Facies of Upper Cretaceous and Palaeocene postrift sediments along the southeastern margin of the Potosi basin (Camargo syncline, Eastern Cordillera, Southern Bolivia)

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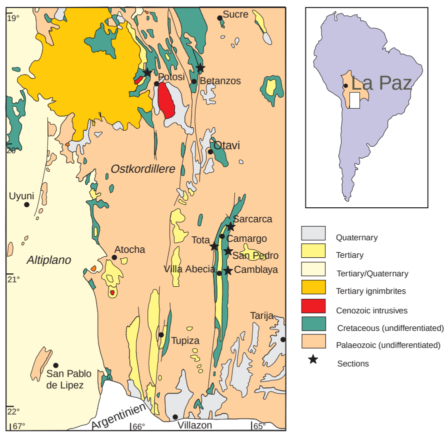

Figure 1 Location of the study area and generalized geological map of the region between Potosi and the Bolivian-Argentine border. Locations of the sections are also shown.

Introduction

The Cretaceous and Palaeocene deposits record changing environments in the Central Andean foreland basin called Potosi basin. It is located in the Eastern Cordillera of Southern Bolivia.

Lower Cretaceous deposits accumulated in small rift basins of the Potosi-Tupiza region. Later, during the postrift phase of the Upper Cretaceous-Lower Tertiary, subsidence included adjacent regions to the east and west. However, the Camargo region was integrated into the sedimentation area presumably not earlier than during the Campanian.

The present study was undertaken to reevaluate the lithostratigraphy and facies of the deposits along the southeastern margin of the Potosi basin in the Camargo region. It provides a contribution to the general discussion concerning the development of the Potosi basin. We selected four well exposed sections - Sarcarca, San Pedro-Culpina, Tota and Camblaya - for a detailed facies analysis (fig. 1, 3).

Within the Andean orogen the Eastern Cordillera forms a distinct geologic province. In southern Bolivia Ordovician rocks are a constituent part of the Eastern Cordillera, wheras Precambrian and other Palaeozoic rocks crop out only locally. In places, the Palaeozoic is disconformably overlain by Cretaceous and Palaeogene strata, or by the Neogene infill of intramontaneous basins. The Camargo syncline forms an elongated structure in the Eastern Cordillera of southern Bolivia (fig. 1). It consists mainly of Cretaceous and Lower Tertiary sediments with a predominant N-S and NW-SE strike, respectively. Their cumulative thickness attains up to 2500 m near Camargo. The Camargo syncline is partly limited by the high-angle reverse Camargo-Tojo Thrust in the west. At the faulted contact the Cretaceous sediments are locally overturned. In the eastern part of the syncline the Cretaceous deposits overly the Ordovician strata with an angular unconformity of up to 10°.

The sedimentary sequence of ?Campanian, Maastrichtian and Palaeocene age is combined into the Puca Group and parts of the Corocoro Group (fig. 2).

Corocoro Group	Camargo Formation Potoco Formation	Selandian - Chattian
Puca Group	Impora Formation	Selandian
	Santa Lucia Formation	Danian
	El Molino Formation	Maastrichtian
	Torotoro Formation	?Campanian
Palaeozoic Basement		

Figure 2 Stratigraphical subdivision of formations at the southeastern margin (Camargo syncline) of the Potosi Basin.

Figure 4 Basal breccia of the Torotoro Formation.The angular to subangular clasts orginated from Palaeozoic sediments (section Sarcarca).

Figure 5 Transition from the Palaeozoic sediments to the Cretaceous Torotoro Formation and El Molino Formation. The contact between the basement and the Torotoro Formation is an angular unconformity. Red sandstones represent the basal Torotoro Formation followed by white sandstones. The El Molino Formation begins with a brown carbonate horizon. (section Camblaya)

Torotoro Formation

The Torotoro Formation represents the basal presumably Campanian/Coniacian postrift sediments of the Cretaceous/Lower Tertiary sequence. Thicknesses vary between 20 m on the western limb of the Camargo syncline, and 150 m (Camblaya) in the eastern part.

Argilliceous sandstones, subordinate red pelites and breccias constitute the Torotoro Formation. The fragments of the basal breccias, up to 10 cm thick, consist of weathered angular to subangular Ordovician fragments and subrounded milky quartzes. Their matrix is a red fine-grained sandstone. The basal red sandstones are consolidated with iron oxides. The upper Torotoro Formation is composed of white sandstones cemented by carbonate. Both are middle grained, bad to moderately sorted and mature. The sandstones appear as sheetlike thick massive beds with fining upward cycles. Other attributes are red palaeosol horizons at the top of indidual sandstone beds. Some palaeosols are associated with carbonate material.

