NEOTECTONIC MAP OF THE ATACAMA FAULT ZONE (CHILE) FROM SAR ERS-1 IMAGES

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KEY WORDS : ATACAMA, CHILE, FAULTS, NEOTECTONICS, RADAR, REMOTE SENSING

INTRODUCTION

The Atacama Fault Zone (AFZ) runs for more than 1,100 km long and 30 to 50 km large in northern Chile. Mapping of the neotectonic fault pattern is needed in the frame of fault activity analysis. For analysis of large regions, satellite imagery has already proved to be an efficient tool allowing estimate of finite displacements along faults (Mercier et al., 1992; Chorowicz et al., 1995). Radar imagery is particularly convenient because it accentuates topographic features, specially scarps and thalwegs which mainly express neotectonic structures. The aim of our work is to map the neotectonic faulting from radar imagery.

THE ATACAMA FAULT ZONE

The Northern Chilean Coastal Cordillera (Fig.1) has suffered several tectonic events since the beginning of the Andean cycle in late Triassic time (Scheuber and Reutter, 1992; Scheuber et al., 1994). In the early Jurassic, the Andean back-arc basin was separated from the Pacific Ocean by a volcanic arc. A first tectonic event in the late Jurassic-early Cretaceous prompted intra-arc ductile deformation, including 1 km wide mylonitic shear zones along the N-striking Atacama fault zone (Scheuber and Andriessen, 1990; Scheuber, 1994). In the early Cretaceous a belt was formed in the west, probably in a compressive (or transpressive ?) regime (Turner et al., 1984). In mid-Cretaceous time (Peruvian event), the Andean basin suffered compression. From Oligocene to Miocene, extensional regime occurred. Since the late Miocene, the AFZ has suffered major brittle reactivations, continuing until Present. All these events have produced fault activity and our aim is to map the neotectonic active faults only.

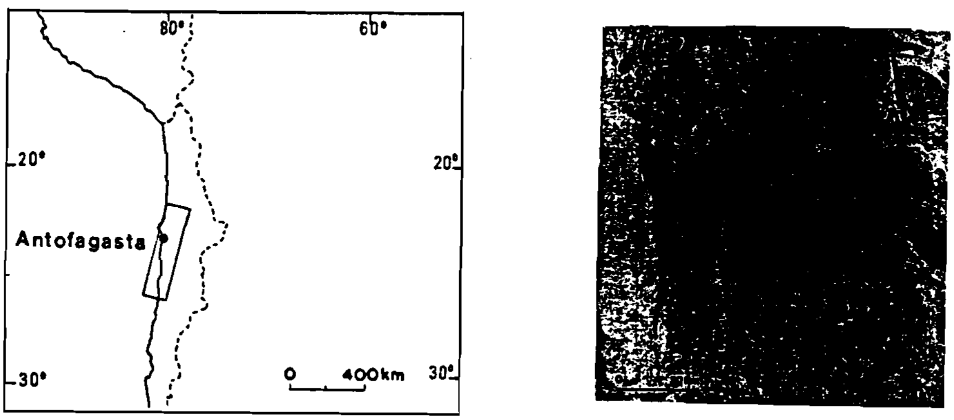

Figure 1. Location of the studied area and example of SAR ERS image.

