PALEOMAGNETISM, STRIKE-SLIP FAULT SYSTEMS AND CRUSTAL ROTATION IN THE REGION 25-27ºS OF NORTHERN CHILE.

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INTRODUCTION

The Coastal Cordillera, Central Depression and PreCordillera of northern Chile between 25-27ºS are separated or dissected by major strike-slip fault systems, namely the Atacama Fault Zone, the Central Valley Shear Zone and the La Ternera-Domeyko fault systems (Figure 1). These fault systems are dominantly sinistral (Brown et al., 1993; Cornejo et al., 1993). Palaeomagnetic data from geological units affected by these fault systems indicate substantial clockwise crustal rotation upto ~47º (Randall et al., in press). In general the palaeomagnetic data appear to show a decrease in rotation eastward across the whole region, but are difficult to reconcile with previously proposed large scale models developed to explain the observed change in sense of rotation about the Bolivian Orocline.

THE FAULT SYSTEMS

The oldest strike-slip fault system which affects the Coastal Cordillera is the Atacama Fault Zone (AFZ), which is characterised as a ductile sinistral, trench-linked, strike-slip fault system which had previously developed as an extensional fault system (Grocott et al., 1994). Ar^{40}-Ar^{39} dating indicates that the ductile motion on the fault zone was Early Cretaceous in age and was intimately associated with the emplacement of granitic plutons during the period 132-126 Ma and motion may have continued until 106 Ma (Dallmeyer et al., 1996). Recent field mapping by ourselves and others (Arévalo 1995), coupled with Landsat interpretation shows that the principal fault zone is not a continuous feature, as previously thought, but is segmented and cross-cut by major sinistral NW trending faults. These faults cut the youngest pluton in this region (106 Ma), and appear to sole into a N-S to NE-SW trending fault zone which separates the Coastal Cordillera from the Central Depression. This shear zone we term the Central Valley Shear Zone (CVSZ) which, together with the NW trending strike-slip faults, define an Atacama Fault System. This fault system affects the entire width of the Coastal Cordillera and appears traceable from at least 29 to 25ºS (Taylor et al., in press). In the region around Inca de Oro, the CVSZ is a transpressive strike-slip fault zone which is intruded by syn-tectonic plutons dated to ~80 Ma (Sylvester & Palacios, 1992) while east of Copiapo it is a narrow fold and thrust belt dissected by a sinistral mylonite zone (Arévalo, 1995) which affects Late Cretaceous sedimentary units.

The structure in the east of the area is dominated by the La Ternera-Domeyko fault system which is again a major transpressive sinistral strike-slip fault system. Detailed field studies and geochronology reveal that this fault system was active during the period 42-33 Ma when it was kinematically linked to the fold and thrust belt of the Porterillos-El Salvador area in the north and to a set of NW trending sinistral faults to the south of Porterillos (Cornejo et al., 1993). Clockwise rotation of crustal blocks was predicted from the structural geometry and has been confirmed palaeomagnetically.

PALAEOMAGNETISM AND ROTATION

Table 1 lists published palaeomganetic results from the region and adjacent areas and two new results, one from layered gabbros at Caldera (Early Jurassic) and the second from volcanics and intrusives of the Sierra de Duchasa Fm. (Late Cretaceous) which crop out 15 km east of Copiapo, east of the CVSZ (Table 1). Work is in progress on a range of units from this latter area and from near Inca de Oro. One problem in defining the amount of rotation observed at any location is the reference directions with which the observed data are compared. We have rotated African data into S. American co-ordinates to supplement the available data from the S. American plate and have selected poles on the basis of reliability criteria (Table 2). The most doubtful of these reference directions is that for the Early Jurassic which is markedly different from the younger directions and must either imply rapid plate motion at this time or that the available poles are inaccurate.

CONCLUSIONS

The data show a general W-E decrease in the magnitude of the rotations across the major fault systems. Previous models used to explain rotations in the S. American margin include oroclinal bending, dextral shear crustal shear, differential shortening across a pre-existing bend and block rotation in a transpressive sinistral fault system (Figure 2a-d) (references in Randall et al., in press). The oroclinal bending and dextral shear zone hypotheses are rejected as the observed geology in this part of northern Chile does not support such models. The differential shortening model, as originally proposed, would not lead to the variation in rotation observed nor to rotations greater than 20º or so. We favour a model involving repeated deformation and rotation in a series of sinistral transpressive fault systems, due to oblique convergence at an advancing subduction boundary, which have migrated eastward through time. and may incorporate a lesser component of rotation due to differential shortening in Neogene times.

