The link between megathrust segmentation and upper plate faulting along the N-Chilean subduction system

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Motivation

While the seismic cycle and segmentation of the subduction zone in Northern Chile has been well examined, only few studies focus on the upper plate faulting of the Atacama Fault Zone (AFZ). As an irregular surface feature, the Mejillones Peninsula indicates a linkage between upper plate faulting and megathrust (Metois et al., 2012; Victor et al., 2011). Compiling data from high resolution satellite images, seismic catalogues and field investigations, we look for further evidence that the upper plate faulting is directly linked to the segmentation of the subduction zone.

Mapping the AFZ (Fig. 1)

The hyper-arid climate of Northern Chile and extremely low vegetation cover makes it possible to easily trace lineaments and other surface structures such as alluvial fans, drainage basins and dried out stream beds on high resolution satellite images.

In this study, we differentiate between active (<Pleistocene), potentially active and inactive or unresolved, following these criteria:

(1) Pre-existing data confirming fault activity (i.e. published literature)
(2) Displacement of Pleistocene features (i.e. cross-cutting relationships with alluvial fans)
(3) Occurrence of cracks and crack fields in the hanging block
(4) Geomorphic indices (i.e. fault scarp morphology, knickpoints, mountain sinuosity, drainage basin asymmetry)

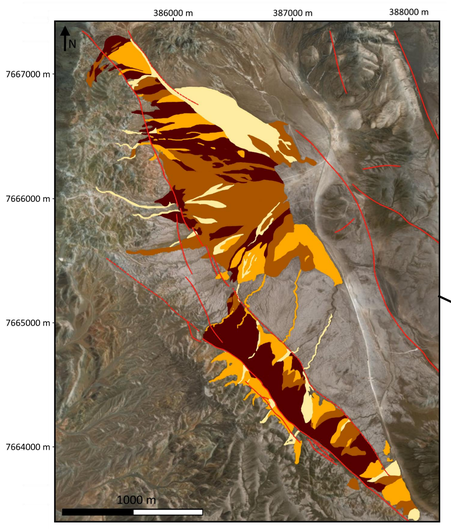


Figure 2: Antena & Bahía Blanca faults and blocked alluvial fan generations

A. Chomache Fault System (CFS)

The Salar Grande area is the most active part of the AFZ. A field study in the CFS revealed that the Antena Norte Fault dips east, while the Bahía Blanca and Antena Sur faults are dipping to the West (Fig 2.). A number of successive transform faults connects the two fault segments.

Signs of activity:

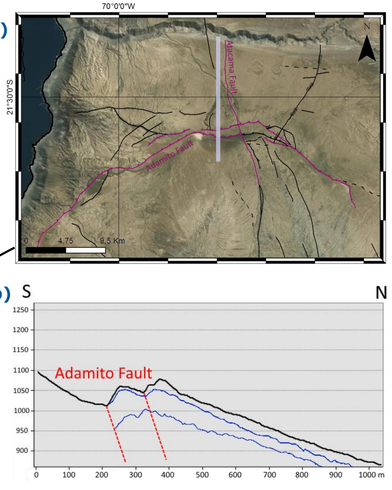
- Four generations of blocked alluvial fans
- Knickpoints of 65-130cm height along the fault
- Displaced stream beds
- Fault parallel crack fields along the southern faults

Figure 1: Structural map of the AFZ in Northern Chile with upper plate seismicity between 1/1/2007 -16/3/2014 and rupture propagation width of the most recent megathrust earthquakes

Figure 4: Seismic profile across the Adamito Fault

B. Adamito Fault

The north-dipping Adamito Fault (Fig. 3a) stretches over a length of 50 km and extends from the surface down towards the subduction zone. In the central part, the fault exhibits two parallel strands, creating a 40-80 m high scarp.



Signs of recent fault activity:

- Clay pan ponding of 40 m depth along the scarp
- Warping of three stream beds (Fig. 3b)
- Fault-parallel crack fields in the hanging block
- Recent upper plate seismicity along the fault (Fig. 4)

Figure 3: a) The Adamito Fault in plan view
b) Topographic cross section of the Adamito Fault, showing river channels warped across the fault scarp

Seismicity and segmentation

North of the Adamito Fault, we have the highly active Salar Grande segment, whereas little to no seismic activity has been observed south of it (Fig. 4). The fault trace seems to align with the segmentation of the megathrust, possibly presenting another link between segment boundaries and upper plate faulting.

Conclusion

Using high resolution satellite images, seismic catalogues, and field data, we can propose upper plate activity. The segmentation of the megathrust is mirrored by surface features such as the Mejillones Peninsula and Adamito Fault, providing possible evidence for linkage between the subduction zone and upper plate faulting.

References: Metois et al. (2012) Interseismic coupling, segmentation and mechanical behavior of the central Chile subduction zone, doi: 10.1029/2011JB00873
Victor et al. (2011) Long-term persistence of subduction earthquake segment boundaries: Evidence from Mejillones Peninsula, northern Chile, doi: 10.1029/2010JB007771