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LATE CRETACEOUS AMMONITES FROM SENO SKYRING-STRAIT OF MAGELLAN AREA, MAGALLANES PROVINCE, CHILE

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ABSTRACT—An Upper Cretaceous ammonite fauna consisting of *Maorites, Gunnarites, Hypophylloceras,* and *Diplomoceras* species is described and its stratigraphic position is discussed. Species found by other authors at the type localities of the studied formations are also included and some statements of former works on the Magellan area are revised. A *Gunnarites kalika* Zone is proposed and embraces the studied formations. The Foraminifera found together with the ammonites establish the age of this fauna as late Maestrichtian. Chronological indicators among the foraminiferids are *Bolivinoides draco dorreeni* Finlay, *Globigerinella messinae messinae* Brönnimann, and trochoid forms of *Rugoglobigerina rugosa* (Plummer).

INTRODUCTION

In an attempt to determine the position of the Cretaceous-Tertiary boundary in the region between the north coast of Seno [Sound] Skyring and the west coast of the Strait of Magellan (Text-figs. 1, 2), we studied six stratigraphic sections. One of the sections is El Ganso No. 1 well drilled by Empresa Nacional de Petroleos (ENAP), the Chilean State Petroleum Company. The other five sections were studied in the field and measured by plane table at scales of 1 :3000 and 1 :5000.

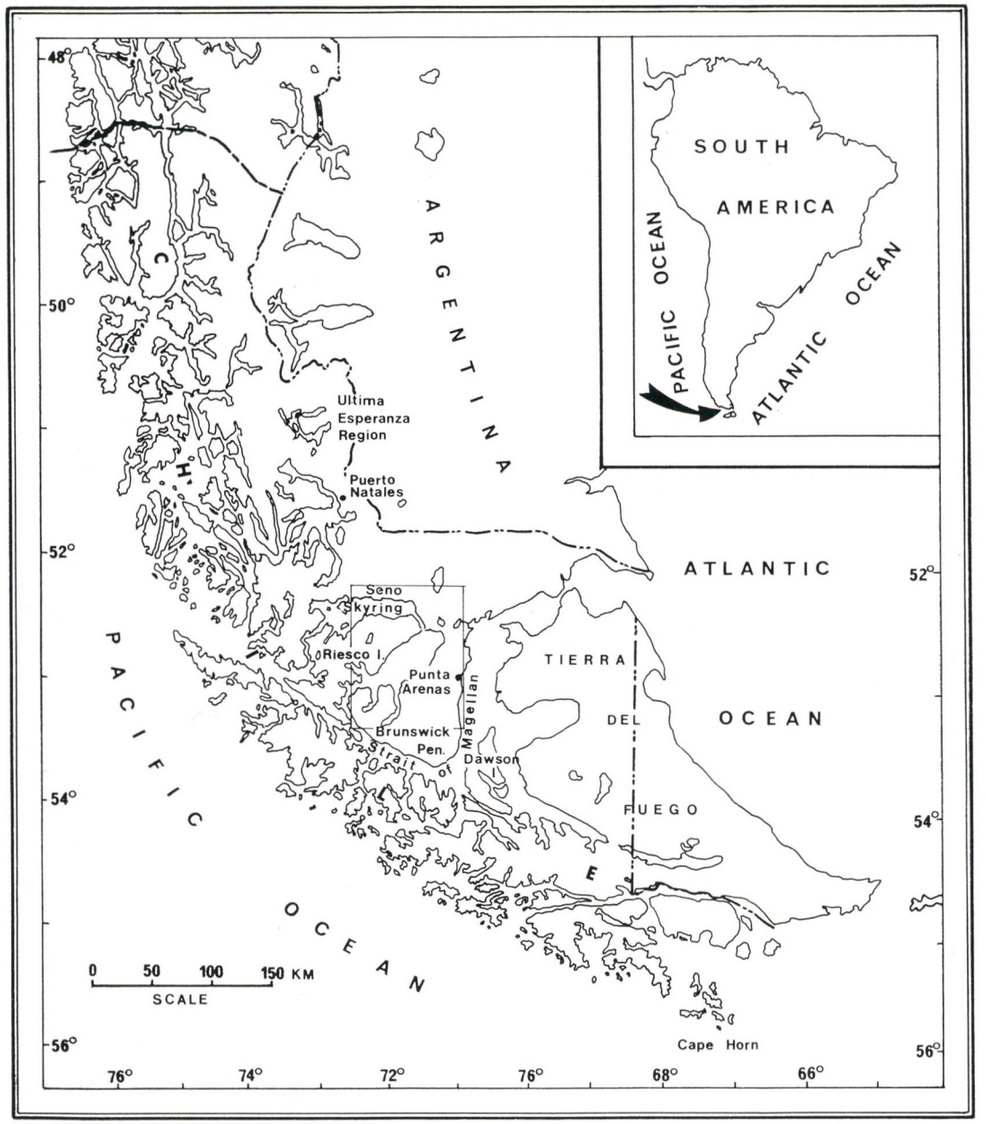
Previous work.—The first geologic studies of the southern part of South America were done in the eighteenth and nineteenth centuries by naturalists with scientific expeditions. Some classic works are those of Darwin, d'Orbigny, and Grange (e.g. Darwin, 1846). At the end of the last century and during the present century the whole of Patagonia and Tierra del Fuego have been subjected to an intensive geologic survey in the search for oil. Because of the interesting stratigraphic and paleontologic problems, a long list of workers including Ameghino, Auer, Berry, Favre, Feruglio, Florin, Gaudry, Halle, Hauthal, Hünicken, Paulcke, Steinmann, Wilckens and others (see Léxique Stratigraphique International, Chili, 1957) outlined the stratigraphy and studied the faunas of this region.

The development of the paleontologic and stratigraphic knowledge of the Magallanes Province has been greatly increased by the constant work of the ENAP and of foreign and Chilean geologists. Thomas (1949) in the Seno Skyring area and von Goetsche (1953) in the Brunswick Peninsula (Text-fig. 2) established the still accepted stratigraphic subdivisions based on the work of Bonarelli, Decat & Pomeyrol, Felsch, Keidel & Hemmer, Hollister, Shaw & Mohr, and Thomas (see Léxique Stratigraphique International, Chili, 1957, cum. bibliog).

Later studies have introduced slight modifications to the basic outline of the stratigraphy of the Magallanes Province. Cecioni (1954, 1955, 1956a, 1956b, 1957a, 1957b) made most of the regional correlations, primarily on the basis of paleontologic evidence. Hauser (1964, (unpub. thesis, Univ. Chile, Santiago)) studied the Foraminifera of subsurface formations equivalent to those studied by us in outcrops. Herm (1966) reviewed the present state of the micropaleontology of this region. Fasola (1968) studied the palynologic content of the Oligocene Loreto Formation in the Brunswick Peninsula. Charrier & Lahsen (1968) analyzed the planktonic Foraminifera at the Cretaceous-Tertiary boundary in the sections studied here. Among the paleontologists who have identified elements of the Magallanes fauna are Todd & Knicker (1952), Robles & Gómez (1956), Leanza (1963), Martínez-Pardo (1965), and Cookson & Cranwell (1967).

