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IN THIS ISSUE:
Middle Jurassic ammonite biochronology, Snowshoe Formation

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Main Office: 910 State Office Building, 1400 SW Fifth Ave., Portland 97201, phone (503) 229-5580.

Baker Field Office: 1831 First Street, Baker 97814, phone (503) 523-3133 Howard C. Brooks, Resident Geologist

Grants Pass Field Office: 312 SE "H" Street, Grants Pass 97526, phone (503) 476-2496 Len Ramp, Resident Geologist

Mined Land Reclamation Program: 1534 Queen Ave. SE, Albany 97321, phone (503) 967-2039 Gary W. Lynch, Supervisor

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OIL AND GAS NEWS

ARCO continues operations at Mist

ARCO has continued drilling at Mist Gas Field, Columbia County. The LF 32-20-65R-RD1 was drilled and completed as a gas producer, as was the CFW 12-15-64. This well is now the easternmost producer in the field. The wells CC-24-9-64 and CC 12-19-65 were drilled and have been suspended. ARCO plans to begin operations next on the CFI 23-16-64 well.

Mist Gas Field: Gas storage summary

The following service wells were drilled by Oregon Natural Gas Development Corporation during 1988 as part of the gas storage project at Mist Gas Field. Four injection-withdrawal wells were drilled, two each in the Flora and Bruer Pools. These are the IW 22D-10, IW 23B-3, IW 33D-3, and the IW 42C-10. The final well was an observation-monitor well, OM 43B-10. The company continues to make modifications and additions to the gas treatment and compressor plant at the gas storage site.

ARCO abandons Morrow County well

ARCO plugged and abandoned its wildcat well in the Columbia River Basin of eastern Oregon. The Hanna 1 well was the first well drilled in Morrow County and was located about 6 mi northeast of Heppner. Information has not been released from the well.

Recent permits

Permit no.	Operator, well, API number	Location	Status, proposed total depth (ft)
413	ARCO Columbia Co. 22-17-75 36-009-00247	NW¼ sec. 17 T. 7 N., R. 5 W. Columbia County	Location; 2,760.
414	ARCO Sterling 12-24-66 36-007-00019	NW¼ sec. 24 T. 6 N., R. 6 W. Columbia County	Location; 3,150.
415	ARCO Greenup 1 36-049-0003	NE¼ sec. 9 T. 2 S., R. 28 E. Morrow County	Denied (application withdrawn).
416	ARCO Greenup 2 36-049-0004	NW¼ sec. 24 T. 2 S., R. 28 E. Morrow County	Denied (application withdrawn).
417	ARCO Longview Fibre 24-8-75 36-009-00248	SW¼ sec. 8 T. 7 S., R. 5 W. Columbia County	Location; 3,100.

□

COVER PHOTO

Example of ammonite species *Euhoploceras crescenticostatum* n. sp., one of the new species from the Showshoe Formation in east-central Oregon described in article beginning on next page. Maximum diameter of specimen shown is 218 mm (approximately 8½ in.).

CONTENTS

Middle Jurassic (late Aalenian and early Bajocian) ammonite biochronology of the Snowshoe Formation, Oregon

by David G. Taylor, Department of Geology, Portland State University, Portland, Oregon 97207

The John Day inlier of east-central Oregon is known for having a relatively undisturbed Jurassic sequence. Ammonite-rich molluscan faunas from it have proved to be important for dating these rocks. A relative time scale based on such fossil organisms is called a zonation. Historically, in using the ammonites for dating, paleontologists have turned to the European standard ammonite zonation for calibration, since there was no independent zonation for North America.

In recent years, however, it has become evident that an independent zonation is necessary. In the current effort to zone the Jurassic in our continent, attention is being turned to Oregon. This paper, which establishes an ammonite zonation for part of the lower Middle Jurassic, is a contribution to that effort. It is based on the Snowshoe Formation, which yields the finest sequence in North America for that part of the lower Middle Jurassic discussed in this paper. Such zonations as the one provided herein are indispensable not only for refining our picture of the Jurassic history of Oregon but also for interpreting the Mesozoic history of western North America.

ABSTRACT

This paper provides the description of one new ammonite genus (*Freboldites*) and 26 new species from the Snowshoe Formation. The ammonite biochronology established herein encompasses the latest Aalenian and much of the early Bajocian and furnishes five new zones and three new subzones.

INTRODUCTION

The Snowshoe Formation is part of a thick, lower Mesozoic volcaniclastic sequence in the John Day inlier in east-central Oregon (Dickinson and Vigrass, 1965; Dickinson and Thayer, 1978; Smith, 1980). The western exposures of the Snowshoe Formation in the Suplee area (Figure 1) yield a diverse and well-preserved ammonite fauna treated by Imlay (1973), when he described Bajocian ammonites from eastern Oregon. Detailed work by the author in the Suplee area (Taylor, 1981, 1982) resulted in the ammonoid succession established herein. Because the fauna has Tethyan affinities, the new biochronologic units described herein will assist in providing a zonal standard of reference for coeval faunas elsewhere in North America referable to the Tethyan Realm. Moreover, the Oregon fauna furnishes a critical key for close correlation between the East Pacific and Europe. The zonation, in fact, permits the first definitive correlation of the Aalenian-Bajocian stage boundary between the two regions. Preliminary description of new ammonite taxa is provided in advance of their monographic treatment to facilitate the description of the zonation.

STRATIGRAPHY

This study is based on the Weberg and Warm Springs Members (Lupher, 1941; Dickinson and Vigrass, 1965), which are the lower two members of the Snowshoe Formation in the Suplee area. The Snowshoe Formation was deposited in an intra-arc setting (Dickinson and Thayer, 1978), and the facies in the Suplee area reflect deposition on a local "platform" relative to the basin to the east in the Izee area (Dickinson and Vigrass, 1965; Smith, 1980). The Weberg Member, which is restricted to the Suplee area, is a transgressive calcareous sandstone and siltstone unit up to 65 m thick (Dickinson and Vigrass, 1965; Taylor, 1981), while the superjacent Warm Springs Member is a siltstone and laminated mudstone unit that in the Suplee area attains a stratigraphic thickness of up to 275 m. That member occurs, as well, farther east in the Izee area (Smith, 1980).

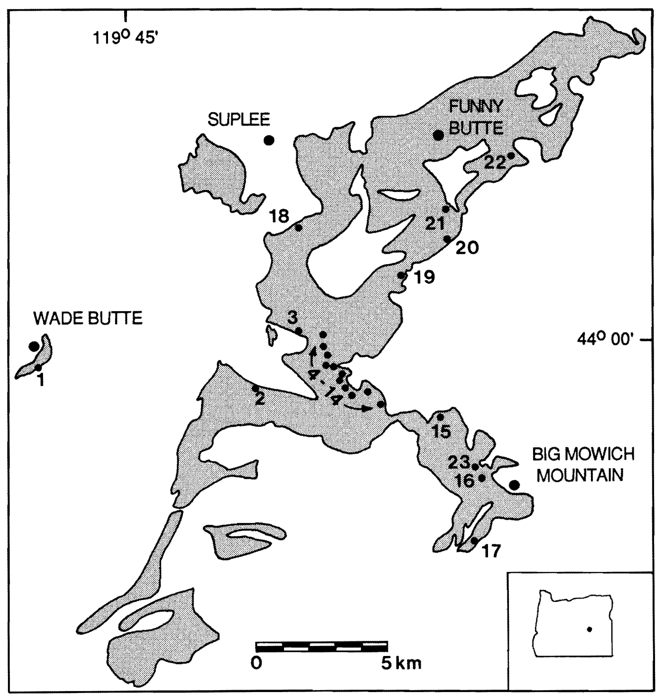


Figure 1. Map giving distribution of the Snowshoe Formation (shaded) in the Suplee area and localities of measured stratigraphic sections. Localities 1-17 are equivalent to those provided in Taylor (1982, Figures 1, 2).

BIOCHRONOLOGY

The data for the ammonite zonation are provided through closely spaced ammonite collections from 23 measured stratigraphic sections (Taylor, 1981, 1982). Figure 1 shows the locations of the stratigraphic sections, while Figure 2 is a composite range chart for the ammonites in the Suplee area. The zones recognized herein are discrete biochronologic units sensu Guex (1987a).

The earliest zones given below (Sparsicostatus through Tuberculatum Zones) are Tethyan Realm counterparts to the Howelli and Widebayense Zones in Alaska, belonging to the Boreal Realm. The latest zones (Crassicostatus and Kirschneri), on the other hand,

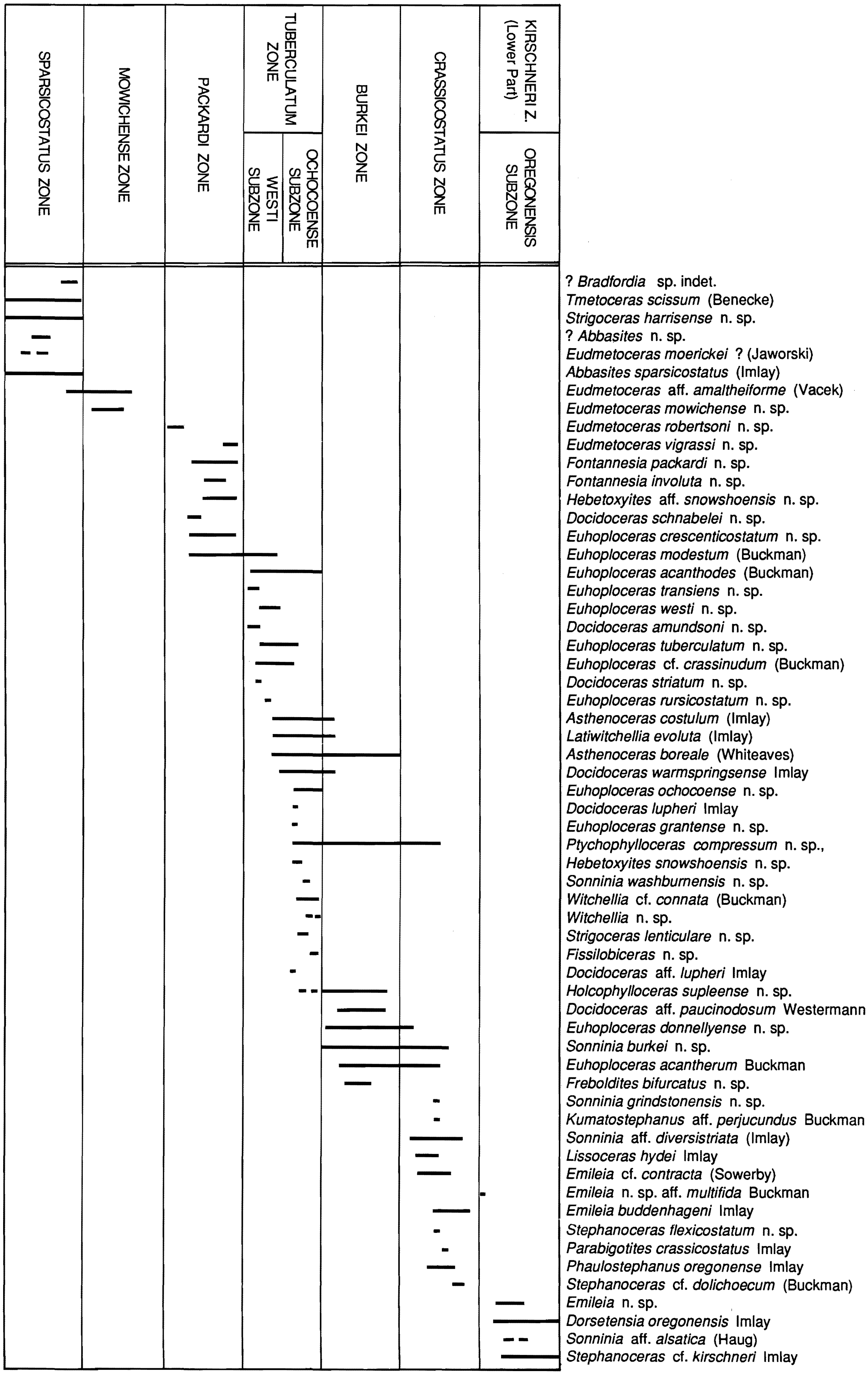


Figure 2. Ranges and zonal allocations of ammonites from the Snowshoe Formation near Suplee, Oregon.

represent an interval of time when the Boreal Realm was quite weakly differentiated from the Tethyan Realm. As a result, these zones are recognizable in the conterminous United States as well as in Alaska and Canada.

The chronologically diagnostic association for each zone in Figure 2 consists of those species that range no higher than, no lower than, or are restricted entirely to a given zone. Correlation of the zonation with Alaska, South America, and Europe is provided in Figure 3 (South American zonal terminology is based on Westermann and Riccardi, 1979, and Hillebrandt and Westermann, 1985).

Sparsicostatus Zone (nov.)

The name bearer for this zone is *Abbasites sparsicostatus* (Imlay). No type section is selected, since no section demonstrates superpositional control with both subjacent and superjacent zones. The type area is the Suplee area, and the fauna is best developed at Locality 22 (Figure 1), where it occurs in the lower part of the Weberg Member.

Mowichense Zone (nov.)

This zone is named after *Eudmetoceras* (*Planammatoceras*) *mowichense* n. sp. The type section for this zone is at Locality 4 (Figure 1), where ammonites characterizing it occur from 1 m to 5 m above the base of the Warm Springs Member. At that locality, the zone is sandwiched between the subjacent Sparsicostatus Zone and the superjacent Packardi Zone.

Packardi Zone (nov.)

The type section for the Packardi Zone (name bearer *Fontannesia packardi* n. sp.) is at Locality 14 (Figure 1), where it is represented 18.7 m to 20.1 m above the base of the Weberg Member and occurs in sequence with the superjacent Tuberculatum Zone. Crudely preserved material indicates that *Fontannesia* ranges into the base of the Tuberculatum Zone.

Tuberculatum Zone (nov.)

