

Zeitschrift: Eclogae Geologicae Helvetiae
Herausgeber: Schweizerische Geologische Gesellschaft
Band: 82 (1989)
Heft: 3

Artikel: Lower Anisian ammonoids from the northern Humboldt Range (northwestern Nevada, USA) and their bearing upon the Lower-Middle Triassic boundary
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DOI: <https://doi.org/10.5169/seals-166409>

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Lower Anisian Ammonoids from the northern Humboldt Range (northwestern Nevada, USA) and their bearing upon the Lower-Middle Triassic Boundary

By HUGO BUCHER¹⁾

ABSTRACT

The northern Humboldt Range section is of critical importance because it provides the most complete low paleolatitude ammonoid record across the Lower-Middle Triassic boundary. The various Lower Anisian faunas, including that of the *Caurus* Zone, are therefore respectively well constrained at their lower limit by the Spathian *Haugi* Zone and their upper limit by the early Middle Anisian *Hyatti* Zone. The newly established Lower Anisian sequence is divided into, in ascending order, the *Japonites welteri*, *Pseudokeyserlingites guexi* beds, *Mulleri* and *Caurus* Zones. Consequently, the scope of the Lower Anisian substage for low paleolatitude faunas is substantially enlarged. Furthermore, this sequence emphasizes the differences between the next underlying latest Spathian *Haugi* Zone, whose substage assignment has been hitherto a matter of controversy, and the various overlying biochronologic units here referred to the Lower Anisian substage.

Recognition of correlative units is hindered by the generally agreed upon pronounced paleolatitudinal distribution of Lower Anisian ammonoids and more prosaically, by both the scarcity and unreliability of low paleolatitude data. Around the Lower-Middle Triassic boundary, the latest Spathian *Haugi* Zone provides the most widely applicable biochronological marker available. Its correlatives are the Canadian *Subrobustus* Zone and the Siberian *Spiniplicatus* Zone. The Lower-Middle Triassic boundary is thus placed above the *Haugi* Zone and its correlatives, and below the varied, ill-correlated faunas of Lower Anisian age. The Nevada record demonstrates that the *Paracrochordiceras-Japonites* pair of low paleolatitude affinity has little significance for intra-substage correlations. The *Pseudokeyserlingites guexi* beds are expected to have correlatives in California (Inyo Range) and in China (Qinghai). Unfortunately, none of these additional occurrences is known to display clear superpositional relationships with respectively older or younger faunas. Both the *Mulleri* and *Caurus* Zones of the northern Humboldt Range are assumed to correlate at least partly with the more comprehensive British Columbia *Caurus* Zone and the upper part of the Siberia *Taimyrensis* Zone. These preliminary rough correlations, as yet not formally demonstrated, are amenable to further refinements when a more detailed scheme of the British Columbia Lower Anisian will be made available.

Two new genera and fifteen new species are also described.

1. Introduction

This paper deals with Lower Anisian ammonoids from northwestern Nevada. The studied sequence spans throughout the lower part of the Fossil Hill Member (Prida Formation, Star Peak Group) and is geographically restricted to the northern Humboldt Range (Pershing County, see Fig. 1), the only area where the oldest Fossil Hill strata escaped subsequent Middle Triassic uplift and erosion (NICHOLS & SILBERLING 1977).

The Fossil Hill Member yielded only few Lower Anisian ammonoids in comparison with its wealth of Middle and Upper Anisian ammonoids. Out of the long list of Anisian ammonoids described by HYATT & SMITH (1905) and SMITH (1914), only *Isculites meeki* (HYATT & SMITH) actually turned out to be a Lower Anisian taxon.

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The presence of the *Caurus* Zone, indicative of the Lower Anisian substage (TOZER 1967), was not firmly established until recently in the northern Humboldt Range by SILBERLING & WALLACE (1969) and SILBERLING & NICHOLS (1982).

Additional Lower Anisian faunas discovered between the *Haugi* Zone (Spathian) and the *Caurus* Zone are newly reported here. The scope of the Lower Anisian substage is substantially enlarged, at least with regard to low paleolatitude faunas, by being subdivided into four biochronologic units. Hence, the initially one-zone Lower Anisian substage concept advocated by SILBERLING & TOZER (1968) is furtherly developed and

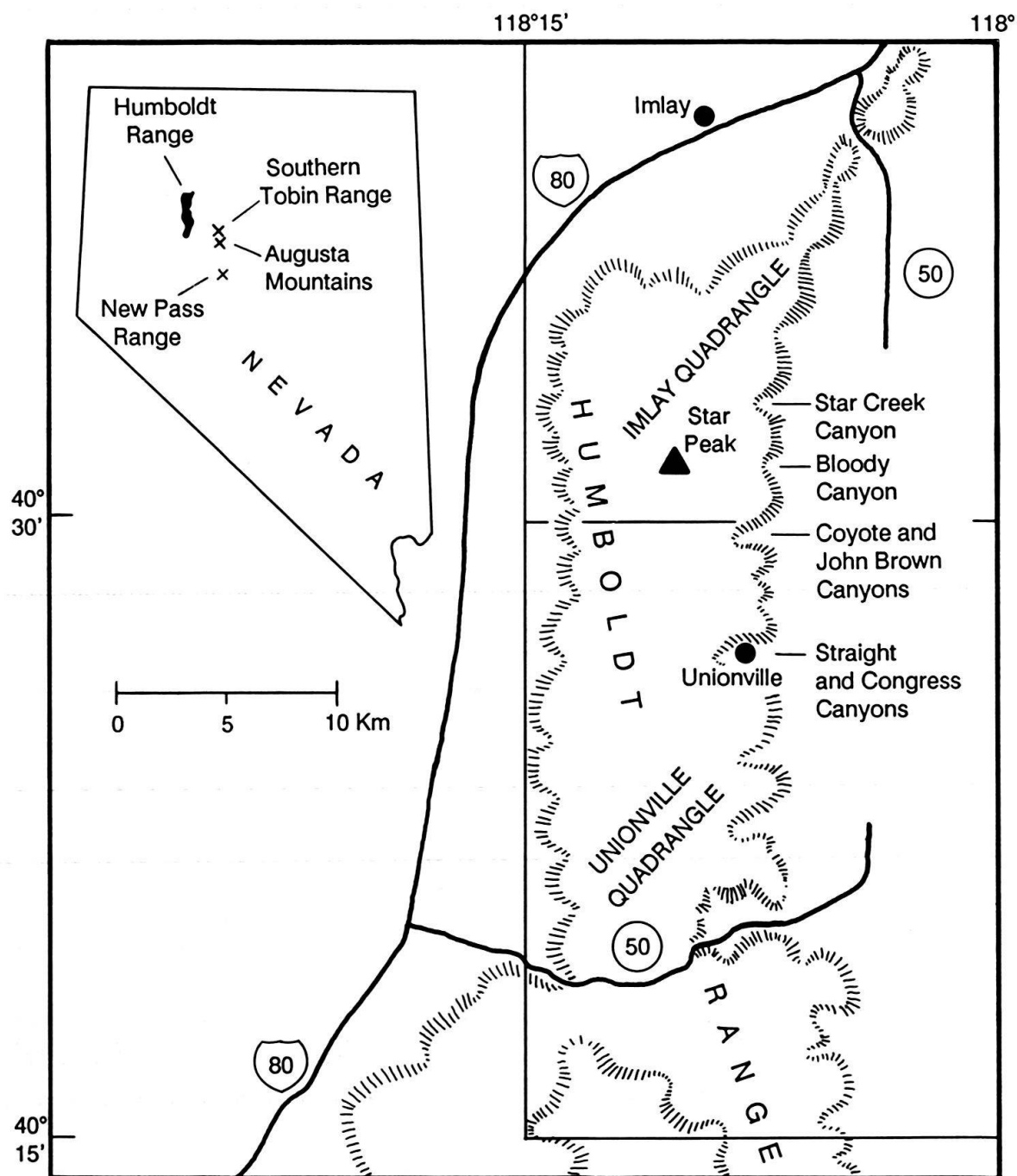


Fig. 1. Index map showing the location of northern Humboldt Range and other place names referred to in the text.

the threefold substage division of the Anisian by TOZER (1974, 1981b) gains appreciable support.

Owing to the apparent paleolatitudinal pattern of ammonoids distribution (TOZER 1982, WANG 1985, DAGYS 1988a), the Lower Anisian substage remains one of the less well understood time intervals of the Triassic period. In addition, a second major, inevitable obstacle comes from the general scarcity of low paleolatitude Lower Anisian marine deposits. The present results obtained from the northern Humboldt range contribute a great deal to the knowledge of the substage faunal content but correlations at zonal rank with other contemporaneous sequences are still a matter of conjecture. On the other hand, the whole of this unusually complete Spathian and Anisian faunal succession gives valuable insights into the Lower-Middle Triassic and Lower-Middle Anisian boundaries respectively.

2. Stratigraphic context

Block-faulting synsedimentary tectonics has been shown to play a major role during deposition of both the mainly calcareous Star Peak Group (NICHOLS & SILBERLING 1977) and the underlying volcanic Koipato Group (BURKE 1973). Lower Anisian strata, as well as the whole of the Fossil Hill pile were deposited below the wave base, in a euxinic environment. To its greatest paleogeographic extent, the Fossil Hill blanketed an area exceeding 5000 km² as estimated by NICHOLS & SILBERLING (1977). Subsequent Middle Triassic uplift and erosion of the central part of the basin at least partly accounts for the comparatively modest, present distribution of the oldest strata, i.e. Lower Anisian of the Fossil Hill Member. These are only known to occur in the northern Humboldt Range, that is at the northwestern limit of what is presently left of the Star Peak Basin.

On a much smaller scale and for our purpose, the effects of synsedimentary tectonics cannot be here disregarded when trying to set up a biochronologic scale of early Anisian time in the northern Humboldt Range. Because of nearly total absence of lithological markers and of variable sedimentation rates of the oldest Fossil Hill strata, partial Lower Anisian sequences of each section were linked by means of their own faunal content, in order to obtain the most comprehensive sequence as possible.

In the northern Humboldt Range, SILBERLING & WALLACE (1969) recognized two major basement highs, running more or less North-South, formed by the Koipato Group (namely the Star-Humboldt and the Arizona highs). The oldest age-diagnostic fossils found on top of both highs are of *Hyatti* Zone age, thus indicating that these highs underwent non-deposition and shallow to subaerial erosion, approximately until the Lower-Middle Anisian boundary. A third, comparatively minor high can be discerned between the Star-Humboldt and Arizona basement highs. The so-called Coyote high occurs along the same "ridge" as defined by the two former highs (Fig. 2). However, the latter differs in that its activity spanned at least the entire Lower Member deposition time (Spathian) and ceased approximately at the onset of the Anisian stage.

East of the Star-Humboldt and Coyote basement highs, the Carbonate Unit of the Lower Member is affected by sudden lateral facies changes portrayed in Figure 2. The distribution of the facies belt apparently matches the North-South trend delineated by the three basement highs. The deepest facies of the Carbonate unit are confined to the

Coyote Canyon Area - northern Humboldt Range

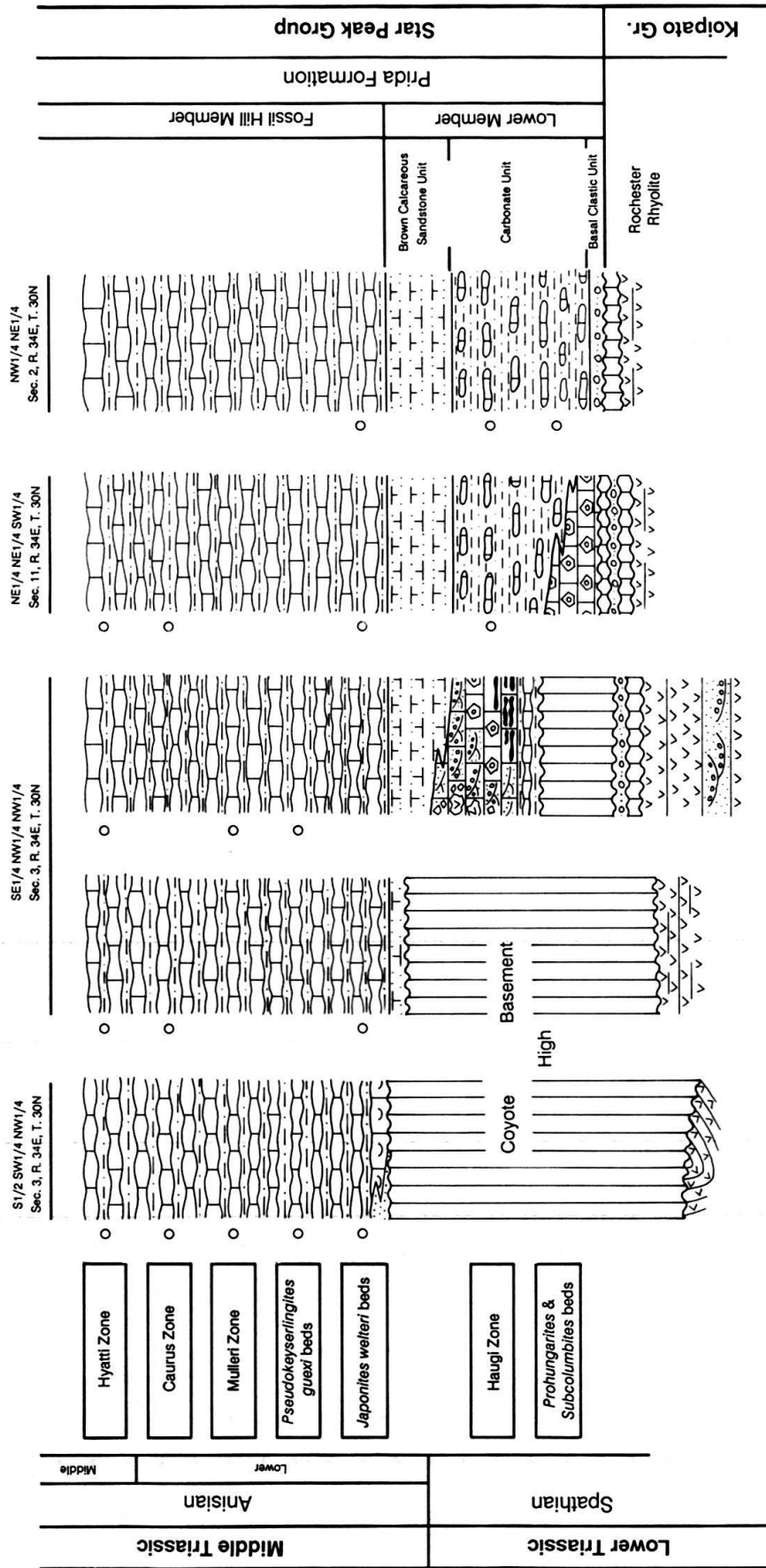


Fig. 2. Correlation chart of the lowermost part of the Star Peak Group in the Coyote Canyon Area, northern Humboldt Range. Open circles indicate occurrences of age-diagnostic fossils; vertical ruling, stratigraphic hiatuses. On top of the Coyote basement high, the very base of the Fossil Hill Member contains unusually abundant benthonic organisms (brachiopods, thick-shelled bivalves) embedded in impure limestones or beige siltstones. Transitional facies of the Carbonate Unit consist of mainly crinoidal limestones with subordinate black nodular cherts and syndimentary breccias formed of Koipato volcanics.

easternmost part of the range where its time-span (*Prohungarites* and *Subcolumbites* beds up to *Haugi* Zone) and lithology are similar to these of the Tobin Formation. Typical exposures of the latter formation are found in the southern Tobin Range, and there are also extensive outcrops further South, in the Augusta Mountains and New Pass Range (NICHOLS & SILBERLING 1977).

The next overlying Brown Calcareous Sandstone Unit pinches out before final truncation against the three basement highs of the northern Humboldt Range. Its marine depositional environment is ascertained by the presence of extremely scarce and unidentifiable ammonoids and a few brachiopods occurring at its upper limit. The detritic character of these evenly fine-grained rocks and their uniform siliciclastic composition markedly contrast with the enclosing lithologic units and do not suggest derivation from a nearby source. The Brown Calcareous Sandstone Unit is here regarded as a shallow marine, distal equivalent of the mainly conglomeratic and partly subaerial Dixie Valley Formation which overlies the Tobin in the eastern part of the Star Peak Basin (southern Tobin Range, Augusta Mountains and to a lesser extent in the New Pass Range). The Brown Calcareous Sandstone and the Dixie Valley Formation are both thought to record the same major detritic input which originated at the eastern edge of the Star Peak Basin, at the close of the Lower Triassic.

Strata deposited during early transgression of the Fossil Hill here locally escaped later uplift and erosion, which did not occur in central part of the Star Peak Basin. In the northern Humboldt Range, most of the preexisting topography was drowned, except for the Star-Humboldt and Arizona which were then residual basement highs. The former pronounced depositional trend which prevailed during Spathian time did not subsist later on, as inferred from the comparatively much more evenly deposited Fossil Hill Member. Though much more uniform, sedimentary rates of the Fossil Hill nevertheless vary from block to block. In such circumstances, lithostratigraphic thickness are not of much help and may even be somewhat misleading in that lowest rates as inferred from faunal sequences are not necessarily to be found above a formerly emerged basement high (reversion).

A Lower Anisian age can reasonably be assumed for the Lower Member of the Favret Formation which conformably rests upon the Dixie Valley Formation in the eastern part of the basin (NICHOLS & SILBERLING, 1977). No more accurate age-diagnostic fossils than coiled nautiloids and brachiopods could be obtained from this limited shallow carbonate platform. Its upper limit is rather well age-constrained by the overlying Fossil Hill, the basal strata of which may be either of Lower or Upper Hyatti age depending on various synsedimentary faulted blocks (BUCHER, 1988, Pl. 7).

3. The latest Spathian and Lower Anisian ammonoid sequence from Nevada

The basic biochronologic scheme was produced by SILBERLING & TOZER (1968), SILBERLING & WALLACE (1969) and SILBERLING & NICHOLS (1982). The biochronologic procedure employed both by the workers mentioned above and in the present note are all consistent with concurrent-range-type units.

Three newly recognized biochronologic units are fitted into the Lower Anisian succession (Tabl. 1). They are intercalated between the formerly known *Haugi* Zone (late Spathian) and *Caurus* Zone (Lower Anisian). The forthcoming attempt in correlating

S T A G E / S U B S T A G E		S P A T H I A N				L O W E R A N I S I A N			
Biochronologic Units		Upper Haugi Zone	J. welteri beds	P. guexi beds	Mulleri Zone	Caurus Zone			
Neopanoceras haugi (Hyatt & Smith)		*****							
"Acrochordiceras" inyoense Smith		*****							
"Hungarites" yatesi Hyatt & Smith		*****							
Keyserlingites subrobustus (Mojsisovics)		*****							
Metadagnoceras pulchrum Tozer		*****							
Preloriantes sp. indet.		*****							
Olenekites sp. indet.		*****							
Isculitoides sp. A		*****							
Karangatites multicaemeratus (Smith)		*****	*****						
Japonites welteri n. sp.		*****	*****						
Japonites starenis n. sp.		*****	*****						
Hemilecanites cf. H. paradiscus Kummel		-----	*****						
Metadagnoceras sp. indet.		-----	*****						
Paracrochordiceras sp. indet.			*****						
Pseudokeyserlingites guexi n. gen. n. sp.			*****						
Paracrochordiceras silberlingi n. sp.			*****						
Leiophyllites sp. indet.			*****						
Grambergia sp. indet.			*****						
Ussurites sp. indet.			*****						
Caucasites nicholsi n. sp.			*****						
Silberlingites mulleri n. gen. n. sp.			*****						
Silberlingites tregoi n. gen. n. sp.			*****						
Paracrochordiceras cf. P. americanum (McLearn)			*****						
Paracrochordiceras mclearnii n. sp.			*****						
Paradanubites crassicoatus n. sp.			*****						
Metadagnoceras youngi n. sp.			*****						
Sageceras cf. S. walteri Mojsisovics			*****						
Groenlandites pridaense n. sp.			*****						
Gymnites billingsi n. sp.			*****						
Paracrochordiceras plicatus n. sp.			*****						
Japonites cf. J. surgriva Diener			*****						
Isculites meeki Hyatt & Smith			*****						
Gymnites tregorium Silberling & Nichols			*****						
Lenotropites caurus (McLearn)			*****						
Groenlandites merriami n. sp.			*****						
Ussurites detwilleri n. sp.			*****						

Table 1: Stratigraphic distribution of latest Spathian and Lower Anisian ammonoids in the northern Humboldt Range.

the Nevada succession necessitates inclusion of these two zones in the time interval described hereinafter in ascending order. Location of the author's relevant localities is given in the appendix (p. 1002).

Haugi Zone

Index species: *Neopopanoceras haugi* (HYATT & SMITH)

Type locality: USGS Mesozoic loc. M114, Union Wash, Inyo Mountains (SILBERLING & TOZER 1968). Union Wash Formation (MOUNT 1971).

Occurrence: USGS Mesozoic loc. M2834, 2823, 2824, 2827 (SILBERLING & WALLACE 1969); loc. HB 107, 140, 141, 142, 108, 110, 111, 143, 219, 236 (northern Humboldt Range, Carbonate Unit of the Lower Member of the Prida Formation).

In the northern Humboldt Range where the *Haugi Zone* is in close succession with the *Subcolumbites* and *Prohungarites* beds, it has potential for further refinements or subdivisions. This zone includes at least two discernible associations, the younger of which is represented at localities M2834 or HB 110, 111, 143, 219 and 236. For our purpose here, this upper subdivision is conveniently, though provisionally, labelled as Upper *Haugi Zone* and is apparently a nearly exact correlative of the type locality in the Inyo (see remark by SILBERLING & TOZER 1968, p. 39). The entire *Haugi Zone* will be treated separately (BUCHER, GUEx & TAYLOR, in prep.) and we are presently only concerned with its upper part.

