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Fluoride melts in subduction zones: Occurrence, origin and implications for mantle metasomatism

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Hitherto unknown fluoride melts were found in metasomatized mantle xenoliths from New Zealand [1]. These fluoride melts were only preserved in rock fragments that were carefully polished using non-hydrous polishing liquids. The protogranular spinel wehrlites consist of mm-sized olivine, clinopyroxene, amphibole, accessory minerals as apatite and spinel and, on grain boundaries and in melt pockets on triple junctions, silicate and fluoride glasses. Fluoride glasses occur as veinlets and as thin films on grain boundaries, as well as in melt pockets on triple junctions. The fluoride glass is transparent, slightly yellowish and sometimes contains small secondary clinopyroxenes, and only rarely sulfide blebs or fluid inclusions. The fluoride melts are interpreted to be derived immiscibly from a precursor silicate melt and the most spectacular textural evidence for liquid immiscibility is found in one of the xenoliths.

Minerals and melts in the xenoliths were analysed for major and trace elements using electron microprobe and Laser Ablation ICPMS. Trace elements are effectively partitioned between immiscible fluoride and silicate melts. For example, separation of immiscible silicate and fluoride melts fractionates light REE from heavier REE or HFSE from REE. [1].

In many cases, silicate glasses found within mantle xenoliths are products of infiltration of the host magma into the mantle xenoliths during ascend. This is, however, not the case here as comparison of the major and trace element composition of the host lava with the silicate glass indicates. The major element composition of the immiscible silicate glasses is characterised by extreme enrichment in Mg and Al, which places them close to high-Mg magmas that are commonly found in subduction zones. The genetic link to subduction zones is further substantiated by extremely low high-field strength element concentrations (e.g., Ti, Zr, Hf) that are characteristic for magmas observed in subduction zone settings.

References

[1] Klemme S. (2004) *Geology*, in press.

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Immiscible liquids during high pressure melting of carbonaceous pelites and marls

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Phase relations were studied in simplified model systems (KNCaFMAS-HC and KCaMAS-HC) at 2-5 GPa, 750-1300 °C, targeting the composition of melts, the conditions of melting, and just-below-the-solidus reactions in carbonaceous pelites and marls. Bulk compositions had saturation hierarchies quartz>kyanite>mica>carbonate, comparable to natural marls consisting of siliceous, pelitic and carbonaceous components. Experiments were carried out in end-loaded piston cylinders and Walker-type multi anvil apparatus. Starting materials were mixtures of glasses or gels with mixed fluid (H₂O-CO₂) added as Al(OH)₃ and CaCO₃. For the KNCaFMAS-HC system a Fe-rich marl from the Antilles (Plank&Langmuir 1998, Chem.Geol.145,325f) was used.

Melting relations were constructed from the experimental results. At fluid-absent conditions, 3.7 and 5 GPa, KNCaFMAS-HC system, phengitic micas disappear near 1000 °C forming a potassic granite melt coexisting with calcite, cpx, garnet and kyanite. At higher temperatures (~1100 °C) a Ca-carbonatite and a silicate melt coexist with garnet, kyanite and cpx defining a distinct two-melt field.

Reaction textures and mass balance calculations imply achievement of equilibrium in the experiments. At 3.7 GPa and 1050 °C the calculated silicate melt fraction in the system of 0.32 is in agreement with modal estimates and results from incongruent melting out of phengite in a narrow temperature interval at the solidus. Very surprising, the silicate melts are poor in Na and coexist with a cpx that has up to 80% jadeite component ($D_{Na}^{cpx/melt}$ up to 6.5). At 1100 °C the calculated silicate melt fraction is 0.43 and that of the carbonatite liquid 0.03, however, in the absence of segregation, analyses of the droplets of carbonatite liquid are difficult.

At 2.0-3.0 GPa (in the simplified KCaMAS-HC), zoisite+cpx are present in addition to the saturation phases at subsolidus conditions. Melting at 850-900 °C is still dominated by the micas, and results in potassic silicate melts. At higher temperatures, carbonatites are expected to appear at above 2-2.5 GPa. Depending on pressure, carbonates disappear during melting near 850 °C and kyanite saturated melts form garnet only at 150 °C higher temperatures. The observed melting of the carbonates provides a mean of transferring CO₂ into the mantle wedge (a process which is completely inefficient with fluids), where the carbonatites and potassic granites would react and probably get stuck, thus metasomatizing the mantle.