MARGIN-PARALLEL V/S MARGIN-ORTHOGONAL COMPRESSION ALONG A CONVERGENT MARGIN: THE ANDES OF CENTRAL - SOUTHERN CHILE AND WESTERN ARGENTINA

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INTRODUCTION

The central and southern Andes constitute a segment of the type-example of mountain building related to subduction of an oceanic plate beneath a continental plate margin. Oceanic plate subduction is commonly believed to drive significant margin-orthogonal shortening in the overriding plate which in turn is throught to produce mountain-building.

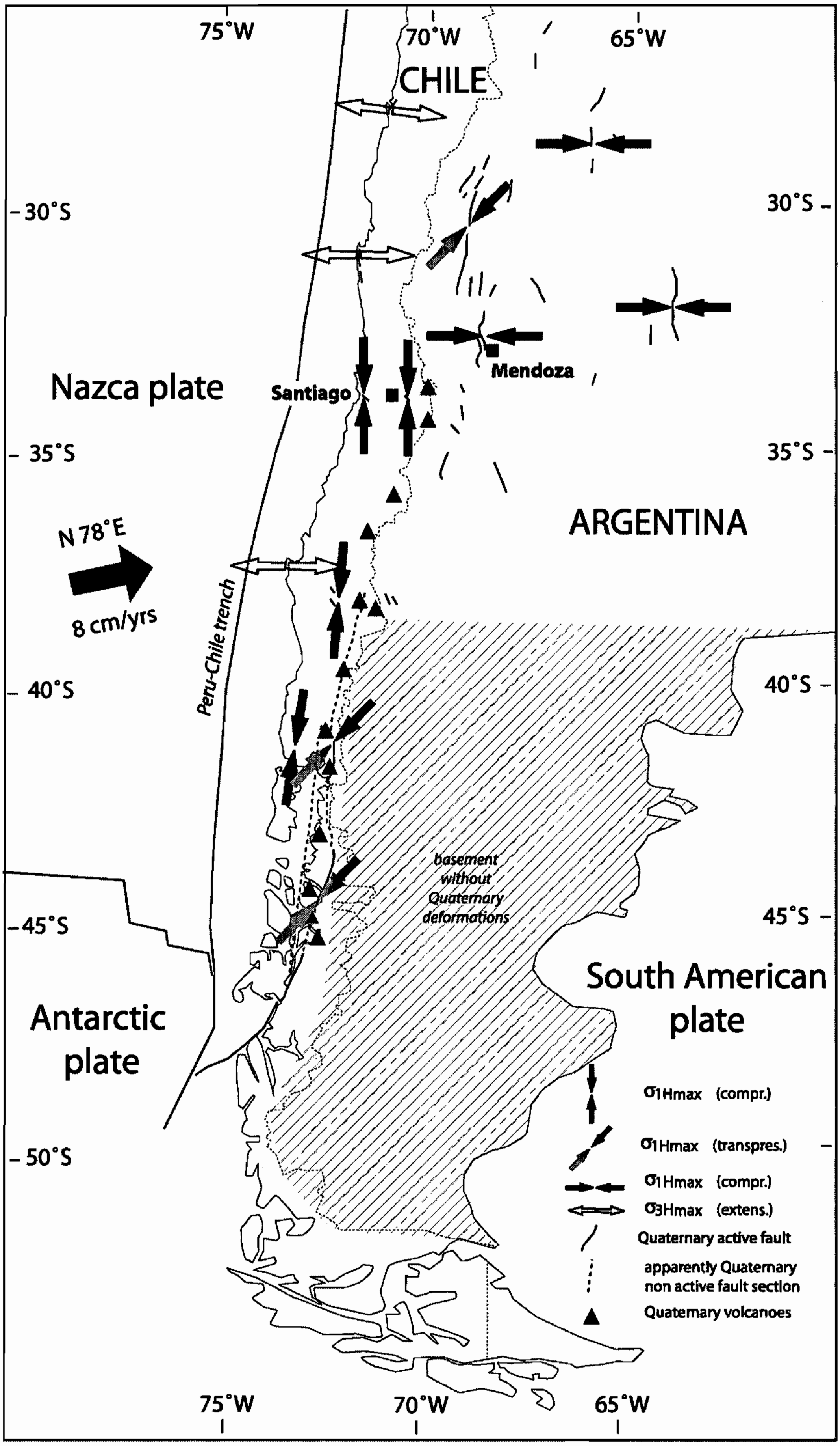
In particular, forearc deformation should be strongly coupled with the plate convergence vector, however, the relationship between convergence and tectonics on the overriding plate is not yet fully understood. Evolution of this zone appears to be controlled by several other processes such as margin consumption, margin accretion, subsidence, uplift and formation of sedimentary basins.

