The Lower Cretaceous (Albian) Ammonite Genera *Leconteites* and *Brewericeras*

GEOLOGICAL SURVEY PROFESSIONAL PAPER 503-F

The Lower Cretaceous (Albian) Ammonite Genera *Leconteites* and *Brewericeras*

By DAVID L. JONES, MICHAEL A. MURPHY, *and* EARL L. PACKARD

CONTRIBUTIONS TO PALEONTOLOGY

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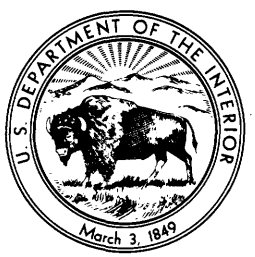
A report simplifying the complex nomenclature of the ammonite genera Leconteites *and* Brewericeras



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CONTENTS

ILLUSTRATIONS

[Plates 1–11 follow index]

THE LOWER CRETACEOUS (ALBIAN) AMMONITE GENERA *LECONTEITES* AND *BREWERICERAS*

By DAVID L. JONES, MICHAEL A. MURPHY,[1] and EARL L. PACKARD [2]

ABSTRACT

Lower Cretaceous (Albian) ammonites from the Pacific coast region of North America designated as *Leconteites lecontei, L. modestum* (in part), *Puzosigella mulleri, P. taffi, P. rogersi,* and *P. perrinsmithi* (in part), are herein regarded as forming one highly variable but intergrading species to which the name *L. lecontei* (Anderson) is applied. *Puzosigella sacramentica* (Anderson) is regarded as a separate species of *Leconteites,* and the name *Puzosigella* is rejected. A new subspecies, *L. lecontei whiteavesi,* is recognized from the Albian beds of Queen Charlotte Islands, and one species, *L. deansi,* is abundant in the lowest Albian beds of southern Alaska.

The genus *Brewericeras* is regarded as a direct descendant of *Leconteites* and contains two species: *B. breweri* (Gabb) and *B. hulenense* (Anderson). *B. breweri* is known only from one specimen, but *B. hulenense* is abundant and widespread in upper lower Albian deposits. This species shows a wide range in morphologic variation from smooth compressed forms to ribbed slightly inflated forms.

INTRODUCTION

Ammonites assigned to various species of the genera *Leconteites* Casey, *Puzosigella* Casey, and *Brewericeras* Casey are locally abundant in Albian strata in California, Oregon, British Columbia, and Alaska. Because of their wide distribution and short geologic range, these ammonites are very useful in correlation, but because of the proliferation in specific names, uncertainty of generic affinities, and obvious synonymy of some of the types, their proper identification is impossible using the present nomenclature.

Likewise, an apparent evolutionary sequence of the early Albian *Leconteites* leading to the late early Albian or early middle Albian *Brewericeras* has been obscured by placing these two genera in different families: *Leconteites* in Hoplitidae and *Brewericeras* in Desmoceratidae (Wright in Arkell and others, 1957).

In recent years, studies of large populations of ammonites have shown that some species exhibit a surprisingly wide range of morphologic variation. Studies of the Upper Cretaceous Collignoniceratids by Haas (1946), the Triassic genus *Tropites* by Silberling (1959), and the mid-Cretaceous genus *Neogastroplites* by Reeside and Cobban (1960) conclusively demonstrate that intraspecific variation from finely ribbed compressed individuals to robust coarsely ornamented forms is normal for some ammonites and that finely drawn taxonomic distinctions based on differences in whorl proportions or strength of ornamentation do not hold up when a sufficiently large sample is available. On the other hand, some groups of ammonites are remarkably constant morphologically and show little range in variation. Why this difference exists is not clear, but it seems probable that the highly variable species are most important from an evolutionary point of view, as they provide a wider basis upon which natural selection can operate to produce separately evolving strains.

This study attempts to document another example of extreme variation and also to elucidate what seems to be a clear evolutionary sequence.

NOMENCLATURE

The genera *Leconteites* and *Puzosigella* are based on two species, *Desmoceras lecontei* and *Pachydiscus sacramenticus,* first named by Anderson (1902). According to Anderson, the former species is characterized by a compressed whorl section, narrow umbilicus, nearly vertical umbilical wall, angular umbilical shoulder, and weak ornamentation; the latter species is characterized by a more inflated whorl section, wider umbilicus, sloping umbilical wall, rounded umbilical shoulder, and coarse ornamentation. Holotypes of both species apparently were obtained from the same place on the east fork of Huling (Hulen) Creek near Ono, northern California (California Acad. Sci. loc. 152, see Anderson, 1902, p. 96, 105; 1938, p. 195, 196).

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Hall and Ambrose (1916, p. 69; see Wiedey, 1929, p. 25, pl. 2, fig. 2) subsequently named a new species, *Sonneratia rogersi*, a closely related form obtained from Tesla quadrangle in central California. Anderson (1938, p. 192, 193) later referred *Desmoceras lecontei* to *Cleoniceras* and named a new species, *C. modestum*, which was also obtained from Huling Creek (California Acad. Sci. loc. 1668). In the same publication, Anderson (1938, p. 184, 195) referred *Pachydiscus sacramenticus* to the genus *Sonneratia* and named as new species *S. perrinsmithi*, *S. taffi*, and *S. mulleri* all of which, together with plesiotypes of *S. rogersi*, were obtained from the east fork of Huling Creek (California Acad. Sci. loc. 152).

Casey (1954) recognized that none of the species cited above belong to either *Cleoniceras* or *Sonneratia*, and he therefore erected two new genera, *Leconteites* and *Puzosigella*, and *D. lecontei* and *P. sacramenticus*, respectively, were designated as generic types.

To the genus *Puzosigella*, Casey assigned the following species: *P. sacramenticus*, *S. mulleri*, *S. taffi*, and *S. rogersi*. The distinctive features of *Puzosigella* were described by Casey (1954, p. 110), as follows:

> * * * evolute, subdiscoidal, strongly costate. Whorl-sides flattened, subparallel. Venter broadly rounded. Umbilicus with subvertical wall and distinct rim, surmounted, in the early whorls, by obtuse bullae, from which the sigmoidal ribs take origin in bundles. Ribs later tending to differentiate into (long) primaries and (short) secondaries, the latter either free-ending or branching from the primaries at or below the middle of the sides. All ribs broadening slightly and fading on the venter, which they traverse in a forwardly directed arc, inner lateral area tending to smoothness at large diameters. Periodic narrow constrictions, not persistent to the adult. Suture line puzosoid.

Only one species, *D. lecontei*, was definitely assigned to *Leconteites*, but Casey (1954, p. 110) stated that "This genus, * * * comprises the Californian '*Cleoniceras*' of Anderson (1938)." Thus, at least by implication, *C. modestum* also was meant to be included in the genus. *Leconteites* was said to differ from *Puzosigella*.

> in its greater involution, compression, finer ribbing, more delicate and less persistent umbilical tubercles, tendency to smoothness in the adult, and in the presence of periodic desmoceratid-like peripheral ridges. Constrictions, if ever present, disappear before the neanic stage (Casey, 1954, p. 110).

Imlay (1960) reported both *Leconteites* and *Puzosigella* in Albian deposits of the Chitina Valley, Alaska, where he recognized *Puzosigella* cf. *P. rogersi*, *Leconteites modestus* and *L. deansi* (Whiteaves). According to Imlay (1960, p. 108):

> The genus *Puzosigella* differs from *Leconteites* mainly in having more prominent umbilical bullae, by the flank ribs originating in bundles at these bullae, and by possessing many, rather conspicuous, narrow constrictions on immature specimens.

A study of large collections of ammonities from Oregon, California, British Columbia, and Alaska have convinced the authors of this paper that the differentiation of leconteitid and puzosigellid ammonites into six species and two genera is untenable and that the generic differences expressed by Casey and by Imlay are invalid. Specimens from a single locality show a complete gradation from compressed finely ornamented forms (*Leconteites*) to the more inflated coarsely ribbed forms (*Puzosigella*). This same range of variation can be demonstrated to occur throughout the entire stratigraphic interval in which these forms occur. Thus only one generic name should be applied to this entire morphologic plexus.

The genus *Brewericeras* was named by Casey (1954, p. 112), who cited *Ammonites breweri* Gabb as type species. *Ammonites breweri* was originally based on a large fragment (UC 12098) figured by Gabb in 1864 and reproduced here on plate 8, figures 3 and 5. This specimen has strongly developed ribs that are continuous across the lower flanks and that show a slight tendency to weaken near the umbilical shoulder and on the venter. Because the specimen is worn and damaged in these areas, it is difficult to be sure that this weakening is inherent rather than due to erosion. In 1869, Gabb illustrated another specimen (ANSP 4798) as *A. breweri*, and this was refigured by Anderson (1938, pl. 44, figs. 1, 2) and erroneously designated by him as the holotype. That specimen, reproduced in this report on plate 8, figures 1, 2, and 4, has ribs that are well developed on the outer flank but are weakly developed on both the inner flank and the venter, in marked contrast to the holotype.

In this same publication, Anderson (1938, p. 190, pl. 44, figs. 3, 4) named a new species, *Beudanticeras hulenense*, which differs from *A. breweri* by having ribs that are less prominent on the umbilical shoulder, absent on the lower flanks, and weak or absent on the venter. Typical specimens of *B. hulenense* are nearly smooth, but a completely intergrading series can be shown between smooth forms and more coarsely ribbed forms such as Gabb's 1869 specimen referred to as *A. breweri*. A complete intergradation cannot be demonstrated with the holotype of *A. breweri* (Gabb, 1864), as that specimen has coarser more uniformly developed ribs on the lower flank in contrast to all known specimens of *B. hulenense*, which lack the ribs or have only striae or, in the highly inflated varieties, irregularly developed riblets.

Therefore, these two species of *Brewericeras* are considered distinct, although *B. breweri* is known only from the single original (1864) specimen; all other cited examples of *B. breweri* are herein referred to *B. hulenense*.

ACKNOWLEDGMENTS, MEASUREMENTS, AND ABBREVIATIONS

We are indebted to Dr. Leo Hertlein, of the California Academy of Sciences, for providing casts of Anderson's type specimens; to Dr. F. H. McLearn, of the Geological Survey of Canada, for making available specimens of *Leconteites* from the Queen Charlotte Islands; to Dr. A. Sutherland-Brown, of the British Columbia Department of Mines and Petroleum Resources, for furnishing maps and giving advice on fossiliferous localities in the Queen Charlotte Islands; to Dr. Horace Richards, of the Academy of Natural Sciences of Philadelphia; and to Mr. Joseph Peck, Department of Paleontology, University of California, Berkeley, for loaning us Gabb's original specimens. We also thank Dr. Marshall Maddox of San Jose State College for donating large collections of *Leconteites* made by himself and students in the Hospital Creek area, central California.

Measurements and abbreviations used in this report are as follows:

Measurements	*Abbreviations*	*Remarks*
Diameter of shell	D	Maximum diameter not always measured, particularly where outer part of the whorl is damaged.
Whorl height	H	Measured along radial line where diameter is measured. Taken on top of ribs on all forms.
Whorl breadth	B	Measured at same place as H. Taken on top of ribs but not including prominent umbilical bullae.
Ratio of whorl breadth to whorl height.	B/H	
Width of umbilicus	Um	Measured in millimeters and also expressed as percent of diameter.

Abbreviations.—CAS, California Academy of Sciences, San Francisco, Calif.; GSC, Geological Survey of Canada; LSJU, Leland Stanford, Jr. University, Stanford, Calif.; ANSP, Academy of Natural Sciences of Philadelphia; UC, University of California, at Berkeley; UCR, University of California, at Riverside; UO, University of Oregon, at Eugene; USGS, U.S. Geological Survey; USNM, U.S. National Museum, Washington, D.C.

MATERIAL STUDIED

Examples of *Leconteites* and *Brewericeras* were studied from nearly all known occurrences in the Pacific coast region of North America. Figured specimens were selected from four localities: Huling Creek in northern California, where Gabb's and Anderson's types were obtained; near Mitchell, in central Oregon, where abundant specimens of *Leconteites* collected from throughout a very small stratigraphic interval reveal a nearly complete sequence of intergrading morphologic types; the Queen Charlotte Islands, B.C.; and southern Alaska. Specimens of *Leconteites deansi* (Whiteaves) from southern Alaska have recently been adequately figured by Imlay (1960), so only one specimen from that locality is illustrated in this report.

Approximate numbers from each general locality are tabulated as follows: (These include specimens in the collections of the U.S. Geol. Survey, Menlo Park; the California Academy of Sciences, San Francisco; and the University of California at Riverside and Los Angeles).

	Leconteites deansi	*Leconteites lecontei*	*Brewericeras hulenense*
Southern Alaska	300		100+
Northern California		200	200+
Central California		100+	100+
Central Oregon		200	
Queen Charlotte Islands [1]		15	80

[1] Specimens from Queen Charlotte Islands are regarded as a new subspecies of *L. lecontei.*

STRATIGRAPHIC POSITION AND AGE OF LECONTEITES AND BREWERICERAS

In the following summary, brief descriptions are given of the stratigraphic succession of beds containing *Leconteites lecontei, L. deansi,* and *Brewericeras hulenense* in the Ono area, northern California; near Mitchell in central Oregon; in Skidegate Inlet and Beresford Bay in the Queen Charlotte Islands; and in the upper Chitina Valley area in southern Alaska. Other areas are known where either or both genera occur, but the stratigraphic relations and faunal associations are best known and developed in the areas described.

ONO AREA

The beds in the vicinity of Ono have been studied by Gabb (1864, 1869), by Anderson (1938), and by Murphy (1956; in Murphy and Rodda, 1960; Murphy and others, 1964). This area contains one of the most continuous and richly fossiliferous sequences of Lower Cretaceous beds known on the west coast of North America. It has been the source of most of the stratigraphic nomenclature and serves as the local standard of reference for this region. Aptian and Albian beds are particularly fossiliferous, and a great number of described species were first collected there. These beds are well exposed along Huling Creek and along the East Fork of Huling Creek (fig. 1), where some of the specimens described in this report were obtained.

The *Leconteites lecontei* zone overlies the *Acanthohoplites reesidei* zone on and near Huling Creek and

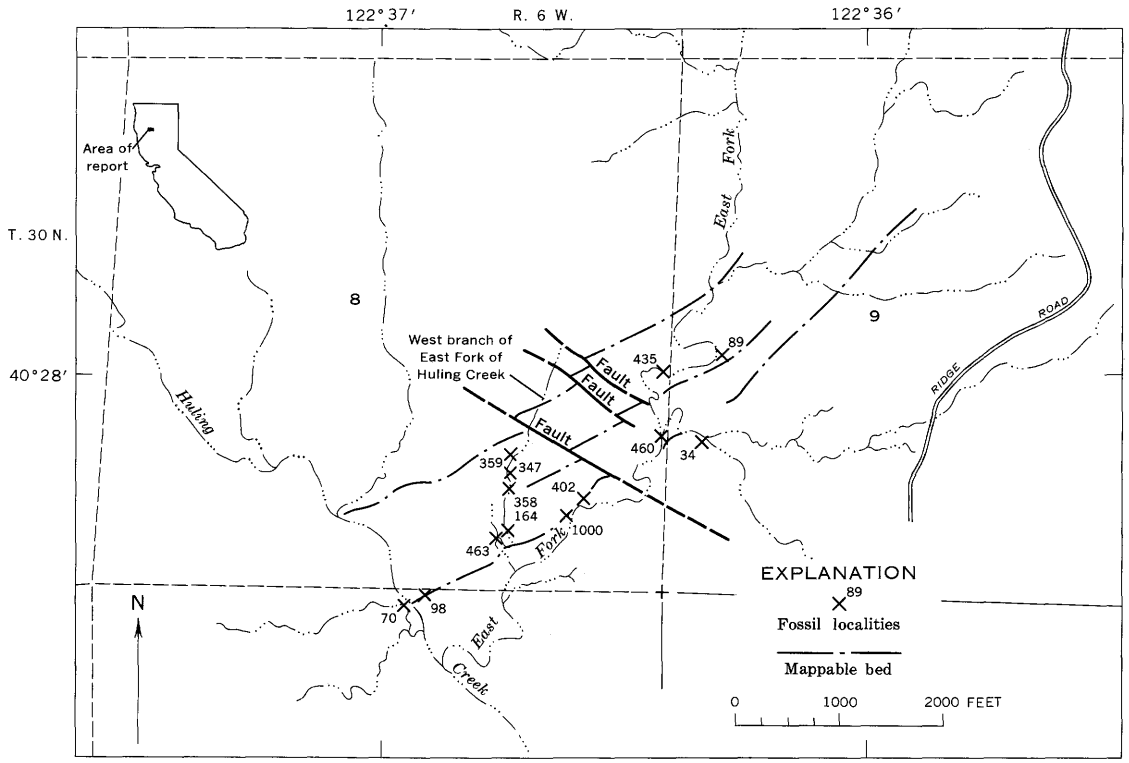

FIGURE 1.—Index map of the Ono area, northern California, showing generalized geology and University of California at Riverside localities from which specimens of *Leconteites* and *Brewericeras* were obtained.

ranges through about 270 feet of dominantly dark-gray siltstone and mudstone which contains abundant limestone concretions (fig. 2). Throughout this thickness, but especially in the upper half, *Leconteites lecontei* s. s. is abundant and shows a wide range of morphologic variation. Three groups, each containing several specimens, were selected from the lower, the middle, and the upper part of the zone to show that throughout its known range, the species exhibits a similar degree of morphologic variation. From the lower part of the zone, illustrated specimens were obtained from UCR localities 347, 359, and 435; from the middle part, from UCR localities 89 and 358; and from the upper part, from UCR localities 164, 460, and 463.

Other ammonites associated with *Leconteites lecontei* in the Ono area are:

Silesites puzosiaformis Anderson
Ptychoceras laeve (Gabb)
Hypophylloceras californicum (Anderson)
Tetragonites sp.
Douvilleiceras cf. *D. mammillatum* (Schlotheim)
Anagaudryceras gainesi (Anderson)
A. aurarium (Anderson)
A. cf. *A. sacya* (Forbes)

As pointed out by Popenoe, Imlay, and Murphy (1960, p. 1509), this assemblage is undoubtedly of early or middle Albian age. An early Albian age is favored because it overlies beds containing *Acanthohoplites*, which ranges from late Aptian to early Albian, and is overlain by beds having abundant *Douvilleiceras* cf. *D. mammillatum*, of probable late early Albian age. The zone of *Leconteites lecontei* is correlative with at least part of the *Leymeriella tardefurcata* zone (see Wright, in Arkell and others, 1957, p. L128) of the European Albian, but a precise correlation is not possible.

