Garnet–sillimanite–spinel–plagioclase geobarometer

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Spinel coexisting with quartz is well known as one of the ultrahigh-temperature metamorphic mineral assemblages. This coexistence is produced for example by a reaction, Grt + Sil = Spl + Qz. In this case, spinel comes in contact with quartz directly. Spinel-bearing pelitic metamorphic rocks are present in a wider pressure–temperature (*P–T*) range from amphibolite facies to granulite facies conditions. Although quartz is present in such rocks, spinel does not come in contact with quartz directly.

We studied spinel-bearing metamorphic rocks from (1) the Lützow–Holm complex, East Antarctica; (2) the Hidaka Metamorphic Belt, northern Japan; (3) the Uetsu area, northeastern Japan; and (4) the Ryoke metamorphic belt, southwestern Japan. These metamorphic terrains are known as clockwise *P–T* path areas. In their thin sections, sometimes spinel crystals occur around garnet or sillimanite and are in contact with plagioclase. This texture implies a reaction Grt + Sil = Spl + Pl, which can be solved using the following net-transfer reactions:

CFAS system: 5Grs + Alm + 12Sil = 3Hc + 15An

CMAS system: 5Grs + Prp + 12Sil = 3Spl + 15An

We employed thermodynamic data from [1] for these reactions. Consequently, we propose the following new geobarometers:

$P_{[CFAS]} = (-134940 + 29.392 + 561.5\ T + RT \ln K_{Fe})/29.392$

$P_{[CMAS]} = (-132130 + 29.294 + 557.2\ T + RT \ln K_{Mg})/29.294$

where P is in bar, T is in K, $K_{Fe} = (a_{Grs}{}^5 a_{Alm})/(a_{Hc}{}^3 a_{An}{}^{15})$, and $K_{Mg} = (a_{Grs}{}^5 a_{Prp})/(a_{Spl}{}^3 a_{An}{}^{15})$.

Because the dP/dT slopes of the above mentioned equations are very gentle, these are good geobarometers. Other previously used spinel-bearing geobarometers (e.g., [2, 3, 4]) include quartz or corundum in their reaction equations. The proposed new geobarometers are free from quartz and corundum within the equations. These are useful for analyzing spinel-bearing metamorphic rocks within a wider *P–T* range.

[1] Holland & Powell (1998) *JMG* **16**, 309–343. [2] Harris (1981) *CMP* **76**, 229-233. [3] Shulters & Bohlen (1989) *J.Pet.* **30**, 1017-1031. [4] Nichols (1992) *CMP* **111**, 362-377.