Upper Jurassic Mollusks from Eastern Oregon and Western Idaho

GEOLOGICAL SURVEY PROFESSIONAL PAPER 483-D

Upper Jurassic Mollusks from Eastern Oregon and Western Idaho

By RALPH W. IMLAY

CONTRIBUTIONS TO PALEONTOLOGY

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Faunal evidence for the presence of Upper Jurassic sedimentary rocks in eastern Oregon and westernmost Idaho

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON : 1964

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, D.C. 20402

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CONTRIBUTIONS TO PALEONTOLOGY

UPPER JURASSIC MOLLUSKS FROM EASTERN OREGON AND WESTERN IDAHO

By Ralph W. Imlay

ABSTRACT

Jurassic ammonites of early Callovian age occur throughout more than 13,000 feet of strata exposed along and near the South Fork of the John Day River near Izee in east-central Oregon. They occur also in several hundred feet of dark shale exposed along Dennett Creek near Mineral, Idaho. Other ammonites of early Oxfordian age were found in Idaho about 400 feet above the base of 1,000 feet of tough noncalcareous black shale exposed in the canyon of the Snake River near the northeast corner of Oregon and the southeast corner of Washington. These Oxfordian ammonites were collected in Idaho about one-third of a mile east of the Snake River. The black shale in which they occur is well exposed on the Oregon side of the canyon.

The early Callovian is represented by the ammonites *Xenocephalites, Lilloettia, Kepplerites* (*Gowericeras*), *Parareineckeia, Cobbanites, Pseudocadoceras*?, and *Choffatia*. All these except *Pseudocadoceras*? occur in the upper part of the Snowshoe Formation of Lupher (1941) near Izee in east-central Oregon and are excellent evidence for the age of the upper part of that formation. The first three ammonites listed are not known below the Callovian and the next two listed are not known above the lower Callovian.

The middle and lower middle parts of the overlying Trowbridge Formation of Lupher (1941) contain the ammonites *Xenocephalites*?, *Lilloettia*, and *Kepplerites* (*Gowericeras*) of early to early middle Callovian age. The species present occur in beds of early Callovian age in British Columbia and Alaska. An early Callovian age is confirmed by the ammonite genera present in the overlying Lonesome Formation of Lupher (1941).

The overlying Lonesome Formation has furnished *Xenocephalites* and fragments probably belonging to that genus throughout most of its great thickness. It is, therefore, probably entirely of early Callovian age. This age is confirmed locally by the association of *Xenocephalites* with *Cobbanites* and *Lilloettia*. The presence of *Pseudocadoceras*? in two places is not evidence of a younger age as the genus in Europe ranges from the upper lower Callovian to near the top of the stage.

Several hundred feet of dark shale near Mineral, Idaho, contains the ammonites *Xenocephalites, Lilloettia*, and *Cobbanites* of early Callovian age. The species present are identical with species in the Trowbridge and Snowshoe Formations of east-central Oregon.

The early Oxfordian is represented by the ammonite *Cardioceras* obtained from black shale exposed on the Idaho side of the Snake River Canyon near the northeast corner of Oregon. This is the first faunal evidence for rocks of that particular age on the Pacific coast south of British Columbia.

The Upper Jurassic (Callovian and Oxfordian) ammonites from east-central Oregon and westernmost Idaho are identical or closely comparable to species in western British Columbia and Alaska. Assemblages of the same age in the western interior of North America differ considerably in generic composition and do not appear to have any species in common. Some faunal resemblances exist with ammonites of early Callovian age in California. Comparisons are difficult, however, because in California few ammonites of early Callovian age have been described and none of early Oxfordian age has been recognized.

INTRODUCTION

The ammonites described herein have been studied in order to demonstrate the existence of thick sequences of early Late Jurassic strata in eastern Oregon and western Idaho. Proof that more than 13,000 feet of strata were deposited in eastern Oregon during only part of the Callovian stage should interest geologists concerned with sedimentation and tectonics. The close affinities of the ammonites with those of the same age in western British Columbia and Alaska should interest geologists concerned with paleogeography. In particular the presence of the boreal ammonite *Cardioceras* in shale in the Snake River Canyon near the northeast corner of Oregon suggests that the sea in which it lived extended across the area of the state of Washington.

The fossils were collected by R. L. Lupher in 1930 and 1937, D. C. Livingston prior to 1932, W. R. Wagner in 1945, S. W. Muller in 1956, L. W. Vigrass in 1956, John Beeson in 1956 and 1957, R. W. Imlay in 1956–58 and 1962, W. R. Dickinson in 1957, Reed Christner in 1958, Marvin Beeson in 1959–61, Richard Bateman in 1961, Howard Brooks in 1962, and R. F. Morrison in 1961 and 1962.

Correlation charts of the Upper Jurassic formations and faunas of the Pacific coast region have been published previously (Imlay, 1961, figs. 1 and 2 on p. D4–D5) and are not repeated herein.

BIOLOGIC ANALYSIS

The Upper Jurassic ammonites from east-central Oregon and western Idaho described herein include about 175 specimens of which 90 specimens are too poorly preserved for generic identification. Their biologic distribution from subgenus to family is shown in table 1. This table shows that the Macrocephalitidae is by far the dominant family. The Cardioceratidae, Perisphinctidae, and Kosmoceratidae are much less common. The Phylloceratidae and Reineckeiidae are of minor importance.

Other megafossils collected from Upper Jurassic beds in east-central Oregon and western Idaho consist only of pelecypods. They include 3 specimens of *Posidonia*, 20 of *Ostrea*, and 50 of *Gryphaea*. Many more specimens of *Gryphaea* could have been readily collected from exposures near Mineral, Idaho.

STRATIGRAPHY SUMMARY

NORTHEASTERN OREGON AND ADJOINING IDAHO

Jurassic black shale at least 1,000 feet thick is well exposed in the Snake River Canyon in the extreme northeast corner of Oregon and in adjoining Idaho (Morrison, 1961, p. 107–110) (fig. 1). The shale is black, thin bedded, evenly bedded, hard, and noncalcareous; it contains some interbedded quartz sandstone and chert pebble conglomerate; it is marked basally by a clean crossbedded sandstone that includes large limestone boulders; and it rests with angular unconformity on Triassic limestone and conglomerate.

One notable feature of this shale is a paucity of fossils. A few ammonites were found at one spot after many hours of labor. Elsewhere not a trace of a fossil was found in spite of the fact that exposures are fairly extensive. Large areas of bedrock and talus were examined by R. F. Morrison and the writer during the summer of 1962 without finding fossils. Even the particular beds that yielded the ammonites did not contain any fossil remains on weathered surfaces. Apparently the bottom conditions during deposition were unfavorable for benthonic organisms and present weathering conditions destroy any fossils that become exposed.

MINERAL AREA, WESTERN IDAHO

The Jurassic rocks exposed in the canyon of Dennett Creek near the old mining town of Mineral (abandoned), Idaho, have been described by Livingston (1932, p. 33, 34) as follows:

> The lowest rock exposed is a quartz diorite sill. The bottom of the sill has not been exposed but the top grades through a purplish andesitic phase into a reddish rock to which the field name of Lower Rhyolite has been assigned to distinguish it from a flow of rhyolite higher in the series.
>
> Immediately above this reddish rock lies a fine gray sandy tuff, which merges upward into a series of coarse pebble conglomerates. Above the conglomerate lie more tuffs, darker in color, and above these a series of dark carbonaceous and calcareous shales about 200 to 300 feet thick. The whole series from the top of the quartz diorite to the top of the shales is between 500 and 600 feet thick.
>
> The shales yield excellent fossil ammonites which have been identified by Dr. Packard of the University of Oregon and by Ralph L. Lupher of Washington State College, as Upper Jurassic in age.

Above the dark shale is a rhyolitic unit as much as 200 feet thick and above that is a schistose agglomerate that Livingston interprets as a fault gouge. These appear to be much younger than the Jurassic.

The sequence near Mineral, Idaho, is virtually as described by Livingston according to observations made in 1959 and 1962 by Norman Wagner and Howard Brooks of the Oregon Department of Geology and Mineral Resources and by the writer. The dark shale and the underlying sandy tuff crop out on the south

TABLE 1.—*Ammonite genera and subgenera from beds of Late Jurassic age in eastern Oregon and western Idaho, showing biological relationships and relative numbers available for study*

Family	Subfamily	Genus and subgenus	Number of specimens
Phylloceratidae	Phylloceratinae	*Phylloceras*	2
	Calliphylloceratinae	*Calliphylloceras*	1
Lytoceratidae	Lytoceratinae	*Lytoceras?*	1
Macrocephalitidae		*Xenocephalites*	11
		Xenocephalites?	20
		Lilloettia	49
		Lilloettia?	18
Kosmoceratidae		*Kepplerites (Gowericeras)*	5
		Kepplerites?	1
Cardioceratidae	Cadoceratinae	*Pseudocadoceras?*	41
	Cardioceratinae	*Cardioceras (Scarburgiceras)*	5
Reineckeiidae		*Parareineckeia*	1
Perisphinctidae	Zigzagiceratinae	*Cobbanites*	7
		Cobbanites?	9
	Pseudoperisphinctinae	*Choffatia*	4

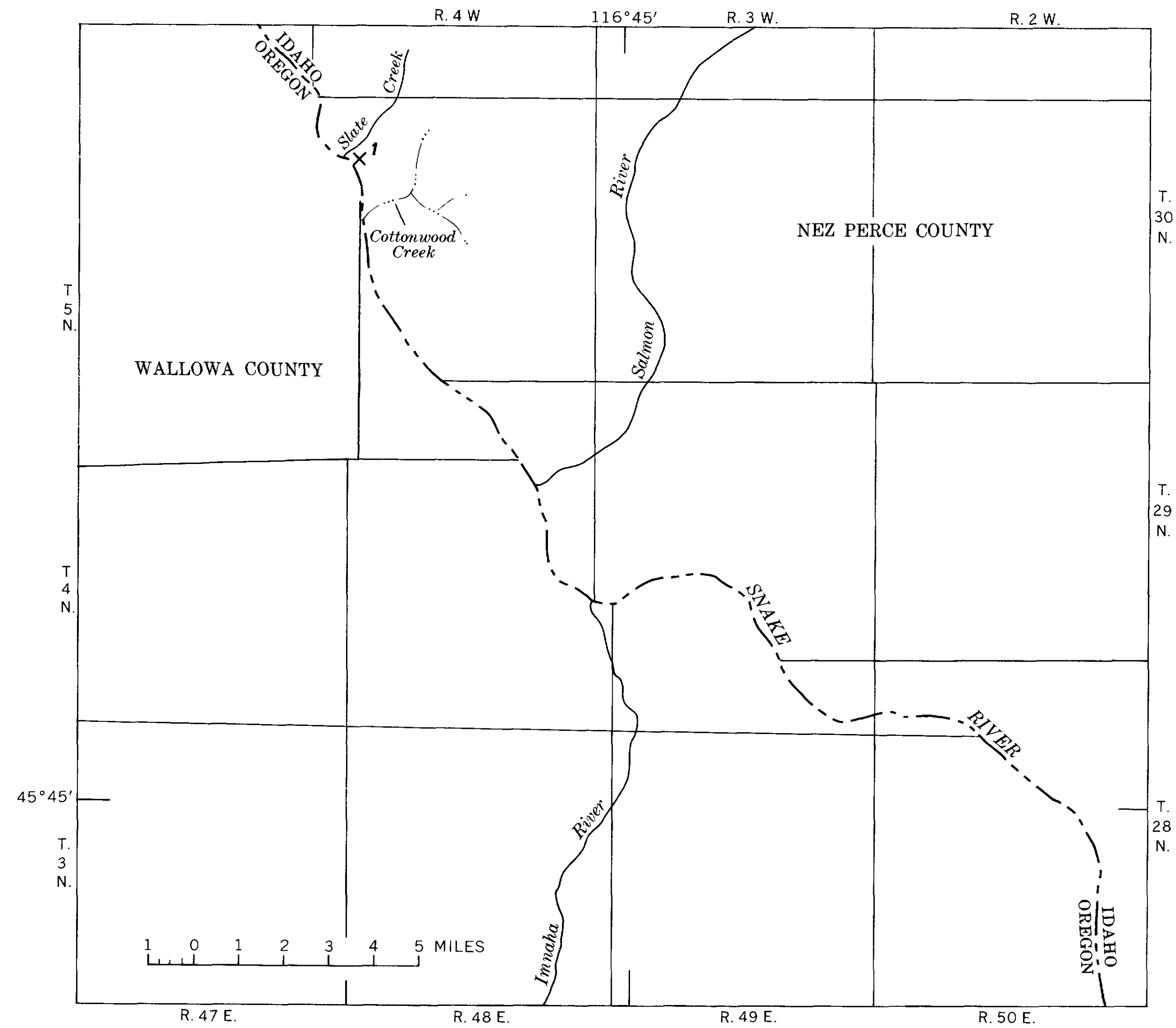

FIGURE 1.—Index map showing Upper Jurassic fossil locality in west-central Idaho. Number on map refers to that given in table 2.

side of Dennett Creek near its junction with the North Fork and on both sides of the canyon of the North Fork of Dennett Creek for about 1 mile north of Mineral. They also crop out extensively along the south side of the Middle Fork for at least 1½ miles above its junction with the North Fork (fig. 2).