Updating the faunal content of the Upper *Haugi Zone* as listed by SILBERLING & WALLACE (1969) is desirable, at least in regard to the taxonomy. New generic names are evidently needed for "*Acrochordiceras*" cf. "*A. inyoense* SMITH and "*Hungarites*" *yatesi* HYATT & SMITH. It should be made clear that both are respectively distinct from exclusively Anisian *Paracrochordiceras*, nor *Acrochordiceras* s.s. and Ladinian *Hungarites* s.s., but at least "*H. yatesi*" was adequately illustrated by SMITH (1914) to prevent it from being considered of having Anisian affinity (ASSERETO and others 1980, DAGYS 1988b).

Besides several still unidentified ammonoids, two noteworthy additions to the Nevada Upper *Haugi Zone* are representatives of *Preflorianites* and *Olenekites*. Specimens of *Preflorianites* collected at locality HB 236 are closely similar to *P. intermedius* TOZER from the *Subrobustus Zone* but have stronger ribbing. Presence of *Olenekites* is indicated by a single specimen collected by N.J. Silberling at locality M2834.

Presence of *Keyserlingites subrobustus* (MOJSISOVICS) in the Upper *Haugi Zone* as first suggested by SILBERLING & WALLACE (1969) and later asserted by GUEx (1978) is well established. Specimens collected by N.J. SILBERLING at the same locality M2834 (= "*Tirolites*" *pacificus* HYATT & SMITH, in SILBERLING & WALLACE 1969) are unequivocally assigned to this species. In the Inyo Range, *Keyserlingites subrobustus* occurs again but was found several tens of feet above the type locality of the *Haugi Zone*, at USGS Mesozoic locality M2595 (SILBERLING & TOZER 1968). From the same bed, J. Guex and N.J. Silberling collected additional, undescribed ammonoids which include *Olenekites* and a new genus (BUCHER, GUEx & TAYLOR, in prep.). The latter is characterized by a compressed, evolute shape and is provided with both single and looped ribs. Its body chamber also bears conspicuous marginal tubercles related to the looped ribs only. This locality presumably yielded the youngest Spathian ammonoids

but still needs detailed taxonomic treatment. Therefore, this locality is not yet taken into account.

As noticed by DAGYS and others (1979) and DAGYS (1988b) "*Xenodiscus*" *bittneri* HYATT & SMITH and "*X*". *multicameratus* SMITH resemble the Lower Anisian Siberian genus *Karangatites* POPOV. Such a generic attribution seems justified on morphological grounds and therefore is adopted here. However, the significance allocated to *Karangatites* for correlations diverges from that of DAGYS (1988b) (see comparisons and correlations).

In taking into exclusive consideration the northern Humboldt Range succession, one can already state that there are only few Upper *Haugi* Zone or even older genera ranging up to the next overlying Anisian biochronologic units (e.g. *Metadagnoceras* and *Hemilecanites*). At a higher taxonomic rank, *Sageceratidae*, *Xenodiscidae*, *Khvalinitidae*, *Aplococeratidae*, *Acrochordiceratidae*, *Longobarditidae* and *Keyserlingitinae* which originated during Spathian time, undoubtedly extend to the Nevada Anisian strata.

It must be stressed that a nearly barren lithological unit, whose maximal thickness is of about 100 m (i.e. the Brown Calcareous Sandstone Unit of SILBERLING & WALLACE 1969), is intercalated between the *Haugi* Zone and the Lower Anisian faunas of the Fossil Hill Member. It must be kept in mind that the lack of age-diagnostic fossils from the Brown Calcareous Sandstone Unit induces a non-negligible gap into the Nevada ammonoid sequence.

Japonites welteri beds

Index species: *Japonites welteri* n.sp.

Type locality: USGS Mesozoic loc. M2364 (=HB 184), Star Creek Canyon, northern Humboldt Range (locality plotted on SILBERLING & WALLACE 1967).

Occurrence: Loc. HB 92, 109, 181, 235, northern Humboldt Range (Fossil Hill Member, Prida Formation).

This biochronologic unit occurs at the very base of the Fossil Hill Member, about 4 m above the boundary with the Brown Calcareous Sandstone Unit at its type locality. The *Japonites welteri* beds are located there at the top of conspicuous blocky outcrops formed by a dense group, 1 m thick, of impure dark-grey limestone beds. Such a lithology somewhat contrasts with the usually soft-weathering black micritic limestones-silty shales alternation that makes up most of the Fossil Hill. Allowing for some minor lithological variations, this horizon has proved a useful lithological marker that is traceable throughout the easternmost outcrop belt, between Star Creek and Coyote Canyons. This lithological horizon invariably yielded the same *Japonites welteri* fauna.

Further west, towards the core of the Range, the same fauna was found at locality HB 92, right on top of the Coyote basement high, at about 8 m above the Koipato-Fossil Hill disconformity. At that place, the lithology of the *Japonites welteri* beds has lost its peculiar character and conforms to that of the regular facies of the Fossil Hill Member.

The *Japonites welteri* beds correspond to the *Eophyllites* sp. A-bearing strata of SILBERLING & WALLACE (1969). Because enough well preserved specimens showing the suture line were obtained, *Eophyllites* sp. A turned out to be a japonitid, referred to

as *Japonites welteri*. This is by far the most common form of this low diversity fauna. Other scarce co-occurring ammonoids are *Japonites starensis*, *Paracrochordiceras* sp. indet., *Hemilecanites* cf. *H. paradiscus* and *Metadagnoceras* sp. indet. At first sight, this assemblage displays both Spathian (*Hemilecanites*, *Metadagnoceras*) and Anisian (*Paracrochordiceras*, *Japonites*) ammonoids. As demonstrated by its occurrence in the indisputably Anisian *Mulleri* Zone, *Metadagnoceras* is a long ranging genus which is not significant with respect to the stage assignment of the *Japonites welteri* beds. A Lower Anisian age is thus largely favoured for these beds on the grounds of *Japonites-Paracrochordiceras* co-occurrence. Association with the Spathian hold-over *Hemilecanites* nevertheless permits erection of this low diversity fauna as a concurrent-range unit.

Pseudokeyserlingites guexi beds

Index species: *Pseudokeyserlingites guexi* n. gen. n. sp.

Type locality: HB 138, Coyote Canyon, northern Humboldt Range.

Occurrence: Loc. HB 147, 223, 250, 251, northern Humboldt Range (Fossil Hill Member, Prida Formation). USGS Mesozoic loc. M1599, Union wash, Inyo Mountains (Union Wash Formation).

On the northeastern edge of the Coyote basement high, the *Pseudokeyserlingites guexi* beds at loc. HB 223 were found stratigraphically 12 m below the type locality of the *Mulleri* Zone (loc. HB 56). Right on top of the same Koipato basement high, the type locality of the *P. guexi* beds occurs stratigraphically 6 m above the *Japonites welteri* beds (loc. HB 92).

Though momentarily of very low diversity, this biochronologic unit contains two characteristic and readily identifiable ammonoids (*P. guexi* and *Paracrochordiceras silberlingi*). However, *P. guexi* has more than a local biochronologic significance because it is known in the Inyo Range (California), where at least one undoubtedly recognizable specimen was collected by Miller Ellis in 1948 at the USGS Mesozoic loc. M1599 (White Pine Quad.). Unfortunately, locality M1599 is not in sequence with the *Haugi* Zone strata (N. J. SILBERLING, written com. 1989).

Mulleri Zone

Index species: *Silberlingites mulleri* n. gen. n. sp.

Type locality: HB 56, Coyote Canyon, northern Humboldt Range.

Occurrence: Loc. HB 59, 88, 91, 94, 95, 115, ?120, 222, Coyote Canyon, northern Humboldt Range (Fossil Hill Member, Prida Formation).

The *Mulleri* Zone is found to have its typical development in the northern tributary of the Coyote Canyon where it is in stratigraphic sequence with the next underlying biochronologic units. Within the same area, the next overlying available bedrock localities occur stratigraphically 15 to 20 m higher in the section and are of Lower *Hyatti* age.

On the Coyote basement high, a single talus block containing ammonoids indicative of the *Caurus* Zone (loc. HB 247) was collected a few meters stratigraphically above the *Mulleri* Zone at bedrock locality HB 88. For want of more conclusive evi-

dence, this is by now the unique superpositional relationship available between *Mulleri* and *Caurus* Zones. It must be added that no fault that would obscure the succession was noticed from loc. HB 88 upwards, until the next overlying bedrock localities of Lower *Hyatti* age. The beds from which the float *Caurus* Zone block is derived could unfortunately not be precisely relocated, however there is no other possible provenance than from the strata bracketed between the *Mulleri* and Lower *Hyatti* Zones.

In Bloody Canyon, where the *Caurus* Zone occurs on strike about 30 to 40 m above the *Japonites welteri* beds, the *Mulleri* Zone has so far not been found in sequence. However, these apparently unfossiliferous strata leave ample room for the *Mulleri* Zone.

If not formally demonstrated by first order evidence, occurrence of the *Mulleri* Zone below the *Caurus* Zone is nevertheless the most likely. This well diversified fauna is here formally introduced at zonal rank. *Silberlingites*, *Groenlandites* and *Caucasites* are the most common forms of the *Mulleri* Zone.

Caurus Zone

Index species: *Lenotropites caurus* (McLEARN)

Type locality: East limb of anticline west of Mile Post 375, Alaska Highway, north-east British Columbia, Toad Formation (TOZER 1967).

Occurrence: USGS Mesozoic loc. M2367, M2358, M2828 (SILBERLING & WALLACE 1969); loc. HB 51, 74, 180, 201, 225, 247, 252, northern Humboldt Range (Fossil Hill Member, Prida Formation).

The *Caurus* Zone was first recognized in the northern Humboldt Range sequence by SILBERLING & WALLACE (1969). Taxonomic treatment of this low diversity assemblage was given later, by SILBERLING & NICHOLS (1982). *Japonites* cf. *J. surgriva*, *Groenlandites merriami* and *Ussurites detwilleri* are here newly reported from this zone.

4. Comparisons and correlations

Biochronologic comparisons are summarized on Table 2. This is a deliberate selection of the most relevant Lower Anisian sections. Absence of manifest condensation and vertical continuity (i.e. lower and upper limits respectively in sequence with Spathian and Middle Anisian faunas) formed the prime criteria along which data were selected. This leads to a critical examination of the available literature, followed then by acceptance of a few sections only. Data from Hallstatt-type limestone exotics (Himalayan crags, DIENER 1895; Nifoekoko block of Timor, WELTER 1915) are consequently among those that were discarded. Ammonoids collected from these exotics are interesting from the point of view of systematics but they will remain of equivocal biochronologic significance as long as the internal stratigraphy of these blocks is not adequately and cautiously reinvestigated.

When both unreliable and spotty data are taken out, the synthetic chart merely highlights the poor knowledge of the Lower Anisian substage which mainly consists of gaps and unrelated faunas. Vertical lines on Table 2 emphasize the uncertainty about the correlation of either individual or groups of biochronologic units.

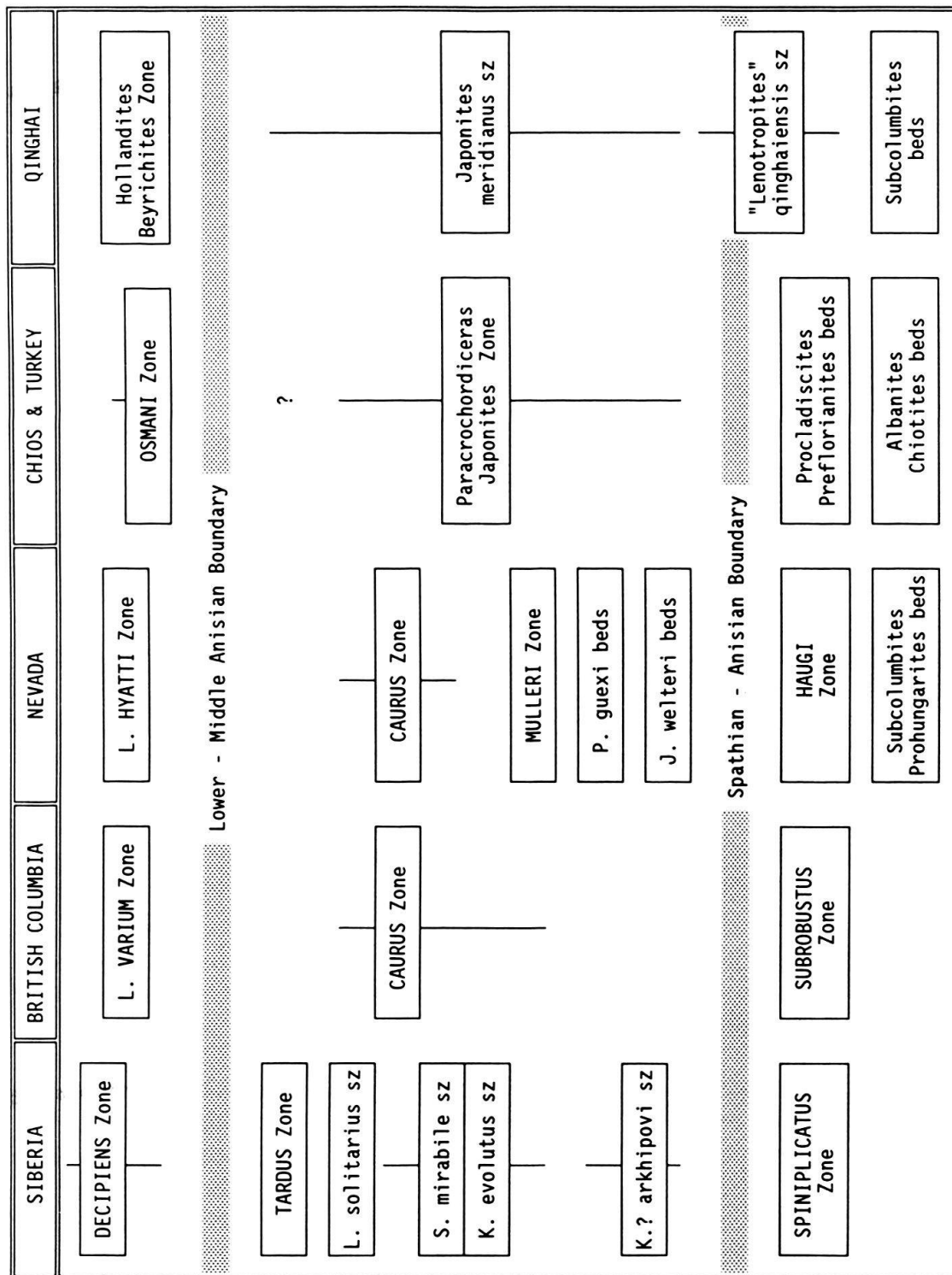


Table 2: Lower Anisian zonation and correlations, with illustration of the substage boundaries.

The history of the Lower Anisian ammonoids was surely complex enough to do without this kind of confusion that arises from forgetting the fossil record is far from complete. Especially in the present study, what one has to deal with is scarcely something other than a few snapshots scattered simultaneously over time and huge distances.

It is a truism to say that correlating several successions requires having a minimum of common elements between them – but one must face this as being an attribute not yet satisfied by the meager amount of Lower Anisian data. The use of concurrent-range-type units, an intrinsically discontinuous approach, has among its merits of faithfully reflecting the natural gaps of the record. Any other non-discrete method would inevitably discount those gaps that may eventually be found to contain new faunas. This approach equally tolerates much flexibility and adaptability in splitting or lumping biochronologic units as prompted by data currently made available.

The *Haugi* Zone and its correlatives

First of all, let us consider the controversial status of the *Haugi* Zone, for it provides the safest link around the Lower-Middle Triassic boundary. An often debated problem is the stage assignment of this zone, which is alternatively regarded as late Spathian (TOZER 1967, 1981b; SILBERLING & TOZER 1968; SILBERLING & WALLACE 1969; GUÉX 1978; WANG 1985) or as early Anisian (SPATH 1934; SHEVYREV 1968; KUMMEL 1969; DAGYS and others 1979; ASSERETO and others 1980; JACOBSHAGEN & NICORA 1981; DAGYS 1988b).

What is of primary importance is finding the correlatives of the Upper *Haugi* Zone. Co-occurrence of *Olenikites*, *Preflorianites*, *Isculitoides* and *Keyserlingites subrobustus* warrants correlation with the *Subrobustus* and *Spiniplicatus* Zones. The first reported occurrences of *Olenekites* and *Preflorianites* support this correlation which was formerly demonstrated by GUÉX (1978).

The Siberian Lower Anisian succession was hitherto correctly thought to be more comprehensive than the Nevada *Caurus* Zone solely (DAGYS 1988b). However, to bring to the fore what was then a gap within the Nevada record does not at all imply the next underlying *Haugi* Zone correlates with the lower part of the *Taimyrensis* Zone (i.e. *Karangatites? arhipovi* and *Karangatites evolutus* Subzones) as inferred by DAGYS (op. cit.). Anyway, the three newly recognized Lower Anisian biochronologic units now fitted into the *Haugi-Caurus* interval cut short any bias of that kind.

Next, DAGYS (op. cit.) backed up his correlation with the presence of “*H. yatesi*”, “*A. inyoense*” and *Karangatites* in the *Haugi* Zone, three ammonoids allegedly of Anisian affinity. As already mentioned, such a statement does not any longer apply to “*H. yatesi*” and “*A. inyoense*”. On the other hand, *Karangatites* actually appears as the single form shared by both the Upper *Haugi* Zone and lower part of the *Taimyrensis* Zone – a somewhat tenuous tie for correlation... Various occurrences of *Karangatites* are better explained in assuming this genus ranges from the *Haugi* Zone up to the *Taimyrensis* Zone, i.e. across the Lower-Middle Triassic boundary.

In the initial proposals for the Agean substage by ASSERETO (1974, p. 37), there is absolutely no mention of the *Haugi* Zone among the correlatives of the *Paracrochordiceras-Japonites* beds of Chios. Whatever his conception of the Lower Anisian was,

this was not of accidental character because ASSERETO (op. cit.) himself placed the Nevada *Caurus* Zone as an equivalent of the *Paracrochordiceras-Japonites* beds.

Later papers dealing with the Hallstatt limestone section of Chios did not reflect Assereto's original view which became somewhat distorted after his death. Despite the condensed faunas and fissure filling problems that were known to attend Hallstatt limestones biochronology (KRYSTYN and others 1968, TOZER 1971, WENDT 1973), subsequent contribution by ASSERETO, JACOBSHAGEN, KAUFFMANN & NICORA (1980), for which the late Assereto cannot be blamed, includes an evidently unnatural fauna into the Chios Agean substage. The remaining authors already suspected locality CH 258 of being a mixed assemblage, for their section G (Fig. 4, p. 722) conspicuously shows that CH 258 comes from a fissure filling. From taking into account the Spathian-Anisian condensed locality CH 258 (*Procarnites*, *Leiophyllites*, *Eophyllites*, *Psilocladiscites*, *Cladiscitidae* n. gen. n. sp., *Preflorianites*) arose a pervasive circular argument (ASSERETO and others 1980, p. 727–728; JACOBSHAGEN & NICORA 1981). These authors managed to compel equivalence between CH 258 and the *Haugi* Zone in assuming that earliest Agean faunas are ought to contain both Spathian and Anisian forms. In the Chios context, this statement is largely biased because of condensation, nor does it apply to the *Haugi* Zone (here come "*H.* *yatesi* and "*A.* *inyoense* again!). As felt by FANTINI-SESTINI (1981, p. 46), the ultimate snag about this rigged correlation is that it leads inevitably to assign both the *Subrobustus* and *Spiniplicatus* Zones to the Anisian stage...

The *Haugi* Zone is regarded as Spathian by WANG (1985) but with a different significance in that it would represent the upper part of the *Subcolumbites* beds. This assertion does not hold up when confronted with the Nevada succession where the *Haugi* Zone overlies the *Subcolumbites* beds (SILBERLING & WALLACE 1969). These two units are readily distinguishable (GUDEX 1978) and one can only reiterate here that it is unfounded to merge them. Such an additional misadventure of the *Haugi* Zone is merely symptomatic of the absence of any readily recognizable correlative in the Naocanjiaoguo section (Maduo, Qinghai) of HE and others (1986) and WANG (1985).

Recognition of a *Haugi* Zone equivalent at Ziyun, Guizhou (WANG 1978) is obscured by condensation, for this single level yielded ammonoids of both Spathian and Anisian ages as noticed by TOZER (1981b, p. 407–408; see also ASSERETO and others 1980, WANG 1985).

The Lower Anisian succession

The Paracrochordiceras-Japonites beds (*Ugra* Zone) of chios

Data from Nevada demonstrate the *Paracrochordiceras-Japonites* pair ranges throughout the entire succession. Among low paleolatitude faunas, this means that this couple characterizes most of what is presently known of the substage and hence is not suitable for correlations at zonal rank. Even when the *Paracrochordiceras-Japonites* faunas are found to contain the distinctive genus *Aegeiceras* (Chios, Middlemiss Crag near Chitichun #1, bed #2 of Nifoekoko block), they correlate with the whole interval from the *J. welteri* beds to the *Caurus* Zone, without further precision. Wherever *Aegeiceras* is reported from, it has either an ambiguous stratigraphic occurrence (Hallstatt-type limestones from either exotic blocks or undisturbed sequences) or is not

accurately located in the sequences (e.g. Caucasus, see SHEVYREV 1968 [= *Japonites ugra*]; also Lilang in Spiti, see DIENER 1907).

