Lithos 192–195 (2014) 240–258

Contents lists available at ScienceDirect

Lithos

journal homepage: www.elsevier.com/locate/lithos

Miocene magmatic evolution in the Nefza district (Northern Tunisia) and its relationship with the genesis of polymetallic mineralizations

Sophie Decrée [a,b,*], Christian Marignac [c], Jean-Paul Liégeois [b], Johan Yans [d], Randa Ben Abdallah [e], Daniel Demaiffe [f]

[a] Institut Royal des Sciences Naturelles de Belgique — Service Géologique de Belgique, 29 Rue Vautier, B-1000 Bruxelles, Belgique
[b] Musée Royal de l'Afrique Centrale, Geodynamics and Mineral Resources, 13 Leuvensesteenweg, B-3080 Tervuren, Belgique
[c] Géologie et Gestion des Ressources Minérales et Energétiques — G2R (CNRS/Université Henri Poincaré), Ecole Nationale Supérieure des Mines de Nancy, Campus ARTEM, F-54042 Nancy, France
[d] Université de Namur, Département de Géologie, 61 rue de Bruxelles, B-5000 Namur, Belgique
[e] Laboratoire de Valorisation des Matériaux Utiles-CNRSM Technopôle de Borj Cédria BP 273, 8020 Soliman-Tunisie, Tunisia
[f] Université Libre de Bruxelles (ULB), CP 160/02, Laboratoire de géochimie - DSTE, 50 av. F. Roosevelt, B-1050 Bruxelles, Belgique

ARTICLE INFO

Article history:
Received 26 March 2013
Accepted 1 February 2014
Available online 15 February 2014

Keywords:
Cenozoic magmatism
Polymetallic mineralizations
Post-collisional
Sr–Nd–Pb isotopes
Nefza
Tunisia

ABSTRACT

The Nefza mining district in Northern Tunisia comprises late Miocene (Serravallian to Messinian) magmatic rocks belonging to the post-collisional magmatism of the Mediterranean Maghreb margin. They are mainly made up of Serravallian granodiorite (Oued Belif massif), Tortonian rhyodacites (Oued Belif and Haddada massifs) and cordierite-bearing rhyodacites (Ain Deflaia massif) in addition to rare Messinian basalts. They are all characterized by LILE and LREE enrichment and strong enrichment in Pb and W. The Messinian basalts, which are also enriched in LILE, exhibit transitional characteristics between calc-alkaline and alkaline basalts.

Geochemical (major and trace elements) and Sr, Nd and Pb isotopic compositions indicate that: (1) granodiorite is linked to the differentiation of a metaluminous calc-alkaline magma derived from a lithospheric enriched mantle source and contaminated by old crustal materials; (2) rhyodacites result from the mixing of the same metaluminous calc-alkaline magma with variable proportions of melted continental crust. Cordierite-bearing rhyodacite, characterized by the highest $^{87}Sr/^{86}Sr$ isotopic ratios, is the magma comprising the highest crustal contribution in the metaluminous–peraluminous mixing and is close to the old crustal end-member; (3) late basalts, transitional between the calc-alkaline and alkaline series, originated from an enriched mantle source at the lithosphere–asthenosphere boundary.

In the Nefza mining district, magmatic rock emplacement has enhanced hydrothermal fluid circulation, leading to the deposition of polymetallic mineralizations (belonging to the Iron–Oxide–Copper–Gold and the sedimentary exhalative class of deposits, among others). Magmatic rocks are also a source for the formation of lead (and probably other metals) in these deposits, as suggested by their Pb isotopic compositions.

Magmatic rock emplacement and connected mineralization events can be related to the Late Mio-Pliocene reactivation of shear zones and associated lineaments inherited from the Variscan orogeny.

1. Introduction

The Nefza mining district of Northern Tunisia (Fig. 1), although extending over a rather small area, displays a wide variety of Middle–Late Miocene magmatic rocks, from plutonic granodiorite to (sub-)volcanic rhyodacite and basalt, related to the Cenozoic circum-Mediterranean geodynamic history. The Nefza magmatism is especially related to the development of the Maghreb indenter that acted as a locking zone during the regional compression phase, inducing lithospheric breaks, which favored the partial melting of the consequently rising asthenosphere. These events started in Central Eastern Algeria during the Langhian age (16–14 Ma; lower Miocene) and propagated both eastwards and westwards (Maury et al., 2000; Piqué et al., 1998). In the Nefza district, the post-collisional calc-alkaline rocks (granodiorite and rhyodacite) emplaced during the Serravallian–Tortonian age and the basalts during the Messinian age.

