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AMMONITE FAUNA, STRATIGRAPHY AND ECOLOGY OF THE BATHONIAN-CALLOVIAN (JURASSIC) TECOCOYUNCA GROUP, SOUTH MEXICO

BY

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With 20 plates, 9 figures and 2 tables in the text

Zusammenfassung

Diese Arbeit beschreibt neue Sammlungen von Mittel-Jurassischen Ammoniten, die 1984/85 von MARSHALL und SANDOVAL an der klassischen Fundstelle nahe Cualac (Coauilote) in Nordost-Guerrero gesammelt wurden, sowie taxonomische, biostratigraphische und biogeographische Revisionen von Sammlungen, die von WESTERMANN, CORONA & CARRASCO (1984) während der vorhergehenden Dekade gemacht und beschrieben wurden.

Die etwa 700 m mächtig aufgeschlossene Folge der Tecocoyunca Gruppe (Otatera und Yucunuti Formationen) ist oben wahrscheinlich durch eine Störung abgeschlossen, an der mächtige Kreidekalke überschoben sind. Die kürzlich in den Anden unterschiedenen Ammoniten-Standardzonen des Ober-Bathonium und Unter-Callovium werden auch bei Cualac unterschieden und in mehrere Faunen-Gemeinschaften unterteilt. In absteigender Folge, mit wahrscheinlichem Alter (Mediterranische Standardzonen):

(4) *Hectococeras proximum* Standardzone (Proximum Zone), mit wenigen *H.* cf. *boginense* — obere Gracilis Zone.

(3) *Neuqueniceras bodenbenderi* Standardzone (Bodenbenderi Zone); (c) *Rehmannia* gr. *rehmanni* Gemeinschaft, auch *Reineckeia* cf. *franconica* — etwa Rehmanni Subzone.
(b) *Guerrericeras inflatum* Gemeinschaft, auch mit häufig *N.* cf. *bodenbenderi*, und *Eurycephalites* cf. *rotundus* und *Parapatoceras* — obere Macrocephalus Zone.
(a) *Frickites* Gemeinschaft, mit häufig *Neuqueniceras* (*Frickites*) gr. *bodenbenderi*, *N.* (*N.*?) *gleimi*, und oben mit einigen *Eurycephalites* — etwa mittlere Macrocephalus Zone.

(2) *Eurycephalites vergarensis* Standardzone (Vergarensis Zone), mit wenigen *E.* cf. *vergarensis* und späten *Neuqueniceras* s. str. — (?) basales Callovium, untere Macrocephalus Zone.

(1) *Lilloettetia steinmanni* Standardzone (Steinmanni Zone); (a) *Lilloettia* Gemeinschaft, reich an *L. steinmanni*, *Choffatia* spp. und *Neuqueniceras* (*N.*) *plicatum* — (?) oberstes Bathonium, Discus Zone.
(a) *Epistrenoceras histricoides* Gemeinschaft, auch wenige *Probecticoceras blanazense* und *Bullatimorphites bullatum* — (untere) Retrocostatum Zone.

Ptychophylloceras ist mehr oder weniger häufig in allen Gemeinschaften, während *Oxycerites (Alcidellus)* spp., einschließlich *O. (A.) cualacensis* n. sp., durch den oberen Teil der Folge reicht.

Die biogeographischen Ähnlichkeiten dieser Ammoniten-Fauna besteht erstens mit den Mittleren und Südlichen Anden und zweitens mit dem Mediterrangebiet. Von insgesamt 39 Ammonoideen-Arten sind 22% endemisch für Süd-Mexico, 6% sind typisch für das Ost-Pazifische Reich, 33% sind nur mit der Andischen Provinz gemeinsam und 21% nur mit der Mediterranen Provinz. Andererseits gibt es anscheinend keine

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Art gemeinsam mit der Indo-West Pazifischen Provinz. Auch die meisten Ammonoideen-Gattungen und Untergattungen sind die gleichen in den Anden und Mediterrangebiet, oder sind auf Süd-Mexiko und die Anden beschränkt. Die Cualac-Fauna unterscheidet sich von Andischen Fauna in dem höheren Anteil von mediterranen und endemischen Arten.

Diese biogeographische Ausdeutung entspricht den heutigen mega-tektonischen Modellen für den Mittleren Jura von Mittelamerika. Das Mixteca Terrain von Süd-Mexiko, mit der einzig bekannten marinen Entwicklung des vor-Mittel Callovischen Doggers, lag um diese Ze innerhalb einer breiten marinen „Bucht": östlich des Guerrero Terrains, südlich des Yaqui Terrains, und westlich des (Mittel-) Anden Terra Der Pazifische Eingang zum Hispanischen Korridor (die kratonische, Proto-Central Atlantic Meeresstraße) befand sich wahrscheinlich a Nord-Anden-Terrain (heutiges West-Venezuela und Kolumbien), nicht weit entfernt vom Mixteca-Terrain. Die starken Detritus-Schüttungen an, daß Mixteca nahe an den damals kontinentalen Guerrero- und/oder Yaqui-Terrains lag. Diese biogeographische Situation änderte sich und grundlegend während des mittleren Calloviums, wenn sich die Ost-Pazifischen mit den mediterranen Faunen vereinten, i. e. das E Ost-Pazifischen Ammoniten-Reiches. Dieser Wechsel erfolgte zur gleichen Zeit und als Folge der Entstehung des wahren Zentral-Atlan Ozeans durch Driftung, i. e. dem Ende des epikontinentalen Hispanischen Korridors.

Die Bildungsgeschichte der Tecocoyunca Gruppe von Cualac wird litho- und biofaziell erklärt. Die Otatera und Yucunuti Form sind 700 m mächtig aufgeschlossen. Sie bestehen unten aus mehreren aufwärts-vergröbernden, detritischen Folgen, von denen die letzt Küsten- und küstennahe Sedimente abgeschlossen wird. Letztere formte wahrscheinlich eine Landzunge, die hinter sich eine brackische einschloß, hier durch fossilarme Tone vertreten. Darauf folgt ein 400 m dickes Paket von normal-marinen Tonen, welche eine spät-Batho Transgression anzeigen. Das Meer erreichte etwa 300 m Tiefe im Unteren Callovium (Bodenbenderi Zone); dysoxische bodennahe Verhältni sind durch bituminose Schwarztone belegt. Die aufgeschlossene Folge schließt mit Tonen und Feinsand ab, die wiederum flaches, küstenfern Meer anzeigen.

Schlüsselworte: Ammonoideen — Jura — Bathonium/Callovium — Mexico — Biofazies — Lithofazies — Biostratigraphy.

Summary

This work describes new collections of Middle Jurassic ammonoids made during 1984–5 by MARSHALL and SANDOVAL at the classic fo locality near Cualac (Coauilote) in northeastern Guerrero; and it revises collections made and described previously by WESTERMANN, CORO & CARRASCO (1984) as well as their biostratigraphy and biogeography.

The approximately 700 m thick exposed sequence of the Tecocoyunca Group (Otatera and Yucunuti Formations) is truncated at th by overthrusted Cretaceous limestones. The Bathonian-Callovian ammonite standard zones recently distinguished in the Central and Southe Andes are well developed at Cualac where they are now subdivided into ammonite associations. In descending order, with probable ages (Medi ranean standard zones):

(4) *Hecticoceras proximum* Standard Zone (Proximum Zone), based on rare *H.* cf. *boginense* — upper Gracilis Zone.

(3) *Neuqueniceras bodenbenderi* Standard Zone (Bodenbenderi Zone); (c) *Rehmannia* gr. *rehmanni* Association, also *Reineckeia franconica* — ca. Rehmanni Subzone, lower Gracilis Zone.
(b) *Guerrericeras inflatum* Association, with abundant *Guerrericeras* gen. nov., *Eurycephalites* cf. *rotundus* and *Parapatoceras* — u Macrocephalus Zone.
(a) *Frickites* Association, with abundent *R. (Frickites)* gr. *bodenbenderi, N. (N.?) gleimi* and some *Eurycephalites* above — about mid Macrocephalus Zone.

(2) *Eurycephalites vergarensis* Standard Zone (Vergarensis Zone), with rare *E.* cf. *vergarensis* and late *Neuqueniceras* s. str. — (?) basal Call vian, lower Macrocephalus Zone.

(1) *Lilloettia steinmanni* Standard Zone (Steinmanni Zone); (b) *Lilloettia* Association, with rich fauna of *L. steinmanni, Choffatia* spp., including *C. burckhardti* nom. nov., and *Neuqueniceras (N.) plicatum* — (?) latest Bathonian, Discus Zone.
(a) *Epistrenoceras histricoides* Association, also with *Prohecticoceras blanazense* and *Bullatimorphites bullatus* — (lower) Retrocostatu Zone.

Ptychophylloceras is more or less abundant throughout, and *Oxycerites (Alcidellus)* spp., including *O. (A.) cualacensis* n. sp., occur in bot upper zones.

The biogeographic affinity of this ammonite fauna is, firstly with the Andean Province of the East-Pacific Realm (or Subrealm) and, seco ly with the Mediterranean Province of the Tethyan Realm. Of 39 species identified, 22 % are endemic to South Mexico; 6 % are East-Pacific; 33 are exclusively Andean; and 21 % exclusively Mediterranean. On the other hand, there appear to be no species in common with the Indo-W Pacific Province. Even at the genus-group level, the great majority of ammonoids is shared with the Andes and Mediterranean provinces or so el with the former. The South Mexican Bathonian-Callovian ammonoid fauna differs from the Andean fauna in the higher proportion of endem and Mediterranean species.

The biogeographic conclusions are compatible with recent mega-tectonic models for Mid-Jurassic Middle America. The Mixteca Ter of South Mexico, which has the only known pre-Mid-Callovian marine Dogger in Mexico, lay at this time in a wide oceanic embayment bordere by: the terrestrial Guerrero Terrane in the west, the terrestrial Yaqui Terrane in the north, and the North Andes Terrane in the east which was crossed by a shallow seaway, i. e. the western terminus of the Hispanic Corridor. The Guerrero and/or Yaqui Terranes shed large amounts of terrigenous sediments onto Mixteca (roughly 1 m/Ka). The biogeographic situation changed rapidly and greatly in Mid-Callovian time when West-Tethyan and eastern Pacific faunas mingled freely thus terminating the East-Pacific Ammonite Realm — a consequence of the newly develop ing Central Atlantic Ocean and the concomitant eustatic rise of sealevel.

The development of litho- and biofacies throughout the exposed Tecocoyunca section is analyzed. The 700 m thick sequence begins with several shallow-marine, coarsening-upward sequences representing fluctuations of base level due to tectonics, eustatic sea level variation, and/or rates of sediment supply. These are capped by beach and near shore sediments interpreted as a barrier island, and followed by coastal shales presumably deposited in a brackish lagoon. The nearshore sediments are abruptly overlain by 400 metres open-marine shales which reflect a major, latest Bathonian transgression. Maximal water depth of approximately 300 metres was attained in the Early Callovian (Bodenbenderi Zone) and marked by bituminous black shales, reflecting anoxic or dysoxic bottom conditions. The exposed sequence terminates with interbedded siltstones and shales deposited in shallow offshore seas.

Key words: Ammonoidea — Jurassic — Bathonian/Callovian — Mexico — lithofacies — biofacies — biostratigraphy.

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Introduction

The Middle Jurassic Tecocoyunca Group crops out near Cualac in the northeastern part of the state of Guerrero Mexico (Text-fig. 1). Areal extent of the group does not exceed 100 km but the structural and topograp characteristics of the area create excellent exposures. Continuously exposed, but often structurally disturbed, clasti marine to non-marine sequences between 750 and 900 metres thick are common. Some units of the Tecocoyunc Group are highly fossiliferous and have become classic localities for ammonites which date the group as Late Bajocian to Callovian. Bajocian beds, however, are better developed in the only other known outcrop of the Tecocoyunca Group, approximately 100 km east of Cualac in neighboring Oaxaca state. The group is also of exceptional stratigraphic interest because it includes recurrent, usually gradual facies changes from terrestrial and fresh-water to normal-marine environments of deposition.

The Tecocoyunca Group near Cualac was made known by BURCKHARDT (1927) and ERBEN (1956) who concentrated their efforts on the ammonite fauna. WESTERMANN, CORONA & CARRASCO (1984) made revisions of the taxonomy, described additional fauna and improved on the biostratigraphy. ALENCASTER (1963) described the pelecypods. The stratigraphic boundaries of the Tecocoyunca Group are unconformable and may be faulted.

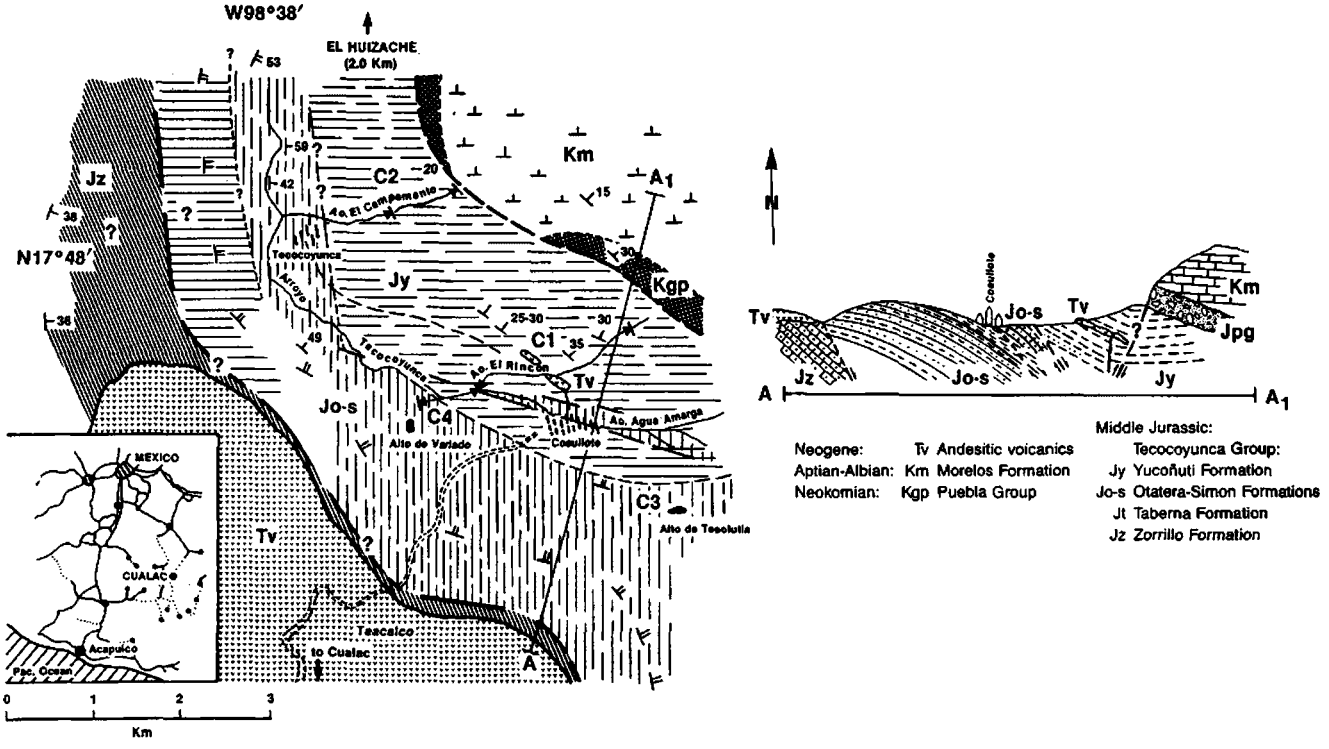
Most workers (e.g., ERBEN 1957, IMLAY 1980, ALENCASTER 1984, SALVADOR 1987) believed that the marine sediments of the Tecocoyunca Group and similar sequences were deposited in a marine embayment of the North American craton named the Oaxaca-Guerrero Embayment. CAMPA & CONEY (1983), on the other hand, proposed that all the eastern and southern parts of Mexico belonged to "suspect" and, probably, allochthonous terranes which accreted onto the craton during the Laramide Orogeny in late Cretaceous to Paleocene times.

The Tecocoyunca Group lies on the Mixteca Terrane (or block) which, according to ammonite biogeography, was located near the western terminal of the Hispanic Corridor (epicontinental Proto-Mid-Atlantic), that is, somewhere near the present Northern Andes (WESTERMANN 1984c, WESTERMANN et al. 1984, SANDOVAL & WESTERMANN 1986). Relative to the other faunas of the eastern Pacific margin, the Mixteca faunas have a large proportion of West-Tethyan ammonite genera and species, and the proportion of Andean species increases during the Bajocian-Callovian interval represented by the Tecocoyunca Group. These biogeographic results are also compatible with recent megatectonic reconstructions.

Our field work has revealed much additional paleontologic and geologic information. Besides the detailed taxonomy and biostratigraphy, this study discusses the depositional environments of the clastic marine sequences based on litho- and biofacies analysis.

Geology

The Tecocoyunca Group (Text-figs. 1, 2) is known from the northeastern part of the state of Guerrero and from northwestern Oaxaca state. This area of the Sierra Madre del Sur belongs to the Mixteca tectonostratigraphic terrane (CAMPA & CONEY 1983).



Text-fig. 1. Geologic sketch map and section of the Coauilote-Tecocoyunca area, near Cualac in NE Guerrero; measured stratigraphic sections indicated (modified from WESTERMANN et al. 1984).

The oldest rocks are schists of the Acatlan Formation which have been dated as Early Paleozoic (ORTEGA 1978). The Los Arcos Formation follows unconformably and is composed of sandstones, black shales, marls and limestones and has yielded Permian ammonoids (CORONA 1981). The Lower Jurassic Cualac Conglomerate lies unconformably (?) on the Permian sediments. This is followed by the Tecocoyunca Group of sandstones, limestones, and shales with coal-bearing horizons. Lower Cretaceous (Neocomian) sandstones of the Puebla Group lie unconformably (? faulted) on the Tecocoyunca Group. The Puebla Group forms the basal portion of an escarpment in the local topography which is the result of thrust faulting. The massive, dolomitic limestones of the Aptian-Albian Morelos Formation follow (unconformably ?), and the superjacent Tlaltepexi Chalk is Upper Cretaceous. The Oligocene-Eocene Balsas Formation of conglomerates and limestones lies on the Paleozoic Acatlan Formation indicating local uplift and erosion. Miocene-Pliocene volcanics are younger than all of the sedimentary rocks in the region, except for Quaternary talus and alluvial deposits which fill the intermittent stream and river valleys. The region near Cualac underwent considerable tectonism during the Laramide Orogeny (Late Cretaceous to Early Tertiary, CAMPA & CONEY 1983).

The Tecocoyunca Group is an 850 to 950 m thick clastic sequence of marine and continental origin. ERBEN (1956) divided the Tecocoyunca Group into five formations separated by transitional 'boundaries'. The brief descriptions of WESTERMANN et al. (1984) are here emended (descending order; *outcropping near Cualac):

Yucuñuti Formation. Approximately 450 m of calcareous shales often with calcareous iron-rich concretions and some interbedded siltstones. Ammonites are abundant at several levels. — Late Bathonian-Early Callovian.

Otatera Formation. Approximately 250 m of sandstones with well developed sedimentary structures and shales with ferruginous concretions partly rich in mollusks including ammonite and oyster horizons. — Late Bathonian.

Simon Formation. 80 to 100 m of sandstones with conglomerate, coal seams and abundant plant debris.

Taberna Formation. 50 to 60 m of siltstones and shales with ferruginous concretions. Rich invertebrate fauna. — Late Bajocian.

Zorillo Formation. 20 to 80 m of ferruginous sandstone and shales with plant debris and coal seams.

Stratigraphic Sections

The principal outcrop is a few kilometres east of Cualac, extending from the village of Coauilote to the village of Tecocoyunca (Text-fig. 1). The outcrop can be reached from Cualac by travelling northeast over 7.5 km of dirt roads. The outcrop forms part of the western limb of a large synclinorium (WESTERMANN et al. 1984). Within the Tecocoyunca Group outcrop, there are a syncline and an anticline both of which have been eroded. They trend northeast-southwest and the anticline plunges to the northeast, so that the bedding of the area generally dips northeasterly to easterly. Field-geologic work by CORONA (in WESTERMANN et al. 1984) and recent field observations indicate the presence of many faults of varying magnitude, including thrust, dip-slip and possible strike-slip faults. In many cases, displacement along faults is not apparent. Small Tertiary andesite sills intruded the sedimentary sequence in several small areas and have imparted narrow contact metamorphism especially on the shales.

The rate of sedimentation for the Otatera and Yucuñuti Formations was high: approximately 700 m of shale and some sandstone were deposited during 3 to 4 ammonite standard chronozones, i. e. 3–4 Ma (WESTERMANN et al. 1984). Based on an average compaction ratio of 5 : 1, the rate of mud and sand sedimentation could have been on the order of 1 m/Ka.

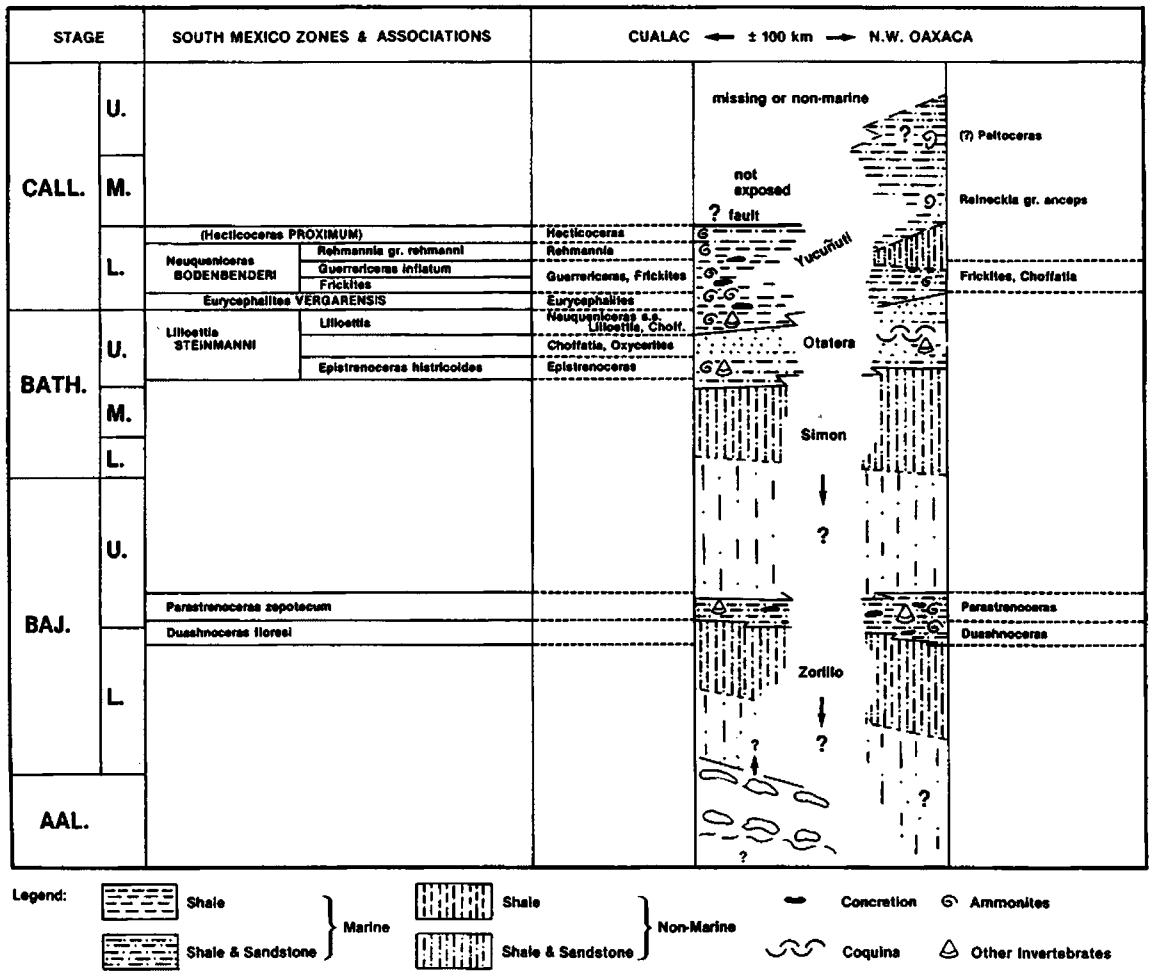
Section C1 — Arroyo del Rincon (Text-fig. 3 a): The most important section is along the creek bed of Arroyo del Rincon (river). The topography of this outcrop begins reasonably flat becoming steeper as the creek head cuts back into a ridge. The reference level for studies of WESTERMANN et al. (1984) and ERBEN (1956) was the andesite sill cut by the road from Coauilote to Tecocoyunca. The exposed Yucuñuti Formation is 340 m thick. The 180 m of shales with interbedded siltstones and calcareous, ironrich concretions above, as well as the 160 m of shales with interbedded siltstones and concretions below this reference level, contain very abundant ammonites at several levels. The lower boundary of this section is located at the junction of Arroyo del Rincon and Arroyo de Tecocoyunca.

Section C4 — Arroyo de Tecocoyunca (Text-fig. 4 b): This section is stratigraphically below and continuous with the C1 section. The upper 50–60 m belongs to the Yucuñuti Formation. The subjacent Otatera Formation is exposed

with a 90–100 m thick package of sandstones with well developed sedimentary structures and thin coal horizons. This is overlain by interbedded sandstones and shales, which bear a rich pelecypod fauna and some ammonites.

Section C2 — Arroyo del Campamento (Text-fig. 3b): Approximately 0.6 km north of Coauilote is another well exposed section of the Yucuñuti Formation in the creek bed, 210 m in thickness. The basal 170 m thick shales with interbedded siltstones and concretions pass upward into limey shales, limestone and shales with abundant sandstone interbeds. The fauna permits correlation of the lower 145 m with the upper portion of the C1 section. The upper 65 m of the C2 section are the youngest Jurassic rocks of the Coauilote area.

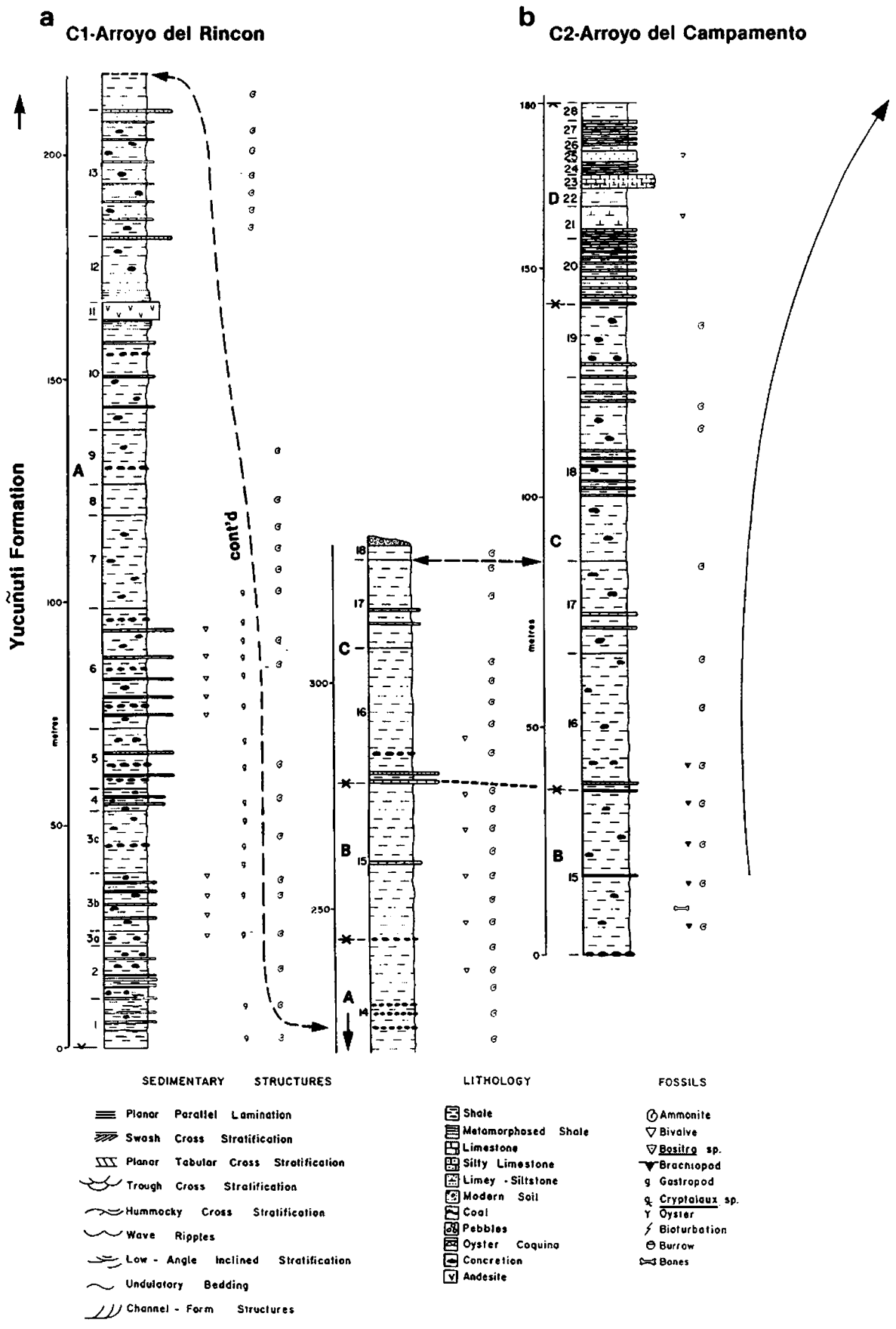
Section C3 — Alto de Teeolutla (Text-fig. 4a): Southeast of Coauilote, near the head of Agua Amarga Creek and Alto de Teeolutla, is another sequence of the Otatera Formation: interbedded buff-coloured sandstone and shale beds with a rich, shallow-infaunal pelecypod fauna. The 50 m exposure yields a small Late Bathonian ammonite fauna.

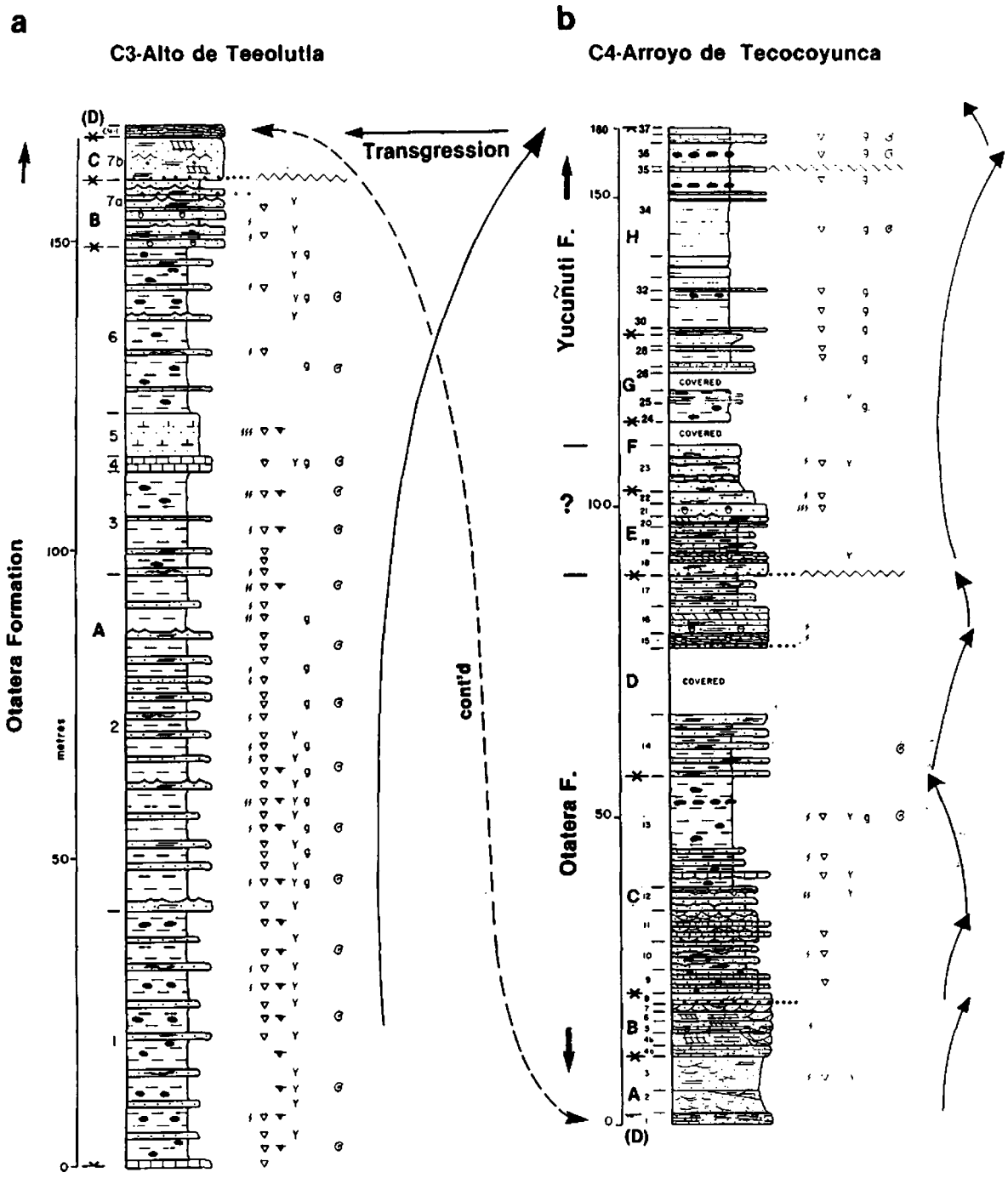


Text-fig. 2. Middle Jurassic lithostratigraphy and facies development in South Mexico, contrasting the basinal Cualac area with near-shore northwestern Oaxaca. The vertical scale is according to estimated relative time (WESTERMANN 1983). The most important ammonite occurrences are indicated. Ammonite zones and associations are the same as in Table 1.