STRATIGRAPHY

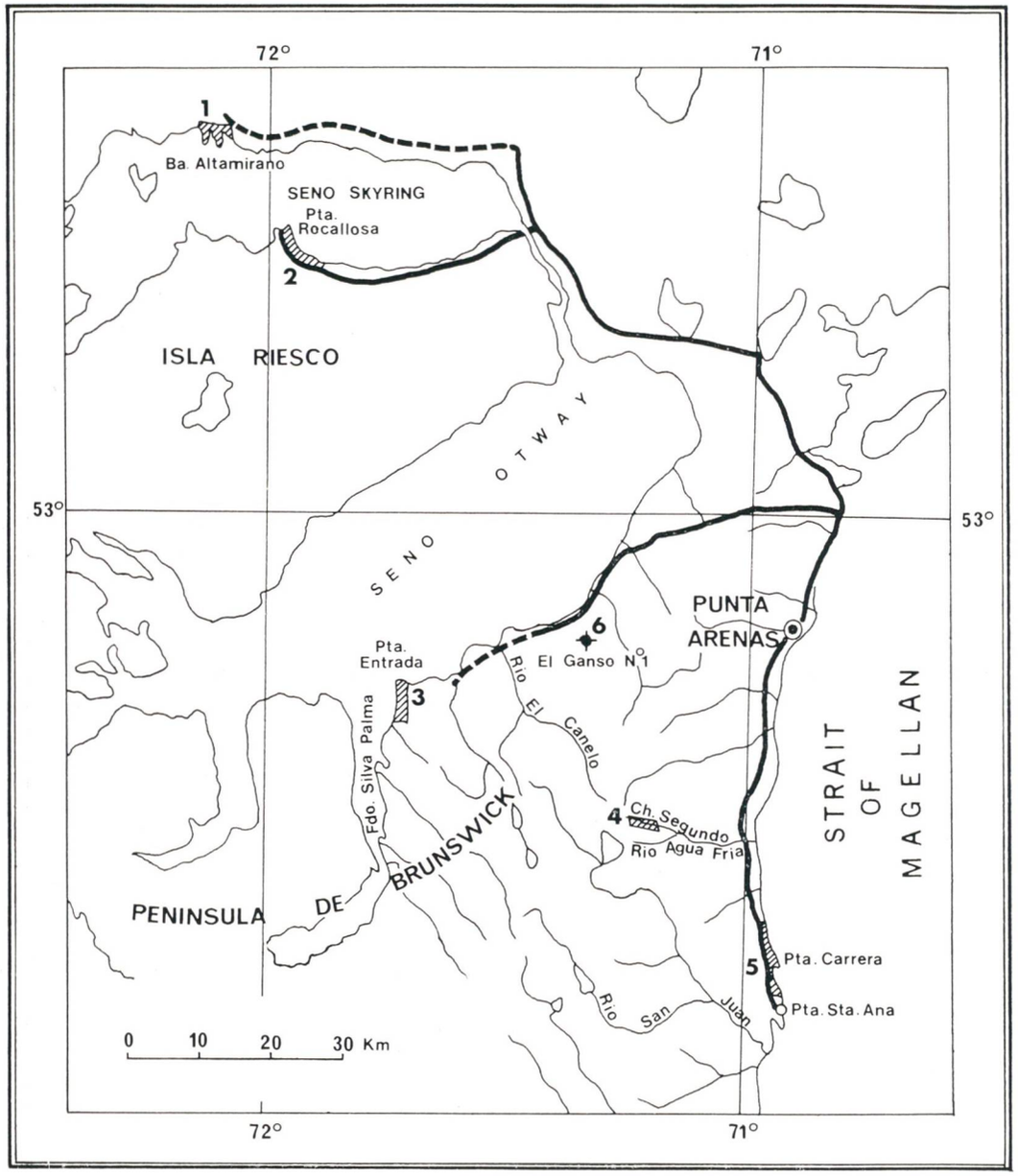
The geologic units of the Seno Skyring-Strait of Magellan area crop out in parallel northwest-southeast bands whose ages and intensity of folding decrease eastward. The sections studied in the present work belong to a



TEXT-FIG. 1—Location map of Magallanes Province area of southern Chile with Ultima Esperanza region and studied area indicated.

Cretaceous-Tertiary band. The lithologic units of the northern part of the studied area are not the same as those found in the southern part. A schematic succession of the marine formations studied in both areas is shown in Table 1. The thicknesses shown for the Agua Fresca, Fuentes, and Santa Ana formations are those indicated in the Léxique Stratigraphique International, Chili (1957). The other units were measured by us at the type localities.

No agreement exists concerning the correlation of the lower formations. Charrier & Lahsen (1969) suggested that the middle part of the Rocallosa Formation and the Carrera Formation are equivalent based on geochemical analysis to determine the elemental composition of their fine

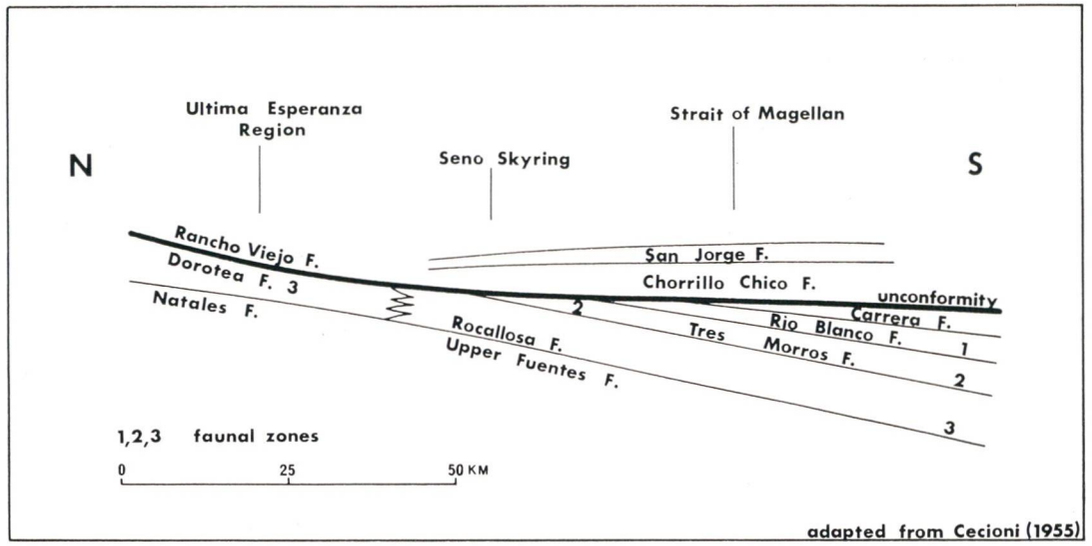


TEXT-FIG. 2—Seno Skyring-Strait of Magellan area with studied sections shown by numbers.

fractions. More detailed work is needed to solve this problem.

The studied formations consist of hard terrigenous sediments, e.g. glauconitic graywackes, siltstones, and argillites. The samples show very poor sorting, only slight alterations of the feldspar grains, and a great predominance of angular grains. All these features indicate rapid erosion, transport and deposition. Argillaceous graded bedding and the presence in the matrix of "floating" grains, support deposition by turbidity currents or viscuous flows.

A brief analysis of the benthonic Foraminifera indicates decrease through time of the depth of deposition. The Fuentes and Rocallosa formations contain specimens of *Allomorphina* and *Cyclammina*, genera that have a bathyal depth distribution (Bandy, 1964). Five species of *Elphidium* were found in the Agua Fresca Formation (Todd & Knicker, 1952). The presence of *Elphidium* indicates a very shallow sea less than 80 m deep (Phleger, 1960; Bandy, 1964). Formations between the Fuentes-Rocallosa and the Agua Fresca stratigraphic levels show a benthonic fauna indicating both bathyal and inner shelf environments.



TEXT-FIG. 3—Stratigraphic and geographic distribution of Upper Cretaceous faunal zones of Cecioni (1955).

