Journal of African Earth Sciences 125 (2017) 27–41

Contents lists available at ScienceDirect

Journal of African Earth Sciences

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

Geological Society of Africa Presidential Review

An overview on the origin of post-collisional Miocene magmatism in the Kabylies (northern Algeria): Evidence for crustal stacking, delamination and slab detachment

Gilles Chazot [a, *], Fatiha Abbassene [a, b], René C. Maury [a], Jacques Déverchère [a], Hervé Bellon [a, c], Aziouz Ouabadi [b], Delphine Bosch [d]

[a] Université de Brest, CNRS, UMR 6538 Domaines Océaniques, Institut Universitaire Européen de la Mer (IUEM) Place Nicolas Copernic, 29280 Plouzané, France
[b] Université des Sciences et de la Technologie Houari Boumedienne, Bab Ezzouar, Laboratoire de Géodynamique, Géologie de l'Ingénieur et Planétologie (LGGIP/FSTGAT/USTHB), Algiers, Algeria
[c] Université de Brest, CNRS, UMR 6538 Domaines Océaniques, 6 avenue Le Gorgeu, c.s. 93837, 29238 Brest, France
[d] Université de Montpellier II, CNRS-UMR 5243, Géosciences Montpellier, Place E. Bataillon, c.c. 060, 34095 Montpellier, France

ARTICLE INFO

Article history:
Received 7 June 2016
Received in revised form
7 October 2016
Accepted 19 October 2016
Available online 19 October 2016

Keywords:
Calc-alkaline magmas
Post-collision
Delamination
Slab tearing
Algeria

ABSTRACT

Miocene (17-11 Ma) magmatic activity in the Kabylies emplaced K-rich (and minor medium-K) calc-alkaline plutonic and volcanic rocks in five zones, delineating a ~450 km long EW trending strip located along the northern coast of Algeria, between Annaba and Algiers. Their most likely source is the Kabylian subcontinental lithospheric mantle previously metasomatized during the Paleogene subduction of the Tethys oceanic lithosphere. Our preferred tectono-magmatic model involves a Tethyan slab detachment combined with African mantle delamination and crustal stacking, leading to the superimposition of the African continental crust over the Kabylian metasomatized lithospheric mantle. At ca. 17 Ma, the asthenospheric upwelling arising from lithospheric delamination and Tethyan slab tear triggered the thermal erosion of the latter mantle, inducing its partial melting. The corresponding mafic medium-K calc-alkaline magmas interacted with the African basement units during their ascent, generating intermediate to felsic K-rich calc-alkaline melts that display a characteristic trace element and isotopic crustal signature. Later on, slab tears propagated eastward and westward, promoting slab rollback perpendicular to plate convergence and inducing the emplacement of magmatic rocks of decreasing ages from central-eastern Algeria towards Tunisia and Morocco.

Contents

* Corresponding author.
E-mail address: Gilles.Chazot@univ-brest.fr (G. Chazot).

http://dx.doi.org/10.1016/j.jafrearsci.2016.10.005
1464-343X/

1. Introduction

The western Mediterranean domain experienced an especially complex Cenozoic tectonic evolution (including the eastward and southeastward retreat of the Apennine-Calabria trench, and the southward and then westward retreat of the Betic trench) coupled with an unusually diversified igneous activity (Savelli, 2002; Duggen et al., 2005; Lustrino and Wilson, 2007; Lustrino et al., 2011, 2013; Carminati et al., 2012). The origin of the latter is attributed to a complex interplay between geodynamic processes including active subduction, slab rollback and detachment, and associated back-arc basin spreading and crustal thinning (Réhault et al., 1984; von Blanckenburg and Davies, 1995; Lonergan and White, 1997; Gueguen et al., 1998; Carminati et al., 1998a, b; 2012; Jolivet and Faccenna, 2000; Rollet et al., 2002; Mauffret et al., 2004; Faccenna et al., 2004, 2014; Lustrino et al., 2011; Mancilla et al., 2015).