The name bearer *Euhoploceras tuberculatum* n. sp. is restricted

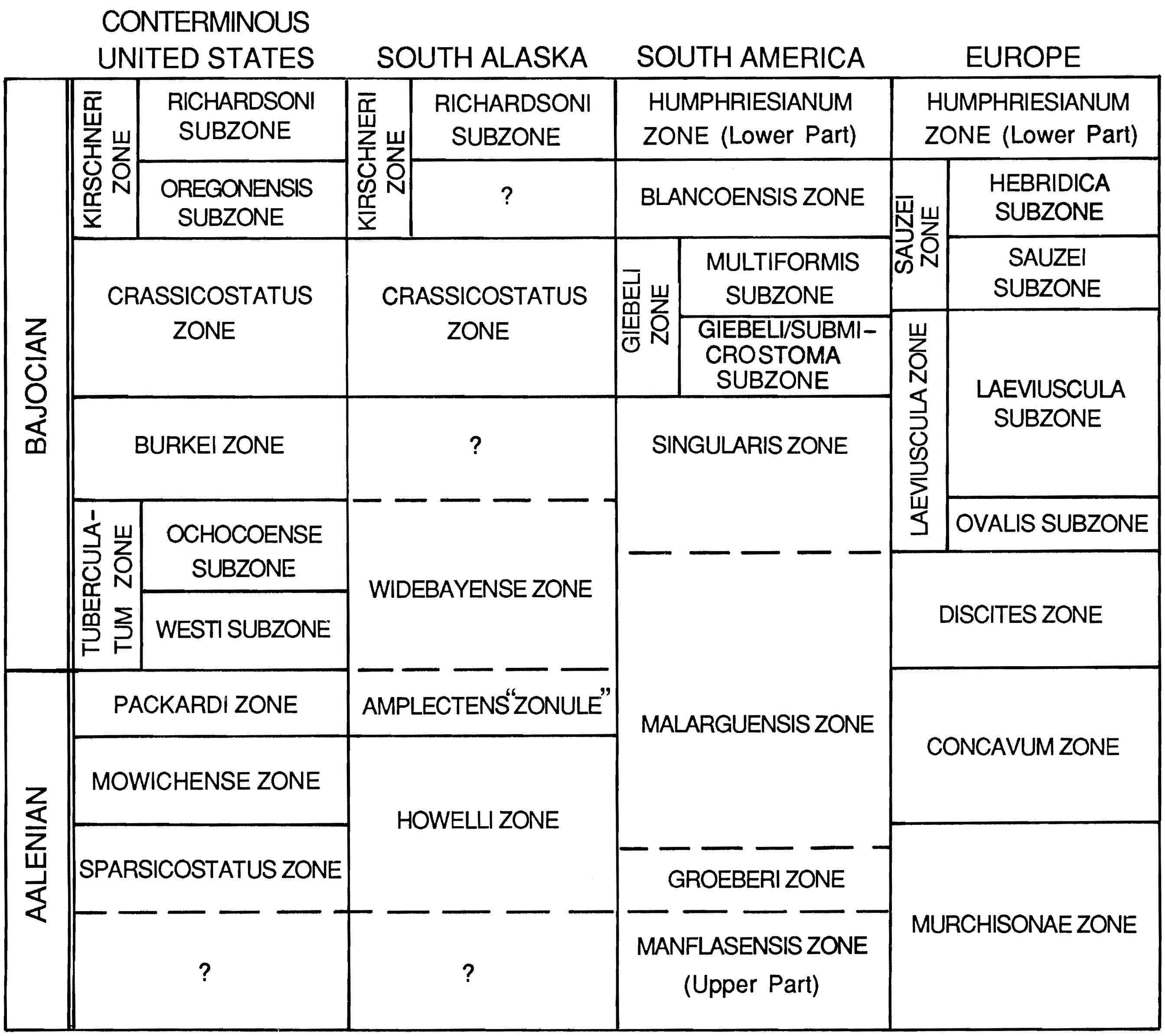


Figure 3. Correlation of late Aalenian-early Bajocian zonations from the conterminous United States, South Alaska, South America, and Europe.

to the lower two-thirds of the zone. The type section for the zone is at Locality 14 (Figure 1), where it occurs in succession with contiguous zones and is represented from 26.3 m to 34 m above the base of the Weberg Member.

Two subzones are assigned to the Tuberculatum Zone: (1) the Westi Subzone (nov.), name bearer *Euhoploceras westi* n. sp., type section at Locality 14 (Figure 1), from 26.3 m to 31.5 m above the base of the Weberg Member; and (2) the superjacent Ochocoense Subzone (nov.), name bearer *Euhoploceras ochocoense* n. sp., type section at Locality 14 (Figure 1), from 32 m to 34 m above the base of the Weberg Member.

The joint occurrence of early *Euhoploceras*, *Docidoceras*, and *Fontannesia* in the Packardi Zone and basal Tuberculatum Zone provides close correlation with the Aalenian-Bajocian boundary in Europe (Figure 3). Biostratigraphic studies in Scotland (Morton, 1976), southern England (Parsons, 1974), France (Pavia, 1983; Mouterde and others, 1972), and Portugal (Mouterde and others, 1972) provide detailed documentation for correlation.

The species of *Euhoploceras* that Morton (1975, 1976) tentatively allocated to the Concavum Zone are remarkably similar in morphology to some examples of *Euhoploceras crescenticostatum* n. sp. from the Packardi Zone.

Correlation is uncertain with the condensed Bradford Abbas section in southern England (Parsons, 1974), from which *Fontannesia* was not reported. The unfigured records of *Euhoploceras acanthodes* (Buckman) and *E.* cf. *crassiformis* (Buckman) that Parsons (1974) reported from the Concavum Zone apparently would be more like material in Oregon from the superjacent Tuberculatum Zone.

The sections that Mouterde and others (1972) reported from Marcous, France, and Murtinheira, Portugal, are expanded and provide a diverse fauna. Although the ammonites are not figured, both sections reveal the transitional nature of the ammonite sequence near the Aalenian-Bajocian stage boundary (=Concavum-Discites zonal boundary), and both yield *Fontannesia* together with *Euhoploceras*. The occurrences of *Fontannesia* at Marcous are allocated to the Concavum Zone, while the genus at Murtinheira is placed within the transitional interval between the Concavum and Discites Zones. Of the species of *Euhoploceras* described from the transitional interval from Murtinheira, *E. substriatum* (Buckman) is clearly comparable to *E. modestum* (which occurs in Packardi Zone), while figures of the other two species are required for certain assessment.

Another excellent work is that of Pavia (1983), based on sections in southeastern France. There, he drew the Concavum-Discites boundary at the first appearance of *Hyperlioceras* (thus allocating all *Euhoploceras* and *Fontannesia* from his study area to the Discites Zone). This boundary appears to be drawn at a lower biochronologic level than that of Mouterde and others (1972), notably from the section at Marcous. The most common practice has been to place all occurrences of *Hyperlioceras* in the Discites Zone, but the evidence provided by Mouterde and others (1972) demonstrates that this would make the *Graphoceras limitatum* horizon (upper part of Concavum Zone) difficult to recognize.

Burkei Zone (nov.)

Sonninia burkei n. sp. is the name bearer for this zone. The type section is at Wade Butte (Figure 1, Locality 1), where it occurs 14.5 m to 18.7 m above the base of the Weberg Member. Wade Butte is the only locality where the zone has been observed in sequence with both subjacent and superjacent zones.

Crassicostatus Zone

This zone was described by Hall and Westermann (1980), who selected its type locality in southern Alaska.

Kirschneri Zone

This zone was established by Hall and Westermann (1980), who selected its type area in southern Alaska. They named an upper Richardsoni Subzone but did not formally define the lower part of the Kirschneri Zone.

The Oregonensis Subzone (nov.), name bearer *Dorsetensia oregonensis* Imlay, type section at Locality 4 (Figure 1), from 207 m to 286 m above the base of the Warm Springs Member, serves to provide definition for the lower part of the Kirschneri Zone. The Richardsoni Subzone occurs in the superjacent Basey Member in the Suplee area.

SYSTEMATICS

Repositories for material referred to below include the Northwest Museum of Natural History (NWMNH), California Academy of Sciences (CAS), and the United States National Museum (USNM). Abbreviations for measurements (Smith, 1986) include maximum measurable shell diameter (DMAX), shell diameter at the end of the phragmocone (DPHRAG), shell diameter at which measurements were made (D), umbilical diameter (UD), whorl width (WW), and whorl height (WH). The term Psiloceratina (=Lytoceratina plus Ammonitina) sensu Guex (1987b) is used.

Order AMMONOIDEA Zittel, 1884
Suborder PHYLLOCERATINA Arkell, 1950
Superfamily PHYLLOCERATACEAE Zittel, 1884
Family PHYLLOCERATIDAE Zittel, 1884
Subfamily CALLIPHYLLOCERATINAE Spath, 1927
Genus *Holcophylloceras* Spath, 1927

Holcophylloceras supleense n. sp.
Plate 1, Figures 1, 2

Holcophylloceras sp., Imlay, 1973, p. 54, Plate 1, Figures 18-21 (not Plate 2, Figures 7, 8).

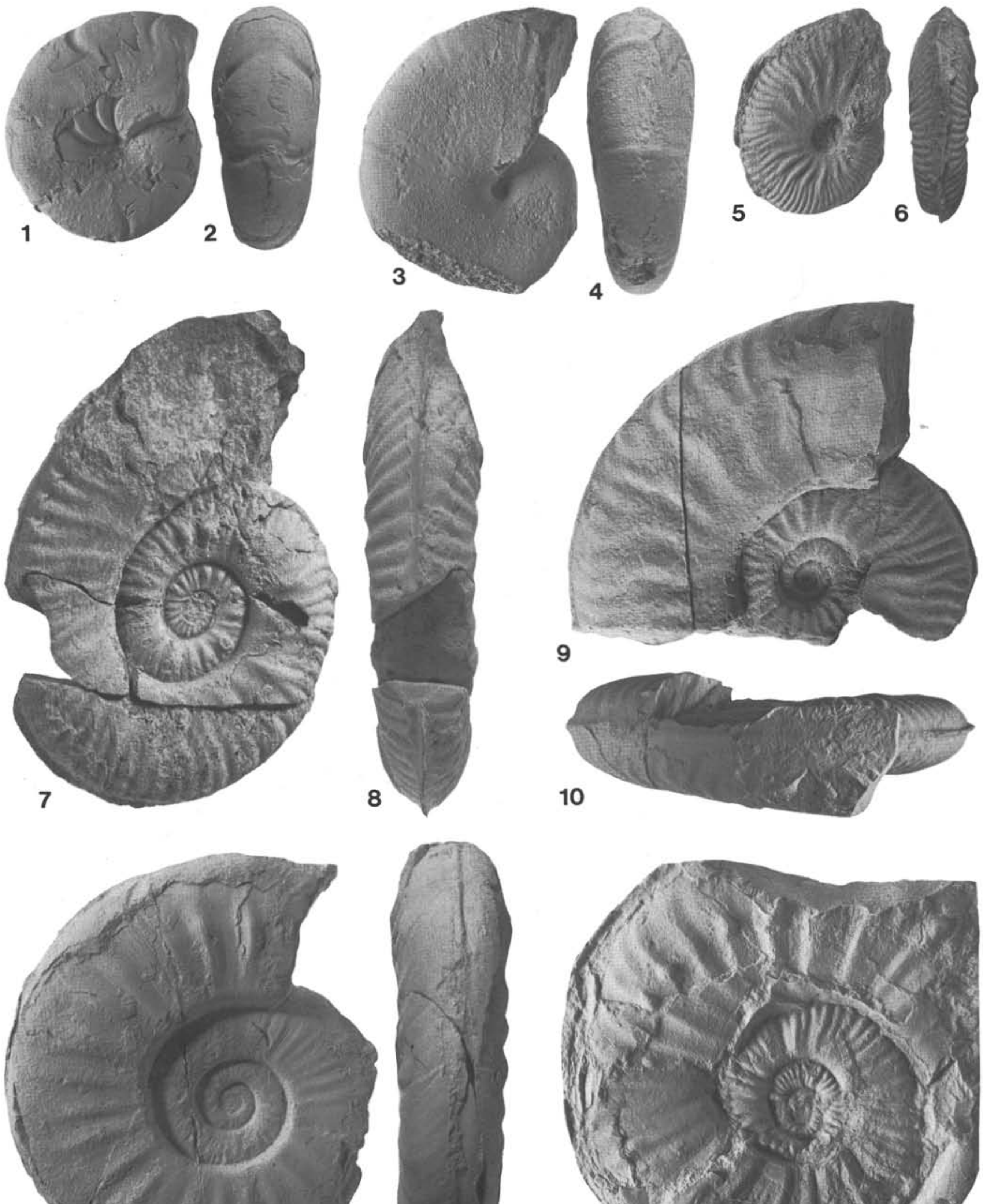
Holotype: NWMNH 25001. Provenance: Locality 18 (Figure 1); 17 m above base of Weberg Member; Burkei Zone. Dimensions: DMAX 44 mm, UD 1.5 mm, WW 20 mm, WH 25 mm.

Diagnosis: Shell weakly compressed; constrictions strongly sigmoidal, moderately strongly convex over venter, six to eight per whorl.

Description: The whorl section on the phragmocone is subovate and weakly compressed, and on the body chamber there is a slight accentuation of the ventro-lateral area. The body chamber comprises one-half volution. The apertural margin is strongly sigmoidal, with short ventral and broad lateral projections. The phragmocone has six strongly sigmoidal constrictions per whorl. The adoral half of the body chamber has three somewhat approximated constrictions, accounting for the counts of seven or eight constrictions on some specimens. The constrictions are moderately strongly convex over the venter. Faint ribbing subparallel to the trend of the constrictions is most noticeable on the upper flank at the largest shell dimensions.