PALEONTOLOGY

The Magallanes fauna is in general very poor in species as well as in individuals. The ammonite species here described were found associated with pelecypods, gastropods, annelids, some corals, and foraminiferids. The foraminifers are represented by a large number of species, some of which are good stratigraphic indicators. The representatives of the other groups are of no known chronologic value. Ammonite species were found only at four of the studied localities (see Text-fig. 2): Bahía Altamirano (loc. 1); Punta Rocallosa (loc. 2); Punta Entrada (loc. 3); and Strait of Magellan (loc. 5). Those ammonite species found in each stratigraphic unit of the studied sections are shown on Table 2. O. Wenzel (ENAP, personal communication) found some ammonite fragments in Member C of the Rocallosa Formation at locality 2 at the same level where Cecioni (1955, p. 143) found the fragment of *Gunnarites* sp. cited in the Table. The former fragments were also seen by us; they may represent a species of *Maorites* or a species of *Grossouvrites*.

FAUNISTIC CONSIDERATIONS ON THE MAGALLANES PROVINCE

Many of the species listed are known in the Ultima Esperanza region and at Dawson Island (Text-fig. 1) in the Strait of Magellan. At this last locality the species are the same and have the same stratigraphic distribution as on the east coast of the Brunswick Peninsula (loc. 5) (Cecioni, 1955). Comparisons with the Ultima Esperanza region are, however, much more difficult to establish. This was attempted by Cecioni (1955), and part of his results are shown in Text-figure 3. Cecioni established six

TABLE 1—Marine formations studied in the Seno Skyring-Strait of Magellan region.

Seno Skyring-Seno Otway Area	Eastern Brunswick Peninsula Area
Agua Fresca Formation (2100 m)	
San Jorge Formation (450 m)	
Chorrilo Chico Formation (275 m)	
Rocallosa Formation (290 m)	Carrera Formation (100 m)
Fuentes Formation (1220 m)	Rio Blanco Formation (400 m)
	Santa Ana Formation (600 m)

TABLE 2—Occurrence of ammonite species in the studied sections.

Bahía Altamirano (loc. 1)
  Upper Fuentes Formation
    Gunnarites kalika (Stoliczka)
    G. antarcticus (Weller)
    Hypophylloceras nera Paulcke *non* Forbes
Punta Rocallosa (loc. 2)
  Rocallosa Formation (Member C)
    Gunnarites sp. (*fide* Cecioni, 1955, p. 143)
  Upper Fuentes Formation
    Gunnarites kalika (Stoliczka)
    G. antarcticus (Weller)
    G. bhavaniformis (Kilian & Reboul)
    **G. zelandicus* (Marshall)
    Maorites tenuicostatus Marshall (*fide* A. Cañón, ENAP)
Punta Entrada (loc. 3)
  Upper Fuentes Formation
    Kossmaticeratidae indet.
East Coast of Brunswick Peninsula (loc. 5)
  Rio Blanco Formation
    Maorites cf. *M. densicostatus* (Kilian & Reboul)
    **M. densicostatus* (Kilian & Reboul)
    **M.* cf. *M. suturalis* Marshall
    **Gunnarites* cf. *G. kalika* (Stoliczka)
    **Diplomoceras* aff. *D. undulatum* Forbes
  Santa Ana Formation
    Maorites cf. *M. densicostatus* (Kilian & Reboul)
    M. cf. *M. tenuicostatus* Marshall
    Diplomoceras notabile (Whiteaves)
    **D. notabile* (Whiteaves)

* These species were found by von Goetsche (1953) at the type localities of the indicated formations and were determined by G. Cecioni whose identifications appear at the end of von Goetsche's report.

faunal zones for the Cretaceous of the Magallanes Province. The three upper zones include genera also found by us. Zone 1 is characterized by species of *Maorites*, Zone 2 is characterized by species of *Maorites* and *Gunnarites*, and Zone 3 has species of *Gunnarites* only. Cecioni stated that Zones 1 and 2 are not present in the Seno Skyring area, but he found all three of them in the Strait of Magellan area (loc. 5) in the Rio Blanco, Tres Morros, and upper Fuentes and Santa Ana formations respectively.

Ultima Esperanza region.—The following species were found in an upper level of the stratigraphic section from Cerro Cazador studied by Brandmayr & Bracaccini (*fide* Feruglio, 1949, p. 265–266; and Léxique Stratigraphique International, Chili, 1957, p. 59–62): *Maorites densicostatus* (Kilian & Reboul) cited as *Kossmaticeras* (*Madrasites*) *bhavani* Stoliczka *densicostatum* Kilian & Reboul [Cecioni, 1955, p. 142, indicated that this identification could be wrong], *Nautilus* sp., *Baculites* sp., *Pseudokossmaticeras* cf. *P. hauthali* Paulcke (Collignon) cited as *Holcodiscus* cf. *H. hauthali* Paulcke, and possible dinosaur bones. This fossil assemblage should belong to a higher level than Cecioni's Faunal Zone 3 (Cecioni, 1955, p. 142).

Hünicken (1955, p. 22) reported the following from the middle part of the Cerro Cazador beds in the Sierra Dorotea region: *Maorites densicostatus* (Kilian & Reboul), *M. seymourianus* (Kilian & Reboul) cited as a subspecies of *Kossmaticeras* (*Madrasites*) *bhavani* Stoliczka, *Diplomoceras notabile* (Whiteaves), *Tetragonites epigonum* Kossmat, *Grossouvrites gematus* Huppé, and *Lahillia luisa* Wilckens. In his 1965 paper Hünicken (p. 72) reassigned the forms earlier identified as *M. seymourianus* to *M. suturalis* Marshall and established a new species, *Diplomoceras australis*, for those reported as *D. notabile*. This fossil assemblage also corresponds to a high level in Cecioni's faunal zonation, and possibly is equivalent to the Rio Blanco Formation.

In the lower part of the Dorotea Formation (*non* Feruglio, *non* Katz) at the Tres Pasos River, Cecioni (1955, p. 143) found *Gunnarites flexuosus* Spath. At the base of this formation at Cancha Carrera (15 km south of Cerro Cazador), Cecioni (1955, p. 143) found *Pachydiscus* aff. *P. gollevilensis* (d'Orbigny) and *Eutrephoceras simile* Spath. This faunal assemblage corresponds to his Faunal Zone 3 (Text-fig. 3) which he traced up to the Seno Skyring area (locs. 1, 2) into the Rocallosa Formation. Based on *P.* aff. *P. gollevilensis*, he interpreted the Dorotea Formation, and therefore also the Rocallosa Formation, to be of Maestrichtian age.

Region studied in the present work.—From the above cited list of ammonites found in the studied region either by other workers or by us, it follows that the uppermost genera are *Maorites* and *Gunnarites*.

For the studied formations, many species indicated in the Léxique Stratigraphique International, Chili, (1957) and in unpublished ENAP reports have been found not only at their type localities but also in strata which have been correlated with these formations. Correlations are very difficult to establish in this region because of the thick forests and the small lithologic differences between the formations. Thus to avoid confusion as to the real stratigraphic positions of the studied fossils, we consider in this work only those species found by other authors at the type localities of the studied units, as described in Charrier & Lahsen (1969).

Some faunal indications given for the studied formations in the Léxique Stratigraphique International, Chili, (1957) should now be revised.

Only *Gunnarites* of the *kalika* group are reported to occur in the Santa Ana Formation (p. 329), but von Goetsche (1953) and we also found *Maorites* in this formation along the east coast of the Brunswick Peninsula (loc. 5). It is also stated (p. 310) that the Rio Blanco Formation only contains *Maorites* species; however, von Goetsche (1953) found at the type locality a species of *Gunnarites* that was conferred to *G. kalika*.

