Ammonites of Early Cretaceous Age (Valanginian and Hauterivian) from The Pacific Coast States

By RALPH W. IMLAY

SHORTER CONTRIBUTIONS TO GENERAL GEOLOGY

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The ammonite succession provides correlations within the Pacific Coast States and with other areas. This suggests that Cretaceous strata in California and Oregon rest disconformably on Jurassic strata

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SHORTER CONTRIBUTIONS TO GENERAL GEOLOGY

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By Ralph W. Imlay

ABSTRACT

Study of the ammonites in the earliest Cretaceous of California, Oregon, and Washington has made possible the recognition of 4 ammonite zones in beds of Valanginian age and 5 ammonite zones in beds of Hauterivian age. These zones provide general correlations with the Valanginian and Hauterivian stages in other parts of the world and detailed correlations along the Pacific coast. These correlations are strengthened by the associations of the Valanginian ammonites with the Valanginian pelecypod *Buchia crassicollis* (Keyserling) and by the absence of earlier Cretaceous species of *Buchia* that occur from Washington northward to Alaska. On the basis of such associations, the oldest Cretaceous beds exposed in California and Oregon are considered to be not older than Valanginian and probably not older than middle Valanginian.

Failure to find in California certain ammonite zones of late Valanginian to early Hauterivian age that are present in southwestern Oregon may be explained by nondeposition, slow deposition, unfavorable facies, inadequate collections, or some combination of these possibilities.

The Valanginian-Hauterivian ammonites found in the Pacific Coast States have a local aspect, owing to the presence of genera not yet found elsewhere, or only rarely elsewhere, and to the absence of genera that are common elsewhere. Provincial genera include *Wellsia*, *Hannaites*, *Hollisites*, and *Hertleinites*. Besides these genera *Shasticrioceras* has been found elsewhere only in British Columbia and Japan, and *Homolsomites*, only in British Columbia and Greenland. The absence of such ammonites as *Rogersites*, *Valanginites*, *Distoloceras*, and *Leopoldia* is in contrast to their abundance in the Mediterranean province, and Mexico. With these exceptions the Valanginian ammonites from the Pacific coast show affinities more strongly with ammonites in the Mediterranean province than with northern Eurasia, and the Hauterivian ammonites show affinities mostly with ammonites in northern Eurasia.

INTRODUCTION

This study of the Early Cretaceous (Valanginian-Hauterivian) ammonites from the Pacific Coast States is based primarily on collections at the California Academy of sciences described in 1938 by Frank M. Anderson and on collections made by members of the Geological Survey since 1890. It includes, also, a few specimens from several universities. Special thanks for assistance or loan of specimens are due V. S. Mallory, of the University of Washington, Wyatt Durham, of the University of California at Berkeley, W. P. Popenoe, of the University of California at Los Angeles, Michael Murphy, of the University of California at Riverside, Calif., and Leo Hertlein and Dallas Hanna, of the California Academy of Sciences in San Francisco. Larry Lucas, of Agness, Oreg., contributed several excellently preserved ammonites.

The description of the Valanginian-Hauterivian ammonities from the Pacific coast is a byproduct of paleontological assistance to Francis Wells and associates of the Geological Survey in compiling the geologic map of Oregon. Some of the problems involved included demarcation of the Jurassic-Cretaceous boundary, evaluation of the age significance of the fossils in the mappable units above and below that boundary, and determination of which species would be useful to field geologists for mapping purposes. It was found that only species of the pelecypod *Buchia* (hitherto generally called *Aucella*) occurred in sufficient numbers and places to be useful in mapping or in drawing a boundary between Jurassic and Cretaceous rocks. Determination of the ages of the mappable units, however, in terms of European stages involved detailed studies of the ammonites as well as of the species of *Buchia*.

The evidence furnished by the ammonites was particularly pertinent because many field parties in Alaska had found the same species of *Buchia* in the same relative stratigraphic positions as on the west coast, but had not found any associated ammonites. Consequently, determination of the ages of the species of *Buchia* in Alaska had to be made on the assumption that the species had the same ranges as in Eurasia. That assumption could now be tested by studying the ammonites found in the Pacific Coast States. It seems fitting, therefore, to publish descriptions of the ammonites and interpretations of their significance to supplement those already presented concerning *Buchia* (Imlay, 1959, p. 164–166).

Abbreviations appearing in the text and on table 5 include UW for the University of Washington, CAS for the California Academy of Sciences, UCLA for the University of California at Los Angeles, and USGS Mes. loc. for U.S. Geol. Survey Mesozoic locality. The number 9.3.54.6 represents a field locality of Peter Misch of the University of Washington.

BIOLOGIC ANALYSIS

The Valanginian-Hauterivian ammonites from the Pacific coast that have been examined during preparation of this paper number about 470 specimens. Their distribution by genera, subfamilies, and families and the known ages of the genera on the Pacific coast are shown in table 1. For purposes of this analysis the ranges of the genera within, or beyond, the Valanginian-Hauterivian stages are not shown, but are discussed herein in the section dealing with correlation.

TABLE 1.—*Ammonite genera in the Valanginian and Hauterivian beds of the Pacific Coast States, showing biological relationships, relative numbers available for study, and ages represented*

Family	Subfamily	Genus	Number of specimens	Stages
Phylloceratidae	Phylloceratinae	*Phyllopachyceras*	45	V and H
		Hypophylloceras	5	H
Lytoceratidae	Lytoceratinae	*Lytoceras*	15	V and H
Bochianitidae	Bochianitinae	*Bochianites*	3	V
Ancyloceratidae	Crioceratinae	*Crioceratites*	14	V and H
		Hoplocrioceras	13	H
		Shasticrioceras	4	H
Hemihoplitidae	Ancyloceratinae	*Acrioceras*	4	H
		Pseudothurmannia?	2	H
Ptychoceratidae		*Anahamulina*	1	H
Craspeditidae	Tolliinae	*Homolsomites*	100	V
Olcostephanidae	Olcostephaninae	*Olcostephanus*	25	V and H
	Polyptychitinae	*Polyptychites*	2	V
		Neocraspedites	6	V
		Wellsia	90	H
		Hertleinites	9	H
	Simbirskitinae	*Simbirskites*	50	H
		Speetoniceras	1	H
		Hollisites	14	H
Berriasellidae	Neocomitinae	*Neocomites?*	2	V
		Thurmanniceras	32	V
		Hannaites	11	H
		Kilianella	4	V
		Sarasinella	15	V
		Acanthodiscus	1	V
Holcodiscidae		*Spitidiscus*	2	H

The table shows that the Berriasellidae is the dominant family in the Valanginian on the Pacific coast and is represented mostly by *Thurmanniceras*, *Sarasinella*, and *Kilianella*. The family is represented in the Hauterivian by only one genus, *Hannaites*, which to date has been found solely in Oregon. This genus shows some resemblance to *Leopoldia*, which occurs characteristically in beds of early Hauterivian age throughout the Mediterranean region. The fact that only one specimen of *Acanthodiscus* has been found on the Pacific coast is likewise a contrast with the Mediterranean region.

The family Olcostephanidae is dominant in the Hauterivian beds of the Pacific coast, where it is represented by the genera *Olcostephanus*, *Wellsia*, *Hertleinites*, *Simbirskites*, *Speetoniceras*, and *Hollisites*. The family is less well represented in the Valanginian beds by the genera *Olcostephanus*, *Polyptychites*, and *Neocraspedites*. All the occurrences of *Olcostephanus* except one are from the upper part of the Valanginian. The absence of other genera of the Olcostephaninae is in contrast with the abundance of that subfamily in the Valanginian of the Mediterranean region and particularly of the Mexican area.

The family Ancyloceratidae occurs in fair abundance only in the Hauterivian beds. Two specimens belonging to *Crioceratites* have been found below the Hauterivian near the top of the occurrence of *Buchia crassicollis* (Keyserling). Otherwise all occurrences of *Crioceratites*, *Hoplocrioceras*, and *Acrioceras* are from Hauterivian beds. The genus *Shasticrioceras* is represented in the Hauterivian by only a few specimens from the zone of *Hertleinites aguila*.

The families Lytoceratidae and Phylloceratidae are fairly well represented throughout the Valanginian-Hauterivian beds. The Bochianitidae is represented by one genus, *Bochianites*, found only at one locality in Tehama County, Calif., in beds of late Valanginian age. The Hemihoplitidae is possibly represented by two specimens that are questionably assigned to *Pseudothurmannia*. These could belong to the genus *Hoplocrioceras*. The Ptychoceratidae is represented by one specimen of the genus *Anahamulina* in the zone of *Hertleinites aguila*. This occurrence is unusually low for the genus. To the Craspeditidae is assigned the genus *Homolsomites* because it has strong constrictions on its intermediate and outer whorls, and pinched primary ribs on its intermediate whorls similar to those of the genus *Tollia*. Except for these features it shows considerable resemblance to *Neocraspedites*, which Wright (1957, p. L348) places in the Olcostephanidae. The Holcodiscidae is poorly represented by the genus *Spitidiscus* in the Hauterivian of Oregon.

Of the genera mentioned above, *Wellsia*, *Hertleinites*, *Hollisites*, and *Hannaites* have not been recorded outside of California and Oregon. *Shasticrioceras* has been recorded from Washington, British Columbia, and Japan. *Homolsomites* has been recorded from Washington, British Columbia, and Greenland. The other genera have been found in many parts of the world.

STRATIGRAPHIC SUMMARY

The Valanginian sequence in both California and Oregon has certain lithologic features that permit rather easy recognition. It consists mostly of units of olive-gray to dark-gray slightly sandy siltstone and silty claystone interbedded with thinner units of gray to greenish-gray sandstone that may be thin bedded or massive and that are locally pebbly. The siltstone units generally contain thin interbeds of sandstone and in places contain limestone lenses and concretions. The base of the Valanginian sequence in both States is marked at many places by a massive conglomeratic sandstone or conglomerate that rests on Late Jurassic (Portlandian) beds. The Valanginian sequence as a whole is characterized by the robust pelecypod *Buchia crassicollis* (Keyserling), occurring in such large numbers that it constitutes an important lithologic feature and may be used for mapping purposes.

The Valanginian in Oregon forms the middle part of the Myrtle formation at its type locality on Myrtle Creek as mapped by Diller (1898) and the upper part of the Knoxville formation in the Riddle quadrangle as mapped by Diller and Kay (1924). The generalized section along the South Umpqua River just south of Days Creek in Douglas County from top to bottom is as follows:

Section of Valanginian beds along west side of South Umpqua River in NW¼ sec. 15, T. 30 S., R. 4 W.

[Measured by Hollis Dole, Dallas Peck, Len Ramp, and R. W. Imlay]

	Feet
Siltstone, slightly sandy, olive-gray; contains *Olcostephanus pecki* Imlay, n. sp., 85 ft. below top; *Buchia crassicollis* (*Keyserling*) occurs rarely throughout	141
Sandstone, massive, fine-grained, silty, dark-greenish-gray; contains an abundance of *Buchia crassicollis* (Keyserling). *Olcostephanus pecki* Imlay, n. sp., obtained 15 ft. above base of unit	75
Siltstone dominant, medium-gray; some beds sandy; includes a few beds of medium- to fine-grained dark-greenish-gray sandstone from 8 to 14 in. thick; some limestone lenses and concretions occur in siltstone. Contains *Buchia crassicollis* (Keyserling) throughout; *Olcostephanus pecki* Imlay, n. sp., obtained 41, 52, and 87 ft. below top of unit; *Homolsomites stantoni* (McLellan) obtained 87 ft. below top of unit	114
Sandstone, medium-fine- to fine-grained, silty, dark-greenish-gray; no *Buchia* noted	46
Total thickness of Valanginian beds	376

The Valanginian is probably absent in the area immediate east and southeast of Roseburg, Oreg., although J. S. Diller and his assistants obtained collections of the Valanginian fossil *Buchia crassicollis* (Keyserling) from five localities within that area. This occurrence is questioned becaused subsequent search has not yielded any specimens of *Buchia*; because the rocks from which this genus was reported resemble the Dothan formation according to Francis Wells and Hollis Dole; and because the Whitsett limestone lentils of Diller (1898), which are younger than the Dothan-like rocks, have furnished an ammonite that resembles immature specimens of *Durangites*. (See pl. 31, figs. 11, 12.)

The Valanginian sequences exposed on Cow Creek below Riddle and on Myrtle Creek in Douglas County, Oreg., were not measured, but appear to be similar in lithology and in thickness to that on the South Umpqua River near Days Creek. Westward in Oregon the Valanginian sequences thicken considerably, but careful measurements of them have not been made. At the head of the road along Foggy Creek, in sec. 16, T. 32 S., R. 10 W., Coos County, the conglomeratic part of the Valanginian is about 1,000 feet thick and the overlying siltstone-claystone part is many hundreds of feet thick (oral communication from Francis Wells, March 1958). In the Port Orford quadrangle the Valanginian appears to be at least as thick.

The Valanginian sequence in California crops out discontinuously in the Coast Ranges from Santa Barbara County on the south to the Trinity River, in central Trinity County, on the north (Anderson, 1938, p. 49–55) and ranges in thickness from a few hundred to 1,500 feet or more. It was included by Stanton (1895, p. 11, 17, 18 [1896]) in the upper part of the Knoxville formation, whose top as then defined coincided with the upper limit of the sandy beds containing *Buchia crassicollis* (Keyserling). It was included by Anderson (1902, p. 43–47; 1933, p. 311–326; 1938, p. 44–48) in his Paskenta group. Anderson intended, apparently, that his Paskenta group should include all the Early Cretaceous beds containing *Buchia*, and he consistently correlated it with the Valanginian stage of Europe.

Unfortunately, in its type area near Paskenta, Tehama County, the Paskenta group was extended upward by Anderson above the beds bearing *Buchia crassicollis* (Keyserling) to include several thousand feet of shale and siltstone from which he recorded *Buchia* at several levels. These records are possibly misidentifications of *Inoceramus* or *Aucellina*, as the writer has discussed in another paper (Imlay, 1959, p. 164), and are from beds of Hauterivian or later ages. Unfortunately, also, all the beds near Ono, in Shasta County, that Anderson (1938, p. 46–49) referred to his Paskenta group are younger than Valanginian and have not furnished a single specimen of *Buchia*. As this last fact was admitted by Anderson (1938, p. 47) and as he states, also, that the boundary between his Paskenta and Horsetown groups (1938, p. 42, 43, 46, 62) is mainly paleontological, his Paskenta group does not appear to be either a mappable unit or a faunal unit.

The writer believes that the term Paskenta formation may be useful if redefined to include only the alternating sandstones and shales characterized by *Buchia crassicollis* (Keyserling), but that must await detailed mapping.

Beds of Hauterivian age in California have been identified faunally at only three places. The southernmost occurrence is on the eastern part of the Wilcox Ranch, in western Tehama County, where ammonites of middle to late Hauterivian age, described herein, have been obtained in the lower 500 feet of shales overlying the beds containing *Buchia crassicollis* (Keyserling). These shales were included by Anderson (1938, p. 46) in the upper part of his Paskenta formation and by Stanton (1895, p. 18 [1896]) in the lower part of the Horsetown formation. They were described by Anderson as being clay shales that contain some thin beds of limestone and sandstone.

A second occurrence of Hauterivian rocks in California is near Ono in western Shasta County. These have been recently described by Murphy (1956, p. 2103–2113) and are included in his Rector formation and the lower part of the Ono formation. These include at least 800 feet of sandstone, conglomerate, and mudstone that have little in common lithologically with equivalent beds in western Tehama County. The upper part of the sequence includes the *Hertleinites aguila* zone (Murphy, 1956, p. 2113), which is herein considered to be of late Hauterivian age. The lower part of the sequence includes some of the fossils in Hamlin-Broad zone of Anderson (1938, p. 47), which was based on ammonites found from 4 to 6 miles southwest of Ono below the Roaring River tongue of the Ono formation. This zone is of middle to late Hauterivian age.

A third occurrence of Hauterivian rocks in California is on and near the Clements Ranch on Redding Creek, in the central part of Trinity County (Anderson, 1938, p. 50). The fossils found there suggest a correlation with beds in Shasta County that were placed by Anderson (1938, p. 47) in his Hamlin-Broad zone. The preservation and lithologic characteristics of the fossils indicate that the beds are probably lithologically similar to the early and middle Hauterivian beds of Oregon. Thicknesses are at least 600 feet (Anderson, 1938, p. 203).

The Hauterivian sequence in Oregon differs from that in California by being much sandier and probably much thicker. The best exposed sections that have been found are on Cow Creek near Riddle, in Douglas County; on the South Umpqua River near Days Creek, in Douglas County; on the Foggy Creek road, in Coos County; on the south bank of the Rogue River 1½ miles below Agness, in Curry County; and in the Waldo-Cave Junction area, in Josephine County. At none of these places is the entire Hauterivian represented. The section exposed along the South Umpqua River just south of Days Creek is one of the best exposed and from top to bottom is as follows:

Partial section of Hauterivian beds along the west side of the South Umpqua River in NW¼ sec. 15, SW¼ sec. 47, and E½ sec. 9, T. 30 S., R. 4 W., Douglas County, Oreg.

[Measured by Hollis Dole, Dallas Peck, Len Ramp, and R. W. Imlay]

	Feet
Siltstone, sandy, massive, dark-greenish-gray; grading into silty sandstone, weathers spheroidally; contains many small fossiliferous limestone concretions. *Wellsia packardi* (Anderson) obtained 120 and 180 ft below top of unit: *Hannaites riddlensis* (Anderson) obtained 140 ft below top; *Wellsia oregonensis* (Anderson) obtained 190 ft below top. Fault truncates top of unit	210+
Sandstone, silty, very fine-grained, dark-greenish-gray; some limestone concretions present	95
Sandstone, massive, in beds 12 to 20 ft thick separated by some lenses of siltstone from several inches to several feet thick; contains many fossiliferous limestone lenses. Sandstone constitutes about 90 percent of unit. Wood fragments and pelecypods scattered throughout unit. *Hannaites riddlensis* (Anderson) and *Wellsia oregonensis* (Anderson) obtained at top of unit. *H. truncata* Imlay, n. sp., and *Wellsia oregonensis* (Anderson) obtained 70 ft below top	128
Total exposed thickness of Hauterivian beds	433

This section is entirely of early Hauterivian age. A similar section of the same age is exposed in the bed of Cow Creek about a quarter of a mile below the bridge at the town of Riddle, in Douglas County. At the bridge itself is exposed 15 feet of massive gray sandstone that has furnished the ammonites *Simbirskites* and *Hollisites*, of middle Hauterivian age. Beds of sandstone and sandy siltstone occurring in the creek above the bridge for at least a mile are assigned a middle Hauterivian age on the basis of stratigraphic position, but have furnished only one ammonite, *Lytoceras aulaeum* Anderson. These beds are repeated by gentle folding and cannot be measured, but are probably some hundreds of feet thick.

A poorly exposed, discontinuous sequence of early and middle Hauterivian age occurs on the side of the road up Foggy Creek in T. 32 S., R. 10 W., Coos County. The exposures consist of soft massive greenish-gray sandstone and siltstone that weather in a spheroidal manner. Along the road *Simbirskites* (USGS Mes. loc. 25211) was obtained four-tenths of a mile above the junction with the Eden Valley road; *Hannaites riddlensis* (Anderson) (USGS Mes. loc. 25212) was obtained 1 miles from the junction; *Wellsia oregonensis* (Anderson) (USGS Mes. loc. 25213) was obtained 1.3

miles from the junction; and *Buchia crassicollis* (Keyserling) (USGS Mes. loc. 25196) was obtained 1.5 mile from the junction. The beds at the last three mentioned localities have a southeast dip and are presumably overturned. The beds containing *Simbirskites* have a northwest dip and are presumably not overturned. The thickness of the beds containing *Wellsia* and *Hannaites* is at least 400 feet and may be much thicker. The thickness of the younger beds containing *Simbirskites* cannot be estimated because of poor exposures.

Beds of middle Hauterivian age are well exposed on the south side of the Rogue River about 1½ miles below Agness, Curry County. They consist mostly of greenish-gray sandstone and siltstone that weather to brownish spheroidal masses. Their thickness is apparently some hundreds of feet, but cannot be measured because of folding and faulting. Fossils of middle Hauterivian age have been found from 100 to 200 feet above exposures of serpentine and 100 feet or less above beds containing *Buchia crassicollis* (Keyserling), of Valanginian age. Beds of early Hauterivian age have not been identified faunally, and there is less than 100 feet of beds that could be of that age. The jumbled character of the exposures suggest that the middle Hauterivian beds are in fault contact with the Valanginian beds.

Beds of middle to late Hauterivian age crop out in the Takilma-Waldo-Cave Junction area, T. 40 S., R. 8 W., in the southernmost part of Josephine County, Oreg. The oldest beds rest on Late Jurassic rocks (Galice formation) and are lithologically similar to the early and middle Hauterivian beds elsewhere in southwestern Oregon. They have furnished fragments of pelecypods and gastropods but no ammonites. Elsewhere in the same area fossils have been obtained (USGS Mes. locs. 3339, 2166) that are probably of late Hauterivian and Barremian age, as discussed herein under the heading *Hertleinites agulia* zone. The thickness of the Cretaceous beds in the area is unknown.

FAUNAL ZONES AND CORRELATIONS

KILIANELLA CRASSIPLICATA

This is a provisional zone (table 3) representing the lower third to fourth of the sandy beds bearing *Buchia crassicollis* (Keyserling) in Tehama County, Calif. It is characterized by the species *Kilianella crassiplicata* (Stanton) and *Thurmanniceras californicum* (Stanton).

This zone is considered provisional because it is based on only three collections. One of these (USGS Mes. locs. 1001 and 1095), containing both of the characteristic species, was made, according to Stanton (1895, p. 17, 77, 82 [1896]), on McCarthy Creek about half a mile east of the buildings of the Henderson Ranch and from 1,500 to 2,000 feet below the top of the *Buchia*-bearing beds. Its location, based on the generalized geologic map published by Anderson (1933, p. 314), is near the base of the *Buchia* beds in the NW¼ sec. 29, T. 24 N., R. 6 W. From the same location on McCarthy Creek was obtained the specimen of *Kilianella crassiplicata* (Stanton) illustrated by Anderson (1938, pl. 83, figs. 3, 4).

Another collection (Mes. loc. 5339), containing *Kilianella crassiplicata* (Stanton) and *Lytoceras saturnale* Anderson, was made one-third of a mile west of the Wilcox Ranch buildings in the NW¼ sec. 4, T. 24 N., R. 6 W. Its stratigraphic position, based on the map published by Anderson (1933, p. 314), is considerably below the middle of the *Buchia crassicollis* beds. It should be about 500 feet above the base of those beds if their thickness is 1,500 feet, as stated by Anderson (1933, p. 321).

Of the three species of ammonites found in the *Kilianella crassiplicata* zone, *Lytoceras saturnale* Anderson ranges considerably higher (Anderson, 1938, p. 47) into beds containing the middle Hauterivian ammonite *Simbirskites*. *Kilianella crassiplicata* (Stanton) and *Thurmanniceras californicum* (Stanton) have not been found, however, above the lower third of the *Buchia crassicollis* beds. If these species ranged higher they should have been found in some of the many collections made from higher parts of the *Buchia crassicollis* beds in Oregon and California. Anderson (1933, p. 321) inferred that the type specimens of these species were obtained about 1,300 feet above the base of the *Buchia crassicollis* beds, but he evidently misunderstood the statements published by Stanton (1895, p. 77, 82 [1896]).

The specimen described herein as *Kilianella* cf. *K. besairiei* Spath, obtained from Strawberry Canyon in Berkeley Hills, Alameda County, Calif., is reported by Anderson (1938, p. 53) to be from the lower beds of his Paskenta group. If so, it and the other fossils mentioned by Anderson may belong in the zone of *Kilianella crassiplicata*.

Other fossils that may belong in the *Kilianella crassiplicata* zone include 24 species obtained by Stanton (1895, p. 14 [1896]) from northern Tehama County about half a mile and a little north of west of Stephenson's Ranch houses near the Cold Fork of Cottonwood Creek (USGS Mes. loc. 1069). These were listed or described by Stanton under the following names:

Pentacrinus sp.
Rhynchonella sp.
Terebratula californica Stanton

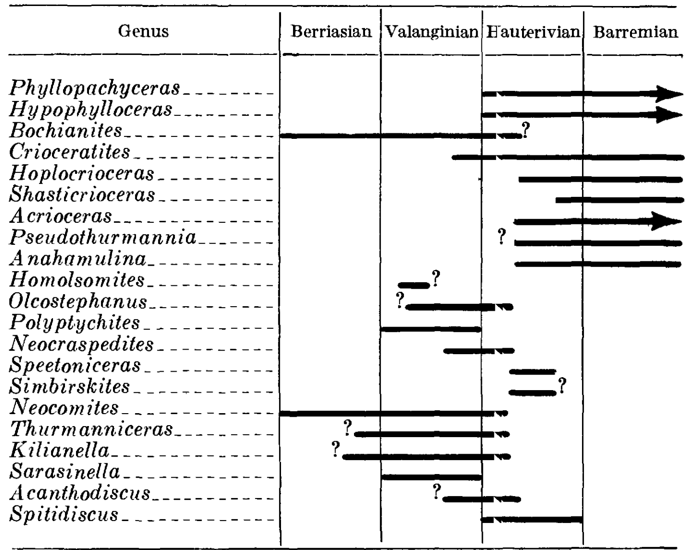
Terebratula **sp.**
Ostrea **sp. cf.** ***O. skidgatensis*** Whiteaves
Lima multilineata Stanton
Spondylus fragilis Stanton
Aucella crassicollis Keyserling
Myoconcha americana Stanton
Arca textrina Stanton
Pectunculus? ovatus Stanton
Leda glabra Stanton
Opis californica Stanton
Cyprina occidentalis Whiteaves
Astarte californica Stanton
Solecurtus? dubius Stanton
Corbula filosa Stanton
Helcion granulatus Stanton
Fissurella bipunctata Stanton
Pleurotomaria **sp.**
Turritella **sp.**
Cerithium **sp.**
Belemnites impressus **Gabb**

Concerning the above fossils, the association of *Buchia crassicollis* (Keyserling) needs confirmation, as the collections from locality 1069 now on hand do not contain that species. According to Stanton's notebook, dated October 6–8, 1893, the fossils listed were obtained from several hundred feet of beds. The stratigraphically lowest collections consisted of several poorly preserved specimens of *Buchia*, *Pleuromya?*, and *Pecten?*; about 40 feet higher were obtained rhynchonellid brachiopods and pectens; and about 260 feet still higher were obtained the remainder of the fossils. An excellent collection of *Buchia crassicollis* (Keyserling) was made in a ravine about 200 yards west of Stephenson's ranch houses (USGS Mes. loc. 1071) in beds which Stanton considered to be a few hundred feet lower than those at Mesozoic locality 1069. Stanton noted that the beds under discussion were all part of a conformable sequence and belonged in the upper part of the Knoxville formation as then defined. The beds were later examined by Anderson (1938, p. 43, 113, 119) who concluded that the fossils at Mesozoic locality 1069 were obtained near the base of his Paskenta group.

The age of the beds characterized by *Kilianella crassiplicata* is considered middle Valanginian (chart 1), although both *Kilianella* and *Thurmanniceras* have a considerably longer range. (See table 2.) This age assignment is based on the close resemblance of *Kilianella crassiplicata* (Stanton) to *K. roubaudi* (d'Orbigny) (Sayn, 1907, p. 47, pl. 6, figs. 9, 10a, b), from the middle Valanginian of France; on the considerable resemblance of the inner whorls of *Thurmanniceras californicum* (Stanton) to *T. pertransiens* (Sayn), from the middle Valanginian of France (Sayn, 1907, pl. 5, fig. 10) and Argentina (Leanza, 1945, p. 64, pl. 10, figs. 5–7); on the resemblance of the largest whorls of *T. californicum* to the large whorls of *T. novihispanicum* Imlay (1937, pl. 78, fig. 8, pl. 79, fig. 6), from the middle Valanginian of Mexico; on the fact that *Thurmanniceras* attained its greatest development in the middle Valanginian and *Kilianella* in the middle and upper Valanginian; on the fact that the associated pelecypod *Buchia crassicollis* (Keyserling) attained the climax of its development during middle and late Valanginian times; on the absence of any species of ammonite or of *Buchia* indicative of the early Valanginian; and on the position of the beds containing *Kilianella crassiplicata* some hundreds of feet below other beds of late Valanginian age.

TABLE 2.—*World ranges of certain Early Cretaceous ammonites present in Oregon and California*

[An arrow indicates that the genus ranges higher than the Barremian stage]



All these considerations strongly favor a middle Valanginian age for the *Kilianella crassiplicata* zone, but do not exclude the possibility that the zone is of early Valanginian age. The best evidence that the zone is not older than the middle Valanginian consists of the abundance of *Buchia crassicollis* (Keyserling) and the absence of such species as *B. sublaevis* (Keyserling) and *B. volgensis* (Lahusen) that are recorded from beds of early Valanginian age in the Boreal region.

SARASINELLA HYATTI

This is another provisional zone (table 3) that probably represents part of the beds between the *Kilianella crassiplicata* zone and the *Homolsomites mutabilis* zone. It has not been identified in California. In Oregon it has been found near Riddle (USGS Mes. loc. 26405), near Bald Mountain (USGS Mes. loc. 2107, 2136) in Curry County, and near the forks of Elk River (USGS Mes. locs. 4384, 4386, 4391) in Curry County. On Elk River *Sarasinella hyatti* (Stanton) was found one-fifth

TABLE 3.—*Zonal distribution of Valanginian and Hauterivian ammonites in Washington, Oregon, and California*

	Berriasian	Valanginian				Hauterivian					Barremian
	No fossil evidence	No fossil evidence	*Thurmanniceras californicum, Kilianella crassiplicata,* and *Sarasinella hyatti*	*Homolsomites mutabilis*	*Olcostephanus pecki* and *Homolsomites stantoni*	*Wellsia oregonensis*	*Wellsia packardi*	*Hollisites dichotomus* and *Simbirskites* aff. *S. elatus*	Hamlin—Broad zone of Anderson	*Hertleinites aguila*	*Shasticrioceras poniente*
Phyllopachyceras trinitense (Anderson)						—	—	—			
cf. *P. trinitense* (Anderson)					—						
umpquanum (Anderson)						—	—	—			
cf. *P. umpquanum* (Anderson)								—			
Hypophylloceras aff. *H. onoense* (Stanton)						—	—	—	—	—	
Lytoceras aulaeum Anderson				—	—	—	—	—	—	—	
saturnale Anderson			—	—							
cf. *L. traski* Anderson										—	
Bochianites paskentaensis Anderson				—							
Crioceratites latus (Gabb)									—	—	
cf. *C. yollabollium* (Anderson)								—			
cf. *C. tehamaensis* (Anderson)									—		
sp. indet				—	—	—					
Hoplocrioceras remondi (Gabb)									—	—	
cf. *H. remondi* (Gabb)								—			
duncanense (Anderson)									—	—	
sp. indet						—	—	—			
Shasticrioceras aff. *S. whitneyi* Anderson										—	
cf. *S. poniente* Anderson											—?
sp									?—		
Acrioceras voyanum Anderson								—			
cf. *A. voyanum* Anderson								—			
vespertinum (Anderson)									—		
hamlini (Anderson)									—		
Pseudothurmannia? *russelli* (Anderson)									—		
? *jupiter* (Anderson)									—		
Anahamulina wilcoxensis Imlay, n. sp									—		
Homolsomites mutabilis (Stanton)				—							
stantoni (McLellan)					—						
Olcostephanus pecki Imlay, n. sp					—						
cf. *O. pecki* Imlay, n. sp					←						
popenoei Imlay, n. sp					←						
cf. *O. quadriradiatus* Imlay						—?					
Polyptychites trichotomus (Stanton)				—							
sp				—							
Neocraspedites giganteus Imlay, n. sp				—							
Wellsia oregonensis (Anderson)						—					
packardi (Anderson)						?	—				
vigorosa Imlay, n. sp						?—	—?				
Hertleinites aguila (Anderson)										—	
signalis (Anderson)									—		
Simbirskites broadi Anderson									—		
lecontei (Anderson)									—		
sp. juv. aff. S. *elatus* (Trautschold)								—			
sp. juv. aff. S. *prograediens* Lahusen								—			
spp. juv								—			
? sp										—?	
Hollisites lucasi Imlay								—	—		
cf. *H. lucasi* Imlay								—			
dichotomus Imlay, n. sp								—			
inflatus Imlay, n. sp									—		
Speetoniceras agnessense Imlay, n. sp								—			
Neocomites? cf. *N. indicus* Uhlig				—?							
Thurmanniceras californicum (Stanton)			—								
wilcoxi (Anderson)				?—							
jenkinsi (Anderson)				—							
stippi (Anderson)				—							
sp. juv. cf. *T. stippi* (Anderson)					—						
Hannaites riddlensis (Anderson)						—	—	—			
truncatus Imlay, n. sp						—					
Kilianella crassiplicata (Stanton)			—								
cf. *K. besairiei* Spath			?—								

TABLE 3.—*Zonal distribution of Valanginian and Hauterivian ammonites in Washington, Oregon, and California*—Continued

	Berriasian	Valanginian				Hauterivian					Barremian
	No fossil evidence	No fossil evidence	*Thurmanniceras californicum, Kilianella crassiplicata,* and *Sarasinella hyatti*	*Homolsomites mutabilis*	*Olcostephanus pecki* and *Homolsomites stantoni*	*Wellsia oregonensis*	*Wellsia packardi*	*Hollisites dichotomus* and *Simbirskites* aff. *S. elatus*	Hamlin—Broad zone of Anderson	*Hertleinites aguila*	*Shasticrioceras poniente*
Sarasinella densicostata Imlay, n. sp				X							
cf. *S. densicostata* Imlay, n. sp				X							
cf. *S. subspinosa* (Uhlig)				X							
hyatti (Stanton)			X								
cf. *S. hyatti* (Stanton)			X								
angulata (Stanton)				X							
cf. *S. angulata* (Stanton)				X							
sp				X							
Acanthodiscus sp. juv. aff. *A. subradiatus* Uhlig				X							
Spitidiscus oregonensis Imlay, n. sp						X	X	X			

of a mile up the South Fork at a position that is estimated to be 500 feet below the beds containing *Homolsomites mutabilis* (Stanton) at Mesozoic localities 2154 and 4390. This is the only place where the relative stratigraphic positions of the two species has been determined.

As both of the provisional zones of *Kilianella crassiplicata* and *Sarasinella hyatti* underlie the *Homolsomites mutabilis* zone, there is no assurance that one zone is younger than the other. The matter cannot be settled until more ammonites are found and relative stratigraphic positions are determined. The assumption that the *Sarasinella hyatti* zone is the younger is based on the resemblance of its characteristic species to *S. densicostata* Imlay, n. sp., in the *Homolsomites mutabilis* zone and the fact that *Sarasinella hyatti* (Stanton) was found closer stratigraphically to the *Homolsomites mutabilis* zone than was *Kilianella crassiplicata* (Stanton).

HOMOLSOMITES MUTABILIS

This zone (table 3) is characterized by the ammonites *Homolsomites mutabilis* (Stanton), *Polyptychites trichotomus* (Stanton), *Neocraspedites giganteus* Imlay, n. sp., *Thurmanniceras jenkinsi* (*Anderson*), *T. stippi* (Anderson), *Sarasinella angulata* (Stanton), *S. densicostata* Imlay, n. sp., *Bochianites paskentaensis* Anderson, and *Acanthodiscus* aff. *A. subradiatus* Uhlig. It has been identified only in Tehama County, Calif., and in Curry County, Oreg. In Tehama County it occurs in the upper part of the range of *Buchia crassicollis* (Keyserling) and is represented by many collections (USGS Mes. locs. 1009, 1010, 1087, 1088, 1091, 1093, 2266). These were obtained, according to Stanton, near the upper limit of the *Buchia*-bearing beds. Anderson (1933, p. 321, 322) notes that the collections were made from 1,200 to 1,300 feet above the base of the *Buchia crassicollis* beds, which according to him are about 1,500 feet thick. The *Homolsomites mutabilis* zone in Curry County, Oreg., has been identified definitely only near the Forks of the Elk River (USGS Mes. locs. 2154, 4390, 4393, 6142), where its stratigraphic position relative to the top or bottom of the *Buchia crassicollis* beds is unknown.

The age of the *Homolsomites mutabilis* zone is middle or late Valanginian age on the basis of the ranges of the ammonite genera present. (See table 2.) The presence of *Sarasinella*, *Polyptychites*, and *Homolsomites* implies that the zone is not younger than Valanginian. The presence of *Acanthodiscus* and *Neocraspedites* indicates an age not older than the middle Valanginian. In fact these genera strongly favor a late Valanginian age because *Acanthodiscus* reached its climax in the early Hauterivian and *Neocraspedites* in the late Valanginian. Also the presence of the uncoiled ammonite *Crioceratites* (USGS Mes. loc. 1009), is strong evidence that the age of the zone is not older than late Valanginian because the genus occurs typically in rocks of Hauterivian and Barremian ages (Sarkar, 1955, p. 25, 33; Wright, 1957, p. 1208). The genus *Homolsomites* is of unknown value at present for close dating of the beds in which it occurs, because it has been found at only a few places in California, Oregon, Washington, and Greenland (Imlay, 1956, p. 1146). In Greenland, however, it is associated with ammonites that Donovan (1953, p. 135, 136; 1957, p. 149) considers to be of late Valanginian age.

Comparisons by species favors a late Valanginian or a late middle Valanginian age for the *Homolsomites mutabilis* zone. *Homolsomites mutabilis* (Stanton) is closely similar to *H. paucicostatus* (Donovan) (1953, p. 110–112, pl. 23, figs. 1a, b), from beds of probable late Valanginian age in East Greenland. *Polyptychites trichotomus* (Stanton) resembles *P. ramulicosta* A. Pavlow (1892, p. 481, pl. 8, figs. 10a, b, pl. 15, figs. 6a, b), from the late middle Valanginian at Speeton, England. *Neocraspedites giganteus* Imlay, n. sp., resembles *N. flexicosta* (Von Koenen) (1902, p. 74, pl. 5, figs. 14–16), from the late Valanginian of Germany. *Thurmanniceras jenkinsi* Anderson resembles *T. duraznense* Gerth (1925, p. 97, pl. 4, figs. 1, 1a; Leanza, 1945, table opposite p. 96), from the late Berriasian of Argentina. *Sarasinella angulata* (Stanton) is closely similar to *S. trezanensis* (Sayn) (1907, p. 34, pl. 3, figs. 20, 25a, b), from the middle Valanginian of France. *Acanthodiscus* sp. juv. aff. *A. radiatus* Uhlig resembles a species from the late Valanginian of India much more than any of the species from the early Hauterivian of Europe.

The *Homolsomites mutabilis* zone in Oregon has furnished few mollusks other than ammonites and *Buchia crassicollis* (Keyserling). *Inoceramus* cf. *I. vallejoensis* Anderson occurs at Mesozoic localities 2154, 2156, 4390, 4393, and 4394 on Elk River. *Acroteuthis* sp. and *Turbo?* cf. *T. morganensis* Stanton occur at Mesozoic locality 2154. In contrast, in Tehama County, Calif. between McCarthy Creek and Elder Creek, the *Homolsomites mutabilis* zone has furnished a large molluscan fauna that has been described by Stanton (1895 [1896]) under the following names:

Buchia crassicollis (Keyserling) (Mes. locs. 1071, 1087, 1091, 1093, 1095)
Anomia senescens Stanton (Mes. locs. 1009, 1087)
Avicula (*Oxytoma*) *whiteavesi* Stanton (Mes. loc. 1093)
Pinna sp. (Mes. loc. 1093)
Arca tehamaensis Stanton (Mes. loc. 1093)
Nucula gabbi Stanton (Mes. loc. 1088)
Leda glabra Stanton (Mes. locs. 1069, 1093)
Astarte corrugata Stanton (Mes. loc. 1093)
Astarte trapezoidalis Stanton (Mes. loc. 1088)
Dentalium californicum Stanton (Mes. loc. 1093)
Turbo trilineatus Stanton (Mes. loc. 1088)
Turbo? humerosus Stanton (Mes. loc. 1088)
Hypsipleura gregaria Stanton (Mes. loc. 1093)
Cerithium strigosum Stanton (Mes. loc. 1093)
Belemnites impressus Gabb (Mes. locs. 1088, 1093)
Belemnites sp. (Mes. loc. 1093)

OLCOSTEPHANUS PECKI

This zone has been identified definitely only near Days Creek and Myrtle Creek, in Douglas County, Oreg., but probably is represented in northwestern Washington. Its stratigraphic position in the upper part of the *Buchia crassicollis* beds directly beneath beds containing early Hauterivian ammonites has been determined only on the South Umpqua River near its junction with Days Creek. At this place a sequence nearly 1,900 feet thick, involving beds of Portlandian, Valanginian, and Hauterivian ages, was measured by Hollis Dole, Dallas Peck, Len Ramp, and R. W. Imlay. The beds assigned to the Valanginian are about 375 feet thick and are characterized by the presence of the pelecypod *Buchia crassicollis* (Keyserling) in their upper 330 feet. They have furnished the ammonite *Olcostephanus pecki* Imlay, n. sp., at four levels from 73 feet to 291 feet above their base, and a single specimen of the ammonite *Homolsomites stantoni* (McLellan) at 73 feet above their base. Other mollusks present include *Lytoceras* cf. *L. saturnale* Anderson, *Phylloceras* cf. *P. trinitense* Anderson, belemnite fragments, and *Pleuromya*, *Entolium*, and *Inoceramus*.

