GeoResearch Forum Vols. 1-2 (1996) pp. 221-234

Upper Tithonian Ammonites and Floras from the Chicama Basin, Northern Peruvian Andes

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Keywords: Tithonian, Ammonites, Floras, Biostratigraphy, Correlations, Southern America, Perú

ABSTRACT. The 3000 meters-thick Chicama Group is the infilling of a basin which was opened during late Tithonian time in the western platform of Northern Peru. The lithology and sedimentology express the evolution from slope apron to slope deposits (Punta Moreno Formation), then to prodelta or basinal facies (Sapotal Formation), and finally to nearshore and deltaic environments ending with fluvial deposits (Tinajones Formation).
Ammonites were found mainly in the upper part of the Punta Moreno and in the Sapotal Formations. Micracanthoceras is steadily present, and is associated with genera known in Tethyan Europe and Mexican-Andean areas (Proniceras, Durangites, ?Protacanthodiscus), with genera so far unknown in South America (Moravisphinctes, Zittelia) and with classical components of peripacific regions (Parodontoceras). The fauna is ascribed to the Alternans zone of the Andean biochronological standard, which is probably equivalent to the Microcanthum zone of Europe, of early Late Tithonian age.
Plants remains occur somewhat higher in the section (Upper Punta Moreno, Sapotal and Tinajones Formations). Bennettitales (Ptilophyllum acutifolium, Otozamites) are dominant, associated with less abundant Caytoniales (Sagenopteris) and Coniferales (Cupressinocladus). This assemblage is similar to the Late Jurassic/Early Cretaceous paleofloras from Gondwanaland.

RESUME. Le Groupe Chicama, épais de 3 000 m, représente le remplissage d'un bassin créé sur la plate-forme occidentale du Nord du Pérou au Tithonien supérieur. La succession lithologique traduit l'évolution depuis des turbidites proximales de pied de pente vers des dépôts de talus (Formation Punta Moreno), des argiles de bassin ou de prodelta (Formation Sapotal), et des dépôts clastiques de plate-forme ou delta, terminés par des dépôts fluvio-deltaïques (Formation Tinajones).
Les ammonites se trouvent principalement dans les Formations Punta Moreno supérieure et Sapotal. Micracanthoceras est constamment présent, associé à des genres connus dans la Téthys européenne et les régions mexico-andines (Proniceras, Durangites, ?Protacanthodiscus) ou nouveaux pour l'Amérique du Sud (Moravisphinctes, Zittelia), et des éléments classiques des régions péripacifiques (Parodontoceras). Les faunes sont datées de la zone à Alternans de l'échelle standard andine, équivalent probable de la zone à Microcanthum d'Europe téthysienne, de la partie inférieure du Tithonien supérieur.
Les restes végétaux se trouvent plus haut dans la série (Formations Punta Moreno supérieure, Sapotal et Tinajones). Les Bennettitales (Ptilophyllum acutifolium, Otozamites) dominent, associés à des Caytoniales (Sagenopteris) et des Coniférales (Cupressinocladus) moins abondants. Ces paléoflores sont proches de celles connues du Jurassique supérieur/Crétacé inférieur gondwaniens.

Mots-clés : Tithonien, Ammonites, Flores, Biostratigraphie, Correlations, Amérique, du sud, Pérou.

