that of the lower part of the middle third of the Chinitna formation in the Cook Inlet region, Alaska (Imlay, 1953b, p. 53). If *Paracadoceras* and *Xenocephalites* are correctly identified, the age of the beds is probably not younger than the *Sigaloceras calloviense* zone of Europe.

On the basis of these ammonites, the lower and middle parts of the Foreman formation and a considerable thickness of the Kettle meta-andesite of the Taylorsville area may be correlated with the lower part of the Logtown Ridge formation and probably the adjoining transitional upper part of the Cosumnes formation on the Cosumnes River. Stratigraphically, the North Ridge formation of Crickmay, the Hinchman sandstone, and the Bicknell sandstone, all of Callovian age, could be correlative with part of the Cosumnes formation beneath the beds containing *Pseudocadoceras*.

Faunal evidence is lacking for the existence of Oxfordian or younger Jurassic beds in the Taylorsville area. Crickmay (1933b, p. 902, 903) described some new formations above the Foreman formation and assigned them a middle Late Jurassic to Tithonian age, but he did not publish any evidence. Taliaferro (1942, p. 100) considered that the Foreman formation was equivalent to the Mariposa formation but that could be true only for the upper part that has not furnished fossils. The fact that the Foreman formation includes slates similar to those in the Mariposa formation is not a sound basis for correlation because similar slates occur in the beds of Callovian age near Colfax and locally in the Cosumnes formation, which are both appreciably older than the Mariposa formation.

CENTRAL OREGON

Lower Callovian ammonites have been found in the Izee-Suplee area of central Oregon throughout about 9,000 feet of beds ranging from the upper part of the Snowshoe formation of Lupher (1941) to within 300 feet of the eroded top of the Lonesome formation of Lupher (1941), which is the youngest Jurassic formation exposed. The collections from the basal part of Lupher's Trowbridge shale have been mentioned by Lupher (1941, p. 264, 265). They include *Lilloettia buckmani* (Crickmay) and *Kepplerites* (*Gowericeras*) cf. *K. spinosum* (Imlay). Ammonites from the upper part of the Snowshoe formation, as mapped by William Dickenson of Stanford University, include *Choffatia* sp., *Xenocephalites vicarius* Imlay, *Lilloettia* sp., and *Gowericeras* cf. *G. spinosum* Imlay (USGS Mesozoic locs. 26778–26780). Ammonites from the Lonesome formation, obtained at various levels from near the base to within 1,000 feet of the top, belong mostly to the genus *Xenocephalites*, and some are identical with *X. vicarius* Imlay (USGS Mesozoic locs. 26781, 26782, 27372, 27373). One small ammonite obtained 300 feet below the top of the Lonesome formation is probably an immature specimen of *Xenocephalites* (USGS Mesozoic loc. 27383). The ammonite *Pseudocadoceras* is probably represented in the Lonesome formation in a collection from the southeast corner of sec. 25, T. 19 S., R. 28 E.

Judging from these collections, most of the Callovian in central Oregon represents only the lower part of the Callovian stage and is comparable to the lower half of the Chinitna formation and to the upper part of the Bowser member of the Tuxedni formation in the Cook Inlet region, Alaska (Imlay, 1953b, p. 51–53). The presence of *Pseudocadoceras*? in the Lonesome formation of Lupher (1941) suggests that some part of that formation is as young as the Foreman formation of the Taylorsville area and the lower part of the Logtown Ridge formation of the Cosumnes River area in California.

SOUTHWESTERN OREGON

The Callovian has not been identified faunally in southwestern Oregon. If present, it is possibly represented by the Dothan formation (Diller, 1907, p. 407–411) and the overlying Rogue formation (Wells and Walker, 1953) that lithologically bear considerable resemblance to the California Cosumnes formation and Logtown Ridge formation, respectively. In contrast, the late Oxfordian to early Kimmeridgian has been identified faunally in the Galice formation (Diller, 1907, p. 403–407), which consists mostly of slates similar to those of the Mariposa formation of California. The faunal evidence consists of the presence of the pelecypod *Buchia concentrica* (Sowerby) at 18 localities and of perisphinctid ammonites at 4 localities. Most of these ammonites are fragmentary, but one laterally crushed specimen (see pl. 4, fig. 2) from the Almeda mine on the Rogue River, 3 miles below the mouth of Galice Creek (USGS Mesozoic loc. 3326), is a typical representative of the subgenus *Dichotomosphinctes* and is similar in appearance to *Perisphinctes* (*Dichotomosphinctes*) *wartaeformis* Burckhardt (1912, p. 25, pl. 5, figs. 1–4, 6) and to *P.* (*Dichotomosphinctes*) aff. *P.* (*D.*) *plicatilis* d'Orbigny in Burckhardt (1912, pl. 4, figs. 2–4) from the upper Oxfordian beds of northern Mexico. This ammonite constitutes excellent evidence that part of the Galice formation is of late Oxfordian age.

WESTERN BRITISH COLUMBIA

In the Harrison Lake area the ammonites *Cadoceras catostoma* Pompeckj, *Paracadoceras harveyi* Crickmay, and *Pseudocadoceras schmidti* (Pompeckj) are listed from the middle of the Mysterious Creek formation of Crickmay (1930, p. 55–57). This association of species and genera in Alaska (Imlay, 1953b, p. 50–53) occurs in beds that are correlated with the *Sigaloceras calloviense* zone of Europe. It is probably about the same age as the faunule found in the Kettle meta-andesite on Hosselkus Creek in the Taylorsville area, previously discussed herein. It could be of the same age as the basal part of the Logtown Ridge formation on the Cosumnes River, but the presence there of coarsely ribbed specimens of *Pseudocadoceras* comparable to *P. crassicostatum* Imlay (1953b, p. 50, 94) suggests a slightly younger age probably equivalent to the middle Callovian.

In the Queen Charlotte Islands an ammonite faunule from the upper part of the Yakoun formation consists of species of *Kepplerites* (*Seymourites*) (McLearn, 1929, p. 4–12) identical with species in the lower and middle thirds of the Chinitna formation in the Cook Inlet region, Alaska (Imlay, 1953b, p. 50–53, 95–99). The fact that *Kepplerites* on the Queen Charlotte Islands is not associated with *Cadoceras* or *Pseudocadoceras* suggests correlation with only the lower third of the Chinitna formation. These occurrences are mentioned because Arkell (1956, p. 554) suggested that *Kepplerites* (*Gowericeras*) *lindgreni* (Hyatt) from near Colfax, Calif., is similar to species of *Kepplerites* from the Queen Charlotte Islands. The present studies show, however, that the species is quite different, and resembles species in Alaska from the very base of the Chinitna formation (Imlay, 1953b, p. 31, pl. 22, figs. 10–13) and in the western interior from the zone of *Gowericeras costidensum* (Imlay, 1953a, p. 6, 7, 31, pl. 22, figs. 10–13) which zone lies below the lowest known occurrence of *Kepplerites* (*Seymourites*). Also, the fact that the new species of *Kepplerites*, described herein, from near Colfax differs considerably from any described species of *K.* (*Seymourites*) from British Columbia suggests that the beds near Colfax are probably of slightly different age.

ALASKA PENINSULA AND COOK INLET REGIONS, ALASKA

The lower and middle Callovian are well represented by a varied succession of ammonites in the Alaska Peninsula and in the Cook Inlet region except possibly for the lowest European zone of *Macrocephalites macrocephalus* (Imlay, 1953b, p. 51–55). That zone may be represented by the upper part of the Bowser member of the Tuxedni formation, which includes such typical Callovian ammonites as *Grossouvria*, *Kheraiceras*, *Xenocephalites*, and *Kepplerites* along with the long-ranging ammonites *Phylloceras*, *Macrophylloceras*, and *Calliphylloceras*. The species that are present all range up into the lower part of the Chinitna formation, so that the upper part of the Bowser member cannot be much older. In fact the presence of one specimen of *Kepplerites* similar to *K. tychonis* Ravn suggests that at least part of the Bowser member is equivalent to the lower part of the *Sigaloceras calloviense* zone of Europe (Imlay, 1953b, p. 53). Nevertheless, the absence of such ammonites as *Lilloettia*, *Cadoceras*, *Paracadoceras*, *Pseudocadoceras*, *Gowericeras*, and *Cosmoceras* from the upper part of the Bowser member implies a position low in the Callovian.

The succession of Callovian ammonites that has been established for Alaska cannot yet be demonstrated for California and Oregon because of meager collections and complicated structure. It is implied, however, by the fact that many of the Callovian ammonites that have been found in California and Oregon are identical specifically with the Callovian ammonites of Alaska. Assuming that the succession is approximately the same in all three States, certain correlations may be made, as discussed in the section dealing with "Ages and correlations." Thus the beds near Colfax, Calif., that contain *Kepplerites* and *Gowericeras* are correlated with the basal part of the Chinitna formation and the highest part of the Tuxedni formation of Alaska and hence with the European *Sigaloceras calloviense* zone and possibly the *Macrocephalites macrocephalus* zone. The beds containing *Pseudocadoceras* at the base of the Logtown Ridge formation contains species identical with those in the middle to upper thirds of the Chinitna formation and are correlated with the middle Callovian of Europe. In contrast, the ammonite *Peltoceras* from the Logtown Ridge(?) formation on Big Indian Creek in Amador County, Calif., has no counterpart in Alaska where the upper Callovian is missing—as it is generally throughout the Arctic region.

The Oxfordian and Kimmeridgian stages in Alaska are represented mostly by a succession of species of the pelecypod *Buchia* (Imlay, 1955, p. 83–86). However, the lower Oxfordian, present locally in the Naknek formation of the Cook Inlet region and the Alaska Peninsula, is represented by the ammonite *Cardioceras* (Reeside, 1919, p. 9, 18, 24, 25, 27) that is not associated with *Buchia*. The overlying beds in the lower part of the Naknek formation contain an abundance of *Buchia concentrica* (Sowerby) that is associated with the typical late Oxfordian ammonites *Amoeboceras* (*Prionodoceras*) (Reeside, 1919, p. 30) and *Perisphinctes* (*Dichotomosphinctes*). (See pl. 4, fig. 6.) Near the middle of the Naknek formation, *Buchia concentrica* (Sowerby) is associated for several hundred feet with *B. rugosa* (Fischer) and *B. mosquensis* (von Buch). The last two species continue upward for many hundreds of feet to the top of the Naknek formation. Their range in Alaska cannot be dated accurately because of lack of associated ammonites other than *Phylloceras* and *Lytoceras*, but by comparisons with their ranges in Eurasia and Mexico, they do not occur lower than the lower Kimmeridgian zone of *Aulacostephanus pseudomutabilis* or higher than the lower Portlandian (Imlay, 1955, p. 74, 75, 85; 1959, p. 165).

The lower part of the Naknek formation in Alaska shows faunal relations to the Mariposa formation in northeastern California and to the Galice formation in southwestern Oregon and northwestern California. As in those formations, *Buchia concentrica* (Sowerby) is the most common fossil. Associated with this species in all three formations is the ammonite *Perisphinctes* (*Dichotomosphinctes*). The species of this subgenus present in the Naknek formation (USGS Mesozoic loc. 10796) may be identical with *Perisphinctes* (*Dichotomosphinctes*) *mühlbachi* Hyatt from the Mariposa formation. The genus *Amoeboceras* occurs rarely both in the lower part of the Naknek formation and in the Mariposa formation but is represented by different subgenera of slightly different ages. The species of *Phylloceras* that ranges throughout most of the Naknek formation, but is particularly common in its lower part, is identical specifically with the *Phylloceras* in the Galice formation (USGS Mesozoic locs. 3322, 3335) and possibly includes some fragmentary specimens of *Phylloceras* in the Mariposa formation (USGS Mesozoic loc. 27318).

In contrast, the upper part of the Naknek formation has nothing in common faunally with the Mariposa formation and the Galice formation except for the ammonite *Phylloceras*. The pelecypod *Buchia rugosa* (Fischer), which is common in the upper part of the Naknek formation, has not been found in the Pacific coast south of northwestern Washington. Its absence in Oregon and California is in harmony, however, with the absence in those States of any ammonites of middle Kimmeridgian to early Portlandian age.

MEXICO

The only Callovian ammonities from Mexico that have been described are from the southern part of the country in the states of Oaxaca and Guerrero (Burckhardt, 1927; 1930, p. 26, 32, 35, 36, 43; Arkell, 1956, p. 564). Most of them are different from any ammonites that have been found in the Callovian of California. There are relationships, however, on the generic level. Thus the species of *Reineckeia* (*Reineckeites*) described by Burckhardt (1927, pl. 16, pl. 17, pl. 18, figs. 1, 2, 7) from Mexico resemble *R.* (*Reineckeites*) *dilleri* (Crickmay) (1933b, pl. 32, fig. 2, pl. 34) from the Taylorsville area, in California. *Choffatia waitzi* Burckhardt (1927, p. 75, pl. 30, figs. 2–5) is too small for comparison with *Choffatia hyatti* (Crickmay) (1933b, pl. 33) from the Taylorsville area. *Xenocephalites nikitini* (Burckhardt) (1927, pl. 16, figs. 4–9) recalls the presence of a questionable example of the genus in the Kettle meta-andesite of the Taylorsville area. The species of *Peltoceras* described by Burckhardt (1927, pl. 32, pl. 33, figs. 4–7, pl. 34) differ considerably from the specimen of *Peltoceras* from Indian Creek, Amador County, Calif., but possibly have significance paleogeographically as no other occurrence of *Peltoceras*, or of late Callovian fossils, are known in North America.

The Mexican Callovian has no representatives of such ammonites as *Cadoceras*, *Paracadoceras*, *Pseudocadoceras*, *Kepplerites*, and *Gowericeras* that occur in the Callovian from California to Alaska along with *Reineckeia* (*Reineckeites*), *Choffatia*, and *Xenocephalites*. It appears, therefore, that except for the presence of *Peltoceras*, the Callovian of California is much more similar faunally to that of Alaska than to that of Mexico. This does not imply, of course, that there was any physical barrier between the seas in California and those in Mexico.

The Oxfordian ammonites of Mexico that have been described mostly from the area of San Pedro del Gallo, Durango (Burckhardt, 1912, p. 1–40, 203, 204, 209–213, pls. 1–7). At this place the upper 100 meters of Oxfordian strata have furnished the ammonites *Ochetoceras*, *Taramelliceras* (*Proscaphites*), *Perisphinctes* (*Discosphinctes*), and *Euaspidoceras*, which probably represent the *Epipeltoceras bimmamatum* zone of central and southern Europe (Burckhardt, 1912, p. 213; Arkell, 1956, p. 563). From the underlying 150 meters of strata have been obtained ammonites belonging to *Creniceras*, *Taramelliceras*, and *Perisphinctes* (*Dichotomosphinctes*). This faunule is correlated with the *Perisphinctes plicatilis* zone of northwest Europe (Arkell, 1956, p. 563) and with the *Gregoryceras transversarium* zone of central and southern Europe (Burckhardt, 1930, p. 64; Arkell, 1956, p. 114).

