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NEOCOMIAN AMMONITE BIOSTRATIGRAPHY OF THE ANDEAN BASINS OF ARGENTINA AND CHILE

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ABSTRACT

This contribution provides comprehensive updated information on the ammonoid biostratigraphy of the Neocomian Andean basins of Argentina and Chile. Comments on the ammonoid faunal affinities and possible correlations with the European Standard zones are also discussed. Several plates illustrate the most important components of the different assemblages.

Keywords: Neocomian, Biostratigraphy, Andean Basins, Argentina, Chile.

RESUMEN

Esta contribución provee información actualizada sobre la bioestratigrafía de las Cuencas Andinas Neocomianas de Argentina y Chile, basada en sus faunas de ammonoideos. Se discuten además las afinidades faunísticas de los ammonoideos presentes y su posible correlación con las zonas estandard europeas. Varias láminas ilustran los componentes más importantes de las distintas asociaciones.

Palabras clave: Neocomiano, Biostratigrafía, Cuencas Andinas, Argentina, Chile.

INTRODUCTION

The marine Andean basins of Chile and Argentina, in southern South America are richly fossiliferous, and their Jurassic-Cretaceous invertebrate fauna has extensively been studied since last century. Classic monographs with illustrations of Neocomian ammonites include Stanton (1901), Favre (1908), Gerth (1925), Weaver (1931), and Feruglio (1936-1937). In recent years revisions and new findings of these ammonite faunas are from A. Leanza (1970), Riccardi *et al.* (1971, 1987), Blasco *et al.* (1980), H. Leanza and Wiedmann (1980), Wiedmann (1980), Aguirre-Urreta and Klinger (1986), Riccardi and Aguirre-Urreta (1989), among others (see Riccardi, 1988 for a revision).

More information is scattered in short publications and local papers. Thus, the aim of this contribution is to provide comprehensive updated information on the ammonite biostratigraphy of the Neocomian Andean basins of Argentina and Chile based on current research, with comments on the faunal affinities and possible correlations. Fossil identifications are based on the literature and the author's experience. The readers are referred to the systematic papers cited in each section for detailed taxonomic studies.

Repositories: The illustrated specimens are housed in the following institutions: CPBA: Cátedra de Paleontología, Facultad de Ciencias Exactas y Naturales, Universidad de Buenos Aires, 1428 Buenos Aires, Argentina.

MLP: División Paleozoología de Invertebrados, Museo de Ciencias Naturales, Universidad Nacional de La Plata, 1900 La Plata, Argentina.

GEO-PI: Colección Paleontología, Museo Nacional de Historia Natural, Santiago, Chile.

SERNAGEOMIN: Colección Paleontología, Servicio Nacional de Geología y Minería, Santiago, Chile.

REGIONAL SETTING

The Andean basins of Argentina and Chile extend from 18° to 24°S latitude, from 25°30' to 39°S, and from 44° to 55°S latitude, with gaps between 24°-25°30'S and 39°-44°S that are characterized by the presence of abundant volcanic rocks. These basins encompass five major depocenters, from north to south: Tarapacá (18°-24°S), Copiapó-Vallenar (25°30'-31°S), Aconcagua-Central Chile (31°-35°S), Neuquén embayment (35°-39°S), and Austral (44°-55°S) (Fig. 1).

The northern and central depocenters have a long and complex history with a diversity of marine and continental facies, closely controlled by the variable tectonic setting through Late Jurassic to Neocomian times (Mpodozis and Ramos, 1990). The carbonate Neocomian deposits are interfingered with volcanic and pyroclastic rocks, either to the west or to the east, outlining a series of intra-arc basins as defined by Nasi y Thiele (1982) and Charrier (1984), as well as back-arc and fore-arc basins (Malumián *et al.*, 1983).

South of 35°S latitude, the Neuquén basin expands towards the eastern foreland forming a large embayment where the Cretaceous is represented by two major sedimentary cycles: The Andean and Riograndian (Groeber, 1953). The first encompasses the pacific marine

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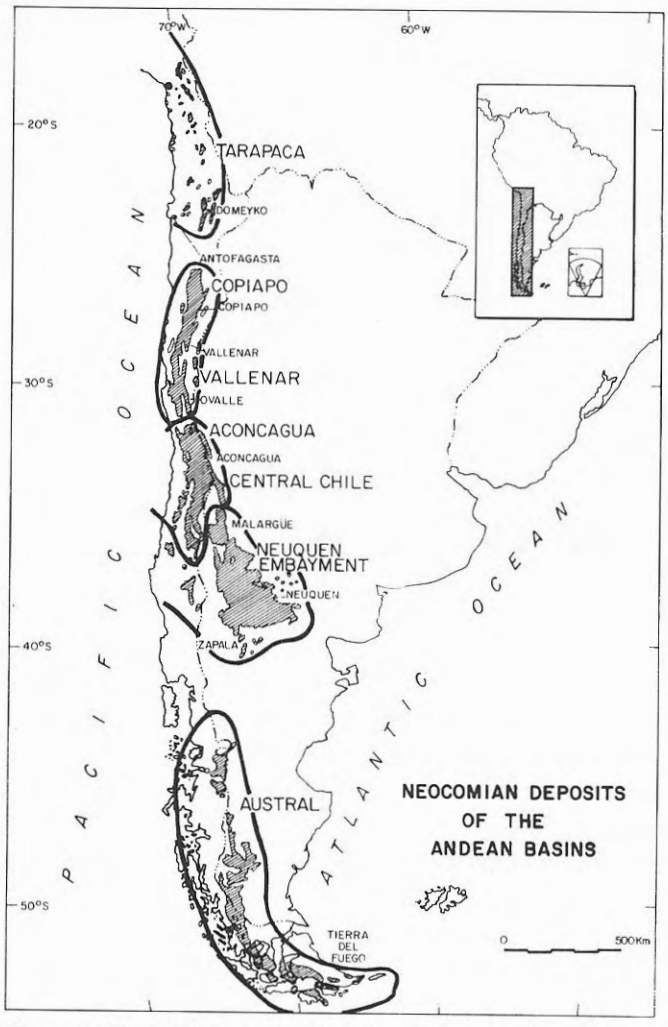


Figure 1. Neocomian deposits of the Andean Basins of Chile and Argentina (modified from Riccardi, 1988).

transgression of Tithonian-Neocomian age while the second records the first Atlantic marine deposits during Maastrichtian-Danian times (Weaver, 1927). Both marine sequences are separated by thick continental deposits that comprise most of the Aptian till Campanian (Legarreta and Uliana, 1989; Legarreta *et al.*, 1989).

The southern Austral basin extends from 44° to 55°S latitude, in the southern tip of the South American plate. It is a typical retro-arc basin developed synchronically with the opening of the South Atlantic ocean since Middle and Late Jurassic times. The sedimentary sequence accounts for more than 8 kilometers of sediments from the Late Jurassic to the Cenozoic (Russo and Flores, 1972). The Cretaceous sediments crop out in a narrow, but complex band extending in a north-south trend along the eastern foothills of the Cordillera in the northern part of the basin, while towards the south they also expand to the east (Macellari, 1988). Table 1 shows a correlation chart of the Neocomian rocks of Argentina and Chile.

STRATIGRAPHY AND AMMONITE FAUNA

Tarapacá

The Neocomian marine deposits in this region are discontinuously exposed in the western flank of the Cordillera Domeyko, with minor outcrops in the Cordillera de la Costa. The more classic and studied section is located 10 kilometers south of Antofagasta (Fig. 2).

The stratigraphic column presents a lower unit of more than 600 meters of conglomerates, shales, limestones, and red reds of the Caleta Coloso Formation. The upper unit corresponds to the 250 meters thick

AGE \ BASIN	TARAPACA	COPIAPO	VALLENAR	CENTRAL CHILE-ACONCAGUA	NEUQUEN EMBAYMENT	AUSTRAL
NEOCOMIAN – BARREMIAN	EL WAY Fm.	CHAÑARCILLO GROUP: PABELLON Fm.	OVALLE GROUP: ARQUEROS Fm.	LO PRADO Fm. / SAN JOSE Fm. / BAÑOS DEL FLACO Fm / LO VALDES Fm. / MENDOZA GROUP	AGRIO Fm.	RIO BELGRANO Fm.
NEOCOMIAN – HAUTERIVIAN		TOTORALILLO Fm. / NANTOCO Fm.				RIO MAYER Fm.
NEOCOMIAN – VALANGINIAN	CALETA COLOSO Fm.	ABUNDANCIA Fm.	TAMAYA Fm.		MULICHINCO Fm.	
NEOCOMIAN – BERRIASIAN		PUNTA DEL COBRE Fm.			QUINTUCO Fm. / VACA MUERTA Fm.	SPRINGHILL Fm.
TITHONIAN						

Table 1. Neocomian correlation chart of the Andean Basins of Argentina and Chile.

Plate I. Berriasian Ammonites from Aconcagua-Central Chile and Neuquén Embayment.

1 *Argentiniceras noduliferum* (Steuer), CPBA 7605, lateral view, locality Arroyo Salado, Mendoza, Lower Berriasian.