* Corresponding author at: Institut Royal des Sciences Naturelles de Belgique — Service Géologique de Belgique, 29 Rue Vautier, B-1000 Bruxelles, Belgique.
E-mail addresses: sophie.decree@naturalsciences.be (S. Decrée), christian.marignac@mines.inpl-nancy.fr (C. Marignac), jean-paul.liegeois@africamuseum.be (J.-P. Liégeois), johan.yans@fundp.ac.be (J. Yans), randa.benabdallah@gmail.com (R. Ben Abdallah), ddemaif@ulb.ac.be (D. Demaiffe).

http://dx.doi.org/10.1016/j.lithos.2014.02.001
0024-4937/

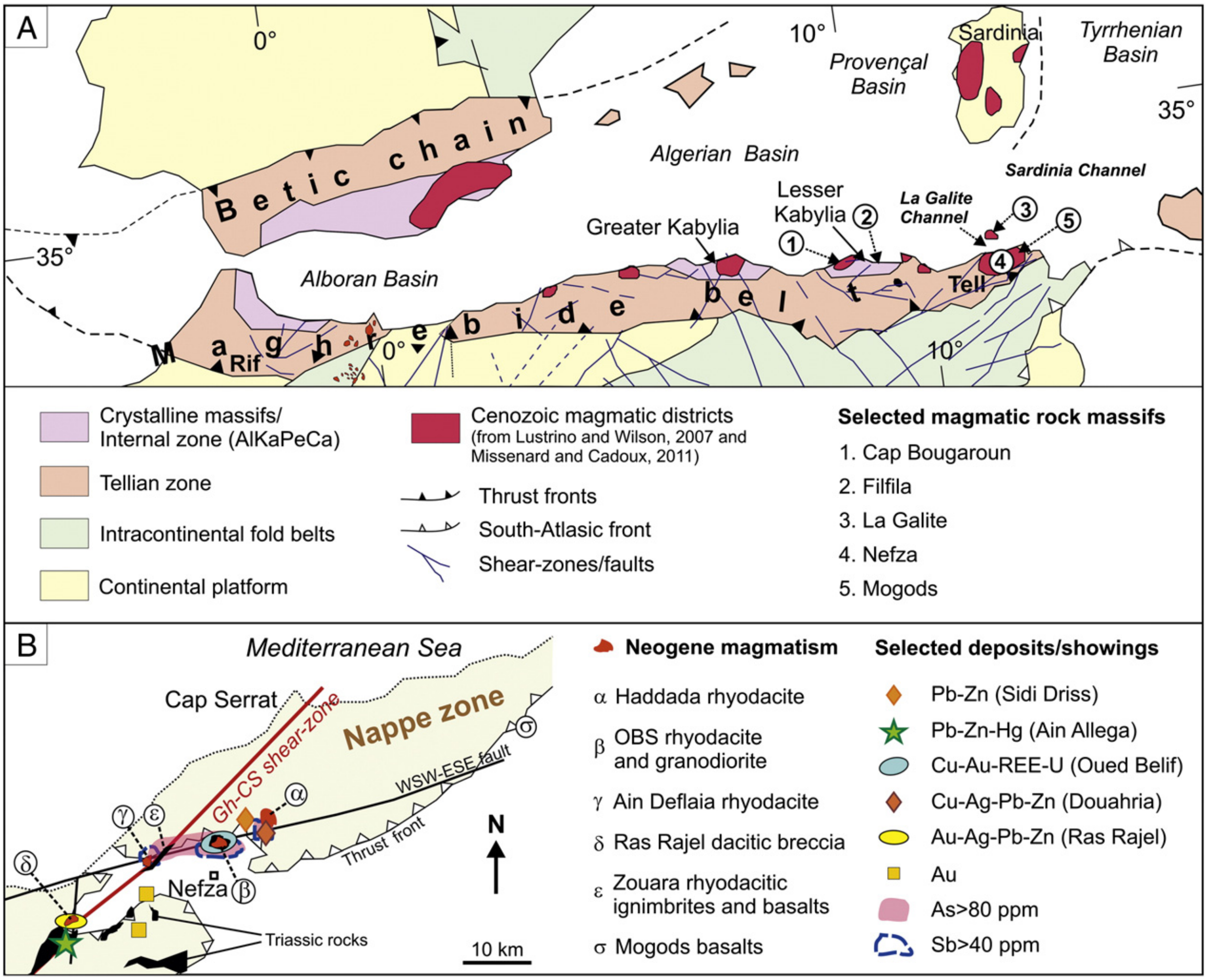

Fig. 1. A. Tectonic sketch map of the western Mediterranean region (modified after Piqué et al., 1998; Bouaziz et al., 2002), with Cenozoic magmatic districts (from Lustrino and Wilson, 2007 and Missenard and Cadoux, 2012); B. Structural settings and mineralizations in the Tunisian Nappe Zone (modified from Gharbi, 1977 and Albidon Limited, 2004; As and Sb anomalies are personal communications from the Office National des Mines de Tunisie) (modified from Decrée et al., 2013); Gh-CS is for the Ghardimaou-Cap Serrat shear-zone.

According to Maury et al. (2000), the Nefza calc-alkaline rocks (granodiorite and rhyodacite) resulted from the partial melting of the lithospheric mantle, previously metasomatised during the Eocene by oceanic subduction caused by the uprise of the asthenosphere. Available isotopic data indicate a significant contamination of the mantle-derived magma(s) by a heterogeneous continental crust (Maury et al., 2000). The younger Messinian basalts of the Nefza and Mogods (~40 km to the NE of Nefza) areas display mineralogical and chemical features which are transitional between calc-alkaline and alkali basalts (Halloul and Gourgaud, 2012). They result from partial melting of the mantle generated in the uprising lithosphere–asthenosphere boundary during the widening of the lithospheric break (Maury et al., 2000).