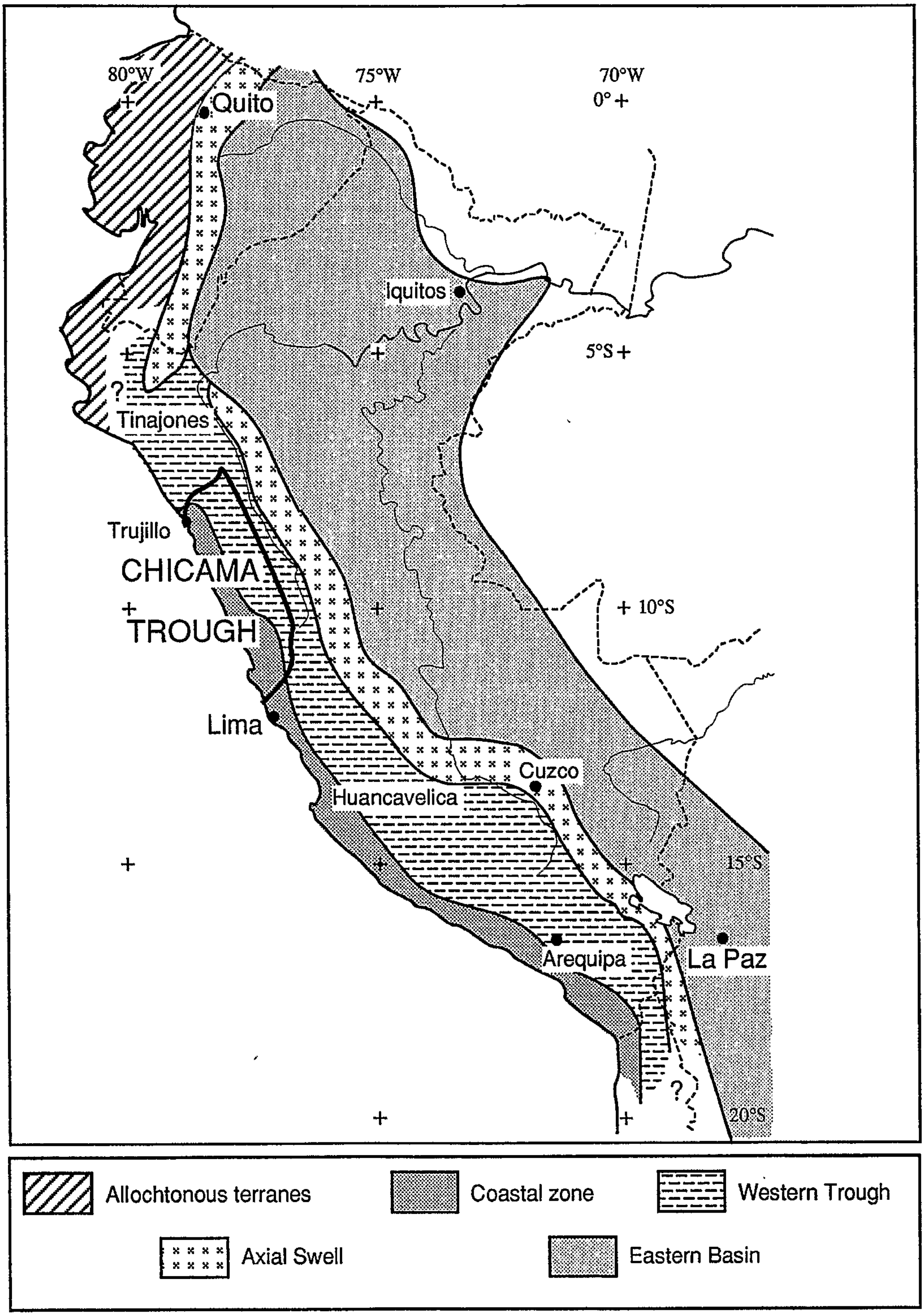

Fig. 1 - Palaeogeographic and situation map.

INTRODUCTION

During latest Jurassic time, the peruvian margin included (fig. 1): a subsident western trough with paralic to marine sedimentation, an axial threshold probably submitted to erosion, and an eastern basin, which experienced a weak subsidence and received detrital continental sediments. The late Jurassic evolution of the coastal zone is poorly known because of subsequent erosions; a volcanic arc activity is known in the Lima area. North-westernmost Peru is considered as a displaced terrane, the accretion of which would explain the tectonic phase of latest Jurassic-earliest Cretaceous age (1 ; 2 ; 3). The present-day western part of Ecuador is made of oceanic terranes accreted during late Cretaceous to early Tertiary times (4 ; 5).

In the western part of the peruvian margin, sediments bearing late Tithonian to Berriasian fauna and flora are known for a long time (review in 6). From North to South, these are the Chicama Beds (7 ; 8 ; 9 ; 10 ; 11 ; 12 ; 13); the Puente Piedra Formation of the Lima area (14 ; 15 ; 16 ; 17 ; 18 ; 19 ; 20 ; 21); and the black shales of the Huancavelica (Huaytara: 22) and Arequipa regions (Tiabaya: 23 ; 13). However, in most of the cases, the fossils were collected without precise stratigraphic location.

