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Progressive deformation of a zone of magma transfer in a transpressional regime: The Variscan Mérens shear zone (Pyrenees, France)

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ABSTRACT

The EW-striking Variscan Mérens shear zone (MSZ), located on the southern border of the Aston dome (Pyrenees), corresponds to variously mylonitized gneisses and plutonic rocks that are studied using the Anisotropy of Magnetic Susceptibility (AMS) technique. The plutonic rocks form EW-striking bands with, from south to north, gabbro-diorites, quartz diorites and granodiorites. The MSZ underwent a mylonitic deformation with an intensity progressively increasing from the mafic to the more differentiated rocks. The foliations are EW to NW–SE striking and subvertical. A first set of lineations shows a moderate WNW plunge, with a dextral reverse kinematics. More recent subvertical lineations correspond to an uplift of the northern compartment. To the east, the MSZ was cut by a N120°E-striking late shear band, separating the MSZ from the Quérigut pluton. The different stages of mylonitization relate to Late Variscan dextral transpression. This regime allowed the ascent of magmas along tension gashes in the middle crust. We interpret the MSZ as a zone of magma transfer, which fed a pluton now eroded that was similar to the Quérigut and Millas plutons located to the east. We propose a model of emplacement of these plutons by successive pulses of magmas along en-échelon transfer zones similar to the MSZ.

1. Introduction

It is now generally accepted that the orogenic domains that underwent transpression were favourable sites to the ascent of magmas and to the emplacement of plutons because of the strong pressure gradients generated by such a regime (Hutton, 1997; Tikoff and Saint-Blanquat, 1997; Saint-Blanquat et al., 1998; Ferré et al., 2002; Koukouvelas et al., 2002; Romeo et al., 2006). In fact, only a small differential stress added to the lithostatic pressure allows a higher production of melt (Hand and Dirks, 1992) and/or a more efficient segregation and migration of this melt (Dell'Angelo and Tullis, 1988; Rutter and Neumann, 1995; Rushmer, 1996; Rabinowicz and Vigneresse, 2004). Major tectonic structures may play an important role by creating dilational space (D'Lemos et al., 1992; Tikoff and Teyssier, 1992; Román-Berdiel et al., 1997; Crawford et al., 1999). It has been proposed that sheet-like flow through crustal shear zone systems is the ascent mechanism of granitic magmas in convergent orogens (Brown and Solar, 1998a,b). However, though many studies dealing with magma transfer along shear zones have been published (Rosenberg et al., 1995; Druguet and Hutton, 1998; Benn et al., 1999; Brown and Solar, 1999), only few of them display a detailed petrographic and geometric description of the root zone and none gives quantitative data on the progressive deformation undergone by the granitic magmas emplaced in transpression.

The Variscan segment of the Pyrenees is a good example that documents the relationship that exists between deformation and emplacement of granitic plutons in transpressional contexts. Indeed, this segment is characterized by numerous calc-alkaline plutons emplaced in a dextral transpressive regime (Fig. 1a), as shown by systematic petrostructural studies (Leblanc et al., 1996; Gleizes et al., 1998, 2001, 2006; Auréjac et al., 2004; Román-Berdiel et al., 2004; Olivier et al., 2007). The main structural features observed in these plutons are sigmoidal magmatic lineation and foliation trajectories along with shear bands with dextral reverse movements (Fig. 1b). The country rocks display an EW-striking vertical foliation bearing horizontal lineations with a dextral component of shear (e.g. Evans et al., 1997). Moreover, this foliation "wraps" the plutons and forms asymmetrical neutral points, which agree with the dextral movement (Fig. 1b). The Variscan plutonism of the Pyrenees is dated between 312 and 305 Ma by the U/Pb zircon technique (Paquette et al., 1997; Roberts et al., 2000; Maurel et al., 2004; Olivier et al., 2004, 2007; Gleizes et al., 2006).

