Slowly migrating tectonic microearthquake swarms in the Icelandic Rift Zone: driven by pore-pressure or aseismic slip transients?

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Swarms of microearthquakes on a network of conjugate strike-slip faults in the rift zone in Central Iceland have been detected and located using a dense local seismic network operational since 2007. These swarms have been recorded since the 1970s, but the cause of their clear swarm-like nature remains enigmatic.

We use the QuakeMigrate earthquake detection and location software – which is able to detect earthquakes separated by very small inter-event times – to produce a highly complete catalogue. Automatic hypocentre locations have been refined using waveform cross-correlation and double-difference relocation, and focal mechanisms and manual earthquake locations have been produced for a subset of events by manual picking. Analysis of the resulting high-resolution earthquake catalogue reveals systematic migration of hypocentres at velocities of ~1 km/day along sharply defined fault planes ranging from 1 – 10 km in length. In the majority of swarms we also observe clusters of identical repeating events, providing evidence for re-loading of the brittle asperities that produce earthquakes.

For a selection of swarms, our high resolution seismic observations are complemented by GPS and InSAR measurements, allowing us to constrain the amount of fault slip. Comparing this, and the area of the fault plane activated in the swarm, to the seismic moment release reveals a significant contribution of aseismic slip, or very low effective stress drop. Analysis of swarms triggered on these faults by the static coulomb stress increase induced by the 2014 Bárðarbunga-Holuhraun dike intrusion provides a further estimate of the amplitude of the stress cycle.

We combine our observations with comparisons to numerical & laboratory modelling studies, observed swarm scaling properties and knowledge of the geological and permeability structure of the Icelandic crust to determine the nature of the transient forcing driving these exceptionally well-recorded tectonic earthquake swarms.