In our opinion Cecioni's three upper zonal divisions have lost, in the light of the new facts, some validity for the studied area. Faunal Zone 1 (Rio Blanco Formation) also has *Gunnarites* species, and Faunal Zone 3 (Santa Ana and upper Fuentes formations) also has *Maorites* species. Furthermore, for stratigraphic and paleontologic reasons, it seems that the Tres Morros Formation is the temporal equivalent of the Santa Ana, Rio Blanco, and Carrera formations. This statement was made earlier by von Goetsche (1953).

We therefore propose to include the faunal association found in the studied area, that is in the upper Fuentes and Rocallosa formations for the Seno Skyring-Punta Entrada area, and in the Santa Ana and Rio Blanco formations for the east coast of the Brunswick Peninsula, in a single faunal zone, that of *Gunnarites kalika*. This name seems to be the most appropriate one because of the predominance of this species in the studied sections.

Cecioni (1955) concluded that the Chorrillo Chico Formation lies unconformably on different faunal zones that are older northward (Text-fig. 3). We did not observe such unconformity in the field, and we have no paleontologic, structural or sedimentologic arguments (Charrier & Lahsen, 1969) to support this statement, except that *Gunnarites* predominates in the northern sections and *Maorites* in the east coast of the Brunswick Peninsula. Therefore, if Cecioni's statement that *Maorites* is somewhat younger than *Gunnarites* is right, although both genera are present throughout the entire section in the studied area, the different distribution of these forms in the studied region could indicate a somewhat younger age for the Santa Ana and Rio Blanco formations compared to the Rocallosa and upper Fuentes formations.

Finally, this means that the Chorrillo Chico Formation represents a regressive facies which covered younger formations while being deposited toward the south. This is supported by the fact that between the upper Maestrichtian and the Eocene the formations studied by Charrier & Lahsen (1969) were deposited in increasingly shallow water, and is also sustained by the gradual upheaval of land and retreat of sea (transitional to continental facies) that began in the Ultima Esperanza region in the Upper Cretaceous and advanced slowly toward the south to Tierra del Fuego where continental deposition began in the Pliocene. (Charrier & Vicente, 1972).

CHRONOLOGICAL COMPARISONS WITH OCCURRENCES IN OTHER PARTS OF THE WORLD

The ages of the studied species are controversial. Collignon (1955, p. 48) placed *Maorites* in the early Campanian and said, "La présence de *Maorites* aux niveaux 4c, 5a, 5b, 5c (Berere, Madagascar) bein datés, dans la partie moyenne du Campanien inférieur permet de comparer ces assises à celles ou cette ammonite pullule à la Terre de Graham (y compris les Iles de Seymour et Snow Hill), a la Nouvelle Zelande et aux couches qui la renferment dans le Groupe de l'Arraillour de l'Inde. Il parait évident qu'elle y est du même âge."

In Antarctica and India *Maorites* species are associated with *Gunnarites* species, and for this reason Collignon (1955) assigned early Campanian age to the latter genus. In Antarctica *Gunnarites* is represented by a great number of species and belongs to a faunal group that is essentially late Campanian in age (Spath, 1953, p. 43). In this same group are some ammonites that could also belong in the earliest Maestrichtian (Spath, 1953, p. 43). Cecioni (1955, p. 4, 7) considered the *Gunnarites* and *Maorites* fauna to be of Maestrichtian age because these forms were found above the *Hoplitoplacenticeras* fauna which generally is accepted as an indicator for the top of the Campanian. It seems, furthermore, that *Gunnarites* and *Maorites* have a wider stratigraphic distribution in the Magallanes region than that accepted by other authors for other regions of the world.

Gunnarites kalika (Stoliczka) is known in both Antarctica and India. In Antarctica it is associated with several other *Gunnarites* species as well as representatives of *Maorites*. In the Ariyalur Group of the Trichynopoli District of India only one specimen of *G. kalika* has been found (Collignon, 1955, p. 48). This specimen is associated with *Maorites aemilianus* Stoliczka (Spath, 1953, p. 47). The Ariyalur Group and the Valundayur Group in the Pondicherry District were considered by Haug (1908, p. 1346) and Cotter (1938, p. 48) to be Maestrichtian. Later, Stephenson (1941) assigned the same age to this fauna after comparing it with that of the Navarro Group in Texas. Collignon (1955,

TABLE 3—Occurrence of Foraminifera in the ammonite bearing strata.

Bahía Altamirano (loc. 1)
Rocallosa Formation (Member C)
Rugoglobigerina rugosa (Plummer)
R. aff. *R. loeterllei* (Naus)
Upper Fuentes Formation
Rugoglobigerina rugosa (Plummer)
Globigerinella messinae Brönnimann
Punta Rocallosa (loc. 2)
Rocallosa Formation (Member B)
Bolivinoides draco dorreeni Finlay [*fide* Martínez-Pardo, 1965]
Punta Entrada (loc. 3)
Rocallosa Formation (Member B)
Globigerinella messinae messinae Brönnimann
Upper Fuentes Formation
Racemiguembelina sp.
Guembelitria sp.
Guembelina complanata Marie
G. ultimatumida Cushman [*non* White]
G. striata (Ehrenberg)
G. globulosa (Ehrenberg)
G. sp.
Rugoglobigerina rugosa (Plummer)
Rugoglobigerina beldingi Gandolfi
R. aff. *R. loeterllei* (Naus)
R. circumnodifer (Finlay)
Globigerinella messinae messinae Brönnimann
G. messinae Brönnimann
Globotruncana mayaroensis Bolli?
Globotruncanella havanensis (Voorwijk)
Bolivinoides draco dorreeni Finlay

p. 80, 82), however, assigned to the Ariyalur Group an age ranging from late Campanian to early Maestrichtian based on the age he accepted for *Maorites* in Madagascar.

In New Zealand, *Maorites tenuicostatus* Marshall has, according to Marshall (1926, *fide* Wright, 1957, p. L375), a Campanian age. However, Wellman (1956, p. 352) included *Maorites* and *Diplomoceras,* among other forms, in the Haumurian Stage which he considered to be Maestrichtian. Hornibrook (1962) confirmed the Maestrichtian age for the Haumurian Stage by means of planktonic Foraminifera.

Diplomoceras notabile (Whiteaves), which was found in the Santa Ana Formation with *Maorites densicostatus* and *M. tenuicostatus,* is also present in the Cedar District, Lambert and Northumberland formations, middle and upper part of the Nanaimo Group of the Vancouver and Sucia Islands, which Usher (1952, *fide* Popenoe, et al., 1960, p. 1516) indicated as ranging from latest Campanian to early Maestrichtian. However, the same author (1957) restricted these ammonites to the Campanian. According to Matsumoto (1960) the genus *Diplomoceras* is not represented in strata older than Campanian (*Hoplitoplacenticeras vancouverensis*) and reaches the late Maestrichtian in the Moreno Formation of California (Popenoe, et al., 1960, p. 1516). From previous considerations, we are inclined to include the studied fauna in the Maestrichtian.