Various structural levels of plutons are exposed in the Variscan segment of the Pyrenees, yielding the rare opportunity to describe the shape of these plutons from the shallowest to the deepest parts. Their roofs are located in low grade metapelites ($T = 300$–$400\,^{\circ}$C,

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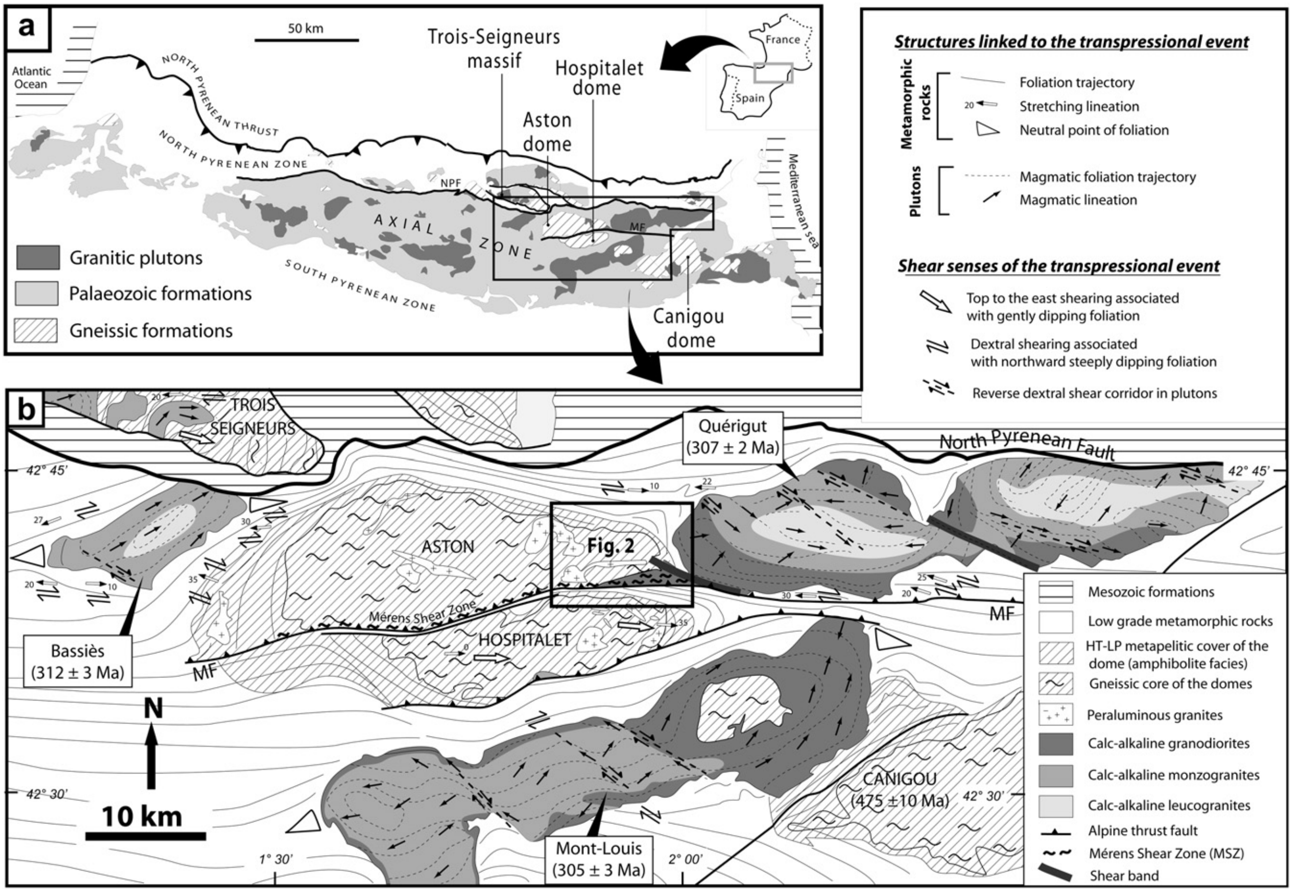

Fig. 1. Sketch maps of the Variscan segment of the Pyrenees. (a) The Variscan formations of the Pyrenees. NPF: North Pyrenean Fault. (b) Geological map of the Mérens shear zone (MSZ) and Mérens Fault (MF) area. The references for the structures and ages of the plutons are given in the text.

