Evidence for arc-related origin of a Mesoarchean layered ultramafic-mafic intrusion from Limpopo Complex, southern Africa

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The geodynamic setting of formation of Archean layered ultramafic to mafic intrusions is a topic of considerable debate. This study reports field, petrographic, mineral chemical, geochemical and isotope chemical data on meta-ultramafic and meta–mafic rocks of the ~3.35 Ga Messina layered intrusion occurring within the high-grade (amphibolite- to granulite-facies) metamorphic Central Zone of the Limpopo Complex, southern Africa.

Mapping of a section along the Sand River in the Central Zone, delineated meta-peridotite, meta-pyroxenite and meta-gabbro occurring as conformable layers in the host supracrustal rocks. U-Pb zircon geochronologic data obtained from these rocks indicate evidence for polymetamorphic (~2.65 Ga and ~2.03 Ga) overprint.

Although metamorphic re-equilibration is obvious, no new metamorphic mineral is formed in the different rocks studied. Detailed evaluation of grain margins between the prominent minerals indicated two types of grain margins, with their mutual relation used to support the poly-metamorphic nature of overprint on the different rocks. Inclusion-host relations between the prominent minerals helped to infer the original igneous order of crystallization. Petrographic and mineral chemical analyses permitted distinction of two varieties of amphiboles in the different rocks, the earlier primary magmatic ones occurring as polygonal grains as well as inclusions in olivine and pyroxenes, and the later occurring along grain margins, often replacing clinopyroxene.

Considering the polymetamorphic nature of the study area, detailed element mobility tests were carried out to address their effect on the whole-rock geochemical data. Different prevailing models on the origin of layered intrusions are tested using trace and rare earth elements. In the process, a set of immobile-element based tectonic discrimination diagrams is highlighted for their ability to infer the likely tectonic setting of Archean layered intrusions. Like the scenario of experiments, which simulate natural, arc magma compositions, possible derivation from a hydrous parental melt like those characteristic of arc magmas is suggested for the Mesoarchean layered intrusion from the Limpopo Complex.