The shale is dark gray, calcareous, weathers into chunky to conchoidal fragments, contains many black brittle concretions, and is probably several hundred feet thick. The concretions yielded only the spat of oysters or Gryphaeas. Nevertheless the ammonites reported by Livingston from the shale in Dennett Creek at his locality 88 were probably obtained from similar concretions. The ammonites are preserved in a black limestone matrix, are mostly undeformed, and are identical specifically and in preservatoin with ammonites obtained from concretions in the Trowbridge Formation of Lupher (1941) on Flat Creek in the Izee area of east-central Oregon. Presumably during the months that Livingston (1932, p. 31) mapped the geology of the Mineral area, either he or his students were fortunate to find some concretions containing ammonites.

The sandy tuff beds underlying the dark shale are mostly thin to medium bedded, gray to brownish gray, weather reddish to yellowish brown, range in thickness from a few feet to at least 100 feet, and grade upward into shale within a few feet. They are best exposed along the North Fork of Dennett Creek from ¼ to ½ mile above its mouth. Their upper part contains fairly well preserved Gryphaeas that were found in abundance only on the east side of the North Fork about 320 feet above the creekbed in the NE¼NW¼ sec. 9, T. 14 N., R. 6 W. This is the place from which W. R. Wagner (written communication dated Dec. 31, 1962) obtained the Gryphaeas that were examined by J. B. Reeside, Jr. These were erroneously reported to be

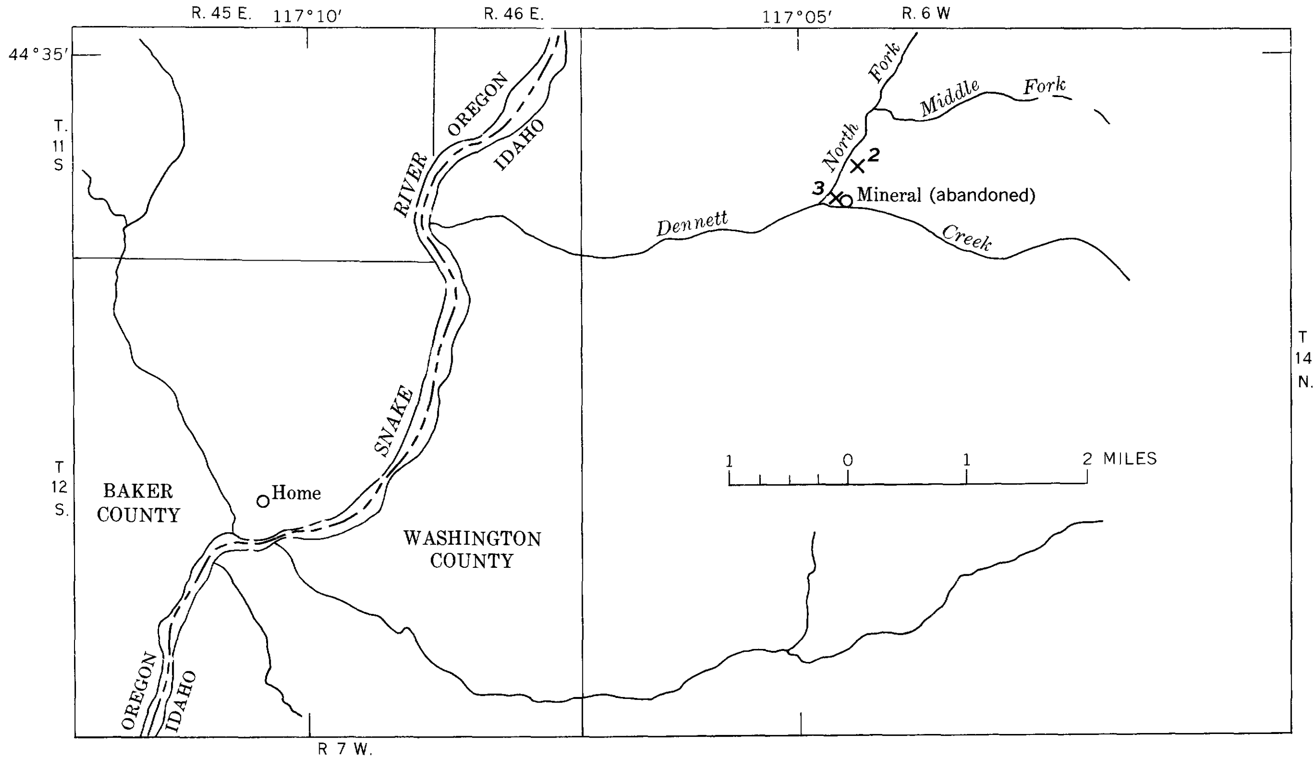

FIGURE 2.—Index map showing Upper Jurassic fossil localities near Mineral (abandoned), Idaho. Numbers on map refer to those given in table 2.

from the Snake River Canyon in Oregon (McKee and others, 1956, p. 2).

EAST-CENTRAL OREGON

In east-central Oregon (fig. 3) near Izee, Callovian fossils have been obtained from more than 13,000 feet of sedimentary rock which includes all the Lonesome and Trowbridge Formations of Lupher (1941) and the upper part of the Snowshoe Formation of Lupher (1941). Most of the fossils were obtained from concretions in the upper part of the Snowshoe Formation and in the middle and lower middle parts of the Trowbridge Formation. A few fossils were obtained from mudstone and graywacke in various parts of the Lonesome Formation from about 1,250 feet above its base (Mesozoic loc. 26782) to within 300 feet of its eroded top (Mesozoic loc. 27383) as exposed near the junction of Lewis Creek with the South Fork of the John Day River.

Most of the fossils obtained from these formations are ammonites. However, from the concretions in the upper part of the Snowshoe Formation were obtained 20 nondescript oysters and 1 specimen of the pelecypod *Posidonia*. This genus is represented, also by two specimens from a tuffaceous bed in the Lonesome Formation.

The lithologic characteristics of the formations of Callovian age in the Izee area have been described by Lupher (1941, p. 227, 259–266) and Dickinson (1962a, p. 251–153; 1962b, p. 483). In brief, the Snowshoe Formation is about 3,000–3,500 feet thick and consists of dark gray to black thin-bedded mudstone, volcanic siltstone, and sandstone. The Trowbridge Formation is 2,750–3,250 feet thick and consists mostly of black mudstone, but it contains some thin beds of volcanic sandstone and dark limestone. In addition its lower 900 feet contains green mudstone and four units of clastic volcanic rocks that range from volcanic sandstone to vitroclastic tuff. The lowermost of these units crops out as conspicuous cliffs about 400 feet above the base of the Trowbridge Formation.

The Lonesome Formation in the Izee area consists of thick-bedded volcanic graywacke and interbedded dark gray to black mudstone but includes some conglomeratic beds. It is characterized by thick cliff-forming units of graywacke, by graded bedding, and by sole markings. Its thickness was considered by Lupher (1941, p. 265, 266) to be about 4,000 feet and by Dickinson (1962a, p. 252, 253) to be at least 10,000 feet. Dickinson, after a field conference with Lupher, however, selected a much lower unit for the base of the formation than that originally selected by Lupher (oral communication from Dickinson, 1957).

The Lonesome Formation in the Sawtooth Creek quadrangle, south of the Izee area, has been studied by Marvin Beeson for a master's thesis at the University

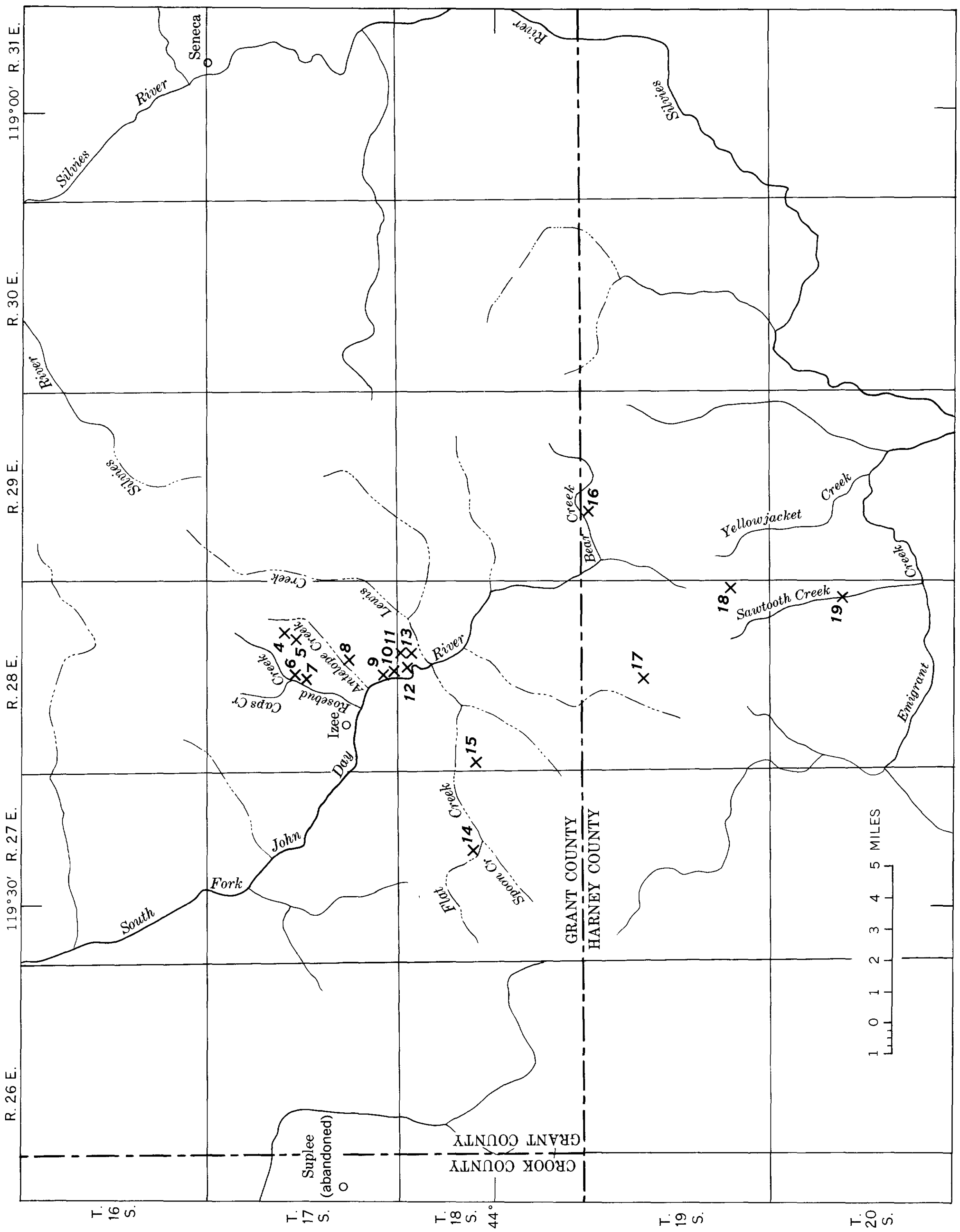

FIGURE 3.—Index map showing Upper Jurassic fossil localities near Izee in east-central Oregon. Numbers on map refer to those given in table 2.

of Oregon and has been described by him (written communication of Dec. 30, 1962) as follows:

> In the Sawtooth Creek quadrangle the Lonesome Formation consists mostly of interbedded volcanic graywacke and black mudstone, contains a few pebble beds near its middle, and is estimated to be approximately 10,000 feet thick. About 4,000 feet of black mudstone that contains very few beds of graywacke is exposed in the upper part of the formation along the South Fork of the John Day River just south of its junction with Bear Creek. A bed of light-colored pinkish gray, fossiliferous tuff occurs in the N.W. corner of sec. 13, T. 20 S., R. 28E.

CONDITIONS OF DEPOSITION

The black shale exposed in the Snake River Canyon in the northeast corner of Oregon and in adjoining Idaho appears to have been deposited in quiet water as indicated by its even and thin bedding. The absence of benthonic organisms could reflect rapid sedimentation, a muddy bottom, a considerable depth of water, or a combination of these possibilities. The lack of calcareous material could mean that the waters were cool and had a northern source. This is suggested by the fact that the shale contains the ammonite *Cardioceras* which is a northern migrant and that similar *Cardioceras*-bearing shale in Alaska is likewise noncalcareous.

The Jurassic beds exposed near Mineral, Idaho, are of shallow water origin as shown by the presence of Gryphaeas in the basal sandy tuffs and the spat of oysters or Gryphaeas in concretions in the overlying dark-gray shale.

The upper part of the Snowshoe Formation that contains early Callovian ammonites is also considered to be of shallow-water origin as shown by the occurrence of oysters in concretions associated with ammonites or attached to ammonites.

The Trowbridge and Lonesome Formations were deposited very rapidly as shown by their enormous thicknesses, flyschlike characteristics, and the presence almost throughout of ammonites of early Callovian age. The absence of benthonic organisms could be explained by rapid deposition, or considerable depth of water, or both.

AGES AND CORRELATIONS

UNNAMED BEDS IN NORTHEASTERN OREGON AND ADJOINING IDAHO

Five small ammonites belonging to the genus *Cardioceras* were obtained at one spot from black shale exposed on the Idaho side of the Snake River Canyon near the northeastern corner of Oregon (USGS Mesozoic loc. 28652). These ammonites are identical with the inner whorls of *Cardioceras* (*Scarburgiceras*) *martini* Reeside (1919, p. 27, 28, pl. 9, figs. 5–8) from the basal part of the Naknek Formation in the Cook Inlet region, Alaska. In that region *Cardioceras* occurs directly below beds containing the ammonite *Amoeboceras* and the pelecypod *Buchia concentrica* (Sowerby) of late Oxfordian to early Kimmeridgian age.

