Senonian–Paleocene charophyte succession of the Peruvian Andes

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A synthesis of the available sedimentological and stratigraphic data on the Late Cretaceous and Paleocene deposits of the Peruvian Andes permits determination of the age-range of the succession and stratigraphic range of the main charophyte species. *Feistiella ovalis* may appear in the late Santonian(?). It persists up to the middle(?) Campanian, where it is associated with *Platychara perlata*, which still occurs in the late Campanian. *Feistiella gildemeisteri* and *Platychara grambastii* are commonly found in association with *Amblyochara peruviana*. In other parts of Peru, these species occur together with *Amblyochara rolli, A. begudiana, Feistiella costata* and *Saportanella* aff. *maslovi,* strongly supporting a pre-Tertiary, mainly Maastrichtian age. Early Paleocene species are only local and poorly known. The *Nitellopsis supraplana–Maedleriella* association seems to characterize a late time-span of the Paleocene, though a possible extension into the Eocene cannot be ruled out.

KEY WORDS: charophytes; stratigraphy; Late Cretaceous; Paleocene; Andes; correlations.

1. Introduction

By Senonian times the western part of the central Andean margin was becoming progressively emergent, whereas widespread, fine-grained continental to very shallow marine sediments were laid down in the eastern regions (Figure 1). These deposits mainly contain vertebrate remains (fishes, dinosaurs, reptiles and mammals), palaeofloras (charophytes and palynomorphs) and some poorly known molluscs. In order to determine the stratigraphy of these beds, detailed study and exhaustive sampling of some well-exposed sections of southern Peru have been undertaken. The recognition in the field of good correlations between the sedimentary sequences of southern Peru and Bolivia, and the determination of precisely located palaeontological samples allow us to propose a correlation chart, which in turn permits us to constrain the age of each sequence and that of their fossil content.

In Peru detailed works on the charophyte associations and succession were carried out in the eastern Amazonian Basin (Oriente, Figure 1), and led to the definition of a charophyte biozonation (Koch & Blissenbach, 1960; Rivera, 1961; Fyfe, 1963; Gutierrez, 1975, 1982). The age of these zones was constrained by palynological studies of the Cretaceous beds (Müller & Aliaga, 1981). In contrast, excepting Newell (1949) and Peck & Reker (1947), numerous charophytes have been collected in the Peruvian Andes (Figure 1) without having been located on a stratigraphic column (Kalafatovich, 1957; Grambast *et al.,*
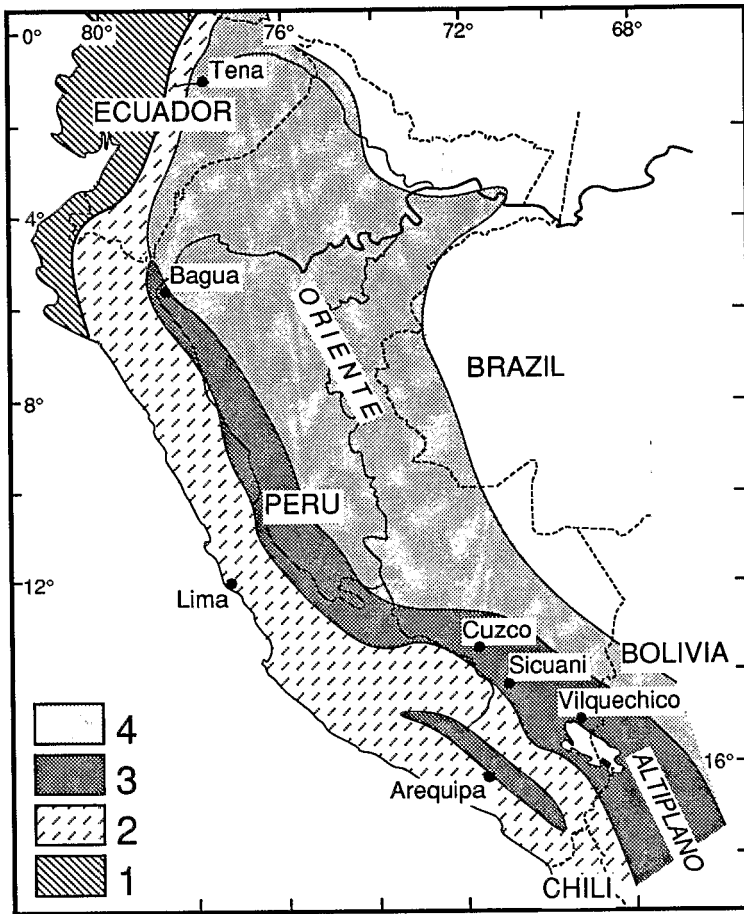
Figure 1.   Senonian–Paleocene palaeogeography of the Peruvian margin and location of the main
   localities cited in the text. 1, Allochthonous terranes; 2, emergent areas subjected to erosion; 3,
   Andean area of Senonian–Paleocene sedimentation; 4, Oriente (widespread Senonian–Paleocene
   deposits).