The *Leconteites lecontei* zone on and near Huling Creek is overlain by slightly calcareous silty sandstone in which *Brewericeras hulenense* and other fossils are abundant. About 10 feet of barren beds intervene between the highest occurrence of *L. lecontei* and the lowest occurrence of *B. hulenense*, but deposition was probably nearly continuous and only a relatively short time interval is represented by the barren beds.

The *Brewericeras hulenense* zone on and near Huling Creek is restricted to a single 10-foot-thick bed of sandy and pebbly mudstone. This bed may represent a submarine mudflow as it shows no internal bedding and the clasts have no preferred orientation. A few miles to the northeast near the old mining camp of Horsetown, a much greater thickness of strata, composed of poorly sorted sandstone, also represents the *Brewericeras*

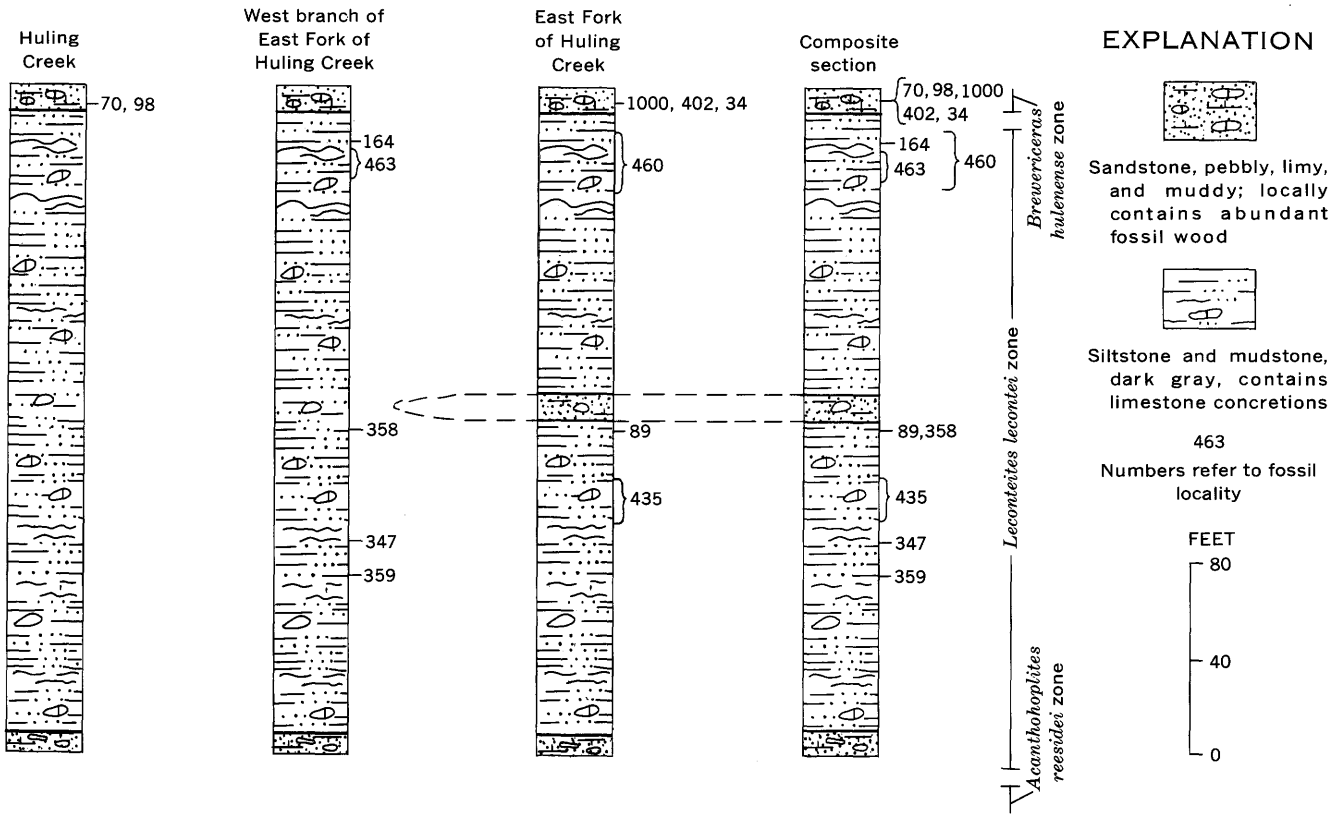

FIGURE 2.—Generalized diagrammatic columnar sections showing stratigraphic position of fossil localities in the Ono area from which specimens of *Leconteites* and *Brewericeras* were obtained.

hulenense zone, and it is possible that the bed exposed at Huling Creek was derived from that area.

Other fossils associated with *B. hulenense* are:

Douvilleiceras cf. *D. mammillatum* (Schlotheim)
D. restitutum? Anderson
Puzosia subquadrata (Anderson)
Desmoceras merriami (Anderson)
Hypacanthoplites sp.=*Parahoplites stantoni* Anderson (holotype, not small specimen figured by Anderson, 1938, pl. 36, fig. 2)
Hypophylloceras californicum (Anderson)
Jauberticeras cf. *J. michelianum* (d'Orbigny)
Anagaudryceras gainesi (Anderson)
A. aurarium (Anderson)
Tetragonites sp.

In addition, the lowest beds of this zone on Huling Creek contain a few specimens intermediate in character between *Brewericeras* and *Leconteites*.

The *Brewericeras hulenense* zone is probably about equivalent to the *Douvilleiceras mammillatum* zone of European usage (see Wright, in Arkell and others, 1957, p. L128) and is assigned a late early Albian age.

Overlying the *Brewericeras hulenense* zone is 200 feet of barren siltstone, followed by a thin zone containing *Oxytropidoceras packardi* Anderson and associated fauna of probable middle Albian age.

CENTRAL OREGON

The sedimentary sequence of Albian age near Mitchell, central Oregon, consists of about 4,700 feet of mudstone, siltstone, and a minor amount of sandstone, which rests unconformably on Permian metasedimentary rocks (McKnight, 1964). The oldest fossil known is *Leconteis leconteites*. s. which occurs at many localities near the base of the sequence. These lower beds, in turn, are overlain by strata of the *Brewericeras hulenense* zone. As yet no detailed biostratigraphic studies have been carried out in the Mitchell area, and the thickness of strata included in these two zones is unknown.

The *Leconteites* beds have furnished more prolific and better preserved fossil collections than have the *Brewericeras* beds, and only specimens from the former are figured in this report. In order to avoid complexities due to time or facies differences, numerous specimens from the richest locality were first analyzed and the range of variation of what was considered to be a sample of a single ammonite population was established. Specimens from other localities were then compared to the control sample and differences or similarities noted. The specimens from the control sample were obtained

from a bed of concretionary limestone nodules ranging from an inch to a foot or more in thickness interbedded with gray mudstone. This locality, consisting of separate collections numbered USGS Mesozoic locality 26262, 26378, M 2284, and UO 4082, is exposed north of the old Frizzell ranchhouse in sec. 3, T. 11 S., R. 22 E.; it is designated locality A in figure 3. Most of the figured specimens from Oregon were obtained from this locality, but a few are from equivalent nearby strata. The exact locality of two figured specimens from USGS Mesozoic locality 15801 is uncertain.

Because of minor structural complexities, lack of key beds, and widely scattered fossil-collecting localities, it has not been possible to arrange all the specimens of *Leconteites lecontei* from Mitchell in precise stratigraphic order and demonstrate that the range of variation is constant, or nearly so, throughout the vertical range of the species. It could be argued that the wide range of morphologic variation shown by the specimens from locality A was the result of mixing together, in a condensed deposit, fossils of widely differing ages. This argument can be readily countered, for the species show virtually the same wide range in variation at every locality known, and specimens from the stratigraphically controlled sequence of Huling Creek, Calif., are figured to further document this variation.

QUEEN CHARLOTTE ISLANDS

Albian beds are best and most continuously exposed along the north shore of Skidegate Inlet (fig. 4) and

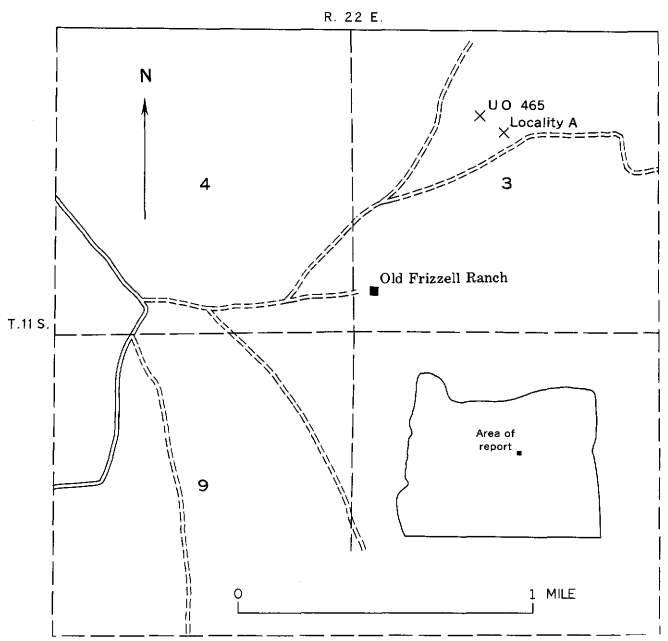

FIGURE 3.—Index map of Mitchell area, central Oregon, showing location of University of Oregon locality 465 and locality A (which includes USGS Mesozoic locs. 15801, 26262, 26378, M 2284, and UO loc. 4082).

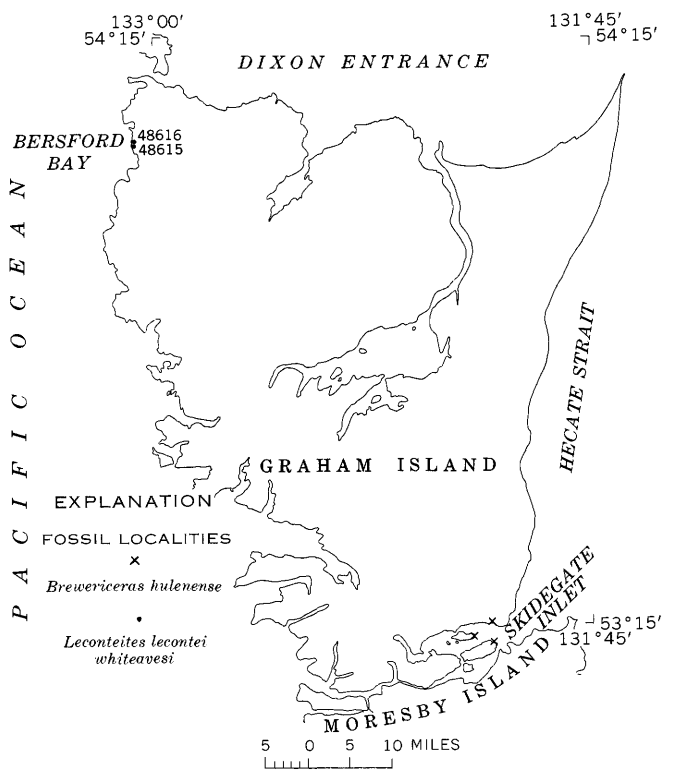

FIGURE 4.—Index map of Graham Island, Queen Charlotte Islands, B.C., showing localities where specimens of *Brewericeras hulenense* and *Leconteites lecontei whiteavesi* n. subsp. were obtained.

nearby islands (Whiteaves, 1876). Study of the fossils from this sequence is in progress by F. H. McLearn, of the Geological Survey of Canada, and by D. L. Jones, who recently collected from this region.

The basal Albian beds in Skidegate Inlet contain *Brewericeras hulenense* and other species, but *Leconteites* is unknown. This absence is puzzling, as Whiteaves (1893, p. 441) reported that the type specimen of *L. deansi* was obtained from Skidegate Inlet. *Leconteites* is known from the north end of Graham Island at Beresford Bay, but these specimens appear to be closer to *L. lecontei* than to *L. deansi*.

In Skidegate Inlet, *Brewericeras hulenense* occurs with the following species:

Cleoniceras sp.
Douvilleiceras spp.
Grantziceras sp.
Arcthoplites belli McLearn
Puzosia alaskana Imlay
Anagaudryceras sp.
Parasilesites sp.
Tetragonites sp.

This assemblage shows similarities to that of the *Brewericeras hulenense* zone of California, but also has forms that are abundant in southern Alaska and in the western interior of Canada.

At Beresford Bay, *L. lecontei whiteavesi* n. subsp. occurs with *Aucellina* sp., *Anagaudryceras* cf. *A. aurarium* (Anderson), and *Phyllopachyceras* sp.

SOUTHERN ALASKA

Strata bearing *Leconteites* and *Brewericeras* are widespread in the upper Chitina Valley region, southern Alaska (fig. 5). Fossils from there have been figured by Imlay (1960), and the stratigraphy of the beds in the McCarthy A–4 quadrangle was described by Jones and Berg (1964).

Leconteites deansi occurs near the base of the Cretaceous sedimentary sequence (fig. 6) in association with the following forms, among others (see Imlay, 1960, p. 91):

Moffitites robustus Imlay
Kennicottia bifurcata Imlay
Anagaudryceras aurarium (Anderson)
Phyllopachyceras cf. *P. shastalense* (Anderson)
Calliphylloceras cf. *C. aldersoni* (Anderson)
Ptychoceras cf. *P. laeve* (Gabb)
Aucellina sp.

As shown in the columnar section (fig. 6), *Moffitites robustus* and *Leconteites deansi* are restricted to the basal sandstone unit in the Fohlin Creek area. In shale a few feet above the top of the sandstone, a single specimen of *Leconteites* having well-developed umbilical bullae was found associated with *Aucellina*. This specimen is referred to *L. lecontei*. The upper beds of this shale and siltstone unit contain scarce specimens of *Brewericeras*. Elsewhere in the upper Chitina Valley, beds of the *Brewericeras hulenense* zone are present and abundantly fossiliferous (Jones and Berg, 1964). Associated with *B. hulenense* are (see also Imlay, 1960, p. 91):

Phyllopachyceras chitinanum Imlay
Hypophylloceras cf. *H. californicum* (Anderson)
Calliphylloceras nizinanum Imlay
Anagaudryceras cappsi (Imlay)
Tetragonites sp.
Puzosia alaskana Imlay
Valdedorsella? *whiteavesi* Imlay
Desmoceras sp. juv.
Parasilesites bullatus Imlay
P. irregularis Imlay
Hulenites cf. *H. reesidei* (Anderson)
Cleoniceras overbecki Imlay
Arcthoplites belli McLearn
Arcthoplites talkeetnanus (Imlay)

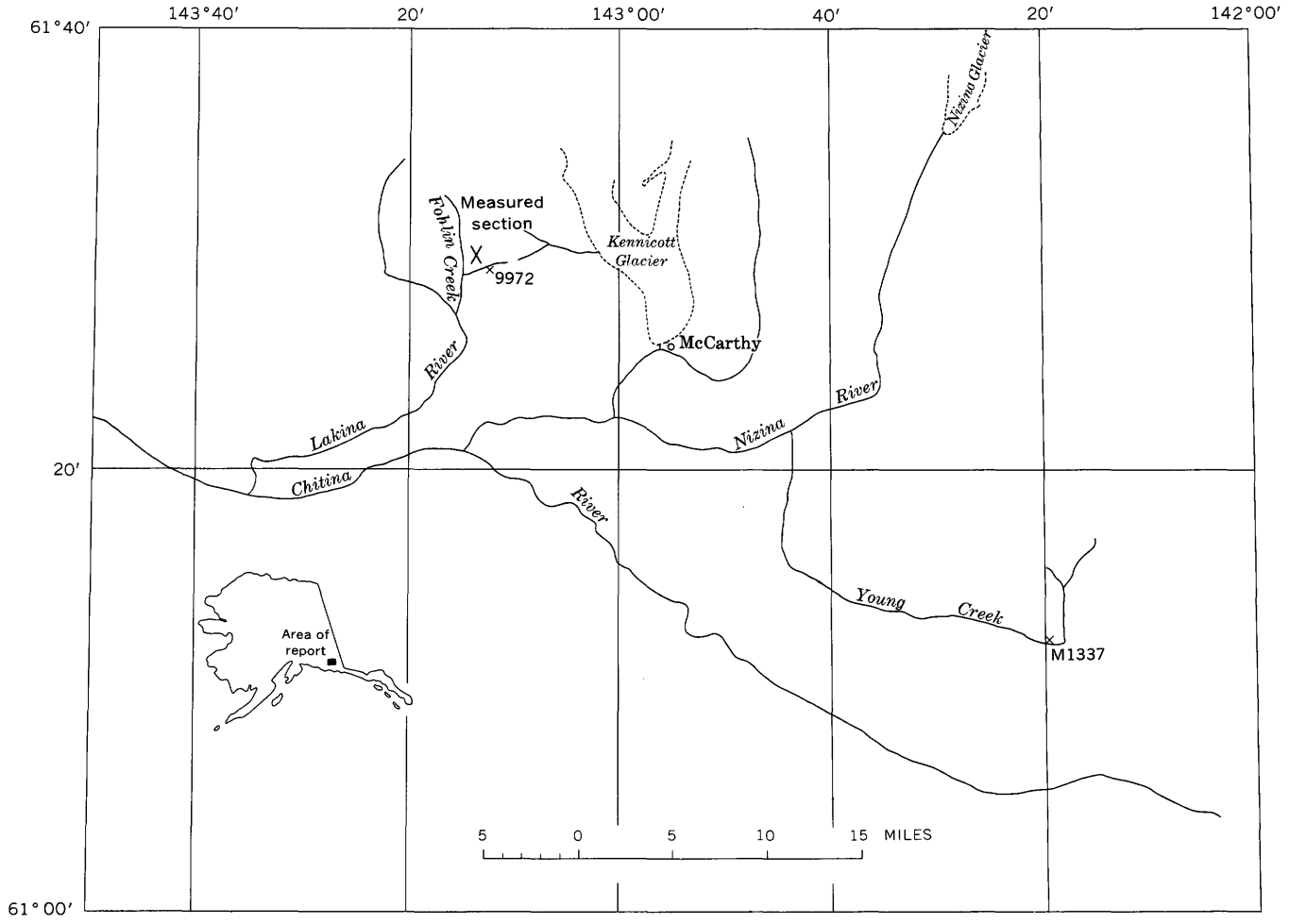

FIGURE 5.—Index map of the upper Chitina Valley, southern Alaska.

