LATE QUATERNARY SLIP RATES OF THE MEJILLONES FAULT, NORTHERN CHILE (23°S), USING ^{10}BE DATES

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INTRODUCTION

The Mejillones Peninsula is located along the arid coast of northern Chile and belongs to the Central Andes fore arc. It is the fore arc emerged part the closest to the subduction trench. Quaternary alluvial fans and uplifted abrasive marine terraces (and associated deposits) are well preserved, and both are affected by several normal faults. Our study aims to date the displaced alluvial fans surfaces, using *in-situ* produced cosmogenic ^{10}Be, to quantify the slip rate along the faults.

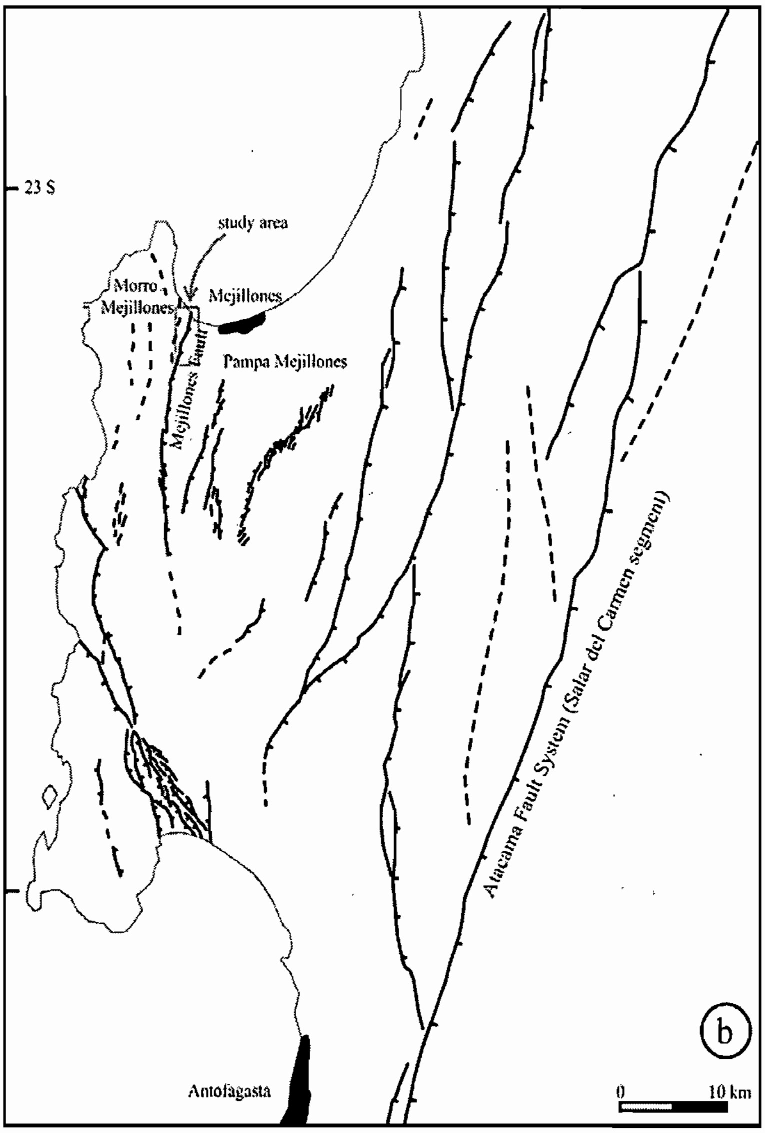
THE MEJILLONES FAULT

Located at the northern part of the Mejillones Peninsula, the Mejillones Fault belongs to the Mejillones Faulting System but can also be considered as the most western part of the Atacama Fault System which has a Mesozoic origin (Fig. 1). The Mejillones peninsula is deformed by an E-W extension during the Plio-Quaternary and is affected by numerous normal faults, tension gashes, tilted blocks and vertical motions (*e.g.*: Okada, 1971; Armijo and Thiele, 1991; Hartley and Jolley, 1995; Niemeyer *et al.*, 1996; Delouis *et al.*, 1998). This extensional deformation is expressed in the morphology by a series of horsts and grabens (or half grabens).

The Mejillones Fault limits to the east the uplifted peninsula (Morro Mejillones range) which displays a staircase morphology corresponding to wave-cut platforms abraded in basement rocks. To the east, the Pampa Mejillones defines an isthmus, filled by Neogene marine deposits and covered by Quaternary sequence of beach-ridges. The whole system (Mejillones fault, Morro Mejillones and Pampa Mejillones) can be described as a half graben developed at least from the Neogene time, in the northern half part of the peninsula.

The last movements along the Mejillones Fault affect several generations of alluvial fans at outlets of deep-incised drainage basins developed in the eastern flanks of the Morro Mejillones. This alluvial fans cover Quaternary beach-ridges of Pampa Mejillones formed during the last half million years (Ortlieb, 1995; Ortlieb *et al.*, 1996). These faults are supposed to have a very recent activity, but no historical seismic activity has been reported along this fault, and moreover, no significant crustal seismicity is associated to the fore arc at this latitude.

