NEOGENE TECTONICS OF THE CENTRAL DEPRESSION AND PRECORDILLERA (NORTH CHILE) FROM THE ANALYSIS OF A DRAINAGE BASIN EVOLUTION

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INTRODUCTION

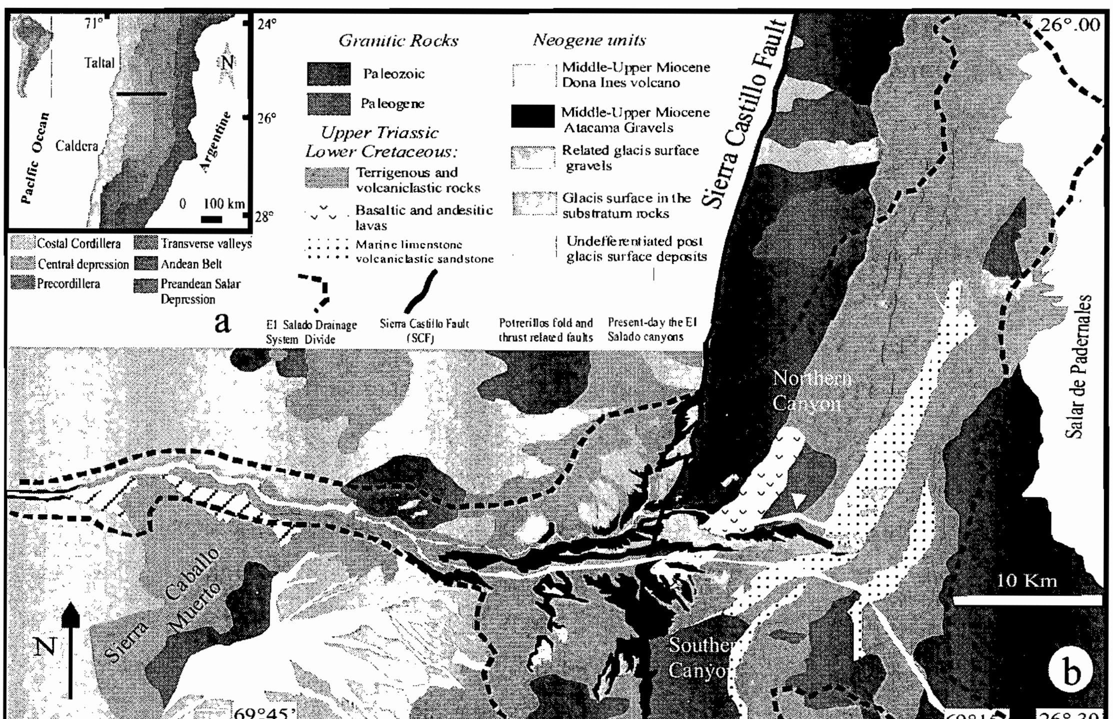

Figure 1: location map of the studied area; a) Principal morphologic units crossed by El Salado valley. b) Main geologic features.

The drainage basin of the El Salado river valley corresponds to the most important drainage system in the southern Atacama Desert between 25° to 27° S.L. (Central Andes). The El Salado river valley cross the Chilean fore-arc perpendicularly to the main morphologic units of the region (fig.1a). Throughout the El Salado river valley in the Central Depression and Precordillera three landscape surfaces corresponding to different stages of the Noegene geomorphologic evolution of this area can be differentiated: (1) the base of a thick series of Middle to Upper Miocene gravel deposits (Atacama Gravels of Sillitoe et al., 1968), (2) the extensive glacis surface that composes the top of the Atacama Gravels (Atacama Pediplain of Sillitoe, 1968), (3) the landscape surface related to the present-day the El Salado river valley development. Here, we present the main features of these landscape surfaces, we discuss their meaning in the erosional or depositional evolution and their implications for the Neogene tectonic evolution of Central Andes.

GEOLOGIC AND TECTONIC SETTING

The studied area is located in the forearc region. The major structural feature of the area is located in the Precordillera and corresponds to the Sierra Castillo Fault (SCF) that forms part of the Domeyko Fault System (fig.1b). It is a north-south trending subvertical master faults (Tomlinson et al., 1993) active since the Mesozoic (Cornejo et al., 1993). The last important movements recorded in this fault have been dated at the Eocene-Oligocene boundary (Tomlinson et al., 1993). The El Salado Drainage System (SDB) is composed in the Central Depression for a single E-W oriented canyon, without development of tributary basins (fig.1b). Upstream, in the Precordillera, the single canyon is divided in two, very close to each other (3-4 kilometers) sub-parallel tributary canyons. These two canyons are perpendicular to the structural Potrerillos fold and thrust belt. Further East, in the Precordillera-Puna the northern canyon becomes NS oriented, paralleling the structural orientation of the Potrerillos fold and thrust belt, whereas the southern canyon becomes NW-SE oriented, oblique to the Potrerillos fold and thrust belt.