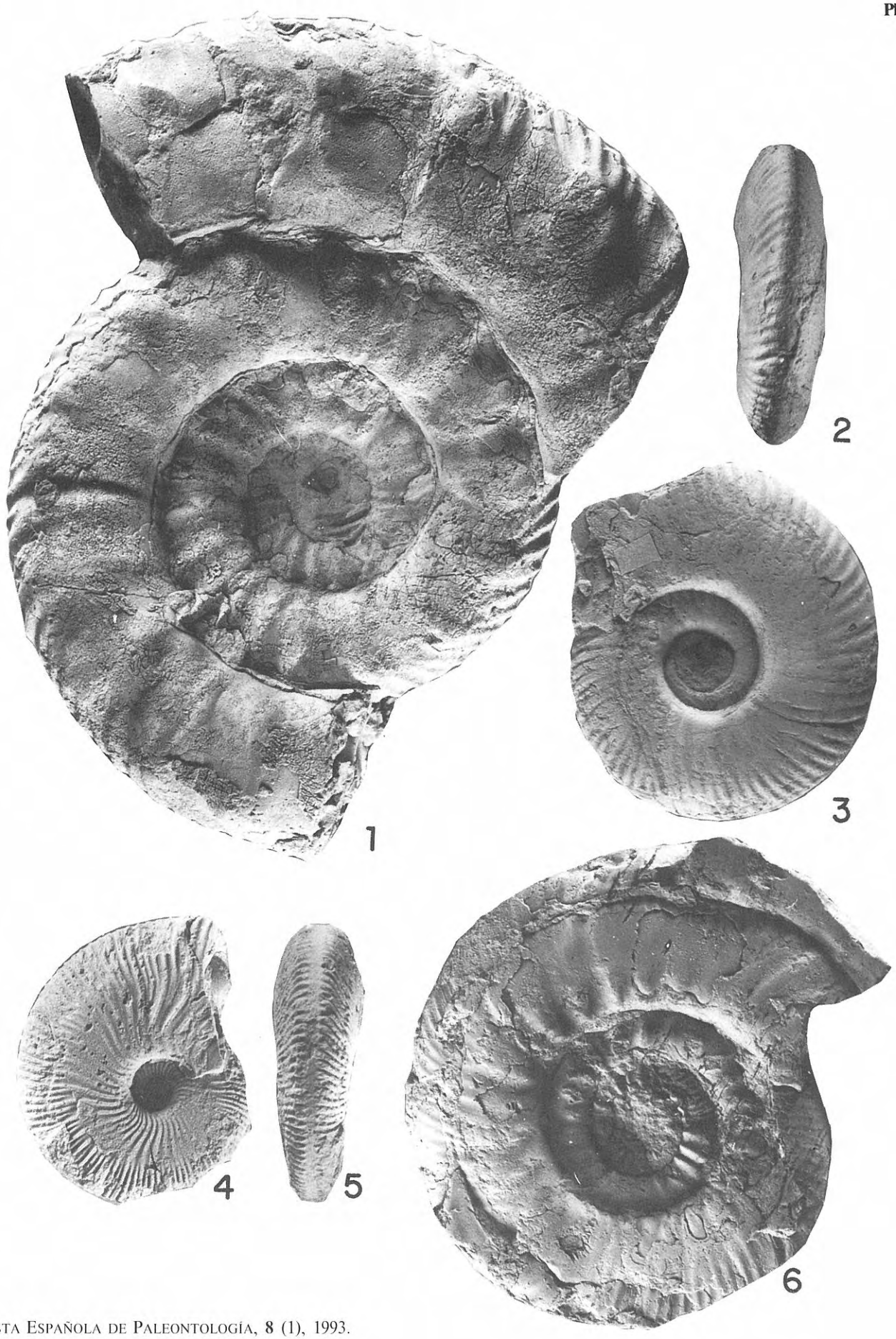
2-3 *Groebericeras bifrons* Leanza, CPBA 8065, ventral and lateral views, locality Mallín Quemado, Mendoza, Lower Berriasian.

4-5 *Neocomites regularis* Leanza, GEO-PI-4804, lateral and ventral views, locality Paso Los Bayos (Chile), Upper Berriasian.

6 *Spiticeras damesi* (Steuer), CPBA 7606, lateral view, locality Malargüe, Mendoza, Upper Berriasian.

All figures natural size.

Plate I



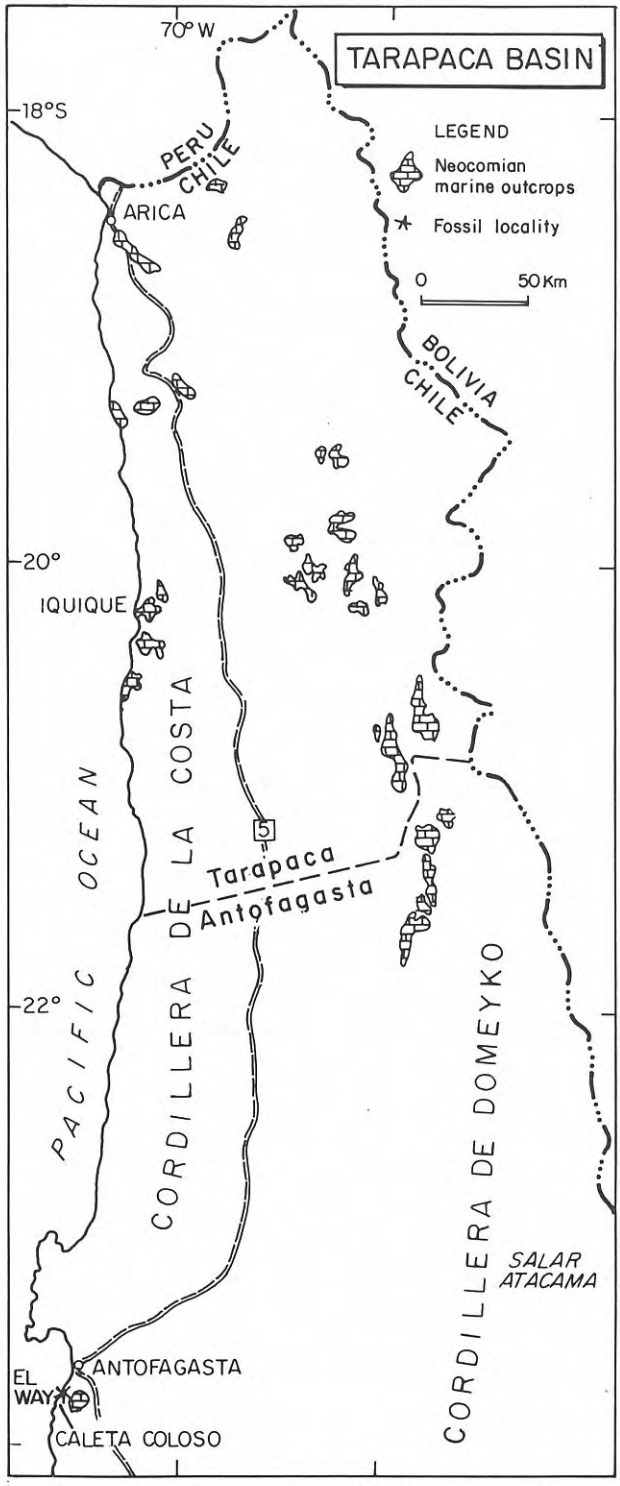


Figure 2. Neocomian outcrops in the Tarapacá Basin, with main fossil localities (based on Riccardi, 1988).

limestones, calcareous sandstones, shales and marls of the El Way Formation (Alarcón and Vergara, 1964; Boric *et al.*, 1990). The mollusk fauna is abundant and was monographed by Leanza and Castellaro (1955), but unfortunately the ammonites are rare and usually badly preserved. Fragmentary specimens were assigned to *Douvilleiceras* by Leanza and Castellaro (1955), thus suggesting an Albian age for the sequence. Alarcón and Vergara (1964) listed *Dufrenoya* sp. aff. *joserita, Dufrenoya*? sp., and *Kazanskyella*? sp. (see pl. III, figs. 5-7) of Middle Aptian age among several species of bivalves, gastropods, brachiopods, echinoderms, and corals. Observations of the specimens illustrated by Leanza and Castellaro (1955) (housed at the collections of the University of Buenos Aires), the photographs of Alarcón and Vergara (1964), and personal field collections suggest that they correspond to indeterminate crioceratitids of Hauterivian-Barremian affinities.

Copiapó - Vallenar

The marine Neocomian deposits in the Copiapó region are represented in the Chañarcillo Group (Biese, 1942), with nearly continuous exposures along a north-south trend, parallel to the Main Cordillera (Fig. 3). To the south, in the Vallenar and Ovalle areas, they correspond to the Arqueros Formation, which is partially equivalent to the Chañarcillo Group (Aguirre and Egert 1965; Thomas, 1967).

The Chañarcillo Group comprises, from bottom to top, andesitic flows (Punta del Cobre Formation), calcareous sandstones, limestones, and cherts (Abundancia Formation), limestones, bituminous limestones, and shales (Nantoco Formation), limestones, marls, and shales (Totoralillo Formation), and limestones, cherts, and sandstones (Pabellón Formation) (Corvalán, 1974). Total thickness reaches more than 2000 meters. Towards the southeast, the Neocomian deposits are represented by the Ovalle Group, characterized by a basal sequence of volcanic rocks (Tamaya Formation), and an upper section of marine limestones, shales, and calcareous sandstones also interbedded with volcanics (Arqueros Formation).

Ammonites are abundant on top of the Abundancia Formation (Late Valanginian *Olcostephanus* spp.), and through the rest of the sequence, especially in the Totoralillo and Pabellón Formations. Corvalán (1974) cited *"Crioceras" andinum* and *"C." diamantense* from several levels of Nantoco, Totoralillo, and Pabellón Formations, and *Ancyloceras* sp., from the top of Totoralillo Formation. Jürgan (1977) reported *Crioceras* cf. *hildesiense, Paracrioceras andinum, Shasticrioceras* sp., and

Plate II. Berriasian-Valanginian Ammonites from Aconcagua Central Chile and Neuquén Embayment.

1 *Neocosmoceras* sp. cf. *N. sayni*, GEO-PI-4806, lateral view, locality Paso Los Bayos (Chile), Upper Berriasian.

