Geophysical Research Abstracts, Vol. 8, 08865, 2006
SRef-ID: 1607-7962/gra/EGU06-A-08865

Earthquake magnitude indicated by push-up structures along active strike-slip faults of the South Iceland Seismic Zone

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Because instrumental records do not reliably constrain the largest possible magnitudes over long periods, seismic hazard studies imply evaluation from geological data. The South Iceland Seismic Zone is subject to co-seismic strike-slip faulting and the historical knowledge is good. The most reliable information about earthquake magnitudes comes from the estimation of co-seismic offsets, knowing that empirical relationships between magnitude and peak/average offsets are applicable in Iceland.

These offsets are determined through analyses of push-up structures, which are common. However, such determination of offsets is subject to several biases. A simple geometrical approach based on length measurements cannot suffice because (i) surface deformation occurs with near-base thrusting and near-top extension, (ii) co-seismic deformation induces variations in volume because voids develop in the broken rock mass of the push-up, and (iii) post-seismic deformation also occurs, with progressive gravitational collapse of the push-ups hillocks. A volumetric study taking into account density changes and décollement depth is thus compulsory (see Journ. Struct. Geol. 26, 2004, 709-724).

We carried out extensive structural analysis of push-up structures along several postglacial faults of the South Iceland Seismic Zone (from E to W: the 1912 Selsund Fault, the Tjörvafit, Leirubakki and Réttarnes faults, and the 1630 Fault). We take advantage of new observations about volume changes (e.g., soft material collapse inside push-ups) and depth of décollement (e.g., thickness of lava flows). We also attempt at

evaluating changes in density of push-up mass by means of image analysis and local gravimetric surveys across push-up hillocks.

The results indicated that (i) magnitude estimates from offset determinations are consistent with available instrumental information, such as for the 1912 and 2000 earthquake faults, and (ii) post-glacial earthquakes with magnitudes larger than 7 have occurred, such as for the Leirubakki Fault. Difficulties also arose: in one case (the 1630 Fault), the magnitude evaluation highly depends on whether the two branches of the fault moved during a single earthquake or during two distinct earthquakes, which is not clearly documented.