A potential geothermometer for antigorite serpentinite

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Geothermobarometry in antigorite serpentinite is traditionally hampered by the lack of assemblages buffering the antigorite composition, and customarily relies on the conditions at which breakdown reactions occur of phases like brucite, diopside or titanian clinohumite and/or alternatively on associated mafic assemblages. The aluminium-content in antigorite may provide an independent constraint of the pressure-temperature conditions for serpentinite phase equilibria. Such information would permit a more precise estimation of the conditions for the subduction and exhumation structures recorded in serpentinite during orogenic cycles. Additionally, the relation between the Al-content and the modular structure in antigorite could be investigated more precisely without the need of indirect temperature constraints based on associated mafic rocks.

A model for the incorporation of alumina in FeO-MgO-Al_2O_3-SiO_2-H_2O (FMASH) serpentinites has been developed by considering ideal Tschermak ($Al_2Mg_{-1}Si_{-1}$) solid solution in antigorite [1]. In the assemblage antigorite-olivine-chlorite-fluid the Al-content of antigorite is buffered and temperature sensitive. This temperature sensitivity is the basis for a serpentinite geothermometer at greenschist, amphibolite and eclogite facies conditions. The buffer assemblage is stable in harzburgite bulk compositions for relatively moderate amounts of Al_2O_3 (> 1.8 wt. %) and is widespread in lherzolites protoliths, where it occurs together with diopside or, in a narrow higher temperature field, with tremolite.

The utility of the Tschermak solid solution model in antigorite has been applied to serpentinite samples from the Betics (Cerro del Almirez, Spain) and the Western Alps (Zermatt-Saas). Agreement with previous estimates of metamorphic PT conditions supports the reliability of this new geothermomether.

[1] Padrón-Navarta *et al*.., 2013 Tschermak's substitution in antigorite and consequences for phase relations and water liberation in high-grade serpentinites. Lithos (in press)

Quantifying effective ferric iron content in hematite-rich metapelites through phase equilibria modelling

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Iron is a common element in metapelites and is usually approximated to be entirely ferrous. Underestimating the ferric iron (Fe^{3+}) content, however, may result in erroneous whole-rock compositions and thus incorrect P-T estimates when dealing with Fe^{3+}-oxides-rich metapelites. A geothermobarometric-based approach to infer the rock Fe_2O_3 content is here presented using hematite-rich metapelites from Palaeozoic basement of the Pisani Mts. (Northern Apennines, Italy) as example. The paragenesis is represented by phengitic white mica, chlorite ($XFe^{2+} = Fe^{2+}/(Fe^{2+}+Mg) = 0.54$), chloritoid porphyroblasts ($XFe^{2+} = 0.86$), quartz and rutile. Hematite is widespread in the matrix and locally forms mm-thick layers. Because of the lack of reliable Fe^{3+} recalculation scheme for major rock-forming minerals, thermodynamic modelling was first attempted assuming whole-rock total iron as FeO. This assumption failed to reproduce the observed paragenesis and mineral compositions. This mismatch suggested that a certain amount of bulk Fe_{tot} must be converted into Fe^{3+}, which is mainly contained in hematite. In order to calculate the Fe_2O_3 content a P-X_{Fe2O3} ($X_{Fe2O3} = Fe_2O_3/(FeO + Fe_2O_3)$) pseudosection was performed at a fixed T = 475 °C, estimated through the chloritoid-chlorite geothermometer [1]. XFe^{2+} in chlorite and chloritoid intersect in the field corresponding to the observed paragenesis, at $P \approx 9$-10 kbar and $X_{Fe2O3} \approx 0.6$, which is the effective Fe^{3+} content needed to stabilise the observed paragenesis. The inclusion of Fe^{3+} in the modelling increases the whole-rock $MgO/(MgO+FeO_{tot})$ ratio, which in turn affects chloritoid and chlorite XFe^{2+}. The new P-T constraint agrees with available thermobaric conditions for the Alpine metamorphism in Northern Apennines recorded in Triassic metasedimentary cover, especially in the Verrucano facies rocks [2]. Our modelling suggests that the generally overlooked Northern Apennine Palaeozoic basement was deeply involved during the Paleogene collision between the Adria and Corsica-Sardinia microplates.

[1] Vidal et al.. (1999) Journal of Metamorphic Geology **17**, 25–39. [2] Franceschelli et al.. (2004) Periodico di Mineralogia **73**, Spec. Issue 2, 43-56.

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