The stratigraphy of the Tithonian-Berriasian series of Northwestern Peru (Chicama Beds) was recently studied and revised in the type-locality, the middle course of the río Chicama, through detailed stratigraphic and sedimentological sections, measured at Punta Moreno and Simbal (fig. 1) (24 ; 25). The results of the study of numerous fossils collected in the upper part of the section (25) are presented in this paper. We analyzed also some plant remains collected farther north by T. Mourier in 1983-1985 (1), near the type-locality of the Tinajones Formation (26).

LITHOSTRATIGRAPHY - SEDIMENTOLOGY

The Berriasian-Tithonian Chicama Beds of Northwestern Peru represent the very rapid infilling of a deep sedimentary basin, abruptly created by an important extensional tectonic event. In the lower part of the section, the detrital material is provided by the erosion of a volcanic arc that was active from the late Early Jurassic until the early Late Jurassic, whereas in the upper part, it proceeds from the erosion of crystalline rocks uplifted by the tectonic phase (24).

The Simbal Formation is ascribed to the Early to Middle Tithonian, by correlation with comparable, well-dated sediments. It begins with 400 metres of shales, sandstones, subordinate limestones and scarce evaporitic beds, interpreted as barrier-island and lagoon deposits (24). The upper part is made up of 150 meters of black shales interbedded with thin sandstone beds, deposited in a prodelta or basinal environment, thus expressing a first deepening event (fig. 2). These layers yielded a Substeueroceras sp. (det. Riccardi).

The overlying Chicama Group is 2500 to 3000 meters thick, and includes three formations (24).

The Punta Moreno Formation includes two Members. The lower Member (850 m) is made up of thick conglomerates, greywackes and lithic sandstones, deposited on a proximal turbiditic fan or a slope apron by high-density turbidity currents (25). This member yielded poorly preserved ammonites : Berriasellidae, and ?Neocosmoceras sp. (det. Riccardi). The upper Member (900 m) expresses an