The petrographical and geochemical characteristics (major and trace elements) of the Nefza magmatic rocks have been regularly studied (Badgasarian et al., 1972; Bellon, 1976; Faul and Foland, 1980; Halloul, 1989; Halloul and Gourgaud, 2012; Laridhi Ouazaa, 1989a,b, 1990; Mauduit, 1978; Metrich-Travers, 1976; Tzekova, 1975) but no detailed isotopic studies have been performed on these rocks to this day. The aim of this study is to reconsider the magmatic processes leading to the formation of the various Nefza district magmatic rocks on the basis of literature data, new geochemical (major and trace elements) and isotopic data (Pb, Sr, Nd). In addition, the Pb isotopic data obtained on regional polymetallic mineralization (Pb–Zn–Fe–REE–U–Au–Cu–Hg; e.g. Abidi et al., 2010, 2011, 2012; Decrée et al., 2008a,b, 2010, 2013) allow us to reconsider magmatic contribution as a heat and metal source to the mineralization process.

2. Geological context

2.1. The Maghrebide belt

The Maghrebide belt, running E–W in Northern Africa, belongs to the Western Mediterranean Alpine belt stretching west to east from the Betic Cordillera in Spain to the Apennine Belt in Italy (Fig. 1A). It resulted from the collision between the African plate (part of the former Gondwana supercontinent) and a microplate called "Meso-Mediterranean" derived from the European continent during the Neo-Tethysian oceanic aperture in the Early Jurassic. The collision was followed by the eastward migration of the former subduction front and the opening of back-arc basins, namely the present-day oceanic West Mediterranean basin (Gueguen et al., 1998; Jolivet, 2008, and references therein). The Meso-Mediterranean microplate, now preserved as "internal crystalline massifs" within the Maghrebide and Betic belts, is also known as "Alkapeca", an acronym formed from the initial letters of the Alboran basin (which has a thin continental crust) and the names of the main internal massifs stretching from west to east: the Kabylian massifs in Algeria and the Peloritain mountains in Sicily and Calabria (Bouillin, 1977; Guerrera et al., 1993) (Fig. 1A).

The present-day Maghrebide belt consists of three areas stretching from north to south: (i) the Internal Zone, comprising the internal massifs and a Flysch Zone, which is overthrust towards (ii) the Tellian Zone (or Tellian Atlas), which is in turn overthrust towards (iii) a deformed foreland (Saharan platform and intracontinental Atlas fold belts, the