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Garnet-orthopyroxene and garnet-olivine geothermometry: the influence of Fe3+

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The application of Fe2+-Mg-exchange thermometers will lead to incorrect temperature estimates, if the Fe3+ effects in coexisting phases are not taken into account. This can cause an underestimation of calculated temperatures of more than 200°C in garnet-olivine or garnet-orthopyroxene- thermometers (O'Neill 1979, Harley 1984). In order to quantify this effect, high pressure experiments were carried out in a belt apparatus in a natural system close to CFMAS (CaO-$Fe2O_3$-FeO-MgO-$Al2O_3$-SiO_2) at 5GPa and 1000 to 1400°C under Re/ReO_2 buffered conditions (Pt-capsules were lined with Re-foil). This should generate higher Fe3+/Fe2+ ratios in our experimental phases compared to those experiments which were carried out previously in graphite containers. Two mineral mixtures were prepared as starting materials which differ in their Fe3+/Fe2+ ratios and the nature of the mineral phases. A relatively reduced starting material consists of a mixture of natural olivine and orthopyroxene (sample SC-1; Brey et al., 1990), synthetic larnite (Mg96Ni4)2SiO4. The oxidized material is made up of SC-1 orthopyroxene, natural andradite and synthetic forsterite, (Mg96Ni4)2SiO4, and larnite. Moisture was added to the experimental charges by breathing onto the starting material. The duration of the experiments varied between 2 days and 2 weeks, depending on temperature.
The composition of the starting materials was such that all four phases olivine, orthopyroxene, clinopyroxene and garnet were present after the experiment. The run products were analysed by EPMA using the JEOL JXA-8900 Superprobe. So far, we evaluated the 1100, 1300 and 1400°C runs by applying various thermometers assuming all Fe to be present as Fe2+. The deviations for the Fe-Mg thermometers from the experimental temperatures and the two-pyroxene thermometer should be a measure of the increased Fe3+ which is present compared to the experiments in graphite containers. The effect must be small for a grt-cpx thermometer.
The two-pyroxene thermometer of Brey et al. (1990) reproduced the temperatures to ±26°C and the grt-cpx Fe-Mg thermometer by Krogh underestimated the temperatures on average by 25°C. The ol-grt thermometer by O'Neill and Wood (1979) underestimated at 1100°C by 200°C, at 1300°C by 140°C and at 1400°C by 40°C. The corresponding differences for the Harley (1984) grt-opx thermometer are -70°C, -145°C and -80°C.
The Fe3+/ΣFe - proportions of the experimental garnets will be determined in situ with the flank method (Höfer and Brey, 2007). With these results a correction factor for the garnet-orthopyroxene and garnet-olivine thermometers will be developed.

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