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Upper Jurassic Lithographic Limestones from Argentina (Neuquén Basin): Stratigraphy and Fossils

Oberjurassische lithographische Kalke aus Argentinien (Neuquén Becken): Stratigraphie und Fossilien

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CONTENT

SUMMARY

This report describes the geological setting (with map and cross-section) of the Upper Jurassic marine lithographic limestones near Zapala, Neuquén province, Argentina. The local succession is displayed and a new member, the 'Los Catutos Member', is proposed for the lithographic limestones within the Vaca Muerta Formation. A survey of the fossils, kept in the Prof. Dr. Juan A. Olsacher Museum in Zapala, shows that ammonites, crabs, fishes and reptiles predominate in these limestones. Coccolithophorids are also very frequent on bedding-planes. With the exception of a few pterosaurians the fauna and flora seem not to be significant for a lagoonal environment. In contrast to the lithographic limestones of Solnhofen, Southern Germany, the fine-grained Argentinian limestones were not deposited within a lagoonal environment surrounded by reefs, but in a restricted area of the open shelf. The next coastline was about 100 km off. The fauna contains two new taxa of ammonites: *Zapalia fascipartita* n. gen. et n. sp., and *Djurjuriceras catutosense* n.sp. For the first time the genus *Djurjuriceras* is described from Southern America. The same region supplied the largest specimens of *Laevaptychus* ever found, attributed to giant shells of *Aspidoceras*; furthermore the first rhyncholites from the Upper Jurassic of Southern America have been found there. The lithographic limestones of the Zapala region were deposited at the Middle/Upper Tithonian boundary.

RESUMEN

En este trabajo se da a conocer el marco geológico (con mapa y perfil transversal) de las calizas litográficas de Los Catutos en las cercanías de Zapala, provincia del Neuquén, Argentina. Se brinda una nueva interpretación de la estratigrafía de la formation Vaca Muerta, proponiéndose el Miembro Los Catutos nov. para identificar al conjunto de calizas litográficas de 70 metros de espesor alojadas en ella. Una primera aproximación sobre los fósiles de estas calizas las colecciones del Museo Juan Olsacher de Zapala muestra que la fauna se compone principalmente de amonites, cangrejos, peces, reptiles, algas y cocolitofóridos, estos últimos presentes en los planos de estratificación. Con referencia a

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los amonites se han distonguido 2 nuevos taxones: *Zapalia fascipartitan.* gen et n. sp. y *Djurjuriceras catutosense* n. sp. El género *Djurjuricerasse* cita per primera vez en América del Sur. El quizás más grande hallazgo de *Laevaptychus* se atribuye a aspidocerátidos gigantes del grupo de *rafaeli*, ilustrándose asimismo los primeros restos de Rhyncholithes de América del Sur. Las calizas litográficas de Los Catutos se ubican temporalmente en el límite Tithonia no medio/ superior, que en parte corresponde a la zona de *Windhauseniceras internispinosum*. En contraste con las calizas litográficas tithonianas de Solnhofen, Alemania Occidental, depositadas en mares someros rodeados de arrecifes, las calizas argentinas se depositaron en una plataforma en mar abierto. La líneas de costa se encontraria a unos 100 kilómetros de distancia y, con excepción de aislados restos de pterosaurios, no se registró ningún signo de proximidad de tierra firme a arrecifes.

1 INTRODUCTION

Lithographic Limestones or more generally 'Plattenkalke', are sediments which were deposited only sporadically during the earth's history. In the Upper Jurassic they are a particularly characteristic facies in marine basins surrounded by reef complexes, which provide protection against the waves of the open sea, thus leading to a quiet-water sedimentation. Some of them are famous for the excellent preservation of the fossils found in them. The origin of these limestones was discussed by HEMLEBEN (1976, 1977), KEUPP (1977) and BARTHEL (1978). DEHM(1957) noted the rather unique worldwide distribution of lithographic limestones in the Upper Jurassic. Based on observations by v. HUENE (1931) he realized that there might be an equivalent of Upper Jurassic lithographic limestones in the province of Jujuy (northwestern Argentina). The age of this occurrence was rather uncertain (Lias – Neocomian), but is now considered to be Upper Cretaceous. The locality in the Neuquén basin represents very well-dated Upper Jurassic 'Plattenkalke'. In contrast to the brackish environment of the Jujuy locality, the new occurrence is marine.

In Southern Germany originally the terms "Lithographische Schiefer" and "Lithographie-Steine" were used, from which the English term "lithographic limestones" had been derived. As the vulgar term "Schiefer" has a misleading meaning in these non-metamorphic rocks and as the term "Lithographie-Steine" was only used for the rare layers which could be used for lithographic purposes, the old names have been displaced by the term 'Plattenkalke', which comprises all varieties of "lithographic limestones". In this broad meaning the latter term is used in this paper.

In 1983 during the Second Field Meeting of the Circumpacific Jurassic Research Group, the authors visited the 'Museo Professor Dr. J. A. Olsacher' in Zapala (Prov. Neuquén), where they saw a collection of fossils very similar in preservation to those of the Solnhofen area in Southern Germany. This led to the recognition of another occurrence of marine Upper Jurassic Lithographic Limestones or 'Plattenkalke' in South America. An Argentinian-German research project started in 1986 with an excursion to the Province of Neuquén during and after the 'IV Congreso Argentino de Paleontologia y Bioestratigrafia' in Mendoza. Investigations included the documentation of all fossils from the lithographic limestones in the Professor Dr. J. A. Olsacher Museum in Zapala, an inspection of all quarries yielding lithographic limestones in the vicinity of Zapala, as well as a collection of ammonites from different levels. 110 ammonites and numerous remains of fishes from five distinct levels were found. The need for a detailed geological map and revision of the local geology became evident from these field studies. This basic work was done by H. LEANZA in 1987, whose results are presented below. Further studies shall clarify the sedimentary processes which lead to the deposition of these lithographic limestones. Geochemical studies are undertaken by W. Bausch (Erlangen).

This report provides a survey of the Zapala lithographic limestones and their fossil content giving supplements to our first paper (CIONE et al. 1987).

2 UPPER JURASSIC STRATIGRAPHY OF LOS CATUTOS AREA, NEUQUÉN PROVINCE, ARGENTINA (H. Leanza)

2.1 Geological setting

The marine basin of Neuquén and Mendoza had the form of a gulf elongated in northwest-southeast direction. This gulf was closed in at its southern end, while its northern end was in free water exchange with the Pacific Ocean (cf. Fig. 1). During most of the Jurassic and the Early Cretaceous this basin occupied almost the whole province of Neuquén north of latitude 40° and the southwestern part of the Mendoza province south of latitude 33°. The marine environment persisted continuously throughout the whole area from the Tithonian to the early Barremian. Information dealing with the stratigraphy of the Neuquén Basin was provided by DIGREGORIO & ULIANA (1980), LEANZA (1981) and GULISANO et al. (1984), as well as a comparison with the Chilean counterpart of the basin by HALLAM et al. (1986). Sequence stratigraphy of Upper Jurassic and Lower Cretaceous sediments was studied by MITCHUM & ULIANA (1985) and LEGARRETA & ULIANA (1989).

The Tithonian lithographic limestones are located in the southern part of the Neuquén Basin, and crop out in the Los Catutos area, situated only 13 kilometers northwest of Zapala, Neuquén province, Argentina (Fig. 2).

References to the geology of the Los Catutos area were given by LAMBERT (1956: 39, Figs. 8, 21, 22), who recognized and mapped the Tithonian strata at the scale of 1 : 200 000; these strata rest conformably upon sandstones and conglomerates of Kimmeridgian age (now Tordillo Formation). LEANZA (1973: 116) described the Piedras Blancas section, situated immediately north of route 22, referring it to the Picún Leufú Formation, consisting of 93 meters of calcareous sandstones with a large number of bivalves and subordinated ammonites of Upper Tithonian/Lower Berriasian

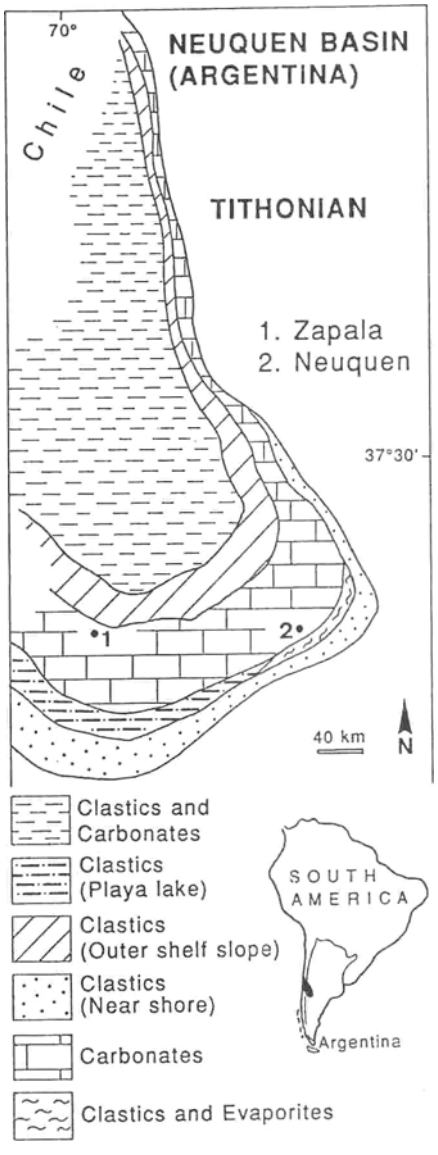

Fig. 1. Paleogeographic map of the Neuquén Basin during the Tithonian (Modified after LEGARRETA & ULIANA 1989).

age. LEANZA & HUGO (1977: 253) briefly described the Los Catutos-Pichi Moncol section, assuming that the thickness of the Tithonian/Berriasian sediments was reduced, because of the presence of a paleo sea floor elevation. Cenozoic sediments are widespread in the mapped area. They consist mainly of basaltic tuffs and lavas, eolian and aluvial deposits (LAMBERT 1956, LEANZA 1985).

