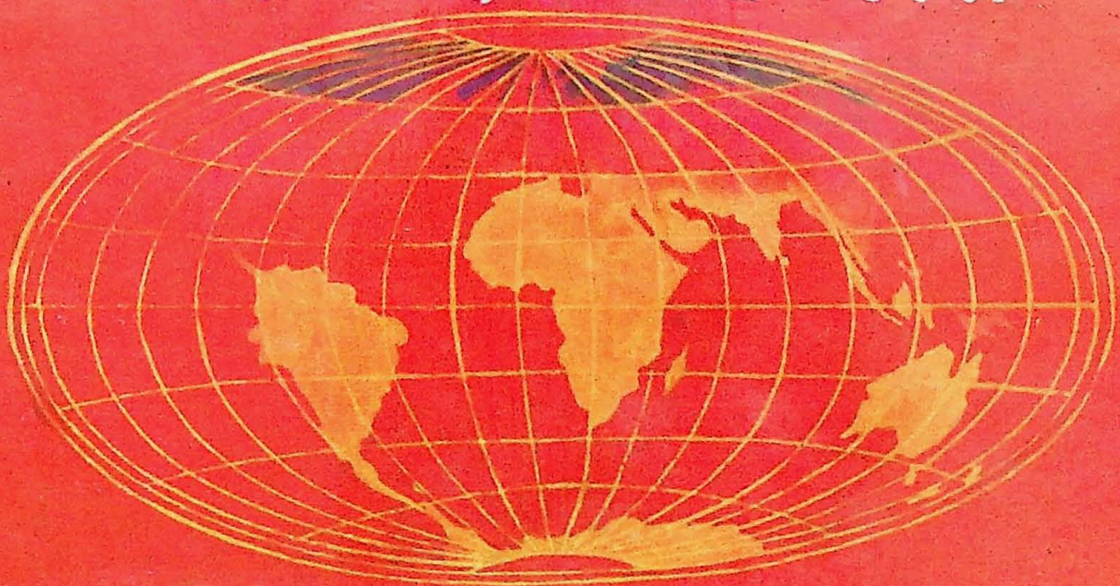
FOURTH INTERNATIONAL GONDWANA SYMPOSIUM

CALCUTTA, INDIA. 1977.



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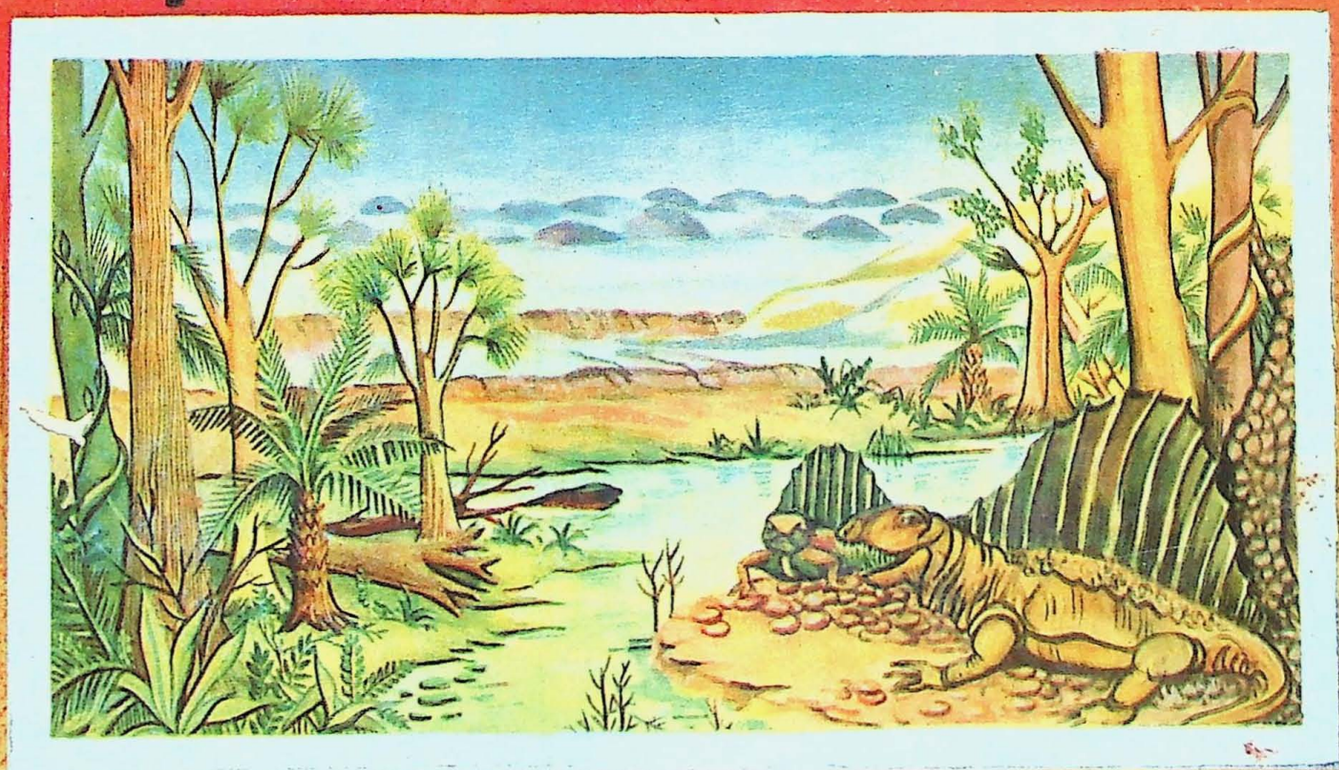

