Geophysical Research Abstracts
Vol. 16, EGU2014-6092-1, 2014
EGU General Assembly 2014

The Great Sumatran Fault Strike-slip Syntaxes in North Sumatra: New Insights From DEM and Fieldwork Data Analyses

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Oblique subduction produces slip partitioning or decoupling, in which underthrusting of the subducting slab accommodates the margin-normal component of slip while a trench-parallel strike-slip fault accommodates margin-parallel slip. This process triggers the individualization of slivers of lithosphere between the trench slope and the large-scale strike-slip fault, that control the location of earthquakes and volcanic eruptions. This tectonic setting is seen in the Sumatran section of the Sunda arc-trench system, in which the Great Sumatran Fault (GSF) acts as the main strike-slip system. The accurate definition of the structure and geometry of the GSF, as well as that of its main splays, allow proper constraints on the relative motion of the fore-arc sliver plate and its internal deformation. We present a detailed structural analysis on the basis of GDEM and outcrop data at the northernmost tip of Sumatra, including the northwest islands (i.e. between 4,5N and 6N). In this area, we identify two main deformation domains along the GSF, in relation to a western and an eastern branch. The GSF's splays form the structural highs bounding the Aceh Basin as well as distinctive offshore strike-slip syntaxes responsible for the formation of the NW Sumatra islands. Fieldwork observations in relation to the western branch of the GSF show strike-slip or oblique-slip motions and roughly N-S main stress indicators. A >500m2 fault plane exposure shows well-preserved calcite crystallizations and slickenlines, which mark a transition from pure strike to oblique-slip during N-S transpression. In the offshore, the Pulau Aceh islands developed as a transpressional system of thrust splays splitting westwards from the NNW-SSE western trending line of the GSF. These top-to-the-north thrusts, which become younger northward, formed by N-S to NE-SW main stresses. A tectonic restoration based on the geometry of the thrust system points to >20% shortening accommodated by pure reverse dip-slip. The eastern branch of the GSF built the Pulau Weh Island, a tens-of-kms scale Riedel system, which principal stress axis is N-S.

The GSF eastern branch further bifurcates in Pulau Weh, resulting in the development of two NNW-trending ridges to the sides of the island, which are parallel to the main deformation zone. Synthetic R and P systems, with N and NW orientations, are marked regionally by structural highs. The strike-slip syntaxes and the wide distribution of deformation of and within the Sumatra fore-arc sliver document the delocalization of the GSF system. More than 20% of the strike-slip motion in the GSF is accommodated by pure contraction and similar or larger percentages are expected from associated fault splays and strike-slip systems at oblique angles.