2.2 Geology of Los Catutos Area

The outcropping Tithonian beds of the Los Catutos area form a tectonic part of the southern extremity of the eastern flank of the major anticline of the Vaca Muerta range (LAMBERT, 1956). They display a subcircular syncline with no distinct trend - the relictic Pichi Moncol structure is in the center - and a continuing anticline structure in the northeastern area - the Tordillo Formation forms the nucleus (Figs. 2, 3).

In the stratigraphical composite section the total thickness of the Tithonian strata reaches 420 meters (Fig. 4). The lithographic limestones, intercalated within the Vaca Muerta Formation are designated here as the 'Los Catutos Member'.

2.3 The Lithostratigraphic Units and their Faunal Content

2.3.1 Pretordillo: Substratum of the Tordillo Formation

This unit comprises a number of formations not differentiated on the map, ranging in age from the Bajocian to the Oxfordian; they belong to the Cuyo and to the Lotena Group. In the northwestern part of the mapped area these sediments crop out in the form of an E-W crescent along the right bank of the Covunco creek.

2.3.2 Tordillo Formation

This formation was described by GROEBER (1946: 182) as "Tordillense" and constitutes the basal portion of the Andico Supergroup, just above the Inter-Upper Jurassic or Araucarian Unconformity (LEANZA et al., 1977). The Tordillo Formation is composed of conglomerates, sandstones, siltstones and shales mostly of dark red, reddish and greenish colour. This unit was deposited in a marginal marine (littoral) and a deltaic-fluviatil environment. In the mapped area outcrops occur in the western part along a sigmoidal belt between the Covunco creek and Laguna Miranda, and as an anticline nucleus between the El Ministerio and Los Catutos quarries, just northeast of the Pichi Moncol structure. LAMBERT (1956) reported a fossiliferous outcrop 2500 meters to the northwest of Laguna Miranda, immediately south of route 13, containing *Trigonia mirandaensis* LAMBERT, *Maputrigonia pichimoncolensis* (LAMBERT), *Pentacrinus* sp., *Pecten* sp. and unidentifiable ammonite fragments.

2.3.3 Vaca Muerta Formation

This formation was described by WEAVER (1931) as 'Tithonian Strata'. It is composed of dark grey calcareous shales with a large amount of bitumin, common variably-sized calcareous nodules and concretions. At its base the Virgatosphinctinae Beds (cf. LEANZA, 1980) occur, which are uniform throughout the basin. The Vaca Muerta Formation measures 328 meters in a composite section. In the depocenter of the basin (Loncopué, Huncal, Trahuncura), a hundred kilometers to the north, the same unit attains a thickness of 1250 meters, ranging in age from the upper Lower Tithonian to the Early Valanginian (LEANZA & HUGO, 1977).

In the Los Catutos area the Vaca Muerta Formation has been subdivided into three easily recognizable members: the Lower and Upper Vaca Muerta Members, exhibiting the normal facies of the major unit, and the middle 'Los Catutos Member' representing the yellowish white fossiliferous lithographic limestones known from several quarries of the region.

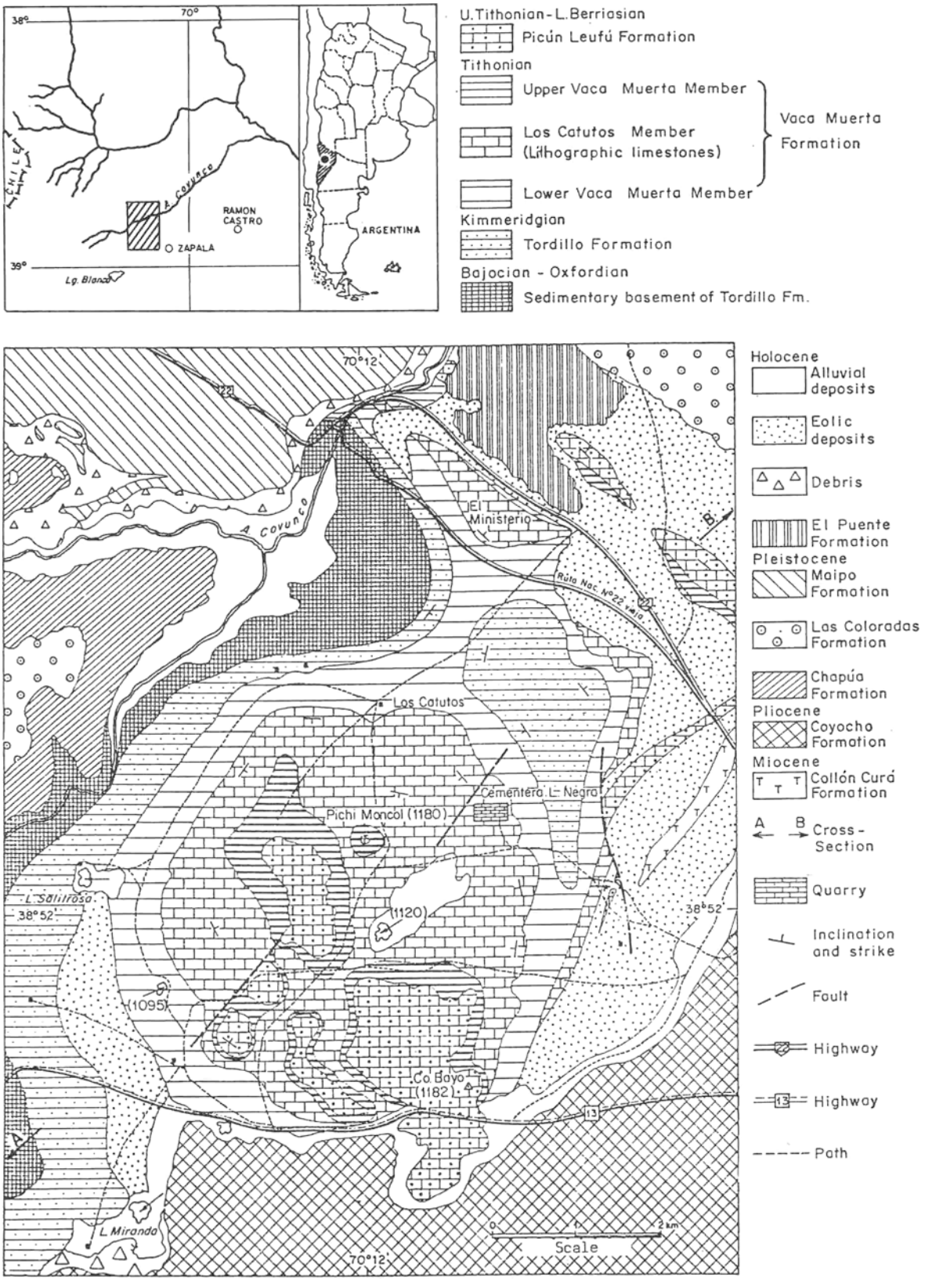

Fig. 2. Geographical situation and geological map of the lithographic limestones in the Los Catutos area, NW Zapala, Neuquén Province, Argentina.

Lower Vaca Muerta Member

This member consists of the normal facies of the Vaca Muerta Formation: dark grey to dark brown or black, thin-bedded soft shales and marls with calcareous concretions and nodules at the base. It conformably and transitionally overlies the Tordillo Formation and is covered in the same

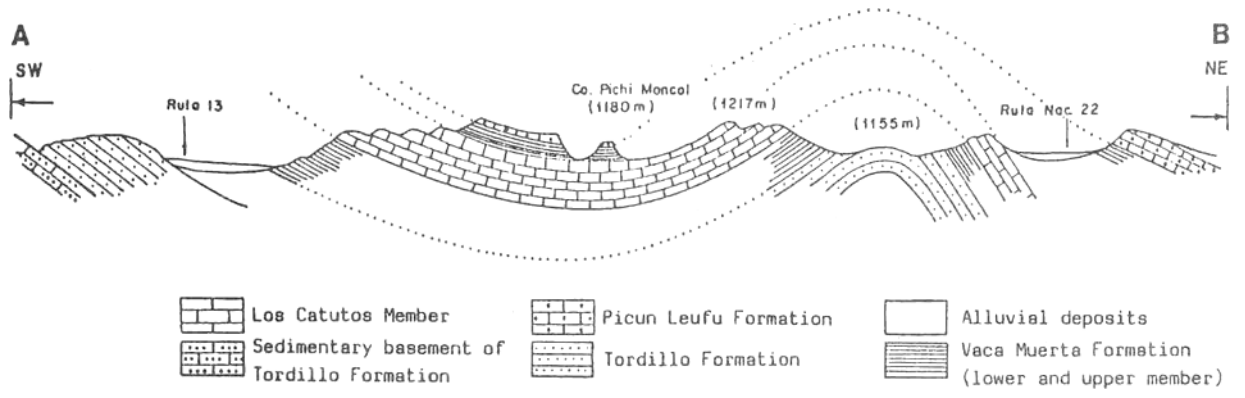

Fig. 3. Geological cross-section of the Los Catutos area, NW Zapala, Neuquén province, Argentina (section A-B of the geological map, see Fig. 2)

way by the lithographic limestones of the Los Catutos Member. A stratigraphic section just 500 meters to the east of the Los Catutos quarry is 164 meters thick, with beds striking 115°N and dipping 12° SW. A number of well-preserved remains of Virgatosphinctinae, especially *Choicensisphinctes* LEANZA 1980, were found in the basal contact, in the right bank of the Covunco creek, 1 kilometer southeast of Cementera Loma Negra and 2,5 kilometers southeast of Los Catutos.