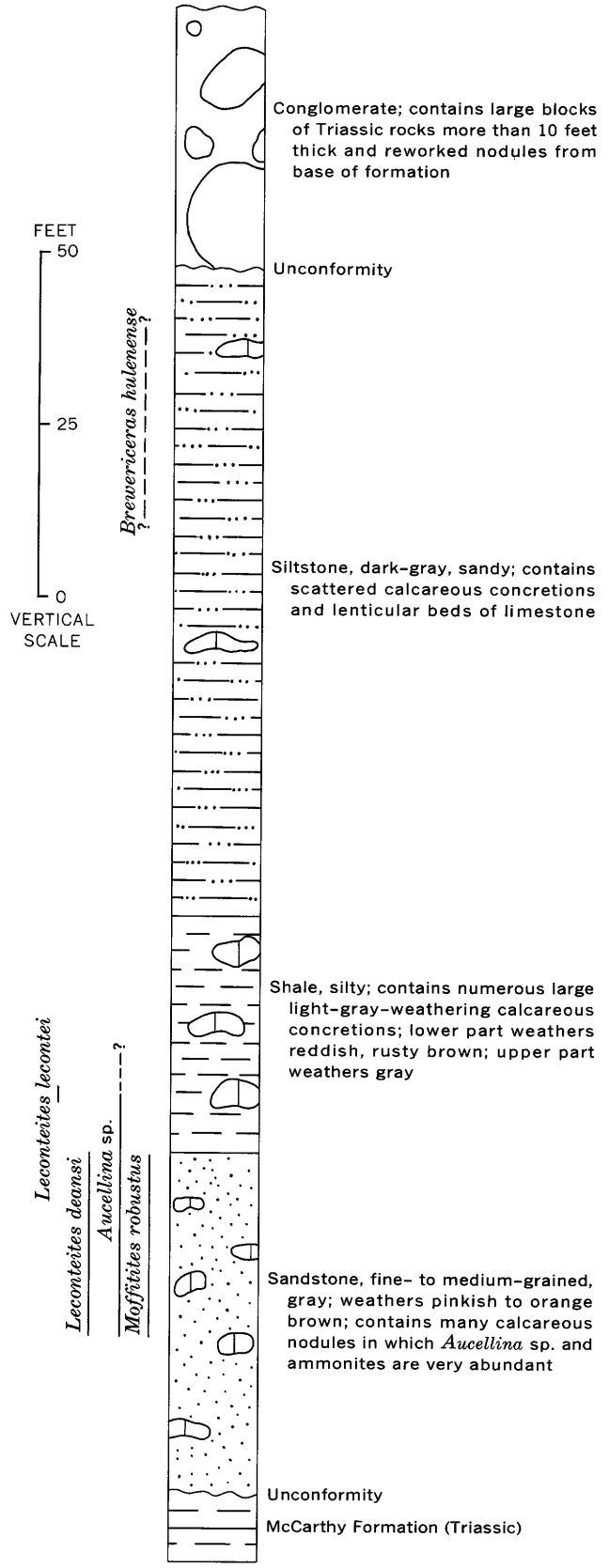

FIGURE 6.—Generalized composite columnar section, Fohlin Creek area, upper Chitina Valley, southern Alaska, showing ranges of early Albian fossils.

Grantziceras glabrum (Whiteaves)
G. affine (Whiteaves)
Douvilleiceras cf. *D. mammillatum* (Schlotheim)
Freboldiceras singulare Imlay

This fauna is of particular importance as it contains a mixture of species known from the western interior of Canada along with those known from the Pacific faunal realm. In particular, *Grantziceras* (=*Beudanticeras* of authors) *glabrum* and *G. affine*, *Arcthoplites belli*, and *Freboldiceras* are abundant in Albian deposits in the Rocky Mountain foothills of western Canada. Apparently the connection between these two provinces was through northern Alaska, as *Grantziceras* occurs in several places in the Alaskan Arctic (Imlay, 1961, p. 57). The farthest known southern penetration of elements of this interior fauna is the Queen Charlotte Islands. Specimens of *B. hulenense* from USGS Mesozoic locality M1337 (fig. 5) are shown on plate 10.

EVOLUTIONARY SEQUENCE

The postulated evolutionary sequence of *Leconteites* and *Brewericeras* is shown in figure 7. *L. deansi* is considered to be the oldest representative of the genus and to have given rise to *L. lecontei* through emphasis of umbilical bullae. Ancestors of *Leconteites* have not yet been recognized. The change from *Leconteites* to *Brewericeras* was effected by the loss of umbilical bullae, simplification of ribbing, a tendency for excentric growth, and the development of a more deeply incised and interlocking suture. No descendants of *Brewericeras* have been recognized.

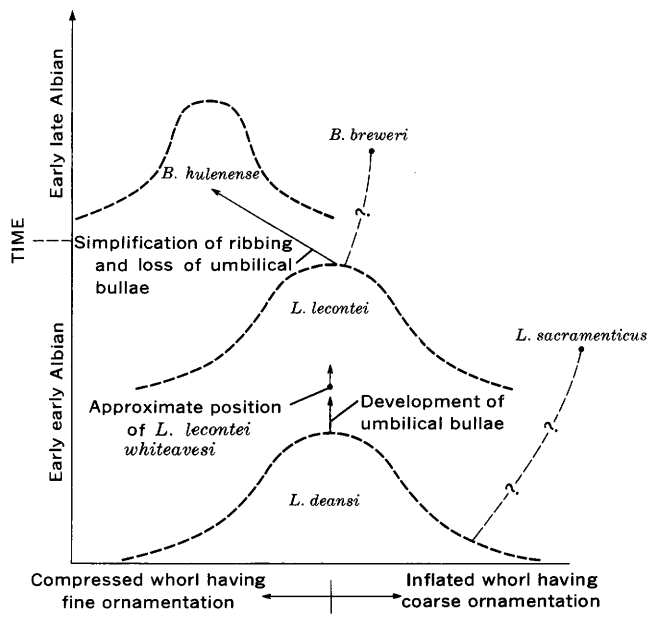

FIGURE 7.—Postulated evolutionary sequence of *Leconteites* and *Brewericeras*. Bell-shaped curves represent hypothetical adult populations that show a wide range in morphologic variation.

Because of the close affinities of *Leconteites* and *Brewericeras*, their differentiation by Wright (1957) into two different families, Hoplitidae (subfamily? Cleoniceratinae) for the former and Desmoceratidae (subfamily Beudanticeratinae) for the latter, cannot be maintained. Both forms are herein referred to the family Desmoceratidae, subfamily Beudanticeratinae.

SYSTEMATIC DESCRIPTIONS

Family DESMOCERATIDAE
Subfamily BEUDANTICERATINAE

Genus LECONTEITES Casey

1954. *Leconteites*, Casey, Washington Acad. Sci. Jour., v. 44, no. 4, p. 110.

Type species (by original designation).—*Desmoceras lecontei* Anderson, 1902.

Synonomy.—*Puzosigella* Casey, 1954, idem.

REVISED GENERIC DESCRIPTION

Shell small to moderate in size, compressed to moderately inflated, and ratio of whorl breadth to whorl height ranges from about 0.52 to more than 1.10. Umbilicus moderately narrow, ranging from 17 to 30 percent of diameter, with umbilical wall vertical to subvertical and shoulder abruptly rounded or angular on compressed specimens. Ornamentation consists of flexed primary ribs that arise singly on umbilical wall (pl. 6, fig. 16) or that spring singly in pairs or in bundles from umbilical bullae (pls. 3 and 4). Ribs project forward on ventrolateral area and tend to weaken and disappear on ventral shoulder; secondary ribs split off from primary ribs above midflank, and some intercalate freely between primary ribs; constrictions variably developed or absent, and peripheral collars characteristic of desmocerids are present on some specimens. Suture line consists of massive asymetrically bifid first lateral saddle, irregularly trifid and deep first lateral lobe; thin and shallow second lateral lobe; and auxiliary saddles that descend obliquely to umbilical seam.

Puzosigella is herein regarded as a subjective synonym of *Leconteites* because the characters that separate the generic type *Pachydiscus sacramenticus* from *L. lecontei* are deemed to be, at most, of only specific importance. The main differences shown by *P. sacramenticus* are a more rounded umbilical shoulder and the lack of umbilical tubercles at a late growth stage. Other species assigned to *Puzosigella* by both Casey and Imlay clearly intergrade with *L. lecontei;* however, among our specimens from Oregon, none were found that are similar to *P. sacramenticus* so it cannot be proved that that intergrading plexus ever produced the form of the typical *Puzosigella.* Among the California collections, a few specimens similar to *P. sacramenticus* are known, but these likewise cannot be demonstrated to intergrade with *L. lecontei.* It seems likely that the *sacramenticus* form is simply an extremely scarce product of the *L. lecontei* strain and thus could be repressed as a nominal species, but in the absence of definite proof of this relationship, we permit the species to stand as *Leconteites sacramenticus* but suppress *Puzosigella* as an unnecessary proliferation.

Leconteites deansi (Whiteaves), which is closely allied to *L. lecontei*, differs from that species also by lacking well-developed umbilical tubercles at all growth stages (see Imlay, 1960, p. 109, pl. 19, figs. 7–14). In other morphologic features, such as general whorl shape, nature of ribbing, and suture line, these three species—*lecontei, sacramentica,* and *deansi*—are similar, and they form a closely related group to which the generic name *Leconteites* is applicable.

Leconteites lecontei (Anderson) s. s.

Plate 1, figures 1–3, 6–11, 13–22; plate 2, figures 1–8, 10–14, 17, 21; plate 3; plate 4; plate 5; plate 11, figures 4–6; and text figures 8–13.

1902. *Desmoceras lecontei* Anderson, California Acad. Sci. Proc., v. 2, no. 1, p. 95, pl. 3, figs. 94, 95; pl. 10, fig. 190.
1916. *Sonneratia rogersi* Hall and Ambrose, Nautilus, v. 30, p. 69, 70.
1929. *Sonneratia rogersi* Hall and Ambrose. Wiedey, Nautilus, v. 44, p. 25, pl. 2, fig. 2.
1938. *Cleoniceras lecontei* (Anderson). Anderson, Geol. Soc. America Spec. Paper 16, p. 192, pl. 38, fig. 4; pl. 47, figs. 3, 4.
1938. *Cleoniceras modestum* Anderson [in part], idem, p. 193, pl. 50, figs. 3, 4.
1938. *Sonneratia mulleri* Anderson, idem, p. 195, pl. 51, fig. 4; pl. 54, figs. 3, 4.
1938. *Sonneratia taffi* Anderson, idem, p. 194, 195, pl. 49, figs. 4, 5.
1954. *Leconteites lecontei* (Anderson). Casey, Washington Acad. Sci. Jour., v. 44, no. 4, p. 110.
1954. *Puzosigella mulleri* (Anderson). Casey, idem.
1954. *Puzosigella taffi* (Anderson). Casey, idem.
1954. *Puzosigella rogersi* (Anderson). Casey, idem.
1960. *Leconteites lecontei* (Anderson). Imlay, U.S. Geol. Survey Prof. Paper 354–D, p. 109, pl. 19, figs. 1–3.
1960. *Leconteites modestus* (Anderson). Imlay, idem, p. 109, pl. 19, figs. 4–6.
1960. *Puzosigella* cf. *P. rogersi* (Hall and Ambrose). Imlay, idem, p. 108, pl. 19, figs. 33–35.
1938. [not] *Cleoniceras modestum* Anderson, Geol. Soc. America Spec. Paper 16, pl. 50, fig. 2 (CAS holotype 8870),
1938. [not] *Sonneratia perrinsmithi* Anderson, idem, pl. 51. fig. 6 (CAS paratype 8883).

Leconteites lecontei s. s. shows an extreme range of morphologic variation and the named "species" cited above are merely variants within an intergrading series. Nearly all morphologic features, such as whorl shape, width of umbilicus, and strength of ornamentation are variable, and few specimens are identical.

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The whorl section varies progressively from compressed (B/H ratio of 0.50–0.60) to inflated (B/H ratio of 0.90 to more than 1.0); the compressed forms have flat convergent flanks, an abruptly rounded venter that tends to be flattened, a narrow steplike umbilicus (equal to 20–25 percent of the diameter) that has vertical umbilical walls and an angular umbilical margin and inconspicuous umbilical bullae and fine ribs. In forms having a more inflated whorl section, the flanks and venter are more rounded, the umbilicus is wider (equal to 26 to more than 30 percent of the diameter), has sloping walls and a rounded shoulder, and the umbilical bullae are larger and the ribs coarser (fig. 8). Every transitional stage can be observed between the compressed forms and the inflated forms, and no natural subdivisions into two or more categories can be established on the basis of whorl proportions or strength of ornamentation (figs. 9, and 10 and following measurements). Of a sample of 38 measurable specimens from locality A in central Oregon, about 8 percent have a B/H ratio between 0.50 and 0.59, 60 percent have a ratio between 0.60 and 0.79, and 32 percent have a ratio of 0.80 or greater. These proportions are probably greatly influenced by collecting failures and perhaps by unknown sorting influences, but a general impression given by all known collections is that the extremely inflated forms with a B/H ratio of 1.00 or greater are scarce.

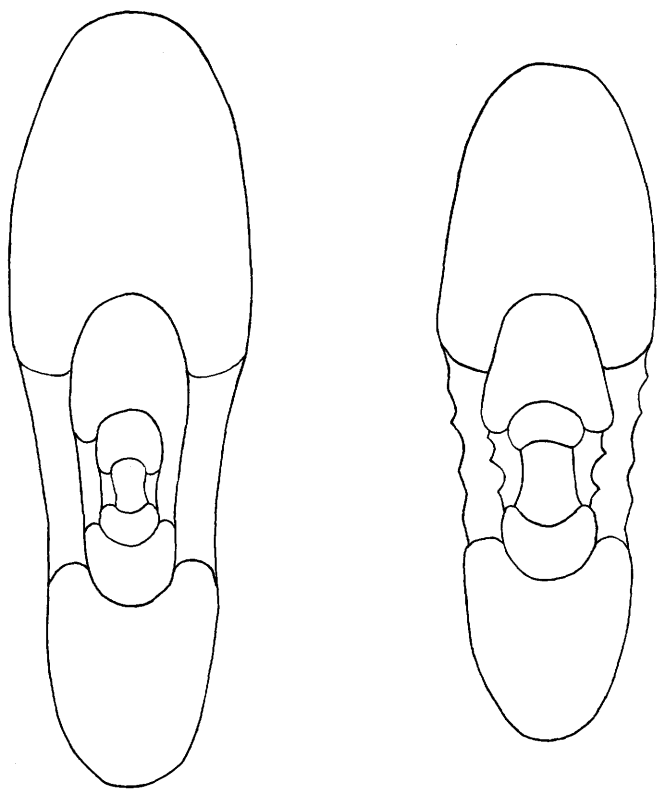

FIGURE 8.—Cross sections of *Leconteites lecontei* s. s. from locality A, central Oregon. Figure *A*, hypotype, USNM 121525a; weakly ribbed form (× 3). Figure *B*, hypotype, USNM 121525*b*, moderately ribbed form (× 3).

Ornamentation consists of bundled ribs that spring obliquely forward from umbilical bullae, although some bullae bear only single ribs, and an occasional rib rises freely on the lower part of the flank. Small umbilical bullae first appear at a diameter of about 3 mm; at a whorl height about 4 mm, faint ribs extend obliquely from these across the flank. The ribs have a falcate course across the flanks, project strongly forward on the outer flank, and tend to weaken on both the lower flank and the venter. Secondary ribs bifurcate from the main ribs near or above midflank or are intercalated freely between primary ribs on the outer third of the flanks. The number of secondary ribs per primary rib is highly variable. Finely ribbed compressed forms may have five or more secondary ribs, and more coarsely ribbed inflated forms may have only one or two. Constrictions are present on some specimens and absent on others. Because some individuals have constrictions only during a particular growth stage, no particular taxonomic significance can be placed on their presence or absence.

A progressive series of changes in ornamentation can be traced from finely ribbed forms (for example, pl. 3, figs. 1–3) to very coarsely ribbed forms (pl. 4, figs. 33–35), and clearly defined, distinct groups within this series cannot be delimited. The specimens illustrated on plates 3 and 4 are arranged so that their progressive changes can be traced step-by-step. On plate 3, ornamentation becomes coarser from the upper left-hand corner to the lower right-hand corner; on plate 4, the ornamentation becomes coarser from top to bottom. Umbilical bullae on finely ribbed forms are indistinct swellings along the umbilical margin. On coarsely ribbed forms, umbilical bullae are very prominent. On some specimens (pl. 3, fig. 45), early whorls are bullate but later whorls have only indistinct swellings along the umbilical shoulder. Most specimens of *L. lecontei*, however, show some indication of umbilical bullae, however faint, in contrast to *L. deansi* (Whiteaves), in which they are only rarely and weakly developed.

The suture lines of *L. lecontei* s. s. are shown in figures 11–13. No essential difference is seen between the suture of the compressed form (figs. 11, 12) and that of the more inflated form (fig. 13). The ventral lobe is broad and has a low bifid saddle; the first lateral lobe is wide, very deep, and trifid; the first saddle is massive, high, and bifid; the second lateral lobe is narrow and shallow; auxiliary saddles rapidly decrease in size and descend abruptly to the umbilical seam.

