Mid-Miocene basalt driven volcanic field development in the Pacific Northwest, USA

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Mid-Miocene volcanism in the Pacific Northwest initiated at ~16.5 Ma with the onset of regional Steens-Columbia River flood basalt volcanism. During the duration of flood basalt activity, numerous, dominantly silicic eruptive loci and volcanic fields formed (e.g. Santa Rosa-Calico; SC). SC activity initiated at ~16.4 Ma at lasted ~2 Ma. In the SC, a complex volcanic history is recorded by a diverse volcanic assemblage and eruptive history. SC eruptive loci and shallow intrusive bodies are dominantly found in N-S trending zones, parallel to regional mid-Miocene structural trends (e.g. the northern Nevada rift) and illustrate the presence of multiple SC magmatic systems. Additionally, field evidence demonstrates that the SC was characterized by a paucity of caldera-forming silicic volcanism, unlike other contemporaneous volcanic fields. Texturally, SC intermediate and silicic products are characterized by abundant disequilibrium textures, including xenoliths of local granitoid crust and mafic units. Chemically, SC eruptive products and shallow intrusive bodies span a compositional spectrum from basalt through high-Si rhyolite. Most SC mafic units chemically are identical to Steens Basalt, with the exception of a high Mg#, high Ni, low LIL and HFSE suite that resembles regionally exposed HAOT. Mafic units isotopically are identical to Steens Basalt ($^{87}/^{86}Sr_i$=<0.7040). The SC intermediate units are subalkaline to calc-alkaline and exhibit more diverse isotopic compositions than SC mafic units ($^{87}/^{86}Sr_i$=0.7045-0.7056). Silicic units also are chemically diverse and exhibit trace element variations along separate evolutionary paths suggesting open-system differentiation in multiple magmatic systems. These silicic units also are isotopically diverse ($^{87}/^{86}Sr_i$ up to 0.7070) and resemble local granitoid crust ($^{87}/^{86}$Sr@16 Ma= 0.7045 to 0.7058 and 0.7061 to >0.7070). These physical, chemical, and isotopic variations reflect a complex set of open-system petrogenetic processes facilitated by upwelling Steens basaltic magma and localized lithospheric extension. Accordingly, the evolution of the SC is a direct result of the availability of mafic magma, its tectonic setting, the pre-SC lithospheric structure and composition, and mid-Miocene petrogenetic processes. These observations suggest that that the development and styles of volcanism found within other Pacific Northwest mid-Miocene volcanic systems may also be complex and highly dependant on local basaltic input and tectonism.

The noble gas character of mantle fluids associated with Cenozoic volcanism in the SW USA

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Noble gases, and the $^3He/^4He$ ratio in particular, provide critical information about the character and processes controlling the mantle volatile source. We present here new noble gas data that provides a unique insight into the volatile character of the sub continental lithospheric mantle sourcing the Cenozoic volcanism in the SW US. While some volcanic localities allow local mantle $^3He/^4He$ to be determined from xenoliths, suitable samples are not always available, and air contamination of this sample type precludes resolution of the heavy mantle-derived noble gases. Magmatic CO_2 well gases provide a new and exciting resource that enables the $^3He/^4He$, heavy noble gas isotope and relative abundance determination of the mantle source (Ballentine et al., 2005).

Magmatic CO_2 well gases from three systems to the east of the Colorado Plateau uplift, and two systems from within the uplift area have been collected. To the east of the uplift full data sets now exist for Bravo Dome (Harding Co, NM) (Ballentine et al., 2005) and Sheep Mountain (Huerfano Co, CO). Bravo Dome is associated with basaltic Cenozoic volcanism from the Raton-Clayton volcanic field. Sheep Mountain is associated with intermediate to acidic lacoliths. $^3He/^4He$ of the Bravo dome mantle source (5-7Ra) is similar to convecting mantle values of 8±1Ra (where Ra is $^3He/^4He=1.4x10^{-6}$), and the resolved mantle noble gas elemental abundance pattern is indistinguishable from MORB. In contrast, resolved Sheep Mountain mantle $^3He/^4He$~2Ra, pointing to a more evolved mantle source. Importantly, resolved mantle $^4He/^{40}Ar$, $^3He/^{22}Ne$ and $^4He/^{21}Ne$ are also indistinguishable from both Bravo dome and MORB. This requires that the process modifying the $^3He/^4He$ (either U+Th enrichment or gas loss) cannot significantly fractionate the magmatic volatile system during regional evolution of the Cenozoic volcanism.

Completion of data sets for McCallum, (Jackson Co, north CO) and St Johns and McElmo CO_2 gas fields, both from within the Colorado Plateau uplift region, will provide further insight into the regional tectonic control of the mantle volatiles associated with the Cenezoic volcanism.

Reference

Ballentine C.J., Marty B., Sherwood Lollar, B. and Cassidy M. (2005) *Nature* **433**, 33-38