KIMBERLITE AND CARBONATITE PETROGENESIS: CONSIDERATION OF ROLES FOR MELT DENSITY AND VISCOSITY

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Kimberlites and carbonatites are exotic, typically small volume, melts found on several continents on earth. While these melts can be important from a resources point of view due to their tendency to transport diamonds to the surface, they are also likely important players in the earth's carbon cycle as they contain significant amounts of CO_2 [1]. Additionally, it is possible CO_2 is present in the mantles of other terrestrial planets (namely Venus in our Solar System), and it is important to understand this volatile's role in shaping planetary mantles, crusts, and atmospheres.

Kimberlite and carbonatite formation is thought by many to stem from partial melting of carbonated mantle peridotite or melting of metasomatized mantle [e.g., 2, 3, and references therein]. Several other processes, such as liquid immiscibility and xenolith assimilation, have been invoked to operate during the ascent of these melts in order to explain some of their observed field relationships, geomorphic expressions, and chemical signatures [e.g., 4, 5-7].

Previous studies have suggested depths of generation for highly carbonated melts in the earth cover a large extent, from the upper mantle to the deep earth [e.g., 2, 7, 8]. However, another angle from which to constrain the formation, evolution, and role of such melts is through their physical properties, mainly those properties related to melt transport and eruptability. For example, should a carbonated silicate melt become more dense than the surrounding mantle, it will be negatively buoyant and cannot erupt to the surface. Likewise, if the melt is too viscous to percolate through the mantle, it either will remain trapped in the mantle or requires an alternate mechanism of eruption. Both of these outcomes could lead to the existence of deep carbon cycles that operate largely out of contact with the surface carbon cycles, involving ponded melts or melt circulation within the deepest parts of the planet.

Experimental studies have utilized the capabilities of experimental apparatus combined with synchrotron facilities in order to make quality measurements of melt densities and viscosities [e.g., 9, 10, 11]. Many of these studies have focused on the carbonate component only, however, some models of kimberlite magmatism call on processes such as digestion of silicate minerals into the melt during ascent [e.g., 4, 5, 12]. If this mechanism is true, it would mean a continuous modification of melt properties would occur during eruption, and ways to calculate the density and viscosity of the constantly evolving carbonated silicate melt would be required to model these properties during ascent. Thus, synchrotron studies of carbonate and silicate melt endmembers, mixed to varying degrees, will prove useful in understanding the genesis and implications of these melts for planetary evolution.

References

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