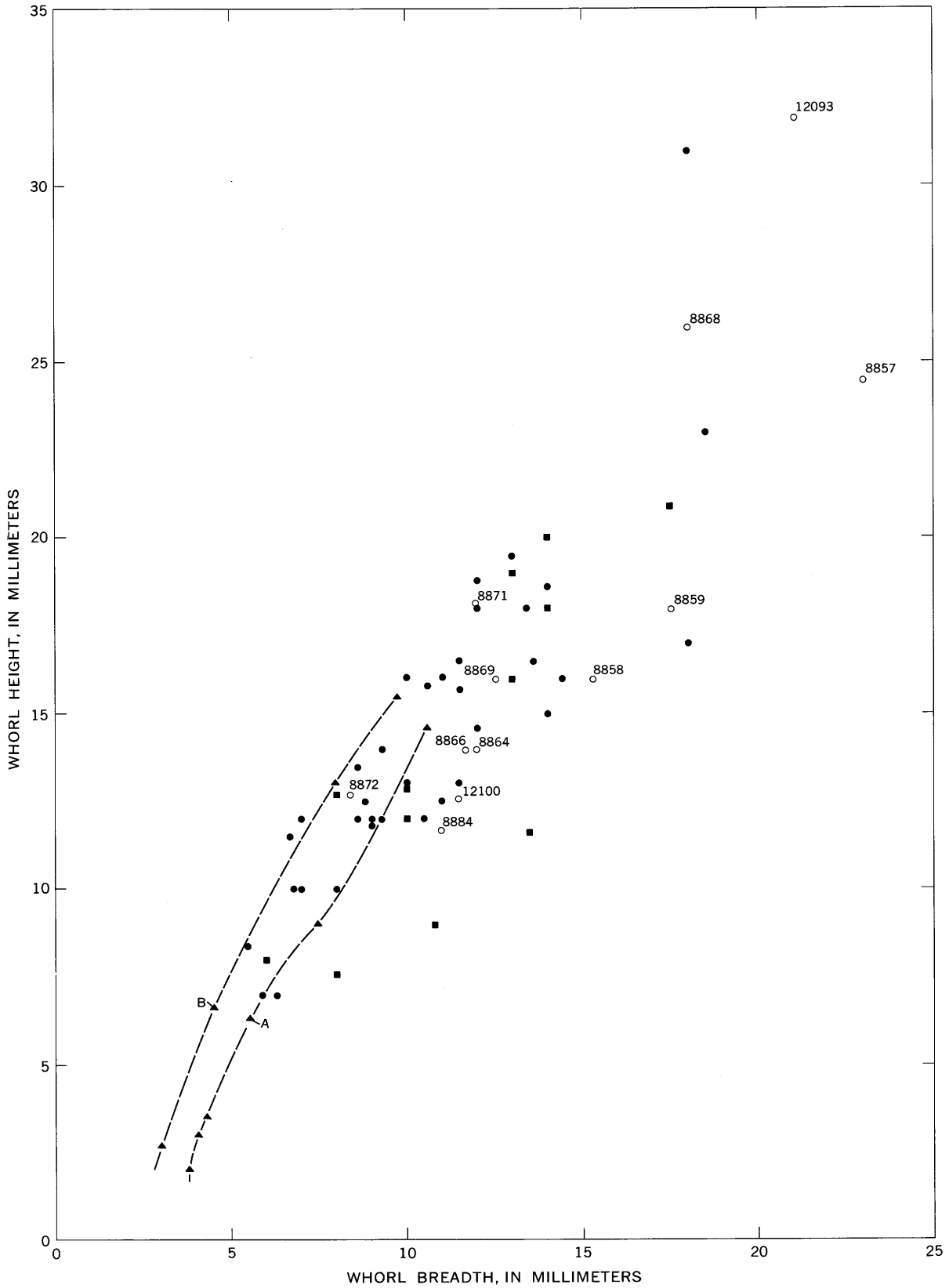

FIGURE 9.—Scatter diagram showing relation of whorl height to whorl breadth in *Leconteites lecontei* s. s. Black dots are specimens from locality A, central Oregon. Triangles and dashed lines connect measurements of single specimens from this same locality. Open circles refer to Anderson's type specimens. Squares are selected specimens from northern California.

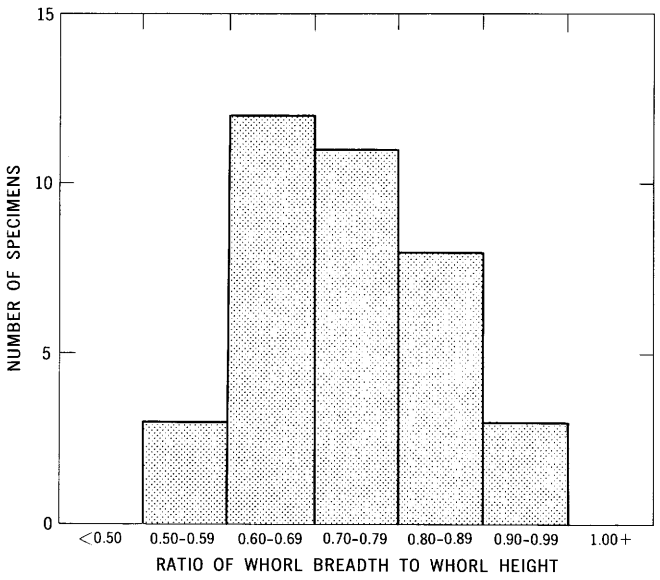

FIGURE 10.—Bar graph showing frequency distribution of ratio of whorl breadth to whorl height for specimens of *Leconteites lecontei* s. s. from locality A, central Oregon.

FIGURE 11.—Suture line of finely ribbed specimen of *Leconteites lecontei* s. s., hypotype, USNM 121499 from USGS Mesozoic locality 15801. Specimen figured on plate 3, figures 42–44 (× 3).

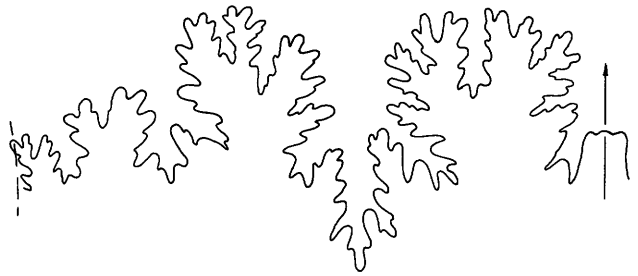

FIGURE 12.—Suture line of weakly ribbed example of *Leconteites lecontei* s. s. Hypotype USNM 121490 from USGS Mesozoic locality 26262. Specimen figured on plate 3, figures 13–15 (× 5½).

Two specimens referred by Anderson to species herein regarded in part as synonyms of *L. lecontei* do not belong to this species. The holotype of *Cleoniceras modestum* Anderson (1938, pl. 50, fig. 2; CAS 8870) has widely spaced falcate ribs, slightly inflated convergent flanks, a narrow umbilicus having a steep wall, and a narrowly

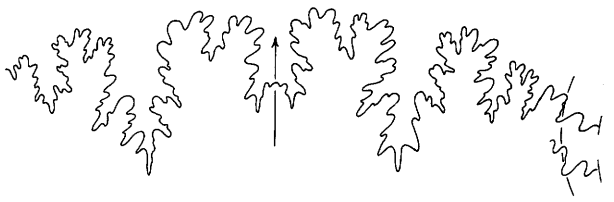

FIGURE 13.—Suture line of moderately ribbed example of *Leconteites lecontei* s. s. Hypotype, USNM 121503 from University ofOregon locality 465; specimen figured on plate 4, figures 9–11 (× 3½).

rounded venter. This form is fairly close to *Beudanticeras newtoni* Casey (see Casey, 1961, p. 147). The other specimen, a paratype (CAS 8883) of *Sonneratia perrinsmithi* (pl. 1, figs. 4, 5, and 12), has perisphinctid ribbing consisting of primary ribs that rise on the umbilical wall, project obliquely forward on the lower flank, bend slightly backward at midflank, and split on the outer flank into two or three secondary ribs that cross the venter with only a very slight forward projection and without a tendency to weaken at mid-venter. Periodic weak sinuous constrictions are also present. The proper generic placement of this form is not clear, and no additional specimens are known to the writers.

Measurements, in millimeters, of selected groups of specimens from California and from USGS Mesozoic locality 26262, central Oregon

[Whorl height and breadth data are plotted in fig. 9]

Specimen	Diameter	Whorl height	Whorl breadth	Ratio of breadth to height	Width of umbilicus	Ratio of width of umbilicus to diameter (percent)
Figured specimens from central Oregon						
USNM 121488	15	7	5.9	0.85	3	20
121487	20	10	7	.70	5.5	27.5
121501	15	7	6.3	.90	5	33
121486	22	11.5	6.7	.58	4.6	21
121489	24	11.8	9	.76	7	29
	32	14.6	12	.82	8.4	26
121490	32	14	9.3	.66	6	19
121491	27	12.5	8.8	.70	5.7	21
121492	26	13.5	8.6	.64	6	23
121493	40	18.8	12	.64	8.7	22
121498	36	15	14	.93	10	28
121496	29	12	9.3	.77	7.6	26
121497	----------	12	9	.75	----------	----------
121495	26	12	7	.58	6	23
121494	30	13	10	.77	7.6	25
121525a	20	9	7.5	.83	7	35
	5	2	3.8	1.8	----------	----------
	8	3	4	1.3	----------	----------
	12	6.4	5.5	.86	3.5	29
	30.4	14.6	10.5	.72	6.9	23
121525b	----------	6.6	4.5	.68	----------	----------
	----------	2.7	3.0	1.1	----------	----------
	----------	13	8	6.1	----------	----------
	33	15.5	9.7	.63	7	21
	47	21	----------	----------	12	25.5
121507	47	21	----------	----------	12	25.5
121506	33	15.7	11.5	.73	8.5	25.5
121505	----------	16	14.4	.90	----------	----------
121504	29	12	10.5	.88	9	31
121503	22	10	8	.80	8	36
121502	34	15.8	10.6	.67	7.7	22.5
121508	29	13	11.5	.88	8	27.5
121509	40	19.5	13	.66	10	25
	----------	31	18	.58	----------	----------
121510	30	12.5	11	.88	9	30
121512	----------	17	18	1.06	----------	----------
121499	----------	16.5	13.6	.82	----------	----------

Measurements, in millimeters, of selected groups of specimens from California and from USGS Mesozoic locality 26262, central Oregon—Continued

Specimen	Diameter	Whorl height	Whorl breadth	Ratio of breadth to height	Width of umbilicus	Ratio of width of umbilicus to diameter (percent)
Unnumbered specimens from central Oregon						
1	52	23	18.5	0.80	13.6	26
2	39	18	13.4	.74	10	26
3	20	10	6.8	.68	4.6	23
4	38	18	12	.67	8	21
5	36	16	11	.69	9	25
6	33	16	10	.63	7.5	23
7	25	12	8.6	.72	5.5	22
8	15	8.4	5.5	.66	3	20
9	40	18.6	14	.75	10	25
10	35	16.5	11.5	.70	7.5	21.5
Anderson's figured specimens of *Leconteites* spp. and *Puzosigella* sp.						
CAS 8858	41	16	15.3	0.97	13	31.5
8859	43	18	17.5	.97	12	28
8864	36	14	12	.85	11	30.5
8857	63	24.5	23	.93	19	30
UC 12093	62	32	21	.66	13	21
CAS 8868	59	26	[1] 18	.69	14	23.5
8871	42	18	12	.67	10	24
8869	35	16	12.5	.78	7	20
UC 12100	[1] 100	45	36	.80	31	31
		12.6	11.5	.91		
CAS 8866	33	14	11.7	.83	10	33
8884	29	11.7	11	.94	9	31
8872	28	12.7	8.4	.66	6	21.5
unnumbered	39	18	14	.78	9	23
Figured specimens of *Leconteites lecontei* from Huling Creek						
USNM 121523		12	10	0.83		
121521	41.7	16	13	.81	12	24
121517	27	12.7	8	.64	5.9	22
121515	18	7.6	7	.92	5.8	32
121514	19	8	6	.75	5	26.5
121519	42	20	14	.70	9	21.5
121522	50	20.9	17.5	.87	13.7	27.5
121524	44	19	13	.68	11	25
121520	30	13	10	.77	7.5	25
121516	23	9	10.8	1.20	8	35
121518		12.6	12.5	.99		

[1] About.

Measurements of selected groups of specimens are shown above and whorl height and breadth data are plotted in figure 9. Measured and illustrated specimens from Oregon include only those from locality A of figure 3; specimens from California were selected from three stratigraphic levels (fig. 2), near the base, the middle, and the top of the *Leconteites*-bearing sequence on Huling Creek. Several specimens from each level were chosen to demonstrate that the full range of morphologic variation from compressed to inflated forms occurs throughout the known range of the species. No attempt is made to thoroughly document the complete intergradation at each level, as this would only duplicate the sequence shown by the Oregon specimens.

Holotype: UC 12093.

Type locality: CAS loc. 152, east branch of Huling Creek, northern California.

Figured specimens: USNM 121486–121510, 121512–121524, 121525a, b, 121537, CAS 8866, 8884, 8882, 8858, 8857, 8868, 8872, 8871, 8869, 8864, UC 12093, Stanford Univ. paleont. type colln. 511.

Geologic age: Early Albian, zone of *Leconteites lecontei*.

Leconteites lecontei whiteavesi Jones, Murphy, and Packard, n. subsp.

Plate 6, figures 1–9, 12–14; plate 7, figures 1–3

Specimens of *Leconteites* from Beresford Bay, Queen Charlotte Islands, were recently collected by A. Sutherland-Brown, of the British Columbia Department of Mines and Petroleum Resources, and made available for study through the courtesy of F. H. McLearn of the Geological Survey of Canada. These specimens are closely related to typical *Leconteites lecontei* but differ by subtle features of ornamentation and by attaining a larger size. Although the weakly ornamented forms from Queen Charlotte Islands are nearly identical to those from California and Oregon (pl. 6, figs. 1–3), the more coarsely ribbed forms (pl. 6, figs. 12–14; pl. 7) have less strongly developed umbilical bullae from which primary ribs arise singly rather than in bundled pairs; none of the 15 specimens available to the writers have strong umbilical bullae, although they show a moderate range in variation of strength of ribbing. Some of the small specimens or early whorls of larger specimens (for example, pl. 6, figs. 12–14) have nearly smooth lower flanks, which is rare in typical forms of *L. lecontei;* they also have a slightly more rounded umbilical shoulder.

The Queen Charlotte Islands specimens also differ from Alaskan specimens of *Leconteites* referred to *L. deansi.* The main differences are the presence in the former of weak umbilical bullae and the tendency of the ribbing on the inner and outer flanks to be clearly separated by a band on which ribbing is weak, in contrast to the latter, which lacks umbilical bullae and has ribs that tend to thicken slightly on the lower or middle flank.

The specimen shown on plate 7 is the largest example of *Leconteites* known to the writers; it exceeds by more than 80 mm the maximum diameter of specimens known to us from California or Oregon. This size difference may not be specifically important, but it seems worthy of note that of the 15 specimens available to us from the Queen Charlotte Islands, 6 specimens, or fragments, exceed the maximum size known for typical *L. lecontei.*

This new subspecies is named in honor of J. F. Whiteaves, who described many of the Cretaceous fossils known from the Queen Charlotte Islands.

Measurements, in millimeters, of specimens from Queen Charlotte Islands

GSC specimen	Diameter	Whorl height	Whorl breadth	Ratio of breadth to height	Width of unbilicus	Ratio of width of umbilicus to diameter (percent)
19098	40	19	14	0.74	8	20
19099	17	8	6.3	.79	3.6	21
19100	23	10.7	6.9	.64	5.5	24
19101	33	16.4	11	.67	7.4	22.5
19102	152	58	46	.79	46	30
19097	185	68	59	.87	63	34

Types: Holotype GSC 19097; paratypes GSC 19098–19102.
Type locality: GSC loc. 48615, Beresford Bay, Queen Charlotte Islands.
Figured specimens: Types cited above.
Geologic age: Early Albian.

Leconteites sacramenticus (Anderson)

Plate 2, figures 9, 15, 16, 18–20

1902. *Pachydiscus sacramenticus* Anderson, California Acad. Sci Proc., v. 2, no. 1, p. 105, pl. 6, figs. 133, 134; pl. 10, fig. 105.
1938. *Sonneratia sacramentica* (Anderson). Anderson, Geol. Soc. America Spec. Paper 16, p. 195, pl. 49, figs. 1–3.
1954. *Puzosigella sacramentica* (Anderson). Casey, Washington Acad. Sci. Jour., v. 44, no. 4, p. 110.

Leconteites sacramenticus, the generic type of *Puzosigella*, is questionably distinct from *Leconteites lecontei*. The shell is moderately inflated, has rounded flanks, a broadly rounded venter, a moderately wide umbilicus, and a steeply sloping umbilical wall. Early whorls, to a diameter of 30–35 mm, have prominent primary ribs that rise from thickened elongate umbilical bullae and that cross the flanks with a gently flexed course. At or just above midflank, the primary ribs bifurcate into secondary ribs that project moderately forward on the outer flank and weaken on the venter. As the shell diameter increases, umbilical bullae disappear and ribs on the lower flanks weaken progressively so that, on large shells, only bundled striae can be seen. Ribbing on the outer flank remains fairly strong and projects forward, but differentiation into primary and secondary ribs is lost. An occasional rib crosses the venter, but most ribs split up into two to five fine striae. Very faint spiral lines are on the venter of the holotype, and the intersection of these and the transverse striae produce a faint reticulate pattern.

Leconteites sacramenticus is a very scarce form and is known only from Anderson's type specimens. No specimens from Oregon exhibit the same combination of characteristics, nor can any of the known specimens of *L. lecontei* from Huling Creek be shown to intergrade with these forms. We feel that this lack of intergradation is due probably to an insufficient collection of specimens, but in the absence of definite proof of this, it seems best to regard *L. sacramenticus* as a distinct species. No necessity is seen, however, for the genus *Puzosigella*, and it is herein considered as a subjective synonym of *Leconteites*. Measurements of the holotype and paratype are given on page F13 and are shown in figure 10.

Holotype: UC 12100.
Paratype: CAS 8859.
Type locality: CAS loc. 152.
Figured specimens: UC 12100, CAS 8859.
Geologic range: Probably from *Leconteites lecontei* zone judging from nature of preservation and from Anderson's locality information.

Leconteites deansi (Whiteaves)

Plate 6, figures 10, 11, 15, 16

1893. *Olcostephanus (Astieria) deansi* Whiteaves, Canadian Record Sci., ser. 1, v. 10, sec. 14, p. 442–444, pl. 7, figs. 1, 1a.
1960. *Leconteites deansi* (Whiteaves). Imlay, U.S. Geol. Survey Prof. Paper 354–D, p. 109, pl. 19, figs. 7–14.
1960. *Leconteites* cf. *L. deansi* (Whiteaves). Imlay, idem, p. 109, pl. 19, figs. 15–17.
1960. *Leconteites modestus* (Anderson). Imlay, idem, p. 109, pl. 19, figs. 4–6.
1960. *Puzosigella* cf. *P. rogersi* (Hall and Ambrose). Imlay, idem, p. 109, pl. 19, figs. 33–35.