The presence of the zone of *Olcostephanus pecki* in northwestern Washington is indicated by two fragments probably belonging to that species that were obtained 3 miles east of Glacier, Wash. (Washington Univ. loc. WA538), in association with *Homolsomites stantoni* (McLellan) and *Buchia crassicollis* (Keyserling). This occurrence is similar to that on the South Umpqua River, Oreg., just discussed, where the same species of ammonites and *Buchia* are likewise associated (USGS Mes. loc. 26788). These associations indicate that the beds containing *Homolsomites stantoni* (McLellan) on Spieden Island belong in the *Olcostephanus pecki* zone.

The ammonite, *Olcostephanus pecki* Imlay, n. sp., differs from most described species of *Olcostephanus* by having closely spaced ribs and by lacking umbilical tubercles except on its innermost whorls. In these respects it greatly resembles *O. jeannoti* (d'Orbigny) (1841, p. 188, pl. 56, figs. 3–5), from the latest Valanginian and early Hauterivian of France. By comparison *O. pecki* could be of either age. A Valanginian age is shown, however, by its association with the Valanginian pelecypod *Buchia crassicollis* (Keyserling) and by the fact that its highest occurrence is about 85 feet below a thick sequence of beds containing ammonities of early Hauterivian age.

As the zones of *Olcostephanus pecki* and *Homolsomites mutabilis* have not been found in a single section, their relative stratigraphic positions have not been determined. However, a higher stratigraphic position for the *Olcostephanus pecki* zone is indicated by its position at the very top of a Valanginian sequence near Days Creek, Oreg., whereas the *Homolsomites mutabilis* zone in California and Oregon occurs at least several hundred feet below the top of the Valanginian beds containing *Buchia crassicollis* (Keyserling). The possibility that the two zones reflect environmental differences rather than time differences is discounted because the sedimentary rocks present in the zones have the same lithologic characteristics and contain an abundance of the same species of *Buchia*. Combined with this, the fact that the characteristic species of one zone have not been found in the other implies that they occupy somewhat different positions.

The zone of *Olcostephanus pecki* may still be found in California in the uppermost part of the range of *Buchia crassicollis* (Keyserling) above the *Homolsomites mutabilis* zone. If Anderson's data (1933, p. 321, 322) are correct, this zone in Tehama County is overlain by 200 to 300 feet of beds containing *Buchia crassicollis* (Keyserling), which could account for the *O. pecki* zone. Against this possibility is the record by Anderson (1938, p. 46, 164, 165) of certain fossils from the lower part of the shaly sequence overlying the beds containing *Buchia crassicollis* (Keyserling) in abundance. The fossils (CAS loc. 33502) were assigned by Anderson to *Neocomites jenkinsi* Anderson, *Thurmannia paskentae* Anderson, *Subasteria* sp., *Berriasella crassiplicata* (Stanton), and to two species of *Aucella* (now called *Buchia*). The ammonites have been examined by the writer and are herein referred to *Thurmanniceras jenkinsi* (Anderson), *T.* sp. juv. cf. *T. stippi* (Anderson), *Polyptychites* sp. juv. (see pl. 31, fig. 14), and *Kilianella* sp. As all these are characteristic of the *Homolsomites mutabilis* zone, the zone of *Olcostephanus pecki* may be still higher stratigraphically, or may not be represented by sediments.

WELLSIA OREGONENSIS

This zone is characterized by the ammonites *Wellsia oregonensis* (Anderson). Other ammonites in the zone include *Phylloceras trinitense* Anderson, *P. umpquanum* Anderson, *Lytoceras aulaeum* Anderson, *Spitidiscus oregonensis* Imlay, n. sp., *Hannaites riddlensis* (Anderson), *H. truncata* Imlay, n. sp., and *Crioceratites latum* (Gabb). All these except *Wellsia oregonensis* (Anderson) range into the overlying zone of *Wellsia packardi*, and the species of *Spitidiscus* ranges still higher into the zone characterized by *Simbirskites*. Associated with these ammonites are many species of pelecypods and some gastropods, belemnites, and crustaceans. Described pelecypods include *Periplomya trinitensis* Anderson, *Periplomya reddingensis* Anderson, *Pleuromya papyracea* (Gabb), *Trigonia kayana* Anderson, and *Entolium operculiformis* (Gabb). The pelecypod genera *Astarte*, *Trigonia*, *Oxytoma*, *Solecurtus*, *Cercomya*, and *Mytilus* are represented by undescribed species. *Pleuromya* and *Entolium* are represented by many more individuals than the other genera. The interesting feature concerning the pelecypods is that not a single species occurs in the older beds containing *Buchia crassicollis* (Keyserling) but that the range of many of the species extends higher into beds of middle Hauterivian age.

The zone of *Wellsia oregonensis* has been identified only in southwestern Oregon. Most of the occurrences of *Wellsia oregonensis* (Anderson) are near Days Creek and Riddle in Douglas County, but the species has been found at one place in Coos County. All its occurrences in Douglas County are in gray siltstone and greenish-gray sandstone directly overlying gray sandstone containing *Buchia crassicollis* (Keyserling). On the South Umpqua River near Days Creek, *W. oregonensis* (Anderson) has been collected from 58–243 feet above the top of the beds containing *Buchia*. On the Foggy Creek road in Coos County, *W. oregonensis* (Anderson) was collected (Mes. loc. 25213) 400 feet below *Hannaites riddlensis* (Anderson) (USGS Mes. loc. 25212) and 1,200 feet above the top of conglomeratic beds containing *Buchia crassicollis* (Keyserling), which are about 1,000 feet thick.

WELLSIA PACKARDI

This zone (table 3) is characterized by the ammonite *Wellsia packardi* (Anderson) and has been found only in Douglas County, Ore., near Days Creek and Riddle. It is considered provisional because its relative position above *W. oregonensis* (Anderson) has been established only in one sequence and because the associated megafossils belong to the same species as those in the *W. oregonensis* zone. Differentiation of the two zones was indicated by collecting along the South Umpqua River near Days Creek which showed that *W. packardi* occurred stratigraphically higher than *W. oregonensis* and ranged from 253 to 413 feet above the beds containing *Buchia crassicollis* (Keyserling). Some of the collections (USGS Mes. locs. 718, 1243, 1252) made between 1890 and 1900 on Cow Creek below Riddle contain both *Wellsia oregonensis* and *W. packardi*. These collections were not made stratigraphically, however. The fact that the specimens of *W. packardi* in these collections are browner and generally more crushed than the specimens of *W. oregonensis* suggests that the species were obtained in different beds.

HOLLISITES DICHOTOMUS

This zone, identified only in southwestern Oregon, is characterized by the ammonites *Hollisites dichotomus* Imlay, n. sp., *Speetoniceras agnessense* Imlay, n. sp., *Simbirskites* aff. *S. elatus* (Trautschold), and *Simbirskites* aff. *S. progrediens* Lahusen. Associated with these species are others that range upward from older Hauterivian beds in Oregon, including *Phyllopachyceras trinitense* (Anderson), *P. umpquanum* Anderson, *Hannaites riddlensis* (Anderson), *Lytoceras aulaeum* Anderson, and *Spitidiscus oregonensis* Imlay, n. sp. Also, associated with these species are others that are similar to, or identical with species in California in the middle Hauterivian Hamlin-Broad zone of Anderson and the late Hauterivian *Hertleinites aguila* zone. These species include *Acrioceras voyanum* Anderson, *A. cf. A. voyanum* Anderson, *Hoplocrioceras* cf. *H. remondi* (Gabb), and *Hollisites lucasi* Imlay, n. sp. The pelecypods found with these ammonites include *Pleuromya papyracea* (Gabb) (USGS Mes. locs. 1245, 25214), *Trigonia kayana* Anderson (USGS Mes. locs. 1243, 25214), *Trigonia* cf. *T. leana* Gabb (USGS loc. 1245), *Entolium* sp. (USGS Mes. loc. 24449), *Inoceramus* sp. (USGS Mes. loc. 24449). In addition to these pelecypods, a subcircular *Inoceramus* similar to the Albian species *I. anglicus* Woods occurs at USGS Mesozoic localities 2093, 3352, 25210, and 25215,

The *Hollisites dichotomus* zone has been identified in Douglas County near Riddle (USGS Mes. locs. 1251, 1245, 25210) and is probably present on the South Umpqua River below the bridge at the mouth of Days Creek (UCGS Mes. locs. 3352 in part). In Curry County it occurs at several places near Agness (USGS Mes. locs. 2078, 2080, 2093, 25214, 25215, 25216, and 26879). In Coos County a large collection was made near the Foggy Creek Road USGS Mes. locs. 25211, 24449).

The stratigraphic position of the *Hollisites dichotomus* zone relative to the *Wellsia packardi* zone has been determined only in Cow Creek at the town of Riddle, Douglas County. Collections containing both *Wellsia packardi* (Anderson) and *W. oregonensis* (Anderson) USGS Mes. locs. 718, 1252, 25208) have been obtained from a couple hundred feet of beds about a quarter of a mile below the bridge across Cow Creek at Riddle. A collection containing *Hollisites dichotomus* Imlay, n. sp., and *Simbirskites* sp. juv. aff. *S. elatus* (*Trautschold*) was obtained from 15 feet of gray sandstone exposed at the west end of the bridge across Cow Creek (USGS Mes. loc. 1251). The thickness of the beds between these collections cannot be accurately determined because of minor folding and faulting, but, according to Stanton's notes of October 23, 1894, and the writer's own observations, the collections at Mesozoic locality 1251 are only slightly higher stratigraphically than the others.

Another locality where the relative stratigraphic positions of *Simbirskites* and *Wellsia oregonensis* has been determined is on the Foggy Creek road in Coos County. Numerous specimens of *Simbirskites* and other ammonites were obtained on the west side of the Foggy Creek road about a quarter of a mile above its junction with the Eden Valley road (USGS Mes. loc. 25211). Specimens of *Hannaites riddlensis* Anderson (Mes. loc. 25212) were obtained 1 mile upstream from the junction; *Wellsia oregonensis* (Anderson) (Mes. loc. 25213) was obtained 1.3 miles upstream and *Buchia crassicollis.* (Keyserling) was obtained 1.5 miles upstream. According to Francis Wells (oral communication, March 1958) the collection containing *Simbirskites* was apparently obtained 3,000 feet higher stratigraphically than that containing *Hannaites riddlensis* (Anderson) and 3,400 feet above that containing *Wellsia oregonensis* (Anderson). He considers that a thickness of 3,000 feet between the first 2 collections probably includes repetition of beds by faulting or folding, but that the fossil collections are in correct stratigraphic sequence.

The *Hollisites dichotomus* zone has not been identified in California. The possibility that it is equivalent to part of Hamlin-Broad zone of Anderson (1938, p. 47–49) in Shasta and Tehama Counties, Calif., is unlikely because most of the ammonites that have been found in it belong to different species than those in Anderson's (Hamlin-Broad zone and it includes a number of ammonite species that range up from the *Wellsia packardi* zone, but are not known from California.

The age of the *Simbirskites dichotomus* zone is indicated as middle to early late Hauterivian on the basis of the presence of the ammonite *Simbirskites*, cf the resemblance of the genus *Hollisites* to *Speetoniceras* and on the presence of the genus *Speetoniceras* itself. At Speeton, England, *Simbirskites* is recorded by Spath (1924, p. 76, 77) as ranging from the beds containing *Subastieria sulcosa* (Pavlow) into the beds containing *Simbirskites progredicus* Lahusen and to be most abundant in the upper part of its range. *Simbirskites* in northern Germany (Von Koenen, 1902, p. 420, 433; Stolley, 1908, p. 145, 151) and in Russia (A. Pavlow, 1892, p. 558, 559; 1901, p. 46, 47) is reported to occur a little above the middle of the Hauterivian. The range of *Speetoniceras* in Europe is similar to that of *Simbirskites*. At Speeton, England, *Speetoniceras* has been found only in the lower part of the range of *Simbirskites* (Spath, 1924, p. 76, 77), but in Russia the genus is reported to occur in the upper part of the range of *Simbirskites* (Spath, 1924, table 3, faces p. 80). If the *Hollisites dichotomus* zone in Oregon is older than beds in California that contain *Simbirskites broadi* Anderson, it may reasonably be correlated with the lower part of the range of *Simbirskites* in Europe.

HAMLIN-BROAD ZONE OF ANDERSON

Some beds characterized by species of the ammonites *Simbirskites*, *Hoplocrioceras*, *Acrioceras*, and *Crioceratites* were named by Anderson (1938, p. 47, 48) the Hamlin-Broad zone after the specific names of two ammonite species, *Aspinoceras hamlini* Anderson and *Simbirskites broadi* Anderson. He included in his zone the fossils from CAS localities 1665, 113, and nearby places from 3 to 6 miles southwest of Ono in Shasta County. He states on page 47 that the fossils at locality 113 were obtained 450 feet below a conglomerate marking the base of his Horsetown group and were more than 1,000 feet above the base of the Cretaceous section. On pages 122, 147, 154, 208, he states that the fossils were collected 500 feet below the conglomerate and on page 111 he states they were collected 600 feet below the conglomerate. On table 2 opposite page 44 he indicates that locality 113 has *B* and *C* subdivisions. The probable explanation for these discrepancies is that the fossils in CAS locality 113 were collected from 3 places near each other and from an interval ranging from 450 to 600 feet below the conglomerate. This particular conglomerate was named the Roaring River tongue of the Ono formation by Murphy (1956, p. 2108, 2111).

The stratigraphic position of the Hamlin-Broad zone according to Anderson (1938, table 2, p. 47–49, 64) is definitely below beds containing *Hertleinites aguila* (Anderson). However, Michael Murphy, paleontologist at the University of California at Los Angeles, has found *Simbirskites broadi* Anderson associated with *Hertleinites aguila* (Anderson) southwest of Ono, Calif. Furthermore, concerning CAS locality 113, he states (written communication, Jan. 9, 1959):

> There are two fossil zones at the head of Mitchell Creek west of the road * * *. You may recall that Anderson indicated the specimens he collected came from 450 to 600 feet below a conglomerate and that he gave all specimens the same locality number CAS 113. This apparently was standard procedure with him. He regarded his localities as areas from which he collected fossils and paid little attention to whether or not all the specimens at a particular locality came from the same stratigraphic position.

Murphy's fieldwork shows, therefore, that one species, *Simbirskites broadi* Anderson, that Anderson considered characteristic of his Hamlin-Broad zone actually occurs in, or ranges into the *Hertleinites aguila* zone. He indicates, however, that some of the species from Anderson's Hamlin-Broad zone are from beds older than those containing *Hertleinites aguila* (Anderson). This conclusion seems reasonable considering that most of the ammonites from CAS localities 1665 and 113 have not been found with *Hertleinites aguila* (Anderson).

The fossils from CAS locality 1665 described or listed by Anderson are as follows:

Neocomites russelli Anderson (1938, p. 201)
Crioceras duncanense Anderson (Anderson, 1938 p. 201)
Crioceras latum Gabb (1938, p. 200)
Crioceras cf. *C. nolani* Kilian (Anderson, 1938, p. 48)
Hoplocrioceras remondi (Gabb) (Anderson, 1938, p. 202)
Hoplocrioceras sp. (Anderson, 1938, p. 47)
Spiticeras duncanense Anderson (1938, p. 160)
Pleuromya papyracea Gabb (Anderson, 1938, p. 115)
Pholadomya clementina Anderson (1938, table 2)

Of these species the writer assigns *Neocomites russelli* Anderson questionably to *Pseudothurmannia*, *Crioceras duncanense* Anderson is considered a synonym of *Crioceratites latum* (Gabb), and *Spiticeras duncanense* Anderson belongs to the genus *Hoplocrioceras*. The reasons for these assignments are discussed herein under the description of the species.

The fossils from CAS locality 113 described or listed by Anderson are as follows:

Lytoceras saturnale Anderson (1938, p. 47)
Lytoceras aulaeum Anderson (1938, p. 147)
Subastieria chanchelula Anderson (1938, p. 156)
Simbirskites broadi Anderson (1938, p. 155)
Polyptychites lecontei Anderson (1938, p. 154)
Polyptychites hesperius Anderson (1938, p. 154)
Crioceras latum Gabb (Anderson, 1938, p. 200)
Aspinoceras hamlini Anderson (1938, p. 207)
Anahamulina vespertina Anderson (1938, p. 219)
Acroteuthis shastensis Anderson (1938, p. 226)
Ostrea indigena Anderson (1938, p. 108)
Plicatula onoensis Anderson (1938, p. 111)
Venus collinium Anderson (1938, p. 111)

The fossils from CAS locality 113B described or listed by Anderson are as follows:

Thurmannia jupiter Anderson (1938, p. 162)
Phylloceras occidentale Anderson (1938, table 2)
Lytoceras traski Anderson (1938, table 2)
Acroteuthis impressa (Gabb) (Anderson, 1938, table 2)
Modiolus onoensis Anderson (1938, table 2)

The fossils from CAS locality 113C described or listed by Anderson are as follows:

Discohelix planigyroides Hanna in Anderson (1938, p. 128)
Arca textrina Stanton? Anderson (1938, table 2)
Trigonia cf. *T. kayana* Anderson (1938, table 2)

Of the ammonites from CAS locality 113, 113B, and 113C the writer considers that *Subastieria chanchelula* Anderson is an immature specimen of *Simbirskites broadi* Anderson; *Polyptychites lecontei* Anderson is assigned to the genus *Simbirskites* and is probably a synonym of *Ammonites traski* Gabb, which Shimizu (1931, p. 15) designated as the type of *Californiceras; Polyptychites hesperius* Anderson probably belongs to the genus *Hollisites* Imlay (1957, p. 276); *Crioceras latum* Gabb belongs to *Crioceratites; Aspinoceras hamlini* Anderson and *Anahamulina vespertina* Anderson belong to *Acrioceras;* and *Thurmannia jupiter* Anderson probably belongs to *Pseudothurmannia.* The reasons for these assignments are discussed herein under the description of the species.

The Hamlin-Broad zone of Anderson is possibly represented at one place in Tehama County where T. W. Stanton, James Storrs, and J. S. Diller made a large collection (USGS Mes. loc. 1092) on the Wilcox Ranch. Stanton states in his notebook, dated October 16, 1893, that the collection was made from 50 to 200 feet above the sandy beds containing *Buchia crassicollis* (Keyserling). The fossils at this locality, listed by Stanton (1895, top of p. 18 [1896]), have been restudied and are as follows:

Hypophylloceras cf. *H. onoense* (Stanton)
Lytoceras aulaeum Anderson
Crioceratites cf. *C. tehamaensis* (Anderson)
Anahamulina wilcoxensis Imlay, n. sp.
Hertleinites pecki Imlay, n. sp.
Hollisites lucasi Imlay
Hollisites inflatus Imlay, n. sp.
Shasticrioceras sp.
Acroteuthis sp.
Pleuromya papyracea Gabb
Plicatula variata Gabb
Entolium? operculiformis (Gabb)
Parallelodon cf. *P. breweriana* (Gabb)
Tessarolax bicarinata (Gabb)
Potamides diadema Gabb
Ampullina cf. *A. avellana* Gabb

Concerning the preceding fossils, a position in the *Hertleinites aguila* zone rather than in the Hamlin-Broad zone is indicated by the particular species of gastropods, by the resemblance of the fragment of *Hypophylloceras* to *H. onoense* (Stanton) and by the presence of the genus *Hertleinites* and *Shasticrioceras.* The genus *Hollisites*, however, has not been previously found in the *Hertleinites aguila* zone and is common in Oregon in beds containing *Simbirskites.*

In 1900 Stanton made additional collections on the Wilcox Ranch. According to his notes of September 3d and 4th he made several collections over a distance of about a mile at a stratigraphic position from 400 to 500 feet above the sandy beds containing *Buchia crassicollis* (Keyserling). He assumed that the fossiliferous beds were the same in which he collected in 1893 at Mesozoic locality 1092. His collections, however, contain different species, particularly *Hertleinites aguila* Anderson and *Inoceramus ovatoides* Anderson, than he obtained in 1893; so the probabilities are that they were obtained from a slightly higher stratigraphic position. The fossils obtained in 1900 will be listed and further discussed under the description of the *Hertleinites aguila* zone.

Considering the reported differences in the stratigraphic intervals from which collections were made and the differences in faunal characteristics of the fossil collections made in 1893 with those made in 1900, the probabilities are that the fossils collected in 1893 (USGS Mes. loc. 1092) are slightly older than those collected in 1900 (USGS Mes. locs. 2267–2269), or represent mixture from different levels and are in part from the *Hertleinites aguila* zone. If the Hamlin-Broad zone of Anderson is not represented, there is only a slight thickness of beds above the *Buchia crassicollis* beds to account for the early and middle Hauterivian zones that are so richly developed in southwestern Oregon. The matter can only be settled by additional fieldwork.

Another area in California that may contain beds slightly older than *Hertleinites aguila* zone is on the Clements Ranch in the valley of Redding Creek, Trinity County. A collection made near the building of the Clements Ranch by James Storr (USGS Mes. loc. 4415) contains the following described species:

"Phylloceras" trinitense Anderson
Crioceratites latum Gabb
Pleuromya papyracea Gabb
Goniomya vespera Anderson
Pinna pontica Anderson
Entolium? operculiformis (Gabb)

The following species are listed or described by Anderson (1938) from about the same place (CAS loc. 1691):

Pleuromya papyracea Gabb (Anderson, 1938, p. 118)
Periplomya trinitense Anderson (1938, p. 118)
Periplomya reddingensis Anderson (1938, p. 118)
Goniomya vespera Anderson (1938, p. 117)
Pholadomya altiumbonata Anderson (1938, p. 116)
Pholadomya clementina Anderson (1938, p. 116)
"Venus" collinium Anderson (1938, p. 111)
"Syncylonema" operculiformis (Gabb) (Anderson, 1938, p 200)

In addition Anderson reports the following species from a nearby area:

"Phylloceras" trinitense Anderson (1938, p. 200)
"Crioceras" latum Gabb (Anderson, 1938, p. 200)
"Hoplocrioceras" yollabollium Anderson (1938, p. 203)

The last mentioned species is reported to have been obtained about 600 feet below the beds exposed at the Clements Ranch buildings and to be similar to *Crioceratites bederi* (Gerth) from Argentina.

Most of these species occur in the Hamlin-Broad zone of Anderson at CAS localities 113 and 1665 in California. The presence of *"Phylloceras" trinitense* Anderson might be taken as evidence for correlation with the early or middle Hauterivian of Oregon. However, the collections from the Clements Ranch do not contain certain species of *Astarte*, *Solecurtus*, *Arcomya*, *Oxytoma*, and *Trigonia* that are common in the Hauterivian beds in Oregon and do contain species of *Pholadomya* and *Goniomya* not known in Oregon. Also, the specimens of *Crioceratites* in Oregon appear to differ a little from *Crioceratites latum* (Gabb), which species occurs in California both in the Hamlin-Broad zone of Anderson and in the *Hertleinites aguila* zone.

The age of beds at CAS localities 113 and 1665 near Ono, Calif., is either late middle or late Hauterivian on the basis of the association of the ammonites *Hoplocrioceras*, *Acrioceras*, and *Simbirskites*. (See table 2.) The resemblance of *Hollisites* to *Speetoniceras* and of *Neocomites russelli* Anderson to *Pseudothurmannia* also indicates such an age.

HERTLEINITES AGUILA

This zone was established by Murphy (1956, p. 2113, 2114) for essentially the same beds that Anderson (1938, table 2, faces p. 44, 64) included in his Ono zone. Murphy lists the following species:

Entolium operculiformis (Gabb)
Goniomya vespera (Anderson)
Periplomya trinitense Anderson
Nucula gabbi Stanton
Inoceramus ovatoides Anderson
Pinna pontica Anderson
Parallelodon brewerianа (Gabb)
Plicatula variata Gabb
Pholadomya altiumbonata Anderson
Pleuromya papyracea Gabb
Potamides diadema Gabb
Turbo festivius Anderson
Palamede perforata (Gabb)
Tessarolax bicarinata (Gabb)
"*Neocraspedites*" *aguila* Anderson
Lytoceras aulaeum Anderson
Shasticrioceras sp. indet.
Acroteuthis aboriginalis Anderson

Anderson lists most of these species and in addition the following:

Modiolus onoensis Anderson (1938, p. 114)
Astarte californica Stanton (Anderson, 1938, p. 64)
Pholadomya clementina Anderson (1938, p. 116)
Corbula filosa Stanton (Anderson, 1938, p. 64)
Dentalium californicum Stanton (Anderson, 1938, p. 126)
Ampullina avellana Gabb (Anderson, 1938, p. 64)
Nerinea archimedi Anderson (1938, p. 64)
Clisocolus indubitus Anderson (1938, p. 121)
Lytoceras traski Anderson (1938, pp. 64, 146)
Phylloceras occidentale Anderson (1938, pp. 64, 139)
Hoplocrioceras remondi (Gabb) (Anderson, 1938, p. 201)
Hoplocrioceras onoense Anderson (1938, p. 202)
Crioceras latum Gabb (Anderson, 1938, p. 200)
"*Neocraspedites*" *rectoris* Anderson (1938, p. 157)
Acroteuthis onoensis Anderson (1938, p. 227)
Acroteuthis kernensis Anderson (1938, pp. 64, 227)

The collections of the Geological Survey made by T. W. Stanton near Ono, Calif., contain most of the species listed by Murphy and Anderson. One of the most interesting additions is *Hypophylloceras* aff. *H. onoense* (Stanton) (USGS Mes. locs. 2223-2225).

Other collections made by Stanton on the Wilcox Ranch, in Tehama County, Calif, show the existence of the *Hertleinites aguila* zone in that area. These collections were made according to Stanton's notes of September 3 and 4, 1900, from 400 to 500 feet above the top of the sandy beds containing *Buchia crassicollis* (Keyserling). In addition to the common pelecypods and gastropods characteristic of the zone, they include the following:

Lytoceras aulaeum Anderson (Mes. loc. 2267)
Lytoceras cf. *L. traski* Anderson (Mes. loc. 2268)
Hertleinites aguila (Anderson) (Mes. loc. 2267)
Hoplocrioceras remondi (Gabb) (Mes. loc. 2268)
Acrioceras cf. *A. voyanum* Anderson (Mes. loc. 2269)

At Mesozoic locality 2269 Stanton found a small specimen of *Inoceramus ovatoides* (equals *I. colonicus* Anderson) which he mistook for *Aucella* (now called *Buchia*). Its shape is similar to that of *Puchia piochii* (Gabb), but its nacreous shell layer is unlike that of any *Buchia*. The species is fairly common in the *Hertleinites aguila* zone near Ono, Calif., as well as in the overlying *Shasticrioceras poniente* zone (Murphy, 1956, fig. 6, p. 2114), but has not been recorded from the Hamlin-Broad zone of Anderson.

The *Hertleinites aguila* zone is possibly represented in southwestern Oregon about 4 miles south of Cave Junction by a collection (USGS Mes. loc. 3339) containing the following fossils:

Inoceramus ovatoides Anderson (abundant)
Trigonia cf. *T. leana* Gabb (abundant)
Entolium operculiformis (Gabb)
Pleuromya sp.
Astarte sp.
Protocardia sp.
Dentalium sp.
Simbirskites? sp.

The ammonite referred questionably to *Simbirskites* is small and fragmentary but suggests a middle to late Hauterivian age. The occurrence of *Inoceramus ovatoides* Anderson in abundance suggests an age as young as the *Hertleinites aguila* zone, because the species has not been identified in older beds in California.

About 5 miles south of Cave Junction another collection (Mes. loc. 2166) contains the following species:

Inoceramus ovatoides Anderson
Pleuromya papyracea Anderson
Trigonia cf. *T. leana* Gabb
Trigonia kayana Anderson
Meekia sp.
Nucula sp.
Goniomya sp.
Entolium operculiformis (Gabb)
Corbula sp.

Solecurtus sp.
Acrioceras? sp.
Shasticrioceras cf. *S. poniente* Anderson

Concerning the age significance of the above fossils, the presence of *Shasticrioceras* similar to *S. poniente* Anderson is strong evidence that the fossiliferous beds belong in the *Shasticrioceras poniente* zone (Murphy, 1956, p. 2113), although the genus has been recorded in the underlying *Hertleinites aguila* zone. *Inoceramus ovatoides* Anderson has been recorded from both of these zones (Murphy, 1956, fig. 6, p. 2114) but not higher or lower. *Trigonia kayana* Anderson occurs in Oregon in beds of early to middle Hauterivian age. In California it is recorded by Anderson (1938, p. 108) from beds probably as low as the *Hertleinites aguila* zone. It is recorded by Murphy (1956, p. 2116) as being particularly abundant in the lower part of his *Gabbioceras wintunium* zone of early Aptian age. The holotype specimen of *Trigonia kayana* Anderson was obtained near Ono, Calif., at an unknown stratigraphic position. Apparently this species has a much longer stratigraphic range than the *Shasticrioceras poniente* zone.

The beds in California included in the *Hertleinites aguila* zone were considered by Anderson (1938, table 2, faces p. 44, 64) to be not younger than early Hauterivian because of the presence of ammonites that he assigned to *Neocraspedites*, *Hoplocrioceras*, and *Crioceras* and because he considered (1938, p. 47) the ammonites from the underlying Hamlin-Broad zone of Anderson to be Valanginian. The writer interprets the age significance of the ammonites in these zones somewhat differently as discussed herein.

The only fossils in the *Hertlenites aguila* zone that have much significance in intercontinental correlation are the ammonites *Hertleinites* (equals *Neocraspedites* of Anderson), *Simbirskites*, *Hoplocrioceras*, and *Crioceratites* (equals *Crioceras* of Anderson). Of these, *Hertleinites* has not been recorded outside of California, but its resemblance to the late Hauterivian genus *Craspedodiscus* may indicate a similar age. *Simbirskites* is a characteristic Hauterivian genus. *Hoplocrioceras* at Speeton, England, ranges from the zone of *Simbirskites progredicus* through the Hauterivian (Spath, 1924, p. 78). Wright (1957, p. 208) indicates that the genus occurs likewise in the Barremian. The genus is mostly recorded, however, from the late Hauterivian corresponding to the European zone of *Pseudothurmannia angulicostata*. *Crioceratites* is recorded as ranging through the Hauterivian and Barremian (Sarkar, 1955, p. 25) but it is mostly recorded from the Hauterivian. In summation the evidence from the ammonites favors a Hauterivian rather than a Barremian age and a late Hauterivian rather than an early Hauterivian age.

A late Hauterivian age assignment is supported, also, by the relative stratigraphic position of the *Hertleinites aguila* zone above beds containing *Simbirskites* and below beds containing *Pulchellia* and *Ancyloceras*. As previously mentioned *Simbirskites* is mostly recorded as from beds of middle or late middle Hauterivian age. The Barremian age of the overlying *Shasticrioceras poniente* zone is definite, considering that *Pulchellia* occurs at one place in the lower part of the zone and *Ancyloceras* is common in the upper part. The genus *Pulchellia* ranges through the Barremian, but most of its occurrences are from the early Barremian. As *Ancyloceras* ranges from late Barremian into early Aptian, its occurrence above *Pulchellia* in California is normal.

COMPARISONS WITH OTHER FAUNAS

The ammonite faunules in beds of Valanginian and Hauterivian ages in the Pacific Coast states have a peculiar local aspect owing to the fact that some of the common genera present have either not yet been found elsewhere, or rarely elsewhere, and to the fact that some genera that are common in other parts of the world are either unknown or are rare in these States. There appears to be a commingling of local, or provincial, genera with others that are common either in the Mediterranean province or in northern Europe. Interestingly, resemblance with ammonites of Valanginian age in Mexico are no greater than with those in India or in southern France, and the Hauterivian ammonites of the Pacific coast are much more similar to those of England, northern Germany, and central Russia than to those of Mexico. (See chart 1). Unfortunately, for comparative purposes ammonites of these ages from Alaska and Canada are unknown or undescribed.

The affinities of the Valanginian ammonites from Oregon and California are predominantly with ammonites of the Mediterranean province. Comparable species of the genera *Kilianella*, *Sarasinella*, *Thurmanniceras*, *Acanthodiscus*, *Neocomites?*, *Olcostephanus*, and *Bochianites* occur in various parts of that province, particularly in India, southern France, and Switzerland. Some affinities with ammonites of central and northern Europe are suggested, however, by the presence of species of *Neocraspedites* and *Polyptychites* similar to species in northern England and northern Germany. Also, the genus *Homolsomites*, known elsewhere only in Washington, British Columbia, and Greenland, probably belongs to the boreal subfamily Tolliinae. In contrast with the Valanginian beds in most parts of the world the Valanginian of the west coast has furnished very few species of the subfamily Olcostephaninae. This scarcity is surprising, considering the abundance of that subfamily in Mexico. The absence in Oregon and California of such typical Valanginian genera as *Rogersites*, *Valanginites*, *Distoloceras*, or even typical species of *Neocomites*, is striking and needs a special explanation.

Such differences may be due in part to inadequate collecting, to the fact that beds containing an abundance of *Buchia* seldom contain many ammonites, to provincial preferences of certain genera and families of ammonites, or to time differences of the faunules compared. Considering that in the Valanginian beds only the zone of *Homolsomites mutabilis* has furnished even a moderate number of ammonites, the environmental factor is probably very important. If certain genera did not inhabit the waters where *Buchia* lived in abundance, they may still have lived offshore in slightly deeper waters. If so, their shells should at times have been washed inshore among the *Buchia* beds. The importance of this factor relative to the others listed can only be settled by additional collecting.

The affinities of the Hauterivian ammonites of Oregon and California are mostly with those of northern Europe, rather than with southern Europe, and particularly are with those in northern England, northern Germany, and central Russia. These affinities are shown by the presence of the genera *Hoplocrioceras*, *Speetoniceras*, and *Simbirskites* and by the resemblance of the west coast genera *Hollisites* and *Hertleinites* to *Speetoniceras* and *Craspedodiscus*, respectively. The species of *Crioceratites*, *Acrioceras*, *Anahamulina*, *Olcostephanus*, and *Spitidiscus* in Oregon and California may be compared to species in either northern or southern Europe. Other affinities with the Hauterivian of Europe are furnished by the resemblances of the west coast genera *Hannaites* and *Wellsia* to *Leopoldia* and *Neocraspedites*, respectively. A contrast with the Hauterivian in most parts of Eurasia and the Mediterranean region in general, including Mexico, is furnished by the absence of such genera as *Leopoldia*, *Acanthodiscus*, and *Distoloceras*. A contrast with northern Europe is furnished by the absence of *Lyticoceras*.

These differences with Hauterivian ammonite assemblages in other parts of the world are difficult to explain by facies control, or inadequate collecting, or time differences of the ammonite faunules compared, as was suggested for the Valanginian ammonites of the Pacific coast. The chances of future collections resolving the differences are not very great, because ammonites in beds of Hauterivian age in both Oregon and California are moderately abundant at many levels and are associated with a normal marine, shallow-water assemblage of pelecypods, gastropods, and crustaceans. Evidently facies control of Hauterivian ammonites of the Pacific coast does not appear to be very important. In particular the presence of *Lytoceras* and the *phylloceratids* throughout the Hauterivian beds show that the ammonites of the open sea entered freely into the areas where these beds now crop out. These considerations plus the presence of such genera as *Wellsia*, *Hannaites*, *Hollisites*, and *Hertleinites* show that the Hauterivian ammonite assemblage on the Pacific coast has certain local peculiarities that distinguish it from assemblages of that age in other continents or even in Mexico.

ECOLOGIC CONSIDERATIONS

Acceptable conclusions concerning the characteristics of the sea that covered parts of the Pacific coast during Valanginian and Hauterivian times cannot be drawn until much more lithologic, stratigraphic, and paleontologic data are obtained. In the meantime some facts that may be useful in making interpretations concerning temperature, depth of water, and habitats are given.

The genus *Buchia* was the dominant benthonic organism during Valanginian time in the Pacific coast region. It existed in enormous numbers in silty, sandy, and pebbly beds, but was locally rare in such beds. It disappeared abruptly at the end of the Valanginian.

With the disappearance of *Buchia*, many pelecypod genera that had been rare in the Pacific coast region became common. These include in particular such genera as *Periplomya*, *Pleuromya*, *Cercomya*, *Trigonia*, *Oxytoma*, *Entolium*, *Solecurtus*, and *Mytilus*. Associated with these are some crustaceans and many wood fragments.

There are few records of corals, echinoderms, or of the pelecypod family Ostreidae in the Valanginian and Hauterivian beds of the Pacific coast.

The pelecypod *Inoceramus* is rare in California below the zone of *Hertleinites aguila*. In Oregon many examples of *Inoceramus* have been found in various parts of the Valanginian-Hauterivian sequence. The examples from the Valanginian beds are generally associated with ammonites in beds that contain only a few specimens of *Buchia*. *Inoceramus* has not yet been found in beds containing *Buchia* in abundance.

Beds containing abundant *Buchia* contain few specimens of other benthonic pelecypods.

The long-ranging ammonites, the phylloceratids and *Lytoceras*, occur throughout the Valanginian-Hauterivian sequence, but the phylloceratids are uncommon below the uppermost Valanginian.

The short-ranging ammonites of the Valanginian beds show affinities both with the Mediterranean region and with the northern Europe, but not particularly with Mexico.

Many of the short-ranging ammonites of the Hauterivian beds show affinities with ammonites of that age in England, northern Germany, Japan, and central Russia and little at all with the Hauterivian ammonites of Mexico.

The Hauterivian beds contain several ammonite genera that have not yet been found outside the Pacific coast region, although they do resemble certain genera of that age elsewhere.

Both the Valanginian and the Hauterivian beds are characterized by an absence of certain ammonite genera that are common in beds of those ages in many parts of the world.

From these data certain broad generalizations may be drawn. For example, the presence of the thin-shelled ammonites, the phylloceratids and *Lytoceras*, in fair abundance suggests that the Valanginian and Hauterivian marine waters along the Pacific coast were connected broadly with the main ocean immediately to the west. The affinities of many of the other ammonites with ammonites in distant parts of the world such as Japan, the Russian platform, Germany, England, India, and the Caucasus, implies marine connections northward, westward, and southward. The lack of any close affinities with Valanginian and Hauterivian faunas in Mexico is rather surprising and suggests the presence of some kind of a barrier, either physical or environmental or both. Perhaps the abundance of *Buchia* in the Valanginian beds of the west coast and its absence in Mexico reflect an environmental barrier. The affinities with Eurasia and the lack of them with Mexico are suggestive that major currents in the northern part of the Pacific Ocean were similar to those existing today.

The data should be considered, also, in terms of certain events that affected large parts of the world during Early Cretaceous times. These include the near extinction of ammonites in Barremian time (Arkell, 1949, p. 412), the general disappearance of the pelecypod *Buchia* near the end of Valanginian time (Pavlow, 1907, p. 84 and facing table) except for a few stragglers locally in the Hauterivian in Europe (Woods, 1905, p. 71; Wollemann, 1900, p. 56–59; Pavlow, 1907, p. 79; Sokolov and Bodylevsky, 1931, p. 118), and the Arctic Ocean becoming much more restricted during Hauterivian to early Aptian times than it had been previously in the Cretaceous or in the Jurassic.

The evidence for such restriction consists of the absence, with possibly one exception, of sedimentary beds of Hauterivian to early Aptian ages in the lands adjacent to the present Arctic Ocean (Maync, 1949, p. 242; Imlay and Reeside, 1954, p. 241). The exception may exist in northwest Canada near the Arctic Ocean (Jeletsky, 1958, p. 9–15). Elsewhere near the present Arctic Ocean, Valanginian beds are overlain directly by Aptian, or Albian, beds. The northernmost records of marine beds of Hauterivian and Barremian ages in Europe are in the Russia platform, northern Germany, and northern England. In the Pacific Ocean area the northernmost records are in Japan and in southernmost British Columbia.

Some of the items mentioned above, such as the extinction of *Buchia* and the near extinction of ammonites are probably related in some way to restriction of the Arctic Ocean during middle Early Cretaceous time. The provincial aspect of the Valanginian-Hauterivian ammonites may be similarly related, but their conspicuous lack of affinities with ammonites of the same ages in Mexico suggests that provincialism was also related to some kind of barrier in Central America separating the Atlantic and Pacific Oceans. Further interpretations do not seem warranted at present.