The genus *Cardioceras* in northwest Europe occurs in the lower part of the Oxfordian stage (zones of *Quenstedtoceras mariae* to *Perisphinctes plicatilis* inclusive). The subgenus *Scarburgiceras* is characteristic of the European zone of *Quenstedtoceras mariae* (Arkell, 1941, p. lxxvii) but ranges higher into the lower part of the zone of *Cardioceras cordatum* (Arkell, 1956, p. 548).

The presence of beds of early Oxfordian age in the Snake River Canyon is interesting because beds of that age have not hitherto been identified faunally in California, Oregon, Washington, or western Idaho. They are widespread, however, in the western interior of the United States (Reeside, 1919) and in western Canada including many places in western British Columbia (Frebold, 1957, p. 29, 30; Frebold and others, 1959, p. 1–11).

UNNAMED BEDS NEAR MINERAL, IDAHO

Some ammonites reported by D. C. Livingston (1932, p. 33, 34) to be from dark shale exposed in the canyon of Dennett Creek near Mineral include *Xenocephalites vicarius* Imlay, *Lilloettia buckmani* (Crickmay), and *L.* cf. *L. mertonyarwoodi* Crickmay.

Another collection of ammonites (USGS Mesozoic loc. 28651) from shale exposed in a roadcut near the junction of the road along Dennett Creek with a road up the North Fork includes *Xenocephalites* cf. *X. vicarius* Imlay, *Lilloettia*? sp., and *Cobbanites* sp. juv.

These ammonites are identical with those from the Trowbridge Formation and with some of the ammonites from the upper part of the Snowshoe Formation of east-central Oregon. As in those formations, *Xenocephalites* and *Lilloettia* provide correlation with the lower third of the Chinitna Formation of Alaska which is correlated with the lower Callovian of Europe (Imlay, 1953b, p. 51–53).

The sandy tuffaceous beds underlying the dark shale at Dennett Creek appear to be of Jurassic age and probably are not much older than the shale. This is indicated by the gradational contact between the shale and tuffaceous beds and by the presence of many specimens of *Gryphaea* of post-Triassic aspect in the upper part of the tuffaceous beds.

The only recorded specimens of Triassic *Gryphaea*, according to Cox (1952, p. 79), are from the Upper Triassic beds of northern Italy (Scalia, 1912, p. 21–23, pl. 2, figs. 6–21) and from Bear Island (Bäreninsel) near Spitzbergen (Böhm, 1903, p. 16, 17, pl. 1, figs. 35–41, 44–46, 49–54; Frebold, 1951, p. 74). The specimens from those places do not bear sulci on the left valve as do many Jurassic Gryphaeas, and they are less than an inch in height, which dimension is much less than in normal Jurassic Gryphaeas. They are placed in *Gryphaea* because of their strongly convex left valve and incurved beak.

In contrast with these Triassic species, the species of *Gryphaea* from Dennett Creek, Idaho, is comparable in size and ornamentation with Jurassic species. In particular it resembles *G. calceola* Quenstedt from the lower Bajocian (Aalenian) of Europe (Quenstedt, 1858, pl. 48, figs. 1–3) and from the Bajocian to Callovian of Argentina (Gottsche, 1878, pl. 5, figs. 17 a, b, 18 a–c; Weaver, 1931, pl. 19, fig. 93).

SNOWSHOE FORMATION OF LUPHER, 1941, IN EAST-CENTRAL OREGON

The upper part of the Snowshoe Formation in the Izee area, as mapped by W. R. Dickinson (1962a, p. 253), has furnished the ammonites (table 2) *Lytoceras*? sp., *Calliphylloceras* sp., *Xenocephalites vicarius* Imlay, *Lilloettia* cf. *L. buckmani* (Crickmay), *L.* sp., *Kepplerites* (*Gowericeras*) cf. *K.* (*G.*) *torrense* (McLearn), *Parareineckeia* cf. *P. hickersonensis* Imlay, *Cobbanites* cf. *C. talkeetnanus* Imlay, and *Choffatia* (*Loboplanulites*) cf. *C.* (*L.*) *ceralis* Arkell.

These fossils were collected from concretions in thin-bedded mudstone and siltstone about 500–1,000 feet below the unconformable upper contact with the Trowbridge Formation (written communication from W. R. Dickinson, May, 1963). Most of the fossils were obtained at or near the top of a divide between Antelope Creek and Rosebud Creek in sec. 14, T. 17 S., R. 28 E. (USGS Mesozoic loc. 26778).

Of the ammonite genera listed, *Xenocephalites*, *Lilloettia*, and *Kepplerites* are good evidence of a Callovian age, whereas *Parareineckeia*, *Cobbanites*, and *Choffatia* indicate a Bathonian to Callovian age. *Xenocephalites* has been recorded from beds of early Callovian age in Alaska (Imlay, 1953b, p. 51–53, 78, 79; 1962a, p. C3), in the western interior of Canada (Frebold,

TABLE 2.—*Geographic distribution of Upper Jurassic mollusks in east-central Oregon and western Idaho*

[Numbers 1–19 refer to those in figs. 1–3. Most of the larger numbers refer to Mesozoic collections in the U.S. Geol. Survey. Collections referred to Livingston and Lupher are at the California Acad. of Sci. Collections referred to Dickinson are at Leland Stanford Junior Univ.]

	Idaho					Oregon																								
	Nez Perce County	Washington County				Grant County																			Harney County					
	Snake River Canyon	Mineral area				Izee area																			Sawtooth Creek quadrangle					
	Unnamed beds					Snowshoe formation of Lupher, 1941					Lonesome formation of Lupher, 1941						Trowbridge formation of Lupher, 1941								Lonesome formation of Lupher, 1941					
	1	2			3	4	5		6	7	8	9	10	11	12	13	14								15	16	17	18	19	
	28652	Livingston 88	20389	27582	28651	27367	26778	26779	27368	27369	26782	26781	27372	Dickinson F 124	27373	27383	Lupher 129a	Lupher 129b	Lupher 130	Lupher 131	Lupher 132	Lupher 139	Dickinson F 121	Dickinson F 122	26780	28376	28668	28667	28666	28377
Ostrea sp.							×		×	×																				
Gryphea sp.		×	×	×																										
Posidonia ornati Quenstedt							×																						×	
Phylloceras sp.																										×				×
Calliphylloceras sp.							×																							
Lytoceras? sp.									×																					
Xenocephalites vicarius Imlay		×					×							×												×				
cf. *X. vicarius* Imlay					×						×																		×	
? sp.												×	×		×	×		×			×									
Lilloettia buckmani (Crickmay)		×															×					×	×							
cf. *L. buckmani* (Crickmay)							×																							
cf. *L. mertonyarwoodi* (Crickmay)		×																	×	×										
cf. *L. stantoni* Imlay																										×				
sp.								×															×							
? sp.					×	×							×		×														×	
Kepplerites (*Gowericeras*) cf. *K.* (*G.*) *torrensi* (McLearn)							×			×								×						×						
? sp.							×		×																					
Pseudocadoceras? sp.																									×			×		
Cardioceras (*Scarburgiceras*) *martini* Reeside	×																													
Parareineckeia cf. *P. hickersonensis* Imlay							×																							
Cobbanites aff. *C. talkeetnanus* Imlay							×			×																				
Cobbanites sp. juv.					×																								×	
? sp.									×																		×			
Choffatia (*Loboplanulites*?) cf. *C.* (*L.*) *cerealis* Arkell							×																							

1957, p. 3, 24, 58, 59) and the United States (Imlay, 1953a, p. 6, 8, 18, 19), in southern Mexico (Burckhardt, 1927, p. 33, pl. 16, figs. 4–9), and in Argentina (Stehn, 1924, p. 86–88, 92). The recorded occurrence of *Xenocephalites* from beds of Bathonian age in East Greenland (Spath, 1932, p. 45, 133) is erroneous according to Calloman (1959, p. 507) who says that the specimen assigned to *Xenocephalites* by Spath (1932, p. 44) is a septate nucleus of *Cranocephalites*. One ammonite fragment questionably assigned to *Xenocephalites* (Imlay, 1962a, p. C22) has been found in western Montana in beds of probable late Bathonian age.

Lilloettia has been recognized to date only in beds of early to middle Callovian age in Alaska (Imlay, 1953b, p. 50, 52–54, 75–78) and western British Columbia (Crickmay, 1930, p. 60–62) and in beds of early Callovian age in Montana (Imlay, 1953a, p. 18).

Kepplerites and its subgenera, *Seymourites* and *Gowericeras*, occur in beds of early Callovian to early middle Callovian age in Alaska (Imlay, 1953b, p. 51–53, 95–99), in the Queen Charlotte Islands (McLearn, 1929, p. 4–12), in western Alberta (Frebold, 1957, p. 63, 64), in Montana (Imlay, 1953a p. 6–8, 25–28), and in East Greenland (Spath, 1932, p. 138, 139, 145, 146; Calloman, 1959, p. 508, 509). In northwest Europe *Kepplerites* ranges through the entire Lower Callovian (Calloman, 1955, p. 255, 1959, p. 511; Arkell, 1953, p. 117, 119). Calloman (1959, p. 507–511) noted, also, that the lowest occurrence of *Kepplerites* in Greenland is of latest Bathonian age, apparently on the basis that the overlying beds, belonging to the *Kepplerites tychonis* zone, contain the same species of *Kepplerites* as occur in the *Macrocephalites macrocephalus* zone of Europe.

Parareineckeia has been found previously only in south-central Alaska, associated in the lower part of its range with ammonites of probable late Bathonian age (Imlay, 1962a, p. C20, C25, C26) and associated in the upper part of its range with ammonites of early Callovian age (Imlay, 1953b, p. 54, 101, 102; 1962a, p. C26). The species of *Parareineckeia* from the upper part of the Snowshoe Formation closely resembles the species of probable Bathonian age from Alaska.

Cobbanites has been found previously in southcentral Alaska, in western Alberta, and in western Montana. In Alaska it occurs in the basal part of the Chinitna Formation of early Callovian age (Imlay, 1953a, p. 33) and in underlying beds of probable Bathonian age (Imlay, 1962a, p. C27). In Alberta it includes *"Procerites" engleri* Frebold (1957, p. 65, pl. 39, fig. 1, pl. 40, figs. 1a, b) which is associated with other ammonites, such as *Kepplerites* and *Xenocephalites* of early Callovian age (Frebold, 1957, p. 21, 23) in a 4-foot bed characterized by *Gryphaea impressimarginata* McLearn. In Montana, *Cobbanites* occurs in the upper part of the Sawtooth Formation of probable late Bathonian age (Imlay, 1962a, p. C27, C28) and in the lower part of the Rierdon Formation of early Callovian age (Imlay, 1953a, p. 33, pl. 23, figs. 13, 17, pl. 24, figs. 9–11) associated with *Gryphaea impressimarginata* McLearn. The highest occurrences in the Rierdon Formation are in beds containing *Kepplerites* (*Gowericeras*) and *Gryphaea nebrascensis* Meek and Hayden which is stratigraphically higher than the beds containing *Gryphaea impressimarginata* McLearn.

The ammonite *Choffatia* is reported by Arkell (1958, p. 211) to range from middle Bathonian to middle Callovian in northwest Europe. The Oregon species is assigned to the subgenus *Loboplanulites* Buckman (1925, pl. 596; Arkell, 1958, p. 212) because of its rounded slightly depressed whorl section and its strong widely spaced primary ribs. The subgenus has the same range as the genus but is particularly common in the upper Bathonian of Europe. *Choffatia* "is the only ammonite genus known to pass in strength across the boundary between the Bathonian and the Callovian" (Arkell, 1958, p. 235, 236).

The ranges of the ammonites from the upper part of the Snowshoe Formation show that that part of the formation is of early Callovian age, provided the genera listed actually occur together. Such association cannot be certain, however, as the ammonites were collected from concretions scattered over a considerable area. Therefore, the age of the upper part of the Snowshoe Formation could be partly late Bathonian as well as early Callovian. This does not seem likely but cannot be excluded as a possibility.

In considering the exact age of the upper part of the Snowshoe Formation, the absence of the ammonite *Cadoceras* in the collections may be significant because that genus in Alaska is very common in the Chinitna and Shelikof Formations of early to middle Callovian age (Imlay, 1953b, p. 50–54). Its absence in the upper part of the Snowshoe Formation might be explained by unfavorable ecological conditions, by insufficient collecting, or by deposition of the Snowshoe Formation before *Cadoceras* existed, or became common, in the Pacific coast province. The last possibility is suggested by the fact that in the Cook Inlet region, Alaska the upper 600–650 feet of the Bowser Formation underlying the Chinitna Formation contains an early Callovian ammonite assemblage that does not include *Cadoceras* (Imlay, 1962a, p. C3). By comparison, the failure to find *Cadoceras* in the Snowshoe Formation in association with such typical Callovian genera as *Kepplerites*, *Xenocephalites*, and *Lilloettia* suggests that the beds containing those ammonites are not younger than earliest Callovian.

