Preferential eruption of andesitic magmas through recharge filtering.

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Andesitic compositions dominate the output of many subduction zone volcanoes. In this environment most andesites are produced by magma mixing, typically between mafic magmas, ultimately derived from the underlying mantle wedge, and felsic magmas produced by crustal melting or extensive differentiation. The high relative abundance of andesitic magmas in arcs require that they erupt in preference to the mafic and felsic magmas that mix to produce them, although the factors that control this remain less well understood.

We investigate this issue through studies of Mount Hood, Oregon, which represents a class of intermediate volcanoes characterized by long-term outputs of compositionally monotonous andesitic magmas, and where recharge and magma mixing play a dominant role in petrogenesis. At Mount Hood 95% of magmas erupted over the last ~500,000 years have SiO_2 contents between 58-66 wt.%, and textural and petrological evidence of magma mixing is ubiquitous. Estimates of the composition of endmember magma compositions involved at Mount Hood can be made by the combination of textural (CSD) and compositional data, and suggest that erupted magmas result from the mixing of mafic (50.7 ± 4.3 wt.% SiO_2) and felsic (70.9 ± 2.1 wt.% SiO_2) endmembers in approximately subequal proportions. These endmember compositions appear to have remained broadly constant through time but are virtually absent from the spectrum of erupted lavas.

Mineral zoning and diffusion modeling shows that mafic and felsic endmember magmas evolve separately, and that mafic recharge and efficient mixing occurs weeks to months prior to eruption. Petrological estimates of pressure and temperature, melt inclusions measurements of volatile abundances and mineral ages from U-series, CSD and additional diffusion modeling also provide additional constraints on the dynamics of the system.

The dependence on recharge for eruption also suggests that crustal and or magmatic conditions beneath Mount Hood prevent eruption of mafic or felsic endmember magmas by themselves, although these are demonstrably involved in magma genesis. We speculate that this relates to difficulties that these magmas have in surmounting density and viscosity barriers, but other mechanisms may also be important. Recharge appears to be the only means by which the volcano can erupt. Because recharge also results in mixing between mafic and felsic endmember magmas, this effectively filters erupted magmas to be mixed andesitic compositions, a process that we term “recharge filtering”.

We suggest that recharge filtering behavior is important at many subduction zone volcanoes, including those which appear highly dependent on recharge to initiate eruptions (Mount Unzen, Soufriére Hills, Mont Peleé) as well as those where recharge and mixing is still common (e.g. Mount St. Helens, Mount Shasta), but where more diverse magma compositions also erupt. This implies that local crustal conditions play an

important role in dictating the compositions of erupted magmas at a given volcano, and that the range and proportions of erupted magma compositions may differ significantly from those present within the magmatic system beneath a given volcano.