1967; Marocco, 1978; Mégard, 1978; Ramirez, pers. comm.) and the age of
these species was not precisely known (Mourier *et al.*, 1988; Feist *et al.*, 1989).

NORTHERN PERU		EASTERN PERU		SOUTHERN PERU	BOLIVIA	
SAMBIMERA Fm	middle EOCENE to late PALEOCENE	POZO Fm	EOCENE	MUÑANI Fm	CAYARA Fm	EOCENE
RENTEMA Fm 54 ma	late PALEOCENE to early EOCENE	Upper (Sol 3) YAHUARANGO Fm Lower (Sol 1)	late (?) PALEOCENE / early (?) PALEOCENE	4th Megaseq. CHILCA Fm	Santa LUCIA Fm	PALEOCENE
Fundo el TRIUNFO Fm	late CAMPANIAN to MAASTRICHTIAN	CASA BLANCA Fm	late MAASTRICHTIAN	3rd seq	3rd seq	earliest PALEOCENE ?
		HUCHPAYACU Fm CACHIYACU Fm	MAASTRICHTIAN	2nd seq	2nd seq	MAASTRICHTIAN
		VIVIAN Fm	late SENONIAN	1st seq	1st seq	
	mid CAMPANIAN			2nd seq	2nd seq	early CAMPANIAN to SANTONIAN
CELENDÍN Fm	early SANTONIAN	upper CHONTA Fm	early SANTONIAN	1st seq	1st seq	
	early CONIACIAN		early CONIACIAN	1st Megaseq	AROIFILLA Fm	85 ma CONIACIAN ?
CAJAMARCA Fm	late TURONIAN	middle CHONTA Fm	late TURONIAN	COTACUCHO Gp	MIRAFLORES Fm	TURONIAN ?

(Southern Peru column: VILQUECHICO Gp and YUNCAYPATA Fm, with 1st/2nd/3rd Megaseq. Bolivia column: EL MOLINO Fm, CHAUNACA Fm)
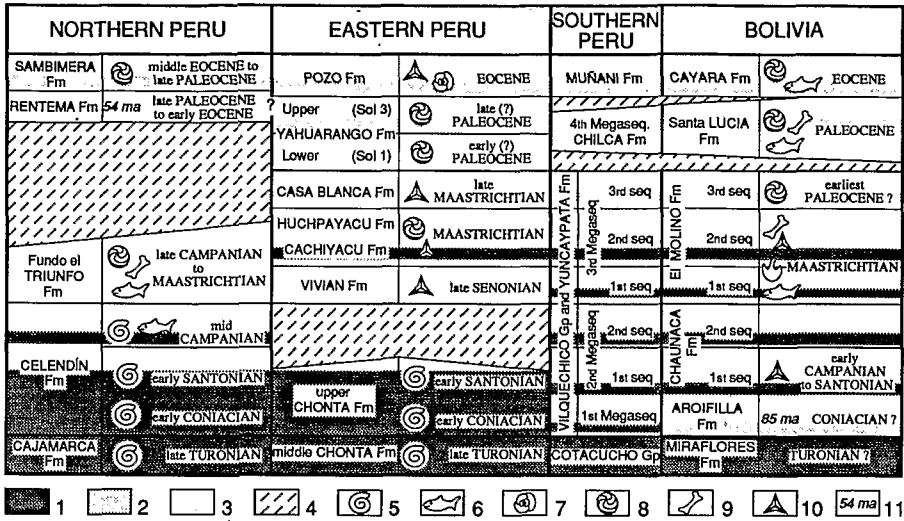
1 2 3 4 5 6 7 8 9 10 54 ma 11