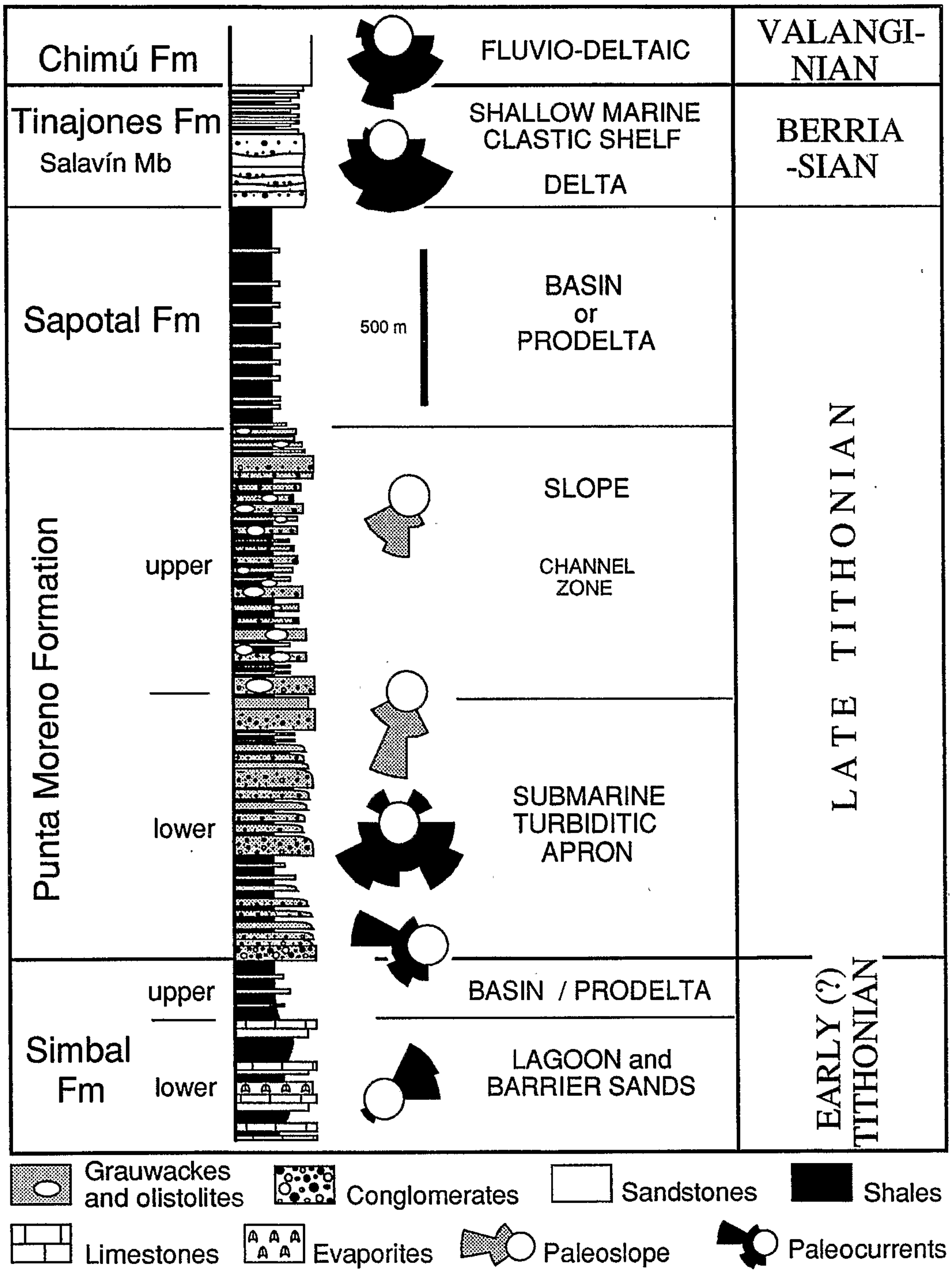

Fig. 2 - Synthetic section of Tithonian-Berriasian deposits in the Chicama basin.

evolution toward a slope environment characterized by feeding-channels, olistoliths and sedimentary slidings (fig. 2). It yielded most of the ammonites studied in this work and a few plant remains.

The Sapotal Formation is a thick series of black shales with thin layers of fine-grained sandstones deposited in a prodelta environment, which contains abundant ammonites and plant remains (fig. 2). Because of probable tectonic duplications, the observed thickness varies from about 300 to 700 metres. Most of the ammonites studied by Geyer (13) seems to proceed from this formation.

The Tinajones Formation rests abruptly upon the Sapotal Formation. It begins with a 400 metre-thick series (Salavin Member) of lithic sandstones sometimes conglomeratic, intercalated with red shales, of shallow marine platform to deltaic environment (fig. 2). Farther North, it yielded a Berriasellid (26). The upper member (Huancay Member), only locally preserved, is constituted by black and red shales with lithic sandstone layers of fluvial origin, in which no fossils were found. It seems to correspond to an important eustatic sea-level drop, that would be one of those of latest Berriasian-early Valanginian age. The formation yelded most of the studied flora remains.

The Goyllarisquizga Group is composed of clean, well-sorted, massive sandstones of fluvial to deltaic environment, that disconformably overlay the Chicama Group (27 ; fig. 2). By correlation with well-dated areas, the age of the disconformity appears to be close to the Berriasian-Valaginian boundary (6).

AMMONITE FAUNA

Almost 45 layers yielded ammonites. Their occurrence is in good agreement with the environment evolution described above (fig. 3). The scarce samples found at the top of the Simbal Formation (SM.1) and in the lower Member of the Punta Moreno Formation (COM.1 and COM.9) were determined by A.C. Riccardi and have not been studied. The ammonite-bearing layers are much more abundant in the upper Member of the Punta Moreno Formation (COM.10 to COM.65), and become scarcer and poorer in the Sapotal Formation. The Tinajones Formation did not yield ammonites as yet. The preservation of this material varies a lot, and only part of it could be determined, often in a approximate way. Most of them are impressions or casts, frequently deformed and incomplete, and difficultly identifiable. The samples in volume have been preserved in the nodule-bearing layers COM.60 and COM.64, the latter being the only one bearing a rich and diversified association. The preservation of the latter is uneven : the siliceous matrix is very hard, whereas the ammonites are frequently made of crystalline calcite, at least for their external tours, and entirely for the small-scale specimens.

