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Evolution of a lateral dike intrusion revealed by relatively-relocated dike-induced earthquakes: The 2014–15 Bárðarbunga–Holuhraun rifting event, Iceland

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Understanding dikes is vital as they serve both as bodies that build the crust and as conduits that feed eruptions, and must be monitored to evaluate volcanic hazard. During the 2014–15 Bárðarbunga rifting event, Iceland, intense seismicity accompanied the intrusion of a $\sim$ 50 km lateral dike which culminated in a 6 month long eruption. We here present relocations of earthquakes induced by the lateral dike intrusion, using cross-correlated, sub-sample relative travel times. The $\sim$ 100 m spatial resolution achieved reveals the complexity of the dike propagation pathway and dynamics (jerky, segmented), and allows us to address the precise relationship between the dike and seismicity, with direct implications for hazard monitoring. The spatio-temporal characteristics of the induced seismicity can be directly linked in the first instance to propagation of the tip and opening of the dike, and following this – after dike opening – indicate a relationship with magma pressure changes (i.e. dike inflation/deflation), followed by a general 'post-opening' decay. Seismicity occurs only at the base of the dike, where dike-imposed stresses – combined with the background tectonic stress (from regional extension over > 200 yr since last rifting) – are sufficient to induce failure of pre-existing weaknesses in the crust, while the greatest opening is at shallower depths. Emplacement oblique to the spreading ridge resulted in left-lateral shear motion along the distal dike section (studied here), and a prevalence of left-lateral shear failure. Fault plane strikes are predominately independent of the orientation of lineations delineated by the hypocenters, indicating that they are controlled by the underlying host rock fabric. This high-resolution study provides unprecedented opportunity for comparison with both geodetic and field (frozen dike) observations, and development and consolidation of analytical and analogue models, with implications for rifting processes and real-time monitoring of magma intrusion.