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Preservation of the Miocene Atacama Gravels: Climatic/depositional-erosional balance in the El Salvador area, North Chilean Andes

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Introduction

Recent syntheses have drawn attention to the possible correlation between the morphology of the Central Andes and the N.-S. climatic zoning on their western slope. Both a higher shear stress along the sediment-starved plate interface (Lamb and Davis, 2003) and crustal thickening by tectonic wedge propagation (Montgomery et al., 2001) have been invoked as triggering factors to the uplift of the Altiplano-Puna plateau in response to an arid climate since the middle Miocene (Hartley, 2003). In the El Salvador area (26-27°S), southern Atacama Desert, a Miocene sedimentary blanket (Atacama Gravels; Mortimer, 1973) extending from the Western Cordillera towards the eastern slope of the Coastal Range fills the Central Depression with debris-flow deposits, distal playa sands and evaporites. This study aims at establishing the record of Miocene erosion-deposition phases and redrawing the broad local climate history.

Atacama Gravels

Deposits in endoreic basins (salars), but also in the Central Depression of the Atacama desert, west of the Western Cordillera (Fig. 1), have often been used to detail the Miocene western South American desertification episode (e.g. Lamb and Davis, 2003; Hartley, 2003).

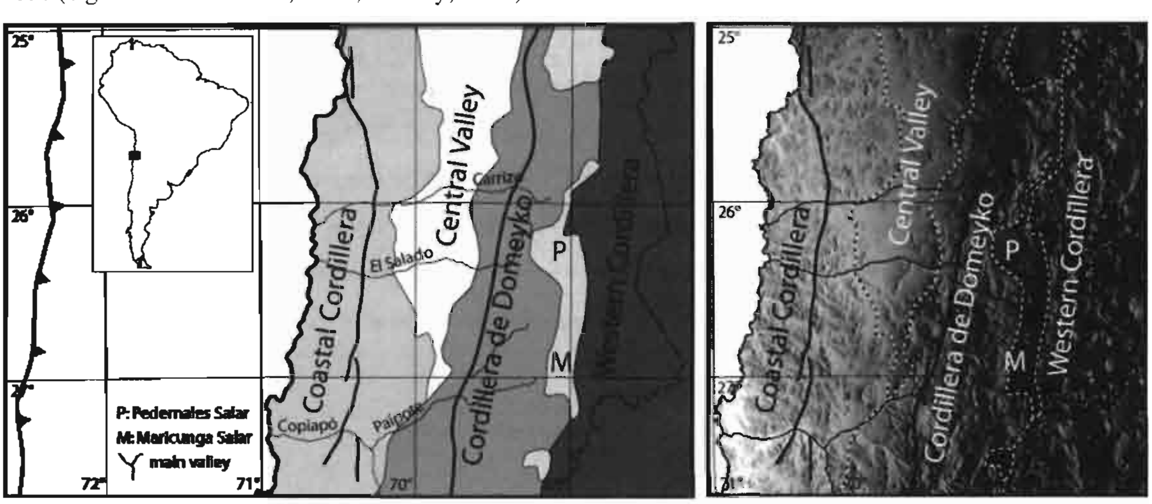

Figure 1:Studied area, southern rim of the Atacama desert and west to the Puna Plateau, Chile.

The Miocene Atacama Gravels Formation in the Central Depression comprises a range of coarse to fine terrigenous conglomerates, intercalating with ash layers dated between 17 and 3 Ma. The sediments fill in an antecedent drainage network sharply incised in the Mesozoic volcano-sedimentary basement (Riquelme et al., 2003). At a regional scale, these Gravels appear to represent a giant arid-region alluvial fan, as defined by Hooke (1966). The present-day surface slope and drainage pattern indicate that at least the upper part of the Formation's source-area is the Domeyko Cordillera.

Through a detailed sedimentological study along a proximal-distal transect, we undertook to delineate the stratigraphic geometries (Progradation *vs.* Retrogradation) of the deposit, with the aim to identify the role played by eustasy, tectonics and climate.

Following an Oligocene-early Miocene fairly humid period (see also Hinojosa, 2005) having led before 17 Ma to an incised bedrock morphology, a first member of debris-flows-dominated Atacama Gravels (Mga) forms during a shift towards more arid conditions in the Central Depression. The occurrence of a by-pass or locally erosional surface unconformably filled with finer material and a 10 Ma ash layer marks the limit with MPa, the upper member of the Atacama Gravels (*s.l.*). Localized areas of fine sand indurated with gypsum topping the Atacama Gravels may support the hypothesis of a Pliocene shift to hyper-aridity (Hartley, 2003), and the present-day straight and constant character of the El Salado valley bearing might witnesses a rain shadow effect of the Western Cordillera catching more abundant Pleistocene westerlies. Finally, new low-temperature thermochronology data bring guidelines about the migration of source areas through time..

Discussion

Three factors (Eustasy, Tectonics, Climate) may influence the depositional settings recorded in the studied Formation.

To be consistent with an eustatic-only explanation, the retrogradation phases (Fig. 2) should occur during a global rise of the sea-level. Mga does not comply with this condition, and therefore a disconnection from with the Ocean may be invoked (endoreism), either through a coastal uplift accommodated by the Atacama Fault System, or because the climate is so dry that the rivers dry out before reaching the sea (virtual endoreism). Nevertheless, the intra-Gravels erosional surface originates probably in the harsh Serravallian marine regression, when the rivers had to cut through the Coastal Cordillera to restore an equilibrium profile.

