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The 1998 Aiquile, Bolivia earthquake: A seismically active fault revealed with InSAR

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Abstract

Using SAR interferometry (InSAR), the deformation field of the M_w=6.6, 1998 Aiquile, Bolivia earthquake is mapped, and the epicentre accurately located for the first time. Elastic dislocation modelling is used to demonstrate that the measured displacements are best explained with a ~N–S oriented fault, with a strike that is oblique to the principal topographic features in the region, and a location that agrees with a Modified Mercalli Intensity map constructed from observations of damage in the surrounding area. A variable-slip solution for a fault in this orientation is obtained which predicts peak slip of 1.42 m at depths of ~4–5 km on the fault plane and has an estimated seismic moment, M_0=8.44×10^{18} N m, which agrees with estimates from long-period seismology. This is the first time that a fault has been demonstrated unambiguously to be active in the Central Andes, and since there was no previous knowledge of an active fault with this location or orientation, a necessary conclusion is that our understanding of seismic hazard in this region is limited.
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1. Introduction

The town of Aiquile is situated in the Eastern Cordillera of the Bolivian Andes, between the actively shortening fold-and-thrust belt of the Sub-Andes and the high plateau of the Altiplano (Fig. 1, [1]). Folding and thrusting ceased in the Eastern Cordillera in the late Miocene, around 10 Ma [2,3]; however, the region lies

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in the core, or 'hinge zone', of the Bolivian Orocline, and palaeo-magnetic studies and observations of shortening gradients and the pattern of active deformation along the Sub-Andes suggest that relative rotations have occurred in the region in the last 10 My [4–8]. There are several means by which these relative rotations could be accommodated—for instance, by conjugate strike-slip faulting in the hinge zone or by tangential extension along the outer bend of the orocline [7,9].

The topography of the area is dominated by a series of subparallel ridges of intensely deformed Palaeozoic clastic sediments striking predominantly N–S in the southern limb of the orocline and WNW–ESE in the northern limb of the orocline, mirroring the larger-scale changes in strike of the mountain chain. There are steep changes in elevation across the area on several length scales. The total elevation change from the foreland in the east to the edge of the high Altiplano to the west is approximately 3500 m over 200 km, with around 2000 m of this relief across the study area. Locally, individual ridges can rise 500–750 m above their neighbouring valleys over distances of just a few kilometres. It is possible to identify many strong lineations in this topography, many of which have

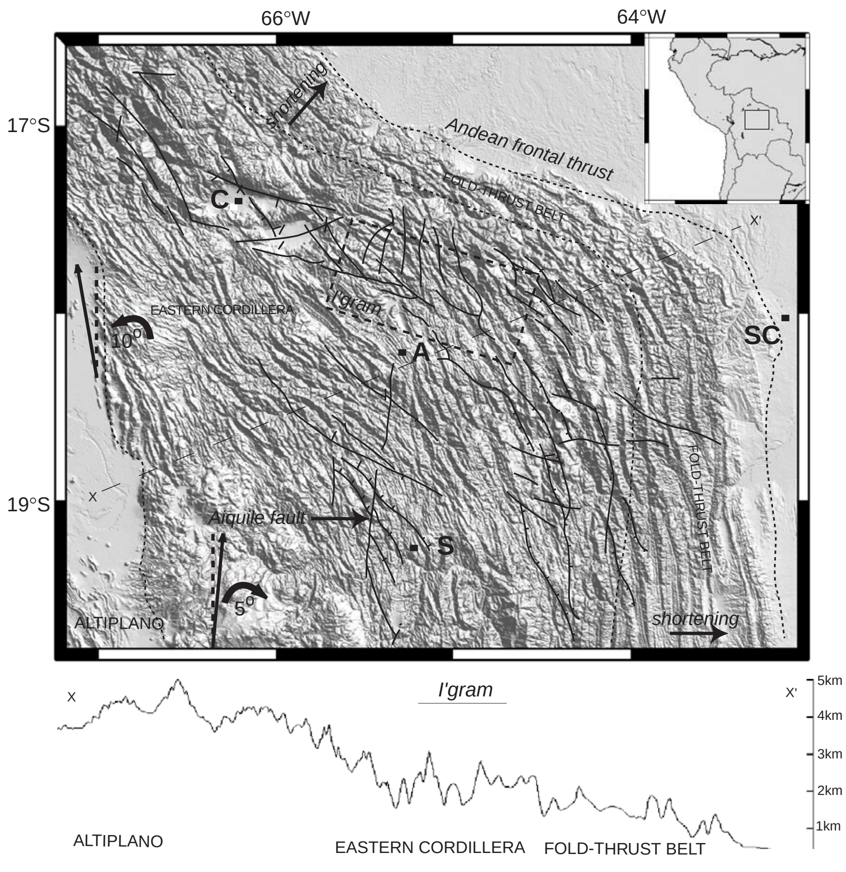

Fig. 1. Simplified tectonic map of the Central Andes, overlaid upon shaded relief topography. The Altiplano, Eastern Cordillera and Sub-Andean fold-and-thrust belt are delineated. Shortening is focussed in the fold-and-thrust belt in the directions marked, measured palaeomagnetic rotations [6] indicate the motion of the hinge zone since 10 Ma. Mapped lineations in the topography [10] are marked with solid lines; however, to date, none have been confirmed to be currently active. The area covered by the coherent portion of the SAR interferogram is outlined (dashed box). A topographic profile shows the steep changes in relief across the area, and across the interferogram (labelled I'gram). Topography is taken from the 90 m SRTM dataset. A=Aiquile, C=Cochabamba, S=Sucre, SC=Santa Cruz.

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