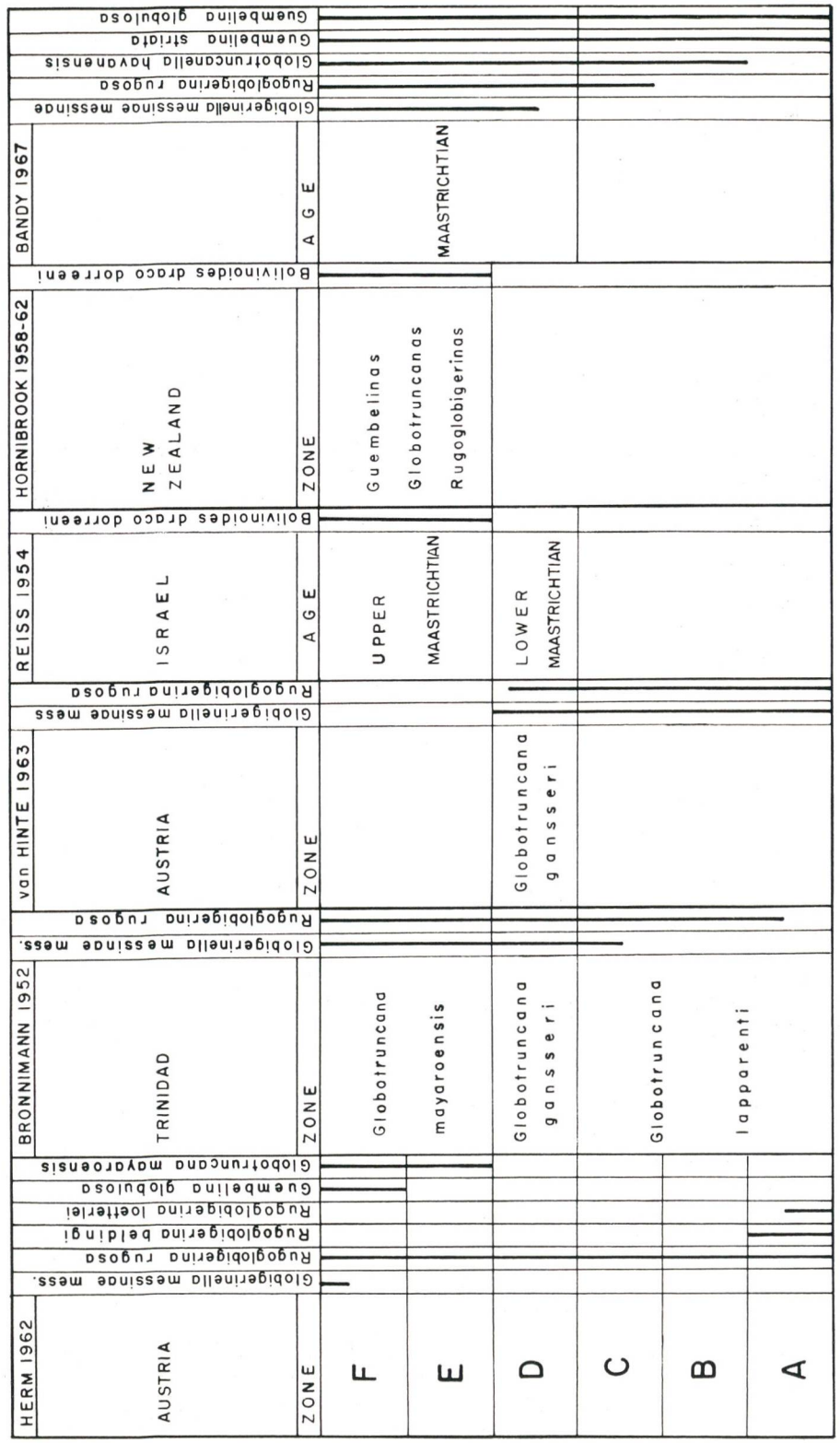
FORAMINIFERA ASSOCIATED WITH THE AMMONITES

The presence of Foraminifera in the ammonite bearing strata allows a more precise dating of the whole faunal association (Text-fig. 2; Table 3). In addition to the occurrences indicated, *Bolivinoides draco dorreeni* Finlay was also found by Martínez-Pardo (1965, figs. 3a, 3b, 3c) in the Rocallosa Formation in the north coast of Seno Syring near locality 1. The relative positions of the ammonite and Foraminifera species can be determined by comparing Table 2 and Table 3. Most of the fauna was found at the top of the upper Fuentes Formation.

Text-figure 4 shows the ranges in age of the Foraminifera. Charrier & Lahsen (1968, 1969) placed this assemblage in the late Maestrichtian, primarily on the presence of *B. draco dorreeni* Finlay (Reiss, 1954; Hornibrook, 1958a, 1968b, 1962) and on the pronounced trochoidal aspect of *Rugoglobigerina rugosa* which indicates an advanced evolutionary stage at the end of the Maestrichtian (Herm, 1962). The associated ammonite fauna can be assigned, therefore, to the late Maestrichtian. *Diplomoceras* and *Maorites* from New Zealand were already indicated for this stage (Hornibrook, 1962). In the southernmost part of South America *Gunnarites* should be added to *Diplomoceras* and *Maorites,* although they do not appear together always. It is likely that these ammonites have, in this region, a wider vertical range than in other parts of the world, reaching higher stratigraphic levels. We think that such a distribution can be postulated for other regions as already discussed.

CONCLUSIONS

1) On the basis of micropaleontologic evidence, we show that *Gunnarites kalika* (Stoliczka), *G. antarcticus* (Weller), *G. bhavaniformis* (Kilian & Reboul), *G. zelandicus* (Marshall), *Maorites tenuicostatus* Marshall, *M. densicostatus* (Kilian & Reboul), *M.* cf. *M. suturalis* Marshall, *Hypophylloceras nera* Paulcke [*non* Forbes], *Diplomoceras notabile* (Whiteaves), and *D.* aff. *D. undulatus* Forbes have an upper Maestrichtian age in the region between Seno Skyring and the Strait of Magellan. This age was already pointed out by Cecioni (1955).



TEXT-FIG. 4—Range in age of the Foraminifera species from the studied sections based on occurrences in other parts of the world.

TABLE 4—Measurements in mm of a specimen of *Diplomoceras notabile* (Whiteaves).

	Width	Height	Width/ Height	Distance between measured points
Section 1	80	90	0.88	260
Section 2	75	84	0.89	

2) Instead of the three Upper Cretaceous faunal zones of Cecioni (1955), we propose to include the studied formations (upper part of Fuentes, Rocallosa, Santa Ana, and Rio Blanco) in a single zone, the *Gunnarites kalika* Zone, because of the predominance of this species in the studied sections.

3) The predominance of *Maorites* species in the upper part of the southern sections and of *Gunnarites* in the lower part of the northern sections could indicate slightly different ages for both genera, as proposed by Cecioni (1955). The different stratigraphic positions of these genera in relation to the base of the Chorrillo Chico Formation is explained by the regressive character of this formation which gradually covered younger and different formations southward.

ACKNOWLEDGMENTS

We are greatly indebted to G. Cecioni for his continuous encouragement and most valuable suggestions during the present work. D. Herm, University of Munich, the late H. Fuenzalida and R. Martínez-Pardo, both of the University of Chile, made very helpful criticisms. M. Hünicken sent us a plaster mold of *Diplomoceras australe*, and A. Cañón (ENAP) sent us photographs of ammonites found by other workers at the localities studied in the present work. Empresa Nacional de Petróleos (ENAP) gave financial support for the field work and allowed us to review unpublished reports. C. Marangunic kindly reviewed the English version. To each of these persons and institutions we express our sincere appreciation.

SYSTEMATIC PALEONTOLOGY

Phylum MOLLUSCA
Class CEPHALOPODA
Order AMMONOIDEA
Suborder LYTOCERATINA Hyatt, 1889
Superfamily TURRILITACEAE Meek, 1876
Family DIPLOMOCERATIDAE Spath, 1926
Genus DIPLOMOCERAS Hyatt, 1900
DIPLOMOCERAS NOTABILE (Whiteaves, 1879)
Pl. 2, figs. 1,2

Material.—Five internal molds, two of which are well preserved; the others are deformed or strongly weathered.