Discussion: *Holcophylloceras supleense* n. sp. differs from the Alaskan and Oregonian *H. costisparsum* Imlay in having a more

***Facing page:** Plate 1. (All localities refer to Figure 1) — 1, 2.* Holcophylloceras supleense *n. sp.; holotype, NWMNH 25001 from Locality 18 (× 1). — 3, 4.* Ptychophylloceras compressum *n. sp.; holotype, NWMNH 25002 from Locality 11 (× 1). — 5, 6.* Eudmetoceras (Planammatoceras) mowichense *n. sp.; holotype, NWMNH 25003 from Locality 16 (× 1). — 7, 8.* Eudmetoceras (Planammatoceras) vigrassi *n. sp.; holotype NWMNH 25004 from Locality 16 (× 1). — 9, 10.* Eudmetoceras (Planammatoceras?) robertsoni *n. sp.; holotype NWMNH 25005 from Locality 16 (× 0.67). — 11, 12.* Sonninia burkei *n. sp.; holotype, NWMNH 25006 from Locality 18 (× 0.67). — 13.* Sonninia grindstonensis *n. sp.; holotype, NWMNH 25007 from Locality 2 (× 1).*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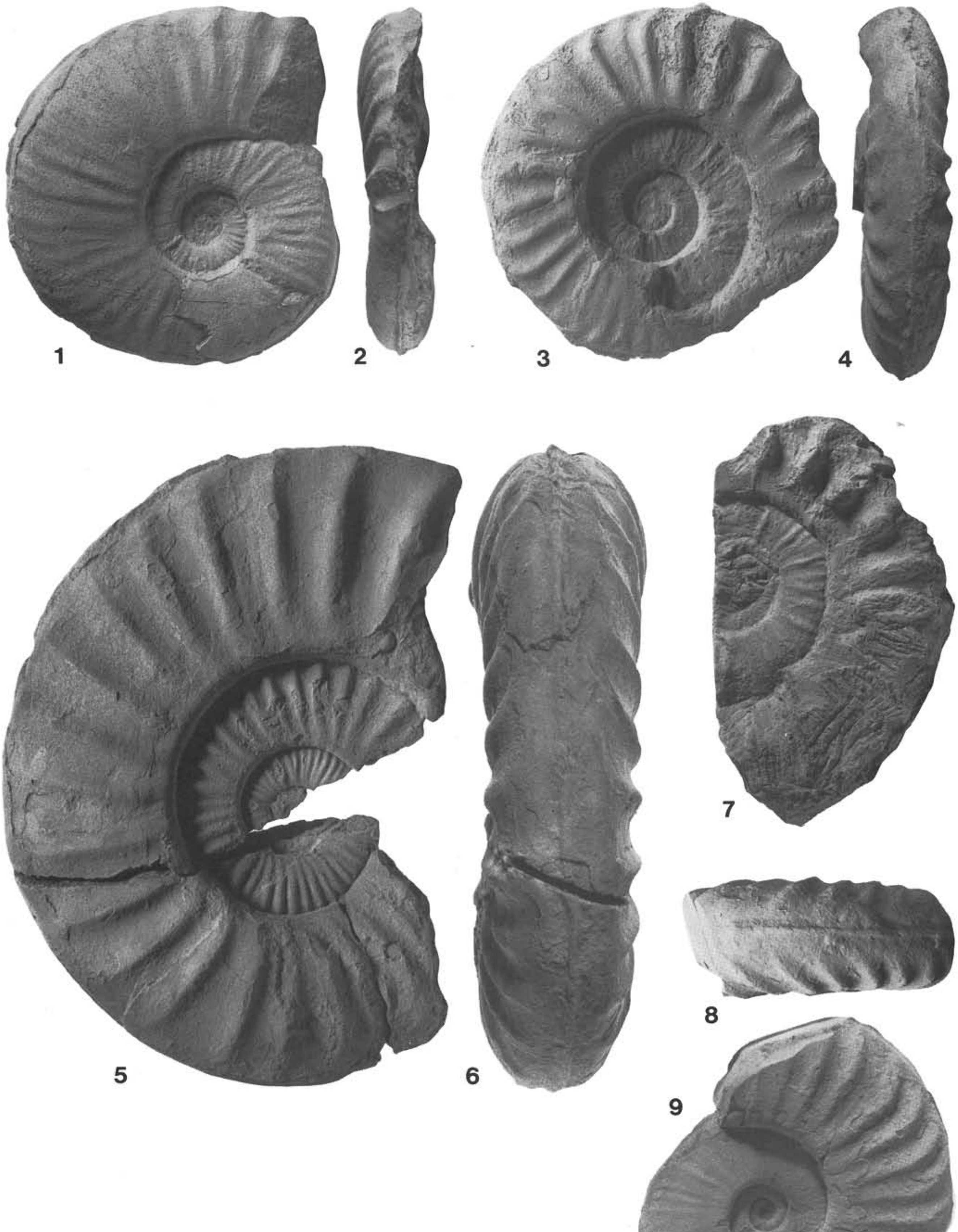
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inflated whorl section and constrictions that are more strongly flexed and distinctly approximated on the body chamber. The new species is similar to Alaskan material that Westermann (1964) identified as *H.* cf. *ultramontanum* (Zittel). *Holcophylloceras supleense* differs from that species in having constrictions that are less strongly flexed over the venter. The quite similar Californian *H. falciferum* (Crickmay, 1933) is considered to be nomen dubium, because it is based on a single crudely preserved mold consisting only of the body chamber. That species has more closely spaced constrictions than any specimen referred to the new species. *Holcophylloceras ultramontanum* is perhaps the European species closest to *H. supleense*. The new species has a stouter whorl section, closer spaced and more strongly flexed constrictions, and a narrower umbilicus.

Genus *Ptychophylloceras* Spath, 1927

Ptychophylloceras compressum n. sp.
Plate 1, Figures 3, 4

Holotype: NWMNH 25002. Provenance: Locality 11 (Figure 1); Weberg Member; Tuberculatum Zone. Dimensions: D 44 mm, UD 2.5 mm, WW 15.5 mm, WH 27.5 mm.

Diagnosis: Whorl section strongly compressed; constrictions feeble, not adorally flexed over venter; vague ventral folds present.

Description: The strongly compressed shell has flattened to gently convex flanks and an evenly rounded umbilical wall and venter. The shell is smooth except for feeble prorsiradiate, weakly flexed constrictions and folds (some specimens have no constrictions or folds preserved). The folds, which occur on the outer flank and venter, are weak but conspicuous (only on holotype), beginning at about 40-mm shell diameter, and are not noticeably arched adorally over the venter.

Discussion: This species has a much more compressed whorl section than others of this genus, except *Ptychophylloceras longarae* Sturani from the Venetian Alps. That species differs in having a wider umbilicus, a shallow groove on the lower flank, and constrictions that are conspicuously arched adorally over the venter.

Suborder PSILOCERATINA Houša, 1965
Superfamily HILDOCERATACEAE Hyatt, 1867
Family PHYMATOCERATIDAE Hyatt, 1867
Subfamily HAMMATOCERATINAE Buckman, 1887
Genus *Eudmetoceras* Buckman, 1920

Remarks: Because of the apparently close relationship between *Eudmetoceras* and *Planammatoceras* and the transitional nature of the morphology between these taxa (some species are not readily allocated to one or the other), *Planammatoceras* is assigned as a subgenus of *Eudmetoceras*.

Subgenus *Planammatoceras* Buckman, 1922

Eudmetoceras (*Planammatoceras*) *mowichense* n. sp.
Plate 1, Figures 5, 6

Eudmetoceras (*Euaptetoceras*) cf. *E.* (*E.*) *hauthali* (Burckhardt). Imlay, 1973, p. 60, Plate 6, Figures 6-9.

Holotype: NWMNH 25003. Provenance: Locality 16 (Figure 1); from 2 to 3.5 m above base of Warm Springs Member; Mowichense Zone. Dimensions: DMAX 38 mm, UD 6.5 mm, WW 11 mm, WH 20 mm.

Diagnosis: Involute, falcoid to falcate ribbing; keel small.

Description: The nucleus has a subcircular and slightly depressed whorl section. The adult section is compressed; the umbilical wall is subvertical and rounds sharply onto the flank, which is widest near mid-height of the whorl. The venter bears a low but distinct and thin keel. Ribbing on the intermediate whorls is falcoid to falcate and not strongly projected on the venter. The primaries are swollen just below mid-flank. Outer flank ribbing is characteristically bifurcate, although costae commonly arise through trifurcation and intercalation, as well. On the outer whorl, the ribbing becomes more gently flexed and weakens, particularly on the lower flank. The suture on the outer septate whorl is fairly complexly incised. The umbilical lobes are weakly retracted, and the associated saddle boundary is straight.

Discussion: This species is very similar in appearance to the Japanese *Eudmetoceras* (*Planammatoceras*) *ikianum* (Yokoyama) but differs by having a lower keel and perhaps ribbing that is more falcate on some specimens.

Eudmetoceras (*Planammatoceras*) *vigrassi* n. sp.
Plate 1, Figures 7, 8

Holotype: NWMNH 25004. Provenance: Locality 16 (Figure 1); 17.5 m above base of Warm Springs Member; Packardi Zone. Dimensions: DMAX 90 mm, UD 36 mm, WH 31 mm.

Name derivation: In reference to Lawrence W. Vigrass, who contributed to the knowledge of the geology of the Suplee area (Dickinson and Vigrass, 1965).

Diagnosis: Shell evolute; nodes on intermediate whorls only; suture essentially nonretracted.

Description: The evolute shell preserves an incomplete body chamber of one-half volution and has a compressed subovate section and high keel. Primary ribbing most commonly is weak, low on the flank, while secondary ribbing is stronger, concave, and only slightly projected where it abuts the keel. Nodes are restricted to the intermediate whorls, where they are widely spaced. On the body chamber, bullate swellings occur in their place. The tubercles and bullate swellings are set just below mid-flank. The suspensive lobe is only slightly retracted dorsal to U_2.

Discussion: The high keel on the new species reveals its affinities with *Eudmetoceras* rather than *Puchenquia*. This species is affiliated with a cluster of species that have evolute coiling, nodose ornamentation, and a comparatively compressed whorl section, such as *E.* (*Planammatoceras*) *lorteti* (Dumortier), *E.* (*P.*) *allobrogense* (Dumortier), and *E.* (*P.*) *spinosum* (Hantken in Prinz). The coiling is most like that of *E.* (*P.*) *lorteti*. *Eudmetoceras* (*P.*) *spinosum* shows some resemblance in the wide spacing of its nodes. Nodose ornamentation restricted to intermediate whorls sets *E.* (*P.*) *vigrassi* n. sp. apart from any of its congeners.

Eudmetoceras (*Planammatoceras*?) *robertsoni* n. sp.
Plate 1, Figures 9, 10

Holotype: NWMNH 25005. Provenance: Locality 16 (Figure 1); 15.5 m above base of Warm Springs Member; Packardi Zone. Dimensions: D 107 mm, UD 32 mm, WW 27 mm, WH 45 mm.

Name derivation: In honor of Les Robertson, a rancher from the Suplee area.

Diagnosis: Not nodose; inner whorls finely costate; keel low at largest shell dimensions.

Description: The whorl section is subcircular on the inner whorls and subogival on the adult whorls. The venter is somewhat narrow,

Facing page: *Plate 2. (All localities refer to Figure 1) — 1, 2.* Sonninia washburnensis *n. sp.; holotype, NWMNH 25008 from Locality 11 (× 0.5). — 3, 4.* Euhoploceras grantense *n. sp.; holotype, NWMNH 25010 from Locality 8 (× 0.5). — 5, 6.* Euhoploceras crescenticostatum *n. sp.; holotype, NWMNH 25009 from Locality 19 (× 0.55). — 7.* Euhoploceras rursicostatum *n. sp; holotype, NWWMNH 25014 from Locality 9 (× 0.5). — 8, 9.* Euhoploceras ochocoense *n. sp.; holotype, NWMNH 25011 from Locality 11 (× 0.5).*

and the keel is high on the penultimate whorl; on the last whorl, the venter broadens somewhat, and the keel becomes low and blunt. The primaries are concave and on the inner whorls comparatively weak at the base of the flank. The secondaries are gently projected on the venter of the outer whorl. Overall, costation is biconcave, with greatest flexure on the outer flank. Ribbing weakens on the adoralmost part of the phragmocone and on the body chamber.

Discussion: This species is readily distinguishable from its congeners in having such finely ornate inner whorls for a comparatively evolute species. Ribbing style of *Eudmetoceras* (*Planammatoceras*) *planinsigne* (Vacek) is quite similar on the intermediate whorls; otherwise, it is quite dissimilar in having nodes and an outer whorl that retains strong ribbing and a high keel. Ribbing is also quite dissimilar on the inner whorls. The new species is more similar to *E.* (*P.*) *planiforme* (Buckman), which is also nontuberculate. That species differs in having significantly stronger prorsiradiate ribbing and, apparently, a keel that remains high on the last whorl.

Family SONNINIIDAE Buckman, 1892
Genus *Sonninia* Bayle in Douvillé, 1879

Sonninia burkei n. sp.
Plate 1, Figures 11, 12

Sonninia (*Papilliceras*) *stantoni* (Crickmay). Imlay, 1973, p. 68 (part), Plate 26, Figure 10.
Sonninia (*Papilliceras*) cf. *S.* (*P.*) *espinazitensis* Tornquist. Imlay, 1973, p. 69, Plate 27, Figures 5, 6.

Holotype: NWMNH 25006. Provenance: Locality 18 (Figure 1); 17 m above base of Weberg Member; Burkei Zone. Dimensions: DMAX 120 mm; D 115 mm, UD 42 mm, WW 29 mm, WH 40.5 mm.

Name derivation: In memory of Bernard V. Burke, son of Mrs. Bernard V. Burke, who assisted in this project.

Diagnosis: Nucleus nonspinose; outer whorls with subogival section; on outer whorl, ribbing upright, with 10-12 papillate costae per half whorl.

