GEODYNAMICS OF ANDEAN BASINS: AN EXAMPLE FROM THE SALAR DE ATACAMA, BASIN, NORTHERN CHILE

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INTRODUCTION

We describe the history of the Salar de Atacama, a long-lived (Permo-Triassic - Recent) nonmarine basin which, owing to the geodynamic development of the Central Andes, has evolved from a non-arc-related rift basin, through complex "arc-related" stages, to a Miocene-Recent forearc basin. We attempt to demonstrate that sedimentary basins at convergent plate margins preserve the most complete record of the local geodynamic history of the orogen and their analysis is an essential component in studies of crustal evolution. Our database includes over one hundred logged sections (some 20 km of stratigraphy), field maps, and the interpretations of aerial photographs/satellite images and several regional seismic lines across the basin.

GEOLOGICAL SETTING

The Salar de Atacama has a long geological history, from Permo-Triassic to Recent, all of it non-marine. The composite, approximately 10 km of stratigraphy can be divided into five unconformity-bounded megasequences (Fig. 1). These are the Permo-Triassic Peine Formation and equivalents, the latest Cretaceous-Eocene Purilactis Group (Hartley et al., 1992), the Oligocene-earliest Miocene Paciencia Group (Flint, 1985), the early Miocene-Plio-Pleistocene San Bartolo Group/Vilama Formation (Jolley et al., 1990) and the Holocene alluvial fans and saliferous deposits. The major types and periods of faulting and folding within the composite stratigraphy of the Salar de Atacama include:-

1. Permian listric normal faults, striking north-south, downthrowing to the east.
2. Late Cretaceous reactivation of the Permian fault system, resulting in thickening of the Purilactis Group in the hanging walls of these faults.
3. Local intense folding of the Purilactis Group in the northwest of the basin, linked to dextral strike-slip faulting (late Eocene).
4. East to southeast thin-skinned thrusting and related folding in the early Miocene.
5. Neotectonic thrusting of Tertiary strata over Holocene gravels.

Outcrop and particularly seismic reflection data indicate that the dominant control on basin formation and deposition of the bulk of the Salar basin fill was extensional to oblique extensional faulting. Our seismic stratigraphic analysis indicates 1500 m+ of pre-Purilactis Group sedimentary rocks, characterized by discontinuous reflectors. This earliest basin fill unit shows large thickness variations across the Salar de Atacama area; these variations coincide with the positions of several large faults. Thickening of stratal units towards the faults indicates synsedimentary fault activity, which defined several sub-basins. The Cordon de Lila was a basement high during this time. We think that the whole Permo-Triassic succession represents a major episode of rifting; the internal unconformities interpreted from seismic data and in the limited outcrops are interpreted as the products of discrete extensional faulting events. Our data also indicate that Permo-Triassic extension here did not continue into the Jurassic, as in the case of the Domeyko basin to the west, as no marine strata were deposited. We thus conclude that the El Bordo area represents a Paleozoic basement high, separating the easterly Salar "failed rift" from the western Domeyko basin. The Salar basin thus received some continental detritus during the late Triassic but had probably filled to depositional base level by Jurassic time. A seismic interpretation of lines across the northern Salar basin (Macellari et al. 1991) defined five unconformity-bounded depositional megasequences but the inferred stratigraphy of their units 1 and 2 and ties to western outcrops differ from ours for the Paleozoic through Purilactis Group.

DISCUSSION

We consider that the dominance of extensional tectonics in the Late Paleozoic-early Miocene of the Central Andean belt is due to several causes (Fig. 2):
1) the late Permian hosted the splitting of Pangea, due to thermal doming and rifting (Mpodozis and Kay, 1992). Thus the early Salar basin extension was driven by stretching in a setting with no direct evidence of subduction or volcanic arc activity. Continued extension and thermal subsidence took place through the Triassic and early Jurassic.
2) following middle Cretaceous contraction and uplift of the proto Cordillera de Domeyko (driven by the opening of the South Atlantic ocean), Purilactis Group deposition was controlled by extension, now in a back-arc basin setting. This extension re-used the Permo-Triassic fault systems.
3) extension and oblique slip during Paciencia Group time (Oligocene) was partially controlled by collapse of the Cordillera de Domeyko, which had been uplifted again during late Eocene transpression.