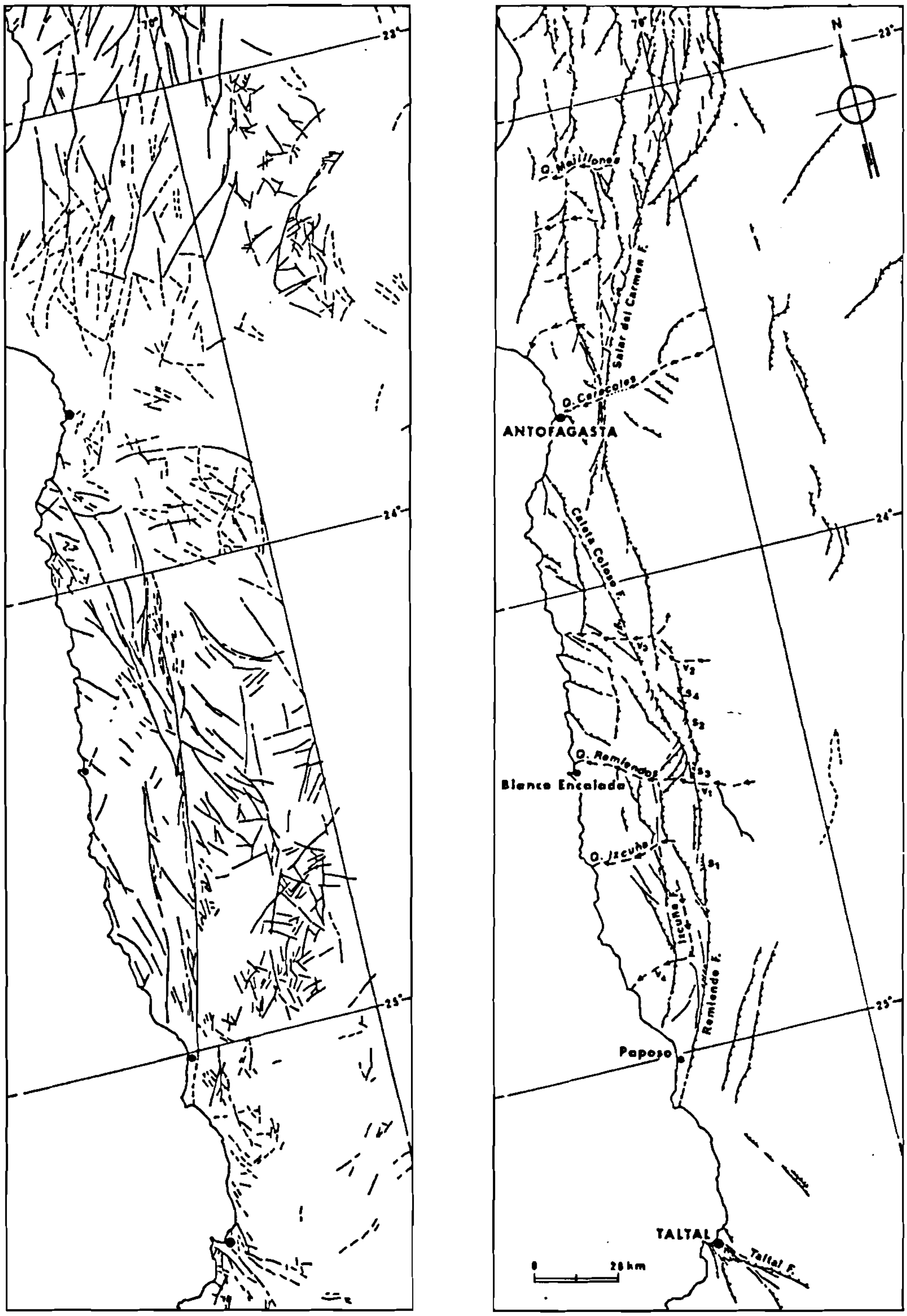

Figure 2. Comparative maps of the AFZ fault pattern. Left: faults previously mapped; right: neotectonic faults drawn from radar image analysis.

*-We have analysed a set of Synthetic Aperture Radar (SAR) scenes of the first European Remote Sensing (ERS-1) satellite. ERS-1 was launched on July 1991. This satellite views the earth surface using a SAR operating in band C (5.3 GHz). Each scene covers an area 100 x 100 km. From the original records with 12.5 m ground pixel size, we have generated images yielding 25 m ground resolution. Images were produced at 1/250,000 scale, in negative prints (Fig.1). This type of presentation of the image has the advantage to display saturated slopes facing the radar in dark, giving the impression of shadows, and is more convenient for geological analysis. These slopes are anyway poor in information because of shortening and layover. Slopes backing the radar are then clear and give the impression to be illuminated. They are rich in information because stretched.

In the study area, active faults can be identified from continuous scarps. Some have been first described by Okada (1971), and afterwards by other workers who sometimes changed the names. When possible, we below preferably use the original terminology from Okada (1971). Active faults are characterised by scarps changing in height along the strike. Most of fault scarps in the studied area look east, nearly at right angle to the radar beam illuminating the scene from ESE. The fault scarps are more or less straight in the whole, but in the detail they present acute changes in direction.