From these Oxfordian strata the ammonite *Amoeboceras* cf. *A. alternans* (von Buch) has also been recorded, from about 4 kilometers north of San Pedro del Gallo north of Potrero de las Tunas (Burckhardt, 1930, p. 66). This occurrence is the southernmost record of the genus in North American and perhaps in the world, being much further south than the *Amoeboceras* from northern Italy recorded by Arkell (1956, p. 175).

The faunal sequence at San Pedro del Gallo is of considerable interest in determining the age of the Mariposa formation and of equivalent formations on the Pacific coast. One of the ammonites, *Perisphinctes* (*Discosphinctes*) *carribeanus* (Jaworski) (Burckhardt, 1912, p. 35, pl. 7, figs. 4–14) from the upper 100 meters of the Oxfordian sequence at San Pedro del Gallo may be identical with *P.* (*Discosphinctes*) *virgulatiformis* Hyatt (1894, p. 422) from the Mariposa formation. Another ammonite, *Perisphinctes* (*Dichotomosphinctes*) *durangensis* Burckhardt (1912, p. 16, pl. 3, figs. 1, 2), from the lower 150 meters of the Oxfordian at San Pedro del Gallo is apparently identical with *P.* (*Dichotomosphinctes*) *mühlbachi* Hyatt (1894, p. 426) from the Mariposa formation and with a specimen of *P.* (*Dichotomosphinctes*) (pl. 4, fig. 6) from the lower part of the Naknek formation, Alaska. *P.* (*Dichotomosphinctes*) *elisabethaeformis* Burckhardt (1912, p. 31, pl. 6, figs. 1–5) from the same lower beds at San Pedro del Gallo resembles a specimen of *Dichotomosphinctes* from the Monte de Oro formation near Oroville, Calif. (pl. 4, figs. 4, 7). Finally, *P.* (*Dichotomosphinctes*) *wartaeformis* Burckhardt (1912, p. 25, pl. 5, figs. 1–4, 6) resembles a specimen of *P.* (*Dichotomosphinctes*) (pl. 4, fig. 2) from the Galice formation of southwestern Oregon.

The Kimmeridgian ammonite faunas of Mexico are varied, well described (Burckhardt, 1906, 1912, 1919, 1921; Imlay, 1939, p. 21, 22, tables 4–7), and obviously have little in common with the fossils from the Mariposa formation in California. They do not contain a single representative of the genus *Amoeboceras*. They do contain a few representatives of *Subdichotomceras* (Burckhardt, 1906, pl. 31, figs. 1–4; Imlay 1939, pl. 10, figs. 1–3, 13) that are similar to *Subdichotomoceras*?

aff. *S. filiplex* (Quenstedt) from the Mariposa formation. They do contain *Buchia concentrica* (Sowerby) which was found by Burckhardt (1930, p. 67, 80) near Mazapil, Zacatecas, in a thin bed lying above beds characterized by species of *Idoceras* similar to *I. balderum* (Oppel) and below beds containing *Glochiceras fialar* (Oppel). This occurrence was confirmed by collections made by C. L. Rogers and others (1956, p. 23) in his unit B. Associated with this species of *Buchia* is another species that Burckhardt (1930, p. 67) compares to *Aucella pallasi* var. *plicata* Lahusen but which probably belongs to *B. rugosa* (Fischer). (See Imlay, 1955, p. 84; 1959, p. 158–159.)

The stratigraphic occurrence of these species of *Buchia* is interesting because the overlying beds containing *Glochiceras fialar* (Oppel) are correlated with the European zone of *Aulacostephanus pseudomutabilis* (Burckhardt, 1930, p. 64; Imlay, 1952, pl. 2) and the underlying beds containing *Idoceras balderum* are correlated with the European zone of *Rasenia mutabilis*. By comparison with the Jurassic of California, the absence of *Buchia rugosa* (Fischer) from the Mariposa formation would suggest that that formation is older than the beds in Mexico that contain *Glochiceras fialar* (Oppel). This is supported also by the absence of *Buchia mosquensis* (von Buch) from the Mariposa formation, as that species is present in the *Glochiceras fialar* beds near San Pedro del Gallo, Durango (Burckhardt, 1912, p. 216, 217).

GEOGRAPHIC DISTRIBUTION

The occurrence by county and locality of the species described in this report is indicated in table 2. The general position of each locality is shown on figure 3. Detailed descriptions of the individual localities are shown in table 3.

SUMMARY OF RESULTS

1. The Jurassic ammonites from the western part of the Sierra Nevada include 12 genera and subgenera and 21 species. Only one species is described as new. *Seymourites* and *Gowericeras* are considered subgenera of *Kepplerites*. *Discosphinctes* and *Dichotomosphinctes* are considered subgenera of *Perisphinctes*.
2. These ammonites are all of Late Jurassic age and in terms of European stages, represent the early to late Callovian, the late Oxfordian, and the early Kimmeridgian.
3. The exact stratigraphic positions of most of the fossils relative to formational boundaries is not known because of complicated stratigraphy or inexact field descriptions. However, the faunal evidence is sufficient to show the exact ages of the formations at certain spots and the approximate age range of the formations locally.
4. The Jurassic beds near Colfax, Placer County, have furnished the Callovian ammonites *Grossouvria colfaxi* (Gabb), *Kepplerites lorinclarki* Imlay, n. sp., and *K.* (*Gowericeras*) *lindgreni* (Hyatt). An early Callovian age is indicated by the presence of *Kepplerites* and by the close resemblance of *K. lindgreni* (Hyatt) to a species in Alaska that occurs considerably below beds of middle Callovian age.
5. The Cosumnes formation at its type locality on the Cosumnes River is at least in part of Callovian age as it has furnished an ammonite, *Pseudocadoceras*?, about 500 feet below its top, and its highest beds are transitional into the Logtown Ridge formation.
6. The Logtown Ridge formation on the Cosumnes River has furnished the Callovian ammonite *Pseudocadoceras grewingki* (Pompeckj) in its lower part about 600 to 675 feet above its base. With this species is associated a coarsely ribbed species that is probably identical with *P. crassicostatum* Imlay. By comparisons with Alaska, these ammonites indicate a correlation with the upper third of the Chinitna formation and thence with the middle part of the Callovian stage. The presence of *Pseudocadoceras* itself is evidence of an age not older than the late early Callovian zone of *Sigaloceras calloviense*.

The Logtown Ridge formation is probably represented also by the ammonite *Peltoceras* that was obtained at, or near, Indian Creek. This ammonite is excellent evidence of a late Callovian age.

The upper part of the Logtown Ridge formation on the Cosumnes River has furnished the ammonite *Idoceras* of latest Oxfordian to early Kimmeridgian age.

7. The Mariposa formation and similar slatey units containing *Buchia concentrica* (Sowerby) have furnished a number of ammonites of late Oxfordian to early Kimmeridgian age. The late Oxfordian is represented by *Perisphinctes* (*Dichotomosphinctes*) *mühlbachi* Hyatt and by *P.* (*Discosphinctes*) *virgulatiformis* Hyatt, which are essentially identical with species in Mexico and Cuba. The early Kimmeridgian is represented by *Amoeboceras* (*Amoebites*) *dubium* (Hyatt) and probably by *Subdichotomoceras*? aff. *S. filiplex* (Quenstedt). This age range is confirmed by the presence of *Buchia concentrica* (Sowerby) at a number of places in the Mariposa formation from near its base to at least several thousand feet above its base. The late Oxfordian ammonites from the Mariposa formation

TABLE 2.—*Geographic distribution of Late Jurassic megafossils in the western Sierra Nevada, Calif.*

[Numbers 1–31 refer to numbers on fig. 3. Most of the larger numbers refer to Mesozoic collections in the U.S. Geological Survey. Collection numbers from the University of California at Berkeley are preceded by the letters UC; from Leland Stanford Junior University by the letters SU; and from the Museum of Comparative Zoology at Harvard University by the letters MCZ]

	Butte County							Placer County			Eldorado County									Amador County			Calaveras County					Tuolumne County													Mariposa County					
	Monte de Oro formation							Colfax formation of Smith			"Mariposa" formation				Logtown Ridge formation				Cosumnes formation	Logtown Ridge(?) formation	"Mariposa" formation	Formation unknown	Mariposa formation					Mariposa(?) formation		Mariposa formation																
	1	2	3					4	5		6	7	8		9	10	11		12	13	14	15	16	17			18	19		20			21		22	23		24	25		26	27	28	29	30	31
	16625	3990	3991	3992	4801	4802	SU9063	27313	MCZ5287	27516	27517	490	25638	27318	SU9065	UC A-4996	24710	27317	22175	SU9062	18937	27387	24317	719	904	27566	903	27395	27396	27315	27394	27397	901	27518	SU9064	20554	27459	27398	902	27311	27312	253	1982	243	27460	1983
Phylloceras sp.														X																																
Taramelliceras? (*Proscaphites*?) *denticulatum* (Hyatt)																																	X													
Kepplerites lorinclarki Imlay, n. sp.								X																																						
(*Gowericeras*) *lindgreni* (Hyatt)										X																																				
Pseudocadoceras grewingki (Pompeckj)																	X	X																												
cf. *P. grewingki* (Pompeckj)																						X																								
cf. *P. crassicostatum* Imlay																		X																												
P.? sp.																			X																									X		
Amoeboceras (*Amoebites*) *dubium* (Hyatt)																								X																						
Grossouvria colfaxi (Gabb)									X																																					
Perisphinctes? sp.															X																															
Perisphinctes (*Discosphinctes*) *virgulatiformis* Hyatt																																	X													
(*Dichotomosphinctes*) *mühlbachi* Hyatt											X																																			
cf. *P. mühlbachi* Hyatt																																	X												X	
cf. *P. elisabethaeformis* Burckhardt							X																																							
(*Dichotomosphinctes*?) spp.												X											X			X																				
Idoceras cf. *I. planula* (Heyl) *in* Zeiten																X																														
Idoceras? sp.																																			X											
Subdichotomoceras? aff. *S. filiplex* (Quenstedt)																									X		X												X							
Peltoceras (*Metapeltoceras*?) sp.																				X																										
"*Belemnites*" *pacificus* Gabb												X	X	X											X		X						X										X			
"*Belemnites*" sp.		X	X	X	X																							X																		
Turbo? sp.																																	X													
Cerithium? sp.																																	X													
Gastropods undet.					X			X																				X		X		X														
Pinna sp.			X																																											
Modiolus sp.					X																																									
Mytilus sp.																														X																
Avicula? sp.																																	X													
Meleagrinella sp.	X	X	X		X																																									
Meleagrinella? sp.																																X														
Buchia concentrica (Sowerby)													X	X							X			X	X		X						X	X		X		X	X	X	X	X		X		X
cf. *B. concentrica* (Sowerby)					X																																X									
Chlamys? sp.					X																																									
Entolium? *aurarium* (Meek)																									X																					X
sp.																					X																									
Lima sp.					X																																									
Lima? sp.																													X								X	X								
Ostrea sp.					X	X																																								
Trigonia sp.	X		X		X																											X														
Tancredia? sp.																								X																						
Corbis? sp.								X																																						
Rhynchonellid brachiopod								X																																						
Echinoid fragments																															X															

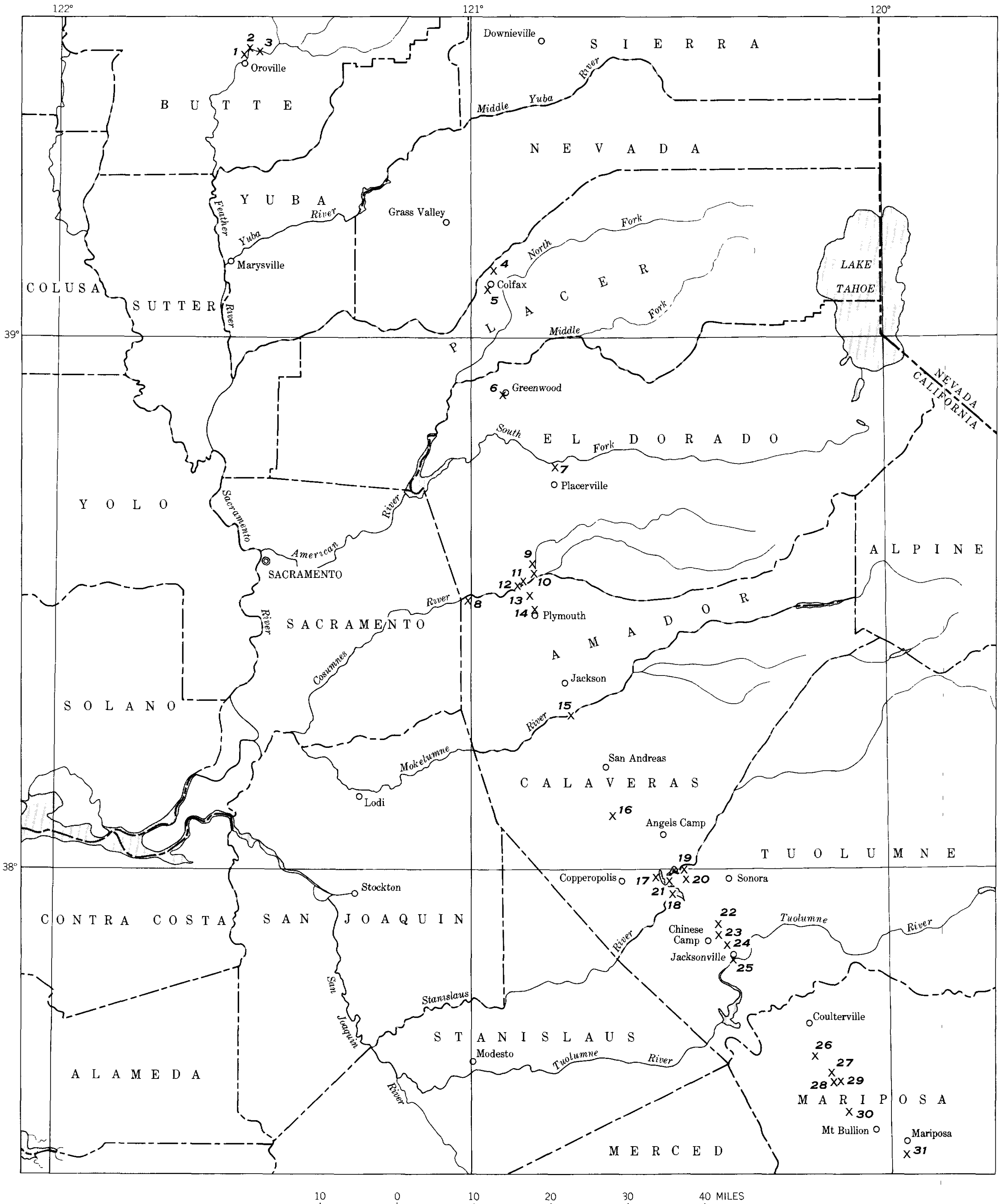

FIGURE 3.—Index map of Jurassic localities in the western Sierra Nevada, Calif.

