Effects of pressure and water on electrical conductivity of carbonate melt with implications for conductivity anomaly in continental mantle lithosphere

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MT surveys have detected electrical conductivity anomalies in the subcontinental lithospheric mantle (SCLM) of the Slave and Brazilian Cratons. Due to the higher conductivity of carbonate melt in comparison to silicate melt, we hypothesize that a small carbonate melt fraction may be responsible for these anomalies. To test this hypothesis, hydrous and dry carbonate materials were synthesized and subjected to an electrical conductivity measurement under high temperature and pressure via a Kawai-type multi-anvil experiment. These experiments were performed at temperatures up to 1800 K and over a pressure range of 3.4 to10.9 GPa. Dry carbonate was synthesized as a combination of $MgCO_3$ and Na_2CO_3 while hydrated carbonate was a synthesis of $Mg_5(CO_3)_4(OH)_2 \bullet 4(H_2O)$ and Na_2CO_3. All compositions are a eutectic fraction to avoid partial melting or partial crystallization during heating and cooling.

Our experiments show that the hydrous carbonate system has a lower eutectic temperature than the dry carbonate system. In each case, the eutectic temperature increases with increasing pressure. It is also shown that molten carbonates, both hydrous and dry, can be closely modelled with an Arrhenius relationship and the negative pressure dependence of the hydrous carbonate is greater than the anhydrous carbonate mixture. Through the application of the Arrhenius law and the post-experimental volume of the sample, activation volumes are found to be ΔV = 1.81 and 3.61 cm・mol^{-1} for the anhydrous and hydrous carbonates respectively. This suggests that kimberlites and the presence of related carbonate melt in the SCLM can be a candidate for causing the electrical conductivity anomalies at depth in the Slave and Brazilian lithosphere.