The deposits of the Torotoro Formation are interpreted as alluvial to fluvial sediments of a warm climate with dry and rainy seasons. Sediments derived from an eastern source area, due to cross-bedding and imbrications of clasts.

Figure 6 Bioturbated nodular limestones with shells (El Molino Formation - section Culpina).

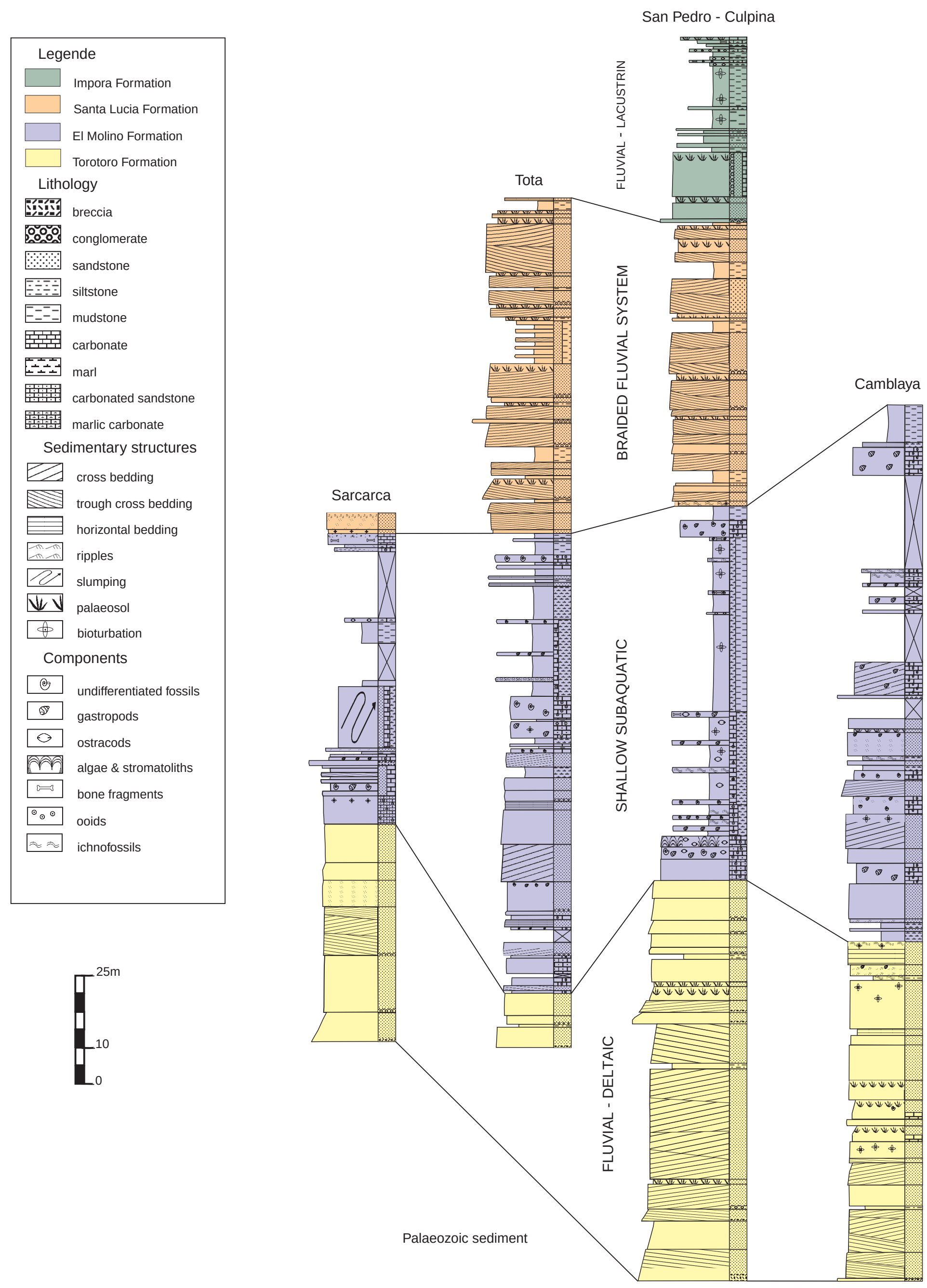

Figure 3 Stratigraphic columns of the sections Sarcarca, San Pedro-Culpina, Tota and Camblaya situated in the Camargo syncline (locations indicated in fig. 1).

El Molino Formation

The criterion for the boundary between the Torotoro and the El Molino Formation is the occurrence of initial carbonate beds. The thickness of the Maastrichtian to Danian twofold El Molino Formation ranges between 100 m and 160 m.