GEOGRAPHIC DISTRIBUTION

The occurrences by area and locality of the fossils described herein is shown in table 4. The general position of each locality is shown on figures 34–36. De-

TABLE 4—*Geographic distribution of the Early Cretaceous*

[Localities 1069, 1071, 2156, 4394, and 25215, discussed in the text, do not contain ammonites, but are included in this table in order to show their

	WASHINGTON							OREGON																																
	Spieden formation			Nooksack group (part)				Shasta series (lower part)																																
								Myrtle formation (middle and upper parts)																																
	1			2				3	4	5																				6	7	8								
	UWA535	UWA536	McLellan	UWA538	17273	93546	McLellan	1681	25207	3352	25192	25193	25194	25197	25198	25199	25200	25201	25202	25203	25204	25205	25206	26252	26257	26787	26788	26789	26790	1245	26405	713	724	726	905	1243	1251	1252	1823	25208
Phyllopachyceras trinitense (Anderson)																							X		X							X				X		X		
cf. *P. trinitense* (Anderson)												X																												
umpquanum (Anderson)															X	X	X								X							X	X	X	X			X		X
cf. *P. umpquanum* (Anderson)																														X										
Hypophylloceras aff. *H. onoense* (Stanton)																							X															X		
Lytoceras aulaeum Anderson																																X			•			X		
saturnale Anderson																																								
cf. *L. traski* Anderson																																								
Bochianites paskentaensis Anderson																																								
Crioceratites latus (Gabb)																																								
cf. (*C. yollabollium*) (Anderson)																																								
cf. (*C. tehamaensis*) (Anderson)																																								
sp. indet															X	X								X																
Hoplocrioceras remondi (Gabb)																																								
cf. *H. remondi* (Gabb)																																								
duncanense (Anderson)																																								
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Shasticrioceras aff. *S. whitneyi* Anderson																																								
cf. *S. poniente* Anderson																																								
sp																																								
Acrioceras voyanum Anderson																																								
cf. *A. voyanum* Anderson																														X										
vespertinum (Anderson)																																								
hamlini (Anderson)																																								
Pseudothurmannia? russelli (Anderson)																																								
jupiter (Anderson)																																								
Anahamulina wilcoxensis Imlay, n. sp																																								
Homolsomites mutabilis (Stanton)																																								
stantoni (McLellan)	X	X	X	X	X	X	X																				X													
Olcostephanus pecki Imlay, n. sp											X	X	X	X												X	X	X	X											
cf. *O. pecki* Imlay, n. sp				X				X																																
popenoei Imlay, n. sp																													X											
cf. *O. quadriradiatus* Imlay																																								
Polyptychites trichotomus (Stanton)																																								
sp																																								
Neocraspedites giganteus Imlay, n. sp																																								
Wellsia oregonensis (Anderson)															X	X	X				X		X	X								X			X	X		X	X	X
packardi (Anderson)									X	X								X	X	X												X		X		X		X		
vigorosa Imlay, n. sp																																						X		
Hertleinites aguila (Anderson)																																								
pecki Imlay, n. sp																																								
Simbirskites broadi Anderson																																								
lecontei (Anderson)																																								
sp. juv. aff. *S. elatus* (Trautschold)																																					X			
sp. juv. aff. *S. progrediens* Lahusen																																								
spp. juv																																								
Simbirskites? sp																																								
Hollisites lucasi Imlay																																								
cf. *H. lucasi* Imlay																																								
dichotomus Imlay, n. sp																																					X			
sp. juv. cf. *H. dichotomus* Imlay, n. sp																																								
inflatus Imlay, n. sp																																								
Speetoniceras agnessense Imlay, n. sp																																								
Neocomites? cf. *N. indicus* Uhlig																																								
Thurmanniceras californicum (Stanton)																																								
wilcoxi (Anderson)																																								
jenkinsi (Anderson)																																								
stippi (Anderson)																																								
sp. juv. cf. *T. stippi* (Anderson)																																								
Hannaites riddlensis (Anderson)																X			X																	X		X		
truncatus Imlay, n. sp															X																									
Kilianella crassiplicata (Stanton)																																								
cf. *K. besairiei* Spath																																								
Sarasinella densicostata Imlay, n. sp																																								
cf. *S. densicostata* Imlay, n. sp																																								
cf. *S. subspinosa* (Uhlig)																																								
hyatti (Stanton)																															X									
cf. *S. hyatti* (Stanton)																																								
angulata (Stanton)																																								
cf. *S. angulata* (Stanton)																																								
sp																																								
Acanthodiscus sp. juv. aff. *A. subradiatus* Uhlig																																								
Spitidiscus oregonensis Imlay, n. sp																																X								

(Valanginian-Hauterivian) ammonites in the Pacific Coast States

approximate geographic postion. Numbers 1–29 refer to numbers in figs. 34–36. Higher numbers are Geological Survey Mesozoic locality numbers]

OREGON—Continued																																		CALIFORNIA																													
Shasta series (lower part)—Continued																																																														
Myrtle formation (middle and upper parts)																																Ono formation (part)											Paskenta formation of Anderson																			
9		10	11				12	13						14	15	16										17		18	19		20		21			22						23	24	25		26			27										28				29
1826	25210	3923	24449	25211	25212	25213	25214	2078	2080	2093	25215	25216	26450	26879	25275	2154	2155	2156	4384	4386	4390	4391	4393	4394	6142	2117	2119	25217	2107	2136	2166	3339	4415	CAS1691	UCLA2816	1062	2222	2223	2224	2225	CAS1353	CAS113	CAS1665	1069	1071	1009	1087	1088	1010	1091	1092	1093	2265	2266	2267	2268	2269	5339	1001	1095	CAS144	CAS33502	26404
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tailed descriptions of the individual localities are given in the following table. Abbreviations used in the list include Univ. Wash. for the University of Washington, UCLA for the University of California at Los Angeles, and Calif. Acad. Sci. for the California Academy of Sciences.

No. on figs. 34-36	Geological Survey Mesozoic localities	Collector's field numbers	Localities of other institutions	Collector, year of collection, description of locality, stratigraphic assignment, and age
1			Univ. Wash. WA 535	Geology students at University of Washington, 1954. Spieden Bluff on northwest side of Spieden Island, San Juan County, Wash. Spieden formation of McLellan (1927). Valanginian.
1			Univ. Wash. WA 536	Mallory, V. S., 1955. Spieden Bluff on northwest end of Spieden Island, San Juan County, Wash. Spieden formation of McLellan (1927). Valanginian.
1				McLellan, R. D., 1922–25. From shales and sandstones near base of conglomeratic sequence at foot of Spieden Bluff on north side of Spieden Island, San Juan County, Wash. Spieden formation of McLellan (1927). Valanginian.
2			Univ. Wash. WA 538	Landes, Henry, 1955; 3 miles east of Glacier in north center of sec. 3, T. 39 N., R. 7 E., Whatcom County, Wash. Nooksack group as used by Danner (1958), upper part. Valanginian.
2	17273			Erdman, C. E., 1936. Argillite on left bank of north fork of Nooksack River 2.1 miles below bridge in north center of sec. 3, T. 39 N., R. 7 E., Whatcom County, Wash., Nooksack group as used by Danner (1958), upper part. Valanginian.
2		9.3.54.6		Misch, Peter, 1954. Hard black siltstone. Skyline Ridge trail near section line in north center of sec. 11, T. 39 N., R. 7 E., 2⅓ miles east of Glacier Creek bridge, Whatcom County, Wash., Nooksack group as used by Danner (1958), upper part. Valanginian.
2				McLellan, R. D., 1922–24. Road cut on south bank of Nooksack River about 2 miles east of Glacier in sec. 5, T. 39 N., R. 7 E., Whatcom County, Wash., Nooksack group as used by Danner (1958), upper part. Valanginian.
3	1681	4008		Diller, J. S., 1895; 2 miles east of Myrtle Creek, Douglas County, Oreg. Valanginian.
4	25207			Imlay, R. W., and Dole, H. M., 1954. East side of Days Creek in NW¼ sec. 8, T. 30 S., R. 3 W., Douglas County, Oreg. Hauterivian.
5	3352	6763		Diller, J. S., 1905. Mouth of Days Creek on the South Umpqua River, Douglas County, Oreg. Hauterivian.
5	25192	Sta. 9D		Imlay, R. W., Dole, H. M., and Peck, D. L., 1954; 108 ft above top of 3d conglomerate on west side of South Umpqua River in W1/2 sec. 16, T. 30 S., R. 4 W., Douglas County, Oreg. Valanginian.
5	25193	Sta. 10A		Same as loc. 25192 except 119 ft above 3d conglomerate. Valanginian.
5	25194			Imlay, R. W., Dole, H. M., and Peck, D. L., 1954. From upper part of beds containing *Buchia crassicollis* (Keyserling) on east side of South Umpqua River in W½ sec. 16, T. 30 S., R. 4 W., Douglas County, Oreg. Valanginian.
5	25197	Sta. 10C		Same as loc. 25192 except 291 ft above 3d conglomerate. Valanginian.
5	25198	Sta. 10E		Same as loc. 25192 except 434 ft above 3d conglomerate. Hauterivian.
5	25199	Sta. 10F		Same as loc. 25192 except 504 ft above 3d conglomerate. Hauterivian.
5	25200	Sta. 11 plus 20		Same as loc. 25192 except 619 ft above 3d conglomerate. Hauterivian.
5	25201	Sta. 11 plus 30		Same as loc. 25192 except 629 ft above 3d conglomerate. Hauterivian.
5	25202	Sta. 11A		Same as loc. 25192 except 669 ft above 3d conglomerate. Hauterivian.

No. on figs. 34–36	Geological Survey Mesozoic localities	Collector's field numbers	Localities of other institutions	Collector, year of collection, description of locality, stratigraphic assignment, and age
5	25203	Sta. 11A plus 20		Same as loc. 25192 except 689 ft above 3d conglomerate. Hauterivian.
5	25204			Imlay, R. W., Dole, H. M., and Peck, D. L., 1954. Sandy shale containing *Wellsia oregonensis* (Anderson) on east side of South Umpqua River in W½ sec. 16, T. 30 S., R. 4 W., Douglas County, Oreg. Hauterivian.
5	25205			Same as loc. 25204 except near top of exposed sequence. Hauterivian.
5	25206	I54-7-22A		Imlay, R. W., Dole, H. M., and Peck, D. L., 1954. North end of bridge across river at town of Days Creek, SE¼ sec. 9, T. 30 S., R. 4 W., Douglas County, Oreg. Hauterivian.
5	26252			Beason, John, and others, 1956. From South Umpqua River in SE¼ sec. 16, T. 30 S., R. 4 W., Douglas County, Oreg. Hauterivian.
5	26257			Beason, John, and others, 1956. Same as loc. 25206. Hauterivian.
5	26787			Imlay, R. W., Imlay, M. J., and Imlay, R. L., 1957. Same as loc. 25192 except 73 ft above 3d conglomerate. Valanginian.
5	26788	I57-8-12A		Same as loc. 26787 except 119 ft above 3d conglomerate. Valanginian.
5	26789			Imlay, R. W., and Peterson, Norman, 1957. Same as loc. 25192 except 175 ft above 3d conglomerate. Valanginian.
5	26790			Imlay, R. W., Imlay, M. J., and Imlay, R. L., 1957. About 119 ft above 3d conglomerate on east side of South Umpqua River, in W½ sec. 16, T. 30 S., R. 4 W., Douglas County, Oreg. Valanginian.
6	1245			Stanton, T. W., 1894; 1½ miles N. 10° W. of Riddle, Douglas County, Oreg. Hauterivian.
7	26405			Brown, W. Q., 1893(?). About 2 miles west of Riddle in SW¼NW¼ sec. 16, T. 30 S., R. 6 W., Douglas County, Oreg. Valanginian.
8	718			Becker, G. F., 1890. At Riddle, Douglas County, Oreg. Hauterivian.
8	724			Same data as loc. 718.
	726	718b		Same data as loc. 718.
8	905			Brown, W. Q., 1891. Bank of Cow Creek just below town of Riddle, Douglas County, Oreg. Hauterivian.
8	1243	151		Stanton, T. W., 1894. ½ mile south of bridge across Cow Creek at Riddle, Douglas County, Oreg. Hauterivian.
8	1251	148		Stanton, T. W., 1894. At west end of bridge across Cow Creek at Riddle, Douglas County, Oreg. Hauterivian.
8	1252	149		Stanton, T. W., 1894. West bank of Cow Creek 400 yd below bridge at Riddle, Douglas County, Oreg. Hauterivian.
8	1823			Rice, Claude, 1898. Near Riddle, Douglas County, Oreg. Hauterivian.
8	25208	I57-7-21A		Imlay, R. W., Dole, H. M., and Peck, D. L., 1954; ¼ mile below bridge (northeast) across Cow Creek at Riddle near center of sec. 24, T. 30 S., R. 6 W., Douglas County, Oreg. Hauterivian.
9	1826			Brown, W. Q., 1898. Jerry Creek near Riddle in SW¼SE¼ of sec. 22, T. 30 S., R. 6 W., Douglas County, Oreg. Hauterivian.
9	25210			Imlay, R. W., and Dole, H. M., 1954. ¼–1 mile above bridge at Riddle in northern part of sec. 26, T. 30 S., R. 6 W., Douglas County, Oreg. Hauterivian.
10	3923	6812		Storrs, James, 1906. South line of sec. 31, T. 30 S., R. 5 W., ⅓ mile southeast of Ashes Ranch houses, Douglas County, Oreg. Hauterivian.
11	24449	FGW-51		Wells, F. G., Dole, H. M., 1951. Sec. 8, T. 32 S., R. 10 W., Coos County, Oreg. Hauterivian.

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No. on figs. 34–36	Geological Survey Mesozoic localities	Collector's field numbers	Localities of other institutions	Collector, year of collection, description of locality, stratigraphic assignment, and age
11	25211	I54–8–4A		Imlay, R. W., Wells, F. G., Dole, H. M., and Peck, D. L., 1954. Massive green sandstone on west side of road along Foggy Creek in NW¼SW¼ sec. 8, T. 32 S., R. 10 W., Coos County, Oreg. Same as loc. 24449. Hauterivian.
11	25212			Imlay, R. W., Wells, F. G., Dole, H. M., and Peck, D. L., 1954. On Foggy Creek road 1 mile upstream from Eden Valley road in SE¼ sec. 8, T. 32 S., R. 10 W., Coos County, Oreg. Hauterivian.
11	25213			Imlay, R. W., Wells, F. G., Dole, H. M., and Peck, D. L., 1954. On Foggy Creek road in northeast corner sec. 17, T. 32 S., R. 10 W., Coos County, Oreg. Hauterivian.
12	25214			Imlay, R. W., and Dole, H. M., 1954. On road from Powers to Agness in north-central part of sec. 7, T. 35 S., R. 11 W., Curry County, Oreg. Hauterivian.
13	2078	S–9–99		Diller, J. S., 1899. Trail on south side of Rogue River 1 mile west of mouth of Illinois River, Curry County, Oreg. Hauterivian.
13	2080	S–11–99		Diller, J. S., 1899. Sandstone 1½ miles below Agness on south side of Rogue River, Curry County, Oreg. Hauterivian.
13	2093	C–37–99		Diller, J. S., 1899. Left bank of Rogue River 1½ miles below Agness, Curry County, Oreg. Hauterivian.
13	25215			Imlay, R. W., 1954. At mouth of small creek just upstream from serpentine on north side of Rogue River about 1½ miles below Agness in NE. corner of sec. 11, T. 35 S., R. 12 W., Curry County, Oreg. Hauterivian.
13	25216			Imlay, R. W., and Dole, H. M., 1954. 100–200 ft above serpentine on south side of Rogue River 1½ miles below Agness, Curry County, Oreg. Valanginian.
13	26450			Lucas, Larry. South side of Rogue River 1½ miles below Agness, Curry County, Oreg. Hauterivian.
14	26879			Stringer, Calvin, 1957. About ½ mile southwest of Agness and ¼ mile south of section boundary in north central part of sec. 13, T. 35 S., R. 12 W., Curry County, Oreg. Hauterivian.
15	25275			Peck, D. L., and Baldwin, E. M., 1954. East bank of Illinois River ¼ mile above mouth of Lawson Creek, SE¼ sec. 29, T. 35 S., R. 11 W., Curry County, Oreg. Valanginian.
16	2154	5446		Diller, J. S., 1900. Elk River between the forks and the mouth of Blackberry Creek, Curry County, Oreg. Valanginian.
16	2155	5447		Diller, J. S., 1900. Elk River below the mouth of Blackberry Creek, Curry County, Oreg. Valanginian.
16	2156	5448		Diller, J. S., 1900. North Fork of Elk River 1 mile above the forks, Curry County, Oreg. Valanginian.
16	4384	S–4		Storrs, James, 1907. ⅕ mile above the forks of Elk River in the South Fork, Curry County, Oreg. Valanginian.
16	4386	S–3		Storrs, James, 1907. ¼ to 1 mile above the forks of Elk River on the South Fork, Curry County, Oreg. Valanginian.
16	4390	S–9		Storrs, James, 1907. ⅓ mile below the forks of Elk River, Curry County, Oreg. Valanginian.
16	4391	S–10		Storrs, James, 1907. About 200 yd above the forks of Elk River on the North Fork, Curry County, Oreg. Valanginian.
16	4393	S–13		Storrs, James, 1907. Fossils from loose pieces in the North Fork of Elk River about 1½ miles above the forks, Curry County, Oreg. Valanginian.
16	4394	S–14		Storrs, James, 1907. Float ½–¾ mile above forks of Elk River in bed of North Fork, Curry County, Oreg. Valanginian.
16	6142	7097C		Diller, J. S., 1909. From boulder at forks of Elk River in streambed, Curry County, Oreg. Valanginian.
17	2117	C–137–99		Diller, J. S., 1899. From big slide on Sixes River opposite mouth of Dry Creek, Curry County, Oreg. Valanginian.

No. on figs. 34–36	Geological Survey Mesozoic localities	Collector's field numbers	Localities of other institutions	Collector, year of collection, description of locality, stratigraphic assignment, and age
17	2119	C–143–99		Divelbise, 1899?. From gravel of Sixes River near Dry Creek, Curry County, Oreg. Valanginian.
18	25217			Peck, D. L., 1954. Along beach ¼ mile north of Rocky Point and 2 miles south of Port Orford in NW¼ sec. 15, T. 33 S., R. 15 W., Curry County, Oreg. Hauterivian.
19	2107	C–88–99		Diller, J. S., 1899. Point on ridge ½ mile S. 10° W., from Bald Mountain, Curry County, Oreg. Valanginian.
19	2136	5269		Diller, J. S., 1899. South end of Bald Mountain, Curry County, Oreg. Valanginian.
20	2166	5549		Diller, J. S., 1900. Simmons Cut, 3 miles north of Waldo, Josephine County, Oreg. Hauterivian or Barremian.
20	3339	6690		Diller, J. S., and Storrs, James, 1905. A deep cut, 4 miles north of Waldo, that drains from Logan Mine to Illinois River, Josephine County, Oreg. Hauterivian.
21	4415	S–21		Storrs, James, 1907. Calcareous nodules in shale and sandstone 100 yds. south of Clements house in Valley of Redding Creek, Trinity County, Calif. Hauterivian.
21			Calif. Acad. Sci. 1691	Anderson, F. M., 1929. From Clements Ranch on Indian Creek 4 miles east of Douglas City, Trinity County, Calif. Hauterivian.
21			UCLA 2816	Rodda, Peter, 1953. Hard sandy dark-gray mudstone. Bed of Redding Creek just north of junction with Panwauket Gulch on section line between secs. 28 and 29, T. 32 N., R. 9 W., Trinity County, Calif. Hauterivian.
22	1062	62		Storrs, James, 1893. From Eagle Creek between its mouth and Ono, Shasta County, Calif. Hauterivian.
22	2222			Stanton, T. W., 1900. On stage road 1 mile east of Ono, Shasta County, Calif. Hauterivian.
22	2223	502		Stanton, T. W., 1900. Near mouth of Byron Creek (now called Rector Creek) at Ono, Shasta County, Calif. Hauterivian.
22	2224	503		Stanton, T. W., 1900. On North Fork of Cottonwood Creek 200–400 yd above bridge at Ono, Shasta County, Calif. Hauterivian.
22	2225	504		Stanton, T. W., 1900. On North Fork of Cottonwood Creek between Ono bridge and Eagle Creek, Shasta County, Calif. Hauterivian.
22			Calif. Acad. Sci. 1353	Anderson, F. M., and Hanna, G. D., 1928. On highway grade near bridge about ¼ mile south of Ono, Shasta County, Calif. Hauterivian.
23			Calif. Acad. Sci. 113	Anderson, F. M. Head of North Fork of Mitchell Creek 3½–4 miles southwest of Ono, Shasta County, Calif. Hauterivian.
24			Calif. Acad. Sci. 1665	Anderson, F. M., 1929 From Duncan Creek 1 mile north of Maxey's house, Shasta County, Calif. Hauterivian.
25	1069	69, 69a, 69b, 72		Diller, J. S., Storrs, James, and Stanton, T. W., 1893. About ½ mile west-northwest of Stephenson's Ranch houses of 1893 and 1½ miles west-southwest of Pettyjohn's houses. North-central part of sec. 30, T. 27 N., R. 7 W., Tehama County, Calif. Valanginian.
25	1071			Diller, J. S., Storrs, James, and Stanton, T. W., 1893. About 200 yds. west of Stephenson's Ranch houses on Cold Fork of Cottonwood in sec. 30, T. 27 N., R. 7 W., Tehama County, Calif. Valanginian.
26	1009	15		Diller, J. S., and Storrs, James, 1893. About halfway between the Lowry and Wilcox Ranch houses. South-central part of sec. 28, T. 25 N., R. 6 W., Tehama County, Calif. Valanginian.
26	1087	Sta. 90		Diller, J. S., Storrs, James, and Stanton, T. W., 1893. Same as loc. 1009.

No. on figs. 34-36	Geological Survey Mesozoic localities	Collector's field numbers	Localities of other institutions	Collector, year of collection, description of locality, stratigraphic assignment, and age
26	1088	Sta. 91		Diller, J. S., Storrs, James, and Stanton, T. W., 1893. About ¾ mile north of Wilcox Ranch houses in south-central part of sec. 33, T. 25 N., R. 6 W., Tehama County, Calif. Valanginian.
27	1010	16 and 17		Diller, J. S., and Storrs, James, 1893. About ¼ mile northwest of Shelton's Ranch houses in north-central part of sec. 9, T. 24 N., R. 6 W., Tehama County, Calif. Valanginian.
27	1091	Sta. 94		Stanton, T. W., Diller, J. S., and Storrs, James, 1893. About ½ mile east of Wilcox Ranch houses in NE. corner sec. 4, T. 24 N., R. 6 W., Tehama County, Calif. Valanginian.
27	1092	Sta. 95		Stanton, T. W., Diller, J. S., and Storrs, James, 1893; ½-¾ mile northeast of Wilcox Ranch houses on road from Lowry's Ranch to Paskenta in SE. corner sec. 33, T. 25 N., R. 6 W., Tehama County, Calif. Hauterivian.
27	1093	Sta. 96		Stanton, T. W., and Storrs, James, 1893. Same as loc. 1010.
27	2265			Stanton, T. W., 1900. South-central part of sec. 28, T. 25 N., R. 6 W., Tehama County, Calif. Hauterivian.
27	2266	536		Stanton, T. W., 1900. Same as loc. 1091.
27	2267	537		Stanton, T. W., 1900. 400-500 feet higher stratigraphically than loc. 2266. ½-¾ mile north of loc. 2266 in SE. corner sec. 33, T. 25 N., R. 6 W., Tehama County, Calif. Hauterivian.
27	2268	538		Stanton, T. W., 1900. Concretions in shale at same level as loc. 2267. About ¾ mile southeast of Wilcox Ranch houses in east-central part of sec. 4, T. 24 N., R. 6 W., Tehama County, Calif. Hauterivian.
27	2269	538a		Stanton, T. W., 1900. Same as loc. 2268 except 8 ft. lower stratigraphically. Hauterivian.
27	5339	24		Storrs, James, 1908; ⅛ mile west of Wilcox Ranch houses in NW¼ sec. 4, T. 24 N., R. 6 W., Tehama County, Calif. Valanginian.
28	1001	6 and 7		Diller, J. S., and Storrs, James, 1893; ½ mile east of Henderson's house on upper road leading from Paskenta to Lowry's Ranch. NW¼ sec. 29, T. 24 N., R. 6 W., Tehama County, Calif. Valanginian.
28	1095	98		Stanton, T. W., and Storrs, James, 1893; 1,500-2,000 ft below top of beds containing *Buchia crassicollis* (Keyserling). Same as loc. 1001. Valanginian.
28			Calif. Acad. Sci. 144	Collector unknown. From south bank of McCarthy Creek opposite Burt's Ranch house in NE¼ sec. 29, T. 24 N., R. 6 W., Tehama County, Calif. Valanginian.
28			Calif. Acad. Sci. 33502.	Anderson, F. M., 1,200 ft southeast of Burt's Ranch house on McCarthy Creek in SE¼ sec. 29, T. 24 N., R. 6 W., Tehama County, Calif. Valanginian. This locality was listed by Anderson (1938) as 2398 and 3398.
29	26404			Lawson, A. C., 1894. From mouth of Strawberry Canyon near Berkeley, Alameda County, Calif. Valanginian.

SUMMARY OF RESULTS

The Early Cretaceous (Valanginian-Hauterivian) ammonites from the Pacific coast discussed herein include 26 genera and 65 species. Of these 65 species, 13 are described as new. Of the 26 genera, 4 were described as new in a preliminary paper (1957, p. 275-277) published during the course of this study.

During the Valanginian the family Berriasellidae was dominant in numbers and genera, and the Olcostephanidae was of secondary importance. During the Hauterivian the Olcostephanidae was dominant, and the Ancyloceratidae was of secondary importance. Of somewhat lesser importance are the Phylloceratidae and Lytoceratidae. The Bochianitidae, Hemihoplitidae, Ptychoceratidae, and Holcodiscidae are represented by only a few specimens. The Craspeditidae is probably represented by the genus *Homolsomites*, which occurs locally in fair abundance in the upper Valanginian.

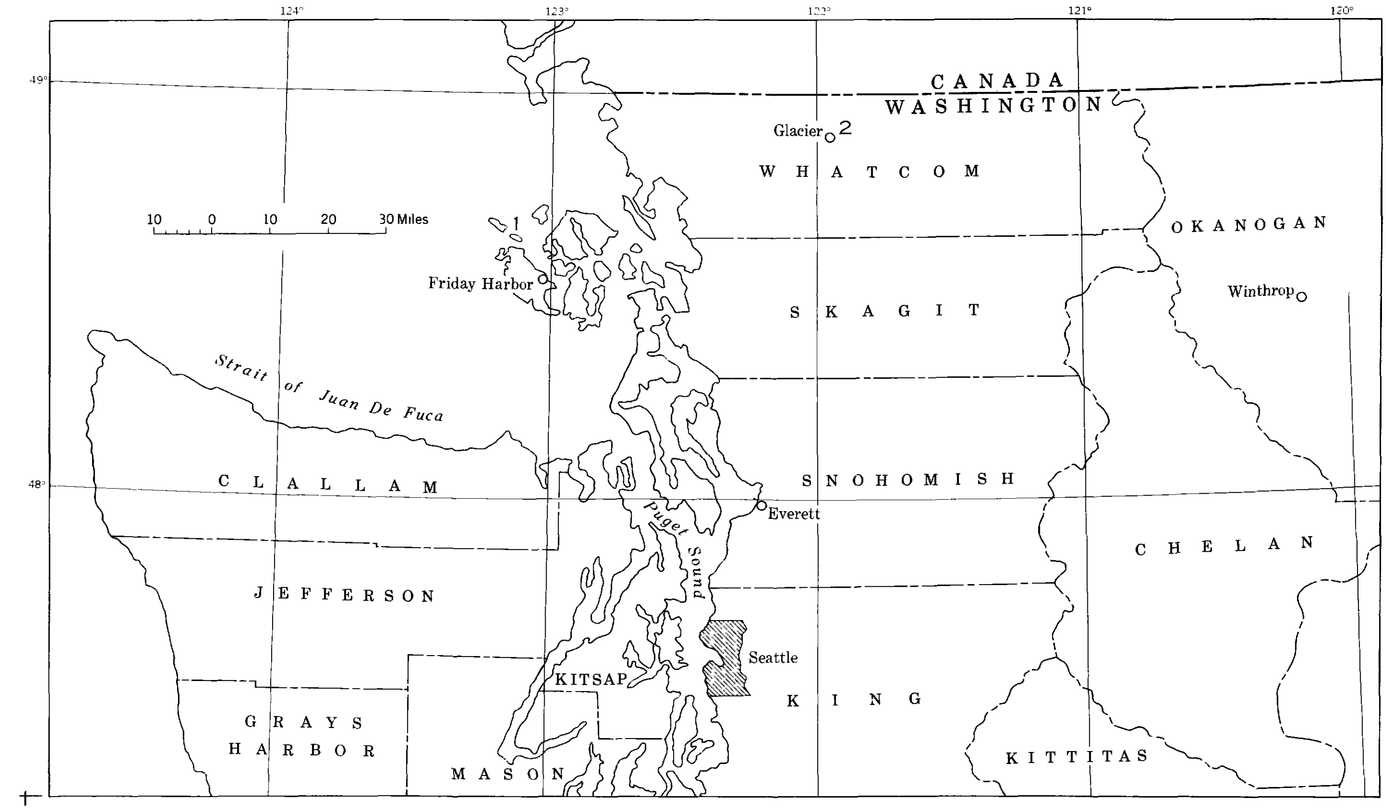

FIGURE 34.—Index map of Early Cretaceous localities in northwestern Washington.

The Valanginian beds are considered to include four ammonite zones. From oldest to youngest these zones are represented by the species *Kilianella crassiplicata* (Stanton), *Sarasinella hyatti* (Stanton), *Homolsomites mutabilis* (Stanton), and *Olcostephanus pecki* Imlay, n. sp. The lower two zones are provisional because they are based on only a few collections.

The zone of *Olcostephanus pecki* is of late Valanginian age because it directly underlies lower Hauterivian beds, because it occurs at the top of the range of the Valanginian species, *Buchia crassicollis* (Keyserling), and because the index species is similar to *O. jeannoti* (d'Orbigny) which occurs in France in beds of late Valanginian to early Hauterivian age.

The zone of *Homolsomites mutabilis* is considered to be late Valanginian because of the association of *Acanthodiscus*, *Neocraspedites*, *Crioceratites*, *Sarasinella*, and *Polyptychites* and because of its stratigraphic position in the upper part of the range of *Buchia crassicollis* (Keyserling).

The zones of *Sarasinella hyatti* and *Kilianella crassiplicata* are considered to be of middle Valanginian age on the basis of stratigraphic position below the zone of *Homolsomites mutabilis*, on the resemblances of *Kilianella crassiplicata* (Stanton) and its associate *Thurmanniceras californicum* (Stanton) to species of middle Valanginian age elsewhere, and on the presence of *Buchia crassicollis* (Keyserling) rather than species of *Buchia* of Berriasian or early Valanginian age.

The Hauterivian beds are considered to include five ammonite zones. From oldest to youngest these are designated as the *Wellsia oregonensis* zone, *W. packardi* zone, *Hollisites dichotomus* zone, Hamlin-Broad zone of Anderson, and *Hertleinites aguila* zone. Of these, only the zones of *Wellsia oregonensis* and of *Hertleinites aguila* are well substantiated.

The zone of *Hertleinites aguila* is considered to be late Hauterivian in age because of its stratigraphic position above beds containing the middle to late Hauterivian ammonite *Simbirskites* and below beds containing the Barremian ammonites *Pulchellia* and *Ancyloceras*. A Hauterivian rather than a Barremian age is indicated, also, by the presence of *Crioceratites* and *Hoplocrioceras*, as most of the records of these genera are from beds of Hauterivian age. Futhermore, the resemblance of *Hertleinites* to *Craspedodiscus* suggests a late Hauterivian age.

The Hamlin-Broad zone of Anderson is either late middle, or late Hauterivian on the basis of the association of the ammonites *Hoplocrioceras*, *Acrioceras*, and

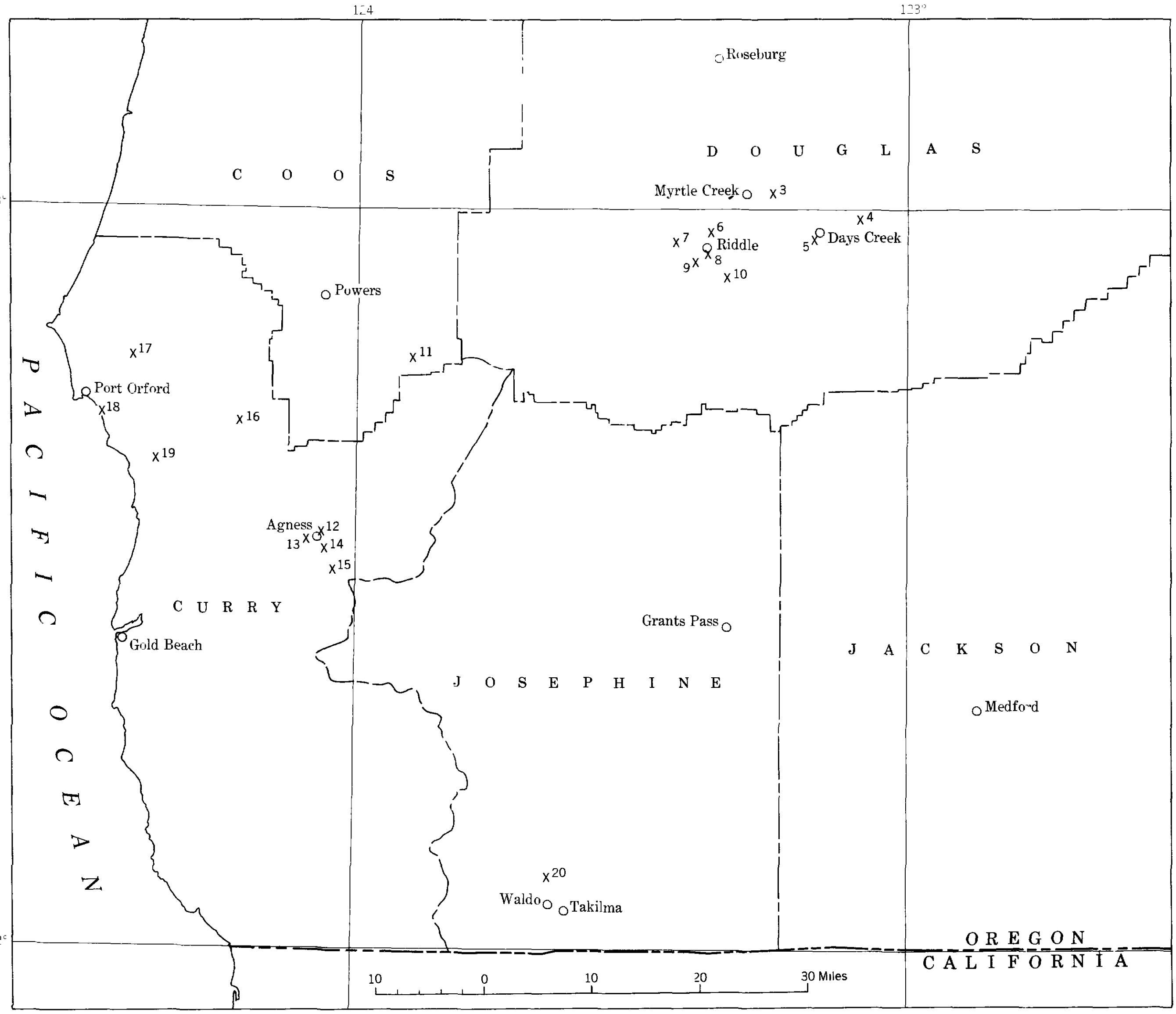

FIGURE 35.—Index map of Early Cretaceous localities in southwestern Oregon.

Simbirskites, on the probability that *Neocomites russelli* Anderson and *Thurmannia jupiter* Anderson belong to the genus *Pseudothurmannia*, and on the stratigraphic position of the zone below *Hertleinites aguila.*

The zone of *Hollisites dichotomus* is of middle to early late Hauterivian age, based on the presence of the ammonite *Simbirskites* and the resemblance of the genus *Hollisites* to *Speetoniceras* in Europe. The zone is not much younger than the zone of *Wellsia packardi* and *W. oregonensis*, as it occurs only a little stratigraphically above those zones near Riddle, Oreg., and it contains a number of species that range upward from those zones. It is not identical with the Hamlin-Broad zone of Anderson because it has only a few ammonite species in common with that zone and none of the species that range upward from the *Wellsia packardi* zone have been found in the Hamlin-Broad zone. Faunally the *Hollisites dichotomus* zone appears to bridge an interval between those zones and consequently to correlate with the lower part of the range of *Simbirskites* in Europe.

The zones of *Wellsia packardi* and *W. oregonensis* are considered to be of early Hauterivian age because of their stratigraphic position above beds containing the Valanginian *Buchia crassicollis* (Keyserling) and below beds containing the middle to late Hauterivian ammonite *Simbirskites.* The zones are not older than the Hauterivian because they contain the ammonite

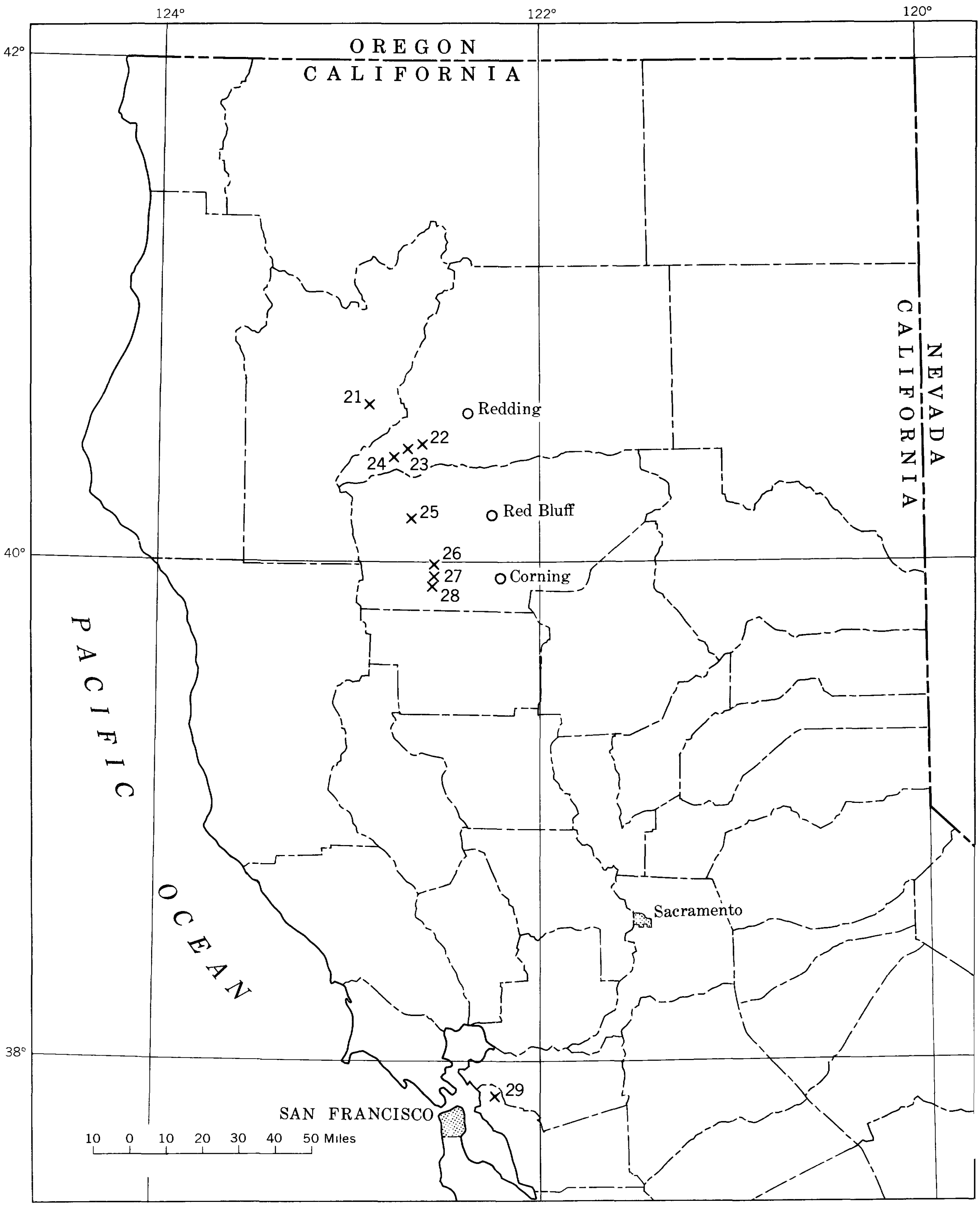

FIGURE 36.—Index map of Early Cretaceous localities in northern California.

Spitidiscus. An age not younger than early Hauterivian is indicated by the resemblance of *Wellsia* to *Neocraspedites* and of *Hannaites* to *Leopoldia*.

The ammonites found in the Valanginian and Hauterivian beds of the Pacific Coast States have a local aspect, owing to the presence of genera not found elsewhere and to the absence of genera that are common elsewhere. Provincial genera include *Wellsia*, *Hannaites*, *Hollisites*, and *Hertleinites*. Besides these genera *Shasticrioceras* has been found elsewhere only in British Columbia and Japan, and *Homolsomites* has been found elsewhere only in British Columbia and Greenland. Conspicuous by their absence are the ammonites *Rogersites*, *Valanginites*, and *Distoloceras* in the Valanginian and *Leopoldia* in the Hauterivian.

The affinities of the Valanginian ammonites from the Pacific Coast States are predominantly with those of the Mediterranean province, as shown by comparisons of species of the genera *Kilianella*, *Sarasinella*, *Thurmanniceras*, *Acanthodiscus*, *Neocomites?*, *Olcostephanus*, and *Bochianites*. In contrast with the Mediterranean province, however, there is a striking scarcity of members of subfamily Olcostephaninae. Also, a central to northern Eurasian aspect is shown by the presence of *Polyptychites* and *Neocraspedites*. The genus *Homolsomites* is probably of boreal or northern Pacific origin.