Leconteites deansi is very abundant in the lowermost Cretaceous beds of the upper Chitina Valley. Recent collecting there by Imlay and Jones has shown that the specimens figured by Imlay (1960) as *Puzosigella* cf. *P. rogersi*, *L. deansi*, *L.* cf. *L. deansi*, and *L. modestus* actually intergrade and form one variable species. This species differs from *L. lecontei* by lacking umbilical bullae and by having ribs that rise singly at or near the umbilical seam, even on the more coarsely ribbed variants. In an occasional specimen, two ribs may join near the umbilical shoulder (see Imlay, 1960, pl. 19, fig. 20), producing what appears to be a small bulla at the junction. This condition is probably pathologic. The ribs tend to become slightly stronger on the lower flank before splitting into two or more secondary ribs, in contrast to *L. lecontei*, in which the ribs weaken with the formation of a nearly smooth band on the lower flank.

The previously determined stratigraphic position of this species requires minor revision. According to Imlay (1960, fig. 21), *Leconteites modestus* and *Puzosigella* spp. questionably occur below *L. deansi* and *Moffitites robustus* Imlay. Further collecting has demonstrated that all of these forms herein referred to *L. deansi* are found together with *M. robustus* and that these occur below a specimen that has well-developed umbilical bullae and that is referred to *L. lecontei*. Thus, *L. deansi* is the earliest known representative of *Leconteites*, and it appears to have given rise to *L. lecontei* by emphasis of the umbilical bullae.

The type locality of *L. deansi* is unknown; according to Whiteaves (1893, p. 442) the original specimen sent to him for study was labeled as having been collected at Skidegate Inlet, Queen Charlotte Islands. Recent extensive collecting at this place by Jones failed to turn up any specimens of this species nor were any fossiliferous Cretaceous rocks older than the *Brewericeras hulenense* zone found there. Specimens of *Leconteites lecontei* are known from the northwestern side of Graham Island, however, no specimens of *L. deansi* have yet been found there.

Figured specimen: Hypotype USNM 130164b from USGS Mesozoic loc. 9972.
Geologic age: Early Albian, zone of *Moffitites robustus*.

Genus BREWERICERAS Casey

1954. *Brewericeras*, Casey, Washington Acad. Sci. Jour., v. 44, no. 4, p. 112.

Type species (by original designation).—*Ammonites breweri* Gabb, 1864, pl. 10, fig. 7 ([not] 1869, pl. 20, fig. 5, as cited by Casey. That specimen is herein referred to *B. hulenense*).

The genus *Brewericeras* was established for Pacific coast Albian ammonites that were previously assigned to *Beudanticeras*. They differ from *Beudanticeras* by having

* * * very flat, subparallel whorl sides, consistently sharp umbilical rim, and no constrictions or peripheral ridges. Costate developments with falciform ribs on the upper lateral area that are sharper and more regular than those of *Beudanticeras* and which weaken on the ventral area (Casey, 1954, p. 112).

Study of large collections of specimens from northern California and southern Alaska necessitates a revision of the generic characteristics described above. A revised generic description follows:

The shell is compressed and has flat to slightly inflated flanks, a narrow evenly rounded venter, a small umbilicus having an abrupt to very sharp umbilical shoulder and a steeply sloping to vertical wall. Ornamentation consists of falcate ribs of varying strength that commonly arise from bundled striae on the lower flank but that rarely arise singly at the umbilical margin or spring from inconspicuous umbilical bullae. The ribs are most prominent on the outer flank, where they project strongly forward, and they may weaken or be indistinguishable on the venter. Constrictions are scarce, although more coarsely ribbed forms tend to have a few falcate constrictions that are bordered on the venter by a posterior peripheral ridge.

Other species referred by Casey to *Brewericeras* include *Ammonites haydeni* Gabb and *Beudanticeras hulenense* Anderson. According to Murphy and Rodda (1960, p. 851–852), *A. haydeni* is a true representative of *Beudanticeras* and differs markedly from *Brewericeras hulenense* by nature of the suture, whorl shape, and ornamentation.

Brewericeras thus includes two species, *breweri* and *hulenense*, and these have been consistently confused. In Casey's citation of the type species, he designated *B. breweri* as the type, but he referred to a specimen that we regard as *B. hulenense*. This misidentification, however, does not have any significant effect on the generic concept, as the two species do not differ greatly.

Brewericeras is clearly closely related to *Leconteites* and could, indeed, be regarded as of no more than subgeneric rank or even regarded as a synonym, but we prefer to retain both generic names. The differences between *Leconteites* and *Brewericeras* are summarized as follows:

Brewericeras	*Leconteites*
Whorl shape mainly thin and compressed; moderately inflated forms are rare.	Whorl shape shows complete range from compressed to inflated forms.
Ornamentation ranges from completely smooth to strong primary falcate ribs that rarely bifurcate on outer flank; umbilical tubercles and paired ribs are absent; constrictions are rare.	All forms ribbed but show a wide range in strength of ribbing; primary ribs furcate on outer flank to form numerous secondary ribs; umbilical bullae may be very prominent; ribs arise singly or spring in pairs or bundles from bullae; constrictions may be common.
Coiling excentric	Coiling shows only a slight tendency to excentricity on very compressed forms.

Brewericeras breweri (Gabb)

Plate 8, figures 3, 5

1864. *Ammonites brewerii* Gabb, California Geol. Survey, Paleontology, v. 1, p. 62, pl. 10, fig. 7.
1954. *Brewericeras brewerii* (Gabb). Casey, Washington Acad. Sci., v. 44, no. 4, p. 112.
1869. [not] *Ammonites brewerii* Gabb, California Geol. Survey, Paleontology, v. 2, p. 130, pl. 19, fig. 5, 6; pl. 20, fig. 5.
1876. [not] *Ammonites brewerii* Gabb. Whiteaves, Mesozoic Fossils, p. 21, pl. 1, fig. 2, 2a, 3, 3a.
1927. [not] *Beudanticeras breweri* (Gabb). Crickmay, Amer. Jour. Sci., ser. 15, v. 13, no. 78, p. 503.
1938. [not] *Beudanticeras breweri* (Gabb). Anderson, Geol. Soc. America Spec. Paper 16, p. 189, pl. 43, fig. 3; pl. 44, figs. 1, 2.
1960. [not] *Brewericeras breweri* (Gabb). Imlay, U.S. Geol. Survey Prof. Paper 354–D, p. 105, pl. 17, figs. 5–10, 12, 13.

Brewericeras breweri was originally obtained from the North Fork of Cottonwood Creek, northern California, and the holotype is the only known specimen of this species. This specimen, which is a fragment of a body whorl that has a part of the inner whorl exposed, is crushed and deformed and cannot be accurately measured. The whorl section is compressed and its height is greater than its breadth; the whorl appears to be somewhat inflated and its greatest breadth is in the lower one-third of the flank. Some of this inflation may be due to secondary deformation, but the flanks do not appear to be as slab sided as in *B. hulenense*. The umbilicus is fairly wide, the umbilical wall nearly vertical, and the umbilical shoulder abrupt. The suture line is unknown.

Ornamentation consists of fairly strong regular falcate ribs that rise on the umbilical shoulder, project forward on the lower flank, bend backward at midflank, and again project forward on the outer flank. The ribs cross the venter and have only a slight tendency to weaken along the midline. Likewise, ribbing on the lower flank tends to be only slightly less prominent than on the outer flank, and a few ribs bundle together on approaching the umbilical shoulder.

The ribs of this specimen extend to the umbilical shoulder and in this respect differ from the closely allied *B. hulenense,* in which the ribbing is absent or very weak on the lower flank. Many specimens of *B. hulenense* are as coarsely ribbed on the outer flank as *B. breweri,* but on all of these specimens the ribs tend to be weak on the lower flank, although on some of the more inflated varieties, an occasional rib may reach the umbilical margin. Also, the ribs are stronger on the venter and the flanks more inflated in *B. breweri* than in *B. hulenense.* These differences are more those of degree than of kind, however, and it would seem logical to treat these two "species" as belonging to a single, highly variable, intergrading population and to repress *B. hulenense* as unnecessary. However, among hundreds of specimens examined, no clear transition from one form to the other was found, and *B. breweri* seems to be unique. Unfortunately, the stratigraphic position of this species is unknown, and until additional specimens are found and their relationship to *B. hulenense* established, it seems best to regard the two forms as separate species.

Holotype: UC 12098.

Type locality: North Fork of Cottonwood Creek, northern California; exact position unknown.

Age: Probably late early Albian. This judgment is based on the position of *B. hulenense,* its congener, and the character of the attached matrix, which is like that of the *B. hulenense* zone of Huling Creek.

Brewericeras hulenense (Anderson)

Plate 8, figures 1, 2, 4; plates 9, 10; plate 11, figures 1–3, 13–14

1876. *Ammonites brewerii* Gabb. Whiteaves, Mesozoic Fossils, v. 1, pt. 1, p. 21, pl. 1, fig. 2, 2a.
1927. *Beudanticeras brewerii* Gabb. Crickmay, Am. Jour. Sci., 5th ser., v. 13, no. 78, p. 509, figs. 1–3.
1938. *Beudanticeras hulenense* Anderson, Geol. Soc. America Spec. Paper 16, p. 190, pl. 44, figs. 3, 4.
1938. *Beudanticeras breweri* (Gabb). Anderson, idem, p. 189, pl. 43, fig. 3; pl. 44, figs. 1, 2.
1943. *Desmoceras haydeni* Gabb. Anderson, Calif. Div. Mines Bull. 118, p. 168–169, figs. 61–68.
1960. *Brewericeras breweri* (Gabb). Imlay, U.S. Geol. Survey Prof. Paper 354–D, p. 105, pl. 17, figs. 5–10, 12, 13.
1960. *Brewericeras* cf. *B. hulenense* (Anderson). Imlay, idem, p. 106, pl. 17, figs. 11, 14–16.
1960. *Brewericeras hulenense* (Anderson). Murphy and Rodda, Jour. Paleontology, v. 34, no. 5, pl. 105, fig. 3.

Brewericeras hulenense is widespread in Albian deposits of the Pacific coast region of North America and occurs in California, Oregon, Washington, Queen Charlotte Islands, B.C., and southern Alaska. Throughout this extent the species exhibits similar morphologic characteristics that show a wide range in variation.

Typical specimens of *B. hulenense* are nearly smooth and have flattened, nearly parallel flanks, an evenly rounded narrow venter, and a small umbilicus having a sharp shoulder and a steep to vertical wall. Excentric growth is well displayed in some specimens (pl. 10; pl. 11, figs. 1, 13; text fig. 14). At a diameter of approximately 45 mm and larger, the umbilical wall is bent midway between the umbilical suture and the umbilical edge so that it appears to have been creased. The growth lines on the wall are inclined posteriorly from the umbilical suture to this crease and then inclined anteriorly from the crease to the umbilical shoulder giving the growth lines a chevron shape on the umbilical wall. This characteristic is useful in distinguishing fragmentary specimens of *B. hulenense* from *Beudanticeras haydeni* on which the chevron shape of the growth lines is lacking. Ornamentation consists of bundled growth striae that rise at the umbilical seam, are curved on the wall as described above, inclined strongly forward on lower flanks, arch gently backward at midflank and cross the upper flanks with marked forward projection.

Like *Leconteites lecontei, Brewericeras hulenense* shows an extremely wide range of variation from very compressed smooth forms to inflated strongly

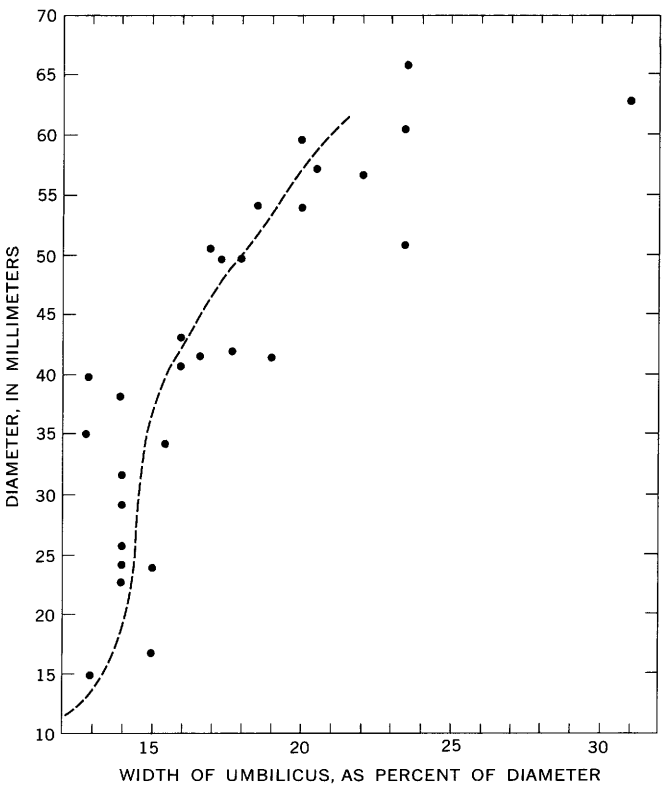

FIGURE 14.—Scatter diagram showing relation of width of umbilicus, expressed as percent of diameter, to diameter for specimens of *Brewericeras hulenense* from USGS Mesozoic locality M1337. A relative increase in umbilical width due to excentric growth is shown by the change in slope of the curve at about a diameter of 30 mm. The heavy dots represent more coarsely ribbed specimens.

ribbed specimens (pl. 10). Costation when present commonly develops at a diameter of about 35 mm. The costae are low, closely spaced, most strongly developed on the outer half of the flanks, and weak or absent across the venter and on the umbilical half of the flank. In some large specimens, periodic widely spaced ridges, associated with constrictions of the shell, are present on the flanks and venter. Some specimens show a slight tendency toward bundling of the striae at the umbilical edge, but bullae are not developed as on species of the closely related *Leconteites*.

An intergrading series that has progressively stronger ornamentation can be demonstrated from the nearly smooth specimens shown on plate 9, figure 4, and plate 10, figure 1, through typical forms that have weak ornamentation as represented by the holotype and by the specimens figured on plate 10, figures 3 to 5, to the coarsely ribbed specimen shown on plate 10, figures 14, 15. Correlated with the increase in coarseness of the ribbing is an increase in the B/H ratio and in the width of the umbilicus. In addition, the whorl section becomes more rounded and the umbilical shoulder may become less sharp as the ribs increase in strength.

The suture line is deeply incised and moderately interlocked (figs. 15 and 16) and has a thin asymmetrically bifid first lateral saddle, a deep trifid first lateral lobe that is much deeper than the external lobe, and a very thin asymmetric second lateral saddle. Three irregular auxiliary saddles descend evenly to the umbilical seam. The internal suture consists of a moderately high arch that has numerous auxiliary saddles and lobes. The suture of *B. hulenense* differs from that of *L. lecontei* by being more deeply incised and by having thinner stemmed saddles.

In a single population the frequency of occurrence of the coarsely ribbed forms similar to the specimen on plate 10, figures 14 and 15, is very low. In one sample from USGS Mesozoic locality M1337 consisting of more than 70 specimens, 38 specimens having a diameter of more than 35 mm are smooth or have only ill-defined riblets composed of bundled striae, 18 specimens have clearly discernible ribs, and only 1 specimen has coarse ribs (fig. 17). Because ribs do not appear on some specimens until a fairly large diameter (55–60 mm) is attained, these proportions may not be too precise, because some of the smaller specimens in the smooth group might ultimately have produced ribs, thus decreasing the difference in frequency of these two groups. Despite this, in all known collections, smooth to faintly or weakly ribbed forms greatly predominate over the more coarsely ribbed forms. A selected series of specimens from USGS Mesozoic locality M1337 are shown on plate 10 and measurements of 27 specimens are given in the table below.

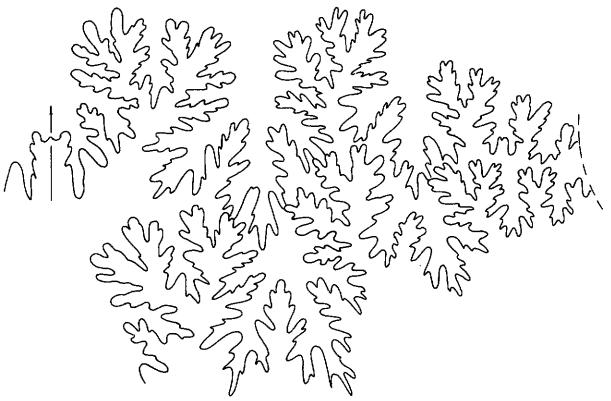

FIGURE 15.—Suture line of *Brewericeras hulenense*, hypotype USNM 121535, from University of California at Riverside locality 1000; specimen figured on plate 11, figures 1–3 (× 4½).

Brewericeras hulenense is closely related to *Leconteites lecontei*, and differs from it mainly in details of

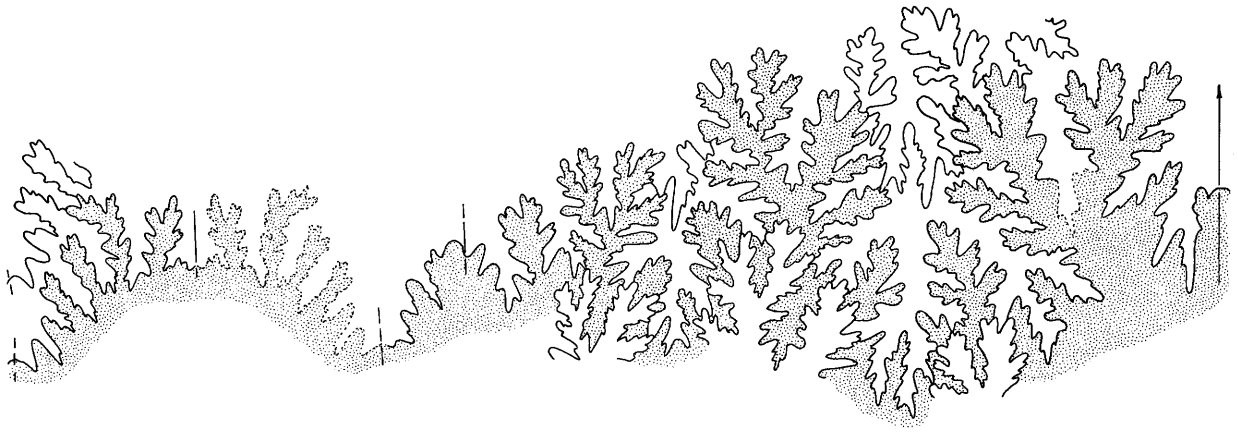

FIGURE 16.—Suture line of *Brewericeras hulenense* (Anderson); hypotype USNM 121511, from University of California at Riverside locality 70 (× 1¾).