The presence of fossils of late Bathonian (?) to early

Callovian age in the upper part of the Snowshoe Formation is interesting because the lower and middle parts of the formation have furnished ammonites of late Toarcian to middle Bajocian age (see list in Imlay, 1959, p. 105), but none of late Bajocian age or of definite Bathonian age such as occur in south-central Alaska (Imlay, 1962a and 1962b). Failure to find fossils of those ages in Oregon may be a result of poor exposures, or inadequate time spent collecting, or absence of beds. A disconformity would be difficult to detect in the Snowshoe Formation because it consists of a repetitious sequence of soft thin-bedded mudstone, siltstone, and sandstone that weathers easily into rounded surfaces that are generally covered with soil and vegetation. The presence of a disconformity is suggested by the fact that as yet there is no definite faunal evidence for the presence of the late Bajocian or the Bathonian in the Pacific coast region south of the Cook Inlet region, Alaska.

TROWBRIDGE FORMATION OF LUPHER, 1941, IN EAST-CENTRAL OREGON

The middle and lower middle parts of the Trowbridge Formation cropping out near Flat Creek in sec. 15, T. 18 S., R. 27 E., Grant County, have furnished the ammonites (table 2) *Xenocephalites*? sp., *Lilloettia buckmani* (Crickmay), *L.* cf. *L. mertonyarwoodi* Crickmay, *L.* sp., and *Kepplerites* (*Gowericeras*) cf. *K.* (*G.*) *torrensi* (McLearn).

These ammonites by comparison with the Jurassic faunas of Alaska (Imlay, 1953b, p. 50–54) are of early to early middle Callovian age. They differ from the assemblage in the upper part of the Snowshoe Formation by lacking such genera as *Paraeineckeia*, *Cobbanites*, and *Choffatia* that could be of Bathonian age. Their presence shows that the Trowbridge Formation is nearly of the same age as the upper part of the Snowshoe Formation.

LONESOME FORMATION OF LUPHER, 1941, IN EAST-CENTRAL OREGON

The Lonesome Formation has yielded some ammonites at places throughout its great thickness but most of them are wretchedly preserved and many cannot be identified generically. An abundance of ammonites was found only at USGS Mesozoic localities 28666 and 28376. The fossils present include (table 2) *Phylloceras* sp., *Xenocephalites vicarius* Imlay, *X.* cf. *X. vicarius* Imlay, *X.*? sp., *Lilloettia* cf. *L. stantoni* Imlay, L.? sp., *Pseudocadoceras*? sp., *Cobbanites* sp. juv., *C.*? sp., *Posidonia ornati* Quenstedt.

In the Izee area, fragments assigned questionably to *Xenocephalites* and *Lilloettia* were obtained in the middle and upper parts of the 10,000 feet of the Lonesome Formation exposed along the South Fork of the John Day River between Antelope Creek and Lewis Creek. One specimen referred to *Xenocephalites*? was found within 300 feet of the top of that sequence (USGS Mesozoic loc. 27383). *Xenocephalites* cf. *X. vicarius* Imlay was collected within 1,250–1,500 feet of the base of the formation in a roadcut near Antelope Creek (USGS Mesozoic loc. 26782). *X. vicarius* Imlay was collected about 4,000 feet above the base of the formation in an outcrop on the South Fork about 3,000 feet southeast of the mouth of Antelope Creek (USGS Mesozoic loc. 26781).

Elsewhere in the Izee area, some crushed limonitic molds, probably representing immature forms of *Pseudocadoceras*, were collected on the south side of Flat Creek near the middle of the Lonesome Formation (USGS Mesozoic loc. 26780).

In the Sawtooth Creek quadrangle, south of the Izee area, the Lonesome Formation has furnished *Xenocephalites vicarius* Imlay, *Lilloettia* cf. *L. stantoni* Imlay, *Cobbanites* sp. juv., and *Pseudocadoceras*? sp. The stratigraphic position of these ammonites within the formation is unknown.

These ammonites by comparison with the Jurassic faunas in Alaska and Europe (Imlay, 1953b, p. 50–54) show that the Lonesome Formation is mostly or entirely of early Callovian age. The presence of *Xenocephalites* is excellent evidence for an early Callovian age. *Lilloettia* occurs with *Xenocephalities* in Alaska but ranges a little higher into beds that probably correspond to the early middle Callovian (*Kosmoceras jason* zone) of Europe (Imlay, 1953b, p. 52, 53). *Cobbanites* has not been found in beds younger than early Callovian (Imlay, 1962a, p. C27, C28). *Pseudocadoceras* in Europe ranges through most of the Callovian (Calloman, 1955, p. 255) but is absent in the basal zone of *Macrocephalites macrocephalus* and in the highest Callovian. In Alaska it is likewise missing from the lowest 1,800 to 2,500 feet of the Callovian sequence as discussed elsewhere (Imlay, 1962a, p. C6).

On the basis of the ranges of these ammonites, the entire Lonesome Formation exposed along the South Fork near Izee is of early Callovian age because it contains *Xenocephalites*, or fragments probably belonging to that genus, throughout most of its thickness. The presence of *Lilloettia*? at two places in association with *Xenocephalites*? is not evidence for a middle Callovian age considering that the two genera are normally associated in Alaska only in beds of early Callovian age.

Likewise, most of the collections from the Lonesome Formation in the Sawtooth Creek quadrangle are of early Callovian age on the basis of the presence of

Xenocephalites in association with *Lilloettia* or with *Cobbanites*.

The only collections that could be of middle Callovian age are those containing questionable *Pseudocadoceras* from south of Flat Creek (USGS Mesozoic loc. 26780) and from the Sawtooth Creek quadrangle (USGS Mesozoic loc. 28667). *Pseudocadoceras* by itself, however, is not evidence for an age younger than late early Callovian (zone of *Sigaloceras calloviense*).

An early Callovian age assignment for the Lonesome Formation is rather astonishing considering its enormous thickness and that ammonites of the same age occur in the Trowbridge Formation and in the upper part of the Snowshoe Formation. Evidently sedimentation in east-central Oregon was exceedingly rapid during Callovian time. Such rapid sedimentation may account for the absence of benthonic organisms except for some small oysters that were found in concretions in the upper part of the Snowshoe Formation.

COMPARISONS WITH OTHER FAUNAS

ALASKA AND WESTERN BRITISH COLUMBIA

The Upper Jurassic (Callovian and Oxfordian) ammonites from east-central Oregon and westernmost Idaho, described herein, are identical or closely similar to species from western British Columbia, the Alaska Peninsula, and the Cook Inlet region, Alaska.

Among the Callovian ammonites, *Lilloettia buckmani* (Crickmay) occurs elsewhere in the Mysterious Creek Formation in the Harrison Lake area, British Columbia (Crickmay, 1930, p. 62, pl. 20, figs. 1–4), in the lower two-thirds of the Chinitna Formation in the Cook Inlet region, Alaska, and in the lower member of Shelikof Formation on the Alaska Peninsula (Imlay, 1953b, p. 50). *Xenocephalites vicarius* Imlay occurs in the lower third of the Chinitna Formation (Imlay, 1953b, p. 50) and in the upper part of the underlying Bowser Formation in Alaska. *Kepplerites* (*Gowericeras*) occurs in the lower half of the Chinitna Formation, Alaska (Imlay, 1953b, p. 50), and in the upper part of the Yakoun Formation in the Queen Charlotte Islands (McLearn, 1929, p. 10, 11). The Oregon specimens of *Parareineckeia* and *Cobbanites* resemble species from the Bowser Formation in Alaska (Imlay, 1962a, p. C25–C27), although similar species occur in the lower part of the Chinitna Formation (Imlay, 1953b, p. 102) and in the lower part of the Shelikof Formation (Imlay, 1953b, p. 101). The genus *Parareineckeia* has been found only in Alaska and Oregon. *Cobbanites* has been found in these States and in the western interior of North America.

The ammonites of early Oxfordian age from the canyon of the Snake River in Idaho are identified with *Cardioceras* (*Scarburgiceras*) *martini* Reeside (1919, p. 27), which until now has been found only in the basal part of the Naknek Formation in the Cook Inlet region, Alaska.

CALIFORNIA

The beds of Callovian age in eastern Oregon and western Idaho have very little in common faunally with the Upper Jurassic of California. The presence of *Kepplerites* (*Gowericeras*) in the Snowshoe and Trowbridge Formations in east-central Oregon is comparable with the occurrence of the subgenus in the Colfax Formation of Smith near Colfax, Calif. (Imlay, 1961, p. D6, D7). The presence of *Pseudocadoceras*? at two localities in the Lonesome Formation is possibly comparable with some of the occurrences of *Pseudocadoceras* in California (Imlay, 1961, p. D5, D6, D9). *Xenocephalites* has not been identified definitely in California, although it is possibly present in the Taylorsville area (Imlay 1961, p. D9). The species of *Choffatia* from the Snowshoe Formation in Oregon belongs to a different subgenus than *Choffatia hyatti* (Crickmay) (1933, p. 901, 913, 914; Imlay, 1961, p. D9) from the North Ridge Formation of Crickmay in the Taylorsville area. The Callovian beds of California have furnished such ammonites as *Cadoceras*, *Peltoceras*, and *Grossouvria* that have not yet been found in Oregon or in western Idaho.

This paucity of faunal resemblances between the Callovian of Oregon and California is not evidence, however, that the faunas lived in different basins or provinces. Actually the lowest beds of Callovian age in California have furnished very few ammonites. Most of the Callovian ammonites from higher beds, such as the Logtown Ridge Formation and the Foreman Formation, indicate ages ranging from late early Callovian (*Sigaloceras calloviense* zone) to late Callovian (Imlay, 1961, p. D5–D9). In contrast most of the Callovian ammonites from eastern Oregon and western Idaho indicate an early Callovian age not younger than the *Sigaloceras calloviense* zone of Europe. The evidence for that zone, or for the middle Callovian is very weak as it consists only of fragmentary ammonites that are described herein, questionably as *Pseudocadoceras*. To date no faunal evidence has been found for the presence of beds of early Oxfordian age in California, or in southwestern Oregon, although ammonites of late Oxfordian age have been found in both places (Imlay, 1961, p. D7–D8, pl. 4, fig. 2).

WESTERN INTERIOR OF NORTH AMERICA

Beds of early Callovian age in the western interior of the United States and Canada have not furnished any specimens of *Parareineckeia*, *Choffatia*, and *Pseudocadoceras* which occur in beds of that age on the Pacific coast. They have furnished a few specimens of *Xenocephalites* (Imlay, 1953a, p. 6, 18, 19; Frebold, 1957, p. 58), *Lilloettia* (Imlay, 1953a, p. 6, 18), and *Cobbanites* (Imlay, 1962a, p. C26–C28) which are fairly common in beds of early Callovian age on the Pacific coast. The presence of these genera suggests a marine connection westward during Callovian time with marine waters in the Pacific coast region. Nevertheless, the early Callovian ammonite faunas of the two regions have few, if any, species in common, contain different associations of genera and subgenera, and some of the ammonite genera that are common in one region are rare or have not been found in the other (Imlay, 1953a, p. 8; 1953b, p. 54, 55).

These distinctions between the Callovian faunas of the two regions could reflect barriers, or ecological differences, or the presence of disconformities in one region not present in the other, or combinations of these possibilities as has been discussed by Frebold (1957, p. 27).

Beds of Oxfordian age are widespread in the western interior of the United States (Imlay 1952, p. 964, 965, 968) and Canada (Frebold, 1953; 1957, p. 27–31). They are characterized by the ammonite genus *Cardioceras* (Reeside, 1919; Frebold and others, 1959) of which some species resemble *Cardioceras* (*Scarburgiceras*) *martini* Reeside from Alaska. Evidence for direct marine connection of the Oxfordian sea of the western interior region of Canada with a sea in the Pacific coast region through British Columbia has been postulated and discussed by Frebold (1957, p. 31; Frebold and others, 1959, p. 16). Direct marine connections westward from the western interior region of the United States seems unlikely considering that the marine beds of early Oxfordian age become sandier westward (Imlay and others, 1948; Imlay, 1957, p. 481, 482; 1956, p. 595–598).

GEOGRAPHIC DISTRIBUTION

The occurrence by area and locality of the fossils described herein are indicated in table 2. The positions of the areas are shown in figures 1–3. Detailed descriptions of the individual localities are given in the following table.

