Melting of clinopyroxene + magnesite and its role on the formation of CO_2-rich magmas

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The assemblage clinopyroxene $Ca(Mg,Fe)Si_2O_6$ (cpx) + magnesite $(Mg,Fe)CO_3$ (mc) has been observed in ultra-high pressure metamorphic rocks from Dabie (China) (Zhang and Liou 1994). This suggests that this mineral association can be stable at high pressure in a subducted slab and/or at the interface between a slab and the mantle wedge. It has been proposed that the rarity of this assemblage at the Earth's surface results from its destabilization during the transfer from the slab to the mantle or during the path to the surface (by tectonic exhumation or magmatic eruption). Kushiro et al (1975) and Brey et al (1983) show experimental evidence for the stability of the iron-free cpx + mc assemblage from 2 to 5 GPa at subduction zones temperatures. This assemblage, however, is destabilized when temperature increases in contact with the mantle wedge. It reacts to form orthopyroxene $MgSiO_3$ (opx) + dolomite $CaMg(CO_3)_2$ (dol) above 950°C at 3 GPa. According to Wyllie and Huang (1976) and Eggler (1978), the opx + dol assemblage also transforms into cpx + forsterite Mg_2SiO_4 (fo) + CO_2 (V) below 3 GPa if the temperature increases to the mantle adiabat. Eggler suggested that a melting reaction that would consume dol, di and V to form fo and melt should occur at 1275°C at 1.8 GPa. The presence of iron in the cpx + mc assemblage could lower its melting temperature and produce a carbonate-silicate melt which may metasomatize the mantle. Martin et al (2012) show experimentally that an iron-bearing assemblage cpx + mc is stable at 6 GPa and subduction zones temperatures. However, the role of iron content and fO_2 variations on the fate of cpx + mc in portions of the mantle away from subducted slabs has not been constrained. Therefore, we performed piston-cylinder experiments at 1.8 and 3 GPa and temperatures corresponding to the Earth mantle adiabat using a starting mixture of diopside $CaMgSi_2O_6$ and magnesite $MgCO_3$. The role of iron and of fO_2 was investigated by replacing magnesite by siderite $FeCO_3$ or by adding either C graphite or Fe metal to the system. We show that melt forms in equilibrium with olivine, clinopyroxene and iron oxides (Martin and Righter 2013). Moreover, the presence of ferrous or metal iron decreases the liquidus temperature and favors the melting of cpx + mc deeper in the mantle. The produced silicate-carbonate melts (10-46 wt% CO_2, 0.1-31 wt% SiO_2, 11-55 wt% CaO, 1.9-18 wt% MgO and 0.01-37 wt% FeO) could play a role in the generation of CO_2-rich magmas (e.g., carbonatites or kimberlites). They could also metasomatize the mantle and modify the petrology (e.g., by increasing the olivine fraction and producing graphite) and chemistry (fO_2, trace elements and REE) of the source of subduction magmas.