2 *Thurmanniceras pertransiens* Sayn, CPBA 538, lateral view, locality Arroyo del Yeso, Mendoza, Lower Valanginian.

3 *Thurmanniceras duraznense* (Gerth), GEO-PI-4803, lateral view, locality Paso Los Bayos (Chile), Upper Berriasian.

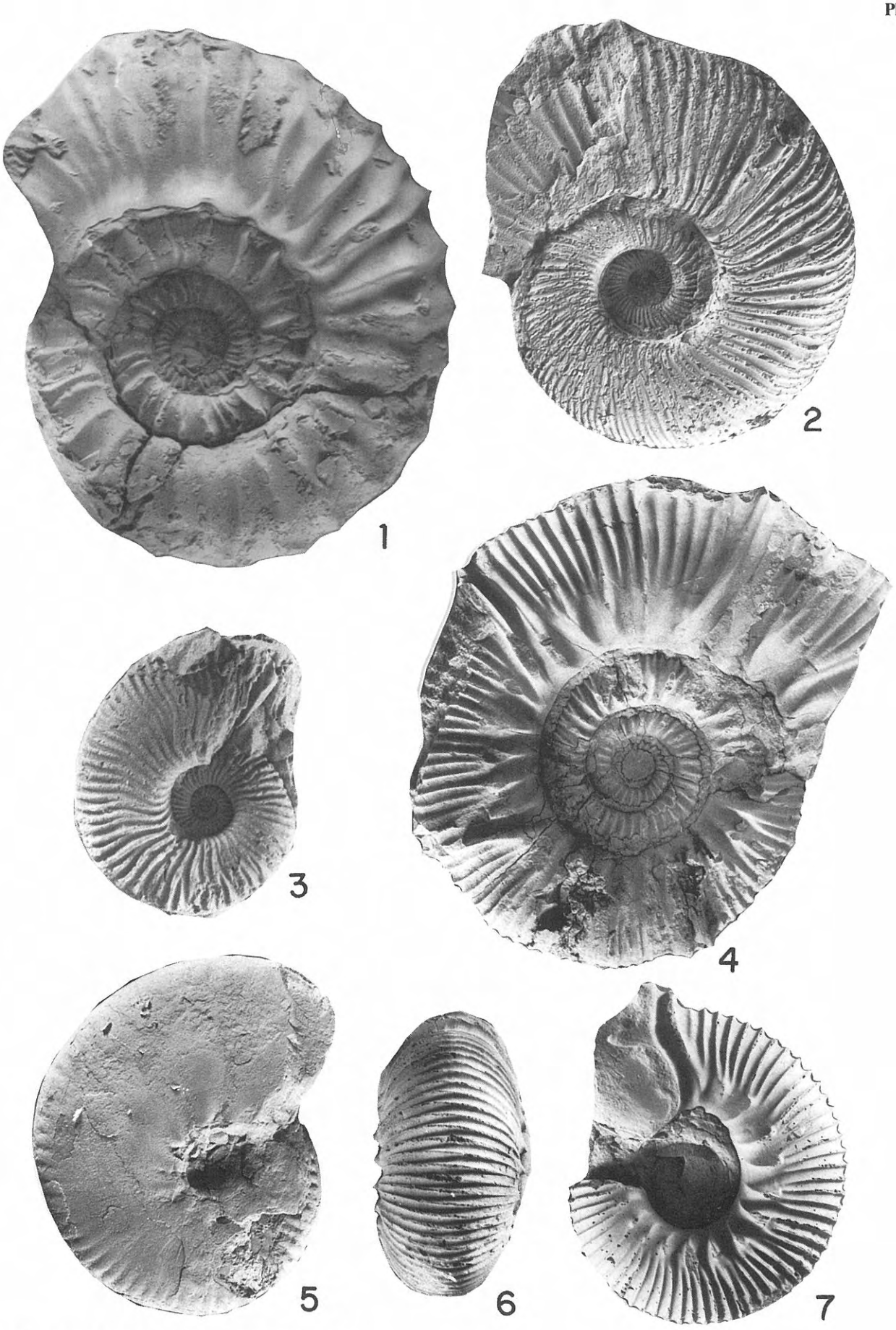
4 *Olcostephanus (Lemurostephanus) permolestus* (Leanza), CPBA 7018, type, lateral view, locality Cordón del Durazno, Neuquén, Upper Valanginian.

5 *Karakaschiceras attenuatus* (Behrendsen) ♂, CPBA 4078, lateral view, locality Chacay Melehue, Neuquén, Upper Valanginian.

6-7 *Olcostephanus (Olcostephanus) atherstoni* (Sharpe), ♂, CPBA 11490, ventral and lateral views, locality Cerro La Parva, Neuquén, Upper Valanginian.

All figures natural size.

Plate II



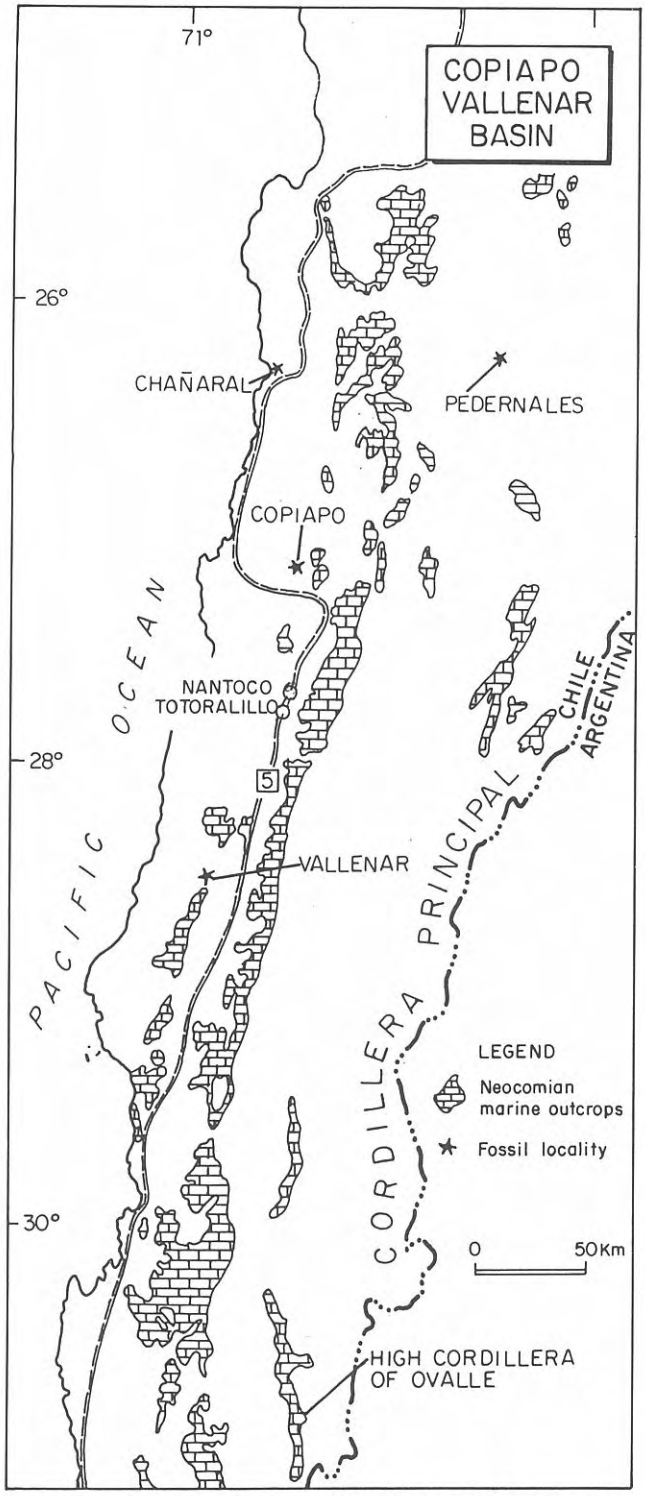


Figure 3. Neocomian outcrops of the Copiapó-Vallenar Basin, with main fossil localities (based on Corvalán, 1974 and Riccardi, 1988).

Menuthiocrioceras (?) sp. juv. from the Totoralillo Formation, and *Shasticrioceras whitneyi, S. inflatum*, and *Crioceratites* (?) cf. *diamantense* from the Pabellón Formation, fauna indicative of a Hauterivian-Barremian age. Pérez *et al.*, (1990) described and illustrated *Parahoplites* gr. *nutfieldiensis*, from the upper part of the Pabellón Formation, proposing a Late Aptian age for the top of the Chañarcillo Group. Recent studies have shown that the complex structure of the Copiapó area hinders the real stratigraphic relationship among the different formations of the Chañarcillo Group (Arévalo and Mpodozis, 1991).

In the Ovalle Group, only the Arqueros Formation has yielded ammonoids, belonging to indeterminate species of the genus *Crioceratites*, but no illustrations were given, except the remarkable engraving of Bayle and Coquand (1851, Pl. 3, Fig. 1). of *"Crioceras duvalii"*, probably collected at the locality Arqueros.

Personal field collections in the Chañarcillo Group reveal the following succession: a) Abundant *Olcostephanus* sp. cf. *O. curacoensis* of the Late Valanginian near the top of the Abundancia Formation, b) *Crioceratites* sp. cf. *C. duvali-C. schlagentweiti* of the early Late Hauterivian of the Nantoco Formation, c) *Crioceratites andinum* and *C. diamantense* from the Late Hauterivian of Totoralillo Formation, d) Hooked heteromorphs (Heteroceratinae?), and *Balearites*-like crioceratitids from the Barremian in the lower section of the Pabellón Formation. Intense search in the Upper Pabellón Formation yielded no ammonites. The author is very cautious with the Late Aptian age assigned to the Pabellón Formation (Pérez *et al.*, 1990), as it is based in a single fragmentary ammonite specimen with no visible suture line. It is also worth noting here, that it would be the first proven marine Aptian section of the north-central Andean basins.