The *V. mendozanus*, *P. zitteli*, *A. proximus* and probably the early *W. internispinosum* ammonite zones were recognized within this member, thus indicating a late Lower Tithonian to early Upper Tithonian age.

Los Catutos Member nov. nom.

This member comprises a homogeneous unit composed of lithographic limestones with intercalated marls and shales. The thin-bedded and fossiliferous limestones consist of fine-grained bioclastic micrite with minute peloids. They are yellowisch and white but dark when unweathered. The name is derived from Los Catutos, a little Indian settlement 13 kilometers northwest of Zapala. The Los Catutos Member conformably overlies the Lower Vaca Muerta Member. The type section was measured in the El Ministerio quarry, where the new member is 70 meters thick. Beds strike 120° N and dip 20° NE.

The outcrops of Los Catutos Member in the central part of the mapped area are tectonically folded as a subcircular syncline with the relictic Pichi Moncol structure in the center. A number of quarries are distributed all over these sediments. Other outcrops of the Member are located in saline belts at the northeastern corner of the Pichi Moncol structure which are strongly faulted and inclined to the south.

The more fossiliferous beds are those of the El Ministerio quarries, where many cephalopods, reptiles and fishes occur in association (cf. CIONE et al., 1987, GASPARINI et al., 1987). Five ammonite horizons have been distinguished from the older to the younger beds, as follows: x + a, x, y, z, and w (Fig. 4). The first three horizons match well with the *W. internispinosum* Zone, from the uppermost Middle Tithonian. The horizon w may still extend to the Middle/Upper Tithonian boundary (sensu LEANZA 1980), the horizon x + a to the *A. proximus* Zone.

Upper Vaca Muerta Member

This member lies between the Los Catutos Member and the Picún Leufú Formation, displaying the normal facies of the Vaca Muerta Formation, although with an upwardly increasing arenaceous input. It is composed of thin-bedded siltstones, marls and bituminous shales usually dark to light brown and greenish brown in colour. Along the right bank on the Covunco creek, it attains a thickness of 94 meters but in the Pichi Moncol hill it is reduced to 60 meters.

The Upper Vaca Muerta Member contains only few fossils and is interpreted as corresponding to the lower Upper Tithonian *C. alternans* Zone.

2.3.4 Picún Leufú Formation

This unit was defined by LEANZA (1973: 118). It contains those sediments lying between the Vaca Muerta Formation and the Mulichinco Formation in the southern part of the basin. It is composed of limestones (grainstones), sometimes with ooids, intraclasts and dolomites. The dominant colour is yellowish grey. It represents a coastal paleoenvironment favouring the occurrence of abundant pelecypod genera ("Bivalve Facies", LEANZA, 1981). The unit is 102 meters thick; the top of the Pichi Moncol hill is interpreted as the base of the unit, and the Piedras Blancas outcrop, just north of route 22 (LEANZA, 1973: 116), as the topmost layers in the area. Extensive outcrops are also present in the southern part of the Pichi Moncol structure, which culminates in Cerro Bayo (1182 m), the highest point in the mapped area.

The following genera of ammonites are found in the Piedras Blancas section: *Aulacosphinctoides*, *Berriasella*, *Substeueroceras*, *Himalayites*, *Micracanthoceras*, *Corongoceras*, *Parodontoceras* and *Volanoceras*. Amongst the bivalves the most notable are *Anditrigonia eximia* (PHILIPPI), *A. lamberti* (LEVY), *Trigonia carinata* AGASSIZ, *Steinmanella erycina* (PHILIPPI), *Ostrea minos* COQUAND, *Exogyra couloni* (DEFRANCE), *Lucina neuquensis* HAUPT, *Panopea dupiniana* d'ORBIGNY, and *Pholadomya gigantea* SOWERBY. A number of gastropods, brachiopods and corals are also present. This invertebrate assemblage belongs to the Upper Tithonian *S. koeneni* Zone. The uppermost 10 meters of the outcropping unit, whose top is not exposed in the area, contain well-preserved specimens of berriasellids closely related to *Pseu-*

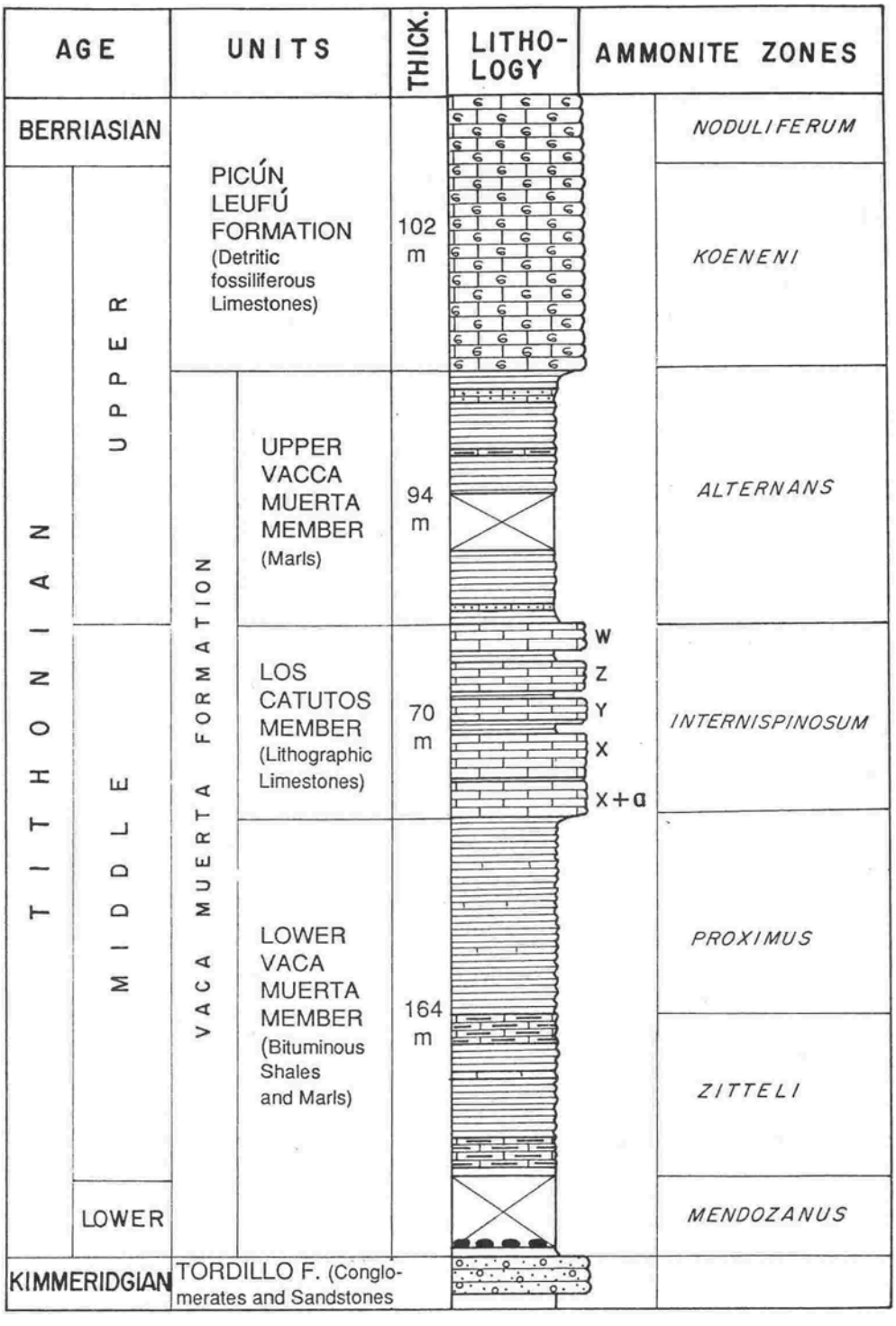

Fig. 4. Stratigraphic column of the Tithonian strata (including the lithographic limestones) in the Los Catutos area, NW Zapala, Neuquén province, Argentina.

dosubplanites grandis in southeastern France. Therefore they are ascribed to the Lower Berriasian.