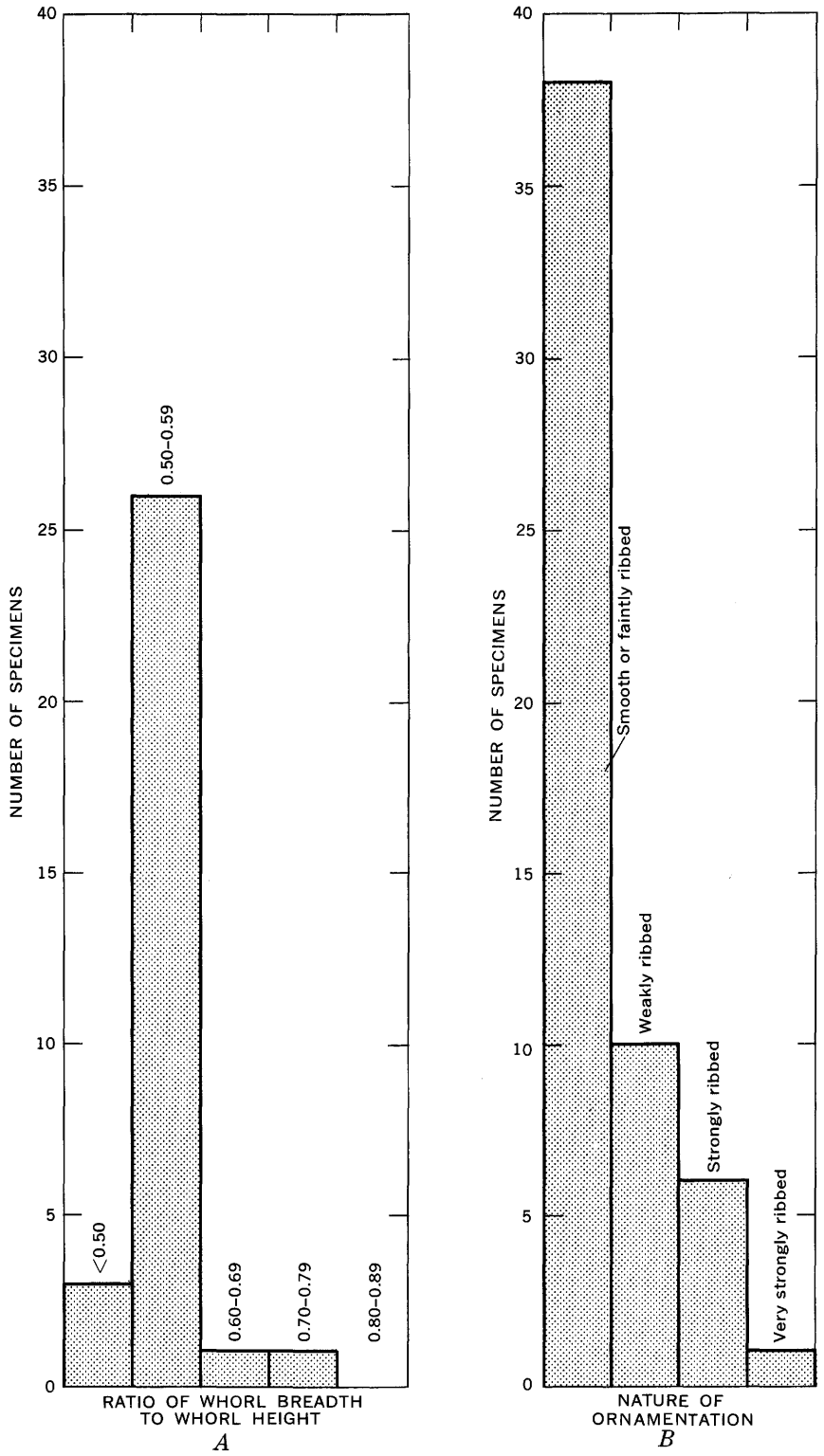

FIGURE 17.—*A*, Bar graph showing frequency distribution of whorl breadth to whorl height ratio in *Brewericeras hulenense* from USGS Mesozoic locality M1337. *B*, Bar graph showing frequency distribution of smooth and ribbed forms of *Brewericeras hulenense* from USGS Mesozoic locality M1337.

ribbing. In *B. hulenense*, the ribs mainly rise singly on the lower flank or, in inflated forms, on the umbilical shoulder, and well-developed umbilical bullae are not present. These ribs do not bifurcate on the outer flank, and if secondary ribs are present, they rise singly between the primaries. In *L. lecontei*, the primary ribs tend to spring in pairs from well developed, pinched umbilical bullae and generally bifurcate on the outer flank. The strongly developed bifurcation of ribs in *L. deansi* clearly separates that species from *B. hulenense*.

In most collections of *B. hulenense*, the differences previously cited clearly separate it from the geologically older species *L. lecontei*. Among the collections from Huling Creek, however, there are some specimens that are clearly intermediate in form between the two genera, and their proper taxonomic position is difficult to determine. For example, the specimen on plate 11, figures 7 to 9, has finer more numerous ribs on the outer flank than is usual for *B. hulenense*, and the umbilical bullae are only slightly weaker than is usual for *L. lecontei* (compare this specimen with the specimen of *L. lecontei* figured on pl. 11, figs. 4–6). The ribs of the outer whorl, however, show no indication of bifurcation and are similar to those of *B. hulenense*. The specimens on plate 11, figures 10–12 and 15–17, have strong umbilical bullae and bifurcating ribs of the *Leconteites* type on the inner whorls and coarse simple ribs of the *B. hulenense* type on the body chamber. These scarce specimens, which occur with the lowest known examples of *B. hulenense* and 10–15 feet above beds having undoubted *L. lecontei* (fig. 2), are considered as intermediate forms linking the two genera.

Holotype: CAS 8831.

Type locality: CAS loc. 1659. East Fork of Huling (=Hulen) Creek, Ono area, northern California.

Figured specimens: USNM 121526–121536 and ANSP 4798.

Geologic age: Brewericeras hulenense zone, upper lower Albian.

Measurements, in millimeters, of selected groups of specimens from California and USGS Mesozoic locality M1337, southern Alaska

Specimen	Diameter	Whorl height	Whorl breadth	Ratio of breadth to height	Width of umbilicus	Ratio of width of umbilicus to diameter (percent)
USNM 121538 [1]	45	21.7	13.6	0.62	9	20
121535	48	21.8	[2] 12.7	.58	12	20
121526	64	30	19	.63	15	23.5
121527	72	37	21	.57	10.8	15
121536	65	25	18	.72	18	27.5
121539 [1]	56	24	[3] 18	.75	15.8	28
121540 [1]	42	16.6	14.6	.87	13.8	33
		21	20	.95		
121528	139	60	38	.63	36	26
121532	61	28	16	.57	14.5	23.5
121529	54	25.5	13.5	.53	10	18.5
121533	66	29	15	.52	17.5	26.5
121531	57	24	13.5	.56	12.5	22
121534	63	25	18	.72	19.8	31
121530	65	30	15	.50	12.6	19.4
LSJU 6506	120	49	38	.77	33	27.5
ANSP 4798	113	48	33	.68	32	20.5

Measurements, in millimeters, of selected groups of specimens from California and USGS Mesozoic locality M1337, southern Alaska—Continued

Specimen	Diameter	Whorl height	Whorl breadth	Ratio of breadth to height	Width of umbilicus	Ratio of width of umbulicus to diameter (percent)
Unnumbered specimens						
1	17	8.0	5.5	0.69	2.5	15.0
2	23	12.9	7.3	.57	3.2	14.0
3	24	12.9	6.8	.53	3.3	14.0
4	24	12.9	7.2	.56	3.5	15.0
5	26	13.6	7.0	.52	3.6	14.0
6	29	15.0	7.7	.52	4.1	14.0
7	32	16.8	9.0	.53	4.5	14.0
8	34	17.5	10.0	.57	5.5	15.6
9	35	18.1	9.4	.52	4.6	13.0
10	38	19.7	10.5	.53	5.3	14.0
11	40	20.0	10.0	.50	5.8	14.0
12	41	21.0	10.1	.48	6.5	16.0
13	42	20.0	10.0	.50	8.0	19.0
14	42	21.5	10.5	.49	6.5	15.6
15	43	21.5	11.0	.51	7.6	17.6
16	44	23.0	10.5	.46	6.6	15.0
17	51	23.0	12.0	.52	12.0	23.5
18	51	24.0	12.5	.52	8.7	17.0
19	50	24.0	12.8	.53	9.0	18.0
20	54	25.0	13.9	.55	10.7	20.0
21	57	26.0	14.0	.54	11.8	20.5
22	50	24.0	12.0	.50	8.8	17.5
23	60	27.5	15.0	.55	12.0	20.0
24	64	28.0	16.0	.57	15.0	23.5
25	71	30.5	17.5	.57	17.0	24.0
26	15	8.7	4.7	.54	2.0	13.0
27	12	7.0	4.0		1.9	16.0

[1] Specimen intermediate between *Leconteites* and *Brewericeras*.
[2] Slightly crushed.
[3] About.

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INDEX

[Italic numbers indicate descriptions]

PLATES 1–11

PLATE 1

[All figures natural size]

FIGURES 1–22. *Leconteites lecontei* (Anderson) s. s. (p. F9).

1–3, 17–19. *Sonneratia rogersi* Hall and Ambrose.

1–3. Plastohypotype, CAS 8866; figured by Anderson (1938, pl. 20, fig. 6).

17–19. Plastohypotype, CAS unnumbered; figured by Anderson (1938, pl. 20, fig. 7).

6–8, 22. *Sonneratia perrinsmithi* Anderson.

6–8. Plastoparatype, CAS 8884; figured by Anderson (1938, pl. 51, fig. 5).

22. Plastoholotype, CAS 8882; figured by Anderson (1938, pl. 31, fig. 5).

9–11, 14, 15, 20. *Sonneratia taffi* Anderson.

9–11. Plastoparatype, CAS 8858; figured by Anderson (1938, pl. 49, fig. 5).

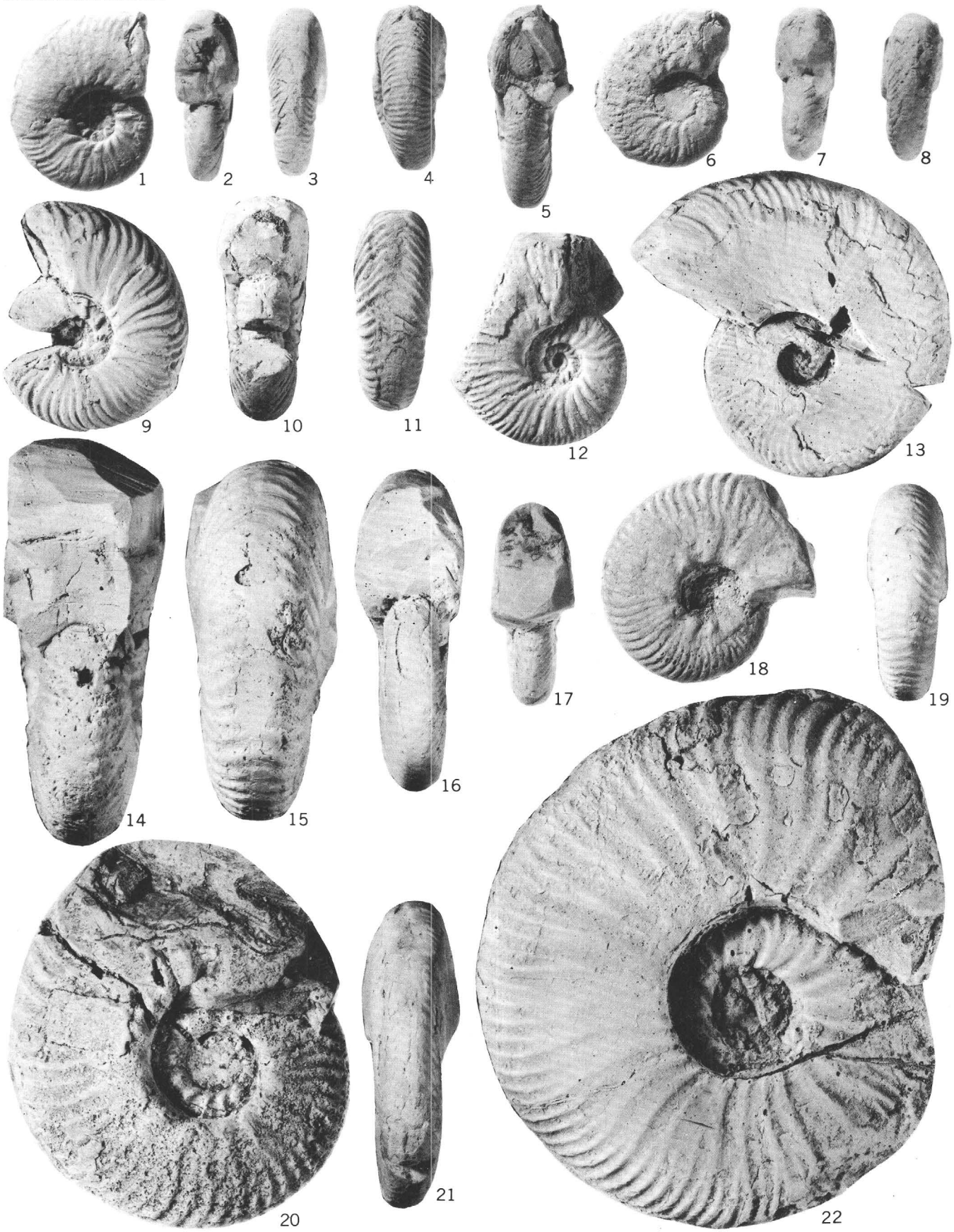
14, 15, 20. Plastoholotype, CAS 8857; figured by Anderson (1938, pl. 49, fig. 4).

13, 16, 21. *Cleoniceras lecontei* (Anderson).

Plastoplesiotype, CAS 8868; figured by Anderson (1938, pl. 47, fig. 4).

4, 5, 12. *"Sonneratia perrinsmithi"* Anderson.

Plastoparatype, CAS 8883; figured by Anderson (1938, pl. 51, fig. 6). This specimen does not belong to *S. perrinsmithi* nor to *Leconteites*.



LECONTEITES

PLATE 2

[All figures natural size]

FIGURES 1–8, 10–14, 17, 21. *Leconteites lecontei* (Anderson) s. s. (p. F9).

1–3, 7, 8, 13. *Cleoniceras modestum* Anderson.

1–3. Plastoparatype, CAS 8872; figured by Anderson (1938, pl. 50, fig. 4).

7, 8, 13. Plastoparatype, CAS 8871; figured by Anderson (1938, pl. 50, fig. 3). The holotype (CAS 8870) of *C. modestum* does not belong to *Leconteites*.

4–6, 12, 14, 21. *Cleoniceras lecontei* (Anderson).

4–6. Plastohypotype, CAS 8869; figured by Anderson (1938, pl. 47, fig. 5).

12, 14, 21. Plastoholotype, UC 12093; figured by Anderson (1902, pl. 3, figs. 94, 95) as *Desmoceras lecontei*.

10, 11, 17. *Sonneratia mulleri* Anderson.

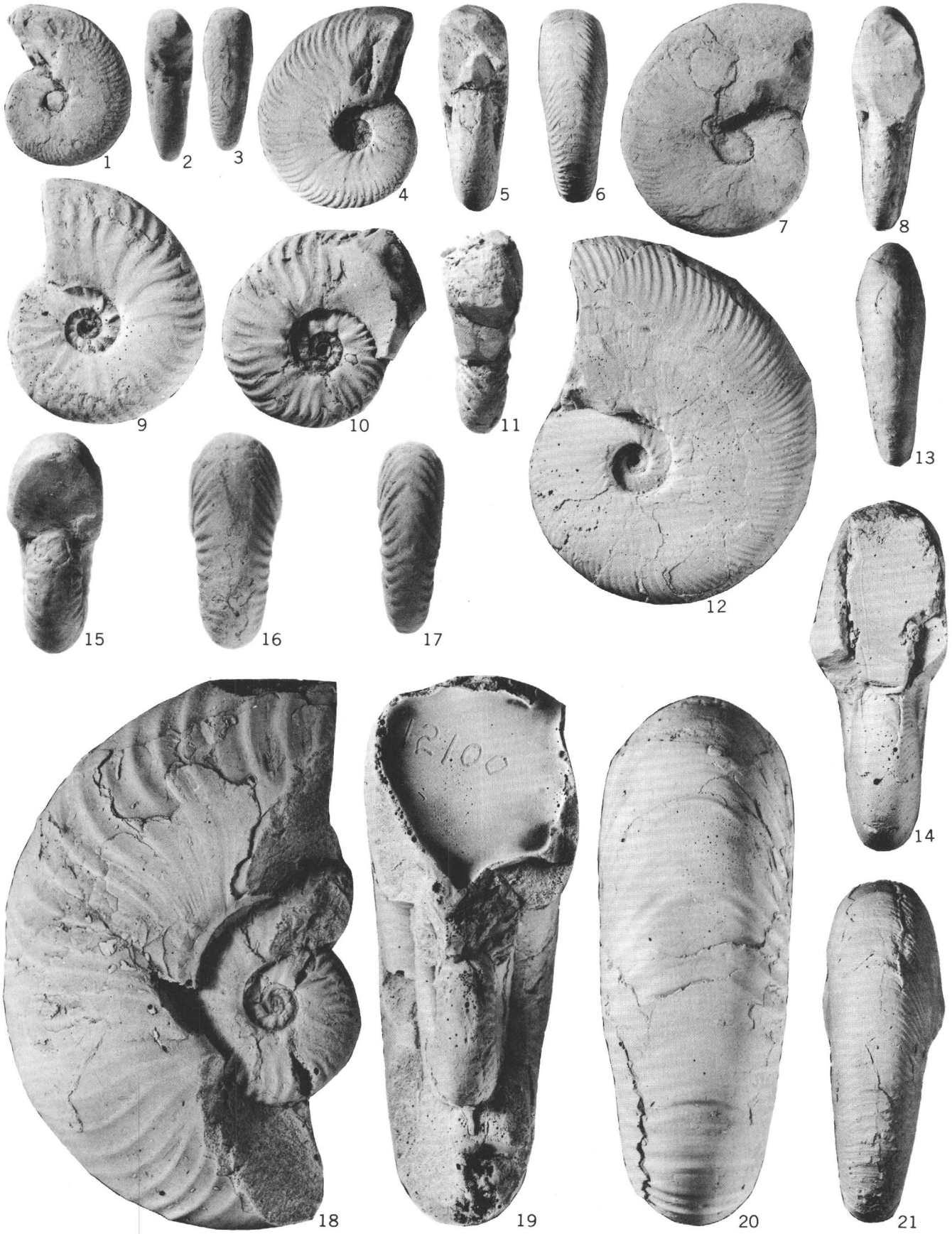
Plastoholotype, CAS 8864; figured by Anderson (1938, pl. 51, fig. 4; pl. 54, fig. 4).

