MULTIDISCIPLINARY INSIGHT INTO PETROLOGIC INDICATORS OF ERUPTION RUN-UP

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Unraveling the sequence and duration of magmatic events preceding volcanic eruption is central to understanding volcanoes and the hazards they pose. Geophysical observations of volcanic unrest give unparalleled insight into stirrings within a magmatic system. However, translation of the signals into magmatic processes is complex, and only a few volcanoes are monitored. Petrology offers powerful tools to study eruption run-up that benefit from direct response to magmatic forcings and applicability to most eruptions. Developing these tools, and tying them to geophysical observations, will help us identify eruption triggers and understand the significance of real-time signals during unrest.

Towards this goal, we investigate eruption run-up at both volcano and global scales. For the former, we study eruptions at Shishaldin, Westdahl, and Cleveland volcanoes in the Aleutians, which span a range in eruptive style, volume, and composition. Mixing timescales are determined by modeling Fe-Mg interdiffusion in olivine. For Shishaldin, the best monitored eruption, mixing timescales show at least two recharge events, which occurred roughly 9 months and 50 days prior to eruption. They were contemporaneous with a swarm of deep long-period earthquakes and a large (M5.2) shallow earthquake, respectively. Preliminary results for diffusion modeling at Westdahl and Cleveland yield similar timescales. To put these findings in a broader context, we compile timescales of eruption precursors identified globally with petrologic, seismic, geodetic, and gas approaches. Mixing timescales for a variety of eruptions are between 10^1 to 10^4 days, consistent with our findings in the Aleutians and generally within the range of run-up times defined using other approaches (10^{-2} to 10^3 days). In some cases, multiple mixing events are captured petrologically. Notably, most mixing timescales for mafic to intermediate eruptions are less than 1-2 years. For basaltic eruptions, petrologically defined run-up times are generally skewed to longer timescales than those defined seismically. These results point to recharge events that are initially aseismic. In certain cases, changes in seismic shear-wave splitting or velocity have been observed preceding the onset of precursory seismicity, conforming this observation. Such events that apparently “prime the pump” underscore the importance of carrying out forensic petrology and precursory stress field analysis following monitored eruptions.