

Accepted Manuscript

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PII: S1464-343X(17)30166-8

DOI: [10.1016/j.jafrearsci.2017.04.022](https://doi.org/10.1016/j.jafrearsci.2017.04.022)

Reference: AES 2890

To appear in: *Journal of African Earth Sciences*

Received Date: 21 December 2016

Revised Date: 26 March 2017

Accepted Date: 20 April 2017

Please cite this article as: Hajjar, Z., Gervilla, F., Essaifi, A., Wafik, A., Mineralogical and geochemical features of the alteration processes of magmatic ores in the Beni Bousera ultramafic massif (north Morocco), *Journal of African Earth Sciences* (2017), doi: 10.1016/j.jafrearsci.2017.04.022.

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1 Mineralogical and Geochemical Features of the Alteration Processes of
2 Magmatic Ores in the Beni Bousera Ultramafic Massif (North Morocco).

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8 **Abstract**

9 The Beni Bousera ultramafic massif (Internal Rif, Morocco) is characterized by the
10 presence of two types of small-scale magmatic mineralizations (i) a mineralization consisting
11 mainly of chromite and Ni arsenides associated to orthopyroxene and cordierite (Cr-Ni ores),
12 and (ii) a mineralization mainly composed of magmatic Fe-Ni-Cu sulfides containing variable
13 amounts of graphite and chromite associated to phlogopite, clinopyroxène and plagioclase (S-
14 G ores). These ores underwent *High-T* (450-550°C) and *Low-T* (150-300°C) alteration
15 processes.

16 The *High-T* alteration processes are tentatively related to intrusion of leucogranite
17 dykes. They are preserved in the Galaros Cr-Ni ore deposit where nickeline is partly dissolved
18 and transformed to maucherite, and orthopyroxene alters to phlogopite. Ni and Co were
19 mobilized to the fluid phase, rising up their availability and promoting their diffusion into
20 chromite and phlogopite, which have significantly higher contents in Ni and Co in phlogopite-
21 rich ores than in orthopyroxene- and nickeline-rich ones.

22 The *Low-T* alteration processes are related to serpentinization/weathering spatially
23 associated with a regional shear zone. They affected both the Cr-Ni and S-G ores. In the Cr-
24 Ni ores, Ni-arsenides were completely leached out while chromite is fractured within a matrix
25 of chlorite, vermiculite and Ni-rich serpentine. In S-G ores, the silicates were altered into
26 amphibole, Fe-rich chlorite and pectolite in clinopyroxene- and plagioclase-bearing ores
27 while sulfides were completely leached out in phlogopite-bearing ores where iron oxides and
28 hydroxides, and Fe-rich vermiculite were deposited. Chromite composition is not affected by
29 the *Low-T* alteration processes. Keywords : Chromite-Ni arsenide ores, Sulfide-graphite ores,
30 alteration processes, serpentinization, Beni Bousera ultramafic massif, Rif, Morocco.

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