Plate-Tectonics

Tectonostratigraphic investigations of the Mexican Cordillera are still in the early stages and even as recently as 1984 the concept of collage (or plate) tectonics was not integrated into biogeographic studies. IMLAY (1980), BUITRON (1984) and ALENCASTER (1984) failed to mention plate-tectonics in their biogeographic studies, and remained supportive of the idea proposed by ERBEN (1957) that the marine sequences in the Mexican Cordillera were deposited in marine


a
C1-Arroyo del Rincon
b
C2-Arroyo del Campamento
Yucuñuti Formation
cont'd
metres
A
B
C
D
SEDIMENTARY STRUCTURES
Planar Parallel Lamination
Swash Cross Stratification
Planar Tabular Cross Stratification
Trough Cross Stratification
Hummocky Cross Stratification
Wave Ripples
Low - Angle Inclined Stratification
Undulatory Bedding
Channel - Form Structures
LITHOLOGY
Shale
Metamorphosed Shale
Limestone
Silty Limestone
Limey - Siltstone
Modern Soil
Coal
Pebbles
Oyster Coquina
Concretion
Andesite
FOSSILS
Ammonite
Bivalve
Bositra sp.
Brachiopod
Gastropod
Cryptalaux sp.
Oyster
Bioturbation
Burrow
Bones



Text-fig. 4. Stratigraphic sections with fossil occurrences: a, C3-Alto de Teeolutla and b, C4-Arroyo del Tecocoyunca. Same symbols as on Text-fig. 3.

Text-fig. 3. Partially overlapping stratigraphic section with fossil occurrences: a, C1-Arroyo del Rincon and b, C2-Arroyo del Campamento.

embayments. CAMPA & CONEY (1983) produced the first useful plate-tectonic map of Mexico. Paleontological evidence of WESTERMANN et al. (1984) and SANDOVAL & WESTERMANN (1986) is consistent with CAMPA & CONEY's hypothesis of collage tectonics. The marine sequences and their ammonite faunas within the Mexican Cordillera could have resulted from a combination of (1) accreted terrane blocks and (2) an epicontinental marine seaway south of Mexico which connected with the Tethys Sea via the Hispanic Corridor (Proto-Atlantic).

Major mega-structural features of Mexico have been recognized for some time. The Mojave-Sonora Megashear (SILVER & ANDERSON 1974), extending from northwestern to southeastern Mexico, was active during the early stages of opening of the Gulf of Mexico (TAYLOR et al. 1984). The Terreon-Monterrey Megashear cut the eastern terranes of the Mexican Cordillera during the Jurassic. The portion of Mexico southwest of the Mojave-Sonora Megashear may have moved 1000 km southeastward relative to the North American craton, and such a translation combined with accretion and counter-clockwise rotation of terrane blocks, prevents the overlap of Mexico with South America in the reconstruction of Pangea.

According to CAMPA & CONEY (1983), the western zone of Mexico consists of the Alisitos, Guerrero, Juarez, Mixteca, Oaxaca, Xolapa and Sonabari terranes which were accreted onto North America during the Laramide Orogeny (Late Cretaceous to Early Tertiary). Tertiary volcanics were emplaced during the latter portion of this tectonism. The Mixteca Terrane contains the Tecocoyunca Group of northeast Guerrero and northwest Oaxaca, and is probably the only terrane with well documented Middle Jurassic bearing ammonite faunas. The basement consists of two tectonically juxtaposed metamorphic complexes with an intervening ultramafic body (CAMPA & CONEY 1983); the lower part is Cambrian to Ordovician (ORTEGA 1978). Paleozoic and Jurassic are overlain by Neocomian shales and limestones, followed by Aptian-Cenomanian limestones and a flysch-like Upper Cretaceous sequence.

Ammonite biogeography has provided the best evidence for the longitudinal paleopositions of terranes. The mid-Bajocian *Parastrenoceras* and *Duashnoceras* associations suggest that the Jurassic Mixteca Terrane lay close to the opening of the Hispanic Corridor (WESTERMANN 1984b, SANDOVAL & WESTERMANN 1986). The late Bathonian-early Callovian ammonite fauna places the terrane in the Andean Ammonite Province suggesting a position near the Northern Central Andes (WESTERMANN et al. 1984, TAYLOR et al. 1984). Faunal evidence indicates that during the Middle Jurassic the Mixteca Terrane moved southward, relative to North America, along the eastern Pacific margin. (For a more detailed discussion, see chapter on Biogeography and Plate-Tectonics.)

Facies Sequences and Environments

The Late Bathonian-Early Callovian Tecocoyunca Group has an overall transgressive trend. Several minor fluctuations of base level are superimposed on the large-scale transgressive sequence (MARSHALL, in prep.).

The following discussion of facies and depositional environments begins with the oldest sediments of section C3, and proceeds upward through the contiguous sections C4, C1 and C2 (Text-figs. 3, 4). The facies within these sections are also discussed in ascending order.

Section C3 — Alto de Teeolutla (Text-fig. 4a)

(A) The lower 150 metres (units 1–6) of this section contain interbedded sandstones and shales; limestone and massive limey siltstone beds are intercalated. The sandstone beds contain hummocky cross-stratification indicative of reworking of sediments below fairweather wave base at 10–20 m depth by storm waves (DOTT & BOURGEOIS 1982, WALKER 1984). Characteristics of these sandstones are those described by AIGNER (1985) for proximal storm deposits found in the transition zone of offshore areas. The sandstone interbeds become slightly thicker and more abundant in the upper 50 metres of this interval, suggesting a proximality trend (AIGNER 1985).

The Interbedded Sandstones, Siltstones and Shales lithofacies coincided with the Sandy Mud Biofacies (community). This diverse biocenosis is dominated by epifaunal and infaunal suspension-feeding bivalves. Other faunal components include suspension-feeding epifaunal brachiopods, large grazing gastropods, and nekto-benthic ammonites. Such a diverse population reflects several features of the environment. Firstly, sand and silts provided a more stable substrate than the muds, but some bivalves require sandier substrate while others prefer muddier substrates. These substrates are conducive to bivalve diversity. The second feature of a suspension-feeding community

is a relatively shallow-water environment with sufficient turbulence to carry suspended organic matter (SELLWOOD 1978). High rates of sedimentation excluded all deep-burrowing bivalves.

The muds contained a flourishing population of shallow infaunal, suspension-feeding bivalves such as *Anisocardia coxi* ALENCASTER, *Unicardium varicosum* SOWERBY, *Isocardia mixteca* ALENCASTER, *Lucina magna* ALENCASTER and *Vaugonia (Vaugonia) v-costata mexicana* ALENCASTER. Abundant feeding traces of *Chondrites*, and *Planolites* indicate that marine worms preferred the silty muds for burrowing.

The sands contained a sparser fauna of the bivalves listed above, due to episodic emplacement and high rate of deposition. Epifaunal and infaunal bivalves, as well as *Chondrites* and *Planolites* are found in the upper few centimetres of the sand beds indicating colonization subsequent to deposition. The epifaunal bivalves *Mytilus (Falcimytilus)* cf. *stricapillatus* HAYAMI and *Liostrea* sp., and rhynchonellid brachiopods are associated with the sands. Occurrence of the rhynchonellids indicates that the water was clear and the sea floor stable enough for pedicle attachment (SELLWOOD 1978). *Mytilus* was also able to byssally attach to the stable substrate. The rhynchonellids and *Mytilus* occur in monospecific clusters. Shallow-burrowing and mobile suspension-feeding bivalves such as *Vaugonia* also colonized the sands.

Salinity appears to have been normal-marine, but some regions may have experienced slightly brackish salinities. Ammonites are stenohaline. *Liostrea* is considered to be eurvhaline (SELLWOOD 1978). Localized occurrences of *Mytilus* and *Corbula* suggest minor periodic influxes of freshwater causing slightly brackish local conditions. Oysters and *Mytilus* are generally associated with relatively shallow nearshore areas in modern environments (KAUFFMAN 1969). However, the seawater above the bottom was sufficiently normal-marine to support ammonites.

Conclusion: Sedimentary and faunal characteristics of this interval are indicative of a shallow offshore marine environment below fairweather wave base.

(B) The 11 m of interbedded siltstone and sandstone (unit 7a) are interpreted as lower shoreface deposits. The sandstone beds have the characteristics of shoreface storm deposits (KUMAR & SANDS 1976, AIGNER 1985). The ratio of sandstone to siltstone beds increases upward, defining a coarsening-upward trend, whereas bioturbation decreases. This is characteristic of the transition from lower to upper shoreface (HOWARD 1972). The fauna, especially the *Skolithos* ichnofacies, is typical of shifting substrates in a moderate to high-energy littoral/infralittoral environment (FREY & PEMBERTON 1984).

(C) The 7 m of blocky sandstones (unit 7b) are erosively based and contain sedimentary structures typical of upper shoreface sandstones (HOWARD 1972, MCCUBBIN 1982, REINSON 1984, CLIFTON et al. 1971, DAVIDSON-ARNOTT & GREENWOOD 1976).

(D) The 1.9 m of sandstone (Section C4, unit 1) containing swash cross-stratification, is indicative of the wave swash zone of the foreshore, where fluctuating water depths result from storm waves and tides (HARMS et al. 1975, CLIFTON et al. 1971). The uppermost 15 cm contains high-density (125/m^2) *Monocraterion* burrows, typical of several metres water depth, rather than the swash zone (M.J. RISK pers. comm.). Small channel-form structures, interpreted as rip-current channels, have incised into the upper portion of the sands. Rip-current channels have been reported in water depths up to 5 m (INGLE 1966) but generally occur 3–4 metres below mean sea level (HUNTER et al. 1979).

Conclusion: The facies progression through Section C3 (including D = C4, unit 1) is interpreted as a progradational (regressive) coarsening-upward sequence, in a wave-dominated environment. This sequence displays a proximality trend of storm deposits, i.e., proximal storm deposits overlain by shoreface and intertidal storm deposits (AIGNER 1985). A deficiency of tidal sedimentary structures, and predominance of wave- and storm-related deposits is suggestive of a storm-dominated shoreline (CLIFTON et al. 1971, DAVIS & HAYES 1984). Preservation potential of moderate to high-energy nearshore deposits is often relatively low except in subsiding basins where sedimentation is rapid (CLIFTON et al. 1971). The rate of sedimentation must have exceeded the rate of subsidence and/or sea-level variation to allow progradation of the shoreline. The thick shoreface sequence (20 m) is a truncated coarsening-upward sequence. Truncation occurs at the erosional base of unit 7b which contains a pebble lag and is most likely the result of an increase in base level (sea level drop or tectonic uplift).

Section C4 — Arroyo de Tecocoyunca (Text-fig. 4b)

(A) Eleven metres of sandstone (units 2–3) gradationally overlie the coarsening-upward sequence of Section C3. This facies is characterized by low-angle inclined stratification consisting primarily of intersecting swaley deposits.

It closely resembles swaley cross-stratification (SCS), a storm-dominated structure formed in shallow water above fairweather wave base (LECKIE & WALKER 1982). Units 2–3 are bounded above and below by foreshore sediments suggesting that the former were deposited in the upper shoreface.

(B) Above follows a 10 m thick alternation of planar-laminated sandstones and parallel-laminated sandstones with tabular and trough cross-stratification (units 4–8). Paleocurrent orientations indicate deposition by both longshore and shore-perpendicular currents of the upper shoreface. This sequence represents a series of minor base-level fluctuations.

(C) Four metres of bioturbated fine-grained sandstone and silty limestone beds (unit 9) lie immediately superjacent. This facies is interpreted as lower shoreface deposits. Unit 10 consists of 4.6 m of amalgamated hummocky cross-stratified sandstones formed by waves of frequent storm events below fairweather wave base (DOTT & BOURGEOIS 1982, WALKER et al. 1983). The 5 m sandstones of unit 11 are coarser-grained than unit 10 and represent a deviation from the overall fining-upward sequence. These sandstones contain small-scale trough cross-stratification reminiscent of the lunate megaripple (outer rough) facies within the wave build-up zone of the lower to middle shoreface (CLIFTON et al. 1971, DAVIDSON-ARNOTT & GREENWOOD 1976). This facies is bounded above and below by finer-grained facies deposited slightly below fairweather wave base. Unit 12 consists of interbedded sandstones and siltstones, interpreted as lower shoreface deposits. Unit 13 is offshore marine shales. Units 9 to 13 mark an overall fining-upward (transgressive) sequence, 25 m in thickness. A covered interval follows.

(D) Unit 14 is an offshore sequence below fairweather base and Unit 15 again foreshore sandstones. The upper bounding surface contains abundant *Monocraterion* burrows indicative of increasing water depth. These follow abruptly (unconformably?) the parallel-laminated, tabular cross-bedded and hummocky cross-stratified sandstones of Unit 16 indicating a shallow nearshore environment. The overlying Unit 17 is again in offshore facies. This approximately 30 m thick sequence indicates fluctuating water depth.

(E) Unit 18a includes a 2 m thick packet of swash zone sediments. The base is sharp and characterized by a pebble lag. These foreshore deposits abruptly overlie offshore deposits, with upper and lower shoreface deposits absent. This may be attributed to the downcutting of the foreshore deposits and 10 to 20 m of shoreface deposits may have been eroded (ELLIOT 1975, HOWARD & REINECK 1972, 1981, CAMPBELL 1971). This sandstone appears to be part of a sandy barrier forming a lagoon behind it. The top erosion surface marks the base of a regressive (progradational) sequence of overlying lagoonal sediments.

Units 18b to 22 are a 11.4 m thick sequence of thinly interbedded sandstones, siltstones, silty shales and coal. The association of several interbedded lithofacies is typical of lagoonal sequences with several overlapping subenvironments (MCCUBBIN 1982). The erosionally based sandstones are interpreted as storm washover deposits, based on their sedimentary structures and position above beach sands and below lagoonal muds (MCCUBBIN 1982, REINSON 1984, SCHWARTZ 1975, LEATHERMAN 1981). The abundance of plant debris and coal horizons suggests proximal marsh environments. The Shifting Sands Community is found within the clean, fine- to medium-grained sandstones. Physical sedimentary structures are dominant over the biogenic structures. High-energy turbulent conditions were conducive to suspension-feeding organisms. Polychaete worms and sea anemones constructed vertical dwelling tubes assigned to *Skolithos, Monocraterion* and *Diplocraterion.* Deep vertical burrows permitted these organisms to feed on the suspended organic matter within the overlying water column, yet provided protection from moving sediments and scouring. Large storm-generated waves eroded extensive portions of the community, as recorded by the planar truncation surfaces. Protrusive and retrusive spreiten are indicative of episodic deposition and erosion of the sands. The paucity of macrofossils may be attributed to the inability of the unstable shifting sands to support populations of siphonate infaunal suspension-feeding bivalves. Some attached epifaunal suspension-feeding bivalves (oysters *Liostrea* sp.) were able to survive in monotypic "nests" or "reefs". Storm waves apparently destroyed these oyster colonies periodically and deposited the fragmented shells as coquina beds. Lack of macrofossils and bioturbation other than the *Skolithos* ichnofacies suggests that gastropods and bivalves other than oysters were absent or existed only in small numbers. The sands are very porous, however, and many shells, especially those composed of aragonite, may have been dissolved. This would explain the preponderance of oyster shells which consist of low-magnesium calcite.

Conclusion: The paleoenvironment was intertidal to subtidal. Fairweather processes were very active and they retained organic matter in suspension within the water column. Suspension-feeding marine

worms and sea anemones lived in vertical dwelling burrows, while macrofossils were rare.

(F) Marsh environments also supplied abundant plant debris to the overlying, 7 m thick bioturbated siltstones of unit 23. The shallow infaunal bivalve *Anisocardia* is profuse within the siltstones. Considering also the sequential relationships with other facies, this unit is interpreted as a mixed tidal flat.

(G) Units 24 to 29 consist of 38 m of thinly bedded, slightly bioturbated dark-grey shales, interpreted as restricted marine (lagoonal) in origin. Thin interbeds consist of sandstone, siltstone, and limestone. These beds typically have erosive and undulatory bases which may be the result of erosion and/or loading, as the sediments were episodically emplaced by storms onto thixotropic muds of the lagoon. This lithofacies is also very rich in disseminated carbonaceous plant material and coal horizons suggestive of proximal marsh environments.

The fauna of the Restricted Mud Community consists mainly of numerous bivalves *Anisocardia coxi* ALENCASTER and tiny cerithiacean gastropods *Cryptalaux* sp. The low diversity-high abundance nature of this association is indicative of high environmental stress and *Cryptalaux* can tolerate lowering of salinity. This suggests brackish conditions and fluctuating salinities (J. SZABO pers. comm.). Bioturbation is significant within this community and the shallow-infaunal suspension-feeding bivalve *Anisocardia*, a sluggish burrower, would have accounted for part of it (MCKERROW 1978). *Cryptalaux*, a detritus feeder, probably grazed and burrowed at or near the sediment surface. The rate of sedimentation must usually have been low to allow bioturbation to keep pace, whereas horizons of poorly bioturbated fissile shale indicate periods during which sedimentation rates exceeded those of bioturbation. An abundant food supply may be inferred by the high population densities and the quiet, sheltered environment, with freshwater influxes acting as an additional source of nutrients. Large volumes of plant debris provided a significant refractory carbon supply. Although *Anisocardia* and *Cryptalaux* were unable to utilize this material directly, they most likely exploited it after partial decomposition by bacteria. The bacteria themselves would also have been an important food source, especially for *Anisocardia*, and Cerithiacean gastropods are thought to have grazed on algae and bacteria (J. SZABO pers. comm.).

In conclusion this interval is interpreted as restricted marine (i.e., lagoon) in origin; deposited in a muddy environment which was sheltered from open-marine salinities. Sheltering was presumably due to a physical barrier (Unit 18a) which also excluded wave energies, thus allowing mud and plant debris to accumulate. Coarser-grained sediments were carried episodically into the restricted water body during periods of elevated wave energy (Units 18b to 22). Fluctuating brackish salinities were the result of freshwater influxes from proximal land areas.

The barrier/lagoonal package (Units 5 to 7) is a fining-upward progradational (regressive) sequence: nearshore, beach, washovers, marsh/tidal flat, and lagoon.

(H) The top of the progradational sequence (lagoonal shales) is abruptly overlain by open-marine offshore shales of Units 30 to 33. These are interpreted as having been deposited below fairweather wave-base. This progression of lagoonal to offshore shales represents a significant and rapid transgressive event. Its origin appears to be a major eustatic sea-level rise but subsidence is also implicated. The mechanism was either landward barrier migration (shoreface retreat) (SANDERS & KUMAR 1975) when eustatic sea-level rise and/or subsidence rates are low relative to the rate of shoreface erosion; or "in-place drowning" (RAMPINO & SANDERS 1980) which involves a rapid rate of transgression.

Sections C1-Arroyo del Rincon and C2-Arroyo del Campamento (Text-figs. 3a, b)

(A) The lower packet of offshore shales, Units 1 to 14 of both sections, is approximately 240 m thick. It contains thin (5–60 cm), sharp-based interbeds of sandstone and siltstone, and is interpreted as distal deposits intercalcated with shelf muds (AIGNER 1985).

The fauna of the shales (Units 7 to 18), the Open-Marine Basinal Community, is dominated by pelagic organisms, especially nekto-benthic ammonites. The small planktonic bivalve *Bositra* sp. also occurs. Benthic faunal components include sparse *Anisocardia coxi* ALENCASTER, a slow and shallow burrowing suspension-feeding bivalve. At the base of the section, this community still contains the gastropod *Cryptalaux* sp. and abundant disseminated plant debris or thin coal seams, but few ammonites (Unit C1–1). This indicates periodic influxes of freshwater, creating localized brackish conditions, and the gradual development of the Open-marine Basinal Com-

munity from the underlying Restricted Mud Community. From Unit 7 upward, the salinity must have been normal-marine to support large populations of stenohaline ammonites within the water column.

Summary: The paleoenvironment developed from shallow to intermediate water depths. Most of the shales are the result of mud accumulation in a quiet, normal-marine environment below fairweather wave base (? 50–150 m). Mud accumulation was interrupted episodically by density currents containing coarser sediments. The basal 50 m of the sequence accumulated in shallower water of a more proximal environment which was affected by freshwater influxes (?20–50 m).

(B) The 36 m of bituminous black shales (Unit 15) probably represent mud deposition in the deepest part of the basin (?200–300 m), with anoxic bottom conditions. The fossil assemblage of the Black Mud Community is composed of planktonic and nektonic macrofossils, e.g., stenohaline ammonites and abundant "Posidonae" bivalves, especially *Bositra* sp., carbonized plant fragments and even marine vertebrates (the crocodile *Steneosaurus* sp.). *Bositra* is an anomaly in what otherwise appears to be a pelagic fossil assemblage. JEFFERIES & MINTON (1965) suggest that *Bositra* was planktonic, based mainly on its facies association with bituminous black shales lacking in benthos, i.e., anoxic or dysoxic bottom conditions. Global distribution of one or two species is compatible with apparent nektonic ability indicated by anterior and posterior gapes, thin shell, and a hinge-line facilitating a wide gape. There is no sign of attachment at any growth stage. KAUFFMAN (1981) refutes this interpretation based on studies of the German Posidonienschiefer, but most of his arguments seem to apply only to that particular lithofacies. The characteristics of the Black Mud Community at Coauilote remain supportive of a nektonic habitat. A pseudoplanktonic mode of life is another possibility with *Bositra*, attached to flotsam. This seems unlikely however, due to the lack of other pseudoplanktonic organisms and flotsam in the typical *Bositra* facies (JEFFERIES & MINTON 1965).

Conclusion: The fine mud accumulated on an oxygen-deficient sea floor had a high preservation potential due to the lack of oxygen and benthos. This unit formed in the deepest portions of the sedimentary basin (?200–300 m). Rich, normal-marine nekton and plankton were present in the main body of seawater, but limited water circulation allowed stagnant anoxic conditions to develop on the sea floor at or near the sediment-water interface.

(C) The approximately 100 m thick shelf shales (Units 16–19) resemble the lower thick shale packet (A) with intermediate water depth.

(E) They in turn are overlain by a 40 m thick succession of interbedded limestone and shale, mud and sandstone (Units 20–29), all of which appear to represent a shallower and more proximal shelf environment.

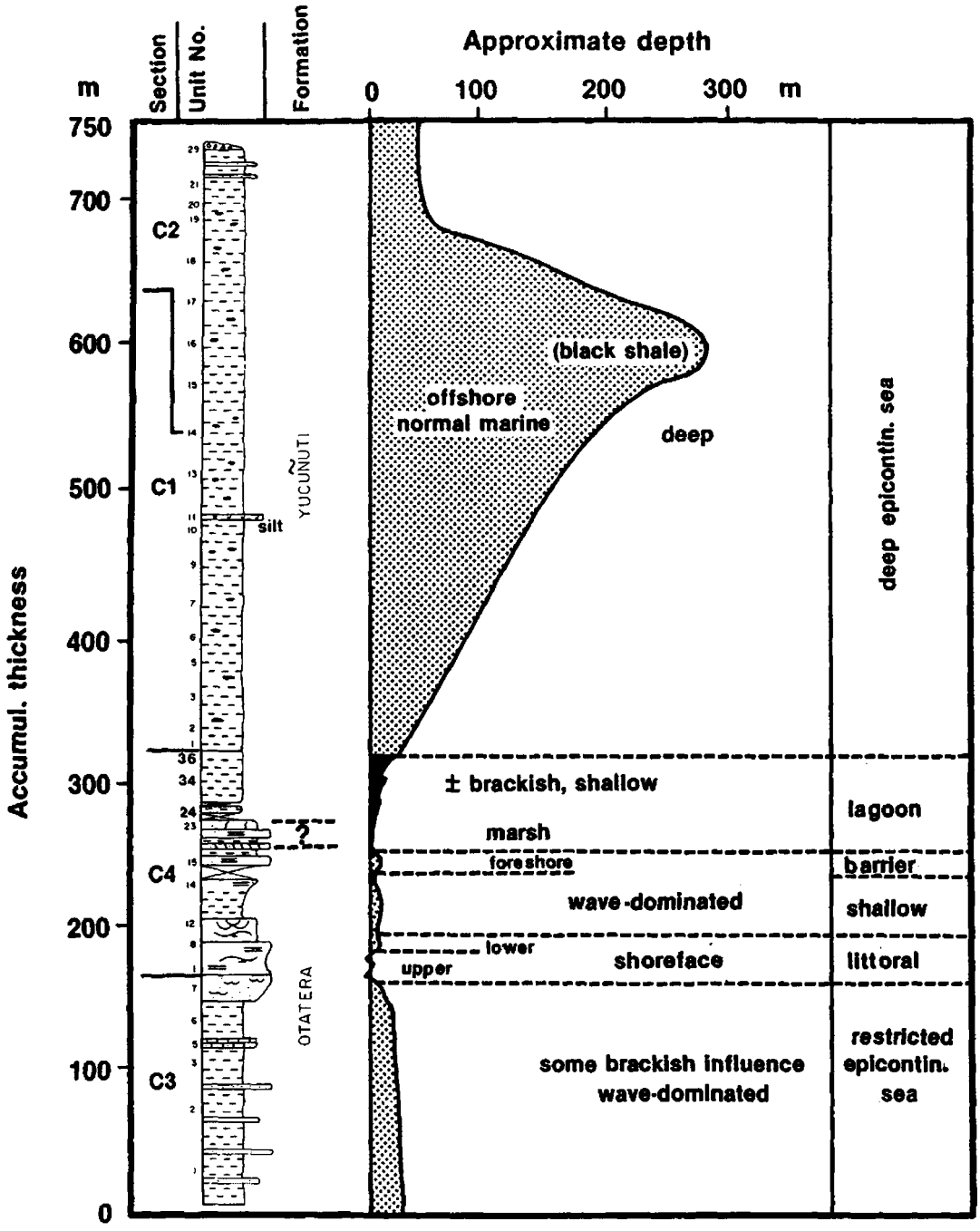
Summary (Text-fig. 5)

The basal 150 m of the Tecocoyunca Group outcropping near Coauilote represent a coarsening-upward transition of shallow offshore shales to shoreface and foreshore facies at a wave-dominated coast. This is overlain by 100 m of sediments containing four smaller coarsening-upward sequences of nearshore and beach sandstones. Each one of these represents fluctuations in base level due to tectonics, eustatic sea-level variations, and/or sediment supply. The fourth of these sequences is capped by beach and nearshore sediments interpreted as barrier island sands capped by washover and backbarrier sands. Brackish lagoon shales follow and terminate the barrier sequence.

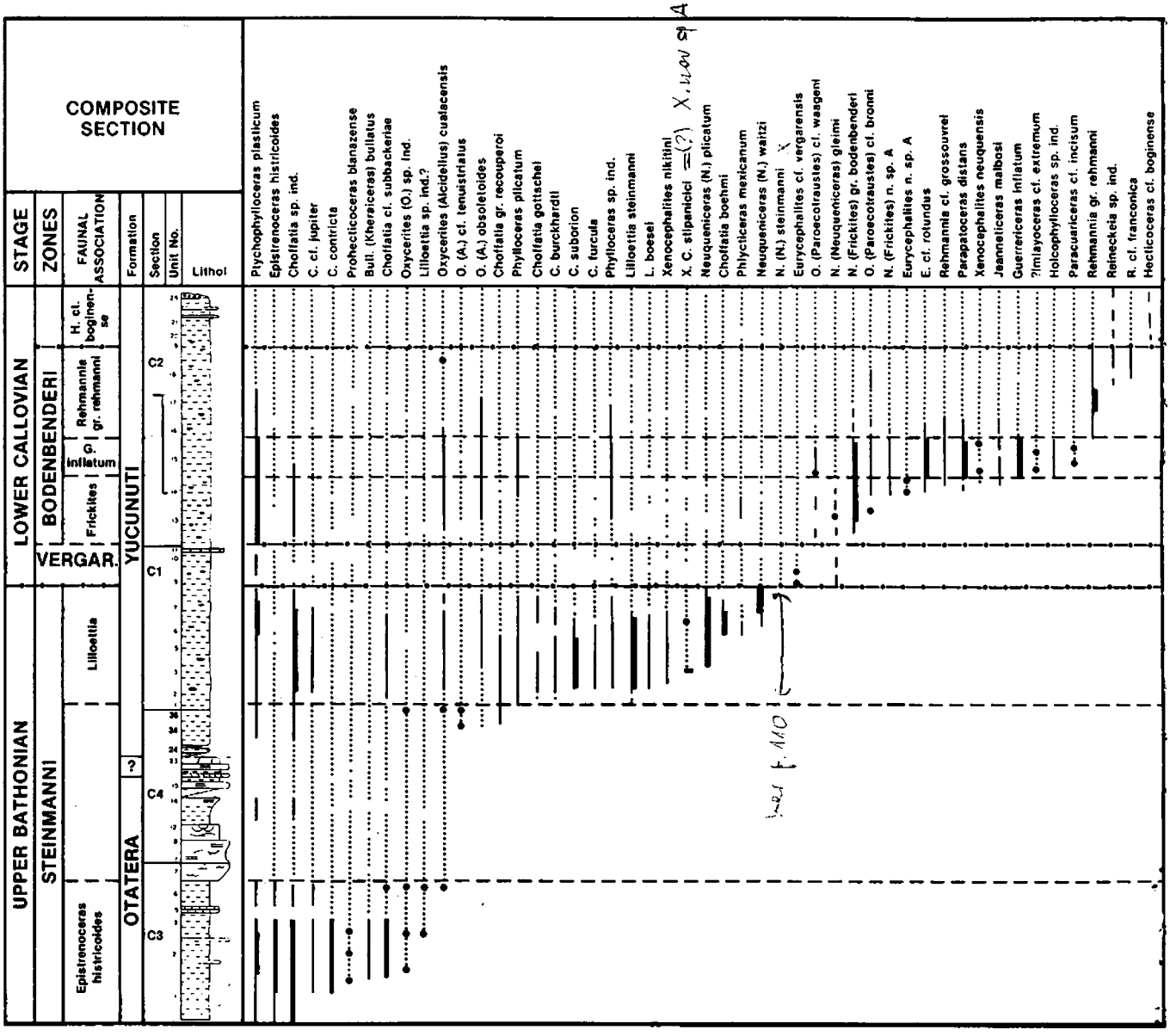
These coastal sediments are abruptly overlain by 400 m thick open-marine shales which represent a major transgression initiated during the latest Bathonian. As the transgression continued into the Early Callovian, deep portions of the basin developed anoxic bottom conditions represented by 36 m of bituminous black shales. These are overlain by 100 m of open-marine shales. The entire outcrop sequence terminates with approximately 50 m of interbedded shales and siltstones deposited in shallower offshore areas.

The basin into which Tecocoyunca Group sediments were deposited, appears to have undergone subsidence at a considerable rate. The rate of sedimentation in this basin was immense (ca. 1 m/Ka for the Otatera and Yucuñuti Formations), i.e., approximately 700 m of sediments during 3 to 4 ammonite standard chronozones.

The Tecocoyunca Group is characterized by abundant plant debris, especially in the nearshore sediments. This suggests that the paleoclimate of the depositional area was humid or subhumid (DICKINSON et al. 1972, ELLIOT 1978).



Text-fig. 5. Composite stratigraphic section of Otatera and Yucuñuti formations at Coauilote near Cualac, with bathymetry and depositional environments indicated.



Text-fig. 6. Vertical ranges of ammonoid species in the composite Coauilote section near Cualac, with Andean Province standard zones and local ammonite associations.

