STABLE S-, O- AND C-ISOTOPES IN THE GRANITOÏDES OF NORTHEASTERN ALGERIA: ORIGIN OF MAGMAS AND RELATED MINERALIZATION

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Introduction

The structure of the North African Alpine belt is believed to be a consequence of the western Mediterranean subduction-collision of the African and European plates during the Oligo-Miocene (e.g. Auzende et al., 1975). In this geodynamic setting a number of igneous bodies were emplaced along the North African margin during the Tertiary period.

The Miocene igneous rocks of NE Algeria (Fig. 1) show different emplacement styles from volcanic through subvolcanic to plutonic rocks, and diverse compositions from acidic to intermediate. These igneous rocks intruded the metamorphic basement and the overlying sedimentary formations of the Internal Zones at around 16 - 15 Ma (Bellon, 1981; Marignac and Zimmermann, 1983).

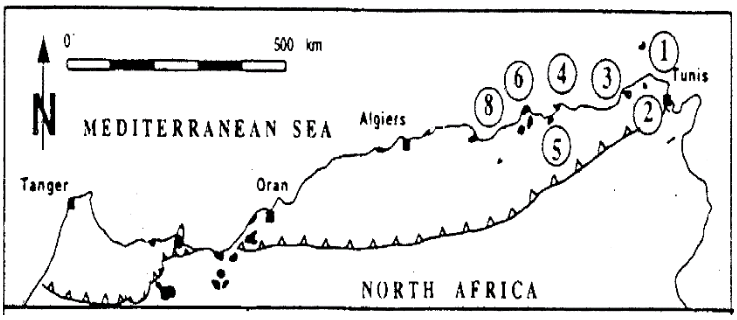

Figure 1. Sketch map of the Maghreb margin showing the location of the igneous bodies in northeastern Algeria. 1. La Galite, 2. Mogods, 3 Nefza, 4 Edough-Chetaibi-Cap de Fer, 5 Fifila, 6 Cap Bougaroun, 7 Beni Touffout, 8 El Aouana, 9 Oued-Amizour.

The igneous events and related hydrothermal alteration are thought to have resulted in three types of mineralization: (1) Pb-Zn-Cu ores, (2) W–As–Au deposits related to skarns, and (3) Sb–Au vein mineralization.

Stable S-, O- and C-isotope analyses were carried out on sulphides, sulphates and gangue minerals in order to show the relationship of the mineralizing fluids with the magmatic event and also the source and isotopic temperature of these fluids.

Igneous Host Rocks

The Edough, Chetaibi, Filfila and Oued Amizour are taken as examples of igneous activity in northeastern Algeria. The microgranites of the Edough and Chetaibi massifs have uniform texture and mineralogical composition and intruded into the metamorphic basement and the sedimentary cover. They have undergone hydrothermal alteration,

The rhyolites are massive lavas and dykes usually associated with the microgranites. They are subaphanitic rocks commonly showing flow banding. The rhyolitic dykes of Ain Barbar district show signs of deuteric alteration.

From the eastern border of the Edough massif to the western part of Cap de Fer, microgranites are relatively homogeneous. The Djebel M_Zihla microgranite is an example of the Chetaibi Cap de Fer subvolcanics. Its mineralogical composition is similar to that of the Edough microgranites except the presence of euhedral phenocrysts of orthopyroxene. The diorites show variations of texture and grain-size within the same intrusion and from one pluton to another. The andesite occurrences vary significantly from one to the other. Massive lavas are usually very dark, whereas the pyroclastic rocks have a light grey colour which changes to light green or dark purple. The Filfila granites occur as two small stocks (3 and 4 km^2) with large contact metamorphic aureole. These igneous rocks show that they are topaz-bearing and RM-rich granites.

The volcano-plutonic rocks of Oued Amizour, which host the main Zn-Pb mineralization, were emplaced within Cretaceous formations. Petrological study shows, from the top to the bottom: : pyroclastites, andesites and dacites, porphyric pyroclastites, volcanic tuff and lava flows, metasomatizied granitoids and finally massive granites. All rocks are affected by post-magmatic alteration,. The contact between the granites and the volcanic rocks is marked by an anhydrite layer of about 20m thickness and massive sphalerite mineralization.

The geochemistry of the Edough, Chetaibi, Cap de Fer, Oued Amizour igneous suite shows a calc-alkaline character. K, Na and Ca enrichment is accompanied by a relatively high Al_2O_3 content. As a result, A/CNK is generally lowand therefore they are metaluminous and were most likely derived from an igneous protolith (I-type) according to the definition of Chappell and White (1992).

On the other hand, the Filfila granites are peraluminous (A/CNK > 1.1), with high SiO_2 contents (72 to 75%), F-rich (1.2–1.54%), and show high Sn (17–30 ppm), W (45–104 ppm) and Ta (9–16 ppm) contents. They are considered S-type granites.

