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CSI-Magmatic: isotopic evidence that every granite was once a gabbro

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How silicic magma forms, emplaces and/or erupts from the crust is fundamental to our understanding of the Earth. Geophysical images fail to show any large tanks of magma despite the enormity of plutons and super-eruption ignimbrite magma chambers (>100s km2 scale). We have posited that silicic magmas form by top down emplacement of andesite sills coupled with a moving temperature gradient crystal-rich reaction process —with the provocative suggestion that every granite was once a gabbro[1]. A proposed two-stage differentiation process adds the important role of upflow of water-rich silicate liquids to both granite and silicic ignimbrite magmagenesis[2].

Silicic rocks are often spatially connected with mafic rocks having distinct Sr isotope ratios in WR analyses as they are in Torres del Paine (Chile) and Aztec Wash (NV) plutons. However, laser ablation MCICPMS 87Sr/86Sr of plagioclase in granites located just above mafic rocks in both plutons have isotope ratios like the gabbro—fully consistent with the hypothesis that granite formed by reaction from gabbro. In essence, the presence of <500°C water-rich liquids in the pluton allows crustal Sr to contaminate the silicic magma during the granite-making 2nd stage of the reaction process[2]. LA-MCICPMS of Pb ratios in Kspar finds no difference in average ratios of mafic vs felsic rocks. Differences in Sr and Pb behavior are consistent with experimentally-constrained differences in concentrations in these water-rich liquids. X-ray maps and petrography document the complexity of reactions in the gabbros.

Does this same differentiation process produce silicic magmas for zoned ignimbrite super-eruptions? We find that identical behaviors of Sr and Pb ratios occur in silicic and mafic rocks from the Carpenter Ridge tuff and Peach Springs tuff supereruptions, implying the same virtually melt-less silicic magma formation. Examination of Sr ratios for each phase of the Fish Canyon tuff[3] corroborates our formation process. This leaves major questions about how such mush zones melt and erupt yet to be answered. Serious hazards implications exist if this differentiation process indeed operates.

[1] Lundstrom(2016), IGR 58, 371-388; [2] Lundstrom et al. (2022), GSABooks, 553; [3] Charlier et al.(2007), JPet, 1875-1894.