We therefore propose that the Salar de Atacama stratigraphy preserves a series of "basins" which, owing to the longevity of the Andean margin and hemisphere-scale tectonic evolution, have evolved from a continental rift, through a back-arc basin and possible inter-arc stages to a Late Tertiary-Recent forearc basin. Accumulation of the sedimentary succession was mainly due to extensional faulting. Important but short-duration contractional episodes do link to known first order plate margin changes (Fig. 2) but their stratigraphic effect appears to be restricted to uplift/erosion rather than creation of significant flexural subsidence.

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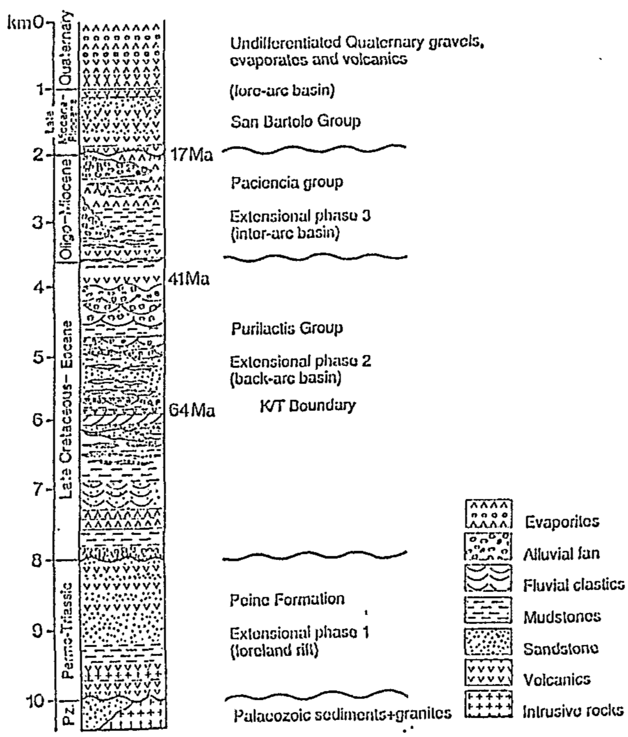

Figure 1: Lithostratigraphy of the Salar de Atacama basin-fill, as exposed on the inverted basin margin and interpreted from seismic data.

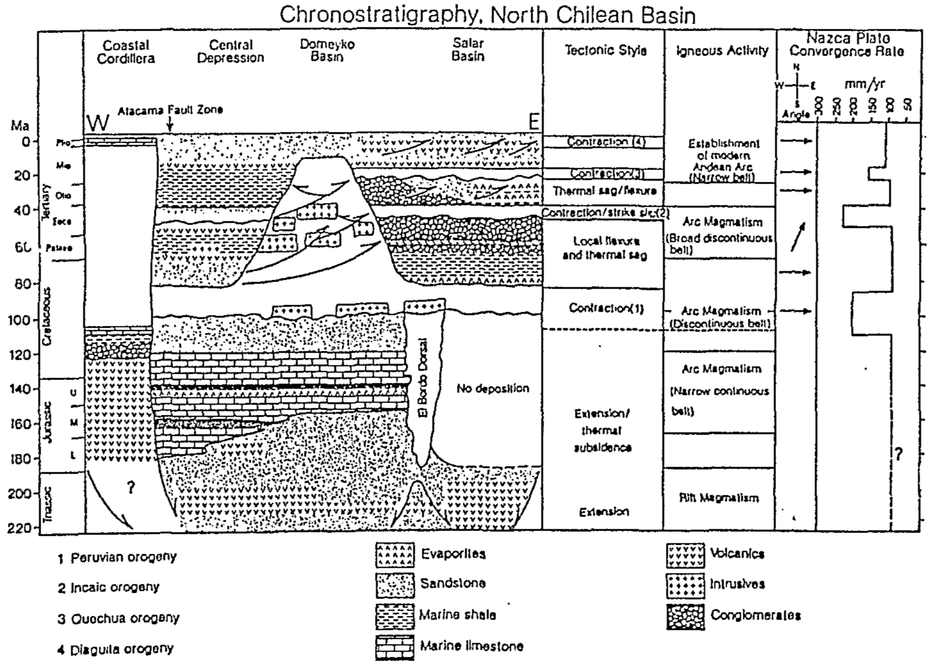

Figure 2: Chronostratigraphic diagram for the Andean forearc, northern Chile, showing all phases of basin filling and inversion. Magmatic and tectonic activity are plotted alongside convergence rate/angle data and show a good correlation between plate dynamics and continental margin evolution.