There are relatively few studies of the Jurassic ammonites of Peru, as compared with the abundant monographies dedicated to the faunas of Argentine and Chile, or Mexico and the Caribbean areas. Moreover, the value of most of the studies on the ammonites of Peru is reduced by the lack of precise stratigraphic location and the poor quality of the samples and illustrations. Although part of the fauna of the Chicama area can be ascribed to or compared with species described in southern South America, it is rare to observe a real identity, and the quality of the material is not the only reason. The

Formations - PM : Ponta Moreno ; S : Sapotal ; T : Tinajones	Beds number which yelded the opposite taxa	AMMONITES FAUNAS																				FLORAS							
		Micracanthoceras sp.	*Micracanthoceras* sp. aff. *koellikeri* (Steuer non Zittel)	*Corongoceras* sp. cf. *lotenoense* Spath	? *Himalayites* n. sp. cf. *egregius* (Steuer)	? *Durangites* cf. *limensis* (Lisson)	? *Protacanthodiscus* cf. *quadripartitus* (Steuer)	*Substeueroceras* / *Parodontoceras*	*Moravisphinctes* sp.	"*Aulacosphinctes*" cf. *subvetustus* Steuer	*Zittelia* sp.	*Parodontoceras* sp.	*Parodontoceras* sp. aff. *tenerum* (Steuer)	*Parodontoceras* cf. *beneckei* (Steuer)	*Parodontoceras* cf. *calistoides* (Behrendsen)	*Parodontoceras angamarscaense* (Welter)	*Parodontoceras* n. sp. aff. *pardoi* (Lisson)	"*Berriasella*" cf. *bardensis* Krantz	"*Berriasella*" *gerthi* Krantz	*Proniceras* sp. aff. *toucasi* Djanélidzé	Gen. nov. sp. nov.	*Cupressinocladus* cf. *pompeckji* (Salfeld) Pons	*Zamites* sp.	*Ptilophyllum* sp.	*Ptilophyllum* cf. *acutifolium* Morris	*Ptilophyllum acutifolium* Morris	*Sagenopteris* sp.	? *Podozamites* sp.	*Otozamites* sp. A and B
T	JM																									●	●	●	●
S	JMO	●																											
	CHG	●						●																●	●				
	CHD											●																	
PM	Com 65											●				●													
	64	●		●	●	●	●		●		●		●	●	●	●	●	●	●	●	●								
	60	●	●									●																	
	52							●																					
	51	●						●																					
	50							●																					
	46									●																			
	44							●																					
	43								●																				
	42																						●						
	34							●																					
	33	●																											
	22							●																					
	19																					●							
	18	●						●																					
	17	●																											

Fig. 3 - Range-chart of the studied ammonites and floras from the Chicama basin.

fauna presented is interesting because it is well-located along a detailed stratigraphic section, and includes species expressing significant Tethyan influences and affinities.

The list of the identified taxas has been restricted (except COM.29) to the samples determinable generically and/or specifically.

PUNTA MORENO FORMATION, UPPER MEMBER

COM.17: ? Micracanthoceras sp., very partial impression of uncertain determination.

COM.18: Micracanthoceras sp., two more complete impressions with an evolute shape;

? Substeueroceras or Parodontoceras sp., impression with fine and tight ribs.

COM.22: ?Substeueroceras or Parodontoceras sp., four fragment suggesting S. subfasciatum (Steuer).

COM.29: Himalayitid, very deformed and unidentifiable impression.

COM.33: Micracanthoceras sp., very partial but well-characterized impression.

COM.34: ?Substeueroceras or Parodontoceras sp., impression with numerous fine ribs.

COM.43: Moravisphinctes sp., one rather complete impression, very close to some complete samples of COM.64.

COM.44: ?Substeueroceras or Parodontoceras sp., rather evolute form.

COM.46: "Aulacosphinctes" cf. subvetustus Steuer, four fragment of an adult specimen with robust ornamentation, particularly in the ventral area.

COM.50: ?Substeueroceras or Parodontoceras sp..

COM.51: Micracanthoceras sp., deformed impression of an evolute form with strong ribs and well-developed ventral tubercles.

?Substeueroceras or Parodontoceras sp..

COM.52: ?Substeueroceras or Parodontoceras sp., exceptionally rather complete impression which suggests S. fasciatum (Steuer).

COM.60: Micracanthoceras sp. aff. koellikeri (Steuer) (28, pl.XXIV, fig.5, non Oppel in Zittel).

Micracanthoceras sp., fragments, of which part of the body chamber presents the shape of that of the M. microcanthum group.