Aconcagua - Central Chile

The marine neocomian deposits are exposed in two narrow belts, one in the Cordillera de la Costa in the west, and the other in the Main Cordillera to the east. They are represented in two different tectonic settings. The fore-arc deposits correspond to the Lo Prado Formation (more than 4000 meters of sandstones, limestones, and shales interbedded with andesites) exposed in the Cordillera de la Costa (Nasi and Thiele, 1982) (Fig. 4). Several levels with ammonites have been identified: *Spiticeras (Kilianiceras)* sp., *Thurmanniceras* aff. *T. duraznense*, and *Cuyaniceras* sp. (Late Berriasian); *Thurmanniceras* sp., *Bochianites* sp., and *Olcostephanus* sp. (late Valanginian); and indeterminate Hauterivian crioceratitids (Nasi and Thiele, 1982).

Plate III. Hauterivian Ammonites from the Neuquén Embayment.

1 *Weavericeras vacaensis* (Weaver), CPBA 13976, lateral view, locality Cerro Bayo, Neuquén, Lower Hauterivian.

2 *Lyticoceras pseudoregale* (Burckhardt), CPBA 13956, lateral view, locality Mina San Eduardo, Neuquén, Lower Hauterivian.

3-4 *Spitidiscus* sp. nov., CPBA 13957, lateral and ventral views, locality Agrio del Medio, Neuquén, Upper Hauterivian.

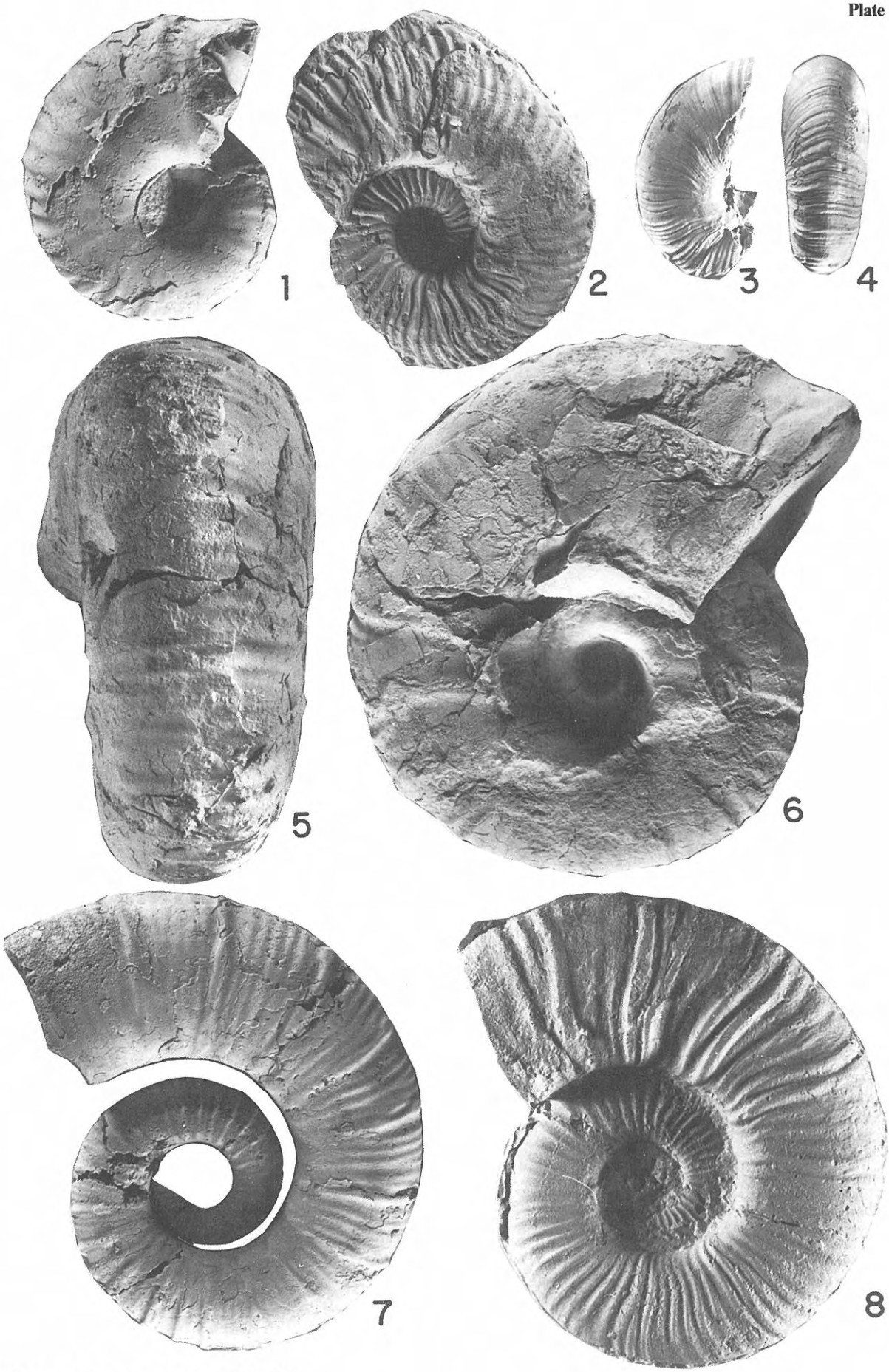
5-6 *Holcoptychites neuquensis* (Douvillé), CPBA 5153, ventral and lateral views, locality Cerro Mesa, Neuquén, Lower Hauterivian.

7 *Crioceratites apricus* (Giovine), CPBA 5320, type, lateral view, locality Cerro Curaco, Neuquén, Upper Hauterivian.

8 *Crioceratites diamantensis* (Gerth), plaster cast of type, lateral view, locality Cerro del Perdido, Mendoza, Upper Hauterivian.

All figures natural size.

Plate III



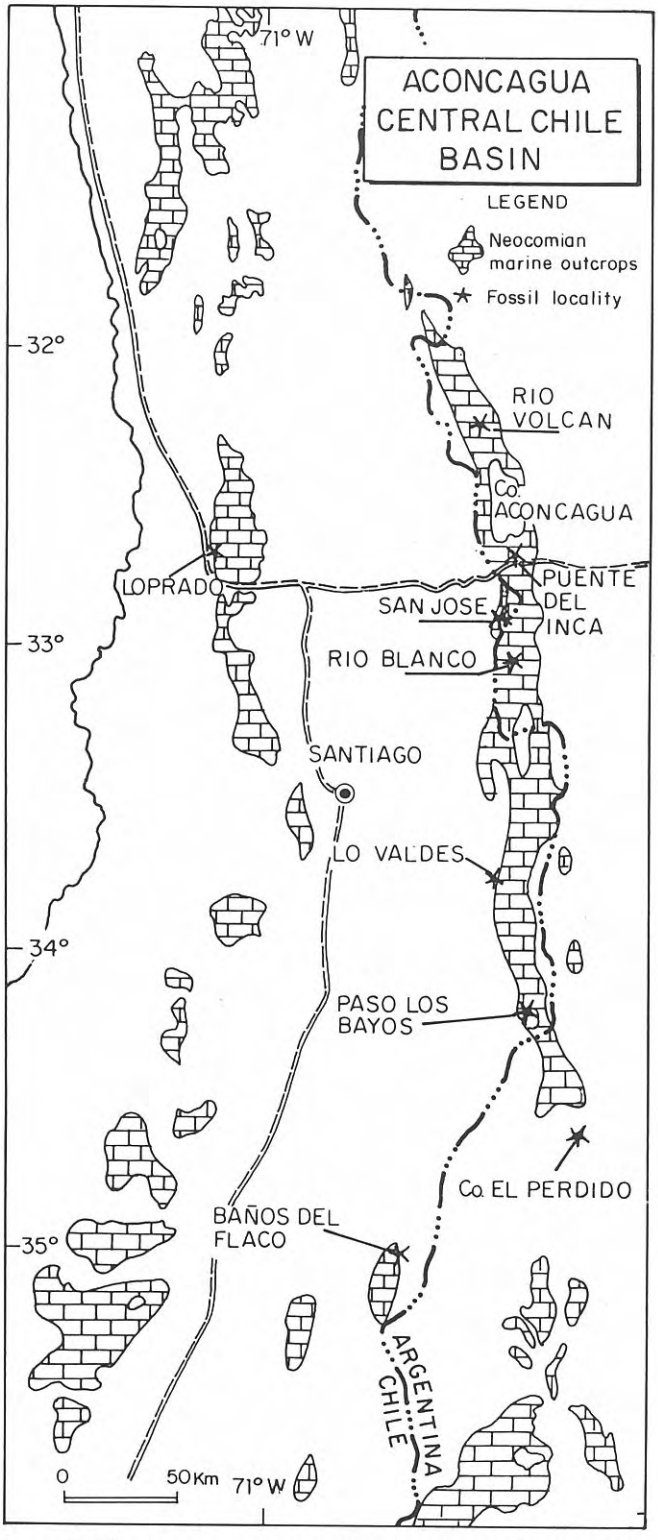


Figure 4. Neocomian outcrops of the Aconcagua-Central Chile Basin, with main fossil localities (based on Ramos and Aguirre-Urreta, 1992).

