NATURE AND TIMING OF CENOZOIC INTRA-ARC DEFORMATION, SOUTHERN CHILE.

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INTRODUCTION

Regional-scale long-lived shear zones spatially associated with ancient and present-day magmatic arcs provide a unique opportunity to address the link between tectonics and magmatism at a crustal scale, both in the long and short-term. Valuable information concerning the tectonics of magmatic arcs also comes from the study of the regional-scale trend of dike swarms, spatial distribution of volcanic centers and focal mechanisms of intra-arc crustal earthquakes. The nature of deformation partitioning of the convergence vector at subduction zones may also be assessed through constraining the kinematics and timing of intra-arc deformation and its correlation with coeval plate motions.

The Cenozoic geodynamic setting of the southern Chilean Andes is well constrained showing relatively steady right-oblique subduction of the Farallon (Nazca) plate beneath South America since 48Ma, with the exception of nearly orthogonal convergence during the 26-20 Ma time span, following the breakup of the Farallon plate (Pardo-Casas and Molnar, 1987). During the last 14 Ma the Nazca-South America-Antarctica triple junction has migrated northward from Tierra del Fuego to its present position at the southern end of the Southern Andes Volcanic Zone (Cande and Leslie, 1986). Both oblique subduction and ridge subduction have been proposed to be driving mechanisms for intra-arc shear (Beck, 1991; Nelson et al., 1994).

We propose that the long-term and short-term kinematics of the Cenozoic magmatic arc in southern Chile are recorded in: (1) Pre-Eocene(?) and Miocene-Pliocene ductile shear zones and Miocene-Pliocene brittle faults of the intra-arc Liquine-Ofqui fault zone (LOFZ) (Herve et al. 1979; Lavenu and Cembrano, 1994; Cembrano et al. 1996) ; (2) Eocene-Miocene dike swarms (Herve et al. 1995); (3) spatial distribution of Holocene volcanic centers (Nakamura, 1977, Lopez-Escobar et al. 1995); and (4) a few, intra-arc crustal earthquakes (Chinn and Isaacks, 1983; Barrientos and Acevedo, 1992) (Figure 1).

In this work we present the results of systematic field and petrographic observations in several E-W transects across the intra-arc northeast-trending LOFZ which extends for more than 1000 km northward from the Nazca-South America-Antarctica triple junction. Geological observations together with new and published geochronological data suggest marked differences in kinematics, physical conditions and possible age of deformation in the magmatic arc of the southern Chilean Andes for the Cenozoic (Figure 1). The spatial distribution of dike swarms and volcanic centers in southern Chile is also addressed to help constraining the intra-arc tectonics.

