Episodic propagation of the 2014 Bárðarbunga-Holuhraun dyke intrusion, Iceland

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Volcanic eruptions in rift zones are frequently preceded by lateral migration of a melt-filled dyke, accompanied by abundant seismicity. The 2014 Bárðarbunga-Holuhraun dyke in the northern rift zone of Iceland propagated 46 km laterally, at 5–7 km depth b.s.l. over 13 days prior to erupting. More than 30,000 earthquakes (local magnitudes 1–4) were recorded by a local network of 76 seismic stations. Earthquakes migrated south-eastwards out of the caldera of the Bárðarbunga volcano, starting 16 August 2014, before turning north-eastwards. A 4-hour eruption at Holuhraun began 29 August, followed by the main eruption on 31 August. It continued until 27 February 2015, erupting 1.6 km^3 of lava across 84.1 km^2.

An advancing earthquake swarm marks the leading edge of a propagating dyke. New segments opened by rapid advance of the dyke tip at 0.4–2.0 km/h, separated by stalled periods up to 81 hours. Seismicity was confined to the front of the propagating dyke, suggesting aseismic flow of magma once a pathway has formed and remains open.

Constructed fault plane solutions exhibit focal mechanisms with one nodal plane sub-parallel to the dyke trend, interpreted as the fault plane. The dominant left-lateral polarity can be explained by obliquity of the normal to the fault planes with respect to the regional extension direction of 106°. There is a surprising lack of normal faulting, even though this is an extensional rift setting.

The observations of strike-slip faulting at the dyke tip do not agree with theoretical models postulating failure ahead of the dyke at angles of 30–60° with the propagation direction. Presumably this is because the dyke is re-using existing dyke-parallel fabric in a tensile environment with high fluid pressures, rather than breaking intact homogeneous rock.