Parodontoceras sp., several well-preserved but incomplete specimens of a large form.

COM.64: Moravisphinctes sp., three specimens preserved in volume, of which a complete adult form with the peristome and a long and narrow lappet.

Zittelia sp., more than ten individuals more or less well-preserved, of which the two thirdspresent complete peristome with the lappets.

Micracanthoceras sp., several fragments and three small individuals, in volume and/or imprint, close to the sample illustrated in Mexico by Imlay (24).

Corongoceras sp. cf. lotenoense Spath, one poorly preserved example in calcite, more compressed than the specimen figured by Leanza (30, pl.6, fig.6).

?Himalayites nov. sp. cf. "H." egregius (Steuer), one fragment of the body chamber of a very large individual, probably adult and complete, which differs from Steuer's species by the persistance of the two ranks of lateral tubercles until the extremity.

?Durangites sp. cf. limensis (Lisson), one well-preserved example, nearly complete, larger than the type specimen.

?Protacanthodiscus cf. quadripartitus (Steuer), the body chamber of a specimen similar to the type specimen. However, the attribution to Protacanthodiscus, already proposed by Rivera (16) is uncertain.

Parodontoceras sp. aff. P. tenerum (Steuer), one impression of a small involute form, with very thin sinuous ribs and a ventral groove, similar to the type specimen.

Parodontoceras cf.beneckei (Steuer), three examples of which two are complete and exhibit the peristome and the uncoiling of the last whorl visible on the lectotype (Steuer) (28, pl.XXXI, fig.6-7) and the paratype (ibid., fig.8-9).

Parodontoceras cf.calistoides (Behrendsen), one nucleus identical to that figured by Leanza (31) (pl.V, fig.5-6).

Parodontoceras cf.angasmarcaense Welter, small example with fascipartite ribs and double bifurcations appearing very soon.

Parodontoceras nov. sp. aff. pardoi (Lisson), an incomplete example, smaller than the type species, but with the same shape and costulation.

"Berriasella" cf. bardensis Krantz, one incomplete body chamber with badly preserved impression of the inner whorls, quite similar to the type specimen*. Also comparable to

"Neocomites" praeneocomiensis Steinmann (10, p.85, fig. 95), but the ventral area is not visible; in addition, the latter name was already given with the same generic attribution to an other species by Burckhardt (32, p.193).

"Berriasella" gerthi Krantz, a quarter of one whorl including the beginning of the well-preserved body chamber.

Proniceras sp. aff. toucasi Djanélidzé, impression with a whorl fragment representing the inner whorls of a form which is close to the example illustrated by Djanélidzé (33).

Gen. nov. sp. nov., four well-preserved individuals, some of which are the macroconch, and five incomplete and poorly-preserved examples, that form a dimorphic pair. They could not be ascribed to any described and illustrated species.

Note : Several other indetermined, may be new forms, are also present, but would not bear any additional age indication.

COM.65: Parodontoceras cf.angasmarcaense Welter, two small examples;

? Parodontoceras sp., fragments or impression.

* During the Congress, Leanza [The Tithonian Ammonite genus Chigaroceras Howarth (1992) as a bioevent marker between Iraq and Argentina, Abstracts, p. 57] ascribed "B." bardensis to the iraquian genus. This proposal seems hasty and risky owing to the correlations which are thus infered on a single species.

SAPOTAL FORMATION

Ch.D.: Parodontoceras sp., example in volume very incomplete.

Ch.G.: Micracanthoceras sp., impression presenting the ventral area of an evolute specimen with strong costulation (cf. COM.51).

?Substeueroceras or Parodontoceras sp., numerous fragments or impressions, with fine and tight ribs.

JM.O.: ?Micracanthoceras sp., impression of the ventral area.

AGES AND CORRELATIONS

Ages and correlations are based upon the whole fauna, not only on the rich association of the COM.64 layer. Micracanthoceras is regularly present from the COM.17 layer up to the JM.O. bed. The less frequent associated forms do not bring much more information, except for some layers such as the COM.64 bed, where peculiar species are present. In addition to taxa considered as pacific or andean ones, others are close to the late Tithonian forms of the Tethyan regions.