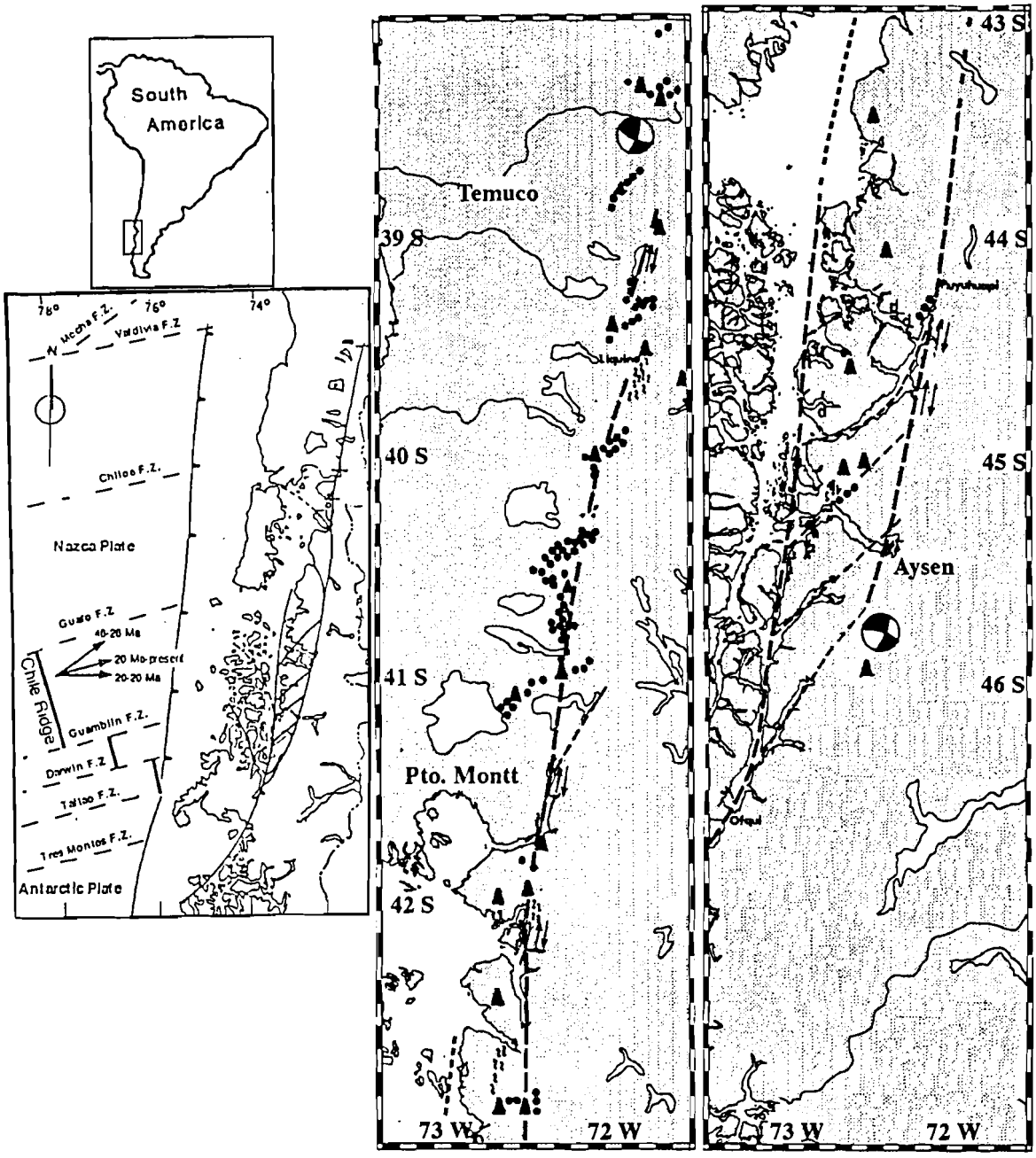

Figure 1. Regional scale sketch map showing the main tectonomagmatic features of the Cenozoic magmatic arc of the southern Chilean Andes (compiled from Barrientos and Acevedo, 1992; Chinn and Isaacks, 1983; Cembrano et al. 1995; Herve et al. 1979; Herve et al. 1995; Lopez-Escobar et al. 1995).

Pre-Eocene(?) to Miocene-Pliocene ductile shear zones

d Eocene-Miocene dike swarms

Miocene-Pliocene brittle faults

Holocene basaltic minor eruptive centers

Holocene stratovolcanoes

Crustal intra-arc earthquakes

Main lineaments of the Liquine-Ofqui fault zone

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Pre-Eocene (?) mylonitic strips up to one km in width document sinistral transpressional ductile deformation near the northern end of the LOFZ (Liquine, 39°S). This is in contrast with post-Miocene ductile to brittle dextral strike-slip deformation further south (Figure 1). At 42°S, new U-Pb zircon ages from one synkinematic and one prekinematic pluton are 9.9±0.6 and 135±12, respectively. Published K-Ar and Ar-Ar ages are mostly ~9-13 Ma in hornblende and ~6-3 Ma on biotite, indicating either uplift and cooling or pervasive thermal resetting of Cretaceous plutons during Miocene time. New Ar-Ar ages on biotite from both ultramylonitic shear zones and less deformed plutonic rocks range from 3.59±0.01 to 3.78±0.01. Microstructural observations suggest the latest ductile fabrics in plutonic rocks formed at greenschist facies conditions (300-350°C) similar to biotite Ar closure temperature.

Work in progress at 44°-46°S near the southern end of the LOFZ (Puyuhuapi-Aysen area, figure 1), shows that brittle faulting predominates over ductile deformation along north and northeast-trending lineaments making up a strike-slip duplex (Cembrano and Herve, 1993). Ductile dip-slip along with dextral strike-slip kinematics has been inferred from fabric studies on meter wide mylonitic shear zones occurring within the Patagonian Batholith and metamorphic wallrock. Kinematic analysis of fault slip data shows transpressional to compressional deformation of possible Miocene-Pliocene age. Eocene-Miocene mafic dike swarms (Figure 1) have a predominant northeast trend over an area of several hundred square km., which is consistent with an overall dextral strike-slip kinematics at the time of emplacement. Likewise, the spatial distribution of Holocene basaltic minor eruptive centers between 38°S and 46°S is mostly restricted to northeast, en echelon, alignments (Figure 1), which are believed to document rapid magma ascent through subvertical tension fractures within a transpressional dextral strike-slip volcanic arc. Previously published seismic data for the southern Andes volcanic arc is limited to only two earthquakes (Chinn and Isaacks, 1983; Barrientos and Acevedo, 1992), both having dextral strike-slip focal mechanism (Figure 1)

CONCLUSIONS

Available long-term and short term data show that the magmatic arc of the southern Chilean Andes has been undergoing transtensional to transpressional dextral strike-slip deformation for several million years. This tectonic regime has exerted a major control in the long-term and short-term magma ascent and emplacement as shown by synkinematic Eocene-Miocene dike swarms, Miocene plutonic rocks and present-day volcanic centers. Different degrees of deformation partitioning of the Farallon (Nazca)-South America convergence vector into arc-parallel shear and arc-orthogonal shortening has likely been responsible for the existence of episodic and/or coeval dextral-strike-slip and dip-slip deformation along the arc.

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