Thermochronology data suggest an eastward migration of denudation through time, with an exhumation peak of the Domeyko Cordillera, the upper Gravels's source area, 20 Ma before the deposition period. Furthermore, the region that experienced a syn-deposition rapid exhumation is the Western Cordillera, from whom the Gravels are separated by a line of endoreic basins (Pedernales Salar, Fig. 1). Therefore the deposition of the giant alluvial fan forming the Atacama Gravels can not be caused by a sudden tectonic uplift upstream.

At least during the deposition of the lower member of the Gravels (Mga, and perhaps MPa) neither the remote effect of eustasy nor an accelerated uplift of the source area can be invoked as key factors in the preservation. Therefore, we propose that a climate change acting on the dynamics of erosion on rocky slopes and on the rivers transport capacity would play this role.

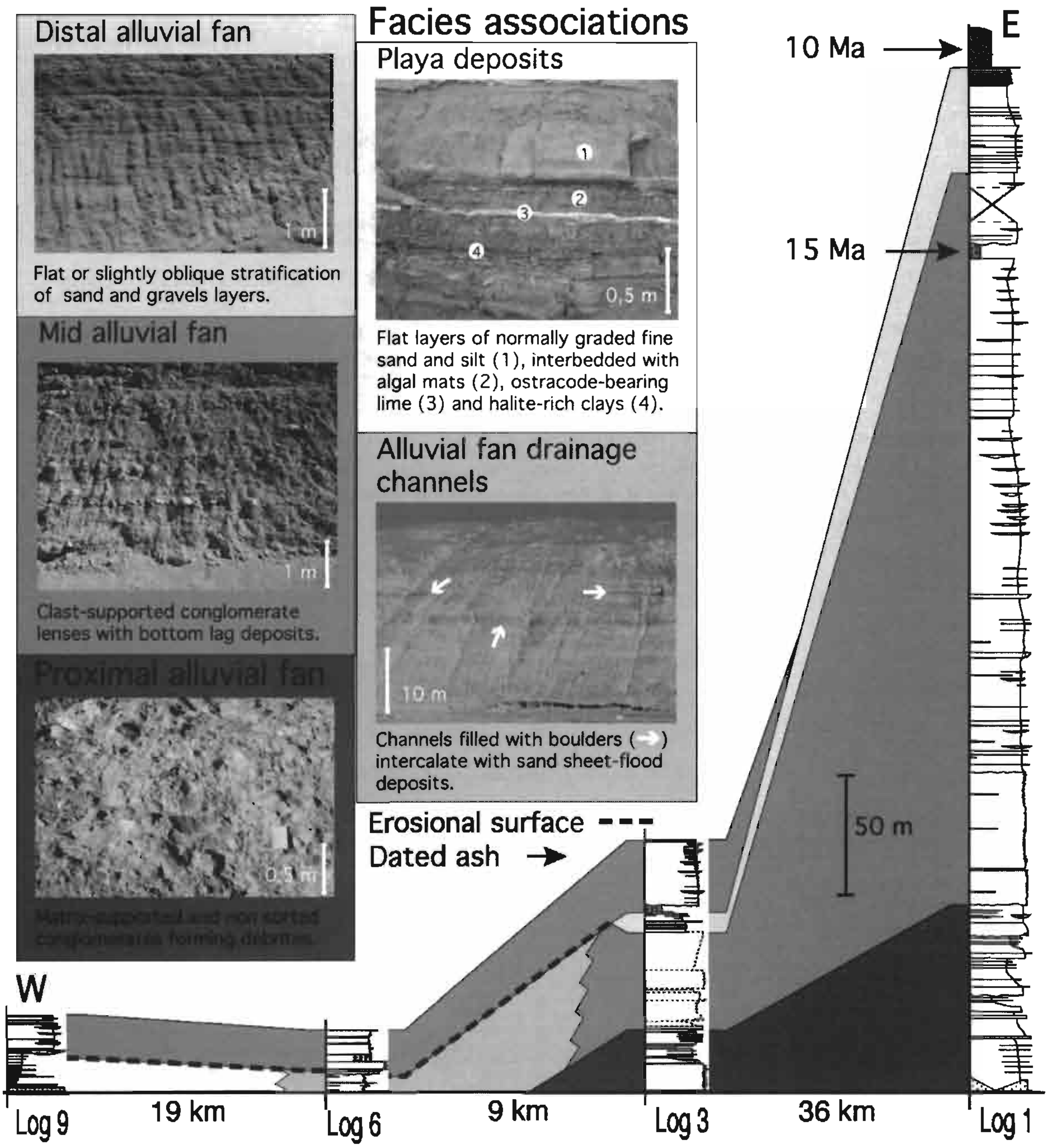

Figure 2: Simplified correlation diagram of five facies associations. Time-lines are established by dated ash layers on the transect itself or nearby similar settings (SERNAGEOMIN; Riquelme, 2003).

Conclusion

The Atacama Gravels (s.l.) infill an early or pre-Miocene sharply incised surface and constitute a record of the Mio-Pliocene relations between climate and sedimentation between the Puna Plateau and the Pacific Ocean.

(1) Eustatic forcing? The strongest marine regression may induce erosion in the Central Depression.

(2) Tectonic forcing? An increase of exhumation in the source area is not stressed by thermochronology data.

(3) Climatic forcing? Climatic changes regulating the sediment supply on the slopes and the outflow capacity is the hypothesis prefered to explain the deposition and sedimentological features of the Gravels.

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