Description.—The best preserved specimen (Pl. 2, fig. 1) is 26 cm long, but its length at the outcrop was 45 cm. It was impossible to remove it completely. Tubular shaped, the whorl section is subcircular and compressed. Ribs are simple, annular and symmetrical, although some are adapically inclined when cut in profile. Eleven ribs were counted in a length equal to the maximum diameter. Suture lines were not preserved, and no constrictions were observed. Measurements of specimen SGO-PI-6013 are shown in Table 4.

Discussion.—This specimen differs from *D. lambi* Spath (1953, p. 17, Pl. II, figs. 1–3; Pl. III, fig. 1) in that its transverse section is not circular but rather is subcircular. *Hamites elatior* Sowerby, briefly described by Forbes (in Darwin, 1846), possibly corresponds to this species. The only characters reported by Forbes are the dimensions and the whorl section, and these correspond perfectly with those of the described specimen.

We compared our specimens with two others collected by Hemmer from the Rio Blanco type locality in the Brunswick Peninsula and kept at the Museo Nacional de Historia Natural in Santiago. The latter specimens are catalogued under the name *Hamites elatior* as 6-A_1, 6-A_2 (two pieces of the same individual, one of which corresponds to the curved section of *Diplomoceras*), and 3-A_1. The following measurements were made from the straight part of specimen 6-A: height, 65 mm; width, 58 mm; width/height ratio, 0.89. In the curved part ribs are

→

EXPLANATION OF PLATE 1

FIGS. *1–3*—*Hypophylloceras nera* Paulcke [*non* Forbes], lateral and ventral views of SGO-PI-6011; uppermost part of the Fuentes Formation at Bahia Altamirano, east side of bay (loc. 1), ×2.
4–6—*Gunnarites antarcticus* (Weller), apertural, lateral, and ventral views respectively of SGO-PI-6012; upper part of the Fuentes Formation at Bahía Altamirano, east side of bay (loc. 1), ×1.

1

2

3

4

5

6

radial but in the straight portion they are inclined adapically (rursiradiated).

In order to be sure that this specimen of *D. notabile* differs from *D. australe* Hünicken, a plaster mold of the holotype of this last species was requested. *D. australe* has an obviously depressed whorl section, and its ribbing is more dense (15 ribs in a length equal to maximal diameter). Ribs are inclined adorally (prorsiradiated).

Locality and horizon.—The specimens (Pl. 2, figs. 1, 2) were found in the upper part of the Santa Ana Formation along the east coast of the Brunswick Peninsula (loc. 5) 60 km south of Punta Arenas.

Repository.—Museo Nacional de Historia Natural, Santiago, Chile; SGO-PI-6013, SGO-PI-6014.

Suborder AMMONITINA Hyatt, 1889
Superfamily DESMOCERATACEA Zittel, 1895
Family KOSSMATICERATIDAE Spath, 1922
Genus GUNNARITES Kilian & Reboul, 1909
GUNNARITES ANTARCTICUS (Weller, 1903)
Pl. 1, figs. 4–6

Material.—Several specimens, differently preserved. The best ones were found in limestones; the others are weathered or distorted. The original shell material still remains in some specimens.

Description.—Somewhat flattened forms, moderately involute, with ovoid whorl section. The ribbing is quite dense and the ribs are always crenelated, slightly prosocline, and continue without interruption along the ventral side. Five constrictions are present on the outer whorl. The last rib before the constriction is generally bifurcated toward the ventral side. These specimens show 11 umbilical bullae from which orginate 3–4 ribs. The incomplete specimen (Pl. 1, figs. 4–6) has 40 ribs on the last half whorl, almost the same number is present on the second half whorl, and on the first whorl 64 ribs were counted. Four constrictions on the last half whorl and three on the second half whorl. No constrictions were distinguished on the first whorl. Eleven tubercles were counted on the second half whorl. The suture line is perfectly exposed in this specimen and is identical to that figured by Spath (1953, Pl. VI, fig. 1a; Pl. VII, fig. 1b).

Dimensions.—Total diameter—82 mm (100%); whorl height—35 mm (43%); whorl thickness—29 mm (35%); umbilicus diameter—25 mm (32%).

Discussion.—This specimen is slightly different from that of Stuart Weller (cited by Spath, 1953, p. 30) in that it has a greater number of ribs. Although it resembles *G. zelandicus* (Marshall), the ribs are less prosocline, it has fewer umbilical tubercles, and the first lateral saddle of the suture line is not divided.

Locality and horizon.—This species was found at Bahia Altamirano (loc. 1) in the upper Fuentes Formation about 30 m below the base of the Rocallosa Formation.

Repository.—Museo Nacional de Historia Natural, Santiago, Chile; SGO-PI-6012.

GUNNARITES KALIKA (Stoliczka, 1925)
Pl. 2. figs. 3–6

Material.—Several internal and external molds, very differently preserved. The original shell material is partially conserved.

Description.—Similar to *G. antarcticus*, it has, however, a finer and denser ribbing. Up to 130 ribs were counted on the last whorl. Ribs are prosocline, slightly sigmoidal, and coarsely crenelated. Thirteen to 15 umbilical bullae are slightly inclined adapically; from the bullae rise groups of 4–5 ribs. The last whorl has five constrictions that are parallel to the ribs. Constrictions are easy to recognize on the internal molds but very difficult to see on the external ones. Specimen of Plate 2, figure 4, has 130 ribs and 15 umbilical bullae on the last whorl; specimen of Plate 2, figure 5, has 90 ribs, 14 umbilical bullae, and two constrictions that do not cut the ribs, on the last whorl.

Dimensions.—Taken from SGO-PI-6016 (Pl. 2, fig. 4): Total diameter—30 mm (100%); whorl diameter—12 mm (40%); umbilicus diameter—9 mm (30%).

←

EXPLANATION OF PLATE 2

FIGS. *1,2—Diplomoceras notabile* (Whiteaves), straight portions of SGO-PI-6013 and SGO-PI-6014 respectively from the upper part of the Santa Ana Formation (loc. 5), ×0.5.

3–6—Gunnarites kalika (Stoliczka), lateral views of SGO-PI-6015, SGO-PI-6016, SGO-PI-6017 and SGO-PI-6018 respectively. *3,6*, From the upper Fuentes Formation at Bahía Altamirano, east side of bay (loc. 1), ×2. *4,5*, Specimens found in the uppermost beds of the Fuentes Formation at Punta Rocallosa (loc. 2), ×1.5 and ×1 respectively.

Discussion.—The Magellan specimens here described have much denser ribbing than Spath's material. Other characteristics are identical to those reported by Spath. We do not consider it necessary to propose a new variety for these forms.

Locality and horizon.—This species was found in the uppermost beds of Fuentes Formation (loc. 1, 2). It has also been found (von Goetsche, 1953) in the upper part of the Rio Blanco Formation at its type locality (loc. 5).

Repository.—Museo Nacional de Historia Natural, Santiago, Chile; SGO-PI-6015 (Pl. 2, fig. 3), SPO-PI-6016 (Pl. 2, fig. 4), SGO-PI-6017 (Pl. 2, fig. 5), SGO-PI-6018 (Pl. 2, fig. 6).

GUNNARITES BHAVANIFORMIS
(Kilian & Reboul, 1909)
Pl. 3, fig. 6

Material.—Only one internal mold, regularly preserved. The original shell is partially conserved.

