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Relative earthquake relocations and detailed evolution of failed and successful lateral dyke intrusions during the 2021-2022 Fagradalsfjall volcano-tectonic rifting event

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The 6-month long fissure eruption that started in Geldingadalir valley within Mt. Fagradalsfjall, Reykjanes Peninsula, SW Iceland, on 19 March 2021 was preceded by three weeks of intense seismic activity associated with a ~10 km long NE-SW oriented dyke intrusion, along the Fagradalsfjall volcanic system. This was the first eruption in over 800 years on the Peninsula. A multi-institutional seismic network, installed prior to the dyke intrusion, comprises 27, 3-component instruments (25 broadband and 2 short-period instruments) covering the whole Reykjanes Peninsula. Here we focus on the Fagradalsfjall area (~12x10 km) with 4 instruments located within a 2.5 km radius of the observed dyke seismicity. Accurate automatic earthquake locations using a new detection and location algorithm QuakeMigrate[1] obtain an order of magnitude higher number of earthquakes than conventional location methods. For high precision locations, events are cross-correlated and then relatively relocated using GrowClust[2]. Here we present detailed earthquake location results from 18 September 2021 to 30 September 2022. This period comprises i) the 2021 post-eruptive seismicity along the 10 km long 2021 dyke path; ii) an earthquake swarm about 5 km NE of the eruption site at 5-7 km depth in October; iii) a 5 day-long dyke intrusion in December 2021 that failed to breach the surface; iv) a 5-day-long dyke intrusion that breached the surface on 3 August 2022, and led to a 6 week-long fissure eruption in Meradalir, located about 0.5 km NE of the 2021 eruption site.

We find that the failed dyke in December 2021 and the 2022 dyke that successfully breached the surface share many of the same features. They both propagated at similar depths of 3-6 km, in the pathway of the initial 2021 dyke and both show some sparser seismicity closer to the surface. The time span of their propagation is almost identical; both are propagating for around 5 days, with

similar lengths of about 6 km, which is considerably shorter than the 10 km long 3-week 2021 dyke propagation. They differ, however, in their location with respect to the 2021 eruption site. The failed 2021 dyke intrusion propagated mainly SW of the 2021 eruption site, whereas the successful 2022 dyke propagated NE of it. Interestingly, our results suggest that during the initial phases of the 2022 dyke intrusion, two dykelets propagate in opposite directions simultaneously.