Description: The inner whorls (beyond nucleus) are compressed and have a subovate section, while the outer whorls are subogival. The venter may be narrowly tabulated where shell is present and weakly sulcate on the internal mold. Ribbing on the inner whorls is rectiradiate or gently prorsiradiate, gently falcoid, and subfasciculate to bifurcate. Beginning on the outer whorl of the phragmocone or on the body chamber, ribbing becomes papillate, widely and evenly spaced, nearly straight, approximately radial, strongest on the inner flank, and weak high on the whorl side.

Discussion: *Sonninia blackwelderi* (Crickmay, 1933) has an ornamentation style like that of some finely ornate specimens of *S. burkei* n. sp. The former apparently is represented by one specimen, the holotype, which consists only of portions of the outer whorls. As such, the specimen is inadequate for certain identification and is considered to be a nomen dubium. The nonspinose nucleus sets the new species apart from most belonging to papillate *Sonninia*. *Sonninia pseudoarenata* (Maubeuge) has an outer whorl similar in appearance but has markedly coarser ribbing on the phragmocone. Imlay (1973) compared material pertaining to this species with the South American *S. espinazitensis* (Tornquist), redescribed in Westermann and Riccardi (1972). That species differs by having a robust keel, spinose inner whorls (on some specimens), rounded umbilical shoulder, more prorsiradiate ornamentation, and papillate and nodose ornamentation set well above mid-flank.

Sonninia grindstonensis n. sp.
Plate 1, Figure 13

Sonninia (*Papilliceras*) cf. *S.* (*P.*) *juramontana* (Crickmay). Imlay, 1973, p. 69, Plate 27, Figure 1.

Holotype: NWMNH 25007. Provenance: Locality 2 (Figure 1); 38 m above base of Warm Springs Member; Crassicostatus Zone. Dimensions: D 76 mm, UD 27 mm, WH 31 mm.

Name derivation: Referring to Grindstone Creek, located in the vicinity in which the holotype for the species was collected.

Diagnosis: Coiling moderately involute; inner whorls nonspinose, outer whorls of nucleus bearing small nodes; phragmocone with dense but well-defined, gently sigmoidal ribbing; papillae on outer whorl closely spaced.

Description: The first couple of whorls are nonspinose, while the nucleus adorally has widely spaced and very weak nodes. Nodose ornamentation does not persist onto the outer whorl of the phragmocone. Phragmocone ribbing is variably simple, subfasciculate, and bifurcate; it is gently falcoid and gently prorsiradiate to rectiradiate. Costation on the outer whorl is nearly upright and slightly falcoid to slightly concave and is stronger on the lower flank than on the upper flank. The papillate ornamentation on the outer whorl is fairly fine and closely spaced and coarsens with shell size.

Discussion: Imlay (1973) compared this species with *Sonninia juramontana* (Crickmay, 1933), which is represented only by the holotype consisting of outer whorls inadequate for identification. *Sonninia grindstonensis* n. sp. differs from *S. burkei* n. sp. in having finer and more closely spaced papillae and nodes on the inner whorls. Also, costate ornamentation is less strongly prorsiradiate on the inner whorls and better defined on the nucleus, extending down to a smaller shell diameter.

Sonninia washburnensis n. sp.
Plate 2, Figures 1, 2

Holotype: NWMNH 25008. Provenance: Locality 11 (Figure 1); 32 m above base of Weberg Member; Ochocoense Subzone. Dimensions: DPHRAG 82 mm, UD 27 mm, WW 25 mm, WH 34.5 mm.

Name derivation: In reference to the "Washburn Homestead," located in the vicinity where the holotype of the species was collected.

Diagnosis: Whorl section of phragmocone subovate; outer whorl compressed subogival; phragmocone with dense, slightly biconcave, prorsiradiate ribbing.

Description: The whorl section of most of the phragmocone beyond the nucleus is subovate, while the outer one to one-and-one-half whorls have a fairly strongly compressed subogival section. The venter (with shell) is slightly tabulated, and the keel is pronounced although not conspicuously high. The nucleus on two of the three specimens bears small spines. The shell is ornamented with closely spaced, slightly biconcave, fasciculate to subfasciculate, commonly striate (on phragmocone) ribbing that is moderately to strongly prorsiradiate. Ribbing is strongest at mid-flank.

Discussion: This species does not compare well with any of those from Europe. Its morphology, however, is most like that of certain specimens of *Euhoploceras acanthodes* (Buckman). The new species differs from finely ornate *E. acanthodes* in that the whorl section is more compressed, the nucleus is more finely spinose, and the closely spaced, biconcave, striate ribbing is more strongly prorsiradiate.

Genus *Euhoploceras* Buckman, 1913

Euhoploceras crescenticostatum n. sp.
Plate 2, Figures 5, 6

Holotype: NWMNH 25009. Provenance: Locality 19 (Figure 1); 38 m above base of Weberg Member; Packardi Zone. Dimensions; DMAX 218 mm, UD 87.5 mm, WW ~51 mm, WH 73 mm.

Diagnosis: Like *Euhoploceras acanthodes* (Buckman) but with nodes consistently restricted to 45-mm shell diameter and body chamber costation gently concave and widely spaced.

Description: The outer whorls have a compressed subrectangular whorl section, with rounded but well-defined umbilical shoulder and gently inflated flanks. The venter commonly has wide shallow sulci. The tuberculate stage is restricted to 40- to 45-mm shell diameter. Phragmocone ribbing is irregular in strength, is gently flexed, and incipiently biconcave and has a density of 15-19 costae per half whorl. Costation on the outer whorl rapidly decreases in density to 11-13 costae per one-half volution. The body chamber costae are highest and sharpest at mid-flank and nearly straight to characteristically gently concave.

Discussion: *Euhoploceras acanthodes* (Buckman), as represented in Europe and Oregon, is a highly variable species in whorl inflation and development of nodose ornamentation. The new species from Oregon is differentiated by having the nodose ornamentation restricted to 45-mm shell diameter and by having slightly crescentic, widely spaced body chamber costation.

Euhoploceras donnellyense n. sp.

Sonninia (*Papilliceras*) *stantoni* (Crickmay). Imlay, 1973, p. 68, Plate 26, Figures 1-9, 13 (not Figures 10, 12).

Holotype: CAS 13406. Imlay, 1973, Plate 26, Figure 13, Locality L57; Snowshoe Formation near Seneca.

Name derivation: In reference to Donnelly Creek (Figure 1, Locality 23), located in the drainage where material referred to this species was collected.

Diagnosis: Nucleus commonly not nodose; phragmocone strongly ribbed; costation radial to gently rursiradiate, nearly straight to weakly convex; "papillate" ornamenation coarse.

Description: The nucleus commonly is nontuberculate. The phragmocone has strong ribbing that is radial to slightly rursiradiate and nearly straight to weakly concave. "Papillate" ornamentation is strong.

Discussion: This new species was described fully by Imlay (1973) under *Sonninia* (*Papilliceras*) *stantoni* (Crickmay). *Euhoploceras donnellyense* n. sp. differs from *E. acantherum* (Buckman) (=*E. stantoni*) in having a more compressed whorl section with flatter flanks and a tightly rounded umbilical shoulder, denser and stronger ribbing on the phragmocone, and markedly straighter ribs.

Euhoploceras grantense n. sp.
Plate 2, Figures 3, 4

Holotype: NWMNH 25010. Provenance: Locality 8 (Figure 1); 12.5 m below top of Weberg Member; Westi Subzone. Dimensions: DMAX 135 mm, DPHRAG 96.5 mm, UD 38 mm, WW 28.5 mm, WH 35 mm.

Name derivation: In reference to Grant County, Oregon.

Diagnosis: Shell rather strongly evolute; inner and intermediate whorls densely costate; body chamber with strong, rursiradiate, falcoid ribbing, that is not nodose.

Description: The whorl section passes from subcircular to subogival by 10- to 15-mm shell diameter. On the outer whorls, the umbilical wall is vertical, the distinct umbilical shoulder is gently rounded, and the slightly convex subparallel flanks round evenly onto the venter. The nucleus is nonspinose. Phragmocone ribbing is gently falcoid or biconcave and may be slightly swollen near mid-flank. Costation is fasciculate to subfasciculate on the phragmocone and becomes more distantly spaced, stronger, and simple on the body chamber. These latter ribs are falcoid, are inflated at mid-flank, and remain strong high on the whorl side.

Discussion: This species bears no resemblance to any European species of *Euhoploceras*. *Euhoploceras grantense* n. sp. is most similar to *Euhoploceras rursicostatum* n. sp. but differs in being nontuberculate.

Euhoploceras ochocoense n. sp.
Plate 2, Figures 8, 9

Sonninia (*Euhoploceras*) *modesta* Buckman. Imlay, 1973, p. 62, Plate 7, Figures 1-4; Plate 8, Figures 3-5; Plate 9, Figures 5, 6; Plate 10.

Holotype: NWMNH 25011. Provenance: Locality 11 (Figure 1); float from 32 m above base of Weberg Member; Ochocoense Subzone. Dimensions: DMAX 116 mm, UD 36 mm, WW 37 mm, WH 46 mm.

Name derivation: Referring to the Ochoco Mountains in central Oregon.

Diagnosis: A comparatively involute compressed species of *Euhoploceras*; spinose stage restricted to 15-mm shell diameter; ribbing quite dense, gently prorsiradiate.

Description: The whorl section on the phragmocone is ogival with steeply inclined to overhanging umbilical wall. The outer whorl most commonly egresses near the end of the phragmocone. The body chamber comprises at least five-eighths of a whorl. The nucleus may be costate or nodose, in which case the spines do not persist beyond 15-mm shell diameter. On the intermediate whorls, ribbing is dense, fasciculate-bifurcate in style, and gently prorsiradiate. Commonly there are widely spaced low undulations on the lower flank. At largest shell dimensions, the ribbing becomes simple (or rarely bifurcate), more widely spaced, and stronger. Rib height is commonly greatest on the outer flank.

Discussion: This species is most similar to *E. modestum* (Buckman), from which it differs in that the ribbing tends to be less prorsiradiate and the height of the ribbing is conspicuously stronger in the ventro-lateral area, rather than at mid-flank.

Euhoploceras rursicostatum n. sp.
Plate 2, Figure 7

Sonninia (*Euhoploceras*) *crassispinata* Buckman. Imlay, 1973, p. 67 (part), Plate 23, Figure 2.

Holotype: NWMNH 25014. Provenance: Locality 9 (Figure 1); 39.5 m above base of Weberg Member; Westi Subzone. Dimensions: D (indet.), WH 41 mm, WW 28 mm.

Diagnosis: Shell evolute; moderately dense costae on phragmocone; outer whorl nodose, with falcoid rursiradiate ribbing.

Description: The evolute shell possesses outer whorls that are subrectangular in section. Shallow sulci are present on the internal mold of the body chamber. Ornamentation on the phragmocone consists of slightly biconcave and fairly dense costae that are irregular in strength. Ribbing is strongest at mid-flank, where the strongest costae may be slightly bullate or pointed. On the body chamber, costation becomes much stronger, more widely spaced, and simple. The ribs arise at the umbilical shoulder, trend rursiradiately, and have strong bullate nodes at mid-flank. The ribs remain strong on the ventro-lateral shoulder, where they bend forward sharply and expire against the sulci.

Discussion: This new species is readily distinguishable from *Euhoploceras polyacanthum* (Waagen). The new species differs in having a more finely costate phragmocone and an outer whorl with ribbing that is more falcoid and relatively stronger high on the flank. The new species is a derivative of *E. westi* n. sp. and differs from the latter in having an outer whorl with predominantly simple falcoid ribbing that is relatively stronger high on the flank. *Euhoploceras grantense* n. sp., on the other hand, is derived from *E. rursicostatum* and is distinguished by lack of nodose ornamentation and denser ribbing.

Euhoploceras transiens n. sp.
Plate 3, Figure 3

Holotype: NWMNH 25012. Provenance: Locality 13 (Figure 1); Weberg Member; Westi Subzone. Dimensions: DMAX 230 mm, UD 94 mm, WH 84 mm.

Diagnosis: Coarse, moderately to widely spaced tubercles on phragmocone; last whorl with strongly inflated but nonbullate, moderately dense body chamber ribbing that is strong on the upper flank.

Description: The inner whorls are subcircular in section, while the last whorl of the phragmocone has a gently rounded umbilical shoulder and may be weakly compressed. The body chamber comprises at least three-fourths of a whorl. The inner adult whorls bear widely spaced bullate tubercles, between which typically there are one or two low, thick ribs that are highest at mid-flank and straight to slightly sigmoidal or gently concave. The tubercle-bearing costae on the lower flank increase rapidly in strength as they ascend to the tubercle crests. These ribs decrease in strength much more quickly above the tubercles. The tuberculate stage drops out on the last whorl of the phragmocone. Adorally (within a quarter to three-quarters of a whorl) the variably strong costae become gently concave. Ribbing becomes nearly even in height on the last whorl. These costae are strongest at mid-flank and are as strong on the upper half of the whorl side as they are on the lower half, or stronger.

Discussion: *Euhoploceras transiens* n. sp. is most similar in appearance to *E. adicrum* (Waagen), from which it differs in that the tuberculate ornamentation on the phragmocone on some specimens is denser and that the body chamber ribbing is denser, more concave, not distinctly pointed or bullate at mid-flank, and strong high on the flank.

Euhoploceras tuberculatum n. sp.

Sonninia (*Euhoploceras*) *polyacantha* (Waagen). Imlay, 1973, p. 64, Plates 18, 19; Plate 20, Figures 1, 5-7; Plate 21, Figures 8, 9.

Holotype: CAS 13385. Imlay, 1973, Plates 18, 19, Locality 39 (L573); Weberg Member.

Diagnosis: Comparatively involute and compressed species of Euhoploceras; nodes (when present) on inner whorls restricted to 25-mm shell diameter; strongly prorsiradiate, dense ribbing; coarse tubercles on outer whorl.

