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Evidence for silicate liquid immiscibility in the Paraná Magmatic Province

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The Paraná Magmatic Province (PMP) stands out as one of Earth's largest and most well-preserved Large Igneous Provinces (LIP). Like other LIPs worldwide, it features tholeiitic basalts/basaltic-andesites alongside subordinate silicic rocks, which results in a bimodal compositional spectrum constituting two contrasting suites (Low- and High-Ti). At least two primary explanations, including fractional crystallization of basalts and differing sources for basic-intermediate and silicic compositions, dominate discussions in the literature aiming to explain the scarcity/lack of intermediate compositions in the volcanic record (the Daly Gap). However, the potential role of silicate liquid immiscibility in contributing to this compositional gap on the volcanic record has been underexplored and seldom considered. The discovery of natural immiscible Fe- and Si-rich silicate melts, preserved as apatite-hosted silicate Melt Inclusions (MIs) within the sub-volcanic Limeira Intrusion, provides compelling evidence for the involvement of immiscibility in this occurrence. In the plutonic record, incomplete unmixing within a mush emerges as the primary mechanism explaining the presence of intermediate compositions in these intrusions. Furthermore, our findings when allied with new experimental results have broader implications for understanding the Daly Gap within the PMP, suggesting extensive magmatic differentiation facilitated by immiscibility in the High-Ti suite. The interruption of the main liquid line of descent during fractionation, possibly owing to the onset of immiscibility, may account for the silicic rocks, the counterpart most probable to reach the surface and erupt. Thus, a reevaluation of which mechanism - fractionation or immiscibility - best explains the Daly Gap is warranted, especially for cogenetic basic-intermediate and silicic suites. Investigating the magmatic evolution of a relatively simple sub-volcanic body through the geochemical features of apatite crystals and natural immiscible liquids can provide valuable insights into both processes, offering more precise 'smoking guns' for further research. Trace element contents in apatite crystals from the stratigraphic zones that bear Si- and Fe-rich MIs are similar to cumulus apatite from the Sept-Iles intrusive suite. Thus, these compositional similarities (*e.g.*, REE + Y, Sr, V, and Th/Lu and Eu/Eu* ratios) suggest that apatite could represent an indicator mineral for liquid immiscibility in mafic layered intrusions.

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