TABLE 3.—*Descriptions of the Late Jurassic fossil localities in the western Sierra Nevada, Calif.*

Locality on fig. 3	Geological Survey Mesozoic localities	Collector's field Nos.	Localities of other institutions	Collector, year of collection, description of locality, and stratigraphic assignment
1	16625			V. T. Allen, 1927. From hydraulic mine north of Oroville and about 3 miles southwest of fossil locality near Banner Mine, Oroville quad., Butte County, Monte de Oro formation.
2	3990	5-1		James Storrs, 1906. North bank of Feather River a quarter of a mile below mouth of Morris Ravine and 3 miles above Oroville, SE. cor. sec. 32, T. 20 N., R. 4 E., Oroville quad., Butte County, Monte de Oro formation.
3	3991	5-2		James Storrs, 1906. North bank of Feather River, about 4 miles above Oroville, at mouth of ravine west of Banner Mine, probably NW. cor. sec. 3, T. 19 N., R. 4 E., Oroville quad., Butte County, Monte de Oro formation.
3	3992	5-3		James Storrs, 1906. Along stage road a quarter of a mile southwest of Banner mine, probably east central part of sec. 33, T. 20 N., R. 4 E., Oroville quad., Butte County, Monte de Oro formation.
3	4801	5-17		James Storrs, 1907. Western part of the plant-bearing beds and north side of the Feather River from 3-4 miles above Oroville, probably SE¼ sec. 33, T. 20 N., R. 4 E., Oroville quad., Butte County, Monte de Oro formation.
3	4802	5-16		James Storrs, 1907. Near eastern part of plant beds on north side of the Feather River from 3-4 miles above Oroville, probably SE¼ sec. 33, T. 20 N., R. 4 E., Oroville quad., Butte County, Monte de Oro formation.
3			Stanford Univ. Mus. Paleontology 9063.	R. S. Creely, 1956. From north bank of Feather River just north of Sycamore Hill, about 3 miles northeast of Oroville, 450 ft south of NE. cor. sec. 4 near its east edge in T. 19 N., R. 4 E., Oroville quad., Butte County, Monte de Oro formation.
4	27313	LC-53-282		L. D. Clark, 1953. Road cut on west side of U.S. Highway 40, 0.1 mile north of Midget Auto Court and 0.85 mile northeast of road turnoff to Grass Valley, NW¼ sec. 26, T. 15 N., R. 9 E., Colfax quad., Placer County, Colfax formation of J. P. Smith.
5			MCZ-5287 Harvard	J. D. Whitney. "From railroad cut at station 2777, sec. 53, 1 mile west of Colfax, 14 ft below surface of ground." Colfax quad., Placer County, Colfax formation of J. P. Smith.
5	27516			Collector and year unknown. Half a mile south of Colfax and a quarter of a mile west of railroad station, Colfax quad., Placer County, Colfax formation of J. P. Smith.
6	27517			Collector and year unknown. Near Greenwood, Georgetown quad., Eldorado County, "Mariposa" formation.
7	490			G. W. Kimble and H. W. Turner, probably 1884. Slates Big Canyon about 2 miles north of Placerville, SW¼ sec. 36, T. 11 N., R. 11 E., Georgetown quad., Eldorado County, "Mariposa" formation.
8	25638	LC-55-30		L. D. Clark and N. K. Huber, 1955. South bank of Cosumnes River 0.1 mile east of the Michigan Bar bridge in the SE¼ sec. 36, T. 8 N., R. 8 E., Folsom quad., Sacramento County, "Mariposa" formation.
8	27318		Stanford Univ. Mus. Paleontology 9065.	R. W. Imlay, 1958, same as Mesozoic loc. 25638.
9				J. C. Heald. Nashville, Placerville quad., Eldorado County, probably from Logtown Ridge formation.
10			Univ. Calif. Berkeley A-4996.	Collector and year unknown. From metamorphosed andesitic tuff. "Presumably from a building stone quarry near the Huse bridge over the Cosumnes River about 6 miles north of Plymouth." Placerville quad., either southern Eldorado County, or northern Amador County, Logtown Ridge formation, near top.
11	24710	LC-53-283		L. D. Clark and E. H. Pampeyan, 1953. North bank of Cosumnes River, 4,550 ft S. 55° W. of Huse bridge, at point where river bends sharply southward for half a mile, south central part of sec. 15, T. 8 N., R. 10 E., Fiddletown 7½-min quad. Eldorado County, Logtown Ridge formation, about 600-675 ft above base.

TABLE 3.—*Descriptions of the Late Jurassic fossil localities in the western Sierra Nevada, Calif.*—Continued

Locality on fig. 3	Geological Survey Mesozoic localities	Collector's field Nos.	Localities of other institutions	Collector, year of collection, description of locality, and stratigraphic assignment
11	27317	I-58-9-28A		R. W. Imlay, 1958. Fossils obtained 100–300 ft above Cosumnes River at same place as Mesozoic loc. 24710 in thin-bedded tuffs from 600–640 ft above base of Logtown Ridge formation.
12	22175			J. H. Eric and A. A. Stromquist, 1949. About 600 ft west of base of Logtown Ridge formation on right bank of Cosumnes River about 2 miles below the Huse Bridge and 1,850 ft east of west edge of Fiddletown 7½ min quad., lat 38°31′50″ N., long 120°51′00″ W., NW¼ sec. 22, T. 8 N., R. 10 E., Eldorado County, Consumnes formation, upper part, about 500 ft below top.
13			Stanford Univ. Mus. Paleontology 9062.	F. M. N. Hamilton, 1914. Big Indian Creek, southwest corner of Placerville 30-min quad., Amador County. Probably from Logtown Ridge formation.
14	18937	Heyl 1		G. R. Heyl, 1944. Small gulley three-fourths of a mile NNW of Plymouth, Sutter Creek 15-min quad., Amador County "Mariposa" formation.
15	27387			Collector and year of collection unknown. Mokolumne River downstream from Middle Bar Bridge, T. 5 N., R. 11 E., Sutter Creek quad., Amador or Calaveras County, formation unknown.
16	24317	LC-52-260		L. D. Clark and D. B. Tatlock, 1952. Cherokee Creek, sec. 22, T. 3 N., R. 12 E., San Andreas quad., Calaveras County loose boulder in stream bed along a major fault zone. "Mariposa" formation.
17	719			G. F. Becker, probably 1890. Texas Ranch, in valley of Angels Creek near north edge of sec. 28 or 29, T. 2 N., R. 13 E., Copperopolis quad., Calaveras County, Mariposa formation.
17	904			Cooper Curtice, 1891. Six miles from Copperopolis on road to Sonora and on grade to Angels Creek near center of sec. 33, T. 2 N., R. 13 E., Copperopolis quad., Calaveras County, Mariposa formation.
17	27566			Cooper Curtice, probably 1891. Wagon road 2 miles west of Reynolds Ferry and 1 mile west of Motherlode, Copperopolis quad., Calaveras County, Calif., Mariposa formation.
18	903			Cooper Curtice, 1891. West bank of Stanislaus River opposite mouth of Bear Creek near center sec. 11, T. 1 N., R. 13 E., Copperopolis quad., Calaveras County, Mariposa formation, about 1,000 ft above base.
19	27395	292		A. A. Stromquist, 1940–50. About 0.7 mile north of Mormon Creek and 0.5 mile east of Stanislaus River in NE¼SE¼ sec. 25, T. 2 N., R. 13 E., Sonora quad., Tuolumne County, Mariposa(?) formation.
19	27396	293		A. A. Stromquist, 1940–50. Soldiers Gulch north of Mormon Creek, SE¼NE¼ sec. 25, T. 2 N., R. 13 E., Sonora quad., Tuolumne County, Mariposa(?) formation.
20	27315			A. A. Stromquist, 1940–50. Mormon Creek, probably near east boundary of sec. 36, T. 2 N., R. 13 E., Sonora 15-min quad., Tuolumne County, Mariposa formation.
20	27394	263		A. A. Stromquist, 1940–50. About 0.4 mile south of Mormon Creek in SW¼SW¼ sec. 31, T. 2 N., R. 14 E. Sonora 15-min quad., Tuolumne County, Mariposa formation.
20	27397	294		A. A. Stromquist, 1940–50. On fault cutting metavolcanic rock north of Mormon Creek, SE¼SW¼ sec. 30, T. 2 N., R. 14 E., Sonora 15-min quad., Tuolumne County, Mariposa(?) formation.
21	901			Cooper Curtice, 1891. On trail opposite Bosticks Bar near Reynold's Ferry across the Stanislaus River, SE¼ sec. 34, T. 2 N., R. 13 E., Copperoplois quad., Tuolumne County, Mariposa formation.
21	27568	LC-59-101		L. D. Clark, D. L. Jones, and N. J. Silberling, 1959. From placer sluiceway trench on north bank of Stanislaus River about 15 ft above low-water mark of Melones Reservoir in the NW¼NW¼ sec. 3, T. 1 N., R. 13 E., Copperopolis quad., Tuolumne County, Calif., Mariposa formation, about 1,000 feet above base.

TABLE 3.—*Descriptions of the Late Jurassic fossil localities in the western Sierra Nevada, Calif.*—Continued

Locality on fig. 3	Geological Survey Mesozoic localities	Collector's field Nos.	Localities of other institutions	Collector, year of collection, description of locality, and stratigraphic assignment
22			Stanford Univ. Mus. Paleontology 9064.	Vander Hoof. From Wood Canyon(?) near Sonora, Sonora quad., Tuolumne County, Mariposa formation.
23	20554	Heyl 255		George Heyl, 1947. Woods Creek Canyon, 3 miles northwest of Jacksonville, sec. 2 or 3, T. 1 S., R. 14 E., Sonora 15-min quad., Tuolumne County, Mariposa formation.
23	27459			G. F. Becker, probably 1884. Woods Creek, northwest of Jacksonville, Sonora 15-min quad., Tuolumne County, Mariposa formation.
24	27398	183		G. R. Heyl, 1946. Crest of Woods Creek Ridge 1 mile northwest of Jacksonville, sec. 12, T. 1 S., R. 14 E., Sonora 15-min quad., Tuolumne County, Mariposa formation, 2,000–3,000 ft above base.
25	902			Cooper Curtice, 1891. South bank of Tuolumne River at Moffat Bridge, SW. cor. sec. 18, T. 1 S., R. 15 E., Sonora quad., Tuolumne County, Mariposa formation.
25	27311	LC–53–42A		L. D. Clark and R. Pack, 1953. Moffat Bridge site near Jacksonville. Railroad cut on south side of Tuolumne River, 200–225 ft east of contact between Mariposa formation and mafic volcanic breccia. SW. cor. sec. 18, T. 1 S., R. 15 E., Sonora 15-min quad., Tuolumne County, Mariposa formation, 200 ft above base.
26	27312	LC–53–280		L. D. Clark, 1953. North bank of Merced River, NW. cor. sec. 26, T. 3 S., R. 16 E., Coulterville quad., Mariposa County, Mariposa formation, about 1,000 ft above base.
27	253			H. W. Turner, G. F. Becker, and C. A. White, 1884. Left bank of Merced River a quarter of a mile below Bagby (formerly called Bentons Mills), sec. 6?, T. 4 S., R. 17 E., Coulterville 15-min quad., Mariposa County, Mariposa formation.
28	1982			H. W. Turner, 1892. Hell Hollow, north of Bear Valley in northwest part of T. 4 S., R. 17 E., Coulterville quad., Mariposa County, Mariposa formation.
29	243			H. W. Turner, 1884. Mariposa estate near Pine Tree Mines, about half a mile east of head of Hell Hollow, T. 4 S., R. 17 E., lat 37°36′ N., long 120°07′ W., Coulterville quad., Mariposa County, Mariposa formation, probably 3,000–4,000 ft above base.
30	27460			W. D. McLearn, received at Natl. Mus. May 3, 1922. Bullion Mountain. Coulterville quad., Mariposa County, Mariposa formation.
31	1983			James Storrs, 1895. Five miles southeast of Princeton (Bullion Mountain post office), probably Mariposa quad., Mariposa County, Mariposa formation.

indicate that its lower part locally is of approximately the same age as the upper part of the Logtown Ridge formation on the Cosumnes River where a specimen of *Idoceras* was obtained.

8. The Monte de Oro formation is of late Oxfordian to early Kimmeridgian age. The evidence consists of 1 ammonite similar to *Perisphinctes* (*Dichotomosphinctes*) *elisabethaeformis* (Burckhardt) from the late Oxfordian of Mexico and of 2 crushed specimens of *Buchia* that probably belong to *Buchia concentrica* (Sowerby).
9. The affinities of the Callovian ammonites in the western part of the Sierra Nevada are mainly with those of British Columbia and Alaska as indicated by the presence of such ammonites as *Cadoceras*, *Paracadoceras*, *Pseudocadoceras*, *Kepplerites*, and *Gowericeras*. Ammonites in common with both Alaska and southern Mexico include *Reineckeia*, *Choffatia*, and *Xenocephalites*. *Peltoceras* occurs in common with Mexico but not with Alaska. In Alaska, however, late Callovian beds that might contain *Peltoceras* have never been found and in the Cook Inlet region, the late Callovian is represented by an unconformity.
10. The affinities of the late Oxfordian ammonites from California are mostly with Mexico and Cuba, but astonishingly one of the ammonites, *Perisphinctes* (*Dichotomosphinctes*) *mühlbachi* Hyatt is essentially identical both with *P. durangensis* Burckhardt from Mexico and with a specimen from the Alaska Peninsula.
11. Among the early Kimmeridgian ammonites from California, the presence of *Amoeboceras* in-

dicates affinities with Alaska and the Boreal region. The ammonite *Subdichotomoceras* has not been found in Alaska but has been found in Mexico and in many other parts of the world.

12. The ammonite faunas that existed in California from early Callovian to early Kimmeridgian times appear to have had free marine connections northward to Alaska and southward to southern Mexico, but during Callovian time the Alaskan influence was dominant.

SYSTEMATIC DESCRIPTIONS

Class CEPHALOPODA
Genus PHYLLOCERAS Suess, 1865

Phylloceras sp.

The genus is represented by fragmentary external and internal molds of a single specimen that has been crushed laterally. The external mold shows that the species has a very small umbilicus and very fine dense flexuous ribs that are grouped in low broad folds on the lower part of the flanks. There is no trace of sigmoidal constrictions.

The folds on the lower part of the flanks appear to be much less pronounced than in a species of *Phylloceras* from the Galice formation of southwestern Oregon (USGS Mesozoic locs. 3322, 3335) or from the Naknek formation of Alaska, but the poor preservation of the specimens makes specific identification impossible.

Nonfigured specimen: USNM 130784.
Occurrence: "Mariposa" formation at USGS Mesozoic loc. 27318.

