Zn-spinel + quartz assemblage in a garnet-chlorite schist from Buhwa-Mweza Greenstone Belt, southern Africa

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The Buhwa-Mweza Greenstone Belt (BMGB) is located at the southern end of the Archean Zimbabwe Craton. The BMGB is an ENE-WSW-trending belt of about 100 km in length and up to 15 km in width, running parallel to the Umlali-Muponjani Shear Zone to the south. The belt is composed predominantly of crystalline schists, the protoliths of which correspond to sandstones, shales, cherts, banded iron formations, limestones, basalts, and komatiites. A sample of Zn-spinel beairg schist was collected from a narrow 200 m layer of pelitic to psammitic schist enclosed by ultramafic and mafic schists, quartzite, banded iron formations, and granitic gneiss. The outcrop exhibits a layered structure of garnet-chlorite schist, quartzite, quartz-chlorite-hornblende schist, and quartz-garnet schist with minor mafic schists. The garnet-chlorite schist is composed of quartz, garnet, chlorite, cummingtonite, and accessory amounts of ilmenite, magnetite, and gahnite.

Gahnite is present as pale greenish, euhedral to subhedral crystals, occurring around porphyroblastic garnet. Euhedral gahnite typically coexists with matrix quartz and chlorite. The length of gahnite grains varies from 0.08 mm up to 0.45 mm, and the grains exhibit a poikiloblastic texture with inclusions of quartz, ilmenite, and rare magnetite. The inclusion minerals are oriented parallel to the schistosity defined by the matrix minerals, suggesting that the gahnite, rather than being detrital, crystallized during metamorphism following major deformation. The timing of the gahnite growth could be coincident with garnet growth, as suggested by the similar distribution patterns of inclusion minerals. Subhedral gahnite is present as vermicular crystals within aggregates of fine-grained quartz. Gahnite in the sample has a composition of Ghn67-73 Hc22-28 Spl4-6, with Zn decreasing slightly and Fe increasing from core to rim. The Cr content in gahnite is very low (Cr2O3 less than 1.2 wt.%). There is no compositional gap between euhedral and subhedral crystals.

The temperature calculated from adjacent mafic schists in the BMGB falls in the range 530-560C, which probably corresponds to the peak temperature of the area. The temperature range is significantly lower than the lower stability limit of both Mg-spinel + quartz (T more than 900C) and hercynite + quartz (T more than 770C) assemblages. However, this gahnite spinel can coexist with quartz at lower amphibolite-facies conditions probably because of its high ZnO content (up to 30 wt.%). The lower stable temperature of the gahnite + quartz assemblage compared to Mg-spinel + quartz and hercynite + quartz has been inferred empirically, although no experimental verification has been performed. However, the reduction of the stable temperature of spinel by Zn substitution is tentatively supported by previous experimental works, which reported that the fraction of gahnite spinel coexisting with garnet, sillimanite, and corundum increases with decreasing temperature or increasing pressure. The thermal stability of gahnite + quartz under amphibolite-facies conditions is comparable to or lower than the available temperature conditions for other gahnite + quartz-bearing rocks such as rocks of the Isua Greenstone Belt (540C) and Namaqualand (650-700C). The gahnite + quartz assemblage reported here is therefore one of the lowest-temperature spinel + quartz assemblages reported to date.