Reykjanes Peninsula unrest 2020-2023, Iceland: Deformation history of multiple volcanic systems

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There are several distinct volcanic systems on the Reykjanes Peninsula (RP) in SW Iceland: Reykjanes, Svartsengi, Fagradalsfjall, Krýsuvík, Brennisteinsfjöll, and Hengill, with Fagradalsfjall being least developed. All the systems on the RP except Brennisteinsfjöll have shown signs of volcanic unrest in the past years and decades. We review here the course of events in the ongoing unrest with focus on volcano geodesy. During 2020-2023, localized deformation and seismicity have "ping-ponged" between different systems on the RP. Three uplift episodes occurred at Svartsengi during 2020 and one in May 2022. One subtle deformation event occurred further west on Reykjanes in 2020. Inflation at Krýsuvík occurred during the summer of 2020, after about a decade of subsidence.

To date, three eruptions have occurred at Fagradalsfjall: in 2021, 2022, and July 2023. Each eruption has been preceded by a dike intrusion, often intertwined with complex patterns of faulting, near-surface fracturing over wide areas, and creep along segments of the plate boundary. An additional dike intrusion in December 2021 did not breach the surface. The largest earthquakes during the unrest were M5.65, accompanied by a myriad of earthquakes. The dike growth has spanned days to weeks; furthermore, small dikelets accompanied new vent openings during the 2021 eruption. The dikes were emplaced in the brittle crust, above ~8 km depth, spanned several decimeters in thickness. Co-eruptive deflation was observed in 2021, however, the other eruptions were much smaller in volume, with little co-eruptive deformation. Following the 2021 eruption immediate re-inflation was observed, but the deformation pattern was more subtle following the 2022 eruption, with increased inflation rates in the ~month before the July 2023 eruption. Inflation rates resumed in late 2023. The Fagradalsfjall dikes and associated seismicity released locally a great amount of stored plate-tectonic stresses. However, stress increased locally in several locations, affecting both future earthquakes and possibly locations of future dikes and eruptive vents.

The detailed deformation observations and modeling for the unrest period have revealed complex interactions of tectonics and magmatism across several volcanic systems, highlighting the usefulness of volcano geodesy.