Genus TARAMELLICERAS Del Campana, 1904
Subgenus PROSCAPHITES Rollier, 1909

Taramelliceras? (Proscaphites?) denticulatum (Hyatt)

Plate 1, figures 9–11

Oecotraustes denticulata Hyatt, 1894, Geol. Soc. America Bull., v. 5, p. 427.
"Oecotraustes" denticulata Hyatt. Crickmay, 1933a, U.S. Geol. Survey Prof. Paper 175–B, p. 58, pl. 17, figs. 11–13.

This species is characterized by a compressed shell, a narrow venter, a very narrow umbilicus, a row of midventral serrations, and by weak gently flexuous ribs that become stronger ventrally on the flanks but weaken on the venter and do not extend to the median ventral serrations.

The suture line is poorly exposed. It has been described and illustrated adequately by Crickmay (1933a, pl. 17, figs. 12, 13).

This species was compared by Hyatt with *Ammonites lochensis* Oppel (1863, p. 207, pl. 54, figs. 1a–d) from the late Oxfordian of Germany. It appears to be similar in most respects, but has somewhat sparser ribbing. It also shows some resemblance to *Ammonites pichleri* Oppel (1863, p. 212, pl. 51, figs. 4a–c). That species differs by having fine ribs and many intercalated ribs of which all extend to the midventral serrations (Jeannet, 1951, pl. 29, figs. 7a, b; pl. 30, figs. 2a, b). These species from Europe have been placed by Jeannet (1951, p. 95, 96) in a new genus *Richeiceras*, which Arkell (1957, p. L281) considers to be a synonym of *Proscaphites*, a subgenus of *Taramelliceras*.

Similar appearing species of *Taramelliceras* from the late Oxfordian of Mexico (Burckhardt, 1912, p. 12–14, pl. 2, figs. 5–12) all have somewhat finer ribbing than the California species. Interestingly the Mexican species are associated with species of *Discosphinctes* and *Dichotomosphinctes* similar to those associated with *Taramelliceras*? *denticulatum* (Hyatt).

Types: Cotypes USNM 30206.
Occurrence: Mariposa formation at USGS Mesozoic loc. 901.

Genus KEPPLERITES Neumayr and Uhlig, 1892

Kepplerites lorinclarki Imlay, n. sp.

Plate 1, figures 1–8

Twelve fragmentary molds represent a species that is characterized by being fairly small and by having unusually prominent ribbing for the genus. It has stout ovate whorls and evenly rounded flanks. Its venter is poorly exposed but is probably evenly rounded. The umbilicus is fairly narrow on the inner whorls but widens considerably on the body whorl. The body chamber is represented by about half a whorl. The aperture is marked on the internal mold by a broad forwardly inclined constriction that is nearly smooth. The external mold shows that the aperture is marked by an abrupt constriction that is followed by a flattened area bearing weak riblets.

The ribs on the body whorl are high, triangular in section, and sharp topped. They trend backward on the umbilical wall and curve forward strongly on the flanks. The primary ribs are thicker and higher than the secondary ribs and terminate at about one-third of the height of the flanks in prominent tubercles. From the tubercles pass pairs of secondary ribs that are separated from adjoining pairs by single ribs that begin at or above the zone of furcation. The nearly complete whorl shown on plate 1, figure 7, has about 23 primary ribs. The suture line cannot be traced.

This species has sharper, sparser, and coarser ribbing than any species of *Kepplerites* at a comparable size that has been described from North America. It shows a little resemblance to *Kepplerites* (*Seymourites*) *kuzuryuensis* Kobayashi (1947, p. 29, pl. 7, fig. 3) from Japan, but that species has much finer ribbing, more secondary ribs, and attains a much larger size. Among European species it shows considerable resemblance in ribbing, whorl shape, and coiling to the inner whorls of *Kepplerites keppleri* (Oppel) as figured by Buckman (1922, pl. 289a, b) and somewhat less resemblance to *K. cereale* (Buckman) (1922, pl. 286; Arkell, 1954, fig. 42 on p. 118). It differs from these species by having fewer secondary ribs, by having prominent ribs and tubercles on its body chamber, and by its much smaller size. This species is named in honor of Lorin Clark of the Geological Survey who collected the type specimens.

Types: Holotype USNM 130777; paratypes USNM 130778.

Occurrence: Colfax formation of Smith at USGS Mesozoic loc. 27313.

Subgenus GOWERICERAS Buckman, 1921

Kepplerites (Gowericeras) lindgreni (Hyatt)

Plate 1, figures 12, 14

Olcostephanus lindgreni Hyatt, 1894, Geol. Soc. America Bull., v. 5, p. 427.

"Galilaeiceras" lindgreni (Hyatt). Crickmay, 1933a, U.S. Geol. Survey Prof. Paper 175-B, p. 57, pl. 17, figs. 9, 10.

This species is known only from one specimen that has been somewhat elongated and crushed. Allowing for deformation, the whorl appears to be ovate in section and probably higher than wide. The flanks and venter are evenly rounded. The coiling is evolute, the umbilicus fairly wide, and the outer whorl does not retract appreciably from the remainder of the shell. The body chamber includes at least half a whorl.

The ribs curve backward on the umbilical wall, curve forward on the flanks, and apparently cross the venter transversely. The primary ribs are sharp and moderately spaced. At about two-fifths of the height of the flanks they pass into fascicles of weaker secondary ribs that outnumber the primary ribs 4 or 5 to 1. Most of the furcation prints are swollen and were probably originally tuberculate. Some of the secondary ribs appear to rise freely near the middle of the flanks. The suture line cannot be traced accurately. Details of the dimensions have been published by Crickmay (1933a, p. 57).

"Olcostephanus" lindgreni Hyatt was considered by Crickmay (1933a, p. 57) to be close to *Galilaeiceras* Buckman (1922, pls. 290, 291), which Arkell (1957, p. L298) regards as a synonym of *Gowericeras* in the family Kosmoceratidae. This general assignment seems reasonable as the species bears many resemblances to *Gowericeras costidensum* Imlay from the western interior region (Imlay, 1953a, p. 31, pl. 22, figs. 10-13) and to *Gowericeras snugharborensis* Imlay from Alaska (Imlay, 1953b, p. 99, pl. 53, fig. 9). It shows even closer resemblances to a specimen of *Gowericeras* from the Talkeetna Mountains (see pl. 1, fig. 13), and is possibly identical specifically. Specific identification will be difficult, however, until other specimens of *O. lindgreni* Hyatt are found in California that show the characteristics of the species better than the holotype.

"Olcostephanus" lindgreni Hyatt was identified as *Kepplerites* (*Gowericeras*? or *Seymourites*)(?) *lindgreni* Hyatt by Arkell (1956, p. 554) who said the species seems "to be much like *Seymourites* figured from Canada by McLearn (1929, pls. 1-8)."

The writer considers, however, that *"Olcostephanus" lindgreni* Hyatt has more evolute coiling and a wider umbilicus than any of the species of *Seymourites* including *Yakounoceras* and *Yakounites*) described by McLearn and that it greatly resembles certain species from Alaska and the western interior region described under the generic name *Gowericeras* in the sense used by Spath (1932, p. 81, 94). In this sense *Gowericeras* Buckman (1921, p. 54, pl. 254; 1922, pls. 287, 288, 404) includes *Galilaeiceras* Buckman (1922, pls. 290, 291), *Galileanus* Buckman (1922, pl. 293, and *Galilaeites* Buckman (1922, pl. 309).

Recently Arkell (1957, p. L289) placed *Gowericeras* in synonymy with *Kepplerites* without explanation and this assignment apparently is supported by Callomon (1955, p. 235). Nevertheless, the group of species that have been included under *Gowericeras* as defined by Spath differ from typical *Kepplerites* and its subgenus *Seymourites* by having more evolute coiling and by the body chamber not retracting appreciably from the septate whorls. In addition it differs from typical *Kepplerites* by earlier loss of ventral flattening and by the persistence of tubercles on the flanks of the body chamber. In conformity with the scaled-down classification used by Arkell (1940, p. LXVI; 1950, p. 354, 355), *Gowericeras* probably would rank as a subgenus under *Kepplerites* at least as different from typical *Kepplerites* as the subgenus *Seymourites*.

A number of features by which the European species of *Gowericeras* may differ from the American species assigned to that genus have been mentioned by Donovan (1953, p. 132; 1957, p. 135). These include bituberculate primary ribs, strongly curved primary ribs, an abrupt backward bend of the secondary ribs near their junction with the primary ribs, and the presence of a tabulate venter on the inner whorls. An examination of various illustrations of European species of *Gowericeras* suggests, however, that these are not constant features on all the species and are, therefore, probably not of generic or subgeneric importance (compare J. de C. Sowerby, 1827, pl. 549; Buckman, 1921, pl. 254; 1922, pls. 288, 290, 291, 293, 294, 309; 1923, pl. 404; Corroy, 1932, pl. 24, figs. 3, 4; Douville, 1915, p. 29, pl. 8, figs. 1, 4, pl. 9, figs. 1, 5). Even a flattened venter on the inner whorls is not known to be present in all European species that have been assigned to *Gowericeras*.

Similarly in all the species of *Gowericeras* from Alaska and in most of those from the western interior of the United States, the characteristics of the inner whorls are unknown. Some of the species may have tabulate venters on their inner whorls as do some of the European species. As far as the outer whorls are concerned the assignment of certain species from North America to *Gowericeras* seems reasonable and has been confirmed by Arkell (1956, p. 550).

Types: Holotype USNM 30205.

Occurrence: USGS Mesozoic loc. 27516 from the Colfax formation of Smith half a mile south of Colfax and a quarter of a mile west of the railroad, Placer County, Calif.

Genus PSEUDOCADOCERAS Buckman, 1918

Pseudocadoceras grewingki (Pompeckj)

Plate 2, figures 1–8, 11–13

For synonomy see Imlay, 1953b, U.S. Geol. Survey Prof. Paper 249–B, p. 93.

Nearly 80 molds of *Pseudocadoceras* have been collected from thin beds of tuff in the lower part of the Logtown Ridge formation on the north bank of the Cosumnes River. Most of these are from a stratigraphic interval of about 40 feet, but one of the largest specimens (see pl. 2, fig. 7) was obtained about 75 feet above the others. Most of the specimens are so crushed and deformed that they cannot be identified specifically, but at least 12 specimens may be identified on the basis of ornamentation and coiling with *P. grewingki* (Pompeckj) from Alaska (Imlay, 1953b, p. 93, pl. 49, figs. 1–12). (See pl. 2, figs. 11–13.)

This species is characterized by its narrowly rounded venter, fairly wide umbilicus, and strong sharp ribs that coarsen anteriorly and incline forward on the venter. Bifurcation occurs fairly regularly a little below the middle of the flanks, but on the body whorl the branches tend to be loosely united with the primary ribs. Some ribs remain unbranched.

Pseudocadoceras grewingki (Pompeckj) in Alaska is much more common than the other species of the genus and has a longer range. It ranges through most of the upper two-thirds of the Chinitna formation (Imlay 1953b, table 2 on p. 50) and through the middle part of the Shelikof formation. In the upper part of its range it is associated locally with other species of *Pseudocadoceras* of which 2 have much finer and denser ribbing and 1, *P. crassicostatum* Imlay (1953b, p. 94, pl. 49, figs. 19, 20, 22–24), has coarser and sparser ribbing. The beds containing *P. grewingki* (Pompeckj) in Alaska are correlated with the European zones of *Erymnoceras coronatum, Cosmoceras jason,* and the upper part of the *Sigaloceras calloviense* zone. (Imlay, 1953b, p. 53).

Types: Plesiotypes USNM 130779, 130781.

Occurrence: Logtown Ridge formation at USGS Mesozoic locs. 24710 and 27317.

Pseudocadoceras cf. P. grewingki (Pompeckj)

Plate 2, figure 22

Five crushed ammonite fragments from the Mokulumne River show all the characteristics of the genus *Pseudocadoceras*. In particular the largest and least crushed fragment, herein illustrated, greatly resembles the adult body chamber of *P. grewingki* (Pompeckj). It bears sharp fairly widely spaced primary ribs that bifurcate a little below the middle of the flanks. The secondary ribs are sharp, a little broader than the primary ribs, and arch forward on the venter.

Figured speciemen: USNM 130783.

Occurrence: From unknown stratigraphic position at USGS Mesozoic loc. 27387.

Pseudocadoceras cf. P. crassicostatum Imlay

Plate 2, figures 14–21

Associated with *Pseudocadoceras grewingki* (Pompeckj in the basal part of the Logtown Ridge formation on the Cosumnes River are 15 specimens of the genus that have much coarser and more widely spaced ribbing and probably belong to *P. crassicostatum* Imlay (1953b, p. 94, pl. 49, figs. 19, 20, 22–24) from Alaska (See pl. 2, figs. 9, 10). The specimens are so deformed and fragmentary, however, that the identification is not positive. They could be a coarse variant of *P. grewingki* (Pompeckj).

Figured specimen: USNM 130780.

Occurrence: Logtown Ridge formation, lower part, at USGS Mesozoic loc. 27317.

Pseudocadoceras? sp.

Plate 2, figure 23

One ammonite from the upper part of the Cosumnes formation on the Cosumnes River probably belongs to *Pseudocadoceras* although it is too corroded for positive identification. It has moderately evolute coiling and strong closely spaced primary ribs most of which bifurcate at or below the middle of the flanks. At one place the secondary ribs curve backward on the upper part of the flanks, but at other places they curve forward. Because of this backward curvature the ammonite was once compared by Imlay (1952, p. 975) with the perisphinctid genus *Grossouvria* of Callovian age. However, its coiling is not nearly evolute enough for it to belong to *Grossouvria* and it does resemble the genus *Pseudocadoceras* in both coiling and rib pattern.

The local backward curvature of the secondary ribs on the flanks could be a result of deformation.

This ammonite is significant because it is the only ammonite known from the upper part of the type section of the Cosumnes formation and is the only evidence that that part is of Callovian age.

Figured specimen: USNM 130782.
Occurrence: Cosumnes formation, upper part, at USGS Mesozoic loc. 22175.

Genus AMOEBOCERAS Hyatt, 1900
Subgenus AMOEBITES Buckman, 1925

Amoeboceras (Amoebites) dubium (Hyatt)

Plate 2, figures 24–28

Cardioceras dubium Hyatt, 1894; Geol. Soc. America Bull., v. 5, p. 420–422.
?*Cardioceras whitneyi* Smith, 1894, Geol. Soc. America Bull., v. 5, p. 253, 254.
Amoeboceras dubium (Hyatt). Reeside, 1919, U.S. Geol. Survey Prof. Paper 118, p. 38, pl. 24, figs. 5–8.
(Hyatt). Crickmay, 1933a, U.S. Geol. Survey Prof. Paper 175–B, p. 56.
Amoeboceras (*Amoebites*) *dubium* (Hyatt). Spath, 1935, Meddelelser om Grönland, v. 99, no. 2, p. 34.
Amoeboceras dubius (Hyatt). Hanna and Hertlein, 1941, California Dept. Nat. Res., Div. Mines Bull. 118, pt. 2, p. 166, fig. 60(23).