Paracrochordiceras-Japonites-Aegeiceras could possibly characterize a reproducible association (however restricted to the biochronologically suspect Hallstatt limestones i.e. Chios, Chitichun and Nifoekoko) but its biochronologic position *within* the Lower Anisian substage remains as yet unravelled.

The Himalayan "Lower Muschelkalk"

The *Paracrochordiceras-Japonites* faunas were commonly believed to correlate with the *Keyserlingites dieneri* beds of the Himalayas (Spiti and Painkhanda). This raises the question of the Himalayan "Lower Muschelkalk" of DIENER (1895, 1907, 1912) again. There are quite opposite views about the age of these *Keyserlingites* (= "*Durgaites dieneri*") beds which are classed either in the Anisian (DIENER op. cit.; SPATH 1934; KUMMEL 1969; ASSERETO and others 1980; WANG 1985) or in the Spathian (TOZER 1965, 1971, 1981b; SILBERLING & TOZER 1968). For the lack of any pertinent recent data, no definite age can be objectively drawn from DIENER's lists (1907, p. 131; 1912, p. 62–63), but there is reason to believe that his "Lower Muschelkalk" fauna from both Spiti and Painkhanda encompasses ammonoids of distinct stratigraphic occurrences. For instance, presence of an unquestionable *Hollandites* (*H. vyasa*, DIENER 1895, 1907) amidst the *Keyserlingites dieneri* beds is hardly explainable for this genera is characteristic of early Middle Anisian faunas. On the other hand, presence *Dalmatites ropini* (DIENER 1907), whose generic attribution appears correct, would indicate the *Keyserlingites dieneri* beds also contain at least one typically early Spathian form. In front of such inconsistent association, one can't help thinking that both Spiti and Painkhanda "Lower Muschelkalk" faunas as described by DIENER (1907, 1912) have an unnatural character due either to condensation or to inaccurate sampling. In view of the collecting methods that were practiced at Diener's time, it wouldn't be surprising as a matter of fact, that his composite "Lower Muschelkalk" was mistakenly based on several different horizons. The recent contribution by NICORA and others (1984) on the western continuation of the Triassic belt into the Zaskar area does not supply decisive arguments about this question.

Incidentally, "*Stacheites webbianus*" (DIENER 1907, p. 91, Pl. 5, Fig. 6) which is reported from the same beds is here regarded as a khvalinitid instead of a dinaritid. "*S. webbianus*" is evidently allied to *Metadagnoceras* and *Alanites* but is distinguished from both by its less indented suture line, absence of ribs nor folds and early acquisition of tabulate venter.

The Lenotropites-Japonites Zone of Qinghai (China)

Valuable information on the Guizhou Lower Anisian was obtained by WANG (1985) and HE and others (1986). Their Naocangjiangou section (Maduo County) records what is termed the *Lenotropites-Japonites* Zone in sequence with the Spathian *Subcolumbites* beds and Middle Anisian faunas (*Beyrichites-Hollandites* Zone). This *Lenotropites-Japonites* Zone is subdivided in ascending order into the *Lenotropites qinghaiensis* and *Japonites meridianus* Subzones.

As quoted HE and others (1986, p. 262) "the lower subzone is characterized by the abundance of *Longobarditidae*". From the illustrations given by these authors, there is no convincing evidence that neither *Lenotropites*, nor *Grambergia*, *Groenlandites*, *Pearylandites* and *Arctohungarites* occur in the "*Lenotropites*" qinghaiensis Subzone. The alleged *Lenotropites*, *Arctohungarites* and *Groenlandites* should preferably be assigned to *Qilianshanites* WU. Furthermore, recognition of *Arctohungarites* should be substantiated by illustration of its diagnostic tabulate body chamber. The specimens attributed to *Pearylandites* do not have the coronate innermost whorls diagnostic of that genus but have more affinity with *Tienjunites* WU, a possible junior synonym for *Subolenekites* ZAKHAROV which is of Spathian age. *Qilianshanites* and *Tienjunites* are both described from the lower part of the Qierma Member of the Junzihe Formation in the Qilian Mountains (WU, in YANG and others 1983). The beds with *Qilianshanites* and *Tienjunites* are only known to occur in sequence above beds with *Tirolites* and are therefore very weakly age-constrained, especially at their upper limit. They are regarded as Pelsonian (latest Middle Anisian) in age by WU (in YANG and others 1983), a statement which apparently has no sound foundation. With the exception of *Norites*, there is no one unequivocal Lower Anisian ammonoid reported from the "*Lenotropites*" qinghaiensis Subzone.

Conversely, a Lower Anisian age assignment of the *Japonites meridianus* Subzone is not ambiguous for it contains *Megaphyllites*, *Japonites*, *Psilosturia*, *Paradanubites*, and true *Grambergia*. Presence of *Paracrochordiceras* in the *Japonites meridianus* Subzone cannot be ruled out for "*Paradanubites*" phyllus HE has an acrochordiceratid-like suture line and apparently tuberculated inner whorls (HE and others 1986, Text-Fig. 26 d-e; Pl. 6, Fig. 28). *Paracrochordiceras* is quite often hardly distinguishable from the approximately coeval *Paradanubites* but the latter distinctively lacks the tuberculated inner whorls.

Representatives of the *Keyserlingites dieneri* group are seemingly a prominent feature of the *Japonites meridianus* Subzone. Granted that data of HE and others (1986) are reliable, it would so far provide the unique record of *Keyserlingites* from strata of undoubted Anisian age. In this view, it implies *Keyserlingites* ranges across the Lower-Middle Triassic boundary (WANG 1985). Another side of the question would equally demand some more clarification. As previously seen, the northern Humboldt Range record reveals *Keyserlingitinae* might range across the Lower-Middle Triassic boundary. They are represented there by *Pseudokeyserlingites*, a distinctive genus which was described from Qinghai as "*Gymnotoceras*" sp. (WANG and others 1979, p. 31, Pl. 7, Figs. 27–34, see also systematic descriptions). In addition to the fact that the *Pseudokeyserlingites guexi* beds might inevitably have some correlatives in the Qinghai sequence, the exact occurrence and its superpositional relationship with (or within) the *Japonites meridianus* Subzone would probably give some clues about the *Keyserlingites* question.

Interpretation of Qinghai section still remains very conjectural but the previous remarks lead us to speculate that the "*Lenotropites*" qinghaiensis fauna might be included in the time interval bounded by the *Subcolumbites* beds and the *Japonites welteri* beds. Whether the "*Lenotropites*" qinghaiensis beds should be assigned to earliest Lower Anisian or to latest Spathian cannot be definitively answered at the present state of knowledge. The *Japonites meridianus* Subzone solely can be roughly correlated with other Lower Anisian faunas.

British Columbia

In its original definition (TOZER 1967, McLEARN 1969), the *Caurus* Zone is probably more comprehensive than the *Caurus* Zone as recognized by SILBERLING & WALLACE (1969) and SILBERLING & NICHOLS (1982) in the northern Humboldt Range. The Canadian *Caurus* Zone may presumably include equivalents of the *Mulleri* Zone (*Grambergia*, *Paracrochordiceras* cf. *P. americanum*) but do not overlap the time interval covered by the *Japonites welteri* and *Pseudokeyserlingites guexi* beds.

Further refinements in correlating the British Columbia succession with that of Nevada should await publication of significant progress made by TOZER (in prep.). According to the latter (oral com., 1988), "*Arctohungarites*" *bufonis* (McLEARN 1969, p. 45, Pl. 7, Figs. 9–11) is more closely allied to *Azarianites* (DAGYS 1987) than to *Arctohungarites*. This view is endorsed here and consequently, occurrence of *Arctohungarites* in the *Caurus* Zone is no longer considered valid.

Siberia

The biochronology of Siberia Lower Anisian has been summarized by DAGYS (1988b). A more detailed faunal inventory is available through the contributions by DAGYS and others (1979) and DAGYS & KAZAKOV (1984).

Subzonal scheme of the *Taimyrensis* Zone is partly based on differences at the species level that may perfectly well have regional significance but these subzonal subdivisions are somewhat altered when based on genera only. For instance, the *Karangatites? arkipovi*, *K. evolutus* and *Stenopopanoceras mirabile* Subzones could thus be merged into a single unit.

On the other hand, the *Lenotropites solitarius* subzone of the *Taimyrensis* Zone and *Tardus* Zone remain essentially unchanged. According to VAVILOV & ARKADIEV (1986), *Taimyrites* is to be added to the *Tardus* Zone. Next, occurrence of acrochordiceratids in the *Taimyrensis* Zone (DAGYS and others 1979, p. 39; DAGYS 1988b, Tabl. 1) may not be taken for granted in that they have hitherto never been illustrated. As suggested by VAVILOV & ARKADIEV (1986), the specimens discovered by DAGYS may possibly be referred to danubitids. Indeed, *Danubites tozeri*, which was first described from the Spitsbergen *Caurus* Zone (KORCHINSKAYA 1982), has been found to occur in the *Stenopopanoceras mirabile* subzone of Cape Tsvetkova.

It is well known that the Siberia sequence has much in common with that of British Columbia and secondarily with these of Ellesmere Island, Peary Land (North Greenland) and Spitsbergen (TOZER 1967; KUMMEL 1953; TOZER & PARKER 1968; KORCHINSKAYA 1982), but less rough correlations necessitate refinement of the key-succession of the British Columbia Lower Anisian. However, one can surmise that the time intervals represented by the *Karangatites? arkipovi* Subzone as well as the *Japonites welteri* and *Pseudokeyserlingites guexi* beds are pre-*Caurus* in age. Though the *Tardus* Zone is the only Siberia unit from which *Lenotropites* is reported, co-occurrence of early representatives of *Czekanowskites* and *Arctohungarites* impedes correlation with the Canadian *Caurus* Zone. On the other hand, presence of *Lenotropites* precludes correlation with the Lower and Middle *Varium* Zone of British Columbia. The *Lenotropites*-*Czekanowskites*-*Arctohungarites* concurrent interval is thus inevitably post-

Caurus and pre-Middle Anisian in age and therefore has no exact correlative known from some place else. The Lower-Middle Triassic boundary has customarily been placed between the *Spiniplicatus* Zone and the *Karangatites* beds of the *Taimyrensis* Zone (DAGYS and others 1977), what is consistent with both Canada and Nevada.

Other various Lower Anisian ammonoids occurrences

Lower Anisian ammonoids have been reported from several section of lesser importance. In Central Iran, a few Lower Anisian ammonoids were found in the Alam Formation (TOZER 1972a). *Ugraites*, a genus generally thought to be of Lower Anisian age and *Caucasites* are both listed in the “second ammonoid assemblage” of SHEVYREV (1968, p. 34). This suggests that Lower Anisian may potentially be recognized in the sequence of northwestern Caucasus, for the only unquestionable available occurrence of *Caucasites* is that from the *Mulleri* Zone. Lower Anisian is possibly present in the poor faunas known from the Khabarovsk area. The *Karangatites* beds and the rather age-ambiguous *Leiophyllites pradyumna* Zone are reported from this area by OKUNEVA (1976) and OKUNEVA & JELEZNOV (1976). Co-occurrence of *Karangatites* with *Claraia* cf. *C. aranea* (TOZER) would illustrate the supposed long range of this ammonoid for *Claraia aranea* is considered as diagnostic of the late Spathian *Subrobustus* Zone (TOZER 1967; TOZER & PARKER 1968). Finally, the Primorye sequence (ZAKHAROV 1968) merely has no bearing on the problem, having no ammonoid record between its *Subcolumbites* beds and the ill-defined *Leiophyllites pradyumna* Zone.

5. Systematic descriptions¹⁾

Order *Ceratitida*

Superfamily **Xenodiscaceae** FRECH 1902

Family **Xenodiscidae** FRECH 1902

Genus *Hemilecanites* SPATH 1934

Hemilecanites cf. *H. paradiscus* KUMMEL

Plate 6, Figures 7–8, Text-Figure 3

Hemilecanites paradiscus KUMMEL 1969, p. 375, Pl. 29, Figs. 11–12; Pl. 31, Figs. 15–16 [holotype]; Pl. 35, Figs. 12.

Description. Moderately evolute, high whorled and compressed shell with an angular, nearly acute venter. Umbilical margin well defined, evenly sloping towards the umbilical suture. Outer flanks gradually converge towards the narrow venter. Surface smooth, with sinuous and slightly prorsiradiate growth striae. At D = 37 mm, H = 35%, W = 21% and U = 35%. The goniatitic suture line conforms to that of *H. paradiscus*.

Discussion. The few available specimens from the *Japonites welteri* beds are comparable to the species described by KUMMEL (1969) from the lowermost part of the Tobin Formation (*Subcolumbites* beds, USGS Mesozoic loc. M2562).

¹⁾ The systematic descriptions follow the classification by TOZER (1981a). Repository of figured specimens is abbreviated USNM (National Museum of Natural History, Washington D.C.).

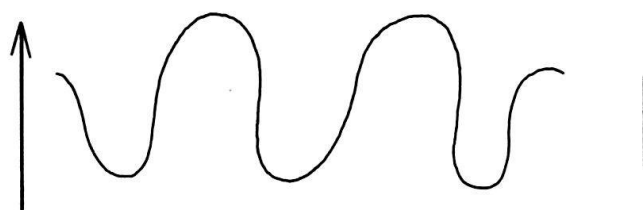


Fig. 3. Suture line ($\times 6$) of *Hemilecanites* cf. *H. paradiscus* KUMMEL at $D = 25$ mm. Plesiotype USNM 438371.

Figured specimens. Plesiotypes USNM 438370 and 438371.

Occurrence. Loc. HB 184 (4), Star Creek Canyon, northern Humboldt Range. *Japonites welteri* beds, Lower Anisian.

Superfamily **Sagecerataceae** HYATT 1884

Family **Sageceratidae** HYATT 1884

Genus *Sageceras* MOJSISOVICS 1873

Sageceras cf. *S. walteri* MOJSISOVICS

Plate 4, Figures 13–14; Text-Figure 4

Sageceras walteri MOJSISOVICS 1882, p. 187, Pl. 53, Fig. 9a–9c [holotype], 11a–11b?, 12a–12b?, 13? SPATH 1934, p. 56, 58–59. SILBERLING & NICHOLS 1982, p. 18, Pl. 5, Figs. 10–12.

Sageceras gabbi MOJSISOVICS 1873. HYATT & SMITH 1905, Pl. 74, Figs. 8–9; Pl. 75, Figs. 14–15. SMITH 1914, Pl. 11, Figs. 8–9; Pl. 12, Figs. 14–15; Pl. 21, Figs. 18–20. SILBERLING 1962, p. 156.

Sageceras cf. *S. walteri* MOJSISOVICS. BUCHER 1988, p. 726, Fig. 2.

Description. Extremely oxycone shell, with a narrowly rounded venter on internal mold. Bicarination barely visible, only present on outer shell when preserved. Umbilicus extremely small but open. Surface of internal mold smooth. At $D = 33$ mm, $H = 57$ – 60% , $W = 18$ – 20% and $U = 4$ – 5% . Suture line with U-shaped bifid lobes and up to 5 adventitious lobes.

Discussion. There is no significant difference between the specimens collected from the *Mulleri* Zone and those recorded from the Middle and Upper Anisian strata (SILBERLING & NICHOLS 1982, p. 18; BUCHER 1988, Fig. 2). *Sageceras* cf. *S. walteri* thus ranges through the whole Anisian sequence of the Fossil Hill Member without any perceptible change.

Figured specimens. Plesiotypes USNM 438349 and 438350.

Occurrence. Loc. HB 56 (5), Coyote Canyon, northern Humboldt Range, Nevada. *Mulleri* Zone, Lower Anisian (occurrences from Middle and Upper Anisian not listed).



Fig. 4. Suture line ($\times 6$) of *Sageceras* cf. *S. walteri* MOJSISOVICS at $H = 15$ mm. Plesiotype USNM 438349.

Superfamily **Dinaritaceae** MOJSISOVICS 1882Family **Dinaritidae** MOJSISOVICS 1882Subfamily **Khvalynitinae** SHEVYREV 1968Genus *Metadagnoceras* TOZER 1965*Metadagnoceras* sp. indet.

Plate 1, Figure 1

Description. Although tectonically deformed, a single specimen from the *Japonites welteri* beds can be referred to this genus. It mainly consists of a fragmentary body chamber with its diagnostic first low rounded and then tabulate venter and with its discrete strigation still visible on outer flanks. Shell otherwise smooth and relatively thick whorled. Suture line not known.

Discussion. This specimen does not provide enough characters for identification at the species level. However, it can easily be distinguished from *Alanites* SHEVYREV by absence of flared umbilical margins, foldlike falcooid ribs and rounded venter. This form differs from *Metadagnoceras youngi* n. sp. by its thicker whorls and smooth flanks. It stands comparatively closer to *M. pulchrum* TOZER than to *M. youngi* n. sp.

Figured specimens. USNM 438308.

Occurrence. Loc. HB 184 (1), Star Creek Canyon, northern Humboldt Range, Nevada. *Japonites welteri* beds, Lower Anisian.

Metadagnoceras youngi n. sp.

Plate 1, Figures 2–5; Text-Figure 5

Description. Relatively compressed *Metadagnoceras* with a low rounded venter. Whorl section high, subrectangular with flanks first subparallel and then gently converging towards venters. Ornamentation consists of dense, weak sinuous ribs that fade on outer flanks. Because outer shell is not preserved, a possible strigation could not be observed. At $31 < D < 45$ mm, $47 < H < 49\%$ and $19 < U < 22\%$. Although quite variable, the suture line conforms to that of *Metadagnoceras* (TOZER 1965, Fig. 9). The last visible suture lines of the holotype (Fig. 5a) overlap in their umbilical part thus indicating an essentially complete and mature phragmocone. They are characterized by a wide, relatively shallow and finely incised single lateral lobe. The ventral lobe is apparently strongly reduced. The lateral saddle has a crude rectangular outline with a wavy tip. It is also intersected by the umbilical edge and suture. The same sutural pattern also extend to smaller diameters (Fig. 5b). The last suture line of another mature specimen (Fig. 5c) from the same locality shows some differences with that of the holotype. Its lateral lobe is comparatively narrower with less numerous but larger indentations. Its lateral saddle is equally narrower, with a well rounded tip and is not concealed by whorl overlapping.

Discussion. Out of 8 specimens from loc. HB 56, only 2 have suture lines that do not conform to that of the holotype (see description above). Although poorly preserved, they do not obviously differ in their general shape from that of the holotype. It thus seems preferable to group them provisionally under the same species name because the few available specimens do not permit assessment of sutural variability.

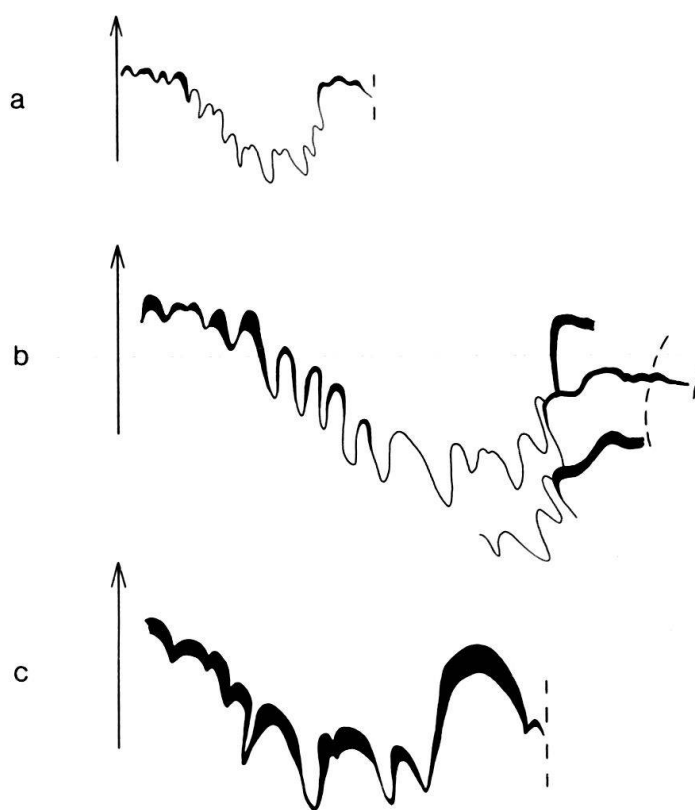


Fig. 5. Suture lines ($\times 3$) of *Metadagnoceras youngi* n. sp. a: H = 9 mm; b: H = 19 mm; Holotype USNM 438310. c: H = 15 mm; Paratype USNM 438312.

Metadagnoceras youngi is invariably distinguished from all Spathian congeneric species (see review by KUMMEL 1969; see also *M. amidii* TOZER 1972a) by its compressed shell shape and its suture line. Distinctive features of the latter are the loss of a well individualized first lateral saddle, the wide and shallow first lateral lobe provided with numerous indentations and a residual ventral lobe. Among the Spathian form revised by KUMMEL (op. cit.), only *M. pulchrum* TOZER (occurrences from both *Subrobustus* and *Haugi* Zones) shows a reduced first lateral lobe along with a relatively shallow first lateral saddle. This trend is even more accentuated with *M. rotundum* WANG from Ziyun (WANG 1978, Text-Fig. 5b, Pl. 2, Figs. 4–7) which yet differs from *M. youngi* by its smooth and trigonal whorl shape. *M. youngi* is easily distinguished from the younger *Alanites mulleri* SILBERLING & NICHOLS (Lower *Hyatti* Zone) by its suture line, but apart from the absence of flared umbilical margins, it has somewhat comparable gross whorl proportions. In spite of its shell shape, generic attribution of this new species to *Metadagnoceras* is supported by its characteristic suture line.

Species named for D. YOUNG of New Pass Mine, Nev.

Figured specimens. Holotype USNM 438310, paratypes USNM 438309, 438311 and 438312.