3 THE MUSEO 'PROF. DR. JUAN A. OLSACHER'

(H. Leanza, J. I. Garate-Zubillaga, A. Zeiss)

The 'Museo Prof. Dr. Juan A. Olsacher' is the centre for collections and research work on the Jurassic and Lower Cretaceous rocks and fossils in the Neuquén Province. Thanks to the attention of the present Museum Director J. I. Garate-Zubillaga, the fossils of the lithographic limestones were already collected many years ago. Since the founding of the Museum, the collections have expanded rapidly. The "Museo" is dedicated to the memory of the late Prof. Dr. Juan A. Olsacher (1904-1964), professor of mineralogy at the university of Córdoba (Argentina). It was established in 1969, the core being the important private mineralogical and paleontological collection donated by the present Director Mr. José I. Garate-Zubillaga. It is dependent on the Mining

Bureau of the Neuquén province and is located in the town of Zapala on the eastern slope of the 'Cordillera de los Andes'. Zapala is situated approximately 200 km west of the capital of Neuquén. At present the collections of paleontology, mineralogy and petrography contain more than 70,000 specimens. The paleontological collection includes the most complete set of fossil invertebrates in the Neuquén Basin, with a large number of unique specimens. Thus, the collection of the Bivalve family Trigoniidae contains more than 200 different species; 78 are known only from the province of Neuquén and were described by LEANZA & GARATE-ZUBILLAGA, 1987).

Particularly important for the paleontological collection was the discovery of fossiliferous lithographic limestones of Upper Jurassic (Tithonian) age in the quarries near Zapala. Two fine specimens of *Ophthalmosaurus* (Ichthyosauria), two fragmentary specimens of Pterosauria, and three marine turtles came from these outcrops. In addition, more than two hundred samples with various fish remains and a large collection of flattened ammonites as well as the most complete *Plesiosaurus* skeleton of the Upper Jurassic of America, which was found in the Cajón de Almaza, Neuquén province, is housed in the museum.

Active collaboration takes place with the Universities of Buenos Aires and La Plata (Argentina), Erlangen (West Germany) and the Servicio Geologico Nacional (Argentina). The museum houses the type specimens for many new taxa.

4 THE FOSSILS OF THE ZAPALA LITHOSTRATIGRAPHIC LIMESTONES

All the fossil groups recorded up to now from the lithographic limestones of the El Ministerio and Los Catutos quarries are described here (Fig. 2, 3). No higher plants, lower invertebrates, amphibians, birds and mammals have been found to date.

4.1 Plants

4.1.1 Coccolithophorids (Ch. Dullo & E. Flügel)

SEM examinations of the bedding-planes of lithographic limestone slabs yielded several plates of coccolites some of which can be attributed to the genus *Ellipsogelasphaera* (Pl. 38/3); they seem to represent the dominant elements occurring frequently as fragments. Of minor importance are complete coccospheres belonging to the genus *Watznaueria* (pl. 38/11). These coccospheres indicate a coprogenous sedimentation similar to the lithographic limestones of Solnhofen (KEUPP 1977).

4.1.2 Algae (E. Flügel)

Non-calcareous soft algae are preserved as thin carbonaceous films and impressions on bedding planes. These macroscopic fossils most probably belong to the Phaeophyta. This is indicated by the existence of bifurcated thick fronds exhibiting irregular restrictions Pl. 37/6, arrow) similar to those of *Phyllothallus latifrons* ROTHPLETZ, known from the Solnhofen limestone (ROTHPLETZ 1896, MAYR 1953).The alga occuring in Zapala is characterized by an erect and spreading thallus, exceeding 10 cm in height. the tips of the branches exhibit conspicuous tufts of free separated filaments similar to the Recent brown alga *Sporochnus*-MONTAGNE. This alga occurs predominantly on rocks close to the low tide mark in shallow water (WOELKERING 1976).

4.2 Animals

4.2.1 Molluscs (H. Leanza & A. Zeiss)

Cephalopods

40 specimens of ammonites in the museum derived from indistinct levels, as well as 110 specimens collected from five different levels (El Ministerio) are used for this study. An inspection of this new material resulted in a somewhat different generic composition for each level.

Table 1. Ammonite genera from the El Ministero quarry. Level x+a is the oldest horizon followed by x, y, z and w (cf. Fig. 4). Numbers in brackets refer to field observations.

	x+a	x	y	z	w
Aspidoceras rafaeli group			7		
Aspidoceras sp., with *Aptychus*			1		
Laevaptychus sp.			3	1	
Aulacosphinctes sp.	8	1			
Aulacosphinctes? sp.	1	1			
Corongoceras sp.	3				
Corongoceras? sp.	3	1			
Danubisphinctes? sp.		3			2
Djurjuriceras catutosense			1		
Djurjuriceras? sp.	(18)	1			
Zapalia fascipartita n. sp.			6	3	6
Zapalia div. sp.			11	2	2
Parapallasiceras s.l. sp.	2	9		2	2
Simoceras? sp.					2
Sublithacoceras? sp.		13	2	2	
Windhauseniceras sp.					1
Hildoglochiceras? sp.			1		

The fauna seems to fit well into the zone of *Windhauseniceras internispinosum* of the uppermost Middle Tithonian (LEANZA, 1980). TAVERA (1985) corrrelated this zone with the basal Upper Tithonian zone of *Simplisphinctes* of southern Spain. The exact age of this zone is thus unclear but it is definitively approximately near the Middle/Upper Tithonian boundary.

The differences in the faunal composition of the five levels may be due partly to changes in the ecological conditions: Level x+a consists of a normal limestone facies, which weathers white like the 'White Jurassic' of Southern Germany. However, if split, these limestones are dark, smelling of bitumin. Level x is the large surface of the quarry with

hundreds of ammonites (Pl. 36/5); all of them have been crushed and many are fragmentary. This is the beginning of the lithographic limestone facies. Level x is still affected by some water currents. Level y-w are those horizons quarried for building stone slabs. In these levels the signs for quiet water conditions are more evident, e.g. by very large ammonites with complete body chambers, aptychi with both valves, and sometimes ammonites with aptychi. The yellowish white limestones were originally blue-grey in color like the 'Solnhofener Plattenkalke'. In the El Ministerio quarries there are occasionally large lenses (0.5 – 1m) which have still preserved the blue-grey colour. In the larger quarries of Los Catutos – Cementera L. Negra area the blue-grey coloration is predominating.

Description of important ammonites

In the Los Catutos Member of the Vaca Muerta Formation a large number of a new giant ammonite genus have been found. To present a first glance of this new genus some of the forms are described here. The first occurrence of the genus *Djurjuriceras* in South America is worth describing for biostratigraphical reasons. Giant aspidoceratids of the *rafaeli* group represent an interesting immigration from Europe and the largest *Aptychus* ever found (ca. 32 cm) is attributed to this group.

Zapalia nov. gen.

Type species: *Zapalia fascipartita* n. sp.
Derivatio nominis: Named after the occurrence near Zapalia
Diagnosis: Giant to medium-sized evolute shells. Ribs on inner whorls bifurcating; three or more branching ribs on penultimate whorl. Ultimate whorl ornamented with coarse, distant, bifurcate or trifurcate ribs.
Remarks: Related forms exhibit a continuous biplicate ribbing style up to the last half whorl of the body chamber, where prominent single ribs appear. For general information of this group a specimen from El Ministerio has been figured, too (Pl. 36/2).

Zapalia fascipartita nov. sp. (Pl. 36/1, 7)

Holotype: Pl. 36/7, Museum Olsacher, Zapala
Locus typicus et stratum typicum: Los Catutos member of the Vaca Muerta Formation, level y, El Ministerio quarry.
Dimensions: D 110, H 60, U 45. IR 12, ER 38-40 at 45-50 mm D.

Description: Inner whorl with rather distant bifurcate ribs. Penultimate whorl in the beginning still bifurcate ribbed, then 3-4 secondaries. On the outer whorl transition to bifurcate ribs with one or two intercalatories. Larger specimens loose the intercalatories as the diameter increases and then only exhibit very strong single or highly branched bifurcate ribs. The branching points on the inner and penultimate whorls lie in the middle or in the upper two thirds of the flanks. Specimens belonging to this species are very common in the Los Catutos and El Ministerio quarries (Pl. 36/1).

Genus *Djurjuriceras* ROMAN 1936, emend. OLORIZ 1978
Djurjuriceras catutosense n. sp. (Pl. 36/6)

Holotype: Museum Olsacher, Zapala, P 3827
Stratum typicum et locus typicus: Los Catutos Member of Vaca Muerta Formation, Level w, Tithonian, El Ministerio quarry.
Derivatio nominis: After the small settlement of Los Catutos (Fig. 2).
Dimensions [mm]: D = 140, H = 40, W–, U = 66.

Diagnosis: A species of medium size, evolute, with regular biplicate ribbing on the inner whorls, thus appearing rather like a persiphinctid. The last quarter of the outer whorl has simple, distant and elevated ribs, collar-like. Deep radial constrictions accompany them. The aperture of the body chamber is simple, somewhat resembling an attenuated sigma. The prominent ribs show that the specimen is a full-grown macroconch.
Comparisons and remarks: *D. catutosense* n. sp. differs from *D.* sp. gr. *ponti* (FALLOT & TERMIER) from Southern Spain as figured by OLORIZ (1978: 645, Pl. 53, Figs. 1-3) in its larger size and rectiradiate ribbing as well as the much later beginning of the coarse ribs. In *D. armonicum* OLORIZ (1978: 647, Pl. 53, Fig. 4) and *D. annularium* OLORIZ (1978: 648, Pl. 53, Fig. 5) from the same region, which are somewhat larger in size, the coarsening and separation of the ribs, and consequently the increase of the interspaces also begin much earlier than in the South-American species. In *D. djurjurense* the ribs on the inner whorls are prorsocostate and somewhat sigmoidal on the last whorl; the coarse ribs of the last growth stage are usually arranged in pairs with large interspaces between them.

