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Dyke Propagation and Deformation under the Icelandic Rift Zone Tracked by Seismicity.

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Using a large array of 27 three-component seismometers deployed around the northern neovolcanic rift zone in Iceland we have mapped seismicity produced by progressive melt intrusion from 18 to 13.5 km depth along a dyke dipping at 50 degrees in the mid-crust beneath Upptyppingar. Surface deformation measurements from inSAR and GPS suggests that the dyke thickness reached about 1 metre. Local magnitudes of the earthquakes vary from 0–2. Precise locations derived from an automated procedure supplemented by interactive manual refinement of the arrival times enable us to map hypocentres to within 55 m (2-sigma), and show that the seismicity lies on a plane with an rms misfit of only 115 m.

Moment tensor solutions show double-couple failure, with fault mechanisms sometimes flipping between normal and reverse within minutes in the same location. Although the faulting is produced by melt movement, there is no resolvable volumetric component in the moment tensor solutions. The inferred fault planes from microearthquakes align precisely with the overall dyke orientation delineated by hypocentres. We attribute the micro-earthquakes to melt moving along the dyke and either breaking previously frozen melt or intruding in adjacent sub-parallel fractures. Melt injection occurs in bursts travelling at 2–3 m/min along narrow channels only $\sim$0.1–0.2 m thick, producing swarms of microearthquakes lasting several hours. Intervening quiescent periods last tens to hundreds of hours. We have captured the igneous crust in the process of being generated by melt moving upward along an inclined dyke from a sill at 18 km depth and then freezing. We discuss mechanisms that account for the rapid flipping of fault types from normal to reverse as the dyke is intruded.