Explosive pulse following the late Neogene initiation of the Central Oregon High Cascades

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The Deschutes Formation of Central Oregon (~7.4- 4.0 Ma) preserves a remarkable stratigraphy that records the initial stages of the High Cascade arc following an eastward shift in volcanism ~7.5 Ma. Over 120 (uncorrelated) tephra fall units and 130 ignimbrite units are contained within the formation, suggesting that the arc may have been much more magmatically productive and explosive during this phase than at any other time within the last 17 Ma. This study aims to evaluate this history of explosive volcanism by establishing a comprehensive record of the ages, volumes, composition, and petrogenesis of each explosive deposit in the within the Deschutes Fm.

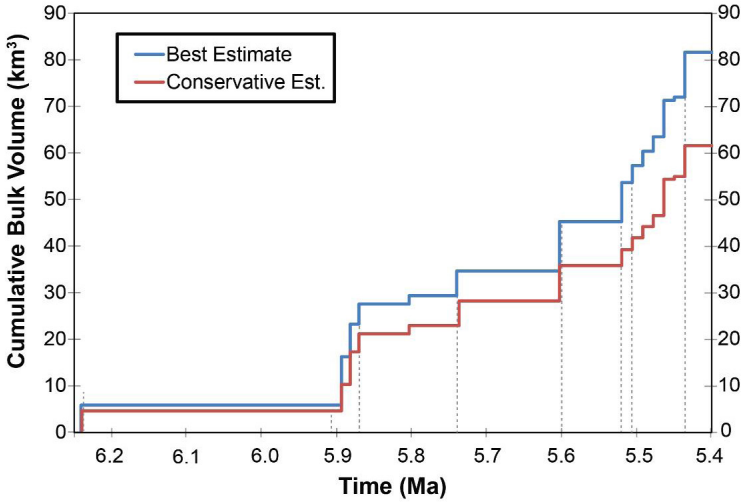

Figure 1. Cumulative bulk volume through time for just the 14 marker ignimbrites. "Conservative estimates" were calculated by assuming the closest possible source, given local geology. "Best estimates" were calculated by assuming a source at the locations of either modern Mt. Jefferson or modern South Sister (as indicated by field evidence). However, both likely underestimate real volumes, as conservative areal extents were assumed, erosion was not accounted for, and thicknesses were not allowed to increase towards the source. Additionally, over 120 (uncorrelated) airfall tuffs and 130 ignimbrites were not included in the cumulative volume. DRE is not included here. Dashed grey lines indicate ^{40}Ar-^{39}Ar plagioclase ages, which have been treated with Bayesian statistics, with the apriori assumption that stratigraphy be met. Eruption ages of ignimbrites without ^{40}Ar-^{39}Ar data were interpolated.

Initial estimates for some of the larger ignimbrite units suggest volumes ranging up to 10 km^3, with sources near the Three Sisters and Mt. Jefferson regions. Conservative estimates of the cumulative volume for only 14 marker ignimbrites is greater than 80 km^3 (Fig. 1). Furthermore, ^{40}Ar-^{39}Ar dating of plagioclase from 7 different ignimbrites indicate that this large volume of silicic material was erupted in less than 1 million years, between 5.44 ±0.04 Ma and 6.24 ±0.07 Ma (2σ). Using the estimated volumes of only these 14 marker ignimbrites, the Central Oregon Cascades had an average silicic eruption rate of 2.1 km^3/m.y. per km of arc length, more than 3 times the rate calculated for the 10 million years prior and 3 million years following this short period. It is likely that after correlating some of the over 300 tuff samples collected within the Deschutes Fm., this regional eruption rate may approach 10 times that of background levels. This seems to suggest that this early phase of the High Cascades in this region were marked by a relative silicic flare-up event.

Glass compositions of pumice from ignimbrites and select tephra fall units (n=718) range from 54 to 76 wt. %

SiO_2. Single eruptions can contain multiple populations of pumice which, in some cases, span a compositional range of almost 20 wt. % SiO_2. This, and the widespread existence of banded pumice, suggests that many eruptions involved multiple magma types. In particular, two marker ignimbrites which contain banded pumice are characterized by a compositional gap between 62 and 68 wt. % SiO_2, possibly suggesting limited mingling of a mafic magma with one derived from partial crustal melting. Trace element data (e.g. Nb, Ce, Th) demonstrate differing trends between pumice sourced from the Mt. Jefferson area and those sourced from the Three Sisters area, indicating that each source sampled compositionally different crust (i.e. Siletzia terrain in the North) and/or mantle sources.

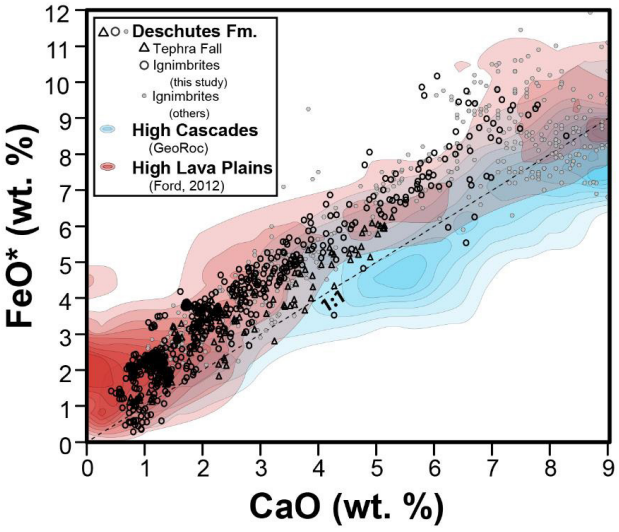

Figure 2. FeO total vs. CaO for the High Cascades (n=2,998), High Lava Plains (n=784), and Deschutes Fm. (n=751, this study). Note that Deschutes Fm. ignimbrites are generally much higher in FeO* for a given CaO [and SiO_2] than Quaternary Cascade products, and instead are more similar to volcanics from the High Lava Plains.

Analyses of pumice glass also indicate that Deschutes Fm. ignimbrites are generally much higher in FeO* for a given CaO or SiO_2 than Quaternary Cascade products, and instead are more similar to volcanics from the High Lava Plains (Fig. 2). This suggests hotter and drier melting conditions during rift-related mantle upwelling and partial melting of mafic crust. We suggest that extension, expressed locally by the Cascade graben, may have contributed to the formation and eruption of large volumes of silicic magma. Furthermore, the eastward shift of magmatic activity to the High Cascades, and subsequent anatexis of previously un-melted crust, could have helped to produce large volumes of silicic magma.