The original type lot contains 15 molds of which all have been crushed laterally. The species is characterized by fairly straight sharp mostly simple moderately to widely spaced ribs that incline slightly forward on the flanks and terminate on the ventrolateral margin in prominent clavate tubercules. On several specimens two adjoining ribs terminate in a single tubercle. A few ribs fade out on the upper part of the flanks below the zone of tubercles. The tubercles curve strongly forward and terminate at shallow grooves. The midline of the venter bears a stout low serrated keel whose serrations outnumber the tubercles nearly 2 to 1.

This species was referred to *Amoebites* by Spath (1935, p. 34) because some of its ribs disappeared on the flanks below the tubercles. He compared three specimens from Greenland (see Spath, 1935, pl. 3, fig. 1, pl. 5, figs. 1, 6) with both *A. dubium* (Hyatt) and *A.* (*Amoebites*) *elegans* Spath (1935, p. 33, pl. 4, figs. 1–3) and noted that the holotype of *A. elegans* Spath differs from *A. dubium* (Hyatt) by having denser more regularly spaced ribbing near the umbilicus. It appears, also, that *A. dubium* (Hyatt) may be distinguished by having fewer secondary ribs and by developing stronger tubercles on the larger whorls.

Types: cotypes USNM 30201.
Occurrence: Mariposa formation at USGS Mesozoic loc. 719.

Genus GROSSOUVRIA Sieminadzki, 1898

Grossouvria colfaxi (Gabb)

Plate 2, figure 29; plate 3, figures 13–17

Ammonites colfaxi Gabb, 1869, Am. Jour. Conch., v. 5, pt. 1, p. 7, 8, pl. 4, fig. 2 [and v. 4, pl. 16].
Perisphinctes colfaxi (Gabb). Hyatt, 1894, Geol. Soc. America Bull., v. 5, p. 424, 425.

The species is represented by a nearly complete internal mold and by part of an external mold of a single specimen. Both molds have been stretched considerably, but before stretching the whorls were probably nearly circular in section. The coiling is evolute and the whorls embrace each other about one-fifth. The umbilicus is very wide and shallow. The body chamber is represented by slightly more than half a whorl and is probably nearly complete. Its adoral end is slightly flexuous and is curved forward near the middle of the flank, but is not sufficiently well preserved to show if the specimen had a lateral lappet.

The ornamentation on the inner whorls consists of variably strong variably spaced forwardly inclined ribs and constrictions. On the adoral half of the penultimate whorl the ribs are alternately single and forked. On the earlier formed whorls single ribs outnumber forked ribs. Most of the forked ribs are coarser and higher than single ribs. Bifurcation of the ribs occurs at various heights below the middle of the flanks.

The ornamentation of the body whorl is similar to that on the penultimate whorl, but single ribs become more common toward the aperture. Bifurcation occurs at various heights, but mostly below the middle of the flanks. The bifurcation points are particularly prominent but probably were not tuberculate. The ribs on the internal mold are high and sharp. On the external mold they are high and round. Most ribs are curved backward on the upper part of the flanks and on the venter and appear to weaken somewhat on the venter. On the body chamber some of the secondary ribs arise freely high on the flanks and others are indistinctly connected with primary ribs.

Parts of a simple suture line are preserved near the adoral end of the last septate whorl. The ventral lobe is not exposed. The first lateral lobe is slender and trifid. The second lateral lobe is much shorter than the first. The auxilliaries are weakly developed and are somewhat distorted owing to deformation.

This species is assigned to *Grossouvria* because of the highly irregular and variable ribbing on its inner whorls, the presence of many constrictions and single ribs, the backward curvature of the secondary ribs on the body whorl, its rounded whorl section, and the characteristics of the suture line. Except for the irregular ornamentation on the inner whorls, the presence of many deep constrictions, and its round whorl section, it could be assigned to *Siemeradzkia*. Arkell (1957, p. L 319; 1958, p. 212) notes, however, that the Bathonian *Siemeradzkia* is replaced by the Callovian *Grossouvria* and that the two are difficult to separate generically "except on stratigraphic grounds."

Grossouvria colfaxi (Gabb) differs from most species of *Grossouvria* and *Siemeradzkia* by having stronger ribbing and by attaining a larger size. *G. anomala* (Loczy) (1915, p. 386, pl. 8, figs. 8–11, pl. 14, fig. 5; Neumayr, 1871, pl. 12, figs. 2a, b; Spath, 1931, p. 364, pl. 60, fig. 8) is probably the most similar but has somewhat weaker ribbing. *G. pseudocobra* Spath (1931, p. 371, pl. 48, figs. 7a, b) has finer ribbing on its inner whorls. *G. leptus* Gemmellaro figured by Corroy (1932, pl. 23, figs. 1, 2) is as large as *G. colfaxi* (Gabb), but has more secondary ribs and fewer unbranched ribs. *Siemeradzkia de-mariae* Parona and Bonarelli (1895, p. 147; Neumayr, 1871, pl. 12, figs. 4a, b, 5) is similar in size and appearance but is more involute, has fewer simple ribs, fewer constrictions, and the ribbing on its inner whorls is more regular.

Most species of *Choffatia* and *Subgrossouvria* differ from *G. colfaxi* (Gabb) by having more regular ribbing on their inner whorls, by developing more distant primary ribs on their outer whorls, and by not having backwardly curved secondary ribs. A possible exception is *Choffatia* (*Grossouvria*?) *aurita* Spath (1931, p. 362, pl. 40, figs. (6a, b) from India.

G. colfaxi (Gabb) shows some resemblance to the genus *Rursiceras* Buckman (1919, pl. 145), but its ribbing is more irregular in strength and spacing, single ribs are more common, and its secondary ribs do not curve backward on the venter nearly as strongly. It may be compared, also, to *Parapeltoceras annulosum* (Quenstedt) (1886–87, pl. 88, fig. 22; Jeannet, 1951, p. 164, pl. 75, figs. 3a, b) but is readily distinguished by its deep constrictions, by its variable ribbing, and by some of its ribs bifurcating low on the flanks.

Type: Holotype 5287, Mus. Comparative Zoology, Harvard College.

Occurrence: Colfax formation of Smith "From railroad cut at sta. 2777, sec. 53, 1 mile west of Colfax, 14 ft. below surface of ground," Placer County, Calif.

Genus PERISPHINCTES Waagen, 1869

Perisphinctes? sp.

Plate 5, figure 4

One small ammonite bears sharp, nearly straight primary ribs that incline forward on the flanks. Most of them bifurcate at or below the middle of the flanks into slightly weaker secondary ribs that cross the venter transversely. Several short ribs are intercalated on the upper part of the flanks. Two constrictions are present.

The preservation of this specimen does not permit positive generic or even family identification. It appears to be a perisphinctid ammonite, although its ribs branch lower than in most genera of the Perisphinctidae. Its rib pattern shows some resemblance to that in *Reineckeites* of the family Reineckeiidae, but the ventral ends of the primary ribs are not swollen or tuberculate.

Figured specimen: Stanford Univ. Mus. Paleontology 9065.

Occurrence: The label accompanying the specimen states "Mariposa formation, Nashville, Eldorado County." The lithologic features of the specimen suggest that it was obtained from the Logtown Ridge formation instead of from the Mariposa formation.

Subgenus DISCOSPHINCTES Dacque, 1914

Perisphinctes (Discosphinctes) virgulatiformis Hyatt

Plate 3, figures 1–10

Perisphinctes virgulatiformis Hyatt, 1894, Geol. Soc. America Bull., v. 5, p. 422, 423.

Virgatosphinctoides virgulatiformis (Hyatt). Crickmay, 1933a, U.S. Geol. Survey Prof. Paper 175–B, p. 56, 57, pl. 16, figs. 24–25, pl. 17, figs. 1–8.

?*Perisphinctes virgulatus* Quenstedt. Burckhardt, 1912, Inst. geol. Mexico Bol. no. 29, p. 35–38, pl. 7, figs. 4–14.

?*Perisphinctes* (*Planites*) *virgulatus* Quenstedt var. *carribeana* Jaworski, 1940. Neues Jahrb., Beilage-Band, Abt. B, p. 109–114, pl. 3, figs. 1–2, pl. 4, fig. 5, pl. 7, fig. 6.

?*Discosphinctes* cf. *D. virgulatus* (Quenstedt) of Burckhardt, Imlay, 1945, Jour. Paleontology, v. 19, p. 274, pl. 41, figs. 9–11.

?*Discosphinctes carribeanus* (Jaworski). Arkell, 1956, Jurassic Geology of the World, p. 573, London.

The shell is compressed, discoidal. The whorls are flattened, higher than wide, and embrace the preceding whorls considerably. The umbilicus is fairly narrow for a perisphinctid ammonite.

The ornamentation consists of narrow closely spaced forwardly inclined ribs and of weak forwardly inclined constrictions. The primary ribs curve backward on the umbilical margin and curve forward gently on the flanks. Many of them remain simple but many others bifurcate between the middle and the upper third of the flanks. Trifurcating ribs are present locally near constrictions. (See pl. 3, fig. 3.) The secondary ribs are not interrupted on the venter.

The suture line is similar to that of *Perisphinctes* (*Discosphinctes*) *carribeanus* (Jaworski) figured by Burckhardt (1912, pl. 7, fig. 8). The first lateral lobe is long and trifid. The second lateral lobe is much shorter. There are three small auxilliary lobes. The second lateral saddle is as high as the first.

This species is placed in the subgenus *Discosphinctes* Dacque as defined by Arkell (1937, p. XLVIII–XLIX) because of its high whorls, involute coiling, dense forwardly inclined ribs, and weak constrictions. It shows no tendency to develop bundles of ribs as in *Lithacoceras*. *Virgatosphinctoides*, which Arkell (1957, p. L 329) considers a synonym of *Subplanites*, has more evolute coiling and the primary ribs become coarse and widely spaced. *Dichotomosphinctes* has more evolute coiling, deeper constrictions, and nearly radially trending ribs of which most bifurcate regularly on the ventral margin.

Perisphinctes (*Discosphinctes*) *virgulatiformis* Hyatt appears to be identical with *P.* (*Discosphinctes*) *caribeanus* Jaworski (see pl. 3, figs. 11, 12) from the late Oxfordian of Cuba (Jaworski, 1940, p. 109, pl. 3, figs. 1, 2; pl. 4, fig. 5, pl. 7, fig. 6) and Mexico (Burckhardt, 1912, p. 35, pl. 7, figs. 4–14) as far as the fragmentary condition of the type specimens of the California species permits comparison. Until better preserved, or more complete specimens of *P. virgulatiformis* are found, the exact specific relationship cannot be determined.

Types: USNM 30204.

Occurrence: USGS Mesozoic loc. 901 from the Mariposa formation.

Subgenus DICHOTOMOSPHINCTES Buckman, 1926

Perisphinctes (Dichotomosphinctes) mühlbachi Hyatt

Plate 4, figure 8

Perisphinctes mühlbachi Hyatt, 1894, Geol. Soc. America Bull., v. 5, p. 426.

Dichotomoceras? mühlbachi (Hyatt). Crickmay, 1933a, U.S. Geol. Survey Prof. Paper 175–B, p. 57, pl. 18, figs. 1, 2.

?*Perisphinctes durangensis* Burckhardt, 1912, Inst. geol. Mexico Bol. 29, p. 16, pl. 3, figs. 1, 2, pl. 4, fig. 6.

The holotype, represented mostly by an external mold, is characterized by evolute coiling, by moderately spaced high narrow ribs that bifurcate above the line of involution, and by deep constrictions. The primary ribs curve backward at the edge of the umbilicus, and incline forward gently on the flanks. The secondary ribs, exposed at one place on the penultimate whorl where the suture line is preserved (see Crickmay, 1933, pl. 18, fig. 1), arise in pairs from the primary ribs and curve gently backward on the flanks. The dorsal ends of the secondary ribs are likewise exposed on part of the outermost whorl. Some of these arise in pairs from the primary ribs and others arise indistinctly from or alternate with the primary ribs. A few of these secondary ribs curve backward at their junction with the primary ribs.

One external mold of an ammonite (pl. 4, fig. 3) from the Stanislaus River opposite Bosticks bar (Mesozoic loc. 901) shows the ribbing typical of *Dichotomosphinctes* and matches very well with the inner whorls of *P.* (*Dichotomosphinctes*) *mühlbachi* (Hyatt) at a comparable size. The specimen was referred to *Perisphinctes* sp.? by Hyatt (1894, p. 423) who notes that

The whorl is broader at the same age than is any other species mentioned in this paper; there are consequently fewer whorls at the same age. The lateral costae are single and very long, the bifurcations occurring well up on the abdomen.

The immature growth stage of *P. mühlbachi* Hyatt is possibly represented also, by one small specimen (pl. 4, fig. 5) from Mount Boullion (Mes. loc. 27460). It bears ribs and constrictions a little coarser and sparser than those on the inner whorls of the holotype. The venter is somewhat worn, but is clearly marked by deep forwardly arched constrictions and by faint continuations of the flank ribs. Some of the primary ribs appear to bifurcate at the margin of the venter, but others appear to remain simple.

P. mühlbachi Hyatt was assigned by Crickmay (1933a, p. 57) tentatively to *Dichotomoceras* on the basis of its suture line. That genus as defined, however, does not have constrictions and its ribs generally bifurcate at or below the line of involution. Except for these features *P. mühlbachi* Hyatt greatly resembles the genotype of *Dichotomoceras* (Buckman, 1919, v. 3, pl. 139A). In shape and ornamentation *P. mühlbachi* Hyatt likewise greatly resembles *Orthosphinctes*, but it differs by having a higher point of rib branching and by lacking trichotomous ribs.

Considering all its features *P. mühlbachi* Hyatt shows more resemblances to *Dichotomosphinctes* than to the other genera mentioned and it greatly resembles several described species of *Dichotomosphinctes*. For example, *P. durangenis* Burckhardt (1912, p. 16, pl. 3, figs. 1, 2), from Durango, Mexico, is nearly identical in appearance. *P. plicatiloides* O'Connell from Cuba (O'Connell, 1920, p. 670, pl. 36, figs. 1, 2; Jaworski, 1940, pl. 4, fig. 4, pl. 5, figs. 5 a, b, pl. 6, figs. 1 a, b) and Mexico (Burckhardt, 1912, pl. 3, figs. 3–6) has somewhat sparser ribbing. *P. antecedens* Salfeld (in Arkell, 1938, p. 83, pl. 15) and *P. rotoides* Ronchadze (in Arkell, 1938, p. 90, pl. 16, figs. 1–7) from Europe appear to differ only in minor details of ribbing.

The assignment of *P. mühlbachi* Hyatt to the subgenus *Dichotomosphinctes* is strengthened also by its apparent identity with a well-preserved specimen of *Dichotomosphinctes* from the Naknek formation of Alaska shown on plate 4, figure 6. Unfortunately the holotype of *P. mühlbachi* Hyatt is not sufficiently preserved to show all the features necessary for a positive specific identification.

Types: Holotype USNM 30203; comparable specimen from Mount Boullion, USNM 130786; comparable specimen from Reynolds Ferry, USNM 103460; comparable specimen from Alaska, USNM 130789.