The back-arc sequence is represented by the Mendoza Group in Argentina and the San José, Lo Valdés, and Baños del Flaco Formations in Chile. These last three units, predominantly calcareous, are partially equivalent among each other. The San José Formation exposed in the northern part of the region has ammonites in three distinct stratigraphic levels. A lower one contains *Cuyaniceras* sp., *Spiticeras* sp., and *Neocosmoceras*? sp. of Late Berriasian age (Corvalán, 1959). A middle horizon has *Olcostephanus* sp. of the Late Valanginian, and the upper sequence bears *Lyticoceras pseudoregale* and *Pseudofavrella angulatiformis* of Early Hauterivian age (Lo Forte, 1992).

Towards the south, the Lo Valdés Formation is a richly fossiliferous, thick sequence of more than 1000 meters of limestones, sandstones, shales, and submarine lavas. It bears ammonites from the Tithonian to the Hauterivian that were assembled in eight faunistic zones. The four upper zones correspond to the Early Berriasian *(Argentiniceras bituberculatum* and *Thurmannites discoidales* Zone*),* Late Berriasian (*Cuyaniceras transgrediens* Zone), Valanginian (*Favrella* cf. *angulatiformis* Zone), and Hauterivian (*Paracrioceras andinum* Zone) (Biro-Bagoczky, 1980). The Baños del Flaco Formation correlates well with the Lo Valdés Formation and shows similar ammonite faunas, but Biro-Bagoczky (1984) based on personal collecting, restricted the Baños del Flaco Formation to the Tithonian-Berriasian. This criterion is not followed here (see also Riccardi, 1988 and Aguirre-Urreta and Charrier, 1991).

The Mendoza Group in the Aconcagua area of Argentina is less fossiliferous than its equivalents in the Chilean side (Ramos and Aguirre-Urreta, 1992), most probably related to a shallower environment, which is in fact dominated by bivalves and gastropods. However, ammonites indicative of Early Hauterivian were found near the Aconcagua, in arroyo Relincho (Lo Forte and Pérez, 1991) and in Puente del Inca (Aguirre-Urreta, unpublished). The Mendoza Group in the Aconcagua area presents its uppermost fossiliferous levels in the Early Hauterivian, while towards the west and south, the marine transgression continues up to the Late Hauterivian-Early Barremian (see below). Table 2 summarizes de Neocomian ammonite assemblages of Aconcagua - Central Chile and the Neuquén Embayment, with reference to the European standard zones.

Neuquén Embayment

The Andean cycle in the Neuquén basin, as defined by Groeber (1953) comprises both marine and continental deposits, that are assembled in the Mendoza Group (Fig. 5). The marine Tithonian-Early Valanginian is represented by rich, organic dark shales with

Plate IV. Hauterivian-Barremian Ammonites from the Neuquén Embayment and Copiapó.

1 *Crioceratites andinus* (Gerth), plaster cast of type, lateral view, locality Cerro del Perdido, Mendoza, Upper Hauterivian.

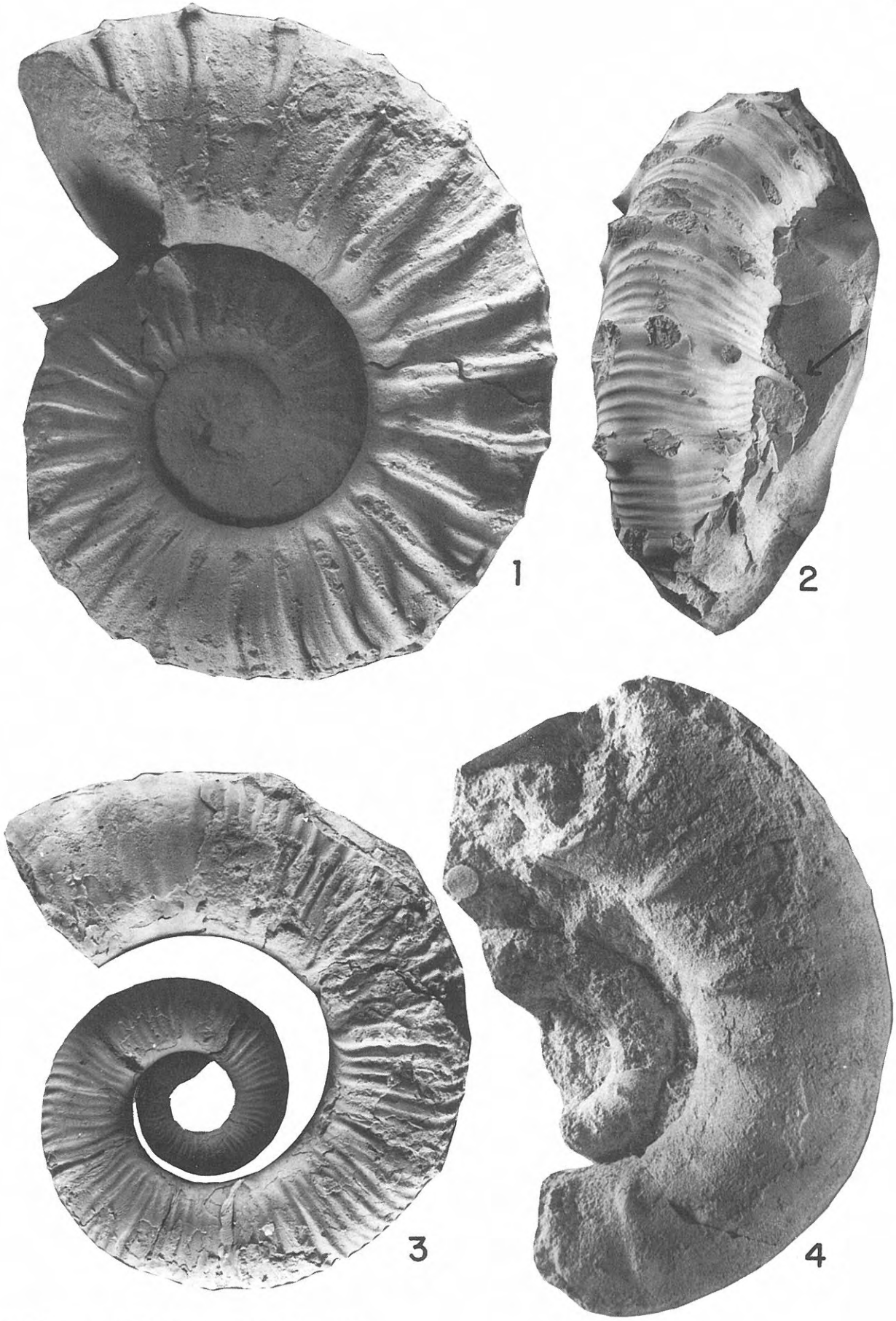
2 *Crioceratites andinus* (Gerth), SERNAGEOMIN s/n, ventrolateral view showing umbilical spine (arrowed), locality Chañarcillo, Copiapó (Chile), Upper Hauterivian.

3 *Crioceratites schlagintweiti* (Giovine), CPBA 5151, type, lateral view, locality Estancia Gallardo, Neuquén, Upper Hauterivian.

4 *Paraspiticeras groeberi* Aguirre-Urreta, MLP 17648, lateral view, locality Cañada de los Perros, Mendoza, Lower Barremian.

All figures natural size.

Plate IV



calcareous nodules (Vaca Muerta Formation, Tithonian-Berriasian), and thinly laminated limestones (Quintuco Formation, Berriasian-Valanginian). The paleogeography was complex, especially during the Valanginian, when a regression took place, and there was a coexistence of continental and volcaniclastic beds, marine shales and thick carbonate deposits (Legarreta and Uliana, 1989). A transgressive phase occured in the latest Valanginian-Earliest Hauterivian with the deposition of the shales and limestones of the Agrio Formation (Uppermost Valanginian-Early Barremian). The top of the sequence indicates the regression of the Pacific sea during Barremian times.

Marine mollusk fossils are abundant through the sequence, except in part of the Valanginian, where the faunas are only found in the deeper parts of the Neuquén Embayment.

Leanza (1981) distinguished fourteen ammonites zones for the Mendoza Group, ranging from Lower Tithonian to? Lower Barremian. Riccardi (1984, a, b) proposed a succession of ammonoid assemblages for the Cretaceous of the Andean Basins and compared them with the European Standard Zones. These zonations were later updated (Riccardi, 1988).

Recent studies and current research modified part of this knowledge, and there are also some additions: a) the finding of Late Berriasian *(Berriasella callisto, Kilianella primaeva*, and *Protancyloceras*, sp.), and Early Valanginian ammonites *(Valanginites argentinicus)* in the upper section of the Vaca Muerta Formation (Leanza and Wiedmann, 1989). b) the precise location of *"Hoplitocrioceras" gentili*, (a genus that is a probable junior synonym of *Acanthodiscus*), and *Olcostephanus leanzai* in the Lower Member of the Agrio Formation, Early Hauterivian (Aguirre-Urreta, unpublished). c) the location of a distinctive horizon with *Spitidiscus* spp. few meters above the Avilé Member of the Agrio Formation (Aguirre-Urreta, in preparation). d) the separation of species of *Crioceratites* in two distinct assemblages of Late Hauterivian age in the Upper Member of the Agrio Formation (Aguirre-Urreta and Rawson, 1992). e) several species of *Spitidiscus* and *Plesiospitidiscus* (Lean-