Description.—Flattened, moderately involuted form similar to *G. antarcticus.* The ribbing is very typical; on the first whorls it is very fine, resembling that of *G. kalika,* later it is coarser, and on the body chamber in a more advanced growth stage it is again fine and dense. On the last whorl are about 13 umbilical bullae, that are slightly inclined adapically, and from which rise 4–5 ribs. At least four radial constrictions cutting one or two ribs were counted.

Discussion.—The figured specimen is almost identical to those reported by Spath (1953, Pl. VIII). The only difference is that Spath's specimens have slightly coarser and more separated ribs. This could be interpreted as a form transitional to *G. kalika.*

Locality and horizon.—This specimen was found in the uppermost beds of the Fuentes Formation at its type locality (loc. 2).

Repository.—Museo Nacional de Historia Natural, Santiago, Chile; SGO-PI-6022.

Genus MAORITES Marshall, 1926
MAORITES cf. M. TENUICOSTATUS
Marshall, 1926
Pl. 3, figs. 1,2

Material.—An internal and an external mold of the same specimen, moderately well preserved. It was impossible to obtain the whole specimen from the outcrop, but it was photographed before removal.

Description.—Somewhat involute form, possibly compressed, with rather high whorls. Ribbing is very fine and dense and remains constant throughout the entire specimen.

Discussion.—This specimen is somewhat similar to that of *Gunnarites kalika* found by us, but it has no crenelated ribs, and its umbilicus is wider. It also shows some similarities with *Grossouvrites gematus,* but has a finer and denser ribbing along all of the whorls.

Locality and horizon.—North side of Punta Askow, 3 km south of Punta Carrera, at the top of the Santa Ana Formation.

Repository.—Museo Nacional de Historia Natural, Santiago, Chile; SGO-PI-6019.

MAORITES cf. M. DENSICOSTATUS
(Kilian & Reboul, 1909)
Pl. 3, figs. 3–5

Material.—Several badly preserved fragments, two of which, from different localities, are figured and described.

Description.—Fragment of Plate 3, figures 3, 4, corresponds to a rather involute form with a compressed whorl section. Limbs are almost flat in their internal half and slightly convergent to the dorsal edge. Along the umbilical edge of the whorl are several nodes stretched radially. Ribbing is dense and fine; ribs are flexuous and some are bifurcated in the proximity of the umbilical edge. One slightly flexuous and prorsiradiated constriction is visible, undercutting at least three ribs. No suture line was observed.

Fragment of Plate 3, figure 5, has fine ribs, somewhat flexuous. The separation between the ribs is thicker than the ribs themselves. Two or three ribs start at umbilical tubercles and continue with the same intensity to the siphonal side. No constriction or suture line has been observed in this fragment.

Discussion.—The above described characteristics partially fit the description of *M. densicostatus* from Antarctica and New Zealand given by Marshall (1926) and by Spath (1953).

Locality and horizon.—Specimen figured in Plate 3, figures 1, 2, was found, together with several badly preserved molds and fragments, in the upper part of the Rio Blanco Formation at its type locality (northern shore of the Blanco River and 600 m from its mouth on the Strait of Magellan). The fragment shown in Plate 3, figure 5, was found in the uppermost beds of the Santa Ana Formation on the southern shore of Bahia Buena on the east coast of the Strait of Magellan (loc. 5).

Repository.—Museo Nacional de Historia Natural, Santiago, Chile; SGO-PI-6020 (Pl. 3, figs. 3, 4), SGO-PI-6021 (Pl. 3, fig. 5).

KOSSMATICERATIDAE indet.
Pl. 3, fig. 7

A very deformed specimen of a rather involute form. In the last whorl are seven constrictions that are parallel to and alternate in position with seven rectilinear ribs.

Repository.—Museo Nacional de Historia Natural, Santiago, Chile; SGO-PI-6023.

Suborder PHYLLOCERATINA Arkell, 1950
Superfamily PHYLLOCERATACEAE Zittell, 1884
Family PHYLLOCERATIDAE Zittel, 1884
Subfamily PHYLLOCERATINAE Zittel, 1884
Genus HYPOPHYLLOCERAS Salfeld, 1924
HYPOPHYLLOCERAS NERA Paulcke [*non* Forbes]
Pl. 1, figs. 1–3

Material.—One fragment of an internal mold that represents approximately one-half of an individual.

Description.—A moderately flattened and involute form. The ribbing is fine and dense with radial ribs slightly prosocline. Suture lines are very well preserved and coincide exactly with those figured by Paulcke (1906, Pl. 14, fig. 5c).

Discussion.—Wright (1957, p. L189) considered *Hypophylloceras* to include *Neophylloceras* Shimizu, 1934, and *Hyporbulites* Breistroffer, 1947, as junior synonyms. The figured specimen is similar to *Hyporbulites bererensis* Collignon (1956, p. 22, Pl. III, fig. 1) which was found together with some *Maorites* specimens in Madagascar.

Locality and horizon.—This species was found in the upper Fuentes Formation at Bahia Altamirano (loc. 1).

Repository.—Museo Nacional de Historia Natural, Santiago, Chile; SGO-PI-6011.

REFERENCES

Bandy, O. L. 1964. General correlation of foraminiferal structure with environment, p. 75–90. *In* John Imbrie and Norman Newell (eds.), Approaches to paleoecology. John Wiley and Sons, New York.

——. 1967. Cretaceous planktonic foraminiferal zonation. Micropaleontology. 13:1–31.

Brönnimann, P. 1952. Globigerinidae from the Upper Cretaceous (Cenomanian-Maastrichtian) of Trinidad, B. W. I. Bull. Amer. Paleontol. 34:1–70.

Cecioni, Giovanni. 1954. Posición estratigráfica y descripción de algunos amonites del Cretáceo superior de la Provincia de Magallanes. Empr. Nac. Petroleos, Santiago, Chile, unpub. rep.

——. 1955. Distribuzione verticale di alcune Kossmaticeratidae nelle Patagonia Cilena. Soc. Geol. Ital., Boll. 74:141–149.

——. 1956a. Significato della ornamentazione in alcune Kossmaticeratidae della Patagonia. Riv. Ital. Paleontol. Strat. 62:3–10.

——. 1956b. *Leopoldia? payensis* Favre: sua posizione stratigrafica in Patagonia. Soc. Ital. Sci. Nat., Atti. 95:135–145.

——. 1957a. Etá della flora del Cerro Guido e stratigrafia del Departamento Ultima Esperanza, Provincia di Magellano, Cile. Soc. Geol. Ital., Boll. 76:1–16.

——. 1957b. Cretaceous flysch and molasse in Departamento Ultima Esperanza, Magallanes Province, Chile. Amer. Ass. Pet. Geol., Bull. 41: 538–564.

Charrier, Reynaldo, and Alfredo Lahsen. 1968. Contribution a l'étude de la limite Crétacé-Tertiaire de la Province de Magellan extreme-sud du Chili. Rev. Micropaléontol. 11:111–120.

——, and ——. Stratigraphy of Late Cretaceous-Early Eocene Seno Skyring-Strait of Magellan area, Magallanes Province, Chile. Amer. Ass. Pet. Geol., Bull. 53:568–590.

——, and J. C. Vicente. 1972. Liminary and geosynclinal Andes: major orogenic phases and synchronical evolutions of the Central and Magellan Sectors of the Argentine-Chilean Andes. Solid Earth Problems Conference, Upper Mantle Project, Buenos Aires, Argentina, October 1970, [in press].

Collignon, Maurice. 1955. Ammonites néocrétacées du Menabe (Madagascar); III; Les Kosmaticeratidae. Madagascar Serv. Mines, Ann. Geol., no. 22, 54 p.