Descriptions of upper Jurassic fossil localities in east-central Oregon and western Idaho

No. on figs. 1-3	Geological Survey Mesozoic localities	Collector's field numbers	Collector, year of collection, description of locality, and stratigraphic assignment
1	28652	F-12	R. F. Morrison, R. W. Imlay, and H. C. Brooks, 1961 and 1962. From black hard mudstone ¾ mile S. 80° E. of mouth of Slate Creek, 1¼ miles N. 5° W. of mouth of Cottonwood Creek and ⅛ mile east of Snake River on north side of small creek. Probably in NW¼ sec. 8, T. 30 N., R. 4 W. (unsurveyed). Nez Perce County, Idaho. Unnamed beds about 400 feet above top of Triassic.
2		88	D. C. Livingston. Collected prior to 1932. Label states "from shales in Snake River Canyon near Mineral, Idaho." Livingston (1932, p. 34) stated that the collection was made in the canyon of Dennett Creek near Mineral, Idaho.
2	20389		W. R. Wagner, 1945. North Fork of Dennett Creek, NW¼ sec. 9, T. 14 N., R. 6 W., Washington County, Idaho. From tuffaceous sandstone.
2	27582		R. W. Imlay, N. S. Wagner, and H. C. Brooks, 1959. East side of North Fork of Dennett Creek, about 320 ft above streambed, in NE¼NW¼ sec. 9, T. 14 N., R. 6 W., Washington County, Idaho. From tuffaceous sandstone overlying rhyolite exposed below mine tunnels.
3	28651		R. W. Imlay, and H. C. Brooks, 1962. From cut on road up North Fork of Dennett Creek near junction with road up main Dennett Creek just below abandoned mining town of Mineral near center of SW¼NW¼ sec. 9, T. 14 N., R. 6 W., Washington County, Idaho. Unnamed beds.
4	27367	I58-8-27C	R. W. Imlay, 1958. Black concretions in SW¼NW¼SE¼ sec. 14, T. 17 S., R. 28 E., Grant County, Oreg. Snowshoe Formation. Estimated 3,000–3,500 ft above base in area of complex minor folding.
5	26778	F115(3–48–1)	W. R. Dickinson and R. W. Imlay, 1957. From black concretions about 500–750 ft northeast of road on divide between Antelope Creek and Rosebud Creek in S½SW¼ sec. 14, T. 17 S., R. 28 E., Grant County, Oreg. Snowshoe Formation. Estimated 3,000–3,500 ft above base in area of complex minor folds. Poorly exposed.
5	26779	F115(3–48–2)	W. R. Dickinson and R. W. Imlay, 1957. Black concretions on hillside about 600 ft north of Mesozoic loc. 26778. Snowshoe Formation. Estimated 3,000–3,500 ft above base. Poorly exposed.
6	27368	I58-8-28A	R. W. Imlay, 1958. Black concretions on east side of Rosebud Creek southeast of mouth of Caps Creek in SW¼NW¼SW¼ sec. 15, T. 17 S., R. 28 E., Grant County, Oreg. Snowshoe Formation. Estimated 2,500–3,000 ft above base in area of complex minor folding. Poorly exposed.
7	27369	I58-8-28B	R. W. Imlay, 1958. Black concretions on east side of Rosebud Creek just east of old farm house in NE. cor. sec. 21, T. 17 S., R. 28 E., Grant County, Oreg. Snowshoe Formation, near top. Estimated 2,500–3,000 ft above base in area of complex minor folding.
8	26782	F125	R. W. Imlay, 1957. In roadcut on Antelope Creek about 1¼ miles by road southwest of Emil Hyde ranch house in SE. cor. NW¼ sec. 27, T. 17 S., R. 28 E., Grant County, Oreg. Lonesome Formation, 1,250–1,500 ft above base.

Descriptions of upper Jurassic fossil localities in east-central Oregon and western Idaho—Continued

No. on figs. 1-3	Geological Survey Mesozoic localities	Collector's field numbers	Collector, year of collection, description of locality, and stratigraphic assignment
9	26781	F123(1–44–1)	W. R. Dickinson, 1957. Interbedded massive graywacke and black mudstone on west bank of South Fork of John Day River about 3,000 ft southeast of mouth of Antelope Creek in SW¼SW¼ sec. 34, T. 17 S., R. 28 E., Grant County, Oreg. Lonesome Formation, about 4,000 ft above base.
10	27372	I58–9–1B	R. W. Imlay and Reed Christner, 1958. Roadcut near bend in South Fork of John Day River about 1 mile below mouth of Antelope Creek in SW. cor. sec. 34, T. 17 S., R. 28 E., Grant County, Oreg. Lonesome Formation, near middle of sequence exposed between Antelope Creek and Lewis Creek, about 4,000 ft above base of formation.
11		F124(3–44–3) of Dickinson.	L. W. Vigrass, 1956. On the crest of highest hill near north edge of the NE¼ sec. 3, T. 18 S., R. 28 E., Grant County, Oreg. Lonesome Formation, about 7,000 ft above base.
12	27373	I58–9–1c	R. W. Imlay and Reed Christner, 1958. Near beginning of big bend in South Fork of John Day River, south-central part of NW¼ sec. 3, T. 18 S., R. 28 E., Grant County, Oreg. Lonesome Formation, about 8,000 ft above base and about 1,500 ft below highest beds in Lonesome syncline.
13	27383	I58–9–13	R. W. Imlay, 1958. On road up hill from the South Fork road to the Old Borg Ranch about 300 ft below top of ridge marked by trough of the Lonesome syncline. East-central part of sec. 3, T. 18 S., R. 28 E., Grant County, Oreg. Lonesome Formation, near top of sequence exposed between Antelope Creek and Lewis Creek, about 9,500 ft above base of formation.
14		129a	R. L. Lupher, 1930. On north side of Flat Creek above mouth of Spoon Creek and about 200 ft above creek level. Probably a little east of center of sec. 15, T. 18 S., R. 27 E., Grant County, Oreg. Trowbridge Formation, estimated 1,000–1,250 ft above base.
14		129b	R. L. Lupher, 1937. Probably same as loc. 129a. Location is 800 ft upstream from junction of Flat Creek and the main tributary along north side of a prominent ridge in the Spoon Creek basin. This tributary is separated from Spoon Creek by a small gully and a fairly large gully. Trowbridge Formation, lower part. Estimated 1,000–1,250 ft above base.
14		130	R. L. Lupher, 1937. From next spur east of loc. 129b. Trowbridge Formation, higher than loc. 129b. Estimated 1,500 ft above base of formation.
14		131	R. L. Lupher, 1937. North side of Flat Creek about midway between loc. 129b and first main tributary of Flat Creek that comes in from the west below Big Flat. Trowbridge Formation, probably near middle. Estimated 1,500 ft above base of formation.
14		132	R. L. Lupher, 1937. Next gully to northwest of loc. 131. Trowbridge Formation, lower part, about 300 ft stratigraphically below green sandstone that overlies concretionary shale. Estimated 1,250 ft above base of formation.
14		139	R. L. Lupher, 1937. Near top of shale exposures on north side of Flat Creek at either loc. 131 or 132. Trowbridge Formation.
14		F121 (8–10–1 and 8–10–2) of Dickinson.	S. W. Muller, R. W. Imlay, W. R. Dickinson, L. W. Vigrass, John Beeson, 1956. On slope north of Flat Creek near center of sec. 15, T. 18 S., R. 27 E., Grant County, Oreg. Trowbridge Formation, about 1,000 ft above base.
14		F122 (8–10–3) of Dickinson.	S. W. Muller and others, 1956. Near loc. F121 described above. Estimated 1,250 ft above base of Trowbridge Formation.
15	26780	DDV (4–82–20)	John Beeson, 1957. About half a mile south of Flat Creek in SW¼ sec. 18, T. 18 S., R. 28 E., Grant County, Oreg. Lonesome Formation.
16	28376	B–94	Marvin Beeson, Richard Bateman, and R. W. Imlay, 1961. South side of road near junction of Bear Creek and a small tributary. In NW¼NW¼ sec. 4, T. 19 S., R. 29 E., Sawtooth Creek quadrangle, Harney County, Oreg. Lonesome Formation, near top.
17	28668		Marvin Beeson, 1959. Center of NE. cor. sec. 16, T. 19 S., R. 28 E., Sawtooth Creek quadrangle, Harney County, Oreg. Lonesome Formation.
18	28667		Marvin Beeson, 1959. On road from Sawtooth Creek to Yellowjacket Creek in SE. cor. sec. 25, T. 19 S., R. 28 E., Sawtooth Creek quadrangle, Harney County, Oreg. Lonesome Formation, near middle.
19	28666	B–87	Marvin Beeson and R. L. Bateman, 1959. Light colored tuff near Sawtooth Creek in SE¼NW¼ sec. 13, T. 20 S., R. 28 E., Sawtooth Creek quadrangle, Harney County, Oreg. Lonesome Formation, near middle of lower third.
19	28377	B–87	Marvin Beeson, 1960. On east side of Sawtooth Creek in center of sec. 13, T. 20 S., R. 28 E., Sawtooth Creek quadrangle, Harney County, Oreg. Lonesome Formation.

SYSTEMATIC DESCRIPTIONS

Family OSTREIDAE Lamarck
Genus OSTREA Linné, 1758

Ostrea sp.

The genus *Ostrea* is represented by 20 fragmentary specimens from the upper part of the Snowshoe Formation. Most of them are small and all are nondescript. All were obtained from concretions and most of them were attached to molds of ammonites. It seems probable that the ammonites or the concretions served as relatively hard objects on the sea floor on which the spat of oysters could start to grow.

Occurrences: Showshoe Formation, upper part, at USGS Mesozoic locs. 26778, 27368, and 27369.

Genus GRYPHAEA Lamarck, 1801

Gryphaea culebra Imlay, n. sp.

Plate 1, figures 1–21

The species is represented in the Geological Survey collections by 48 specimens from Dennett Creek, Idaho.

The outline of the shell is elongate ovate on the young but becomes trigonal on the largest specimens. The height exceeds the length but becomes relatively shorter during growth. The left valve is strongly convex, its umbone is strongly incurved, and its beak is deflected posteriorly. The posterior margin is concave and is generally extended basally. The anterior margin is also concave but less so than the posterior. Most left valves bear both posterior and anterior sulci that delimit narrow posterior and anterior lobes. Generally the posterior sulcus is deeper than the anterior sulcus and develops earlier. On a few left valves the anterior sulcus is deeper than the posterior sulcus. On still other left valves the anterior sulcus is very weak. The surface is marked by weak growth lamellae that bend dorsally where they cross the sulci. In addition several specimens bear weak radial striae on the umbones. The right valve is slightly concave, subovate in outline, and bears fine growth lamellae.

The dimensions in millimeters of several specimens are as follows:

Specimen	Length	Height	Inflation of left valve
Holotype USNM 132346	38	43	17
Paratype USNM 132348	34	44	20
Paratype USNM 132356	33	44	19

The Idaho species is characterized by its left valve developing both posterior and anterior sulci, a trigonal outline, concave posterior and anterior margins, an extension of the basal margin posteriorly, and in some shells, an extension of the basil margin anteriorly.

The specimens bearing the weakest anterior sulcus have some resemblance to the European Bajocian species *Gryphaea calceola* Quenstedt (1858, pl. 48, figs. 1–3) but are much shorter and are trigonal rather than ovate in outline. Some South American specimens that have been compared or referred to *G. calceola* Quenstedt (Gottsche, 1878, pl. 5, figs. 17 a, b, 18 a–c; Burckhardt, 1900, pl. 22, figs. 14–16; Weaver, 1931, pl. 19, fig. 93) have a very weak anterior sulcus on the left valve, but this sulcus is much less developed than in the Oregon species. Also, the shape of the South American specimens is elongate ovate, as in European specimens of *G. calceola* (Quenstedt).

Well-developed anterior and posterior sulci as on the Idaho species are found on several South American Jurassic species (Gottsche, 1878, pl. 4, figs. 12a, b; Phillipe, 1899, pl. 5, figs. 2a–c, 3) of Bajocian to Callovian age but all differ from the Oregon species by having a sharp umbonal ridge instead of a rounded umbone.

Gryphaea nebrascensis Meek and Hayden (Imlay, 1949, pl. 5, figs. 7, 8), from Callovian beds in the western interior of North America, differs from the Oregon species by its much more elongate shape, narrower umbones, more strongly incurved beak, and generally by an absence of a sulcus on the anterior side of the left valve. Examination of hundreds of specimens resulted in the discovery of only one specimen that had an incipient anterior sulcus.

The Idaho species was once considered by J. B. Reeside, Jr., to belong to the group of *Gryphaea arcuata* Lamarck (written communication to W. R. Wagner dated Sept. 26, 1945) and was the basis for a probable Early Jurassic age assignment (McKee and others, 1956, p. 2). It differs from *G. arcuata* sharply, however, by having an anterior sulcus as well as a posterior sulcus, by being short and trigonal in outline instead of elongate-ovate, by being less inflated, and by its beak being less incurved.

Types: Holotype USNM 132346; paratypes USNM 132347–132356.

Occurrences: USGS Mesozoic loc. 27582 from sandy tuffaceous beds on east side of North Fork of Dennett Creek in NE¼NW¼ sec. 9, T. 14 N., R. 6 W., Washington County, Idaho; Livingston's loc. 88 and Mesozoic loc. 20389 are from the canyon of Dennett Creek and probably from the same place as Mesozoic loc. 27582.

Family POSIDONIIDAE Frech, 1909
Genus POSIDONIA Bronn, 1828

Posidonia ornati Quenstedt

Plate 1, figure 22

(For synonymy see Cox, 1940, Palaeontologia Indica, ser. 9, v. 3, pt. 3, p. 103, 104; Imlay, 1963, Jour. Paleontology, v. 37, p. 102.)

This species is represented in Oregon by one specimen from the upper part of the Snowshoe Formation (USGS Mesozoic loc. 26778) and two specimens from the Lonesome Formation (USGS Mesozoic loc. 28666).

Family MACROCEPHALITIDAE Buckman, 1922

Genus XENOCEPHALITES Spath, 1928

Xenocephalites vicarius Imlay

Plate 1, figures 23–27

Xenocephalites vicarius Imlay, 1953b, U.S. Geol. Survey Prof. Paper 249–B, p. 78, 79, pl. 28, figs. 1–8.

This species is characterized by being moderately compressed for the genus and by its ribbing coarsening markedly on the adult body whorl. On the inner whorls the ribbing is fine dense and nearly radial. On the body whorl the ribs become high, widely spaced, thick ventrally, strongly flexuous on the flanks, and arched forward gently on the venter.

The species is represented by 4 specimens from near Mineral, Idaho, and 27 specimens from east-central Oregon.

Types: plesiotypes USNM 132358; plesiotypes CAS 12543–12545.

