How small-volume basaltic magmatic systems develop: A case study from Jeju, Korea

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Jeju is a volcanic field active since c. 1.8 Ma ago. Eruptive activity began with dispersed, basaltic, monogenetic, volcanism. Continuing monogenetic volcanism was later joined by more voluminous, alkali and sub-alkalic, evolved lava effusion events building a central composite edifice. Samples from older (>0.7 Ma) and younger (<0.2 Ma) monogenetic centres were analysed for whole-rock major elements, trace elements and Sr-Nd-Pb isotopic compositions. Early monogenetic centres are depleted in MgO, Cr and Ni reflecting considerable olivine fractionation. By contrast, younger monogenetic magmas fractionated clinopyroxene + olivine at deeper levels. Isotopes show little variation across the suite, but the younger monogenetic centres have generally lower $^{87}Sr/^{86}Sr$ and $^{208}Pb/^{204}Pb$ and higher $^{143}Nd/^{144}Nd$ than the older centres and sub-alkali lavas. Major and trace element and isotope data suggest a common, shallower source for older monogenetic magmas and sub-alkali lavas, in contrast to a deeper source for younger monogenetic magmas. We propose that mantle melting was initiated near the garnet to spinel transition at a depth of near 2.5 GPa, followed by extension of the melting zone to 3-3.5 GPa, with a concomitant increase in the volume of melt derived from the shallower part of the system to produce sub-alkali magmas, possibly related to accelerated heat transfer resulting from deepening of the melting zone, and/or increased mantle upwelling. A classical mantle plume model for Jeju is not viable due to physical constraints; however decompression melting is still responsible for magmatic activity in the area. Uplift of mantle blocks under Jeju occurred due to lubrication by shear zones created during the opening of the Sea of Japan/East Sea c. 15 Ma ago, and reactivated during rotation of the direction of subduction of the Philippine Sea plate c. 2 Ma ago. This is the first attempt to directly link subduction processes and intraplate volcanism on Jeju.

Volume control on magmatic evolution and eruption style transition, Jeju, Korea

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Jeju is a volcanic field active over the last c. 1.8 Ma. Eruptive activity began with dispersed, basaltic, monogenetic, volcanism. Continuing monogenetic volcanism was later joined by more voluminous, alkali and sub-alkali lava effusion events building a central composite edifice. From three deep cores (400-500 m) through the main edifice flanks, lava samples were analysed for major, trace-element and Sr-Nd-Pb isotope compositions. The low-volume monogenetic volcanoes erupted mainly primitive alkali basalts, whereas the larger-volume lavas have chemical variability spanning alkali basalt to trachyte compositions. The oldest erupted lavas form part of a high-Al alkali suite and evolved to Sanbangsan trachytes (SiO_2 c. 62 wt%). The topmost lavas show less Al_2O_3 enrichment and MgO depletion and hence form a low-Al alkali suite, which evolved to the Hallasan trachytes (SiO_2 c. 66 wt%). The similarities in the chemical evolution trends between low- and large volume magmas suggests similar magma sources and analogous crystal fractionation processes. This implies that the volume and proportions of parent melt was the dominating factor in determining the eventual course of magmatic activity. Based on the chemical trends, the proportions of partial melts must have increased in the middle and later stages of Jeju Island's formation. This may relate to increased uplift of mantle domains (or increased mantle convection) beneath the island, leading to accelerated decompression melting, compared to the early stages of activity. This resulted in the construction of the central composite edifice. Mantle upwelling was greater in the core of the system, resulting in the larger volume lava outpourings, compared the lower supply in distal parts of the field, resulting in low-volume monogenetic activity. These results have implications for hazard forecasting in monogenetic volcanic fields, with a first conclusion being that eruptions situated in the centre of the field may give rise to larger volume lava outpourings compared to those at the outer margins.