The Maghrebides segment of the circum-Mediterranean Alpine belt forms a ~1200 km-long EW-trending magmatic lineament that extends along the southern Mediterranean margin from La Galite Island in Tunisia to Ras Tarf in Morocco (Fig. 1). It includes mostly Miocene K-rich calc-alkaline plutonic and volcanic rocks, and minor younger (Messinian to Plio-Quaternary) alkali basalts and basanites (Maury et al., 2000; Savelli, 2002; Lustrino et al., 2011; Carminati et al., 2012). These igneous rocks crosscut and/or overlie both the inner and the outer zones of the Maghrebides or their African foreland. Their geological position and ages as well as their petrographic and geochemical features are typical of post-collisional magmatism (Hernandez and Lepvrier, 1979; Maury et al., 2000). Indeed, the latter is characterized by a considerable geochemical variability and often displays temporal trends from calc-alkaline to K-rich calc-alkaline and shoshonitic compositions, usually followed by the emplacement of alkaline magmas (Harris et al., 1986; Turner et al., 1996; Lustrino and Wilson, 2007). The origin of the calc-alkaline signature is generally ascribed to mantle metasomatism by hydrous fluids or melts during an earlier subduction event (Miller et al., 1999; Wang et al., 2004; Chung et al., 2005). However, the tectonic processes triggering the partial melting of this subduction-modified mantle after the collision event are debated. Complex combinations of processes involving slab rollback and/or slab detachment and/or lithospheric delamination have often been suggested (Harris et al., 1986; Pearce et al., 1990; Mahéo et al., 2002; Chung et al., 2005; Duggen et al., 2005). In the case of the Maghrebides coastal magmatic belt, the nature of these processes as well as the geological positions and origins of the mantle and crustal magma sources are still a matter of debate (Maury et al., 2000; Lustrino et al., 2011; Carminati et al., 2012; Roure et al., 2012).

The aim of this work is to discuss these questions based on the study of the Miocene magmatic rocks in the Kabylies, located along the Mediterranean margin in Central and Eastern Algeria. This area includes the oldest granitic plutons emplaced at ~17 Ma (Abbassene et al., 2016), that are also the largest magmatic bodies of the whole lineament (~200 km^2 and a minimum of 500 km^3 for the Bougaroun granite; Bouillin, 1979, 1983). These intrusive bodies are unequivocally post-collisional (Hernandez and Lepvrier, 1979; Maury et al., 2000) because they crosscut either the high-grade metamorphic basement of Lesser Kabylia that has been tectonically exhumed at ~17.8–17.4 Ma (Bruguier et al., 2009), its Oligo-Miocene cover and/or the flysch nappes emplaced during the Upper Burdigalian at ~17.6 Ma. Finally, the Lesser Kabylia and easternmost Greater Kabylia overlie a present-day “no-slab” upper mantle region located between two segments of the African oceanic slab that have recently been identified around 200–300 km depth beneath the Algerian coast according to Fichtner and Villaseñor (2015).

2. The Maghrebides chain in the Kabylies (northeastern and central Algeria)

2.1. The Kabylides within the circum-Mediterranean Alpine chains

The Maghrebides (Rif and Tell alpine chains) represent the southern active margin of the Western Mediterranean domain (Fig. 1) and their structure is rather similar to that of their northern equivalent, i.e. the Betics (Wildi, 1983), with an opposite vergence. They include Internal Zones, in northern position, and External Zones, in southward position. In the Kabylides (Greater Kabylia and Lesser Kabylia, Figs. 1 and 2), the Internal Zones are mostly made up of old allochtonous Precambrian continental crust massifs that have recorded multiple tectono-metamorphic events since the Hercynian orogeny (granulite facies conditions at ~275–285 Main Greater Kabylia; Peucat et al., 1996; Hammor et al., 2006) and were exhumed during the Miocene (~18-16 Ma in Edough, Lesser Kabylia; Monié et al., 1992; Hammor and Lancelot, 1998; Bruguier et al., 2009). These basement massifs originate, like those of the Betics, Sicily and Calabria, from the « AlKaPeCa » domain (Alboran-Kabylides-Peloritani-Calabria) dismantled by the opening of the Mediterranean back-arc basins (Bouillin, 1986; Jolivet and Faccenna, 2000). In the Maghrebides, they are overlain to the south by a limestone cover (Fig. 2) preserved as tectonic slices (Coutelle, 1979).

The External (southern) Zones of the Kabylides are mostly composed of flysch nappes of Cretaceous or Paleogene (Numidian flyschs) ages derived from the Tethys Ocean (Fig. 2), thrust over the Tellian units that merge into the autochtonous cover of the African basement. In the northern part of the Kabylides, their basement is unconformably overlain by the Oligo-Miocene Kabylian (OMK) series, a molassic formation that includes Upper Oligocene conglomerates overlain by metatuffs (silexites) dated at 19.4 Ma (K-Ar) in Greater Kabylia (Bellon, 1976; Rivière et al., 1977; El Azzouzi et al.,