'Pachysphinctes' americanensis LEANZA (1980: 41, Pl. 7, Figs. 1a-d) from the Middle Tithonian of Cerro Lotena shows some affinities with *D. catutosense* but differs in its far larger size, bi- and tripartite branching ribs, coarsening of the ribs on the whole last whorl, projection of ribs, and a somewhat more evolute coiling. This species is considered by the authors to belong to a different new genus. The resemblance with *Pachysphinctes* from the Kimmeridgian-Tithonian of Eastern Africa is only superficial.

There are many specimens on the surface of level x which have a somewhat similar ribbing style, but never produce such strong, collar-like ribs (Pl. 36/4-5, 8). They appear to belong to a group of virgatosphinctid ammonites, from which the South-American *Djurjuriceras* probably can be derived.

Genus *Aspidoceras* ZITTEL 1868
Aspidoceras aff. *altum* BIRO-BAGOCZKY, 1980 (Pl. 36/3)

Many giant aspidoceratids closely resemble *Aspidoceras altum* from the Central Cordillera of Chile. This species belongs to the group of *A. rafaeli* (OPPEL) studied by CHECA (1985). The specimens from the Los Catutos Member differ from *A. altum* in their much larger size and in a somewhat more irregular arrangement of the two rows of tubercles: they do not always correspond, but often alternate. On the ultimate part of our specimens the tubercles disappear alto-

gether and only fine ribs can be observed. This is evidently a characteristic of the adult stage of the specimen. Possibly the smaller specimens, described by BIRO-BAGOCZKY (1980, Pl. 2, Fig. 1) and LEANZA (1980, Pl. 8, Fig. 1) from Lo Valdes, Chile, and Cerro Lotena, Argentina, are the microconchs of the large specimens in Los Catutos.

Aptychi

Some aspidoceratids are found together with aptychi. These specimens are difficult to determine taxonomically because of the crushing and poor conservation. In general, all aptychi belong to *Laevaptychus* (Pl. 37/7) which has always been considered as belonging to *Aspidoceras*. There is a *Laevaptychus* with a length of 32 cm which seems to be one of the largest, if not the largest aptychus ever found. This very large specimen would fit well to the large *Aspidoceras* aff. *altum* as described here. Most aptychi have been found in the same levels (y-z) as the large *Aspidoceras*. Many aptychi have been preserved with both valves, indicating quiet water conditions at the time of burial. The aptychi-pair figured here (Pl. 37/7) as well as that figured by CIONE et al. (1987), can be considered as belonging to *Laevaptychus brevis* (DOLLFUSS), other specimens including the giant one appear to fit better in *Laevaptychus meneghinii* (ZIGNO) and its variation *rugosa* as described by TRAUTH (1931).

Rhyncholites (Pl. 38/6)

Two specimens of rhyncholites from the Zapala lithographic limestones seem to be the first ones recorded from South America. IMLAY (1942) reported a specimen of *Hadrocheilus* from the Tithonian in Central America and HOUSA (1969) some from the Lower Cretaceous of Cuba. The specimen figured (Pl. 38/6) shows some affinity to *Leptocheilus*. Similar, but not identical species are *L. tenuis* as figured by HUCKRIEDE (1971) and *L. ricotensis* GEYSSANT & GEYER (1972). These two rhyncholites differ from the typical *Leptocheilus* in certain characteristics. Their exact systematic position has still to be clarified.

Bivalves and gastropods

Some poorly preserved bivalves were found in level x of the El Ministerio quarry, as well as some small oysters and an *Arca* in the marginal facies of the Los Catutos Member. Gastropods are poorly preserved, too, and remain undetermined.

4.2.2 Crustaceans (Pl. 38/4)

A few decapod crustaceans are badly preserved. A comparison might be possible with *Pehuenchia magna*, described and depicted from the Jurassic of Mendoza (Argentina) by RUSCONI (1948).

4.2.3 Echinodermata

There is only one questionable, poorly preserved fossil in the museum, indicated as 'Crinoidea'.

4.2.4 Fishes (A. Cione)

Fishes are the most common vertebrates in the "Plattenkalke". The recognized taxa are: Halecostomi incertae sedis: 1. – Semionotidae, cf. *Lepidotes* (Pl. 37/4) (thick smooth scales, high operculum and cleithrum). Halecomorphi: 2. – caturid-like halecomorphs, Pl. 37/2 (hemichordacentra, cycloidal scales, hypurals 1-3 non-fused as *Caturus dartoni* and differing *C. pachyurus*, see SCHAEFFER & PATTERSON, 1984). Teleostei: 3. – Pachycormidae indet., Pl. 37/3 (typical hypural plate); 4. – Aspidorhynchidae, cf. *Belonostomus*, Pl. 37/5 (enlarged rostrum, vertebrae with well developed contra, deep keeled ganoid scales); 5. – teleosts *Tharsis*-like, Pl. 37/1 (sculptured autocentra greatly obliterating the notochord, epipleural intermuscular bones in the middle of the trunk, see PATTERSON & ROSEN, 1977).

The assemblage is typical of the Late Jurassic. All the taxa are also present in the Solnhofen Plattenkalke; however, other taxa reported from there (e.g. sharks, batoids, chondrosteans, pycnodontiforms and macrosemiids) are still unknown at the El Ministerio quarry. The family Aspidorhynchidae (cf. *Belenostomus*) was observed for the first time in the Upper Jurassic of South America; better preserved specimens are known from Cerro Lotena in the Neuquén Basin. The fish fauna consists of microphagous (teleosts *Tharsis*-like) and active predatory forms (cf. *Belonostomus*, caturid-like halecomorphs), some of them similar in body outline to tuna fish (pachycormids). No bottom-feeders (i.e. pycnodontiforms, batoids) occur except for the unique record of a probable *Lepidotes*. This fact can be related with the lack of benthonic molluscs. However, SAINT-SEINE (1949) indicated that pycnodontiforms fed mainly on reef organisms and not on bottom dwellers. But this explanation is difficult to use: in the Upper Jurassic Neuquén Basin reefs are unknown.

Almost all the specimens show some disarticulation not clearly attributable to predators but probably due to a relatively slow sedimentation rate, which delayed the final embedding.

4.2.5 Reptiles (Z. Gasparini)

The comparatively scarce reptiles found in the lithographic limestones of the Middle Tithonian of the Los Catutos area fit well in with the general composition of faunas of the Neuquén basin characterized by an abundance of invertebrates, especially ammonites and fishes. The most significant specimens are the articulated skeleton of an ichthyosaur, several turtles, the tibia of a pterosaur and another more complete specimen of a pterosaurid and the tooth of a plesiosaur (Pl. 38).

The ichthyosaur is a young specimen belonging to *Oph-*

thalmosaurus monocharactus APPLEBY (Pl. 38/1). It is very well preserved and shows no deformations, some elements of the skull, however, such as the anterior part of the snout, the left sclerotic ring and part of the palate, have shifted from their natural position (Pl. 38/2) (GASPARINI 1989). This shifting is a common feature in the skull and mandible of the ichthyosaurs because there are no serrate sutures. *Ophthalmosaurus monocharactus* is abundant in the Oxford Clay of England; an undescribed specimen of a group found in Solnhofen, shares some characteristics with that of Cantera El Ministerio.

Four marine turtles were discovered, which belong to different infraorders. One of them (Pl. 38/9) belongs to the pleurodiran *Notoemys laticentralis* Cattoi & Freiberg (M. de la Fuente, pers. comm.), also found in the Early Tithonian of Las Lajas and Cerro Lotena (Neuquén). One specimen of Cryptodira is *Eurysternum* (?) *neuquinum* FERNANDEZ & DE LA FUENTE 1988) (Pl. 38/8).

Pterosaurids are represented by two specimens. One of them belongs to a pterodactyloid, from which only a tibia was preserved (Pl. 38/9), that is different from any known pterosaurid. But this element is not sufficient for a more accurate determination (GASPARINI et al. 1987). The other specimen (Pl. 38/10) is an incomplete and disarticulated skeleton.

A tooth, notably striated (Pl. 38/7), is the only evidence of the presence of the plesiosaurids.

The preservation of the reptiles in the Los Catutos area indicates the lack of any kind of transport. Those with stronger skeletons, such as the ichthyosaurs and turtles, remained complete, the post-mortem fractures and shiftings are not really significant. The pterosaurs with their more fragile skeletons suffered a first quick disarticulation as a result of decay which was completed once they were deposited on the sea floor. The remains figured on Pl. 38/10 are restricted to a small area, the bones are not broken suggesting that the animal was not attacked by a predator. As the plesiosaurs changed their teeth an isolated tooth is no indicator of burial conditions.

Owing to the incomplete systematic work no detailed comparison with the reptile fauna of the lithographic limestones of Solnhofen is possible. Significant coincidences between the Late Jurassic marine herpetofauna of the Neuquén Basin with those of the European Tethys are known (GASPARINI, 1985). These areas share at least one species of Ichthyosauridae (*Ophthalmosaurus monocharactus*), one of Pliosauridae (*Stretosaurus* cf. *macromerus*) and one of Metriorhynchid crocodiles (*Metriorhynchus* and *Geosaurus*).