Biostratigraphy and Chronostratigraphy

An abundant and relatively well preserved fauna has been collected from the sections C1-Arroyo del Rincon, C2-Arroyo del Campamento, C3-Alto de Teeolutla and C4-Alto del Variado-Arroyo de Tecocoyunca, all near Coauilote. We are therefore able to establish a detailed zonal succession for the Upper Bathonian and Lower Callovian of the Cualac area which can be correlated with the Andean and Submediterranean Standard Zones (Table 1).

Table 1. Correlation chart for the ammonite standard zones of the Andean Province aaplicable also at Cualac, Mexico, and of the Cualac ammonite associations.

STAGE		SUBMEDITERRAN. STANDARD ZONE	ANDEAN STANDARD ZONE (Riccardi et al. 1989)	SOUTH MEXICO: Cualac area (here)	
CALLOVIAN	M.	JASON	[Reineckeia s. str.]	not exposed	
	LOWER	GRACILIS	Hecticoceras PROXIMUM	PROXIMUM Std. Zone [Hecticoceras cf. boginese]	
		"MACRO-CEPHALUS"	Neuqueniceras BODENBENDERI	BODENBENDERI Std. Zone	Rehmannia gr. rehmanni Assoc.
					Guerreric. inflatum Assoc.
					Frickites Assoc.
			Eurycephalites VERGARENSIS	VERGARENSIS Standard Zone	
BATHONIAN	UPPER	DISCUS	St. gerthi Sz./Ch. jupiter Hor.	STEINMANNI Std. Zone	Lilloettia Assoc.
		RETROCOSTATUM	Lilloettia STEINMANNI		[Choffatia & Oxycerites cf. tenuistriatus]
			[Prohectic. blanazense]		Epistren. histricoides Assoc.
					non-marine

1. Steinmanni Standard Zone — RICCARDI, WESTERMANN & ELMI 1989; for *Lilloettia steinmanni* Zone of RICCARDI et al. 1988

This zone has been documented in northern Chile and the Neuquen Basin of west-central Argentina. The base is defined by the first occurrence of the index species *Lilloettia steinmanni* (SPATH) in the Chacay-Melehue section, and the top by the base of the Vergarensis Standard Zone.

In the cemetary section at Caracoles in northern Chile, the lower part of this zone has yielded *Prohecticoceras blanazense* ELMI, index species for the Submediterranean Blanazense Standard Subzone of the lower Retrocostatum Standard Zone (RICCARDI et al. 1989, WESTERMANN & CALLOMON 1988). The Chilean section contains the wide-spread *Choffatia jupiter* Horizon at the top.

(a) *Epistrenoceras histricoides* Association (here): This is the oldest ammonite assemblage in the Middle Jurassic of the Cualac area and occurs in the Otatera Formation. In the sections of Alto de Teeolutla and Alto del Variado, the association is defined by the vertical distribution of the index species. *Epistrenoceras histricoides* ROLLIER is abundant, *Choffatia contricta* (BURCKHARDT) and *C.* gr. *subbackeriae* (D'ORBIGNY) are frequent, and *Kheraiceras bullatum* (D'ORBIGNY) and *Ptychophylloceras plasticum* (BURCKHARDT) are moderately abundant. Ancillaries are *Oxycerites (O.)* sp. ind., *O. (Alcidellus) cualacensis* n. sp., *Prohecticoceras blanazense* ELMI and *Lilloettia* sp. Abundant bivalves (Mytilidae, Pteroidae, Trigoniidae, Lucinidae, Corbulidae, Mactronyidae) and brachiopods (Rynchonellidae) are also associated.

An *E. histricoides* subzone/zone has been identified in the Upper Bathonian of Europe (ELMI 1967, ELMI et al. 1971) and Madagascar (COLLIGNON 1958, 1964 a, b), and this assemblage is possibly present also in the Cordillera Domeyko of northern Chile (GRÖSCHKE & HILLEBRANT 1985, p. 153).

This association is coeval, at least in part, to the Submediterranean Retrocostatum Standard Zone and to the N.W. European Orbis Standard Zone (olim Aspidoides) (cf. WESTERMANN & CALLOMON 1988). The association in Mexico of *Epitrenoceras histricoides* with *Bullatimorphites bullatus* and *Prohecticoceras blanazense* indicate that *E. histricoides* has a larger vertical range here than in Europe, where the entire genus *Epistrenoceras* is known only from the upper Retrocostatum Zone (WESTERMANN & CALLOMON 1988, p. 14).

(b) Beds with *Choffatia* and *Oxycerites (Alcidellus)* gr. *tenuistriatus*: Overlaying the *histricoides* Association are approximately 160 m thick siltstones, sandstones and some intercalations of shales (Otatera Formation) which have yielded only a very few *Ptychophylloceras plasticum, Oxycerites (Alcidellus)* cf. *tenuistriatus* (DE GROSSOUVRE) and *Choffatia* gr. *recouperoi* (GEMMELLARO). *O. tenuistriatus* is a typical member of the N.W. European Orbis Zone (WESTERMANN 1958).

(c) *Lilloettia Association* (here): At Coauilote, this rich and diverse ammonite assemblage is present in Units 1 to 6 of section C1-Arroyo del Rincon. Perisphinctidae and Eurycephalitinae are dominant. *Choffatia* is very frequent throughout these beds: *C. suborion* (BURCKHARDT), *C. burckhardti* n. n., *C. boehmi* (STEINMANN), *C. gottschei* (STEINMANN), *C.* cf. *jupiter* (STEINMANN), *C. furcula* (NEUMAYR), *C.* gr. *subbackeriae* (D'ORBIGNY) and *C.* cf. *recouperoi* (GEMMELLARO). *Lilloettia steinmanni* (SPATH) is abundant, *L. boesei* (BURCKHARDT) and *Xenocephalites nikitini* (BURCKHARDT) are frequent, and *X. stipanicici* RICCARDI et al. is rare. The Reineckeiidae occur in this zone with frequent *N. (Neuqeniceras) plicatum* (BURCKHARDT), *N. (N.) waitzi* (BURCKHARDT) and a few *N. (N.) steinmanni* (SPATH). The scarce Oppeliidae are represented by *Oxycerites (Alcidellus) obsoletoides* RIC. et al. and *O. (A.) cualacensis* n. sp. The Phlycticeratinae, with scarce *Phlycticeras mexicanum* n. sp., are recorded for the first time. Some *Phylloceras* and *Ptychophylloceras*, as well as abundant Bivalvia and Gastropoda also occur in this zone.

The Mediterranean *Choffatia* species recorded here (*C.* cf. *recouperoi, C. furcula* and *C.* "gr." *subbackeriae*) occur in Europe in both the Upper Bathonian and Lower Callovian (MANGOLD 1970, SANDOVAL 1983, COX 1988). *Phlycticeras* was previously known from the Mediterranean Lower Callovian only.

2. Vergarensis Standard Zone — RICCARDI, WESTERMANN & ELMI 1989; for *Eurycephalites vergarensis* Zone of RICCARDI et al. 1988, 1989; elevated from subzone of RICCARDI (1984).

The base of this zone has been defined at Chacai-Melehue (Argentina) near the first occurrence of the index *Eurycephalites vergarensis* (BURCKHARDT). The top of the zone is defined by the base of the Rotundus Standard Zone. The absence of typical Mediterranean fauna in this assemblage prevents good correlation, but earliest Callovian is probable.

At Coauilote this zone is indicated by rare *Eurycephalites* cf. *vergarensis*, some *Choffatia* sp. indet., possibly some *Neuqueniceras (N.) gleimi, Ptychopylloceras* and *Oxycerites*. The bivalve *Bositra* and the minute gastropod *Cryptalaux* are abundant at certain levels.

At Coauilote, this zone ranges from Units 9 to 11 of section C1–Arroyo del Rincon.

3. Bodenbenderi Standard Zone — RICCARDI, WESTERMANN & ELMI 1989; for *Neuqueniceras (Frickites) bodenbenderi* Zone of RICCARDI et al. 1988.

This zone is present at Chacay-Melehue (stratotype) and Paso del Espinacito in Argentina, and at Caracoles in Chile (RICCARDI et al. 1989).

At Coauilote this zone is identified by the vertical range of *Neuqueniceras (Frickites)* and *Rehmannia*. The ammonite fauna is abundant and varied, with different Reineckeiidae, Eurycephalitinae, Oppeliidae and Phylloceratidae. The Perisphinctidae are not characteristic and very scarce. Three faunal assemblages may be differentiated: a lower one where *N. (Frickites)* is dominant and *Guerrericeras inflatum* (WESTERMANN) is virtually absent; a middle one where *G. inflatum* is characteristic; and an upper assemblage in which *N. (Frickites)* is replaced by *Rehmannia* and *Reineckia*.

This zone also outcrops near Santa Maria Yucuñuti (ERBEN 1956 and personal observations).

(a) ***Frickites*** Association (here): The dominant ammonite fauna consist of the subgenus *Frickites*, especially *Neuqueniceras (F.)* gr. *bodenbenderi* (TORNQUIST) & *antipodum* (GOTTSCHE) and *N. (F.)* sp. n. A. *N. (Neuqueniceras?) gleimi* (STEINMANN) is rare. Eurycephalitinae have become abundant, with *Eurycephalites* cf. *rotundus* (TORNQUIST). *E.* n. sp. A, *Xenocephalites* gr. *nikitini* (BURCKHARDT), *X. neuquensis* (STEHN) and *X.* n. sp. A. Oppeliidae present are *Oxycerites (Alcidellus) cualacensis* n. sp., *O. (A.) obsoletoides* RIC. et al., *O. (Paroecotraustes)* cf. *bronni* (ZEISS) sensu ELMI, *O. (P.)* gr. *waageni* (STEPHANOV), and the last *Phlycticeras mexicanum* n. sp. The first record of *Rehmannia* cf. *grossouvrei* (PETITCLERC) is from the upper part of this assemblage. Some Phylloceratina (*Holcophylloceras, Ptychophylloceras* and *Phylloceras*), the gastropod *Cryptalaux* and the bivalve *Bositra* are also present.

This assemblage occurs in the Units 11 to 14 of sections C1 and C2. The age of this assemblage is indicated by *Rehmannia* cf. *grossouvrei* and *Oxycerites bronni* which in Europe occur in the upper Macrocephalus and lower Gracilis Zones (ELMI 1967, CARIOU 1980, 1984).

(b) ***Guerrericeras inflatum*** Association (here): This fauna is characterized by the frequent occurrence of *Guerrericeras inflatum* (WESTERMANN) which occurs at all levels. Some species of *Neuqueniceras (Frickites)* range into

this association, but *N. (Neuqueniceras)* and *Phlycticeras* are now virtually absent. Eurycephalitinae, especially *Eurycephalites* and *Xenocephalites*, are also abundant; two specimens of ? *Imlayoceras* cf. *extremum* (TORNQUIST) are recorded. *Parapatoceras distans* (BAUGIER & SAUZE), *Paracuariceras* cf. *incisum* SCHINDEWOLF and *Jeanneticeras* cf. *malbosi* (ELMI) have been found only in this association. Oppeliidae, e. g. *Oxycerites (Alcidellus) obsoletoides* RIC. et al., *O. (A.) cualacensis* n. sp. and *O. (Paroecotraustes)* sp., and also *Rehmannia* cf. *grossouvrei* (PETITCLERC) range up from below. Phylloceratina, bivalves and gastropods occur throughout.

This association occurs in Units 15 and 16 of section C1 and Units 15–17 of section C2. The Mediterranean *Jeanneticeras* cf. *malbosi* and *Rehmannia* cf. *grossouvrei* indicate the Gracilis Zone (ELMI 1967).

(c) ***Rehmannia gr. rehmanni*** Association (here) (or Rehmanni Standard Subzone): This association contains *Rehmannia* gr. *rehmanni* (OPPEL), *R.* sp. ind. and *Reineckeia* cf. *franconica* (OPPEL), together with scarce *Oxycerites (Alcidellus), O. (Paroecotraustes) bronni* and Phylloceratina. There is a subcontinuous clade development from *Neuqueniceras (Frickites)* via *Rehmannia* to *Reineckeia* (WESTERMANN & RICCARDI 1988).

This association is represented in the uppermost part of the Yucuñuti Formation, Units 17–18 of section C1 and Units 18–20 of section C2.

In Europe the Rehmanni Standard Subzone was placed formerly in the Upper Macrocephalus Zone (CARIOU 1980), but recently in the Lower Calloviense Zone (e. g. CALLOMON & WESTERMANN 1988).

4. We also point to the presence of a single *Hecticoceras* cf. *boginense* (PETITCLERC) (WESTERMANN et al. 1984, p. 105, pl. 3, fig. 11) at or near the unfossiliferous top of section C2. This level can be correlated with the Andean Proximum (Standard) Zone of RICCARDI et al. (1989) and with the upper Gracilis Zone of the Mediterranean Standard.

Biogeography and Plate-tectonics (by WESTERMANN)

Biogeography

Previous discussions of the world-wide affinity of Bathonian-Callovian ammonite associations from the Cualac area, southern Mexico, were based on less complete collections than are now available to us (WESTERMANN 1981, 1984b, c, TAYLOR et al. 1984, WESTERMANN et al. 1984). Yet our new collections and the systematic revision of all material have only confirmed the original conclusions: The biogeographic affinity of ammonoid faunas of the Otatera and Yucuñuti Formations is, firstly, with the Andean Province of the short-lived East Pacific Realm (or Subrealm) and, secondly, with the Mediterranean Province (West-Tethys). The Mixteca Terrane/Block which comprises these faunas was therefore at this time located in proximity to both, the northwestern corner of South America and the Pacific entrance of the Hispanic Corridor (proto-Central Atlantic).

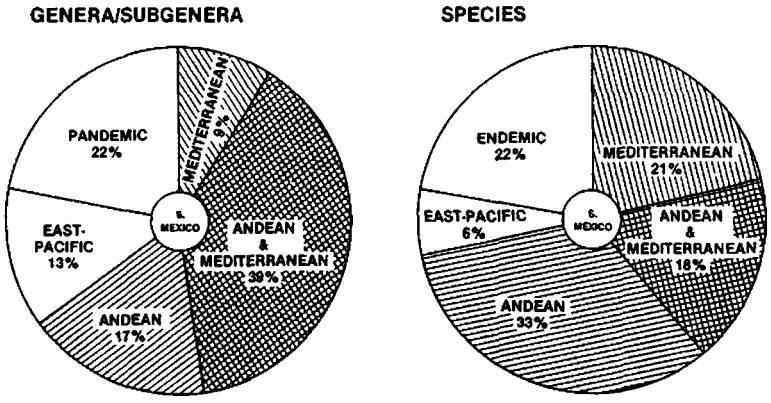
The occurrence of Cualac ammonoid genera, subgenera and species in other bioprovinces (Table 2) and the relative affinities calculated from thes data (Text-fig. 7) are illucidated by the following comments.

The "leiostracan" genera *Phylloceras, Ptychophylloceras* and *Holcophylloceras* have pandemic distributions but, in the Bathonian-Callovian, are more abundant in the Mediterranean than along the eastern Pacific margin. As recently summarized (WESTERMANN 1989), all these phylloceratids occupied marginal oceanic habitats and *Holcophylloceras* lived less deep than the other named genera. The deep-water species *Ptychophylloceras plasticum* (HEWITT & WESTERMANN 1987) is by far the most abundant phylloceratid in South Mexico and occurs throughout most of the Coauilote section, indicating close proxity to the open ocean. The species is also strictly endemic to South Mexico, suggesting some oceanic barrier.

The Oppeliidae *Oxycerites* s. str., *O. (Alcidellus)* and *O. (Paroecotraustes)*, as well as the Hecticoceratinae occur also in the Mediterranean and Andean Provinces; with the same species in the Andes, but partly different species in Eurafrica. The genus *Phlycticeras* is known also from the Mediterranean and Andean Provinces, *P. mexicanum* is endemic to Mexico (and ? N. Chile). *Guerrericeras* n. gen. has recently been found also in northern Chile, but in slightly younger beds (GRÖSCHKE pers. commun. 1988).

The typically East-Pacific Eurycephalitinae are well represented at Cualac; they have closer affinities to the Andean than to the North Cordilleran (Athabascan Province) fauna; and several species are possibly endemic.

Epistrenoceras is more abundant and probably slightly older in South Mexico than in Europe and perhaps has its origin in the East-Pacific Realm. Other occurrences are in the Andes of northern Chile, Mediterranean Europe and Madagascar. Several typical heteromorphs are also present: *Parapatoceras* is known from both the Andean and Mediterranean Provinces, whereas *Paracuariceras incisum* has previously been known from the Mediterranean only. Many heteromorphs, especially the extreme ones like Parapatoceras and *Paracuariceras*, however, were presumably planktonic and could thus have drifted across oceans. Alternatively, these and perhaps also *Epistrenoceras* may have lived in sargasso-type, floating algal mats and drifted with them, forming very local enriched cenocoenoses. At Coauilote, *Epistrenoceras* occurs abundantly in shallow near-shore deposits (Otatera Formation); the *Ptychophylloceras* found together with it would have drifted in from the proximal ocean.



Text-fig. 7. Pie-diagrams of biogeographic affinity at genus-group and species level for the Bathonian-Callovian Cualac ammonoid fauna.

Among the Perisphinctaceae, *Bullatimorphites (Kheraiceras) bullatus* is also well known from the Mediterranean and Andean Provinces. *Choffatia* is a truly pandemic genus and very abundant in Mexico, the Andean Province and the entire Tethyan Realm. The Cualac species, however, appear to be partly endemic to South Mexico. Among the Reineckeiidae is the Andean genus *Neuqueniceras* which, highly disjunctly, was also described from western Japan (Sato 1962), but this form has recently been placed in a new genus of the ?Morphoceratidae (Riccardi & Westermann, in press). It is dominant at Cualac, both in species diversity and abundance, resembling the occurrences in the Southern Andes. The Mediterranean genera *Rehmannia* and *Reineckeia* are only ancilories at Cualac (but *Reineckeia* is abundant in the slightly younger beds of Oaxaca). The faunal succession of Coauilote indicates a phyletic morphocline (trend) which leads from *Choffatia* via *Neuqueniceras* s. str. and the *N. (Frickites) bodenbenderi* group, to *Rehmannia* and early *Reineckeia*. We therefore support the hypothesis of Westermann (in Westermann et al. 1984), Westermann & Riccardi (1985) and Cariou (1984b) that the Reineckeiidae originated in the tropical East Pacific in the latest Bathonian and expanded from there into western Tethys during the Early Callovian.

Of the 39 ammonoid species identified from the Otatera and Yucuñuti Formations near Cualac, 22% are endemic to South Mexico; fully one-half (51%) occur also in the Andean Province from northern Chile (Peru ?) to west-central Argentina, and over one-third (39%) in the Mediterranean Province, but many (8 species) of them are common to both the Andes and Mediterranean; only a few (6%) are exclusively East-Pacific, ranging from Alaska to the Southern Andes. On the other hand, there appear to be no species in common with coeval faunas of the western Pacific and eastern Tethys (Westermann & Callomon 1988). Even at the genus-group level, the great majority of ammonoids is shared with the Andean and Mediterranean provinces or solely with the former. The Cualac fauna, however, differs from the Andean fauna in the higher proportion of Mediterranean species and also in the higher degree of species endemism. Yet part of this difference is perhaps only apparent and due to our incomplete knowledge of the Andean faunas. Within the coeval Andean faunas, furthermore, exist significant differences between those of the northern parts (northern Chile and Peru) and the Neuquen Basin in the south, giving rise to two subprovinces currently being named (Westermann, unpubl.). It is interesting that the Cualac fauna is closest to the North Chilean fauna although that occurs in carbonate facies, whereas the lithofacies of Cualac resembles the shaley facies of the Neuquen Basin.

Table 2. Biogeographic affinity of Cualac ammonoid.

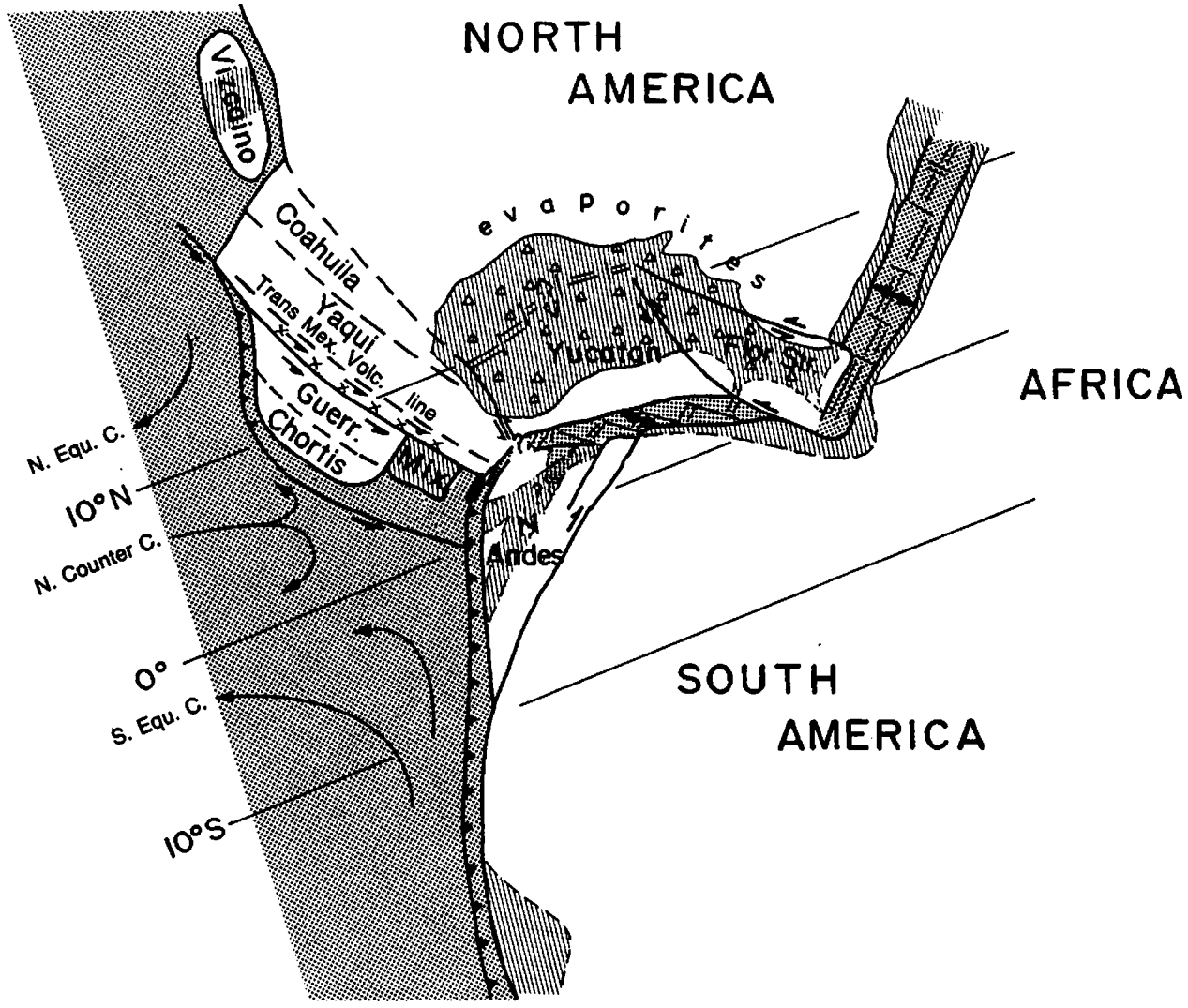
Genera and Subgenera	Endemic	Pandemic	North Cordilleran	Andean	Mediterranean
Eurycephalites				x	
Lilloettia			x	x	
Imlayoceras			x	x	
Xenocephalites			x	x	
Choffatia		x			
Holcophylloceras		x			
Ptychophylloceras		x			
Phylloceras		x			
Epistrenoceras				x	x
Paroecotraustes				x	x
Alcidellus				x	x
Oxycerites		x			
Prohecticoceras				x	x
Guerrericeras				x	
Jeanneticeras				x	x
Phlycticeras				x	x
Neuqueniceras				x	(and Japan)
Frickites				x	
Reineckeia				x	x
Rehmannia				?	x
Parapatoceras				x	x
Paracuariceras					x
Kheraiceras				x	x
totals 23	0	5	3	15	11

Species	Endemic	Pandemic	North Cordilleran	Andean	Mediterranean
Eurycephalite (E.) vergarensis				x	
E. (E.) cf. *rotundus*				x	
E. (Lilloettia) steinmanni			?	x	
E. (L.) boesei	x				
E. (Imlayoceras) cf. *extremus*			?	x	
Xenocephalites nikitini			x	x	
X. neuquensis			?	x	
X. n. sp. A				x	
Choffatia constricta	x				
C. cf. *jupiter*				x	
C. burckhardti	x				
C. suborion	x				
C. gottschei				x	
C. boehmi				x	
C. furcula					x
C. gr. subbackeriae					x
Phylloceras plicatum					x
Ptychophylloceras plasticum	x				
Epistrenoceras histricoides				x	x
Oxycerites (Alcidellus) cualacensis				x	
O. (A.) obsoletoides				x	
O. (A.) cf. *tenuistriatus*					x
O. (Paroecotraustes) gr. *waageni-bronni*				x	x
Prohecticoceras blanazense				x	x
Hecticoceras cf. *boginense*				x	x
Jeanneticeras cf. *malbosi*				x	x
Phlycticeras mexicanum	x				
Guerrericeras inflatum	x				
Bullatimorphites (Kheraiceras) bullatum				x	x
Neuqueniceras (N.) steinmanni				x	
N. (N.) waitzi	x				
N. (N.) plicatum	?			?	
N. (N.) gleimi				x	
N. (Frickites) gr. *bodenbenderi*				x	
Rehmannia gr. *rehmanni*					x
R. cf. *grossouvrei*					x
Reineckeia cf. *frankonica*					x
Parapatoceras distans				x	x
Parauariceras cf. *incisum*					x
totals 39	8.5	0	2.5	22	15

This fauna existed toward the end of the East-Pacific (Sub-)Realm which developed rapidly in the Late Bajocian and disappeared more gradually in the Early Callovian, a duration of 9 to 10 million years (WESTERMANN 1981, 1988). The isolation of the eastern Pacific faunas came about mainly through constriction of the Hispanic Corridor. It is probably also related to the increased latitudinal provincialism at a global scale, and to the (causal?) low stand of the eustatic sealevel.

Plate-tectonics

As outlined in the geological part, the Cualac and Yucuñuti (Oaxaca) areas, perhaps even the entire area with marine pre-Mid-Callovian Middle Jurassic in southern and central Mexico (see WESTERMANN in TAYLOR et al. 1984), belonged to the Mixteca Terrane/Block.



Text-fig. 8. Plate-tectonic reconstruction of Middle America during the earliest Callovian. The Mixteca Terrane (Mix.), covered by sea, is surrounded by terrestrial terranes and lies at the Pacific gate of the Hispanic Corridor, at the beginning of drifting of the Central Atlantic (modified from PINDELL 1985).

The most recent plate-tectonic reconstructions of Mexico (PINDELL 1985, PINDELL et al. 1988, ROSS & SCOTES 1988) still assume large-scale translations along several northwest-southeast megashears. During the pre-Callovian rifting (stretching) of the Proto-(Central)Atlantic, i.e. the Hispanic Corridor, the North American cratoi

including northeastern Mexico moved northward, while the southern blocks moved southeastward, one-by-one closing up on the Northern Andes Terrane of northwestern South America. The Northern Andes Terrane was probably transected by the western terminus of the mainly cratonic Hispanic Corridor, which until the early Callovian acted as an intermittent seaway between the eastern Pacific and the western Tethys sea. The Yaqui and, in turn, the Mixteca and Guerrero terranes restricted the opening of the seaway until the Early Callovian, when initial drifting might already have separated the North American and African plates (JANSA 1986, ZIEGLER 1988). The first documented Atlantic ocean floor, however, is Mid-Callovian (SHERIDAN & GRADSTEIN 1983), coincident with the first large-scale faunal exchange between West-Thethys and the East-Pacific (WESTERMANN 1984c).

These contemporary plate-tectonic reconstructions of Mexico, however, omit the Mixteca Plate/Terrane. It was presumably east of the Guerrero Block, or the eastern part of it (PINDELL 1985). We modify his reconstruction by adding the Mixteca Terrane east of the Guerrero Terrane and combine PINDELL's model together with that of JANSA (1986) for the southern North Atlantic (Text-fig. 8). The Mixteca Terrane thus lay south of the Yaqui Terrane and west of the Northern Andes Terrane (western Venezuela & Columbia). The Guerrero and Yaqui terranes were presumably entirely terrestrial at the time, whereas the Northern Andes Terrane contained the western end of the Hispanic Corridor which, at this time could have partially been a drift. Mixteca thus was situated in a large oceanic embayment just north of the equator, and within the equatorial ocean currents system. This would explain the relative faunal isolation from the North American allochthonous terranes situated within the northern gyre, and the high degree of endemism.

Systematic Descriptions

Measurements and Storage

Measurements: The measurements of the figured specimens and of some other specimens listed in the tables, were all taken in the conventional manner. D = diameter; H = whorl height at a given D, from umbilical seam to venter in the plane of coiling; W = whorl width at a given D, perpendicular to the plane of coiling; U = umbilical width at given D. Some specimens were measured at different diameters representing morphogeny of the phragmocone (phrag.) and bodychamber (bodych.). The number of primary ribs (P) were counted per whorl and secondary ribs (S) per half-whorl.

Storage: Instituto de Geología, Universidad Nacional Autónoma de México, 04510 Mexico (IGM); Department of Geology, McMaster University, Hamilton, Ontario, Canada (McM).

Order Ammonoidea ZITTEL, 1884

Suborder Phylloceratina ARKELL, 1950

Family Phylloceratidae ZITTEL, 1884

Subfamily Phylloceratinae ZITTEL, 1884

Genus *Phylloceras* SUESS, 1865

Phylloceras plicatum NEUMAYR, 1871

Pl. 1, figs. 2a–b, 3, 5

v. 1927 *Phylloceras* cf. *Kudernatschi* — BURCKHARDT, p. 2, pl. 1, figs. 1–3.

* 1976 *Phylloceras plicatum* — JOLY, p. 169, pl. 5, fig. 8, pl. 6, fig. 2, pl. 40, figs. 3, 7 (with synonymy).

Material: Numerous completely septate specimens from Units 6, 7, 14–15 of C1-Arroyo del Rincon.

Comment: This species is characterized by an involute, compressed shell, deep umbilicus with rounded shoulder, very slightly convex flank and rounded venter. Dense, fine, radial lirae on the test and some less pronounced

radial folds appear periodically on the whorl sides. The ornamentation and especially the whorl-section of the Mexican specimens are typical of the Mediterranean species *Phylloceras plicatum.*

Subfamily Calliphylloceratinae SPATH, 1927

Genus *Ptychophylloceras* SPATH, 1927

Ptychophylloceras plasticum (BURCKHARDT, 1927)

Pl. 1, figs. 1a–b, 4a–b, 6a–b, 7

v. 1927 *Phylloceras plasticum* n. sp. — BURCKHARDT, p. 10, pl. 1, figs. 4–8, pls. 2–10, pl. 11, figs. 1–3.

Material: Abundant complete phragmocones from Units 1–9, 14–18 of C1-Arroyo del Rincon; Units 13–15 of C2-Arroyo del Campamento; Units 2–6 of C3-Alto de Teeolutla; and Units 1, 2, 8 of C4-Alto del Variado.

Description: Specimens are compressed and very involute with rapidly expanding inner whorls. Venter is broadly rounded and the flank flattened. Whorl-section is much higher than wide with the maximal whorl width at about ½ whorl height. Ornamentation consists of very fine, flexuous, biconvex lirae which are most visible on the whorl flanks near the umbilical edge and lessen in prominence as they pass evenly over the venter. Lirae have adoral inflexions at ⅓ whorl height, and, less so at ⅔ whorl height. Most prominent ornamentation is furrows and labial ridges; furrows at umbilical edge are moderately deep, becoming shallow beyond ⅓ whorl height and accompanied by labial ridges at ⅔ whorl height. Ridges are most prominent as they pass over the venter. There are approximately 7 furrow-and-ridge pairs per half-whorl; they follow the flexuous pattern of the lirae.

