THE LOADING AND RELAXATION PROCESSES IN THE NORTHERN CHILE SUBDUCTION ZONE USING SAR INTERFEROMETRY AND GPS MEASUREMENTS

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INTRODUCTION

The North Chile region, located between 18°S and 23°S is one of the most important seismic gaps in the world (Nishenko, 1985) with no rupture having occurred since 1877 in this area. The two extremities of this gap have experienced major earthquakes in recent years (the Mw=8.1 Antofagasta earthquake in 1995; the Mw=8.4 South Peru earthquake in 2001). Sar interferometry and GPS measurements are powerfull tools to constrain the loading (inter-seismic) and the relaxation (co- and post-seismic) processes that take place on the subducting interface.

1995 ANTOFAGASTA EARTHQUAKE

Combined with GPS and seismic modelling (Ruegg & al, 1996; Ihmlé & al, 1997), SAR interferometry (figure 1) has proved to be essential to constrain the surface deformation and to characterize the source mechanism of 1995 Antofagasta earthquake. The slip direction is parallel to Nazca-South America relative plate convergence indicating no slip partitionning; the variation of slip distribution on the fault plane indicates non homogeneous strain release reaching a maximum of 5.5m; blocked in the north by the presence of the geometrical asperity of Mejillones penninsula, the rupture propagates toward to the south and do not reach the 1877 northern Chile gap (Delouis, 1997).

INTERSEISMIC AND POSTSEISMIC PROCESSES

We have mapped the crustal deformation by processing interferograms of ERS satellites during the three years immediately after the 1995 earthquake (figure 2) and by determining the GPS vectors of 40 points measured between 1996 and 2000, on an area of more than 700 km long by 100 km wide including the 1877 Chile gap and Antofagasta rupture zone. The GPS signal observed in the central part of the gap is dominated by an elongated interseismic velocity gradient parallel to the arc with 20-30 mm/yr eastward displacement with respect to stable South America (Ruegg & al, in preparation; Kendrick & al, 2001). This is consistent with the 15-20 mm/yr range decrease determined by SAR interferometry. South of this gap, the interferometric map exhibits a different pattern and the GPS vectors are significantly different in direction and amplitude. This change is located in the area where the M=8.1 Antofagasta earthquake occured in 1995 and is interpreted to be post-seismic relaxation.

We model the interseismic with points source embeded in an elastic half-space by 100% coupling of the thrust interface of the subduction to a depth of 35km with a 50km wide transition zone beneath. The slip in this zone increases linearly from zero to the plate convergence rate (79mm/yr from NUVEL-1).

We model the postseismic relaxation following Antofagasta earthquake as after-slip located in the transition zone (35-55km depth). The maximum post-seismic slip reach 75cm, in the prolongation in depth where the maximum of energy have been release during the 1995 earthquake (5.5m of slip).

Between the 1877 gap and the 1995 rupture, the structures associated with the Mejillones Peninsula seem to have an important role. The 1995 event nucleated in this region appears to have acted as a barrier to northward propagation. During the 4 years following the earthquake some slip within lower part of seismogenic depth zone (20-45 km) is also required in this area to explain the observations. We propose a simple slip model for the seismic cycle where the transition zone has alternating behaviour with both plastic shear (inter-seismic) and seismic slip (co-seismic). The sum of co-seismic and inter-seismic slip do not explain the whole cycle. The post-seismic slip occurring in the transition of the thrust interface fills the remaining gaps with both seismic and aseismic slip.

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Figure 1 - 1995 Antofagasta earthquake displacement field in North Chile.

The map corresponds to a mosaic of 7 ERS interferograms superimposed on shaded topography. Positive displacements (in cm) correspond to range increase (increase of ground satellite distance). In the Antofagasta region where the 1995 Mw=8.1 subduction earthquake occured, range is increased and corresponds to a combination of subsidence and westward displacement as shown by GPS measurements (red arrows) during the same period. This is interpreted as coseismic elastic rebound. Plate convergence from De Mets & al. (1990). Focal mechanism from Ruegg & al. (1996). White star is location of the 1995 epicenter.