PALAEOGEOGRAPHY · FLORA · FAUNA · COAL DEPOSITS
AND GLACIAL DEPOSITS

LATE PALEOZOIC MARINE FAUNA OF SUBANDEAN BOLIVIA : AFFINITIES, AGE AND PALEOGEOGRAPHIC IMPLICATIONS

A. C. ROCHA-CAMPOS
Instituto de Geociências, Universidade de São Paulo, São Paulo, SP, Brazil

ABSTRACT

A collection of marine fauna obtained in three localities of Southern Subandean Bolivia (Parapeti River and Serrania de Balapuca) from the Taiguati (and possibly San Telmo Formation) contains *Levipustula levis* Maxwell, *Limipecten* cf. *L. burnettensis* and species of *Stulchburia, Cypricardinia* (?), *Myonia* and *Mourlonia*.

Levipustula levis and the affinities of some of the other species indicate an Upper Carboniferous (probably Westphalian) age for the fauna, its Gondwanic nature and link with similar faunas from Australia and Argentina. The implication of this in the paleogeographic interpretation of the area is discussed.

HISTORICAL REVIEW

A revision of the available previous information may be an useful exercise to understand the evolution of concepts on the nature of the Late Paleozoic marine fauna of Subandean Bolivia. The following comments are only pertinent to the lists presented by preceding authors, since reassesment of the original collections could not be made yet.

The first finding of marine fossils in the Late Paleozoic strata (Gondwana) of Subandean Bolivia was probably that of Catchcart (1926, in Padula and Reyes, 1960) which appeared in an unpublished report of Standard Oil Company of Bolivia. The fossils proceeded from the Taiguati Formation outcropping along the Quebrada no. 4 of the Charagua range, and were identified by K.V.W. Palmer, who recognized the bivalves *Leiopteria* sp., *Myalina* sp., *Sphenotus* sp., *Naiadites* sp. and the gastropod *Ptycomphalina* sp. (or *Mourlonia*). These are long ranging Paleozoic genera occurring worldwide, mostly in Late Paleozoic marine rocks. The only exception is *Naiadites*, usually known from Carboniferous non-marine or brackish facies sediments in the Northern Hemisphere. There are, however, reports of species of this genus in Lower Permian marine faunas (e.g. Gonzalez, 1974). Palmer considered the fauna as of probable Carboniferous affinity.