Description: The whorl section is compressed and ogival to subrectangular, and the venter may have wide shallow sulci. The inner whorls of some specimens are nodose up to 25-mm shell diameter. The ribbing on the phragmocone is slightly falcoid; commonly it is slightly swollen near mid-flank, comparatively strong in the ventro-lateral area, and oriented prorsiradiately between 10° and 20°. The body chamber is strongly tuberculate, and costae there are highly variable in strength and pattern.

Discussion: The phragmocone of this distinctive species is more involute and has much finer ribbing than on *Euhoploceras polyacanthum* (Waagen), while the body chamber has much coarser tuberculate ornamentation. The phragmocone ribbing is most like that of *E. modestum* (Buckman), which differs by lacking tuberculate ornamentation on the body chamber.

Euhoploceras westi n. sp.
Plate 3, Figures 1, 2

Sonninia (*Euhoploceras*) *crassispinata* Buckman. Imlay, 1973, p. 67, Plate 22, Figures 1, 2, 4; Plate 23, Figures 3, 4 (not Figures 1, 2); Plate 24, Figures 1, 4; Plate 25, Figures 17-19.
Sonninia (*Euhoploceras*) cf. *S.* (*E.*) *crassispinata* Buckman. Imlay, 1973, p. 68, Plate 22, Figure 3; Plate 24, Figure 5.

Holotype: NWMNH 25013. Provenance: Locality 13 (Figure 1); Weberg Member; Westi Subzone. Dimensions: DMAX 127 mm; D 96 mm, UD 40 mm, WW ~24 mm, WH 32 mm.

Name derivation: In honor of the late Roy West, who conducted studies in the paleoecology of the Robertson Formation, Lower Jurassic.

Diagnosis: Phragmocone may be strongly tuberculate but has marked tendency for reduction of ornamentation on inner whorls; outer whorl has coarse, typically widely spaced tubercles.

Description: The whorl section is subcircular, subquadrate, or subogival on the phragmocone beyond the nucleus, and the outer whorl is weakly compressed. The innermost whorls usually are nontuberculate. Widely spaced tubercles appear at a variable stage beyond the nucleus. Costation fades adorally, and the lower flank between the tubercles on the last whorl is nearly smooth. Rib trajectory most commonly ranges from gently prorsiradiate to gently rursiradiate and usually is nearly straight. Coarser ribbing is straight to gently concave, while fine ribbing is gently sigmoidal. Secondary bifurcate and intercalatory ribbing is gently sigmoidal. The upper flank ribs may be strong but most commonly are weak.

Discussion: This species, in general, is most similar in appearance to *Euhoploceras adicrum* (Waagen) but differs from any European species of *Euhoploceras* in its strong tendency for paedomorphic development of finely costate ornamentation on the phragmocone, coupled with the development of coarse tuberculate ornamentation on the body chamber.

Genus *Fontannesia* Buckman, 1902

Fontannesia packardi n. sp.

Fontannesia cf. *F. evoluta* (Buckman). Imlay, 1973, p. 59, Plate 5, Figures 1-3.
Fontannesia cf. *F. carinata* Buckman. Imlay, 1973, p. 58, Plate 5, Figures 4-13.
Fontannesia cf. *F. luculenta* Buckman. Imlay, 1973, p. 58, Plate 5, Figures 14-19.

Holotype: CAS 13355. Imlay, 1973, Plate 5, Figures 18, 19, Locality L355; Weberg Member.

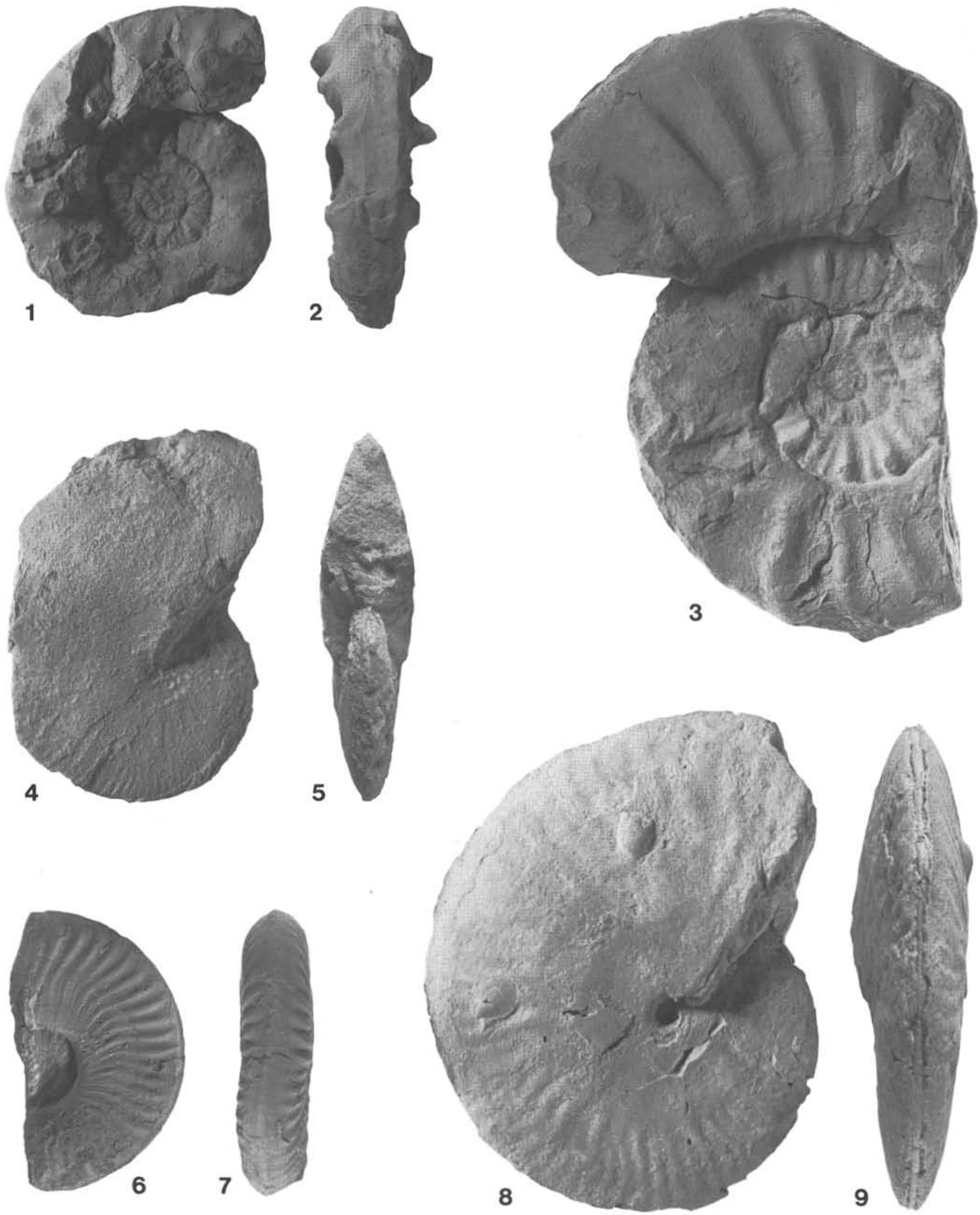
Name derivation: In honor of Earl L. Packard, who contributed to our knowledge of the pre-Tertiary geology of central Oregon.

Diagnosis: Nodose ornamentation present in ventro-lateral area.

Description: This species attains a shell diameter of at least 105 mm. The whorl section ranges from subrectangular to subcircular on the inner adult whorls and becomes more compressed through ontogeny. The venter is broadly rounded to fastigate and supports a low, prominent keel. The ribbing ranges from straight (uncommonly) to markedly falcoid. While a few examples have simple ribbing, ribs commonly arise by intercalation or in pairs on the lower half of the flank. Subnodose to tuberculate ornamentation often occurs in the ventro-lateral area and is strongest on the inner whorls. Tubercles do not persist to large shell dimensions.

Discussion: This species is most similar in coiling and ribbing style to *Fontannesia grammoceroides* (Haug), as recognized by Buckman (1892) prior to his subdivision of the species (Buckman, 1905). The most notable difference of the Oregon species from *F.*

***Facing page:** Plate 3. (All localities refer to Figure 1) — 1, 2.* Euhoploceras westi *n. sp.; holotype, NWMNH 25013 from Locality 13 (× 0.5). — 3.* Euhoploceras transiens *n. sp.; holotype, NWMNH 25012 from Locality 13 (× 0.5). — 4, 5.* Strigoceras harrisense *n. sp.; holotype, NWMNH 25015 from Locality 22 (× 1). — 6, 7.* Fontannesia involuta *n. sp.; holotype, UCMP 38158 from Locality 20 (× 1). — 8, 9.* Strigoceras lenticulare *n. sp.; holotype, NWMNH 25016 from Locality 11 (× 1).*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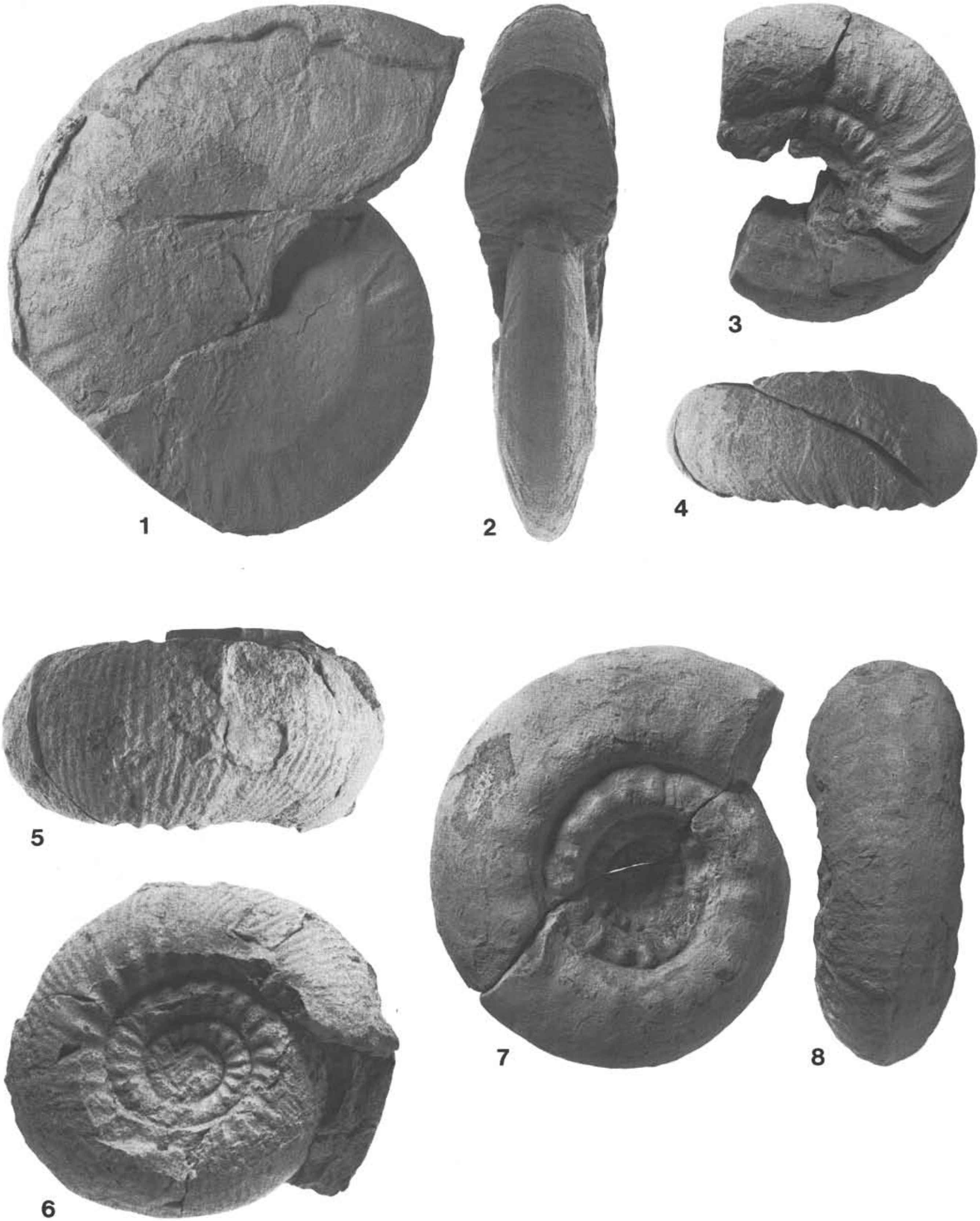
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grammoceroides or any other species of *Fontannesia* is the presence of nodose ornamentation.

Fontannesia involuta n. sp.
Plate 3, Figures 6, 7

Holotype: UCMP 38158. Provenance: Locality 20 (Figure 1); 23 m above base of Weberg Member; Packardi Zone. Dimensions: DMAX 52.5 mm, UD 15.2 mm, WW 13.5 mm, WH 22 mm.

Diagnosis: Involute; whorl section strongly compressed, umbilical shoulder well defined, flanks flattened.

Description: The shell is strongly involute, and the whorl section is markedly compressed. The inner whorls have a shallow umbilical slope; however, the outer whorl has a nearly vertical umbilical wall and a gently rounded but well-defined umbilical shoulder. The flanks are flattened and subparallel. Ribbing is gently flexuous on the lower flank, becomes well defined about a third of the distance up the flank, and is strongest in the ventro-lateral area.

Discussion: This species is readily differentiated from most others in the genus by being strongly involute and having a strongly compressed whorl section. *Fontannesia involuta* n. sp. differs from *F.* aff. *clarki* (Westermann and Getty) in that it has no distinct tabulae bordering the keel.

Superfamily HAPLOCERATACEAE Zittel, 1884
Family STRIGOCERATIDAE Buckman, 1924
Genus *Strigoceras* Quenstedt, 1886

Strigoceras harrisense n. sp.
Plate 3, Figures 4, 5

Praestrigites cf. *P. deltotus* (Buckman). Imlay, 1973, p. 75, Plate 35, Figures 4, 8, 9, 13 (not Figures 1-3, 5-7, 11, 12, 14).

