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Paleoseismic evidence of the 1715 C.E earthquake on the Purgatorio Fault in Southern Peru: Implications for seismic hazard in subduction zones

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ABSTRACT

Active faults in the forearc of southern Peru pose a poorly understood hazard to the region. The Purgatorio Fault is a 60 km-long fault that extends between Moquegua and Tacna that has hosted several scarp-forming earthquakes over the last 6 ka. We present new measurements of the fault scarp geomorphology along the Purgatorio Fault, and use dating of the stratigraphy within a new paleoseismic trench excavated across the fault to establish the chronology of scarp formation. We find that the most recent surface-rupturing earthquake on the Purgatorio Fault occurred sometime between 1630C.E and 1790C.E and had a moment magnitude (M_w) of ~7. We propose that this most recent surface-rupturing earthquake on the Purgatorio Fault was the 1715C.E earthquake recorded in the historical catalogue of the region, which was previously attributed to the megathrust offshore. Our results highlight the importance of establishing a paleoseismic record of onshore faults to differentiate between major megathrust and forearc earthquakes. Given the proximity of these shallow, onshore faults to coastal communities in Peru, the shallow earthquakes they generate may pose a severe, yet often overlooked, seismic hazard.

1. Introduction

The historical record of earthquake shaking in coastal regions adjacent to subduction zones provides important information for estimating the timing, extent and magnitude of past megathrust earthquakes (Dorbath et al., 1990). One approach to quantifying the hazard associated with future megathrust earthquakes is to combine the historical record of large earthquake ruptures with modern geodetic measurements of the slip-rate deficit to estimate the total slip deficit at different points along the subduction interface (e.g. Villegas-Lanza et al., 2016). Where the slip deficit is largest, the possibility of a future megathrust earthquake is generally inferred to be high. Another approach is to compile the along-strike extent of historical megathrust ruptures to infer the presence of persistent 'barriers' on the megathrust that may limit the rupture area of future earthquakes (Dorbath et al., 1990). Ultimately, both methods rely on the accuracy of the historical record of earthquake shaking, and its interpretation, for identifying the along-strike extent and magnitude of past megathrust earthquakes. However, identifying megathrust earthquakes from the historical shaking record is complicated by the fact that shallow faults in the forearc can also host large earthquakes of $M_w > 7$ (Hall et al., 2008; Audin et al., 2006; Benavente and Audin, 2009; Benavente et al., 2021). Forearc earthquakes will rupture faults that dip steeply through the wedge of rock overlying the megathrust, and may reach the surface either on land or offshore. Misidentification of large forearc earthquakes as megathrust events can, therefore, lead to inaccurate hazard estimates for both megathrust and forearc faults. For example, while a megathrust earthquake may pose a larger coastal tsunami hazard, a shallow earthquake on an onshore forearc fault may pose a larger shaking hazard to communities living further inland from the coast.

Subduction of the Nazca Plate beneath the western margin of South America has generated a series of large megathrust earthquakes within southern Peru, most recently in the Mw 8.42001 Arequipa earthquake (Pritchard et al., 2007). The rupture areas and magnitudes of these past

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