The second important discovery was reported by Chamot (1960) who found another marine fauna in the Taiguati Formation outcropping along the Parapeti river, in the western flank of the Charagua anticline. The fossils were collected from a 2-3 m thick "coquinoid" accummulation in a coarse sandstone. According to recent information (Marcimio Lopez P., Ruben Dario Lopez M., and F. Jimenez, 1974, personal communication), the Taiguati Formation is about 80 m thick in this area and the fossiliferous horizon occurs some 20 m below the contact with the overlying sandstones of the Escarpment Formation. Chamot listed from this assemblage the brachiopod *Productus* probably *P. cora* (?), other "productids", *Derbyia* (?), the bivalve *Allorisma subcuneata*, orthoceratid cephalopods, gastropods, crinoids and stems of *Cyclodendnon leslii*(?) (misspelled *leslei* in the original).

Linoproductus cora is a widespread Late Paleozoic productoid which occurs in the Tarma Group of Peru (Middle Pennsylvanian) and in the Copacabana Group of Peru and Bolivia (Wolfcampian). The cosmopolitan brachiopod *Derbyia* is also relatively common in these faunas. *Allorisma subcuneata* (= *A. terminale* Hall) is a typical Carboniferous (Pennsylvanian) species in the Northern Hemisphere (Tethyan Province) assemblages. Specimens identified by Derby (1894) as *Allorisma subcuneata* from the Itaituba Formation (Middle Pennsylvanian) of the Amazon Basin are presently doubtfully referred to as the *Wilkingia* Wilson by Mendes (1966). The same may perhaps apply to specimens of the Copacabana Group from Yaurichambi, Totorani and Estrellani illustrated by Branisa (1965, pl. 58, figs. 1-3). The lycopsid *Cyclodendron leslii* is known from Lower Gondwana beds of South Africa and India, where it occurs associated with a Glossopteris-Gangamopteris flora (Crausel, 1961; Surange, 1966, 1975).

On the basis of the species identified, Chamot (1960) compared the Taiguati assemblage with that of the Copacabana Group. He then concluded for a Permian (or partly Triassic) age for the Taiguati (which appears as the basal unit of the Mandiyuti

Group in the table of p. 206), plus the other formations of the Mandiyuti Group, with the rest of the Gondwana section, corresponding to the Machareti Group, representing the Carboniferous. These ideas caused much controversy and apparently never gained much support, initially on the basis of stratigraphical and paleogeographical evidence (e.g. Suarez Roca, 1962; Schlatter and Nederlof, 1966; Lohmann, 1970), and later, in view of the identification of Upper Carboniferous palynomorphs in the Taiguati and overlying beds (e.g. Schlatter and Nederlof, 1966; Ayaviri, 1972; Reyes, 1972).

Information on findings of marine fauna in Subandean Bolivia appears also in Branisa (1965), Ayaviri (1972, p. 57, fig. 6) and Reyes (1972), who refer to the presence of mollusks and brachiopods (including specimens listed as *Derbyia buchi*(?) in the Taiguati Formation (Branisa, 1965), or San Telmo Formation (Ayaviri, 1972; Reyes, 1972).

Recently, a locality at the Parapeti river identified as the one described by Chamot (1960) was rediscovered by YPF Bolivianos geologists (Reyes, 1972) and preliminarily reported by Lopez Murillo (1974), who mentioned the presence of the productoid *Levipustula levis* Maxwell in the fauna, thus indicating an Upper Carboniferous (Westphalian) age for the Taiguati Formation. In 1974, together with Ings. Marcimio Lopez p., Ruben Lopez M. and Felix Jimenez M., of YPFB, I had the opportunity to examine briefly part of the Late Paleozoic section along the Parapeti river, when another marine horizon in the upper part of the Taiguati was identified. The fossils, including bivalves and gastropods reported below, occur in dense concentration in a few decimeters thick red-brick to brightmarroon, medium grained sandstone outcropping on the right bank of the Parapeti river, a few km east from the latter locality. The fossiliferous lithology and the mode of occurrence of the fossils are thus remindful of Chamot's description.

A small collection from the two localities of the Parapeti river, plus some gastropods from the Balapuca section (Ayaviri, 1972) are now under description (Rocha-Campos, Amos and Carvalho, in preparation). A preliminary identification already made will serve as a basis for a short discussion on affinities and age of the fauna and its bearing on the Late Paleozoic paleogeographic reconstruction of Subandean Bolivia.