Occurrence. Loc. HB 56 (8), Coyote Canyon, northern Humboldt Range, Nevada. *Mulleri* Zone, Lower Anisian.

Superfamily **Megaphyllitaceae** MOJSISOVICS 1896Family **Parapopanoceratidae** TOZER 1971Genus *Stenopopanoceras* POPOV 1961*Stenopopanoceras* sp. indet.

Plate 2, Figure 6

Description. A single incomplete specimen conforms to this genus. It has the diagnostic concentric coiling of *Stenopopanoceras* and is compressed and moderately evolute (at D = 42 mm, H = 37%, W = 29% and U = 30%). The arched venter on the penultimate whorl becomes bluntly angular on the ultimate whorl, thus probably indicating transition to the body chamber. Concave, prorsiradiate growth striae barely visible on the outer shell. Suture line too poorly preserved to be drawn.

Discussion. *Stenopopanoceras* is here first reported from the Nevada Anisian sequence. By its general shell shape, this specimen resembles involute representatives of *Stenopopanoceras* such as *S. transiens* TOZER and *S. primulum* POPOV. The poor state of preservation and failure in obtaining the suture line prevent which one of these two species the Nevada specimen should be referred to. Comparison with *S. zvetkovi* (POPOV), which has thicker whorls and even greater involution, must be ruled out (see DAGYS & ERMAKOVA 1981 for a comprehensive study of Siberian *Parapopanoceratidae*).

Figured specimens. USNM 438324.

Occurrence. Loc. HB 96 (1), Coyote Canyon, northern Humboldt Range, Nevada. Talus block derived from Lower Anisian strata above the *Pseudokeyserlingites guexi* beds.

Superfamily **Ceratitaceae** MOJSISOVICS 1879Family **Sibiritidae** MOJSISOVICS 1886Subfamily **Keyserlingitinae** ZAKHAROV 1970Genus *Pseudokeyserlingites* n. gen.

Type species. *Pseudokeyserlingites guexi* n. sp.

Description. Keyserlingitid with shallow bisulcate and roughly serraticarinate venter on inner whorls. Carination persists whereas the sulci fade on outer whorls. Venter strongly adorned by dense, chevron-shaped ribs that cross the keel thus defining a crude, wavy serration. Whorl section at first coronate and then subhexagonal.

Composition of the genus. *Pseudokeyserlingites guexi* n. sp.

Discussion. The unique ventral pattern of *Pseudokeyserlingites* enables making generic distinction with the otherwise overall comparable *Keyserlingites* HYATT (= *Durgaites* DIENER). *Pseudokeyserlingites* has much more affinities with *Keyserlingites* than with *Olenekoceras*, a clearly distinct genus which unites varied species of the *middendorfi* group (DAGYS & ERMAKOVA 1986). *Pseudokeyserlingites* differs from *Taimyrites* of the Siberia *Tardus* Zone (VAVILOV & ARKADIEV 1986) by its subhexagonal whorl section, its spinose tuberculation and its serraticarinate venter. According to TOZER (written com. 1989), *Taimyrites* is regarded as a better representative of *Groenlanditinae* than of *Danubitidae* as initially proposed by VAVILOV & ARKADIEV (1986).

Pseudokeyserlingites guexi n. sp.

Plate 2, Figures 2–5; Text-Figure 6

Description. Innermost whorls carinate and bisulcate. At this growth stage, keel and ventral furrows apparently evenly smooth. With increasing shell size, keel changes rapidly into a low rounded, crudely serrated shape. Linked with development of ventral ribbing, furrows become simultaneously shallower. On strongly divergent flanks, slightly sigmoidal, faint looped ribs merge at both ends of crescentic, flat-topped tubercles placed on outer flanks. The width of the rather diffuse adapical rib increases outwards whereas the adoral rib is frequently reduced to clustered growth striae. The crescentic scars and the flat top of tubercles go together with the presence of hollow spines. These usually break away during extraction but are preserved on inner whorls of the holotype. Up to 3 stout prorsiradiate ribs branch from the tubercles and further enlarge into ventrolateral swellings. Then, they cross the ventral furrows with decreasing strength and meet the keel at an angle of about 100–120°. The largest available specimen, although still immature, has an estimated diameter of about 10 cm. Suture line imperfectly known but with a proportionally oversized first lateral saddle.

Discussion. Relatively coarse, U or V-shaped ventral ribbing is a character already encountered among some representatives of *Keyserlingites*. For instance, this noticeable feature is shared by *K. dieneri* (MOJSISOVICS) and *K. qinghaiensis* WANG but both contrast from *Pseudokeyserlingites* in lacking the keel. The keeled “*Ceratites* nov. sp. ind. from *C. robusti* group” (DIENER 1895, Pl. 5, Fig. 6) was later removed from keyserlingitids on safer grounds by DIENER himself (1905, p. 788). In fact, both suture line and whorl section evidently preclude relationships of any kind with keyserlingitids. Much closer are the specimens from Qinghai referred as “*Gymnotoceras*” sp. by WANG and others (1979, p. 31, Pl. 7, Figs. 27–34). From their illustrations and suture line, one can state that these specimens are by no means comparable to beyrichitids but strikingly resemble *Pseudokeyserlingites*. “*Gymnotoceras*” sp. was found to be associated with other ammonoids out from which no definite age can be inferred. The co-occurring alleged *Gymnotoceras* sp. (WANG and others 1979, p. 31, Pl. 7, Figs. 24–26) is not well enough preserved for unambiguous generic identification and the accompanying *Gymnites* is a rather long ranging genus. Unfortunately, there is no further mention of this “*Gymnotoceras*” sp., even in the synonymy lists, in the paper by HE and others (1986) on Lower and Middle Triassic ammonoids of Central Qinghai.

Pseudokeyserlingites guexi may presumably be regarded as an offshoot of the equally low paleolatitude *Keyserlingites dieneri* stock.

Species named for J. GUËX of the Institute of Geology and Paleontology, Lausanne University.

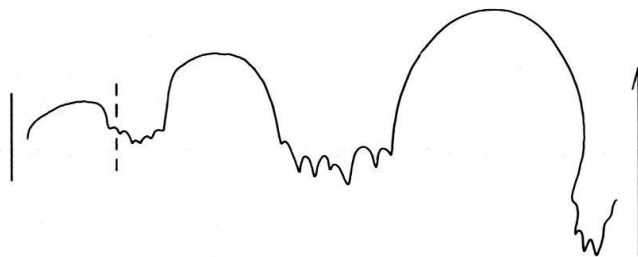


Fig. 6. Suture line ($\times 6$) of *Pseudokeyserlingites guexi* n. gen. n. sp. at $H = 7.6$ mm. Plesiotype USNM 438321.

Figured specimens. Holotype USNM 438323, paratype USNM 438322, plesiotypes USNM 438320 and 438321.

Occurrence. Loc. HB 138 (2), HB 223 (1), HB 250 (1), Coyote Canyon; HB 251 (1) and single float specimen found above the *Japonites welteri* beds, Bloody Canyon, northern Humboldt Range. USGS Mesozoic loc. M1599 (1), Inyo Range, California. *Pseudokeyserlingites guexi* beds, Lower Anisian.

Subfamily **Silberlingitinae** n. subfam.

Genus *Silberlingites* n. gen.

Type species. *Silberlingites mulleri* n. sp.

Description. Shell compressed and permanently keeled. Allowing for some variation, ontogenetic pathway undergoes at least three basic stages, the first and third of which are markedly contrasted and separated by a second, somewhat transitional and brief stage. Innermost whorls coronate, provided with one or two rows of hollow spine-bearing tubercles on outer flanks or at ventrolateral margin. The smooth, partially hollow floored keel may be occasionally bordered by two furrows. On flanks, the strength of diffuse rectiradiate ribs increases towards the parabolic, flat-topped, spine-bearing tubercles. From them stem an usually single, very sharply projected rib that rapidly fades on venter. With further increase in shell size, whorl section gradually becomes first subquadrate and then subrectangular. During this second stage, tuberculation progressively fades and then completely disappears. Below tubercles, ribs become much better defined and are commonly looped. Additional intercalatory ribs may even develop between groups of looped ribs. The resulting pattern is a much denser, more or less rursiradiate ribbing. At the end of this stage, ribbing becomes uniform, going together with the progressive loss of ventrolateral tubercles and possible ventral furrows. At beginning of last stage, whorl height has considerably increased and slightly convex flanks grade evenly into the narrowly arched, permanently carinate venter. The extension of thin, projected and occasionally fasciculate ribs to larger diameters depends on initial strength of ribbing. These commonly wear off before the end of mature phragmocone and only similarly pathed growth striae subsist at transition to body chamber. This third stage apparently still prevails on the imperfectly known body chamber. The latter does not display any further notable modifications aside from short umbilical margins and gentle ventral shoulders. Suture line ceratitic. Lobe-endings commonly if not invariably truncated by sutural overlapping on last half whorl of mature phragmocone. Ventral lobe with a single, narrow indentation and as deep as the finely crenulated lateral lobe. Umbilical lobe reduced to a single indentation. Dorsal lobe lituid.

Composition of the genus. *Silberlingites mulleri* n. sp., *Silberlingites tregoi* n. sp.

Discussion. *Silberlingites* embodies a unique combination of characters quite unlike that of any previously known Triassic genus. Its innermost whorls suggest affinity with *Pseudokeyserlingites* but the rest of the shell is so profoundly altered that it justifies introduction of a new subfamily among *Sibiritidae*. Partial resemblances between *Silberlingites* and Spathian hellenitids or Lower Anisian groenlanditids such as *Taimyrites* are probably not of phylogenetic significance.

Genus named for N.J. SILBERLING of the U.S. Geological Survey at Denver.

Silberlingites mulleri n. sp.

Plate 3, Figures 1–11; Plate 4, Figures 1–4; Text-Figure 7

Description. *Silberlingites* with a single row of tubercles placed on outer flanks. Inner whorls usually devoid of ventral furrows. However, these furrows may occur on some rare variants but are then rather shallow. Population obtained from locality HB 56 exhibits a considerable range of variability regarding the extension of the two tuberculated stages. Figure 8 shows that the frequency distribution of maximal umbilical width corresponding to the last tubercle fits a normal distribution. Strength of both tuberculation and ribbing obviously depends on the maximal diameter attained by the two first stages. The second stage may also be drastically abbreviated on some variants. H% and U% are respectively plotted on Figures 9 and 10. Suture line with relatively elongated saddles whose walls are subparallel.

Discussion. *Silberlingites mulleri* is distinguished from *S. tregoi* by the characters of its two first stages. These have a single row of comparatively larger tubercles, a less well defined ribbing and more markedly coronate whorl section.

Species named in honor of the late S. W. MULLER.

Figured specimens. Holotype USNM 438327, paratypes USNM 438326, 438428 to 438340.

Occurrence. Loc. HB 56 (81), HB 59 (5), HB 115 (2), Coyote Canyon, northern Humboldt Range. *Mulleri* Zone, Lower Anisian.

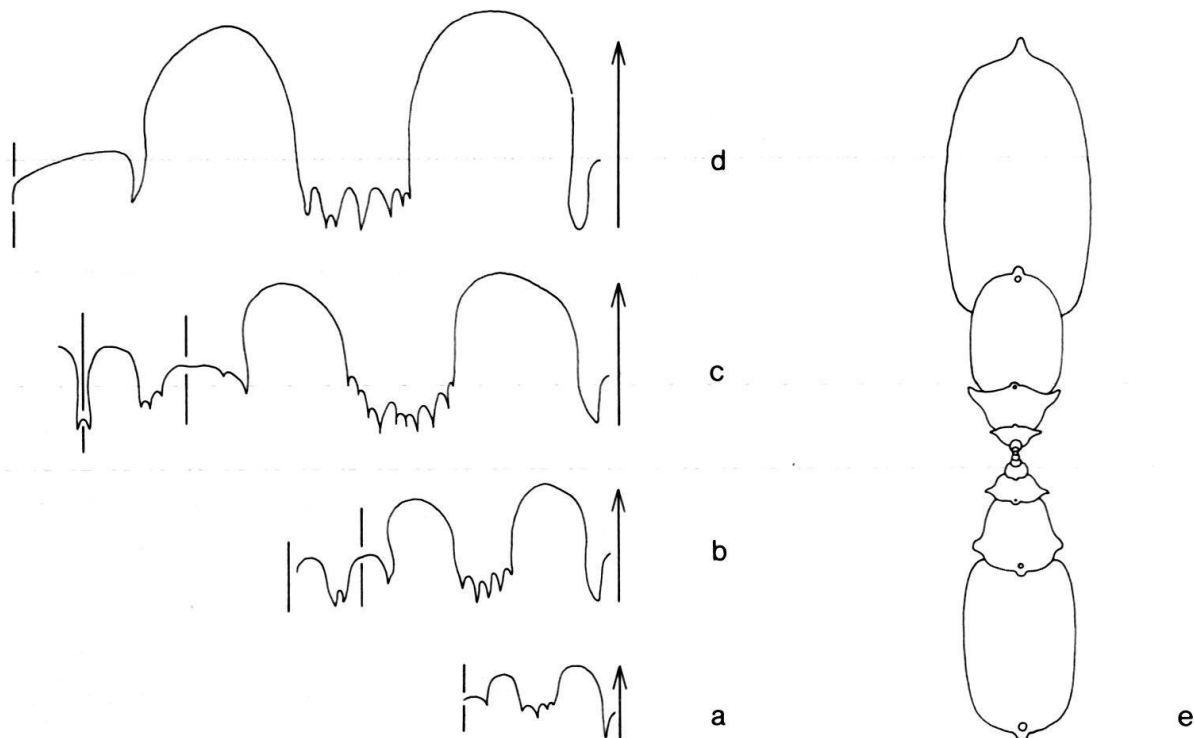


Fig. 7. *Silberlingites mulleri* n. gen. n. sp. Loc. HB 56, *Mulleri* Zone, Coyote Canyon. Suture lines ($\times 3$): a: H = 3.8 mm; Paratype USNM 438386 (specimen not figured). b: H = 6.6 mm; Paratype USNM 438385 (specimen not figured). c: H = 14 mm; Paratype USNM 438384 (specimen not figured). d: H = 20 mm; Paratype USNM 438337 (specimen not figured). Section ($\times 1.5$) e: Paratype USNM 438387 (specimen not figured).

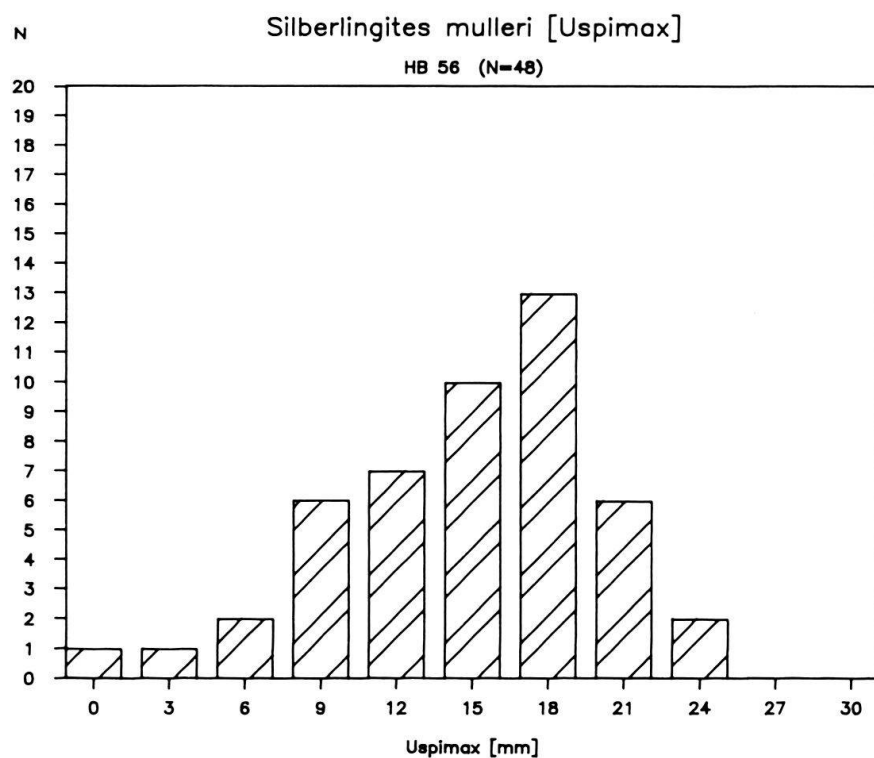


Fig. 8. Frequency distribution of maximal umbilical width of spinose stage [Uspimax] for 48 specimens of *Silberlingites mulleri* n. gen. n. sp. from locality HB 56 in the *Mulleri* Zone; Coyote Canyon.

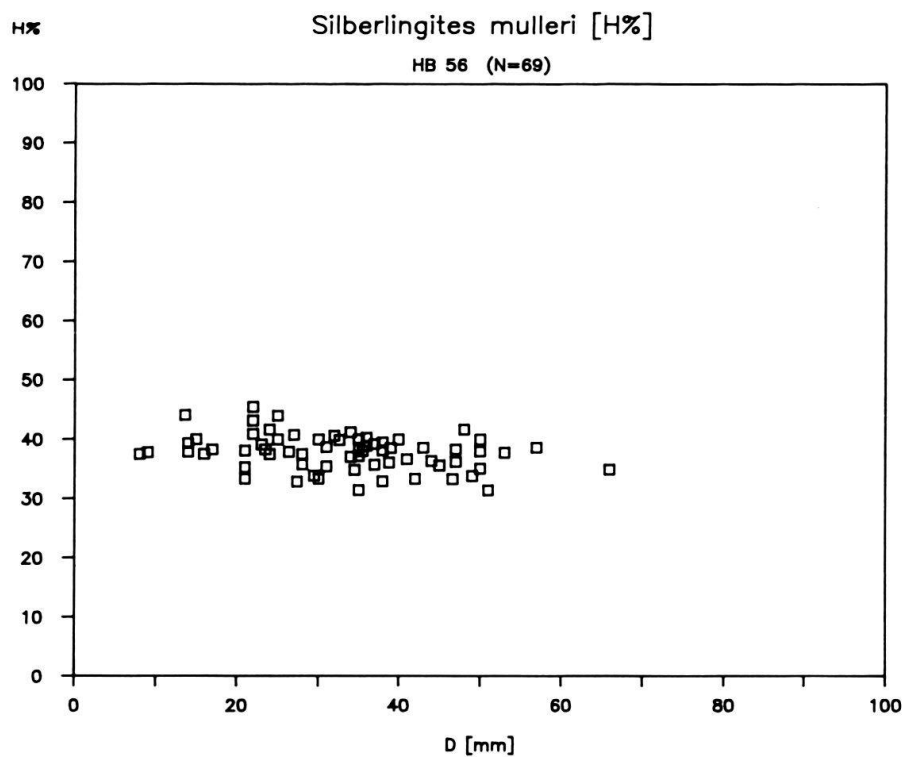


Fig. 9. Scatter diagram of H% against corresponding diameter for 69 specimens of *Silberlingites mulleri* n. gen. n. sp. from locality HB 56 in the *Mulleri* Zone; Coyote Canyon.

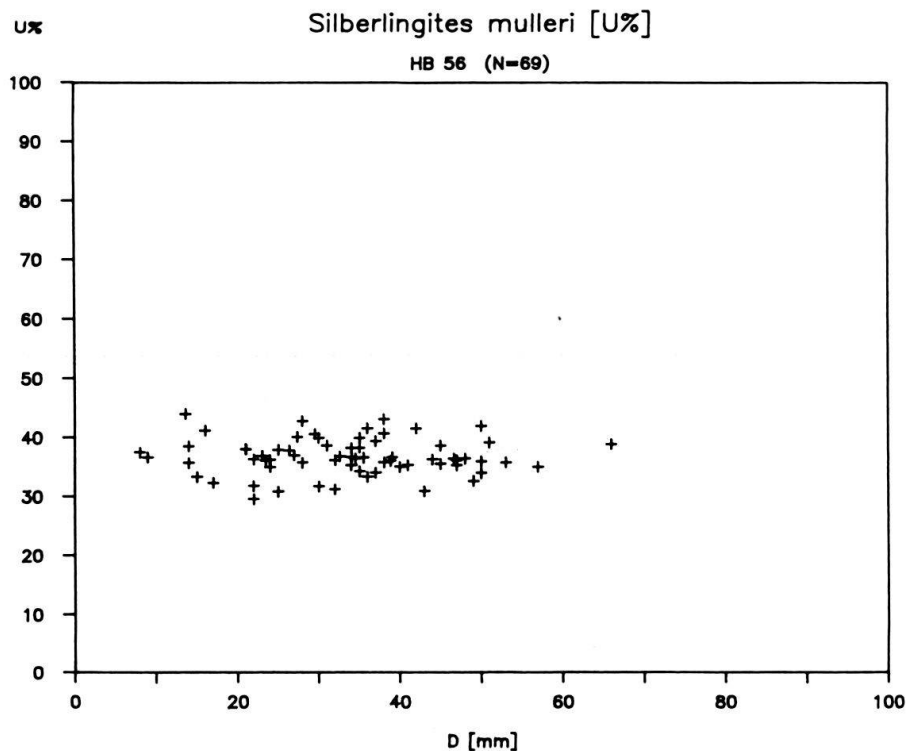


Fig. 10. Scatter diagram of U% against corresponding diameter for 69 specimens of *Silberlingites mulleri* n. gen. n. sp. from locality HB 56 in the *Mulleri* Zone; Coyote Canyon.

Silberlingites tregoi n. sp.

