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Geodynamic evolution of the Touareg shield in the Neoproterozoic: A perspective from serpentinites

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Chains of deeply serpentinized peridotites are exposed along narrow shear zones in the Pan-African belt of the Western Hoggar (Algeria). These rocks were interpreted as altered mantle rocks marking the sutures between blocks originally separated by oceanic domains. Through a multidisciplinary approach, we investigated several representative serpentinite bodies to decipher the nature of their mantle protolith and shed light on their origin and significance.

Two episodes of serpentinization corresponding to deformation episodes under decreasing temperature have been recognized. First, a high temperature interaction of the peridotites with hydrothermal fluids (at 400–680˚C) resulted in an episode of almost total serpentinization. This results in dominant crystallization of antigorite, which shows a mesh textures indicating that serpentinization probably occurred in a static environment. A second, low temperature, episode (<200˚C) is revealed by lizardites veins and bastite along pyroxenes cleavage. These latters fill joints and fractures of olivine and clino/ortho-pyroxene megacrystals that resisted to alteration, resulting in a pseudomorphic texture. These minerals point to serpentinization by seawater. In addition, talc-rich layers developed along normal faults pointing to a lubrication of the faults planes by fluids that made exhumation of serpentinites easier. Evolution under decreasing temperature is also supported by Fe loss in serpentine and brucite that led to the formation of magnetite and ferrian chromite. Finally, a late episode of carbonation of serpentinites, characterized by the precipitation of magnesite in veins has occurred.

Field data suggest that the serpentinite massifs were tectonically emplaced, first in an extensional E-W setting associated to a shallowly eastward dipping decollement fault. Then, reworked in a N-S transpressive tectonics that affected the whole Hoggar massif during the Panafrican orogeny.

Major and trace element compositions of the serpentinites are roughly consistent with a mantle origin but further comparison with mantle rocks is hampered by hydrothermal alteration. Calcium was severely leached from the samples whereas several incompatible elements – notably U and the Light Rare Earth Elements (LREE) – were enriched. Eu anomalies, both positive and negative, and low Zr/Nd values negatively correlated with U/Th indicate that the Middle REE (MREE) were also strongly modified by alteration. In contrast, the Heavy REE (REE) show a positive correlation consistent with the mantle array suggesting that they have preserved the composition of the peridotite protolith. Sc and the High-Field Strength Elements Nb, Ta, Zr, and Hf also probably preserved their original contents. Based on the low Al_2O_3 and HREE (0.5 - 1 % Al_2O_3; 0.01 - 0.08 chondrite-normalized Yb), the analyzed serpentinites are akin to the harzburgites commonly found in ophiolitic complexes and may therefore represent lithospheric mantle from oceanic or back-arc basins.

These results suggest a mantle origin for serpentinites in the Western Hoggar, which progressively intruded the crust as a result of successive deformation episodes under decreasing temperature, including hydrothermal processes.