AFFINITIES AND AGE OF THE FAUNA

The fossils examined proceed from three localities in southern Subandean Bolivia (Plate 62) :

(*a*) Balapuca section : a little above the middle part of the San Telmo (?) Formation, outcropping along the road Bermejo-Tarija (see Ayaviri, 1972, p. 57, fig. 6). (YPFB Loc. RL-76.)

(*b*) Parapeti River section : western flank of the Charagua anticline, at the upper part of the local section of the Taiguati Formation (80 m thick), about 20 m below the contact with the Escarpment Formation (see Chamot, 1960, p. 207; Lopez Murillo, 1974). (YPFB Loc. RL-96A.)

(*c*) Parapeti River section : eastern flank on the Charagua anticline; outcrop at the right bank; same stratigraphic position as above; some 6 km upstream from San Antonio de Parapeti (YPFB Loc. V-74.)

A preliminary list is as follows :

Brachiopods

Levipustula levis Maxwell (Loc. b)

Bivalves

Cypricardinia(?) sp. nov. (Loc. c)
Limipecten cf. *L. burnettensis* Maxwell (Loc. b)
Stuchburia sp. nov. (Loc. b)
Myonia sp. nov. (Loc. b)

Gastropods

Mourlonia sp. nov. (Locs. a, b, c)

Confrontation of this and other collections formerly identified from Subandean Bolivia cannot be made at the moment; the following discussion will then be circumscribed to the material examined. Other species may, however, be present, as suggested by undeterminable fragments.

Levipustula levis Maxwell is undoubtedly the more important component of the assemblage. It is a spiny productoid which characterizes the *Levipustula levis* zone in Eastern Australia (Campbell, 1961; Maxwell, 1964; Mckellar, 1965) and in the Central-Patagonian and Calingasta-Uspalata basins of Argentina (Amos, 1960; Amos *et al.*, 1973). The evidence for the age of the *Levipustula levis* zone in Australia has been previously discussed by Campbell (1961), Mckellar (1965) and McClung (1975), who interpreted it as Westphalian. It is worthwhile noticing that the range of *L. levis* may be relatively long in Eastern Australia, possibly encompassing the pre-Namurian or Late Visean (McClung, 1975).

In the Central Patagonian Basin of Argentina *Levipustula levis* seems to occur both above and

below strata with the cephalopods *Gordonites argentinensis* (Gordon, 1964 = *Anthracoceras*(?) *argentinense* Miller e Garner, 1953) and *Eosianites* sp. (or *Glaphyrites* sp., Gordon, 1964), and is associated with *Sueroceras chubutense* (Riccardi and Sabatini, 1975 = *Dolorthoceras chubutense* Closs, 1967) in the upper part of the "Tepuel System" and the Las Salinas Formation (Gonzalez, 1972; Riccardi and Sabatini, 1975). Of these, the first is known to occur in strata of Late Mississipian to Middle Pennsylvanian in the U.S. The Argentinian species was compared to Lower Pennsylvanian species of North America by Miller and Garner (1953). The fossils associated with *Levipustula levis* in the Central Patagonian Basin were considered as indicative of an Upper Carboniferous age (Amos *et al.*, 1973). *Levipustula levis* occurs also in the Callingasta-Uspallata Basin of the Argentinian Precordillera associated to other brachiopods interpreted as of Upper Carboniferous age (Amos and Rolleri, 1965; Amos *et al.*, 1973).

Cypricardinia(?) is a rather variable cosmopolitan bivalve in beds of Carboniferous and Permian age (Dickins, 1963). As noted by Dickins (1963) its relationship with the typical *Cypricardinia* is doubtful and the Upper Paleozoic species may represent a different genus. A few internal moulds of the Bolivian species are similar to undescribed specimens from the Cerro Prieto Formation (Pennsylvanian) of northern Peru (= *Sphenotus*(?) sp. ind., Thomas, 1928, pl. 10, fig. 1) and to (?) *Cypricardinia* sp. from beds below *Levipustula levis* in the Booral Formation (Westphalian) of Eastern Australia (Campbell, 1961, p. 469, pl. 61, figs. 6-7). Two species of *Cypricardinia*(?), including one identified as *Cypricardinia*(?) *elegantula* of the Australian Lower Permian (Dickins, 1963), were reported by Gonzalez (1972*b*) in the Upper part of the Las Salinas Formation (Lower Permian), in the Central Patagonian Basin, probably at the same stratigraphic horizon as *Levipustula levis* and also below the levels with *Cancrinella* cf. *C. farleyensis* and its associates (Gonzalez, 1974).

