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Petrological, geochemical and isotopic characteristics of the Collo ultramafic rocks (NE Algeria)

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ABSTRACT

The ultramafic rocks of the Collo region in northeastern Algeria crop out as "stratified" masses that cut across older metamorphic formations of the Petite Kabylie basement. Based on petrological compositions and mineralogical observations, these rocks are mainly peridotites and serpentinites. The peridotites are identified as lherzolites, but dunites may occur rarely. The lherzolites are composed of olivine, orthopyroxene, clinopyroxene and chromian spinel. Their chemical composition shows high MgO (34.4–37.5 wt%), Cr (0.14–0.27 wt%), Ni (0.14–0.26 wt%) and Co (34–133 ppm) contents and low CaO and Al_2O_3 concentrations (0.02–2.2 wt% and 0.5 to 2.8 wt%, respectively). The chromite, which represents approximately 1–3% of the rock, is ubiquitous and shows two different generations: primary millimetric euhedral crystals and secondary fine xenomorphic grains and interstitial aggregates. The primary chromites are alumino-ferro-magnesian crystals that show high Al_2O_3 (25.77%–27.36%) and MgO (10.70%–13.36%). Cr# ($100 \times Cr/(Al + Cr)$) ranges from 45 to 48, and Mg# ($100 \times Mg/(Mg + Fe^{2+})$) from 49 to 59. The secondary interstitial grains are iron-rich chromites. They show low Al_2O_3 (4.67%–9.54%) and MgO (4.60%–4.65%). Cr# is relatively high (77–88), whereas Mg# shows relatively low values, ranging from 22 to 25. Primary chromite and whole-rock chemistry show that the Collo ultramafic rocks belong to Alpine-type peridotites that were emplaced within an orogenic setting. The oxygen isotopic composition of both peridotites and chromites is consistent with their derivation from a mantle source ($\delta^{18}O$ ranges from +3.0 to +5.9‰). Low $\delta^{18}O$ values (<+4.4‰) are recorded in serpentinites and are attributed to the effect of serpentinization processes through high-temperature metasomatic fluids. Magnesite-bearing serpentinites show the lowest $\delta^{18}O$ values. These are interpreted as the result of surface water input.

1. Introduction

The North African Alpine belt that extends along the Algerian coast is characterized by the presence of scarce ultramafic rocks, which crop out within older metamorphic formations of the basement. The best-known outcrops in northeastern Algeria are those of the Edough massif (Sidi-Mohamed mafic-ultramafic formation) and of the Collo region (Tamanart and Beni Said peridotites and serpentinites) (Fig. 1).

In the Edough Massif, the Sidi-Mohamed mafic-ultramafic formation was first described by Bossière et al. (1976) as peridotites,

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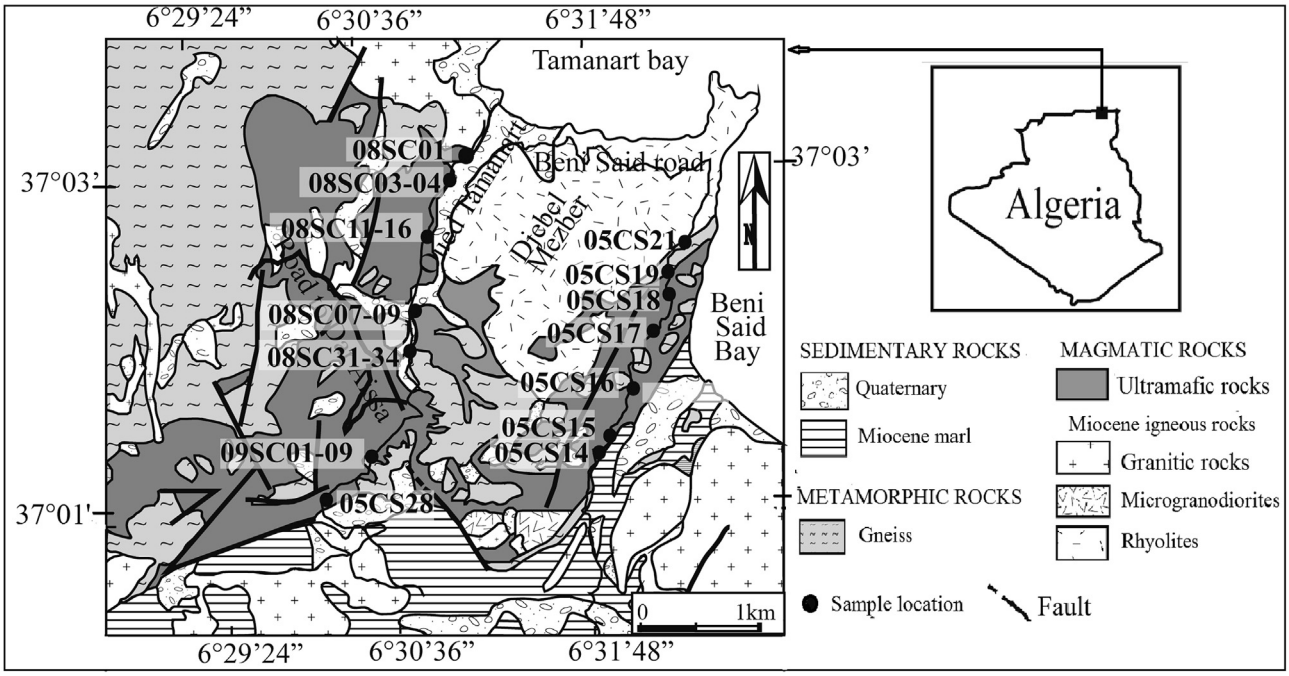