The affinities of the Hauterivian ammonites of the Pacific Coast States are mostly with those of northern Eurasia, particularly with those in northern England, northern Germany, and central Russia. A contrast with the Hauterivian in most parts of the world is furnished by the absence of *Leopoldia*, *Acanthodiscus*, and *Distoloceras* and by the presence of the provincial genera *Wellsia*, *Hannaites*, *Hollisites*, and *Herteleinites*.

The oldest Cretaceous beds exposed in Oregon and California contain genera of ammonites and species of *Buchia* of Valanginian age. They have not yet furnished fossils of Berriasian age. As the Valanginian beds directly overlie beds of Late Jurassic (Portlandian) age, a break in deposition is indicated. Such is supported by the common occurrence of a massive conglomerate at the base of the Cretaceous. In contrast, the oldest beds exposed in northwest Washington contain species of *Buchia* which have been identified by J. A. Jeletsky, of the Canadian Geological Survey, as being of Berriasian age (written communication from Wilbert R. Danner dated Oct. 2, 1957, concerning fossil identifications by J. A. Jeletsky). The nature of the Jurassic-Cretaceous contact in all three States needs more investigation before the presence or absence of an unconformity can be established beyond doubt.

SYSTEMATIC DESCRIPTIONS

Genus PHYLLOPACHYCERAS Spath, 1925

Phyllopachyceras trinitense (Anderson)

Phylloceras trinitense Anderson, 1938, Geol. Soc. America Spec. Paper 16, p. 140, pl. 55, figs. 3–6.

This species is characterized by its stout whorls, by coarse, sparse ribbing that is continuous across the venter, and by a smooth area on the flanks near the umbilicus. It was recorded by Anderson (1938, p. 140) from Redding Creek, eastern Trinity County, Calif., and from the Riddle area, Douglas County, Oreg., in beds that he considered to represent the Valanginian stage of the Early Cretaceous. The Geological Survey collections from Douglas County, Oreg., that contain this species likewise contain other ammonites that the writer considers to be of early Hauterivian rather than Valanginian age, as discussed herein. In addition the species has been found in Coos County, Oreg., at Mesozoic locality 25211 and in Curry County, Oreg., at Mesozoic locs. 2080 and 2093 associated with ammonites of middle Hauterivian age. The species has not been identified definitely in beds that the writer considers to be of Valanginian age, although one fragment possibly belonging to the species was obtained with *Buchia crassicollis* (Keyserling) at Mesozoic loc. 25193, near Days Creek, Douglas County.

Associated with *P. trinitense* (Anderson) at Mesozoic locs. 1243, 2080, 2093, and 25211 in southwest Oregon are some nearly smooth specimens of *Phyllopachyceras* that differ from *P. trinitense* only by having much weaker ribbing. They resemble *P. trinitense* in shape and in sparseness of ribbing and are probably only a variant.

Localities: USGS Mesozoic locs. 718, 1243, 1252, 2080, 2093, 25206, 25211, 26257; CAS loc. 1691.

Phyllopachyceras umpquanum (Anderson)

Phylloceras umpquanum Anderson, 1938, Geol. Soc. America Spec. Paper 16, p. 143, pl. 30, figs. 9, 10.
Phylloceras oregonense Anderson, 1938, idem, p. 144, pl. 30, fig. 8.
Phylloceras myrtlense Anderson, 1938, idem, p. 144, pl. 30, fig. 7.

Phyllopachyceras umpquanum (Anderson) differs from *P. trinitense* (Anderson) by being more compressed, somewhat smaller, and by having finer, denser ribbing. It is associated with *P. trinitense* (Anderson) in beds of early and middle Hauterivian age in Oregon and has not been recorded from beds of Valanginian age.

The holotype specimens of the three species *P. umpquanum* (Anderson), *P. oregonense* Anderson, and *P. myrtlense* Anderson were obtained from a single locality 1 mile east of Riddle, Douglas County, Oreg. These species were distinguished from each other by trifling differences in whorl shape and in the size of the umbilicus that were probably induced by compaction of sediments. They do not appear to the writer to be worthy of even subspecific rank. Accordingly only the name of the first-mentioned species is considered to be valid.

Localities: USGS Mes. locs. 718, 724, 726, 905, 1252, 24449, 25198, 25199, 25200, 25208, 25211, 25212, 26257.

Genus HYPOPHYLLOCERAS Salfeld, 1927

Hypophylloceras aff. H. onoense (Stanton)

Plate 25, figure 4

Some specimens of *Hypophylloceras*, associated with *Hertleinites aguila* (Anderson), differ from *H. onoense* (Stanton) (1895, p. 74 [1896]) by having a stouter whorl section, a broader venter, and slightly coarser ribbing. At a whorl height of 46 mm, the whorl thickness is 26 mm. On a specimen of *H. onoense* (Stanton) at the same whorl height the whorl thickness is 23 mm. Similar specimens occur in Oregon in beds of early Hauterivian age.

Figured specimen: USNM 129672.
Localities: USGS Mes. locs. 1092, 1252, 2223, 2225, 25206.

Genus LYTOCERAS Suess, 1865

Lytoceras aulaeum Anderson

Lytoceras aulaeum Anderson, 1938, Geol. Soc. America Spec. Paper 16, p. 146, pl. 14, figs. 1–4.

This species is distinguished from *L. saturnale* Anderson by its whorl sections being higher than wide and in certain details of the ornamentation that have been well described and illustrated by Anderson. The holotype was recorded by Anderson (1938, p. 147) from California Academy Science locality 113, about 4 miles southwest of Ono, Shasta County, Calif. He mentions the occurrence of fragments as high as the lower beds of his Horsetown group. For the same area Murphy (1956, p. 2113) shows that *L. aulaeum* has a range coextensive with that of "*Neocraspedites*" *aguila* Anderson. These occurrences in the writers opinion are of middle to late Hauterivian age.

Farther south in the Paskenta area of Tehama County *L. aulaeum* occurs with "*Neocraspedites*" *aguila* Anderson at Mesozoic locality 2267, which is about two-thirds of a mile northeast of the Wilcox Ranch buildings and from 400 to 500 feet above the sandy beds containing *Buchia crassicollis* (Keyserling). From the top of these sandy beds at Mesozoic locality 1091, Stanton (1895, p. 17, 75, pl. 13, fig. 11 [1896]) obtained a specimen of *Lytoceras* that has the whorl section and ornamentation characteristic of *L. aulaeum*, rather than of *L. saturnale*, as suggested by Anderson (1938, p. 145). This occurrence is of late Valanginian age. Stanton also obtained a specimen belonging to *L. aulaeum* from the base of the shales overlying the *Buchia*-bearing beds at a spot (USGS Mes. loc. 2265) about halfway between the Wilcox and Lowry Ranches.

In southwestern Oregon, *L. aulaeum* Anderson has been obtained at Mesozoic localities 718, 1252 and 25210, near Riddle, Oreg., in association with other ammonites of early to middle Hauterivian age.

On the basis of these occurrences, *L. aulaeum* Anderson ranges in age from late Valanginian to late Hauterivian and, therefore, overlaps the upper part of the range of *L. saturnale* Anderson.

Localities: USGS Mes. locs. 718, 1091, 1092, 1252, 2225, 2265, 2267, 25210; CAS loc. 113.

Lytoceras saturnale Anderson

Lytoceras saturnale Anderson, 1938 Geol. Soc. America Spec. Paper 16, p. 145, pl. 13, fig. 1.

Lytoceras saturnale is characterized by its whorl sections being much wider than high. Anderson (1938, p. 146) noted that the species "has a stratigraphic range throughout the Paskenta group in its type district, and has been found in the Cottonwood district at various levels in the same group."

The only specimens of *L. saturnale* in the Geological Survey collections are from the sandy beds containing *Buchia crassicollis* (Keyserling) in the Paskenta area between the Lowry and Wilcox Ranches, Tehama County. One collection (Mes. loc. 1087) was made near the top of these beds about 1 mile north of the Wilcox Ranch houses, and the other (Mes. loc. 5339) was made near the base of the sandy beds about one-third of a mile west of the Wilcox Ranch buildings. These collections are dated by other ammonites present as late and middle Valanginian respectively.

Lytoceras saturnale Anderson is probably uncommon in the Cottonwood Creek area of western Shasta County, considering that Murphy (1956, fig. 6) did not find any in that area after many months of careful searching and that Anderson (1938, p. 47) actually lists only two such occurrences. One of these (Calif. Acad. Sci. loc. 113), from about 4 miles southwest of Ono, contains the ammonite *Simbirskites* of middle Hauterivian age. There is no published evidence that *L. saturnale* ranges as high as the zone of "*Neocraspedites*" aguila Anderson.

Genus CRIOCERATITES Léveillé, 1837

Crioceratites latus (Gabb)

Plate 26, figures 6, 7

Crioceras latus Gabb, 1864, Paleontology Calif., v. 1, p. 76, pl. 14, fig. 25b, pl. 15, figs. 25, 25a.
Gabb. Paleontology Calif., v. 2, p. 218, 1869.
Crioceras latum Gabb. Anderson, 1938, Geol. Soc. America Spec. Paper 16, p. 200, pl. 55, fig. 1.
Crioceras duncanense Anderson, 1938, Idem, p. 200, pl. 55, fig. 2.

This species is assigned to *Crioceratites*, as that genus is generally defined, on the basis of having crioceratid coiling, ribs of 2 sizes, and from 1 to 3 rows of tubercles on the major ribs. As the major ribs on *C. latus* (Gabb) are separated by only from 3 to 5 ribs, the species might be assigned to the genus *Emericiceras*, which Sarkar (1955, p. 21, 74, 75) separates from *Crioceras* on the basis of having much stronger trituberculation more major ribs, and fewer minor ribs. The tuberculation on *C. latum* (Gabb), however, is not as strong as on most species that Sarkar (1955, p. 75–98) assigns to *Emericiceras* and is of nearly the same strength as that of the trituberculate *Crioceratites nolani* (Kilian) (1907, p. 224, pl. 4, figs. 3a, b; d'Orbigny, 1840, p. 459, pl. 113, figs. 1–4).

Crioceras duncanense Anderson was separated from *C. latus* (Gabb) by Anderson (1938, p. 201) because it was more tightly coiled and had more minor ribs between major ribs. These differences seem minor, however, when the holotype of *C. duncanense* is compared with the inner whorl of the holotype of *C. latus* (Gabb) (Anderson, 1938, pl. 55, fig. 1). At a comparable size both holotypes have from 4 to 5 minor ribs between major ribs and both have equally prominent triberculation of the major ribs. Such close resemblances, plus Anderson's record (1938, p. 201) that both species occur at the same place (Calif. Acad. Sci. loc. 1665), suggest rather strongly that *C. duncanese* is only a variant of *C. latus* and is not worthy of even a subspecific name.

The occurrences of *C. latus* (Gabb) recorded by Anderson (1938, p. 200) are mostly from the Cottonwood Creek area of Shasta County, Calif., in beds containing *Simbirskites broadi* Anderson and "*Neocraspedites*" *aguila* Anderson. The writer considers these to be of middle and late Hauterivian age respectively.

Localities: CAS locs. 113, 1353, 1665; USGS Mes. loc. 4415.

Crioceratites cf. C. tehamaensis (Anderson)

One specimen from Tehama County consists of parts of two whorls similar to "*Holcodiscus*" *tehamaensis* Anderson (1938, p. 191, pl. 83, fig. 5). The largest part is similar to the adoral end of the holotype of "*H.*" *tehamaensis*, but differs by having more pronounced tubercles and only one minor rib between major ribs. The smaller part has from 10 to 12 minor ribs between the major ribs.

Nonfigured specimen: USNM 129845.
Locality: USGS Mes. loc. 1092.

Crioceratites cf. C. yollabollium (Anderson)

One specimen from the Riddle area in Oregon is probably identical with "*Hoplocrioceras*" *yollabollium* Anderson (1938, p. 308, pl. 72, fig. 2) from Trinity County, Calif. The specimen from Oregon has from 2 to 4 minor ribs between major ribs. The major ribs bear pronounced umbilical tubercles and somewhat weaker lateral and ventral tubercles. Some of the minor ribs bear ventral tubercles, also.

The holotype of *Crioceratites yollabollium* (Anderson) has umbilical swelling and traces of lateral tubercles. As the venter is not preserved its characteristics are unknown. It does not show rib bundling at the umbilical border in the manner characteristic of the genus *Hoplocrioceras*.

Nonfigured specimen: USNM 129841.
Locality: USGS Mes. loc. 1826.

Crioceratites sp. indet.

Plate 26, figures 1, 5

Crioceras latus Gabb. Stanton, 1895, U.S. Geol. Survey Bull. 133, p. 17, 18, 83 [1896].

The specimen, referred by Stanton to *Crioceras latus* Gabb, was obtained at the top of the beds containing *Buchia crassicollis* (Keyserling) in association with other ammonites of late Valanginian age. It differs from *C. latus* Gabb by having from 8 to 9 minor ribs instead of 3 to 5 minor ribs between the major ribs, by bifurcation of some of the minor ribs high on the flanks, by the major ribs bearing much weaker umbilical and lateral tubercles, and by the ribbing in general being finer, and more flexuous. Its general appearance is similar to that of *Crioceratites duvali* Léveillé as figured by d'Orbigny (1842, pl. 113, fig. 1) from the Hauterivian of France.

Figured specimen: USNM 23101.
Localities: USGS Mes. loc. 1009. Fragments probably belonging to the same species as the specimen illustrated were obtained in Oregon from beds of Valanginian age at Mes loc. 25275 and of early Hauterivian age at Mes. locs. 25198, 25199, and 26252.

Genus HOPLOCRIOCERAS Spath, 1924

Hoplocrioceras remondi (Gabb)

Plate 24, figures 1–4, 8, 9, 11, 12

Crioceras (?*Ancyloceras*) *remondi* Gabb, 1864, Paleontology Calif., v. 1, p. 75, pl. 14, figs. 24, 24a.

Ancyloceras remondi Gabb, 1869, Paleontology Calif., v. 2, p. 138, pl. 23, fig. 17.

Hoplocrioceras remondi (Gabb). Anderson, 1938, Geol. Soc. America Spec. Paper 16, p. 201, pl. 62, figs. 1–3, 5 [not pl. 63, figs. 1, 2].

The Geological Survey collections contain six fragmentary specimens of this species. The whorls are subquadrate in section, higher than wide. The dorsum and flanks are flattened. The venter is slightly convex on the inner whorls and is arched on adult whorls.

The shell is ornamented with three rows of tubercles and with flexuous fasciculate ribs. The internal molds are marked in addition by shallow constrictions. The ribs on the dorsum are rather weak, arch forward strongly, and become faint at the umbilical edge. The ribs on the flanks arise in two's, or rarely three's, from umbilical tubercles or in part arise freely at the umbilical edge. They incline forward on the flanks in a gently flexuous manner and arch forward weakly on the venter. On the lower part of the flanks, the ribs are broad, low, and wider than the interspaces; on the middle of the flanks, they are sharp and narrower than the interspaces; on the upper part of the flanks and on the venter, they are broad, fairly strong and about as wide as the interspaces. Some ribs bifurcate high on the flanks or even on the venter.

The shells are distinctly trituberculate, although one row situated on the flanks is so weak that neither Gabb nor Anderson mentioned its presence. On a small specimen, such as shown on plate 24, figures 1, 3, the umbilical tubercles are blunt and low, give rise to 2 or 3 ribs, and are separated from each other by 1 to 3 flank ribs that arise freely. On this speciment nearly every rib bears a tiny tubercle along a zone slightly above the middle of the flanks. The ventral tubercles are blunt and low but are a little stronger than the umbilical tubercles. Most ventral tubercles mark the junction of two lateral ribs. Between adjoining ventral tubercles are from 1 to 4 ribs that are nontuberculate, or only weakly swollen.

On larger septate whorls (pl. 24, fig. 8) the umbilical tubercles become more prominent and develop a forward twist. The lateral tubercles weaken and nearly disappear, but generally a few are present on some of the flank ribs that pass from the umbilical tubercles. Toward the aperture all ventral tubercles weaken gradually and all ribs tend to develop weak ventral tubercles.

One large specimen (pl. 24, figs. 9, 12) is probably an adult of the species. It shows parts of two inner whorls and nearly half a whorl of body chamber. On the body chamber the umbilical tubercles are distinct, but variable in strength; lateral tubercles are absent; and weak ventral tubercles are present only at the beginning of the body chamber.

The resemblance of *Hoplocrioceras remondi* (Gabb) to *H. laeviusculum* (Von Koenen) (1902, p. 350, pl. 28, figs. 4–6) from Germany was the basis for Anderson's (1938, p. 201) generic assignment. The ribbing of the two species is closely similar. *H. remondi* is differentiated by more open coiling, a higher whorl section, probably more fasciculate ribbing, and the presence of lateral tubercles. The presence of lateral tubercles does not bar an assignment to *Hoplocrioceras* because other species with lateral tubercles were assigned by Spath (1924, p. 78) to *Hoplocrioceras* when he proposed the genus.

H. remondi (Gabb) also shows some resemblance to *Pseudothurmannia mortilleti* (Pictet and Loriol) (1858, p. 21, pl. 4, figs. 2a–d) from Switzerland, but differs by having lateral tubercles and a rounded instead of a truncated venter. The presence of a rounded venter on *H. remondi* at all stages of growth bars any assignment to *Pseudothurmannia*, even though the adults of certain species of that genus, according to Sarkar (1955, p. 152), acquire rounded venters and lateral tubercles.

Anderson (1938, p. 47, 202, 307) records *H. remondi* (Gabb) from several stratigraphic levels in the Cottonwood Creek area near Ono, Calif. One is in the zone of "*Neocraspedites*" *aguila* (CAS loc. 1353), which the writer considers of late Hauterivian age. Another is in the underlying zone of *Simbirskites broadi* (CAS 1665), which is of middle Hauterivian age. Anderson (1938, p. 307, pl. 62, fig. 6) also assigned to *H. remondi* (Gabb) a specimen from 1 mile east of Riddle, Oreg., in beds containing "*Lyticoceras*" *packardi* Anderson, which the writer considers to be of early Hauterivian age. This specific assignment is questioned. The Geological Survey collections contain *H. remondi* from the "*Neocraspedites*" *aguila* zone near Ono, Calif., and from the same zone on the eastern part of the Wilcox Ranch in the Paskenta area, California.

Type: Plesiotypes USNM 129661, 129662, 129664.
Localities: USGS Mes. locs. 1062, 2225, 2268; CAS loc. 1353, 1665; UCLA loc. 2816.

Hoplocrioceras cf. H. remondi (Gabb)

Plate 24, figures 5, 6

One specimen from Oregon is possibly an adult variant of *H. remondi* (Gabb). It differs, however, from the adult specimens that Anderson (1938, pl. 62, figs. 2, 2a, pl. 63) assigns to that species by having finer ribbing on the flanks. The ribs arise singly or in pairs from pronounced umbilical tubercles, are flexuous on the flanks, generally bifurcate indistinctly on the upper half of the flanks, become swollen or weakly tuberculate at the edge of the venter, and arch forward slightly on the venter. The surface of the flanks is covered, also, by flexuous striae that are stronger on the ribs than on the interspaces. No trace of lateral tubercles is visible.

Figured specimen: USNM 129665.
Locality: USGS Mes. loc. 2080.

Hoplocrioceras duncanense (Anderson)

Plate 25, figures 1, 3, 8, 9

Spiticeras duncanense Anderson, 1938, Geol. Soc. America Spec. Paper 16, p. 160, pl. 27, figs. 1, 2.
?*Hoplocrioceras onoense* Anderson, 1938, Idem., p. 202, pl. 53, fig. 3, 3a, b, pl. 61, fig. 4.

It is astonishing that Anderson failed to recognize the resemblance of the holotype of this species to the specimens of *Hoplocrioceras* that he identified from the same locality and from other localities near Ono, Calif. The presence of the rows of ventral tubercles that he described and illustrated should have barred an assignment to *Spiticeras*, but in addition the holotype specimen bears a row of widely-spaced lateral tubercles a little above the middle of the flanks. One of these is evident near the middle of the lateral view published by Anderson, but under oblique lighting seven tiny lateral tubercles are visible. On the opposite side of the holotype, at least five lateral tubercles are visible. Anderson likewise failed to mention the presence of several shallow constrictions.

H. duncanense (Anderson) greatly resembles *H. remondi* (Gabb) in ornamentation. The holotype differs from *H. remondi* by retaining ventral and lateral tubercles to a later growth stage, by its umbilical tubercles being separated by from 2 to 5 nontuberculate ribs, by having 3 ribs in many rib bundles, and by having a much stouter, rounder whorl section. Whether these differences are actually of specific value cannot be determined until enough specimens are obtained to show the range of variation of the species.

In addition to the holotype, one specimen (pl. 25, figs. 1, 3) having a similar stout whorl has been found in the zone of "*Neocraspedites*" *aguila* near Ono, Calif. Furthermore *H. onoense* Anderson (CAS loc. 1353) probably is a synonym of *H. duncanense*, judging by its broad whorl section and by the features mentioned by Anderson (1938, p. 202).

Types: Plesiotype, USNM 129674; holotype, CAS 8810.
Localities: USGS Mes. loc. 2224; CAS loc. 1665.

Genus SHASTICRIOCERAS Anderson, 1938

Shasticrioceras aff. S. whitneyi Anderson

Plate 25, figures 7, 10

One specimen of *Shasticrioceras* from the *Hertleinites aguila* zone is illustrated to prove that the genus occurs as low as that zone. The specimen greatly resembles *S. whitneyi* Anderson (1938, p. 205, pl. 58, fig. 1) in lateral view and may be a variant of that species. It differs, however, by having a less distinctly truncated venter, by having rather weak, ventral tubercles that become indistinct adorally, and by its ribs arching forward on the venter instead of crossing the venter transversely. Both this specimen and the holotype of *S. whitneyi* differ from *S. poniente* Anderson and *S. hesperium* Anderson in lateral view by having a more open coil and by their flank ribs being straighter, more widely spaced, and a little less regular in strength.

Only one other specimen of *Shasticrioceras* has been recorded from the *Hertleinites aguila* zone (Murphy, 1956, p. 2114). That specimen, according to Murphy (oral communication 1958), resembles *S. whitneyi* Anderson in its open coil but is otherwise not particularly different from *S. poniente* Anderson.

Figured specimen: USNM 129673.
Locality: USGS Mes. loc. 2225.

Genus ACRIOCERAS Hyatt, 1900

Acrioceras voyanum Anderson

Plate 26, figures 2–4

Acrioceras voyanum Anderson, 1938, Geol. Soc. America Spec. Paper 16, p. 206, pl. 59, fig. 1.

One ammonite from Oregon, consisting of a shaft and a recurved limb, is nearly identical in shape and ornamentation with the holotype of *A. voyanum* Anderson. It differs by being a little smaller and by the shaft bearing prominent comma-shaped tubercles on the edge of the dorsum and a row of weak tubercles on each side of the venter. Anderson mentions the presence of a few tubercles on the shaft but he does not state their position. His illustration, however, indicates the presence of tubercles at the edge of the dorsum such as occur on the specimen from Oregon.

The holotype was obtained from the Cottonwood Creek area of Shasta County, Calif., at an unknown stratigraphic position. Anderson (1938, p. 206, 304) considered that the characteristics of the concretion in which the ammonite was partly enclosed indicated a position from or just above his Ono zone, which is herein referred to as the *Hertleinites aguila* zone following the usage of Murphy (1956, p. 2113). Confirmation of a position as low as that zone is furnished by the occurrence of *Acrioceras voyanum* Anderson in Oregon in association with the middle Hauterivian ammonite *Simbirskites* described herein. Also, a fragment possibly belonging to *A. voyanum* Anderson (see pl. 24, figs. 7, 10) was obtained at USGS Mes. loc. 2269 only 8 feet below an occurrence of *Hertleinites aguila* (Anderson).

In general appearance, *A. voyanum* Anderson is similar to *A. maheswariae* Sarker (1955, p. 108, pl. 8, fig. 17) from the Barremian of France.

Types: Plesiotype USNM 129862; holotype, Univ. Calif. Berkeley 110.

Localities: USGS Mes. loc. 24449. A specimen possibility belonging to this species was obtained at USGS Mes. loc. 2269.

Acrioceras vespertinum (Anderson)

Plate 26, figures 11–14

Anahamulina vespertina Anderson, 1938, Geol. Soc. America Spec. Paper 16, p. 219, pl. 23, figs. 3, 3a.

The shaft of this species bears three rows of tubercles. All ribs on each side of the venter bear weak tubercles arranged in a row. The major ribs bear prominent tubercles at the edge of the dorsum and near the middle of the flanks. These ribs are separated by 1 to 3 minor ribs that are nontuberculate except on the venter. On the recurved limb only lateral and dorsal tubercles are visible and these are weaker than on the shaft.

This species has much coarser ribbing than either *A. voyanum* Anderson or *A. hamlini* (Anderson). Its ribbing compares in coarseness to that on some specimens of *Acrioceras* figured by Sarkar (1955, pl. 6, fig. 8, pl. 7, fig. 5, pl. 9, fig. 12) from the Neocomian of France. The specimen of *A. tabarelli* (Astier) figured by Uhlig (1883, pl. 28, fig. 2) from the Barremian of the Carpathian Mountains is comparable to *A. vespertinum* in size and coarseness of ornamentation, but differs by its flank ribs inclining forward less strongly and by having fewer minor ribs.

Type: Holotype Calif. Acad. Sci. 8915.
Locality: Calif. Acad. Sci. loc. 113.

Acrioceras hamlini (Anderson)

Plate 26, figures 8–10

Aspinoceras hamlini Anderson, 1938, Geol. Soc. America Spec. Paper 16, p. 207, pl. 60, figs. 1, 2.

This species, known only by the holotype, was made the type of a new genus by Anderson on the basis of the absence of tubercles and the presence of alternating simple and forked ribs. Actually the holotype does bear tubercles and is so similar to *Acrioceras voyanum* Anderson in shape and ornamentation that the two species may reasonably be placed in the same genus. The most conspicuous difference is the greater breadth and strength of the ribs on *A. hamlini.*

Most of the holotype specimen of *A. hamlini* is much worn. The shell is fairly well preserved only at two small places on the venter. At both places weak ventral tubercles are discernable. On the left side of the venter, 6 consecutive ribs bear tiny tubercles; and on the right side, 4 consecutive ribs bear tubercles. On the right flank at one spot where some of the shell is preserved, two of the ribs bear distinct tubercles a little above the middle of the flanks. Elsewhere on the flanks faint swellings are visible on the worn ribs along the same zone. The dorsal edges of the flanks are so much worn that neither the presence or absence of tubercles can be proved. However, the ribs at the dorsal edge are twisted in a comma-shaped manner very much as in a specimen of *A. voyanum* from Oregon (pl. 26, figs. 2, 4)—this feature suggests that originally umbilical tubercles or swellings were present on the shell.

The general appearance of *A. hamlini* (Anderson) is similar to *A. muckleae* Sarkar (1955, p. 109, pl. 9, fig. 3), from the Neocomian of France. Its apparently weaker tuberculation is at least in a part a result of corrosion.

A. hamlini (Anderson) is considered to be of middle Hauterivian age because of its association with *Simbirskites.*

Type: Holotype Calif. Acad. Sci. 8879.
Locality: Calif. Acad. Sci. loc. 113.

Genus PSEUDOTHURMANNIA Spath, 1923

Pseudothurmannia? russelli (Anderson)

Neocomites russelli Anderson, 1938, Geol. Soc. America Spec. Paper 16, p. 165, pl. 27, figs. 3, 3a.

The holotype of this species has not been located in the collections of the California Academy of Sciences, and consequently its proper generic assignment remains in doubt.

Judging from Anderson's description and illustrations the holotype of "*Neocomites*" *russelli* Anderson has ribbing similar to that of *Pseudothurmannia angulicostata* (d'Orbigny) (1841, p. 146, pl. 46, figs. 3, 4). That species differs apparently by having a truncated venter, ventral tubercles along the edge of the venter, and a wider umbilicus. Those differences may be related, however, to the size and growth stages of the specimens compared. In this regard, Sarkar (1955, p. 151, 152) points out that the adult whorls of certain species of *Pseudothurmannia*, as illustrated by Sarasin and Schöndelmayer (1901, pl. 10, figs. 1, 2, 6, pl. 11, fig. 4), acquire a rounded whorl section and loose the ventral tubercles. Wright (1955, p. 564) notes that *P. cruasensis* (Torcapel) (1884, p. 137, 138, pl. 6) likewise has a rounded instead of an angulated venter. The general appearance of these species is similar, therefore, to that of "*N.*" *russelli* Anderson.

An assignment of "*N.*" *russelli* to *Pseudothurmannia* rather than to *Thurmanniceras* or *Neocomites* seems reasonable on the basis of its association with *Hoplocrioceras*, which did not appear in Europe until late middle Hauterivian time, whereas *Thurmanniceras* and *Neocomites* are not known later than early Hauterivian. The correct generic identification of "*N.*" *russelli*, must await the discovery of specimens that show the inner whorls.

Locality: Calif. Acad. Sci. loc. 1665.

Pseudothurmannia? jupiter (Anderson)

Thurmannia jupiter Anderson, 1938, Geol. Soc. America Spec. Paper 16, p. 162, pl. 31, fig. 1.

Anderson's illustration of the holotype of this species is about one-half natural size, and consequently the ribbing appears to be much denser than in reality. Actually the inner whorls bear ribbing only slightly closer spaced than the ribbing on *Pseudothurmannia*? *russelli* Anderson (1938, p. 165, pl. 27, figs. 3, 3a). As the other characteristics of the inner whorls of *P.*? *jupiter* appear closely similar to those of *P.*? *russelli*, the two species are possibly identical. This cannot be proved, or rejected, until the growth stages of *P.*? *jupiter* are better known.

The characteristics of the ornamentation on the large outer whorl of *P.*? *jupiter* (Anderson) were not fully described by Anderson. Most of the ribs begin singly at weak umbilical tubercles, a few arise in pairs from the tubercles, and a few branch indistinctly low on the flanks. They are slightly swollen on the edge of the venter, but not tuberculate. They cross the venter nearly transversely without reduction in strength. On the flanks the ribs are sickle-shaped and variable in strength. From 7 to 8 weak constrictions are present. Lateral tubercles are not present.

Type: Holotype Calif. Acad. Sci. 8792.
Locality: Calif. Acad. Soc. loc. 113B.

Genus ANAHAMULINA Hyatt, 1900

Anahamulina wilcoxensis Imlay, n. sp.

Plate 25, figures 2, 5, 6

The species is represented by two straight fragments of a shaft that probably belong to a single individual. The largest fragment is mostly sutured, but at its anterior end it includes a little of the body chamber, which is crushed laterally. The uncrushed sutured part is nearly circular in section, is a little higher than wide, and is less convex on the dorsum than on the ventor. The shell is marked by fine ribs of somewhat irregular strength that are strongest on the venter. The ribs arch forward weakly on the dorsum, incline forward strongly on the flanks, and arch forward moderately on the venter. The venter bears several pronounced constrictions that fade out dorsally near the middle of the flanks. Each constriction is followed anteriorly by a slightly swollen rib.

The suture line is highly frilled. The first lateral lobe is irregularly bifid and a little longer than the ventral lobe. The second lateral lobe is trifid and is much shorter than the first lateral lobe. The dorsal lobe is trifid and terminates in a long slender point.

A. wilcoxensis resembles the finely ribbed nontuberculate species that Gignoux (1920, p. 128, 129) places in the group of "*Hamulina*" *subcylindrica* d'Orbigny. Its ribbing in particular is similar to that of *A. paxillosa* (Uhlig) (1883, p. 94, pl. 14, figs. 3, 5, 6), from the Barremian of the Carpathian Mountains. It differs from that species by its shaft tapering less gradually, and in that respect bears a closer resemblance to another specimen of *Anahamulina* figured by Uhlig (1883, pl. 13, fig. 1). *A. wilcoxensis* appears to have more numerous and more pronounced constrictions on its venter than the other species of *Anahamulina* that have been described.

Type: Holotype USNM 129671.
Locality: USGS Mes. loc. 1092.

Genus HOMOLSOMITES Crickmay 1930

Homolsomites mutabilis (Stanton)

Plate 28, figures 1–22

Olcostephanus (*Simbirskites*) *mutabilis* Stanton, 1895, U.S. Geol. Survey Bull. 133, p. 77–78, pl. 15, figs. 1–5 [1896].
Subcraspedites? *mutabilis* (Stanton). Spath, 1923, Geol. Soc. London Quart. Jour., v. 79, pt. 3, no. 313, p 306.
Dichotomites mutabilis (Stanton). Anderson, 1938, Geol. Soc. America Spec. Paper 16, p. 160.
Dichotomites tehamaensis Anderson, 1938, Idem, p. 158, pl. 28, fig. 2, pl. 30, fig. 6.
Dichotomites gregerseni Anderson, 1938, Idem, p. 158, 159, pl. 28, figs. 3, 4.
Dichotomites burgeri Anderson, 1938, Idem, p. 159, pl. 28, fig. 5.
Homolsomites mutabilis (Stanton). Imlay, 1956, Jour. Paleontology v. 30, no. 5, p. 1144, 1145.

The specimens of *Homolsomites* described by Stanton and Anderson were obtained from the same small exposures on a hill northwest of the houses of the Shelton Ranch, about 5 miles north of Paskenta, Tehama County, Calif. (Mes. locs. 1010 and 1093). Both Stanton and Anderson collected about 40 specimens.

Stanton noted variations in the ornamentation of the specimens that he examined, but concluded that the specimens all belonged to a single variable species. Anderson assigned the specimens that he examined to 4 species of which 3 were described as new.

The 40 specimens available to Stanton have been divided by the writer into 4 lots based on coarseness of ribbing and number of ribs. Each lot contains 1 or 2 specimens that might nearly as well have been placed in another lot, although the differences between the most finely ribbed and the most coarsely ribbed specimens are rather striking. One lot contains seven specimens that agree with the definition and illustration of "*Dichotomites*" *tehamaensis* Anderson (1938, p. 158, pl. 28, fig. 2). These specimens are finely and densely ribbed, secondary ribs outnumber primary ribs about 5 to 1, and the ribs fade out rapidly adorally on the lower part of the body chamber.

A second lot contains 17 specimens, including 2 specimens illustrated by Stanton (1895, pl. 15, figs. 3–5 [1896]). These agree with the definition and illustration of "*Dichotomites*" *burgeri* Anderson (1938, p. 159, pl. 28, fig. 5). Their ribbing is slightly coarser and sparser than in "*D.*" *tehamaensis*, and the secondary ribs outnumber the primary ribs about 4 to 1 on the larger whorls and 3 to 1 on the smaller whorls.

A third lot contains 12 specimens, including 1 illustrated by Stanton (1895, pl. 15, figs. 1, 2 [1896]). These agree with the definition and illustrations of "*Dichotomites*" *gregerseni* Anderson (1938, p. 158, pl. 28, figs. 3, 4). They differ from "*D.*" *burgeri* by having slightly coarser and sparser ribbing. The secondary ribs outnumber the primary ribs 3 to 1 on the larger whorls and 2 to 1 on the smaller whorls. These specimens include the lectotype of *Homolsomites mutabilis* (Stanton) that was selected by Anderson (1938, p. 160).

A fourth lot contains five specimens that are characterized by being still coarser and sparser ribbed than the specimens in the other lots and by having fewer secondary ribs. These coarsely ribbed specimens are herein given the subspecific name *crassicostatus* under the species *H. mutabilis* (Stanton), and the specimen shown on plate 28, figures 3, 4, is designated the type of the subspecies. In conformity with this usage "*Dichotomites*" *burgeri* Anderson and "*D.*" *tehamaensis* Anderson are likewise considered subspecies of *H. mutabilis* that are finer ribbed than the typical subspecies *mutabilis*, but are connected with it by many transitions.

The suture line of *H. mutabilis* Stanton is characterized by having long, nearly symmetrical lobes. The first lateral lobe is appreciably longer than the ventral and second lateral lobes. The second lateral saddle is nearly as broad as the first lateral saddle.

The various species of *Homolsomites*, from Washington, British Columbia, and Greenland have been listed by the writer (1956, p. 1144) recently under a discussion of the characteristics of the genus. Of these species *H. stantoni* (McLellan), from Washington and British Columbia, has fine, dense ribbing similar to that of *H. mutabilis tehamaensis* Anderson, but is distinguished by a more narrowly rounded venter and consequently by a subtriangular rather than an elliptical cross section. *H. paucicostatus* Donovan (1953, p. 110–112, pl. 23, figs. 1a, b), from Greenland, was considered by its author to be a variety of *H. gregerseni* (Anderson), differing only by having fewer ribs. *H. paucicostatus* does not, however, have fewer ribs than some of the typical specimens of *H. mutabilis* of which *H. gregerseni* (Anderson) is a synonym. *H. paucicostatus* (Donovan) is possibly differentiated from *H. mutabilis* (Stanton) by a more narrowly rounded venter and weaker ribbing.

Types: Lectotype of *H. mutabilis mutabilis* Stanton, USNM 23089a; plesiotypes, USNM 129689, 129691, 129693. Holotype of *H. mutabilis crassicostatus* Imlay, n. subsp., USNM 129690; paratype, USNM 129692. Plesiotypes of *H. mutabilis burgeri* (Anderson), USNM 23089b, c, 129688a–c. Plesiotypes of *H. mutabilis tehamaensis* (Anderson), USNM 129687, 129694.

Localities: All the California specimens of *H. mutabilis* (Stanton) in the Geological Survey are from USGS Mes. loc. 1093 (equals 1010). In Oregon 2 typical specimens of *H. mutabilis* were found at Mes. loc. 2154 and 2 specimens of the subspecies *tehamaensis* at Mes. loc. 4390. Some ammonites from Mes locs. 1088 and 1091 that Stanton (1895, p. 17 [1896]) referred to *H. mutabilis* (Stanton) are herein described under *Neocraspedites giganteus* Imlay, n. sp.

Homolsomites stantoni (McLellan)

Plate 27, figures 1–16

Holcodiscus? stantoni McLellan, 1927, Washington Univ. Pub. in Geology, v. 2, p. 115, pl. 12, figs. 3–5.

Homolsomites poecilochotomus Crickmay, 1930, Canada Natl. Mus. Bull. 63, Geol. Ser. 51, pp. 63, 64, pl. 21, figs. 1–4.

Homolsomites stantoni (McLellan). Imlay, 1956, Jour. Paleontology, v. 30, pp. 1143–1146, pl. 120.

One large adult of *Homolsomites stantoni* (McLellan) has been found on the South Umpqua River in southwestern Oregon, in association with *Olcostephanus pecki* Imlay, n. sp., about 257 feet below the top of the beds containing *Buchia crassicollis* (Keyserling). This adult specimen appears so different from the small immature type specimens (see pl. 27, figs. 8, 9, 11–13) described by McLellan (1927, p. 115, pl. 12, figs. 3–5) that identification would not have been possible without breaking the adult specimen enough to show the characteristics of inner whorls. These revealed that the specimen during growth passed through the various changes in ornamentation and shape as illustrated recently by Imlay (1956). The identification became positive after the acquisition of additional topotype specimens and of plaster casts of the type specimens furnished through the courtesy of V. Standish Mallory and Warren S. Drugg, of the University of Washington at Seattle.

The innermost exposed whorl of the specimen from the South Umpqua River shows ribbing comparable in coarseness to the small type specimens. Its primary ribs incline forward on the flanks and are slightly stronger than its secondary ribs. Secondary ribs arise in pairs between the lower fourth and lower third of the flanks. Many of the secondary ribs branch again between the middle and upper third of the flanks. All secondary ribs incline forward strongly on the upper parts of the flanks and arch forward on the venter, and are not reduced in strength on the venter. These small whorls bear 7 or 8 weak forwardly inclined constrictions per whorl.

On specimens larger than the types, the primary ribs become more prominent than the secondary ribs, acquire a pinched appearance, and then gradually fade on the penultimate and body whorls. The ribbing on the venter remains fairly strong even on the adult body chamber, as shown on the large specimen from the South Umpqua River, in which the body chamber occupies three-fourths of a whorl.

The specimens of *H. stantoni* (McLellan) now available show some variation in ribbing. The type specimens and some others (pl. 27, figs. 9, 13, 15) have about 4 secondary ribs for each primary rib and are similar in this respect to *H. mutabilis burgeri* Anderson. Others have about 5 secondary ribs for each primary (pl. 27, figs. 3, 4) and are similar in this respect to *H. mutabilis tehamaensis* Anderson. *H. stantoni* differs, however, from *H. mutabilis* (Stanton) and its subspecies by having a more narrowly rounded venter, a smaller umbilicus, less pinched primary ribs, and more common furcation low on the flanks on immature specimens. It appears, also, to attain a much larger size.

The distinctions between *Homolsomites stantoni* (McLellan) and *Wellsia oregonensis* (Anderson) are described under the description of the latter.

H. stantoni (McLellan) shows some resemblance to *Neocraspedites carteroni* (d'Orbigny) (1841, p. 209, pl. 61, figs. 1–3), from the lower Hauterivian of France. It differs by lacking swollen primary ribs near the umbilical margin by having more distinct furcation points from which the secondary ribs arise in pairs rather than in bundles, by having a more narrowly rounded venter, and by the primary ribs being rather prominent on the small and intermediate size whorls and then fading uniformly on the penultimate and body whorls instead of near the medial parts of the flanks.

Types: Holotype Univ. Wash. 15001; paratype, Univ. Wash. 15002; plesiotypes, Univ. Wash. 12763–12767; plesiotypes, USNM. 129695, 129696.

Localities: USGS Mes. locs. 17273, 26788; Univ. Washington locs. WA 535, 536, 538; field number 9.3.54.6 of Peter Misch.