Mineralization

Four types of mineralization are known in the Edough massif: (1) Fe–(Pb–Zn–Cu) deposits hosted by marbles and skarns; (2) base-metal veins (Cu–Pb–Zn) hosted by the Maestrichtian flysch; (3) W–As–Au skarns hosted by the gneisses; and (4) Sb–Au veins occurring within the metamorphic complex. At Chetaibi Cap de Fer region, mineralization is scarce. Veins contain pyrite, chalcopyrite, galena, carbonates, iron oxides and rare zeolites. In the Dj. M_Zihla microgranite, sulphide mineralization is rare, and only present in fractures. The main phases are aggregates of euhedral to subhedral grains of (1–3 mm) of chalcopyrite and galena. At Filfila massif, several rare metal minerals were found in the topaz-bearing rocks: rare cassiteriteand ferberite; and very abundant Ta-rutile included in zinnwaldite or K-feldspar and itself including rare small columbo-tantalite crystals.At Oued Amizour, the main base metal mineralization consists of sphalerite, pyrite, galena and rare chalcopyrite.

Stable Isotopes

Measured $\delta^{34}S$ of sulphides hosted by the igneous rocks from the Edough and Chetaibi massifs, and Oued Amizour ore field (pyrite, sphalerite, chalcopyrite, galena) has a range from -7‰ to +5‰ (n=57 samples). These values reflect the major influence of magmatic fluid for the origin the sulphide mineralization. They also confirm the I-type signature of the granitoids. Magmatic fluid is also reflected when observing $\delta^{18}O_{V\text{-}SMOW}$ and $\delta^{13}C_{V\text{-}PDB}$ data of gangue calcite (+11.2‰ to +20.2‰ and -3.7‰ to -11.0‰ respectively) for Oued Amizour.

On the other hand, the Ain Barbar Pb-Zn-Cu deposit and the Filfila base-metals hosted by skarns both show negative $\delta^{34}S$ values between -5 to -11‰ similar to the isotopic composition of the metamorphic basement and overlying sediments ($\delta^{34}S \approx -9$ to -17‰). Therefore, the origin of the sulphur has more likely been leached from the metasedimentary and sedimentary rocks.

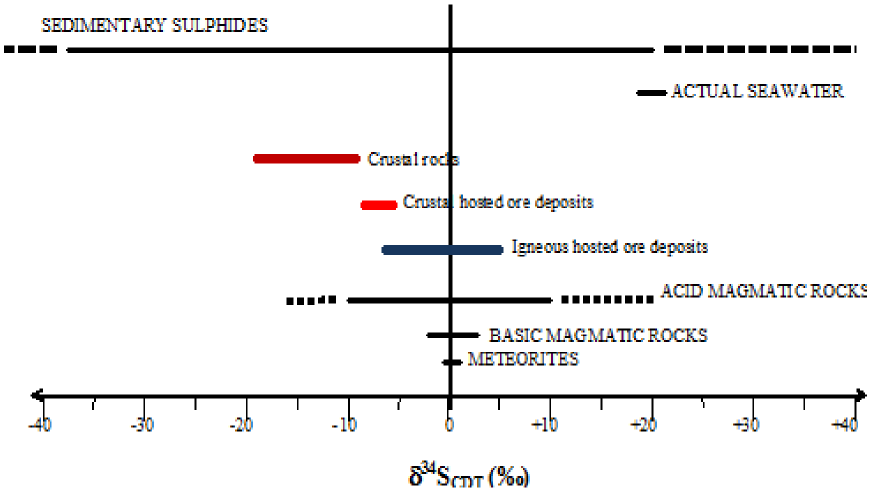

Figure 2. Sulphur isotopic composition of ore deposits related to Tertiary igneous activity in northeastern Algeria compared to typical ranges of $\delta^{34}S$ in natural materials.

Conclusion

The Miocene magmatic event in northeastern Algeria is a consequence of the western Mediterranean subduction-collision between the African and European plates during the Oligo-Miocene. This event was accompanied by the emplacement of a number of economic and non-economic ore bodies that show variable nature (Pb-Zn-Cu, As-Au, Sn-W) and different emplacement styles (veins, masses, disseminations).

The petrology and geochemistry of the igneous rocks shows that the majority of the magmas are calc-alkaline and originate from the lower crust or upper mantle source region (I-type). Mineralization hosted by the igneous bodies show also a magmatic signature for the mineralizing fluids through their stable S-, O- and C-isotopic compositions. On the other hand, mineralization hosted by the country rocks shows a crustal origin of the mineralizing fluids; the igneous activity being the heat engine for the crustal fluids.

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