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Linking diffusion chronometry to geophysical indicators of volcanic unrest – Insights from the 2021 Fagradalsfjall eruption

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Effective eruption forecasting and volcanic hazard management depend heavily on our ability to detect when a volcanic system switches from a state of unrest into a state of eruption. The 2021 eruption at Fagradalsfjall in SW Iceland, the first deep-sourced eruption on a mid-ocean ridge system monitored with modern instrumentation, presents an ideal opportunity to compare geophysical and petrological datasets to explore processes of deep magma mobilization and eruption priming. We show that deep magmatic unrest at Fagradalsfjall preceded geophysical eruption precursors by a few years, suggesting that early phases of magma accumulation in the roots of volcanic systems may occur largely undetected with existing monitoring tools. Exceptional parallelism between geophysical and diffusion age records in the months and days prior to eruption signals the rapid transition from a state of priming to full scale mobilization in which magma begins to traverse the crust. Our findings provide new insights into the dynamics of near-Moho magma storage and mobilization and emphasize how combining comprehensive petrological and geophysical records with a near real-time sampling approach can provide powerful insights into the state of magmatic systems in the critical period before eruption run-up begins.