Fig. 1. Geological sketch map of the study area showing the sample locations (modified after Bouillin, 1977).

pyroxenites and amphibolites. These rocks were later studied in detail by Hadj-Zobir (2007) and Hadj-Zobir et al. (2007). Based on their petrological and geochemical characteristics, the Sidi-Mohamed ultramafic rocks were recently considered by Hadj-Zobir and Oberhansli (2013) and Bosch et al. (2014) as depleted sub-continental lithospheric peridotites tectonically incorporated into the gneiss units of the Edough massif during the Burdigalian (Bruguier et al., 2009).

The ultramafic rocks of the Collo region, which are dealt with in this study, crop out within the Cap Bougaroun area and are associated with granulite facies gneisses, mainly kinzigites. They were described by Roubault (1934) and later by Bouillin and Kornoprobst (1974). Based on field observations, Bouillin (1979) considered these rocks as tectonites or peridotites, similar to those observed in the Lherz (Pyrenees), the Lanzo massif (Italian Alps), Ronda (southern Spain) and Beni Boussera (the Moroccan Rif). The structure and deformation of the Collo peridotites were studied by Misseri (1987), who attributed the observed deformation of the rocks to a horizontal asthenospheric flow direction along a vertical plane, which could have been produced in the asthenosphere below a north-south rift or an incipient ocean spreading centre.

In their chromian spinel study of these peridotites, Leblanc and Temagoult (1989) noted that the ultramafic rocks are plagioclase-bearing lherzolites associated with kinzigite layers and that the chromitites show podiform structures with textures and chemistry typical of ophiolite complexes, i.e., of oceanic lithosphere.

In this paper, we present detailed mineralogical, chemical and O-isotope characteristics of the Collo chromian spinel-bearing peridotites. The obtained results help to more precisely define the origin of these ultramafic rocks and their emplacement style within the Alpine belt of the Maghrébides.

2. Geology

The Collo ultramafic rocks crop out over approximately 20 km^2 and are associated with low-pressure granulite facies metamorphic lithologies (Peucat et al., 1996), mainly gneisses (kinzigites and calc-silicate rocks). They constitute the Bougaroun basement unit that is intruded by Tertiary igneous rocks (rhyolites, microgranites and granites) (Fig. 1), some of which (the Cap Bougaroun granites) were recently dated at c. 17 Ma (Abbassene et al., 2016).

The basement metamorphic rocks have suffered polyphase tectono-metamorphic events related to, at least, two Hercynian orogenic phases dated at ca. 370 ± 6 Ma (Peucat et al., 1996; Mahjoub et al., 1997) and 270–280 Ma (Peucat et al., 1996; Hammor et al., 2006) and an Alpine overprint testified by Ar-Ar and Rb-Sr mica ages scattering between 22 and 30 Ma (Monié et al., 1984; Peucat et al., 1996; Hammor et al., 2006). This basement was thrust southeastward over the Mesozoic and Cenozoic sedimentary formations (Mahjoub et al., 1997). Close to the peridotites, the gneisses or kinzigites show N-S-trending subvertical foliations, similar to those of the peridotites, but the contact between the two formations is always tectonic, showing mylonitic sinistral shear-zones (Misseri, 1987; Leblanc and Temagoult, 1989) before emplacement of the Burdigalian granitoids (Abbassene et al., 2016). These kinzigites were studied in detail by Bouillin (1977). They are of two types: (1) cordierite-bearing mesocratic kinzigites composed of quartz, orthoclase, plagioclase, cordierite, tourmaline and biotite and (2) sillimanite-bearing leucocratic kinzigites with quartz, feldspar, sillimanite, cordierite and minor biotite and tourmaline. Bouillin (1977) noted that the complex thermodynamic evolution of these kinzigites is similar to that of the metamorphic rocks associated with the Alpine-type peridotites of the Betico-Rifan internal zones already described by Kornprobst (1971). The calc-silicate rocks crop out as irregular, metric slabs within the kinzigites and are mainly composed of calcite, epidote, clinopyroxene, quartz, Ca-amphibole and rare garnet. The Tertiary igneous rocks consist of Cap Bougaroun granites and Collo town microgranites, microdiorites and rhyolites. The granites are medium-grained cordierite-bearing granites that show a peraluminous character (Ouabadi, 1994) and were emplaced at 17 Ma (Abbassene et al., 2016). The mineral composition consists of quartz,