Comments: *Ptychophylloceras plasticum* has a large vertical range at Coauilote and is associated with typically Bathonian and Callovian Ammonitina. In some characters this species is intermediate between *Ptychophylloceras, Holcophylloceras* and even *Phylloceras.* For example, the whorl-section is typical of *Phylloceras* and *Holcophylloceras*; some ontogenic stages are smooth as in *Phylloceras*, but other stages have only furrows as in *Holcophylloceras*, or furrows and ridges as in *Ptychophylloceras.* Some Mediterranean Bajocian species such as *Ptychophylloceras haloricum* (HAUER), *P. longarae sturanii* PAVIA and *P. xeinosulcatum sturanii* PAVIA, resemble *P. plasticum* (see PAVIA 1983a, b), although they are slightly less compressed than the Mexican species. The Mediterranean Bathonian and Callovian species, however, are clearly distinct (see SEQUEIROS 1974, JOLY 1976, GALACZ 1980 and unpublished observation of SANDOVAL in the Betic Cordillera, Southern Spain).

Genus *Holcophylloceras* SPATH, 1927

Holcophylloceras ? sp.

Pl. 1, figs. 8, 9a–b

Material: Several specimens from Unit 15 of C1-Arroyo del Rincon and C2-Arroyo del Campamento.

Comment: Small, smooth, compressed involute forms with rounded venter and periodic sigmoid constrictions on the internal mold. They may represent the inner whorls of *Holcophylloceras zignodianum* (D'ORBIGNY).

Family Oppeliidae BONARELLI, 1894

Subfamily Oppeliinae BONARELLI, 1894

Genus *Oxycerites* ROLLIER, 1909

Oxycerites (Oxycerites?) sp. ind.

Pl. 3, figs. 3a–b

Material: One small, incomplete phragmocone from Unit 4 of C4-Alto del Variado; 1 fragment from Unit 14 of C1-Arroyo del Rincon; and 1 fragment Unit 15 of C2-Arroyo del Campamento.

Description: Shells are typically compressed, involute oxycones with subtriangular whorl-section, steep umbilical wall, slightly rounded umbilical shoulder, gently convergent flank and narrow unicarinate venter. Only very blunt cresented secondaries exist on the outer flank of the phragmocone. Septal suture, partially preserved, is rather complicated as in typical Oxycerites.

Comments: These fragments resemble *Oxycerites oppeli* ELMI from the Upper Bathonian of Europe, but the European species has more prominent secondaries and a better eveloped mid-lateral spiral ridge. One of our specimens was found in the Upper Bathonian and the two bodychamber fragments in the Lower Callovian.

Measurements (mm)

	D	U	H	W	U/D%	W/H
IGM-4208, bodych.	61	6	34	15.5	9.8	0.46

Subgenus *Alcidellus* WESTERMANN, 1958

Oxycerites (Alcidellus) cualacensis SANDOVAL & WESTERMANN n. sp. ♀

Pl. 2, figs. 1a–b, 4; Pl. 3, fig. 11; Text-fig. 9a

v. 1984 *Oxycerites (Paroxycerites)* n. sp. ex. gr. *subdiscus* — WESTERMANN et al., p. 111, pl. 1, figs. 1a–b (holotype).

Derivation of name: From Cualac, Mexican village near the type area.

Holotype: The complete macroconch, previously figured by WESTERMANN et al. 1984, pl. 1, figs. 1a–b (originally McM. J2109; now IGM 4010); here pl. 2, figs. 1–b.

Locus typicus and stratum typicum: Section C1-Arroyo del Rincon, near the village of Coauilote, Cualac Area, Mexico. Bodenbenderi Zone.

Diagnosis: Large, moderately involute macroconch; venter tricarinate (tegulate) becoming obtuse or rounded on inflated bodychamber; smooth except for gently curved lirae.

Material: Holotype; several incomplete specimens from unit 6 of C3-Alto de Teeolutla, Units 3, 6, 7, 13–16 of C1-Arroyo del Rincon, and Units 17–18 of C2-Barranco del Campamento. — Two specimens from the Cemetary section at Caracoles, Antofagasta Province, Chile.

Description: Large macroconchs attain 150 mm in diameter. Inner whorls are unknown; end of phragmocone is involute and bodychamber becomes slightly more open (U/D = 0.12). Whorls are strongly compressed (W/H ≃ 0.5) and subtriangular in the phragmocone; slightly inflated and subovate in the bodychamber, with steep, overhanging, rounded umbilical wall and slightly converging flanks. Venter is typically tricarinate (tegulate) on the phragmocone, with the central keel containing the siphuncle; venter becomes rounded toward end of bodychamber. Ribs are absent on last phragmocone whorl and bodychamber; only shell surface has fine, curved lirae. Septal suture, as in typical Alcidellus, is very simple with non-telescoping lobes.

Comments: The outer whorl of *O. (Alcidellus) cualacensis* resembles *O. (Paroxycerites) subdiscus* (D'ORBIGNY) (see WESTERMANN & CALLOMON 1988, p. 29, text-fig. 5), but the Mexican species is more involute, more typically tricarinate, has a less complicated septal suture and, presumably no tertiary ribs on the inner whorls. *O. (A.) tenuistriatus* (GROSSOUVRE 1888) is also similar, but smaller and with more compressed whorl-section than the Mexican species. *O. (A.) prahecqensis* (PETITCLERC 1915) and *O. (A.) obsoletoides* RICCARDI et al. (1989) are smaller and more strongly ribbed than our new species.

O. (A.) cualacensis comes from the Steinmanni Zone, *Epistrenoceras* and *Lilloettia* Associations, and the Bodenbenderi Zone.

Measurements (mm)

		D	U	H	W	U/D%	W/H
Holotype,	bodych.	134	16	64	46	11.9	0.72
	bodych.	102	9	58	33	8.8	0.57
IGM-4202	bodych.	152	20	73	47.5	13.2	0.65
McM-J1149-9	bodych.	160	—	80	47	—	0.59
IGM-4215	phrag.	105	9	60	32	8.6	0.53
	phrag.	74	5.8	42.5	21	7.8	0.49

Oxycerites (Alcidellus) obsoletoides RICCARDI, WESTERMANN & ELMI, 1989 ♀

Pl. 3, figs. 1a–b, 2a–b; Pl. 10, fig. 4a–b

v. 1989 *Oxycerites (Alcidellus) obsoletoides* n. sp. RICCARDI et al., p. ..., pl. 9, figs. 3, 4 (Holotype)

Material: One almost complete specimen, 1 complete, abraded phragmocone and 9 fragments from Units 3, 6, 7, 14–16 of C1-Arroyo del Rincon, and Unit 17 of C2-Arroyo del Campamento.

Description: This small macroconch attains only 80 mm in diameter. Inner whorls are very involute and compressed, with steep umbilical wall, slightly rounded umbilical margin, gently convergent flank, and a rather broad tricarinate (tegulate) venter which on the bodychamber becomes slightly rounded. Crescented and blunt secondary ribs are developed on the outer half of the flank. Outer whorl has fine lirae parallel to ribs. Septal suture is simple to moderately complicated.

Comments: The assignment of this species to the subgenus *Alcidellus* and its affinities to other species have been discussed by RICCARDI et al. (1989). *O. cualacensis* n. sp. is larger and lacks ornament entirely. The holotype came from the Bodenbenderi Zone of northern Chile; Mexican specimens are from the Steinmanni Zone (*Lilloettia* Association) and Bodenbenderi Zone (*Inflatum* and *Frickites* Associations), i. e., uppermost Bathonian and Lower Callovian.

Measurements (mm)

		D	U	H	W	U/D %	W/H
IGM-4206	bodych.	75	6.5	43.9	20	8.7	0.46
	bodych.	52	—	31.5	14	—	0.44
IGM-4255	bodych.	65	7.8	37	21	12	0.57
Holotype,	bodych.	77	6.3	42.5	21.6	8.2	0.51
	bodych.	56	4.8	32.8	15.9	8.6	0.48

Subgenus *Paroecotraustes* SPATH, 1929

Comments: The probable dimorphic association of *Paroecotraustes* and *Alcidellus* was already proposed by WESTERMANN (1958). The Mexican fauna fully supports this view.

Oxycerites (Paroecotraustes) cf. *bronni* (ZEISS, 1958) sensu *Elmi* ♂

Pl. 2, figs. 3a–b; Pl. 3, fig. 9

cf. 1897 *Oppelia stenorhyncha* PARONA & BONARELLI, p. 96, pl. 2, fig. 6 (holotype).
1918 *Oppelia? stenorhyncha* — PETITCLERC, p. 19, pl. 16, figs. 5 & 6.
cf. 1959 *Hecticoceras (Lunuloceras?) bronni* ZEISS, p. 29.
cf. 1967 *Paroecotraustes (Paroecotraustes) bronni* — ELMI, p. 725, pl. 14, fig. 13.

Material: One specimen from Unit 8 of C4-Arroyo de Tecocoyunca; 2 complete specimens and many fragments from Units 13, 15, 18 of C1-Arroyo del Rincon, and Units 15, 16 of C2-Arroyo del Campamento.

Description: This microconch reaches 35 mm diameter. Shell is involute to very slightly evolute (U/D ≃ 0.29), with steep umbilical wall and slightly convex, convergent flank. Venter is carinate on inner whorls and in most specimens, becomes rounded with bodychamber. A shallow groove is present at midflank on the bodychamber of all complete specimens. Several specimens are entirely smooth; others develop very blunt, falcoid secondaries between mid-lateral groove and ventro-lateral margin. Septal suture, partially preserved in some specimens, is very simple.

Comments: WESTERMANN et al. (1984) suggested that this microconch may belong to *Oxycerites* "ex. gr. *subdiscus*" = *O. (Alcidellus) cualacensis* n. sp. Both forms have a similar vertical range, and are involute and almost smooth, and their suggestion is here supported. *O. (Paroecotraustes) waageni* STEPHANOV 1961 (Neotype: WESTERMANN 1958, pl. 1, figs. 6a–e) is slightly more evolute and more strongly ribbed. In Europe, *O. (P.) bronni* has been recorded from the Gracilis Zone. The Mexican specimens came mostly from the Bodenbenderi Zone; but one of them seems to come from the Upper Bathonian. Similar forms occur in the Lower Callovian of Argentina and Chile.

Measurements (mm)

		D	U	H	W	U/D%	W/H
IGM-4914	bodych.	36	5.6	18	—	15.5	—
McM-J2210a	bodych.	31.2	6.1	14.5	8	19.6	0.55
McM-J2210b	bodych.	24.5	4.7	11.4	—	19.2	—
McM-J2210c	bodych.	20	4.5	10	—	2.5	—
McM-J2210d	bodych.	23	4.8	10.5	6.5	20.9	0.62
IGM-4204	bodych.	16.5	3.4	7.8	4.5	20.6	0.6

Oxycerites (Paroecotraustes) ex. gr. *waageni* STEPHANOV, 1961 ♂

Pl. 3, figs. 7, 10, 16

Material: One complete specimen and two fragments from Unit 15 of C1-Arroyo del Rincon; 1 small, complete specimen from unit 8 of C4-Arroyo de Tecocoyunca.

Comments: This small microconch (D = 29 mm) has a relatively wide umbilicus and a steep umbilical wall. Flanks are very slightly convex, with groove at mid-flank which becomes prominent on the bodychamber. Venter is subcarinate, becoming rounded at the end of the bodychamber. Inner whorls are smooth; outer whorl has rursiradiate. sickle-shaped secondaries which sometimes become prominent towards the venter.

This microconch may be the partner of *O. (Alcidellus) obsoletoides* ♀, which occurs at the same levels and is ribbed only on the outer whorls.

Measurements (mm)

		D	U	H	W	U/D%	W/H
IGM-4213	bodych.	29.5	6.5	10.3	6.5	22.4	0.63
IGM-4212	bodych.	22.5	6	10	6	26.5	0.60

Subfamily Hecticoceratinae SPATH, 1925

Genus *Prohecticoceras* SPATH, 1925

Prohecticoceras blanazense ELMI, 1967 ♀

Pl. 10, figs. 5a–6

1967 *Hectoceras (Prohecticoceras) ochraceum blanazense* ELMI, p. 588, pl. 4, figs. 4–6, text-figs. 122–127.
v. 1989 *Hecticoceras (Prohecticoceras) blanazense* — RICCARDI et al., pl. 4, figs. 1–6.

Material: Two fragments from Unit 2 of C3-Alto de Teeolutla.

Description: Shell is slightly evolute; whorl-section is subrectangular with tectiform venter in the inner whorls, becoming subtriangular on the outer whorl. Phragmocone has prominent ornamentation with strong, proverse primaries; dividing into 2 or 3 secondaries which terminate with small nodes at the ventro-lateral shoulder. At end of phragmocone, ribbing becomes blunt and gradually obsolete.

Comments: The taxonomic affinities have recently been debated by RICCARDI et al. (1989). This species is quite abundant in the Upper Bathonian of the French Jura Mountains where it occurs below the level of *Epistrenoceras* MANGOLD 1970) and is index species of a subzone in the lower Retrocostatum Zone. *P. blanazense* occurs also in western Algeria (ELMI 1985–1987) and at Caracoles, Chile (RICCARDI et al. 1989). In the Cualac area this species occurs in the *Epistrenoceras* Association of the Otatera Formation.

Genus *Jeanneticeras* ZEISS, 1956

Jeanneticeras malbosi ELMI, 1967 ♂

Pl. 3, figs. 4a–b, 5, 6a–b, 8

1967 *Jeanneticeras perlatum malbosi* ELMI, p. 761, pl. 16, figs. 11, 14, Text-figs. 195–196.

Material: One specimen from Unit 14 and 3 from Unit 15 of C2-Arroyo del Rincon.

Description: This microconch attains only 25 mm diameter. It is rather evolute, with compressed-ovate to subrectangular and unicarinate whorl-section. Inner whorls are smooth, but the last whorl may become strongly ribbed. Primary ribs curve adorally to approximately one-third whorl height where they are abruptly reduced to form a very slight furrow. Secondary ribs are prominent on the upper flank and terminate at the ventro-lateral shoulder in well pronounced nodes.

Comments: The Mexican specimens closely resemble French specimens of this species which differ only in larger size and slightly stronger ribbing.

J. malbosi has previously been known only from the Gracilis Zone of Mediterranean Europe. The Cualac specimens are from the *Frickites* and *inflatum* associations of the Bodenbenderi Zone.

Genus *Guerrericeras* SANDOVAL & WESTERMANN n. gen.

Type species: *Clydoniceras inflatum* WESTERMANN, 1984.

Derivation of the name: The genus name refers to the State of Guerrero (Mexico) where the type locality is located.

Diagnosis: Shell small, involute with narrow and deep umbilicus, subquadratic or subrectangular whorl-section, carinate-bisulcate venter, and prominent ribbing.

Distribution: Bodenbenderi Zone; so far the genus has been found only in the Cualac area, Mexico and in northern Chile (GRÖSCHKE, pers. commun. 1988, cast seen).

Comments: WESTERMANN (in WESTERMANN et al. 1984) described the species *inflatum* for some specimens found at Coauilote and provisionally included it in the genus *Clydoniceras*. We found additional topotypes in beds of undisputed Early Callovian age. A detailed study of the new material which includes well preserved septal sutures shows that the Cualac species differs from the Clydoniceratidae mainly in the normally developed suture which resembles that of the otherwise also similar Hecticoceratinae. Ribbing style, very involute coiling, and mainly the flat, carinate and bisulcate venter distinguish *Guerrericeras* from the more typical Hecticoceratinae. The closest resemblance is to some *Prohecticoceras* (e. g. *P. pseudolunula* ELMI), *Chanasia* (e. g. *C. ardescica* ELMI, *C. chartroni*) and *Bonarellites*. The most similar genus, however, is the perfectly homeomorphic, Lower Bajocian *Poecilomorphus cycloides* (D'ORBIGNY) of the Haploceratidae (SANDOVAL 1986), except for details of the septal suture and its smaller size.

Guerrericeras inflatum (WESTERMANN, 1984) ♀ & ♂

Pl. 2, figs. 5a–b; Pl. 3, figs. 12–15; Text-figs. 9b, c

v. 1984 *Clydoniceras inflatum* WESTERMANN (in WESTERMANN et al.), p. 103; pl. 1, figs. 2a–c (holotype); pl. 3, figs. 6a–b, 7a–b.

Material: Four almost complete specimens and several fragments from Unit 15 of sections C1-Arroyo del Rincon and C2-Arroyo del Campamento.

Description: Macro- and microconchs are relatively small, but some specimens are septate up to 52 mm diameter. Shell is involute and inflated, with vertical umbilical wall, rounded umbilical edge, slightly convex flanks with maximum width at one-third whorl-height, and with broad, carinate-bisulcate venter. Ribs are thin and strongly proverse on the lower third of the flank; they become coarse just above maximum whorl width and exceptionally prominent on the ventro-lateral shoulder; here they project slightly and are cut off by the paired, deep furrow. Septal suture is as in the Hecticoceratinae: E is less deep than L which is wide and trifid; saddle L-U2 is wide; and the small umbilical elements are not retracted.

Comments: This species is more involute and more strongly ribbed than most other Hecticoceratinae, except for some *Prohecticoceras* which are more compressed and have divided ribs. Some Clydoceratidae, such as the Bathonian *Micromphalites micromphalus* (PHILLIPS) in ARKELL (1951, p. 45, pl. 4, figs. 1–5), are similar in coiling and prominence of ribs, but are more compressed, have more radial, branched ribbing and are not bisulcate. The Madagascan *Clydoniceras (Delecticeras) anjohense* COLLIGNON (1958, pl. 9, fig. 47) resembles *Guerrericeras inflatum*, but it is slightly more compressed and has thinner ribs. All Clydoniceratidae, however, differ in the simplified septal suture.

Measurements (mm)

		D	U	H	W	U/D%	W/H	P
Holotype,	bodych.	22	4.4	10.5	10	20	0.95	15
	phrag.	16	3	8	8	18.8	1	—
McM-J2125	bodych.	47	6.4	24	24	13.6	1	18
McM-J2124	bodych.	44.5	5.8	21.5	—	13.0	—	14
IGM-4216	bodych.	60	9	30.5	26.5	15	0.88	16

Subfamily Phlycticeratinae Spath, 1928

Genus *Phlycticeras* Hyatt, 1900

Phlycticeras mexicanum Sandoval & Westermann n. sp. ♀

Pl. 4, figs. 2, 3a–b (holotype), 4a–b; Text-fig. 9d

Holotype: The complete bodychamber, IGM-4219, illustrated on pl. 4, figs. 3a, b.

Locus typicus and stratum typicum: Unit 6 of section C1-Arroyo del Rincon, near the village of Coauilote, Cualac area, State of Guerrero, Mexico; Lower Callovian, Bodenbenderi Zone.

Diagnosis: A large species of *Phlycticeras*; involute whorls with compressed and subpentagonal section; 3 rows of tubercles, umbilical, mid-lateral and ventrolateral; keel highly serrated.

Material: The holotype, 2 septate fragments and 1 bodychamber fragment from Units 6 and 13 of C1-Arroyo del Rincon; 1 complete phragmocone obtained from villagers of Coauilote (Corona & Westermann 1980); fragments from Yucuñuti (Oaxaca).

Description: Phragmocone is involute and moderately compressed, approximately one-third higher than wide, with pronounced shoulders and flattened whorl sides. Hollow-floored keel, preserved on 2 specimens is highly serrated; 3 specimens have only the floor. Umbilicus is deep, moderately large, with a vertical wall and slightly angular shoulder. Costae are distant and strong, with three lines of large, rounded tubercles. Each primary rib commences at a prominent, rounded tubercle on the umbilical shoulder and increases in height as it passes radially to the second set of tubercles at mid-flank. There are approximately eight primaries per half-whorl. The primaries bifurcate at the second set of tubercles. Secondary ribs, approximately 32 per whorl, are stronger than the primaries and terminate in a round tubercle at the ventral shoulder. At this third set of tubercles, arise tertiary ribs which are weaker than the secondaries but stronger than the primaries, slightly adorally convex and extend to the serrated keel. Well preserved specimens are strongly strigate. The septal suture is well preserved in one specimen and illustrated in Text-fig. 9d.

Comments: The original illustration of *S. pustulatum* by Quenstedt (1846) is small and insufficient for comparison. The *"Amm. pustulatus"* of d'Orbigny (1846) has weaker ribbing, a more depressed whorl-section and a less serrated keel than the specimens from Coauilote. Mid-flank tubercles are strongest in our specimens, whereas the ventro-lateral ones are strongest in d'Orbigny's specimens. Also, whorl section of the Mexican forms is more compressed. *"Amaltheus pustulatus"* of Waagen (1873) has a keel identical to that of our specimens but ribbing of the latter is more complicated and bifurcates at tubercles. The whorl-section of the Mexican specimens is less quadratic and more compressed than those figured by Waagen. The diagnostic feature of *P. mexicanus* is the umbical row of tubercles.

This is the first reported find of *Phlycticeras* in North America. *Phlyticeras* has been recorded from northern Chile (Covacevich & Corvalan, pers. commun. 1972) and, mainly, from the Lower Callovian in Europe. The Mexican specimens are from the upper part of *Lilloettia* Association, Steinmanni Zone, and from the *Frickites* Association, Bodenbenderi Zone.

? Family Parkinsoniidae Buckmann, 1920

Genus *Epistrenoceras* Bentz, 1928

Epistrenoceras histricoides (Rollier, 1911)

Pl. 9, figs. 6–8

1846 *Ammonites Contrarius* D'ORBIGNY, pl. 145, figs. 3–4 (lectotype designated by ROLLIER 1911).
? 1886 *Ammonites subcontrarius* BEHRENDSEN, p. 23, pl. 11, figs. 1a–c.
1911 *Cosmoceras histricoides* ROLLIER, p. 290.
v. 1927 *Cosmoceras paracontrarium* BURCKHARDT, p. 90, pl. 16, figs. 10–16.
1928 *Strenoceras (Epistrenoceras) histricoides* — BENTZ, p. 167, pl. 15, figs. 1a, b.
1958 *Epistrenoceras histricoides* — COLLIGNON, pl. 8, figs. 42–43.
1967 *Epistrenoceras histricoides* — ELMI, p. 463, Text-figs. 88–3, 88–5.
v. 1984 *Epistrenoceras* aff. *histricoides* — WESTERMANN (in WESTERMANN et al.), p. 109, pl. 2, figs. 4–7.

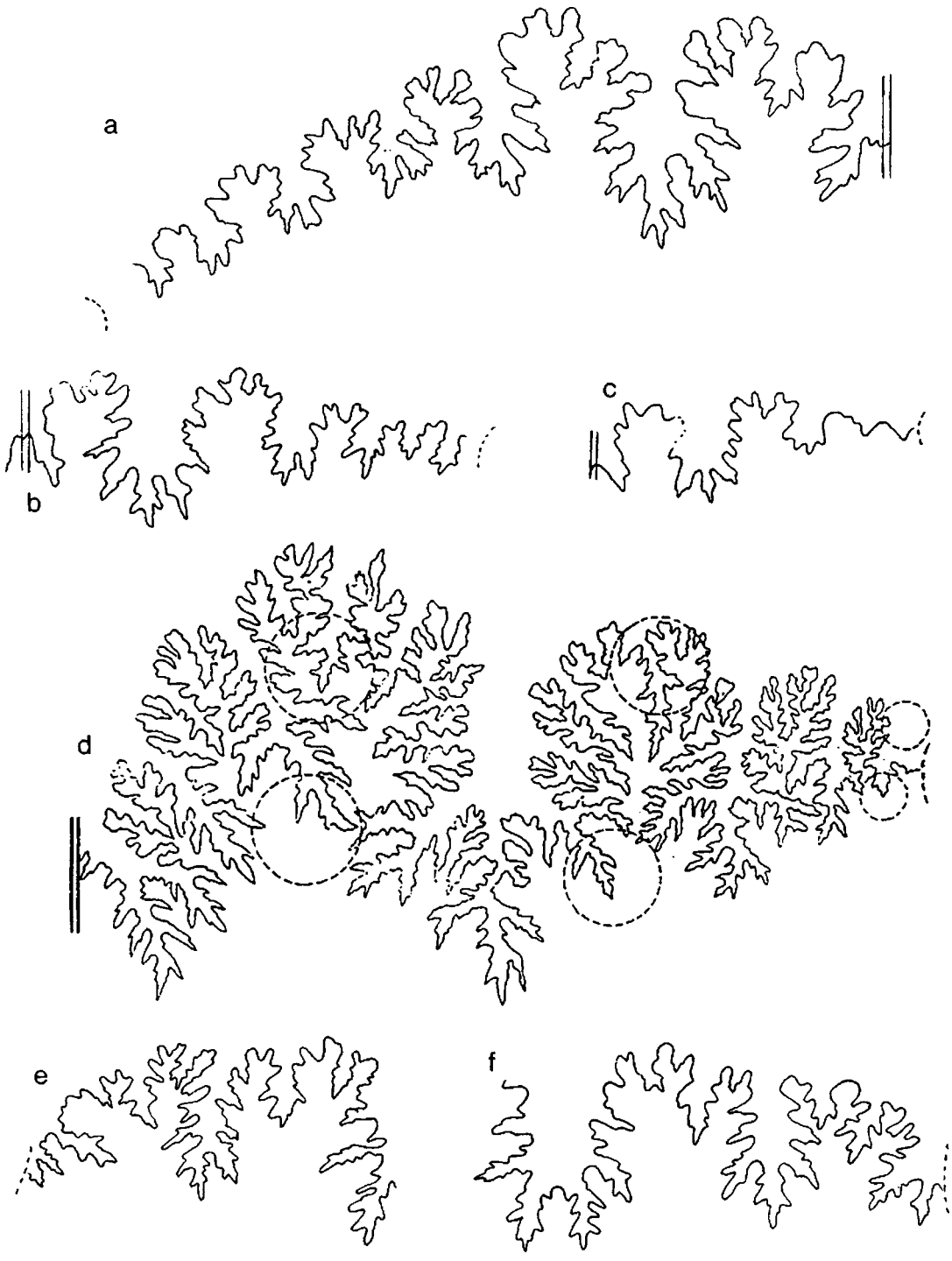
Material: Ten complete or almost complete specimens and 140 fragments of bodychambers and phragmocones from Units 1–3 and 6 of C3-Alto de Teeolutla, and Units 1–2 of C4-Alto del Variado.

Description: Septate specimens, 25 to 40 mm in diameter, are serpenticonic; whorl-section varies from subcircular to ovate with maximal whorl width at two-fifths whorl height. The prominent, distant and prosiradiate primary ribbing has an adoral inflexion at three-fifths whorl height where division and some intercalatories occur. The dense secondary ribs end in blunt nodes along the sulcate venter, with prominence depending on the development of blunt nodes. Some specimens have pronounced nodes while they are blunt on others. One small phragmocone (D = 20 mm) has sharper, more prominent ventro-lateral nodes which develop into spines on the ultimate quarter-whorl. Bisected complete specimens show the development of the ventro-lateral spines at a diameter of 8 to 10 mm and their increase in prominence up to 1.8 mm at about 20 mm diameter. Subsequently, the spines become abruptly reduced to ventro-lateral nodes which persist to the aperture. Two complete specimens (D = 29.5 and 33.5 mm) are mature with the last 4 to 6 septa approximated. The adult bodychamber occupies approximately three-eights of a whorl. The aperture is simple.

Comments: The Coauilote specimens are more involute than *E. contrarium* (D'ORBIGNY 1846, pl. 145, figs. 1, 2 only) and have variocostate secondary ribbing. These differences and the presence of ventro-lateral spines on the adolescent stage, ally our specimens with *E. histricoides* (ROLLIER). *"Ammonites subcontrarius"* BEHRENDSEN seems to be identical with ROLLIER's form, but the poor original illustration does not permit a firm statement. DIETL (1978) considered *E. histricoides* as a descendent of *Strenoceras/Parastrenoceras*, rather than of *Spiroceras* sp. But the interrelation of these genera is unknown; no Parkinsoniidae or Spiroceratidae are known from the long interval of latest Bajocian-Middle Bathonian. DIETL (1978) also suggested that *E. histricoides* was the ancestor of the heteromorphic Parapatoceratids. The septal suture of *E. histricoides* is greatly simplified and similar to that of *Parapatoceras* sp. Juvenile ventro-lateral and ventral interruptions through ontogeny are also very similar between *E. histricoides* and *Parapatoceras distans.*

Measurements (mm)

		D	U	H	W	U/D%	W/H
IGM-4251	bodych.	38	17.5	11	12	46.1	1.01
	bodych.	31.5	13	11	11.5	41.2	1.05
McM-J2108a	bodych.	32	11	12.5	14	34.4	1.12
McM-J2211a	bodych.	41	15.8	14.5	15	38.5	1.03
IGM-4250	bodych.	33	12.2	12.5	13.2	37.0	1.07
	phrag.	26.5	9	10.3	10.5	34.0	1.02
McM-J2211b	bodych.	34	13	12.1	13	38.2	1.07
	phrag.	25	7.7	10.3	11	30.8	1.07
McM-J2212a	bodych.	41	17	14.8	16.5	41.5	1.14
McM-J2108b	bodych.	32	11	12.3	13	34.4	1.06
	phrag.	20	7	9.6	10.8	35	1.12
McM-J2212b	phrag.	31	11	11.5	12.7	35.5	1.02
McM-J2211c	phrag.	28	9.7	11.1	11.8	34.6	1.06



Text-fig. 9. Mature septal sutures of: a, *Oxycerites (Alcidellus) cualacensis* n. sp., holotype at D = 88 mm; b–c, *Guerrericeras inflatum* (WESTERMANN), b, microconch IGM 4026 at D = 38 mm and c, microconchiate holotype at D = 12 mm; d, *Phlycticeras mexicanum* n. sp., IGM 4030 at H = 40 mm; e, *Neuqueniceras (N.)* gr. *bodenbenderi* & *antipodum* at D = 60 mm; f, *N. (Frickites)* n. sp. A at D = 65 mm.

Subfamily Parapatoceratinae Buckman, 1926

Genus *Parapatoceras* Spath, 1924

Parapatoceras distans (Baugier & Sauze, 1843)

Pl. 4, figs. 5–9

1978 *Parapatoceras distans* — Dietl, p. 46, pl. 8, figs. 7–11, pl. 9, figs. 1, 2, pl. 10, fig. 4, pl. 11, figs. 2–4, Text-figs. 7, 10, 13 (with synonymy).
v. 1984 *Parapatoceras* cf. *distans* — Westermann (in Westermann et al.), p. 109, pl. 2, fig. 2.

Material: Numerous phragmocone and bodychamber from limey concretions of Units 15 and 16 of C1-Arroyo del Rincon and C2-Arroyo del Campamento.

Description: Whorls form an open, planar but irregular spiral and the mature stage may be straight. Expansion rate (W of Raup) may vary through ontogeny. Whorl-section changes slightly through ontogeny, from transversely ovate in the juvenile, circular in the middle stages, to dorso-ventrally ovate in the adult stage. Whorl height and width exceed 1 cm only in very large specimens. Ribs are straight and simple (undivided), with some variability. Protoconch and first whorl lack costae: blunt ribs appear early on the second whorl (see Dietl 1978). The first few ribs are rectiradiate, gradually becoming slightly prosiradiate. Adolescent ribs are again rectiradiate, becoming very prominent at maturity. In the siphonal region, the ribs are strongly interrupted by a smooth band, and each rib has a sharp and prominent terminal tubercle. Ribs and tubercles lessen in prominence toward the aperture which is simple. The septal suture is not preserved.

Comments: The Coauilote specimens are identical to *Parapatoceras distans* as figured by Dietl (1978). In nor thern Chile, *P. tenue* (Baugier & Sauze) is said to occur together with *P. distans* (Westermann et al. 1984). *P. tenue* differs in the less prominent tubercles and the more closely spaced, prosiradiate ribbing with weaker tubercles.

At Coauilote, *P. distans* occurs in the Bodenbenderi Zone. Dietl (1978) notes that in Europe *P. tenue* is found only in the Upper Bathonian, whereas *P. distans* extends into the Lower Callovian.

Genus *Paracuariceras* Schindewolf, 1963

Paracuariceras cf. *incisum* Schindewolf, 1963

Pl. 7, fig. 4

cf. 1978 *Paracuariceras incisum* — Dietl, p. 48, pl. 9, figs. 3–6, Text-figs. 7h, 17 (with synonymy).

Material: One bodychamber fragment from Unit 15 of C1-Arroyo del Rincon.

Description: Our bodychamber fragment is 46.1 mm long, has terminal whorl diameters of 6.8 mm and 4.7 mm respectively, and is circular in section. The bodychamber is orthoconic, except for a slight dorsal-upward curvature of the adapical portion. According to Dietl (1978), only the protoconch is tightly coiled. Ornamentation consists of rursiradiate labial ridges and furrows which are most prominent on the flanks and moderate on dorsum and venter. Each ridge is usually preceeded by a furrow, but the converse also occurs.

Comments: Dietl's (1978) illustrations of *P. incisum* made our identification secure only at the generic level. In Europe the genus occurs in the Macrocephalus to Jason zones (Dietl 1978).

