

THE RUN-UP TO VOLCANIC ERUPTION UNVEILED BY FORENSIC PETROLOGY AND GEOPHYSICAL OBSERVATIONS

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Volcanoes often warn of impending eruptions. However, one of the greatest challenges in volcano research is translating precursory geophysical signals into physical magmatic processes. Petrology offers powerful tools to study eruption run-up that benefit from direct response to magmatic forcings. Developing these tools, and tying them to geophysical observations, will help us identify eruption triggers (e.g., magmatic recharge, gas build-up, tectonic events) and understand the significance of monitored signals of unrest.

We present an overview of petrologic tools used for studying eruption run-up, highlighting results from our study of the 1999 eruption of Shishaldin volcano. Olivine crystals contain chemical gradients, the consequence of diffusion following magma mixing events, which is modeled to determine mixing timescales. Modeled timescales provide strong evidence for at least three mixing events, which were triggered by magmatic recharge. Petrologic barometers indicate these events occurred at very shallow depths (within the volcanic edifice). The first mixing event occurred nine months before eruption, which was signaled by a swarm of deep-long period earthquake. Minor recharge events followed over two months, which are indicated by a second deep-long period earthquake swarm and a change in the local stress orientation measured by shear-wave splitting. Following these events, the system was relatively quiet until a large mixing event occurred 45 days prior to eruption, which was heralded by a large earthquake (M5.2). Following this event, geophysical signals of unrest intensified and became continuous. The final mixing event, beginning roughly a week before eruption, represents the final perturbation to the system before eruption. Our findings point to a relatively long run-up, which was subtle at first and intensified several weeks before eruption. This study highlights the strong link between geophysical signals of volcanic unrest and magmatic events, and helps open the door for the application of forensic petrology to unmonitored eruptions.