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The Montagne Noire migmatitic dome emplacement (French Massif Central): new insights from petrofabric and AMS studies

Nicolas Charles*, Michel Faure, Yan Chen

Université d'Orléans, CNRS/INSU, Université François-Rabelais de Tours, Institut des Sciences de la Terre d'Orléans (ISTO), 1A rue de la Férollerie, 45100 Orléans cedex 2, France

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ABSTRACT

In the southern French Massif Central, the Montagne Noire axial zone is a NE-SW elongated granite–migmatite dome emplaced within Visean south-verging recumbent folds and intruded by syn- to late-migmatization granitoids. The tectonic setting of this dome is still disputed, thus several models have been proposed. In order to better understand the emplacement mechanism of this dome, petrofabric and Anisotropy of Magnetic Susceptibility (AMS) studies have been carried out. In the granites and migmatites that form the dome core, magmatic texture and to a lesser extent weak solid-state texture are dominant. As a paramagnetic mineral, biotite is the main carrier of the magnetic susceptibility. On the basis of 135 AMS sites, the magnetic fabrics appear as independent of the lithology but related to the dome architecture. Coupling our results with previous structural and geochronological studies, allows us to propose a new emplacement model. Between 340–325 Ma, the Palaeozoic series underwent a compressional deformation represented by nappes and recumbent folds involving the thermal event leading to partial melting. Until ~325–310 Ma, the dome emplacement was assisted by diapiric processes. An extensional event took place at ~300 Ma, after the emplacement of the late to post-migmatitic granitic plutons. In the northeast side of the dome, a brittle normal-dextral faulting controlled the opening of the Graissessac coal basin.

1. Introduction

Since Eskola (1949), first recognized their existence, gneiss and migmatite domes have been frequently observed in orogenic belts but their tectonic settings remain disputed (e.g. Whitney et al., 2004 and enclosed references). Nevertheless, a good understanding of the dome dynamics of such a migmatite dome can help structural geologists to understand the regional geodynamics of a large part of the orogen. Several models have been proposed to account for emplacement mechanisms, namely: i) diapirism, ii) anticlinal stacking, iii) post-thickening extension, or a combination of these processes (e.g. Ramberg, 1967; Ramberg, 1980; Davis and Coney, 1979; Wernicke and Burchfield, 1982; Whitney et al., 2004).

In the French Variscan Belt, gneiss and migmatites that develop in the Massif Central, the southern part of the Massif Armoricain or the Pyrénées are variously analyzed and interpreted in terms of their bulk architecture, kinematics, age, emplacement process, and tectonic setting (e.g. Schuiling, 1960; Zwart, 1986; Vissers, 1992; Carreras and Capella, 1994; Brown, 2005; Mezger, 2009). Among these structures, the Montagne Noire axial zone (Fig. 1) is one of the most typical metamorphic domes recognized in the Variscan Belt since Gèze (1949), but its emplacement mechanism and tectonic significance remain highly controversial. Numerous studies have been carried out since more than half a century in order to decipher the doming processes and the relationships with the regional tectonics (e.g. Gèze, 1949; Schuiling, 1960; Nicolas et al., 1977; Beaud, 1985; Faure and Cottereau, 1988; Echtler and Malavieille, 1990; Maluski et al., 1991; Van Den Driessche and Brun, 1992; Brun and Van Den Driessche, 1994; Mattauer et al., 1996; Brunel and Lansigu, 1997; Matte et al., 1998; Demange, 1999; Soula et al., 2001 and enclosed references; see Discussion section below for details).

Furthermore, several weak points have hampered the validity of these models. Firstly, the timing of the polyphase deformation has long been poorly constrained by the lack of accurate geochronological data (Hamet and Allègre, 1976; Maluski et al., 1991). However, recently, more and more geochronological data became available for the various generations of granitoids that form the centre of the Montagne Noire axial zone (Cocherie, 2003; Roger et al., 2004; Bé Mézème, 2005; Charles et al., 2008). Secondly, mainly due to outcrop quality, most of studies focussed on the eastern termination and southern flank of the dome where extensional deformation overprints older features. A few studies

* Corresponding author. Tel.: +33 2 38 49 46 52; fax: +33 2 38 63 64 88.
E-mail address: nicolas.charles@univ-orleans.fr (N. Charles).