Family Sphaeroceratidae Buckman, 1920

Subfamily Eurycephalitinae Thierry, 1976

Genus *Eurycephalites* Spath, 1928

Comments: We follow the recent taxonomy by Riccardi, Westermann & Elmi (1989) in separating *Eurycephalites, Lilloettia* and *Imlayoceras* at the genus-level.

Eurycephalites vergarensis BURCKHARDT, 1903 ♀

Pl. 5, figs. 4a–c

v. 1900 *Sphaeroceras rotundum* TORNQUIST — BURCKHARDT, p. 37, pl. 23, figs. 3, 6 (lectotype, des. RICCARDI et al. 1989).
v. 1989 *Eurycephalites vergarensis* — RICCARDI, WESTERMANN & ELMI, pl. 7, figs. 1–2.
v. 1990 *Eurycephalites vergarensis* — RICCARDI & WESTERMANN, pls. 1–3 (with complete synonymy).

Material: Two specimens from Unit 8 of C1-Arroyo del Rincon.

Comments: This species has an inflated and globose shell. Primary ribs are blunt and adorally concave below the umbilical shoulder. Secondary ribs are prominent on the venter and disappear on the flanks of the bodychamber. *E. vergarensis* is index species in the basal Callovian of the Andes (RICCARDI 1985, RICCARDI et al. 1989). The occurrence of this species (Unit 8 of section C1) slightly above the Late Bathonian *Lilloettia* Association of the Steinmanni Zone is very important for intercontinental correlation and for placing the Bathonian-Callovian boundary.

Measurements (mm)

		D	U	H	W	U/D%	W/H
IGM-4229	bodych.	68	7	28.8	38.8	10.3	1.35
	phrag.	51	5	26	32	9.8	1.23
McM-J2213	bodych.	62	5.7	30	36	9.1	1.20

Eurycephalites cf. *rotundus* (TORNQUIST, 1898) ♀

Pl. 7, figs. 2a–b

v. cf. 1898 *Sphaeroceras rotundum* TORNQUIST, p. 49 (181), pl. 6 (19), figs. 1 (lectotype, des. RICCARDI et al. 1989), 4.
v. cf. 1989 *Eurycephalites rotundus* — RICCARDI et al., pl. 7, figs. 8–9.
v. cf. 1990 *Eurycephalites rotundus* — RICCARDI & WESTERMANN, pls. 4–7 (with complete synonymy).

Material: Several incomplete specimens and bodychamber fragments from Units 14–16 of C1-Arroyo del Rincon and C2-Arroyo del Campamento.

Comments: This species is characterized by its inflated, globose, involute shell. The flanks of the inner whorls are smooth, but the bodychamber has faint primaries; secondary ribs are blunt but moderately developed toward the venter. Some shallow radial grooves appear periodically near the umbilical shoulder, fading rapidly at mid-flank. RICCARDI (1985) suggested a phyletic morphocline from (Late Bathonian) *Lilloettia steinmanni* via (Early Callovian) *Eurycephalites vergarensis* to *E. rotundus*. The Coauilote specimens have fainter ventral ribbing on the bodychamber than the lectotype of *E. rotundus*.

The occurrence of *E.* cf. *rotundus* in the Bodenbenderi Zone of Coauilote indicates Lower Callovian.

Eurycephalites n. sp. A ♀

Pl. 6, figs. 4a–b

Material: One specimen from Unit 14 of C1-Arroyo del Rincon.

Comments: The shell with complete bodychamber is involute with ovate and depressed whorl-section. The primary ribs (8 per half-whorl) are strongly projected and bifurcate at mid-flank. The secondary ribs are slightly wider than the primaries and pass radially or slightly forward-convex over the venter. The aperture is simple and parallel to the ribbing.

Measurements (mm)

		D	U	H	W	U/D%	W/H
IGM-4234	bodych.	82	8	37	47.3	9.8	1.27

Genus *Lilloettia* CRICKMAY, 1930

Lilloettia steinmanni (SPATH, 1928) ♀

Pl. 5, figs. 3a–c; Pl. 7, figs. 1a–b

1881 *Stephanoceras macrocephalum* — STEINMANN, p. 271, pl. 11, fig. 4 (lectotype, des. RICCARDI et al. 1989).
v. ? 1927 *Macrocephalites* aff. *macrocephalus* — BURCKHARDT, p. 32, pl. 16, figs. 1–3, pl. 17, fig. 7.
v. 1989 *Lilloettia steinmanni* — RICCARDI et al., pl. 3, fig. 4.
v. 1990 *Lilloettia steinmanni* — RICCARDI & WESTERMANN, pls. 9–10 (with complete synonymy).

Material: 39 specimens from Units 3, 4, and 6 of C1-Arroyo del Rincon.

Description: This abundant species averages 70–80 mm in diameter and is highly involute. The whorl-section is slightly depressed, ovate to subcircular or subtriangular with the maximum width at the lower third of the flanks. Costae bifurcate on the lower third of the flank on inner and middle whorls. Primaries disappear on the bodychamber.

Comments: According to CALLOMON (1984), the age of *Lilloettia* in northwestern North America is earliest Callovian. The most recent reviews of South American Eurycephalitinae by RICCARDI (1984, 1985) and RICCARDI et al. (1989), on the other hand, indicate that in the Andes, this genus is restricted to the Upper Bathonian. The North Cordillera species *L. tipperi* FREBOLD (see FREBOLD 1967, p. 9, pl. 1, figs. 1–6, pl. 3, fig. 2) resembles the Mexican specimens, but is has more compressed whorl-section and thinner ribbing.

Measurements (mm)

		D	U	H	W	U/D%	W/H	S
IGM-4228	bodych.	58	3	30	34	5.1	1.13	—
	phrag.	42	—	21.8	25	—	1.15	—
IGM-4236	bodych.	52	2.5	28	29.5	4.8	1.05	40
McM-J2119a	bodych.	45	2.2	23.5	25.8	4.9	1.10	42
		32.5	—	17.2	18.8	—	1.10	—
McM-2214a	bodych.	52	—	26	30.5	4.8	1.17	42
McM-2214b	bodych.	63	3.3	34.5	39	5.2	1.13	48

Lilloettia boesei (BURCKHARDT, 1927) ♀

Pl. 5, figs. 1a–b; Pl. 6, figs. 1a–b

v. 1927 *Macrocephalites Boesei* BURCKHARDT p. 31, pl. 15, figs. 1–4 (lectotype, designated by RICCARDI & WESTERMANN 1989).
v. 1984 *Eurycephalites (E. ?) boesei* — WESTERMANN et al., p. 105, pl. 3, fig. 3.
v. 1990 *Lilloettia boesei* — RICCARDI & WESTERMANN, Text-fig. 21a,d, lectotype and paralectotype refigured.

Material: Ten specimens from Units 3, 4, and 6 of C1-Arroyo del Rincon.

Comments: This species averages 55–95 mm in diameter. Ribbing is coarser than in *E. steinmanni*, and primary ribs are more reduced resulting in smoother inner flanks. The whorl-section of *E. boesei* is also more depressed and inflated than in *E. steinmanni*. Both species have apparently identical stratigraphic range in the Cualac area, suggesting that they may be variants of a single biospecies. The associated *Xenocephalites nikitini* (BURCKHARDT) ♂ may represent the corresponding microconch. CALLOMON (1984) suggested that *E. boesei* may also be conspecific with the North Cordilleran *L. buckmani* CRICKMAY, but that one has more coarsely ribbed flanks than the Mexican species (WESTERMANN et al. 1984).

Measurements (mm)

		D	U	H	W	U/D%	W/H	S
IGM-4226	bodych.	96	8	50	57	8.3	1.14	36
	phrag.	61	—	38.5	48	—	1.25	—
IGM-4236	bodych.	92	8.0	51	60	8.7	1.18	34
McM-J2214a	phrag.	60	4.5	35.5	39.5	7.5	1.11	—
McM-J2215b	bodych.	85	6.6	46	54.5	7.8	1.18	—

Genus *Imlayoceras* FREBOLD, 1963

Imlayoceras? cf. *extremum* (TORNQUIST, 1898) ♀

Pl. 8, figs. 1a–b

Material: One complete specimen and one fragment of inner whorls from Unit 15 of C2-Arroyo del Campamento.

Comments: The single complete specimen is 77 mm in diameter. It is involute, inflated, globose with very depressed whorl-section (H/W ≃ 0.5). The gently projected primary ribs are wide and prominent on the phragmocone and simple or bifurcating below mid-flank; intercalatories are also present. Primaries and secondaries tend to fade gradually, becoming obsolete on the bodychamber. The Mexican specimens have the same coiling and whorl-section as the Andean *Imlayoceras extremum*, but appear to have stronger ribs and lower furcation points. The north Cordilleran *I. miettense* (FREBOLD 1967, p. 20, pls. 8–11) has similar whorl-section and coiling in inner whorl, but the ribbing is more clearly divided.

Genus *Xenocephalites* SPATH, 1928

Xenocephalites nikitini (BURCKHARDT, 1927) ♂

Pl. 4, figs. 1a–c; Pl. 5, figs. 2a–b; Pl. 7, figs. 3a–b

v. 1927 *Macrocephalites Nikitini* BURCKHARDT, p. 33, pl. 16, figs. 4–9.
v. ? 1953 *Xenocephalites vicarius* IMLAY, p. 78, pl. 28, figs. 1–8.
v. ? 1989 *Xenocephalites* aff. *nikitini* — RICCARDI et al., pl. 2, fig. 3.

Material: Several specimens from Units 3–6, 13–15 of C1-Arroyo del Rincon, and Unit 15 of C2-Arroyo del Campamento.

Description: This species is very small (D = 10–35 mm). Whorls are depressed ovate with maximum width at lower third of flank. Costae are prominent; primaries strongly arched forward bifurcating on inner third of flank, and secondaries increase in prominence as they pass over venter. Last four or five primaries are simple with intercalated ribs.

Comments: *X. nikitini* is considered to be the microconch of *Lilloettia boesei* (BURCKHARDT) and occurs in the same horizons (Units 3–6 of section C1). CALLOMON (1984) suggests that *X. nikitini* is conspecific with *X. vicarius* IMLAY (1953). We agree tentatively with this synonymy.

The specimens from the Callovian Units 13–15 of section C1, and Unit 15 of section C2, appear to be identical with the supposed microconch of *L. boesei* from Units 3 to 6 of section C1. The former, however, are associated with *Eurycephalites* gr. *rotundus* (TORNQUIST) and could be their corresponding microconch. This illustrates the current problems of specific matching in the Eurycephalitinae.

Measurements (mm)

		D	U	H	W	U/D%	W/H	P	S
IGM-4217	bodych.	32	2.7	15.5	22	8.4	1.42	20	20
IGM-4227	bodych.	25	1.7	12.5	16.7	7.7	1.31	14	18
IGM-4238	bodych.	31	2.4	14	16.5	7.7	1.17	—	20
McM-J2216	bodych.	33	2.7	16	19	8.2	1.19	—	22

Xenocephalites neuquensis (STEHN, 1923) ♂

Pl. 6, fig. 2

v. 1924 *Macrocephalites neuquensis* STEHN, p. 86, pl. I, fig. 3 (lectotype, des RICCARDI et al. 1989), Text-fig. 11.
? 1953 *Xenocephalites hebetus* IMLAY, p. 78, pl. 29, figs. 6–7, and 11 (holotype) non 8.
v. 1989 *Xenocephalites neuquensis* — RICCARDI et al., pl. 2, figs. 4–5 (lectotype refigured) (with complete synonymy).

Material: Two fragmentary specimens from Unit 15 of C1-Arroyo del Rincon.

Comments: Relatively evolute, ovate and depressed whorls and well-spaced, sharp and prominent ribbing, place this microconch close to *X.* gr. *nikitini*; but our form is more evolute with thicker ribs. Our *X. neuquensis* is

from the Early Callovian *Frickites inflatum* association, Bodenbenderi Zone. It also occurs in the uppermost Bathonian to basal Callovian of the Andes (RICCARDI 1985; RICCARDI et al. 1989) and at a similar level very isolated in the Moluccas, Indonesia (WESTERMANN & CALLOMON 1988).

Measurements (mm)

		D	U	H	W	U/D%	W/H	S
IGM-4231	bodych.	42	7.2	21	28	17.1	1.33	11

Xenocephalites n. sp. A ♂

Pl. 6, figs. 3, 5a–b

v. 1924 *Macrocephalites extremus* TORNQUIST — STEHN, p. 83, pl. 1, fig. 4.

Material: Two specimens from Units 14 and 15? of C1-Arroyo del Rincon.

Comments: Specimens are of medium size (52 and 55 mm) and with involute, ovate, slightly depressed whorls. Primary ribs are wide and blunt, slightly curved forward and bifurcating at mid-flank where intercalatories also appear. The secondary ribs are likewise wide and blunt and arch forward as they pass over the venter.

These specimens differ from *X. neuquensis* (STEHN) which has a wider umbilicus and more prominent, sharper ribbing. The North American *X. phyllipsi* IMLAY (1953, p. 18, pl. 1, figs. 1, 2, 5, 9) and *X. hebetus* IMLAY (1953, p. 78, pl. 29, figs. 6–8, 11) are also close but differ in the sharper ribbing.

Measurements (mm)

		D	U	H	W	U/D%	W/H	S
IGM-4232	bodych.	51	6.4	25	32	12.5	1.28	15
	phrag.	34.5	—	—	20	24.5	1.22	—
IGM-4233	bodych.	56	7.3	23.8	28	13.0	1.18	18

Superfamily Perisphinctaceae STEINMANN, 1890

Family Perisphinctidae STEINMANN, 1890

Genus *Choffatia* SIEMIRADZKI, 1898

Comments: We place all the "macroconchiate" and "microconchiate" generic names *Choffatia, Subgrossouvria, Grossouvria, Homeoplanulites* and *Parachoffatia* into the undivided genus *Choffatia*, since their differences are not sufficient for generic distinction.

Choffatia constricta (BURCKHARDT, 1927) ♀

Pl. 9, figs. 5a–b

v. 1927 *Peltoceras constrictum* BURCKHARDT, p. 82, pl. 31, figs. 8–11.

Material: Numerous specimens from Unit 2 of C3-Arroyo de Teeolutla, and from Unit 2 of Alto del Variado.

Description: These small incomplete phragmocones (D = 40 to 50 mm) are very evolute (U/D ≃ 0.50). Primary ribs (30–34 per whorl at 50 mm diameter) are prominent and usually bifurcate or, more rarely, trifurcate at mid-flank; secondary ribs are also prominent and pass straight over the venter, without interruption. There are two modestly strong constrictions per whorl. The whorl-section is almost circular.

Comments: WESTERMANN et al. (1984) suggested that this form is intermediate between Perisphinctidae and Reineckeiidae, resembling the inner whorls of *Neuqueniceras (Frickites)* cf. *bodenbenderi* (TORNQUIST) from Coauilote and of *Choffatia boehmi* (STEINMANN) from Caracoles, Chile. We now prefer to place this problematic species in *Choffatia*

fatia, in the species group of *Ch. jupiter* (STEINMANN). This species occurs in the *Epistrenoceras* Association of the Otatera Formation (Upper Bathonian).

Measurements (mm)

		D	U	H	W	U/D%	W/H	P	S
IGM-4248	phrag.	50	26	14	16.3	52	1.16	31	30
	phrag.	38.5	19	10.4	13.1	49.4	1.26	33	—
McM-J2119b	phrag.	56	28	16	18.5	50	1.15	30	30
	phrag.	45	21.5	12.5	16	47.8	1.28	32	—
McM-2217	phrag.	45	22.5	12.5	15.6	50	1.25	34	26
	phrag.	36	17	10	13	47.2	1.30	35	—

Choffatia burckhardti nom. nov. ♀

Pl. 11, figs. 1a–b

[New name for *Choffatia aberrans* (BURCKHARDT, 1927), non WAAGEN, 1875]

v. 1927 *Reineckeia aberrans* BURCKHARDT, p. 73, pl. 29, figs. 3–5, pl. 30, fig. 1.

Holotype: The holotype of *Reineckeia aberrans* BURCKHARDT 1927 (monotypy).

Derivation of name: In honor of C. BURCKHARDT, German investigator who studied the Middle Jurassic ammonite fauna of the type locality.

Diagnosis: Very evolute, with depressed, subovate whorl-section; prominent radial, blade-like primary ribs; and deep constrictions.

Material: Numerous specimens from Units 2–6 of C1-Arroyo del Rincon.

Descriptions: Shell large (diameter to 160 mm), very evolute (U/D ≃0.50%) with moderately shallow umbilicus. Whorl-section is depressed ovate with maximal width below mid-flank. Strong, radial or slightly proverse, blade-like primary ribs arise near the umbilical seam and increase in prominence up to mid-flank. Secondary ribs, three to five per primary, are fine and blunt, pass over the venter with slight interruption, and are absolete on the bodychamber. Whorls are segmented by deep constrictions.

Comments: When BURCKHARDT (1927) studied the Middle Jurassic ammonite fauna of Oaxaca and Guerrero, he described a great number of new species, among them *"Reineckeia aberrans"*. We now place this species in the genus *Choffatia*. *Perisphinctes aberrans* WAAGEN (1875, p. 175, pl. 40, figs. 1a–c) is the type species by original designation of the genus *Subgrossouvria* SPATH (1924) which we include in *Choffatia* (junior subjective synonym or subgenus). *Choffatia aberrans* (WAAGEN 1875) therefore becomes a senior subjective homonym of *Ch. aberrans* (BURCKHARDT 1927), and a new name is required for BURCKHARDT's species. The holotype is fragmentary and from an unknown stratigraphic level at Coauilote (near Cualac). We illustrate an almost complete topotype.

Three Upper Bathonian to Lower Callovian European species are similar to *Ch. burckhardti*: *Ch. recouperoi* (GEMMELLARO 1872, p. 197, pl. 5, figs. 9–11), *Ch. cerealis* ARKELL (1959, p. 219, pl. 31, figs. 3–6) and *Ch. rakotondromazawai* (COLLIGNON 1958) sensu KRYSTYN (1972) and SANDOVAL (1983, p. 521, pl. 59, fig. 1, pl. 61, figs. 1, 3). But the Mexican species has a more subtriangular and depressed whorl-section, more widely spaced and blade-like primaries, and a ventral costal interruption. *Ch. burckhardti* occurs in the Upper Bathonian *Lilloettia* Association of the Yucuñuti Formation.

Measurements (mm)

		D	U	H	W	U/D%	W/H	P
IGM-4257	bodych.	172	88	50	55	51.2	1.10	20
	bodych.	130	69	35.5	46	53.1	1.30	18
	phrag.	104	56	26	37	53.8	1.42	16
McM-J2218a	bodych.	172	96.5	40	50	56.1	1.25	21
	bodych.	136	78	33	40	57.4	1.21	15
McM-J2218b	bodych.	155	83.5	43	—	53.9	—	20
McM-J2219	bodych.	90	46	23.2	32	51	1.37	17
	phrag.	56	29	15.5	21	51.8	1.35	—

Choffatia suborion (BURCKHARDT, 1927) ♀

Pl. 10, fig. 2; Pl. 12, figs. 1, 2a–b

v. 1927 *Perisphinctes suborion* BURCKHARDT, p. 77, pl. 31, figs. 2–4, 7.
v. 1927 *Perisphinctes* cfr. *Gottschei* — BURCKHARDT, p. 80, pl. 31, figs. 1, 5, 6.
v. ? 1927 *Perisphinctes cualacensis* BURCKHARDT, p. 78, pl. 30, figs. 6–9.

Material: Many specimens from Units 2–6 of C1-Arroyo del Rincon.

Comments: This medium-size (100–120 mm diameter), very evolute (H/D = 0.51 to 0.57) species resemble *Ch. burckhardti*, but *Ch. suborion* differs in the more subquadratic and less depressed whorls; blade-like primary rib which become more prominent on the outer whorls and end lower on the flanks; and the restriction of the ventra costal interruption to mainly the inner whorls.

The Upper Bathonian European species *Ch. vicenti* MANGOLD (1970, p. 136, pl. 1, fig. 1) and *Ch. praecurso* MANGOLD (1970, p. 138, pl. 2, fig. 4) are similar to *Ch. suborion*. But these European species are less evolute and hav a slightly more rounded whorl-section, and less blade-like primaries on bodychamber.

The Upper Bathonian to Lower Callovian *Ch. subbackeriae* (D'ORBIGNY) and *Ch. funata* (OPPEL) also resembl *Ch. suborion*. The Mexican species is more evolute, has a subquadratic rather than subrectangular whorl-section, simpler septal suture, and more radial and blade-like primaries with more elevated division points.

Measurements (mm)

		D	U	H	W	U/D%	W/H	P	S
IGM-4251	bodych.	120	61.5	37	37	51.3	1.16	16	42
	bodych.	95	49	27.1	27.8	51.6	1.03		
	phrag.	74	39	21	24	52.7	1.14	24	—
IGM-4252	bodych.	123	67	31.2	—	54.5	1.10	22	—
	bodych.	115	62.5	30	33.5	54.3	1.11	23	—
	phrag.	~80	~42	21	23	~52.5	1.10	—	—
IGM-4259	bodych.	88	47.5	21	24	54.0	1.14	29	—
	phrag.	69	35.4	18.8	19	51.3	1.01	—	—
McM-J2220	bodych.	96	49	28	27	51.0	0.96	28	—
McM-J2221	bodych.	114	60	30	28.5	52.6	0.95	29	—
	phrag.	91	45	25	24	49.5	0.96	—	—

Choffatia gottschei (STEINMANN, 1881) ♀ & ♂

Pl. 8, fig. 4; Pl. 14, figs. 5a–b; Pl. 15, figs. 2a–b

1881 *Perisphinctes gottschei* STEINMANN, p. 273, pl. 9, fig. 2.

Material: Several specimens from Units 1–3, 5–6 of C1-Arroyo del Rincon.

Comments: Shell small (70–80 mm diameter), with very evolute (U/D ≃ 0.50) and ovate whorls. Ribbing is dense. Radial or slightly proverse, narrow primary ribs bifurcate or trifurcate into less prominent secondary ribs near mid-flank; some secondary ribs are intercalated. There is a moderately well developed ventral interruption. Two to four constrictions are developed per whorl and more proverse than the ribs.

Ch. boehmi (STEINMANN), also first described from Chile, resembles *Ch. gottschei*, but the former has a more rounded whorl-section and less dense, more prorsiradiate primaries.

Measurements (mm)

		D	U	H	W	U/D%	W/H	P	S
IGM-4243	bodych.	96	50	23.4	24	52.0	1.02	—	46
IGM-4273	bodych.	78	40	20	20	51.3	1.0	35	43
	phrag.	61	31	15.3	16.5	50.8	1.08	37	—

Choffatia boehmi (STEINMANN, 1881) ♀ & ♂

Pl. 8, figs. 2–3; Pl. 13, figs. 6a–b; Pl. 14, fig. 6a–b

1881 *Perisphinctes boehmi* STEINMANN, p. 274, pl. 9, figs. 1a, b.

Material: Numerous specimens from Units 6, 7 of C1-Arroyo del Rincon.

Description: Shell of medium size or small and very evolute (U/D = 0.50 to 0.60). Whorl-sections ovate to subquadratic with almost parallel, flat flanks and slightly rounded venter. Primary ribs are moderately strong and radial, bifurcating into dense secondaries at two-thirds of whorl-height, and passing over venter with moderate interruption. Some microconchs have parabola-like swelling on the ventro-lateral shoulder of the phragmocone, whereas other specimens are still septate at approximately 80 mm diameter and presumably macroconchs. These have more widely spaced and broader primary ribs on the bodychamber than the microconchs, and intercalated ribs between the secondaries borne by bifurcation.

Comments: The Upper Bathonian *Ch. homoeomorpha* (BUCKMAN) resembles *Ch. boehmi*, but that frequently recorded European species is slightly less evolute, has a slightly more compressed whorl-section, and less radial ribbing with a higher secondaries/primaries ratio. The Upper Bathonian *"H. (Homoeoplanulites)"* sp. A of MANGOLD (1970b, p. 67, pl. 4, fig. 3) is the most similar European species to *Ch. boehmi*, with equal coiling and the same style of ribbing. *Ch. gottschei* (STEINMANN), is slightly more involute, has a more rounded-depressed whorl-section and less dense primaries. But both "species" are very similar, occur at the same level and could be conspecific.

Measurements (mm)

		D	U	H	W	U/D%	W/H	P	S
IGM-4241	bodych.	130	80	30	—	50.3	—	30?	—
IGM-4242	bodych.	80	42	20	19	52.5	0.95	48	46
IGM-4268	bodych.	71	42	15.4	15.4	59.2	1.0	43	44
	phrag.	57	31.5	13	14.4	55.3	1.1	47	—
IGM-4274	bodych.	57	30.5	13.7	13.7	53.0	1.0	42	38
	phrag.	40	21	10.5	11.8	52.5	1.12	44	35

Choffatia cf. *jupiter* (STEINMANN, 1881) ♀

Pl. 10, figs. 1a–b, 3; Pl. 15, fig. 3

cf. 1881 *Perisphinctes jupiter* STEINMANN, p. 277, pl. 9, fig. 6 (lost).
v. cf. 1989 *Choffatia jupiter* — RICCARDI et al., pl. 5, fig. 1.

Material: A few fragments from Units 1–6 of C3-Alto de Teeolutla and Units 3–6 of C1-Arroyo del Rincon.

Description: This shell is large with evolute, subquadratic to ovate-depressed whorls, especially the bodychamber. The primary ribs are radial, prominent, sometimes narrow and blade-like, and divide into dense secondaries near two-thirds of the whorl-height. The secondaries are well developed on the inner whorls, where they pass uninterrupted over the venter. The bodychamber has widely spaced, bullate primaries, but the secondaries are very blunt to obsolete.

Comments: The Upper Bathonian European species *Ch. vicenti* MANGOLD (1970, p. 136, p. 1, fig. 1) and *Ch. praecursor* MANGOLD (1970, p. 138, pl. 2, fig. 4) are similar to *Ch. jupiter*, but they are more involute and have a slightly greater whorl expansion rate.

Measurements (mm)

		D	U	H	W	U/D%	W/H	P
IGM-4277	phrag.	114	59	29	28.5	51.7	0.98	29
	phrag.	86	44	19.5	19.5	51.2	1.0	36

Choffatia gr. *subbackeriae* (D'ORBIGNY, 1850) ♀

Pl. 16, figs. 1a–b, 2

Material: Several specimens from Units 2–5 of C1-Arroyo del Rincon, and loose from the Arroyo del Campamento.

Comments: This species group is characterized by evolute whorls and dense, fine ribbing. The whorl-section is slightly compressed and much higher than in the other species of *Choffatia* found at Coauilote. The primary ribs occur on the lower third of the flanks and are straight and radial. The primaries divide near mid-flank. The secondary ribs are almost as coarse as the primaries and have only very slight ventral interruption in most specimens. Some of the Coauilote specimens belonging to this group (e.g. pl. 16, fig. 2) are very similar to the holotype (in ARKELL 1958, Text-fig. 78); others (i.e., pl. 16, fig. 1) resemble the European species in the ribbing style, but they are more evolute and have a more depressed whorl-section.

Measurements (mm)

		D	U	H	W	U/D%	W/H	P
IGM-4280	bodych.	145	73	40	38	50.0	0.95	—
	phrag.	93	46.8	25.5	26	50.3	1.02	38
	phrag.	73	37	21	22	50.7	1.05	31

Choffatia furcula (NEUMAYR, 1871) ♀

Pl. 15, figs. 1a–b

1981 *Perisphinctes furcula* NEUMAYR, p. 41, pl. 14, figs. 1a–c.
1915 *Perisphinctes furcula* — LOCZY, p. 156, Text-fig. 129.
1931 *Choffatia* aff. *furcula* — SPATH, p. 353, pl. 54, figs. 7a–b.
1970 *H.* (m. *Homoeoplanulites*) *furculus* — MANGOLD, p. 70, Text-figs. 45, 47, pl. 6, figs. 4, 5.
1984 *Choffatia (Homoeoplanulites) furcula* — KHIMSHIASHVILI, p. 35, pl. 12, fig. 1.

Material: Several specimens from Units 3–7 of C1-Arroyo del Rincon.

Comments: Shell is moderately evolute, with subquadratic whorl-section; flanks are almost flat and venter slightly rounded. Primary ribs are dense, radial or slightly proverse. They bifurcate and, more rarely, trifurcate at mid-flank. Some intercalate ribs may also be present. The ribs pass uninterrupted over the venter. *Ch. furcula* belong to the group of *Ch. subbackeriae-funata.*

Measurements (mm)

		D	U	H	W	U/D%	W/H	P	S
IGM-4275	bodych.	98	46	28	28	46.9	1	38	42
	bodych.	75	31.5	25	24	42.0	0.96	—	—
McM-J2222	bodych.	86	35.2	28	27.5	40.9	0.98	35	46

Choffatia sp. indet. ♂

Pl. 12, fig. 4; Pl. 14, figs. 4a–b

Material: Numerous specimens from Units 1–6 of C1-Arroyo del Rincon.

Description: This small form (D = 40 to 80 mm) is very evolute, with ovate to subtrapezoidal and slightly compressed whorl-section. Primary ribs are radial to slightly proverse and prominent. They divide at mid-flank on the phragmocone, but at two-thirds whorl-height on the bodychamber. Secondary ribs, two or three per primary, are radial or slightly retroverse and pass over venter with a slight ventral depression. Parabolae are moderately developed on the phragmocone. Whorls are somewhat segmented by contrictions.

Comments: This form is very similar to some European species: *Ch.* cf. *ybbsensis* (JÜSSEN) in MANGOLD (1970, p. 67, pl. 4, figs. 4, 5), but the Mexican form has radial rather than prorsiradiate primary ribs. Some species of the *"Grossouvria" kontkiewiczi-variabilis* group are also similar in coiling, whorl-section and style of ribbing. The dif-

ferent *Choffatia* microconchs are associated with *Ch. burckhardti* ♀ and *Ch. suborion* ♀ and possibly represent their dimorphic partners.

Family Tulitidae Buckman, 1921

Genus *Bullatimorphites* Buckman, 1921

Subgenus *Kheraiceras* Spath, 1924

Bullatimorphites (Kheraiceras) bullatus (d'Orbigny, 1846) ♀ & ♂

Pl. 9, figs. 1–4

Macroconch (♀) (Pl. 9, figs. 1, 4)

v. 1983 *Bullatimorphites (Kheraiceras) bullatus* — Sandoval, p. 565, pl. 69, figs. 4a–b, pl. 72, figs. 2, 3a–b, Text-figs. 147b, 153e, g, 154 (with synonymy).

v. 1984 *Bullatimorphites (Kheraiceras) bullatus* — Westermann et al., p. 109, pl. 2, figs. 8a, b.

Material: Six complete specimens and 6 septate fragments from Units 3, 6 of C3-Alto de Teeolutla, and Unit 2 of C4-Alto del Variado.

Description: Phragmocone is very tightly sphaeroconic, whereas the mature bodychamber becomes elliptical. Phragmocone whorls are very depressed but the bodychamber is strongly contracted becoming markedly narrower than the phragmocone. At the beginning of the bodychamber, the umbilical seam extends radially and then bends adorally through 90–100°. Almost vertical umbilical wall has rounded edge. Blunt ribs are straight and pass evenly over the venter. Primary ribs are indistinct at the umbilical edge, divide into two or three secondary ribs near one-third of whorl height, and increase slightly in prominence as they pass over the venter. On the bodychamber, primary ribs are very blunt and disappear near the peristome; secondaries are continuous to the peristome but become less prominent and more widely spaced.

Comments: The subgenus is cosmopolitan and the species widely distributed. The only other *Kheraiceras* species recorded from Mexico is *B. (K.) v-costatus* (Burckhardt 1927). It differs in the curved secondary ribs of the intermediate whorls forming blunt ventral chevrons. Unfortunately, the holotype is lost making specific comparison difficult (Westermann et al. 1984). Perhaps *B. v-costatus* is merely a variant of *B. bullatus.*

At Coauilote, *B. bullatus* is associated with *Epistrenoceras histricoides* (Rollier), which, in Europe is known from the Retrocostatum Zone (Elmi 1967, Westermann & Callomon 1988). *B. bullatus* occurs in Europe in the Upper Bathonian and Lower Callovian (Hahn 1971, Sandoval 1983).

Measurements (mm)

		D	U	H	W	U/D%	W/H
IGM-4247	bodych.	81	19	34	50	23.5	1.47
		60	6.4	31	53	10.7	1.71
IGM-4244	phrag.	64	4	30	60	6.2	2.00
McM-J2223	bodych.	62	11.3	28.8	37.5	18.2	1.29

Microconch (♂) = *Bomburites microstoma* (d'Orbigny, 1846) (Pl. 9, figs. 2a–b, 3a–b)

1846 *Ammonites microstoma* d'Orbigny 1846, p. 413, pl. 142, figs. 3, 4.