The pectinoid *Limipecten burnettensis* Maxwell occurs in the fauna of the Upper Carboniferous Rands Formation of Eastern Australia associated with *Levipustula levis* (Maxwell, 1964).

The other two bivalve species from the Taiguati Formation are more difficult to assess due to the imcompleteness of the record; *Myonia* sp. nov. is a relatively strongly carinate species which reminds several Late Paleozoic species from Australia and South America (Runnegar, 1967; Rocha-Campos, 1970). Specimens of *Stutchburia* sp. nov. available are small and expanded posteriorly. Its occurrence associated to *Levipustula levis* probably implies in the extension of the known range of the genus.

Gastropod specimens identified as *Mourlonia* are presently the only common element in the three localities. They may constitute a new taxon.

In synthesis, on basis of the information available it seems reasonable to assign an Upper Carboniferous (probably Westphalian) age for the fauna studied. It shows links with other Gondwana faunas at the generic and even specific levels. This age assignment for the Taiguati Formation is consistent with the unpublished palynological data mentioned by Ayaviri (1972) which also indicates an Upper Carboniferous (Pennsylvanian) age for the Mandyiuti Group. In South America other assemblages with *Levipustula levis* occur in Central-Patagonian Basin (Amos, 1960; Amos, *et al.*, 1973; Gonzalez, 1972) and in the Calingasta-Uspallata Basin (Amos and Rolleri, 1965; Amos *et al.*, 1973).

PALEOGEOGRAPHIC IMPLICATIONS

Many available paleogeographic reconstructions of the Subandean basin during the Carboniferous (e.g. Frakes and Crowell, 1969; Helwig, 1970, 1972; Amos, 1972; Reyes, 1972; Rocha-Campos, 1973) depict it as a SE-NW elongated, narrow depression (miogeosyncline foredeep, Helwig, 1972; Vicente, 1975), open towards north and closed at its southern extremity in southern Bolivia-northern Argentina area. Its tectonic framework include as main elements, the Pampean system (Schlatter and Nederloff, 1969 = Pampean and Altiplano massives, Lohmann, 1970 = Pampean massif, Helwig, 1970, 1972 = Pempean nesocraton, Reyes, 1972), an elongated N-S positive element, towards west; the Michicola high (Reyes, 1972 = Chaco massif, Lohmann, 1970) to the south, and the Brazilian shield forming the western boundary. The first two elements sparate the Subandean basin from the westerly Altiplano basin (Helwig, 1972; Reyes, 1972), and from the Chaco-Parana (Amos, 1972) or Chaco-Mesopotamian basin (Padula and Mingramm, 1970) of Argentina.

The general facies of the Carboniferous sequence is described as mainly continental grading to paralic towards the Titicaca area (Harrington, 1955; Schlatter and Nederlof, 1965; Helwig, 1970), with substantial contribution of sediments of glacial origin derived from west and east source areas (Schlatter and Nederlof, 1965; Lohmann, 1965, 1970; Frakes and Crowell, 1969), at least in part,

transported by mass movement mechanisms (Frakes and Crowell, 1969). Other interpretations (Reyes, 1972; Ayaviri, 1972; Robrigo, 1973) depict the facies as mainly marine, grading to partially paralic towards the Altiplano area.

The occurrence of the marine fauna in the Taiguati (and possibly San Telmo) Formation its affinities, as discussed above implies in a reinterpretation of the geography of the area. It demonstrates clearly that part of the sequence was deposited in a marine basin (see Plate 62). The path followed by the marine ingression constitutes, however, a major problem.

The possibility of a marine ingression from the north seems less probable in view of the interpreted paralic facies of the Gondwana sequence in the northern Altiplano area, and the present lack of affinity of the fauna studied with marine Carboniferous fauna of the South America Tethyan province (e.g. Tarma Group).

A sea connection between the southern Subandean area and the Argentinian Precordillera, towards southwest should only be possible across the Pampean massif, which behaved as a positive element, at least as early as the Lower Paleozoic (Vicente, 1971).