——. Ammonites néocrétacées du Menabe (Madagascar); IV, Les Phylloceratidae; V, Les Gaudryceratidae; VI, Les Tetragonitidae. Madagascar Serv. Mines, Ann. Geol., no. 23, 107 p.

Cookson, I. C., and L. M. Cranwell. 1967. Lower Tertiary microplankton, spores and pollen grains from southernmost Chile. Micropaleontology. 13: 204–216.

Cotter, G. de P. 1938. The Indian Peninsula and Ceylon. *In* Regional Geologie der Erde, Bd. 1, Abschn. 6, 72 p. Leipzig Akad. Verlag.

Darwin, Charles. 1846. Geological observations on South America, Part III, The geology of the voyage of the Beagle. Smith Elder and Co., London. 279 p.

Fasola, Armando. 1969. Estudio palinológico de la Formación Loreto (Terciario Medio), Provincia de Magallanes, Chile. Ameghiniana. 6:3–49.

Feruglio, Egidio. 1949. Descripción geológica de la Patagonia. Dir. Gen. Yac. Pet. Fiscales, Buenos Aires, 1, 334 p.

Goetsche, G. von. 1953. Informe geológico del área Tres Morros-Agua Fresca-San Isidrio. Empr. Nac. Petroleos, Santiago, Chile, unpub. rep.

Haug, Emile. 1909. Periode Cretace, p. 1153–1396. *In* Traite de Geologie, v. 2. Libr. A. Colin, Paris.

Herm, Dietrich. 1962. Stratigraphische und mikropaläontologische Untersuchungen der Oberkreide in Lattengebirge und im Nierental (Gosaubecken von Reichenhall und Salzburg). Bayer. Akad. Wiss., math-nat. Kl., Abh. 104, 119 p.

——. 1966. Micropaleontological aspects of the Magallanese Geosyncline, southernmost Chile, South America, p. 72–86. *In* 2nd West African Micropaleontological Colloquium Proceedings (Ibadan, 1965). E. S. Brill, Leiden.

Hinte, J. E. van. 1963. Zur Stratigraphie und Mikropaläontologie der Oberkreide und des Eozäns des Krappfeldes (Kärten). Jahrb. Geol. Bundesanst., Wien, Sonder-Bd. 8, 147 p.
Hornibrook, N. de B. 1958a. New Zealand Upper Cretaceous and Tertiary foraminiferal zones and some overseas correlations. Micropaleontology. 4: 25–38.
——. 1958b. New Zealand Foraminifera: Key species in stratigraphy—no. 6. New Zealand J. Geol. Geophys. 1:653–676.
——. 1962. The Cretaceous-Tertiary boundary in New Zealand. New Zealand J. Geol. Geophys. 5: 295–303.
Hünicken, Mario. 1955. Depósitos Neocretáceos y Tertiarios del extremo SSW de Santa Cruz (Cuenca carbonífera de Rio Turbio). Buenos Aires Inst. Nac. Invest. Cienc. Nat., Rev. Cienc. Geol., v. 4, no. 1, 164 p.
——. 1965. Algunos cephalópodos Supracretácicos del Rio Turbio (Santa Cruz): Univ. Córdoba (Argent.), Rev. Fac. Cienc. Fis., Mat., Nat., Ser. Cienc. Nat. 26:47–100.
Kilian, Wilfrid, and P. Reboul. 1909. Les céphalopodes Neocretacés des îles Seymour et Snow Hill. Wiss. Ergeb. Schwed Sud-pol. Exped. 1901–1903, v. 3, no. 6, p. 1–75.
Leanza, A. F. 1963. *Patagoniceras* gen. nov. (Binneyitidae) y otros Ammonites del Cretácico-Superior de Chile Meridional con notas acerca de su posición estratigráfica. Acad. Nac. Cienc. Cordoba, Argent., Bol. 43:203–225.
Lexique Stratigraphique International. 1957. Amerique Latine, Part 7, Chili. Cent. Nat. Rech. Sci., Paris, 444 p.
Marshall, P. 1926. The Upper Cretaceous ammonites of New Zealand. New Zealand Inst., Trans. 56:129–210.
Martínez-Pardo, Ruben. 1965. The presence of *Bolivinoides draco dorreeni* Finlay from the Magellan basin, Chile. Micropaleontology. 11:360–364.
Matsumoto, Tatsuro. 1960. Upper Cretaceous ammonites of California. Kyushu Univ. Fac. Sci., Mem., Part 3, Ser. D, Geol., v. 2, 204 p.
Paulcke, Wilhelm. 1906. Die Cephalopoden der oberen Kreide Südpatagoniens. Naturf. Ges. Freiburg, Ber. 15:167–248.
Phleger, F. B. 1960. Ecology and distribution of Recent Foraminifera. Johns Hopkins Press, Baltimore, Maryland, 297 p.
Popenoe, Willis, R. W. Imlay, and M. A. Murphy. 1960. Correlation of the Cretaceous formations of the Pacific Coast (United States and northwestern Mexico). Geol. Soc. Amer., Bull. 71: 1491–1540.
Reiss, Z. 1954. Upper Cretaceous and lower Tertiary *Bolivinoides* from Israel. Cushman Found. Foraminif. Res., Contrib. 4:154–164.
Robles, M. L., and M. Gomez. 1956. Foraminíferes del Cretácico superior y del Paleoceno de la Provincia de Magallanes, Chile [abs.]. 20th Int. Geol. Congr., Resumenes, p. 184–185.
Spath, L. F. 1953. The Upper Cretaceous cephalopod fauna of Graham Land. Falkland Island Dependencies Surv. Sci., Rep., no. 3, 60 p.
Stephenson, L. W. 1941. The larger invertebrate fossils of the Navarro Group of Texas. Texas Univ. Pub. 4101, 641 p.
Thomas, C. R. 1949. Geology and petroleum exploration in Magallanes Province, Chile. Amer. Ass. Pet. Geol., Bull. 33:1553–1578.
Todd, Ruth, and H. T. Knicker. 1952. An Eocene foraminiferal fauna from Agua Fresca Shale of Magallanes Province, southernmost Chile. Cushman Found. Foraminif. Res., Spec. Pub. 1, 28 p.
Usher, John. 1957. Ammonite faunas of the Upper Cretaceous rocks of Vancouver Island, British Columbia. Geol. Surv. Can., Bull. 21, 182 p.
Wellman, H. W. 1956. The Cretaceous of New Zealand [abs.]. 20th Int. Geol. Congr., Resumenes, p. 351–352.
Wright, C. W. 1957. *Hypophylloceras* Salfeld, 1924, and *Maorites* Marshall, 1926, p. L189, L375. *In* R. C. Moore (ed.), Treatise on Invertebrate Paleontology, Part L, Mollusca 4. Geol. Soc. Amer. and Univ. Kansas Press.

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Explanation of Plate 3

Figs. *1,2*—*Maorites* cf. *M. tenuicostatus* Marshall, lateral views of SGO-PI-6019; upper part of the Santa Ana Formation (loc. 5), ×1.5 and ×1.75 respectively.
3–5—*Maorites* cf. *M. densicostatus* Marshall. *3,4,* Lateral views of SGO-PI-6020 from the upper part of the Rio Blanco Formation (loc. 5), ×3.5. *5,* Lateral view of SGO-PI-6021 from the upper part of the Santa Ana Formation (loc. 5), ×1.
6—*Gunnarites bhavaniformis* (Kilian & Reboul), lateral view of SGO-PI-6022; uppermost beds of the Fuentes Formation (loc. 2), ×1.5.
7—Kossmaticeratidae indetermined. Lateral view of SGO-PI-6023; upper part of the Fuentes Formation at Punta Entrada (loc. 3), ×1.