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Transient deformation indicating rheological variation in the South Iceland Seismic Zone.

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In June 2000 and May 2008, two sets of magnitude 6.5 and 6.0 main shocks struck the South Iceland Seismic Zone (SISZ) – a transform zone that accommodates E-W left lateral shear at depth by faulting on numerous N-S oriented faults in the brittle crust. Both earthquake episodes consisted of a pair of main shocks of similar size rupturing closely spaced faults, where static and dynamic stress changes generated by the first event triggered the second main shock further west. The June 2000 earthquakes occurred in the central part of the SISZ, and the May 2008 events in the western part, close to the Hengill triple junction.

Since June 2000 we have performed annual GPS measurements in a geodetic network in South Iceland and a number of continuous GPS stations have been installed. The aim is to monitor crustal deformation caused by plate motion, earthquakes, post-seismic transients, and magma movement. GPS and InSAR observations revealed rapidly decaying deformation transients in the SISZ following the 2000 main shocks caused by poro-elastic rebound ($\sim$2 months) and a longer term signal lasting for about 4 years, explained by visco-elastic relaxation of the lower crust and upper mantle with viscosities of 10^{19} Pa s and 3×10^{18} Pa s, respectively. The geodetic studies also suggest that the seismic moment released in these earthquakes was at most half of the accumulated stress since the last major earthquake sequence in 1896–1912. Thus, we may expect magnitude 6–7 events in South Iceland in the near future.

Here, we report pronounced GPS station velocity changes, in particular west of the 2008 epicentral area – still significant in 2012. This result is rather surprising as the 2008 main shocks were smaller (magnitude 6.0) than the 2000 events (magnitude 6.5). Rheological models obtained from studies of the post-seismic deformation following the June 2000 main shocks do not apply directly to the May 2008 events. The rapid transient ($\sim$ week) we observe in 2008 is inconsistent with motion due to poro-elastic rebound, and the longer-term transient requires thinner crust and lower viscosities than obtained from studies of the June 2000 events. In addition to plate motion and post-seismic transients, the deformation field is complicated by subsidence and contraction in the Hengill area as a result of fluid withdrawal for geothermal energy production at two power plants. The overall pattern of deformation since May 2008, however, suggests that the crustal structure in the western part of the SISZ is different from the central part. We also note an increase in strain rates in the epicentral area of the May 2008 main shocks from 2004 to 2007, indicating a link between the strain rate anomaly and subsequent earthquakes. Frequent measurements in dense geodetic networks therefore aid in identify crustal rheology and possible locations of future main shocks.