EOCENE LEFT LATERAL STRIKE SLIP FAULTING AND CLOCKWISE BLOCK ROTATIONS IN THE CORDILLERA DE DOMEYKO, WEST OF SALAR DE ATACAMA, NORTHERN CHILE

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RESUMEN: La Cordillera de Domeyko, al oeste de Salar de Atacama, en el norte de Chile, constituye parte de un orógeno transcurrente, originado en el Eoceno, por movimientos de rumbo sinistrales a lo largo del Sistema de Fallas de Domeyko. En el segmento comprendido entre el Salar de Punta Negra, al sur y Sierra de Limón Verde, al norte, el movimiento hacia el norte de la Cordillera de Domeyko fue bloqueado por la presencia de una mole rígida (Sierra Limón Verde); y transferido hacia el este por rotaciones de bloques en sentido horario, en dirección a la la cuenca cretácica de Purilactis (proto salar de Atacama), la más occidental de las cuencas de rift cretácicas del noroeste de Argentina y norte de Chile. La inusual combinación de rotaciones horarias acompañando a movimientos transcurrentes sinistrales se debería a que el sistema transcurrente sinistral estuvo limitado al norte por una mole rígida y a al este, por una cara libre: la cuenca de Purilactis.

Key Words: Northern Chile, Domeyko Fault System, Eocene, Clockwise block rotations

INTRODUCTION

Cordillera de Domeyko and its northern prolongation, Sierra de Moreno, extends for more than 800 km (21-28°S) in Northern Chile (Figure 1) separating the Central Depression, to the west, from a series of closed basins (Salar de Atacama, Punta Negra, Pedernales etc) located along the foothills of the western Cordillera, that is capped by the volcanic centers of the modern volcanic arc of the Central Andes. The narrow (60 km wide) range, reaches altitudes well above 4000 m and is composed mainly of Late Paleozoic volcanic and plutonic complexes (Boric et al, 1990. Mpodozis and Ramos, 1990; Reutter, et al., 1991). Cordillera de Domeyko is a transcurrent orogen formed during Eocene left-lateral strike-slip motion, but also recording late increments of oligocene (right lateral) and even quaternary (normal) faulting activity. The strike slip Domeyko fault system (Maksaev, 1990), is closely related with the northern Chile porphyry copper deposits, most of which were emplaced along strike slip faults along the axis of the Cordillera de Domeyko in the Eocene or Oligocene. Although the Cordillera de Domeyko is dominated by strike slip deformation, the structural grain and the geometry of related structures show important variations along strike. The segment west of Salar de Atacama, between 22°30'-25°S (Sierra Limón Verde to Salar de Punta Negra) exhibits an unusual structural geometry compatible with left lateral strike slip deformation accompanied by clockwise block rotations

STRATIGRAPHY

The Cordillera de Domeyko, between Salar de Punta Negra and Sierra Limón Verde is composed mainly by Late Paleozoic magmatic complexes including a suite of basalts to andesites interbedded with lacustrine sediments of late Carboniferous-Early Permian age (Breitkreutz et al, 1992), extensive outcrops of high silica rhyolites and granitoid plutonic centers, some of which are the eroded roots of large collapse calderas (Sierra Mariposas caldera, Davidson et al, 1985). K-Ar, Rb/Sr and U-Pb (zircon) ages fall in the range between 300-200 Ma (Mpodozis et al, 1993). To the west there are large exposures of late Triassic to early Cretaceous marine carbonates, terrestrial red beds and volcanics of the northern Chile mesozoic back-arc basin, covered by volcanics of the paleocene Cinchado formation and related shallow level intrusives (K-Ar ages ≈70-50 Ma, Figure 1). A major structural discontinuity (Sierra de Varas Fault) and a large shear lens (Ringenbach et al., 1992) straddles the contact with the basement core of Cordillera de Domeyko. To the east

of the range, the Paleozoic is also in fault contact with the up to 5 km thick red bed sequence of the Cretaceous to Eocene Purilactis Group, the infill of a large rift basin formed over the present site of modern Salar de Atacama (Macellari et al., 1991) and connected, to the east, with the Salta Group rift basins of northwestern Argentina (Grier et al., 1992). The tectonic contact between the Cordillera de Domeyko and the Purilactis basin sediments has been recently interpreted as a reactivated, down to the east, listric normal growth fault, developed, in the Cretaceous, along the western edge of the Purilactis rift basin (Macellari et al., 1991; Hartley et al., 1992)