Plate 4, Figures 5–12; Text-Figure 11

Description. *Silberlingites* with two rows of spine-bearing tubercles placed respectively on outer flanks and at ventrolateral margin. At the end of the usually short first stage, whorl section at first slightly coronate, rapidly changes into a subquadrate outline. Ventrolateral spines simultaneously gain further strength and are deeply printed in the umbilical margin of the next overlapping whorl. At this comparatively much longer second stage, both single and looped ribs are prominent and occasionally slightly rursiradiate. Short ventral ribs sharply projected and fading along ventral furrows. Both lateral and ventrolateral spines gradually lose their strength but ventrolateral tuberculation lasts comparatively longer. Transition to the third stage is enhanced by definitive obliteration of ribbing and ventrolateral tuberculation. Whorl section is then compressed and subrectangular.

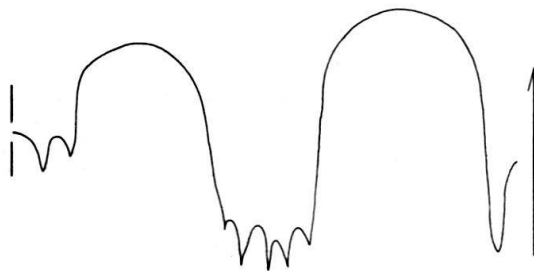


Fig. 11. Suture line ($\times 6$) of *Silberlingites tregoi* n. gen. n. sp. at D = 18.5 mm. Plesiotype USNM 438342.

Discussion. *Silberlingites tregoi* differs from *S. mulleri* in having bituberculated inner whorls. At first and second stages, *S. tregoi* is usually more evolute and less deeply umbilicated than *S. mulleri*. Their third respective stages are identical. The suture line of *S. tregoi* does not differ from that of *S. mulleri*.

Species named for Mrs. P. TREGO of Unionville, Nev.

Figured specimens. Holotype USNM 438344, paratypes USNM 438341 to 438343, 438346 and 438348, plesiotypes USNM 438345 and 438347.

Occurrence. Loc HB 56 (10), HB 59 (3), HB 88 (1), HB 115 (2), Coyote Canyon, northern Humboldt Range. *Mulleri* Zone, Lower Anisian.

Family **Acrochordiceratidae** ARTHABER 1911

Genus *Paracrochordiceras* SPATH 1934

Paracrochordiceras sp. indet.

Plate 1, Figures 8–10

Description. This form is represented by 3 fragments which are highly suggestive of *Paracrochordiceras*. They are characterized by a very slightly sinuous, mainly plicate ribbing. The strength of densely and regularly spaced ribs increases evenly towards outer flanks, with a conspicuous projection at-or near ventrolateral margin. The less poorly preserved specimen shows a subrectangular whorl section with a subtabulate venter and a short, abrupt umbilical margin. The same specimen bears bi- or trifurcated ribs, the apical rib of which being the most pronounced on inner flanks. Branched ribs quickly become of equal strength on mid- and outer flanks. Though eroded, a few ribs may possibly bifurcate again at ventral shoulders. Suture line not known.

Discussion. The few available specimens do not enable identification at the species level. Their regular plicate ribbing makes distinction with *P. silberlingi* n. sp., *P. americanum* McLEARN and *P. mclearnii* n. sp. very likely. These early representatives of *Paracrochordiceras* roughly share a common style of ribbing with *P. plicatus* n. sp. and *P. anodosum* WELTER but apparently lack the well rounded inner whorls. They differ from *Proacrochordiceras* as defined by KORCHINSKAYA (1982, 1984) by having denser and finer ribbing.

Figured specimens. USNM 438315 to 438317.

Occurrence. Loc. HB 235 (2), Coyote Canyon, northern Humboldt Range. *Japonites welteri* beds, Lower Anisian. Single isolated float specimen found at the lower limit of the Fossil Hill Member in the Congress Canyon, northern Humboldt Range; probably derived from the same horizon.

Paracrochordiceras silberlingi n. sp.

Plate 1, Figures 6–7; Text-Figure 12

Description. *Paracrochordiceras* with dense and sharp, crestate ribbing. Shell moderately evolute, with stout whorls, a little thicker than they are high and with a low, broadly arched venter. Ribbing is typically convex on phragmocone of the immature holotype. On innermost whorls, a few ribs bifurcate from discrete lateral nodes occurring about 4 to a whorl. Parabolic scars are barely visible on the nodes. At later stage,

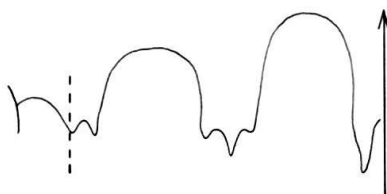


Fig. 12. Suture line ($\times 6$) of *Paracrochordiceras silberlingi* n. sp. at $D = 13$ mm. Holotype USNM 438314.

some ribs are trifurcate, the first branching point being placed on inner flanks, the second at ventral shoulders. With further increasing in shell size, there is no more evidence of nodes placed at branching points. All ribs are uniform in strength and cross the venter to form a slight sinus. A conspicuous feature of the phragmocone are hollow ribs. On inner mould of phragmocone, ribs have a truncated crest and fade when crossing the siphonal line whereas the outer test is sharply but regularly folded. The hollow space thus created just below the top of outer test crests is evidenced by distinct sparitic fillings. This discrepancy between inner mould and outer test of phragmocone results in the presence of a preseptal layer (GUÉX 1970; TOZER 1972b) still partially preserved on the holotype. On the body chamber, ribs are rectiradiate and more pronounced, specially on venter. Some ribs are then quadrifurcate, recalling a reverse virgatotome type of ribbing. At a diameter of 26 mm (body chamber of the immature holotype), $H = 35\%$, $W = 46\%$ and $U = 42\%$. Immature suture line ceratitic, with crudely indented lobes.

Description. Shell shape and suture line conform to these of *Paracrochordiceras*. Distinguished from all other congeneric species in having a very sharp ribbing with up to 4 branched ribs simulating a reverse virgatotome type of ribbing.

Species named for N. J. SILBERLING of the U.S. Geological Survey at Denver.

Figured specimens. Holotype USNM 438314, paratype USNM 438313.

Occurrence. Loc. HB 223 (2), Coyote Canyon; northern Humboldt Range. *Pseudoskeyserlingites guexi* beds, Lower Anisian.

Paracrochordiceras cf. *P. americanum* McLEARN

Plate 7, Figures 3–5; Text-Figure 13

Acrochordiceras (*Paracrochordiceras*) *americanum* McLEARN 1946, p. 3, Pl. 5, Fig. 1. McLEARN 1969, p. 12, Pl. 1, Figs. 1–3.

[not] *Paracrochordiceras* aff. *P. americanum* McLEARN, SILBERLING & TOZER 1968, p. 38. SILBERLING & WALLACE 1969, p. 17, Tabl. 1.

[not] *Paracrochordiceras americanum* McLEARN, SILBERLING & NICHOLS 1982, p. 21, Pl. 29, Figs. 1–9.

Description. Relatively evolute and compressed *Paracrochordiceras*. Innermost whorls slightly depressed and frequently bearing small, discrete lateral parabolic nodes. Further development shows rapid transition to subquadrate or subrectangular whorl section together with loss of nodes. Ribbing is then weak and consists of mainly single ribs that cross the venter with variable strength. A few of them may occasionally bifurcate on inner or at mid-flanks. On outer whorls, some specimens show flexuous, somewhat slightly concave ribbing. At $D = 30$ mm, $H = 28\text{--}33\%$, $W = 30\text{--}33\%$ and $U = 43\text{--}47\%$. The largest known mature specimen has a diameter of about 65 mm. Suture line ceratitic with a wide and deeply crenulated first lateral lobe.

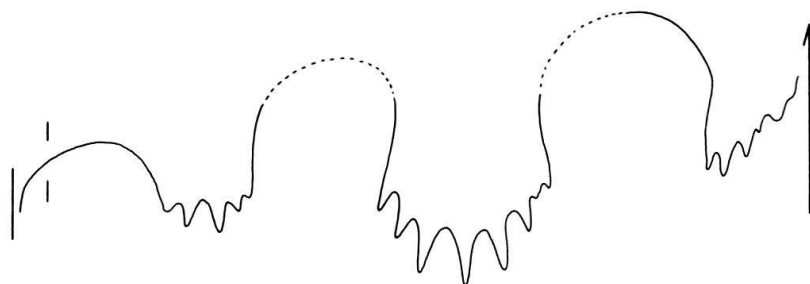


Fig. 13. Suture line ($\times 6$) of *Paracrochordiceras* cf. *P. americanum* McLEARN at $H = 13$ mm. Plesiotype USNM 444087 (specimen not figured). Loc. HB 56, *Mulleri* Zone; Coyote Canyon.

Discussion. Among the various *Paracrochordiceras* from the Nevada Anisian sequence, those presently discussed are the most comparable with the holotype of *P. americanum* which was originally described from the lower part of the *Caurus* Zone of British Columbia. Both share a relatively evolute coiling with subrectangular whorl section and a generally thin ribbing that can not be properly labeled plicate. It must also be mentioned that close examination of the holotype equally suggests presence of discrete lateral nodes on innermost whorls. *P. americanum* is thus distinguished from *P. plicatus* of the Nevada *Caurus* Zone by its thinner, less typically plicate ribbing, its more compressed whorl section and more evolute coiling.

Figured specimens. Plesiotypes USNM 438374 to 438376.

Occurrence. Loc. HB 56 (14), HB 91 (2), HB 115 (3), HB 88 (1), Coyote Canyon, northern Humboldt Range. *Mulleri* Zone, Lower Anisian.

Paracrochordiceras mclearni n. sp.

Plate 7, Figures 6–7; Text-Figure 14

Description. Evolute *Paracrochordiceras* with well rounded whorl section. Rather weak and flexuous ribbing fade on venter. Up to 5 conspicuous parabolic lateral nodes to a whorl are linked up from the two sides by a peristomal scar. At $D = 27$ mm (holotype), $H = 29\%$, $W = 37\%$ and $U = 48\%$. Suture line ceratitic, with a proportionally large sized first lateral lobe.

Discussion. Distinguished from the coeval *P.* cf. *P. americanum* by the rounded whorl section, the much weaker ribbing and the parabolic nodes that extend up to 25 mm in diameter.

Species named in honor of the late F. H. McLEARN.

Figured specimens. Holotype USNM 438377, plesiotype USNM 438378.

Occurrence. Loc. HB 56 (3), HB 95 (2), Coyote Canyon, northern Humboldt Range. *Mulleri* Zone, Lower Anisian.

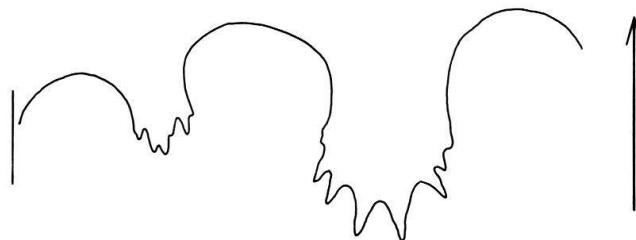


Fig. 14. Suture line ($\times 6$) of *Paracrochordiceras mclearni* n. sp. at $D = 25$ mm. Plesiotype USNM 438378.

Paracrochordiceras plicatus n. sp.

Paracrochordiceras aff. *P. americanum* McLEARN, SILBERLING & TOZER 1968, p. 38. SILBERLING & WALLACE 1969, p. 17, Tabl. 1.

Paracrochordiceras americanum McLEARN, SILBERLING & NICHOLS 1982, p. 21, Pl. 29, Figs. 1 [holotype, here designated] to 9.

Description. Moderately evolute *Paracrochordiceras* with true plicate ribbing. Strength of ribbing usually increases on venter. Inner whorls depressed, with parabolic nodes. Transition to outer whorls is shown by gradual change of whorl section into a subquadrate to subrectangular outline.

Discussion. Differs from *P. cf. P. americanum* and *P. mclearni* in having a more involute coiling, thicker whorls and a true plicate ribbing; from *P. sp. indet.* by its rounded inner whorl section.

Occurrence. USGS Mesozoic localities M 2358 (9), M 2362 (1?), M 2367 (3), M 2828 (1?). Loc. HB 180 (3), Star Creek, Bloody and Coyote Canyons, northern Humboldt Range. *Caurus* Zone, Lower Anisian.

Superfamily **Danubitaceae** SPATH 1951

Family **Danubitidae** SPATH 1951

Genus *Paradanubites* SHEVYREV 1968

Paradanubites crassicostratus n. sp.

Plate 7, Figure 8

Description. Shell serpenticone, with rather indistinct umbilical margin and broadly arched venter. Ribbing simple, coarse, somewhat bulbous and slightly prorsiradiate but fading on venter. From what is left of the body chamber, it shows notable whorl height increasing in that differing from the subquadrate preceding whorls. On body chamber, ribbing changes into a more or less concave path. At D = 62 mm, H = 26%, W = 27% and U = 48%. Suture line not known.

Discussion. Though suture line could not be obtained, this form is distinguished from *Paracrochordiceras* by its very slowly increasing whorl height and absence of nodes. *P. crassicostratus* differs from *P. alternecostatus* (WELTER), *P. naumanni* (MOJSISOVICS) and *P. kansa* (DIENER) by its even more serpenticone coiling and stouter ribbing; from *Danubites* (?*Paradanubites*) *tozeri* KORCHINSKAYA by its coarser ribbing.

Figured specimens. Holotype USNM 438379.

Occurrence. Loc. HB 56 (1), Coyote Canyon, northern Humboldt Range. *Mulleri* Zone, Lower Anisian.

Family **Longobarditidae** SPATH 1951

Subfamily **Groenlanditinae** ASSERETO 1966

Genus *Groenlandites* KUMMEL 1966

Groenlandites pridaense n. sp.

Plate 5, Figures 5–10; Text-Figure 15

Description. Inner whorls relatively evolute, depressed, with lateral tuberculation of variable strength, ranging from weak radial folds to blunt nodes. Venter broadly arched

and perfectly smooth. Allowing for some variability, transition to inflated oxycone stage generally occurs at an average diameter of about 10 mm. Venter becomes then bluntly angular or nearly acute but not carinate. More or less convex ribbing gradually decreases but subsists comparatively longer on inner flanks. $H\%$, $W\%$ and $U\%$ are respectively plotted on Figures 16, 17 and 18. Suture line with quite variable number of auxiliary elements (2 to 5).

Discussion. Less inflated and with earlier transition to oxycone stage than *G. nielsenii* KUMMEL, *G. astachovae* VAVILOV and *G. merriami* n. sp.

Species name derived from the Prida Formation.

Figured specimens. Holotype USNM 438359, paratypes USNM 438357 and 438358, plesiotypes USNM 438355, 438356, 438360.

Occurrence. Loc. HB 56 (36), HB 115 (5), HB 222 (26), 59 (2), HB 95 (5), Coyote Canyon, northern Humboldt Range. *Mulleri* Zone, Lower Anisian.

Groenlandites merriami n. sp.

Plate 5, Figure 11

Description. A single mature specimen refers to this species. Whorl section subtriangular and inflated at end of phragmocone, with a blunt angular venter. On inner flanks, diffuse bullae are made up by groups of 2 or 3 closely spaced and swollen ribs. Both clustered and intercalated ribs fade near or at ventrolateral margin. The last half-whorl (incomplete body chamber) first shows, single, convex ribs that gradually weaken and become flexuous at end of ultimate whorl. Simultaneous changes of whorl section result in considerable increase in height, a short and steep umbilical margin and a less angular periphery. At $D = 46$ mm, $H = 50\%$, $W = 33\%$ and $U = 19\%$. Suture line not known.

Discussion. Distinguished from *G. nielsenii* KUMMEL in having a less acute venter, a more compressed body chamber and more pronounced ribbing; from *G. astachovae* VAVILOV and *G. pridaense* n. sp. by its larger size and more robust shape.

Species named in honor of the late J. C. MERRIAM.

Figured specimens. Holotype USNM 438361.

Occurrence. Loc. HB 225 (1), Bloody Canyon, northern Humboldt Range. *Caurus* Zone, Lower Anisian.

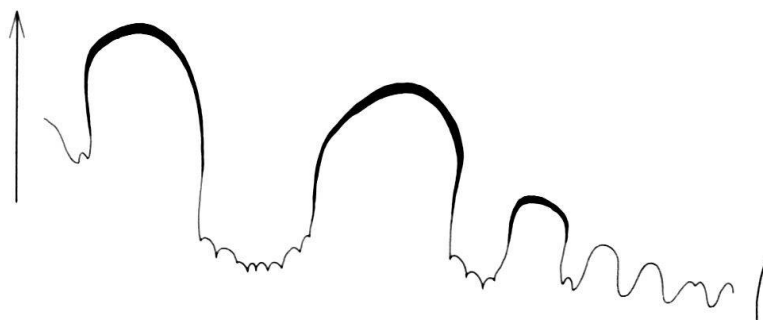


Fig. 15. Third before last suture line ($\times 6$) of *Groenlandites pridaense* n. sp. at $D = 23.5$ mm. Holotype USNM 438359.

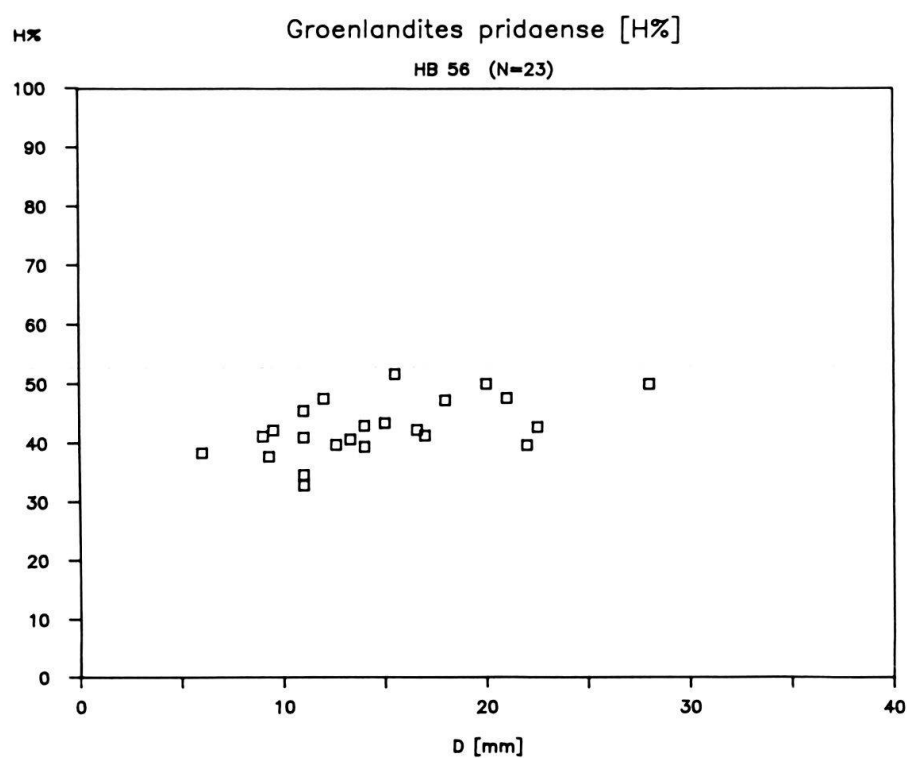


Fig. 16. Scatter diagram of H% against corresponding diameter for 23 specimens of *Groenlandites pridaense* n. sp. from locality HB 56 in the *Mulleri* Zone; Coyote Canyon.

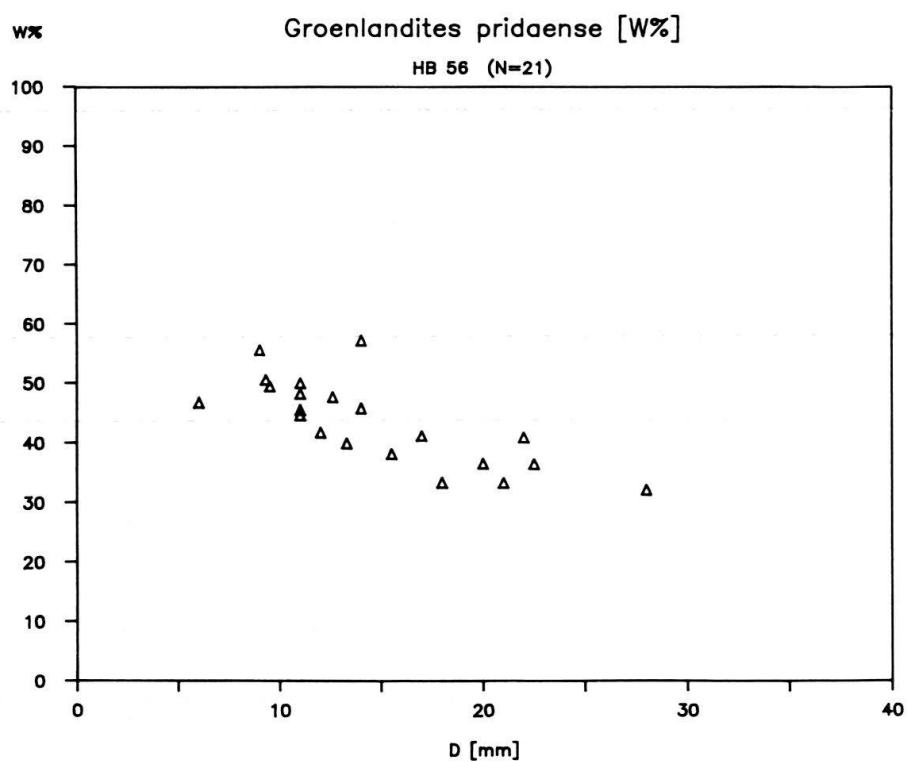


Fig. 17. Scatter diagram of W% against corresponding diameter for 21 specimens of *Groenlandites pridaense* n. sp. from locality HB 56 in the *Mulleri* Zone; Coyote Canyon.