Holotype: NWMNH 25015. Provenance: Locality 22 (Figure 1); Weberg Member; Sparsicostatus Zone. Dimensions: DMAX 68 mm, WW 16.5 mm, WH 42 mm.

Name derivation: Referring to the "Old Harris Place," an abandoned homestead near the locality where the holotype for this species was found.

Diagnosis: Spiral and radial ornamentation weak; flank costation fine, even in strength, prorsiradiate.

Description: The shell is oxyconic, and the minute umbilicus is bordered by a slightly raised shoulder. The thin keel is moderately high. The shell has weak spiral ornamention as well as radial ribs. The spiral ornamentation consists of slight ridges, a vague one about a quarter of the distance up the flank and an even weaker one at mid-flank. The radial ornamentation includes moderately to widely spaced, weak, prorsiradiate primary costae, that at mid-flank may be slightly swollen and convex. The outer flank ribs are more closely spaced, even in strength, and prorsiradiate and expire against the keel.

Discussion: The exceptionally weak radial and spiral ribbing and the prorsiradiate direction of the dense outer flank costae serve to distinguish this species from others belonging to *Strigoceras*. Most of the presumably weakly ornate strigoceratid ammonites Imlay compared with "*Praestrigites*" *deltotus* Buckman are referable to *S. lenticulare* n. sp. (Imlay, 1973, Plate 35, Figures 3, 5-7, 11, 12, 14), while one example (Imlay, 1973, Plate 35, Figures 1, 2) may be an involute and weakly ornate variant of *Eudmetoceras mowichense* n. sp.

Note that *Praestrigites* is a junior synonym of *Strigoceras*. The holotype of the type species from Great Britain, *Praestrigites praenuntius* Buckman, has longitudinal ridges.

Strigoceras lenticulare n. sp.
Plate 3, Figures 8, 9

Praestrigites cf. *P. deltotus* (Buckman). Imlay, 1973, p. 75 (part), Plate 35, Figures 3, 5-7, 11, 12, 14.
Strigoceras cf. *S. languidum* (Buckman). Imlay, 1973, p. 76, Plate 36, Figures 13, 17-21.
Strigoceras sp. undet., Imlay, 1973, p. 76, Plate 36, Figures 14-16.

Holotype: NWMHN 25016. Provenance: Locality 11 (Figure 1); 32-33 m above base of Weberg Member; Ochocoense Subzone. Dimensions: DMAX 92.5 mm, UD 4.5 mm, WW 22 mm, WH 54 mm.

Diagnosis: Umbilicus minute; ribbing feeble, weakly to strongly prorsiradiate on lower flank; on upper flank, ribbing rursiradiate, branching only on finely ornate specimens; three longitudinal ridges.

Description: The shell is septate to 92-mm shell diameter and has a minute umbilicus. Three spiral ridges are present and are spaced at intervals about a quarter of the distance up the whorl side. The mesial ridge is the strongest, while the one closest to the venter is the weakest. The umbilical shoulder is also raised slightly. Ribbing is falcoid, gently to strongly prorsiradiate on the lower flank, becomes rursiradiate a short distance above mid-flank, and is radial to gently projected on the venter. Ribs terminate against the keel. Ribbing most commonly is weak and comparatively sparse on the lower flank. Ribbing on the upper half of the whorl side is simple on coarsely ornate specimens and partly bifurcate and intercalatory on finely ornate material. A few ribs that are sporadically spaced and generally originating low on the flank are stronger than the others.

Discussion: *Strigoceras lenticulare* n. sp. resembles most closely the English species *S. languidum* (Buckman) and Alaskan material described under *S.* cf. *languidum* (Buckman) by Imlay (1964). *Strigoceras languidum* differs in having a markedly narrower L sutural element and a more gently rounded and wider umbilicus. The Alaskan *S.* cf. *languidum* is more umbilicate, has a more gently rounded umbilical shoulder, and is more weakly ornate on the lower flank.

Family OPPELIIDAE Douvillé, 1890
Subfamily OPPELIINAE Douvillé, 1890
Genus *Hebetoxyites* Buckman, 1924

Hebetoxyites snowshoensis n. sp.
Plate 4, Figures 1, 2

Holotype: NWMNH 25017. Provenance: Locality 11 (Figure 1); 33 m above base of Weberg Member; Ochocoense Subzone. Dimensions: D 145.5 mm, WW 34 mm, WH 87 mm.

Diagnosis: Minutely umbilicate; venter evenly rounded (not acutely rounded); outer flank ribbing weak, irregular in strength and spacing.

Description: The compressed shell has a minute umbilicus, the margin of which is not raised. The body chamber comprises half a volution. Spiral ornamentation consists of a pronounced ridge just above mid-flank (it becomes obsolete on the adoral end of the body chamber) and possibly another faint ridge just over three-fourths of the distance up the flank. The latter is perceptible only on the phragmocone.

Phragmocone growth striae are nearly radial on the lower flank, where they are gently concave; they are deflected rursiradiately at the mid-flank ridge, are concave on the upper flank, but have not been observed in the ventro-lateral area. The striae on the adoral

***Facing page:** Plate 4. (All localities refer to Figure 1) — 1, 2.* Hebetoxyites snowshoensis *n. sp.,; holotype, NWMNH 25017 from Locality 11 (× 0.67). — 3, 4.* Docidoceras striatum *n. sp.; holotype, NWMNH 25020 from Locality 9 (× 0.5). — 5, 6.* Docidoceras schnabelei *n. sp.; holotype, NWMNH 25019 from Locality 19 (× 1). — 7, 8.* Docidoceras amundsoni *n. sp.; holotype, NWMNH 25018 from Locality 13 (× 0.5).*

half of the body chamber are more gently falcoid. They are slightly rursiradiate or radial where they pass over the venter. The apertural outline is sigmoidal and parallel to the growth striae.

Ribbing is conspicuous only on the outer three-fourths of the flank and is irregular in strength. The costae are rursiradiate to slightly projected in the ventro-lateral area and are absent on the venter. Costation on the inner adult whorls is very irregular in strength. On the adoral part of the phragmocone and body chamber, the ribbing becomes simple, fairly uniform in strength, and moderately spaced; but adorally on the body chamber, the plicae rapidly become progressively distant, low, and broad, until they are to be seen no more on the last one-eighth volution. The septal suture is fairly complex but not deeply incised.

Discussion: This species is most like *Hebetoxyites hebes* Buckman, from which it differs in details of the septal suture, weaker outer flank ribbing, and more broadly rounded venter.

Superfamily STEPHANOCERATACEAE Neumayr, 1875
Family STEPHANOCERATIDAE Neumayr, 1875
Genus *Stephanoceras* Waagen, 1869
Subgenus *Skirroceras* Mascke, 1907

Stephanoceras (*Skirroceras*) *flexicostatum* n. sp.

Stephanoceras (*Skirroceras*) cf. *S.* (*S.*) *leptogyrale* (Buckman). Imlay, 1973, p. 88, Plate 46, Figure 15.

Holotype: USNM 168610. Imlay, 1973, Plate 46, Figure 15, U.S. Geological Survey Mesozoic Location 29241.

Diagnosis: Inner whorls with dense secondary ribbing, primaries strongly flexed.

Description: Primary ribbing is prorsiradiate and strongly flexed adorally, at least on the phragmocone. Tuberculate ornamentation on the inner whorls consists of small, rounded nodes and on the outer whorls is quite prominent. Secondary ribbing is densely spaced on the inner whorls and coarsens on the outer whorls.

Discussion: Material constituting this species was compared by Imlay (1973) with the English *Stephanoceras leptogyrale* (Buckman), which differs by having less flexed and prorsiradiate primaries and less densely spaced secondary ribbing on the inner whorls. *Stephanoceras flexicostatum* also resembles *S. macrum* (Quenstedt), from which it differs in its much smaller size, more oblique aperture, and the flexed primaries.

Genus *Freboldites* n. gen.

Type species: *Freboldites bifurcatus* n. sp.

Name derivation: In honor of the late Canadian paleontologist Hans Frebold.

Diagnosis: Shell small, exceptionally evolute, inner whorls with nearly smooth venter and nontuberculate, strongly prorsiradiate, bifurcate ribbing.

Discussion: *Freboldites* n. gen. appears to be an important transitional form, having outer whorls with an ornamentation style typical of *Stephanoceras* and ribbing on the inner whorls like that of perisphinctaceans. Also, the new genus just predates the first perisphinctid, *Parabigotites crassicostatus* Imlay. The inner whorls of *Freboldites bifurcatus* n. sp. are so similar to those of *P. crassicostatus* that it is very likely that the latter is a paedomorphic development of the former. Contrary to the assessment given by Pavia (1983), *P. crassicostatus* is probably a true perisphinctid; the species is reported to have a strongly retracted suspensive lobe (Imlay, 1964, p. B54) and does not appear to be a hammatoceratid descendant (as may be the case with *Praeleptosphinctes*; see Pavia, 1983). The stephanoceratid genus *Phaulostephanus*, which also first appears in the superjacent beds, was interpreted by Pavia (1983) to be the radical for the perisphinctids. *Phaulostephanus* is also a logical descendant of *Freboldites*. *Freboldites*, therefore, provides the first adequate demonstration of the transition between *Stephanoceras* (or immediate ancestor) and the Perisphinctaceae. *Phaulostephanus* may also be the radical of *Lupherites*.

Freboldites bifurcatus n. sp.

Stephanoceras (*Skirroceras*) cf. *S.* (*S.*) *dolichoecus* (Buckman). Imlay, 1973, p. 88, Plate 45, Figures 8, 11.
Parabigotites crassicostatus Imlay, 1973, p. 92 (part), Plate 47, Figures 31-32 (not Figures 33-36).

Holotype: CAS 61542. Imlay, 1973, Plate 45, Figure 8, Locality 38; Weberg Member.

Diagnosis: Inner whorls nontuberculate, with bifurcate ribbing; outer whorls finely tuberculate, with three to four secondaries per primary.

Description: The shell has about 10 whorls and is exceptionally evolute. The phragmocone ends at about 60-mm shell diameter, and the maximum preserved shell diameter is 77 mm. The whorl section is depressed in the nucleus, while on the outer whorls it is subcircular. Bullate primaries appear at about 1-mm shell diameter. The primaries are most strongly projected on the inner three whorls but are still moderately strongly projected on the next two to three volutions. The secondaries consistently arise in pairs on the inner whorls and are gently convex over the nearly smooth venter. The finely tuberculate ornamentation characteristic of the outer whorls may begin as late as the fifth or sixth whorl. On the outer whorls, the primaries are weak and rounded and nearly radial to markedly rursiradiate. There usually are three but sometimes as many as four secondaries to each of these primaries. There is no evidence of constrictions. The secondary costation on the outer whorls is at most gently projected over the venter and retains its strength across the venter.

Remarks: Imlay (1973) compared specimens belonging to this new species to *Stephanoceras dolichoecum* (Buckman), perhaps because of the supposed similar highly evolute coiling. He may have been misled by one of the two figures of the holotype of *S. dolichoecum* (Buckman, 1921, v. 3, Plate 265, Figure 1) that is highly reduced photographically, giving the appearance of an extremely evolute ammonite. The specimen figured by Imlay (1973, Plate 47, Figures 31, 32) under *Parabigotites crassicostatus* Imlay also belongs to this new species. The specimen is identical to the holotype of *Freboldites bifurcatus* n. sp. The inner whorls of *Freboldites bifurcatus* n. sp. differ from those of *P. crassicostatus* in that the coiling is more evolute, the whorl section is less depressed, and the primary ribbing is more closely spaced on the sixth whorl. The inner whorls are otherwise very similar between the two species and signify the probable paedomorphic development of *P. crassicostatus* from *Freboldites bifurcatus* n. sp.

Family OTOITIDAE Mascke, 1907
Genus *Docidoceras* Buckman, 1919

Docidoceras amundsoni n. sp.
Plate 4, Figures 7, 8

Holotype: NWMNH 25018. Provenance: Locality 13 (Figure 1); Weberg Member; Westi Subzone. Dimensions: DMAX 158.5 mm, UD 75 mm, WW 57 mm, WH 45 mm.

Name derivation: In honor of Clayton T. Amundson, who has worked extensively in the Suplee area and collected the holotype.

Diagnosis: Quite evolute; deeply umbilicate; coarsely ornate phragmocone.

Description: The evolute inner adult whorls are cadiconic. The whorls increase in height on the outer whorls, so that the body chamber has a depressed subelliptical section with conspicuously rounded flanks. The incomplete body chamber comprises just over one volution, and the last half whorl egresses noticeably. The widest part of the whorl section is near mid-flank on the inner adult whorls and migrates to a quarter or a third of the whorl height on the body chamber.

The inner preserved whorls have 10-11 rounded nodes per half whorl. On the outer whorls, the tubercles become progressively blunter and decrease in number to nine per half whorl. Primary costae are nearly radial to gently projected on the phragmocone, where they consist of low, broad undulations; they become even more diffuse on the body chamber. Equally diffuse prorsiradiate plicae above the nodes extend up the flank only a short distance before expiring. Barely perceptible secondary ribbing on the coarsely preserved penultimate half whorl appears to be fine and adorally arched. Lower broad costae cross the venter with little convexity on the adoral half of the body chamber.

Discussion: Closest correspondence of *Docidoceras amundsoni* n. sp. is with the similarly stout-whorled *Docidoceras zemistephanoides* Geczy from Hungary. The Oregon species is even more deeply umbilicate, has coarser and wider spaced nodose ornamentation, and has an outer whorl that is less depressed.

Docidoceras schnabelei n. sp.
Plate 4, Figures 5, 6

Docidoceras cf. *D. liebi* Maubeuge. Imlay, 1973, p. 79, Plate 37, Figures 13, 14.

Holotype: NWMNH 25019. Provenance: Locality 19 (Figure 1); 38 m above base of Weberg Member; Packardi Zone. Dimensions: DMAX 68 mm, D 57.2 mm, UD 25.7 mm, WW 31 mm, WH 15 mm.