5 CONCLUSIONS

At the boundary Middle/Upper Tithonian (i.e. five ammonite zones later than in Southern Germany) favourable conditions existed for the sedimentation of lithographic limestones in a restricted area of the Neuquén Basin (Western Central Argentina). The distance from the next coast was about 100 km; a reef development is unknown in the Neuquén Basin at this time. The lithographic limestones were deposited under shallow open marine conditions in contrast to the protected interreef areas of Southern Germany. It may be assumed that quiet water conditions in the Los Catutos Member were provided by deposition in a protected area, while the surrounding sedimentation areas of the Vaca Muerta Formation represent the normal facies (dark shales, marls and limestones (LEANZA & HUGO 1977: Fig. 1; DIGREGORIO & ULIANA 1980).Stagnant bottom water conditions which occur frequently in the normal facies of the Vaca Muerta Formation have also been observed in parts of the Los Catutos Member.

The generic composition of the ammonite fauna might indicate a water depth of approximately 10-40 m (ZEISS 1968: 152). Burial most likely took place below the wave base; therefore the water depth may be assumed to have been 30-50 m.

The faunal and floral composition indicates the existence of an open shallow marine environment (many fishes, ammonites, ichthyosaurians and some sea turtles and crabs, frequent coccolites); as in Solnhofen, almost no benthonic animals have been recorded.

Compared with the lithographic limestones of Solnhofen, the site in South America shows some similarities (preservation and microflora) and some differences (quantitative and qualitative composition in the number of certain taxa e.g. the number of certain genera like ichthyosaurs (fragments included), ammonites and fishes is comparatively larger, while the number of other taxa is very much restricted. This is the result of the more open sea environment in the paleogulf of Neuquén, whereas Solnhofen belongs to a lagoonal environment between reefs. Despite these differences similar morphological conditions on the sea floor may have lead to similar types of lithographic limestones: quiet water conditions and a predominant, discontinous calcareous (micritic) sedimentation in a rather hot climate.

This may indicate that similar environmental and biotic factors evoked the formation of this rare kind of limestone in these two areas.

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Plate 36 Ammonites from the Lithographic Limestones of Argentina (Zapala, Neuquén Province; Los Catutos Member of Vaca Muerta Formation, Tithonian)

Fig. 1. Ammonites from a native house in Los Catutos quarry area, belonging to the genus *Zapalia*. This picture demonstrates the delight of the native workmen to use ammonites as ornaments. Some of the ammonites have been colored red or blue.

Fig. 2. A specimen related to the genus *Zapalia* to demonstrate the characteristic ribbing style of high-branching bifurcating ribs. El Ministerio quarry, level y. Museo Olsacher Zapala (M.O.Z.) 3847.

Fig. 3. *Aspidoceras* aff. *altum* Biro-Bagoczky, giant specimen, nearly complete last half whorl of body-chamber. El Ministerio quarry, level y, Diameter is ca.50 cm, M.O.Z. 3783.

Fig. 4. Ammonites of level x of El Ministerio quarry, forerunners of *Djurjuriceras*. Scale is 2 cm.

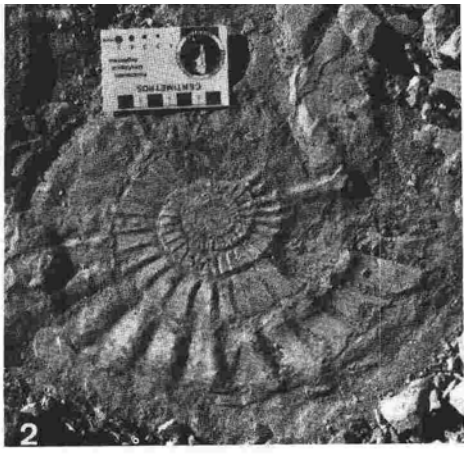
Fig. 5. Surface of level x of El Ministerio quarry, showing the rather frequent ammonites transitional to *Djurjuriceras* and *?Parapallasiceras*.

Fig. 6. *Djurjuriceras catutosense* nov. sp., holotype, nearly complete specimen, level w, El Ministerio quarry, M.O.Z. 3827, Scale is 2 cm.

Fig. 7. *Zapalia fascipartita* nov. gen. et nov. sp., holotype, level y, El Ministerio quarry, M.O.Z. 3793, scale is 28 cm.

Fig. 8. Ammonites from level x, partly broken, precursors of *Djurjuriceras*, El Ministerio quarry. Scale is 2 cm.


1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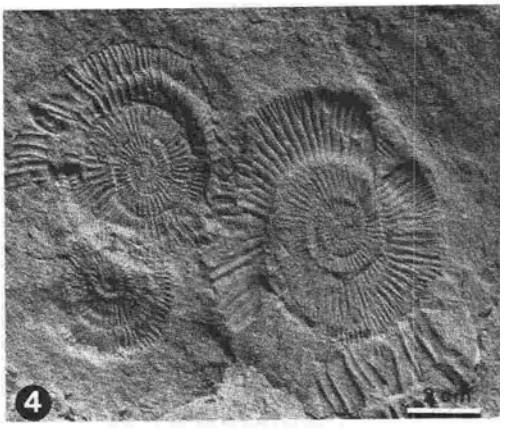
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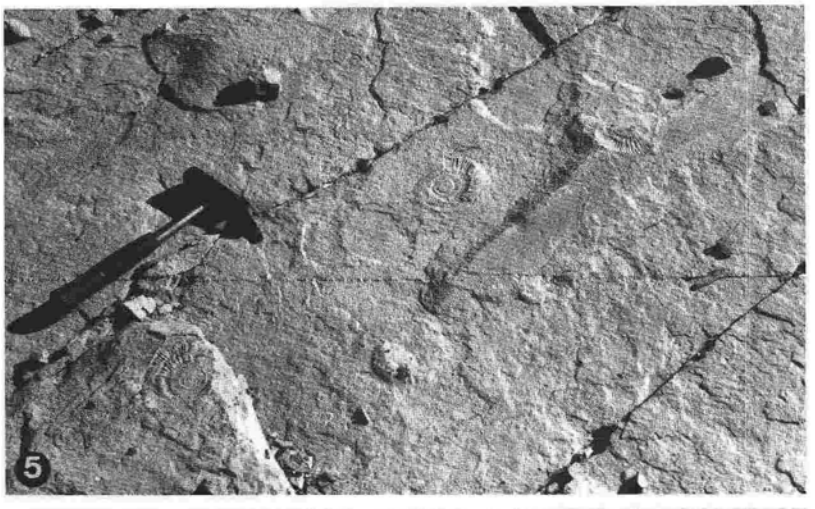
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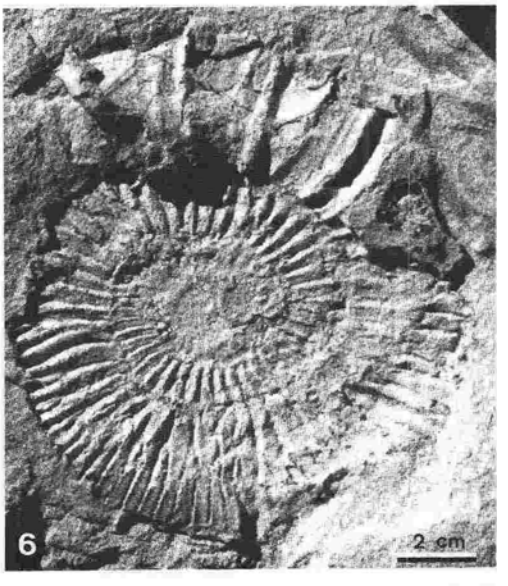
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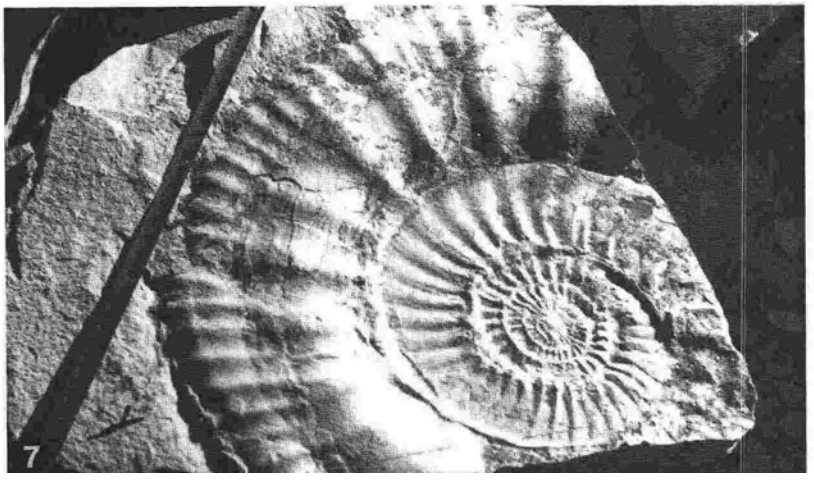
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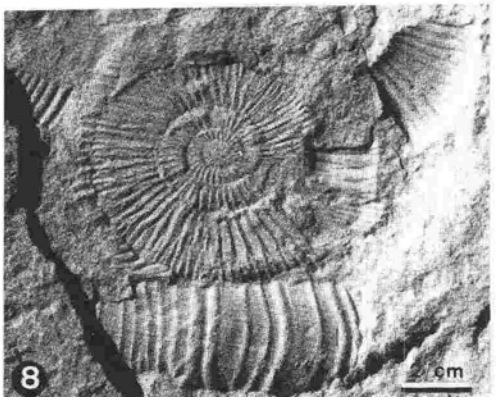
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cm

Plate 37 Fishes (Figs. 1-5), Aptychus (Fig. 7) and Algae (Fig. 6) from the Lithographic Limestones of Argentina (Zapala, Neuquén Province): Los Catutos Member of Vaca Muerta Formation, Tithonian)

Fig. 1. Teleostei: A *Tharsis*-like specimen, M.O.Z. 2806, scale is 2 cm.