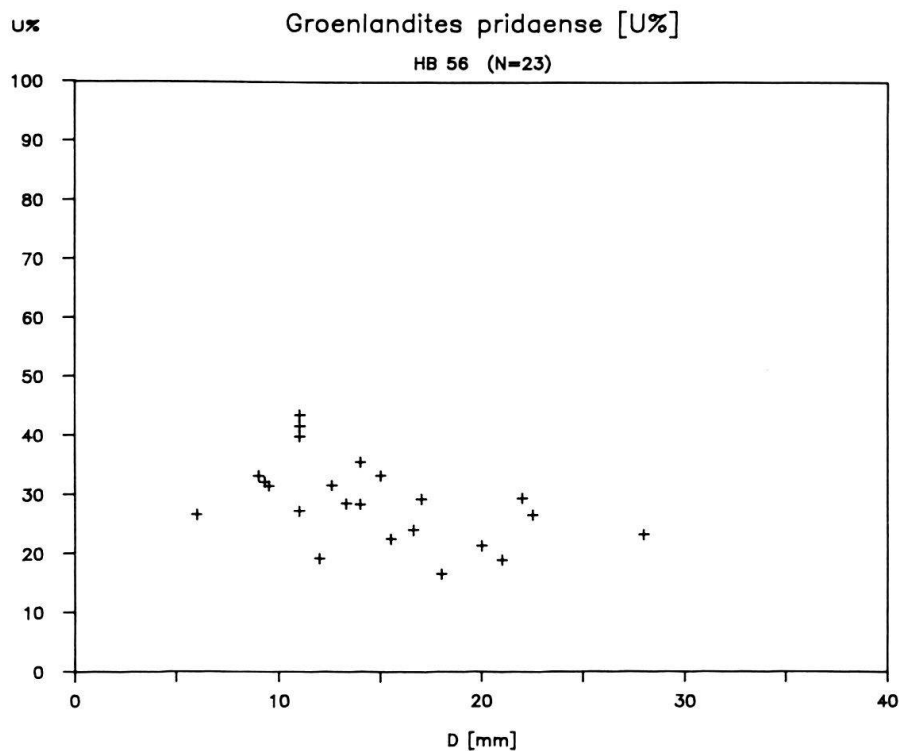


Fig. 18. Scatter diagram of U% against corresponding diameter for 23 specimens of *Groenlandites pridaense* n. sp. from locality HB 56 in the *Mulleri* Zone; Coyote Canyon.

Subfamily Longobarditinae SPATH 1951

Genus *Grambergia* POPOV 1961

Grambergia sp. indet.

Plate 5, Figures 12–13; Text-Figure 19

Description. Innermost whorl ($D < 7$ –10 mm) moderately evolute and smooth. Outer whorls ($D > 10$ mm) extremely oxycone, smooth and with an occluded umbilicus. At $D = 21$ mm, $H = 62\%$ and $W = 26\%$. Suture line with 5 auxiliary elements and crudely indented lobes.

Discussion. Differs from all other congeneric species by very early acquisition of oxycone stage and occluded umbilicus.

Figured specimens. USNM 438362 and 438363.

Occurrence. Loc. HB 56 (3), HB 94 (5), HB 59 (1), Coyote Canyon, northern Humboldt Range, *Mulleri* Zone, Lower Anisian.

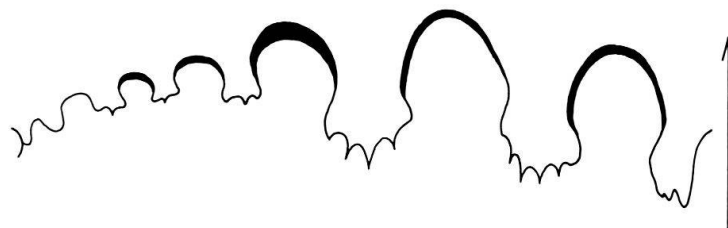


Fig. 19. Suture line ($\times 6$) of *Grambergia* sp. indet. at $D = 22$ mm. USNM 438362.

Superfamily **Pinacocerataceae** MOJSISOVICS 1879Family **Gymnitidae** WAAGEN 1895Subfamily **Japonitinae** TOZER 1971Genus *Japonites* MOJSISOVICS 1893*Japonites welteri* n. sp.

Plate 1, Figure 11; Plate 6, Figures 4–6; Text-Figure 20

Eophyllites sp. A. SILBERLING & WALLACE 1969, Tabl. 1. SILBERLING & NICHOLS 1982, p. 5

Description. Serpenticone japonitid with an almost rounded whorl section on phragmocone and beginning of body chamber. Further development of body chamber shows transition to a platycone shape, with proportionally increasing whorl height and individualization of a short and steep umbilical margin. On phragmocone and beginning of body chamber, ornamentation is reduced to dense, slightly sinuous fine folds that cross the venter. On some variants, strength of folds may even increase when crossing the venter. Transition to mature body chamber is enhanced by gradual appearance of convex and rursiradiate blunt umbilical folds fading towards outer flanks. At $D = 66$ mm (holotype), $H = 20\%$, $W = 22\%$ and $U = 50\%$. Mature suture line subammonitic, with a wide and deeply indented first lateral lobe. First and second lateral saddles of equal height, the former having a particular forked-shaped spatula morphology.

Discussion. At the time this form was first mentioned (SILBERLING & WALLACE 1969), characters of both body chamber and suture line were evidently not known. Its rather featureless phragmocone is actually hardly discernible from that of some *Eophyllites*. Of most probable Anisian age, serpenticone japonitids closely allied to *J. welteri* include *J. ziyunensis* WANG, *J. maduoensis* WANG & CHEN, "*J. raphaelis zojae*" TOMMASI (sensu HE and others 1986) and to a lesser degree *J. meridianus* WELTER. *J. asseretoi* FANTINI-SESTINI, *J. surgiva* DIENER, *J. subacutus* WELTER, *J. magnus* WANG & HE, *J. starensis* n. sp. and *Eogymnites arthaberi* (DIENER)²⁾ differ from the previous group in having either a depressed and – or subtrigonal whorl section with a narrowly arched venter.

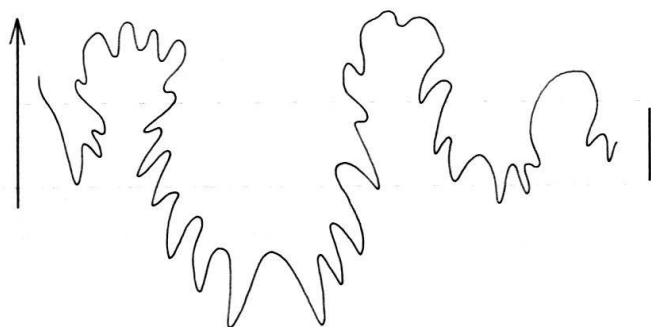


Fig. 20. Suture line ($\times 6$) of *Japonites welteri* n. sp. at $D = 25$ mm. Plesiotype USNM 444088 (specimen not figured). Loc. HB 184, *Japonites welteri* beds; Coyote Canyon.

²⁾ *Eogymnites arthaberi* (DIENER) is the only japonitid of alleged Spathian age (ARTHABER 1911, see also SPATH 1951 and KUMMEL 1969). The Hallstatt limestones stratigraphy and the complex tectonic setting of the Triassic of Albania (ARTHABER 1911, Figs. 1, 2) cast some doubt on the validity of the age assignment of this single specimen. Though not exactly placed in the local sequence, a representative of *Acrochordiceras* (*carolinae* group of Middle Anisian age) illustrated by ARTHABER (1911) makes it probable that *Eogymnites arthaberi* is of Anisian age.

Together with FANTINI-SESTINI (1981), it must be emphasized that *Gymnites raphaelis zojae* was initially described from the Wengener Schichten of Monte Clap-savon by TOMMASI (1889). This confers a Ladinian age to TOMMASI's *Gymnites*. It is also consistent with its occurrence in the Asklepeion Limestone (FRECH & RENZ 1908 [= *Japonites argivus*]; RENZ 1910) where it is found to be associated with other Ladinian ammonoids (confirmed by L. KRYSZYN, oral com., 1988). Subsequent treatment of japonitids from various supposed late Spathian or early Anisian localities as *J. raphaelis zojae* is thus rather unsatisfactory (WELTER 1915; BENDER 1970; HE and others 1986). Timor form 3 of WELTER (1915, Pl. 10, Fig. 1) yet differs from *J. welteri* by its apparently perfectly smooth venter and by lacking the well defined rursiradiate umbilical folds at larger diameter. WELTER's form 1 (Pl. 10, Fig. 3) differs in turn by generalization of umbilical folds to the entire shell and by its subtriangular whorl section. Inclusion of WELTER's form 1 into *J. asseretoi* from Chios Island (BENDER 1967; FANTINI-SESTINI 1981) as suggested by FANTINI-SESTINI is probably justified. "*Japonites raphaelis zojae*" is also recorded from the "*Lenotropites*"-*Japonites* Zone (*Japonites meridianus* Subzone) of Central Qinghai (HE and others 1986, p. 240, Pl. 9, Figs. 15 to 19). Inner whorls of *J. welteri* resemble those of the Qinghai form but the latter differs by its suture line whose first lateral saddle is not spatula-shaped.

J. ziyunensis and *J. meridianus* are distinguished from *J. welteri* by their apparently more compressed, almost platycone inner whorls. Moreover, *J. meridianus* also differs by its finer ribbing.

J. welteri is named in honor of O. A. WELTER.

Figured specimens. Holotype USNM 438369, paratype USNM 438367, plesiotypes USNM 438368 and 438318.

Occurrence. Loc. HB 92 (11), HB 235 (4), HB 109 (9), Coyote Canyon; HB 181 (8), Bloody Canyon; HB 184 (41), Star Creek Canyon, northern Humboldt Range, Nevada. *Japonites welteri* beds, Lower Anisian.

Japonites cf. *J. surgriva* DIENER

Plate 2, Figure 1

Japonites surgriva DIENER 1895, p. 32, Pl. 7, Fig. 1 [holotype]. NOETLING 1905, Pl. 14, Fig. 2.

[not] *Japonites surgriva* DIENER var., ARTHABER 1911, Pl. 20, Fig. 4.

Japonites cf. *J. surgriva* DIENER, SILBERLING & NICHOLS 1982, p. 39.

Description. A single immature fragmentary specimen gives evidence that *Japonites* occurs in the *Caurus* Zone. It has a relatively high trigonal whorl section with convex flanks that converge towards the very narrowly arched venter. The largest width is at inner flanks. Umbilical margin short and very steep. This specimen is apparently smooth except for the penultimate whorl which bears widely spaced wavy folds on inner flanks. Suture line not known.

Discussion. This specimen is undoubtedly closely allied to *Japonites surgriva* DIENER from the "*Ptychites rugifer* Zone" of Shalshal Cliff (DIENER 1895, 1912; NOETLING 1905). *Japonites* cf. *J. surgriva* is also reported from the Upper Hyatti Zone in the northern Humboldt Range (SILBERLING & NICHOLS 1982). Comparison of the latter with the *Caurus* Zone specimen does not lead to different specific assignment.

Figured specimens. Plesiotype USNM 438319.

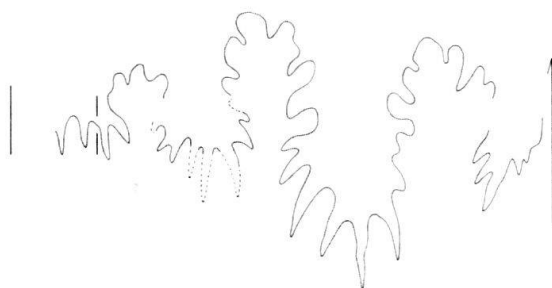


Fig. 21. Suture line ($\times 3$) of *Japonites starensis* n. sp. at $D = 25$ mm. Holotype USNM 438325.

Occurrence. Loc. HB 180 (1), Bloody Canyon, northern Humboldt Range. *Caurus* Zone, Lower Anisian.

Japonites starensis n. sp.

Plate 2, Figure 7; Text-Figure 21

Description. Relatively involute japonitid with subquadrate to subtrapezoidal whorl section. Both whorl height and width increase rapidly. Venter broadly arched and smooth, umbilical wall high and slightly rounded. Short radial ribs on inner flanks become gradually less closely spaced as diameter increases. At $D = 43$ mm, $H = 37\%$, $W = 40\%$ and $U = 35\%$. The suture line concords with that of japonitids. The broad first lateral lobe has remarkably deep incisions.

Discussion. *Japonites starensis* differs from other japonitids by its thicker whorls and its short radial ribs.

Figured specimens. Holotype, USNM 438325.

Occurrence. Loc HB 184 (1), Star Creek Canyon, northern Humboldt Range, Nevada. *Japonites welteri* beds, Lower Anisian.

Genus *Caucasites* SHEVYREV 1968

Caucasites nicholsi n. sp.

Plate 5, Figures 1–4; Text-Figure 22

Description. Shell shape cadicone, with stairs-like umbilicus. Phragmocones obtained from locality HB 56 display a wide variability, ranging from moderately to strongly depressed variants ($H\%$ and $U\%$ plotted on Fig. 23). Shell smooth, with only prorsiradiate growth striae or thin, weak folds that cross the venter. Whorl height proportionally increases on outer whorls and body chamber. Venter, at first broadly arched, then gradually changing into a subfastigate outline. The largest known specimen has an estimated diameter of about 9 cm. Although badly crushed, this specimen bears wavy, blunt folds on lower flanks of ultimate whorl. Suture line ammonitic, with relatively short, finely frilled saddles. First lateral saddle typically more slender than second lateral saddle.

Discussion. *Caucasites nicholsi* compares with *C. inflatus* SHEVYREV as originally described from Caucasus. It is however distinguished from *C. inflatus* in having an invariably more finely frilled suture line. The Upper Anisian age assignment of

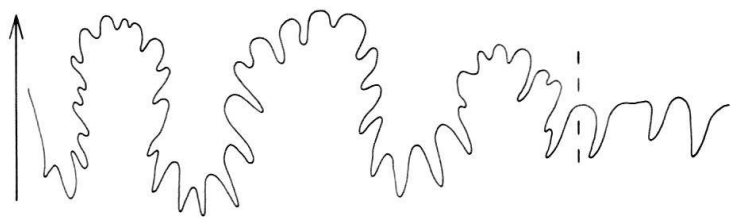


Fig. 22. Suture line ($\times 6$) of *Caucasites nicholsi* n. sp. at $D = 21$ mm. Plesiotype USNM 438352.

C. inflatus by SHEVYREV (1968) is rather questionable. The faunal list of its "second assemblage" (op. cit., p. 34) reveals obvious mixing of non-contemporaneous ammonoids. These include forms which occur distinctively at different time intervals throughout the Anisian stage. As far as known, presence of *Caucasites* in the Lower Anisian substage as exemplified by the Nevada sequence is the only reliable stratigraphic occurrence available by now.

Species named for K. M. NICHOLS of the U.S. Geological Survey at Denver.

Figured specimens. Holotype USNM 438351, plesiotypes USNM 438352 to 438354.

Occurrence. Loc. HB 56 (36), HB 95 (1), HB 115 (2), HB 59 (5), HB 88 (2), HB 91 (2), Coyote Canyon, northern Humboldt Range. *Mulleri* Zone, Lower Anisian.

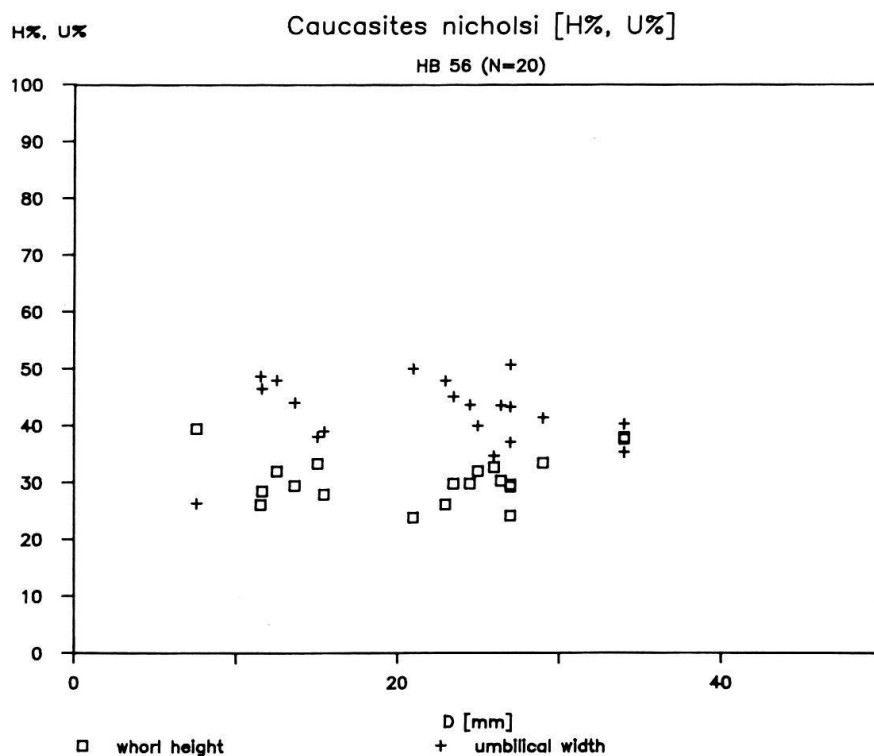


Fig. 23. Scatter diagram of H% (squares) and U% (crosses) against corresponding diameter for 20 specimens of *Caucasites nicholsi* n. sp. from locality HB 56 in *Mulleri* Zone; Coyote Canyon.

Subfamily **Gymnitinae** WAAGEN 1895Genus *Gymnites* MOJSISOVICS 1882*Gymnites billingsi* n. sp.

Plate 6, Figures 1–3; Text-Figure 24

Description. Evolute, extremely compressed, with slightly convex but not flattened flanks. Venter narrow, bluntly angular. Umbilical wall very short and step. Flanks smooth except for weak, irregular, poorly defined folds. At $D = 50$ mm, $H = 35\%$, $W = 14\%$ and $U = 40\%$. Though less complexly subdivided, the suture line conforms with that of other congeneric species. The retracted suspensive lobe has 3 auxiliary lobes external of the umbilical seam.

Discussion. Differs from *G. tregoi* SILBERLING & NICHOLS by its more compressed whorl section and narrower venter. Suture line obtained from newly collected specimens of *G. tregoi* does not significantly differ from that of *G. billingsi*.

Species named for Mr. and Mrs. W. BILLINGS of Unionville, Nev.

Figured specimens. Holotype USNM 438364, paratypes USNM 438365 and 438366.

Occurrence. Loc. HB 56 (7), Coyote Canyon, northern Humboldt Range. *Mulleri* Zone, Lower Anisian.

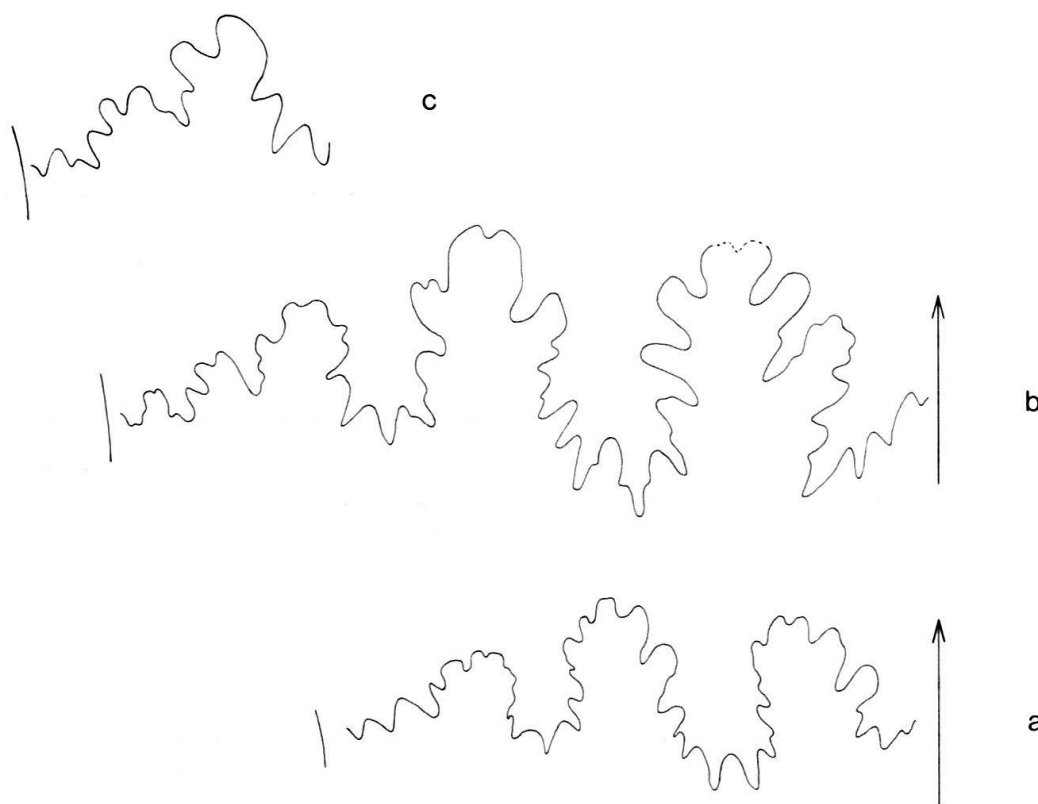


Fig. 24. Suture lines ($\times 6$) of *Gymnites billingsi* n. sp., Loc. HB 56, *Mulleri* Zone, Coyote Canyon. a: $H = 10$ mm, Paratype USNM 438383 (specimen not figured). b: $H = 13$ mm, Paratype USNM 438382 (specimen not figured). c: $H = 14$ mm, Paratype USNM 438382 (specimen not figured).