After Gerth (34), Windhausen (35) and Weaver (36), Leanza (31) proposed an ammonite zonation of Pacific South America for the Tithonian, subsequently completed or slightly modified (37 ; 38 ; 39 ; 40 ; 30 ; 41 ; 19 ; 13 ; 42). Many species described were not precisely located in a stratigraphic column, and are still "out of zonation" (cf. 42) or seem to have been replaced in the reference zones without taking into account their stratigraphic succession.

Among the species determined, only "Berriasella" bardensis is well located in the Alternans Zone [= Lotenoense Zone for Wiedman (19) and Geyer (13)]. In the type-locality, it is associated with two other species present in the COM.64 bed : "B." gerthi, which is very close to "B." bardensis, and P. calistoides (43). Associated with the latter, Steuer (28) mentioned P. beneckei (its microconch ?) and "A." subvetustus. However, in more recent works, only P. calistoides is well-located and ascribed to the upper part of the late Tithonian (Koeneni Zone) by Gerth (34), Leanza (31) and then Leanza (30, 41) and Riccardi *et al.* (42).

However, it seems that the studied fauna is not younger than the Alternans Zone, and does not reach the Koeneni Zone, since the corresponding Substeueroceras genus has not been definitely identified in the material presented here. The mentions ?Substeueroceras or Parodontoceras sp. in the COM.19 to 52 and Ch.G. layers correspond to impressions that never exhibit the ventral region, and could be more probably Parodontoceras specimens. For the forms preserved in volume of the COM.60 and 64 beds, there are no doubts that Substeueroceras is absent. Finally, according to Leanza (41), the range of Parodontoceras and also Substeueroceras includes at least part of the Alternans Zone.

The Koeneni Zone would be present in the Sapotal Formation, which is supposed to have yield most of the fauna of the Quesada de Zapotal (13), dated as Tithonian-Berriasian. Geyer's sampling is not well located in the Chicama Formation (= Group), and includes older forms such as "Thurmanniceras" [here refered to as Parodontoceras angasmarcaense of the COM.64 bed] and Hemispiticeras steinmanni of the Middle Tithonian Internispinosum Zone.

The constant occurrence of Micracanthoceras is probably the strongest argument to attribute the studied fauna to the Alternans Zone (= Lotenoense Zone).This genus is well-represented in this zone

(31 ; 30 ; 41 ; 42), though no one of the recognized forms belong to the very peculiar species described by Leanza (31). This attribution is supported by the occurrence of C. cf. lotenoense (used as an alternative marker by Wiedmann and Geyer), although Leanza (31), Leanza (30 ; 41) and Riccardi *et al.* (42) consider this species to belong to the Internispinosum Zone, of the upper part of their Middle Tithonian. However, the form illustrated by Leanza (30) differs from our sample by a more evolute coiling and a depressed section. A block of glauconitite of the chilean Cordillera, East of Santiago, yielded a small population of this form (10 examples), associated with Pseudohimalayites cf. steinmanni of the Proximus Zone of Middle Tithonian age (30 ; 41 ; 42) and two perisphinctids with fine ribs, close to Substeueroceras striolatum-striolatissimum Steuer (28), with the ventral groove of Parodontoceras.

Correlations between Tethyan and Andean provinces have received different interpretations (30 ; 41, 19 ; 13 ; 44, 45 ; 46, 47 ; 42). The "mediterranean" components of Northwestern Peru bring new clues. The Micracanthoceras are closer from the Mexican (29) and European forms than from those of Leanza (31). In mediterranean Europe, they are well-located in the Microcanthum Zone of early Late Tithonian age. Moreover, Proniceras, of which only one example is known in the Chicama fauna, occurs as early as in the lower Simplisphinctes Subzone, whereas Moravisphinctes and Zittelia are restricted to the upper Transitorius Subzone. Only, Durangites and Protacanthodiscus would indicate the Durangites Zone of late Late Tithonian. However, on one hand, primitive forms of Durangites appear as soon as the Microcanthum Zone (they are currently under study and will lead to the emendation of the genus definition); and on the other hand, the attribution of P. quadripartitus to the genus Protacanthodiscus , although proposed by Rivera (16), is debatable.
Such arrivals of mediterranean taxa well emphasize increasing Tethyan influences from South to North in the andean area, already identified as "largely dominant from Peru" (48, p. 384).

FLORAS

The collected fossil plants are represented by often fragmentary imprints without cuticles. There is no fossil plants in Simbal formation.