Even in those cases when the convergence vector is oblique and partitioned into trench-orthogonal shortening and trench-parallel strike-slip displacement, the instantaneous shortening direction across the orogen does not seem to depart much from that of the convergence vector. Theory and observation predict that trench-orthogonal shortening is accommodated in the forearc regions whereas strike-slip displacement is accomodated within the magmatic arc (e.g. Fitch, 1972; Beck, 1983; Jarrard, 1986; McCaffrey, 1992; Saint-Blanquat *et al.*, 1998). Therefore, in the forearc region, the direction of the maximum horizontal compression should be nearly parallel to the slip vector. While this may be true for the forearc base close to the subduction zone itself, a much more complex geometry of the stress tensor is found at the forearc surface.

In the southern part of the Central Andes of Argentina,Quaternary deformation is characterized by east-verging thrusting giving way inland to high-angle reverse faults that bound the assymetric foreland uplifts of the Sierras Pampeanas (Costa, 2002).

We here document regional-scale margin-parallel compression along a large (>1000 km long) tract of the Chilean Andes forearc that poses important questions regarding the way by which subduction zone deformation is tranferred up to surface. We show that margin-parallel compression may be more common than previously recognized because second-order forces arising from slip partitioning can overcome those directly related to trench-orthogonal displacement.

The Andean segment between 30°S and 45°S lie at the Nazca-South America plate boundary zone. Convergence has been slightly dextral-oblique during the last 20 Ma, at relatively high rates (5-8 cm/year) giving



75°W
70°W
65°W
CHILE
-30°S
30°S
- 35°S
35°S
- 40°S
40°S
-45°S
45°S
- 50°S
Nazca plate
Santiago
Mendoza
ARGENTINA
N 78°E
8 cm/yrs
Peru-Chile trench
basement without Quaternary deformations
Antarctic plate
South American plate
σ1Hmax (compr.)
σ1Hmax (transpres.)
σ1Hmax (compr.)
σ3Hmax (extens.)
Quaternary active fault
apparently Quaternary non active fault section
Quaternary volcanoes

rise to bulk transpressional tectonics in the magmatic arc south of 39°S (Hervé, 1994; Lavenu and Cembrano, 1999)

The forearc region of central and southern Chile is marked by three major, north-south trending morphological units: the Coastal Cordillera, the Central Depression and a significant portion of the Main Range lying west of the present-day volcanic chain. The Coastal Cordillera; up to 2km high, is made up of Paleozoic to Mesozoic metamorphic, plutonic and volcanic rocks. The Central Depression is a low relief region, up to 500 m high, constituted by a thick Oligocene-Quaternary sedimentary infill. The Main Range, whose altitudes west of the volcanic change vary from 4km in central Chile to 2 km in the southern Chile, is formed by highly deformed Mesozoic to Cenozoic volcano-sedimentary rocks cut by Miocene plutons.

The foreland region is characterized by a narrow and eastward-migrating fold and thrust belt, the Sierras Pampeanas basement block uplifts, and the absence of active volcanism.

The present-day tectonic front lies ca. 100 km east of the Andean divide between latitudes 30° and 35°S (Sierras Pampeanas); from latitudes 35° to 47°S, in turn, no significant active deformation has been documented in the foreland region. The Liquine-Ofqui fault zone appears to take up much of the plate boundary crustal deformation, in the magmatic arc between 39° and 47°S.

Forearc deformation was studied by using geometric and geomorphologic analysis of satellite images and from kinematic studies of faults in the field. Major lineaments and subsidiary structures were identified and then checked in the field to search for evidence of nature and timing of motion. When, possible, fault-slip analyses for the stress tensor was carried out through the Carey-Mercier inversion algorithm (Carey and Brunier, 1974; Carey, 1979). This method assummes that the slip direction on a given fault represents the shear stress component of a force F and allows for calculating a stress tensor and the three principal components of the stress tensor, $\sigma 1$, $\sigma 2$, $\sigma 3$.

Our results show that, in contrast to widespread Pliocene E-W compression, the Quaternary stress field is not a single one for the entire range, despite the fact that the convergence vector has been essentially the same for the last 20 Ma [a N-S trending compression in the fore arc (slip vector orthogonal to the convergent motion), a NE-SW trending transpression in the intra arc (slip vector oblique to the convergent motion), and an E-W trending compression in the foreland (slip vector parallel to the convergent motion)]. However, the decrease in convergence rate, may have led to less interplate coupling. On the other hand, significant crustal blok rotations have not been documented for the Quaternary (Roperch *et al.*, 1999).

CONCLUSION

Nazca-South America convergence rate decreased since the Pliocene. The strain partitioning model, as discribed by previous authors (e.g. Fitch, 1972; Jarrard, 1986; Dewey and Lamb, 1992) cannot account for the actual regional stress patterns we have obtained from fault-slip analysis.

Several processes can contribute to this somewhat unexpected strain partitionning in the Andean Range:

- changes in the subduction regime as velocity, coupling, temperature/age of the oceanic plate (DeMets *et al.*, 1994; Somoza 1998);
- concave-convergent margin with "buttress effect" (Beck, 1991; McCaffrey, 1992);
- plate margin geometry;
- slip-vector partition.

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