GEOMORPHOLOGIC LANDSCAPE SURFACES IN THE SDB

Atacama Gravel paleosurface: The Atacama Gravels overlies a deep incised paleosurface extensively and continuously exposed in the Precordillera. This allows the reconstruction of the paleo-drainage network in which these gravels were deposited (Paleo-SDB, fig. 3a). The main stream of the Paleo-SDB runs parallel to the southern present-day canyon of the SDB (1-2 km to the North). In the sides of this canyon a longitudinal profile of the Atacama Gravels Base is well expose (fig.4a). The line drawn up between the bottoms of the paleo-valley exposed in the canyon side, which must approximate the line corresponding to the longitudinal profile of the main stream of paleo-SBD. A change in the slope of the main stream is evidenced at the intersection with the SCF. East of the SCF, the slope of the main stream is greater than West of the fault. The main stream drains into the Central Depression toward the SW, following the eastern slope of Sierra Caballo Muerto.

Glacis surface: The upper glacis surface in the Central Depression corresponds to a smoothly-waved surface. The surface is slightly and regularly incised by very linear E-W oriented channels coming from the eastern reliefs (fig.3a). Some of these channels, developed only tens of meters away of the El Salado canyon, run parallel to the canyon several kilometers before falling into it. Immediately East of Sierra Caballo Muerto an old alluvial cone on the glacis surface is cut by the El Salado valley (fig.3b). Both the elongation of the alluvial cone and the preserved markers of stream flow direction indicate that the river has flowed in a N-S direction. This shows that at this time the relief of Caballo Muerto was not still cut by the El Salado. The longitudinal profiles of the glacis surface are approximately parallel to the present-day talweg profile in the western most section of the Central Depression. Towards the east up to the Precordillera it becomes strongly divergent to the present-talweg of the northern canyon. The divergence is not registered for the southern canyon, but as we show below this canyon is less incised than the northern one.

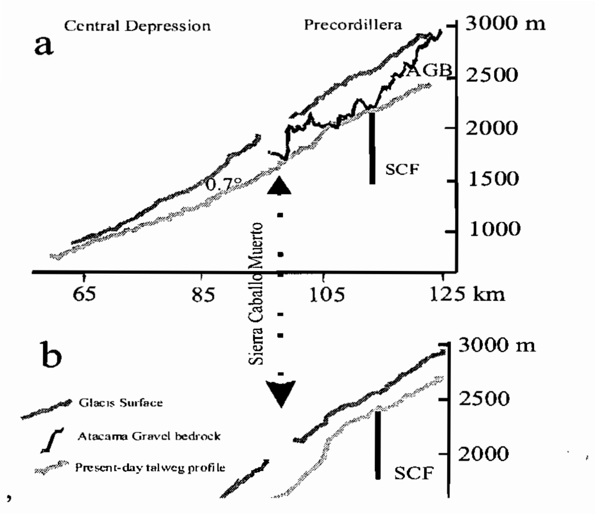

Figure 2: EW profiles of the Atacama Gravel base, glacis surface and present-day valley for the SDB;
a) Northern canyon, b) Southern canyon.

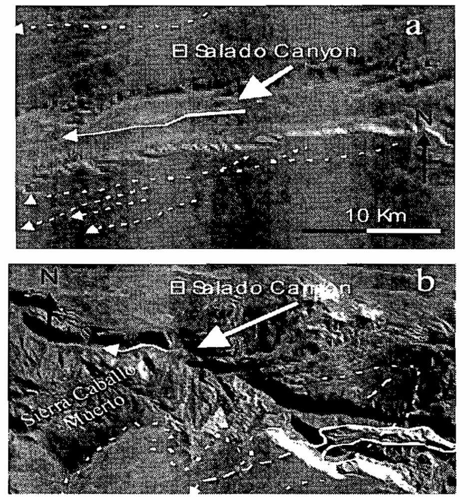

Figure 3: Morphologic features : a) E-W streams of the glacis surface in the Central Depression; b) Oblique Alluvial cone cuts by the EI Saldo canyon.

