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How do grabens form: the influence of plate spreading on topography in a magma starved rift

E. Karlsson (1), F. Sigmundsson (2)

(1) Nordic Volcanological Center, Institute of Earth Sciences, University of Iceland and Department of Physics, Umeå University, (2) Nordic Volcanological Center, Institute of Earth Sciences, University of Iceland

The formation of graben structures at extensional rifts is the central part of this study and especially the role of plate movements. Thingvellir that lies in the western volcanic zone (WVZ) in Iceland is used as site to explore the process of graben formations. In the WVZ, few Holocene volcanic eruptions have occurred and a pronounced graben (Thingvellir graben) has formed. We investigate if subsidence in the Thingvellir graben can be mostly attributed to stretching across the plate boundary and the lack of magma infill. For this purpose was a two-dimensional model constructed in the Abaqus finite element package. GPS measured spreading rates and fault throws are used as constraints. Spreading is about 7 mm/yr at Thingvellir and fault offsets in the inner part of the graben suggest a minimum of Postglacial subsidence of 40 m. Three sets of end-member models that incorporates only stretching of the plate; faulting and dyke injections not considered, were tested with varying rheologies and layer configurations. The models are all subjected to a constant horizontal pull of 7 mm/yr over a distance of 20 km during 10 000 yr which is equivalent to the observed spreading rate at Thingvellir today. The results show that a curved boundary layer is essential to create a relative subsidence of the plate; hence with a horizontal boundary between different rheologies there is no relative subsidence. The maximum relative subsidence achieved is about 30 m, occurring when the elastic plate thickness is thin at the rift axis. Plate stretching, considering realistic rheology, may thus have large influence on graben formation at magma-starved rifts.