Genus OLCOSTEPHANUS Neumayr, 1875

Olcostephanus pecki Imlay, n. sp.

Plate 29, figures 1–5, 7–9; plate 30; plate 31, figure 7

This species is represented by 6 nearly complete specimens and by 16 fragments. The shell is stout and moderately involute. The body whorl is ovate in section, nearly as high as wide, overlaps about three-fifths of the penultimate whorl, and attains its greatest thickness at the umbilical edge. The flanks are gently convex, and the venter is evenly arched. The umbilicus is moderately narrow, its wall is fairly high and vertical, its edge is evenly rounded. On the largest specimens the body chamber represents nearly one whorl. The aperture is marked by a pronounced forwardly inclined swelling, followed by a deep constriction, which is followed in turn by a moderately strong swelling. These swellings are a little stronger than those on the apertures figured by Baumberger (1908), pl. 23, fig. 2; 1910 pl. 32, fig. 1).

The ribs on the smallest whorls (pl. 29, figs. 3, 4) are fine and closely spaced. They incline backward on the umbilical wall, incline forward on the flanks, and cross the venter transversely. The ribs on the umbilical wall are a little stronger than the ribs on the flanks and bear distinct, small conical tubercles at the umbilical edge. From these tubercles pass pairs of ribs. Most pairs are separated by a single rib that arises freely along the zone of tuberculation. In addition the smallest whorls bear pronounced forwardly inclined constrictions that may truncate some of the ribs.

The ribs on the larger whorls become progressively stronger and more widely spaced during growth and are moderately strong at the anterior end of the adult body chamber. Faintly, the ribs begin low on the umbilical wall, incline backward to the umbilical edge. incline forward gently on the flanks, and cross the venter transversely. Most of the primary ribs bifurcate just above the umbilical edge into 2, or rarely 3 secondary ribs. A few secondary ribs branch again higher on the flanks. Most paired ribs are separated by single ribs that arise freely at or near the zone of furcation. The furcation points are slightly swollen but are not tuberculated. Each whorl bears 5 or 6 weak constrictions, and the innermost whorls bear the strongest constrictions.

Accurate measurements cannot be made because all the specimens have been crushed. The suture line is of the olcostephanid type, as described by Uhlig (1903, p. 84, 86, pl. 18, figs. 2e). The lobes are deep and frilled. The saddles are high and not divided by a secondary lobe.

Discussion: This species is characterized by lacking distinct umbilical tubercles except on its innermost whorls, and by having closely spaced ribs that branch by twos and threes near the umbilical edge. Many species of *Olcostephanus* have ribbing comparable in density to *O. pecki* Imlay, n. sp., but most of them have distinct umbilical tubercles from which pass bundles of 4 or 5 secondary ribs. Probably the most similar species is *O. jeannoti* (d'Orbigny) (1841, p. 188, pl. 56, figs. 3–5), from the late Valanginian and early Hauterivian of France. It resembles *O. pecki* in degree of involution, rib ranching, density of ribbing, and absence of tubercules. It differs by being much smaller and more compressed. Another similar species is *O. geei* Spath (1939, p. 26, pl. 7, figs. 6a–c), from the Valanginian of the Salt Range of India. It differs from *O. pecki* by being stouter and by having coarser ribbing. *O. frequens* Zwierzycki (1914, p. 51, pl. 6, figs. 1–5, 10, 11, 14, 15), from east Africa, has ribbing on its outer whorl similar to that on *O. pecki*, but its inner whorls are strongly tuberculate, and it is much more evolute.

Olcostephanus pecki and *O. jeannoti* (d'Orbigny) are similar to some species of *Holcodiscus*, such as *H. uhligi* Karakasch (1907, p. 113, pl. 9, figs. 19a, b), from the Crimea, in such features as their rib pattern and their lack of umbilical tubercles on adult whorls. Spath (1939, p. 12) considered that *O. jeannoti* belonged to a group transitional from *Olcostephanus to Holcodiscus*. That genus differs from *Olcostephanus*, however, by being more evolute, by having stronger constrictions, and by its ribs generally branching higher on the flanks.

Distribution: Olcostephanus pecki has been identified definitely only near Days Creek, Douglas County, Ore. At that place it has been collected throughout 218 feet of beds in the upper part of the sandy unit characterized by an abundance of *Buchia crassicollis* (Keyserling). The highest occurrence of *O. pecki* is 85 feet below the highest occurrence of *B. crassicollis* and 143 feet below the lowest occurrence of *Wellsia oregonensis* (Anderson).

Fragments of *Olcostephanus* that may belong to *O. pecki* have been found with *Homolsomites stantoni* (McLellan) 3 miles east of Glacier, Wash., in the north center of sec. 3, T. 31 N., R. 7 E. (Univ. Washington colln. [see pl. 29, fig. 6] WA 538).

Types: Holotype USNM 129848; paratypes USNM 129846, 129847a–c, 129849.

Localities: USGS Mes. locs. 25192–25194, 25197, 26787–26790. A fragment probably belonging to *O. pecki* was found at Mes. loc. 1681. The species is named in honor of Dallas L. Peck, of the U.S. Geological Survey.

Olcostephanus popenoei Imlay, n. sp.

Plate 31, figures 1–3

This species is represented by a single small specimen that possesses well-developed lateral lappets. The body chamber occupies about four-fifths of a whorl. The whorl is subquadrate in section and slightly higher than wide. As it is somewhat crushed laterally, the width was probably originally as great as the height. The coiling appears to be fairly evolute for the genus.

The ornamentation is similar to that on the inner whorls of *O. pecki* Imlay, n. sp. It differs by having fewer intercalated ribs, weaker and sparser primary ribs, and weaker umbilical tubercles. Pronounced constrictions occur at both ends of the body chamber. On the right side of the shell the lateral lappet is prolonged about 8 mm beyond the final constriction.

Discussion: If it were not for the presence of lateral lappets, the holotype of this species might have been considered an immature specimen of *O. pecki* Imlay, n. sp., although it exhibits minor differences in shape and ornamentation. The presence of lateral lappets shows that it is an adult and that it differs from *O. pecki* in aperatural characteristics as well in its vastly different size. Perhaps these species represent another case of dimorphism (see discussion by Callomon, 1957, p. 62; Arkell, 1957, p. 87–90), but this cannot be proved. Also, the fact that *O. popenoei* is represented in available collections by only 1 specimen, whereas *O. pecki* is represented by many, suggests that the 2 species are not dimorphic.

The presence of lateral lappets in *O. popenoei* does not place that species in a separate genus from *O. pecki* although a simple, sinuous apertural constriction is more common in *Olcostephanus*. Examples of typical *Olcostephanus* that have lappets have been illustrated by Spath (1939, pl. 1, 3a, 8a, pl. 2, fig. 2a, pl. 19, fig. 6a).

The species is named in honor of W. Parkison Popenoe, of the University of California at Los Angeles.

Type: Holotype USNM 129863.

Locality: USGS Mes. loc. 26790.

Olcostephanus cf. O. quadriradiatus Imlay

Plate 31, figure 10

One external mold of an ammonite from a locality near Port Orford, Ore., has a rib pattern similar to that of *Olcostephanus* rather than *Polyptychites*. In particular, the ribbing may be compared to that on the body whorls of *O. quadriradiatus* Imlay (1938, p. 554, pl. 5, figs. 1, 2), *O. astieriformis* (Böse) (1923, p. 72, pl. 1, figs. 1–4), *O. astierianus* (d'Orbigny) (1840, p. 115, pl. 28, figs. 1, 2), and *O. singularis* (Baumberger) (1908, p. 3, pl. 26, fig. 5). All these species are from beds of early Hauterivian age.

The ammonite from Oregon bears very strong, widely spaced umbilical tubercles, from which pass bundles of 4 to 5 ribs that incline forward on the flanks. Generally one rib in each bundle bifurcates on the middle third of the flanks. Most rib bundles are separated by 1 or 2 ribs that arise freely on the flank above the zone of tuberculation.

The ammonite was collected from thick-bedded sandstone some hundreds of feet above beds containing *Buchia crassicollis* (Keyserling). On the basis of stratigraphic position, it should be of Hauterivian age.

Figured specimen, USNM 129861.
Locality: USGS Mes. loc. 25217.

Genus POLYPTYCHITES Pavlow, 1892

Polyptychites trichotomus (Stanton)

Plate 31, figures 13, 15

Olcostephanus (Polyptychites) trichotomus Stanton. Stanton, 1895, U.S. Geol. Survey Bull. 133, p. 78, pl. 16, fig. 1, [1896].
Dichotomites trichotomous (Stanton). Anderson, 1938, Geol. Soc. America Spec. Paper 16, p. 159.

This species was compared by Stanton with *Polyptychites polyptychus* (Keyserling) (Pavlow, 1892, pl. 15 (8), figs. 2a, b), but that species differs by having umbilical tubercles, sharper ribs, and more frequent rib branching. In these respects *P. trichotomus* shows much more resemblance to *P. ramulicosta* Pavlow (1892, p. 481, pl. 8 (5), fig. 10a, b, pl. 15 (8), figs. 6a, b), from the middle Valanginian beds at Speeton, England, or to *P. densicosta* Pavlow (1914, p. 26, pl. 5, figs. 3a–c), from the Valanginian of Russia. It appears to be more evolute than those European species, but that appearance may be a result of crushing. Its assignment to *Dichotomites* by Anderson cannot be maintained because *Dichotomites* has fairly regular rib bifurcation from umbilical swellings or tubercles.

Type: Holotype USNM 23090.
Locality: USGS Mes. loc. 1087.

Genus NEOCRASPEDITES Spath, 1923

Neocraspedites giganteus Imlay, n. sp.

Plate 32, figures 1–6

Desmoceras? sp. Stanton, 1895, U.S. Geol. Survey Bull. 133, p. 77, [1896].

Six specimens of this species were obtained from a locality near the top of the beds bearing *Buchia crassicollis* (Keyserling) in the Paskenta area, Tehama County, Calif.

On the smallest specimen (pl. 32, fig. 1) the whorl section is subovate and a little wider than high. On the other specimens the whorl section is subtrapezoidal and much higher than wide and attains its greatest thickness near the umbilical edge. The flanks on the smallest specimen are gently convex. On the larger specimens the flanks are flattened and converge slightly toward a broadly arched venter. The umbilicus is narrow. The umbilical wall on the smallest specimen is steeply inclined and rounds evenly into the flanks. On all larger specimens the umbilical wall is vertical and rounds abruptly into the flanks. The body chamber is unknown.

The ribbing on the smallest specimen (pl. 32, fig. 1) consists of strong primary ribs that incline forward to the lower third of the flanks, where about half of them bifurcate into higher, sharper secondary ribs. Other ribs arise simply along the zone of furcation. All secondary ribs curve backward slightly on the middle of the flanks and then curve forward strongly on the upper part of the flanks and on the venter. All ribs cross the venter, but some are slightly reduced in strength. Several very weak constrictions are present.

The ribbing on a somewhat larger specimen (pl. 32, fig. 4) is similar to that just described except that fewer ribs bifurcate on the lower third of the flanks and most ribs bifurcate a little above the middle of the flanks. The ribbing is distinctly stronger near the umbilicus and venter than on the middle of the flanks.

On a slightly larger specimen (pl. 32, fig. 2) the lower part of the flank bears about 18 primary ribs that are distinct near the umbilicus, but broaden and become indistinct near the middle of the flanks. The upper third of the flanks and the venter are marked by fine ribs that are closely spaced and forwardly curved and appear to arise in bundles from the primary ribs.

On the largest well-preserved specimen, which is the holotype (pl. 32, figs. 3, 5, 6), the rib pattern is similar. The primary ribs are rather weak but are still strongest near the umbilicus. They incline forward, broaden, and pass indistinctly near the middle of the flanks into numerous sharp secondary ribs that curve forward on the flanks and arch forward gently on the venter. The ribs attain their greatest strength on the venter.

The species probably attained a diameter at least three times as large as that of the holotype specimen as figured. The ventral part of that specimen was originally attached to parts of two outer whorls that are much crushed. The innermost of these two whorls is septate and bears ornamentation on its venter a little coarser than that on the figured holotype. The outermost whorl, represented only by the lower part of the flank, bears traces of broad, low primary ribs.

The suture line is imperfectly preserved and cannot be traced accurately.

The holotype of this species greatly resembles *Neocraspedites flexicosta* (Von Koenen) (1902, p. 74, pl. 5, figs. 14–16), from the late Valanginian of Germany. It appears to have slightly weaker primary ribs near the umbilicus and slightly stronger secondary ribs.

Types: Holotype USNM 23088; paratypes USNM 129833a, b, 129834.

Localities: USGS Mes. loc. 1009, 1087, 1088, and 1091.

Genus WELLSIA Imlay, 1957

This genus was originally defined (Imlay, 1957, p. 275) as follows:

Wellsia bears many resemblances to the genus *Neocraspedites* (Spath, 1923, p. 17) based on *Craspedites semilaevis* Von Koenen (1902, p. 80, pl. 5, figs. 8–10). It differs by its ribs being arched forward more strongly on the venter and somewhat reduced in strength along the midventral line, by its umbilical swellings disappearing at an earlier growth stage, by its venter being more narrowly rounded, and by its umbilicus being slightly smaller. The type species is designated as *Wellsia oregonensis* (Anderson) (1938, p. 159, pl. 30, fig. 5). The genus likewise includes *W. packardi* (Anderson) (1938, p. 164, pl. 31, figs. 2–5).

It is named in honor of Francis G. Wells of the U.S. Geological Survey in recognition of his important contributions to the geologic knowledge of Oregon and California.

Wellsia has been found only in Oregon in beds of early Hauterivian age directly overlying beds containing the pelecypod *Aucella crassicollis* Keyserling and the ammonites *Olcostephanus, Sarasinella,* and *Thurmanniceras.*

Wellsia oregonensis (Anderson)

Plate 32, figures 7–20

Dichotomites oregonensis Anderson, 1938, Geol. Soc. America, Spec. Paper 16, p. 159, pl. 30, fig. 5.

The species is represented in the collections of the Geological Survey by 40 specimens that show the various growth stages. The holotype is an immature specimen. Its description by Anderson is accurate except for failure to mention the presence of several weak constrictions on the internal mold. The larger specimens show that during growth the whorl shape changes from subtrapezoidal to subtrigonal; the ribbing fades first near the middle of the flanks, then near the umbilicus, and finally in the venter; and the point of rib branching rises during growth from a place near the middle of the flank to about two-thirds of the height of the flank and gradually becomes less distinct. As the ribbing fades the surface of the shell becomes marked by faint forwardly inclined striae that are not evident on the internal mold. On the adult body chamber (pl. 32, figs. 18–20) the ornamentation consists only of striae that are faintly visible under oblique lighting.

One feature described by Anderson is the weaking of the ribs along the midline of the venter. Such weakening is evident on all interal molds at all stages of growth. However, small specimens that bear some shelly material (pl. 32, fig. 9) do not show weakening of the ribs on the venter. Larger septate specimens that bear some shell material (pl. 32, figs. 12, 13) do show a little weakening of the ribs on the venter.

An incomplete body chamber, representing about two-thirds of a whorl, is present on the largest known specimen of *N. oregonensis* (pl. 32, figs. 18–20). The beginning of the body chamber is indicated by traces of the suture line at the point indicated on the illustration. The part of the body chamber nearest the aperture appears to be slightly retracted from the remainder of the shell, but this effect is probably related to a small fault induced by lateral compression.

The suture line of *W. oregonensis* (Anderson) could be traced only on an immature specimen at a diameter of 21 mm. It is characterized by slender symmetrical lobes and relatively broad saddles. The first lateral lobe is a little longer than the ventral lobe. The general plan of the suture line is similar to that of a small specimen of *Neocraspedites* figured by Von Koenen (1902, p. 6, fig. 18a, 19) but differs by having more auxiliary lobes on the flanks. The suture line also resembles that of *Homolsomites* except that the second lateral saddle is not nearly as wide as the first lateral saddle.

Immature specimens of *Wellsia oregonensis* (Anderson), such as the holotype, differ from *Neocraspedites stantoni* Imlay, n. sp., at a comparable size by having a smaller umbilicus, a more narrowly rounded venter, slightly weaker primary ribs, and less flexuous ribbing near the middle of the flanks. During growth the differences between the species become more conspicuous as *W. oregonensis* acquires a subtrigonal whorl section and loses most of its ribbing.

The immature specimens of *W. oregonensis* (Anderson) show considerable resemblance to small specimens of *Homolsomites stantoni* (McLellan), as figured by Imlay (1956, pl. 120, figs. 1–5) but differ by having weaker primary ribs that fade earlier, more secondary ribs for each primary rib, less distinct furcation points, weakening of the ribs on the venter, rib branching generally above rather than below the middle of the flanks, and a somewhat wider umbilicus. The adult specimens of *W. oregonensis* differ from those of *H. stantoni* by lacking ribs on the venter and by having a somewhat wider umbilicus.

The small septate specimens of *W. oregonensis* (Anderson) are similar in appearance to those of *Neocraspedites complanatus* (Von Koenen) (1902, pl. 6, figs. 18a, b) at a comparable size but differ by having a narrower venter and a smaller umbilicus.

All specimens of *W. oregonensis* (Anderson) have been collected in southwestern Oregon from siltstone and sandstone directly overlying sandy beds containing *Buchia crassicollis* (Keyserling). On Days Creek, Douglas County, the species has been collected from 58 to 243 feet above the top of the beds containing *B. crassicollis* (Keyserling).

Types: Holotype Calif. Acad. Sci. 8779; plesiotypes USNM 129675–129679.

Localities: USGS Mes. locs. 718, 905, 1243, 1252, 1823, 25198–25200, 25204, 25206, 25208, 25213, 26252.

Wellsia packardi (Anderson)

Plate 33, figures 26–31

Lyticoceras packardi Anderson, 1938, Geol. Soc. America Spec. Paper 16, p. 164, pl. 31, figs. 2, 5 [not 3 and 4].

This species is represented in the Geological Survey collections by 42 specimens. It differs from *W. oregonensis* (Anderson) by having thicker and more prominent ribs and by retaining those ribs to a much larger growth stage. As in *W. oregonensis* the ribs on internal molds arch forward strongly on the venter and weaken along the midventral line. This weakening varies considerably from one specimen to another and is least conspicuous wherever shell layers are preserved.

The suture line, drawn from an immature specimen, at a whorl height of 12 mm, is essentially the same as on *W. oregonensis* (Anderson), previously described.

Discussion: Among European species, *W. packardi* shows some resemblance to *Neocraspedites carteroni* (d'Orbigny) (1841, p. 209, pl. 61, figs. 1–3), from the lower Hauterivian of France. It differs by having a slightly smaller umbilicus, by the adult whorls lacking swollen primary ribs near the umbilical margin, by the ribs weakening along the midline of the venter, and by the venter being more narrowly rounded.

Anderson's assignment of *W. packardi* to the genus *Lyticoceras* is not tenable because *Lyticoceras* is evolute rather than involute and bears ventral tubercles during most of its growth, and because its ribbing does not fade out on the flanks. *W. packardi* shows much greater resemblance to the genus *Leopoldia* (d'Orbigny, 1942, pl. 23, pl. 25, figs. 3, 4; Baumberger, 1906, pls. 4–9 [in part]; Imlay, 1938, pl. 12, figs. 1–4), but it lacks a completely smooth midventral area and ventral tubercles, and its suture line does not have the unsymmetrical first lateral lobe that is characteristic of *Leopoldia*. Immature specimens of *W. packardi* (Anderson) bear a strong resemblance in rib pattern on both flanks and venter to *Leopoldia jodariensis* (R. Douville), as figured by Roman (1933, p. 12, pl. 1, figs. 4, 4a), but they have a smaller umbilicus and a more narrowly rounded venter and lack umbilical tubercles, and the midventral area is not entirely smooth. As the holotype of *L. jodariensis* has continuous ribs across the venter, according to Roman (1933, p. 12), it probably resembles *N. packardi* considerably more than the specimen figured by Roman.

Distribution: In a section measured in 1954 near Days Creek, Douglas County, Ore., *W. packardi* was found stratigraphically higher than *W. oregonensis* in a sequence from 253 to 313 feet above the top of beds containing *Buchia crassicollis* (Keyserling). Most of the specimens of *W. packardi* had undergone more crushing than the specimens of *W. oregonensis* and had weathered to a browner color. Older collections, made during the years from 1890 to 1900 from several hundred feet of beds exposed along Cow Creek near the town of Riddle, Douglas County, contain both species apparently associated. Examination of the collections USGS (Mes. locs. 718, 1243, and 1252) shows, however, that the specimens of *W. packardi* are more crushed than the specimens of *W. oregonensis* and weather much browner. These differences suggest, therefore, that the two species actually occur at slightly different stratigraphic positions, as they do on Days Creek.

Wellsia packardi has been found only in southwestern Oregon. Its absence in northern California probably has stratigraphic significance.

Types: Plesiotypes USNM 129666–129668; holotype, CAS 8738.

Localities: USGS Mes. locs. 718, 726, 1243, 1252, 3352, 3923, 25201, 25202, 25203, 25207.

Wellsia vigorosa Imlay, n. sp.

Plate 33, figures 19–22, 25

Lyticoceras packardi Anderson, 1938, Geol. Soc. America Spec. Paper 16, p. 164, pl. 31, figs. 3, 4 [not 2 and 5].

Four specimens in the survey collections greatly resemble the paratype of "*Lyticoceras*" *packardi* Anderson, which differs from the holotype of "*Lyticoceras*" *packardi* Anderson by having a less narrowly rounded venter, flatter flanks, and much more prominent ribs that are only slightly reduced in strength along the mid ventral line even on internal molds. Owing to the prominence of the ribbing on the venter, the chevronlike arrangement of the ribbing is much more conspicuous than in the holotype of *Wellsia packardi*. These differences seem great enough to justify assigning the four specimens as well as the paratype of *Lyticoceras packardi* to a new species.

W. vigorosa has been found only near the town of

Riddle, Ore. The specimens in the Geological Survey collections are from several hundred feet of beds that have furnished many specimens of *W. oregonensis* (Anderson) and of *W. packardi* (Anderson). The specimens weather to a dark brown, as do the specimens of *W. packardi*, and presumably come from the same beds as that species rather than from the beds containing *W. oregonensis*. It is possible, of course, that they are from a different stratigraphic position than either of those species.

Types: Holotype USNM 129669; paratypes, USNM 129670a, b.
Locality: USGS Mes. loc. 1252.

Genus HERTLEINITES Imlay, 1958

The genus was originally described (Imlay, 1957, p. 275) as *Hertleinia*, but as that name had been used previously (Marks, p. 457, 1949), it was changed to *Hertleinites* (1958, p. 1032). The original description is as follows:

This genus has a moderately compressed shell, subquadrate whorl section, and a moderately arched venter. The umbilicus widens during growth from fairly narrow to fairly wide. The umbilical wall is low and vertical. The ornamentation consists of strong primary ribs that curve backward on the umbilical wall, curve forward on the lower two-fifths of the flanks and then divide into two weaker secondary ribs that continue the forward inclination of the primary ribs. One, or both, secondary ribs of each pair bifurcate between the middle and the upper third of the flanks. A few ribs begin freely near the middle of the flanks. The ribs continue across the venter without diminution in strength and with a gentle forward arching. Many shallow constrictions occur on each whorl. The suture line is characterized by having long, rather slender lobes.

Neocraspedites aguila Anderson (1938, p. 156, pl. 25, figs. 1–3, pl. 68, fig. 4) is designated as the genotype species. The genus, also, includes *H. rectoris* (Anderson) (1938, p. 157, pl. 23, fig. 2) and *H. signalis* (Anderson) (1938, p. 157, pl. 26, fig. 1).

The genus is named in honor of Leo G. Hertlein of the California Academy of Sciences.

Hertleinia [now *Hertleinites*] is distinguished from *Neocraspedites* in which its species were placed by Anderson (1938, p. 156, 157) by its shell being much more evolute in the adult, by its ribs persisting on the middle of the flanks, and by its ribs arching forward much less strongly on the venter. *Hertleinia* differs from *Craspedodiscus* Spath (1924, p. 77) by becoming more evolute during growth, by its venter remaining moderately broad in the adult instead of becoming narrow, by retaining ribbing on its flanks in the adult, and by the ribs being much less strongly arched on the venter.

Hertleinia has been found only in California associated with species of *Hoplocrioceras* a few hundred feet above beds containing *Simbirskites* of middle Hauterivian age and many hundreds of feet below an occurrence of the Barremian ammonite *Pulchellia*. Its age is considered to be only slightly younger than that of *Simbirskites* and, therefore, late Hauterivian.

Such features of *Hertleinites* as degree of involution, rib pattern, and persistence of contrictions suggest that it is more closely related to *Craspedodiscus* than to *Neocraspedites*. It is placed accordingly in the Simbirskitinae rather than the Polyptychitinae, but its systematic position is not considered to be definitely established.

Hertleinites aguila (Anderson)

Plate 34, figures 1–7

Neocraspedites aguila Anderson, 1938, Geol. Soc. American Spec. Paper 16, p. 156, pl. 25, figs. 1–3, pl. 68, fig. 4.

Four specimens of this species are on hand. One of these (pl. 34, fig. 6) has a crushed outer whorl that is similar in size and appearance to the holotype and an inner whorl that is exceptionally well preserved.

This inner whorl at a diameter of 48 mm has a whorl height of 22 mm, a whorl thickness of 19 mm and an umbilical width of 11 mm. The whorls are subquadrate in section and embrace about three-fourths of the preceding whorls. The flanks are flattened below but round evenly above into a moderately arched venter. The umbilical wall is low and vertical and rounds abruptly into the flanks. The primary ribs are sharp and fairly widely spaced. They curve backward on the umbilical wall, incline forward gently on the flanks, and bifurcate at about two-fifths of the height of the flanks. Generally one rib of each pair of secondary ribs bifurcates again near the middle of the flanks. A few ribs arise freely near the middle of the flanks. The secondary ribs arch forward weakly on the venter. Secondary ribs outnumber the primary ribs a little more than 3 to 1. The whorl bears six weak constrictions.

The outer whorl of the specimen under discussion (pl. 34, fig. 6) compares in size with the outer whorl of the holotype (pl. 34, fig. 2). On these whorls the ribbing differs from that just described by the furcation points being less distinct and by most of the secondary ribs bifurcating at, or a little above, the middle of the flanks. The secondary ribs outnumber the primary ribs nearly 4 to 1. Weak constrictions are present.

On the outer whorl of a still larger specimen (pl. 34, figs. 1, 7), the zone of furcation of the primary ribs becomes still less distinct and furcation of the secondary ribs occurs between the middle and the upper three-fifths of the flanks. Secondary ribs outnumber the primary ribs more than 4 to 1. Several weak constrictions are present. The body chamber occupies about half of a whorl.

The dimensions of the holotype as listed by Anderson need correction. The greatest diameter is about 85 mm, the whorl height is about 42 mm, and the umbilical width is 41 mm. The holotype is so crushed that its thickness cannot be estimated.

The suture line, drawn from the specimen shown on plate 34, figure 7, at a whorl height of 46 mm, is characterized by long, slender lobes and saddles. The ventral lobe is the longest, and the other lobes are progressively shorter. The first lateral lobe is irregularly trifid.

The specimens that Stanton (1896, p. 18) identified as *Olcostephanus traski* (Gabb) during his fieldwork in California in 1893 and 1894 belong to *Neocraspedites aguila* Anderson. This mistake in identification was recognized by Stanton in 1900 when he examined the holotype of Gabb's species and is discussed herein under the description of *Simbirskites lecontei* (Anderson).

The holotype of *Neocraspedites rectoris* Anderson (1938, p. 157, pl. 23, fig. 2) (see this paper, pl. 40, figs. 8, 10) is comparable in size to the small whorl of *N. aguila* (pl. 34, fig. 6). It differs by having a stouter whorl section, stronger and fewer primary ribs, and about four secondary ribs for each primary rib.

Hertleinites aguila (Anderson) was assigned to *Neocraspedites* by Anderson (1938, p. 157) on the basis of its resemblance to *Craspedites tenuis* Von Koenen (1902, p. 76, pl. 6, figs. 1–3, pl. 13, figs. 1a, b), which Spath (1924, p. 76, 87) assigned to *Neocraspedites.* The resemblance is apt in regard to degree of involution, general rib pattern, and sutural pattern. *H. aguila* Anderson differs, however, by having a much stouter whorl section, a moderately instead of a narrowly rounded venter, a vertical instead of a steep umbilical wall, and by its ribbing remaining fairly strong on the flanks during growth instead of fading. *H. aguila* differs even more from other European species that have been assigned to *Neocraspedites* (Von Koenen, 1902, pl. 5, figs. 5–16, pl. 6, figs. 18, 19; d'Orbigny, 1942, pl. 61, figs. 1–3; Neumayr and Uhlig, 1881, pl. 26, fig. 2; Danford, 1906, pl. 10, fig. 1) by being much more evolute, by retaining ribbing on the middle of the flanks, by its ribs being weakly instead of strongly arched forward on the venter, and by the persistence of constrictions on adult whorls.

The fact that *Hertleinites aguila* (Anderson) resembles *N. tenuis* (Von Koenen) more than the other species of the genus may have stratigraphic significance, considering that *N. tenuis* is recorded (Von Koenen, 1902, p. 76, 418) as probably from the middle Hauterivian zone of *Craspedodiscus phillipsi*, whereas the other species are recorded from beds of middle Valanginian to early Hauterivian age (Von Koenen, 1902, p. 418). On the basis of stratigraphic position, *Hertleinites aguila* (Anderson) cannot be as old as the middle Hauterivian beds characterized by *Simbirskites* and is therefore younger than any of the European species of *Neocraspedites* except possibly *N. tenuis* (Von Koenen).

Hertleinites aguila, also shows resemblance in ribbing, coiling, and whorl shape to European species of the genus *Craspedodiscus* of middle to late Hauterivian age (Von Koenen, 1902, pl. 37, figs. 1, 2, pl. 38, fig. 4; Neumayr and Uhlig, 1881, pl. 15, figs. 7a–c; Weerth, 1884, pl. 4, figs. 2a, b, 3; Pavlow, A, 1901, pl. 3, figs. 2, pl. 4, figs. 2, 3, pl. 6, figs. 1a–d, pl. 7, figs. 2a–c, 3a–c). Small specimens of *Craspedodiscus* greatly resemble small specimens of the several species from California that Anderson assigned to *Neocraspedites*, except that their primary ribs generally terminate in tiny tubercles, the secondary ribs are more strongly arched on the venter, more secondary ribs arise freely on the flanks, and the whorls are generally more compressed. During growth the species of *Craspedodiscus* become more and more compressed, the venter becomes very narrowly rounded, the ribs disappear from the middle of the flanks and finally from the umbilical region, but the umbilicus remains narrow to fairly narrow. The change in whorl section of *C. discofalcatus* (Lahusen) from moderately compressed to strongly compressed, as illustrated by A. Pavlow (1892, pl. 18 (11), fig. 2b; 1901, pl. 6, fig. 1c), is in striking contrast to the whorl section of the species of *Hertleinites.*

Type: Holotype Calif. Acad. Sci. 8769; Plesiotypes, USNM 129654–129656.

Localities: USGS Mes. locs. 2222, 2223, 2225, 2267; CAS loc. 1353.

Hertleinites pecki Imlay, n. sp.

Plate 35, figures 1, 3–5, plate 43, figures 1–3

Two specimens of this species were obtained by Stanton (Mes. loc. 1092) on the eastern part of the Wilcox Ranch, Tehama County, Calif., at a position from 50 to 200 feet above the sandy beds containing *Buchia crassicollis* (Keyserling). Another specimen was obtained about 3 miles to the south and probably somewhat higher stratigraphically (U. C. Berkeley B–5089).

The holotype (pl. 35, figs. 4, 5) shows the features of two whorls. The inner whorl at a diameter of 82 mm has a whorl height of 39 mm, a whorl thickness of 31 mm, and an umbilical width of 18 mm. The whorl is subquadrate in section and embraces about three-fourths. The flanks are flatened. The venter is evenly rounded. The umbilicus is fairly narrow; its wall is low, vertical, and rounds abruptly into the flanks. The primary ribs are broad and fairly closely spaced. They curve backward on the umbilical wall, curve forward on the flanks, and bifurcate at about two-fifths of the height of the flanks into sharper secondary ribs. Generally one rib of each pair bifurcates again above the middle of the flanks. A few ribs arise freely near the middle of the flanks. Secondary ribs outnumber the primary ribs about 4 to 1. The ribs arch forward gently on the venter. Weak constrictions are present.

The outer whorl of the holotype is much crushed laterally but embraces about three-fifths of the preceding whorl. It bears moderately prominent primary ribs that curve backward on the umbilical wall, incline forward on the flank and bifurcate near the middle of the flanks. A few secondary ribs arise freely on the flanks, and some secondary ribs bifurate on the upper parts of the flanks. Secondary ribs outnumber the primary ribs about 3 to 1. On the venter all ribs arch forward weakly. Several weak constrictions are present.

A larger specimen associated with the holotype shows parts of two whorls. It is much worn, but reveals somewhat coarser ornamentation. As it is entirely septate and has an estimated diameter of 210 mm, the adult of the species must have been at least 300 mm in diameter. The suture line is similar to that of *Hertleinites aquila* (Anderson), differing mainly by the first lateral and external lobes being nearly equally long.

A specimen (pl. 43, figs. 1–3) in the University of California collections at Berkeley shows the last septate whorl and fragments of the body chamber. The septate part of the specimen is comparable in size and ornamentation to the holotype but appears to have a smaller umbilicus. This difference is due mainly to deformation of the specimens and is not considered to be of specific importance.

Compared with *Hertleinites aquila* (Anderson), this species is more compressed, its flanks are flatter, its umbilicus is smaller on its inner whorls, and its ribbing is weaker and denser on its inner whorls but sparser on its outer whorls. Compared with "*Neocraspedites*" *signalis* Anderson (1938, p. 157, pl. 26, fig. 1), this species has a narrower umbilicus, flatter flanks, and much sharper secondary ribs. Its inner whorls compared with the holotype of *H. rectoris* (Anderson) (1938, p. 157, pl. 23, fig. 2) are more compressed, bear finer ribbing, and have fewer secondary ribs per primary rib.

This species is named in honor of Joseph H. Peck, Jr., of the University of California at Berkeley.

Types: Holotype USNM 129835; paratype, USNM 130023; paratype, U. C. Berkeley 12120.
Localities: USGS Mes. loc. 1092. U. S. Berkeley loc. B–5089.

Genus SIMBIRSKITES Pavlow, 1891

Simbirskites broadi (Anderson)

Plate 33, figures 16–18

Simbirskites broadi Anderson [part], 1938, Geol. Soc. America Spec. Paper 16, p. 155, pl. 22, figs. 2, 3, not pl. 28, figs. 1, 1A.
?*Subastieria chanchelula* Anderson, 1938, idem, p. 156, pl. 22, figs. 4, 5.

The original description of the holotype is accurate, except for the statement concerning the lateral tubercles. These arise near the top of the lower third of the flanks instead of near the middle. Also, the ribs arch forward gently on the venter.

The specimen that Anderson figured as a paratype of *S. broadi* on his plate 28, figures 1, 1a (see this paper, pl. 33, figs. 1, 14, 15) is much more compressed than the holotype and has weaker tuberculation. It more likely represents an immature stage of *Simbirskites lecontei* (Anderson) (1938, p. 154, pl. 22, fig. 1, pl. 23, fig. 1). However, the specimen that Anderson named *Subastieria chanchelula* (see this paper, pl. 33, figs. 23, 24) compares very closely in whorl shape and ornamentation with the inner whorls of *S. broadi* and probably represents an immature stage of that species. These probabilities are strengthened by the fact that all the specimens in question were obtained from a single locality.

S. broadi was compared by Anderson (1938, p. 155) with *S. decheni* Pavlow [not Roemer] (A. Pavlow, 1892, pl. 18, (11), figs. 4–6; Spath, 1924, p. 77) from England. Both species have a similarly depressed whorl section, but *S. broadi* has finer, denser ribbing. Some specimens of *Simbirskites* from Russia described by A. Pavlow (1901, p. 69, pl. 1, figs. 4–6) as *S. decheni* Lahusen have ribbing that is only a little coarser than on *S. broadi*.

Type: Holotype Calif. Acad. Sci. 8784.
Locality: Calif. Acad. Sci. loc. 113.

Simbirskites lecontei (Anderson)

Plate 33, figures 1, 14, 15

Polyptychites lecontei Anderson, 1938, Geol. Soc. America Spec. Paper 16, p. 154, pl. 22, fig. 1, pl. 23, fig. 1.
Simbirskites broadi Anderson [part], 1938, idem, pl. 28, figs. 1, 1A, [not pl. 22, figs. 2, 3].

Anderson says that tubercles are not present on the type specimens of *P. lecontei*, but examination of his specimens shows that small tubercles are present at the ends of the primary ribs at about one-third of the height of the flanks. They are visible, also, on the original illustration of the paratype (Anderson, 1938, pl. 23, fig. 1).

The small ammonite that Anderson (1938, pl. 28, figs. 1, 1A) assigned to his species *Simbirskites broadi* has a compressed whorl shape much more similar to that of *S. lecontei* (Anderson) than to that of the holotype of *S. broadi* (Anderson). Its identification definitely with *S. lecontei* must await the discovery of other specimens of intermediate sizes.

The assignment of *S. lecontei* (Anderson) to *Simbirskites* rather than *Polyptychites* is based on rib branching by threes and fours from tubercles that arise a little below the middle of the flanks from prominent primary ribs. On *Polyptychites* the tubercles are situated at or near the umbilicus, and rib branching commonly occurs at several different heights on the flanks.

Among European species, *S. inverselobatus* (Neumayr and Uhlig) (1881, p. 19, pl. 17, figs. 1, 1a) compares with *S. lecontei* (Anderson) in degree of involution, whorl shape, and strong forward curvature of the ribbing on its flanks, but appears to have somewhat sparser ribbing.

"*Ammonites*" *traski* (Gabb) (1864, p. 63, pl. 11, fig. 10, pl. 12, fig. 11) was considered by Anderson (1938, p. 154, 155) to be similar to his species "*Polyptychites*" *lecontei* Anderson. Similarities include the suture lines, subcircular whorls that embrace about one-half of the preceding whorls, mode of rib branching, shape of umbilicus, and probably umbilical tubercles. In his original description, Gabb does not mention the presence of tubercles on *Ammonites traski*, but later (1869, p. 137) he mentions that the Late Cretaceous *Ammonites fraternus* Gabb "is nearly a miniature of *A. traski*, in general appearance * * *." As *A. fraternus* (equals *Canadoceras fraternum*) bears prominent tubercles, it seems probable that the holotype of *A. traski* also was tuberculate.

In particular the characteristics of the suture line of "*A.*" *traski* Gabb (1864, pl. 12, fig. 11) confirm the close relationship of that species with "*Polyptychites*" *lecontei* (Anderson) and show that the similar appearing "*Neocraspedites*" *aguila* Anderson (1938, pl. 25, fig. 2, pl. 68, fig. 4) is not closely related.

Bearing on the identity of *Ammonites traski* (Gabb) is a statement that T. W. Stanton made in his notebook on September 24, 1900, after examining the holotype of that species. He said, "Saw the figured type of *Amm. traskii* Gabb and found it very different from the Horsetown form I have been identifying with it."

The specimens that Stanton had been identifying with *Ammonites traski* Gabb are herein identified with "*Neocraspedites*" *aguila* Anderson. This species differs from the holotype of *A. traski* (Gabb) (1864, pl. 11, fig. 10), as illustrated, by having a slightly compressed instead of a subcircular whorl section, by its whorls embracing three-fifths instead of one-half of the preceding whorls, and by having many more primary ribs on whorls of comparable size.

Although Anderson maintains that "*Ammonites*" *traski* Gabb is a distinct species from "*Polyptychites*" *lecontei* Anderson, his reasons for separating them are not made clear. As the holotype of *A. traski* was destroyed in the San Francisco fire of 1906, the specific identity of that species may never be firmly established. The evidence discussed above indicates, however, that *A. traski* Gabb belongs in the same genus as *Simbirskites lecontei* (Anderson) and is possibly identical.

Types: Holotype Calif. Acad. Sci. 8762; paratype, Calif. Acad. Sci. 8763.
Locality: Calif. Acad. Sci. loc. 113.

Simbirskites sp. juv. aff. S. elatus (Trautschold)

Plate 33, figures 10, 11

One small specimen has a broadly depressed whorl similar to that of the innermost whorl of the holotype of *Simbirskites broadi* Anderson (see pl. 33, fig. 16) but differs by developing bifurcating ribs. The smallest part of the specimen has trifurcating ribs, but adorally bifurcating ribs become more common. A crushed fragment of a still larger whorl of the same ammonite shows that bifurcation continues as the dominant mode of rib branching. Prominent tubercles occur at about two-fifths of the height of the flanks.

This small specimen resembles the immature specimens of *S. decheni* (Lahusen) as figured by A. Pavlow (1901, pl. 1, figs. 6a, b) but differs by developing bifurcating ribs. It is likewise similar to an immature specimen from Speeton, England, that A. Pavlow (1892, pl. 18(11), fig. 5; 1901, p. 68) assigns to *Simbirskites elatus* (Trautschold), but differs by having considerably denser ribbing. It is similar to *S. elatus*, however, in the development of bifurcating ribs after an early stage in which trifurcating ribs predominate.

Figured specimen: USNM 129680.
Locality: USGS Mes. loc. 1251.