1887 *Ammonites microstoma* — Quenstedt, p. 662, pl. 78, fig. 5 and ?8.

? 1905 *Sphaeroceras uhligi* Popovici-Hatzeg, p. 22, pl. 6, fig. 7.

? 1911 *Sphaeroceras suevicum* Roemer, p. 43, pl. 7, figs. 15, 17–21.

1923 *Sphaeroceras uhligi* — Lissajous, p. 89, pl. 19, fig. 4.

? 1954 *Bullatimorphites suevicus* — Arkell, p. 108, fig. 36.

v. 1958 [*Bullatimorphites?*] *Bomburites microstoma* — Westermann, p. 66, pl. 22, figs. 3a, 5.

v. ? 1958 [*Bull.?*] *Bomburites microstoma uhligi* — Westermann, p. 66, pl. 22, figs. 2, 4–6.

? 1959 *Treptoceras crimaciense* — Enay, p. 255, pl. 1, figs. 5–6.

? 1971 *Bullatimorphites (Bomburites) suevicus* — HAHN, p. 106, pl. 8, figs. 5–6, 8–10, Text-fig. 13.
v. 1983 *Bullatimorphites (Bomburites) uhligi* — SANDOVAL, p. 571, pl. 72, fig. 4, Text-fig. 153D.

Material: One complete and one worn specimen from Unit 2 of C4-Alto del Variado.

Description: This microconch attains a diameter of 25–35 mm.

Phragmocone has normal spheroconic coiling, but the mature bodychamber egresses and becomes strongly elliptical. The spindle-shaped whorls of the phragmocone are strongly depressed, whereas the three-quarters whorl long adult bodychamber is contracted and less inflated with flattened sides. Umbilical edge is sharp on the phragmocone but becomes increasingly rounded on the bodychamber. Ribs are blunt and straight, increasing in prominence as they over venter. Primary ribs are indistinct at the umbilical edge and divide into three secondary ribs at approximately one-third whorl-height. Secondary ribs are most prominent on the phragmocone and gradually become more blunt and widely spaced on the bodychamber. The septal suture is not visible.

Comments: Inner whorls and costation of the Coauilote specimens are very similar to the macroconch of *B. bullatus*. In view of the morphological similarity and the consistent association of the two forms, it is very likely that these smaller forms are the corresponding microconchs. *"Sphaeroceras uhligi"*, *"Sphaeroceras suevicum"* and *Treptoceras crimaciense* are very similar to *"Bomburites microstoma"*, normally coexist in the same levels, and therefore are possibly synonymous with the D'ORBIGNY's species.

Measurements (mm)

		D	U	H	W	U/D%	W/D
IGM-4245	bodych.	38	12.5	12.5	15	32.9	1.20
IGM-4245	bodych.	28	3.5	12.5	20	12.5	1.60

Family Reineckeiidae HYATT, 1900

Subfamily Neuqueniceratinae CARIOU, 1984

Genus *Neuqueniceras* STEHN, 1924

Comments: This genus has recently been discussed by RICCARDI et al. (1989) and we follow the classification adopted therein.

Neuqueniceras (Neuqueniceras) plicatum (BURCKHARDT, 1927) ♀

Pl. 12, figs. 3a,b; Pl. 13, figs. 1–5, 7a–b

v. 1927 *Reineckeia plicata* BURCKHARDT, p. 71, pl. 28, figs. 1–2, pl. 29, fig. 1.
v. 1927 *Reineckeia* juv. sp. ind. aff. *plicata* BURCKHARDT, p. 72, pl. 28, figs. 3–6.
v. 1984 *Neuqueniceras* (*Neuqueniceras*?) cf. *"neogeum"* — WESTERMANN et al., p. 108, pl. 1, figs. 5a,b.

Material: Numerous specimens and fragments from Units 3–7 of C1-Arroyo del Rincon.

Description: This medium-sized species has very evolute coiling with very wide (U/D = 0.50–0.60) and relatively shallow umbilicus. Whorl-section is ovate and depressed, especially in the outer whorls. Ornamentation varies through ontogeny: (1) On the inner whorls ribbing is typically perisphinctoid, consisting of prominent radial primaries which bifurcate at mid-flank, and of finer secondaries. These cross straight over the venter with shallow to incipient interruption. (2) This type of ribbing gradually changes to prominent, blade-like primaries which increase on outer whorls to form elongate bullae. (3) The bullae become thick tubercles on the last part of the adult bodychamber. Adult secondaries are less prominent than on the inner whorls. The ratio of secondaries/primaries increases through ontogeny, becoming 5/1 on the last half-whorl. Two deep constrictions occur on each whorl.

Comments: According to BURCKHARDT's original description, this species lacks tubercles, but they are apparent on the last whorl of his figure. *N. plicatum* has some typical characters of *Choffatia*, especially the inner

whorls which may be very similar to *Ch. burckhardti* n. nov. and *Ch. suborion* BURCKHARDT. Both these species, however, miss tubercles, have less depressed and more ovate outer whorls, weaker or no ventral interruptions, and thinner secondaries. *N. (Neuqueniceras) steinmanni* (STEHN) and *N. (N.) caracolense* (STEHN) resemble *N. (N.) plicatum*, but differ in the slightly less depressed whorl-section, longer and less blade-like primaries, and less developed secondaries.

The specimen figured by WESTERMANN et al. (1984) as *N.* (*N.* ?) cf. *"neogeum"*, loose from the Yucuñuti Formation, is a rather typical *N. (N.) plicatum*.

The Mexican species occurs in the Steinmanni Zone and, possibly, the earliest Vergarensis Zone.

Measurements (mm)

		D	U	H	W	U/D%	W/H	P	S
IGM-4260	bodych.	77	44.7	16.5	25.5	58.1	1.55	17	34
		61	35.5	13.0	20	58.2	1.54	—	—
IGM-4262	bodych.	88	52.4	21	28.5	59.5	1.36	17	38
	phrag.	71	41	15.5	22.0	57.7	1.41	—	—
McM-J2224	phrag.	77.5	42	19.5	26.5	54.2	1.36	20	40
IGM-4265	bodych.	60	32.5	16.5	25.0	54.2	1.51	16	34
	phrag.	47	25	12.5	17.8	53.2	1.42	—	—
IGM-4267	bodych.	72	37	17.8	26.0	51.4	1.46	—	—
	phrag.	55	28.7	15.7	21.0	52.2	1.34	—	—
IGM-4266	phrag.	57	28	16.8	20.0	49.1	1.19	24	32
McM-J2225	phrag.	70	38	17.5	25.5	54.2	1.46	18	34
McM-J2226	bodych.	94	48	26	32.7	51.1	1.43	18–19	58–

Neuqueniceras (Neuqueniceras) waitzi (BURCKHARDT, 1927)

Pl. 14, figs. 1a–b, 2; pl. 19, fig. 2

v. 1927 *Perisphinctes waitzi* n. sp. BURCKHARDT, p. 75, pl. 30, figs. 2–5.

Material: Seven phragmocones from Units 6–7 and one loose of C1-Arroyo del Rincon.

Description: The larger specimens are septate to 75 mm in diameter. Shells are evolute with wide and relatively shallow umbilicus. Most inner whorls are ovate and depressed, becoming subquadratic with the last septate whorl. Umbilical wall is low but steep, flanks are slightly convex, and venter is rounded. Ribbing consists of sharp, radial or very slightly proverse primaries, terminating with maximal elevation (without proper tubercles). Primaries bifurcate at mid-flank and later trifurcate into thick secondary ribs, which cross the venter with shallow to well marked interruption. Three or four constrictions per whorl are each followed by a simple rib.

Comments: The holotype (we have a plaster cast) and all of our material are entirely septate; but complete morphogenesis is essential for the systematics of Reineckeiidae. This species should certainly be included in *Neuqueniceras* rather than in Perisphintinae. *N. waitzi* is not very different from *N. steinmanni* (STEHN), a slightly more evolute species with longer primary ribs. *"Reineckeia caracolense"* STEHN (1923, p. 104, pl. 4, fig. 2) and *"R. biscissa"* STEHN (1923, p. 136, pl. 3, fig. 5) are possibly synonymous with *N. steinmanni* (cf. RICCARDI et al. 1989) and differ similarly. The inner whorls of the abundant *N. (Frickites)* cf. *bodenbenderi* (TORNQUIST) from Coauilote resemble *N. waitzi*, but they are more strongly tuberculate at similar diameters. *N. waitzi* occurs in the upper part of the Steinmanni Zone, and in the lower part of Vergarensis Zone.

Measurements (mm)

		D	U	H	W	U/D%	W/H	P	S
IGM-4269	phrag.	78	35.5	23.5	23.5	45.5	1.0	36	48
	phrag.	60	27	18.4	19	45.0	1.02	35	—
IGM-4270	phrag.	62	28.5	19	20	46.0	1.06	29	—
Holotype	(cast)	72	34.4	22	23.2	47.8	1.05	35	—

Neuqueniceras (Neuqueniceras?) gleimi (STEINMANN, 1881) ♂

Pl. 14, figs. 3a–b; Pl. 17, fig. 2

v. 1881 *Perisphinctes gleimi* STEINMANN, p. 272, pl. 9, fig. 5.
1895 *Perisphinctes gleimi* — PARONA & BONARELLI, p. 186, pl. 10, fig. 4.

Material: One specimen from Unit 13 and 3 loose from above Unit 6 of C1-Arroyo del Rincon.

Description: Complete microconchs attain 105 mm in diameter. Whorls are very evolute with wide and shallow umbilicus especially when mature. Whorl-section of inner whorls is ovate depressed; last septate whorl subquadratic; and bodychamber slightly compressed. Earliest whorls (D ≃ 4 mm) are smooth and followed by a stage with proverse, bifurcate or simple ribs without tubercles. The adolescent whorls have dense, sharp and slightly proverse primary ribs which bifurcate at approximately two-fifths of whorl-height. The furcation point carries a small, sharp, blade-like tubercle. The secondaries are almost as coarse as the primaries and pass over the venter with very shallow ventral depression. Constrictions, two per whorl, are of moderate size.

Comments: The holotype (monotypy) is a small inner whorl from Caracoles, Chile. WESTERMANN has examined the type and matched it with a topotype from the Agua Dulce section (McM-J1141). We here describe the first complete specimen.

This species resembles some *"Homoeoplanulites"* species which, however, have parabolic nodes and no tubercles on the furcation point. Among Andean species, *"Perisphinctes andium"* STEINMANN (1881, p. 275, pl. 9, figs. 3–4) resembles *N. gleimi* but has less compressed whorls and shorter primaries. The type of *N. gleimi* came from the Lower Callovian of Caracoles. Mexican species occur together in the Bodenbenderi Zone.

Measurements (mm)

		D	U	H	W	U/D%	W/H	P	S
IGM-4271	bodych.	95	52.8	26.2	23.7	55.6	0.90	43	—
	?	75	39	19.3	18.8	52.0	0.97	40	39
McM-J2227	bodych.	105	56	27.5	—	53.3	—	—	—
	bodych.	74	37	20	18.5	50.0	0.92	—	—
McM-J2110	?	24	10	7.4	—	41.7	—	44	—
		18	7.4	6.5	7.5	41.1	1.16	—	—

Subgenus *Frickites* JEANNET, 1951

Neuqueniceras (Frickites) gr. *bodenbenderi* (TORNQUIST, 1898) & *antipodum* (GOTTSCHE, 1878) ♀ & ♂

Pl. 17, figs. 1a, b, 3–4; Pl. 18, figs. 1a, b; Text-fig. 9e

? 1898 *Reineckeia bodenbenderi* TORNQUIST, p. 51, pl. 10, fig. 1.
v. 1984 *Neuqueniceras (Frickites)* cf. *bodenbenderi* — WESTERMANN (in WESTERMANN et al.), p. 108, pl. 2, figs. 1a–c.
v. 1989 *Neuqueniceras* cf. *bodenbenderi* — RICCARDI et al., pl. 9, figs. 1, 2.

Material: Six almost complete specimens and many phragmocone and/or bodychamber fragments from Units 12–15 of C1-Arroyo del Rincon and Units 12–16 of C2-Arroyo del Campamento.

Description: The macroconch (♀) is large attaining 350 mm in diameter. Shells are very evolute with wide and shallow to sometimes fairly deep umbilicus. Whorl-section is variable, infraspecifically and especially ontogenetically. Inner whorls are ovate depressed; middle whorls subrectangular depressed to subquadratic; and the outer whorl strongly depressed subovate. Umbilical wall is steep with rounded margin; flanks are slightly convex and venter is rounded.

On inner whorls, the ribbing is perisphinctoid, radial or very slightly proverse; primary ribs bifurcate approximately at mid-flank into prominent and dense secondary ribs; a slightly ventral interruption is present. Middle whorls have moderatly short primaries with spinous mid-lateral tubercles; secondaries are very prominent with slight ventral interruption. Immediately following a constriction, the ornamentation changes suddenly with the outer one or two whorls: primary ribs become partially obsolete and very prominent, conical, mid-lateral spines develop; secon-

daries, up to seven or eight per primary, are broad but very blunt and may become obsolete. Near the aperture, three or four primaries tend to become prominent, whereas the blade-like tubercles are reduced. Every whorl has two, rarely three, well developed constrictions accompanied by a prominent and simple rib. The septal suture is strongly retracted (Text-fig. 9e).

The possible microconch (♂), represented by only three small specimens and some fragments, attains 60 mm in diameter. The shells are very evolute with ovate to subquadratic whorl-section and rounded venter. Ribbing remains strong through ontogeny. On the bodychamber, primaries usually bifurcate at mid-flank, whereas some remain single. Tubercles and ventral interruption are absent or very poorly developed.

Comments: The type of *N. (F.) bodenbenderi* is a large and very evolute ammonite from Espinazito Pass, Argentina. Following TORNQUIST (1898), the species has been frequently quoted and some specimens attributed to this species have been figured by WESTERMANN et al. (1984) and RICCARDI et al. (1989). But all of these specimens seem to be slightly more involute and with shorter primary ribs than the type. WESTERMANN and RICCARDI, however, re-examined the type locality. They found that topotypes of *N. bodenbenderi* tend to be somewhat more inflated and involute than the holotype (missing?) which thus appears to be an extreme variant. Mexican specimens from Coauilote are, likewise, more involute and with shorter primaries than the holotype; but they do closely resemble the Andean topotypes. Some Mexican material resembles the Chilean *"Simoceras antipodum"* GOTTSCHE (1878, p. 17, pl. 3, fig. 6) and *"Reineckeia euactis"* STEINMANN (1881, p. 287, pl. 12, fig. 5) which are only slightly more involute and more inflated than *N. bodenbenderi.*

The Andean *Neuqueniceras (N.) steinmanni* (STEHN) is smaller and has longer primaries and less developed tubercles.

Measurements (mm)

		D	U	H	W	U/D%	W/H	P	S
McM-J2228a ♀	bodych.	160	90	41	54	56.0	1.32	12	25
IGM-4284 ♀	bodych.	156	77	52	58	41.4	1.12	15	—
McM-J2228b ♀	bodych.	124	62.5	35	46	50.4	1.31	19?	34
	phrag.	80	40	22	27.2	50.0	1.00?	—	—
McM-J2115 ♀	bodych.	154	78.5	45	—	51.0	—	16	—
	bodych.	137	68	40	50	49.6	1.25	20	—
	phrag.	85	41	29	32	48.2	1.1	39	39?
McM-J2229 ♀	bodych.	194	100	57	73	51.5	1.28	12	—
IGM-4288 ♀	bodych.	156	84	44	56	53.8	1.27	12	30
IGM-4286 ♀	phrag.	60	31	16.3	17.5	51.7	1.07	29?	34
	phrag.	48	24.5	12.2	14	51.0	1.15	29	27
IGM-4285 ♂	bodych.	52	25.5	15	15.5	41.0	1.03	38	33
McM-J2230 ♂	bodych.	58	30	14.4	14	51.7	0.97	34	34

Neuqueniceras (Frickites) n. sp. A.

Pl. 15, figs. 4, 5a–c; Text-fig. 9f

Material: Fourteen incomplete specimens from Units 14, 15 of C1-Arroyo del Rincon; 2 fragments of inner whorls from Units 14, 16 of C2-Arroyo del Campamento.

Description: Shells are very evolute with wide but relatively deep umbilicus. Whorl-section is ovate and depressed through ontogeny, with strongly convex flanks and gently rounded venter. Earliest whorls (D ≃ 2–3 mm) are smooth, followed by a stage (10–12 mm) with dense primary ribs and small tubercles on the furcation points. Subsequently, primaries gradually become blunt and divide above mid-flank, whereas the round tubercles become large on the adult stage. Secondary ribs, 3 per primary on middle whorls and up to 6 on outer whorls, have a well developed ventral interruption. Each whorl has 2 rather deep constrictions.

Comments: This species resembles the European *Reineckeia franconica* (QUENSTEDT) and *R. convexa* (CARIOU) which have a similar ontogeny of ornamentation, but differ in the shorter primaries, coarser secondaries, slightly

greater involution, and more inflated whorl-section. *N.* gr. *bodenbenderi-antipodum*, from the same level, develops a different style of ribbing and later the tubercles, and has less inflated inner and middle whorls.

Measurements (mm)

	D	U	H	W	U/D%	W/H	P
IGM-4218 phrag.	41	21	11	12	51.2	1.09	22
IGM-4219 phrag.	73	41	17	22.5	56.2	1.32	—

Subfamily Reineckeiinae Hyatt, 1900

Genus *Rehmannia* Schirardin, 1956

Rehmannia cf. *grossouvrei* (Petitclerc, 1915)

Pl. 20, figs. 1a, b, 2

cf. 1980 *Rehmannia (Rehmannia) grossouvrei* (forme macroconch) — Cariou, p. 44, pl. 2, figs. 1a–b, 2, 3, pl. 3, figs. 1a–b, Text-figs. 10, 11, 14, 16–18 (with synonymy).

Material: Five bodychamber fragments and 2 complete specimens from Unit 14 and 2 fragments from Unit 17 of C1-Arroyo del Rincon.

Description: The fragments indicate a shell of medium size (D ≃ 140 mm) with wide (U/D ≃ 0.50) and shallow umbilicus. Whorl-section is ovate-subtrapezoid with flat flanks and wide, broadly rounded venter. Primary ribs, radial or slightly arched, bifurcate or, rarely, trifurcate at two-fifth whorl-height in well developed tubercles. Some intercalatory and undivided ribs bearing tubercles are also present. The secondaries, radial or slightly proverse, cross the venter with only slight ventral interruption. Toward bodychamber end, the tubercles become bullae.

Comments: This Mexican material closely resembles some specimens figured by Cariou under *grossouvrei* (e.g. Cariou 1980, pl. 2, fig. 1, pl. 3, figs. 1a–b). The type (Petitclerc 1915, pl. 11, fig. 3, pl. 14, fig. 3), however, seems to have slightly subrectangular, depressed whorls, more concave ribbing, and deeper ventral interruptions. According to Cariou (1980), *R. grossouvrei* occurs in the Rehmanni Subzone of France and Marocco. The probable presence of this species in Mexico, together with *Neuqueniceras (Frickites)* spp., has biogeographic implications for the opening of the Hispanic Corridor.

Measurements (mm)

	D	U	H	W	U/D%	W/H
McM-J2231a bodych.	133	70	32	28	52.6	0.87
McM-J2231b bodych.	140	70	42	33	50	0.79

Rehmannia rehmanni (Oppel, 1856) ♀ & ♂

Pl. 19, figs. 1a, b, 3a, b; Pl. 20, figs. 3a, b

Macroconch (♀)

1980 *Rehmannia (Rehmannia) rehmanni* — (forme macroconch) — Cariou, p. 58, pl. 3, figs. 2a–b, pl. 4, figs. 1–4, Text-figs. 12, 15, 19–22 (with synonymy).

Material: Two almost complete specimens and 1 fragment from Units 17, 18 of C1-Arroyo del Rincon.

Description: Macroconch is up to 245 mm in diameter and very evolute, with wide and shallow umbilicus. The whorl-section is subquadratic, with rounded umbilical and ventro-lateral shoulders of the inner whorls, becoming depressed ovate at phragmocone end and bodychamber. Inner whorls have sharp, radial or slightly projected primary ribs which bifurcate at two-fifth whorl height in a small lamellar spine. Secondaries are as strong as primaries and strongly interrupted at mid-venter. On middle whorls, primaries gradually become blunt, tubercles more developed, and trifurcation the norm with some intercalatories. In the adolescent stage, primaries become more

widely spaced and the secondaries denser. Finally, primary ribs become obsolete, distant tubercles are well developed, and secondaries obsolescent. At aperture, 2 or 3 primaries are again present. Two constrictions occur on each of the outer whorls.

Microconch (♂)

1980 *Rehmannia (Rehmannia)* gr. *rehmanni* Microconch, form *riveli* — CARIOU, p. 72, pl. 4, figs. 5a–c, 6, pl. 5, figs. 1–3, Text-figs. 13a–c, 15.

Material: One complete specimen and 15 fragments from Units (?15), 17, 18 of C1-Arroyo del Rincon, and from Units 16–19 of C2-Arroyo del Campamento.

Description: This microconch reaches about 100 mm in diameter. Shell is evolute with wide and shallow umbilicus. Whorl-section of the phragmocone is depressed ovate and tends to become subquadratic or subrectangular with the bodychamber. Ribbing consists of radial primaries with small, blade-like spines at two-fifth whorl-height on the inner whorls. Primaries bifurcate into radial, prominent secondaries with deep ventral interruption. Some undivided ribs are also present. The blade-like tubercles disappear near the aperture. There are 2 shallow constrictions per whorl.

Comments: WESTERMANN et al. (1984) found forms close to *Rehmannia rehmanni* ♀ near Coauilote. The new collections confirm the presence in Mexico of this and other typically Mediterranean species: *Rehmannia grossouvrei* and *Reineckeia* gr. *franconica.* They resemble *Neuqueniceras* s. str. and *N. (Frickites)* species which occur at lower levels in the same sections (El Rincon and Campamento) and corroborate the Pacific (Andean) origin of the Reineckeiidae first supposed by WESTERMANN & RICCARDI (1985).

The morphogeny of *R. rehmanni* ♂ (m) resembles *Neuqueniceras (N.) waitzi* (BURCKHARDT), *R. rehmanni* ♀ (M.), and the *N. (Frickites) bodenbenderi-antipodum* group, but the *Neuqueniceras* s. str. and *N. (Frickites)* species have longer primary ribs, less developed tubercles, less marked ventral interruptions, and usually, more ovate depressed bodychambers.

Measurements (mm)

		D	U	H	W	U/D%	W/H
IGM-4631 ♀	bodych.	245	136	72	—	55.5	—
	phrag.	195	107	50	60	54.8	1.2
McM-J2232a ♂	bodych.	74	35.5	23	23	48.0	1
McM-J2232b ♂	bodych.	60	29.3	18.2	18.3	48.8	1

Genus *Reineckeia* BAYLE, 1878

Reineckeia gr. *franconica* (QUENSTEDT, 1886) & *convexa* CARIOU, 1980 ♀ & ♂

Pl. 16. figs. 3a–b

Material: One septate macroconch from Unit 18 and 6 small fragments from Units 17–18 of C1-Arroyo del Rincon.

Description: The macroconch is evolute (U/D ≃ 53) with ovate depressed whorl-section through ontogeny. Inner and intermediate whorls have dense, sharp, radial or slightly proverse primary ribs ending at mid-flank in small, punctiform tubercles. Primaries bifurcate or, rarely, trifurcate into radial and sharp secondaries with ventral interruption developed mainly on the internal mold. On the last phragmocone whorl, primary ribs become obsolete, tubercles are well developed, and secondaries (5 per primary) are reduced.

The small fragments belong to evolute microconchs (♂) with ovate-subquadratic whorl-section. Slightly proverse primaries bifurcate or trifurcate in punctiform tubercles between mid-flank and two-fifth whorl height. Secondaries, slightly more blunt than primaries, cross the venter with well developed interruption. Whorls are segmented by constrictions.

Comments: *Reineckeia franconica* closely resembles *R. convexa* CARIOU. According to CARIOU (1980), the former differs only by more ovate whorl-section, coarser ribs on inner whorls, and more prominent tubercles. The Mexican material, from highest unit of the Arroyo del Rincon section, resembles both Mediterranean species,

although the macroconch may be slightly more evolute. *Rehmannia rehmanni* (OPPEL) which occurs below, has a subquadratic (rather than ovate) and less depressed whorl-section, and misses tubercles on the inner whorls. WESTERMANN et al. (1984, p. 108, pl. 1, figs. 6a, b) found *R.* cf. *franconica* in the upper Yunuñuti Formation.

In Europe, *Reineckeia franconica* and *R. convexa* occur in the upper Macrocephalus and lower Gracilis Zones. The Mexican specimens appear to be of similar age.

Measurements (mm)

	D	U	H	W	U/D%	W/H
IGM-4632 phrag.	95	50	24	27	52.6	1.12
	66	33	16	19.2	50.0	1.2

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Explanation of Plates

Plate 1

(nat. size unless otherwise indicated)

Figs. 1, 4, 6-7. *Ptychophylloceras plasticum* (BURCKHARDT).
1, a, b. Complete phragmocene (?) lateral and ventral views, IGM-4192. Unit 14 of section C; Bodenbenderi Zone, *Fricki.* Association.
4 a, b. Complete phragmocone, lateral and ventral views, IGM-4193. Unit 13 of section C1; Bodenbenderi Zone, *Fri.* Association.
6 a, b. Inner whorls, lateral and ventral views, IGM-4194. Unit 6 of section C1; Steinmanni Zone, *Lilloettia* Association.
7. Inner whorls, lateral view IGM-4195. Unit 15 of section C1; Bodenbenderi Zone, *inflatum* Association.

Figs. 2, 3, 5. *Phylloceras plicatum* NEUMAYR
2 a, b. Phragmocone, lateral and ventral views, IGM-4196. Unit 6 of section C1; Upper Bathonian Steinmanni Zone, *Lilloett.* Association.
3. Phragmocone, lateral view, IGM-4197. Unit 7 of section C; Vergarensis Zone.
5. Phragmocone, lateral view, IGM-4198. Unit 6 of section C1; Steinmanni Zone, *Lilloettia* Association.

Figs. 8, 9. *Holcophylloceras* sp. ind.
8. Inner whorls, lateral view, IGM-4199, x.2. Unit 15 of section C1; Bodenbenderi Zone, *inflatum* Association.
9 a, b. Inner whorls, ventral and lateral views, IGM-4200, x.2. Same unit as figure 8.

Plate 2

(nat. size unless otherwise indicated)

Figs. 1, 4. *Oxycerites (Alcidellus) cualacensis* n. sp. ♀
1 a, b. Holotype, complete specimen, lateral and ventral views, IGM-4201. Section C1; Bodenbenderi Zone?
4. Almost complete specimen, lateral view, IGM-4202. Unit 6 of section C1; Steinmanni Zone, *Lilloettia* Association.

Figs. 2 a, b. *Oxycerites (Alcidellus)* gr. *tenuistriatus* (DE GROSSOUVRE). Phragmocone, lateral and ventral views, IGM-4203. Unit 8 of section C4; Steinmanni Zone.

Figs. 3 a, b. *Oxycerites (Paroecotraustes)* cf. *bronni* (ZEISS), sensu ELMI, ♂ x 2; almost complete specimen, lateral and ventral views, IGM-4. Unit 15 of section C1; Bodenbenderi Zone, *inflatum* Association.

Figs. 5 a, b. *Guerriericeras inflatum* (WESTERMANN) ♀; complete specimen, lateral and ventral views, IGM-4205. Unit 15 of section C1; Bodenbenderi Zone, *inflatum* Association.

Plate 3

(nat. size unless otherwise indicated)

Figs. 1-2. *Oxycerites (Alcidellus) obsoletoides* RICCARDI, WESTERMANN & ELMI ♀
1 a-b. Almost complete specimens, lateral and ventral views, IGM-4206. Unit 7 of section C1; Vergarensis Zone.
2 a-b. Complete body chamber, lateral and ventral views, IGM-4207. Unit 8 of section C4; Steinmanni Zone.

Figs. 3 a-b. *Oxycerites* (O. ?) sp. ind., lateral and ventral views, IGM-4208. Unit 2 of section C4; Steinmanni Zone, *histricoides* Association.

Figs. 4-6, 8. *Jeanneticeras malbosi* ELMI ♂
4 a-b. Almost complete specimen, lateral and ventral views, IGM-4209, x 2. Units 15 of section C; Bodenbenderi Zone, *inflatum* Association.
5, 6 a-b. Complete specimen, IGM-4210, same locality as fig. 4; lateral view x 2 (5), and end of the bodychamber, ventral and lateral views x 2 (6 a, b).
8. Fragment of almost complete specimen, IGM-4211 x 2; same locality as Fig. 4.

Figs. 7, 10, 16. *Oxycerites (Paroecotraustes)* gr. *waagenis* (STEPHANOV).
7. Complete specimen, lateral view, IGM-4212. Unit 8? of section C4; Steinmanni Zone.
10. Complete specimen, lateral view, IGM-4213. Unit 15 of section C1; Bodenbenderi Zone, *inflatum* Association.
16. Complete specimen with lappet, lateral view McM-J1141 from Caracoles, Chile. Upper Bodenbenderi Zone.

Fig. 9. *Oxycerites (Paroesotraustes)* cf. *bronni* (ZEISS) sensu ELMI, lateral view, IGM-4214. Unit 15 of section C1; Bodenbenderi Zone; *inflatum* Association.

Fig. 11. *Oxycerites (Alcidellus) cualacensis* n. sp., lateral view, IGM-4215. Loose from section C1.

Fig. 12–15. *Guerriericeras inflatum* (WESTERMANN) ♀ & ♂; Bodenbenderi Zone, *inflatum* Association.
12 a–b. Macroconch fragment of phragmocone and bodychamber, ventral and lateral views, IGM-4216. Unit 15 of section C2.
13 a–b. Microconch fragment, lateral and ventral views. Unit 15 of section C1.
14. Microconch, complete lateral view; same locality as fig. 13.
15. Microconch?, lateral view; same locality as Fig. 13.

Plate 4

(nat. size unless otherwise indicated)

Fig. 1 a–c. *Xenocephalites nikitini* (BURCKHARDT) ♂, lateral and ventral views, IGM-4217, x 2. Unit 6 of section C1; Steinmanni Zone, *Lilloettia* Association.

Figs. 2–4. *Phlycticeras mexicanum* n. sp.
2. Almost complete specimen IGM-4218. Loose from section C1.
3 a, b. Holotype, complete bodychamber, lateral and ventral views, IGM-4219. Unit 13 of section C1, Bodenbenderi Zone, *Frickites* Association.
4 a, b. Phragmocone fragment, lateral and ventral views, IGM-4220. Unit 6 of section C1; Steinmanni Zone, *Lilloettia* Association.

Figs. 5–9. *Parapatoceras distans* (BAUGIER & SAUZE), fragments, ventral and lateral views. 5, IGM-4221; 6, IGM-4222; 7, IGM-4223; 8, IGM-4224; 9, IGM-4225. Unit 15 of section C; Bodenbenderi Zone, *inflatum* Association.

Plate 5

(nat. size unless otherwise indicated)

Fig. 1 a–b. *Lilloettia boesei* (BURCKHARDT) ♀, complete specimen, lateral and ventral view, IGM-4226. Unit 3 of section C1; Steinmanni Zone, *Lilloettia* Association.

Fig. 2 a–b. *Xenocephalites nikitini* (BURCKHARDT) ♂, complete specimen, lateral and ventral views, x 2, IGM-4227. Unit 15 of section C1; Bodenbenderi Zone, *inflatum* Association.

Fig. 3 a, c. *Lilloettia steinmanni* (SPATH) ♀, complete specimen, lateral and ventral views, IGM-4228. Unit 6 of section C1; Steinmanni Zone, *Lilloettia* Association.

Fig. 4 a–c. *Eurycephalites vergarensis* (BURCKHARDT) ♀, complete specimen, lateral and ventral views, IGM-4229. Unit 8 of section C1; Vergarensis Zone.

Plate 6

(nat. size unless otherwise indicated)

Figs. 1 a–b. *Lilloettia boesei* (BURCKHARDT) ♀, almost complete specimen, lateral and ventral views, IGM-4230. Unit 6 of section C1; Steinmanni Zone, *Lilloettia* Association.

Fig. 2. *Xenocephalites neuquensis* (STEHN) ♂, fragmentary specimen; lateral view, IGM-4231. Unit 15 of section C1; Bodenbenderi Zone, *inflatum* Association.