$P = 100$–200 MPa) and are dome-shaped, such as the Bassiès pluton (Gleizes et al., 1991) and the western part of the Mont-Louis pluton (Bouchez and Gleizes, 1995). The middle pluton levels, located in the biotite zone, are represented by downward bevelled and northward dipping, several kilometres wide, sheet-like intrusions such as the Quérigut pluton (Auréjac et al., 2004) and the central part of the Mont-Louis pluton. The lower pluton levels are located near the sillimanite isograd ($T > 600$ °C, $P = 300$–400 MPa) and are represented by steeply northward dipping, kilometre-thick sheets of magmatic rocks, such as the Trois-Seigneurs granite pluton (Leblanc et al., 1996).

In the Pyrenees, levels corresponding to the feeding zones of the plutons have not yet been described and the geometry and kinematics of these zones are unknown. Previous data suggest that these feeding zones could be located in the more or less migmatitic gneissic levels and could correspond to thin EW-striking subvertical bands of granitic to mafic rocks. In the central Pyrenees, such a band 10 km long is known and belongs to the Mérens shear zone (MSZ) which crosscuts the southern border of the Aston gneiss dome (Fig. 1b). In this paper, we present a petrostructural, microstructural and kinematic study realized in this elongate zone of granitic to mafic rocks and its gneissic country rocks. We show that the plutonic rocks belong to a zone of magma transfer for which we propose a model of formation and evolution.

2. Geological setting

The MSZ corresponds to an EW-striking, more than 70 km long, major Variscan shear zone separating the Aston gneiss dome to the north and the Hospitalet gneiss dome to the south (Fig. 1). This shear zone varies in thickness from some metres near its western extremity up to 2 km near the eastern extremity of the Aston Massif. Structural studies of the MSZ (Saillant, 1982; Mc Caig, 1984; Carreras and Cirés, 1986) have shown that reverse dextral movements took place along this band during Variscan times, the northern compartment being thrust onto the southern one. The MSZ is truncated to the south by the Alpine Mérens fault (MF), which brings into contact the MSZ and the country rocks of the Hospitalet orthogneisses (Carreras and Cirés, 1986; Barnolas and Chiron, 1996). In the studied area (Fig. 2), corresponding to the widest part of the MSZ, the rock formations affected by this shear zone are, from west to east, the orthogneisses and anatectic paragneisses of the Aston Massif, a band of calc-alkaline plutonic rocks and the southwestern border of the Quérigut pluton. The calc-alkaline rocks consist of mylonitic tonalites, gabbro-diorites, muscovite granites, pegmatites and aplites, and have been interpreted as forming an apophisis of the Quérigut pluton (Raguin, 1977). These plutonic rocks intrude the strongly anatectic paragneisses of the southern border of the Aston dome that are together mylonitized by the MSZ between ten to a hundred metres in width (Fig. 2).

The mineral paragenesis of the Aston paragneisses (biotite + sillimanite + garnet ± cordierite) yields P-T conditions around 300 MPa – 650 °C similar to those from other gneiss domes of the Pyrenees (Vielzeuf, 1996). This contrasts with the greenschist facies metapelites of the Hospitalet Massif that outcrop to the south of the MSZ, which implies a several kilometres vertical offset along this shear zone. To the north of the paragneisses, the Aston dome is made of orthogneisses similar to those of the Canigou Massif, which have been shown to derive from a thick laccolith of monzogranites