Simbirskites sp. juv. aff. S. progrediens (Lahusen)

Plate 33, figures 2, 3, 8, 9

Eight fragments from one locality in Oregon resemble immature specimens of *S. progrediens* (Lahusen) as figured by A. Pavlow (1892, pl. 18(11), fig. 15; 1901, pl. 2, figs. 5c, d). Their ornamentation is possibly a little sharper than that of *S. progrediens* and in that respect they show some resemblance to *S. concinnus* Phillips, as figured by A. Pavlow (1891, pl. 18(11), fig. 16). That species, however, develops rib furcation by twos, whereas on the Oregon specimen furcation occurs mostly by threes.

Figured specimens: USNM 129681.
Locality: USGS Mes. loc. 25211 (equals 24449).

Simbirskites spp. juv.

Plate 33, figures 4–7, 12, 13

Associated with the coarsely ribbed specimens referred to *Simbirskites* sp. juv. aff. *progrediens* (Lahusen), shown on plate 33, figures 2, 3, 8, 9, are many other immature ammonites that appear to belong to the same genus, but they differ by being much finer ribbed. These can be arranged roughly into three groups based on fineness of ribbing and number of secondary ribs. All three groups have the same shape, the same general rib pattern, and numerous constrictions. In the group with the coarsest ribbing, the secondary ribs arise in pairs from prominent tubercles at the ventral ends of the primary ribs. A few ribs arise singly low on the flanks or are indistinctly connected with a tubercle. In the group with next finest ribbing, secondary ribs arise mostly in pairs from the lateral tubercles, but some arise in threes and many ribs arise freely low on the flanks. In the group with finest ribbing, most secondary ribs arise by threes from very weak lateral tubercles, and most bundles of ribs are separated by a single rib that begins low on the flank.

On the basis of the material on hand, it is impossible to be certain whether these three groups are distinct species or are merely variants of a single species. They are illustrated to show that considerable variation may occur in *Simbirskites* at a single locality.

Figured specimens: USNM 129682.

Genus HOLLISITES Imlay, 1957

The original description of this genus (Imlay, 1957, p. 276) is as follows:

This genus has a stout to fairly stout shell, moderately evolute coiling, regular bifurcating ribs on its inner whorls, virgatoid ribs on its outer whorls, and a suture line characterized by a fairly wide first lateral lobe. *H. lucasi* Imlay, n. sp., is designated as the genotype.

Immature specimens of *Hollisites* have perisphinctoid ribbing similar to that on small specimens of the genus *Speetoniceras* (Spath, 1924, p. 76) from England (Danford, 1906, pl. 12, fig. 3) and Russia (M. Pavlow, 1886, pl. 1, figs. 4, 5; A. Pavlow, 1892, pl. 15(8), figs. 3a–c; pl. 18(11), figs. 12, 14), differing mainly by losing their lateral tubercles at a very small size. Adult specimens of *Hollisites* differ from the adults of *Speetoniceras* (M. Pavlow, 1886, pl. 1, fig. 1, pl. 2, figs. 1a, b; A. Pavlow, 1892, pl. 18(11), fig. 13a; Karakasch, 1907, pl. 13, fig. 4a) by being more involute, by acquiring weaker, denser, virgatoid ribbing, and by lacking tubercles at the points of rib furcation. The branching of the ribs at various heights above and below the middle of the flanks is in striking contrast to the regular bifurcation of the ribs on the adults of *Speetoniceras*.

Among Eurasian species *Hollisites* probably includes "*Simbirskites*" *auerbachi* Eichwald (1868, p. 1092, pl. 34, figs. 9c–d; Karakasch, 1907, p. 130, pl. 13, figs. 1a, b, 5a, b, pl. 24, figs. 30, 31) from the Crimea and "*Perisphinctes*" *koeneni* Neumayr and Uhlig (1881, p. 18, pl. 21, figs. 1, 1a) from Germany.

Hollisites is named in honor of Hollis M. Dole, State Geologist of Oregon.

Hollisites has been found in Oregon associated with the ammonite *Simbirskites* of middle Hauterivian age. In California it occurs with, or slightly below, *Hertleinites aguila* (Anderson) of late Hauterivian age. The large fragment named *Polyptychites hesperius* Anderson (1938, p. 154, pl. 24, figs. 1, 2) probably belongs to *Hollisites* and was found at the same locality as *Simbirskites broadi* Anderson (1938, p. 155, pl. 22, figs. 2, 3). Judging from these occurrences, *Hollisites* is of middle to late Hauterivian age.

Immature specimens of *Hollisites* may be distinguished from *Thurmanniceras* of similar size by their convex instead of flattened venter, by their ribs arching forward on the venter instead of crossing the venter transversely, and by their many shallow constrictions.

Adult specimens of *Hollisites* show some resemblances in rib pattern to adult specimens of *Hertleinites* but differ by having stouter whorls, more evolute coiling, much stronger and sparser ribbing, and a broader first lateral lobe. Immature specimens of the two genera differ in many respects, as shown on plate 38, figures 1–10 and plate 40, figures 8, 10.

Hollisites lucasi Imlay

Plate 35, figure 2; plate 36; plate 38, figures 2, 5; plate 37, figures 1, 2, 11–13

Hollisites lucasi Imlay, 1957, Jour. Wash. Acad. Sci., v. 47, no. 8, p. 276, figs. 1, 2.

The original description of this species is as follows:

The holotype is entirely septate and the body chamber is unknown. At the beginning of the outermost whorl of the holotype the whorl section is ovate and as wide as high. At the adoral end the whorl is a little wider than high. The outer whorl embraces about half of the preceeding whorl. The flanks are gently convex and the venter is evenly rounded. The umbilicus is moderate in width and fairly shallow. The umbilical wall is vertical, fairly low, and rounds abruptly into the flanks.

The ribbing on a small specimen and on the inner whorls of a paratype is perisphinctoid. The primary ribs curve backward on the umbilical wall, incline forward on the flanks, and bifurcate regularly at the middle of the flanks. The secondary ribs incline forward more strongly than the primary ribs and arch forward gently on the venter. The furcation points are swollen but not tuberculate. Toward the adoral end the ribbing tends to become flexuous and at two places is virgatomous. Constrictions are common.

The ribbing on the outer whorl of the paratype, just mentioned, and on the holotype is mostly virgatomous. The primary ribs bifurcate at about two-fifths of the height of the flank and then the posterior rib of each pair of secondary ribs bifurcates again at about three-fifths of the height of the flanks. The secondary ribs are appreciably weaker than the primary ribs, are inclined forward more strongly on the flanks, and arch forward gently on the venter. Eight constrictions occur on half a whorl. Toward the adoral end of the holotype more of the secondary ribs bifurcate above the middle of the flank and some secondary ribs arise freely near the middle of the flanks.

The holotype at a diameter of 170 mm has a whorl height of 67 mm, a whorl thickness of 69 mm, and an umbilical width of 58 mm.

The suture line greatly resembles that of *Hertleinites aguila* Anderson (1938, pl. 25, fig. 2, pl. 68, fig. 4) in general plan. It differs mainly by having a broader first lateral lobe.

H. lucasi Imlay, n. sp., greatly resembles "*Simbirskites*" *auerbachi* Eichwald (Karakasch, 1907, p. 130, pl. 13, figs. 1a, b, 5a, b) from the Crimea in plan of ribbing and in suture line. It differs by having more virgatomous ribs and a somewhat broader venter. Its rib pattern is similar to that of "*Perisphinctes*" *koeneni* Neumayr and Uhlig (1881, p. 18, pl. 21, figs. 1, 1a) from Germany, but it differs by having much stouter whorls and broader sutural lobes.

Hollisites lucasi Imlay, n. sp. is named for Larry Lucas of Agness, Oreg., who collected the holotype specimen on the south side of the Rogue River 1½ miles below Agness, Curry County, Oreg. Its age is probably middle Hauterivian because from the same general location have been found specimens of *Hannaites riddlensis* (Anderson), *Simbirskites?*, and *Hoplocrioceras*. The paratypes were obtained at USGS Mesozoic locality 1092 in association with, or just below, *Hertleinia* [=*Hertleinites*] *aguila* (Anderson) which is considered to be of late Hauterivian age.

Types: Plastoholotype, USNM 129045; paratypes, USNM 129044. The holotype specimen is the property of Larry Lucas at Agness, Oreg.

Localities: USGS Mes. loc. 1092, 26450, and questionably at 25214.

Hollisites dichotomus Imlay, n. sp.

Plate 38, figures 6, 7

This species is represented by one internal mold of a medium-sized specimen that probably is not an adult. The whorls are subquadrate in section, a little higher than wide, and embrace about two-fifths of the preceding whorl. The flanks are flattened below and round evenly above into a gently convex venter. The umbilicus is fairly wide, the umbilical wall is low and vertical, and the umbilical edge is abruptly rounded. The body chamber is represented on the holotype by half a whorl but is incomplete.

The ribbing of the inner whorls of the holotype, as exposed in the umbilicus, consist of fine moderately spaced primary ribs that are radial on the umbilical wall, incline forward on the lower half of the flanks, and divide into two secondary ribs at, or just below, the umbilical seam. Several weak constrictions are present. On the largest whorl of the holotype the ribs branch a little above the middle of the flanks and the furcation points are merely swollen.

The holotype at a diameter of 38 mm has an umbilical width of 12 mm, a whorl height of 14 mm, and a probable whorl width of 12 mm.

This species greatly resembles the immature specimen of "*Simbirskites*" *auerbachi* (Eichwald) figured by Karakasch (1907, pl. 13, figs. 1a, b) from the Crimea. It differs apparently by its ribs bifurcating slightly higher on the flanks. *Speetoniceras inversum* (A. Pavlow (1892, p. 508, pl. 18 (11), figs. 14a, b) from England has much coarser ribbing and a more rounded whorl section. The ribbing on *H. dichotomus* Imlay is similar to that on the specimens of *H. lucasi* Imlay at a comparable size, but differs by being coarser, more widely spaced, and more strongly arched forward on the venter.

Type: Holotype, USNM 129659.

Locality: USGS Mes. loc. 1251.

Hollisites sp. juv. cf. H. dichotomus Imlay, n. sp.

Plate 38, figures 3–5, 8–10

Nine external molds of immature specimens bear ribbing similar to that exposed in the umbilicus of *H. dichotomus* Imlay, n. sp., and possibly belong to that species.

The whorls are ovate in section and broader than high. They are smooth to a diameter of about 7 mm. Then ribbing appears abruptly and becomes fairly strong in one-fourth of a whorl. The primary ribs begin singly low on the umbilical wall, trend radially to the umbilical edge and incline forward nearly straight to the middle of the flanks, where most of them divide into two slightly weaker secondary ribs. The latter arch forward strongly on the upper part of the flanks and on the venter and are not reduced in strength along the midventral line. Weak tubercles are present at the points of rib furcation. Several weak constrictions are present.

Figured specimen: USNM 129657.

Locality: USGS Mes. loc. 2078.

Hollisites inflatus Imlay, n. sp.

Plate 37, figures 1, 3, 4, 6

The species is represented by 1 specimen consisting of parts of 3 septate whorls. The whorls are ovate in section and broader than high and become more depressed during growth. The flanks round evenly into a broadly convex venter. The umbilicus is moderate in width. The umbilical wall is low and vertical at base and rounds rather abruptly into the flanks. The body chamber is unknown.

The ribs are strong, incline forward gently on the flanks, and arch forward slightly on the venter. On the smallest known whorl the primary ribs bifurcate near the middle of the flanks into slightly weaker secondary ribs. The furcation points are swollen, but not tuberculate. On the next larger whorl, rib branching occurs by threes and twos just below the middle of the flanks, and the primary ribs are appreciably stronger than the secondary ribs. The next larger whorl is not well enough preserved to show the secondary ribs, but does show prominent primary ribs that curve backward on the umbilical wall and incline forward on the flanks. Constrictions are numerous and pronounced.

The suture line is only partly preserved but appears to be essentially the same as in *H. lucasi* Imlay.

The smaller whorl of *H. inflatus* Imlay, n. sp., may be compared with *Speentoniceras subinversus* (A. Pavlow) (1892, pl. 18 (11), figs. 13a, b), from Speeton, England. It differs by having finer denser ribbing and a more depressed whorl section and by lacking tubercles at the ends of the primary ribs.

The fragment of a large ammonite that was named *Polyptychites hesperius* Anderson (1938, p. 154, pl. 24, figs. 1, 2) possibly belongs to the genus *Hollisites*, as it shows some resemblances both to *H. inflatus* Imlay, n. sp., and to *H. lucasi* Imlay. It appears to differ from both species by its primary ribs being strongly swollen near the umbilicus and branching mostly on the lower fifth to fourth of the flanks. Some ribs bifurcate again near the middle of the flanks, and some arise singly low or near the middle of the flanks.

H. inflatus differs from *H. lucasi* by having a much wider whorl section and stronger, sparser ribbing.

Type: Holotype USNM 129839.
Locality: USGS Mes. loc. 1092.

Genus SPEETONICERAS Spath, 1924

Speetoniceras agnessense Imlay, n. sp.

Plate 42, figures 6, 9, 10, 15, 17

Only one specimen of this species is known. It shows parts of four whorls including the adoral end of the body chamber. The whorls are depressed ovate in section, wider than high, and embrace about two-fifths of the preceding whorl. The flanks and venter are gently convex. The umbilicus is fairly wide, the umbilical wall is low and vertical, and the umbilical shoulder is evenly rounded. The body chamber is incomplete at its adapical end, but includes at least two-fifths of a whorl.

The two inner whorls, shown in the umbilicus, bear strong, widely spaced, forwardly inclined primary ribs that begin low on the umbilical wall and terminate ventrally in tubercles at the line of involution of the succeeding whorl. The penultimate whorl bears sharp, moderately spaced primary ribs that incline forward on the lower two-fifths of the flanks and terminate in weak radially elongate tubercles. From these arise pairs of sharp secondary ribs that trend radially near the middle of the flanks and then strongly forward on the upper part of the flanks and on the venter. On the body chamber the ribbing becomes much stronger and sparser. The primary ribs are swollen at the furcation points, which become lower adorally. The last three ribs bordering the aperture are a little higher than the others and do not fork at all. The secondary ribs arch forward considerably on the venter without reduction in strength.

The holotype at its anterior end has a whorl height of 20.5 mm and a whorl width of 22 mm measured in the interspaces. The penultimate whorl has a whorl height of 12.5 mm and a whorl width of 15 mm. The body whorl has an umbilical width of 23 mm at an estimated diameter of 60 mm. The suture line is not well preserved.

This species is characterized by a marked increase in the coarseness of its ribbing between the penultimate and body whorls. It is distinguished from most species of *Speetoniceras* by having finer ribbing on its inner whorls and by being less evolute. Probably the most similar species is *S. subinversum* (M. Pavlow) as figured by A. Pavlow (1892, p. 507, pl. 18 (11), figs 12a, b, 13a, b) from Speeton, England. The Oregon species is readily distinguished, however, by the finer ribbing of its inner whorls.

S. agnessense Imlay, n. sp., is assigned to *Speetoniceras* rather than to *Hollisites* because of the persistence of its lateral tubercles and by the development of high, sharp, widely spaced ribs that bifurcate regularly below the middle of the flank.

Type: Holotype USNM 129658.
Locality: USGS Mes. loc. 26879.

Genus NEOCOMITES Uhlig, 1905

Neocomites? cf. N. indicus Uhlig

Plate 41, figures 2, 6

Two fragmentary ammonites have characteristics similar to those of *N. indicus* Uhlig (1910, p. 262–264, pl. 89, figs. 3–6), from the Valanginian of India. On the smaller specimen (pl. 41, fig. 2) the outer whorl embraces about one-third the preceding whorl. The umbilical wall is vertical. The flanks are flattened in their lower half but converge above toward the venter. The venter is narrow and flattened. The ribs begin at the line of involution, incline backward on the umbilical wall, and pass into tubercles of varying prominence on the umbilical edge. On the flanks the ribs are high, thin, slightly flexuous, and forwardly inclined. They arise from the umbilical tubercles singly or in pairs. Commonly the bundles of paired ribs are separated by 1 or 2 single ribs. About two-thirds of the ribs bifurcate on the flanks at heights varying from just below to a little above the middle. Near the anterior end of the specimens, bundling of the ribs at the umbilicus becomes more common. All ribs terminate ventrally in blunt tubercles that bound a smooth midventral area. No lateral tubercles are evident. Constrictions are fairly common.

The larger specimen (pl. 41, fig. 6) shows bundling of the ribs at prominent umbilical tubercles. Between successive bundles occur from 1 to 3 single ribs that are merely swollen at the umbilical edge. Rib branching on the flanks is not evident.

These specimens from Oregon resemble *N. indicus* Uhlig in their high narrow ribs, the bundling of the ribs at umbilical tubercles, and the presence of constrictions. The venter is not sufficiently exposed to show if the cross section is wedge shaped as in *N. indicus* or is elliptical. Another Indian species, *N. theodorii* (Oppel) (Uhlig, 1910, p. 260–262, pl. 89, figs. 1, 2), is likewise similar but has finer ribbing and less frequent rib bundling at the umbilicus.

Both these Indian species were referred questionably by Spath (1939, p. 76, 78, pl. 14, figs. 7a, b) to his genus *Parandiceras* (1939, p. 76), from which they differ by their ribs being more flexuous and irregularly branched on the flanks and rather commonly arising in pairs from umbilical tubercles. Spath (1939, p. 77) considers both species as intermediate in character between *Parandiceras* and *Calliptychoceras* Spath (1924, p. 88; Uhlig, 1910, p. 251, pl. 87, figs. 2a–c). The species of *Calliptychoceras* (Uhlig, 1910, p. 250–255, pl. 86, figs. 1, 2, pl. 87, figs. 1–4, pl. 90, figs. 3, 7) possess bundled ribs at the umbilicus, as in the specimens from Oregon, but differ from them by having an oblique instead of a vertical umbilical wall, somewhat weaker ribbing that tends to weaken even more on the body chamber, and weaker lateral tubercles on the adult whorl.

The Oregon specimens herein compared to *Neocomites indicus* Uhlig likewise show a general resemblance in shape and ribbing to *Sarasinella trezanensis* Lory (Sayn, 1907, p. 34, pl. 3, figs. 25a, b; Baumberger, 1923, p. 307, pl. 8, figs. 2–4), from the middle Valanginian of France and Switzerland, but lack lateral tubercles on their inner whorls.

Figured specimen: USNM 129858.
Localities: USGS Mes. locs. 2117, 2119, Oregon.

Genus THURMANNICERAS Cossmann, 1901

Thurmanniceras californicum (Stanton)

Plate 39, figures 11–15

Desmoceras californicum Stanton, 1895, U.S. Geol. Survey Bull. 133, p. 76, 77, pl. 15, figs. 6, 7 [1896].

The original description and illustrations of this species are fairly accurate but do not depict all the features that can be seen on the type specimens. As mentioned by Stanton, there are three unfigured fragments that probably belong to the same individual ammonite as the figured holotype. Illustrations of these clearly show that the species belongs in the Neocomitinae. In particular, the largest fragment (pl. 39, figs. 11, 13), which is part of the body chamber, resembles the largest whorls of *Thurmanniceras novihispanicum* (Imlay) (1937, pl. 78, fig. 8, pl. 79, fig. 6), from the Valanginian of eastern Mexico. The smaller fragments (pl. 39, figs. 12, 14, 15) greatly resemble *Thurmanniceras pertransiens* (Sayn), as figured by Leanza (1945, p. 64, pl. 10, figs. 5–7) from the Valanginian of Argentina.

Most of the specimens from southern France that Sayn (1907, p. 43, 44, pl. 4, fig. 14, pl. 5, figs. 10–11, 15–17) described under the name of *T. pertransiens* are too small for comparisons, but the largest specimen illustrated by Sayn on his plate 5, figure 10, certainly bears a strong resemblance to the specimens from Argentina and to the smaller specimens of *T. californicum* (Stanton). All these specimens have a similar evolute form, elliptical whorl shape, numerous forwardly inclined constrictions, and fine, dense, forwardly inclined ribbing that during growth tends to fade out on the lower and middle parts of the flanks. As a result the furcation, points of the ribs are rather indistinct on the body whorl and the penultimate whorl.

On the California specimens the furcation of ribs on the upper third of the flanks can be observed at only a few places. The secondary ribs outnumber the primary ribs more than 2 to 1 and arise either freely, or are indistinctly connected with the primary ribs along a zone a little above the middle of the flanks. The ribs are weakly swollen on the edge of the umbilicus and are slightly reduced in strength on the venter. The whorl section becomes subtrapezoidal on the body chamber.

On the basis of the material on hand, *T. californicum* (Stanton) appears to differ from *T. pertransiens* (Sayn), from France, by being more evolute and by having finer ribbing. The specimens from Argentina assigned to *T. pertransiens* by Leanza are closer to *T. californicum* in these respects than to the types of *T. pertransiens* from France and could very well belong to the same species, as *T. californicum.* Such an identification must await the finding in California of additional specimens showing the early growth stages of *T. californicum.*

Associated with the holotype of *T. californicum* (Stanton) is a small specimen that Stanton (1895, p. 17 [1896]) referred to *Hoplites dilleri* Stanton. It belongs to *Thurmanniceras*, however, and probably is an immature representative of *T. californicum.*

Type: Holotype USNM 23087.
Locality: USGS Mes. loc. 1001.

Thurmanniceras wilcoxi (Anderson)

Plate 40, figures 3–5

Neocraspedites wilcoxi Anderson, 1938, Geol. Soc. America Spec. Paper 16, p. 158, pl. 26, fig. 2, pl. 27, fig. 4.

Anderson failed to mention in his original description that the dorsum of the inner whorl of the holotype bears an imprint of a flattened venter which is bordered on both sides by single rows of weak tubercles. (See pl. 40, fig. 3.) The presence of such a venter bars an assignment to *Neocraspedites*, but favors an assignment to the Neocomitidae. In fact, the lateral appearance and the character of the ribbing is rather similar to that of *Thurmanniceras californicum* (Stanton) (illustrated herein on pl. 39, fig. 15). The species are distinguishable easily, however, by their whorl sections, which on *T. californicum* is elliptical and compressed and on *T. wilcoxi* is subquadrate and stout.

The holotype of *T. wilcoxi* (Anderson) was obtained in shales in the eastern part of the Wilcox Ranch well above the standy beds containing *Buchia crassicollis* (Keyserling), according to Anderson (1938, p. 158). It seems improbable, however, that the holotype was obtained as high stratigraphically as the specimen (Mes. loc. 2267) of "*Neocraspedites*" *aquila* Anderson (see pl. 34, fig. 6) that Stanton obtained on the same ranch 400 to 500 feet above the beds containing *Buchia crassicollis* (Keyserling).

Type: Holotype Calif. Acad. Sci. 8771.

Thurmanniceras jenkinsi (Anderson)

Plate 40, figures 1, 2, 6, 7, 9

Neocomites jenkinsi Anderson, 1938, Geol. Soc. America Spec. Paper 16, p. 165, pl. 29, fig. 1.

?*Neocomites neocomiensis* Anderson, 1938, idem, p. 166, pl. 83, figs. 2, 2a.

The collections of the Geological Survey contain three specimens that are definitely assigned to this species. In addition, 9 immature or fragmentary specimens from Mesozoic locality 1091 (equals 2266) and 1 from Mesozoic locality 1093 probably belong to the species. The three largest specimens, including the holotype, are much crushed laterally, but probably had a shape similar to that of the smaller specimen shown on plate 40, figures 1, 2.

This specimen has a stout whorl section, about two-thirds as wide as high. Its whorls overlap about one-half. Its umbilicus is moderate in width, and its umbilical wall is inclined. It bears lateral tubercles on an inner whorl exposed in the umbilicus. It also bears ventral tubercles bordering a smooth midventral area at diameters less than 27 mm. At diameters greater than 27 mm, the ribs cross the venter transversely with slight weakening. Tubercles are not present on the three larger specimens.

All the specimens have the same kind of fairly thick low closely spaced fasciculate ribs. The ribs all begin singly, low on the umbilical wall, are faintly swollen at the edge of the umbilicus, are rather strongly flexuous on the flanks, and cross the venter transversely with only slight reduction in strength along the midventral line. A few of the ribs bifurcate between the lower third and the middle of the flanks. More than half of the ribs bifurcate between the middle and the upper third of the flanks. About one-third of the ribs do not bifurcate. On the internal mold the ribs appear to be fine, but where the shell is preserved they are a little wider than the interspaces. All ribs become wider ventrally. A number of weak constrictions occur on each whorl, and are strongest on the inner whorl of the smallest specimen. The suture line, as preserved on a plaster replica of the holotype, has a slender, trifid, symmetrical first lateral lobe.

This species is placed in *Thurmanniceras* rather than *Neocomites* because it lacks umbilical tubercles, has an oblique instead of a vertical umbilical wall, has a gently rounded rather than a truncated venter, except on immature specimens, does not have rib furcation at the umbilical edge, does have rib bifurcation mostly above the middle of the flanks, does not have a smooth midventral area except at a very small size, and does have constrictions even on large, adult whorls. The presence of a slender, symmetrical first lateral lobe shows that it does not belong to *Lyticoceras*.

Among foreign species the most similar are *Thurmanniceras duraznense* (Gerth) (1925, p. 97, pl. 4, figs. 1, 1a) and *T. discoidalis* (Gerth) (1925, p. 18, pl. 5, figs. 3, 3a), from the Berriasian of Argentina (Leanza, 1945, p. 65–67, table opposite p. 96). Of these, *T. discoidalis* is most similar to *T. jenkinsi* (Anderson), differing mainly by having coarser, sparser ribbing. Both of the Argentine species, as illustrated by Gerth, have a smooth midventral area, but Leanza (1945, p. 66) says that this feature is confined to the internal mold and that wherever the shell is preserved on the venter, the ribs are not interrupted but only weakened.

Another Argentine species with fasciculate ribbing similar to *T. jenkinsi* is *Neocomites wichmanni* Leanza (1945, p. 61, pl. 12, figs. 2, 3), from the lower to middle Valanginian. This species, however, has umbilical and ventral tubercles, a truncated venter, and a smooth midventral area.

Among species of *Thurmanniceras* from California, the most similar is *T. californicum* (Stanton), redescribed herein, which is more evolute, has much coarser primary ribs, fewer secondary ribs, and much less distinct bifurcation points.

Another similar species is "*Neocomites*" *praeneocomiensis* Burckhardt (1912, p. 193, 194, pl. 45, figs. 14, 16–18, 20–23), from the Berriasian of eastern Durango, Mexico. The holotype of this species, compared with *T. jenkinsi* at a similar size (pl. 40, fig. 6), differs by being more involute and by having sharper, less flexuous ribbing. As in *T. jenkinsi* the lack of umbilical and ventral tubercles, the oblique umbilical wall, and the continuation of ribs across the venter suggest generic reference to *Thurmanniceras*, or perhaps *Subthurmannia*, rather than *Neocomites*.

T. jenkinsi is recorded by Anderson (1933, p. 322; 1938, p. 165) from California Academy Science locality 33502 (equals 2398 of Anderson) on McCarthy Creek, Tehama County, at a stratigraphic position stated to be about 2,400 feet above the base of the Cretaceous. The associated species according to Anderson include *Thurmannia paskentae* Anderson (1938, p. 162), *Subastieria chanchelula* Anderson (1938, p. 156), and *Berriasella crassiplicata* (Stanton) (Anderson, 1938, p. 164).

The specimen that Anderson assigned to *Subastieria* is herein referred to *Polyptychites* (pl. 31, fig. 14). The specimen described as *Thurmannia paskentae* Anderson is possibly an immature example of *Thurmanniceras stippi* (Anderson). The specimen referred to *Berriasella crassiplicata* (Stanton) is a small fragment of a whorl of *Kilianella*. It is not the same as the specimen of *Kilianella crassiplicata* (Stanton) figured by Anderson (1938, pl. 83, figs. 3, 4) and cannot be identified specifically.

Types: Holotype, Calif. Acad. Sci. 8775. Plesiotypes, USNM 23223, 129859, 129860.

Localities: USGS Mes. locs. 1088, 1091, 2154; CAS loc. 33502.

Thurmanniceras stippi (Anderson)

Plate 39, figures 1–5, 8–10

Neocomites stippi Anderson, 1938, Geol. Soc. America Spec. Paper 16, p. 166, pl. 29, fig. 2.

Three specimens of this species have been found in southwestern Oregon. The coiling is fairly evolute. The whorls are subquadrate in section, wider than high. The flanks are nearly flat. The venter is narrow, flattened in the young and gently convex in the adult. The umbilical wall is low and steep. Only the beginning of the body chamber is preserved.

The immature whorls, exposed in the umbilicus (pl. 39, figs. 4, 10), have high, sharp, slightly flexuous *Kilianella*-like ribs of which all begin singly at the umbilicus. Some bifurcate at or near the line of involution and are swollen at the furcation points. During growth, bifurcation of the ribs just above the middle of the flanks becomes rather common.

On the penultimate whorl (pl. 39, figs. 5, 8, 9) the ribs begin singly at the umbilicus, about two-thirds of them bifurcate above the middle of the flanks, and all terminate ventrally in elongate tubercles that are weakly connected across the venter.

On the septate part of the body whorl and on the body chamber, the ribs are thick, closely spaced, and gently flexuous. They all begin singly near the umbilicus and are swollen at the umbilical edge; a few bifurcate indistinctly low on the flanks, and about two-thirds of them bifurcate above the middle of the flanks. The ribs are very thick and slightly swollen at the edge of the venter and are only slightly reduced along the midventral line. Several weak constrictions are present.

The suture line on the holotype (Anderson, 1938, pl. 29, fig. 2) has a long, slender, trifid first lateral lobe, which shows clearly that the species does not belong to *Lyticoceras*.

The immature specimen that Anderson (1938, p. 162, pl. 29, figs. 3–6) named *Thurmannia paskentae* has ribbing similar to the inner whorls of *T. stippi* Anderson and possibly belongs to that species. Its reference to *Thurmanniceras* Cossmann (replacing *Thurmannia* and *Thurmannites* of authors) rather than *Neocomites* is justified by the presence of constrictions, the lack of umbilical tubercles, the lack of rib branching at the umbilical edge, the uniform bifurcation of ribs a little above the middle of the flanks, and the presence of swellings at the furcation points.

For the same reasons, *Neocomites stippi* Anderson is herein assigned to *Thurmanniceras*, but that species in addition develops a venter on its outer two whorls that resembles *Thurmanniceras* rather than *Neocomites*. Its venter during growth becomes slightly convex instead of truncated, and its ribs are only slightly weakened on the venter instead of being terminated by a smooth midventral area.

Anderson (1938, p. 166) records *Thurmanniceras stippi* from the south bank of McCarthy Creek in his zone M which he says is about 1,300 feet above the base of the Cretaceous sequence and about 1,000 feet below the beds containing "*Neocomites*" *jenkinsi* Anderson.

Types: Plesiotypes USNM 129836, 129837a, b. Holotype, Calif. Acad. Sci. 10465.

Localities: USGS Mes. locs. 1091, 2154, and 25216; CAS loc. 144.

Genus HANNAITES Imlay, 1957

The original description of this genus (Imlay, 1957, p. 275) is as follows:

> *Hannaites* is characterized by fairly tight coiling of whorls of small to medium size; a compressed, subquadrate whorl section; a truncated venter; a vertical umbilical wall; flexuous ribs that tend to fade out on the lower parts of the flanks; strong forwardly arched ribs on the venter; backwardly inclined umbilical tubercles; spirally elongated ventral tubercles at the ventral shoulder; a body chamber that tends to retract from the remainder of the shell; many shallow constrictions; appreciable variation in the strength of ribs and tubercles; and a fairly short, narrow, slightly asymmetrical first lateral lobe.

The type species is *Hannaites riddlensis* (Anderson) (1938, p. 167, pl. 30, figs. 1–4).

Hannaites greatly resembles *Leopoldia* (Baumberger, 1906, p. 28–47) in lateral view, but differs by having a flatter venter, sharply defined ventral shoulders, continuous strong ribbing across the venter, considerable variation in the strength of its ornamentation, the presence of constrictions in adults, and the tendency of its body chamber to become scaphitoid. Also, the suture line appears to have a much narrower first lateral lobe than that of *Leopoldia*.

Hannaites is named in honor of G. Gallas Hanna of the California Academy of Sciences.

Hannaites has to date been found only in Oregon in beds of early to middle Hauterivian age.

Hannaites riddlensis (Anderson)

Plate 41, figures 5, 7–16

Neocomites riddlensis Anderson, 1938, Geol. Soc America Spec. Paper 16, p. 167, pl. 30, figs. 1–4.

Six specimens of this species in the Geological Survey collections have furnished much data concerning its characteristics. The shell is compressed, much higher than wide, subquadrate in section. The flanks and venter are flattened, but the venter becomes less flattened during growth. The inner whorls are strongly involute and the body whorl tends to become scaphitoid. The umbilicus is narrow, except on the body whorl, its wall is fairly low and vertical, its edge is abruptly rounded.

The smallest available specimen (pl. 41, figs. 10, 11) at a whorl height of 5 mm bears straight, low forwardly inclined primary ribs of variable strength. Some of them divide into two equally strong secondary ribs near the middle of the flanks. A few secondary ribs arise freely on the upper part of the flanks. All ribs terminate on the ventral shoulder in tubercles of variable strength which are connected across the venter by broad low ribs that are as strong as the ribs on the flanks. Two shallow constrictions are present.

The next larger size, represented by the small specimen illustrated by Anderson (1938, pl. 30, fig. 4), is fairly smooth on the lower part of the flanks and has weak ribs on the upper part of the flanks that terminate in small tubercles bordering a flattened, nearly smooth venter.

A little larger specimen (pl. 41, figs. 14, 15) is very similar in shape and ornamentation to small specimens of *Leopoldia* such as *L. flexuosa* Imlay (1938, pl. 11, figs. 5, 6) except for the presence of ribbing across the venter. The umbilical edge bears backwardly inclined nodes that become strong during growth. From these arise faint, forwardly inclined striae that become stronger ventrally, recurve near the middle of the flanks, and then pass a little above the middle into thick forwardly inclined ribs. These terminate on the ventral shoulder in prominent, spirally elongated tubercles. The tubercles are connected across a slightly convex venter by broad, forwardly arched ribs that are nearly as strong as the flank ribs. The ribs and the tubercles are slightly variable in strength. Several shallow constrictions are present.

Still larger specimens have been illustrated by Anderson (1938, pl. 30, figs. 1–3). These show the same features as just described, but have even stronger constrictions and more variable ribbing.

An even larger specimen (pl. 41, figs. 5, 12, 13, 16), probably an adult, shows traces of tightly coiled, weakly ribbed inner whorls in its umbilicus but consists mostly of a body chamber more than half a whorl in length. This body chamber is marked by fairly strong backwardly inclined umbilical nodes from which arise 1 or 2 low, weak ribs that incline gently forward on the flanks. Other weak ribs arise low on the flanks. A little above the middle of the flanks all these recurve slightly and pass into stronger ribs that may remain single or may bifurcate. All these ribs terminate on the ventral shoulder in weak spirally elongate tubercles that are connected across the venter by gently arched ribs that are not reduced in strength. Both ribs and tubercles vary somewhat in strength. A number of constrictions are present.

The suture line can be seen on one specimen (pl. 41, figs. 14, 15) but cannot be traced in detail. The first lateral lobe is moderately slender and slightly asymmetrical, and its inner branch is more strongly developed than its outer branch. It is not nearly as stout, or as asymmetrical, as the first lateral lobe of *Leopoldia* (Baumberger, 1906, p. 43, fig. 25) on a specimen of comparable size.

Hannaites riddlensis was compared by Anderson (1938, p. 167) with *Neocomites montanus* (Uhlig), from the Valanginian of India, but the latter is much less involute, has stronger ribbing on the lower part of its flanks, and has a smooth midventral area. *N. neocomiensiformis* Uhlig (1902, p. 54, pl. 3, figs. 1, 2) from the Carpathian Mountains has ribbing on the flanks similar to that of *H. riddlensis* but differs in the same manner as *N. montanus*.

H. riddlensis resembles species of the genus *Leopoldia* (Baumberger, 1906, p. 28–47, pls. 4–10 [in part]) much more than *Neocomites* in such features as its strongly embracing whorls, the tendency for its ribbing to be faint on the lower part of the flanks and the spiral elongation of its ventral tubercles. For example, the specimen shown on plate 41, figures 14, 15, greatly resembles some immature specimens of *Leopoldia* from Mexico (Imlay, 1938, pl. 11, figs. 5, 6, pl. 12, figs. 1–4). *H. riddlensis* differs, however, from all described species of *Leopoldia* by having a sharply defined ventral shoulder, continuous strong ribbing across the venter, and a more slender first lateral lobe.

Type: Plesiotypes USNM 129850–129853.
Localities: USGS Mes. locs. 1243, 1252, 2093, 25199, 25202, and 25212.

Hannaites truncatus Imlay, n. sp.

Plate 41, figures 1, 3, 4

Only the adoral end of the body chamber of this species is known. The whorl section is subquadrate. It is 34 mm high and 20 mm thick. The flanks are flattened below, and inclined gently above to a moderately narrow, nearly flat, distinctly shouldered venter. The umbilical wall is vertical, and its edge is rather sharp. From weak tubercles on the edge of the umbilical wall arise 1 or 2 faint ribs that incline forward on the flanks, recurve near the middle of the flanks, and pass into 1, or 2 much stronger, narrower ribs on the upper third of the flanks. These ribs at the umbilical shoulder bear low, spirally elongated tubercles that are continued weakly across the interspaces between the ribs. The tubercles are also connected across the venter by thick ribs that arch forward and are a little stronger than the flank ribs. The rib nearest the aperture is much stronger on the flanks than the other ribs, is preceded by a constriction, and is followed by a sinuous margin that probably represents the margin of the aperture.

H. truncatus is easily distinguished from *H. riddlensis* (Anderson) by having much coarser, sparser ribbing, and a more compressed whorl section.

Type: Holotype USNM 129840.
Locality: USGS Mes. loc. 25198.

Genus KILIANELLA Uhlig, 1905

Kilianella crassiplicata (Stanton)

Plate 42, figures 1–5, 7

Hoplites crassiplicatus Stanton, 1895, U.S. Geol. Survey Bull. 133, p. 81–82, pl. 18, fig. 8, [1896].
Berriasella cf. B. crassiplicata 1938 (Stanton). Anderson, Geol. Soc. America Spec. Paper 16, p. 163, 164, pl. 83, figs. 3, 4.

This species is represented in the Geological Survey collections by 2 specimens that show parts of 2 whorls. The whorls are compressed, higher than wide and are probably only slightly distorted. The outer whorl embraces about one-fourth of the preceding whorl. The body chamber is incomplete, but includes about one-fifth of the outer whorl.

The inner whorl bears six pronounced constrictions. Its primary ribs are prominent, fairly closely spaced, and nearly radial. They start at the umbilicus, become high and narrow as they pass over the umbilical wall, and generally bifurcate at, or just below, the line of involution with the outer whorl. The bifurcation points are marked by blunt swellings.

On the outer whorl the contrictions are less pronounced. The primary ribs trend radially across the lower three-fifths of the flanks, then recurve backward, and then sharply forward. On the septate part of the whorl a secondary rib arises from the anterior side of each primary rib at the point where the primary rib curves backward. On the body chamber the secondary ribs are indistinctly joined with the primary ribs and at least one secondary rib arises freely below the middle of the flanks. All ribs terminate ventrally in elongated swellings of variable strength that incline forward and bound a smooth midventral area.

The suture line is rather simple. The ventral lobe is a little longer than the first lateral lobe, which is stocky and slightly asymmetrical. The auxiliary lobes descend abruptly toward the umbilical seam.

Stanton's illustration of the holotype is fairly accurate, but he failed to note that the ribs are swollen ventrally and at the furcation points, or that constrictions are present. These omissions probably misled Uhlig (1910, p. 171), who assigned the specimen questionably to *Thurmannia* (now *Thurmanniceras*). *Kilianella crassiplicata* (Stanton) actually bears considerable resemblance to some of the specimens of *K. roubaudi* (d'Orbigny) as figured by Sayn (1907, p. 47, pl. 6, figs. 9, 10a, b). It appears to have flatter flanks and a higher whorl section. The similarly compressed *K. leptosoma* Uhlig (1910, p. 232, pl. 82, figs. 3a, b), from India, has finer and more flexuous ribs. *K. pexiptychus* Uhlig (1902, p. 41, pl. 4, figs. 4–7; 1910, p. 229, pl. 82, figs. 2a–c) has more flexuous ribs that bifurcate lower on the flanks and has a stouter whorl section.

Types: Holotype USNM 23094; plesiotype USNM 129684.
Localities: USGS Mes. locs. 1001 and 5339.

Kilianella cf. K. besairiei Spath

Plate 42, figure 8

One specimen bears unforked ribs similar to, but weaker than, those on *K. besairiei* Spath (1939, p. 96, pl. 16, figs. 4a, b, 5a–c; Besairie, 1936, p. 138, pl. 24, fig. 13). The ribs are gently flexuous, are sharp on the lower part of the flanks and broaden ventrally. Some become very broad on the upper part of the flanks. One constriction is present. The venter is not preserved.

This specimen was mentioned by Lawson (1914, p. 8) and Anderson (1938, p. 53).

Figured specimen: USNM 129683.
Locality: USGS Mes. loc. 26404.

Genus SARASINELLA Uhlig, 1905

Sarasinella densicostata Imlay, n. sp.