RESULTS

Many of the faults we have observed on the radar images had been previously partly mapped (Fig.2). However, radar imagery has significantly enhanced the mapping of the neotectonic fault system. There is also a number of ancient (lower Cretaceous to early Cenozoic) faults previously mapped, which are not portrayed on the images. Some faults are underlined by distinct scarps but they also are partly overlain by recent deposits. We classify these faults as 'recent but inactive'. The radar system principally displays changes in the relief due to recent (post-Miocene) deformation. The radar images also show regular back-slopes of large dimensions (10 km in the east-west direction.) which all dip westwards. The back-slopes are principally regular planes of tilted blocks, typical of an extensional regime, and we consequently consider that the faults are normal. Reverse faults would have been associated with topographic domes corresponding to anticlines. Most of the Neogene basins located along the footwall are half-grabens. The major faults have already been described as normal and not reverse (Ferraris and Di Biase, 1978; Gonzales et al., in press) dipping 60° to the east.

In the northern Region, the N30°-striking Salar del Carmen major fault divides the region into two domains : (i) to the east, a few inactive but recent (distinct scarp) faults are overlain by late Quaternary deposits; (ii) to the west, the Coastal Cordillera is cut by several active faults. Most of the largest faults strike N160 to N170°. A few smaller faults strike N00 to N20°, and connect southward with the Salar del Carmen fault. The Ordonez fault strikes N170 to N190°.

In the central Region, the faulted part of the Coastal Range is easterly bounded by the N-striking Remiendo fault, facing east (Okada, 1971, referred as the Paposo fault by Hervé, 1987). In the east of the region, the fault scarps are ancient because they are eroded and partly burried under recent deposits.

In the southern region, the Coastal Range is easterly bordered by the Remiendo fault. More to the south, the Atacama fault system reappears on land but the pattern is very different. The coastal range is bounded by the El Salado fault, trending north, quite the same direction as the Remiendo fault. Another N-striking fault is noticed inside the range. These faults are cut to the north by the Taltal N130° striking faults, lying at high angle to the Atacama system.

CONCLUSIONS

SAR ERS imagery has permitted a pertinent discrimination between neotectonic and more ancient faults. The overall fault zone geometry is that of normal faulting bounding west-dipping tilted blocks.

ACKNOWLEDGEMENTS

We thank the European Space Agency for providing ERS SAR data in the frame of research project AO.F7.

REFERENCES

Chorowicz J., Luxey P., Yürür T., Rudant J. P., Gündogdu N. and Lyberis N. 1995. Slip motion estimation along the Ovacik fault near Ercinzan (Turkey) using ERS1 radar image. *Rem. Sens. Environment*, 52, 66-70.

Ferraris F. and Di Biase F. 1978. Hoja Antofagasta. Inst. Inv. Geol. Chile. Carta Geologica Chile 1:250.000, n°30, 48 pp.

Gonzales L.G., Niemeyer R.H. and Martinez D.L.R. in press. Evolucion tectonica cenozoica del borde continental el las inmediaciones de Antofagasra : su relacion con la sedimentacion y la morgologia. Revista Geol. Chile.

Hervé, A. 1987. Movimiento normal de la falla Paposo, Zone de Falla Atacama, en el Mioceno. Chile. *Rev. Geol. Chile*, 31, 31-36.

Mercier J.L., Sébrier M., Lavenu A., Cabrera J., Bellier O., Dumont J.F. and Marchare J. 1992. Change in the tectonique regime above a subduction zone of Andean type: the Andes of Peru and Bolivia during the Plio-Pleistocene. *J. Geophys. Res.*, B.8, 11,945-11,982.

Okada A. 1971. On the neotectonics of thee Atacama region. Preliminary notes on late Cenozoic faulting and geomorphic development of the Coast range of Northern Chile. *Bull. Dept. Geography Univ. Tokyo*, 3, 47-65.

Scheuber E. and Andriessen P.A.M. 1990. The kinematic and geodynamic significance of the Atacama fault zone, norhtern Chile. *J. Struct. Geol.*, 12(2), 243-257.

Scheuber E. and Reutter K.J. 1992. Relation between tectonics and magmatism in the Andes of Northern Chile and adjacent areas between 21° and 25°S. *Tectonophysics*, 205, 127-140.

Scheuber E., Bogdanic T., Jensen A. and Reutter K.J. 1994. Tectonic development of the North Chilean Andes in relation to plate convergence and magmatism since the Jurassic. In: *Reutter K.J., E. Scheuber & P. Wiggereds*, Tectonics of the Southern Central Andes, Springer, 121-139.

Scheuber E. 1994. Tektonische enwicklung des nordchilenischen aktiven kontinentalandes : der einflub von plattenkonvergenz und rheologie. *Geotektonische Forschungen*, 81, E. Schweizerbart'sche Verlaysbuch, Stuttgart, 131p.