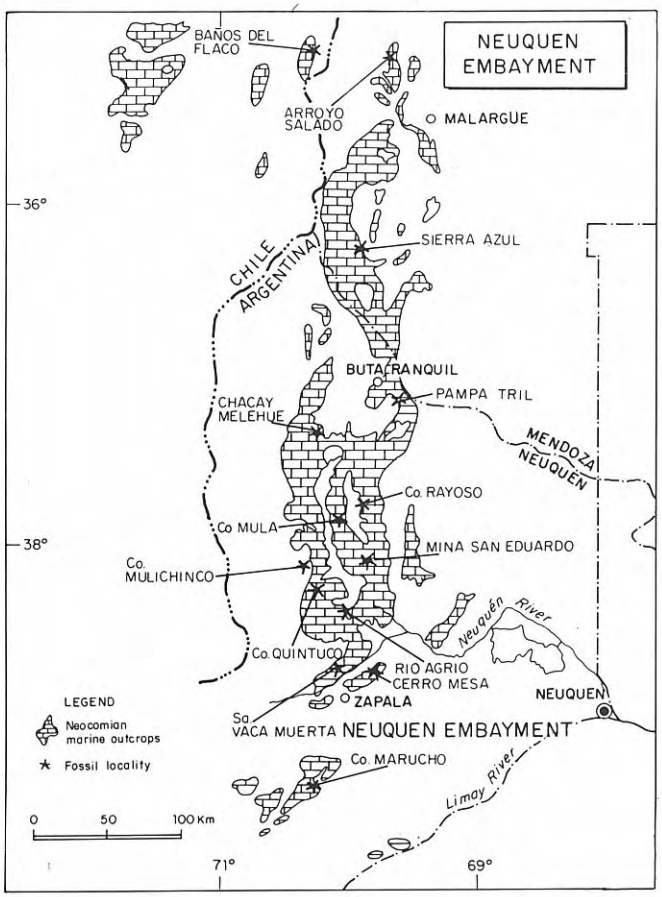


Figure 5. Neocomian outcrops of the Neuquén Embayment, with main fossil localities (based on Gulisano *et al.*, 1984 and Riccardi, 1988).

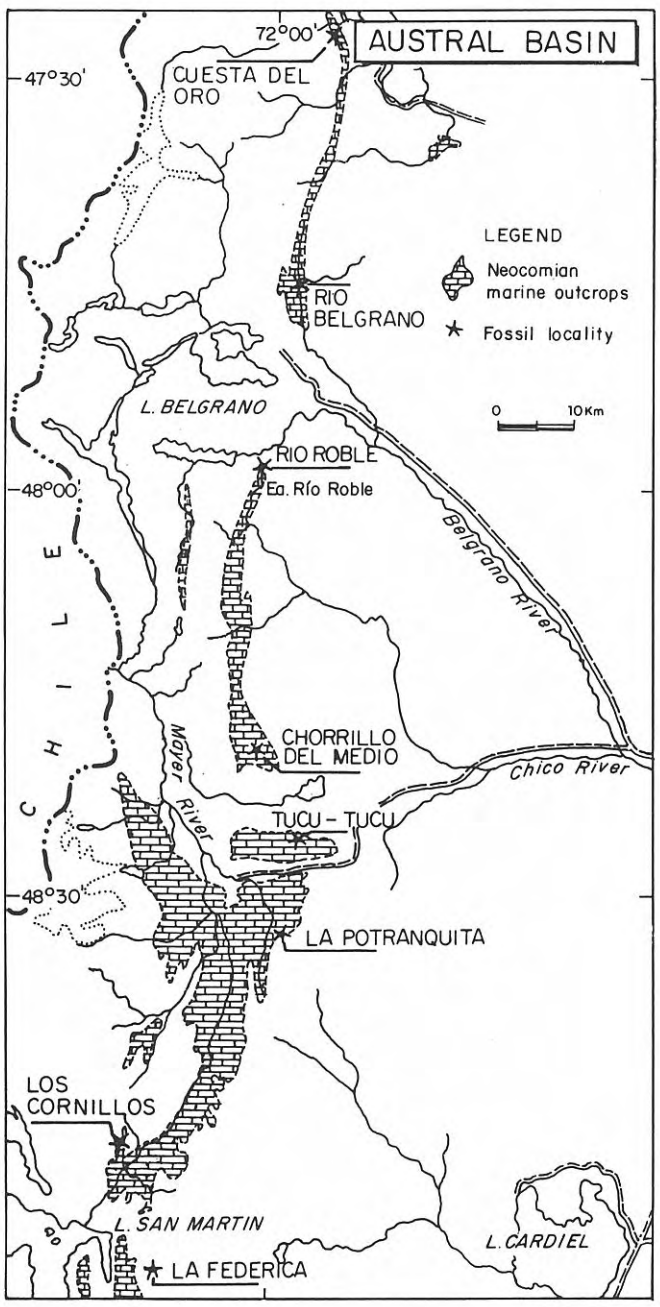


Figure 6. Neocomian outcrops of the northern Austral Basin, with main fossil localities (based on Aguirre-Urreta, 1990).

		EUROPEAN STANDARD ZONES	ARGENTINA & CHILE
LOWER BARREMIAN		*Moutoniceras sp.* *Pulchellia compressissima* *Spitidiscus hugii*	*X. Paraspiticeras groeberi*
HAUTERIVIAN	Upper	*Pseudothurmannia angulicostata* *Plesiospitidiscus ligatus* *Subsaynella sayni*	*IX. Crioceratites diamantense, C. andinus, C. perditus, C. bederi* *VIII. Crioceratites schlagintweiti, C. apricus* *VII. Spitidiscus riccardii, S. aff. S. rotula, S. aff. S. gastaldianus, Plesiospitidiscus gutierrezi, P. coccai*
	Lower	*Lyticoceras nodosoplicatus* *Olcostephanus jeannoti* *Crioceratites loryi* *Acanthodiscus radiatus*	*VI. Holcoptychites neuquensis, H. compressus, H . demissus, Weavericeras vacaensis, "Hoplitocrioceras" gentili, Olcostephanus leanzai* *V. Lyticoceras pseudoregale, L. australe Neocomites crassicostatus, Pseudofavrella angulatiformis, P. garatei, Acanthodiscus vaceki, A. wichmanni, A. aff. hookeri, Teschenites sp.*
VALANGINIAN	Upper	*Neocomites (Teschenites) callidiscus* *Himantoceras trinodosum* *Saynoceras verrucosum*	*IV. Olcostephanus curacoensis, O. atherstoni, O. sakavalensis, O. (Lemurostephanus) araucanus, O. (L.) mingrammi, O. (L.) permolestus. Karakaschiceras attenuatus, Lissonia riveroi*
	Lower	*Thurmanniceras campylotoxus* *Thurmanniceras pertransiens* *Thurmanniceras otopeta*	*III. Neocomites wichmanni, Thurmanniceras pertransiens, Acantholissonia gerthi, Lissonia riveroi, Sarasinella crassicostata, Valanginites argentinicus*
BERRIASIAN	Upper	*Berriasella callisto* *Berriasella picteti* *Malbosiceras paramimounum* *Dalmasiceras dalmasi* *Berriasella privasensis* *Tirnovella subalpina*	*II. Spiticeras damesi, S. andinum, S. bodenbenderi, S. fraternum, S. mammatum, S. singulare, Cuyaniceras groeberi, C. inflatum, C. raripartitum, C. transgrediens, Thurmanniceras duraznense, T. keideli, T. neogaeum, T. huncalense, Neocomites regularis, N. aff. occitanicus, Pseudoblanfordia australis, Berriasella callisto, Kilianella primaeva, Neocosmoceras aff. sayni, Protancyloceras sp.*
	Lower	*Berriasella (Pseudosubplanites) grandis*	*I. Argentiniceras noduliferum, A. bituberculatum, Berriasella laxicosta, Frenguelliceras magister, F. simplex, Groebericeras bifrons, Hemispiticeras steinmanni, Substeueroceras disputabile, Thurmanniceras discoidale*

Table 2. Neocomian Ammonite Assemblages from Aconcagua-Central Chile and the Neuquén Embayment with the European Standard Zones (European zones from Hancock, 1991).

		EUROPEAN STANDARD ZONES	AUSTRAL BASIN
BARREMIAN	Upper	*Colchidites sp.* *Heteroceras astieri* *Hemihoplites feraudianus* *"Emericiceras" barremense*	*VI. Colchidites vulanensis australis, Heteroceras (Heteroceras) elegans, Sanmartinoceras africanum insignicostatum*
	Lower	*Moutoniceras sp.* *Pulchellia compressessima* *Spitidiscus huggi*	*V. Hatchericeras patagonense, H. santacrucense, H. semilaeve, Pseudohatchericeras argentinense, Cryptocrioceras yrigoyeni, Subsaynella Malgasaynella) besairiei, Sanmartinoceras africanum insignicostatum, Hemihoplites varicostatum, Acrioceras sp. aff. merinae*
HAUTERIVIAN	Upper	*Pseudothurmannia angulicostata* *Plesiospitidiscus ligatus* *Subsaynella sayni*	*IV. "Favrella" wilckensi, Protaconoceras patagoniense, Hemihoplites varicostatus*
	Lower	*Lyticoceras nodosoplicatum* *Olcostephanus jeannoti* *Crioceratites loryi* *Acanthodiscus radiatus*	*III. Favrella americana, Hemihoplites ploszkiewiczi, Aegocrioceras sp.*
VALANGINIAN	Upper	*Neocomites (Teschenites) callidiscus* *Himantoceras trinodosum* *Saynoceras verrucosum*	*II. Olcostephanus sp.*
	Lower	*Thurmanniceras campylotoxus* *Thurmanniceras pertransiens* *Thurmanniceras otopeta*	
BERRIASIAN	Upper	*Berriasella callisto* *Berriasella picteti* *Malbosiceras paramimounum* *Dalmasiceras dalmasi* *Berriasella privasensis* *Tirnovella subalpina*	*I. Jabronella sp. aff. michaelis, Neocosmoceras ornatum, Neocosmoceras sp., Delphinella sp., Thurmanniceras sp., Berriasella inaequicostata, Phyllopachyceras aureliae, Berriasella jacobi Bochianites sp.*
	Lo-wer	*Berriasella (Subplanites) grandis*	

Table 3. Neocomian Ammonite Assemblages from the Austral Basin with the European Standard Zones (European zones from Hancock, 1991).