Plate 42, figure 25

One laterally crushed specimen is characterized by fine, dense ribs that rarely bifurcate on the flanks. The shell is fairly evolute. The inner whorls are poorly preserved but show the presence of sharp, closely spaced trituberculate ribs that incline slightly forward. Nearly half of the outer whorl belongs to the body chamber, which is mainly complete. The ribs on the outer whorl are sharp, closely spaced, and gently flexuous. About half of them arise singly from weak elongate umbilical tubercules and the remainder arise by twos or threes from slightly stronger umbilical tubercules. On the septate part of the outer whorl, 1 rib in 4 bifurcates on the upper part of the flank. On the body chamber only two ribs bifurcate high on the flanks. The points of furcation are slightly swollen but not tuberculate. All ribs incline forward on the edge of the venter and terminate in elongate tubercles. Weak constrictions are present on the inner whorls and on the septate part of the outer whorl. The ribs near the anterior end of the body chamber bend forward in a manner suggestive of the base of a lateral lappet.

The suture line is poorly preserved.

The ribs on the outer whorl are as closely spaced as on *S. hyatti* (Stanton) at a comparable size but are sharper and rarely fork on the flanks. None of the described European or Asiatic species have nearly as fine and dense ribbing.

Type: Holotype USNM 129855.
Locality: USGS Mes. loc. 2154.

Sarasinella cf. S. subspinosa (Uhlig)

Plate 42, figure 16

Two crushed specimens from a single locality in southwestern Oregon resemble *S. subspinosa* (Uhlig) (1910, p. 239, pl. 90, figs. 4a–c) in most particulars. The inner whorls of the smaller specimen bear constrictions and sharp, rather widely spaced trituberculate ribs. Some of the ribs are simple, and others fork high on the flanks. The forked ribs bear rather strong tubercles at the furcation points, wherease the simple ribs generally bear weak tubercles along the zone of furcation. The ventral terminations of the ribs are swollen, incline forward, and border a smooth midventral area. On the largest whorls of the same specimen, the umbilical tubercles are strong and give rise to pairs of flexuous ribs of which one generally forks fairly high on the flanks and is slightly swollen at the furcation point.

The larger specimen bears ornamentation similar to that on the outer whorl of the smaller specimen. Most ribs arise in pairs from prominent umbilical tubercles, nearly half bifurcate high on the flank, all are strongly flexuous, and all bend forward sharply at the edge of the venter where they are strongly swollen. The midventral area is marked by weak continuations of the ribs. Several constrictions are present.

The smaller specimen very much resembles a specimen figured by Spath (1939, p. 100, pl. 16, figs. 2a, b) and has much sparser ribbing than *S. angulata* (Stanton), described herein. The larger specimen may be compared with the outer whorl of the holotype of *S. subspinosa* (Uhlig) (1910, p. 239, pl. 90, figs. 4a–c). It differs by its ribs rising more commonly in pairs from the umbilical tubercles, by having more forked ribs on the flanks, and by lacking a smooth midventral area. The bundling of ribs at the umbilical tubercles is similar to that on the much larger outer whorl of *S. varians* (Uhlig) (1910, p. 238, pl. 81, figs. 3a–d). The Oregon specimens probably represent a distinct species but should not be given a name until better material is available.

Figured specimen: USNM 129856a, b.
Locality: USGS Mes. loc. 2154.

Sarasinella hyatti (Stanton)

Plate 42, figures 19–24

Hoplites hyatti Stanton, 1895, U.S. Geol. Survey Bull. 133, p. 79, pl. 16, fig. 2 [1896].

This species is represented by the holotype, which shows a complete body chamber, by another fragment of a body chamber, and by 3 smaller specimens of which 2 (pl. 42, figs. 19, 24) are considered to be micromorphs. One of these has a well-developed lateral lappet and is probably an adult. The other shows the base of a lateral lappet.

All the specimens are more or less crushed. Allowing for crushing, the whorls are subquadrate in section and a little higher than wide and embrace about two-fifths of the preceding whorl. The flanks are flattened below and converge above to a moderately narrow, nearly flat venter. The umbilicus is fairly wide; its wall is low and vertical. The body chamber occupies slightly more than half a whorl.

On the small specimens the septate whorls have high thin ribs that incline backward on the umbilical wall, incline forward on the lower part of the flanks, recurve just above the middle, and then incline forward to the venter. Most of the ribs bifurcate at or a little above the middle of the flanks. A few ribs arise above the middle of the flanks. The ribs are swollen at the edge of the umbilicus are swollen to weakly tuberculate at the bifurcation points on the flanks and bear distinct ventral tubercles. The venter is smooth on the internal molds and is crossed by weak continuations of the ribs wherever the shell is preserved. On each whorl 4 to 6 weak constrictions occur.

The inner whorls of the holotype, partly exposed in the umbilicus, bear closely spaced sharp ribs that incline forward and bear three rows of weak, persistent tubercles. The penultimate whorl bears fine, closely spaced gently flexuous ribs that begin at weak umbilical swellings and terminate ventrally in slightly stronger swellings that incline forward. About half of the ribs remain single, and half bifurcate at about three-fifths of the height of the flanks. The midventral area is marked by weak continuations of the ribs.

At the beginning of the body chamber, the ribbing changes considerably. The umbilical swellings become more pronounced and give rise to pairs of thick flexuous ribs, of which one or both bifurcate on the upper part of the flanks. Toward the aperture the ribs become broader, lower, and more distantly spaced. Weak constrictions are visible on the penultimate whorl and on the posterior part of the body chamber. One constriction occurs at the adoral end of the body chamber preceding a pronounced lateral lappet.

The suture line is too poorly preserved to be reproduced or described.

The body chamber of *S. hyatti* (Stanton) is similar to that of *S. cautleyi* (Oppel), figured by Uhlig (1910, p. 242, pl. 84, figs. 2a–c), but its penultimate whorl has finer more flexuous ribs that branch more frequently on the flanks and that do not arise in bundles from prominent umbilical tubercles. *S. campylotoxus* (Uhlig) (1902, p. 49, pl. 4, figs. 1–3; Sayn, 1907, pl. 5, figs. 12) likewise has a similar body chamber but is distinguished from *S. hyatti* by coarser, sparser ribbing and more pronounced umbilical and ventral tubercles. *S. ambigua* (Uhlig) (1902, p. 45, pl. 6, figs. 3–6) is more involute than *S. hyatti*, has sparser ribbing, and more single ribs.

Type: Holotype USNM 23091; plesiotypes USNM 129842–129844.
Locality: USGS Mes. locs. 2107, 2136, 4384, 4386, and 26405.

Sarasinella angulata (Stanton)

Plate 42, figures 11–14

Hoplites angulatus Stanton, 1895 U.S. Geol. Survey Bull. 133, p. 80, 81, pl. 18, figs. 3, 4 [1896].

The original description failed to mention the presence of constrictions or of lateral nodes. These are well shown on the holotype in its umbilicus and near the beginning of its outer whorl. On most of the outer whorl, the furcation points of the ribs near the middle of the flanks are marked only by swellings. All the tubercles are variable in strength within the rows. The ventral tubercles are more uniform in strength than the others and become more so during growth. The lateral and umbilical tubercles are generally much stronger on every second or third rib than on the intervening ribs. On the outer septate whorl of the type specimens, the prominent umbilical tubercles generally mark the union of 2 lateral ribs, of which 1 remains single and 1 bifurcates at or above the middle of the flank.

The suture line cannot be accurately traced.

S. angulata (Stanton) is closely similar in dimensions and ornamentation to *S. trezanensis* (Sayn) (1907, p. 34, 35, pl. 3, figs. 20, 25a, b, pl. 4, fig. 15), from the middle Valanginian of France but appears to have slightly coarser and denser ribbing.

Type: Holotype USNM 23093; plesiotype USNM 129660.
Locality: USGS Mes. locs. 1093 and 4393.

Genus ACANTHODISCUS Uhlig, 1905

Acanthodiscus sp. juv. aff. A. subradiatus Uhlig

Plate 42, figure 18

One small external mold from Oregon is 28 mm in diameter and has an umbilical width of 12 mm. The outer whorl overlaps about two-fifths of the preceding whorl. The inner whorls exposed in the umbilicus bear sharp forwardly inclined primary ribs that terminate in prominent lateral tubercles along the line of involution. The outermost whorl bears about 33 sharp primary ribs that begin at the edge of the umbilicus, are slightly swollen on the umbilical wall, incline forward gently on the flanks, and terminate a little above the middle of the flanks in more or less prominent conical tubercles. From most of these tubercles arise 2, or less commonly 3, broad secondary ribs that incline forward sharply and terminate ventrally in conical tubercles. At a few lateral tubercles only single secondary ribs arise. The union of the secondary ribs with the tubercles becomes indistinct anteriorly on the outer whorl. The presence of ventral tubercles can be observed at only one place near the anterior end of the specimen.

This small *Acanthodiscus* from Oregon is difficult to compare with the large adult specimens of the genus that have been described. It shows considerable resemblance, however, to an immature specimen from India (Uhlig, 1910, p. 214, pl. 26, figs. 3a–c) that is about one whorl larger and has attained slightly sparser and coarser ribbing. Both of these specimens resemble *A. subradiatus* Uhlig (1910, p. 208, pl. 23, figs. 1a, b, pl. 26, fig. 1), from the Valanginian of India, in their large number of primary ribs, their small number of secondary ribs, and the appearance of trituberculation at a small size. They are differentiated readily by this combination of characters from the described European species of *Acanthodiscus*. (See Neumayr and Uhlig, 1881, p. 165–166, pl. 34, figs. 2, 3, pl. 55, fig. 2; Baumberger, 1906, p. 8–28, pls. 14–18 [in part].)

Figured specimen: USNM 129685.
Locality: USGS Mes. loc. 2154.

Genus SPITIDISCUS Kilian, 1910

Spitidiscus oregonensis Imlay, n. sp.

Plate 31, figures 4–6, 8, 9

The shell is small, compressed, and moderately involute but becomes less involute during growth. The whorls are elliptical in section, higher than wide, and embrace about three-fifths of the preceding whorl. The flanks are weakly convex. The venter is highly arched. The umbilicus is moderately narrow; the umbilical wall is low and vertical and rounds abruptly into the flanks.

The ornamentation consists of 5 or 6 weak, flexuous constrictions and of many low flexuous ribs. Most ribs begin weakly on the umbilical wall. Others arise at various heights on the flanks either freely or indistinctly united with longer ribs. All incline forward on the lower part of the flanks, curve forward more strongly on the upper parts of the flanks, and arch forward gently on the venter. They become broader and a little stronger ventrally and vary somewhat in strength on the venter. Tubercles are not present.

The holotype at a diameter of 28 mm has a whorl height of 13 mm, an estimated whorl thickness of 10 mm, and an umbilical width of 6 mm. The paratype (pl. 31, figs. 4–6) has a whorl height of 15 mm and a whorl thickness of 12 mm. Both specimens have been compressed a little laterally.

This species is similar in shape and ornamentation to *Spitidiscus intermedius* (d'Orbigny) (1841, p. 128, pl. 38, figs. 5, 6; Kilian, 1907, p. 265, pl. 5, fig. 7), from the Hauterivian of France, but has weaker constrictions and ribbing and is probably more involute.

Types: Holotype USNM 129697; paratype USNM 129698.
Localities: USGS Mes. loc. 718 and 25211.

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INDEX

[Italic numbers indicate descriptions]

PLATES 24–43

PLATE 24

[All figures natural size]

FIGURES 1–4, 8, 9, 11, 12. *Hoplocrioceras remondi* (Gabb) (p. 196).

1–4. Ventral and lateral views of plesiotypes, USNM 129664a, b from USGS Mes. loc. 2225.

8. Plesiotype, USNM 129662 from USGS Mes. loc. 1062. Specimen crushed laterally.

9, 12. Plesiotype, UCLA type collection from UCLA loc. 2816. Shows nearly complete adult body chamber.

11. Plesiotype, USNM 129661 from USGS Mes. loc. 2268. Shows change from fine, dense ribbing of inner whorls to coarser, variably-spaced ribbing of outer whorls.

5, 6. *Hoplocrioceras* cf. *H. remondi* (Gabb) (p. 197).

Lateral and ventral views of specimen, USNM 129665 from USGS Mes. loc. 2080.

7, 10. *Acrioceras* cf. *A. voyanum* Anderson (p. 199).

Lateral and ventral views of specimen, USNM 129663 from USGS Mes. loc. 2269.

HOPLOCRIOCERAS

HOPLOCRIOCERAS, ANAHAMULINA, HYPOPHYLLOCERAS, AND *SHASTICRIOCERAS*

PLATE 25

[All figures natural size unless otherwise indicated]

FIGURES 1, 3, 8, 9. *Hoplocrioceras duncanense* (Anderson) (p. 198).
1, 3. Plesiotype, USNM 129674 from USGS Mes. loc. 2224.
8, 9. Holotype, CAS 8810 from CAS loc. 1665. Note presence of lateral tubercles.

2, 5, 6. *Anahamulina wilcoxensis* Imlay, n. sp. (p. 200).
Suture line (× 2), ventral and lateral views of holotype, USNM 129671 from USGS Mes. loc. 1092.

4. *Hypophylloceras* aff. *H. onoense* (Stanton) (p. 195).
Specimen, USNM 129672 from USGS Mes. loc. 2223.

7, 10. *Shasticrioceras* aff. *S. whitneyi* Anderson (p. 198).
Ventral and lateral views of specimen, USNM 129673 from USGS Mes. loc. 2225.

PLATE 26

[All figures natural size]

FIGURES 1, 5. *Crioceratites* sp. indet. (p. 196).
Lateral and ventral views of specimen, USNM 23101 from USGS Mes. loc. 1009. Proves occurrence of the genus in beds of Valanginian age.

2–4. *Acrioceras voyanum* Anderson (p. 198).
2, 3. Lateral and ventral views of internal mold of plesiotype, USNM 129862 from USGS Mes. loc. 24449.
4. Lateral view of rubber cast from external mold of same specimen shown in figs. 2 and 3.

6, 7. *Crioceratites latus* (Gabb) (p. 196).
Ventral and lateral views of holotype of *Crioceras duncanense* Anderson, CAS 8873 from CAS loc. 1665. This specimen is considered herein to be an immature representative of *Crioceratites latus* (Gabb).

8–10. *Acrioceras hamlini* (Anderson) (p. 199).
Lateral and ventral views of holotype, CAS 8879 from CAS loc. 113.

11–14. *Acrioceras vespertinum* (Anderson) (p. 199).
Lateral and ventral views of holotype, CAS 8915 from CAS loc. 113.

CRIOCERATITES AND *ACRIOCERAS*

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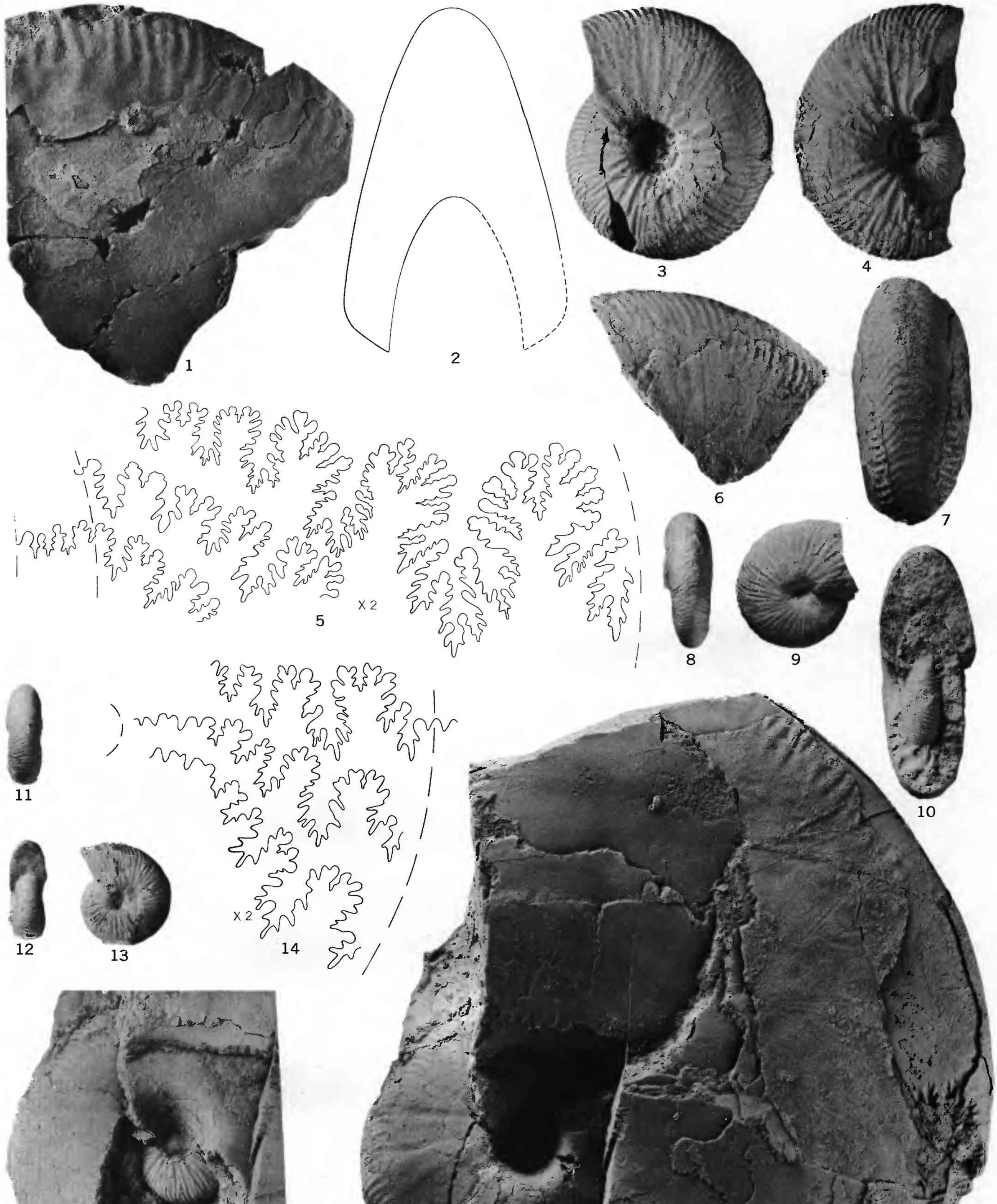


HOMOLSOMITES

PLATE 27

[All figures natural size unless otherwise indicated]

FIGURES 1–16. *Homolsomites stantoni* (McLellan) (p. 201).

1, 2, 5. Suture line (×2), cross section, and lateral view of adapical end of body chamber of a large specimen, University Washington 12763 from U.W. loc. WA535.

6, 7. Lateral and ventral views of part of penultimate whorl of same specimen shown in figure 1.

3, 4, 10. Lateral and cross sectional views of plesiotype, USNM 129696 from U.W. loc. WA 536.

8, 9. Ventral and lateral views of paratype, U.W. 15002 from north shore of Spieden Island, Wash.

11–13. Ventral, apertural, and lateral views of holotype, U.W. 15001 from north shore of Spieden Island, Wash.

14–16. Suture line (×2) at whorl height of 28 mm on specimen shown in figs. 15 and 16. Fig. 15 shows coarse ornamentation of inner whorl comparable to that shown on figs. 4 and 9. Fig. 16 shows about one-quarter of the adult body whorl. Another half whorl of the body chamber is preserved, but is not shown because it is crushed and is similar to the part illustrated. Plesiotype, USNM 129695 from USGS Mes. loc. 26788.

PLATE 28

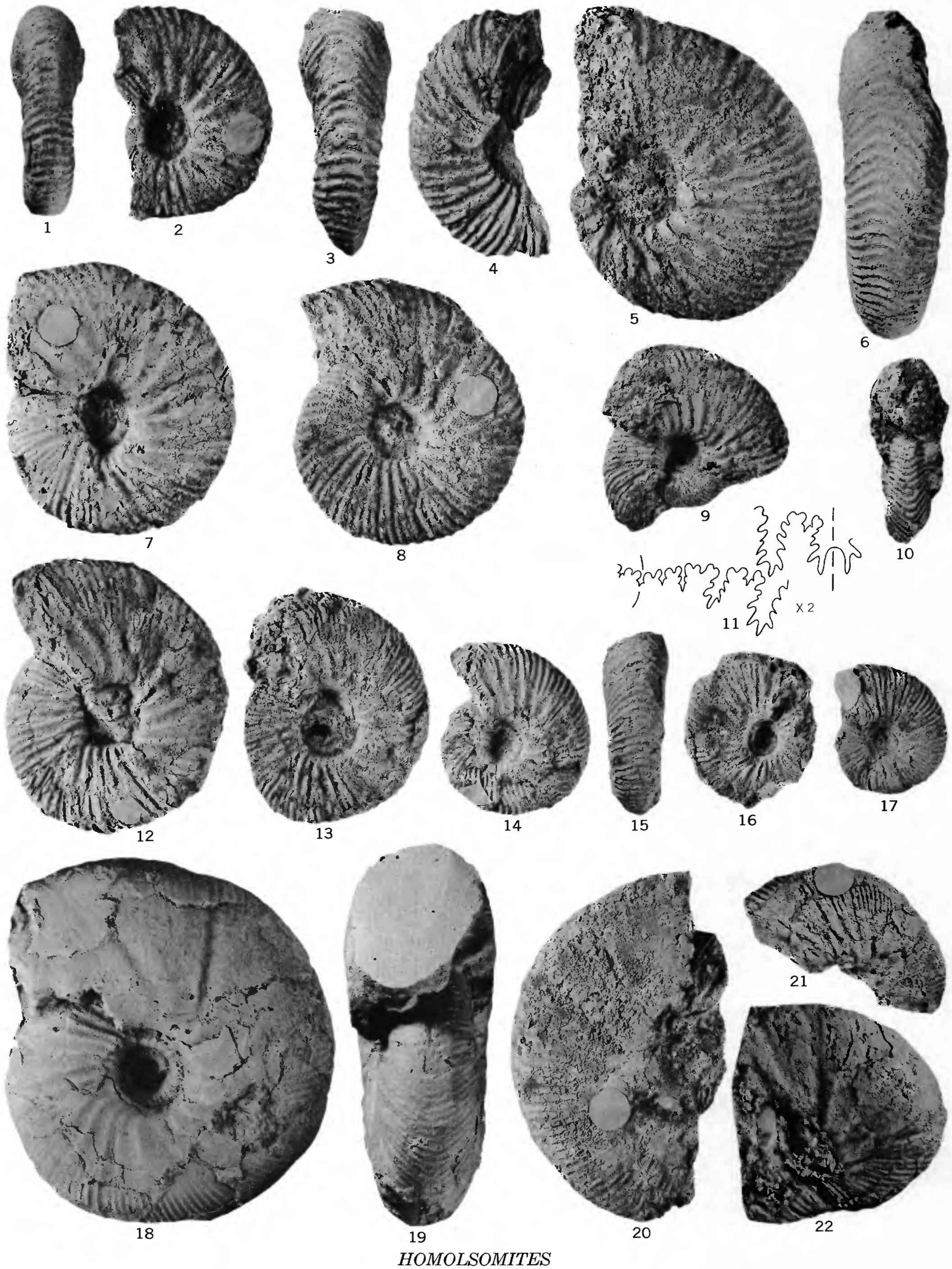
[All figures natural size unless otherwise indicated]

FIGURES 1–4. *Homolsomites mutabilis crassicostatus* Imlay, n. subsp. (p. 201).
- 1, 2. Paratype, USNM 129692 from USGS Mes. loc. 1010.
- 3, 4. Holotype, USNM 129690 from USGS Mes. loc. 1093.

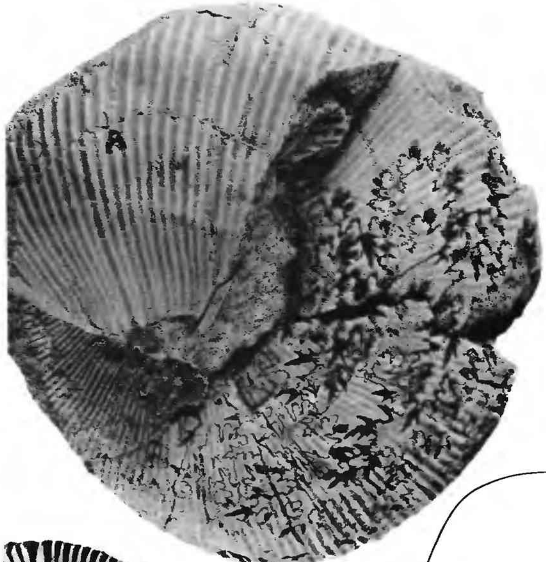
5–11. *Homolsomites mutabilis mutabilis* (Stanton) (p. 201).
- 5, 6. Plesiotype, USNM 129693 from USGS Mes. loc. 2154.
- 7, 11. Lateral view and suture line (× 2) of lectotype, USNM 23089a from USGS Mes. loc. 1010 (lectotype selected by Anderson, 1938, p. 160).
- 8. Plesiotype, USNM 129691 from USGS Mes. loc. 1010.
- 9, 10. Plesiotype, USNM 129689 from USGS Mes. loc. 1010.

12–17. *Homolsomites mutabilis burgeri* (Anderson) (p. 201).
- 12. Plesiotype, USNM 23089b from USGS Mes. loc. 1010.
- 13, 16, 17. Plesiotypes, USNM 129688a–c from USGS Mes. loc. 1093.
- 14, 15. Plesiotype, USNM 23089c from USGS Mes. loc. 1010. Notes that plesiotypes shown in figs. 12, 14, and 15 are part of the original types of *H. mutabilis* (Stanton).

18–22. *Homolsomites mutabilis tehamaensis* (Anderson) (p. 201).
- 18, 19. Holotype, CAS 5943 from CAS loc. 1343.
- 20, 21. Plesiotype, USNM 129687 from USGS Mes. loc. 1093.
- 22. Plesiotype, USNM 129694 from USGS Mes. loc. 4390.



HOMOLSOMITES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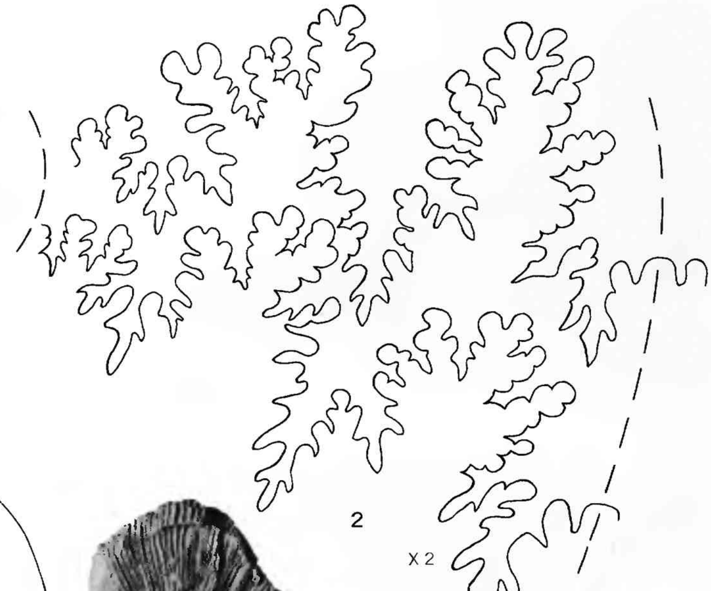

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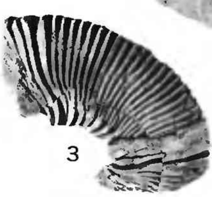
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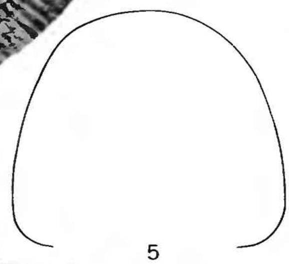
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6


7


8


9

OLCOSTEPHANUS

PLATE 29

[All figures natural size unless otherwise indicated]

FIGURES 1–5, 7–9. *Olcostephanus pecki* Imlay, n. sp. (p. 202).

1, 2, 5, 9. Lateral view, sutur line ($\times$ 2), cross section, and ventral view of paratype, USNM 129847a from USGS Mes. loc. 25193.

3, 4. Lateral views of two small whorls of a single specimen showing tubercles and rib branching. Paratype, USNM 129849 from USGS Mes. loc. 26790.

7. Lateral view of an aperture. Paratype, USNM 129847b from USGS Mes. loc. 25193.

8. Holotype, USNM 129848 from USGS Mes. loc. 25192. Note fine ribbing on an inner whorl. The specimen includes parts of another fourth of a whorl.

6. *Olcostephanus* cf. *O. pecki* Imlay, n. sp. (p. 203). Fragment of an inner whorl showing dense ribbing and tubercles. This was associated with a fragment of an outer whorl bearing ribbing as coarse as on the adoral end of the specimen shown on fig. 8. University Washington loc. WA538.

PLATE 30

[Figure natural size]

FIGURE 1. *Olcostephanus pecki* Imlay, n. sp. (p. 202).
Largest known specimen of species showing body chamber (about four-fifths of a whorl). Paratype, USNM 129846 from USGS Mes. loc. 26789.

1

OLCOSTEPHANUS

OLCOSTEPHANUS, SPITIDISCUS, DURANGITES, AND *POLYPTYCHITES*

PLATE 31

[All figures natural size unless otherwise indicated]

FIGURES 1–3. *Olcostephanus popenoei* Imlay, n. sp. (p. 203).
Ventral and lateral views of holotype, USNM 129863 from USGS Mes. loc. 26790.

4–6, 8, 9. *Spitidiscus oregonensis* Imlay, n. sp. (p. 221).
4–6. Lateral and ventral views of paratype, USNM 129698 from USGS Mes. loc. 718.
8, 9. Lateral and ventral views of holotype, USNM 129697 from USGS Mes. loc. 718.

7. *Olcostephanus pecki* Imlay, n. sp. (p. 202).
Paratype, USNM 129847c from USGS Mes. loc. 25193. Compare ribbing with that shown in figs. 1 and 8 on pl. 29.

10. *Olcostephanus* cf. *O. quadriradiatus* Imlay (p. 203).
Specimen, USNM 129861 from USGS Mes. loc. 25217.

11, 12. *Durangites* sp. juv. (p. 169).
Specimen, 129686 from USGS Mes. loc. 2026. Presented as evidence that the Whitsett limestone lentils of Diller (1898) near Roseburg, Oreg., are of Late Jurassic rather than of Cretaceous age.

13, 15. *Polyptychites trichotomus* (Stanton) (p. 204).
Lateral views of crushed holotype, USNM 23090 from USGS Mes. loc. 1087.

14. *Polyptychites* sp. juv. (p. 176).
Lateral view (× 3) of rubber cast of external mold from CAS loc. 33502. Plaster replica, USNM 129699.

PLATE 32

[All figures natural size unless otherwise indicated]

FIGURES 1–6. *Neocraspedites giganteus* Imlay, n. sp. (p. 204).

1. Paratype, USNM 129834 from USGS Mes. loc. 1088. Shows development of ribbing on an immature specimen.

2, 4. Lateral views of specimens somewhat larger than that shown in fig. 1 to illustrate development of flexuous ribbing. Paratypes, USNM 129833a, b from USGS Mes. loc. 1091.

3, 5, 6. Cross section, ventral, and lateral views of holotype, USNM 23088 from USGS Mes. loc. 1009. The specimen includes fragments of a still larger whorl (not shown).

7–20. *Wellsia oregonensis* (Anderson) (p. 205).

7, 8. Small plesiotype, USNM 129679a from USGS Mes. loc. 25198. Shows ribbing on an internal mold.

9. Plesiotype, USNM 129679b from USGS Mes. loc. 25198. Shows ribbing on shell.

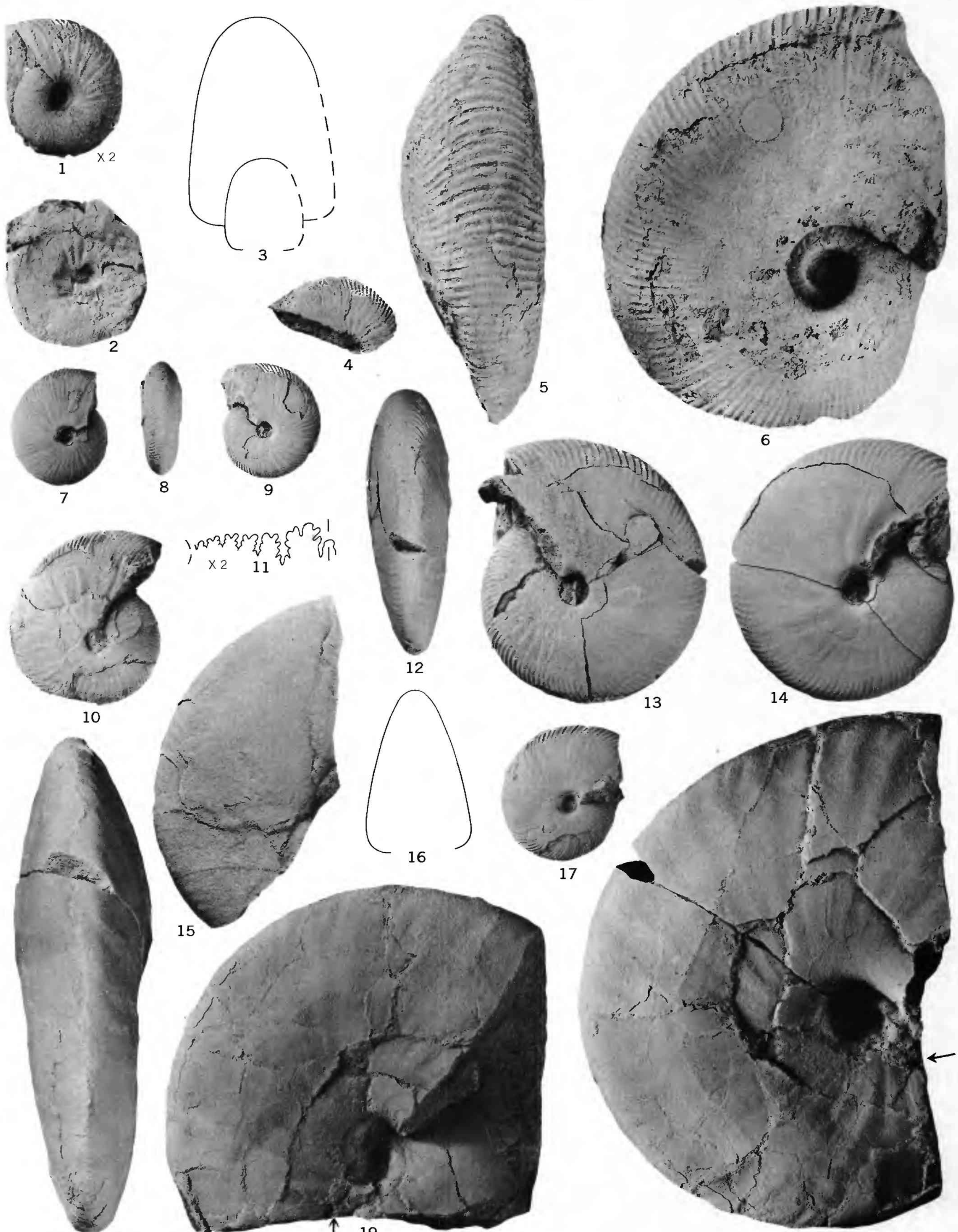
10. Plesiotype, USNM 129677 from USGS Mes. loc. 25199.

11, 17. Suture line ($\times$ 2) drawn at whorl height of 11 mm on left side of specimen shown in fig. 17. Pleisiotype, USNM 129678 from USGS Mes. loc. 1253.

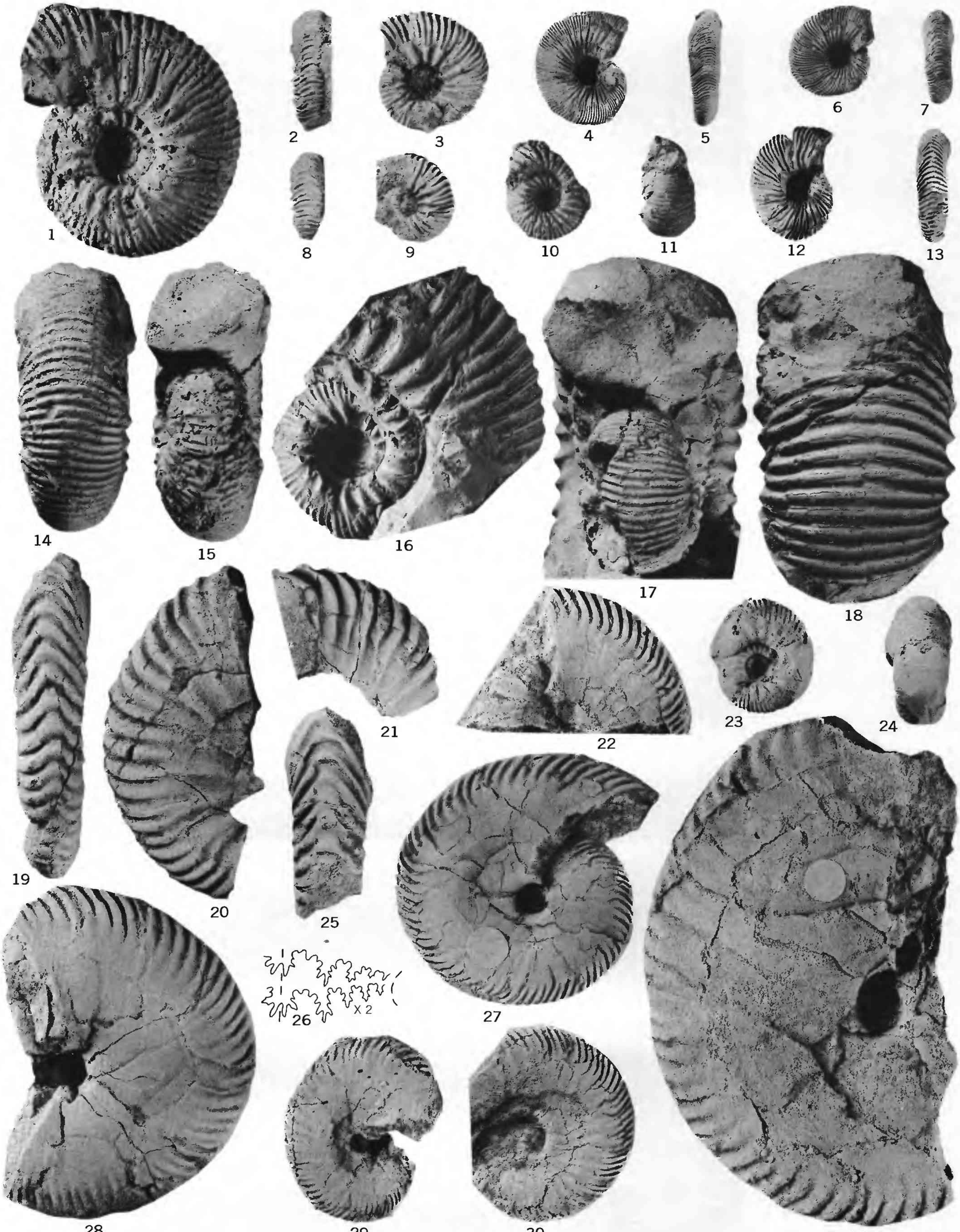
12–14. Plesiotype, USNM 129676a from USGS Mes. loc. 25204.

15, 16. Lateral and cross sectional view of plesiotype, USNM 129676b from USGS Mes. loc. 25204.

18–20. Ventral and lateral views of plesiotype, USNM 129675 from USGS Mes. loc. 1252. Beginning of body chamber is indicated by an arrow.



NEOCRASPEDITES AND *WELLSIA*



SIMBIRSKITES AND *WELLSIA*

PLATE 33

[All figures natural size unless otherwise indicated]

FIGURES 1, 14, 15. *Simbirskites lecontei* (Anderson) (p. 209).
CAS 8785 from CAS 113. The specimen illustrated is a paratype of *Simbirskites broadi* Anderson, but is herein assigned to *S. lecontei* (Anderson).

2, 3, 8, 9. *Simbirskites* sp. juv. aff. *S. progrediens* (Lahusen) (p. 210).
Specimens, USNM 129681 from USGS Mes. loc. 25211.

4–7, 12, 13. *Simbirskites* spp. juv. (p. 210).
Specimens, USNM 129682 from USGS Mes. loc. 25211.

10, 11. *Simbirskites* sp. juv. aff. *S. elatus* (Trautschold) (p. 210).
Specimen, USNM 129680 from USGS Mes. loc. 1251.

16–18. *Simbirskites broadi* Anderson (p. 209).
Lateral, cross sectional, and ventral views of holotype, CAS 8784 from CAS loc. 113.

23, 24. "*Subastieria*" *chanchelula* Anderson (p. 209).
Holotype, CAS 8791 at CAS loc. 113. The specimen illustrated probably represents an immature stage of *Simbirskites broadi* Anderson.

19–22, 25. *Wellsia vigorosa* Imlay, n. sp. (p. 206).
19, 20. Holotype, USNM 129669.
21, 25. Paratype, 129670a.
22. Paratype, 129670b. All types from USGS Mes. loc. 1252.

26–31. *Wellsia packardi* (Anderson) (p. 206).
26. Suture line drawn at whorl height of 10 mm on plesiotype, USNM 129667 from USGS Mes. loc. 25202.
27. Plesiotype, USNM 129668 from USGS Mes. loc. 718.
28–31. Plesiotypes, USNM 129666 from USGS Mes. loc. 1252.