Figure 2. Simplified correlation and stratigraphic chart of the Senonian–Paleocene deposits of the Central Andes, with main diagnostic biostratigraphic data. 1, Marine facies; 2, mainly lacustrine facies; 3, mainly continental facies; 4, sedimentary gaps; 5, ammonites; 6, fishes; 7, foraminifera; 8, charophytes; 9, vertebrates; 10, palynomorphs; 11, radiometric dates.

deposits, overlain by thin, usually black-coloured marine shales and limestones. These grade upwards into green to red-coloured, commonly evaporite-bearing marls and shales of sabkha, lacustrine or distal alluvial plain environments, and then into red-coloured shales including layers of sandstone and conglomerate of alluvial plain to fluvial origin. The early Senonian sequences generally lack the last described unit, whereas in the latest Senonian to Paleocene deposits, the basal marine unit does not occur.

For the early Senonian sequences, the major methodological problem was to correlate the well-dated marine layers of northern and western Peru with the mainly continental beds of southern and eastern Peru. For this purpose we supposed that the thin marine beds intercalated within the terrestrial deposits of southern Peru correspond to synchronous and widespread eustatic 'maximum floodings', and thus can be correlated (Figure 2). However, the age of the charophyte-bearing continental deposits remains poorly constrained. For late Senonian and Paleocene times, the palynological data from correlative formations of eastern Peru and the extensive vertebrate faunas from coeval beds of Bolivia have been used to constrain the age of the south Peruvian sequences and charophyte assemblages (Figure 2). Nevertheless, sedimentary gaps are likely to occur in such continental sediments deposited in an incipient orogenic domain. Their existence is, however, very difficult to detect. As a result, the precise age of the sequence boundaries is impossible to determine accurately.

Finally, many of the charophyte taxa reported from field sections and oil well successions in the Oriente were determined according to a local taxonomy, and numerous so-defined species have not been illustrated. Hence, comparisons between associations described from the Andes and Oriente are somewhat difficult.

Review of the Senonian–Paleocene sequences of southern Peru
The Senonian red beds of the Peruvian Andes overlie platform limestones, the age of which is well established only in northern Peru (Benavides, 1956). In southern Peru comparable rocks (Arcurquina Formation; Benavides, 1962;

Ayavacas Formation; Newell, 1949) and marine red-coloured sandstones (upper Cotacucho Group; Newell, 1949) have been correlated with the Turonian sequence (Jaillard & Sempere, 1989).

The first megasequence (Figures 2 and 3). In southern Peru, the first megasequence consists of evaporite-bearing red shales containing thin and local marine beds in its lower part (Chilcane Formation and lower part of the Vilquechico Group). For its stratigraphic relationships, the marine layer is correlated with the early Coniacian transgression dated in northern and eastern Peru by a rich ammonite association (Benavides, 1956; Ducloz & Rivera, 1956). It can be correlated with the Aroifilla Formation of Bolivia (Jaillard & Sempere, 1989; Sempere, 1994). Near Cuzco, the lower part of the Senonian section yielded *Feistiella ovalis* (Carlotto, 1992). However, the presence of reverse faults has led us to suspect tectonic duplications.

The second megasequence (Figures 2 and 3). This includes two minor sequences. The first begins with a few tens of metres of marine limestones, which yielded *Tissotia steinmanni* in the Arequipa area (Vicente, 1981) and marine fishes, molluscs and foraminifera elsewhere (Middle Vilquechico and Middle Yuncaypata Formations) (Figure 3). This marine layer is correlated with the major early Santonian transgression of northern Peru (Kummel, 1948; Benavides, 1956; Mourier *et al.,* 1988). In the Vilquechico section, *Peckisphaera* sp. A, *Amblyochara* sp. A and *F. ovalis* indicate a Late Cretaceous age for the upper part of the sequence (Jaillard *et al.,* 1993). It correlates with the lower member of the Chaunaca Formation of Bolivia (Jaillard & Sempere, 1989; Sempere, 1994).