Figs. 3, 5. *Xenocephalites* n. sp. A ♂.
3. Almost complete specimen, IGM-4232. Unit 15? of section C1; Bodenbenderi Zone.
5 a–b. Complete bodychamber, lateral and ventral views, IGM-4233. Unit 14 of section C1; Bodenbenderi Zone, *Frickites* Association.

Fig. 4 a–b. *Eurycephalites* n. sp. A. ♀, almost complete specimen, lateral and ventral views, IGM-4234. Unit 14 of section C1; Bodenbenderi Zone, *Frickites* Association.

Fig. 6. *Lilloettia boesei* (BURCKHARDT) ♀ juv. or *Xenocephalites* sp. ind. ♂, almost complete specimen x 2, IGM-4235. Unit 6 of section C1; Steinmanni Zone, *Lilloettia* Association.

Plate 7

(nat. size unless otherwise indicated)

Fig. 1 a–b. *Lilloettia steinmanni* (Spath) ♀, complete specimen, lateral and ventral views, x 2, IGM-4236. Unit 6 of section C1; Steinmanni Zone, *Lilloettia* Association.

Fig. 2 a–b. *Eurycephalites* cf. *rotundus* (Tornquist) ♀, lateral and ventral views, x 2, IGM-4237. Unit 15 of section C2; Bodenbenderi Zone, *inflatum* Association.

Fig. 3 a–b. *Xenocephalites nikitini* (Burckhardt) ♂, almost complete specimen, lateral and ventral views, x 2, IGM-4238. Unit 15 of section C1; Bodenbenderi Zone, *inflatum* Association.

Fig. 4. *Paracuariceras* cf. *incisum* Schindewolf, bodychamber? fragment, lateral view, IGM-4239. Unit 15 of section C1; Bodenbenderi Zone, *inflatum* Association.

Plate 8

(all nat. size)

Fig. 1 a–b. *Imlayoceras*? cf. *extremum* (Tornquist) ♀, complete bodychamber and deformed phragmocone, lateral and ventral views, IGM-4240. Unit 15 of section C2; Bodenbenderi Zone, *inflatum* Association.

Figs. 2, 3. *Choffatia boehmi* (Steinmann) (♀?)

2. Fragment of almost complete specimen, together with the nucleus of *Neuqueniceras* sp., IGM-4241. Unit 7? of section C1; Vergarensis Zone.

3 a–b. Phragmocone, lateral and ventral views, IGM-4242. Unit 6 of section C1; Steinmanni Zone, *Lilloettia* Association.

Fig. 4. *Choffatia gottschei* (Steinmann) (♀?), lateral view, IGM-4243. Unit 6 of section C1; Steinmanni Zone, *Lilloettia* Association.

Plate 9

(nat. size unless otherwise indicated)

Figs. 1–4. *Bullatimorphites (Kheraiceras) bullatus* (d'Orbigny) ♀ & ♂.

1 a–c. Macroconch (♀), complete phragmocone, lateral and ventral views, IGM-4244. Unit 2 of section C1; Steinmanni Zone, *histricoides* Association.

2 a–b. Microconch (♂) = *Bomburites microstoma*, almost complete specimens, IGM-4245. Same locality as Fig. 1.

3 a–g. Microconch (♂), complete IGM-4246. Same locality as Fig. 1.

4 a–c. Macroconch (♀), almost complete, IGM-4247. Same locality as Fig. 1.

Figs. 5 a–b. *Choffatia constricta* (Burckhardt), phragmocone, lateral and ventral views, IGM-4248. Unit 3 of section C3; Steinmanni Zone, *histricoides* Association.

Figs. 6–8. *Epistrenoceras histricoides* (Rollier). Steinmanni Zone, *histricoides* Association.

6 a–b. Inner whorls fragment, lateral and ventral views, IGM-4249, x 2. Unit 3 of section C3.

7. Complete phragmocone, lateral view, IGM-4250. Unit 3 of section C4.

8 a–b. Almost complete specimen, lateral and ventral views, IGM-4251. Unit 6 of section C3.

Plate 10

(all nat. size)

Figs. 1, 3. *Choffatia* cf. *jupiter* (Steinmann) ♀. Steinmanni Zone, *histricoides* Association.

1 a–b. Phragmocone fragment, lateral and ventral views, IGM-4252. Unit 2 of section C3.

3. Bodychamber fragment, lateral view, IGM-4253. Unit 2 of section C4.

Fig. 2. *Choffatia suborion* (Burckhardt) ♀, almost complete specimen, lateral view, IGM-4254. Unit 3 of section C1; Steinmanni Zone, *Lilloettia* Association.

Fig. 4 a–b. *Oxycerites (Alcidellus) obsoletoides* Riccardi, Westermann & Elmi ♀, bodychamber fragment, IGM-4255. Same locality as Fig. 2.

Fig. 5 a–b. *Probecticoceras blanazense* Elmi ♀. Phragmocone fragment, lateral and ventral views, IGM-4256. Unit 2 of section C3; Steinmanni Zone, *histricoides* Association.

Plate 11

(all nat. size)

Fig. 1 a–b. *Choffatia burckhardti* n. nov. SANDOVAL & WESTERMANN ♀, complete specimen without inner whorl, lateral and ventral views, IGM-4257. Unit 3 of section C1; Steinmanni Zone, *Lilloettia* Association.

Plate 12

(all nat. size)

Figs. 1–2. *Choffatia suborion* (BURCKHARDT) ♀. Steinmanni Zone, *Lilloettia* Association.
1. Almost complete specimen, lateral view, IGM-4258. Unit 6 of section C1.
2 a–b. Phragmocone and part of bodychamber, ventral and lateral views, IGM-4259. Unit 3 of section C1.

Fig. 3 a–b. *Neuqueniceras (N.) plicatum* (BURCKHARDT) ♀, almost complete without inner whorls, lateral and ventral views, IGM-4260. Unit 6 of section C1; Steinmanni Zone, *Lilloettia* Association.

Fig. 4 a–b. *Choffatia* sp. ind. ♂ aff. *suborion*, lateral and ventral views, IGM-4261. Unit 6 of section C1; Steinmanni Zone, *Lilloettia* Association.

Plate 13

(all nat. size)

Figs. 1–5, 7. *Neuqueniceras (N.) plicatum* (BURCKHARDT) ♀ & ♂
1 a–b. Almost complete macroconch (♀), lateral and ventral views, IGM-4262. Unit 6 of section C1; Steinmanni Zone, *Lilloettia* Association.
2 a–b. Microconch (♂) phragmocone and bodychamber fragment, lateral and ventral views, IGM-4263. Unit 7 of section C1; Vergarensis Zone.
3 a–b. Microconch (♂), fragment, lateral and ventral views, IGM-4264. Same locality as Fig. 2.
4 a–b. Macroconch (♀), ventral and lateral views, IGM-4265. Unit 6 of section C1; Steinmanni Zone, *Lilloettia* Association.
5 a–5. Macroconch (♀), lateral and ventral views, IGM-4266. Unit 7 of section C1; Vergarensis Zone.
7 a–b. Macroconch (♀), lateral and ventral views, IGM-4267. Unit 6 of section C1; Steinmanni Zone, *Lilloettia* Association.

Fig. 6 a–b. *Choffatia boehmi* (STEINMANN) ♂, almost complete specimen, lateral and ventral views, IGM-4268. Unit 6 of section C1; Steinmanni Zone, *Lilloettia* Association.

Plate 14

(all nat. size)

Figs. 1–2. *Neuqueniceras (N.) waitzi* (BURCKHARDT) (♀?)
1 a–b. Completely septate specimen, lateral and ventral views, IGM-4269. Unit 6 of section C1; Steinmanni Zone, *Lilloettia* Association.
2. Completely septate, lateral view, IGM-4270. Unit 7 of section C1; Vergarensis Zone.

Fig. 3 a–b. *Neuqueniceras (N.) gleimi* (STEINMANN) (♂ ?), complete specimen, lateral and ventral views, IGM-4271; Lower Callovian.

Fig. 4 a–b. *Choffatia* sp. ind. ♂, body chamber fragment, lateral and ventral views, IGM-4272. Unit 4 of section C1; Steinmanni Zone, *Lilloettia* Association.

Fig. 5 a–b. *Choffatia gottschei* (STEINMANN) (♀?), almost complete specimen, lateral and ventral views, IGM-4273. Unit 4 of section C1; Steinmanni Zone, *Lilloettia* Association.

Figs. 6 a–b. *Choffatia boehmi* (STEINMANN) ♂, almost complete specimen, lateral and ventral views, IGM-4274. Unit 6 of section C1; Steinmanni Zone, *Lilloettia* Association.

Plate 15

(nat. size unless otherwise indicated)

Fig. 1 a–b. *Choffatia furcula* (NEUMAYR) ♂, almost complete specimen, lateral and ventral views, IGM-4275. Unit 3 of section C1; Steinmanni Zone, *Lilloettia* Association.

Figs. 2 a–b. *Choffatia gottschei* (STEINMANN) ♂, bodychamber fragment, lateral and ventral views, IGM-4276. Unit 7 of section C1; Vergarensis Zone.

Fig. 3. *Choffatia* cf. *jupiter* (STEINMANN) ♀, almost complete specimen, lateral view, IGM-4277. Unit 4 of section C1; Steinmanni Zone, *Lilloettia* Association.

Figs. 4, 5. *Neuqueniceras (Frickites)* n. sp. A.
4. Completely septate specimen, IGM-4278. Unit 14 of section C1; Bodenbenderi Zone, *Frickites* Association.
5 a–c. Completely septate; 5 a, b, lateral and ventral views. 5 c, inner whorl, x 3, IGM-4279. Unit 15 of section C1; Bodenbenderi Zone, *inflatum* Association.

Plate 16

(all nat. size)

Figs. 1, 2. *Choffatia* gr. *subbackeriae* (D'ORBIGNY) ♀. Unit 6 of section C1; Steinmanni Zone, *Lilloettia* Association.
1 a–b. Phragmocone with bodychamber fragment, ventral and lateral views, IGM-4280.
2. Phragmocone and bodychamber fragment, lateral view, IGM-4281.

Fig. 3 a–b. *Reineckeia* gr. *franconica* (QUENSTEDT) & *convexa* CARIOU ♀, phragmocone, lateral and ventral views, IGM-4282. Unit 18 of section C1; Bodenbenderi Zone, *Rehmannia* Association.

Fig. 4 a–b. *Choffatia* sp. ind. ♂, complete bodychamber and end of the phragmocone, ventral and lateral views, IGM-4283. Unit 6 of section C1; Steinmanni Zone, *Lilloettia* Association.

Plate 17

(all nat. size)

Figs. 1, 3, 4. *Neuqueniceras (Frickites)* ex gr. *bodenbenderi* (TORNQUIST) & *antipodum* (GOTTSCHE) ♀ & ♂. Bodenbenderi Zone, *inflatum* Association.
1 a–b. Macroconch (♀), complete bodychamber with end of phragmocone, lateral and ventral views, IGM-4284. Unit 15 of section C2.
3 a–b. Microconch (♂) complete (?), lateral and ventral views, IGM-4285. Unit 16 of section C2.
4 a–b. Inner whorls of macroconch (♀), lateral and ventral views, IGM-4286. Unit 15 of section C2.

Fig. 2. *Neuqueniceras (N.) gleimi* (STEINMANN) ♂, IGM-4287. Unit 15? of section C1; Bodenbenderi Zone.

Plate 18

(all nat. size)

Fig. 1 a–b. *Neuqueniceras (Frickites)* ex gr. *bodenbenderi* (TORNQUIST) & *antipodum* (GOTTSCHE) ♀, almost complete specimen, lateral and ventral views, IGM-4288. Unit 14 of section C2; Bodenbenderi Zone, *Frickites* Association.

Plate 19

(all nat. size)

Fig. 1, 3. *Rehmannia rehmanni* (OPPEL) ♀ & ♂. Bodenbenderi Zone, *Rehmannia* Association.
1 a–b. Macroconch (♀), bodychamber fragment, lateral and ventral views, IGM-4289. Unit 17 of section C1.
3 a–b. Microconch (♂), bodychamber with phragmocone fragments, ventral and lateral views, IGM-4289. Unit 17 of section C1.

Fig. 2. *Neuqueniceras (N.) waitzi* (BURCKHARDT) (♀?), phragmocone, lateral view, IGM-4269. Unit 7 of section C1; Vergarensis Zone.

Plate 20

(nat. size unless otherwise indicated)

Figs. 1, 2. *Rehmannia* cf. *grossouvrei* (PETITCLERC).
1a–b. Bodychamber? fragment, lateral and ventral views, IGM-4632. Unit 14 of section C1; Bodenbenderi Zone, *Frickites* Association.
2. Bodychamber, lateral view, IGM-4633. Unit 16 of section C1; Bodenbenderi Zone, *Rehmannia* Association.

Fig. 3a–b. *Rehmannia rehmanni* (OPPEL), complete specimen, IGM-4631; 3a, lateral view, x 0.4, and 3b, inner whorls. Unit 17 of section C1; Bodenbenderi Zone, *Rehmannia* Association.

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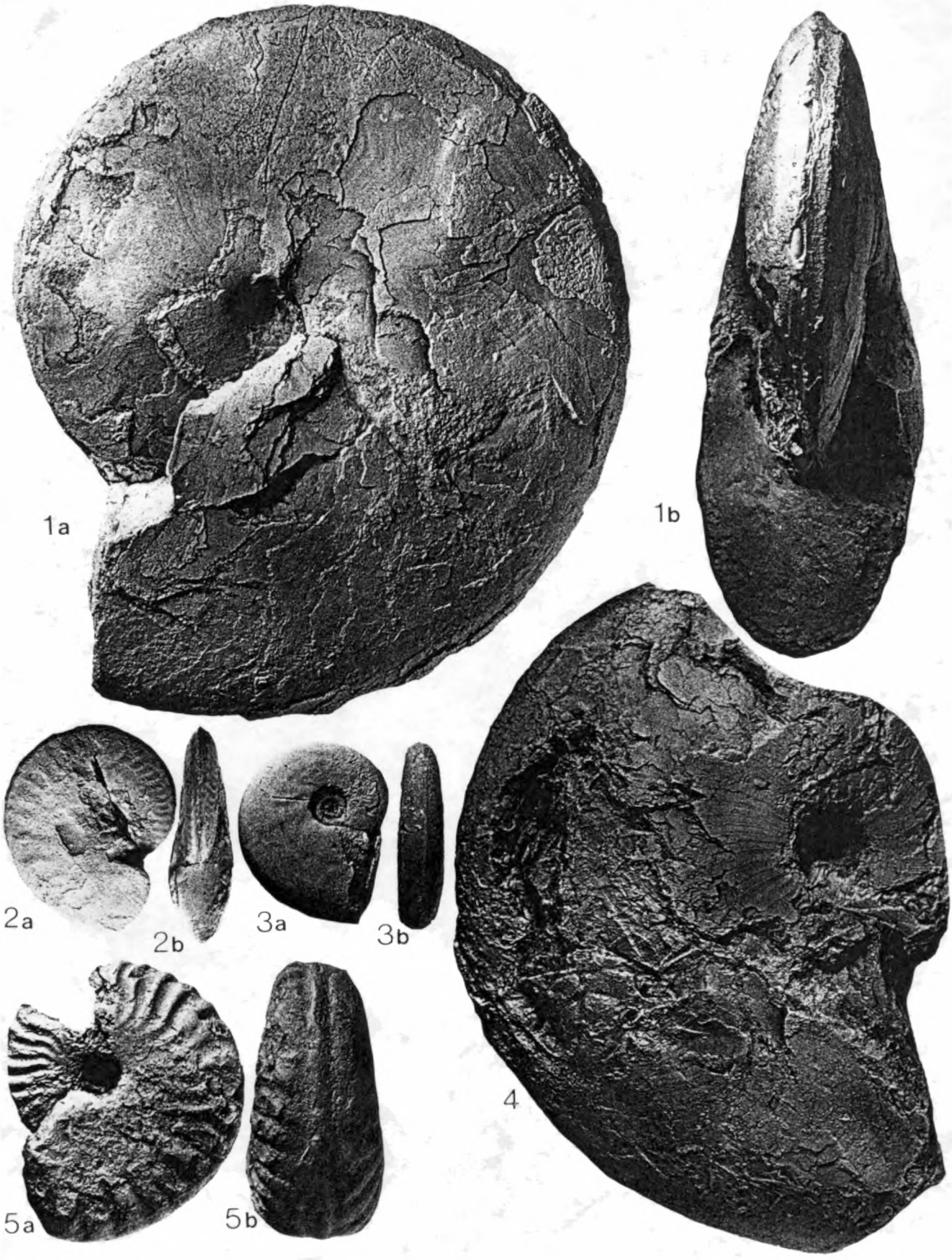

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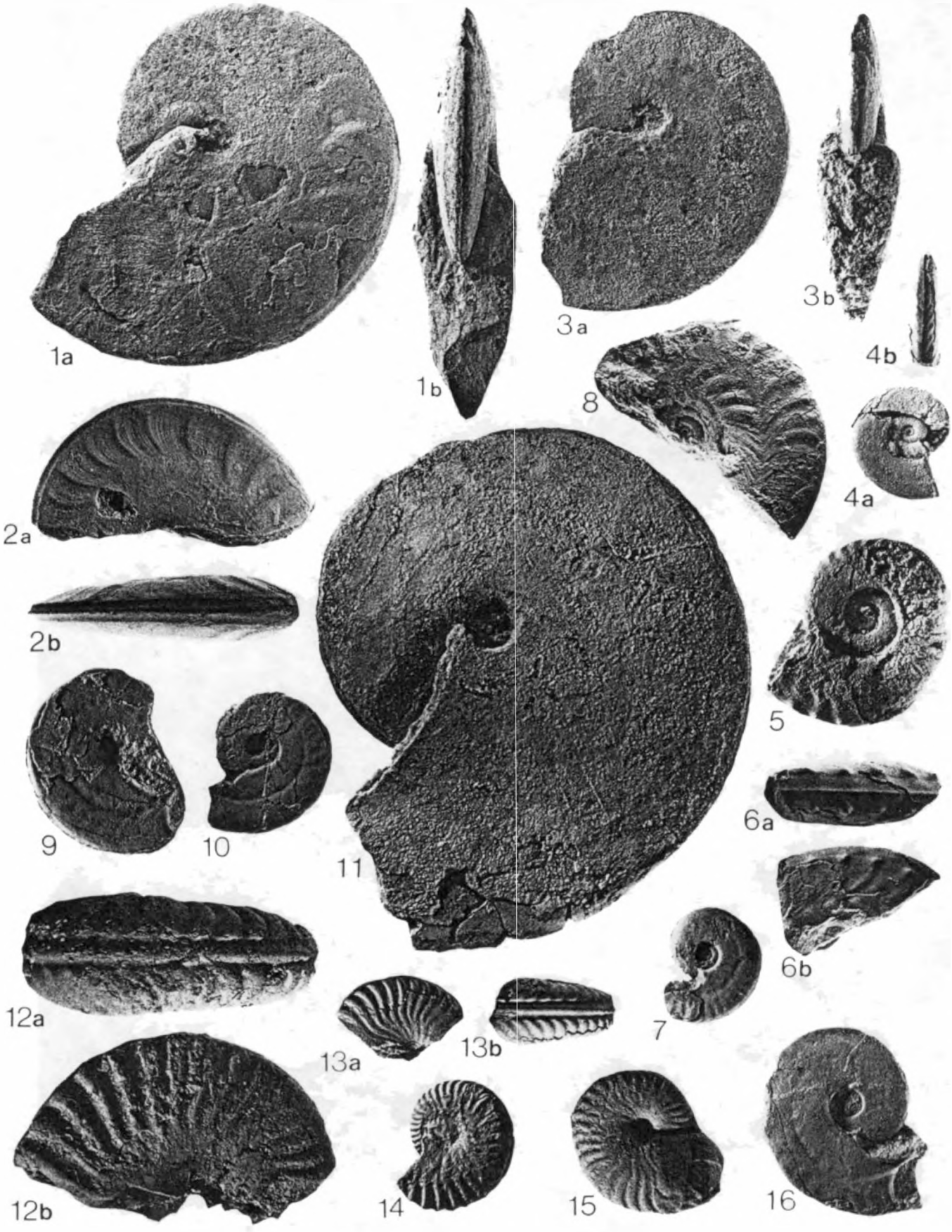
1a
1b
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8
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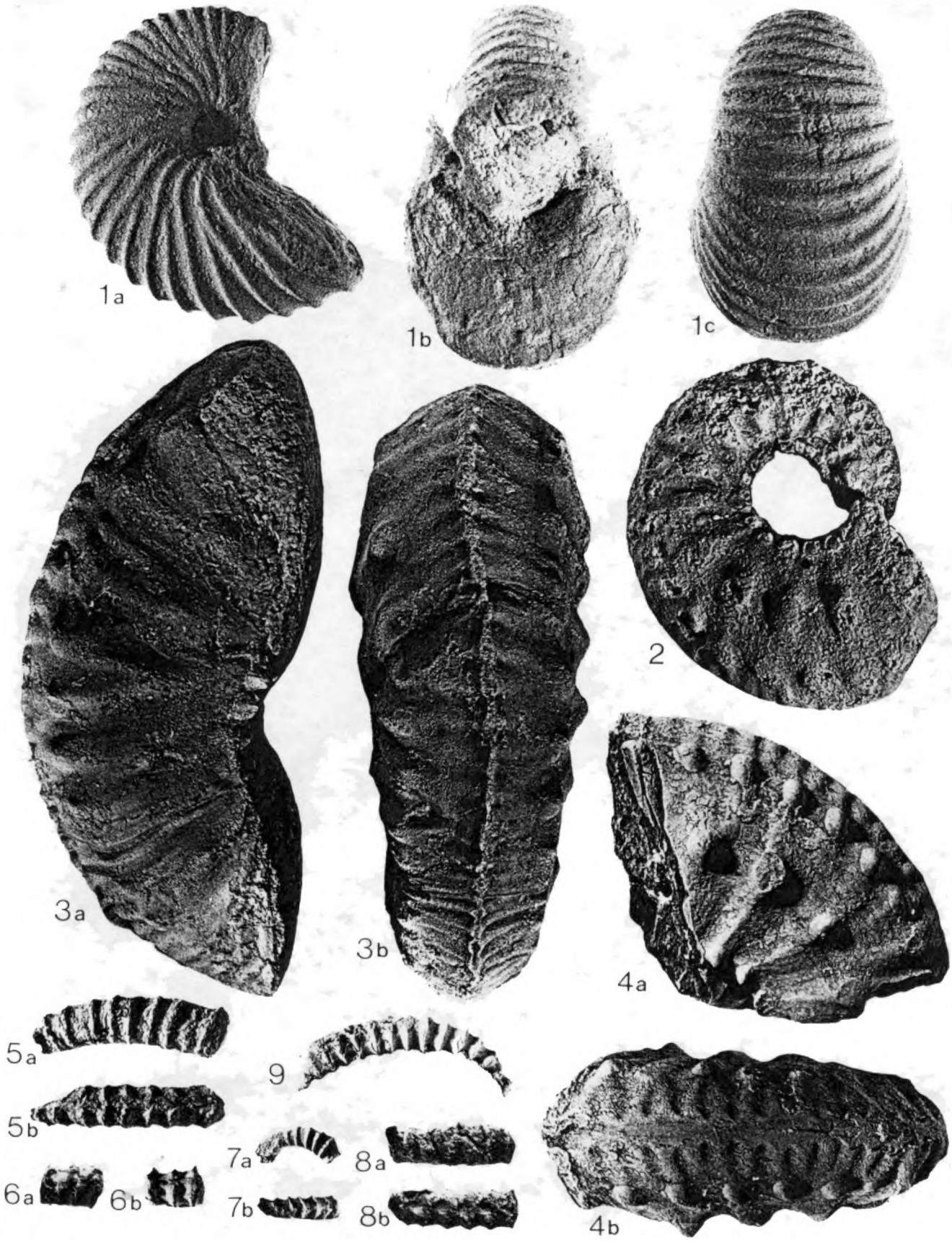

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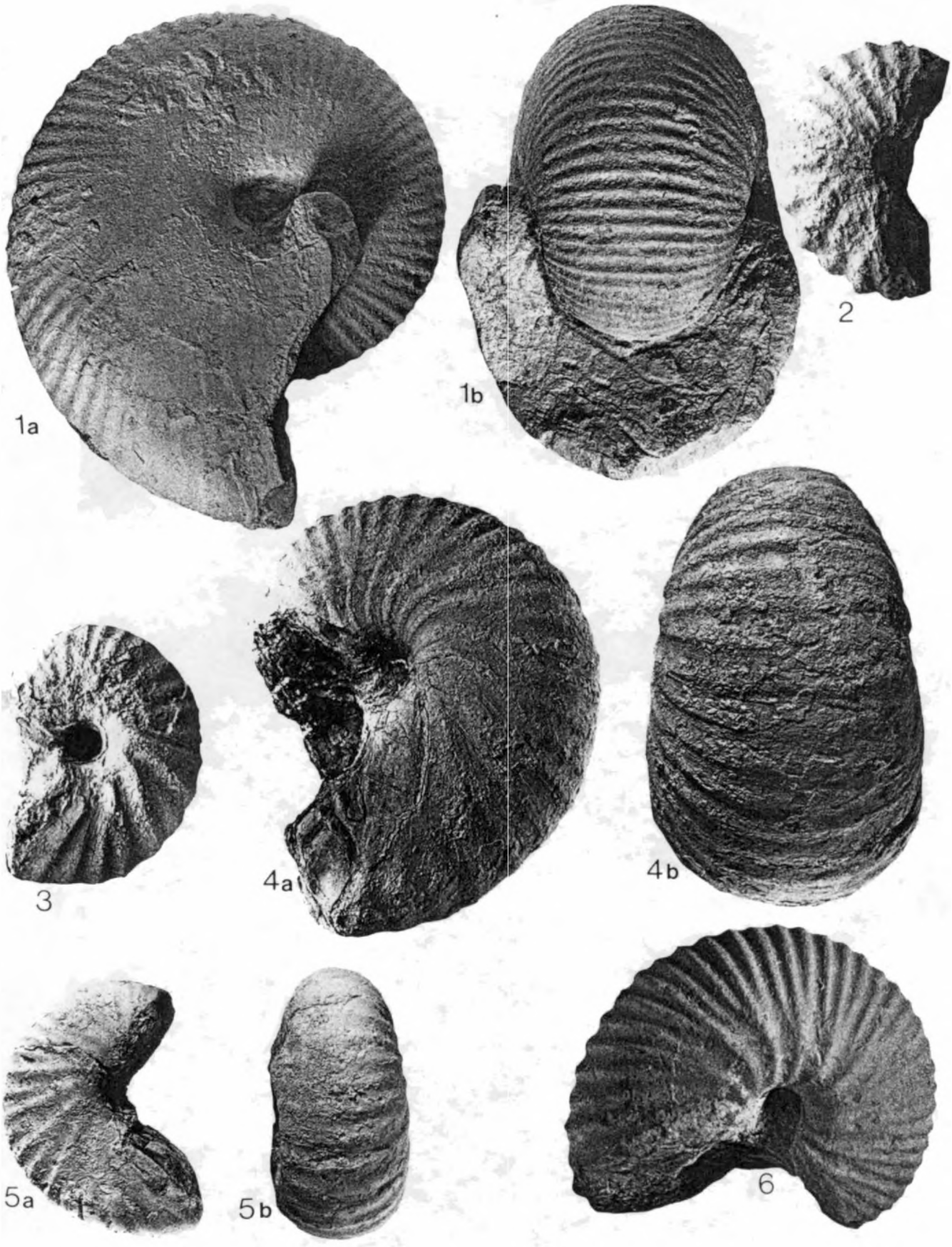
1a
1b
3a
3b
3c
2a
2b
4a
4b
4c



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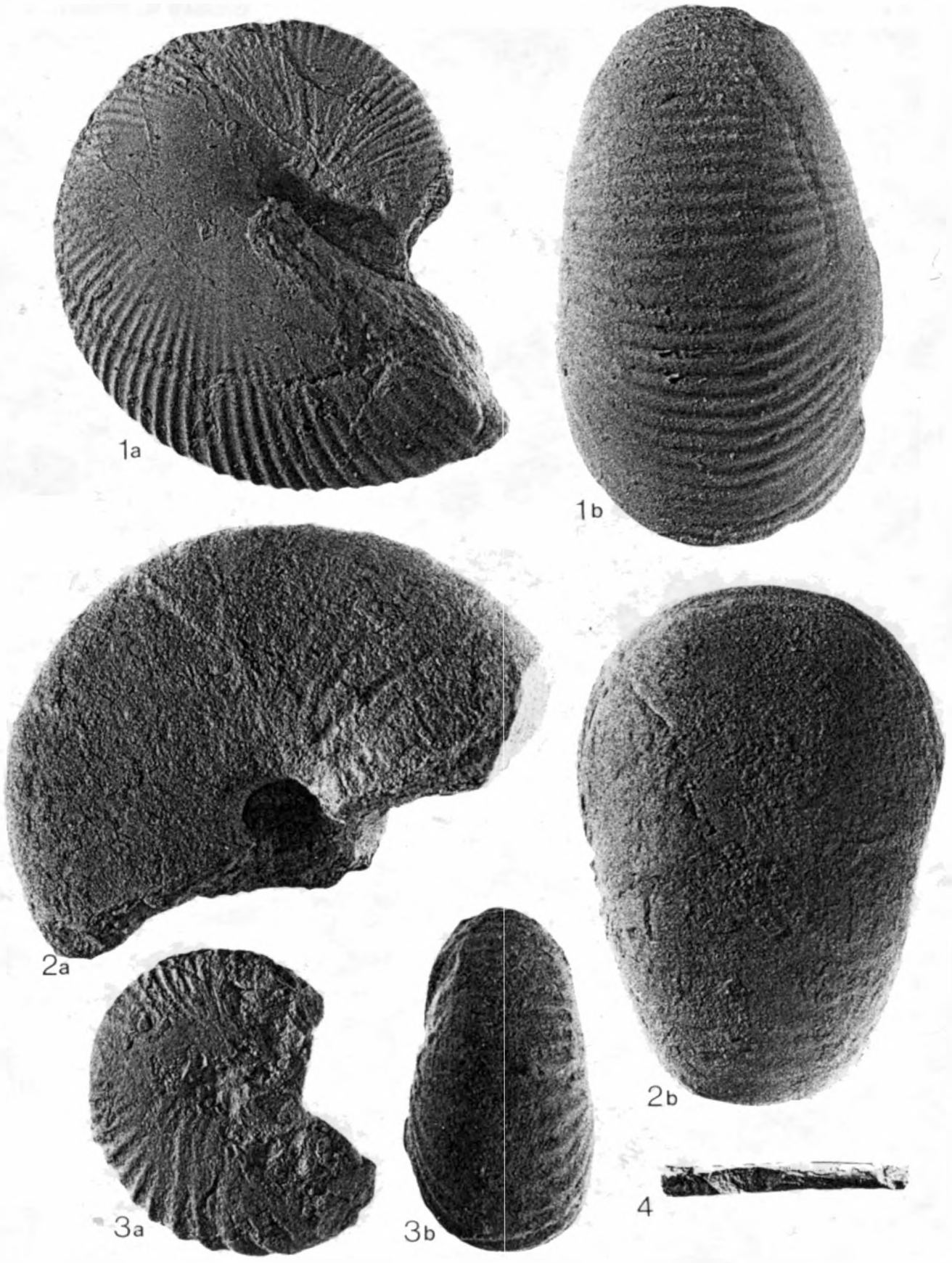

