Contribution ID : **20** Type : **Oral Preference**

Surface rupture associated with a moderate intraplate earthquake: the Mw 6.2 Parina event (December 1st, 2016) in the Peruvian Altiplano

Thursday, 25 October 2018 08:40 (0:20)

Content

Fault displacement and Seismic hazard analyses employ empirical relationships to predict potential earthquake magnitude ("scaling relationships"; e. g., Wells and Coppersmith, 1994), surface slip), probability functions of surface rupture and surface slip amount (e. g., “conditional probability of rupture” and “probability of exceedance”, respectively; see Youngs et al; 2003). Those relationships share the common issue that they rely on a limited number of moderate-to-large magnitude (>=6.5) and pre-2000 cases. Earthquakes from western US and Japan are largely represented, and intraplate cases are few. Here, we report surface faulting evidence that occurred during a moderate earthquake that occurred in the Altiplano of Southern Peru. We present field and high-resolution data that improve the geodynamic knowledge of the region and provide clues to upgrade seismic hazard tools. The 2016 Mw 6.2 Parina normal-faulting earthquake occurred within the high Andes of southern Peru in a region with sparse recent seismicity and no observable geodetic horizontal strain. Field observations and high-resolution DEMs of the surface ruptures allow investigating the relationship between slip on the Parina Fault, local geomorphology and the regional tectonics. We mapped one major NW-SE-trending and 6-km-long segment, with up to ˜27 cm vertical slip (downthrown to the SW) and ˜25 cm tensional opening. Surface slip is not distributed off the main fault, with the exception of a parallel strand 200-m off the major one at its northern tip. One striking point is a minor NW-SE-trending and 1.5-km-long ruptured segment with smaller slip values (up to 8 cm) distant by 5 km to the north, along the same fault zone. The two mapped rupture traces directly coincides with the up-dip projection of the co-seismic fault plane inferred from InSAR measurements, and they therefore may represent two distinct surface sections of the primary earthquake fault, separated by a surface gap. This gap occurs where surface geology is constituted of loose sediments. The ruptures coincide with 10-20 m high scarps cutting through fluvio-glacial deposits that are downthrown to the SW, and they form the southeastward extension of the larger Lagunillas-Mañazo fault system that trends NW-SE across the Peruvian Altiplano. A preliminary estimation leads to infer a repeated normal-sense slip on the Parina Fault since the last major glaciation (˜10-30 ka), implying a vertical slip rate ˜1 mm/y. Besides its regional interest in terms of active tectonics and geodynamics (Wimpenny et al., 2018), the Parina surface rupture 1) constitutes a new case to enrich the pending SURE database with new accurate data, especially for intraplate events, 2) surface geology is a key parameter influencing the surface slip, 3) illustrates once again that moderate earthquakes can rupture the surface in a complex pattern, 3) shows that high-resolution techniques allows improving the characterization of surface ruptures (rupture length and max/mean displacement) and 4) potentially questions the fault parameters that were inferred in the past when such approaches were not available. Those are arguments that support the idea of the need for a deep revision of empirical relationships, based on catalogues of modern earthquakes.

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