STRUCTURE

Figure 1 is a structural sketch of the segment of the Cordillera de Domeyko between Salar de Punta Negra and Sierra Limón Verde. A close inspection of the geological map reveals that in this region: (1) none of the faults of the Domeyko fault system seems to continue north of Sierra Limón Verde; (2) Salar de Punta Negra, at the southern end of the segment, is a Tertiary extensional basin limited at its southern side by a NNW trending normal fault; (3) the Cordillera de Domeyko itself is formed by a series of discrete basement blocks separated by small, interior-drained, basins (Salar de Los Morros, Verónica Elvira... Figure 1); (4) the northwestern faces of the rhomboidal southern blocks (Imilac, San Carlos) are bounded by high angle reverse faults; (5) the northernmost blocks (Quimal, Los Morros, Mariposas) are limited to the west, by left lateral, subcircular to NE oriented, strike slip faults while to the east , they are thrusted over the Purilactis basin sediments; (6) Deformation in the Purilactis sediments is specially strong in front of the basement blocks where the red beds show isoclinal to chevron folds with subvertical axis; (7) Purilactis outcrops away from the basement blocks show no evidences of pervasive deformation.

Sense of asymmetry of large scale "sidewall ripouts" (Swanson, 1989) and displacement of geological contacts indicates left lateral shear along most of the major fault traces. The change from sandstones to coarse grained sediments in the Purilactis basin dated at 44 to 40 Ma (tuffs at the base of the conglomeratic part of the Purilactis Group, Ramírez and Gardeweg, 1982, Hammerschmidt et al.. 1992) and the 45-42 Ma K-Ar ages of the bimodal, syntectonic intrusives and domes of the Cerro Casado complex in the Quimal block indicate a middle to late Eocene age for the beginning of strike slip deformation. A similar age for the onset of the deformation (42 Ma) has been documented further south, in the El Salvador-Potrerillos region (26-27° S, Tomlimson et al., 1993). Oligocene porphyry coppers (Figure 1) were emplaced afterwards along some of major fault strands in the Oligocene, but the tectonic regime seems to have been dominated by dextral shear (at least in the 34-41 Ma Chuquicamata porphyry system, Maksaev, 1990)

DISCUSSION

This special structural association can be described as a strike slip structural province bounded to the north by a rigid butress (Sierra Limón Verde) and, to the east, by a free face: the Cretaceous-Eocene Purilactis basin. This interpretation is similar to the theoretical model recently presented by Beck et al. (1993). In the Eocene, passive northward displacement of the Domeyko range formed an extensional basin (Salar de Punta Negra) at the trailing edge of the displaced block. As northward motion was obstructed by the Limon Verde butress, the displacement could have been transfer to the east towards the Purilactis basin. To overcome the butress, displacement transfer in the Quimal block occurred by a combination of tectonic escape associated with extension (to the west) and compressive deformation and thrusting of the basement block to the east, over the sedimentary fill of the Purilactis basin. In the Mariposas block (Figure 1) deformation seems to have occurred by clockwise rotation along a subvertical axis of a basement sliver bounded by subcircular faults that may correspond to be the reactivated ring fractures of an old, Late Paleozoic, caldera. In this segment of the Cordillera de Domeyko, at least, 30 to 40 km of eocene northward displacement could have been compensated by 10-20% widening of the original surface area of the range.

Critical to this interpretation is the assumption that Sierra Limón Verde behaves a "rigid" butress that prevented northward displacement of the Domeyko block. In fact, as we already stated, none of the major fault traces seems to displace any of the Limón Verde plutonic units. The "West Fissure" fault system of Chuquicamata (Maksaev, 1990) show no obvious connections with the faults to the south. Structurally, Sierra Limón Verde is a huge, northward plunging half dome, cored by late Carboniferous granitoids and metamorphics of early Paleozoic or even Precambrian age; synmagmatic and mylonitic foliations show that the granitoid are deep seated plutons. Jurassic limestones, dipping away from the plutonic core, surround Sierra Limón Verde along its western, northern and eastern margins.

