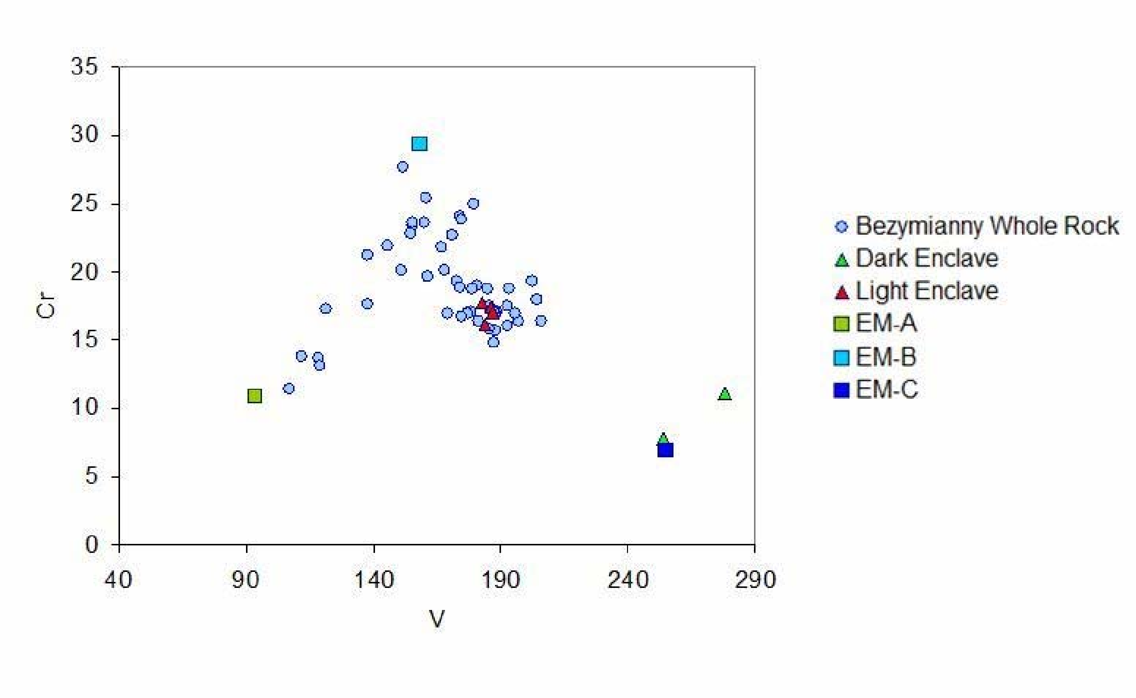
Trace element constraints on the origin of magma diversity at Bezymianny volcano, Kamchatka

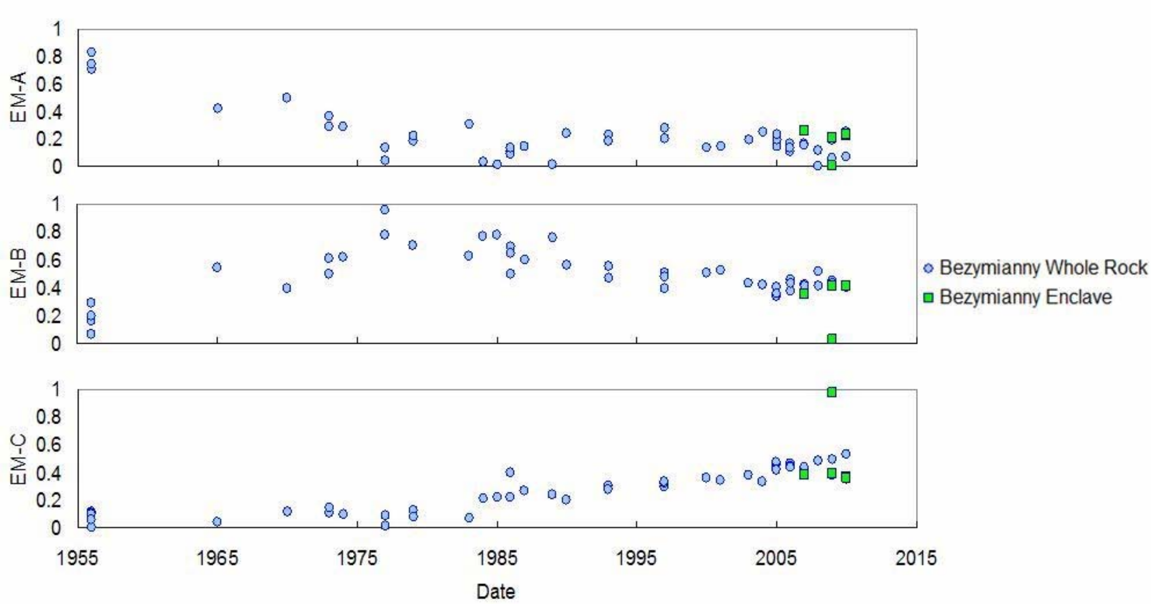
Stephen Turner[1], Jill Shipman[2], Pavel Izbekov[2], and Charles Langmuir[1]

[1]*Harvard University, Cambridge, MA. USA.*
[2]*Geophysical Institute, Alaska Volcano Observatory, University of Alaska Fairbanks, Fairbanks, AK. USA.*

Bezymianny volcano has erupted repeatedly since 1956, providing an opportunity to study real-time processes affecting the chemical evolution of an arc volcano. This work incorporates trace element analyses into the ongoing geochemical and petrological investigation of Bezymianny volcano, Kamchatka. Previous work (e.g. Shipman et al, 2006 & Izbekov et al, 2006) demonstrated a rapid change in major element compositions of the magma since 1956. This trend is characterized by a shift from more silicic magma in 1956 (~60.4% SiO_2) to more mafic compositions (e.g. 56.45% SiO_2 in 2007). Recent eruptive products contain both light and dark colored enclaves, which have also been analyzed for major and trace elements. Trends on element-element variation diagrams support a model in which at least three mixing end-members are combined in various proportions to produce the range of compositional variation seen in the data (figure 1).



Principal component analysis of the dataset, following Weltje (1997), shows that three end-members can reproduce analytical results to within error for 41 elements measured in 53 samples. End-member compositions were determined from the principal component vectors via a least squares fit, enabling the calculation of end-member mixing proportions for each erupted magma. The end-member mixing proportions vary systematically between 1956 and 2010, with maximums for end-members A, B and C during 1956, ~1979, and 2010, respectively (figure 2).



The light colored enclaves are easily reproduced by the calculated mixing end-members, though via different mixing proportions than their host magmas. Two of the dark colored enclaves are likely candidates for end member C.

Measured major element compositions of phenocrysts, combined with published trace element partition coefficients, are used to demonstrate that each of the three end members may have evolved from a common parental magma, provided that their liquid lines of descent differ. The compositional variation of the end members was most likely produced by storage and evolution of a parental magma at three discreet pressures, resulting in fractionation of different mineral assemblages and proportions. The bimodal distribution of amphibole compositions lends additional support to this hypothesis. Systematic variations of the end member proportions through time are consistent with a model in which three magma bodies are connected in series. End member A, presumably stored in the reservoir most directly connected to the vent, dominated the erupted magma compositions in 1956. By 1979, this first reservoir was almost entirely diluted as it drew from a second reservoir initially containing magma with the composition of end-member B. By the 1980s, erupted magmas started to contain detectable quantities of end member C, though this magma may have begun to infiltrate the lower reservoir at any point. Presently, erupted host magmas are a mixture of end members B and C.

References

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