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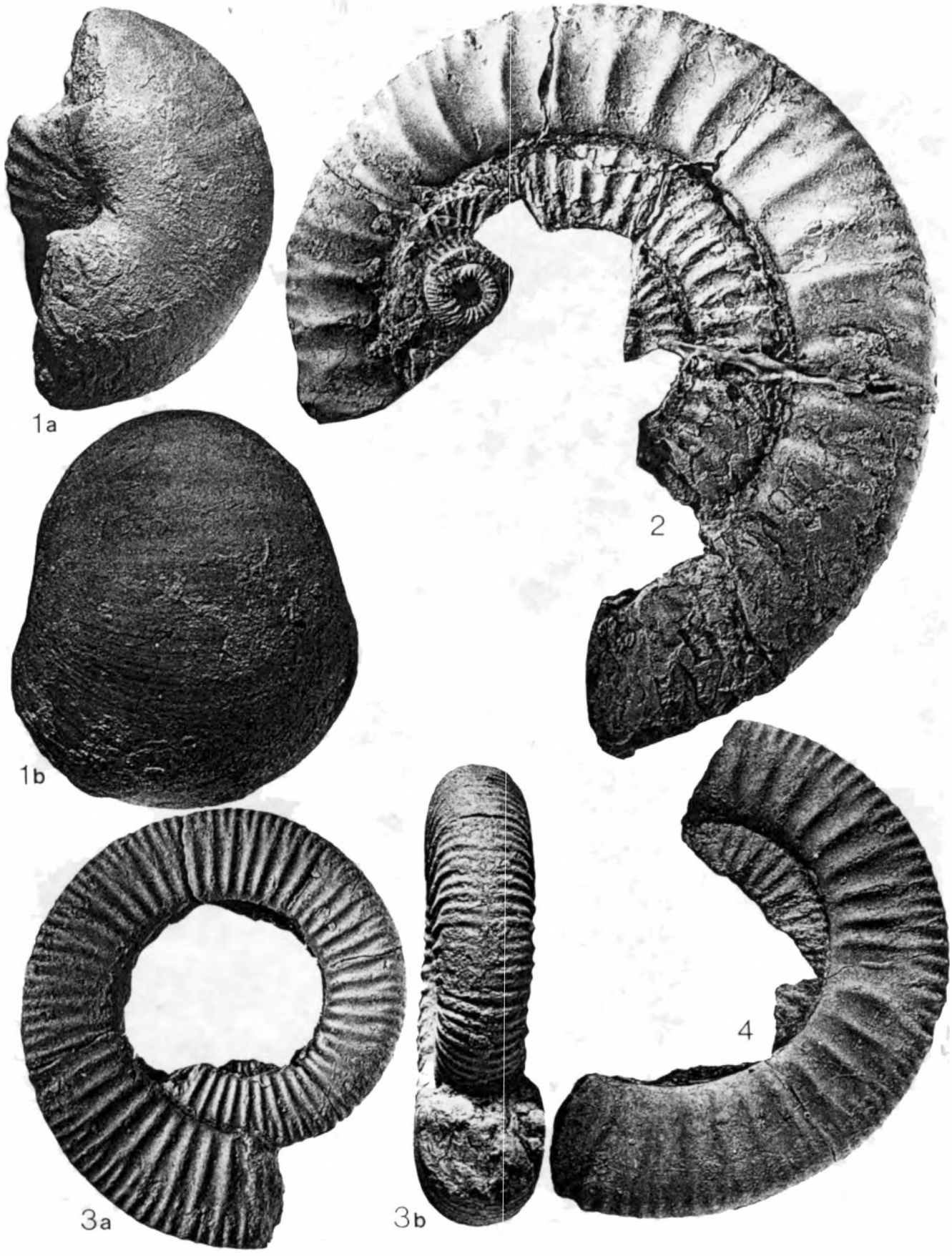
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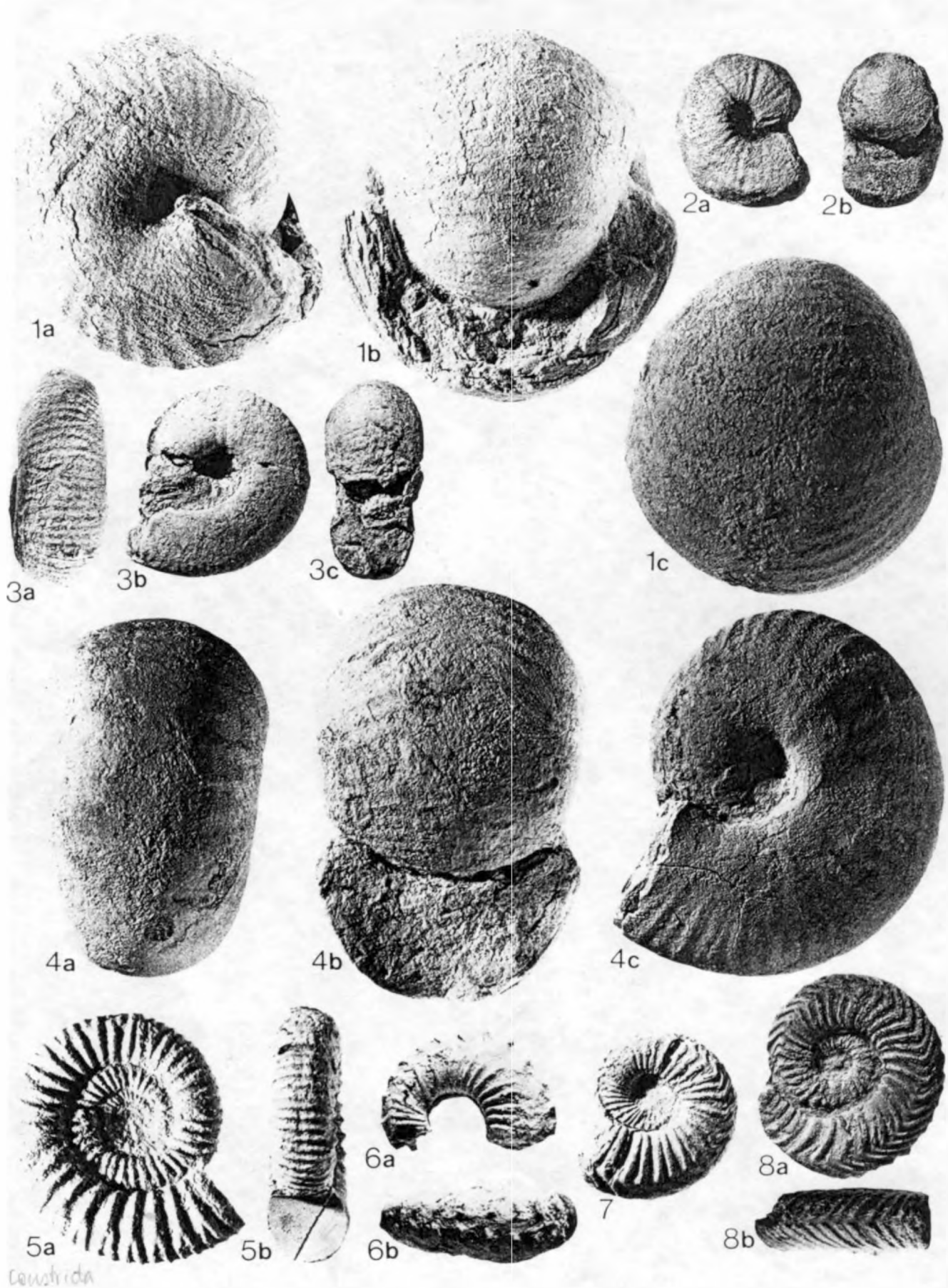

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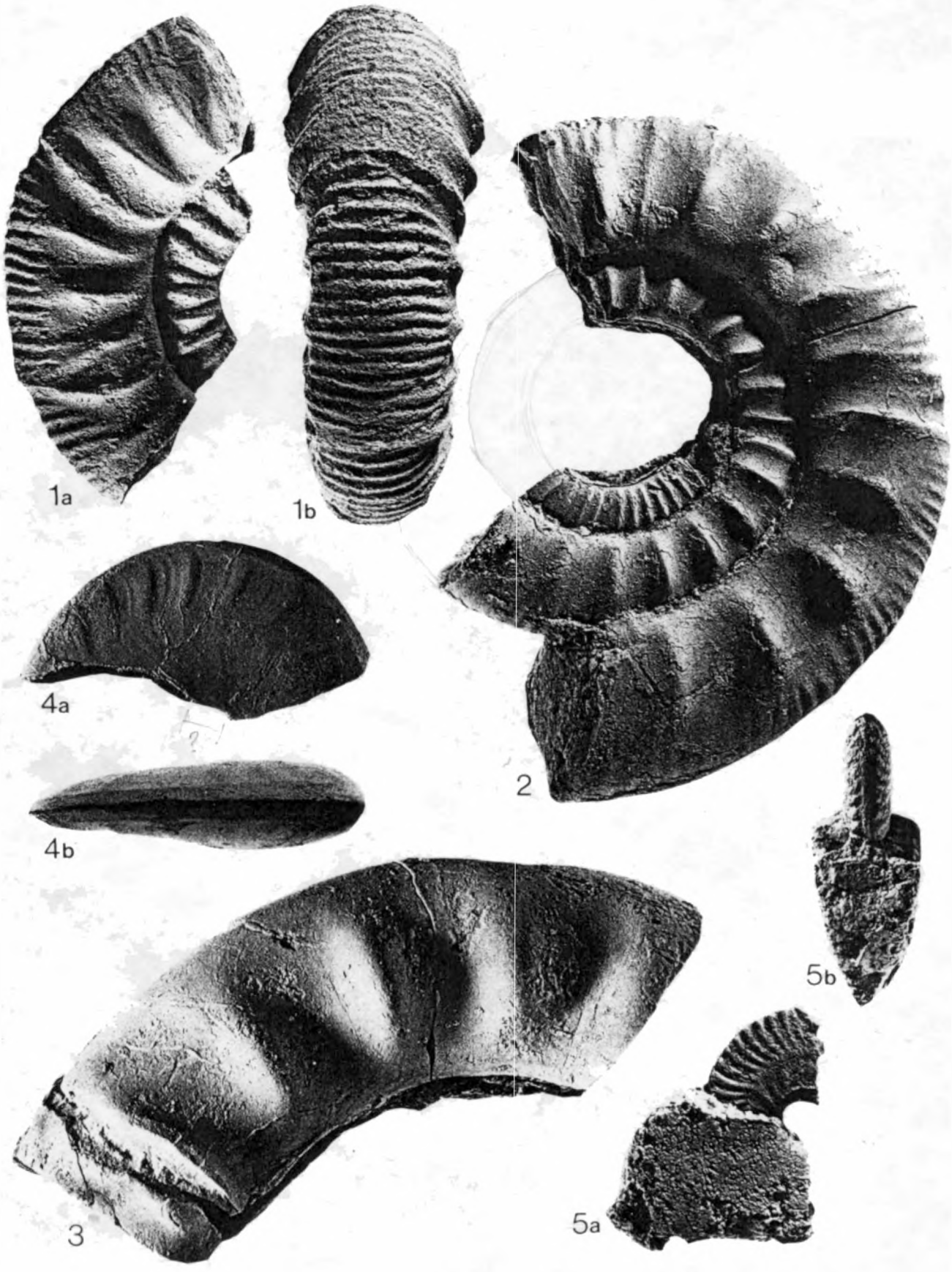

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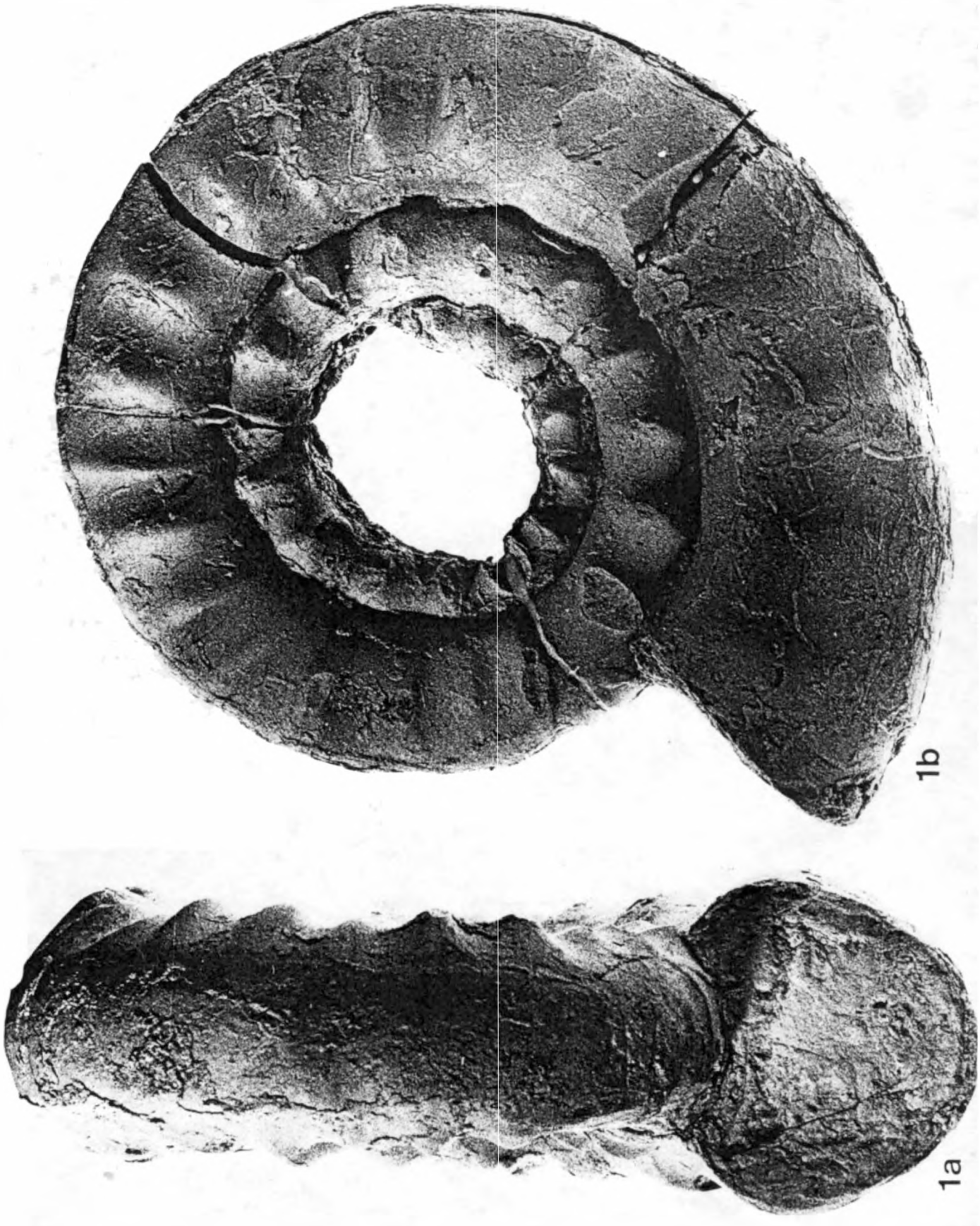

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1

3a

3b

2a

2b

4a

4b

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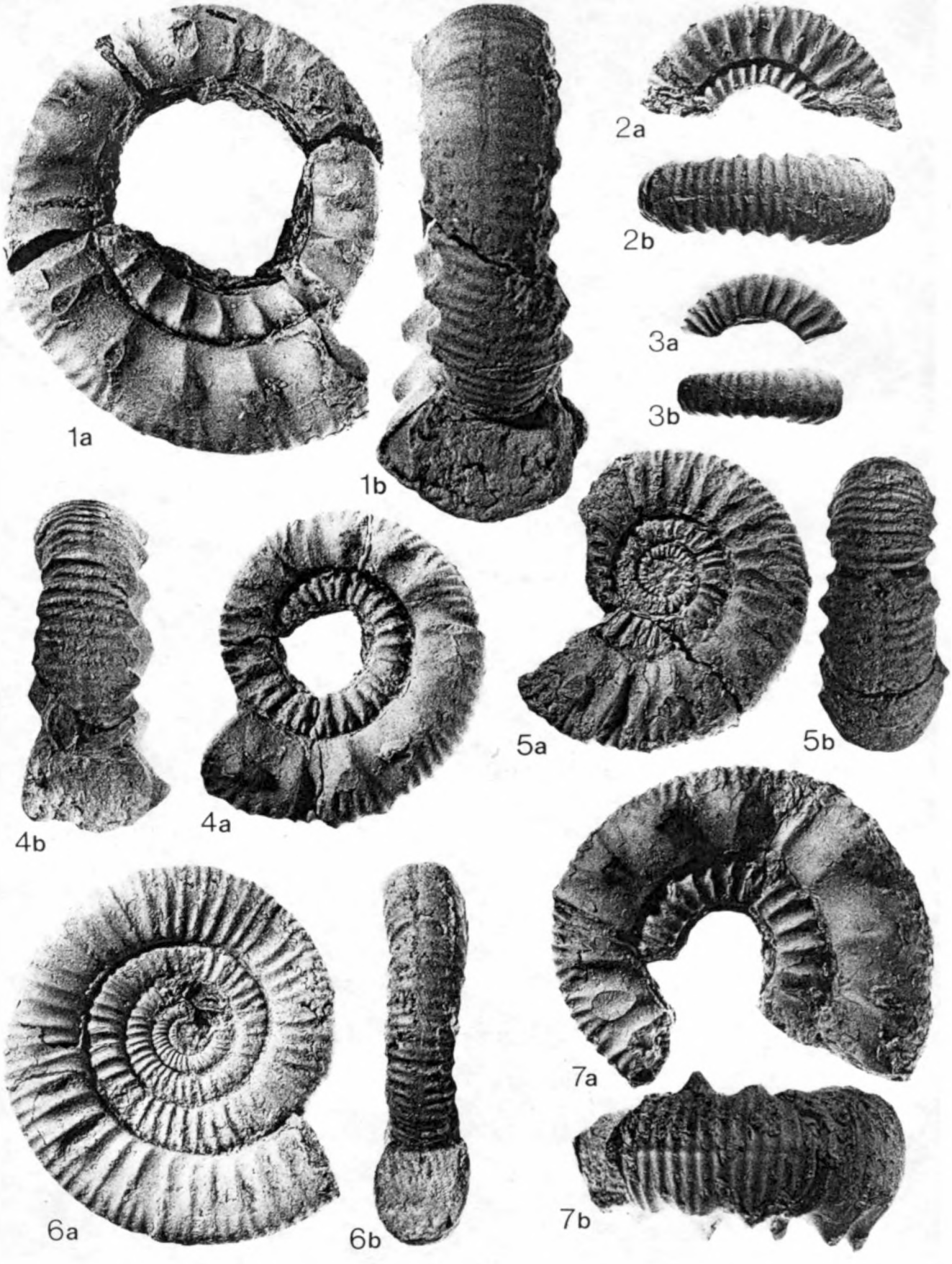
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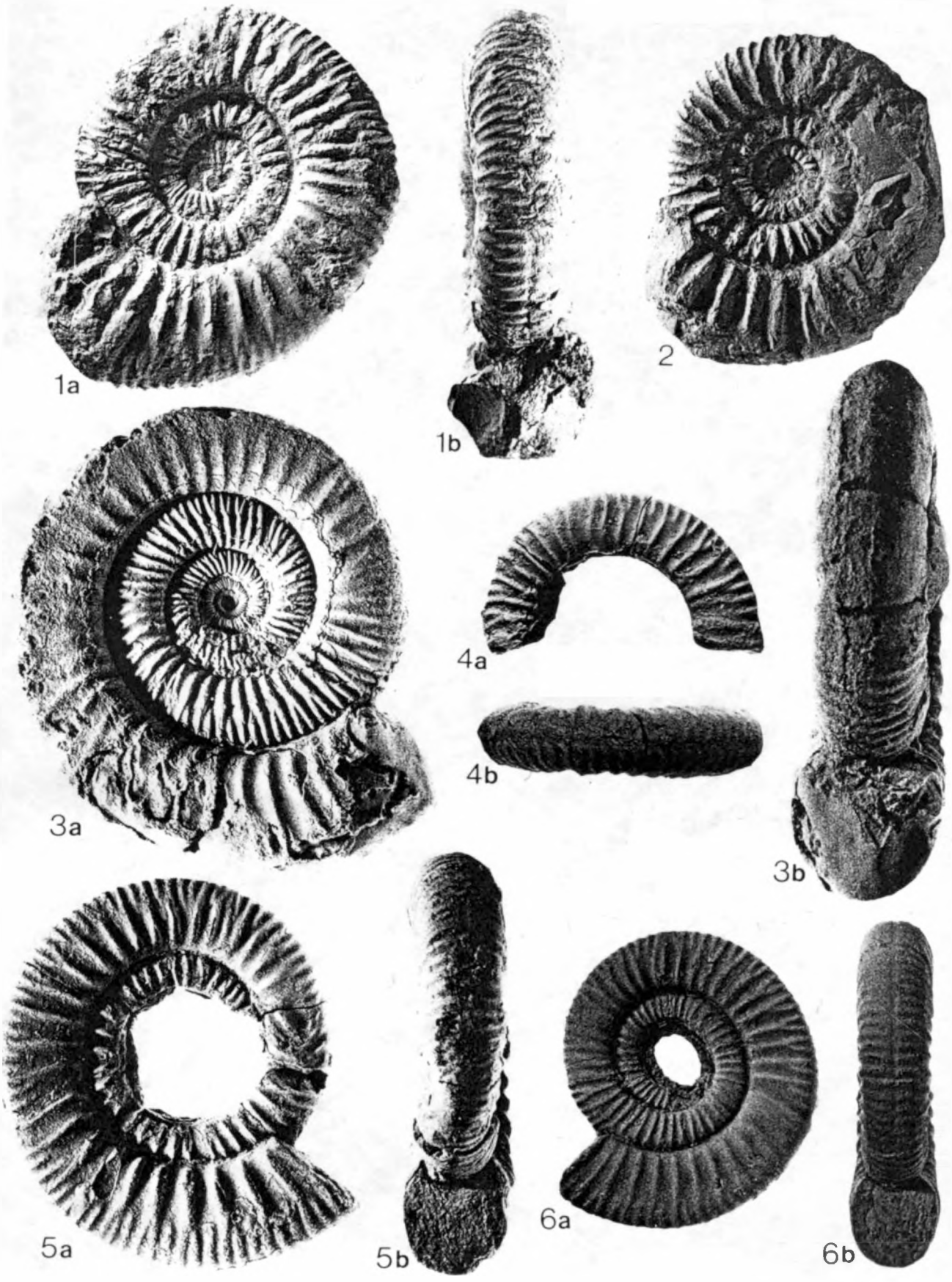
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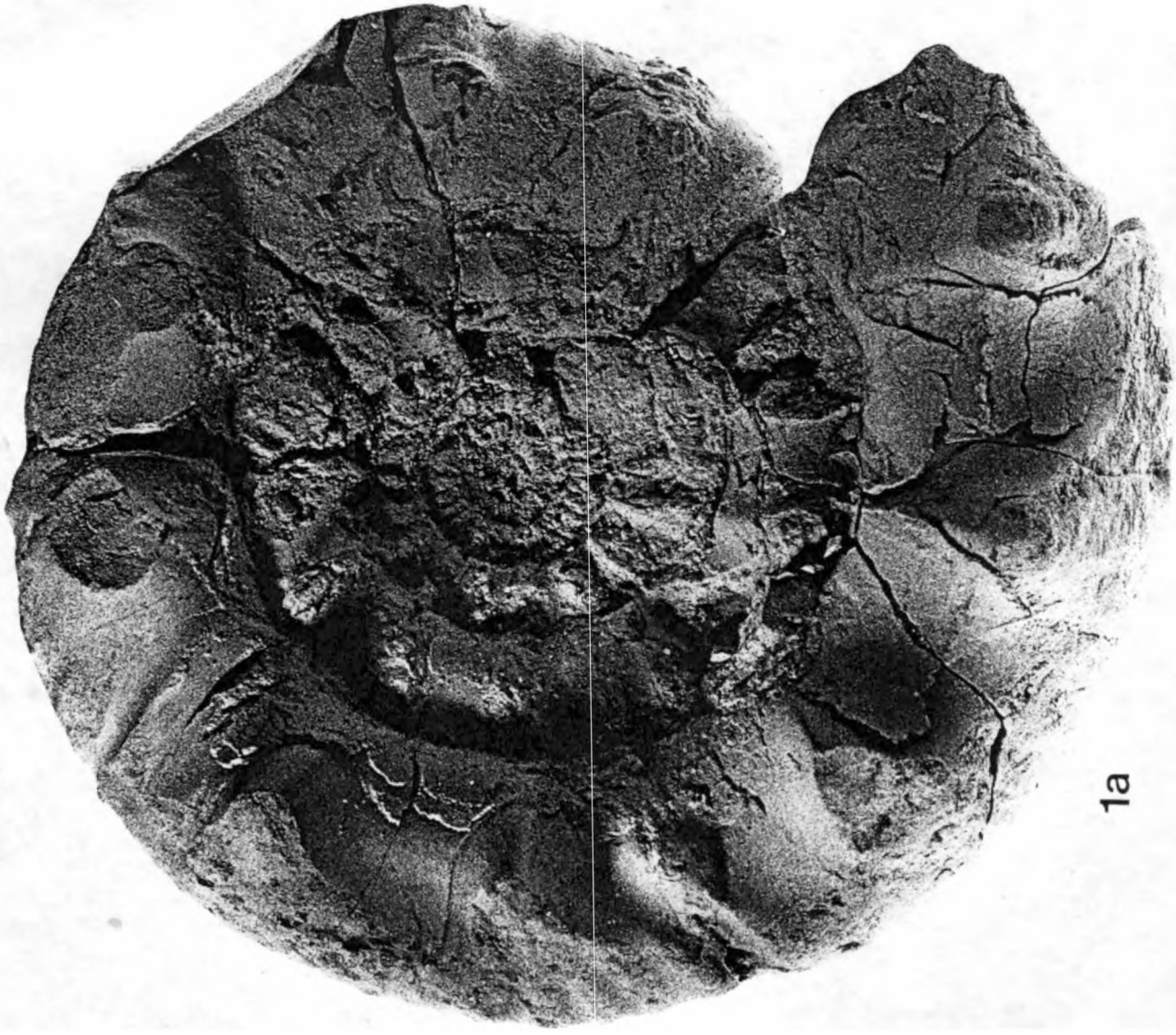
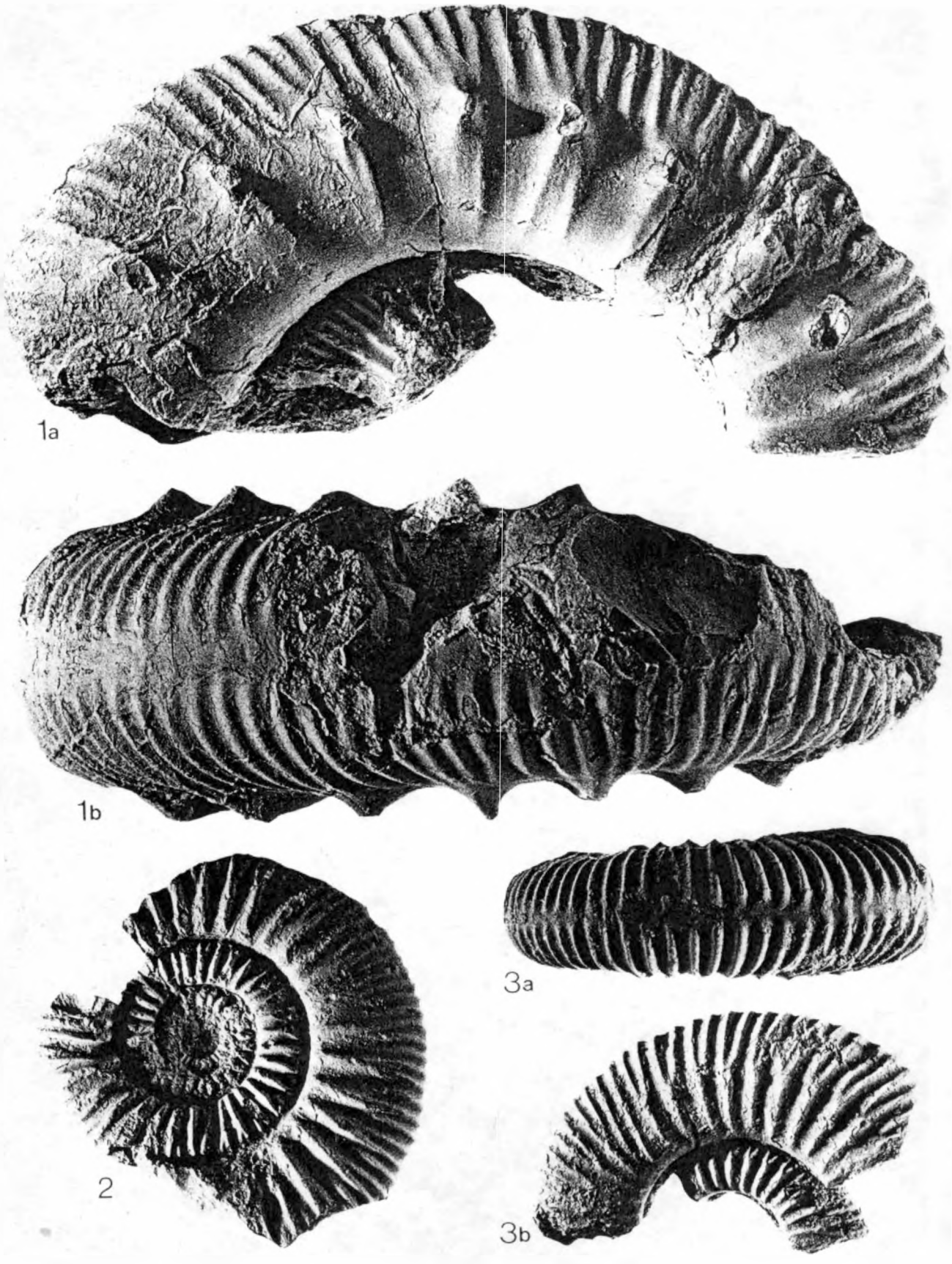


1a



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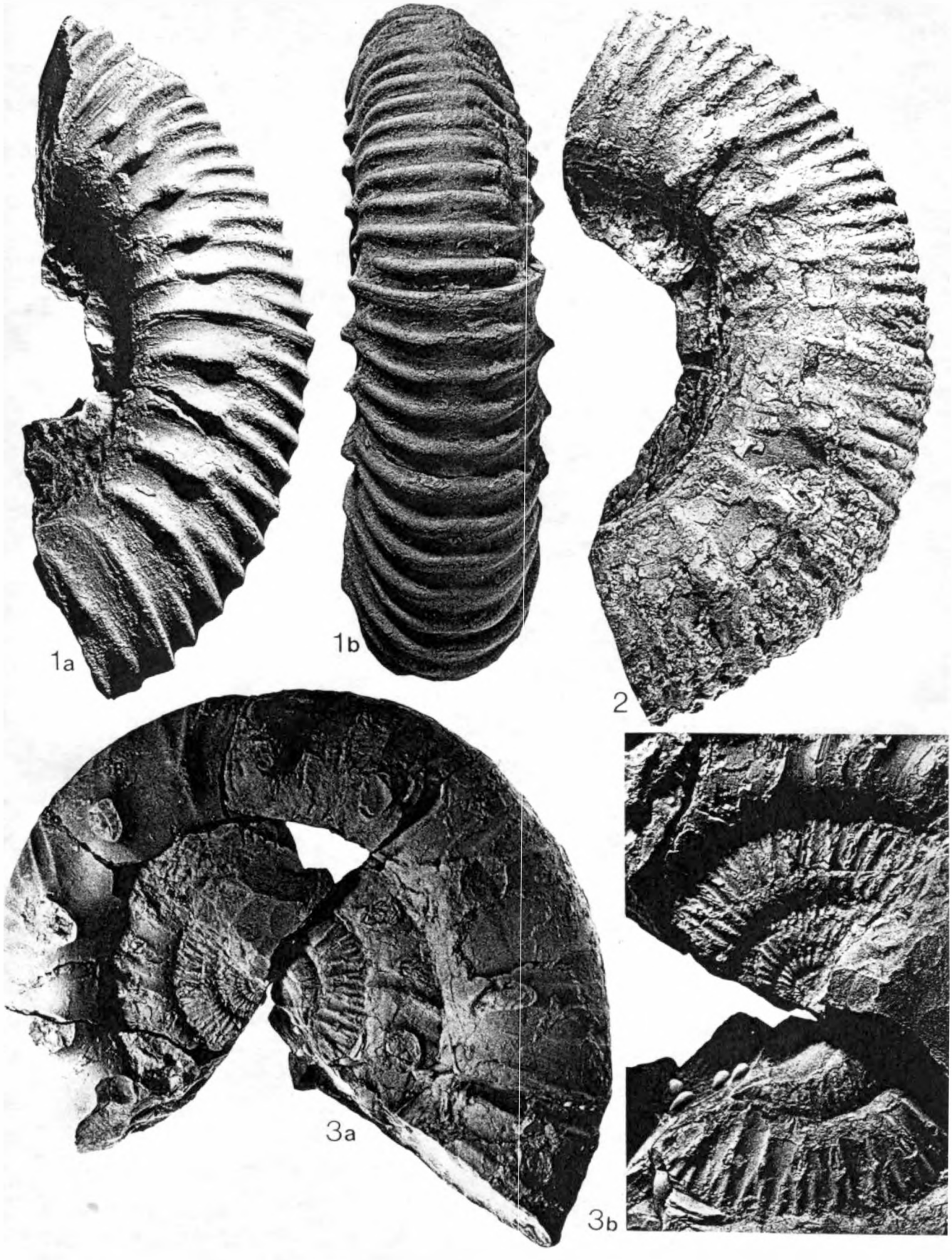

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