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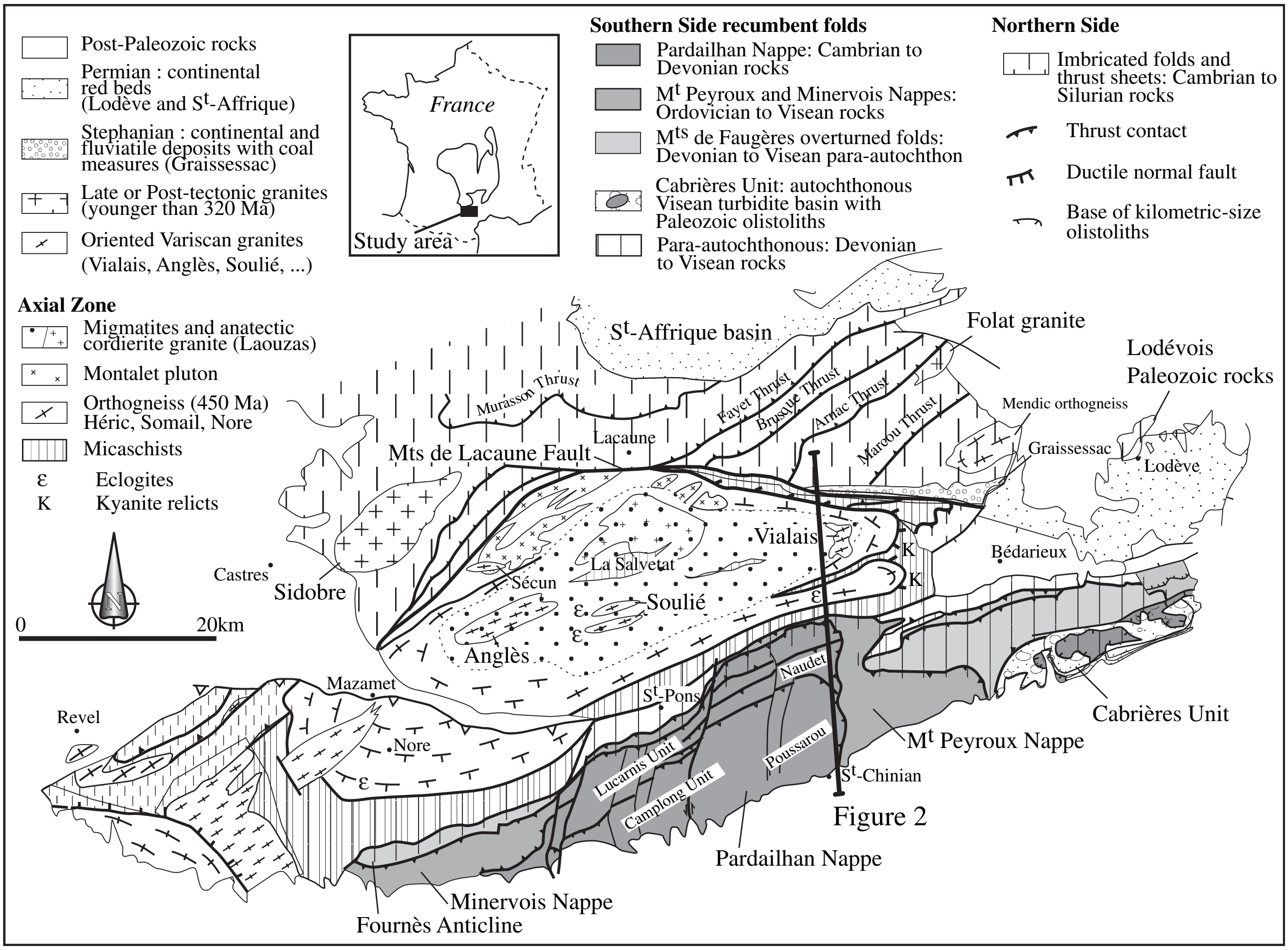

Fig. 1. Structural map of the Montagne Noire (modified from Gèze, 1949 and Arthaud, 1970).

take into account the entire domal structure (see Soula et al., 2001 for extensive references). Lastly, in spite of some petrological works (Bard and Rambeloson, 1973; Demange, 1982; Bogdanoff et al., 1984), the structural features of the migmatites and granites which form the main part of the axial zone have never been considered in any previous models. Indeed, in the field, even if the fabric of these plutonic rocks can be rarely identified, generally the planar and linear structures are not easily recognized. Therefore, the structure of the core of the Montagne Noire axial zone must be investigated by using petrofabric tools such as universal stage or texture goniometer. However, faster and more efficient ones, such as the systematic use of the Anisotropy of Magnetic Susceptibility (AMS), can substitute these time-consuming methods. AMS studies in plutonic rocks are quite common (e.g. Bouchez, 2000; Rochette et al., 1992; Benn et al., 1998; Asrat et al., 2003; Talbot et al., 2003, 2005a, 2005b). Conversely, the AMS approach for fabric analysis in migmatites and anatectic rocks is rare (Ferré et al., 2003). Furthermore, in order to get a meaningful geological significance, the AMS study requires and have to be completed by: i) a careful magnetic mineralogy investigation to identify the bearer of the AMS (e.g. Borradaile, 1988; Rochette et al., 1992; Borradaile and Henry 1997), and also ii) a microscopic observation of the rock forming mineral preferred orientation to define the rheological state experienced by the rock when it acquired its magnetic fabric (e.g. Gapais and Barbarin, 1986; Hibbard, 1987; Paterson et al., 1989; Simpson and Wintsch, 1989).

In the following, petrofabric and AMS analyses of the migmatites and granitoids that constitute the core of the Montagne Noire axial zone are provided. The combination of these new results with previous structural and geochronological data allow us to re-evaluate the existing models, to discuss the emplacement mechanism, and to propose a new evolution model of this southern segment of the French Variscan Belt.

2. The Montagne Noire in the Southern French Massif Central

In spite of some controversial points, most of authors agree on the bulk architecture of the Variscan French Massif Central. It is widely acknowledged that the French Massif Central consists of a stack of ductile and synmetamorphic nappes edificated during Devonian and Carboniferous times (e.g. Ledru et al., 1989; Faure et al., 1997, 2005 and enclosed references). Conversely to the northern areas, the eo-Variscan (Devonian) events are lacking in the southernmost part of the French Massif Central, or Montagne Noire. This area underwent its first deformation during the Middle Carboniferous (Visean to early Namurian) times. Since Gèze (1949) and Arthaud (1970), the Montagne Noire is classically subdivided from north to south in northern, axial and southern zones (Figs. 1 and 2). The Palaeozoic series consist of sedimentary rocks ranging from Early Cambrian to Silurian and from Early Cambrian to Visean in the northern and southern zones, respectively. These series are involved in large-scale, south-verging recumbent folds (Fig. 2) and show a low to moderate metamorphic grade. Emplacement of the recumbent folds is stratigraphically dated of Late Visean to Namurian by the syntectonic foreland sedimentary basin in which they emplace (Engel et al., 1980; Feist and Galtier, 1985).