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Mantle Electrical Conductivity and the Deep Carbon Cycle

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Electrical conductivity of mantle regions where volatiles are entrained at depth by subduction or where volatiles ascend from depth at hotspot and mid-ocean ridge displays anomalously high values, which exceed the conductivity expected from laboratory measurements on fluid-free mantle rocks. There is little doubt that such anomalously conductive regions image the flux of mantle fluids, which directly impacts on the global geodynamics. However, the nature of the fluids and its role on volatile's transfers remains debated. Mantle conductivity has long being related to the presence of water, as defect in minerals, and its impact on mineralogical transition or melting processes in the convective mantle, but recent experimental data question this paradigm. Furthermore, volcanic gases from basaltic centres and geochemical models clearly indicate the presence of carbon in the mantle at concentration levels similar to those of water. All this demands a new global picture of mantle geophysics taking into account the geochemical complexity of mantle volatiles.
Carbon in mantle rocks is very likely in the form of carbonatite melts at grain boundaries. Experimental measurements and molecular dynamics calculations show that the presence of carbonatite melts greatly enhances mantle conductivity, making possible the interpretation of conductive regions as due to carbonatite melts in mantle rocks. I will show that electrical bright spots coincide with the presence of carbonatite melts expected from petrological and geochemical constraints on the deep carbon cycle. I conclude that mantle regions with high conductivity most likely delineate region where carbonatites are stable. If truly indicative of carbonatite melts, such conductive regions should be delimited by thermodynamic boundaries which are expected to be 1-melting of carbonate mineral, 2-reduction of carbonate into graphite or diamonds and 3-incorporation of carbonate melts into silicate melts. I will show mantle electrical conductivity profiles and maps that most likely illustrate each of the 3 geochemical processes above mentioned, and I will outline several implications and questions arising from this new interpretation of mantle electrical anomalies.