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Origin of Neoproterozoic ophiolitic peridotites in south Eastern Desert, Egypt, constrained from primary mantle mineral chemistry

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Abstract The ophiolitic peridotites in the Wadi Arais area, south Eastern Desert of Egypt, represent a part of Neoproterozoic ophiolites of the Arabian-Nubian Shield (ANS). We found relics of fresh dunites enveloped by serpentinites that show abundances of bastite after orthopyroxene, reflecting harzburgite protoliths. The bulk-rock chemistry confirmed the harzburgites as the main protoliths. The primary mantle minerals such as orthopyroxene, olivine and chromian spinel in Arais serpentinites are still preserved. The orthopyroxene has high Mg# [=Mg/(Mg + Fe^{2+})], ~0.923 on average. It shows intra-grain chemical homogeneity and contains, on average, 2.28 wt.% Al_2O_3, 0.88 wt.% Cr_2O_3 and 0.53 wt.% CaO, similar to primary orthopyroxenes in modern forearc peridotites. The olivine in harzburgites has lower Fo (93−94.5) than that in dunites ($Fo_{94.3}$−$Fo_{95.9}$). The Arais olivine is similar in NiO (0.47 wt.% on average) and MnO (0.08 wt.% on average) contents to the mantle olivine in primary peridotites. This olivine is high in Fo content, similar to Mg-rich olivines in ANS ophiolitic harzburgites, because of its residual origin. The chromian spinel, found in harzburgites, shows wide ranges of Cr#s [=Cr/(Cr + Al)], 0.46−0.81 and Mg#s, 0.34−0.67. The chromian spinel in dunites shows an intra-grain chemical homogeneity with high Cr#s (0.82−0.86). The chromian spinels in Arais peridotites are low in TiO_2, 0.05 wt.% and Y_{Fe} [= Fe^{3+}/(Cr + Al + Fe^{3+})], ~0.06 on average. They are similar in chemistry to spinels in forearc peridotites. Their compositions associated with olivine's Fo suggest that the harzburgites are refractory residues after high-degree partial melting (mainly ~25−30 % partial melting) and dunites are more depleted, similar to highly refractory peridotites recovered from forearcs. This is in accordance with the partial melting (>20 % melt) obtained by the whole-rock Al_2O_3 composition. The Arais peridotites have been possibly formed in a sub-arc setting (mantle wedge), where high degrees of partial melting were available during subduction and closing of the Mozambique Ocean, and emplaced in a forearc basin. Their equilibrium temperature based on olivine−spinel thermometry ranges from 650 to 780 °C, and their oxygen fugacity is high ($\Delta \log fO_2$=2.3 to 2.8), which is characteristic of mantle-wedge peridotites. The Arais peridotites are affected by secondary processes forming microinclusions inside the dunitic olivine, abundances of carbonates and talc flakes in serpentinites. These microinclusions have been formed by reaction between trapped fluids and host olivine in a closed system. Lizardite and chrysotile, based on Raman analyses, are the main serpentine minerals with lesser antigorite, indicating that serpentines were possibly formed under retrograde metamorphism during exhumation and near the surface at low T (<400 °C).

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Introduction

The Neoproterozoic ophiolites in the Eastern Desert (ED) of Egypt are a part of the Arabian-Nubian Shield (ANS); the ANS formed during the tectonic evolution (550−900 Ma) of