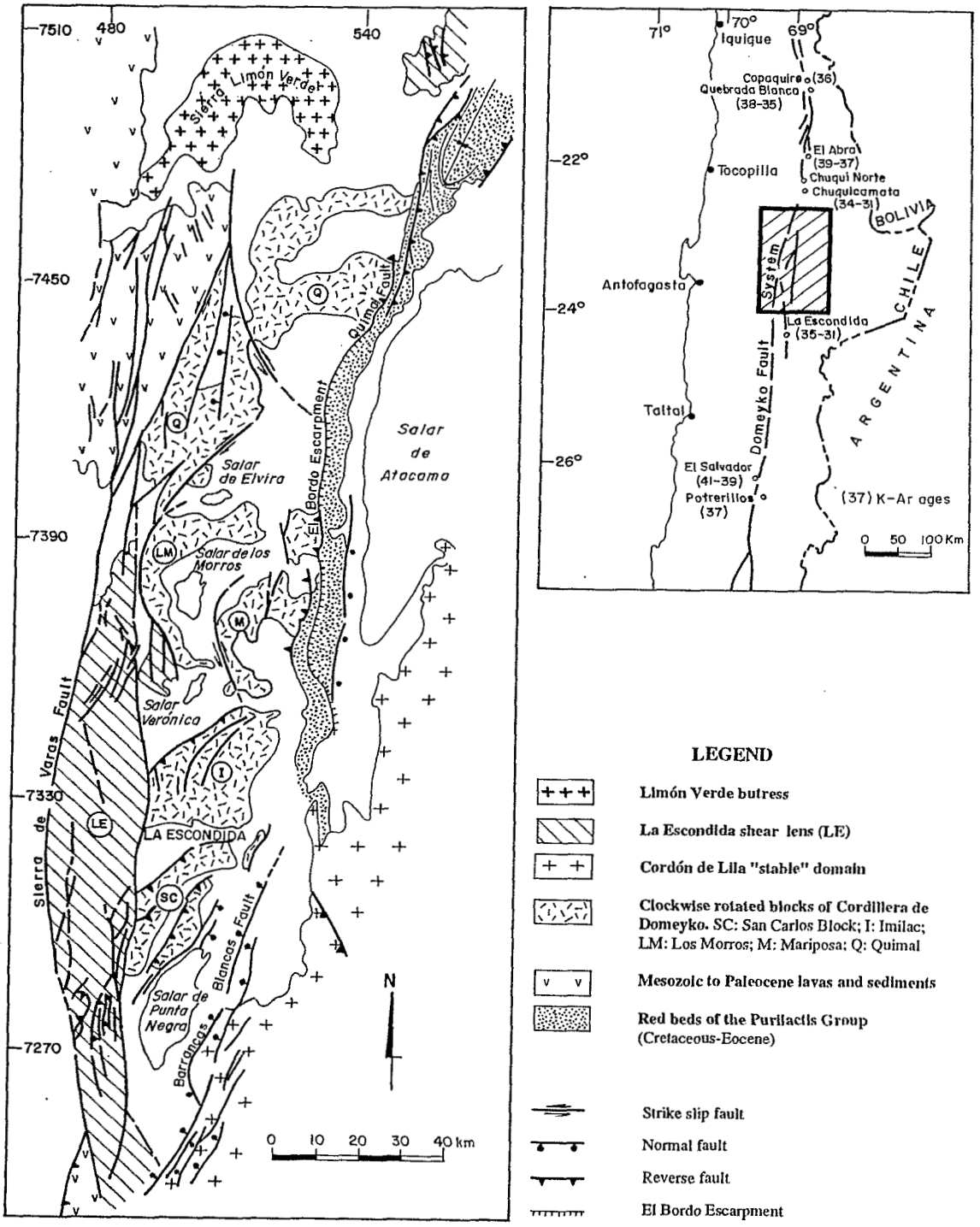

Figure 1: Structural domains and mayor faults of the Cordillera de Domeyko, west of Salar de Atacama, northern Chile.

TECTONIC IMPLICATIONS

Large scale left lateral Eocene strike slip faulting contradicts the Early Tertiary plate reconstructions (Pardo Casas and Molnar, 1987) indicating that during the Eocene deformation along the Chilean active margin should have a significative component of dextral shear If the plate reconstructions for the period are correct, and if he Arica elbow is an ancient feature of the margin, the presence of such a sharp bend in the coastline could effectively prevent,t any kind of northward transport of the coastal sliver (see Beck, 1987). In such an scenario characterized by a locked (and cold) forearc block, it is may be possible to envisage a mechanism to transfer the strain induced by right lateral oblique convergence to the hot and ductile lower crust behind the eocene magmatic front. Northward flow of ductile lower crustal material could result in limited amounts of passive transport of the brittle upper crust, accompanied, at least in the area to the west of Salar de Atacama, by clockwise block rotations.

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