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Oligocene-Neogene tectonics and sedimentation in the forearc of southern Peru, Tacna area (17.5°-18.5°S)

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INTRODUCTION

Fault systems observed in the southernmost Peruvian forearc (Tacna area) provide information on the structure of the inner Bolivian Orocline (Arica elbow). Here we present the characteristics of the main fault systems observed in the Tacna area, as well as evidences of structural control on the deposition of Upper Cenozoic units and regional geoforms. We propose a synthetic chronology of deformation.

CHARACTERISTICS OF THE FAULT SYSTEMS

The present topography is controlled by three main fault systems (Fig. 1). In the NW, the N125E-striking Incapuquio-Challaviento Fault System (SFIC, = *Sistema de Fallas Incapuquio-Challaviento*) is a sinistral transcurrent system that includes subvertical faults and is currently sismically active (David et al, 2004); these possess a reverse component, the NE blocks being generally uplifted (Sempere et al., 2002).

Transpressional motions (which produced cataclasites) have exhumed in Mal Paso the Precambian metamorphic basement and a Late Paleozoic stratigraphic succession, putting them in tectonic contact with Mesozoic units and the Upper Moquegua (~30-23 Ma) and Huaylillas (~23-19 Ma) formations (Sempere et al., 2002; Flores et al., 2004; Pino et al., 2004). Emplacement of Early Eocene granitoids in the SFIC suggests a crustal scale for this system (Sempere et al, 2002). Other intrusions of Middle Miocene age (Martínez & Cervantes, 2003) appear related to the SFIC; in the Cerro Vicuña area, they are apparently associated with down-to-the-west tilting of the upper surface of the Huaylillas Formation ignimbrites.

Southwest of the SFIC, another important structure is the N110E-striking Calientes-Chuschuco Fault System (SFCC, = *Sistema de Fallas Calientes-Chuschuco*), which groups several *en échelon* reverse faults (some producing flexures) with strike-slip components. A few structures indicate left-lateral displacements. The SFCC affects the Upper Moquegua (Late Oligocene), Huaylillas (Early Miocene), Calientes (Late Miocene-Pliocene) and Pachía (~2.7 Ma) formations (Flores et al., 2004), and its reverse component is responsible for uplift of the NE area, where Jurassic to Early Cretaceous marine strata and Paleogene igneous rocks are exposed.

In Chuschuco, the SFCC connects to the N150E-striking Cerro Desconocido Fault System (SFCD, = *Sistema de Fallas Cerro Desconocido*), which groups flexures and reverse faults that also affect the Upper Moquegua and Huaylillas formations; the SFCD prolongates into Chile, where it is known as the Ausipar Fault (García, 2002).

Another structural element is the N145E-striking Magollo-Escritos Fault System (SFME, = *Sistema de Fallas Magollo-Escritos*), which groups small sub-parallel normal faults that affect the Early Miocene Huaylillas and Middle Miocene Magollo (Flores et al., 2004) formations. A gentle stair topography is formed by SW-downwarped blocks. The SFME apparently prolongates at depth beneath the La Yarada lowlands (TDEM geophysical data, INRENA [2003]).