The basal member is represented by hard, mature, fine to medium-grained calcareous sandstones, with occasional intraclasts, and broken and whole superficial ooids. The rocks show cross-bedding and ripples. These calcareous sandstones alternate with oolitic, sandy limestones and ooliths with oscillation ripples (fig. 7). Some intercalations of bioturbated marls with gastropods, ostracods and shell debris appear nodular (fig. 6).

The upper member is characterized by an entire carbonate sequence of grey and green marls and fossiliferous, oolitic, or micritic limestones. The sandy siliciclastic input ceased completely. Thin stromatolitic layers are locally present.

The sediments reveal a shallow aquatic depositional environment at the margin of a basin. Up to now there are no arguments, which indicate a marine or a hypersaline environment. Marine fossils as well as evaporitic minerals are missing. A possible interpretation is a marginal setting of an inland sea. The water was temporary agitated, as documented by ooids, oscillatory ripples and tempestites. However, the shoreline sometimes moved basinward, so that larger areas emerged.

Impora Formation

The sediments of the Impora Formation, about 60 m thick, are restricted to the Camargo area. The deposits developed during the Selandian (Upper Palaeocene).

The lower Impora Formation consists of paracycles with alternating basal sandstones and pelites. White cross-bedded or laminated sandstones are irregularly distributed and thin out laterally over short distances. Conglomerats with sandstone and carbonate fragments accumulated at the base of some local channels. Characteristically, soil horizons are developed at the top of the sandstones beds. The overlying purple to green pelites often show bioturbation and further rooting. This facies association can be interpreted as a fluvial environment with channels and overbank sediments.

Red and grey pelites dominate in the upper part of the Impora Formation. Marls and limestones are intercalated. The marls show horizontal lamination and bioturbation. They contain frequent charophytes, indicating a shallow freshwater lake-environment.

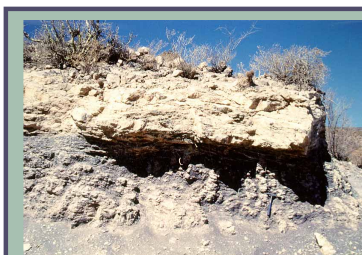

Figure 9 Top of the Impora Formation, a 1 m thick brecciated carbonate with chert and carbonate nodules. Tepee-structures are developed (section Culpina).

Figure 7 Oolith with oscillation ripples (El Molino Formation - section Tota)

Santa Lucia Formation

The Santa Lucia Formation overly the El Molino Formation with a paraconformity. The boundary is marked by a sharp change in colour associated with a change in lithology, from grey marls to red or purple pelites. In the Camargo area thicknesses vary from 92 m in Culpina to more then 200 m in Sarcarca. The Santa Lucia Formation is composed of two members. The basal one is an only up to 15m thick coarsening-upward cycle, and consists mainly of pelites and flasered sandstones at its top. The second member is composed of sandstones and pelites. White-violet, medium-grained sandstones are typically sheetlike. Fining-upward sequences and trough cross-bedding are common. The cross-bedding can pass into horizontal bedding or current ripples. Thin red mudstone layers are sporadically interbedded between sandstone layers. Red clay intraclasts may be intercalated at the base of cross bedding sets and sandstone layers. The massive red pelites are only locally bioturbated.

Red, massive coarse siltstones or fine grained sandstone with calcite nodules are frequently developed. Rooting exists only sporadically in these horizons. They represent calcrete soils and record arid to subhumid conditions (fig. 8).

All this sediments developed in a braided river system, mainly in fluvial multi-storey channels.

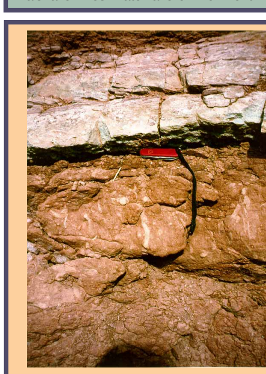

Figure 8 A red palaeosol with caliche nodules in the upper part. A cross bedded sandstone cuts the palaeosol. (Santa Lucia Formation - section Tota)

Conclusions

1. The boundary between the Torotoro Formation and the El Molino Formation is diachronous.

2. The El Molino Formation developed in a shallow, agitated inland sea under near-shore conditions. Marine influences could not be verified.

3. The transition to the Santa Lucia Formation was associated with an important change of the depositional environment. A braided river system replaced the previous inland sea. This replacement could be due to an uplift of the hinterland, which may be a response to a change of regional Andean stress patterns.

4. The Impora Formation was deposited in a distinct fluvial setting and a freshwater lake.