Occurrences: Lonesome Formation, USGS Mesozoic loc. 28376 and W. R. Dickinson's loc. F 124. Upper part of Snowshoe Formation at USGS Mesozoic loc. 26778, Oregon. Unnamed beds at Livingston's loc. 88 near Mineral, Idaho. The species is probably represented in the Lonesome Formation, Oregon, at USGS Mesozoic locs. 26782 and 28666 and in unnamed beds near Mineral, Idaho, at USGS Mesozoic loc. 28651 (pl. 1, fig. 28). In addition the Lonesome Formation along the South Fork of the John Day River has furnished fragmentary macrocephalitid ammonites, probably belonging to *Xenocephalites*, at Mesozoic locs. 26781, 27372, 27373 and 27383. The lower part of the Trowbridge Formation near Flat Creek in east-central Oregon has furnished fragments referred questionably to *Xenocephalites* at Lupher's locs. 129b and 132.

Genus LILLOETTIA Crickmay, 1930

Lilloettia buckmani Crickmay

Plate 2, figures 14, 15, 17, 18

Buckmaniceras buckmani Crickmay, 1930, Canada Natl. Mus. Bull. 63, p. 62, pls. 20, figs. 1–4, text fig. 7.

Lilloettia buckmani (Crickmay). Imlay, 1953b, U.S. Geol. Survey Prof. Paper. 249–B, p. 75, pl. 27, figs. 1–9.

This species has the coarsest ribbing of any described species of *Lilloettia* and, next to *L. milleri* Imlay (1935b, p. 75, pl. 28, figs. 11, 13–15, pl. 29, figs. 14, 15), is the most inflated. It is represented by five specimens from near Mineral, Idaho and five specimens from east-central Oregon.

Types: plesiotypes CAS 12540, 12541.

Occurrences: Trowbridge Formation; Lupher's locs. 129a, 139 and Dickinson's loc. F 121(8–10–2), Oregon. Unnamed beds at Livingston's loc. 88 near Mineral, Idaho.

Lilloettia cf. L. mertonyarwoodi (Crickmay)

Plate 2, figures 19, 20

Eight small specimens bear fine closely spaced ribbing similar to that on the immature whorls of *Lilloettia mertonyarwoodi* Crickmay (1930, p. 62, pl. 19, figs. 1, 2; Imlay, 1953b, p. 76, pl. 30, figs. 3, 5–7, 9–11) and *L. lilloetensis* Crickmay (1930, p. 62, pl. 18, figs. 1–4; Imlay 1953b, p. 77, pl. 30, figs. 1, 2, 4, 8). The largest specimen has a fairly stout whorl section, a narrowly arched venter, and converging flanks as in *L. mertonyarwoodi* Crickmay.

Figured specimen: CAS 12542.

Occurrence: Trowbridge Formation, Lupher's locs. 130, 131, Oregon. Unnamed beds, Livingston's loc. 88, near Mineral, Idaho.

Lilloettia cf. L. stantoni Imlay

Plate 2, figures 13, 16

A dozen specimens from one spot in the Lonesome Formation are compared with *Lilloettia stantoni* Imlay (1953b, p. 77, pl. 29, figs. 1–5, 9, 10) rather *L. buckmani* (Crickmay) (1930, p. 62, pl. 20, figs. 1–4) because of their compressed whorl section and because the septate whorls bear high thin ribs that persist on the lower part of the flanks as far as the adapical end of the body chamber.

Figured specimen: USNM 132365.

Occurrence: Lonesome Formation, USGS Mesozoic loc. 28376, Oregon.

Family KOSMOCERATIDAE Haug, 1887

Genus KEPPLERITES Neumayr and Uhlig, 1892

Subgenus GOWERICERAS Buckman, 1921

Kepplerites (Gowericeras) cf. K. (G.) torrensi (McLearn)

Plate 3, figures 1–6, 10

Cf. *Yakouniceras torrensi* McLearn, 1929, Canada Natl. Mus. Bull. 54, p. 10, pl. 8, figs. 3, 4.

The species is represented by five septate molds that retain considerable shell material. The shell is stout and becomes stouter during growth. The coiling is moderately evolute. The whorls are depressed ovate in section, wider than high, and embrace about two-thirds of the preceding whorls. On the smallest specimen available, the flanks and venter are fairly evenly rounded, but during growth the venter becomes broader and flatter and the flanks become more convex. The umbilicus is moderately wide. The umbilical wall is moderately high, vertical at base, and rounds rapidly into the flanks. The body chamber is not preserved.

The small inner whorls, partly exposed in the umbilicus, bear prominent moderately spaced primary ribs that incline forward and terminate in conical tubercles just below the line of involution. On the larger septate whorls the primary ribs gradually become stronger and more widely spaced adorally. The tubercles, situated at about one-third of the height of the flanks, likewise gradually become stronger adorally. From the tubercles on the smallest specimen (pl. 3, fig. 5) arise two or three sharp secondary ribs that are a little weaker than the primary ribs and that incline slightly forward. On the larger specimens the secondary ribs generally arise in bundles of three. In addition many rib bundles are separated by single intercalated ribs that arise near the row of tuberculation. The ribbing is reduced in strength along the midventral line on the smallest whorls at diameters less than 40 mm.

The smallest specimen at a diameter of 67 mm has a whorl height of 22 mm, a whorl thickness of 31(?) mm, and an umbilical width of 19 mm. On the next larger specimen the same dimensions are 71, 25, 38, and 27 mm, respectively. The suture line cannot be traced.

The smallest specimen from Oregon greatly resembles the holotype of "*Yakounoceras*" *torrensi* McLearn (1929, p. 10, pl. 8, figs. 3, 4) from the Queen Charlotte Islands in coiling, whorl shape, and ornamentation but, at a comparable size, has fewer and more widely spaced secondary ribs. It likewise resembles *Kepplerites newcombii* (Whiteaves) (1900, p. 281, pl. 37, figs. 1, la; McLearn, 1929, p. 12, pl. 5, figs. 2–4), but that species has a distinctly flattened venter and its tubercles are lower on the flanks. *Kepplerites* (*Gowericeras*) *snugharborensis* (Imlay) (1953b, p. 99, pl. 53, fig. 9) from Alaska differs from the Oregon specimens in its stronger tubercles and ribs that become more widely spaced during growth. *K.* (*Gowericeras*) *ventrale* (Buckman) (1922, pl. 288) from England has similar ornamentation but differs in its higher whorl section. *K.* (*Gowericeras*) *chillanum* (Buckman) (1923, pl. 404) has weaker tubercles and a much smaller umbilicus.

Figured specimens: Stanford Univ. Paleontology No. 9709; USNM 132366 a, b.

Occurrences: Snowshoe Formation, upper part, USGS Mesozoic locs. 26778 and 27369, Oregon. Trowbridge Formation, lower part, Dickinson's loc. F122, Oregon.

Family CARDIOCERATIDAE Siemiradzki, 1891
Genus PSEUDOCADOCERAS Buckman, 1918

Pseudocadoceras? sp. juv.

Plate 2, figures 6–12

Pseudocadoceras is probably represented at two localities in eastern Oregon by about 40 specimens. Of these one is an external mold that shows part of the venter and flanks (USGS Mesozoic loc. 28667) and is not deformed. The others (USGS Mesozoic loc. 26780) are small limonitic internal molds that are crushed laterally and represent immature growth stages. On the best preserved limonitic molds the outer whorl overlaps about three-fifths of the preceding whorl. The ornamentation consists of sharp ribs that begin near the umbilical suture, incline forward strongly on the flanks, and arch forward on the venter. From ⅓ to ½ of the ribs bifurcate at about the top of the lower third of the flanks. The ribs are sharpest on the lower part of the flank and broadest on the upper half of the flanks. Constrictions are present on several specimens.

These specimens have a general resemblance to immature specimens of *Pseudocadoceras* and particularly to *P. grewingki* (Pompeckj) (Imlay, 1953b, p. 93, pl. 49, figs. 1–12) as shown by the presence of many unbranched ribs. They have a resemblance, also, to immature specimens of *Cadoceras* (*Stenocadoceras*) such as *C.* (*S.*) *multicostatum* Imlay (1953b, p. 90, pl. 44, figs. 6–8, 12). The molds that bear constrictions are coarser ribbed and more evolute than the others and possibly belong to a different genus.

Figured specimens: USNM 132363, 132364.

Occurrence: Snowshoe Formation, upper part, USGS Mesozoic loc. 26780. Lonesome Formation at Mesozoic loc. 28667.

Genus CARDIOCERAS Neumayr and Uhlig, 1881

Cardioceras (Scarburgiceras) martini Reeside

Plate 2, figures 1–5

Cardioceras martini Reeside, 1919, U.S. Geol. Survey Prof. Paper 118, p. 27, pl. 9, figs. 5–8.
Cardioceras (*Anacardioceras*) *martini* Reeside. Maire, 1938, Soc. géol. France, Mém. new ser., v. 15 (Mém. 34), p. 65.
Cardioceras (*Scarburgiceras*) *martini* Reeside. Spath, 1939, Great Britain Geol. Survey Bull., no. 1, p. 84, 85, 92.
Cardioceras (*Scarburgiceras*) *martini* Reeside. Imlay, 1947, Am. Assoc. Petroleum Geologists Bull., v. 31, p. 264.
Cardioceras (*Scarburgiceras*) *martini* Reeside. Arkell, 1946, London, Palaeontographical Soc. p. 306.
Protocardioceras martini (*Reeside*). Schirardin, 1958, Alsace-Lorraine Service Carte Géol. Bull., v. 11, pt. 1, p. 24.

Five small specimens obtained from one spot near the Snake River in west-central Idaho agree very well in shape, coiling, and style of ribbing with the inner whorls of *Cardioceras martini* Reeside (1919, p. 27, pl. 9, figs. 5–8) from the Cook Inlet region, Alaska.

On the Idaho specimens the outer whorl overlaps about half of the preceding whorl. The umbilical wall is low, vertical at its base, and rounds evenly into the flanks. The flanks are flattened and high. The venter is pinched and keeled. The ribs are high and narrow. The primary ribs incline forward slightly on the flanks and about one-third of them bifurcate at or a little below the middle of the flanks. The secondary ribs are weakest along the zone of the furcation and some are indistinctly joined with the primary ribs. All secondary ribs are projected forward strongly in the ventral region and this projection becomes stronger during growth. All secondary ribs weaken near the keel but are continuous with prominent serrations on the keel. One specimen at a diameter of 24 mm has 38 primary ribs and about 54 secondary ribs. Another specimen at a diameter of 22 mm has 34 primary ribs and about 56 secondary ribs.

On the outer whorl of the holotype of *C. martini* Reeside the mode of rib branching is irregular. Many primary ribs bifurcate a little below the middle of the flanks, but many others remain simple. Most of the simple unbranched ribs alternate with short ribs that arise near the middle of the flanks. In addition in a few places the secondary ribs branch above the middle of the flanks, resulting in a trifid bundling of ribs. This feature according to Arkell (1946, p. 306) is not found in any of the Cardioceratid ammonites from England. *C. martini* Reeside was placed by Schirardin (1958, p. 24) in a new genus *Protocardioceras*. That assignment is questioned, however, because of the presence of many simple unbranched ribs in *C. martini*, whereas *Protocardioceras* is defined as having very few simple ribs.

The small specimens of *Cardioceras martini* Reeside from Idaho resemble the small specimens that Reeside (1919, pl. 8, figs. 4–7) referred to *C. cordiforme* (Meek and Hayden) but differ by having finer, straighter, and lower primary ribs, a more strongly pinched venter, and more unbranched ribs. They show even greater resemblance to small specimens of *Cardioceras bukowski* Maire (1938, p. 64, pl. 7, fig., 8; Arkell, 1946, p. 305, text fig. 108–1) and *C.* cf. *C. reesidei* Maire (Arkell, 1946, p. 307, text fig. 108–3 to 5 on p. 305) from northwest Europe but have less strongly projected ribbing on the venter.

Types: holotype USNM 32317; plesiotypes USNM 132360–132362.

Occurrence: Naknek Formation at USGS Mesozoic loc. 8575 (holotype) and 11017, Alaska. Unnamed beds at USGS Mesozoic loc. 28652 in the canyon of the Snake River, Idaho.

Family REINECKEIIDAE Hyatt, 1900

Genus PARAREINECKEIA Imlay, 1962

Parareineckeia cf. P. hickersonensis Imlay

Plate 4, figures 1–6

Cf. *Parareineckeia hickersonensis* Imlay, 1962a, U.S. Geol. Survey Prof. Paper 374–C, p. C–25, pl. 7, figs. 1–6.

One small ammonite from eastern Oregon greatly resembles the inner whorls of *Parareineckeia hickersonensis* Imlay. It differs mainly by being more coronate and by its lateral tubercles not being alternately weak and strong. It has strongly divergent flanks and a broad depressed venter. Its primary ribs are narrow, widely spaced, incline gently forward on the flanks, and terminate at the top of the flanks in prominent round tubercles of variable strength. From the tubercles on the outermost whorl arise two or three ribs, or rarely single ribs that arch forward slightly on the venter and are reduced in strength along the midline of the venter. From the tubercles on the next smallest whorl arise three to four secondary ribs. These cross the venter nearly transversely and are distinctly reduced in strength along the midline.

Figured specimens: USNM 132368.

Occurrence: Snowshoe Formation, upper part, USGS Mesozoic, loc. 26778, Oregon.

