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Massive magnetite veins in Neoproterozoic serpentinites as a possible relic of a black smoker type hydrothermal system: Aït Ahmane ultramafic unit (Bou Azzer ophiolite, Anti Atlas, Morocco)

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Ophiolites are the only remains of ancient oceanic lithosphere (> 200 Ma), and of the processes affecting it like serpentinization and hydrothermal alteration. If magnetite is a common serpentinization product, centimetric, massive and almost pure magnetite veins are rarely observed in serpentinites. Unique examples of such veins, in the Aït Ahmane ultramafic unit (Bou Azzer Neoproterozoic ophiolite, Anti-Atlas, Morocco), offer the opportunity to assess the hydrothermal processes that prevailed at the end of the Precambrian. Here, magnetic data, petrographic observations, mineral and bulk chemistry are combined to assess iron behavior in these meta-ultramafics and constrain the serpentinites alteration and magnetite veins formation processes.

Very high Cr# and low Mg# of Cr-spinel cores in serpentinites together with low bulk rock incompatible major element concentrations (Al_2O_3: 0.20-1.28 wt. % and Ti: 3-38 ppm) and very low REE support a highly refractory protolith, characteristic of a supra subduction context. Typical lizardite/chrysotile pseudomorphic texture in fresh serpentinites reveals an initial oceanic-like serpentinization, involving temperature <350 °C while the abundance of magnetite (up to 7.86 wt. %) in these unaltered serpentinites attests of a relatively high serpentinization temperature >200 °C. Magnetic measurements reveal a lower magnetite content in hydrothermalized serpentinites hosting the magnetite veins, with lowest values (down to 0.58 wt. %) for bleached serpentinites constituting the wall rock of veins. These magnetic data are consistent with bulk rock chemistry that shows a lower total iron content in hydrothermalized serpentinites hosting the veins. Hydrothermalized samples exhibit a strong LREE enrichment (La/Yb to 212.66), correlated to a positive peak for Eu ((Eu/Eu*)N up to 27.43). This hydrothermal imprint is clearly anticorrelated with total iron content, attesting the important iron mobilization during this fluid/rock interaction. Mineral chemistry reveals a significant chlorine enrichment in serpentine phases from hydrothermalized serpentinites.

In Aït Ahmane, a Cl-rich acidic hydrothermal event involving temperatures below 350 °C appears to have been responsible of an intense magnetite leaching in host serpentinite. Iron provided by this leaching may have conducted to unique magnetite veins formation in the Aït Ahmane ultramafic unit. Two different settings are proposed for the nature of the hydrothermal event: (1) a continental hydrothermal system as advanced for the Co-Ni-As ores in the Bou Azzer inliers or (2) an oceanic black smoker type hydrothermal vent field on the Neoproterozoic sea-floor.