Plate V. Hauterivian-Barremian Ammonites from the Austral Basin.

1-2 *Favrella americana* (Favee), CPBA 13954, lateral and ventral views, locality Lago Belgrano, Santa Cruz, Lower Hauterivian.

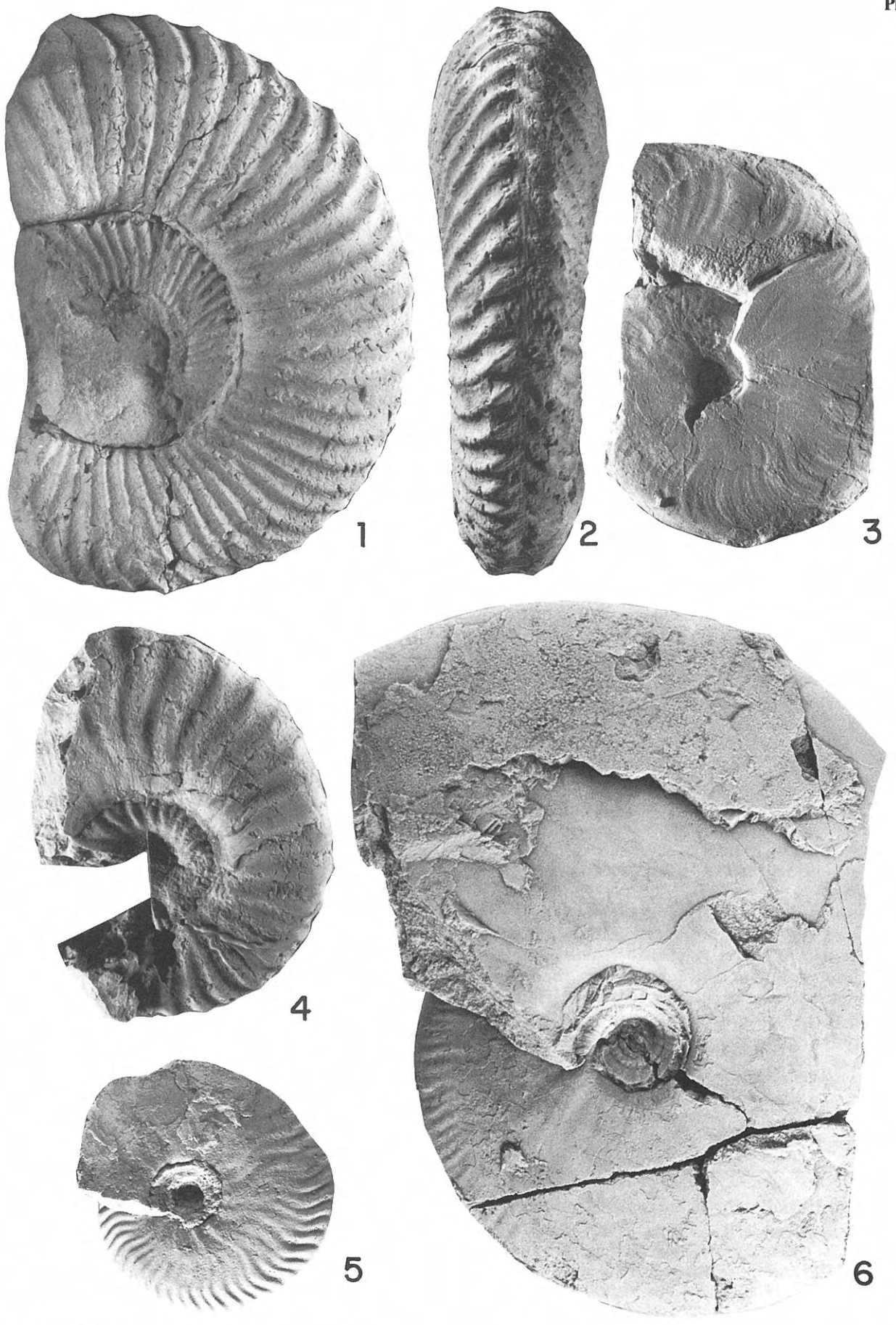
3 *Protaconeceras patagoniensis* (Favre), CPBA 11098, lateral view, locality Río Belgrano, Santa Cruz, Lower Hauterivian.

All figures natural size.

4 *Hemihoplites varicostatus* Riccardi and Aguirre-Urreta, ♀, CPBA 11096, laterla view, locality Río Belgrano, Santa Cruz, Upper Hauterivian.

5-6 *Subsaynella (Malgasaynella) besairiei* (Collingnon), CPBA 11114-11115, lateral views, locality Cuesta del Oro, Santa Cruz, Lower Barremian.

Plate V



za and Wiedmann, 1992), regarded by these authors as Barremian were precisely located in the field by the author in the uppermost Lower Member of the Agrio Formation of Hauterivian age. f) the discovery of proven Barremian faunas near the top of the Upper Member of the Agrio Formation: *Paraspiticeras groeberi* (Aguirre-Urreta and Rawson, 1992) (see Table 2).

Austral Basin

The Neocomian deposits exposed at the foothills of the Patagonian Cordillera (Fig. 6) are mostly marine clastics. The base of the sedimentary sequence is composed of coarse quartzitic sandstones ranging from fluvial continental to littoral marine facies of Tithonian to Valanginian age (Springhill Formation). Thick series of black shales of basinal facies (Rio Mayer Formation) bear fossiliferous calcareous nodules. A progradating sequence of green sandstones and shales (Rio Belgrano Formation, Barremian), bearing horizons with abundant fossils preserved in sandy concretions are covering the previous shales. Towards the south, the Neocomian deposits are represented by deeper water facies, and thus the fauna is scarce and not well preserved. However, ammonites are known from the Zapata and Yahgan Formations (Feruglio, 1936-37; Leanza, 1968).

Ammonites from the Hauterivian-Barremian are widely distributed through the north part of the basin while the Berriasian and Valanginian faunas are only locally found. They were grouped in six assemblages (Riccardi, 1984a, b; 1988) that were recently updated with new studies (Aguirre-Urreta, 1990) (see Table 3). These new finds include: a) Two new species of *Hemihoplites* ranging from the Early Hauterivian to the Early Barremian, in the Rio Mayer Formation (Riccardi and Aguirre-Urreta, 1989); b) *Subsaynella (Malgasaynella) besairiei*, a malagasy species in the Early Barremian Río Belgrano Formation (Aguirre-Urreta and Ramos, 1989); c) *Acrioceras* sp. aff. *A. merinae*, a single specimen that is the first Barremian hooked heteromorph found in the Río Belgrano Formation, associated with *Hatchericeras semilaeve.*

Towards the south, in the area of lake San Martín, the Berriasian ammonites are poorly preserved (Riccardi, 1977), and in the lake Argentino region they have received little attention since Feruglio's monograph (1936-37), later revised by Leanza (1968). In Tierra del Fuego, the record of Neocomian ammonites is restricted to *Favrella americana* in the Yahgan Formation (Suárez *et al.*, 1979).

CORRELATIONS AND FAUNAL AFFINITIES

Berriasian-Lower Valanginian faunas are absent in the northern part of the Andean basins. In Central Chile and the Neuquén Embayment they are abundant and show Mediterranean affinities. Those of the Austral basin, though poorly preserved, share several genera in common with the northern segments.

During the Late Valanginian-Hauterivian there is a sharp change. The cephalopod faunas of the Austral basin become strongly endemic (Riccardi, 1991) and are disconnected with those of the north. They present very low diversity, and are either endemic as *Favrella*, or with episodic links with boreal faunas as evidenced by the presence of *Protaconeceras* and *Aegocrioceras.*

The Late Valanginian-Hauterivian ammonites from Copiapó-Vallenar and Aconcagua-Central Chile are less diverse than those from the Neuquén Embayment, but share the same genera. The apparent high diversity in Copiapó (i.e. *Crioceratites, Shasticrioceras, Paracrioceras, Menuthiocrioceras, Ancyloceras,* etc.) is most probably due to taxonomic splitting. In the Neuquén Embayment the Lower Hauterivian is represented by a series of endemic genera as *Pseudofavrella, Holcoptychites*, and *Weavericeras* together with Mediterranean components *(Acanthodiscus, Lyticoceras).* In the Upper Hauterivian the faunas are dominated by *Crioceratites* of Mediterranean affinities, with the local presence of *Spitidiscus.*

The Barremian ammonites from Copiapó are poorly known due to their scarcity in very shallow facies. Big hooked heteromorph are probable Heteroceratinae, and are associated with very finely ribbed *Balearites*-like crioceratitids. In Aconcagua - Central Chile the higher marine horizons correspond to the Lower Hauterivian, becoming younger to the south. The new findings of Barremian faunas in the Neuquén Embayment (Aguirre-Urreta and Rawson, 1992) point to Mediterranean connections.

During the Barremian, the Austral basin shows strong similarities with coeval faunas of South Africa *(Hatchericeras, ?Hemihoplites, Acrioceras, Sanmartinoceras, Colchidites,* and *Heteroceras)* and the Caucasus *(Colchidites, Heteroceras, Acrioceras, Hemihoplites)*, and with a lesser extent with Madagascar *(Malgasaynella)* and the Mediterranean *(Acrioceras, Hemihoplites).* According to Riccardi (1991) this Barremian fauna marks the inception of an austral ammonoid fauna. The apparent endemic Lower Barremian *Hatchericeras* has been recorded in South Africa (Kennedy and Klinger, 1990), and the heteromorphs are also very similar Recently, Klinger and Kennedy (1992) described these Barremian heteromorphs, including them in *Crioceratites* and *Acrioceras.* Their interpretation of *Paracrioceras, Cryptocrioceras,*

Plate VI. Hauterivian-Barremian Ammonites from the Austral Basin.