The base of the second minor sequence is marked by a persistent, very thin black layer, which locally has yielded marine molluscs and selachians (Jaillard *et al.,* 1993). The upper part of the sequence contains *F. ovalis* and *Platychara perlata* (Jaillard *et al.,* 1993). However, in the Cuzco section, *Feistiella gildemeisteri* and *Platychara grambastii* seem to appear in the last few metres of the megasequence (Carlotto, 1992). The lower marine bed is correlated with the
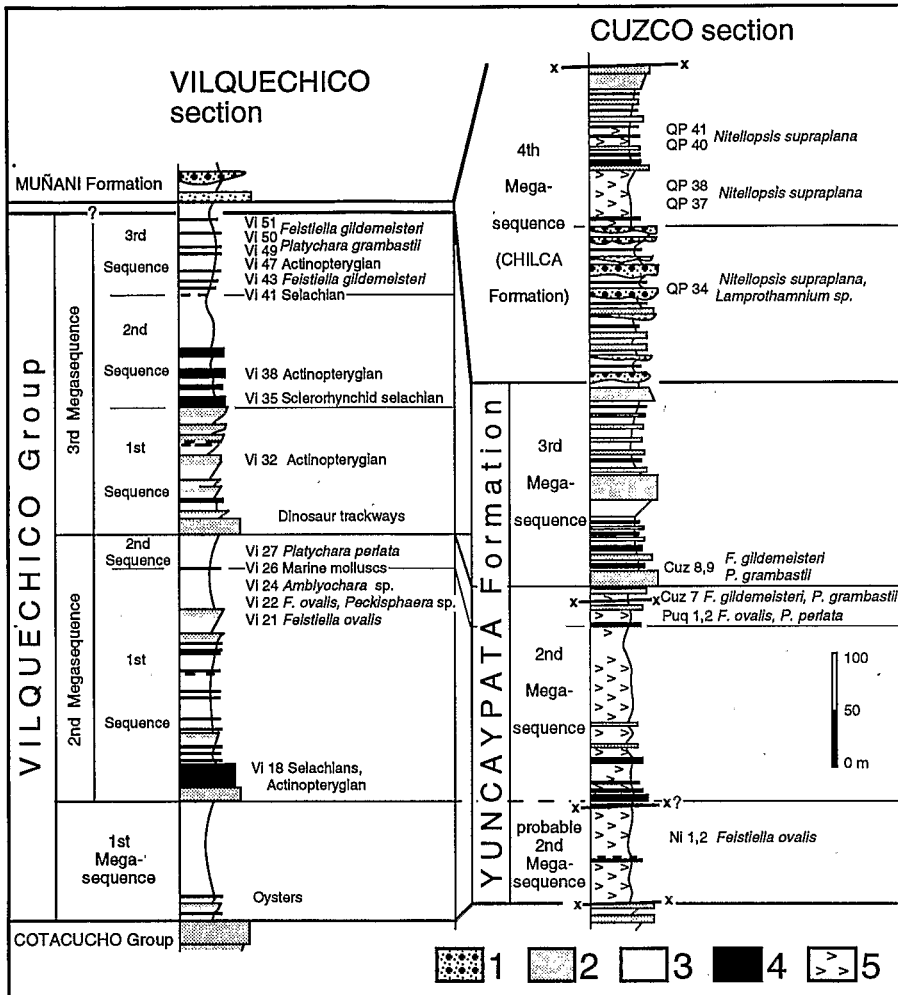
Figure 3. Charophyte occurrence in the two main sections of southern Peru. 1, Conglomerates; 2, sandstones; 3, shales and marls; 4, limestones; 5, evaporite-bearing shales.

The third sequence is marked by green-coloured lacustrine deposits in eastern areas and by light green to white-coloured fluvial sandstones in the southwest. In Vilquechico, it contains *F. gildemeisteri* and *P. grambastii* (Jaillard *et al.*, 1993). The correlative Casa Blanca Formation of the Peruvian Oriente is considered to be late Maastrichtian on the basis of palynological studies (Müller & Aliaga, 1981).

The fourth megasequence. This is probably limited by important sedimentary or erosive gaps and possibly comprises two minor sequences separated by another sedimentary gap (Figure 2).