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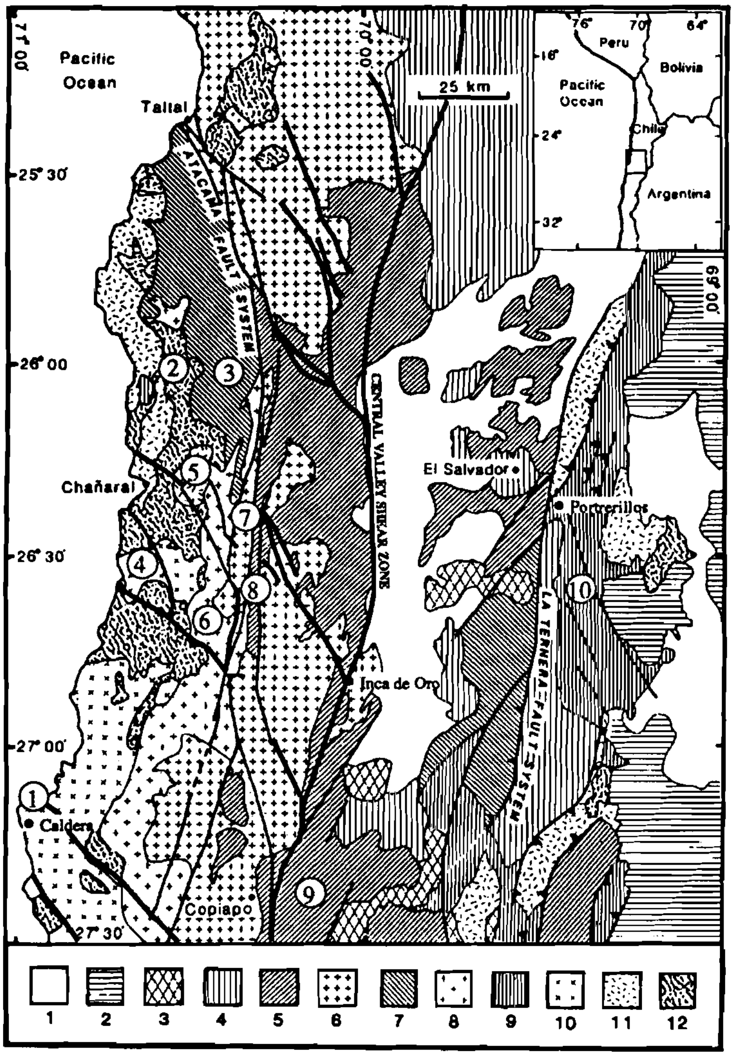

Figure 1. Generalized geological map of northern Chile. Inset shows location with respect to the western margin of South America. 1, Late Cenozoic continental sedimentary rocks; 2, Miocene-Oligocene plutonic rocks; 3, Early Tertiary plutonic rocks; 4, Palaeocene-Eocene volcanic and sedimentary rocks; 5, Cretaceous volcanic and sedimentary rocks; 6, Cretaceous plutonic complexes; 7, Jurassic volcanic rocks; 8, Early Cretaceous-Late Jurassic plutonic rocks; 9, Jurassic-Triassic sedimentary rocks in the east; 10, Early Jurassic plutonic rocks; 11, Triassic-Permian plutonic complexes; 12, Palaeozoic pre-arc basement. Numbers in circles refer to sampled sites (Table 1).