Occurrence: "Mariposa" formation at USGS Mesozoic loc. 27517. Possibly present in the Mariposa formation at Mesozoic locs. 901 and 27460.

Perisphinctes (Dichotomosphinctes) cf. P. elisabethaeformis Burckhardt

Plate 4, figures 4, 7

One external mold shows parts of three evolute whorls that bear fine ribbing similar to that on the inner whorls of *P. elisabethaeformis* Burchkardt (1912, p. 31, pl. 6, figs. 1–5) from the upper Oxfordian of Mexico. The primary ribs begin at the line of involution, are nearly straight on the flanks, incline slightly forward, and generally bifurcate on the upper fourth of the flanks. A few primary ribs remain simple and some of the secondary ribs are indistinctly connected with the primary ribs. Several weak constrictions are present.

This species has much denser ribbing than the specimen of *P.* (*Dichotomosphinctes*) from the Galice formation of southwestern Oregon. (See pl. 4, fig. 2.)

Figured specimen: Stanford Univ. Mus. Palentology 9063.
Occurrence: Monte de Oro formation. North Bank of Feather River just north of Sycamore Hill, about 3 miles northeast of Oroville, and from 450 ft south of NE. cor. of sec. 4, T. 19 N., R. 4 E., Butte County, Calif.

Perisphinctes (Dichotomosphinctes?) spp.

Plate 4, figure 1; plate 5, figures 5, 6

Several ammonites are so crushed and stretched that their correct subgeneric position cannot be determined. The coarseness of the ribs and the positions at which the ribs divide into secondary ribs seem to vary as a consequence of stretching. Nevertheless the ammonites exhibit evolute coiling and moderate to coarse ribbing. Nearly all the ribs bifurcate along a zone somewhat above the middle of the flanks and the secondary ribs incline forward. A few ribs remain simple and none of the ribs trifurcate. Weak constrictions are present.

The bifurcation points appear to be much lower on the flanks than is typical of *Dichotomosphinctes*, but that may be a result of deformation. If it is normal, however, an assignment of the specimens to *Torquatisphinctes* would seem more probable as that genus differs from *Dichotomosphinctes* by having more simple ribs and somewhat lower points of rib furcation.

The specimen shown on plate 5, figure 5, was mentioned by Hyatt (1894, p. 426) as being closely related to *Perisphinctes mühlbachi* Hyatt. It appears, however, to have much finer ribbing and lower points of rib furcation.

Figured specimens: USNM 103461, 103787, 103788.
Occurrence: Mariposa formation at USGS Mesozoic locs. 490, 27566, and 24317.

Genus IDOCERAS Burckhardt, 1906

Idoceras aff. I. planula (Heyl) in Zeiten

Plate 5, figures 12–16

The genus *Idoceras* in California is represented by one specimen that has been crushed laterally. It includes an external mold of the inner whorls and an internal mold of the outer whorls.

On the inner whorls the amount of involution is about two-fifths. On the body whorl it is about one-third. The whorls are subquadrate in section and a little higher than wide. The flanks and venter are nearly flat. The umbilicus is fairly wide. The umbilical wall is low, vertical, and rounds evenly into the flanks. The body chamber is incomplete, but is represented by three-fifths of a whorl.

On the inner whorls the ribs are high, fairly sharp, closely spaced, and incline strongly forward on the upper part of the flanks. The primary ribs bifurcate just above the middle of the flanks into slightly weaker secondary ribs and are slightly swollen along the zone of furcation. The secondary ribs become thicker but slightly lower ventrally. Most forked ribs are separated by short ribs that begin at the line of furcation. The characteristics of the ribbing along the midline of the venter are not well preserved. One deep constriction is present.

On the penultimate whorl the primary ribs are sharp and moderately spaced. Most of them bifurcate at about two-thirds of the height of the flanks, but some remain simple and there are a few short ribs on the upper part of the flanks. The secondary ribs broaden ventrally, incline gently forward, and terminate at a nearly smooth zone along the midline of the venter. Several constrictions are present.

On the body chamber the primary ribs become more widely spaced and curve forward strongly on the flanks. Most ribs bifurcate fairly high on the flanks and virgatoid branching occurs at two places. The secondary ribs are somewhat higher and broader than the primary ribs. The midline of the venter, exposed at only one place, appears to be nearly smooth. The body whorl has about 37 primary ribs.

This species is assigned to the genus *Idoceras* because it has perisphinctid ribbing that is projected forward on the upper parts of the flanks and on the venter and is interrupted along the midline of the venter. It belongs to the group of *Idoceras* characterized by *I. planula* (Heyl) *in* Zeiten and *I. balderum* (Oppel) as defined by Burckhardt (1912, p. 102). This group is generally very evolute, has simple perisphinctid ribbing at all growth stages and commonly has generally pronounced constrictions. It may have some simple ribs but rarely trichotomous ribs. It attains its greatest development in Mexico where it is confined to beds of early Kimmeridgian age (Burckhardt, 1930, p. 64, tables 4-6; Imlay, 1939, p. 21, table 4). In Europe, however, it occurs both in beds of early Kimmeridgian and of late Oxfordian age (Arkell, 1957, p. L 323). In Mexico it is succeeded in slightly younger early Kimmeridgian beds by a group characterized by *I. durangense* Burckhardt. That group is generally less evolute, commonly has trichotomous and bidichotomous ribbing, and the ribs in the adult become swollen near the umbilicus and on the venter but become feeble or indistinct on the middle of the flanks (Burckhardt, 1912, p. 102).

The California specimen of *Idoceras* is similar to the Mexican species *I. soteloi* Burckhardt (1906, p. 52, pl. 9, figs. 9-12), *I. laxevolutum* Fontannes in Burckhardt (1906, p. 48, pl. 10, figs. 1-3), and *I. neogaeum* Burckhardt (1906, p. 51, pl. 11, figs. 5-8) from Zacatecas, Mexico. Of these, *I. soteloi* Burckhardt has somewhat stronger ribbing on its inner whorls and ventral weakening occurs only on the adoral end of the body whorl. *I. laxevolutum* Fontannes in Burckhardt has more closely spaced ribs that are less inclined on the flanks and that become trichotomous near the adoral part of the body chamber. Many of its secondary ribs are indistinctly united with the primary ribs. *I. neogaeum* Burckhardt appears to have weaker secondary ribs on its outer whorls and coarser ribbing on its inner whorls. The density of the ribbing on the inner whorls of the California specimen resembles that on the inner whorls of *I. figueroae* Burckhardt (1906, p. 60, pl. 10, figs. 4-7) but the ribbing on the outer whorls is sparser and apparently sharper. The ribbing on the California specimen would appear less sharp, however, if some shell layers were present as on most of the illustrated Mexican specimens.

Compared with *Idoceras planula* (Heyl) *in* Zeiten from the late Oxfordian of Europe (Quenstedt, 1888, p. 974, pl. 108, figs. 1-5; Wegele, 1929, p. 76, pl. 9, fig. 3) the California specimen is less evolute and has fewer simple and intercalated ribs on its body whorl, but the spacing and sharpness of the ribs are closely similar. *I. schroederi* Wegele (1929, p. 77, pl. 9, fig. 6) has denser ribbing and more simple ribs. *I. balderum* (Oppel) (1863, p. 242, pl. 67, fig. 2; Loriol, 1877, p. 95, pl. 15, fig. 7; Wegele, 1929, p. 78, pl. 9, fig. 7) is more involute and has weaker and broader primary ribs. The specimen figured as *I. laxevolutum* (Fontannes) by Ziegler (1959, p. 28, pl. 1, fig. 6) appears to have coarser and straighter primary ribs.

Figured specimen: Univ. of California [Berkeley] Mus. Paleontology 32724.

Occurrence: Logtown Ridge formation at Univ. of California (Berkeley) loc. A-4996. The field description is as follows: "from a building stone quarry on Logtown Ridge, near the Huse Bridge over the Cosumnes River about six miles north of Plymouth. Ammonite occurs in a metamorphosed andesitic tuff."

Idoceras? sp.

Plate 5, figures 10, 11

One small specimen consists of an external mold of three inner whorls and a fragment of an internal mold of the next larger whorl. The three inner whorls are depressed ovate in section. They are marked by prominent forwardly inclined primary ribs and constrictions. Most of the primary ribs bifurcate slightly above the middle of the flanks, but some remain simple. The secondary ribs arch forward on the venter.

On the next larger whorl the venter bears a strong constriction that is preceded by a swollen rib. The ventral ribs arch forward strongly in a chevronlike manner as in the genus *Idoceras*.

Figured specimen: Stanford Univ. Mus. Paleontology 9064.

Occurrence: The field label states "Mariposa formation, Wood Canyon? near Sonora."

Genus SUBDICHOTOMOCERAS Spath, 1925

Subdichotomoceras? aff. S. filiplex (Quenstedt)

Plate 5, figures 1-3, 9

Perisphinctes filiplex Quenstedt?. Hyatt, 1894, p. 423, 424.

This species is characterized by evolute coiling and by high sharp fairly widely spaced primary ribs of which most bifurcate at about three-fifths of the height of the flanks. A few primary ribs remain simple. The secondary ribs are nearly as prominent as the primary ribs and incline forward slightly. Some of the secondary ribs are indistinctly connected with the primary ribs or arise freely high on the flanks. Several deep constrictions are present on the inner whorls of one fragmentary specimen, but constrictions are not present on any of the outer whorls.

Hyatt's comparison of the California species with "*Ammonites*" *filiplex* Quenstedt (1888, p. 1090, pl. 126, fig. 3) from the middle Kimmeridgian of Europe was apt, but the presence of several simple ribs suggests an even greater resemblance with *Subdichotomoceras inversum* Spath (1931, p. 521, 522, pl. 84, figs. 7a, b, pl. 85, fig. 4) from the middle Kimmeridgian of India. Another species with ribbing nearly identical with that of the California species occurs in the upper Kimmeridgian near Mazapil, Zacatacas, Mexico (Burckhardt, 1906, p. 114, pl. 31, figs. 1-4; Arkell, 1956, p. 562). Also, similar appearing specimens of *Subdichotomoceras* are known from the Kimmeridgian of southern Coahuila, Mexico (Imlay, 1939, p. 35, pl. 10, figs. 1–3, 13).

The California species is placed in *Subdichotomoceras* rather than in *Dichotomosphinctes* because of the coarse ribbing on its inner whorls and its rather low point of rib furcation. Compared with *Perisphinctes* (*Dichotomosphinctes*) *mühlbachi* Hyatt, its ribs are coarser and more widely spaced at comparable sizes and bifurcation occurs much lower on the flanks.

Figured specimen: USNM 30203, 130785.

Occurrence: Mariposa formation, USGS Mesozoic locs. 902, 903, and 904.

Genus PELTOCERAS Waagen, 1871

Subgenus METAPELTOCERAS Spath, 1931

Peltoceras (Metapeltoceras?) sp.

Plate 6, figure 1

The Stanford University collections contain a plaster cast of a large ammonite that is characterized by evolute coiling, perisphinctid ribbing on its inner whorls, and bituberculation on the outer whorls. The inner whorls are not well preserved, but at one place at a diameter of 25 mm they show two blunt tubercles from which arise pairs of strong ribs that trend transversely on the venter. At diameters greater than 50 mm, two rows of tubercles are present and both become very prominent adorally. Apparently the inner tubercles develop first and are stronger than the outer tubercles on the largest whorls, but this appearance may be deceptive because the cast is poorly preserved, the original mold was crushed and distorted, and the venter of the largest whorl is not preserved. No trace of the suture line is visible.

This specimen is assigned to *Peltoceras* because it has two rows of massive lateral tubercles on its outer whorls, perisphinctid ribbing on its inner whorls, and evolute coiling. As the inner rows of tubercles appear to have developed before the outer, the specimen is provisionally assigned to the subgenus *Metapeltoceras* Spath (1931, p. 552. 559, 560, 574–578; Arkell, 1940, p. LXX; Jeannet, 1951, p. 170). However, blunt lateral tubercles appear on the inner whorls at a smaller diameter than in any of the species of *Metapeltoceras* from India figured by Spath (1931, pl. 110, figs. 4a, b, 8a, b; pl. 114, figs. 1a, b; pl. 105, figs. 8a, b; pl. 110, figs. 5a, b; pl. 90, figs. 6a, b; pl. 118, figs. 6a, b; pl. 105, figs. 2a, b; pl. 106, figs. 4a–c), or from Switzerland figured by Jeannet (1951, pl. 72, fig. 5; pl. 73, figs. 5–6, 8; pl. 74, fig. 1; pl. 89, fig. 1; pl. 90, fig. 1, 2; pl. 91, fig. 1, 2).

Figured specimen: Stanford Univ. Mus. Palentology 9062.

Occurrence: The back of the plaster cast bears the statement, "Ammonite from Mariposa slate in Big Indian Creek, Amador County south of Nashville, Eldorado County, Calif. Mold collected by F. M. N. Hamilton, State Mineralogist, May, 1941."

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INDEX

[Italic numbers indicate descriptions]

U. S. GOVERNMENT PRINTING OFFICE : 1961 O - 583565

PLATES 1–6

PLATE 1

[All figures natural size]

FIGURES 1–8. *Kepplerites lorinclarki* Imlay, n. sp. (p. 19).

1–3, 8. Holotype, USNM 130777 from USGS Mesozoic loc. 27313. Figs. 1–3 are from rubber casts of an external mold of the body chamber. Figs. 2 and 3 together represent the same view as fig. 1 but are lighted to emphasize ribbing and tubercles. Fig. 8 is an internal mold of the body chamber of holotype.

4–7. Paratypes, USNM 130778 from USGS Mesozoic loc. 27313. Figs. 4–6 are from rubber casts of external molds. Fig. 4 represents part of an penultimate whorl. Fig. 5 shows the apertural constriction. Fig. 6 shows the strong primary ribs and tubercles on the penultimate whorl. Fig. 7 is an internal mold.

9–11. *Taramelliceras?(Proscaphites?) denticulatum* (Hyatt) (p. 19).