In the north-Peruvian Oriente, the lower part of the Yahuarango Formation is characterized by the *Feistiella costata-'Sphaerochara'* association, presently ascribed to the early Paleocene (Gutierrez, 1982). [The generic assignment to *Sphaerochara* by Rivera (1961) would need to be confirmed; the quality of her illustrations does not allow this.] This flora is lacking in the Andean realm, probably because of a widespread latest Maastrichtian(?)–early Paleocene

sedimentary gap. For instance, in the Cuzco area, a fluvial to lacustrine, locally brackish, detrital sequence which yielded Paleocene charophytes (see below) unconformably overlies the first or second sequence of the Maastrichtian Yuncaypata Formation. Similarly, the Santa Lucia Formation of Bolivia, dated by middle to late Danian vertebrate associations (Gayet *et al.*, 1991), locally unconformably overlies the third, the second or even the first member of the Maastrichtian El Molino Formation (Sempere, pers. comm.).

In the Oriente of central Peru, the '*Sphaerochara*'–*F. costata* zone (Sol 1 Formation) is stratigraphically separated from that succeding it (Sol 3 Formation) by a 10–40 m thick bed of indurated, non-calcareous shales containing abundant iron concretions and kaolinite (Sol 2 Formation), which coincides with a sharp palaeontological break (Koch & Blissenblach, 1960). This layer could represent a palaeosoil reflecting an important intra-Paleocene sedimentary gap, and separating two sedimentary sequences.

In the Vilquechico area, only a few metres of probable Paleocene deposits are preserved below the conglomeratic Muñani Formation of probable Eocene age (Figure 3) (Jaillard *et al.*, 1993). In the Bagua region, a 100-m-thick series of conglomeratic sandstones of late Paleocene age disconformably overlies the Maastrichtian beds (Naeser *et al.*, 1991). Finally, in the western part of the Oriente of Ecuador, the Eocene conglomerates of the Tiyuyacu Formation disconformably overlie the Maastrichtian Tena Formation (Faucher *et al.*, 1971). These observations indicate that an important phase of erosion during the late Paleocene preceded the major sedimentary disconformity of latest Paleocene to early Eocene age that reflects the Inca 1 tectonic phase (54–49 Ma; Noble *et al.*, 1990; Naeser *et al.*, 1991).

3. Occurrence and age of the charophytes of Peru

Mid–Late Cretaceous (≈ Late Santonian–Late Campanian)
Feistiella ovalis has been found in the lower part of the Yuncaypata Formation near Cuzco. However, owing to the presence of numerous reverse faults, this layer could pertain to the second Senonian megasequence. *Feistiella ovalis* is certainly present in the upper part of the first sequence of the second megasequence (Figures 3 and 4). It was reported from unspecified beds of the Yuncaypta Formation (Kalafatovich, 1957; Grambast *in* Marocco, 1978; Peck, 1977, *in* Ramirez, pers. comm.). Newell (1949) found it in association with *Platychara perlata* (Peck & Reker, 1947) in the upper minor sequence of the second megasequence. This species is common in the south-Peruvian Andes but is unknown so far in the Oriente, possibly because of the large-scale Campanian sedimentary gap. Its provisional age assignment is late Santonian(?)–late Campanian.

In the Vilquechico area *Peckisphaera* sp. A and *Amblyochara* sp. A occur in probable early to middle Campanian beds (Figure 3). *Peckisphaera* sp. A seems to be rather scarce in the Andean realm since it is only mentioned in the Rio Suches outcrops of Bolivia (Jaillard *et al.*, 1993).

Platychara perlata is commonly found in the upper part of the second minor sequence of the second megasequence, of middle to latest Campanian age (Jaillard *et al.*, 1993). It was reported from the same layers by Peck & Reker (1947) and Newell (1949), and from unspecified beds of the Yuncaypata

	SOUTHERN PERU		NORTHERN PERU	EASTERN PERU	BOLIVIA	Charophyte assemblages
EOCENE	MUÑANI Fm		? ? ?			?
PALEOCENE	CHILCA Fm					Maedleriella-N. supraplana
						F. costata-Sphaerochara
MAASTRICHTIAN late	YUNCAYPATA upper Fm / 3rd Megaseq	3rd seq				F. gildemeisteri - P. grambastii
middle ?		2nd seq				
early ?		1st seq				
CAMPANIAN late to middle	QUEBCHICO Gp. / 2nd Megaseq	2nd seq				F. ovalis - P. perlata
middle to early		1st seq				
SANTONIAN	VILQUECHICO Gp.					
CONIACIAN		1st Megaseq				

Southern Peru species (stratigraphic ranges): Pecksisphaera sp. A, Amblyochara sp., Feistiella ovalis, Platychara perlata, Nitellopsis supraplana, F. gildemeisteri, P. grambastii, A. peruviana