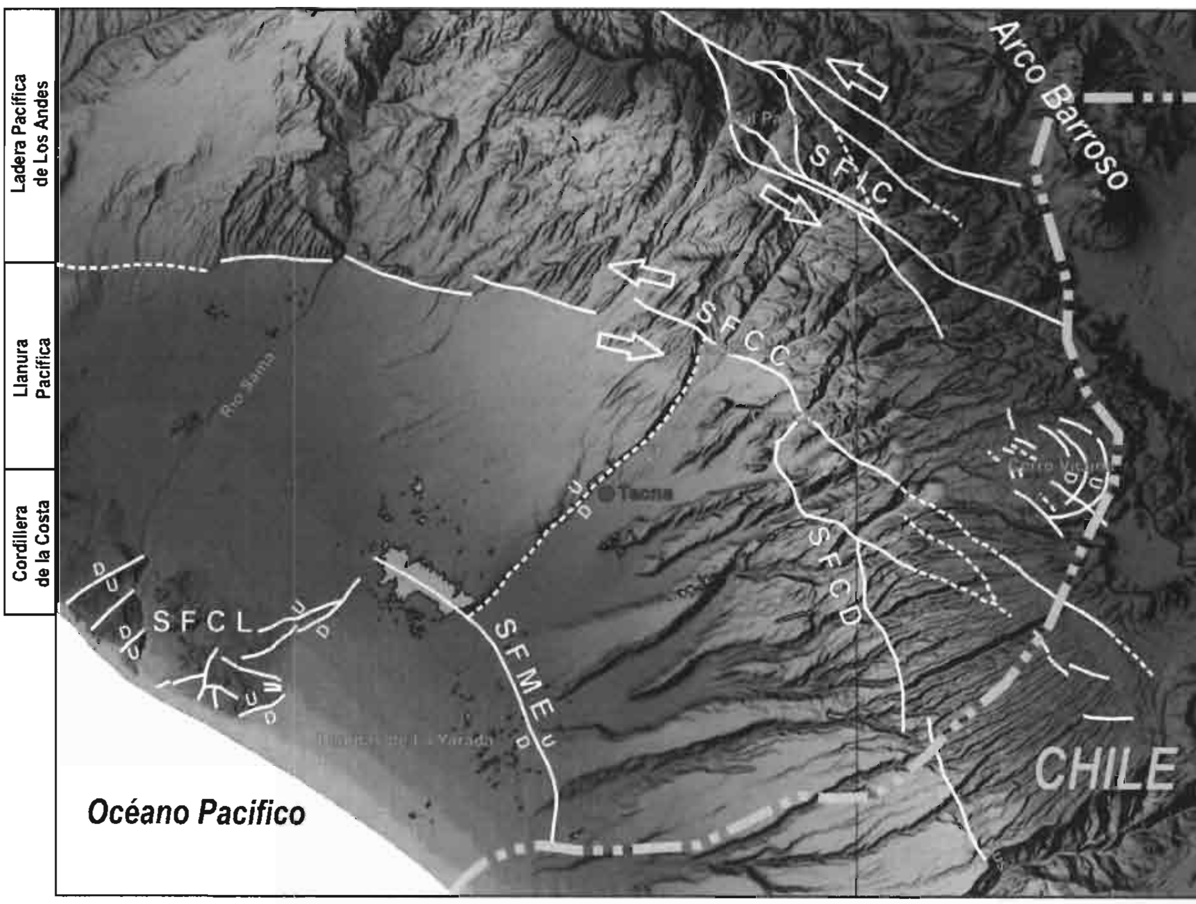

Fig. 1. Topographic image (NASA, SRTM, 90 m resolution) showing the main faults systems recognized in the fore-arc of southermost Peru. Note the strong correlation between main structures and relief configuration.

A second NE-SW fault system dominates the coastal area. The Cerros La Yarada Fault System (SFCLY, = *Sistema de Fallas Cerros La Yarada*) groups normal faults that affect Jurassic marine strata and the Magollo Formation. Old blocks tilted down to the SW and NE are apparently post-dated by younger blocks tilted to the NW and SE.

The NW rim of the current Tacna valley seems to correspond to a small NE-trending normal fault system, with minor offsets on several individual faults.

STRUCTURAL CONTROL ON THE UPPER CENOZOIC SEDIMENTARY ACCUMULATIONS

The distribution and thickness of the Upper Moquegua Formation conglomerates suggest that during the Oligocene the SFIC formed the NE active boundary of the corresponding basin. Southwest of the SFCC, alluvial fan deposits occur in the lower part of the unit, thickness increases toward the SW, and sedimentary intercalations are observed in the lower member of the Huaylillas Formation, suggesting strongly that the SFCC was active during the Late Oligocene and Early Miocene.

The Magollo Formation outcrop distribution suggests that during the Early and Middle Miocene the active boundary of the basin migrated to the southwest, coinciding with the SFCC and SFCD. The thickness of this unit increases southwest of the SFME, suggesting increasing subsidence and synsedimentary activity of this normal fault system.

After incision of the present valleys, their partial Late Miocene - Pliocene infilling (Calientes Formation; Flores, 2004), as well as the Quaternary terraces, was influenced by NO-SE faults.

STRUCTURAL CONTROL ON GEOMORPHOLOGIC FEATURES

Tectonic activity was responsible for the observed changes in regional elevation and slope. Elevation in the rugged area NE of the SFCC-SFCD system ("*ladera pacífica de los Andes*") is typically between 1200 and 4000 m. Erosion has been enhanced in this area, where the upper collecting basins are located. Southwest of it extend the Pacific lowlands ("*llanura pacífica*"), an area with gentle relief and elevations between 200 and 1200 m, that is crossed by the current rivers. Along the coast, a poorly defined and low cordillera (≤ 350 m), representing the SE prolongation of the Coastal Cordillera, was structured by the SFCL. The SFCL and SFME bound the La Yarada lowlands, which coincide with the Río Caplina fan.

CHRONOLOGY OF DEFORMATION

An elongated basin originated between the SFIC and the Coastal Cordillera and was filled during the Oligocene - Middle Miocene interval (Upper Moquegua, Huaylillas and Magollo formations). During the Oligocene, the SFIC was the active boundary of the basin, while the NE region was being uplifted rapidly and submitted to erosion. Within the basin, the SFCC was separating two domains subsiding differentially. The domain located SW of the SFCC was characterized by higher subsidence.

The main depocentre was located between the SFCC and the Coastal Cordillera, because in the latter the Magollo Formation directly overlies the Mesozoic basement, thus recording that the Upper Moquegua Formation was not deposited there.

During the late Early Miocene and Middle Miocene, activity on the SFCC, SFCD and especially SFIC uplifted again the Pacific slope of the Andes, triggering the accumulation of the coarse detritic Magollo

Formation while the active boundary of the basin migrated to the southwest. The coastal area underwent NE-SW stretching, and a low area developed SW of the SFME.

A rapid late Middle Miocene uplift is conjectured to have been produced by NW-SE extension, resulting in incision of the present valleys and in the Cerro Vicuña surface tilting. In the late Neogene, valleys were partly filled SW of the SFIC and large landslides occurred.

CONCLUSIONS

The SFIC and SFCC fault systems have played a major role in the uplift of the southern Peruvian fore-arc. This uplift has resulted from transcurrent tectonics induced by the subduction direction and the structuration of the Arica elbow, in contrast with the compressional deformation described in northernmost Chile (García, 2002). Also in contrast, tectonics in the coastal area of the Tacna region is reminiscent of gravitational collapse. During the entire Neogene, the active tectonic boundary of lowlands where main accumulations occurred changed from the SFIC to the SFCC, where it is now located.

Acknowledgments

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