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A comparative study of chromian spinels in Archean serpentinized ultramafic rocks from the Limpopo Complex and Barberton greenstone belt, southern Africa

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Ultramafic rocks commonly contain small amounts of chromian spinel and are typically one of the earliest phases to crystallize. Because of its refractory nature, with the cores of grains known to retain its primary composition, chemical composition of chromian spinel has been successfully used to infer tectonic setting of the rock which contains them. Here we compare the occurrence and chemistry of chromian spinels occurring in serpentinized ultramafic rocks from two different terrains in southern Africa – the high-grade (amphibolite- to granulite-facies) metamorphic Limpopo Complex, and the lower-grade (greenschist-facies) metamorphic supracrustal sequence of the Barberton greenstone belt.

The studied ultramafic rocks are serpentinized to varying degrees, with those from Limpopo represented by serpentinized harzburgite-dunites to nearly complete serpentinites from Barberton. While the Limpopo samples can be grouped into those preserving silicate minerals or not, those from Barberton are completely serpentinized with almost no trace of the primary silicate minerals. In terms of the preserved silicate minerals, in general, olivine and orthopyroxene are prominent, with primary magmatic amphibole also occurring in the serpentinized rocks from Limpopo.

Irrespective of the degree of serpentinization, chromian spinel occurs as disseminated to semi-massive grains in the studied ultramafic rocks, the latter characteristic of Limpopo samples. While the spinel grains are dominantly sub-rounded with size generally <100 μm in the Barberton samples, those in the Limpopo samples vary shape (elongated to sub-rounded) and size (generally <3 mm in diameter). In general, the studied chromian spinels are associated with serpentine-group minerals (often surrounding and fracturing the spinel grains), minor carbonates, sulphides and magnetite.

Two types of chromian spinel – one with core-rim variation (Cr-spl1) and another with core-intermediate-rim variation (Cr-spl2) – were identified based on chemical composition from the Barberton samples. Rim of both types has magnetite composition with trace amount of Cr, indicating the effect of serpentinization. A detailed characterization of the effect of serpentinization on the different zones was carried out in terms of relative proportion of elements like Mg, Ti, Mn and Zn. The core of the less dominant type of chromian spienl (Cr-spl2) was found to preserve the original primary composition in the Barberton serpentinized ultramafic rocks.

In contrast to the Barberton samples, no or little evidence for ferritchromite or systematic chemical zoning was found in chromian spinels from the Limpopo samples. $Mg/(Mg+Fe^{2+})$ of the chromian spinels varies widely in the different samples. Mn and Ti are present in trace amounts. After a detailed evaluation of the effect of serpentinization on the chromium spinel compositions, the most Cr-rich, Al- and Fe^{3+}-poor, and lowest $Fe^{2+}/(Fe^{2+}+Mg)$ compositions were considered to represent the primary or near-primary spinel compositions for the Limpopo serpentinized ultramafic rocks.

Based on comparison of primary chromian spinel compositions with that of an updated compilation from various tectonic settings (compiled as part of this study), the different tectonic models proposed for the two Archean terrains are evaluated.