Northern Peru species: A. peruviana, A. begudiana, Feistiella costata, Nitellopsis supraplana, Maedleriella sp., "Chara strobliocarpa"

Eastern Peru species: Amblyochara rolli, Feistiella gildemeisteri, "Tolypella" biacuta, Sapottanella riverae, Chara cylindrata, Sphaerochara strobliocarpa, Feistiella costata, Feistiella gildemeisteri solensis, Sphaerochara ssp., Nitellopsis supraplana, Maedleriella monolifera

Bolivia species: Pecksisphaera sp., Amblyochara sp., Platychara sp., F. gildemeisteri, P. grambastii, A. peruviana

Figure 4. Stratigraphic range of the main charophyte species in the Peruvian Andes; comparisons with the Peruvian Oriente and the Bolivian Andes. Black lines, well-located samples; shaded lines, unspecified stratigraphic layers.

Formation by Kalafatovich (1957). The genus *Platychara* ranges from the late Campanian up to the early Paleocene (Grambast-Fessard, 1980; Feist & Colombo, 1983).

Although our observations in southern Peru suggest that *F. ovalis* becomes extinct a little above the first occurrence of *P. perlata*, the presence of the two species in nearby layers can be considered as indicating the middle to late Campanian interval (Figure 4).

Late–Late Cretaceous (Late Campanian?–Late Maastrichtian)
Feistiella gildemeisteri is known throughout the third megasequence of southern Peru (Grambast *et al.*, 1967; Carlotto, 1992; Jaillard *et al.*, 1993; Ramirez, pers. comm.). In Cuzco, its apparent occurrence in the uppermost part of the second megasequence is most probably because of reverse faulting (Figure 3). This widespread species is reported from the Maastrichtian Areniscas de Azúcar, Cachiyacu, Huchpayacu and Casa Blanca Formations of the Peruvian Oriente (Koch & Blissenbach, 1960; Fyfe, 1963; Gutierrez, 1982). It has been noted in undated beds of the Andes of central Peru (Grambast *in* Mégard, 1978) and of northwestern Bolivia (Rio Suches; Jaillard *et al.*, 1993), and is also very common in the El Molino Formation of Bolivia (Sempere *et al.*, 1987; Jaillard *et al.*, 1993). Its probable age is thus latest Campanian to late Maastrichtian (Figure 4).

Platychara grambastii is another widespread species which occurs in association with *F. gildemeisteri* and seems to characterize the same interval (Figures 3 and 4). It has been reported from the El Molino Formation of Bolivia (Jaillard *et al.*, 1993). However, it is unknown so far in the Oriente region (Gutierrez, 1982). The genus *Platychara* is known in Late Cretaceous and early Paleocene beds of western Europe (Grambast-Fessard, 1980) and North America (Peck & Forrester, 1979).

Amblyochara peruviana was described in Peru from fossiliferous layers at Laguna Umayo-Sillustani (Grambast *et al.*, 1967), at Bagua (Mourier *et al.*, 1988) and in the Maastrichtian Tena Formation of Ecuador (Bristow & Hoffstetter, 1977) (Figure 4). It is also very common in the El Molino Formation of Bolivia (Sempere *et al.*, 1987; Jaillard *et al.*, 1993). The genus *Amblyochara* is

well known from Albian to Maastrichtian beds of western Europe (Feist & Freytet, 1983; Philip, 1984), and also from the early Paleocene (Feist, 1979).

The *F. gildemeisteri–P. grambastii* assemblage, frequently associated with *A. peruviana*, seems to characterize the third Senonian megasequence of southern Peru and Bolivia and, locally, the top of that preceding it (Figure 4).

In the Cuzco area this assemblage is associated with '*Chara*' *cylindrata* and *Tectochara* sp. (Grambast, 1963, *in* Ramirez, pers. comm.). In the Bolivian Andes, this three-fold assemblage is associated with *Platychara* sp. (Jaillard *et al.*, 1993), *Amblyochara* sp., *Platychara* cf. *cruciana* and '*Peckichara*' *compressa* (*fide* Sempere *et al.*, 1987). Further north (rio Suches), *F. gildemeisteri* occurs together with *Lamprothamnium* sp. and *Peckisphaera* sp. B (Jaillard *et al.*, 1993). '*Peckichara*' *compressa*, reported in the Bolivian Oriente (Peck *in* Perry, 1963) has been placed in synonymy with *Platychara compressa* (Peck & Forester, 1979).

