Goldschmidt 2025 Abstract
https://doi.org/10.7185/gold2025.30141

Evolution of Magma Chemistry in Subduction Zones - Insights from the Electrical Conductivity of Silicate Melt

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Magmatism along subduction zones produces aluminosilicate-rich melt, often andesitic magma, which helps to create new continental crust. However, this magmatism is largely driven by partial melting of the mantle wedge, which tends to produce silica-poor, basaltic melts. The chemical evolution of sub-arc magma from silica-poor (basaltic) to more aluminosilicate-rich (andesitic) is perplexing. While geochemical analyses provide essential insights into the sub-arc magmatism, these analyses are dependent on erupted/exhumed samples which may provide an incomplete record. Magnetotelluric (MT) soundings provide an alternative means to investigate subduction zone magmatism. The MT observations are both sensitive to the presence of magma and the chemistry of the melt (X). Yet, the mobility of charge-carrying ions in a melt is also influenced by pressure (P) and temperature (T). Therefore, it is essential to complement MT measurements with laboratory-based constraints on the electrical conductivity (σ) of silicate melts. To date, laboratory-based measurements on silicate melt σ have helped to interpret MT observations at ≲ 60 km depth, or pressures ≲ 20 kbar. However, the melting in subduction zones may occur deeper at ≲ 180 - 210 km depth (≲ 60 - 70 kbar). The σ of silicate melt at such conditions is poorly constrained. To address this, we performed experiments at pressures ≤ 60 kbar to examine the σ of basaltic to andesitic melts which are common in subduction zones. We constrained the effects of silica, alumina, alkali, alkaline, and water (H_2O) contents on the σ of silicate melt. We find that basaltic melt is overall more conductive than an andesitic counterpart. The σ of basaltic magma is also less sensitive to pressure than andesitic magma. Water lowers the activation energy and enhances σ for all melt compositions. Our results constrain how the electrical properties of a magma change with an evolving composition in a subduction zone.