1 *Hatchericeras patagonense* Stanton, CPBA 13955, lateral view, locality Cuesta del Oro, Santa Cruz, Lower Barremian.

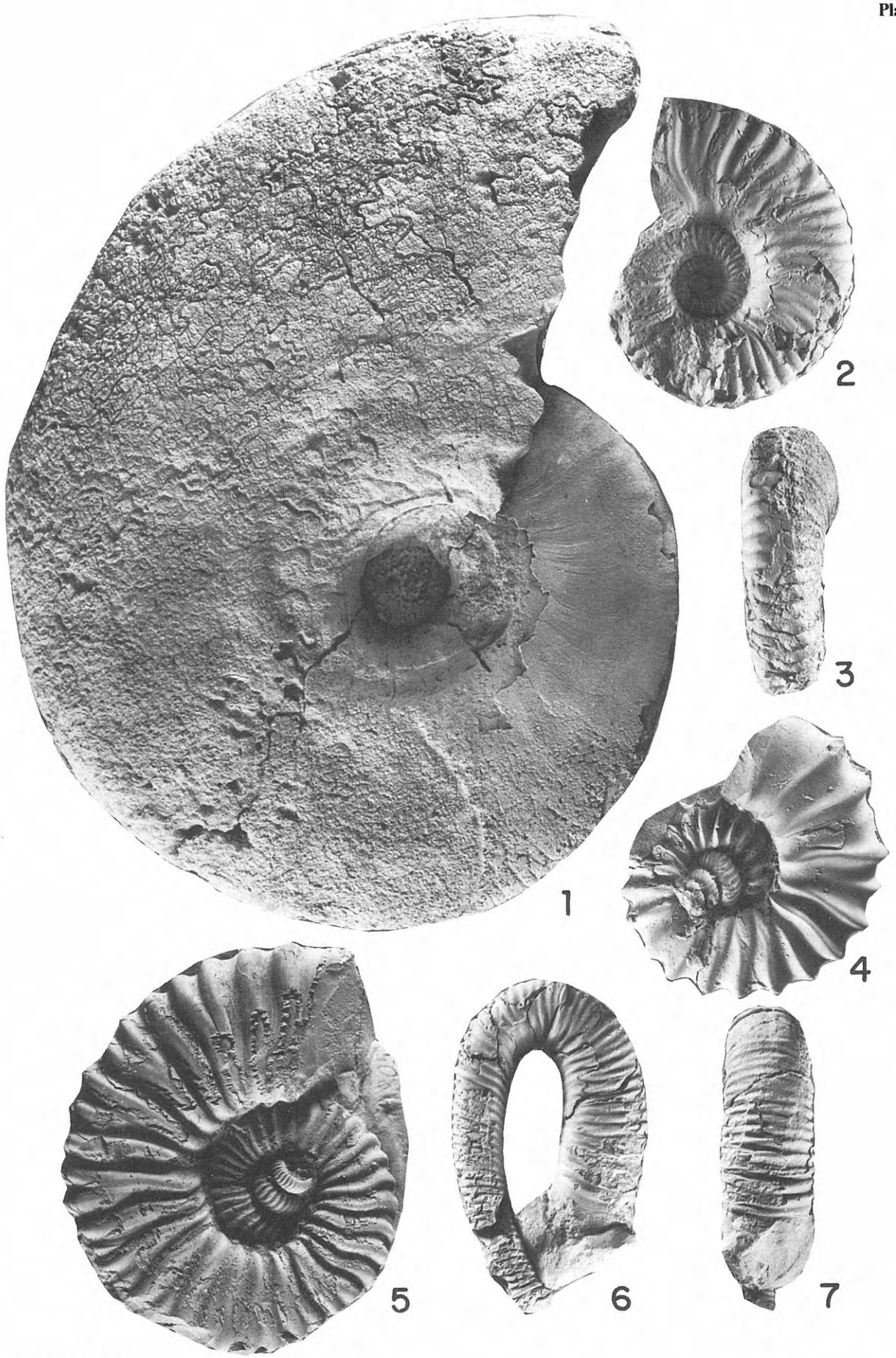
2-3 *Hemihoplites ploszkiewiczi* Riccardi and Aguirre-Urreta, ♂ allotype, CPBA 14149, lateral and ventral views, locality Veranada de la Vinca, Santa Cruz, Lower Hauterivian.

4-5 *Colchidites vulanensis australis* Kennedy, Klinger and Kakabadze, 4 ♂ and 5 ♀, CPBA 11823-11805, lateral views, locality Tucu-Tucu, Upper Barremian.

6-7 *Heteroceras (Heteroceras) elegans* Rouchadzé, CPBA 11121, lateral and ventral views, locality Cerro Los Cornillos, Santa Cruz, Upper Barremian.

All figures natural size.

Plate VI



and *Emericiceras* as younger synonyms of *Crioceratites* is not accepted here, but a detailed discussion of the problem exceeds the scope of this paper.

Although the Andean faunas of southern South America are quite well known, the centers of origin and the migration patterns are still unclear, and more oceanographic, paleogeographic, and paleoclimatic information is required before models can be postulated.

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Plate VII. Barremian Ammonites from the Austral Basin.

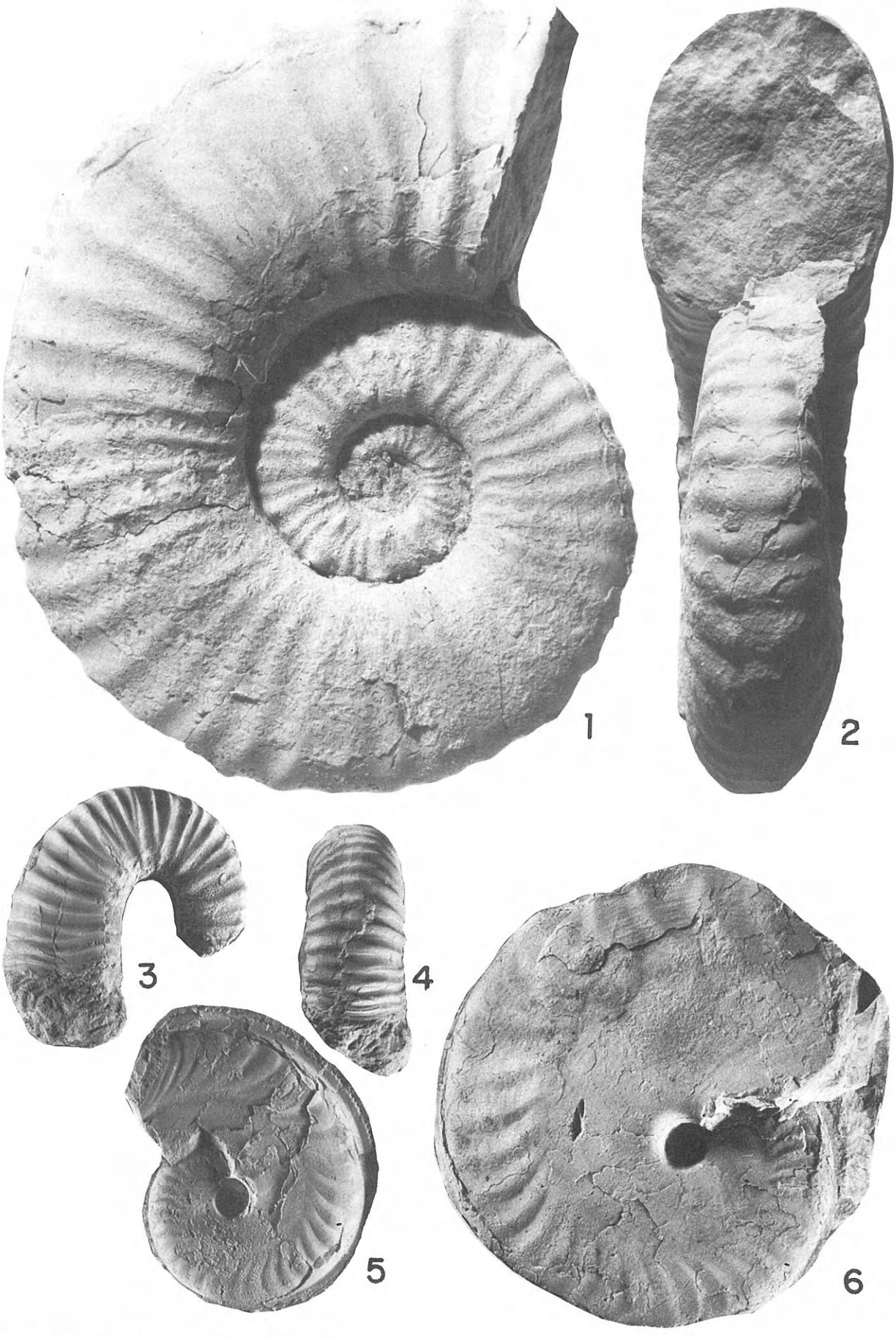
1-2 *Cryptocrioceras yrigoyeni* (Leanza), CPBA 10895, lateral and apertural views, locality Río Roble, Santa Cruz, Lower Barremian.

All figures natural size.

3-4 *Acrioceras* sp. aff. *A. merianae*, CPBA 11050, lateral and ventral views, locality Río Belgrano, Santa Cruz, Lower Barremian.

5-6 *Sanmartinoceras africanun insignicostatum* Riccardi, Aguirre-Urreta and Medina, 5 ♀ and 6 ♂, CPBA 11780-11770, lateral views, locality Tucu-Tucu, Upper Barremian.

Plate VII



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