9, 15, 16, 18–20. *Leconteites sacramenticus* (Anderson) (p. F14).

9, 15, 16. *Sonneratia sacramentica* (Anderson).

Plastohypotype, CAS 8859; figured by Anderson (1938, pl. 49, fig. 3).

18–20. Plastoholotype, UC 12100, figured by Anderson (1902, pl. 6, figs. 133, 134) as *Pachydiscus sacramenticus*.



LECONTEITES

PLATE 3

[All figures natural size]

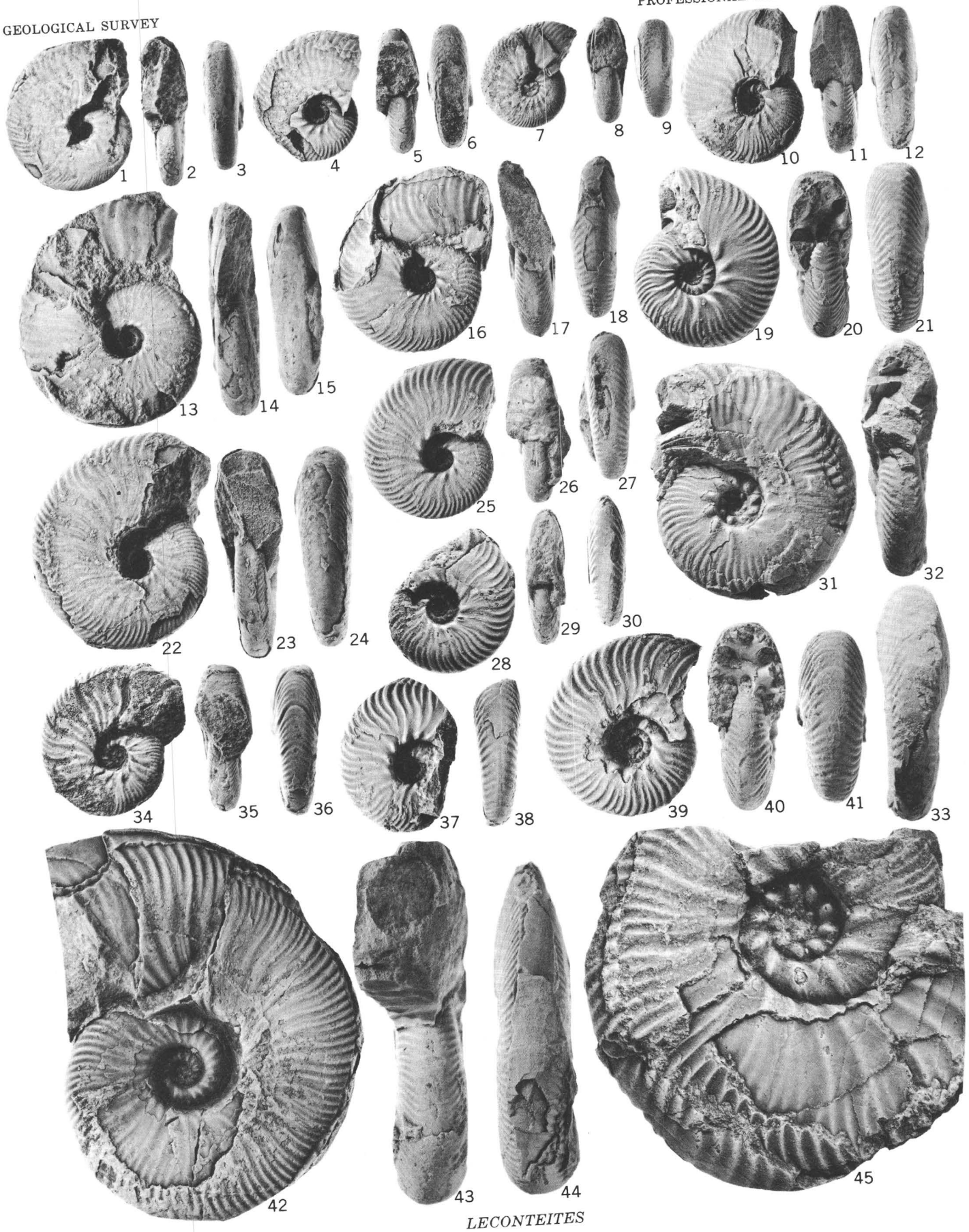
FIGURES 1–45. *Leconteites lecontei* (Anderson) s. s. (p. F9).

All specimens from central Oregon, except figures 31–33, which are from central California. Specimens are arranged with finely ribbed forms on left side of plate and progressively more coarsely ribbed forms to the right.

1–3. Hypotype, USNM 121486 from USGS Mesozoic loc. M2284.
4–6. Hypotype, USNM 121487 from USGS Mesozoic loc. M2284.
7–9. Hypotype, USNM 121488 from USGS Mesozoic loc. 15801.
10–12. Hypotype, USNM 121489 from UO loc. 4082.
13–15. Hypotype, USNM 121490 from USGS Mesozoic loc. 26262.
16–18. Hypotype, USNM 121491 from USGS Mesozoic loc. M2284.
19–21. Hypotype, USNM 121492 from USGS Mesozoic loc. M2284.
22–24. Hypotype, USNM 121493 from USGS Mesozoic loc. M2284.
25–27. Hypotype, USNM 121494 from UO loc. 4082.
28–30. Hypotype, USNM 121495 from UO loc. 4082.
31–33. *Sonneratia rogersi* Hall and Ambrose.

Holotype, Stanford Univ. Paleont. type colln. 511; figured by Wiedey (1929, pl. 2, fig. 2).

34–36. Hypotype, USNM 121496 from USGS Mesozoic loc. 26262.
37–38. Hypotype, USNM 121497 from USGS Mesozoic loc. M2284.
39–41. Hypotype, USNM 121498 from USGS Mesozoic loc. 26262.
42–44. Hypotype, USNM 121499 from USGS Mesozoic loc. 15801.
45. Hypotype, USNM 121500 from USGS Mesozoic loc. 26262.



LECONTEITES

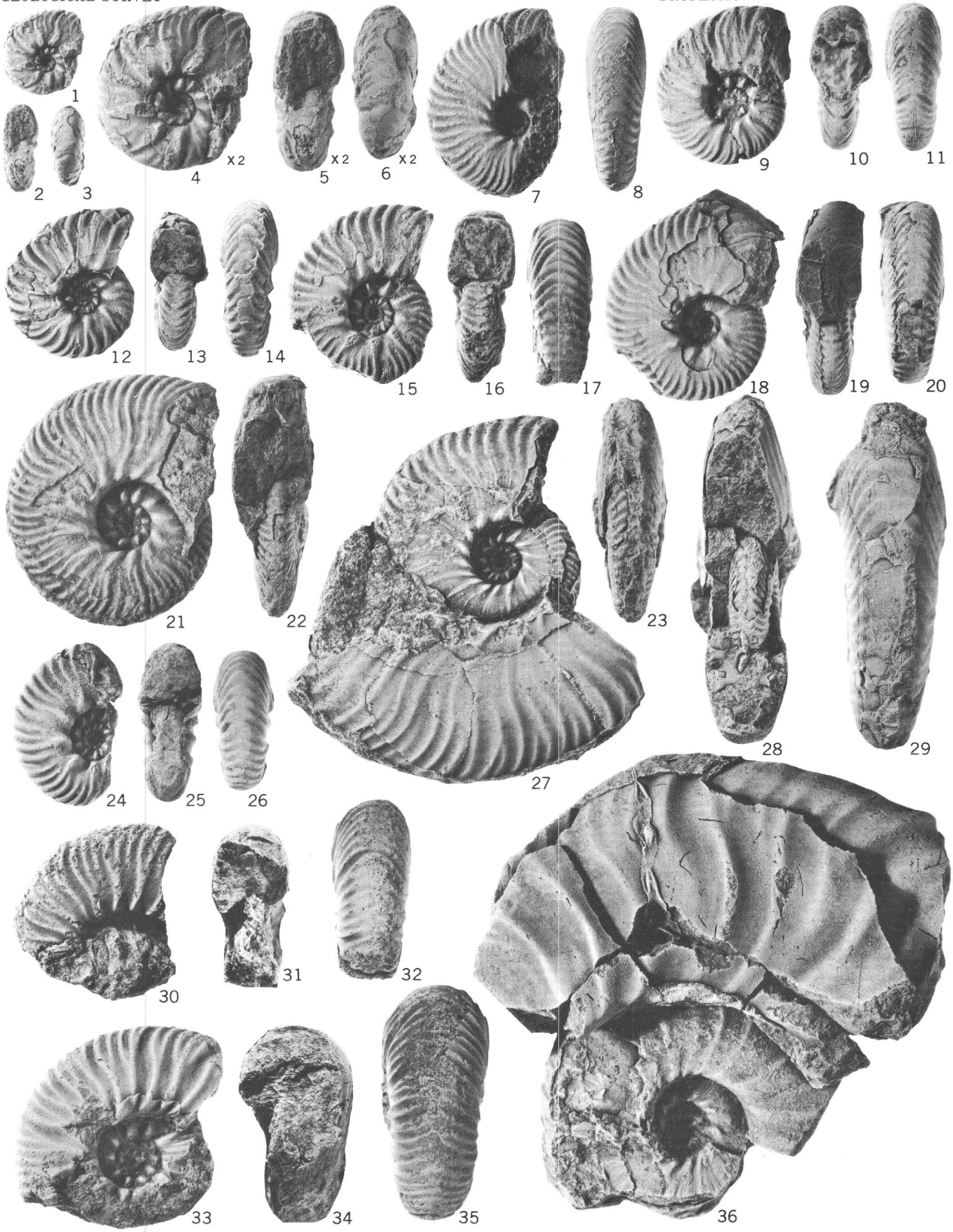
PLATE 4

[All figures natural size except as indicated]

FIGURES 1–36. *Leconteites lecontei* (Anderson) s. s. (p. F9).

All specimens from central Oregon showing coarsely ribbed variants.

1–6. Hypotype, USNM 121501 from USGS Mesozoic loc. M2284 (figs. 4–6 are ×2).
7–8. Hypotype, USNM 121502 from USGS Mesozoic loc. 26262.
9–11. Hypotype, USNM 121503 from UO loc. 465.
12–14. Hypotype, USNM 121504 from UO loc. 4082.
15–17. Hypotype, USNM 121505 from UO loc. 4082.
18–20. Hypotype, USNM 121506 from USGS Mesozoic loc. 26262.
21–23. Hypotype, USNM 121507 from USGS Mesozoic loc. 26262.
24–26. Hypotype, USNM 121508 from USGS Mesozoic loc. M2284.
27–29. Hypotype, USNM 121509 from USGS Mesozoic loc. 26378.
30–32. Hypotype, USNM 121510 from USGS Mesozoic loc. 26262.
33–35. Hypotype, USNM 121512 from USGS Mesozoic loc. 26262.
36. Hypotype, USNM 121513 from USGS Mesozoic loc. M2284.



LECONTEITES

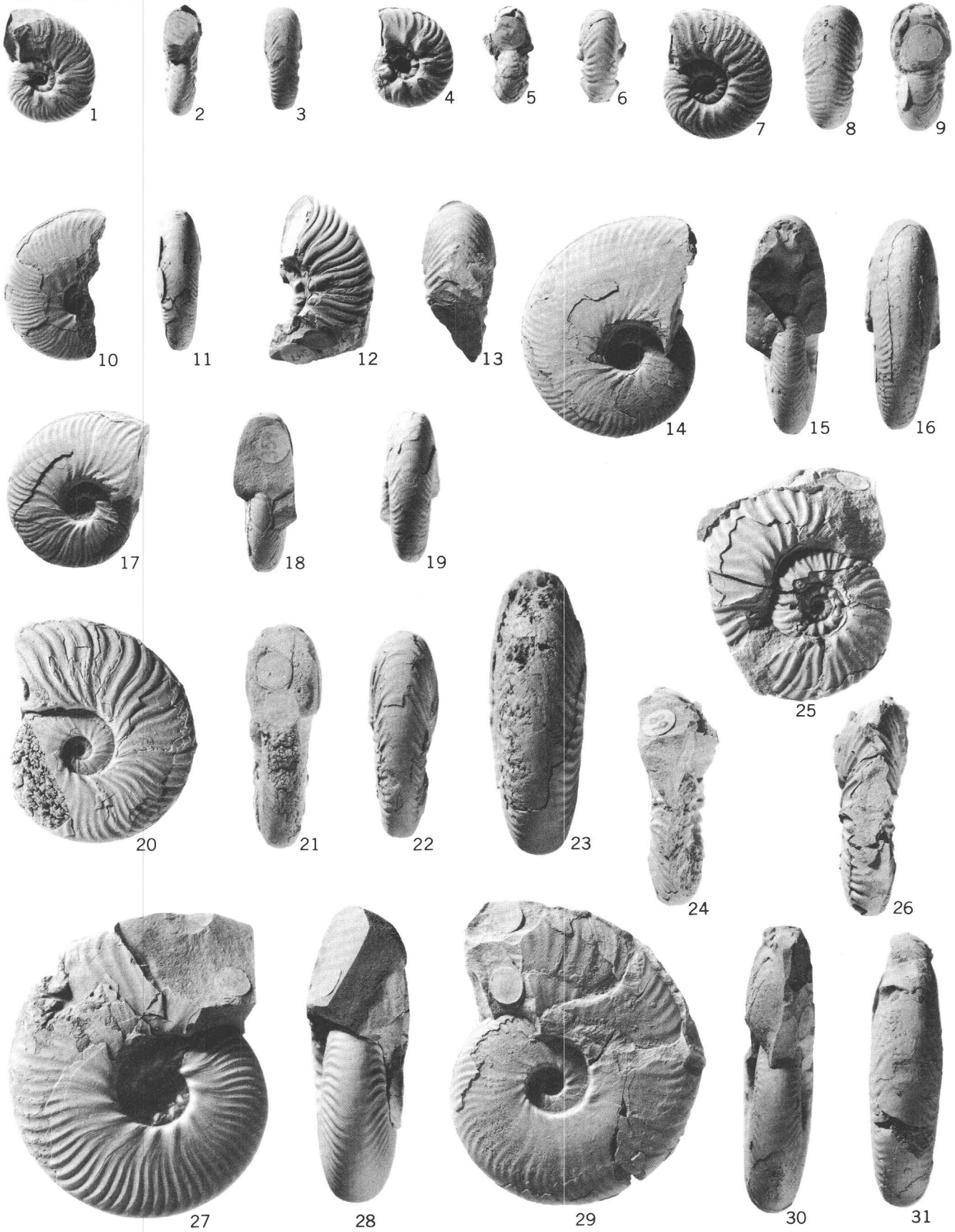
PLATE 5

[All figures natural size]

FIGURES 1–31. *Leconteites lecontei* (Anderson) s. s. (p. F9).

All specimens are from the *Leconteites lecontei* zone on Huling Creek and are figured to demonstrate that a wide range of morphologic variation exists for this species throughout the zone. Specimens shown on figs. 1–6, 14–16, 23, 27, and 28 are from near the top of the zone; those shown on figs. 10–11, 20–22, 24–26, are from the middle of the zone (see also pl. 11, figs. 4–6); specimens shown on figs. 7–9, 12, 13, 17–19, and 29–31 are from the lower part of the zone.

1–3. USNM hypotype 121514 from UCR loc. 164.
4–6. USNM hypotype 121515 from UCR loc. 164.
7–9. USNM hypotype 121516 from UCR loc. 347.
10–11. USNM hypotype 121517 from UCR loc. 89.
12–13. USNM hypotype 121518 from UCR loc. 347.
14–16. USNM hypotype 121519 from UCR loc. 463.
17–19. USNM hypotype 121520 from UCR loc. 359.
20–22. USNM hypotype 121521 from UCR loc. 89.
23, 27, 28. USNM hypotype 121522 from UCR loc. 460.
24–26. USNM hypotype 121523 from UCR loc. 89.
29–31. USNM hypotype 121524 from UCR loc. 435.



LECONTEITES

PLATE 6

[All figures natural size]

FIGURE 1–3, 4–9, 12–14. *Leconteites lecontei whiteavesi*, Jones, Murphy, and Packard, n. subsp. (p. F13). GSC loc. 48615. Beresford Bay, Queen Charlotte Islands.

1–3. Paratype, GSC 19098.

4–5. Paratype, GSC 19099.

6–7. Paratype, GSC 19100.