In the Peruvian Oriente, *F. gildemeisteri* occurs together with *Saportanella riverae*, '*Tolypella*' *biacuta*, '*Chara*' *cylindrata* and '*Brevichara*' *orientensis* (Koch & Blissenbach, 1960; Gutierrez, 1982). According to the illustration of Rivera (1961, pl. 1, fig. 5), *Brevichara orientensis* is likely to correspond to a species of *Platychara*. Within this zone, *Amblyochara rolli* is only present in the lower part, while *F. costata* appears in the upper part (Gutierrez, 1982) (Figure 4). In unspecified layers of the central Andes of Peru, *F.* cf. *gildemeisteri* occurs together with *Amblyochara* sp. (Grambast *in* Mégard, 1978). In another area of the same region, Grambast identified *Amblyochara* sp., *A. rolli*, *Porochara* sp., *Saportanella* sp. and *S.* aff. *maslovi* (unpublished report of the French Institute of Petroleum, 1969, cited by Mégard, 1978). In Bagua, *A. peruviana* is associated with *A. begudiana* and *F. costata* (Mourier *et al.*, 1988). Finally, in the Maastrichtian Tena Formation of the Ecuadorian Oriente *A.* cf. *peruviana* is associated with *F.* cf. *costata* and *Rhabdochara* sp. (Grambast *in* Faucher *et al.*, 1971; Bristow & Hoffstetter, 1977).

Though species of *Platychara* are known from Paleocene beds (Peck & Forester, 1979; Grambast-Fessard, 1980; Feist & Colombo, 1983), the presence in the *F. gildemeisteri–P. grambastii* assemblage of specimens of the Cretaceous genera *Saportanella*, *Amblyochara* and *Feistiella*, and the lack of the common Paleocene and Eocene genera *Maedleriella* and *Nitellopsis*, strongly supports a Late Cretaceous age. Moreover, *A. begudiana* and *S. maslovi* are common in the Upper Cretaceous beds of southern France (Babinot & Freytet, 1983; Feist & Colombo, 1983) that correlate with the late Campanian to late Maastrichtian (Philip, 1984; Galbrun *et al.*, 1991). Because of the known range of these species and of the stratigraphic relationships, the *F. gildemeisteri–P. grambastii* (±*A. peruviana*) assemblage is ascribed to the Maastrichtian stage, with a possible extension into the late Campanian. Their presence in the earliest Paleocene proposed by Gayet *et al.* (1991) cannot be ruled out, but is considered as not sufficiently well documented to be taken into account as yet.

Early Paleocene(?)
The lower part of the Yahuarango Formation of the north-Peruvian Oriente is characterized by the occurrence of *F. costata*, *Sphaerochara ungurahuensis* and *S. huaroensis* (Gutierrez, 1982). This association was considered to be probably Cretaceous by Koch & Blissenbach (1960, Sol 1 Formation) and is presently ascribed to the early Paleocene (*Sphaerochara* Zone; Gutierrez, 1982). According to the range of these genera a Late Cretaceous age cannot be ruled out.

This flora is lacking in the Andean realm, probably because of a widespread sedimentary gap (see above).

Late Paleocene and Eocene(?)

In the Peruvian Oriente, the Sol 3 Formation and the upper part of the Yahuarango Formation are characterized by the presence of *Nitellopsis supraplana, N. supraplana sulcata, Maedleriella monolifera, Nodosochara conincaensis* and the disappearance of *Feistiella costata* (Koch & Blissenbach, 1960; Musacchio, 1981; Gutierrez, 1975, 1982) (Figure 4). In southern Peru, *N. supraplana* is reported from the base of the Chilca Formation of the Sicuani region (Mourier *et al.,* 1988) and of the Cuzco area, where it unconformably overlies the Yuncaypata Formation (Carlotto, 1992). From unspecified beds of the Andes of central Peru, Mégard (1968, 1978) collected *Nitellopsis, Harrisichara* and *Nodosochara* of Eocene age (determined by Grambast). In the Bagua area, the lower part of the Sambimera Formation yielded *N. supraplana* associated with *Maedleriella* sp. B and '*Chara strobilocarpa*' (Mourier *et al.,* 1988). The Sambimera Formation overlies a volcanic tuff of late Paleocene to early Eocene age (54.2 ± 6.4 Ma, Naeser *et al.,* 1991) (Figure 2).