Order **Phylloceratida**
 Superfamily **Ussuritaceae** HYATT 1900
 Family **Paleophyllitidae** POPOV 1958
 Genus *Leiophyllites* DIENER 1915

Leiophyllites sp. indet.

Plate 7, Figures 9–10; Text-Figure 25

Description. Compressed, extremely serpenticone with faint but strongly rursi-radiate folds on flattened flanks. Venter smooth, narrowly arched and umbilical margin rounded. At D = 21 mm, H = 24%, W = 20% and U = 55%. Suture line ceratitic.

Discussion. Shell shape and ornamentation suggest some affinities *L. pitamaha* (DIENER) but the rather simple suture line precludes any further comparisons.

Figured specimens. USNM 438380 and 438381.

Occurrence. Loc. HB 94 (3), Coyote Canyon, northern Humboldt Range. *Mulleri* Zone, Lower Anisian.

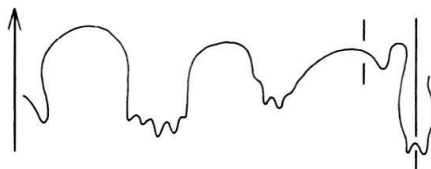


Fig. 25. Suture line ($\times 6$) of *Leiophyllites* sp. indet. at H = 5 mm. USNM 444089 (specimen not figured). Loc. HB 94, *Mulleri* Zone; Coyote Canyon.

Family **Ussuritidae** HYATT 1900
 Genus *Ussurites* HYATT 1900

Ussurites sp. indet.

Plate 7, Figure 2; Text-Figure 26

Description. Smooth, serpenticone ussuritid with subquadrate whorl section. Venter convex, bordered by gentle ventral shoulders. Because outer shell is not preserved, presence of a possible striation could not be confirmed. Suture line with monophyllic saddles, the second lateral saddle having the diagnostic subdivision of ussuritids on its dorsal side.

Discussion. Generic attribution to *Ussurites* is supported by the diagnostic sutural pattern. At comparable whorl height, subdivision of the second lateral saddle is less pronounced and merely absent on the third lateral saddle of *U.* sp. indet., whereas both saddles are deeply indented among representatives of the younger *U. arthaberi* WELTER. *U.* sp. indet. more significantly differs from other congeneric species by its serpenticone and relatively compressed shape. With respect to that, *U.* sp. indet. embodies a combination of a ussuritid sutural pattern with a paleophyllitid shell shape.

Figured specimens. USNM 438373.

Occurrence. Loc. HB 56 (1), Coyote Canyon, northern Humboldt Range. *Mulleri* Zone, Lower Anisian.

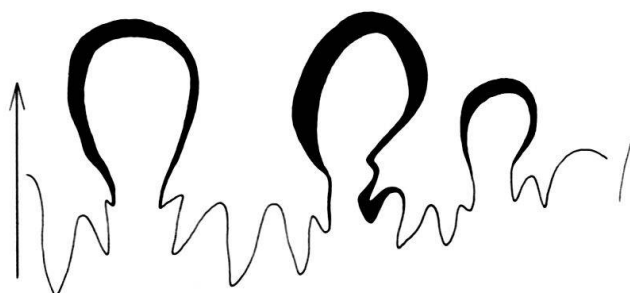


Fig. 26. Suture line ($\times 6$) of *Ussurites* sp. indet. at $D = 24$ mm. USNM 438373.

Ussurites detwilleri n. sp.

Plate 7, Figure 1

Description. Inner whorls evolute, rounded and ribbed. Further development shows increasing spacing of radial ribs which gradually fade on outer whorls. Whorl section simultaneously changes into an ovoid outline. Umbilical margin is then well individualized and slightly convex flanks gently converge towards the permanently broadly arched venter. Striation visible on what is left of outer test. At $D = 37$ mm, $H = 38\%$, $W = 34\%$ and $U = 36\%$. Suture line not known.

Discussion. Though suture line could not be obtained, shell shape and presence of striae make attribution to *Ussurites* very likely. Ribbed inner whorls are the chief difference when compared with *U. arthaberi* WELTER, *U. muskwa* McLEARN, *U. hara* DIENER and *U. kingi* DIENER. This difference equally applies to *U. sp. indet.* which is additionally much more evolute and compressed.

Species named for K. DETWILLER of the Bureau of Land Management, Winnemucca, Nev.

Figured specimens. Holotype USNM 438372.

Occurrence. Loc. HB 225 (1), Bloody Canyon, northern Humboldt Range. *Caurus* Zone, Lower Anisian.

Acknowledgments

Fieldwork and laboratory research was funded by project N° 2.565-0.84 of the Swiss National Foundation for Scientific Research. E.T. Tozer, N.J. Silberling, K.M. Nichols and J. Guex provided valuable advice, unpublished information and material, and critically read the manuscript. H. Rieber lent specimens of the Dagys reference collection housed at the Paleontologisches Institut der Universität Zürich.

P. Trego, W. Billings (Unionville, Nev.), M.C. Stafford, W.M. Thompson, K. Detwiller (Winnemucca, Nev.) and D. Young (New Pass Mine, Nev.) gave much help and assistance during fieldwork. Photographic illustrations were prepared by J.C. Viellefond (Lausanne).

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Manuscript received 4 August 1989

Revision accepted 6 September 1989

Plate 1

All figures natural size

- Fig. 1. *Metadagnoceras* sp. indet. (p. 963). *Japonites welteri* beds. Loc. HB 184, Star Creek Canyon, northern Humboldt Range. USNM 438308.
- Fig. 2–5. *Metadagnoceras youngi* n. sp. (p. 963). *Mulleri* Zone. Loc. HB 56, Coyote Canyon, northern Humboldt Range.
2: paratype, USNM, 438309.
3: holotype, USNM 438310.
4: paratype, USNM 438311.
5: paratype, USNM 438312.
- Fig. 6–7. *Paracrochordiceras silberlingi* n. sp. (p. 971). *Pseudokeyserlingites guexi* beds. Loc. HB 223, Coyote Canyon, northern Humboldt Range.
6: paratype, USNM 438313.
7: holotype, USNM 438314.
- Fig. 8–10. *Paracrochordiceras* sp. indet. (p. 971). *Japonites welteri* beds. Northern Humboldt Range.
8: USNM 438315, loc. HB 235, Coyote Canyon.
9: USNM 438316, float from the lowermost strata of the Fossil Hill Member, Congress Canyon.
10: USNM 438317, loc. HB 235, Coyote Canyon.
- Fig. 11. *Japonites welteri* n. sp. (p. 978). *Japonites welteri* beds. Loc. HB 184, Star Creek Canyon, northern Humboldt Range. Plesiotype, USNM 438318.

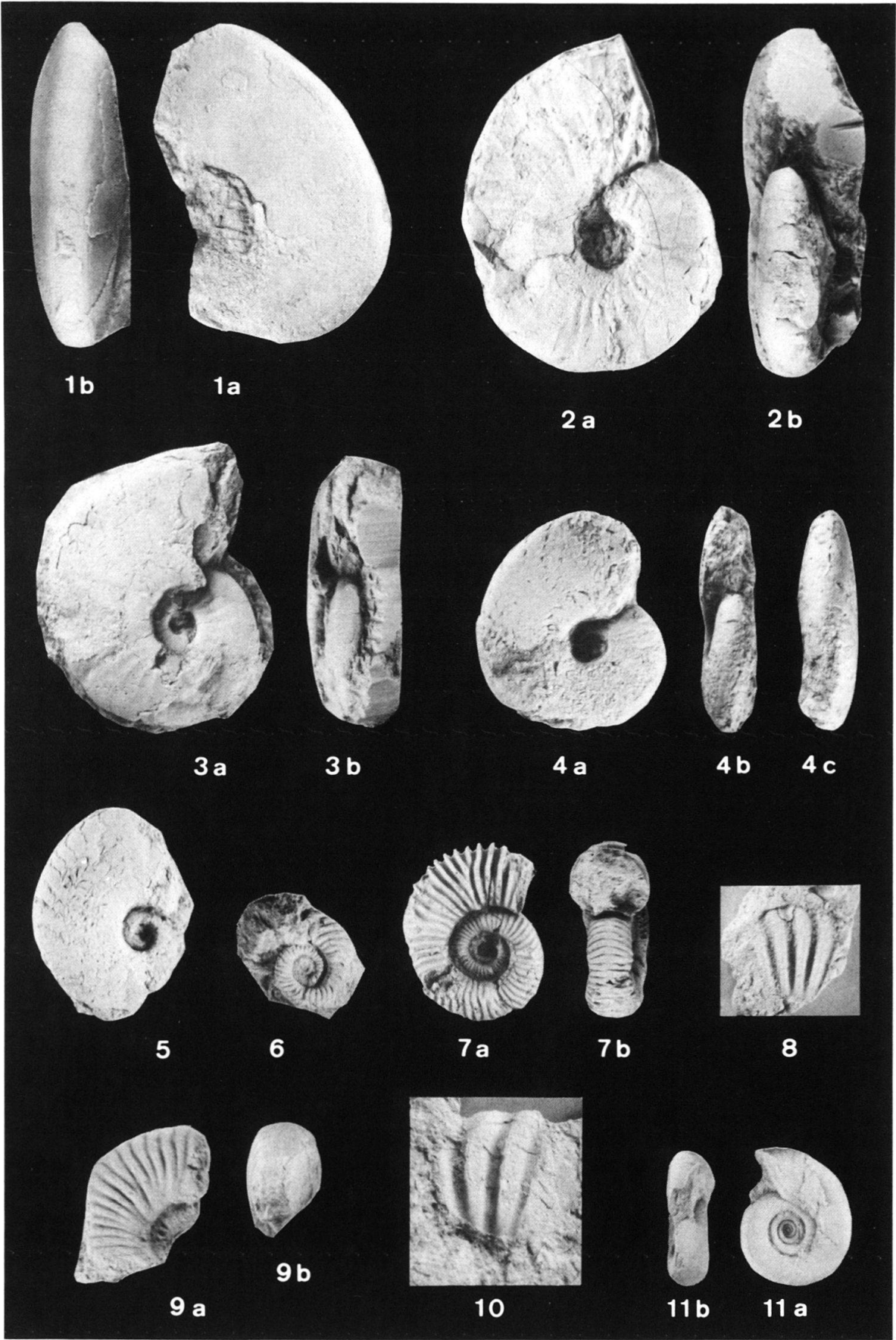


Plate 2

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- Fig. 1. *Japonites* cf. *J. surgriva* DIENER (p. 979). *Caurus* Zone. Loc. HB 180, Bloody Canyon northern Humboldt Range. Plesiotype, USNM 438319.
- Fig. 2–5. *Pseudokeyserlingites guexi* n. gen. n. sp. (p. 966). *Pseudokeyserlingites guexi* beds. Northern Humboldt Range.
2: plesiotype, USNM 438320, loc. HB 250, John Brown Canyon.
3: plesiotype, USNM 438321, loc. HB 251, Bloody Canyon. a, b and c respectively lateral, ventral and dorsal views.
4: paratype, USNM 438322, loc. HB 138, Coyote Canyon.
5: holotype, USNM 438323, loc. HB 138, Coyote Canyon.
- Fig. 6. *Stenopopanoceras* sp. indet. (p. 965). Lower Anisian. Loc. HB 96, Coyote Canyon, northern Humboldt Range. USNM 438324.
- Fig. 7. *Japonites starensis* n. sp. (p. 980). *Japonites welteri* beds. Loc. HB 184, Star Creek Canyon, northern Humboldt Range. Holotype, USNM 438325.

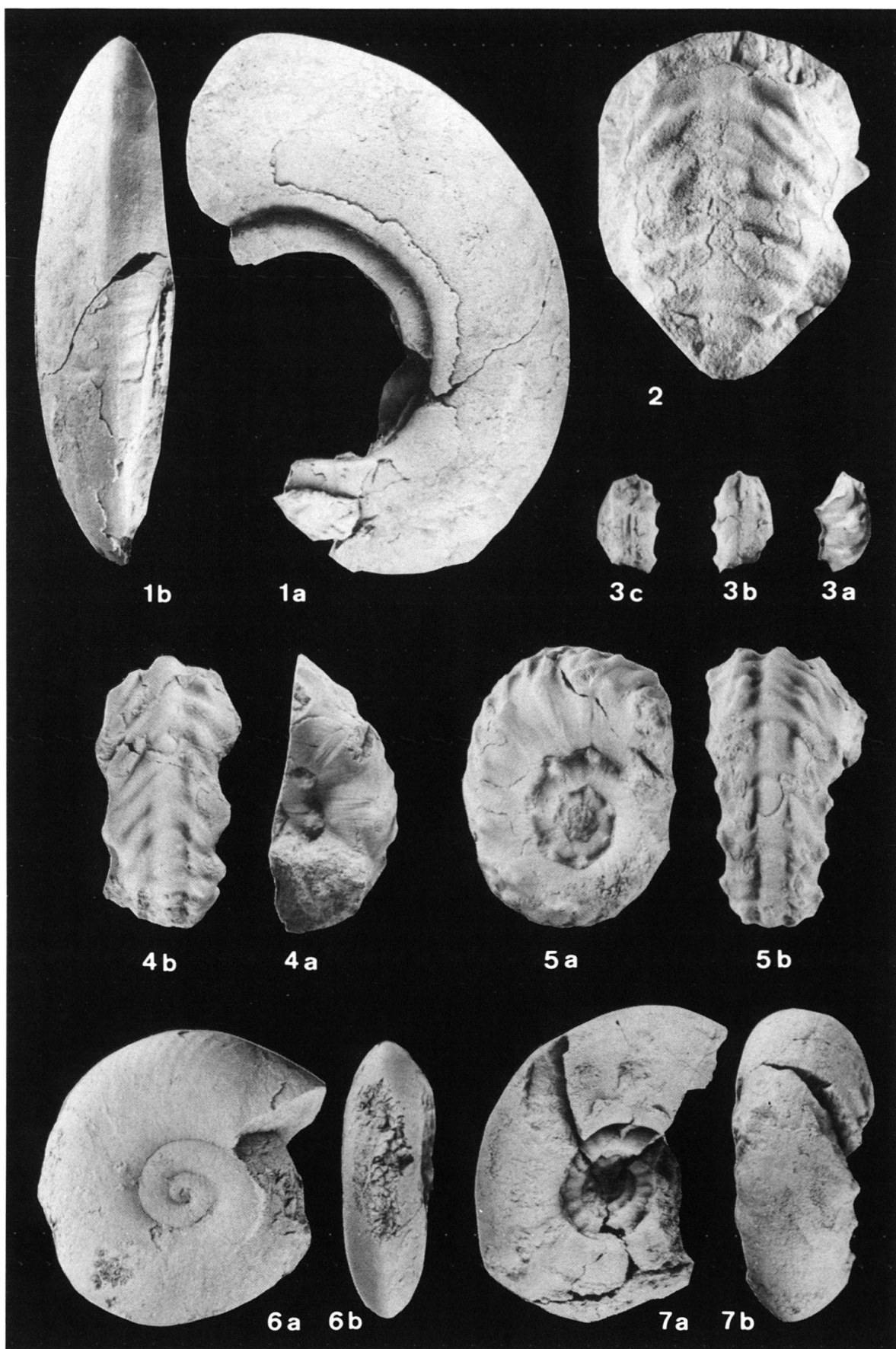


Plate 3

All figures natural size

- Fig. 1–11. *Silberlingites mulleri* n. gen. n. sp. (p. 968). *Mulleri* Zone. Loc. HB 56, Coyote Canyon, northern Humboldt Range.
- 1: paratype, USNM 438326.
 - 2: holotype, USNM 438327.
 - 3: paratype, USNM 438328.
 - 4: paratype, USNM 438329.
 - 5: paratype, USNM 438330.
 - 6: paratype, USNM 438331.
 - 7: paratype, USNM 438332.
 - 8: paratype, USNM 438333.
 - 9: paratype, USNM 438334.
 - 10: paratype, USNM 438335.
 - 11: paratype, USNM 438336.

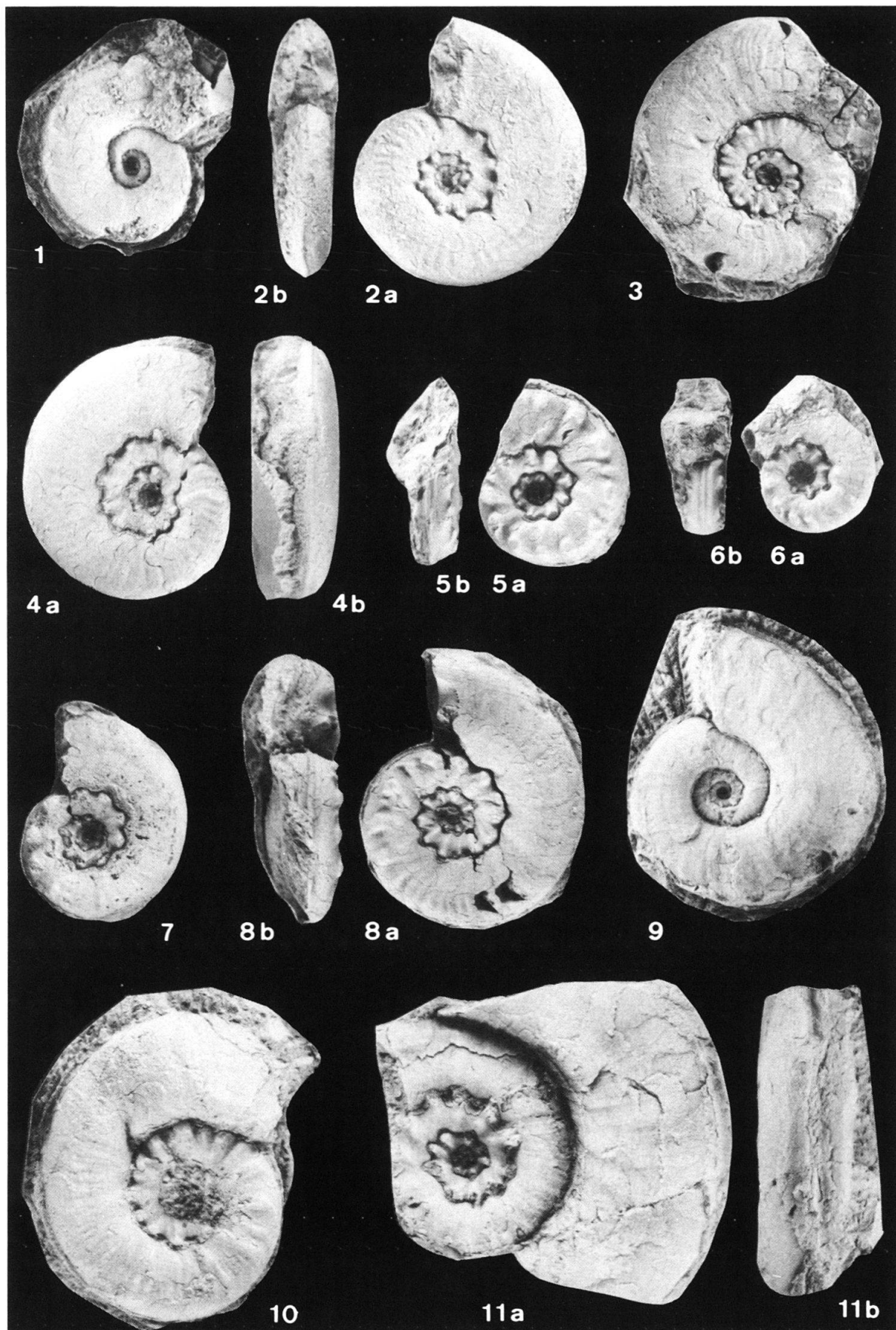


Plate 4

All figures natural size

- Fig. 1–4. *Silberlingites mulleri* n. gen. n. sp. (p. 968). *Mulleri* Zone. Loc. HB 56, Coyote Canyon, northern Humboldt Range.
1: paratype, USNM 438337.
2: paratype, USNM 438338.
3: paratype, USNM 438339.
4: paratype, USNM 438340.
- Fig. 5–12. *Silberlingites tregoi* n. gen. n. sp. (p. 970). *Mulleri* Zone. Coyote Canyon, northern Humboldt Range.
5: paratype, USNM 438341, loc. HB 56.
6: paratype, USNM 438342, loc. HB 56.
7: paratype, USNM 438343, loc. HB 56.
8: holotype, USNM 438344, loc. HB 56.
9: plesiotype, USNM 438345, loc. HB 115.
10: paratype, USNM 438346, loc. HB 56.
11: plesiotype, USNM 438347, loc. HB 115.
12: paratype, USNM 438348, loc. HB 56.
- Fig. 13–14. *Sageceras* cf. *S. walteri* Mojsisovics (p. 962). *Mulleri* Zone. Loc. HB 56, Coyote Canyon, northern Humboldt Range.
13: plesiotype, USNM 438349.
14: plesiotype, USNM 438350.