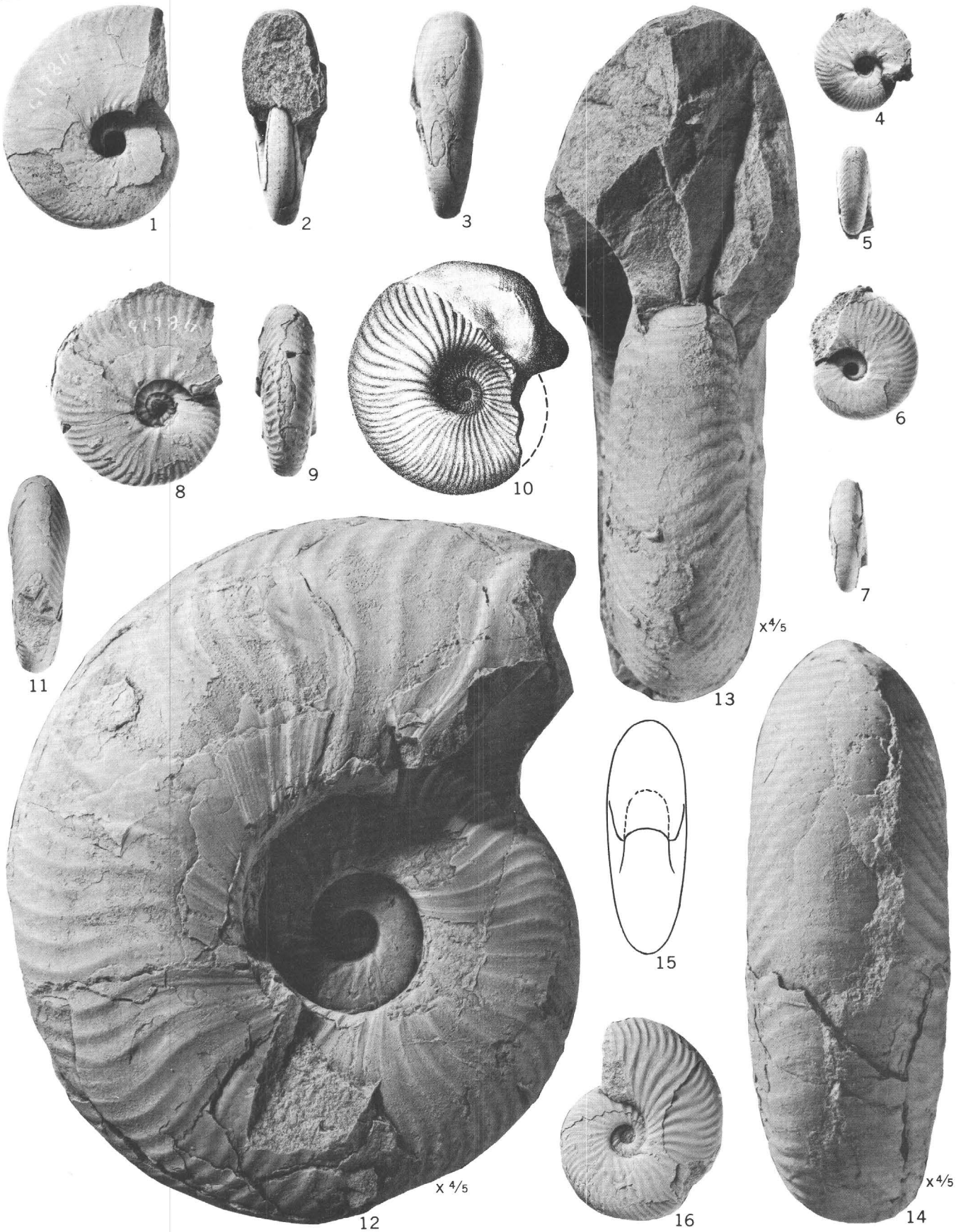
8–9. Paratype, GSC 19101.

12–14. Paratype, GSC 19102 (× 4/5).

10, 11, 15, 16. *Leconteites deansi* (Whiteaves) (p. F13).

10, 15. Copy of Whiteaves, (1893, pl. 7, figs. 1, 1a) original figure of *Olcostephanus* (*Astieria*) *deansii*.

11, 16. Hypotype, USNM 130164b, from USGS Mesozoic loc. 9972, Chitina Valley, southern Alaska, originally figured by Imlay (1960, pl. 19, figs. 12–14).



LECONTEITES

PLATE 7

[All figures × 9/10]

FIGURES 1–3. *Leconteites lecontei whiteavesi* Jones, Murphy, and Packard, n. subsp., (p. F13). Holotype, GSC 19097, from GSC loc. 48615, Beresford Bay, Queen Charlotte Islands.

x 9/10

1

x 9/10

2

x 9/10

3

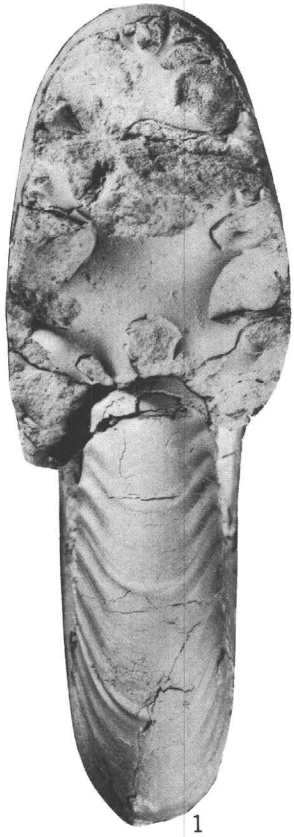
LECONTEITES

PLATE 8

[All figures natural size]

FIGURES 1, 2, 4. *Brewericeras hulenense* (Anderson) (p. F16).
Hypotype, ANSP 4798. Specimen figured by Gabb (1869, pl. 20, fig. 5) as *A. breweri.*

3, 5. *Brewericeras breweri* (Gabb) (p. F15).
Holotype, UC 12098, figured by Gabb (1864, pl. 10, fig. 7).



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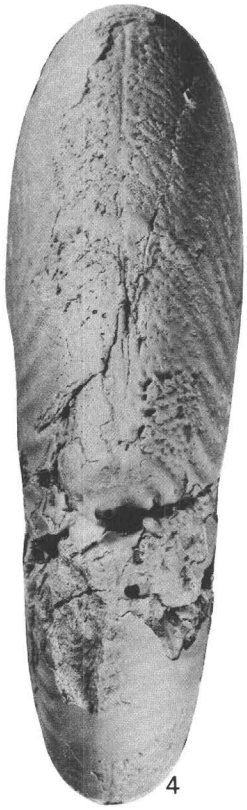


4

5

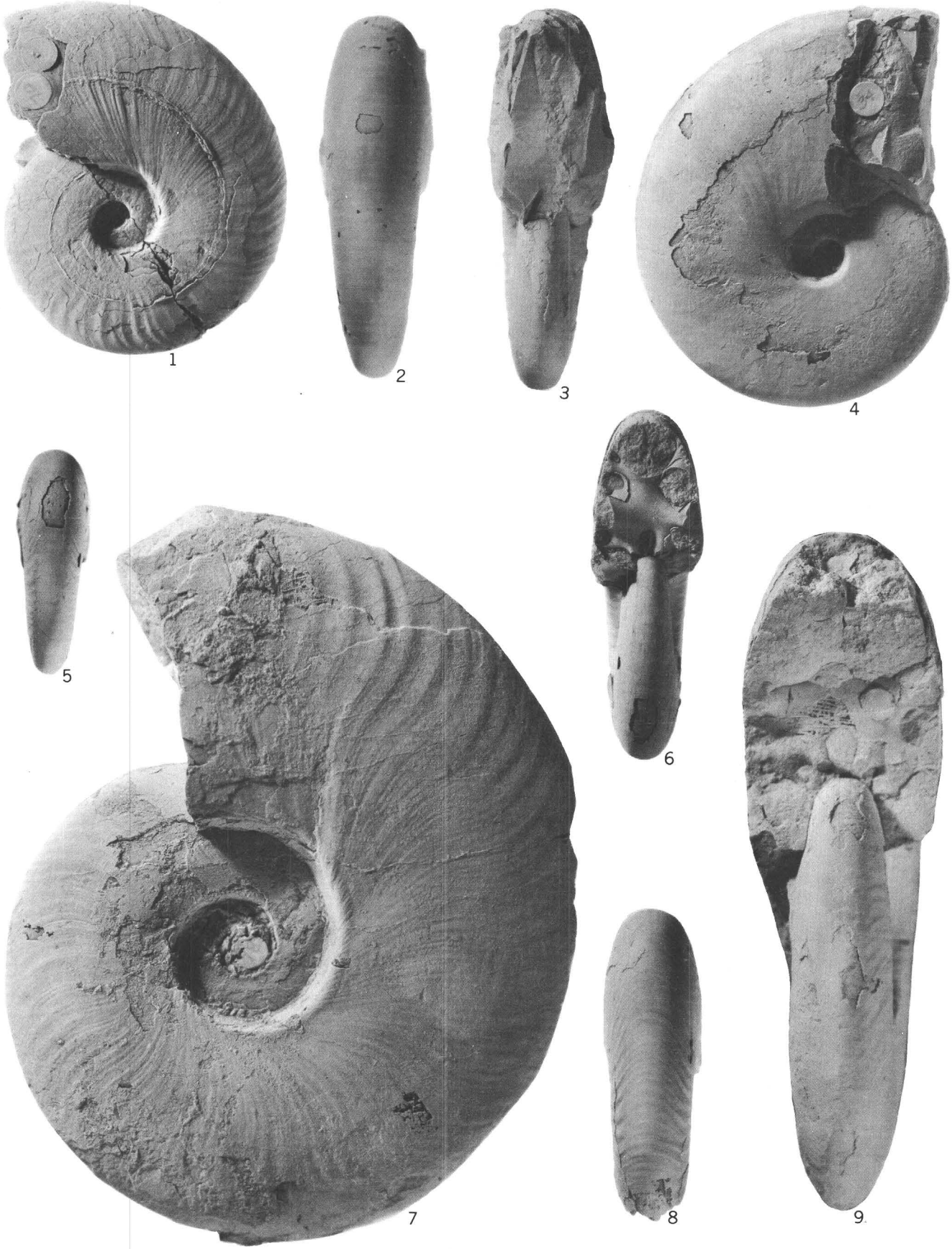
BREWERICERAS

PLATE 9

[All figures natural size]

FIGURES 1–9. *Brewericeras hulenense* (Anderson) (p. F16).
From northern California.

1, 5, 6, 8. Hypotype, USNM 121526, from UCR loc. 70.
2–4. Hypotype, USNM 121527, from UCR loc. 34.
7–9. Hypotype, USNM 121528, from UCR loc. 98.



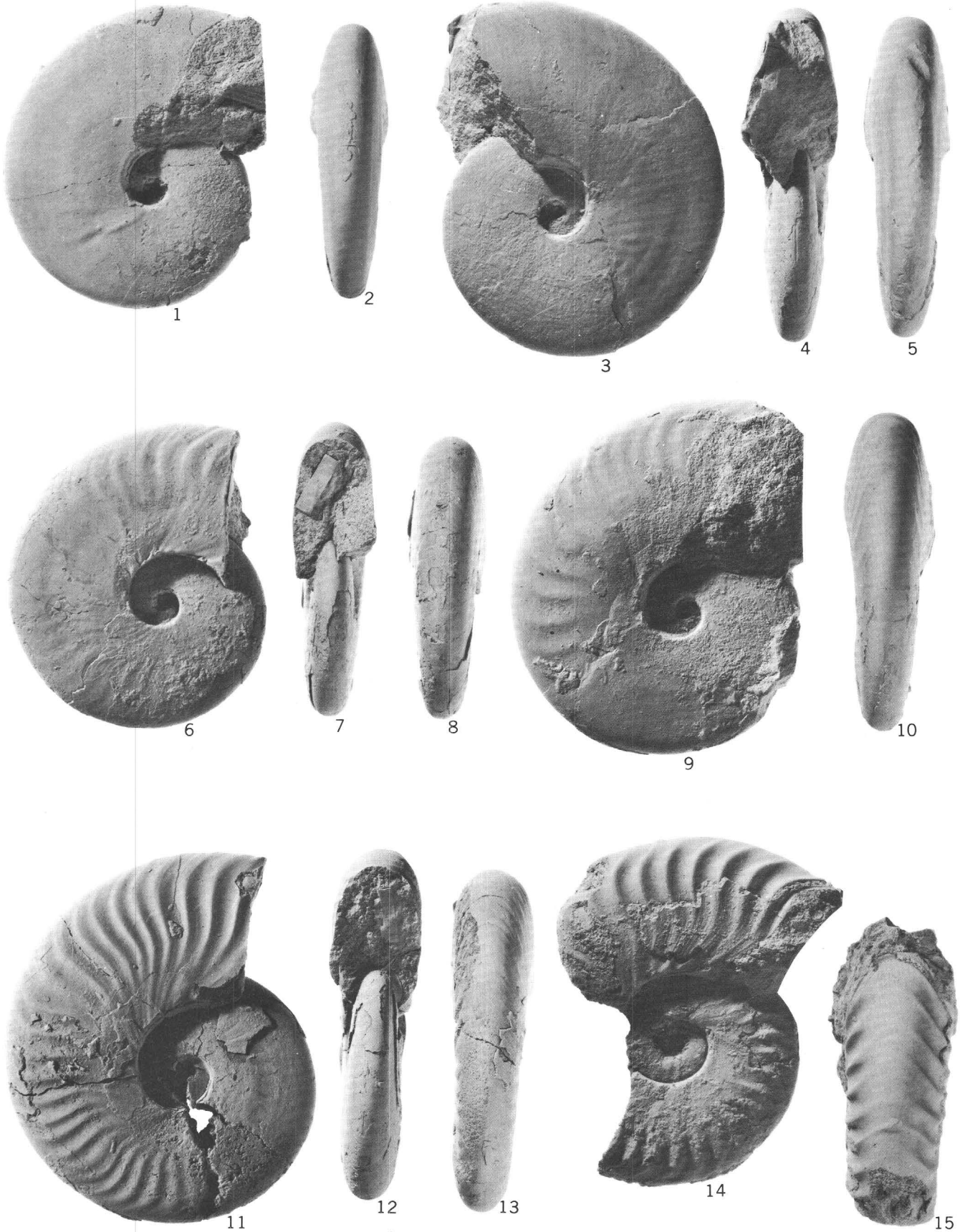
BREWERICERAS

PLATE 10

[All figures natural size]

FIGURES 1–15. *Brewericeras hulenense* (Anderson) (p. F16).
From USGS Mesozoic loc. M1337, Upper Chitina Valley, southern Alaska. Specimens show intergradation from smooth to coarsely ribbed forms.

1– 2. Hypotype, USNM 121529.
3– 5. Hypotype, USNM 121530.
6– 8. Hypotype, USNM 121531.
9–10. Hypotype, USNM 121532.
11–13. Hypotype, USNM 121533.
14–15. Hypotype, USNM 121534.



BREWERICERAS

PLATE 11

[All figures natural size]

FIGURES 1–3, 13, 14. *Brewericeras hulenense* (Anderson) (p. F16).

1–3. Hypotype, USNM 121535, from UCR loc. 1000, northern California.

13, 14. Hypotype, USNM 121536, from UCR loc. 1000. This specimen has coarser ribs on lower flank than is usual for this species.

4–6. *Leconteites lecontei* (Anderson) s. s.

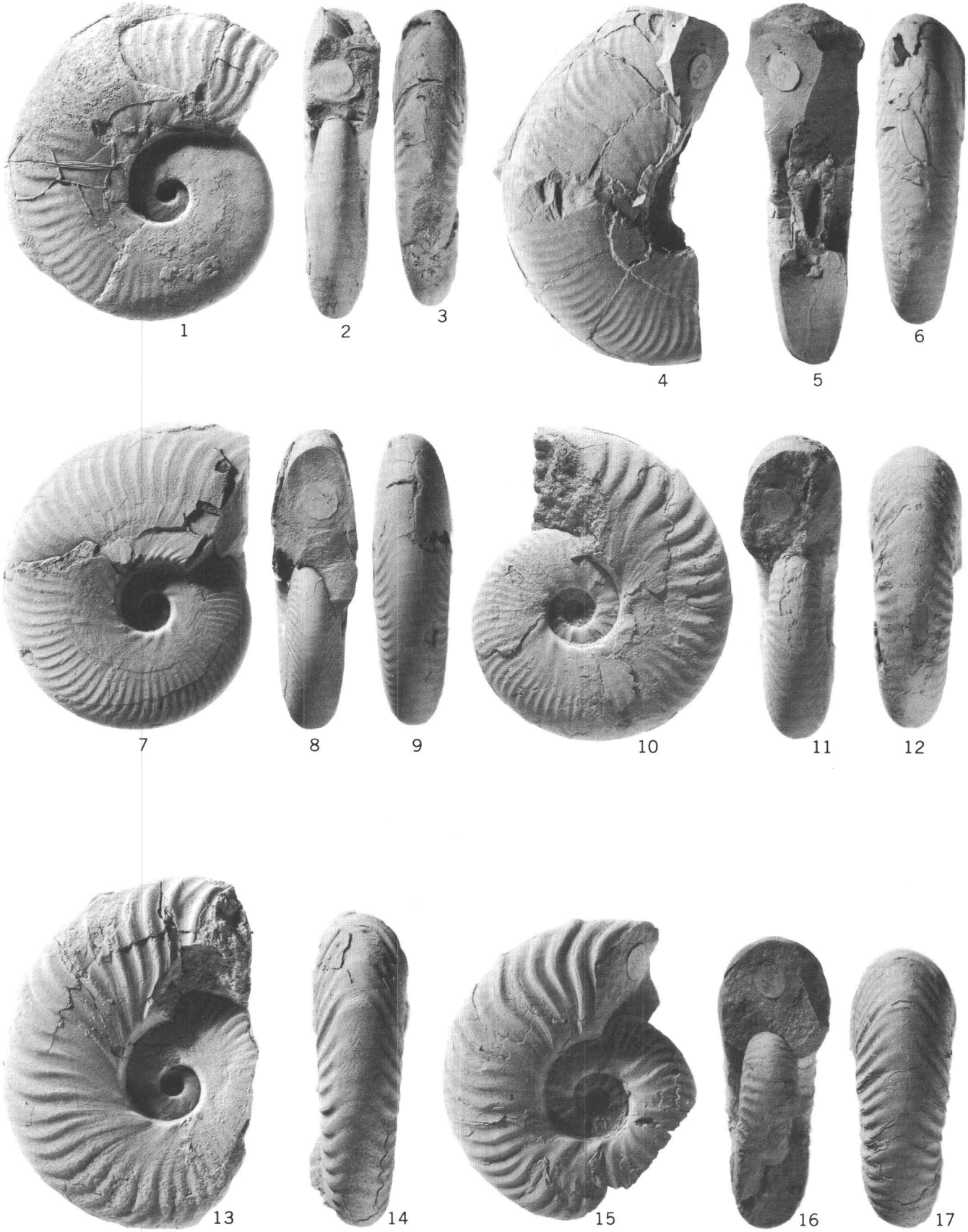
Hypotype, USNM 121537, from UCR loc. 358. Compare bifurcating ribs of this specimen to simple ribs on figs. 1–3.

7–12, 15–17. Forms intermediate between *Brewericeras hulenense* and *Leconteites lecontei.*

7–9. USNM 121538, from UCR loc. 70. Specimen has nonbifurcating ribs that are finer than usual for *B. hulenense* and small umbilical nodes similar to those of *L. lecontei.*

10–12. USNM 121539, from UCR 1000. Inner whorls have strong umbilical nodes and bundled ribs of *L. lecontei;* outer whorls have simple ribs of *B. hulenense.*

15–17. USNM 121540, from UCR loc. 402. Coarse ribbed forms with bifurcating ribs on early whorls and simple but unusually strong ribs on outer whorls.



LECONTEITES AND *BREWERICERAS*

Contributions to Paleontology 1964

GEOLOGICAL SURVEY PROFESSIONAL PAPER 503

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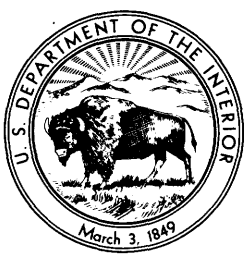

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CONTENTS

[Letters designate the separately published chapters]

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