Although it is certainly of Tertiary age, the age of the *N. supraplana–Maedleriella* assemblage is not precisely established so far. The genera *Maedleriella* and *Nitellopsis* range from Maastrichtian to late middle Eocene, and from early Tertiary to Recent, respectively. *Nitellopsis supraplana* is generally considered as a Paleocene marker (Feist & Colombo, 1983), and Gutierrez (1982) ascribed this association to the upper Paleocene. If accepted, the lacustrine *N. supraplana*-bearing lower part of the Sambimera Formation would correlate with the late Paleocene Sol 3 Formation, rather than with the Eocene Pozo Formation as assumed by Naeser *et al.* (1991). The 6.4 Ma analytical uncertainty for the absolute age of the Bagua tuff does not exclude a late Paleocene age for the lower part of the Sambimera Formation. Whatever the case, it is likely that the lacustrine late Paleocene Sol 3 Formation and the brackish Eocene Pozo Formation have been locally confused; further studies are necessary to precisely determine the age of these beds.

4. Palaeobiogeographic remarks

Although the palaeontological record is far from complete enough to allow definite conclusions, some remarks can be made about the palaeogeographic distribution of the main charophyte species represented within and outside of South America.

Feistiella gildemeisteri is present throughout the Andes of southern Peru and Bolivia and in the Peruvian Oriente, but has not been reported so far in the north-Peruvian Andes or Ecuador. Conversely, *F. costata* is present in the Andes of northern Peru, and in Ecuador and the Peruvian Oriente, but absent in southern Peru and Bolivia. Similarly, representatives of *Amblyochara* are more common in northern Peru and Ecuador than further south. Though they are very common in the Andes, *P. grambastii* or other species of the genus *Platychara* seem to be very scarce in the Oriente.

Amblyochara begudiana, P. compressa, S. maslovi and *N. supraplana* have wide geographic distributions and allow useful stratigraphic correlations between the South American formations and the rest of the world. On the other hand,

although they permit reliable regional correlations, species such as *A. peruviana*, *F. gildemeisteri* and *P. grambastii* seem to be restricted to the South American continent.

Finally, the presence of *Lamprothamnium* in the Paleocene beds of Cuzco and in the Maastrichtian outcrop of Rio Suches suggests a brackish habitat and the proximity of the sea-shore.

5. Conclusions

Sequential and biostratigraphic correlations of the Senonian and Paleocene deposits of the Peruvian Andes have allowed the precise determination of the stratigraphic range of some charophyte species. With our present day state of knowledge, four charophyte assemblages apparently follow one another from

Feistiella ovalis seems to appear as early as the late Santonian. Species of *Amblyochara* and *Peckisphaera* are recorded from probable late Santonian to early Campanian beds. *Platychara perlata* first occurs in mid-Campanian beds, and is not present in Maastrichtian deposits. Thus, the *F. ovalis–P. perlata* association could be of middle to latest Campanian age.

The *F. gildemeisteri–P. grambastii* assemblage, frequently associated with *A. peruviana*, is better documented and seems to characterize mainly the Maastrichtian, with a possible extension into the late Campanian. It often · occurs together with *F. costata* and other representatives of the *Amblyochara*, *Platychara* and *Saportanella* genera.

The *Sphaerochara–F. costata* association of the Peruvian Oriente has not been

found as yet in the Peruvian Andes, thus suggesting a large-scale sedimentary gap of part of the early Paleocene (and latest Maastrichtian?) deposits.

The *N. supraplana–Maedleriella* association can be provisionally considered as indicating a late phase of the Paleocene. However, it is not yet clear whether it is restricted to the Paleocene or extends into the Eocene.

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Appendix

List of the quoted taxa with author attributions and dates.

Amblyochara sp. A Feist & Grambast-Fessard *in* Jaillard *et al.*, 1993
Amblyochara begudiana Grambast, 1962
Amblyochara peruviana Grambast *in* Grambast *et al.*, 1967
Amblyochara relli (Koch & Blissenbach) Grambast *in* Grambast *et al.*, 1967