Delouis *et al.* (1998) proposed that the state of stress in the outer fore arc is linked to the seismic cycle in the subduction zone. As observed during the 1995, Mw = 8.0 Antofagasta earthquake, subduction earthquakes produced coseismic E-W extension and vertical movement in the coastal area, that would produce the reactivation of some branches of the Atacama Fault System and the formation of superficial cracks.



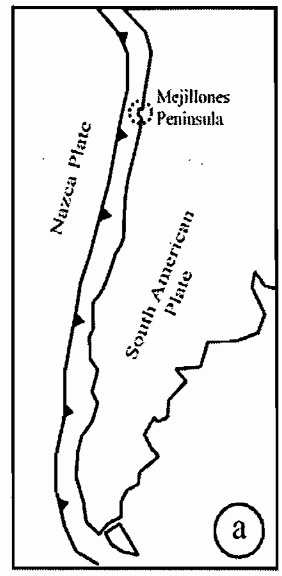


Figure 1.- a) Location map of the Mejillones Peninsula. b) Distribution of the main Quaternary regional faults and the study area.

Quaternary normal faults (certain/probable)

PRELIMINARY MORPHOTECTONICS AND DATINGS RESULTS

We surveyed morphotectonic markers along the northern part of the Mejillones Fault where they were the best preserved from erosion. Three sites were selected in order to measure the cumulated displacements along the fault (Fig. 1). The mean offsets were determined from Digital Elevation Models (DEMs) calculated from differential GPS measurements with 1 cm accuracy. Series of cross-sections in DEMs allowed us to estimate the mean vertical cumulated offsets. We obtained 13 ± 1 m and 5.5 ± 0.5 m for the offsets of two surfaces, S1 and S2 respectively (age of S1 > S2). We collected samples from granitic boulders well incased in the two alluvial surfaces. S1 and S2 surfaces were sampled, and on both sides of the fault scarp. For each surface, 5 boulders were sampled with two or three samples by boulders: one at the top, one in the core and one at the bottom. These samples were dated using in-situ produced cosmogenic ^{10}Be.

The assumption of negligible erosion of boulders allows us to estimate the minimum exposure ages using ^{10}Be production rates, calculated from the latitude and altitude dependent polynomials of Lal (1991). Preliminary available results from S2 surface give a minimum exposure age of 20000 ± 3000 yrs (Table 1), which yields a slip rate of 0.28 ± 0.05 mm/yr.

Table 1.- ^{10}Be concentrations and calculated minimum exposure ages.

Sample	Surface unit	10Be (atoms/g)	Uncertainty (atoms/g)	Minimum age (yr)	Uncertainty (yr)
C99-13	S2	86 480	10 383	18 882	2 267
C99-14	S2	59 561	9 585	20 435	3 289
C99-15	S2	62 145	12 568	13 552	2 741
C99-16	S2	47 136	9 533	19 145	3 872
C99-17	S2	69 121	12 394	15 079	2 704
C99-19	S2	93 154	13 340	20 346	2 914
C99-20	S2	93 630	14 237	32 423	4 930

DISCUSSION

These results, although preliminary (the rest of ^{10}Be analyses are in progress and will be presented during the ISAG workshop), allow us to draw several preliminary conclusions concerning the recent paleoclimatic and tectonic processes along this part of the Mejillones Peninsula.

According with the preliminary ages resulting of S2 (one of the oldest alluvial surface), we estimated that the alluvial unites developed along the northern part of the Mejillones Fault have been deposited during different paleoclimatic events next to last interglacial time (< 125 ka). This way, the sequence of beach-ridge covered by this alluvial fans, in this part of the Pampa Mejillones, can be assigned as maximum to the last interglacial time.

The long-term regional Pleistocene average uplift estimated from the study of marine terraces of the Pampa de Mejillones is 0.2 mm/yr and the double (0.4 mm/yr) for the Morro Mejillones (Ortlieb, 1995). The difference would represent the amount of uplift that is occurring by normal faulting. These calculations are consistent with our estimation of the vertical slip rate along the Mejillones Fault.

Concerning paleoseismology, the features observed along the fault (two offset alluvial surfaces), show that there were at least two events since the abandonment of the surfaces S1. The difference of riser heights of the inset secondary surfaces observed within the main S2 surface, on both sides of the fault, suggest in fact that the cumulated displacements are the results of much more numerous events. Within the most recent alluvial surfaces, inset in S2, we observed a set of cracks trending NS along the trend of the fault scarp. No surface ruptures were reported in the Antofagasta area during the 1995 Mw = 8.0 earthquake (located at the southern part of the peninsula). Nevertheless, tension gashes were described along some faults of the Atacama fault system (Delouis *et al.*, 1998). Therefore, we think that the activity of the Mejillones Fault (and all the system fault of this peninsula) could be related to the occurrence of strong subduction earthquakes (Mw $\geq$ 8.0).

CONCLUSIONS

Late Quaternary deformation in the Mejillones Peninsula is characterised by general coastal uplift and extensional deformation. Tectonic blocks with different uplift rates are separated by normal faults. We estimate the preliminary vertical slip rate along the Mejillones Fault (calculated for the last 20 ka) at 0.28 $\pm$ 0.05 mm/yr. This normal faulting is still active and could be closely associated with subduction earthquakes.

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