Family PERISPHINCTIDAE Steinmann, 1890

Genus COBBANITES Imlay, 1962

Cobbanites aff. C. talkeetnanus Imlay

Plate 4, figures 10–13

The genus *Cobbanites* is represented in the upper part of the Snowshoe Formation, Oregon, by four septate specimens. The whorls are subovate in section, a little wider than high and each whorl embraces about two-fifths of the preceding whorl. The flanks are gently convex and round evenly into the umbilical wall and into the venter. The umbilicus is very wide and shallow; the umbilical wall is low and steeply inclined at its base. The body chamber is unknown.

On the smallest whorls that are preserved (pl. 4, figs. 8, 9), the primary ribs are high, sharp, fairly regularly spaced and are separated by interspaces that are slightly wider than the ribs. They begin near the umbilical seam, incline forward on the flanks, and most of them bifurcate near the middle of the flanks. The secondary ribs are a little weaker than the primary ribs, curve forward on the flanks, and arch forward gently on the venter. Each whorl bears from five to six deep constrictions that incline forward strongly and that are generally bounded by swollen ribs. On whorls at diameters of less than 45 mm the furcation points of the ribs are swollen or weakly tuberculate.

During growth the ribs become weaker, more widely spaced, and less strongly projected forward. On the largest whorl available, the primary ribs are weak and fairly widely spaced. The venter, well exposed only on one specimen, is marked by weakening of the ribs along the midventral line.

The suture line on one specimen is represented by a long, slender irregularly trifid first lateral lobe and part of a retracted suspensive lobe.

This Oregon species differs from *Cobbanites talkeetnanus* Imlay (1962a, p. C–27) from Alaska by having a rounder wider whorl section and somewhat coarser ribbing on its inner septate whorls. Its ribbing compares in coarseness with that of a species of *Cobbanites*, described as *Procerites* sp. (Imlay, 1953b, p. 102, pl. 53, figs. 1–3), from the Chinitna formation of Alaska, and it could belong to that species. *"Procerites"* sp. from the Rierdon formation of Montana (Imlay, 1953a, p. 33, pl. 23, figs 13, 17, pl. 24, figs. 9–11) differs from the Oregon species in its much coarser ribbing and its higher subquadrate whorl section. *Cobbanites engleri* (Frebold) (1957, p. 65, pl. 39, fig. 1, pl. 40, figs. 1a, b) from Canada has much finer denser ribbing and a more compressed whorl section.

Figured specimens: USNM 132371 a, b.
Occurrence: Snowshoe Formation, upper part, USGS Mesozoic loc. 26778 and 27369, Oregon.

Cobbanites sp. juv.

Plate 4, figures 7–9

A few small immature specimens of *Cobbanites* occur in the Lonesome Formation in Oregon and in some Jurassic shale near Mineral, Idaho. These ammonites have sharp closely spaced prorsiradiate primary ribs that bifurcate at or just above the middle of the flanks into slightly weaker forwardly inclined secondary ribs. The furcation points are marked by tiny tubercles, or swellings. Each whorl has several deeply impressed constrictions that project strongly forward.

Figured specimens: USNM 132369, 132370.
Occurrences: Lonesome Formation, USGS Mesozoic loc. 28666, Oregon. Unnamed shale at USGS Mesozoic loc. 28651 near Mineral, Idaho.

Genus CHOFFATIA Siemiradzki 1898

Choffatia (Loboplanulites) cf. C. (L.) cerealis Arkell

Plate 3, figures 7–9

The genus *Choffatia* is represented in eastern Oregon by four fragmentary specimens. The whorl section, preserved only on the largest fragment, is subovate and is wider than high. The coiling is fairly evolute. The primary ribs are prominent, widely spaced, curve backward on the umbilical wall, and then curve forward to near the middle of the flanks. From each primary rib arises two much weaker secondary ribs. In addition one or two weak secondary ribs arise between successive forked ribs at or above the zone of furcation. All secondary ribs project forward on the flanks and arch forward gently on the venter. On the adoral end of the largest specimen the secondary ribs are reduced slightly in strength along the midventral line. Each fragment bears one deeply impressed forwardly inclined constriction. The largest specimen near its adoral end has a whorl height of 47 mm and a whorl thickness of 54 mm.

These specimens are assigned to *Choffatia* because of their evolute coiling, long strong widely spaced primary ribs, much weaker forwardly arched secondary ribs, and deep constrictions (see generic diagnosis by Spath, 1931, p. 281, 325, and Arkell, 1958, p. 211). The genus *Subgrossouvria* Spath (1924, p. 13; 1931, p. 327) has finer less differentiated ribbing on its inner whorls and coarser more distant primary ribs on its outer whorls. These features are shown on species of *Choffatia* from southern Mexico described by Burckhardt (1927, pl. 30, figs. 6, 7, pl. 31, figs. 1–7 pl. 33, figs. 1–3).

The larger specimen of *Choffatia* illustrated herein has ornamentation similar to that on the larger outer whorl of *Choffatia subbakeriae* (d'Orbigny) (1846, p. 148; Arkell, 1958, p. 215, pl. 30, fig. 2) but has a stouter whorl section and its primary ribs are stronger and sparser. In these respects it shows greater resemblance to *C. (Loboplanulites) cerealis* Arkell (1958, p. 219, pl. 31, figs. 4–6), differing apparently by having a more depressed whorl section and somewhat sharper ribbing. *C. (Loboplanulites) recuperoi* (Gemmellaro), as figured by Arkell (1958, p. 221, text fig. 80–1a, b), differs from the Oregon species by having less projected denser ribbing and apparently more evolute coiling. *C. recuperoi* (Gemmellaro), as figured by Sayn and Roman (1930, p. 181, pl. 16, fig. 5, pl. 17, figs. 2, 3, pl. 18, fig. 1), resembles the Oregon species in ribbing but is more evolute. Among American species, both *Choffatia irregularis* (Imlay) (1953b, p. 102, pl. 54; Arkell, 1956, p. 536) from Alaska and *C. hyatti* (Crickmay) (1933, p. 913, pl. 32, fig. 3, pl. 33) from California have much longer, weaker, and more closely spaced primary ribs and more evolute coiling.

Figured specimens: USNM 132367 a, b.
Occurrence: Snowshoe Formation, upper part, at USGS Mesozoic loc. 26778, Oregon.

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[Italic page numbers indicate major references and descriptions]

PLATES 1–4

PLATE 1

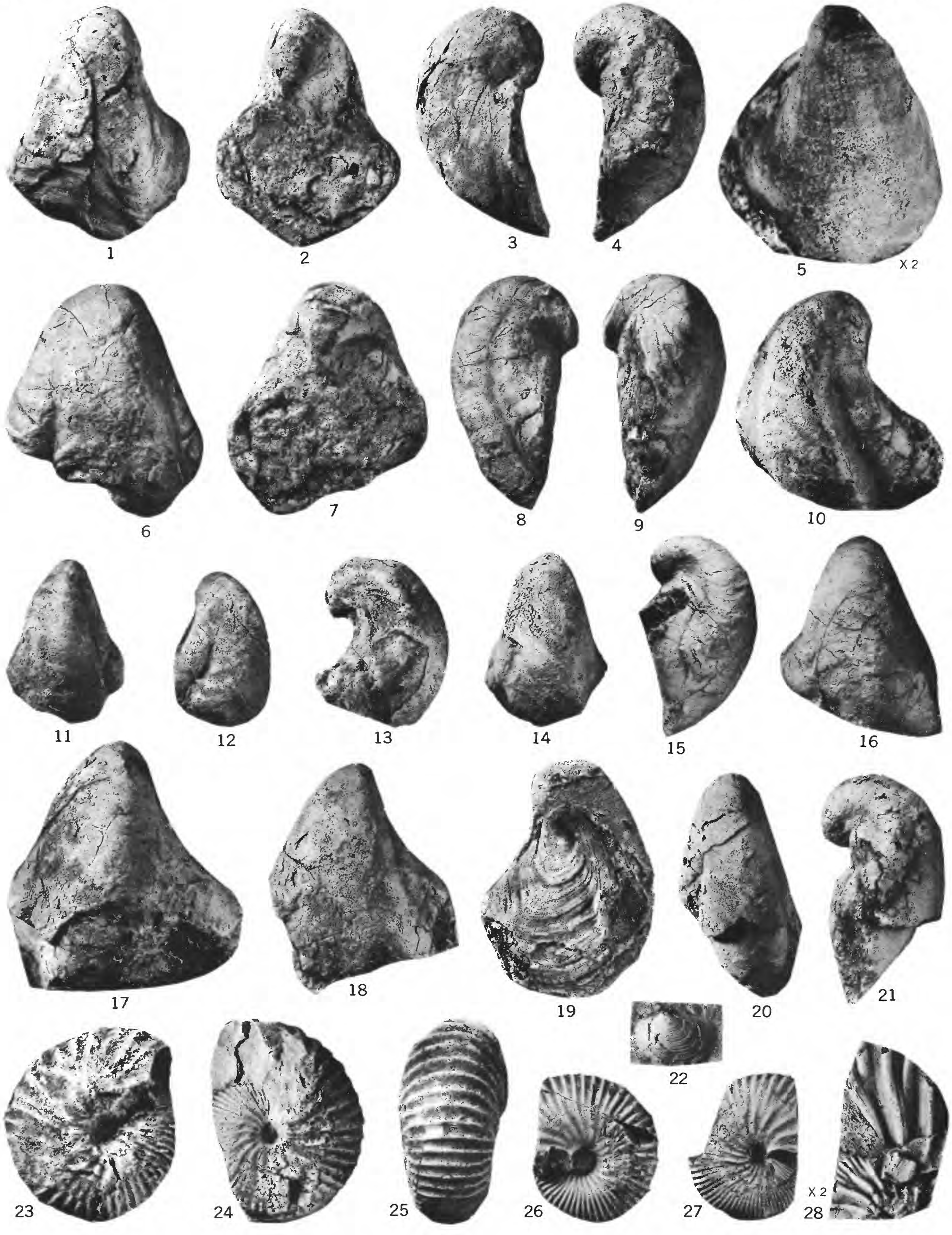
[Figures natural size unless otherwise indicated]

FIGURES 1–21. *Gryphaea culebra* Imlay, n. sp. (p. D13).
- 1–4. Paratype USNM 132348.
- 5. Paratype USNM 132347 (× 2). Shows radial striae on umbonal region.
- 6–9. Holotype USNM 132346.
- 10. Paratype USNM 132349.
- 11. Paratype USNM 132350.
- 12. Paratype USNM 132351.
- 13, 14. Paratype USNM 132352.
- 15, 16. Paratype USNM 132353.
- 17. Paratype USNM 132354.
- 18. Paratype USNM 132355.
- 19. Paratype USNM 132356. Shows concave right valve.
- 20, 21. Paratype USNM 132357. All specimens shown on figs. 1–21 are from USGS Mesozoic loc. 27582.

22. *Posidonia ornati* Quenstedt (p. D13). Plesiotype USNM 13129.

23–27. *Xenocephalites vicarius* Imlay (p. D14).
- 23. Plesiotype CAS 12543 from Livingston's loc. 88 near Mineral, Idaho. Shows adult body whorl.
- 24, 25. Plesiotype CAS 12544 from Livingston's loc. 88 near Mineral, Idaho. Shows most of adult body whorl.
- 26. Plesiotype USNM 132358 from USGS Mesozoic loc. 26778.
- 27. Plesiotype CAS 12545 from Livingston's loc. 88 near Mineral, Idaho.

28. *Xenocephalites* cf. *X. vicarius* Imlay (p. D14).
Figured specimen USNM 132359 (× 2) from USGS Mesozoic loc. 28651.



GRYPHAEA, *POSIDONIA*, AND *XENOCEPHALITES*

PLATE 2

[All figures are natural size]

FIGURES 1–5. *Cardioceras* (*Scarburgiceras*) *martini* Reeside (p. D15).

1. Plesiotype USNM 132360 from USGS Mesozoic loc. 11017, Naknek Formation, lower part on South Shore of Chinitna Bay, Cook Inlet region, Alaska. Part of outer whorl has been removed to show ribbing on inner septate whorls. Compare with figs. 4 and 5.

2, 3. Holotype USNM 32317 from USGS Mesozoic loc. 8575. Naknek Formation, lower part, near lowest outcrop on creek entering Boulder Creek from the northwest 5½ miles above the East Fork, Talkeetna Mountains, Alaska. Included for comparison with figs. 4 and 5.

4. Plesiotype USNM 132361 from USGS Mesozoic loc. 28652.

5. Plesiotype USNM 132362 from USGS Mesozoic loc. 28652.

6–12. *Pseudocadoceras*? sp. juv. (p. D15).

6, 7. Figured specimen USNM 132363 from USGS Mesozoic loc. 28667. Ventral and lateral views of rubber cast of an external mold.

8–12. Figured specimens USNM 132364 from USGS Mesozoic loc. 26780. Figs. 8–11 are lateral views of crushed internal molds. Fig. 12 is from a rubber cast of an external mold of same specimen as shown in fig. 11.

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Figured specimen USNM 132365 from USGS Mesozoic loc. 28376.