PUNTA MORENO FORMATION

In the Lower member the fossil plants are absent ; in the Upper member 7 specimens have been collected :

Com 17 : Two axis probably of botanical nature but indeterminable

Com 19' : Cupressinocladus cf. C. pompeckji (Salfeld) Pons is similar to the figured specimens of Pons (49, pl. IX, fig. 1-8) from the Lower Cretaceous of Peru and determinated as Cupressinocladus pompeckji (Salfeld) Pons. Cupressinocladus pompeckji is present in Peru, Colombia and Venezuela from the Upper Jurassic to Neocomian.

Com 34 : 2 axis, probably of botanical nature, with a more or less parallel venation ; there is no possibility of a generic determination.

Com 42 : 1 botanical axis preserved in volume but indeterminable.

Com 42 : Zamites sp. incomplete leaf bearing pinnae without venation.

SAPOTAL FORMATION

CH G : Ptilophyllum sp. incomplete leaf bearing pinnae without distal part.

CH G : Ptilophyllum cf. Ptilophyllum acutifolium Morris emend. Bose and Kasat. The absence of venation of the pinnae does not allow a precise specific determination.

TINAJONES FORMATION

9 specimens have been collected and studied in lutites and reddish sandstones.

The material is fragmentary, two specimens show numerous fragmentary rests.

6 specimens collected in greyish sandstones, some being well preserved.

J.M. Ptilophyllum acutifolium Morris emend Bose et Kasat, distal part of a leaf identical with the same species figured by Bose et Kasat (50, pl. 1, fig. 1-6) from the Upper Jurassic-Lower Cretaceous of India.

J.M. two cycadophytic fragmentary fronds with no basal part and venation of the pinnae.

J.M. two axis of botanical nature but indeterminable.

J.M. Sagenopteris sp. incomplete leaf but with a typical anastomosing venation.

? Podozamites sp., isolated pinna without distal part ; the generic determination is uncertain.

Otozamites sp. A : isolated pinnae with a typical asymmetry of the pinnae base belonging to the genus Otozamites Braun. They seem similar to those described in the Lower Cretaceous flora from Peru and determinated as Otozamites zeilleri Berry (8, pl. 2, fig. 3).

Otozamites sp. B : isolated incomplete pinna with a typical base of the genus Otozamites Braun. Some affinities with Otozamites zeilleri Berry (8, pl. 2, fig. 3) from the Lower Cretaceous of Peru are possible.

The wealden flora of Peru has been studied by Neumann (51), Zeiller (52, 53), Salfed (54), Berry (8, 55, 56).

It is constituted meanly with Filicales particularly Weichselia reticulata, of Bennettitales (Otozamites, Cycadolepis) and Coniferales (Podozamites - Cupressinocladus).

The studied flora has in its systematic composition Ptilophyllum acutifolium, discovered fo the first time in Peru.

This is a typical species of indian province and distributed form Upper Jurassic to Lower Cretaceous. The other specimens determinated are present in the inventory of previous works. Some specimens have affinities with described species. We can note the absence of Weichselia reticulata, typical from the Lower Cretaceous flora. If we consider this absence as significative evidence, it may be possible to consider the studied flora more oldest than those discribed in previous works from Peru. In Tinajones Formation some specimens show numerous fragmentary fossils plants. Complete leaf of Bennettitales had never observed. Only isolated pinnae are found and indicate some transport of the material.

CONCLUSIONS

Preservation of the ammonites faunas and floras from the Chicama Group is unequal, but they are well situated stratigraphically giving them a strong value in comparison with other jurassic faunas or floras quoted or described in Peru or even in another parts of the andean area.

The floras are present in the middle part (Upper Punta Moreno Formation) and at the top (Tinajones Formation). The identified taxa are known in different parts of Gondwanaland and they give few constrained age during Upper Jurassic Time.

The ammonites are best preserved on the whole and more diverse, giving more precise age for the Upper Punta Moreno and Sapotal Formations. They agree well with the Alternans Zone of the biochronological standard for Pacific South America (Andean Province), in the lower Upper Tithonian. Correlations with the Microcanthum Zone of the Tethyan standard are provided by taxa of mediterranean origin or affinity. Such taxa proove the greater frequency of tethyan arrivals in the northern Andes.

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