Fig. 2. Halecomorphi: A halecomorph caturid-like specimen, M.O.Z. 1645, upper scale is 14,9 cm.

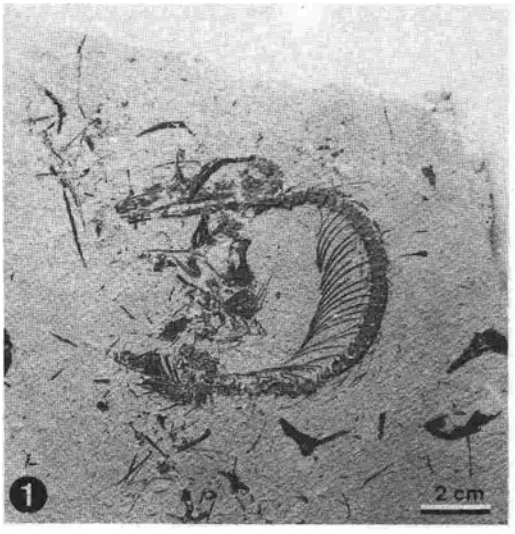
Fig. 3. Teleostei: An indeterminate specimen of the family Pachycormidae, M.O.Z. 1533, scale is 15 cm.

Fig. 4. Halecostomi inc. sed.: cf. *Lepidotes*, M.O.Z. 2306, lower scale is 15 cm.

Fig. 5. Teleostei: A specimen of the family Aspidorhynchidae, cf. *Belonostomus* sp., M.O.Z. 3642, scale is 3 cm.

Fig. 6. Brown alga, comparable with *Phyllothallus latifrons* ROTHPLETZ from the Solnhofen limestone and with the recent genus *Sporochnus* MONTAG. The arrow points to irregular restrictions of the fronds. Note the conspicuous free separated filaments.M.O.Z. 2302, scale is 2 cm.

Fig. 7. A complete specimen of *Laevaptychus brevis* (DOLLFUSS), M.O.Z. 3719, scale is 7 cm.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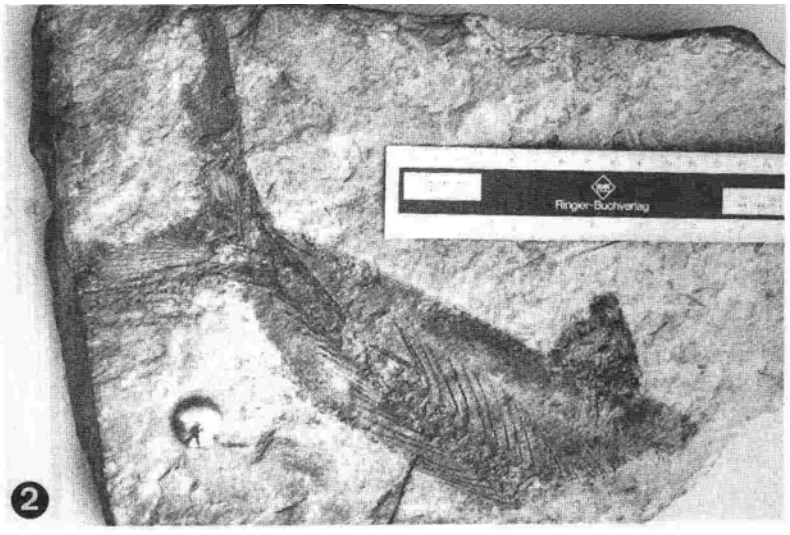
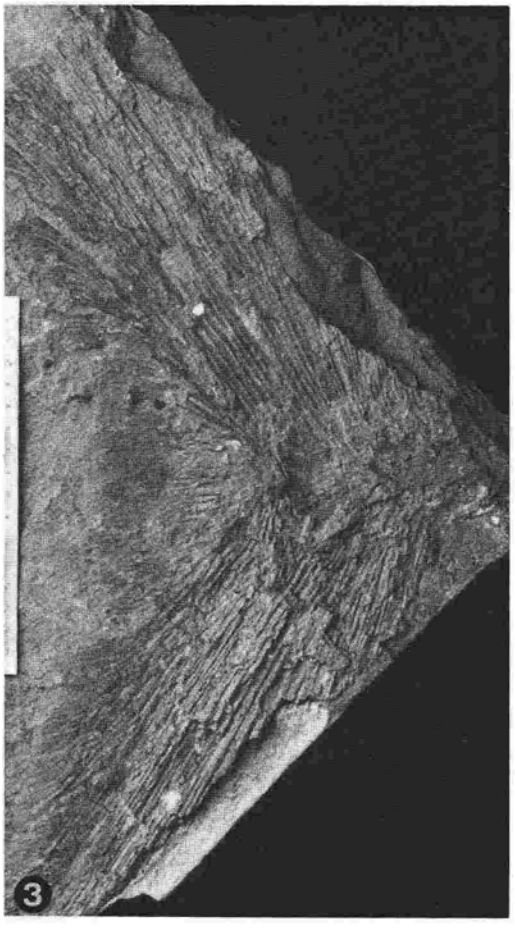
2 cm


2
Ringer-Buchverlag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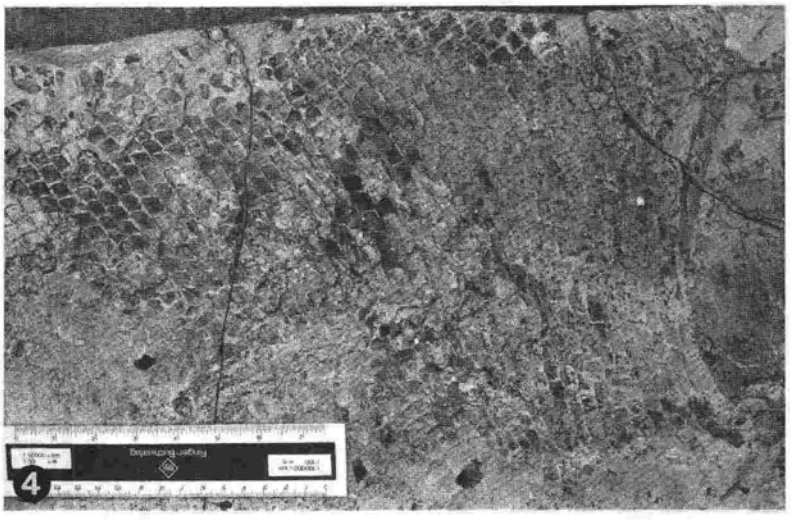
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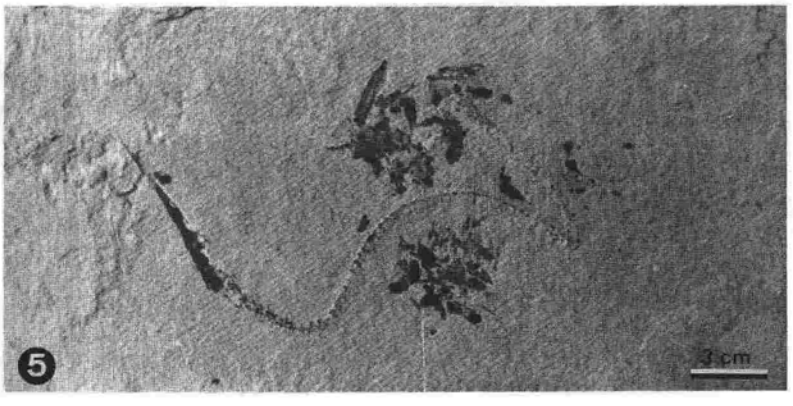
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3 cm


6

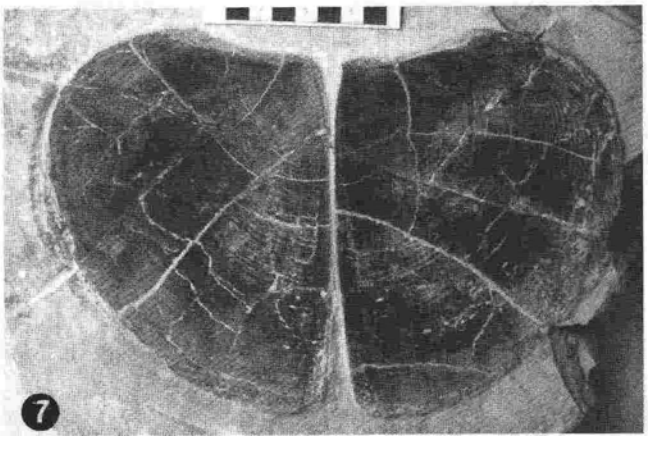
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Plate 38 Reptiles (Figs. 1, 2, 5, 7-10), decapod crustaceans (Fig. 4), Rhyncholites (Fig. 6) and coccolithophorid algae (Fig. 3, 11) from the Lithographic Limestones of Argentina (Zapala, Neuquén Province): Los Catutos Member of Vaca Muerta Formation (Tithonian)

Fig. 1.-2. A specimen of Ichthyosauridae: *Ophthalmosaurus monocharactus* Appleby, M.O.Z. 1854, scale is 15 cm.