The present-day morphology of the SDB: Differences can be established for the drainage systems of the northern and southern canyons of the SDB. Tributary basins of the northern canyons show N-S oriented geometries that follow the strike of the lithologic substratum and they are well correlated with the substratum fracturation pattern (figs.2a and 2b). On the contrary, for the southern canyon the elongation of the tributary basins as well as the mainly direction of the drainage network are oblique to nearly perpendicular to the lithologic unit distributions and fracturation pattern. Therefore, lithologic control can be established for the northern part of the drainage system development, whereas this control is less important in the southern part. Longitudinal talweg profile in the Central Depression shows a regular concave curve. In the Precordillera talweg profiles for northern and southern parts differ from each other. The northern talweg profile registers a clear slope break immediately after junction with the southern canyon (500 m altitude difference in 15 km). For the southern canyon the slope break is not registered, however, the talweg profile becomes slightly convex. Talweg altitudes of northern canyon are smaller than those of the southern one, indicating greater incision degree in the first one.

DISCUSSION AND CONCLUSION

The paleo-SDB lies 2 km below the highest regional summits showing that it incises an already high Precordillera. We show that paleo-SDB is developed mainly on the Western part of the SCF. There is no evidence that the SCF accommodate important movements after the Eocene-Oligocene (Tomlinson et al., 1993). This indicates that the SCF has a passive N-S structural control in the SDB development (fig. 4c). This differs than the present-day SDB (fig. 4b) development where E-W canyon rather suggests a drainage development controlled by the E-W regional slope. The Atacama Gravels glacis corresponds in the Precordillera to a continuous process of sedimentation. The infill of the incised landscape is due to the normal activity of the Atacama Fault System (Riquelme et al., 2002) which creates a barrier for sediments coming from the Precordillera.

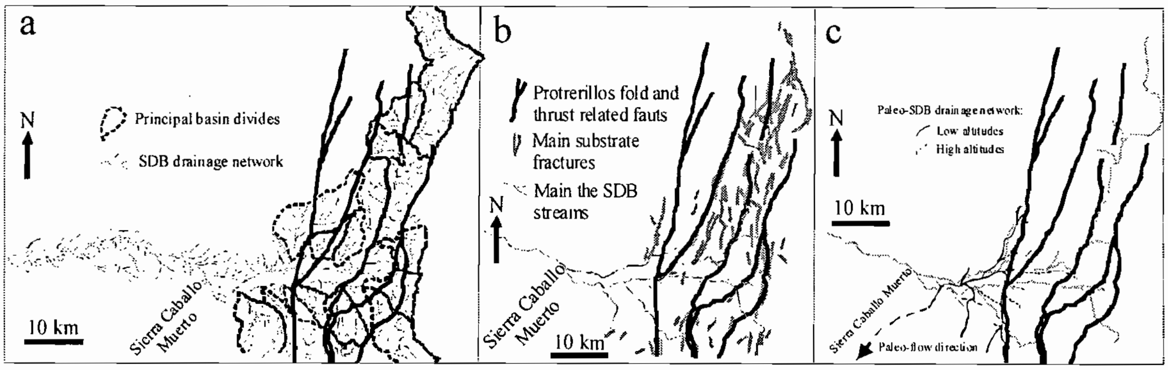

Figure 4: SDB Drainage evolution; a) Present-day SDB drainage network and principal tributary basins; b) SDB Fracturation map; c) Paleo-SDB drainage network showing the influence of the main tectonic structures

At that time, the regional E-W slope was smaller than that of the current. An increase of the E-W regional slope leads to the E-W incision registered in the present-day SDB (Fig. 4b) and it occurred after the glacis formation contrary to the assumptions of other authors (Mortimer, 1973; Naranjo and Paskoff, 1980). A maximum age of 10-11 Ma BP can be established for the reactivation of the E-W incision by considering the ignimbrite that seals the glacis in the Precordillera (Cornejo et al., 1993). The Upper Miocene incision corresponds to the important uplift of the Altiplano and Puna (Gregory-Wodzicki, 2000). The generalized observed tilting (≈3° for Lamb et al.; 1997 in the entire fore-arc and ≈1° for us in the Precordillera) can be explain by an uplift without main fault activities in the Precordillera. The fore-arc tilting explains the anomalous formation of the two parallel canyons of the SDB and the E-W linear streams developed in the glacis surface.

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