PLATE 34

[All figures natural size]

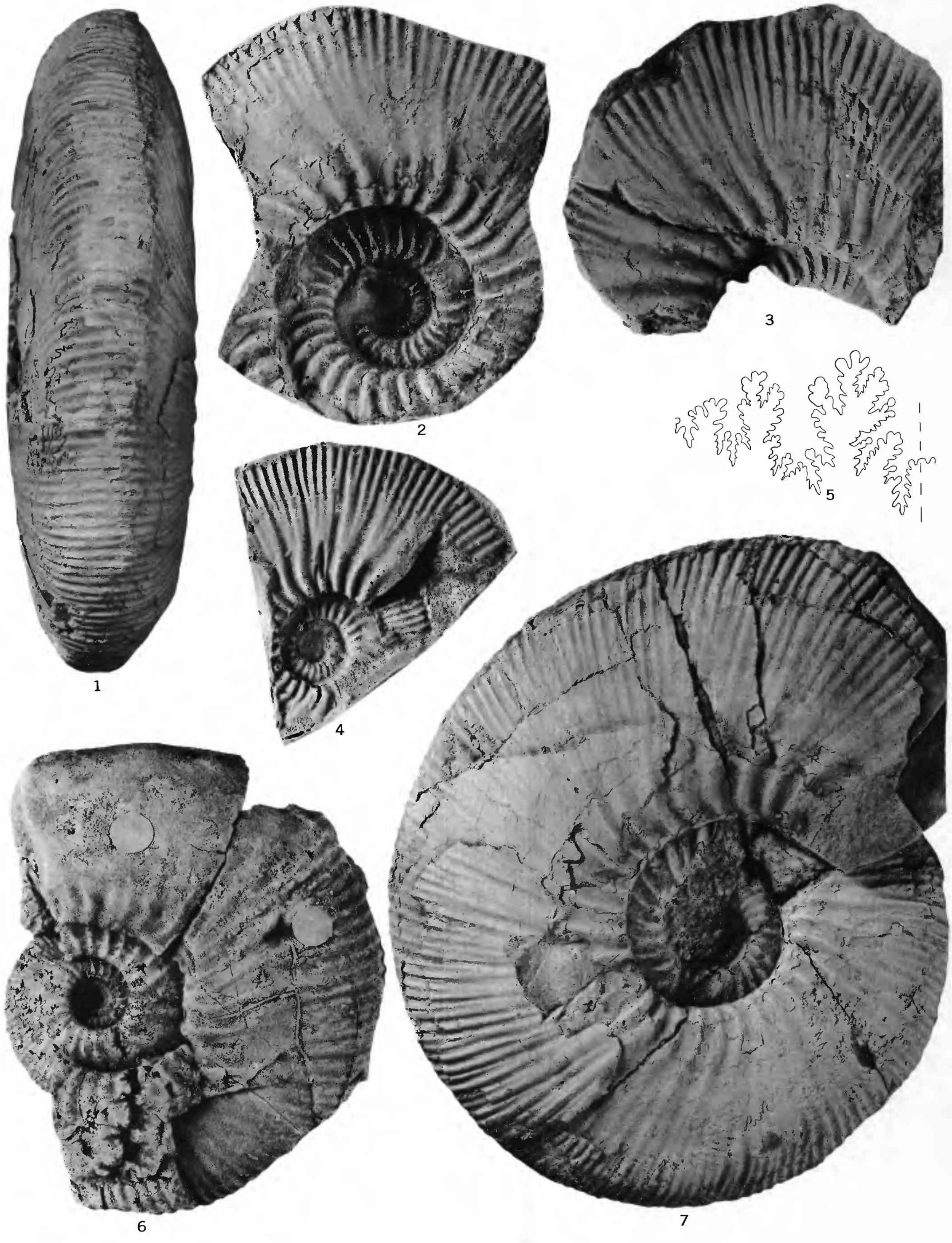
FIGURES 1–7. *Hertleinites aguila* (Anderson) (p. 207).

1, 5, 7. Ventral view, suture line drawn at whorl height of 46 mm, and lateral view of plesiotype, USNM 129654 from USGS Mes. loc. 2223.

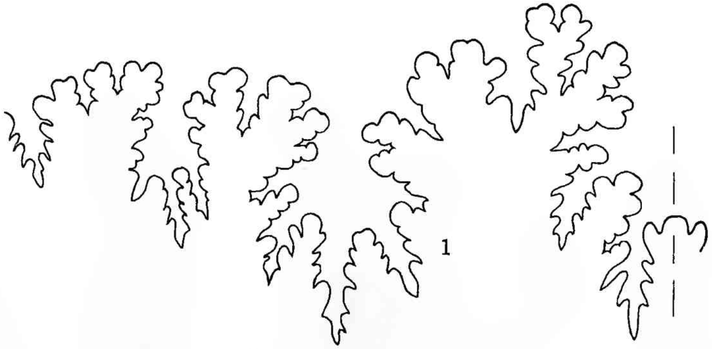
2, 3. Holotype, CAS 8769 at CAS loc. 1353. Fig. 2 represents a rubber cast made from an external mold. Fig. 3 shows the internal mold oriented in the same manner as fig. 2.

4. Rubber cast of an external mold of plesiotype, USNM 129655 from USGS Mes. loc. 2222.

6. Internal mold showing ribbing of inner whorls. Plesiotype, USNM 129656 from USGS Mes. loc. 2267.



HERTLEINITES



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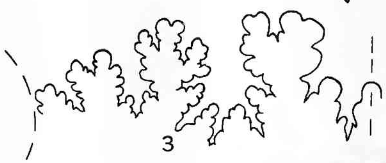

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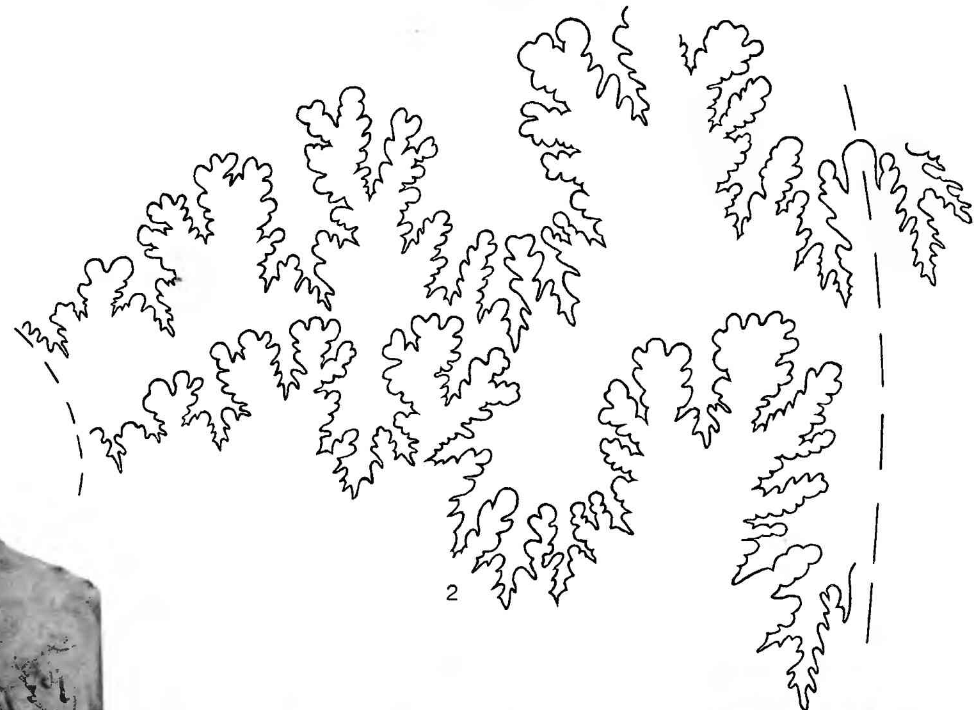

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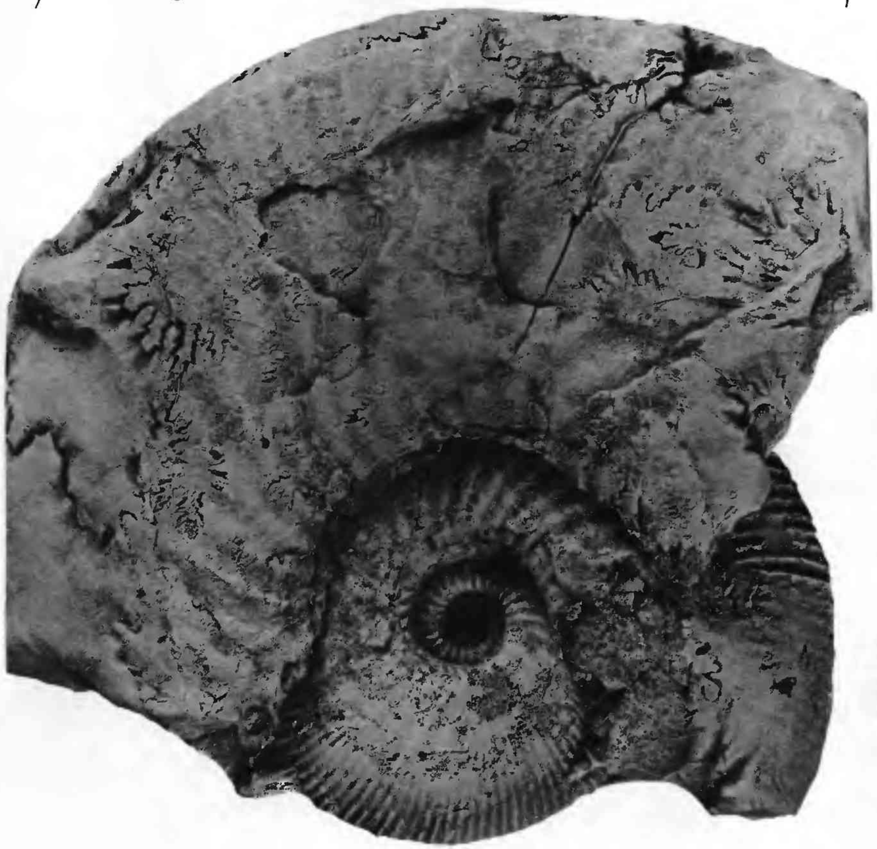

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5

HERTLEINITES AND *HOLLISITES*

PLATE 35

[All figures natural size]

FIGURES 1, 3–5. *Hertleinites pecki* Imlay, n. sp. (p. 208).

1. Suture line drawn from unifigured paratype, USNM 130023 at whorl height of 84 mm.

3, 4, 5. Suture line drawn at whorl height of 44 mm, and lateral views of holotype, USNM, 129835. Both from USGS Mes. loc. 1092.

2. *Hollisites lucasi* Imlay (p. 211).

Suture line drawn at whorl height of 65 mm near adoral end of holotype, USNM 129045 from USGS Mes. loc. 26450.

PLATE 36

[Both figures slightly reduced]

FIGURES 1, 2. *Hollisites lucasi* Imlay (p. 211).

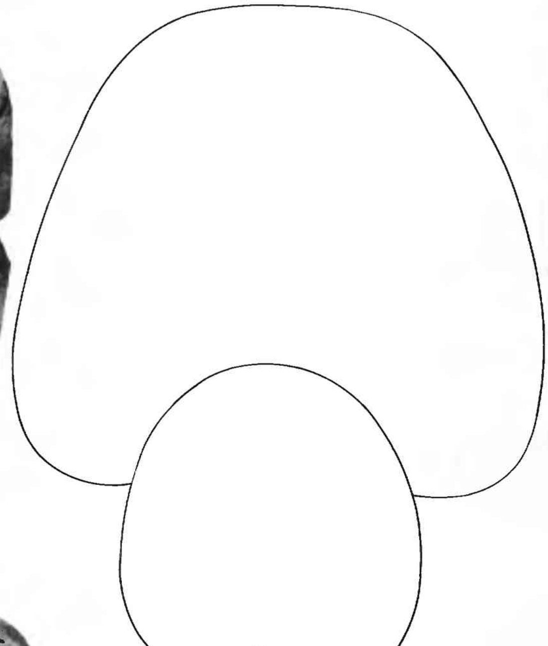
Lateral and apertural views of holotype, USNM 129045 from USGS Mes. loc. 26450. Suture line is shown on pl. 35, fig. 2. Ventral view and cross section of whorl are shown on pl. 37, figs. 2, 5.

1

HOLLISITES

2

1



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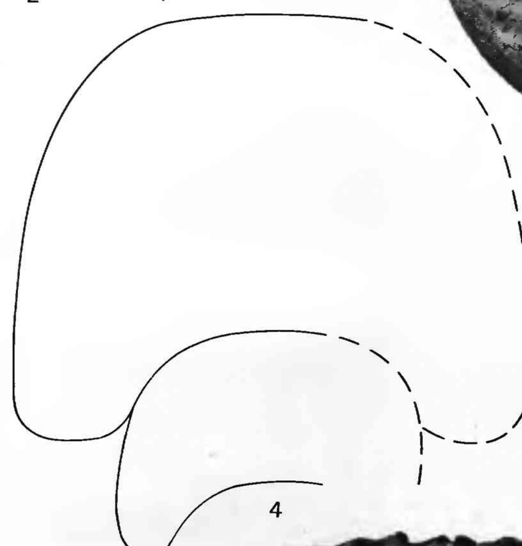

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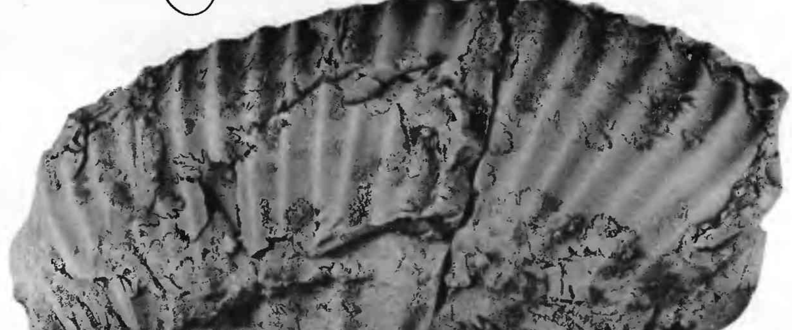


6

HOLLISITES

PLATE 37

[All figures natural size]

FIGURES 1, 3, 4, 6. *Hollisites inflatus* Imlay, n. sp. (p. 212).

Two inner whorls of holotype, USNM 129839 from USGS Mes. loc. 1092. Fig. 4 shows cross section drawn near adoral end of whorl shown in figs. 3 and 6. The specimen is represented, also, by a larger septate whorl that is not figured.

2, 5. *Hollisites lucasi* Imlay (p. 211).

2. Whorl section of holotype, USNM 129045 from USGS Mes. loc. 26450. Drawn near adoral end. Other views of holotype shown on pl. 35, fig. 2, and pl. 36, figs. 1, 2.
5. Ventral view of holotype near adoral end, by comparison with apertural view on pl. 36, fig. 2, shows marked increase in thickness of shell.

PLATE 38

[All figures natural size unless otherwise indicated]

FIGURES 1, 2, 11–13. *Hollisites lucasi* Imlay (p. 211).

Shows ornamentation of small and intermediate-sized specimens. Note fine ribbing exposed on inner whorls in figs. 1 and 11. Both specimens crushed laterally. Paratypes, USNM 129044 from USGS Mes. loc. 1092.

3–5, 8–10. *Hollisites* sp. juv. aff. *H. dichotomus* Imlay, n. sp. (p. 212).

3, 4. Lateral and ventral views of rubber cast (× 2).

5. Lateral view of another rubber cast (× 2).

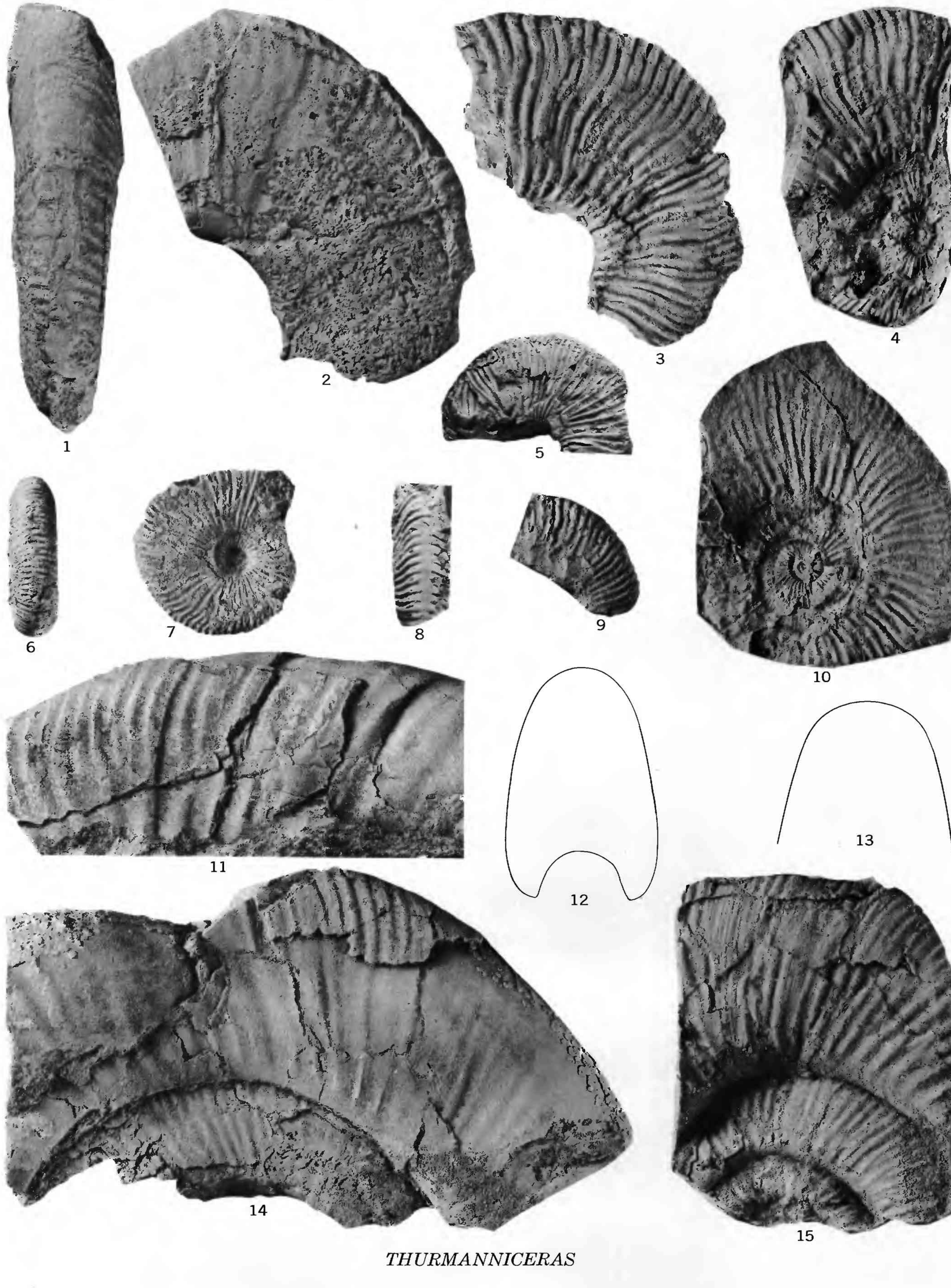
8, 9. Lateral and ventral views of a rubber cast (× 2).

10. Lateral view of a rubber cast (× 2). Specimens, USNM 129657 from USGS Mes. loc. 2078. Owing to the magnification the ribbing resembles that on small specimens of *Speetoniceras*.

6, 7. *Hollisites dichotomus* Imlay, n. sp. (p. 212).

Lateral and ventral views of holotype, USNM 129659 from USGS Mes. loc. 1251. The ribbing on the inner whorl is similar in strength and density to that shown in figs. 3–5, 8–10 on this plate.

HOLLISITES



THURMANNICERAS

PLATE 39

[All figures natural size]

FIGURES 1–5, 8–10. *Thurmanniceras stippi* (Anderson) (p. 216).

1, 2, 8, 9. Outer and inner whorls of internal mold of holotype, CAS 10465 at CAS loc. 144.

3. Plesiotype, USNM 129837a from USGS Mes. loc. 2154, showing strength of ribbing where shell is preserved. This specimen is septate except at extreme adoral end.

4. Rubber cast of external mold of same specimen shown in fig. 3. Shows sharpness of ribs on inner whorls.

5. Another specimen, plesiotype, USNM 129837b from USGS Mes. loc. 2154, showing sharp ribbing on inner whorls.

10. Rubber cast of external mold of plesiotype, USNM 129836 from USGS Mes. loc. 25216.

6, 7. *Thurmanniceras* sp. juv. cf. *T. stippi* Anderson (p. 216).

Internal mold having a rounder venter than is typical of *T. stippi* (Anderson). Figured specimen, USNM 129838 from USGS Mes. loc. 1088.

11–15. *Thurmanniceras californicum* (Stanton) (p. 214).

11, 13. Part of body chamber and cross section of same.

12, 14. Part of penultimate whorl and cross section of same. Holotype, USNM 23087.

15. Rubber cast of external mold. All specimens shown in figs. 11–15 are probably parts of a single ammonite and all are from USGS Mes. loc. 1001.

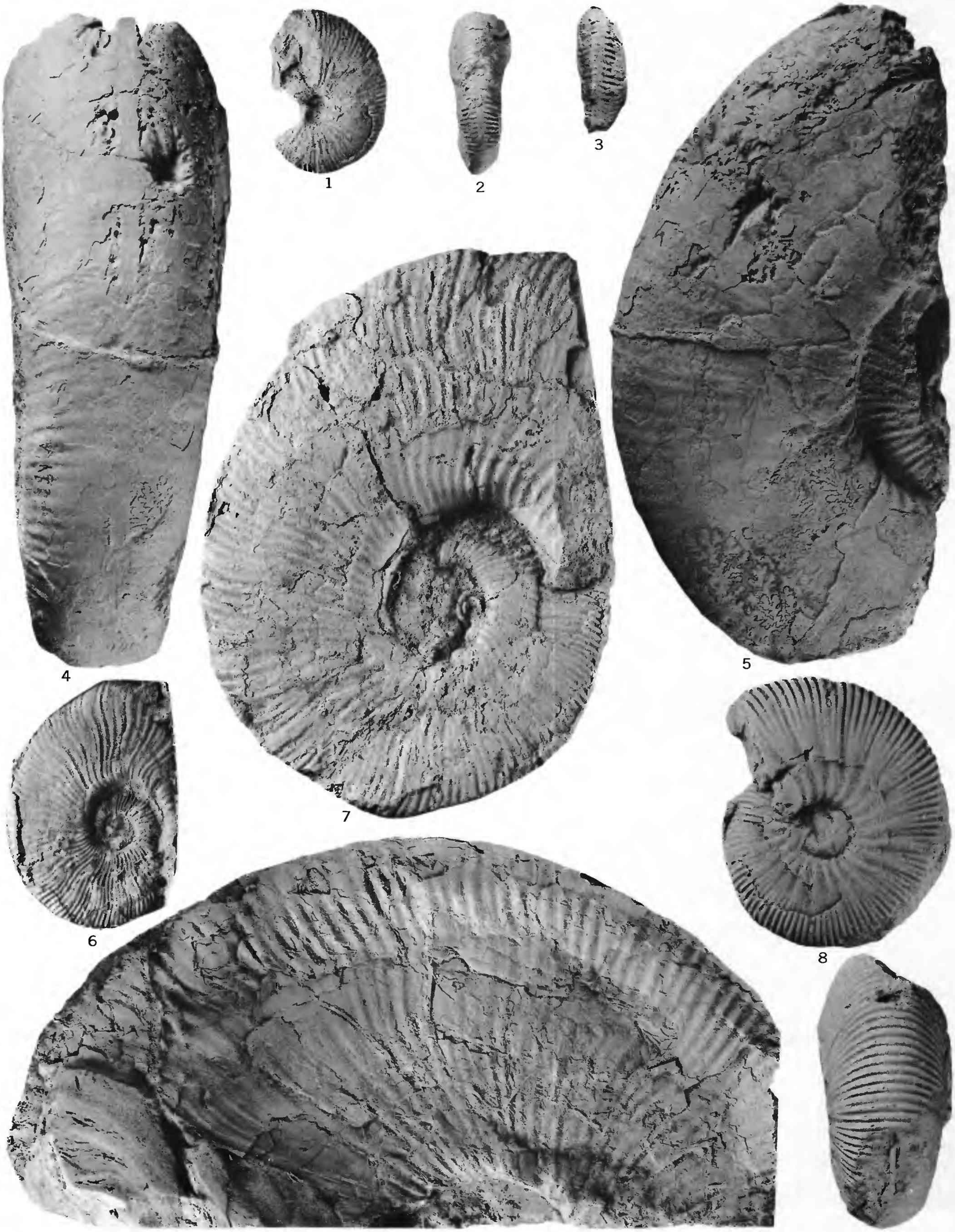
PLATE 40

[All figures natural size]

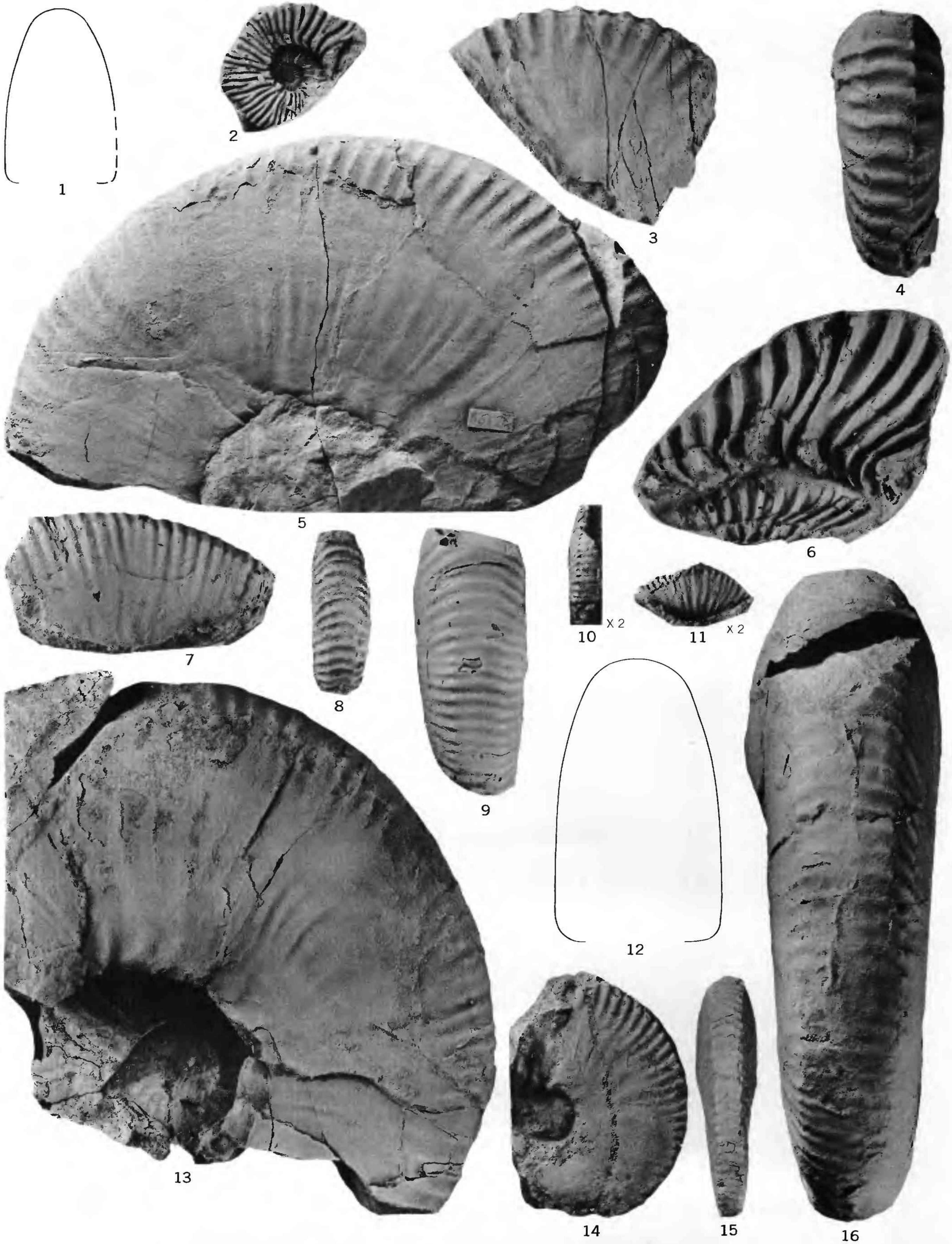
FIGURES 1, 2, 6, 7, 9. *Thurmanniceras jenkinsi* (Anderson) (p. 215).
- 1, 2. Plesiotype, USNM 129860 from USGS Mes. loc. 1088.
- 6. Rubber cast of external mold of plesiotype, USNM 129859 from USGS Mes. loc. 2154.
- 7. Internal mold of holotype, CAS 8775 at CAS loc. 33502.
- 9. Crushed septate fragment referred by Stanton (1896, p. 77) to *Desmoceras*? sp. Plesiotype, USNM 23223 from USGS Mes. loc. 1091.

3–5. *Thurmanniceras wilcoxi* (Anderson) (p. 214).
- 4, 5. Ventral and lateral views of holotype, CAS 8771 from the Wilcox Ranch, 5 miles north of Paskenta, Calif.
- 3. Rubber cast of external mold preserved on dorsum of inner whorl of holotype. Note flattened venter bordered by two rows of tubercles.

8, 10. *Hertleinites rectoris* (Anderson) (p. 208).
Holotype, CAS 8778 from CAS loc. 1353



THURMANNICERAS AND *HERTLEINITES*



HANNAITES AND *NEOCOMITES*

PLATE 41

[All figures natural size unless otherwise indicated]

FIGURES 1, 3, 4. *Hannaites truncatus* Imlay, n. sp. (p. 218).
Cross section, lateral, and ventral views of holotype, USNM 129840 from USGS Mes. loc. 25198.

2, 6. *Neocomites*? cf. *N. indicus* Uhlig (p. 213).
2. Specimen, USNM 129858 from USGS Mes. loc. 2117.
6. Specimen, USNM 129857 from USGS Mes. loc. 2119.

5, 7–16. *Hannaites riddlensis* (Anderson) (p. 217).
5, 12, 13, 16. Plesiotype, USNM 129850 from USGS Mes. loc. 25199. Shows adult body chamber and traces of inner whorls.
7, 9. Plesiotype, USNM 129854 from USGS Mes. loc. 25202.
8. Plesiotype, USNM 129853 from USGS Mes. loc. 1252.
10, 11. Rubber cast of external mold (× 2) of plesiotype, USNM 129852 from USGS Mes. loc. 2093.
14, 15. Plesiotype, USNM 129851 from USGS Mes. loc. 1243.

PLATE 42

[All figures natural size unless otherwise indicated]

FIGURES 1–5, 7. *Kilianella crassiplicata* (Stanton) (p. 218).

1–5. Lateral, ventral views, and suture line (× 2) of holotype, USNM 23094 from USGS Mes. loc. 1001. Fig. 2 represents a rubber cast of an external mold of same side as shown in fig. 1. Suture line drawn at whorl height of 15 mm.

7. Plesiotype, USNM 129684 from USGS Mes. loc. 5339.

8. *Kilianella* cf. *K. besairiei* Spath (p. 218).

Lateral view of rubber cast of external mold. Specimen, USNM 129683 from USGS Mes. loc. 26404.

6, 9, 10, 15, 17. *Speetoniceras agnessense* Imlay, n. sp. (p. 213).

Holotype, USNM 129658 from USGS Mes. loc. 26879. Fig. 6 represents a rubber cast of an external mold. Figs. 9 and 15 show the inner whorl. Figs. 10 and 17 show both inner and outer whorls. Note that figs. 6, 9, and 10 are oriented the same.

11–14. *Sarasinella angulata* (Stanton) (p. 220).

11–13. Apertural, ventral, and lateral views of holotype, USNM 23093 from USGS Mes. loc. 1093.

14. Plesiotype, USNM 129660 from USGS Mes. loc. 1093. Note lateral tubercles.

16. *Sarasinella* cf. *S. subspinosa* (Uhlig) (p. 219).

Specimen, USNM 129856 from USGS Mes. loc. 2154.

18. *Acanthodiscus* sp. juv. aff. *A. subradiatus* Uhlig (p. 220).

Rubber cast of external mold, USNM 129685 from USGS Mes. loc. 2154.

19–24. *Sarasinella hyatti* (Stanton) (p. 219).

19, 23. Internal mold and rubber cast of external mold of a single specimen oriented in a similar manner. Plesiotype, USNM 129843 from USGS Mes. loc. 2136.

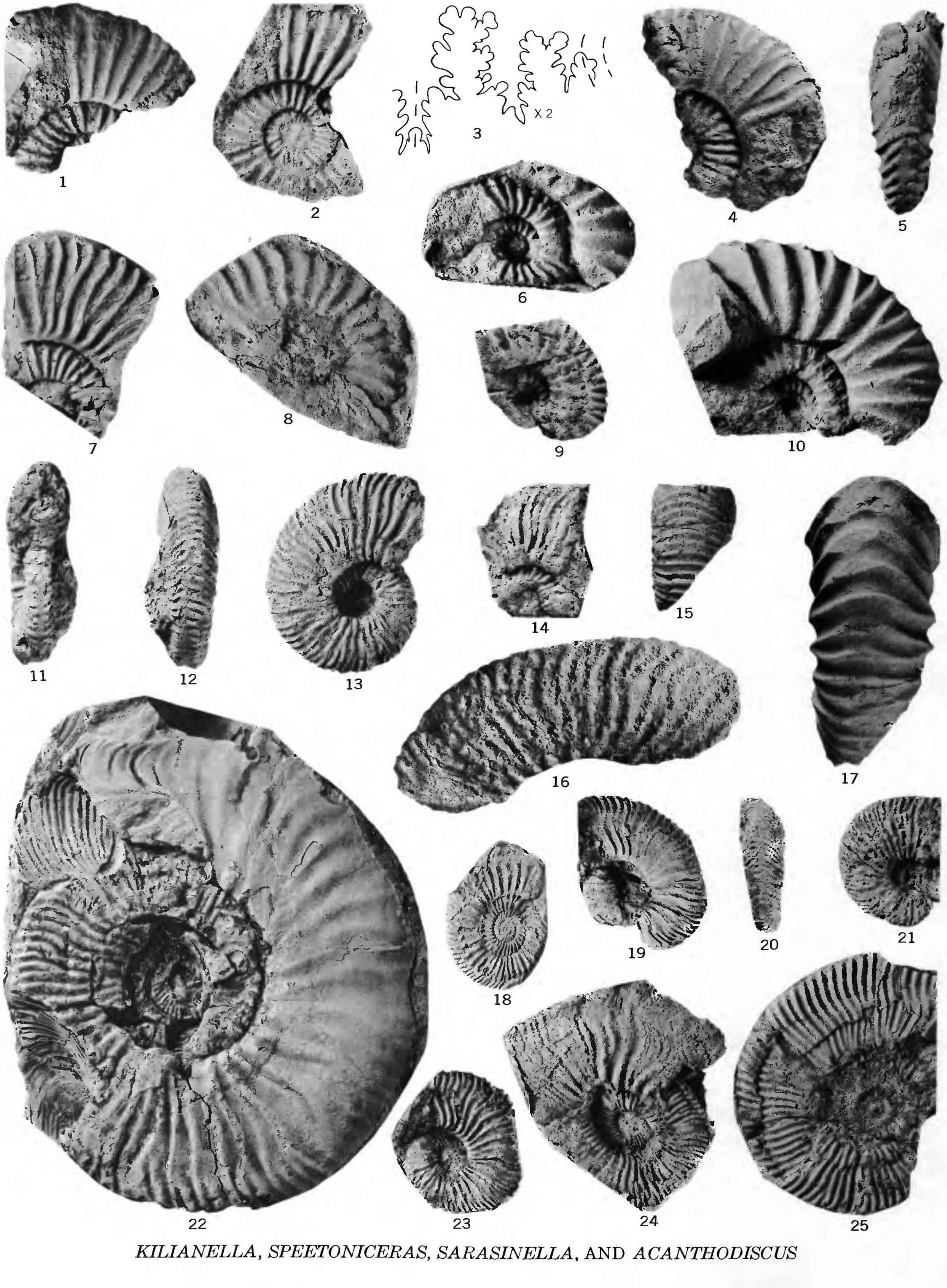
20, 21. Ventral and apertural views of an internal mold of plesiotype, USNM 129844 from USGS Mes. loc. 2107.

22. Holotype, USNM 23091 from USGS Mes. loc. 26405.

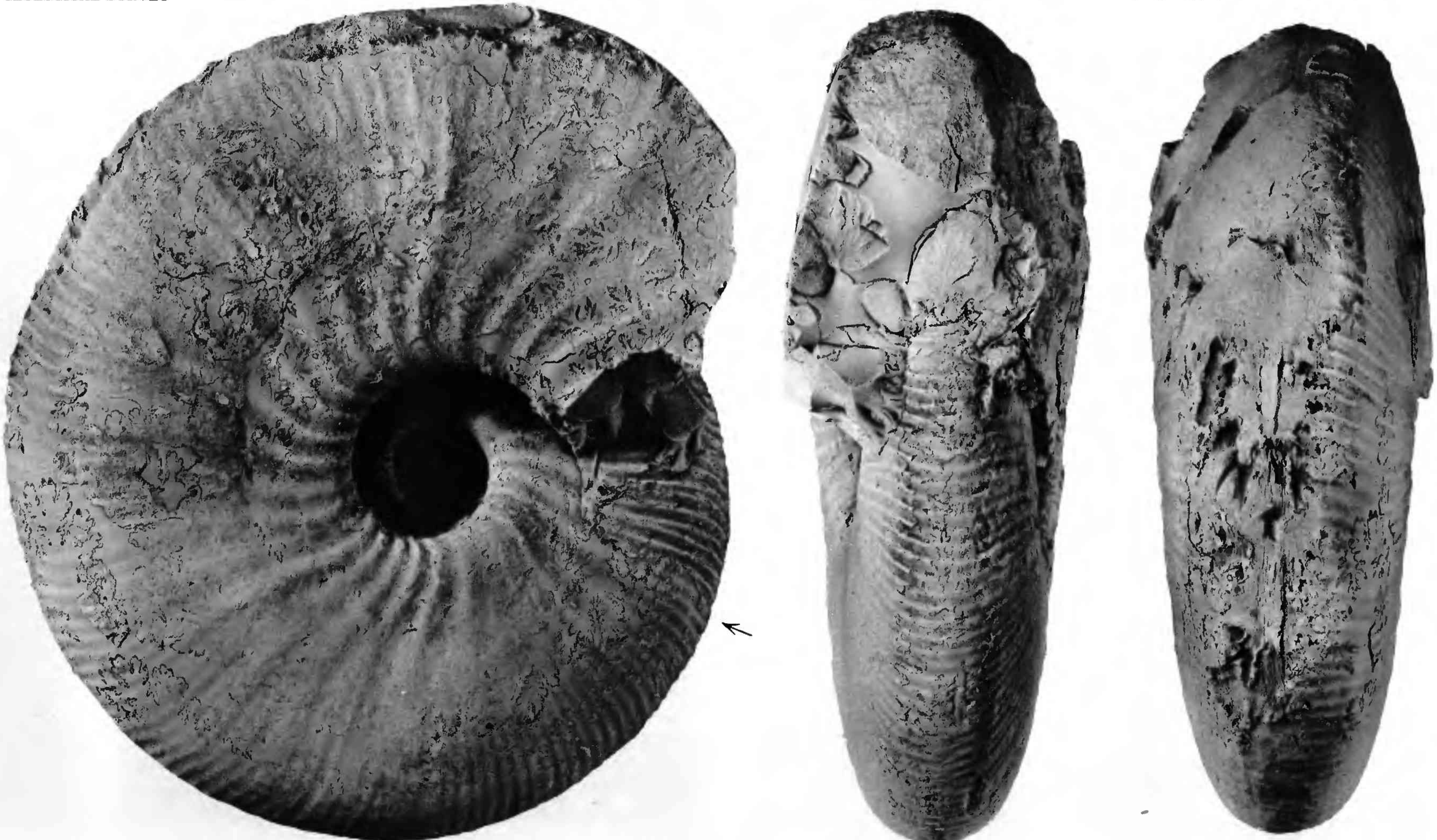
24. Plesiotype, USNM 129842 from USGS Mes. loc. 4386.

25. *Sarasinella densicostata* Imlay, n. sp. (p. 219).

Holotype, USNM 129855 from USGS Mes. loc. 2154.



KILIANELLA, *SPEETONICERAS*, *SARASINELLA*, AND *ACANTHODISCUS*



1 2 3

HERTLEINITES

PLATE 43

[All figures natural size]

FIGURES 1–3. *Hertleinites pecki* Imlay, n. sp. (p. 208).

Lateral, apertural, and ventral views of paratype 12120 of Univ. Calif. at Berkeley. Fragments, not illustrated, show that the body chamber begins at the point indicated by an arrow and extends for three-fifths of a whorl. From U. C. Berkeley loc. B–5089 located upstream 120 feet from junction of small tributary with Nevada Creek in NE¼SE¼ sec. 16, T. 24 N., R. 6 W., Tehama County, Calif.

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