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TI: [Compositional Controls on Melt Polymerization](#)

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AB: The structure and rheology of silicate melts are strongly controlled by composition, namely the concentrations of network-forming and -modifying cations. Melt viscosity is implicated in kinetic theories of phase transformations as a proxy for component mobility, which partly controls rates of crystal and bubble nucleation and growth. To anticipate reaction kinetics in magmas and focus experimental work on key variables, compositional controls on melt structure are systematically investigated using NBO/T (Mysen, 1988), the ratio of non-bridging oxygens to tetrahedrally coordinated cations. Silicon, ferric iron, and aluminum are network-formers, whereas alkalis and divalent cations are network-modifiers unless needed to charge-balance trivalent cations in tetrahedral coordination. NBO/T calculations are performed over 4D composition space (alkalis, silica, divalent and trivalent cations), in which 3 components are varied independently, creating a cube. We assess the effects of individual components using slices through the cube contoured for NBO/T. Ratios are also calculated for naturally occurring liquids and MELTS-generated liquid lines of descent derived from basalts with similar silica contents but varying in alkalis. Naturally occurring melts are highly polymerized (NBO/T of 0-1) compared to silicate minerals (0-4). Calculations show that replacing network-modifiers with network-formers decreases NBO/T; conversely, replacing formers with modifiers increases the ratio. However, polymerization increases when alumina replaces silica or when alkalis replace divalent cations. Natural alkali-rich melts tend to have fewer divalent cations than alkali-poor melts at similar silica contents, thus they are more polymerized and have higher viscosities. Contrary to common perception, the lower viscosities of highly differentiated alkalic melts (e.g. trachytes, phonolites) compared to silica-rich rhyolites are attributed to lower silica rather than greater alkalis. In fact, the greater alkali content of trachyte compared to andesite (10 and 5 wt%, respectively) is equivalent to the polymerization contrast between dacite and andesite (65 vs 60 wt% silica). After ~60% crystal fractionation in MELTS, alkali-poor basalt produces a liquid with an NBO/T value ~2x greater than the trachy-basalt derivative, corresponding to a viscosity ~1 order of magnitude lower.

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