Name derivation: In honor of rancher Les Schnabele.

Diagnosis: Coiling evolute; primaries densely spaced, short, and bullate on last whorl; secondary costation markedly convex adorally.

Description: One specimen with aperture preserved has a maximum shell diameter of 78.5 mm, but other less complete material indicates greater dimensions. The phragmocone whorl section is lenticular but has a rounded lateral edge. On the last half whorl, the body chamber egresses, and the whorl section becomes slightly less depressed. The aperture is strongly flared, markedly oblique, and apparently not collared. Primary ribs on the phragmocone are closely spaced, are radial to projected, and bear pointed bullae or nodes. The ribs are bullate and quite short on the last whorl. The dense secondary costation is conspicuously arched adorally and may be very weak at large shell dimensions. It tends to coarsen over the adoral part of the body chamber.

Discussion: *Docidoceras schnabelei* n. sp. is closely allied with the *D. widebayense* species group (=subgenus *Pseudocidoceras* Westermann, 1969) but differs from any of those Alaskan species in having shorter primaries and a more strongly flared aperture.

Docidoceras striatum n. sp.
Plate 4, Figures 3, 4

Holotype: NWMNH 25020. Provenance: Locality 9 (Figure 1); 38 m above base of Weberg Member; Westi Subzone. Dimensions: DMAX 118 mm, WH ~32 mm.

Diagnosis: Coiling not strongly evolute; phragmocone cadiconic; body chamber finely ornate on venter.

Description: The outer whorls of the phragmocone have a depressed lenticular section; the innermost preserved whorl has a comparatively sharp edge, and the penultimate whorl has a rounded edge. The body chamber is subovate and only moderately depressed. The body chamber comprises at least three-fourths of a volution.

Primary costation on the phragmocone is gently prorsiradiate and terminates in closely spaced, fine tubercles. Three to four secondaries arise from each primary and are projected over the venter. On the body chamber, the primaries are concave and give rise to bullate nodes. The strongly projected secondary ornamentation consists of fine fasciculate rib bundles, and the venter is heavily striate to exceptionally weakly ribbed.

Discussion: This species is readily distinguished by its striate body chamber. The phragmocone is identical in shell proportions and ornamentation to *Docidoceras schnabelei* n. sp., indicating derivation from that species. The latter also has a similar trend in weakening of ventral ornamentation on the body chamber.

ACKNOWLEDGMENTS

The writer is greatly indebted to Ralph Imlay for orienting him in the field and for many helpful discussions. Likewise, the author benefited from discussions with P.L. Smith and R.E. Thoms. Thanks are extended to C. Burke and C.T. Amundson for assistance with the project. The writer is sincerely appreciative of the hospitality of the ranchers from the Suplee area, including the late Melvin Weberg, Les Schnabele, Hugh Robertson, and their families. J. Guex and H.W. Tipper reviewed the manuscript.

REFERENCES CITED

Buckman, S.S., 1887-1907, A monograph of the ammonites of the Inferior Oolite Series: London, Palaeontographical Society, 456 p., 103 pls.; Supplement, cclxii p., XXIV pls.

———1919-1930, Type ammonites: London, Wheldon and Wesley, v. 3-7.

Crickmay, C.H., 1933, Mount Jura investigation: Geological Society of America Bulletin, v. 44, no. 5, p. 895-926.

Dickinson, W.R., and Thayer, T.P., 1978, Paleogeographic and paleotectonic implications of Mesozoic stratigraphy and structure in the John Day inlier of central Oregon, *in* Howell, D.G., and McDougall, K.A., eds., Mesozoic paleogeography of the western United States: Pacific Coast Paleogeography Symposium 2, Sacramento, Calif., Society of Economic Paleontologists and Mineralogists, Pacific Section, p. 147-162.

Dickinson, W.R., and Vigrass, L.W., 1965, Geology of the Suplee-Izee area, Crook, Grant, and Harney Counties, Oregon: Oregon Department of Geology and Mineral Industries Bulletin 58, 109 p.

Guex, J., 1987a, Corrélations biochronologiques et associations unitaires: Lausanne, Presses Polytechniques Romandes, 244 p.

———1987b, Sur la phylogenèse des ammonites du Lias inférieur: Bulletin de la Société Vaudoise des Sciences Naturelles, v. 78, no. 4, p. 455-469.

Hall, R.L., and Westermann, G.E.G., 1980, Lower Bajocian (Jurassic) cephalopod faunas from western Canada and proposed assemblage zones for the lower Bajocian of North America: Palaeontographica Americana, v. 9, no. 52, 93 p.

Hillebrandt, A. von, and Westermann, G.E.G., 1985, Aalenian (Jurassic) ammonite faunas and zones of the southern Andes: Zitteliana, v. 12, p. 3-55.

Imlay, R.W., 1964, Middle Bajocian ammonites from the Cook Inlet region, Alaska: U.S. Geological Survey Professional Paper 418-B, 61 p.

———1973, Middle Jurassic (Bajocian) ammonites from eastern Oregon: U.S. Geological Survey Professional Paper 756, 100 p.

Lupher, R.L, 1941, Jurassic stratigraphy of central Oregon: Geological Society of America Bulletin, v. 52, no. 2, p. 219-269.

Morton, N., 1975, Bajocian Sonniniidae and other ammonites from western Scotland: Palaeontology, v. 18, pt. 1, p. 41-91.

———1976, Bajocian (Jurassic) stratigraphy in Skye, western Scotland: Scottish Journal of Geology, v. 12, pt. 1, p. 23-33.

Mouterde, R., Ruget, C., and Caloo, B., 1972, Les limites d'étages. - Examen du problème de la limite Aalénien-Bajocien, *in* Colloque sur les méthodes et tendances de la stratigraphie: Paris, France, Bureau de Recherches Géologiques et Minières, Mémoire 77, p. 59-68.

Parsons, C.F., 1974, The *sauzei* and 'so-called' *sowerbyi* Zones of the lower Bajocian: Newsletters on Stratigraphy, v. 3, no. 3, p. 153-179.

Pavia, G., 1983, Ammoniti e biostratigrafia del Baiociano inferiore di Digne (Francia SE, Dip. Alpes-Haute-Provence): Museo Regionale di Scienze Naturali, Monografia II, 254 p.

Smith, P.L., 1980, Correlation of the members of the Jurassic Snowshoe Formation in the Izee basin of east-central Oregon: Canadian Journal of Earth Sciences, v. 17, no. 12, p. 1603-1608.

———1986, The implications of data base management systems to paleontology: A discussion of Jurassic ammonoid data: Journal of Paleontology,

v. 60, no. 2, p. 327-340.
Taylor, D.G., 1981, Jurassic (Bajocian) ammonite biostratigraphy and macroinvertebrate paleoecology of the Snowshoe Formation, east-central Oregon: Berkeley, Calif., University of California doctoral dissertation, 317 p.
———1982, Jurassic shallow marine invertebrate depth zones, with exemplification from the Snowshoe Formation, Oregon: Oregon Geology, v. 44, no. 5, p. 51-56.
Westermann, G.E.G., 1964, The ammonite fauna of the Kialagvik Formation at Wide Bay, Alaska Peninsula, Part I, Lower Bajocian (Aalenian): Bulletins of American Paleontology, v. 47, no. 216, p. 327-503.
———1969, The ammonite fauna of the Kialagvik Formation at Wide Bay, Alaska Peninsula, Part 2, *Sonninia sowerbyi* Zone (Bajocian): Bulletins of American Paleontology, v. 57, no. 255, p. 5-226.
Westermann, G.E.G., and Riccardi, A.C., 1972, Middle Jurassic ammonoid fauna and biochronology of the Argentine-Chilean Andes Part I: Hildoceratacea: Palaeontographica, Abteilung A, Band 140, p. 1-116.
———1979, Middle Jurassic ammonoid fauna and biochronology of the Argentine-Chilean Andes Part II: Bajocian Stephanocerataceae: Palaeontographica, Abteilung A, Band 164, p. 85-188. □

USGS reports earthquakes

The world had 26 significant earthquakes during the first six months of 1988, three less than during the same period a year earlier, according to the U.S. Geological Survey (USGS). The USGS defines as significant those earthquakes that have a magnitude of 6.5 or greater. Shocks of lesser magnitude are also called significant, if they cause fatalities or injuries or substantial damage.

Waverly Person, chief of the USGS National Earthquake Information Service (NEIS) in Golden, Colorado, said that two of the significant 1988 earthquakes occurred in the United States or nearby waters.

The U.S. earthquakes included the strongest earthquake in the world during the first half of 1988, a magnitude 7.6 shock on March 6 in the Gulf of Alaska.

Person said that the frequency of significant earthquakes in the first half of 1988 is roughly in line with the long-term average of 60 significant earthquakes per year or 30 for six months.

The USGS scientist said that reports have been received of only 12 people being killed as a result of earthquakes in the first six months of this year. If this annual rate of 24 were continued through the end of the year, 1988 would have the lowest death toll on record since the NEIS began keeping detailed statistics more than 20 years ago. The previous low for a single year was 77 in 1984, and the high was more than 600,000 in 1976, most of them in a devastating earthquake in China.

One of the 1988 deaths was in the United States, from a heart attack after a magnitude 4.8 earthquake February 11 in the Whittier area of southern California.

Four of the 1988 earthquakes had magnitudes of at least 7.0:

- The magnitude 7.6 earthquake on March 6 in the Gulf of Alaska that was felt widely in parts of Alaska and Canada and caused minor damage to some ships. It also created a small tsunami (earthquake sea wave).
- The magnitude 7.1 earthquake on June 18 in Mexico's Gulf of California that was felt in parts of Mexico.
- The magnitude 7.0 earthquake on February 24 in the Philippine Islands that caused some slight damage at Virac on Luzon Island.
- The magnitude 7.0 earthquake on April 12 near the coast of Peru that was felt in various parts of Peru.

The world has now gone more than 20 months without a great earthquake (magnitude 8.0 or larger), Person said. The last one was a magnitude 8.1 shock on October 20, 1986, in the Kermadec Islands area of the South Pacific.

The largest death toll from a single earthquake during the first half of 1988 was eight people killed in a gold mine in a magnitude 5.2 earthquake in South Africa on January 5.

Two people were killed in a magnitude 5.8 earthquake on February 6 along the India-Bangladesh border. That earthquake also injured 100 people and caused extensive damage in some areas.

One person was killed, four were injured, and there was moderate local damage in a magnitude 6.3 earthquake on June 19 on Mindoro Island in the Philippines.

The northern Territory of Australia had three significant earthquakes in a single day, January 22, within less than 12 hours of each other. The magnitudes were 6.3, 6.4, and 6.7. The three earthquakes are believed to be the strongest on record in this area. The last and strongest of the three earthquakes caused damage in the Tennant Creek area and was felt over about two-thirds of Australia.

Three other 1988 earthquakes occurred near the coast of northern Chile: a magnitude 6.8 earthquake on January 19; a magnitude 6.7 earthquake on February 5 that caused minor damage in the Antofagasto-Taltal area; and a magnitude 6.1 earthquake later that same day.

Person said that the USGS, using data from seismograph stations throughout the world, normally locates from 10,000 to 12,000 earthquakes worldwide each year, ranging in magnitude from about 2.0 up to 8.0 or more. "Probably several million earthquakes occur each year," he added, "but most are so small in magnitude, or they occur in such remote areas, that they are not detected by even the the most sensitive instruments throughout the world."

Earthquake data gathered by the USGS are used not only to report on the occurrences of earthquakes worldwide but also to provide basic information used by federal, state, and local governments as well as private industry to study what causes earthquakes, when and where they may occur, and how the hazards of earthquakes might be reduced.

—USGS news release

Astoria Club displays rocks at Capitol

The Trail's End Gem and Mineral Club of Astoria has provided the current display at the State Capitol display case of the Oregon Council of Rock and Mineral Clubs (OCRMC). The collection will be on view until the middle of January of 1989.

More than 100 items from 13 Oregon counties are shown in the display, to which almost all members of the club contributed. Featured are three operating clocks, one of Clatsop County agate, one of Sherman County jasper, and one of red oak petrified wood from Crook County. The Friends Ranch yielded the material for a large frame of black and clear agate cabochons. Bookends on display were made from petrified wood and a large double thunder egg. A miniature set of rock hammer, pick, and shovel shows handles of petrified wood, and mahogany obsidian was used for salt and pepper shakers.

Among the other displays there are one very large slab of moss agate from Maury Mountain, Crook County, much of it a deep purple color; small, colorful zeolites from Quartz Creek, Clatsop County; a quantity of rough and tumbled Oregon sunstones, the State Gemstone; a large specimen of carnelian; agatized coral; tempskya (fern root); fossils from Humbug Mountain, Clatsop County; and five unusual agate geode core specimens, weathered from thunder eggs.

Following the Astoria club's display, from the middle of January 1989, the Oregon Department of Geology and Mineral Industries will present an exhibit.

—OCRMC news release

Baseline Road markers

by Howard F. Horner, Retired Superintendent of Schools, David Douglas School District, Portland, Oregon

On June 4, 1851, John R. Preston, first Surveyor General for the Territory of Oregon, established a point for the intersection of the Willamette Meridian and the Willamette Baseline. That spot, just off the 6500 block of NW Skyline Boulevard in Portland, marked by the Willamette Stone and, since 1945, surrounded by the Willamette Stone State Park, is the foundation for all Oregon and Washington surveys. Every lot, every farm, and every parcel of real estate in Oregon and Washington is referenced to that pin-point intersection of the Willamette Meridian and Baseline.

Benchmark in Willamette Stone State Park fixing the "Initial Point," the intersection of the Willamette Meridian and Willamette Baseline, for the Public Land Survey System for Oregon and Washington.

Preston was careful to set the baseline south of any part of the Columbia River. From the Willamette Stone, the baseline runs west to the Pacific Ocean near Bay City and goes east to the Idaho border near Imnaha. The Willamette Meridian hits California near Ashland and goes north to Canada.