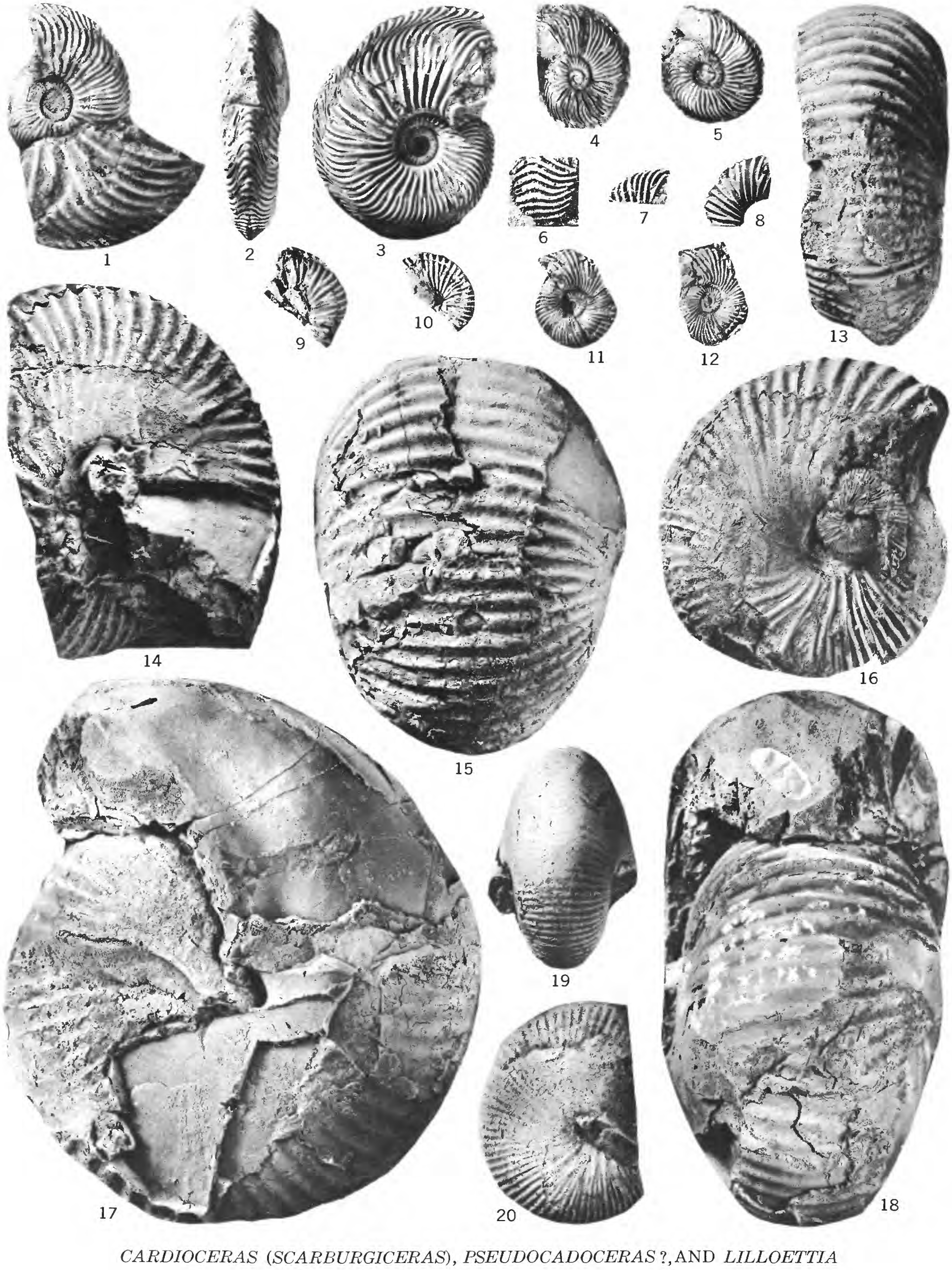
14, 15, 17, 18. *Lilloettia buckmani* (Crickmay) (p. D14).

14, 15. Plesiotype CAS 12540 from Lupher's loc. 129 A.

17, 18. Plesiotype CAS 12541 from Lupher's loc. 129 A.

19, 20. *Lilloettia* cf. *L. mertonyarwoodi* Crickmay (p. D14).

Figured specimen CAS 12542 from Livingston's loc. 88 near Mineral, Idaho.



CARDIOCERAS (*SCARBURGICERAS*), *PSEUDOCADOCERAS* ?, AND *LILLOETTIA*

PLATE 3

[All figures are natural size]

FIGURES 1–6, 10. *Kepplerites* (*Gowericeras*) cf. *K.* (*G.*) *torrensi* (McLearn) (p. D14).

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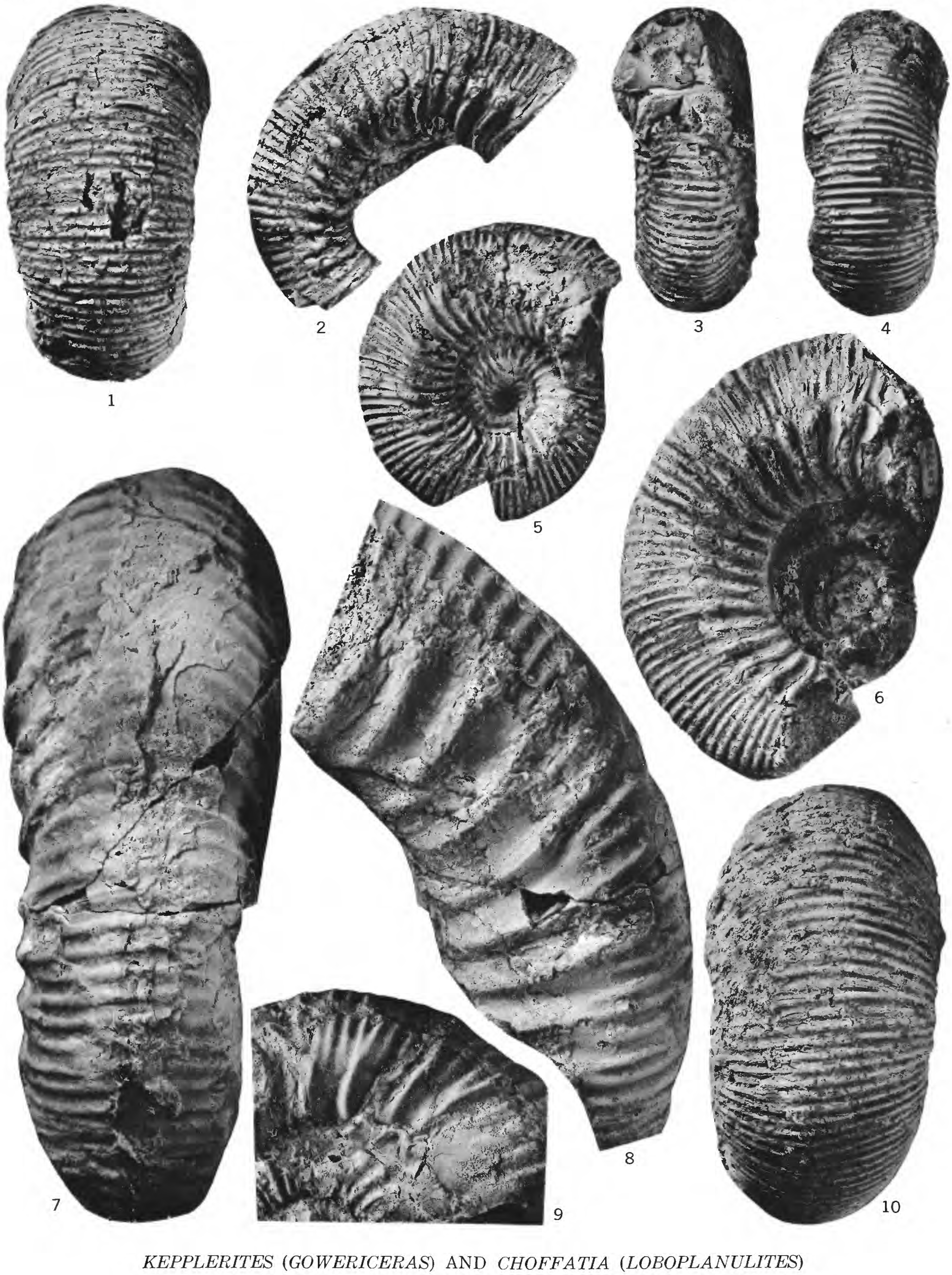
3–5. Apertural, ventral, and lateral views of figured specimen Stanford Univ. Museum Paleonotology 9709 from Dickinson's loc. F 122 (8–10–3).

6, 10. Lateral and ventral views of figured specimen USNM 132366b from USGS Mesozoic loc. 26778.

7–9. *Choffatia* (*Loboplanulites*) cf. *C.* (*L.*) *cerealis* Arkell (p. D17).

7, 8. Ventral and lateral view of large septate whorl. USNM 132367a from USGS Mesozoic loc. 26778.

9. Lateral view of small septate whorls. USNM 132367b from USGS Mesozoic loc. 26778.



KEPPLERITES (*GOWERICERAS*) AND *CHOFFATIA* (*LOBOPLANULITES*)

PLATE 4

[Figures are natural size unless otherwise indicated]

FIGURES 1–6. *Parareineckeia* cf. *P. hickersonensis* (Imlay) (p. D16).

1, 2. Ventral and lateral views (×2) of figured specimen USNM 132368 from USGS Mesozoic loc. 26778.

3, 4. Inner whorls (×2) of same specimen shown in figs. 1 and 2. Note ventral groove.

5, 6. Inner whorls (×1) of same specimen shown in figs. 1 and 2.

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7. Lateral view of rubber cast of external mold of specimen USNM 132369 from USGS Mesozoic loc. 28651.

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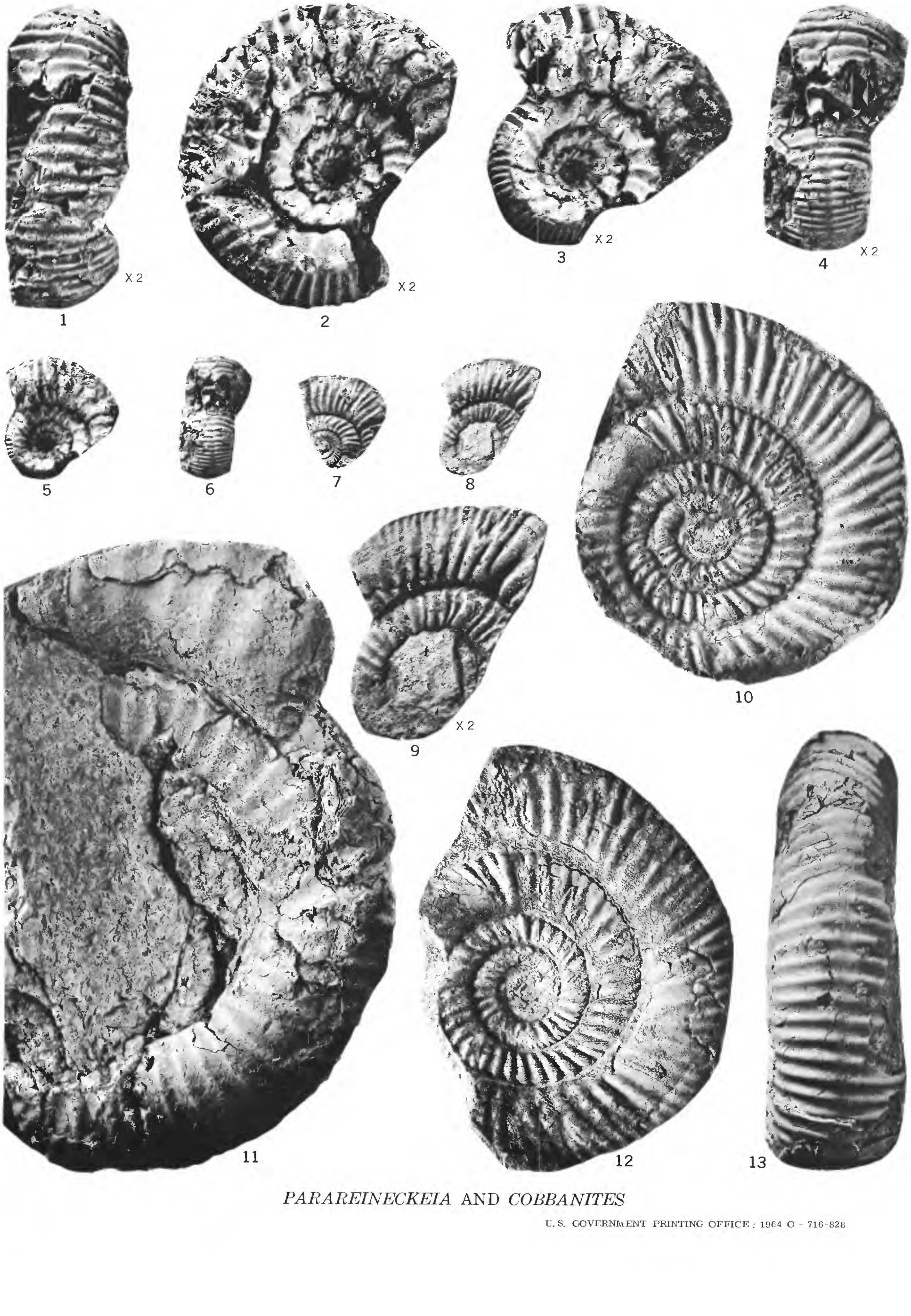
10, 12. Figured specimen USNM 132371a from USGS Mesozoic loc. 26778. Fig. 10 is from a rubber cast of the external mold. Fig. 12 is an internal mold with some shell adhering.

11, 13. Lateral and ventral views of figured specimen USNM 132371b from USGS Mesozoic loc. 26778.



PARAREINECKEIA AND *COBBANITES*

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