Geophysical Research Abstracts
Vol. 14, EGU2012-4980, 2012
EGU General Assembly 2012

Which geodynamic roles for volatile-rich low melt fractions in the Earth's mantle?

F. Gaillard
ISTO CNRS- Univ. Orléans, France (fabrice.gaillard@cnrs-orleans.fr)

Volatiles and melts are thoroughly related in the Earth's mantle because volatiles facilitate melting and melts concentrate mantle volatiles. Mapping of mantle solidus by mean of experimental petrology has long established that melting can occur in numerous mantle regions provided that volatiles are present in the rocks. Volatile concentration in mantle rocks is however small and consequently, associated melt fractions are small. The produced liquids are carbonated melts, which can incorporate variable amount of silicate components and are extremely rich in volatiles (H-Cl-F-S). Because melting profoundly affects rock physical properties and geochemical mass transfers, the localization and recognition of such melts inside the Earth are critical for our understanding of global mantle geodynamics.

Mantle electrical conductivity, rather than seismic methods is most suited to identify the presence of such low melt fractions, because low melt fraction likely to form at depth > 150 km are expected to constitute about 0.1% at the grain boundaries of mantle rocks. Recent electromagnetic surveys (see Tarits et al. this meeting) indicate that underneath Mid-Oceanic Ridges, mantle rocks are continuously conductive from 60 km, the depth of MOR-basalt formation, to >400 km depth. Such conductive mantle rocks are clearly attributed to small fractions of carbonated melts, which furthermore most likely contain high amounts of water (see Sifré and Gaillard, this session). This petrological interpretation of mantle electrical anomalies contrasts with the traditional mineral physic views that attributed high mantle conductivity to crystallographic defects associated to water incorporation in olivine. But the water in olivine model is disputed by nearly all existing experimental data.

The amount of carbonated melts required to explain mantle conductivity suggests about 170-300 ppm CO_2 in the mantle that sources MOR-basalts, which is in excellent agreement with geochemical estimations (180 +/- 100 ppm). The geochemical-geodynamic implications of continuous melt films wetting grain boundaries from the transition zone the MOR-basalt source regions are then discussed following several key observations: (1) The redox transition from carbonate to diamond expected from petrological models to occur at 200-250 km depth is not consistent with geophysical observations implying a revision of mantle redox state in up-welling regions; (2) The petrologically assessed depth of anhydrous melting of carbonate is 350km but high conductivity extends well below, implying a likely hydrous melting of mantle carbonates; (3) A continuous network of low melt fractions from the transition zone to the MOR-B melting regions has major implications regarding the rate of transfer of incompatible elements from the transition zone to the lithosphere-asthenosphere boundary, which might be faster than mantle convection rates; (4) these incompatible elements include volatile species such as water, which would not only sit in olivine and radioactive elements, implying that an important mantle heat source is in fact mobile.