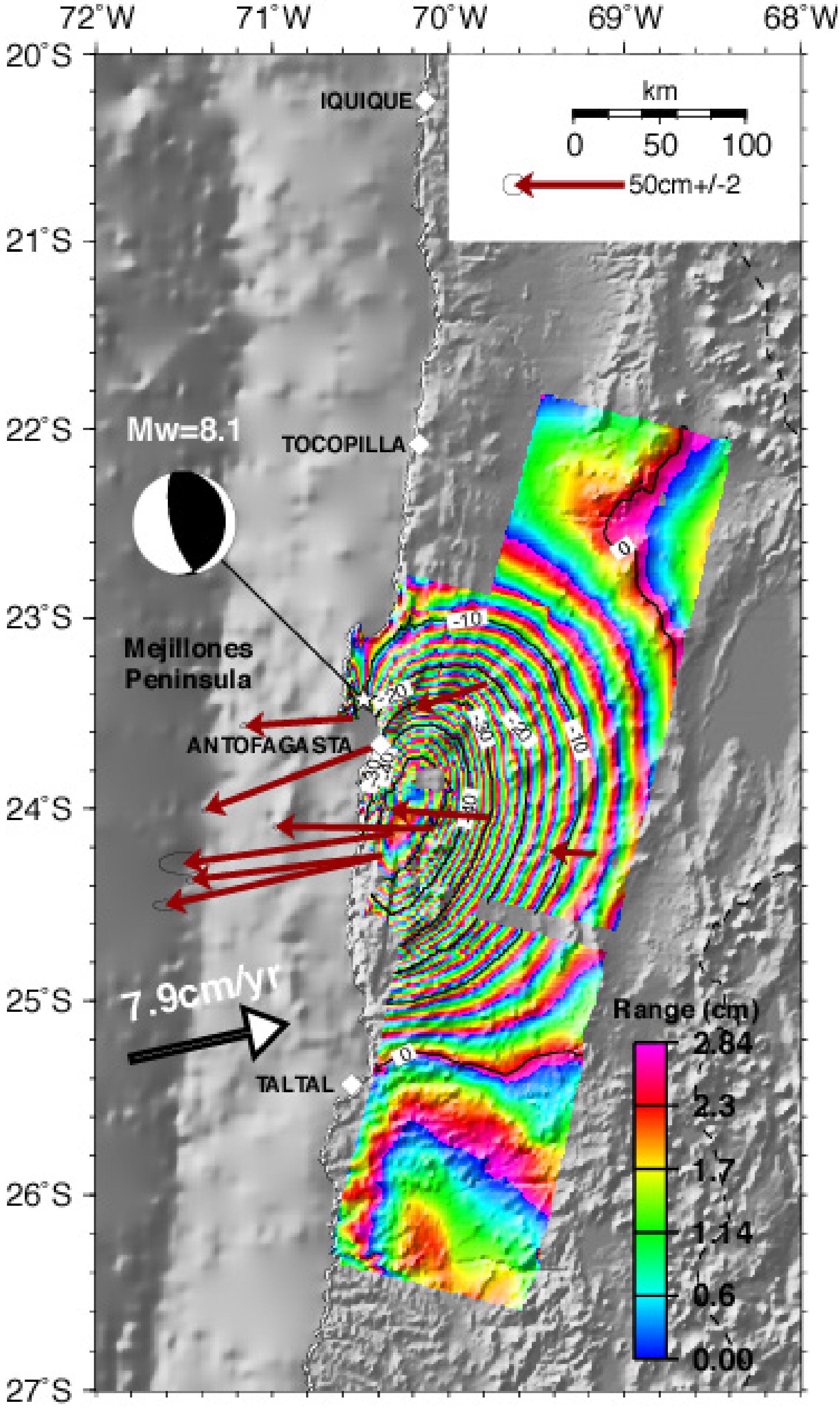

Figure 2 - 1995-1999 displacement field in North Chile.

Each Interferogram Pair (1 and 2) covers 3.6 years (a) and 3.3 years (b) after the Antofagasta earthquake (c). Pair 1 starts 6 hours after the earthquake. The GPS vectors (black arrows) recover same time period and are represented relatively to stable South America.