Alternatively, the sea could have ingressed from the southeast, through the Paraguayan Chado and the Chaco-Parana or Chaco-Mesopotamian basin.

Reyes (1972) describes the Michicola high as a "substable, positive, subdeformable element" which formed an erosional southern limit for the eastern Carboniferous basin (= Carboniferous belt; Helwig, 1972). The generalized isopach map presented by Schlatter and Nederlof (p. 11, fig. 7) shows the Carboniferous extending towards the southeast, in the subsurface of the Chaco-Beni and Paraguayan Chaco. Ayaviri (1972, p. 53, fig. 2) presents a slightly different version, where most of the southern extremity of the basin is bounded by positive areas. He shows, however, a possible narrow extension of the Carboniferous sequence towards southeast, included between the Brazilian shield and a positive protuberance, which seems to correspond to the Izozog high of Reyes (1972). Carboniferous strata correlatable to the Tupambi and Escarpment formations of Subandean Bolivia are actually known to occur in the subsurface of Paraguayan Chaco (Eckel, 1959; Palmieri and Vera-Morinigo, undated).

At present, however, the information available is insufficient to establish which of the last two possibilities is not probable.

ACKNOWLEDGEMENTS

Special thanks are due to Ing. Jayme Oblitas, Gerencia de Exploracion, YPF Bolivianos for providing support for field work in the Parapeti river area in 1974. The cooperation and advice of Ings. Marcimio Lopez P., Ruben Lopez M. and Felix Jimenez M. of YPFB are also gratefully acknowledged. This paper is a contribution of the IGCP Project Upper Paleozoic of South America (Proj. no. 73/1/42).

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IV International Gondwana Symposium, 1977, Calcutta, India

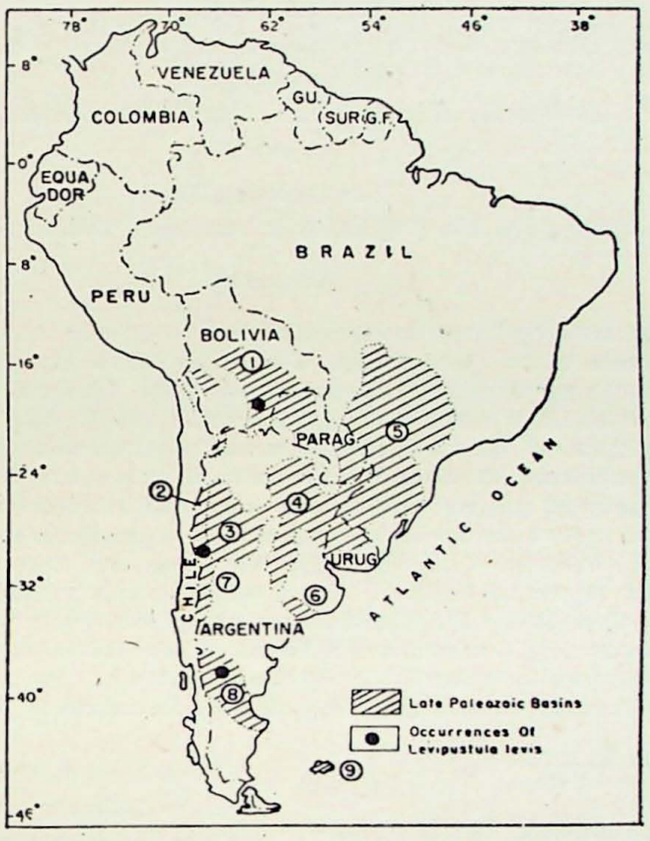

Plate 62. Late Paleozoic basins of South America and known occurrences of *Levipustula levis* faunas. Explanation : (1) Eastern Bolivian Basin; (2) Rio Blanco Basin; (3) Paganzo Basin; (4) Chaco-Mesopotamian Basin; (5) Parana Basin; (6) Sierras Australes; (7) Calingasta-Uspallata Basin; (8) Central-Patagonian Basin; (9) Malvinas (Falkland) Islands. Sources various.

A. C. ROCHA-CAMPOS