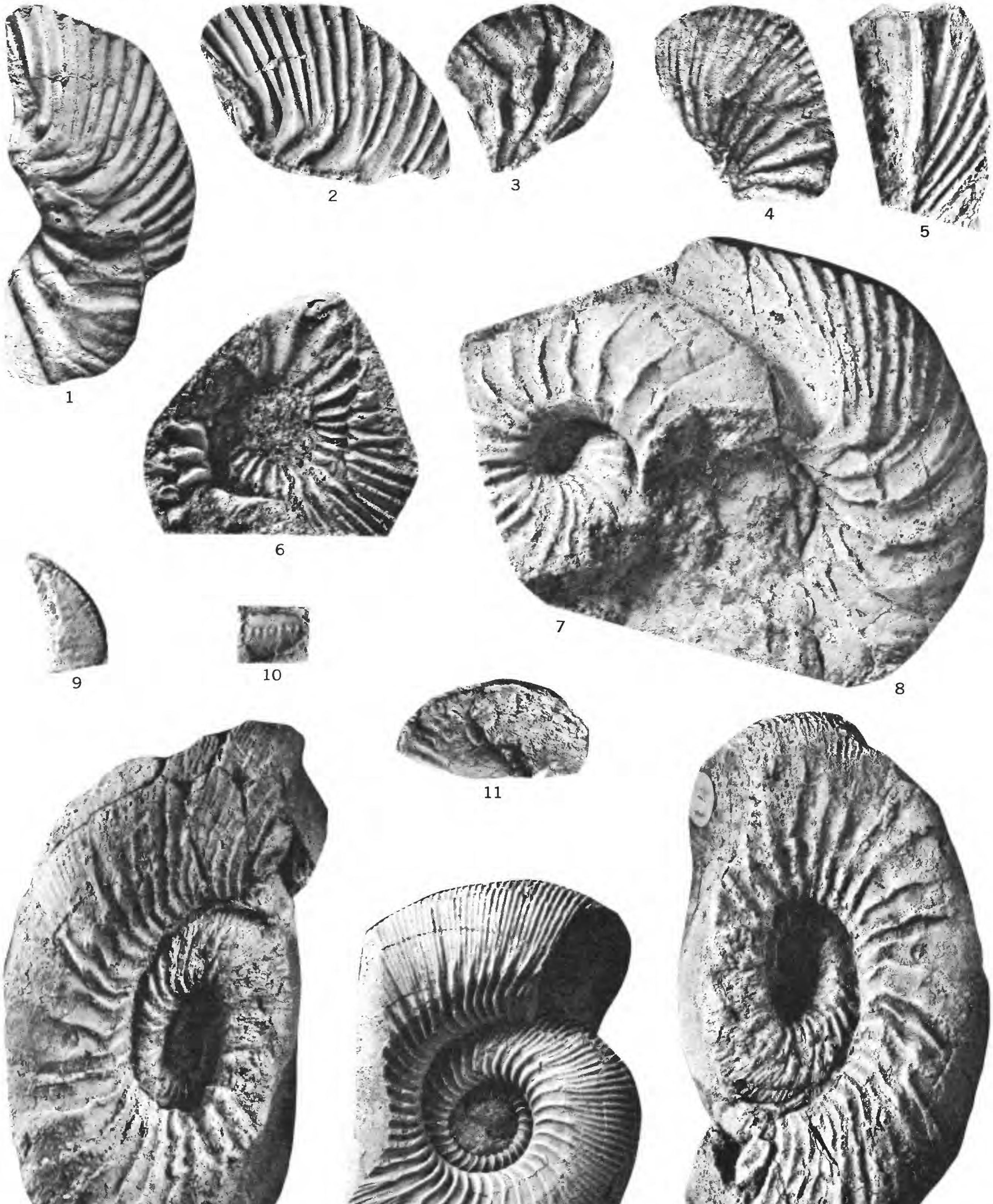
Cotypes, USNM 30206 from USGS Mesozoic loc. 901. Note ventral serrations of figs. 9 and 10. Fig. 11 shows gentle ribs on the flanks. Compare with same view published by Crickman, 1933, Prof. Paper 175–B, pl. 17, figs. 12, 13.

12, 14. *Kepplerites (Gowericeras) lindgreni* (Hyatt) (p. 20).

Holotype, USNM 30205 from USGS Mesozoic loc. 27516.

13. *Kepplerites (Gowericeras)* sp.

Specimen, USNM 130791 from USGS Mesozoic loc. 24793 in the Talkeetna Mountains, Alaska. This specimen is illustrated for comparison with *Kepplerites (Gowericeras) lindgreni* (Hyatt).



KEPPLERITES, *GOWERICERAS*, AND *TARAMELLICERAS*?

PLATE 2

[All figures natural size]

FIGURES 1–8, 11–13. *Pseudocadoceras grewingki* (Pompeckj) (p. 21).

1–7. Rubber casts of plesiotypes, USNM 130779 from USGS Mesozoic loc. 27317; 8. rubber cast of plesiotype, USNM 130781 from USGS Mesozoic loc. 24710; 11–13. plesiotypes, USNM 108114, 108116, 108115 respectively, from Alaska included for comparisons with specimens from California shown on figs. 1–8.

9, 10. *Pseudocadoceras crassicostatum* Imlay (p. 21).

Plesiotypes, USNM 108118 and 108119 from Alaska included for comparisons with specimens from California shown in figs. 14–21.

14–21. *Pseudocadoceras* cf. *P. crassicostatum* Imlay (p. 21).

Rubber casts of specimens, USNM 130780 from USGS Mesozoic loc. 27317. Ventral view shown on fig. 20 shows forward curvature of ribs.

22. *Pseudocadoceras* cf. *P. grewingki* (Pompeckj) (p. 21).

Specimen USNM 130783 from Mesozoic loc. 27387. Note low point of rib branching and forward curvature of ribs on venter.

23. *Pseudocadoceras*? sp. (p. 21).

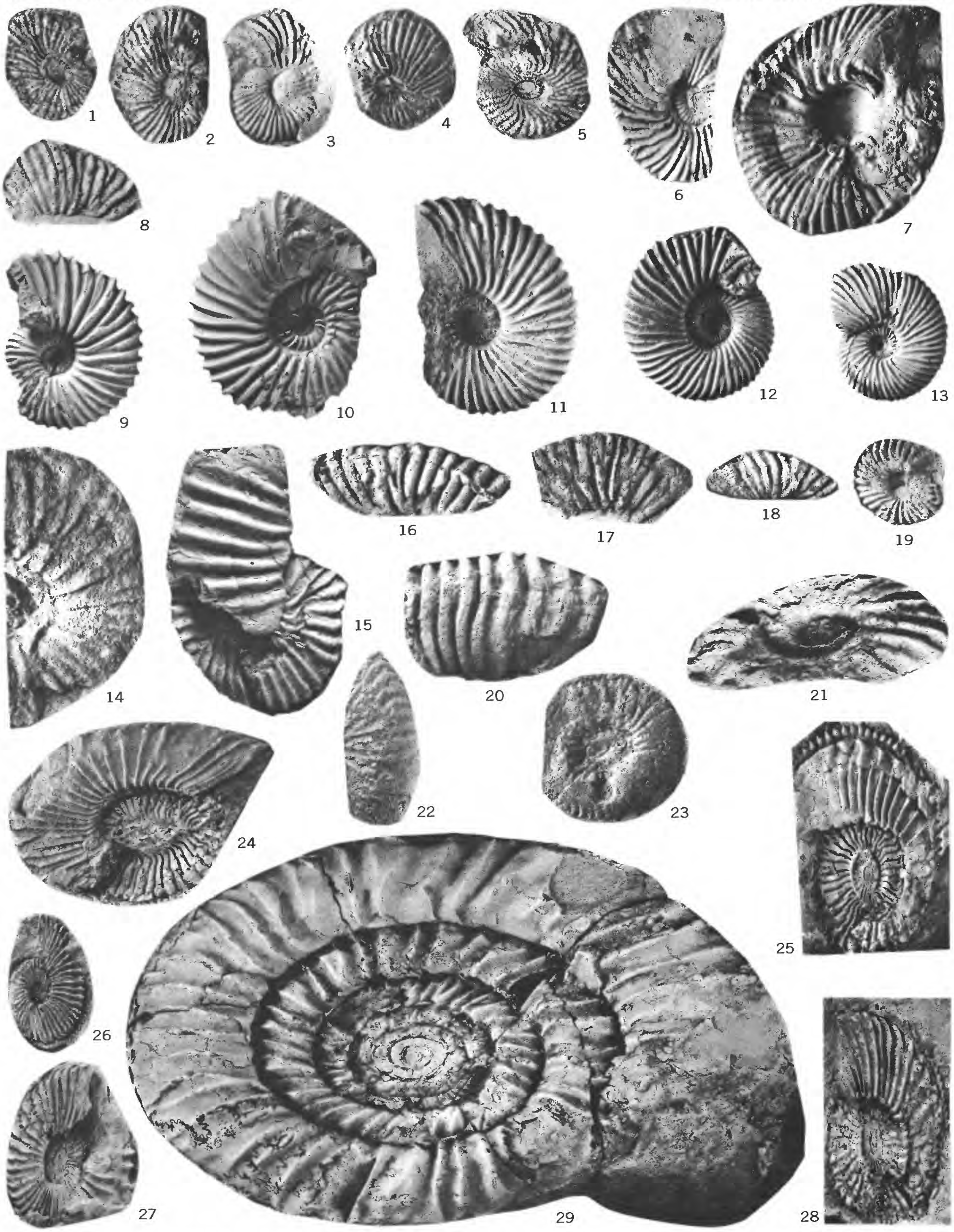
Specimen USNM 130782 from USGS Mesozoic loc. 22175.

24–28. *Amoeboceras* (*Amoebites*) *dubium* (Hyatt) (p. 22).

Cotypes, USNM 30201 from USGS Mesozoic loc. 719.

29. *Grossouvria colfaxi* (Gabb) (p. 22).

Holotype, Harvard University Museum of Comparative Zoology 5287 from near Colfax, Placer County, Calif.



PSEUDOCADOCERAS, AMOEBOCERAS (AMOEBITES), AND *GROSSOUVRIA*

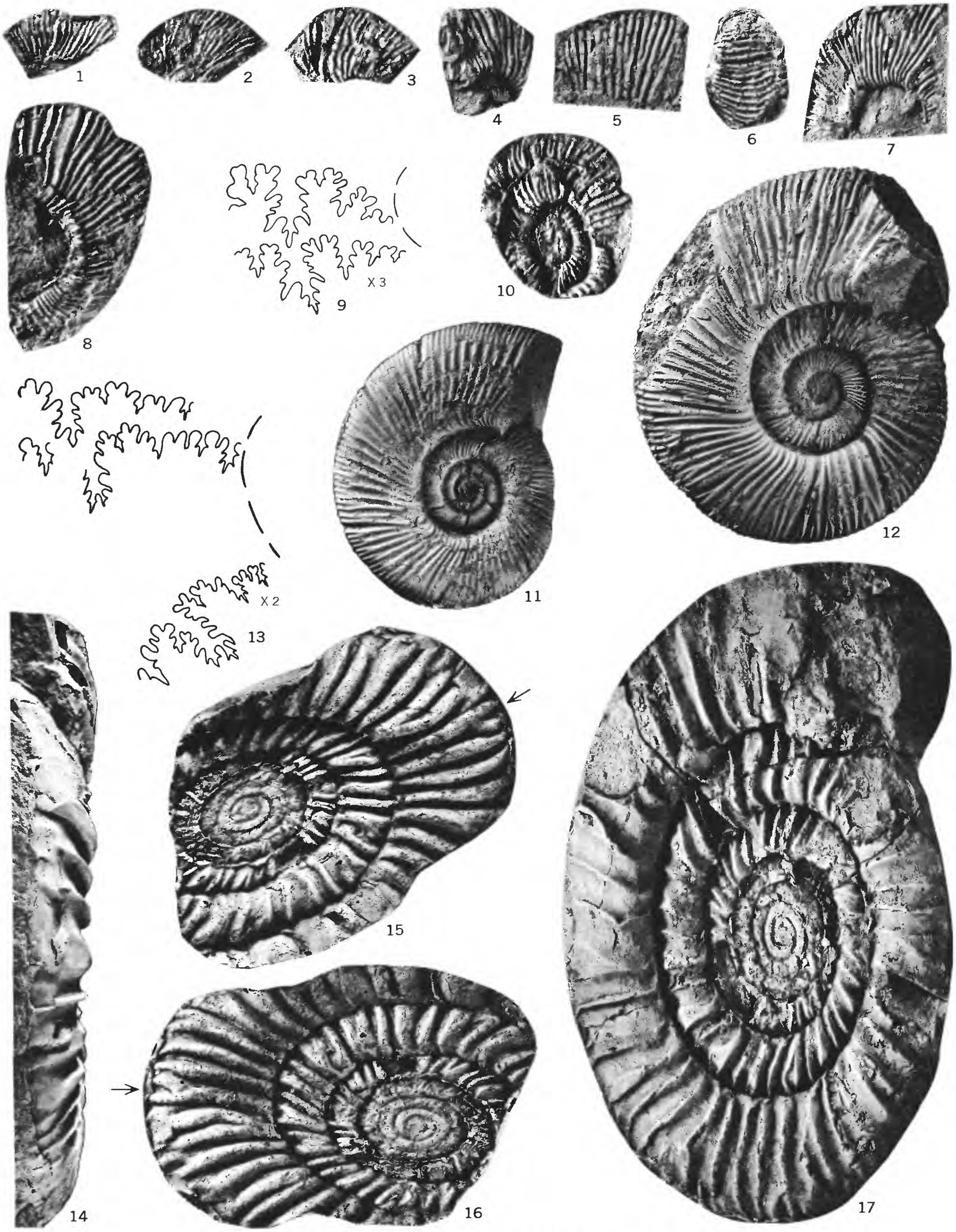
PLATE 3

[Figures natural size unless otherwise indicated]

FIGURES 1–10. *Perisphinctes* (*Discosphinctes*) *virgulatiformis* Hyatt (p. 23).
Cotypes, USNM 30204 from USGS Mesozoic loc. 901. Fig. 6 shows venter with its adoral end pointed downward. Fig. 9 shows suture lines (× 3) drawn from internal mold of specimen represented by fig. 7. Figs. 1, 2, 4, 5, 7, 8, and 10 are from rubber casts of external molds.

11, 12. *Perisphinctes* (*Discosphinctes*) *carribeanus* Jaworski.
Plesiotypes, USNM 130792 from USGS Mesozoic loc. 26382 at Pan de Azucar, Pinar del Rio Province, Cuba. Illustrated for comparison with *P.* (*Discosphinctes*) *virqulatiformis* Hyatt.

13–17. *Grossouvria colfaxi* (Gabb) (p. 22).
Holotype, Harvard Mus. Comp. Zoology 5287, from railroad cut 1 mile west of Colfax, Calif. 13. Suture lines (× 2) drawn near adoral end of last septate whorl; 14, 17. Ventral and lateral views of internal mold; 15, 16. Rubber cast of external mold showing ribbing under different lighting. Arrows on fig. 15 and 16 show position of same forked rib as that illustrated at the bottom of fig. 17. Compare fig. 17 with fig. 29 on pl. 2 to note differences in appearance under different conditions of lighting.



PERISPHINCTES (DISCOSPHINCTES) AND *GROSSOUVRIA*

PLATE 4

[All figures natural size]

FIGURE 1. *Perisphinctes* (*Dichotomosphinctes*?) spp. (p. 25).
Specimen, USNM 130788 from USGS Mesozoic loc. 24317.