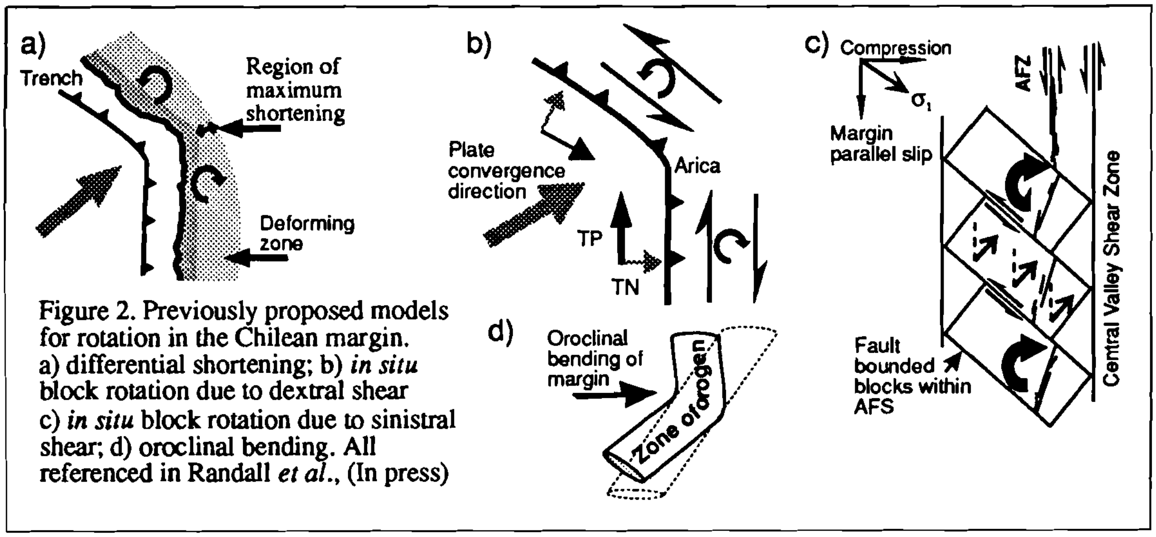

Figure 2. Previously proposed models for rotation in the Chilean margin.
a) differential shortening; b) *in situ* block rotation due to dextral shear
c) *in situ* block rotation due to sinistral shear; d) oroclinal bending. All referenced in Randall *et al.*, (In press)

TABLE 1. PALAEOMAGNETIC ROTATIONS RECORDED BETWEEN 22.5° AND 27.6°S, NORTHERN CHILE

Locality	Age Ma	Lat.°S	Long.°W	No.	Dec. (°)	Inc. (°)	α_{95} (°)	Rotation	Flattening	Ref.
WEST OF ATACAMA FAULT ZONE										
Caldera gabbros[1]	192	27.1	71.0	8	35.1	-30.4	14.5	15.1±16.8	-25.6±12.9	1
La Negra Fm.[2]	M. Jur	26.0	70.6	14	42.0	-35.5	9.6	40.0±11.5	-7.5±9.1	2
Cifuncho Fm.[3]	? M. Jur	25.6	70.6	11	36.6	-50.0	9.6	34.6±13.7	7.0±9.1	3
Flamenco dykes[4]	M. Jur	26.3	70.6	5	45.6	-43.0	8.8	43.6±11.7	0.0±8.5	2
Vetado dykes[5]	M .Jur	26.2	70.4	6	48.9	-49.6	12.1	46.9±16.5	6.6±10.8	2
Las Animas dykes[6]	155	26.2	70.4	5	44.0	-48.6	11.2	42.0±15.2	5.6±10.2	2
Las Tazas dykes[7]	132-126	26.3	70.4	7	38.7	-41.5	12.0	39.7±13.8	-6.5±10.1	2
WEST OF CENTRAL VALLEY SHEAR ZONE										
Remolino dykes8	< 126	26.3	70.3	13	37.2	-39.3	11.6	38.2±13.0	-8.7±9.8	2
WEST OF LA TERNERA FAULT ZONE										
Sierra La Dichusa volcanics[9]	77-62	27.2	70.1	7	29.3	-42.1	8.0	33.3±10.7	-8.9±7.5	1
EAST OF LA TERNERA FAULT ZONE										
Cerrillos Fm. (CEG locality)	? E. Tert.	27.6	69.8	6	21.6	-48.5	22.9	32.6±31.4	-6.5±19.7	4
Quebrada Monardes Fm.	E. Cret	27.6	69.6	8	23.7	-40.9	14.1	27.7±15.3	5.9±11.5	4
Quebrada Monardes Fm.[10]	E. Cret	26.7	69.4	7	22.7	-44.9	12.2	26.7±14.2	9.9±10.1	5
La Ternera Fm.	L. Triass	27.6	69.4	18	33.1	-51.1	6.5	13.1±13.1	-4.9±7.6	4
Lipiyoc	Miocene	22.5	67.0	17	2.6	-44.4	7.9	2.6±8.9	-0.6±6.4	6

TABLE 2. PALAEOMAGNETIC REFERENCE DIRECTIONS

Time period	No.	Dec. (°)	Inc. (°)	α_{95} (°)
Miocene-Recent	-	0	-45	1
Early Cenozoic	3	349	-55	9
Late Cretaceous	12	356	-51	5
mid-Cretaceous	13	359	-48	4
Early Cretaceous	5	356	-39	3
Late Jurassic	1	16	-51	12
Middle Jurassic	5	2	-43	6
Early Jurassic	7	17	-58	8

Table 1. Numbers on localities refer to Figure 1. Lat. and Long. are position of sampling site; No. is number of sites; Dec. and Inc. are declination and inclination of palaeomagnetic vector; α95 is 95% confidence circle. Rotation and flattening calculated according to Beck (1980) with correction of Demarest (1983). References are; 1, This study; 2, Randall *et al.* (In press); 3, Forsythe et al. (1987); 4, Riley *et al.* (1993); 5, Randall (1996); 6, Somoza *et al.* (In press). All referenced in (2).

Table 2. Headings as in Table 1.