Geophysical Research Abstracts,
Vol. 11, EGU2009-5142-1, 2009
EGU General Assembly 2009

Anthropogenic and Natural Deformation on Reykjanes Peninsula, Southwest Iceland, observed using InSAR Time-Series Analysis 1992-2008

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The mid-Atlantic Ridge comes ashore on Reykjanes Peninsula in southwest Iceland and extends to the east-north-east to the Hengill triple-junction, which connects it to the south Iceland seismic zone and the western volcanic zone. The crustal deformation in the area is caused by a variety of natural processes, such as earthquakes, magma accumulation, and plate widening, but also by human activity, primarily geothermal exploitation. In this study I use multiple InSAR images to gather information about the various deformation sources on Reykjanes Peninsula. The data come from the ERS-1/2 satellites dating back to 1992 and from the Envisat satellite 2003-2008.

Measuring ongoing plate-boundary deformation with InSAR is challenging, due to the low deformation rates and large spatial extent of the deformation, which sometimes exceeds the typical size of a single radar frame. Therefore, in our time-series analysis we carefully separate the large-scale deformation from potential orbital contributions. The resulting image-wide deformation appears to be caused by both plate-widening on the peninsula as well by inflation centered further to the east in central-Iceland. It is however, difficult to separate the effects of these two processes with the single-component descending InSAR observations. Other prominent deformation signals on Reykjanes Peninsula are uplift east of Hengill volcano due to magma accumulation in 1994-1998 and displacements caused by the magnitude 5.8 Kleifarvatn earthquake in June 2000. The interferograms also reveal small-scale movement of surface fractures at several locations, some of which can be linked with shallow earthquakes, but other not. These movements are usually small, showing only a few mm displacement across 1-2 km long fractures.

Anthropogenic subsidence is clearly detected around two geothermal power-plants on the Peninsula, subsidence that varies both in space and time during the measurement period. The subsidence rate around the Svartsengi power plant is typically about 1 cm/year, apart from one year in 1992-1993 when the rate was much higher, or about 4 cm/year. The variable deformation pattern and subsidence rate can be linked with the production history of the Svartsengi geothermal field. The more recent Reykjanes power-plant that opened in 2006 is located near the southwestern tip of the Reykjanes Peninsula and the measurements show 12 cm subsidence during the first two years of production. The elliptically-shaped subsidence bowl aligns with the major fracture direction in the area, illustrating anisotropic permeability.