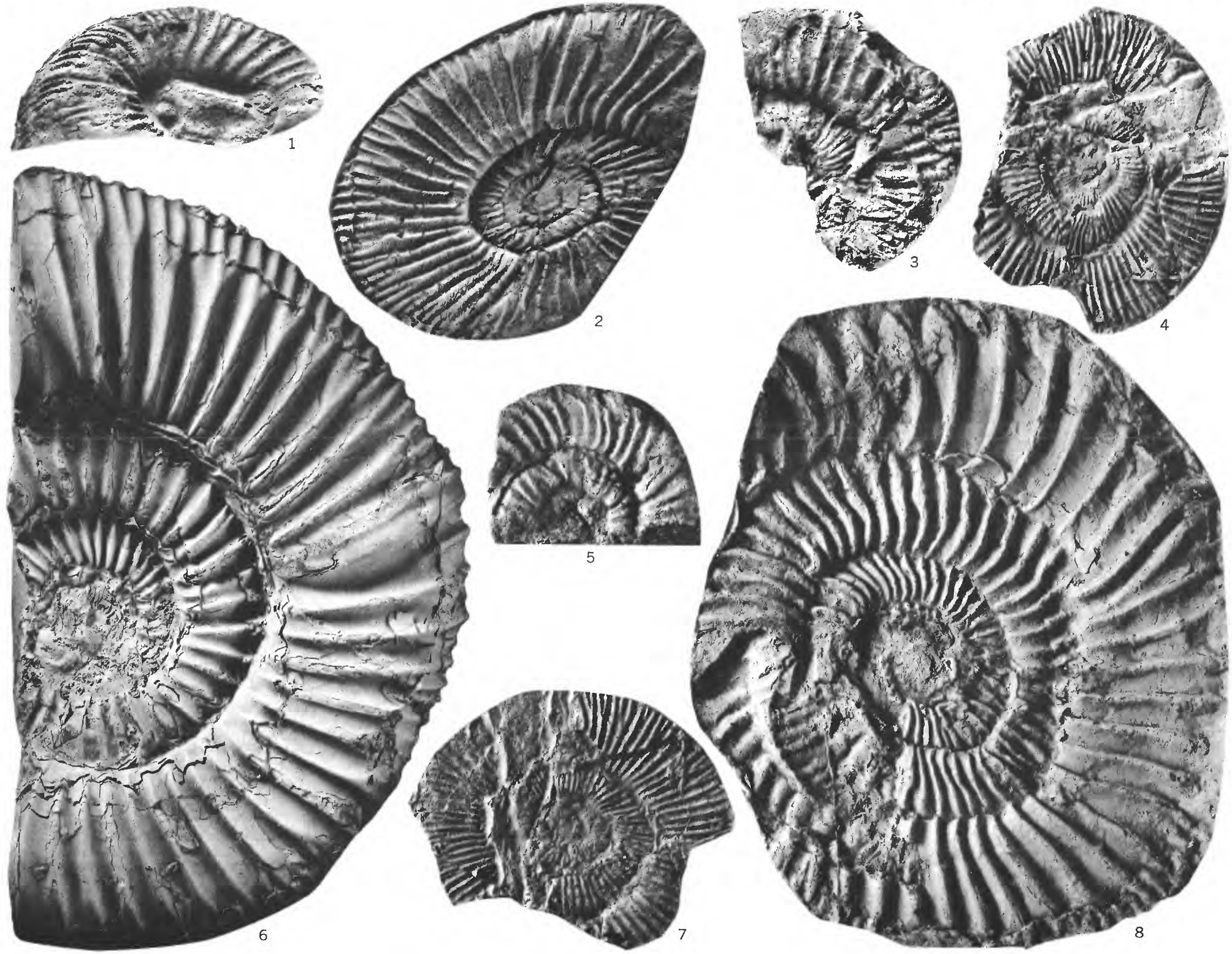
2. *Perisphinctes* (*Dichotomosphinctes*) sp. (p. 25).
USNM 130790 from USGS Mesozoic loc. 3326. From the Galice formation at the Almeda mine on the Rouge River 3 miles below Galice Creek, Josephine County, Oreg.

3, 5. *Perisphinctes* (*Dichotomosphinctes*) cf. *P. D. mühlbachi* Hyatt (p. 24).
Rubber cast of external mold, USNM 103460 from USGS Mesozoic loc. 901.
Internal mold, USNM 130786 from USGS Mesozoic loc. 27460.

4, 7. *Perisphinctes* (*Dichotomosphinctes*) cf. *P. elisabethaeformis* Burckhardt (p. 25).
Stanford University Mus. Paleontology 9063 from north bank of Feather River 3 miles northeast of Oroville, Butte County, Calif. Two views of same specimen under different conditions of lighting.

6. *Perisphinctes* (*Dichotomosphinctes*) cf. *P.* (*D.*) *mühlbachi* Hyatt (p. 24).
Laterally crushed body chamber of specimen, USNM 130789 from USGS Mesozoic loc. 10796 from the Naknek formation 3¾ miles southeast of Mount Lee, Alaska Peninsula. Note close resemblance to *P. mühlbachi* Hyatt shown on fig. 8.

8. *Perisphinctes* (*Dichotomosphinctes*) *mühlbachi* Hyatt (p. 24).
Rubber cast of external mold of holotype, USNM 30202 from USGS Mesozoic loc. 27517.



PERISPHINCTES (DICHOTOMOSPHINCTES)

PLATE 5

[All figures natural size]

FIGURES 1–3, 9. *Subdichotomoceras*? aff. *S. filiplex* Quenstedt (p. 26).

1, 3. USNM 30203a from USGS Mesozoic loc. 902.

2. USNM 30203b from USGS Mesozoic loc. 903.

9. USNM 130785 from USGS Mesozoic loc. 904.

Figs. 1, 2, and 9 are from rubber casts of external molds.

4. *Perisphinctes*? sp. (p. 23).

Stanford Univ. Mus. Palentology 9065 from near Nashville, Eldorado County, Calif. View of rubber cast of external mold

5, 6. *Perisphinctes* (*Dichotomosphinctes*?) sp. (p. 25).

Rubber cast of external mold, USNM 103461 from USGS Mesozoic loc. 27566.

Partly internal and partly external mold, USNM 130787 from USGS Mesozoic loc. 490.

7, 8. *Buchia* cf. *B. concentrica* (Sowerby) (p. 8).

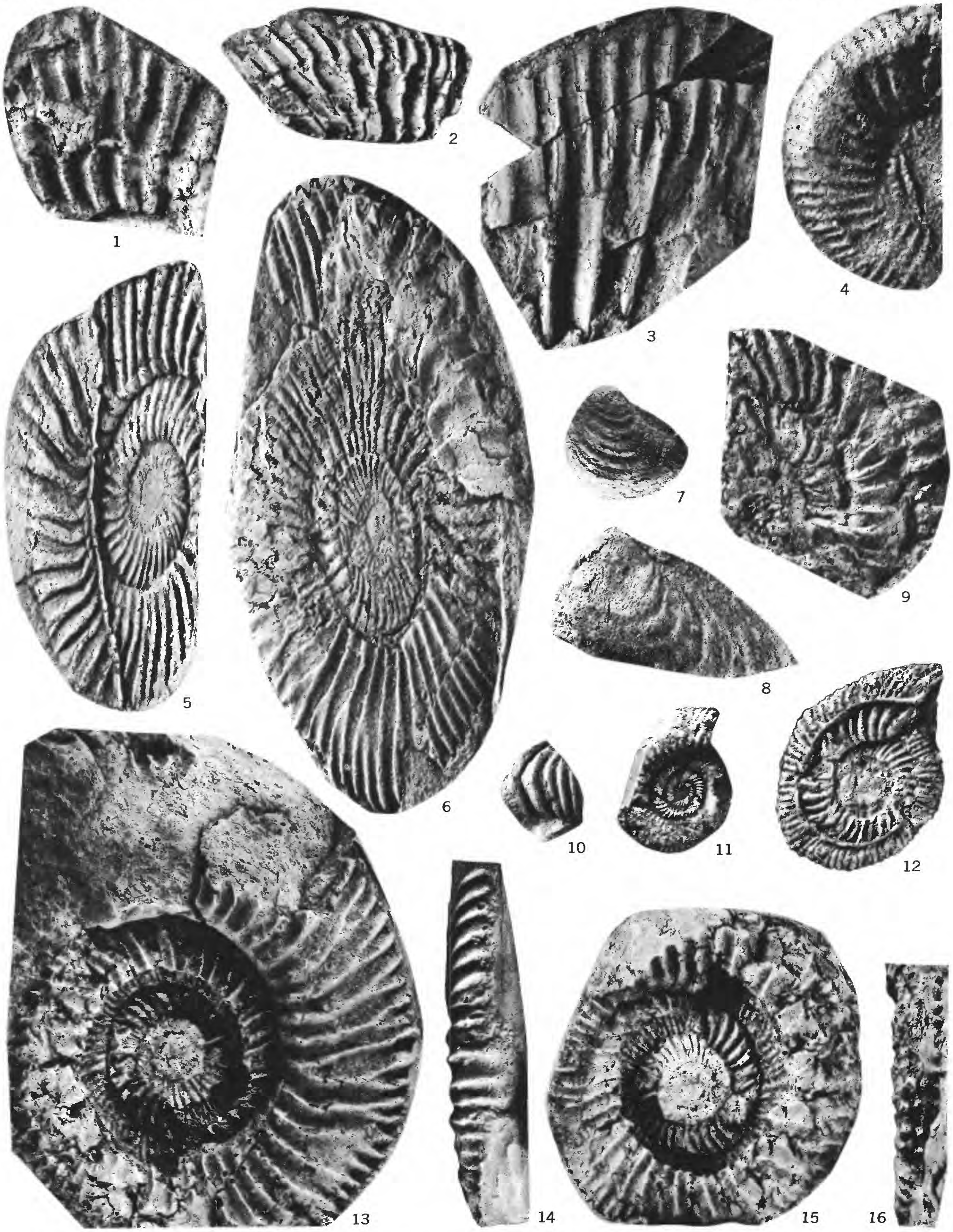
Internal molds bearing traces of fine radial striae, USNM 130793 from USGS Mesozoic loc. 4801.

10, 11. *Idoceras*? sp. (p. 26).

Stanford Univ. Mus. Paleontology 9064. Fig. 10 is an internal mold showing venter of a whorl next larger than the largest shown on fig. 11 which is a rubber cast of an external mold.

12–16. *Idoceras* aff. *I. planula* (Heyl) *in* Zeiten (p. 25).

Holotype, Univ. of California (Berkeley) Mus. Paleontology 32724 from loc. A–4996. 12. Rubber cast of external mold of inner whorls shown in figs. 13 and 15. 13, 14. Lateral and ventral views of plaster replica of complete holotype showing three-fifths of a whorl of body chamber. 15, 16. Lateral and ventral views of holotype without body chamber. A nearly smooth midventral area is shown on fig. 16.



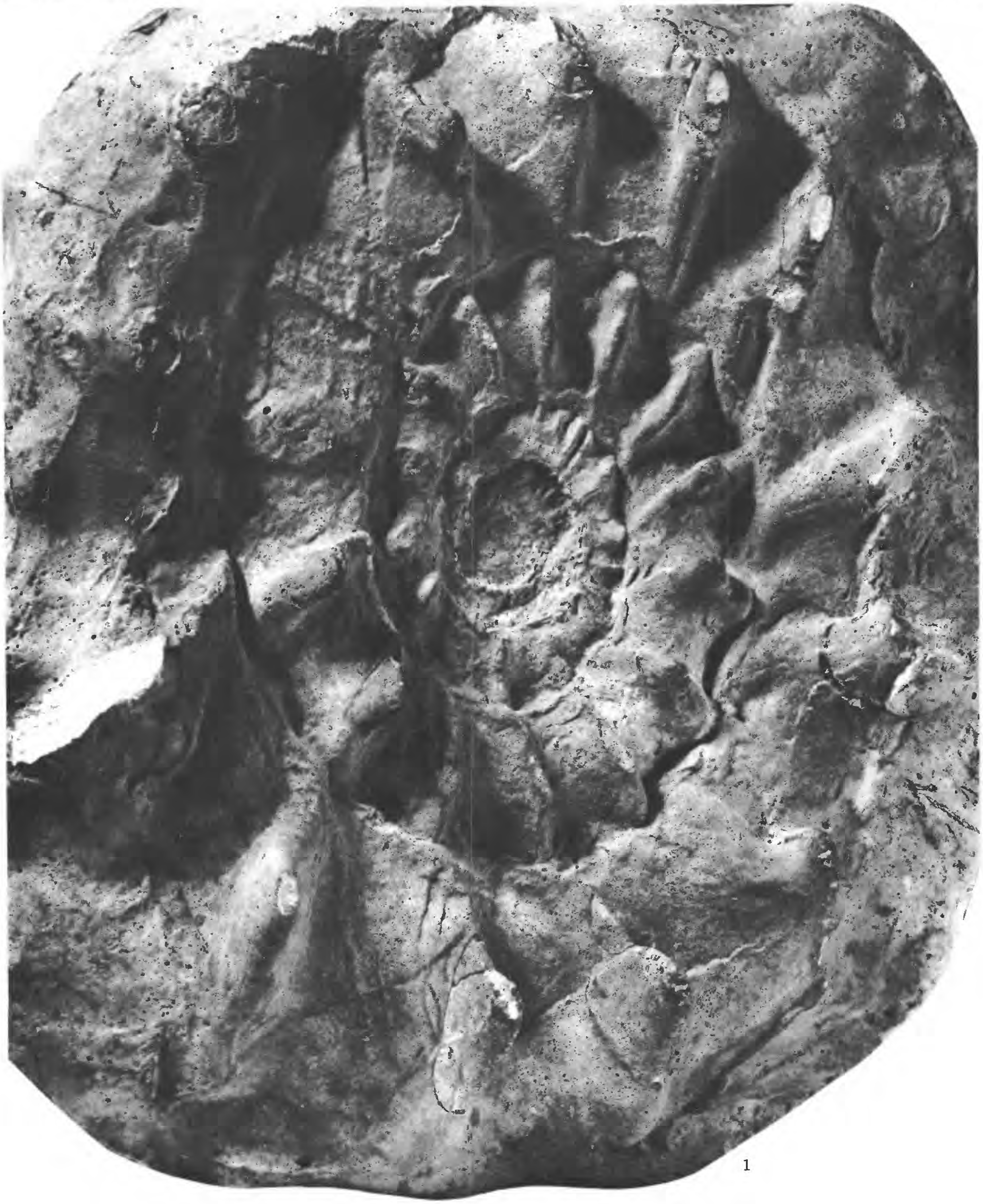
SUBDICHOTOMOCERAS?, *PERISPHINCTES*?, *DICHOTOMOSPHINCTES*?, *IDOCERAS*, AND *BUCHIA*

PLATE 6

[Figure natural size]

FIGURE 1. *Peltoceras* (*Metapeltoceras*?) sp. (p. 27).

Stanford Univ. Mus. Paleontology 9062 from Indian Creek, Amador County, Calif. Plaster cast of external mold that is probably now lost. Note presence of ribbing on innermost whorls and two rows of tubercles on the outer whorls.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PELTOCERAS (METAPELTOCERAS?)