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High interseismic coupling in the Eastern Makran (Pakistan) subduction zone

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ABSTRACT

Estimating the extent of interseismic coupling along subduction zone megathrusts is essential for quantitative assessments of seismic and tsunami hazards. Up to now, quantifying the seismogenic potential of the eastern Makran subduction zone at the northern edge of the Indian ocean has remained elusive due to a paucity of geodetic observations. Furthermore, non-tectonic processes obscure the signature of accumulating elastic strain. Historical earthquakes of magnitudes greater than 7 have been reported. In particular, the 1945 Mw 8.1 earthquake resulted in a significant tsunami that swept the shores of the Arabian Sea and the Indian Ocean. A quantitative estimate of elastic strain accumulation along the subduction plate boundary in eastern Makran is needed to confront previous indirect and contradictory conclusions about the seismic potential in the region. Here, we infer the distribution of interseismic coupling on the eastern Makran megathrust from time series of satellite Interferometric Synthetic Aperture Radar (InSAR) images acquired between 2003 and 2010, applying a consistent series of corrections to extract the low amplitude, long wavelength deformation signal associated with elastic strain on the megathrust. We find high interseismic coupling (i.e. the megathrust does not slip and elastic strain accumulates) in the central section of eastern Makran, where the 1945 earthquake occurred, while lower coupling coincides spatially with the subduction of the Sonne Fault Zone. The inferred accumulation of elastic strain since the 1945 earthquake is consistent with the future occurrence of magnitude 7+ earthquakes and we cannot exclude the possibility of a multi-segment rupture (Mw 8+). However, the likelihood for such scenarios might be modulated by partitioning of plate convergence between slip on the megathrust and internal deformation of the overlying, actively deforming, accretionary wedge.

1. Introduction

Along most subduction zones, interseismic subsidence and coseismic uplift of the forearc occur above major seismic asperities along the megathrust. Therefore, geodetic measurements allow us to infer regions of subduction megathrusts that are coupled (i.e. accumulating elastic strain) from those that are creeping (e.g. Savage, 1983). The spatial distribution of coseismic slip during recent subduction zone earthquakes has been inferred to correspond to regions that appear highly coupled during the interseismic period (e.g. Chlieh et al., 2011; Moreno et al., 2011). In addition, it appears that regions of the megathrust that slip seismically and those creeping in the post-seismic phase are mutually exclusive (e.g. Hsu et al., 2006; Baba et al., 2006; Murray and Langbein, 2006). Therefore, identifying portions of the subduction interface that slip aseismically and those that appear to be highly coupled during the interseismic period is a primary step in the assessment of potential future earthquakes.

The 1000-km long Makran subduction zone extends from southern Pakistan to Iran, with the Himalayas to the east and the Zagros orogenic belt to the west (Fig. 1a). This subduction zone is bounded by the left-lateral Ornach Nal Fault to the east and the right-lateral Minab–Zendan Fault to the west. Along this plate boundary, the Arabia and Ormara Plates subduct northward underneath the Eurasia Plate with a 3 to 4 cm/yr convergence

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