The Seismic Cycle and Strain Rates in the South Iceland Seismic Zone from GPS observations

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Abstract

The South Iceland Seismic Zone (SISZ) accommodates E-W translation due to oblique spreading between the North American/Hreppar microplate and the Eurasian plate, in South Iceland. Strain is released in the SISZ during earthquake sequences that last days to years, at average intervals of 80-100 years. The SISZ is currently in the midst of an earthquake sequence that started with two M6.5 earthquakes in June 2000, and continued with two M6 earthquakes in May 2008. Estimates of geometric strain accumulation, and seismic strain release in these events indicate that at most only half of the strain accumulated since the last earthquake sequence in 1896-1912 has been released. Station velocities are estimated from annual GPS campaigns and continuous measurements in the SISZ during 2001-2015. The GPS station velocities are used to calculate strain rates from a new method using the vertical derivatives of horizontal stress (VDoHS). The new method allows higher resolution of strain rates than previous approaches, as the strain rates are estimated by integrating VDoHS rates obtained by inversion rather than differentiating interpolated GPS velocities. Estimating the strain rates for eight 1-2 year intervals we find high strain rates in the SISZ (0.5 - 1 μstrain/yr) with significant temporal and spatial variation. This agrees with shallow locking depths (10-15 km) in the SISZ, and faulting to 5-10 km depth in earthquake sequences in June 2000 and May 2008. Subtle signals of post-seismic strain rate changes are seen following the June 2000 main shocks, but interestingly, much larger strain rate variations are observed after May 2008. The GPS station velocities indicate more prominent post-seismic transient signals west of the May 2008 main shocks, than further east, suggesting lateral changes in crustal thickness, and/or rheology across the epicentral area. In addition to post-seismic transients, the strain rates in the SISZ reveal contraction in the Hengill area, and inflation of the magma system beneath Hekla volcano is evident as dilatation over a large area. A prominent strain anomaly is evident in the epicentral area *prior* to the May 2008 earthquakes. The strain signal persists over at least four years in the epicentral area, leading up to the M6 main shocks.

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