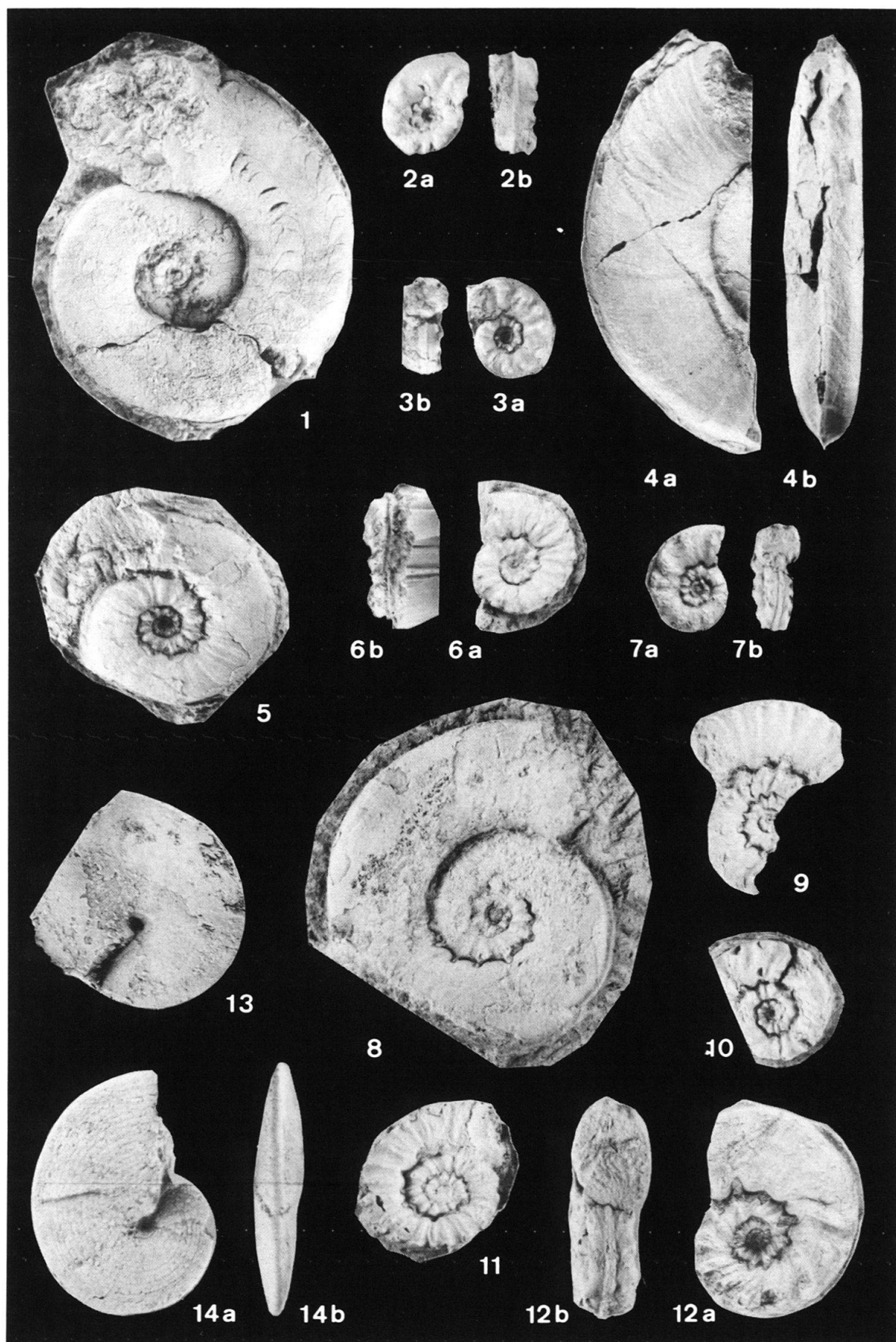


Plate 5

All figures natural size

- Fig. 1–4. *Caucasites nicholsi* n. sp. (p. 980). *Mulleri* Zone. Coyote Canyon, northern Humboldt Range.
1: holotype, USNM 438351, loc. HB 95.
2: plesiotype, USNM 438352, loc. HB 56.
3: plesiotype, USNM 438353, loc. HB 56.
4: plesiotype, USNM 438354, loc. HB 56.
- Fig. 5–10. *Groenlandites pridaense* n. sp. (p. 974). *Mulleri* Zone. Coyote Canyon, northern Humboldt Range.
5: plesiotype, USNM 438355, loc. HB 222.
6: plesiotype, USNM 438356, loc. HB 222.
7: paratype, USNM 438357, loc. HB 56.
8: paratype, USNM 438358, loc. HB 56.
9: holotype, USNM 438359, loc. HB 56.
10: plesiotype, USNM 438360, loc. HB 222.
- Fig. 11. *Groenlandites merriami* (p. 975). *Caurus* Zone. Loc. HB 225, Bloody Canyon, northern Humboldt Range. Holotype, USNM 438361.
- Fig. 12–13. *Grambergia* sp. indet. (p. 977). *Mulleri* Zone. Coyote Canyon, northern Humboldt Range.
12: USNM 438362, loc. HB 56.
13: USNM 438363, loc. HB 94.

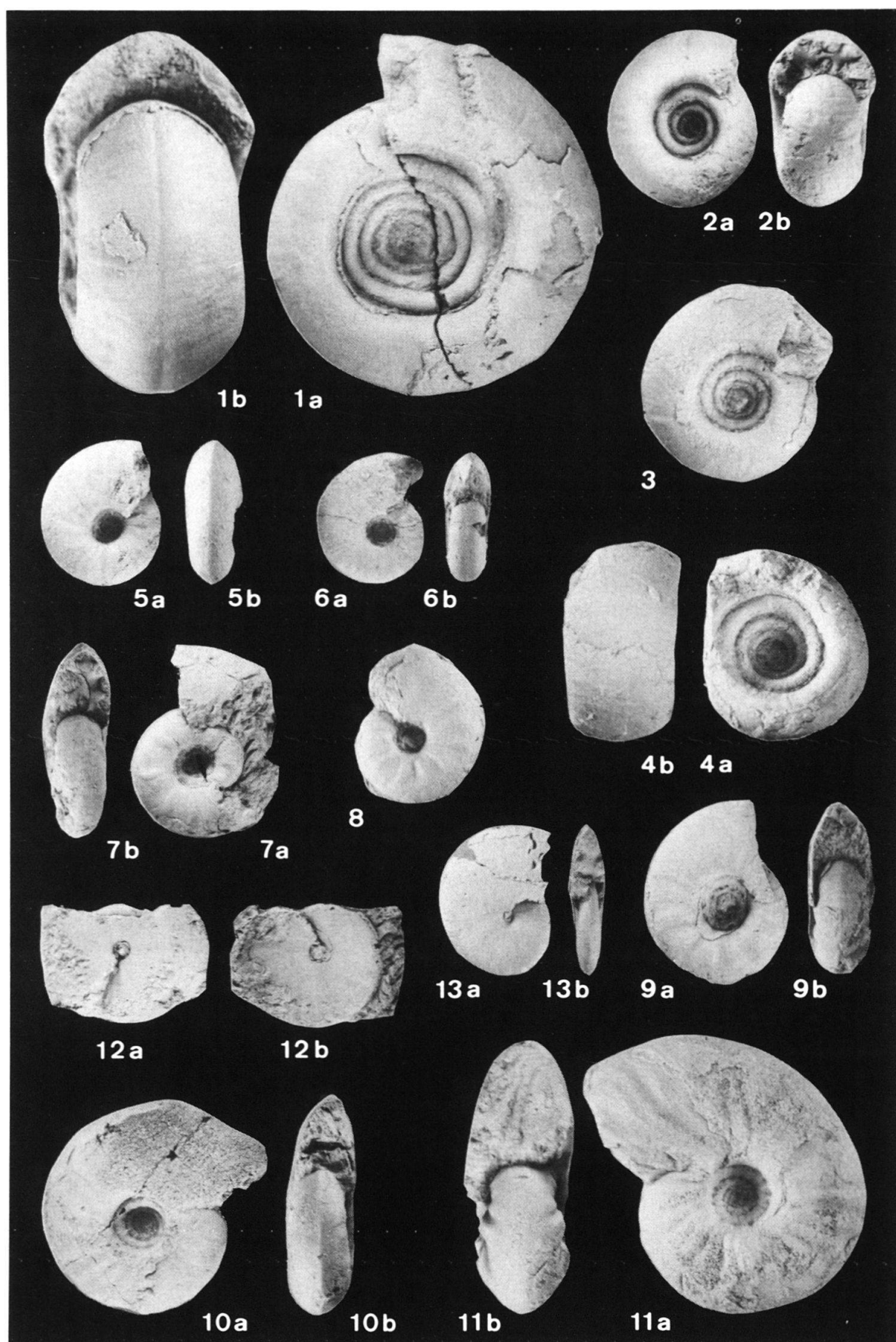


Plate 6

All figures natural size

- Fig. 1–3. *Gymnites billingsi* n. sp. (p. 982). *Mulleri* Zone. Loc. HB 56, Coyote Canyon, Northern Humboldt Range.
1: holotype, USNM 438364.
2: paratype, USNM 438365.
3: paratype, USNM 438366.
- Fig. 4–6. *Japonites welteri* n. sp. (p. 978). *Japonites welteri* beds. Northern Humboldt Range.
4: paratype, USNM 438367, loc. HB 235, Coyote Canyon.
5: plesiotype, USNM 438368, loc. HB 184, Star Creek Canyon.
6: holotype, USNM 438369, loc. HB 235, Coyote Canyon.
- Fig. 7–8. *Hemilecanites* cf. *H. paradiscus* KUMMEL (p. 961). *Japonites welteri* beds. Loc. HB 184, Star Creek Canyon, northern Humboldt Range.
7: plesiotype, USNM 438370.
8: plesiotype, USNM 438371.

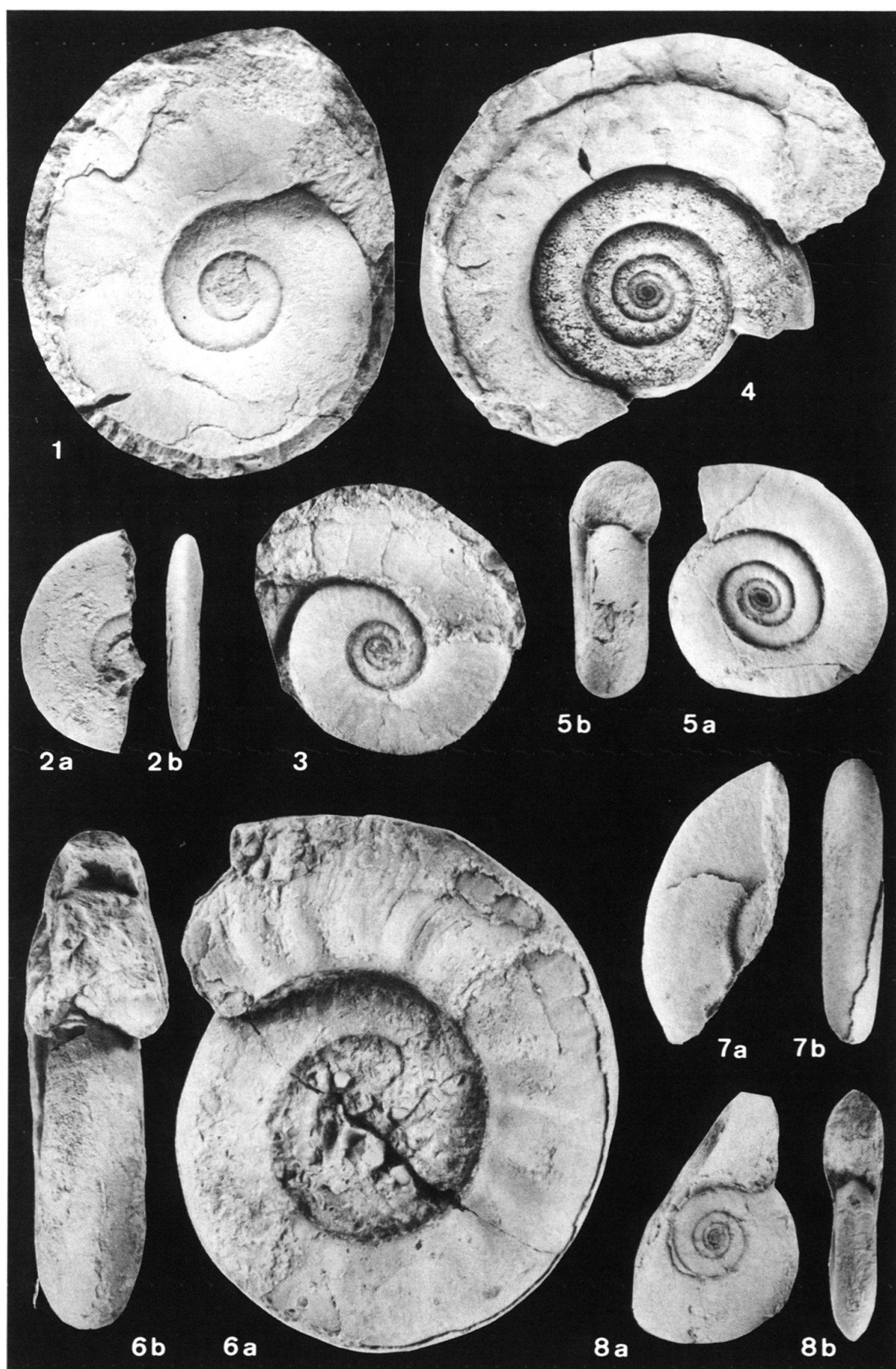
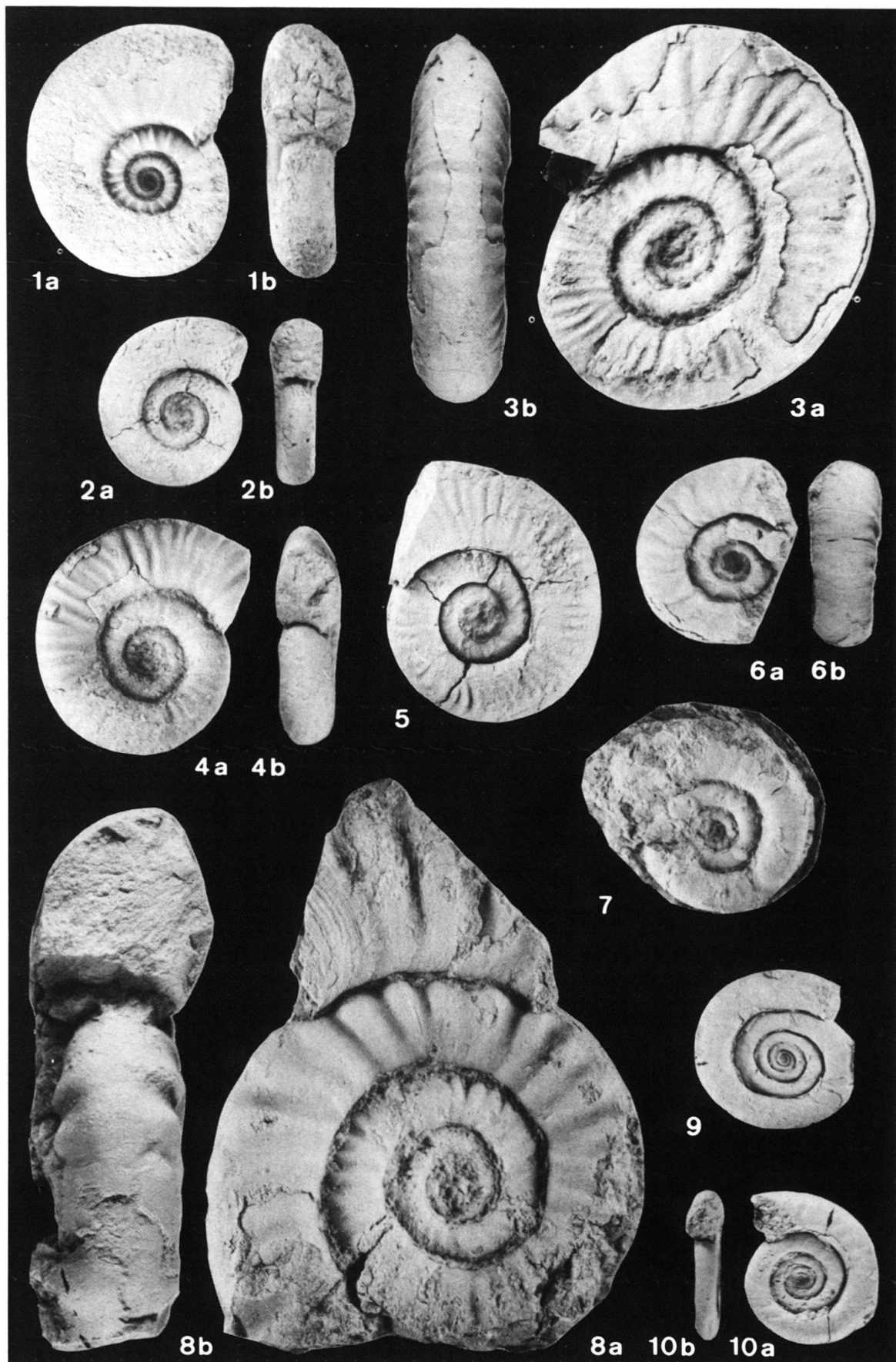
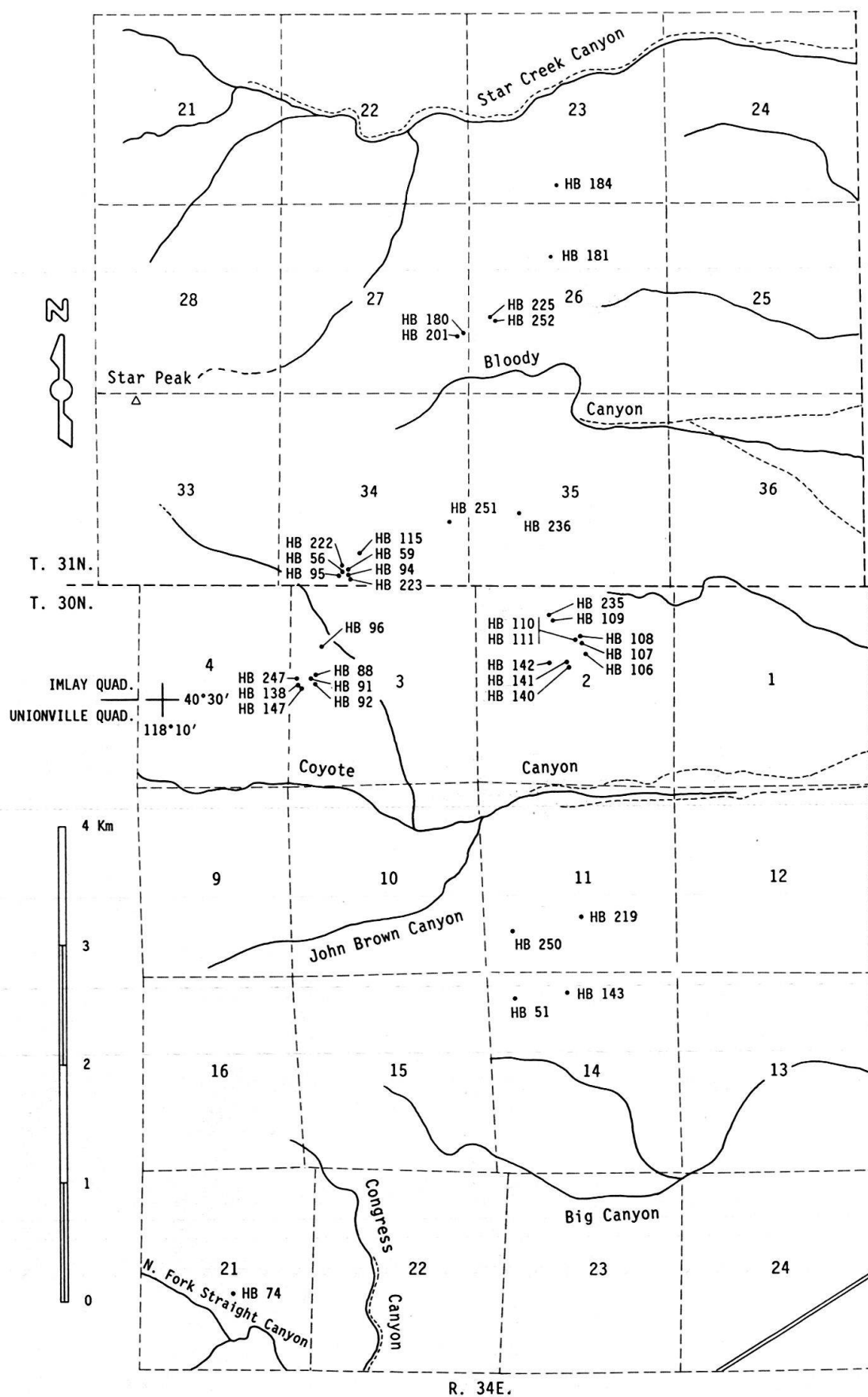


Plate 7

All figures natural size

- Fig. 1. *Ussurites detwilleri* n. sp. (p. 984). *Caurus* Zone. Loc. HB 225, Bloody Canyon, northern Humboldt Range. Holotype, USNM 438372.
- Fig. 2. *Ussurites* sp. indet. (p. 983). *Mulleri* Zone. Loc. HB 56, Coyote Canyon, northern Humboldt Range. USNM 438373.
- Fig. 3–5. *Paracrochordiceras* cf. *P. americanum* McLEARN (p. 972). *Mulleri* Zone. Coyote Canyon, northern Humboldt Range.
3: plesiotype, USNM 438374, loc. HB 95.
4: plesiotype, USNM 438375, loc. HB 56.
5: plesiotype, USNM 438376, loc. HB 95.
- Fig. 6–7. *Paracrochordiceras mclearnii* n. sp. (p. 973). *Mulleri* Zone. Coyote Canyon, northern Humboldt Range.
6: holotype, USNM 438377, loc. HB 95.
7: plesiotype, USNM 438378, loc. HB 56.
- Fig. 8. *Danubites crassicosatus* n. sp. (p. 974). *Mulleri* Zone. Coyote Canyon, northern Humboldt Range.
8: holotype, USNM 438379, loc. HB 56.
- Fig. 9–10. *Leiophyllites* sp. indet. (p. 983). *Mulleri* Zone. Loc. HB 94, Coyote Canyon, northern Humboldt Range.
9: USNM 438380.
10: USNM 438381.





Appendix: Location map of localities referred to in the text. Superpositional relationships are given in chapter 3.