Fig. 3. A coccolite of *Ellipsogelasphaera* sp., scale is 1 μm.

Fig. 4. Chelae of a Decapod crustacean (crab): cf. *Pehuenicha magna* Rusaconi, M.O.Z. 1049, scale is 1 cm.

Fig. 5. A tibia of a Pterosaur (superfamily Pterodactyloidea), M.O.Z. 2880, scale is 7 cm.

Fig. 6. A rhyncholite: cf. *Leptocheilus tenuis* Huckriede, M.O.Z. 3684, scale is 1 cm.

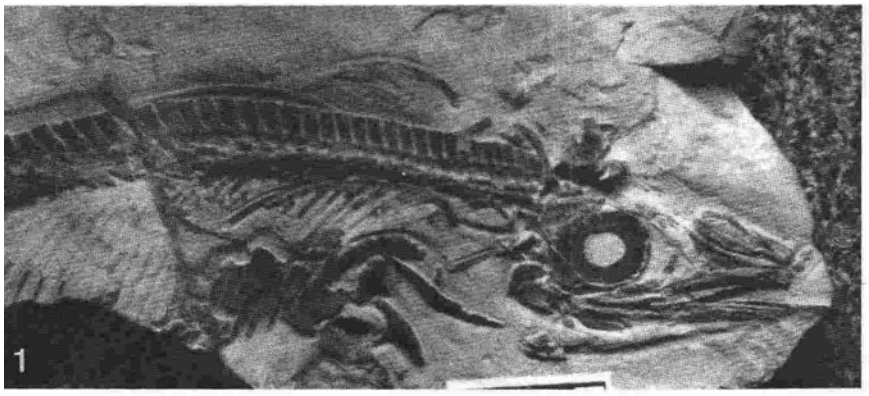
Fig. 7. Plesiosaur tooth, M.O.Z. 1812, scale is 3.7 cm.

Fig. 8. Marine turtle: *Eurysternum* (?) *neuquinum* Fernandez & de la Fuente (1988), M.O.Z. 3681, scale is 5 cm.

Fig. 9. Marine turtle: *Notemys laticentralis* Cattoi & Freiberg M.O. Z. 4040, scale is 6 cm.

Fig. 10. An incomplete and disarticulated skeleton of a Pterosaur. M.O.Z. 3625, scale is 7 cm.

Fig. 11. A complete specimen of *Watznaueria* sp., scale is 1 μm.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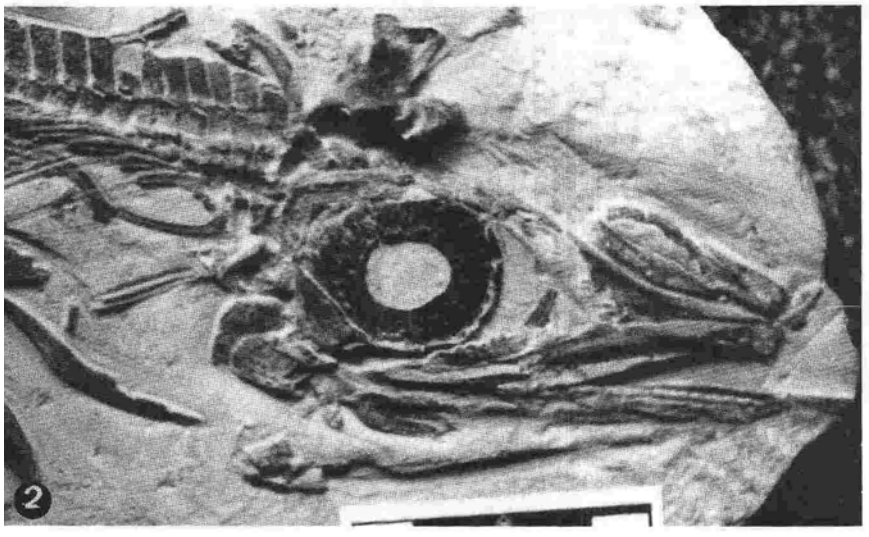
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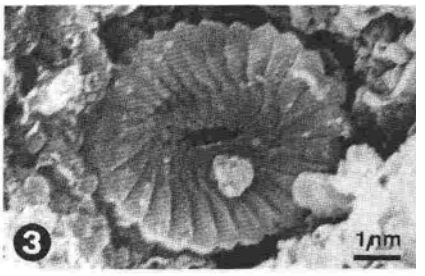
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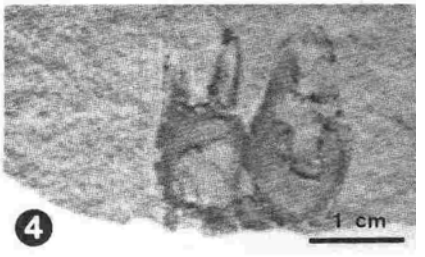
1mm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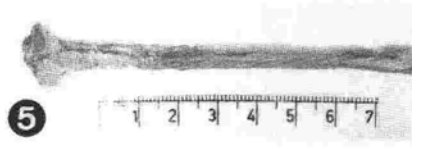
1 cm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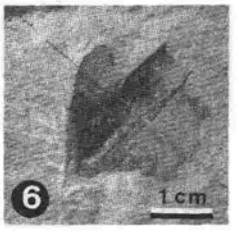
1 2 3 4 5 6 7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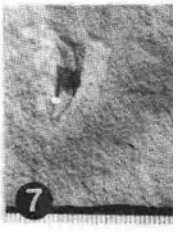
1 cm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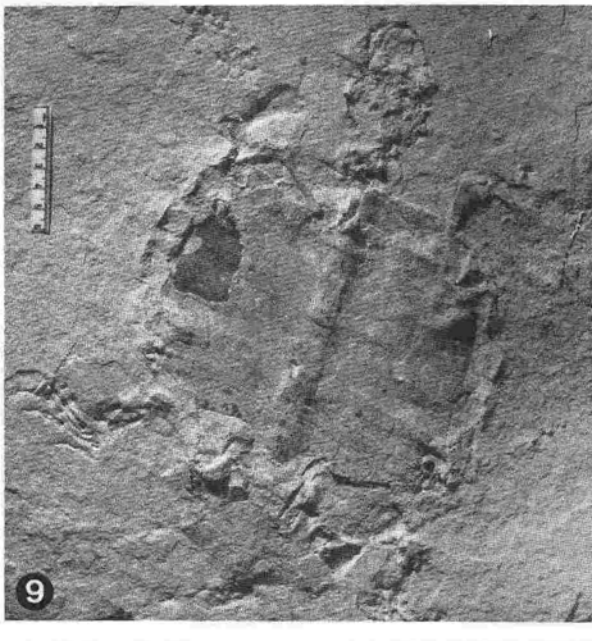
8
5 cm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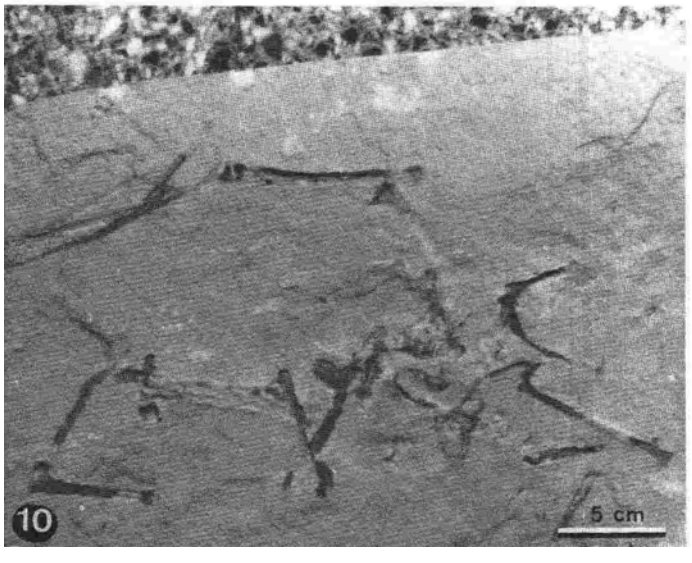
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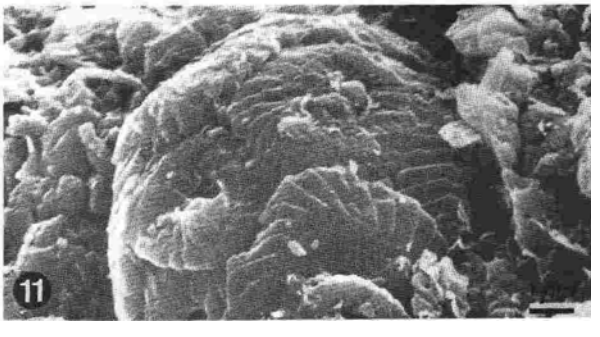
5 cm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