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Paleoseismology of the Mejillones Fault, northern Chile

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Subduction earthquakes are one of the most hazardous geological processes in northern Chile, and result from convergence between the Nazca and South American plates. Despite advances in our understanding of their seismic cycle, a complete assessment of the seismic risk posed by subduction earthquakes has still not been acquired. This is due to the lack of crucial information about slip rates, displacement lengths per event, paleomagnitudes and earthquake recurrence times of upper-plate faults in this region. We address this issue by using paleoseismology and geochronological methods to estimate these parameters for the Mejillones Fault, which is located in the Homonym peninsula and represents one of the main upper-plate faults in the northern Chilean forearc. This fault has developed a conspicuous fault scarp in Late Pleistocene- Holocene alluvial gravels, providing first order evidence of its most recent activity. The gravel accumulation has given way to the development of at least four generations of geomorphological surfaces that are spatially and temporary related to the fault, named from oldest to youngest as S1, S2, S3 and S4. Of these surfaces, S1, S2 and S3 have been vertically offset by the fault.

We distinguished three stages in the recent fault behaviour using OSL ages, cosmogenic 10Be ages and trench logging. Stage one spans from approximately 28 to 13 ka and corresponds to the uplift and abandonment of surface S1. The age of approximately 28 ka was determined by correcting the mean age for surface S1, approximately 49 ka, by the amount of inherited 10Be that we constrained for the samples from this surface. According to this, we suggest a slip rate varying between 0.1-0.2 mm/y for stage one. However, a 14C age of 45 ka obtained from a vertically offset marine conglomerate that underlies the alluvial gravels over which S1 was developed, suggests the inheritance corrected age (approximately 28 ka), and thus a slip rate of 0.2 m/ka, is more appropriate for this period. Detailed paleoseismological logging in trenches dug perpendicular to the fault trace revealed two stacked colluvial wedges covered by a hillslope deposit. This sedimentary arrangement, which accumulated following uplift of surface S2, developed between approximately 13 – 7 ka ago, and it suggests the occurrence of two Mw$\sim$7 paleo-earthquakes that promoted the uplifting and abandonment of surface S2. A slip rate of 0.6 mm/y and an earthquake recurrence interval of 4000 y is calculated for this second stage. The third stage is manifest as the hillslope deposit, currently aggrading along the base of the Mejillones Fault scarp. It extends from around 7 ka ago to the Present. This hillslope deposit indicates a change in the seismic behaviour of the Mejillones Fault, from producing metre-scale displacements to smaller individual offsets on a scale of centimetres. The slip rate we estimate for stage three is 0.3 mm/y and the earthquake recurrence is 240 y. This data supports the hypothesis that the Mejillones Fault is active, and that it must be considered as such in studies of seismic risk in northern Chile.