In June 1851, Preston asked William Ives, Deputy Surveyor, to survey the baseline from the Willamette Meridian east for 36 mi, into the Cascades. Ives completed the survey in July 1851.

In April 1854, the Clackamas County Commission was petitioned for a road to run from the Willamette River to the Sandy River, along and as near as practicable to the baseline. The petition was signed by Perry Prettyman, Samuel Nelson, W.D. Gilham, B.F. Stark, William B. Jones, Gilsner Kelly, and 30 others. After some controversy, the petition was approved. The road followed the baseline survey and was opened to the public as Baseline Road (now NE Stark Street) on November 24, 1854. (A reminder of the baseline exists today as West Baseline Road that leads from the west side of Portland toward Hillsboro and generally follows the Willamette Baseline.)

Travelers leaving Portland to use the new Baseline Road crossed the Willamette River on the Stark Street ferry. A wooden trestle then took them to what is now the SE Grand Avenue area, where they could continue east on Baseline Road.

At some time after 1854, 15 basalt obelisk markers were set along Baseline Road to mark each mile from the Courthouse to the Sandy River. Each stone measures about 12 in. on a side and 6 ft in length, with 3 ft or more set into the ground. The top is rough-sculptured in obelisk form and engraved with the letter P, for Portland, and a number indicating the miles to downtown Portland. No one knows who put the stones in place and precisely when they were emplaced.

Markers P-1, -3, -8, -10, -12, and -15 have been lost, but, although the markers are well over 100 years old, nine have survived road excavations and can be seen along SE Stark Street:

P-2, at about 2350 SE Stark, is partially imbedded in the concrete wall of the Lone Fir Cemetery.

P-4 is at 61st and Stark, near Tabor Heights United Methodist Church. Stan Clarke, church historian and genealogist, rescued the stone from a road construction crew.

P-5 is at 78th and Stark. It has been painted yellow and is near the Portland Auto Upholstery shop. Cy Gengelbach, former owner of that company, moved the stone onto his property to save it. He put an iron hook in the stone and hung an air hose on it for use by early motorists.

Milestone P-7 at 117th and SE Stark in Portland, placed originally about 100 years ago along what was then Baseline Road.

*(Continued on page 141, **Markers**)*

An Oregon cure for Bikini Island? First results from the Zeolite Immobilization Experiment

by Dave E. Leppert, Geologist, Teague Mineral Products, Adrian, Oregon 97901

INTRODUCTION

Bikini Island, a part of Bikini Atoll in the Marshall Islands, was the home of the Bikinians prior to nuclear testing in the area from 1947 through 1958. In 1969, debris from the testing was removed, and plantations were established to prepare the island for resettlement. However, studies in 1978 showed that the settlers had accumulated unacceptable amounts of cesium-137 from food grown on Bikini. The Bikinians again had to leave their homeland until a solution could be found.

The Bikini Atoll Reclamation Committee (BARC) was established by Congress to study the cost and feasibility of rehabilitating Bikini, with decontamination of the island a primary goal. Studies have concentrated on reducing cesium uptake by plants, though excavation of the contaminated topsoil is a possible alternative. Other radionuclides are present on Bikini but do not pose a significant hazard.

I work primarily on development of environmental and agricultural applications for clinoptilolite zeolite. In 1986, I read in the *National Geographic Magazine* (Ellis, 1986) about the cesium-137 uptake by plants on Bikini Atoll and immediately realized that clinoptilolite zeolite might provide an attractive alternative to the possible remedies under discussion. Clinoptilolite occurs in large sedimentary deposits as an alteration product of volcanic tuff (Hay, 1977), and Teague Mineral Products mines three deposits of clinoptilolite in Oregon and Idaho.

Zeolites are hydrous aluminosilicate minerals with a porous framework structure. The pores within the structure contain exchangeable cations and account for the high cation-exchange capacity. The cation-exchange characteristics of clinoptilolite provide the basis for most environmental applications, and the mineral can selectively absorb (or adsorb—both terms hereafter subsumed under "sorb") many radionuclides, heavy metals, ammonium, and organic compounds, immobilizing them sufficiently to reduce uptake by plants.

I contacted Dr. W.L. Robison at Lawrence Livermore National Laboratories, and after he and BARC received background information from me on the ability of clinoptilolite to selectively sorb cesium and on its value as a soil amendment, they decided to test my hypothesis with the Zeolite Immobilization Experiment, which was soon started.

THE EXPERIMENT

In 1986, 15 plywood frames were built for the Zeolite Immobilization Experiment 1.5-m² test plots and installed on Bikini. Clinoptilolite (Feed Grade CH Zeolite), provided by Teague Mineral Products, was mixed by a concrete mixer with the surface foot of soil in three different amounts (9, 18, and 36 tons per acre). Corn and Chinese cabbage were initially planted, and sweet potato was planted later. Two control plots were established, one using excess potassium fertilizer, because previous tests had shown that extra potassium inhibits cesium uptake.

Results from the first crop grown in clinoptilolite-amended soil indicate that cesium-137 uptake was significantly less than in the untreated and potassium-treated controls (Figure 1). However, since a high-potassium clinoptilolite was used, it is unknown how much of the effect was due to cesium sorption by the clinoptilolite and how much was due to the effect of potassium released by the clinoptilolite's cation exchange. Successive cuttings and possibly other tests will be used to determine how much of the reduction was actually due to sorption by the clinoptilolite.

Problems will still have to be solved, no matter what approach is finally taken for the rehabilitation of Bikini. Though excavation

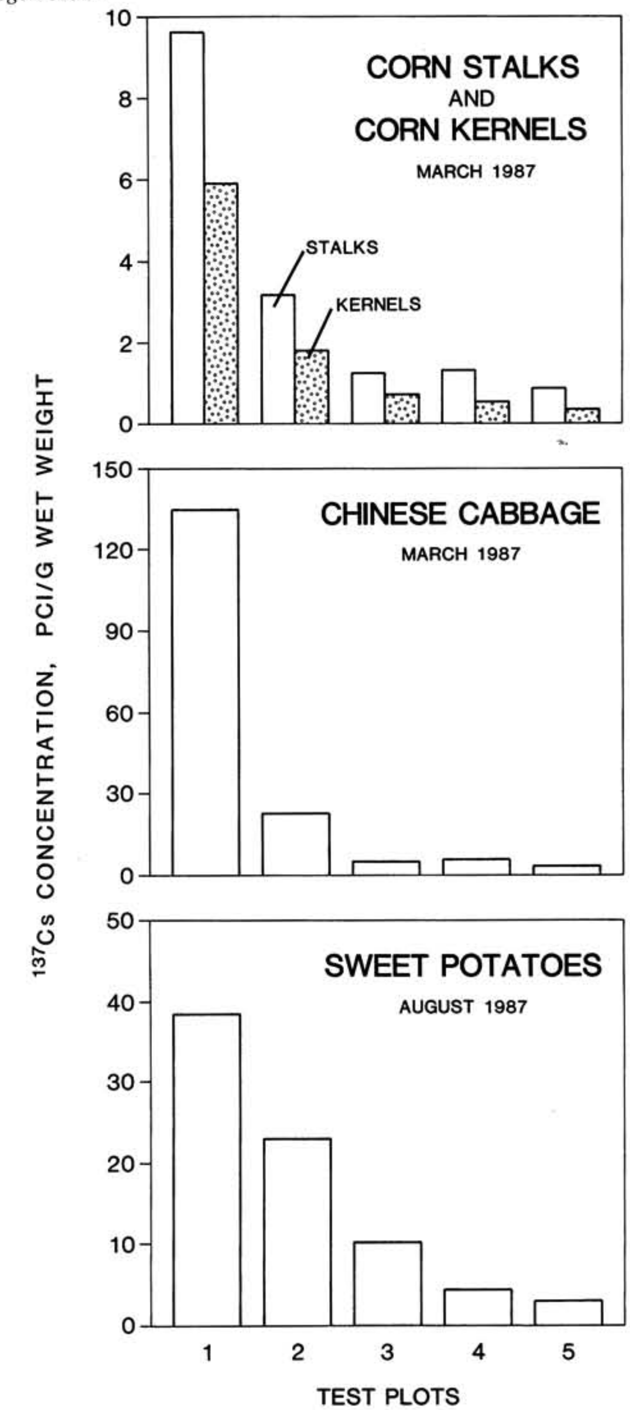

Figure 1. Zeolite Immobilization Experiment, November 1986-March 1987, showing cesium-137 concentrations in corn stalks and corn kernels, Chinese cabbage, and sweet potatoes grown in control plots and plots treated with clinoptilolite zeolite. Test plots were treated in the following ways: 1. Control plot, native potassium (K) only. 2. Control plot, plus 20 gm/m² K (178 lbs/acre). 3. Zeolite-treated plot (2 kg/m²). 4. Zeolite-treated plot (4 kg/m²). 5. Zeolite-treated plot (8 kg/m²).

of the topsoil removes the contamination from the island, revegetation without topsoil may be difficult, and the problem of what to do with the contaminated soil remains. Application of large amounts of potassium may be effective, but repeated applications would be necessary every five years or so for the next 75 years.

Assuming that further testing will support the initial results, incorporation of clinoptilolite into the soil may provide an attractive alternative to and avoid some of the problems associated with the other approaches. Ultimately, a combination of treatments may be the most efficient and cost-effective way to decontaminate the island and finally allow the Bikinians to return home.

REFERENCES CITED

Ellis, W.S., 1986, A way of life lost, Bikini: National Geographic Magazine, v. 169, no. 6, p. 810-834.

Hay, R.L., 1977, Geology of zeolites in sedimentary rocks, *in* Mumpton, F.A., ed., 1977, Mineralogy and geology of natural zeolites: Washington, D.C., Mineralogical Society of America, p. 53-64.

Robison, W.L., and Stone, E.L., 1988, Bikini Atoll Reclamation Committee summary report: Washington, D.C., BARC Report No. 6, p. A5, A45-47. □

NWMA announces 94th annual convention

The Northwest Mining Association (NWMA) will hold its 94th annual convention in Spokane, Washington, from November 30 to December 3, 1988, under the title "Working Together—Exploring Mining's Future." Early registrations and a trade show that sold out by September 1 have raised hopes for an unusually well-attended and successful convention.

A new feature was added to this convention: The program was developed jointly by the NWMA and the Association of Exploration Geochemists. Exploration geochemistry is the topic of this year's short course, to be held November 28-30, and related topics are also part of the general program.

The NWMA's address is 414 Peyton Building, Spokane, WA 99201; phone (509) 624-1158; Fax (509) 623-1241.

—NWMA news release

Fellowship available for engineers

The Education Foundation of the National Society of Professional Engineers (NSPE) has announced its fellowship program for engineers pursuing graduate study on management. The program was endowed by the Society's division of Professional Engineers in Government (PEG) and is now in its fifth year. PEG is funding the $1,000 fellowship to encourage registered Professional Engineers (PE) and Engineers-in-Training (EIT) in any field of practice to pursue continuing professional development in the area of management.

Any PE or EIT employed in government, education, industry, construction, or private practice may apply. Qualifications include a minimum undergraduate grade-point average of 3.0; a desire to earn an MBA in management, engineering management, or public administration; and enrollment in, or acceptance to, a program accredited by the American Assembly of Collegiate Scholars of Business or by the Accreditation Board for Engineering Technology. Information and application materials may be obtained from the NSPE Education Foundation, 1420 King Street, Alexandria, Virginia 22314, phone (703) 684-2830, where applications must be received no later than February 1, 1989.

—NSPE news release

ABSTRACT

The Department maintains a collection of theses and dissertations on Oregon geology. From time to time, we print abstracts of new acquisitions that, we feel, are of general interest to our readers.

THE GEOLOGY AND EPITHERMAL VEIN MINERALIZATION AT THE CHAMPION MINE, BOHEMIA MINING DISTRICT, OREGON, by Kurt T. Katsura (M.S., University of Oregon, 1988), 254 p.

The Champion Mine exploits a gold/base-metal epithermal vein system that cuts a Miocene volcanic center in the Bohemia mining district, Oregon. The Champion vein system consists of four steeply-dipping, subparallel veins that are structurally simple at depth and become increasingly complex upward. The epithermal veins show crustification banding, multiple brecciations, vein sediments, and cross-cutting vein relations that cut an earlier porphyry-copper-style mineralization, associated with tourmaline breccia pipes.

Brecciation events are traced throughout the Champion system, providing time-equivalent markers that define four paragenetic vein stages. Gold occurs in two stages: in crustification bands with sphalerite, chalcopyrite, and galena, where it was deposited from boiling of sulfide-deficient fluids; and in kaolinite crustification bands, where it was deposited from mixing of boiled ascending fluids with a descending acid-sulfate water. Intense argillic alteration overprints the veins and is the product of descending acid-sulfate waters. □

(*Markers, continued from page 139*)

P-6 is at 98th and Stark, near Elmer's Pancake House. Craig Decker, former resident of that area, attached a notice to the stone reading, "Historic stone. If removal is necessary, notify Oregon Historical Society."

P-7 is at 117th and Stark. It was found in a landfill by Mount Hood Community College students and replaced at the southeast corner of Ventura Park. It is flanked by an Oregon Historical Society marker explaining the obelisk-stone mile markers.

P-9 is at 15802 SE Stark, in the front yard of a private residence.

P-11 can be seen near the Stark Street Market at 197th and Stark.

P-13 was rescued from rubble by the Gresham Historical Society. It was kept by that society until road work had been completed and then was reset at 236th and Stark, with a suitable dedication ceremony, on May 13, 1987.

P-14 is on the Mount Hood Community College property, just east of SE Stark and Kane Road.

History buffs of Multnomah County are ever on the lookout for the missing obelisk mile markers. Any persons who might find one of the stones or have any information on them are invited to call the Oregon Historical Society or the Gresham, Troutdale, or David Douglas Historical Societies, or the authors. □

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Index to OREGON GEOLOGY, volume 50, 1988

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