Comparing cordierite from natural hornfelses and low-P experiments on quartzphyllites: implications for petrogenetic use of cordierite

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The mineral cordierite $(Mg, Fe, Mn)_2Al_4Si_5O_{18}*X(H_2O, CO_2)$ is a common and important rock forming mineral in medium- and high-grade aluminous rocks of the amphibolite- and granulite-facies. Cordierte can not only be considered as an important mineral for thermobarometry but since it incorporates large cations such as Na and K as well as uncharged molecules such as H_2O and CO_2, it can be also used as a monitor for the composition of the coexisting fluid phase.
In order to investigate the systematic variation of cordierite composition with temperature, we compared cordierite compositions from the contact aureole along the southern rim of the Brixen granodiorite with low-P experiments on natural quartzphyllites. The experiments were performed on a natural quartzphyllite sample with the chemical bulk rock composition SiO_2 = 60.81, Al_2O_3 = 19.63, Na_2O = 1.68, MgO = 1.12, K_2O = 0.71, CaO = 1.18, FeO = 6.91, H_2O = 2.39 wt. % and with the mineral assemblage quartz + chlorite + muscovite + biotite + garnet + albite in a hydrothermal apparatus at ca. 0.3 GPa. In addition, due to kinetic reasons, the experiments were performed with varying amounts of H_2O present (dry, H_2O-undersaturated, H_2O-saturated).
In contrast to biotite and plagioclase, cordierite shows no systematic variation in MgO, FeO and Na_2O across the contact aureole, which might be due to additional factors such as different bulk compositions and variations in $a(H_2O)$. Cordierites from the innermost contact aureole (< few cm from a dyke) show the lowest Na contents of ca. 0.35 Na a.p.f.u. which yielded temperatures ranging from 500–700 °C at low $a(H_2O)$. Cordierites along a short profile away from a dyke show decreasing Na contents, contrary to what is expected from previous experimental investigations. The experimental investigations yielded the assemblage cordierite + plagioclase + K-feldspar + biotite + melt (only in the fluid-present experiments) at 0.29 GPa and 650 °C after a run time of 14 days. Contrary to the hornfelses, garnet is still present in the experiments and andalusite is still absent. Plagioclase and rarely K-feldspar were also observed and occur as very small (<20 µm) grains in melt pockets. The composition are X_{An} = 0.336, X_{Ab} = 0.619, X_{Or} = 0.045 for the plagioclase and X_{An} = 0.008, X_{Ab} = 0.163, X_{Or} = 0.828 for the K-feldspar, which are in good agreement with the natural feldspars. Temperature conditions, based on coexisting feldspars, were calculated with the program SOLVCALC (Wen, S. 1994 written in comm.) and yielded a temperature of 640 °C in excellent agreement with the experimental conditions. This fact indicates that a large degree of equilibration must have taken place in the experiments. Large (< 80 µm) idiomorphic cordierite crystals with X_{Mg} = 0.40-0.44 (X_{Mg} = Mg/ (Mg + Fe + Mn)

and Na contents of 0.08–0.16 a.p.f.u. were formed at the expense of chlorite and muscovite in the experiments. In the H_2O undersaturated experiments cordierite with approximately the same composition occurred only as smaller (ca. 20µm) grains. Therefore no systematic variation in Na as a function of $a(H_2O)$ has been observed n the experiments. In addition, the Na-contents are significantly higher in the experiments compared to the natural cordierites, which might be due to additional factors such as 1.) the nature of the melt, 2.) the nature of the coexisting mineral assemblage. As long as these discrepancies exist, cordierite cannot be used as a petrologic monitor for T and $a(H_2O)$ in these rocks yet. Therefore, it is planned to conduct buffered, with respect to fO_2, experiments at longer run times to ensure a large degree of equilibration and the formation of a comparable mineral assemblage.

Thompson, P. (2002): Sodium and potassium in cordierite – a potential thermometer for melts? Eur. J. Mineral.

Mirwald, P.W. (1986): Ist Cordierit ein Geothermometer? Fortschr. Mineralogie.