

# Late Devonian–early Carboniferous contraction-dominated deformation in Central Armorica (Monts d'Arrée, Brittany, France) and its relationship with the closure of the Rheic Ocean

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## ABSTRACT

In the Monts d'Arrée (western Brittany, France) a high-strain slate belt is well-exposed. The slate belt is located in the Central Armorica Terrane, a low-grade middle- to upper-crustal domain in the Armorican Massif, composed of a Cadomian basement and its Neoproterozoic and Palaeozoic metasedimentary cover sequence. The slate belt consists of highly deformed siliciclastic rocks of the Pridolian to Lochkovian Plougastel Formation. A structural analysis has demonstrated that the slate belt primarily reflects a coaxial, contraction-dominated deformation history, resulting from a top-to-the-NW shearing on top of a weakly dipping décollement. It resulted in NW-verging folding and a pervasive cleavage development, giving rise to a pronounced subvertical mechanical anisotropy. Only during the later stages of deformation history, incipient strain partitioning on this anisotropy lead to the development of punctuated strain heterogeneities, consistently reflecting dextral, belt-parallel, strike-slip strain. The deformation largely occurred prior to the emplacement of the early Carboniferous granitoid intrusions in Central Armorica, and can therefore be correlated with the late Devonian–early Carboniferous 'Bretonian' tectonometamorphic event. The kinematics, inferred in the Monts d'Arrée, moreover, are consistent with the top-to-the-NW thrusting and nappe stacking inferred in the Léon Terrane, situated to the northwest of the Central Armorican Terrane.

These new insights allow linkage of the early Variscan, contraction-dominated deformation in Central Armorica to the closure of the Rheic Ocean and the continental collision of the Léon microcontinental block with Armorica. Our study also reveals the importance of the 'Bretonian' tectonometamorphic event in the entire north-western parts of Central Armorica; the main – cleavage-forming – deformation was diachronous and followed by subordinate wrench-related deformation.

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## 1. Introduction

The Central Armorican Domain (CAD), located in the Armorican Massif of Brittany (France), is part of an upper-crustal Variscan terrane, the Central Armorican Terrane (CAT), exposing a Pan-African (Cadomian) cratonic basement and its late-Proterozoic to Palaeozoic, low-grade metasedimentary cover sequence (Fig. 1). The Variscan geodynamics, in particular in the western part of the CAD, is considered wrench-dominated (Gapais and Le Corre, 1980; Percevault and Cobbold, 1982; Gumiaux et al., 2004a,b). Gumiaux et al. (2004a) recently define a Central Brittany Shear Belt (CBSB) which they suggest reflects a regional dextral bulk simple shear that affected the western parts of the CAD during the Carboniferous.

To the NW of the CAT, the Léon Terrane (LT) (Le Corre et al., 1989) exposes medium- to high-grade metamorphic rocks intruded by late Variscan granites (Fig. 1). Contrary to the Carboniferous, wrench-

dominated geodynamics of the CAD, the internal structure of the LT reflects contraction-dominated, thrust tectonics (Le Corre et al., 1989; Rolet et al., 1994). Moreover, this thrusting event occurred during the late Devonian–early Carboniferous, 'Bretonian' tectonometamorphic event ('phase bretonne', e.g. Paris et al., 1982; Rolet, 1982).

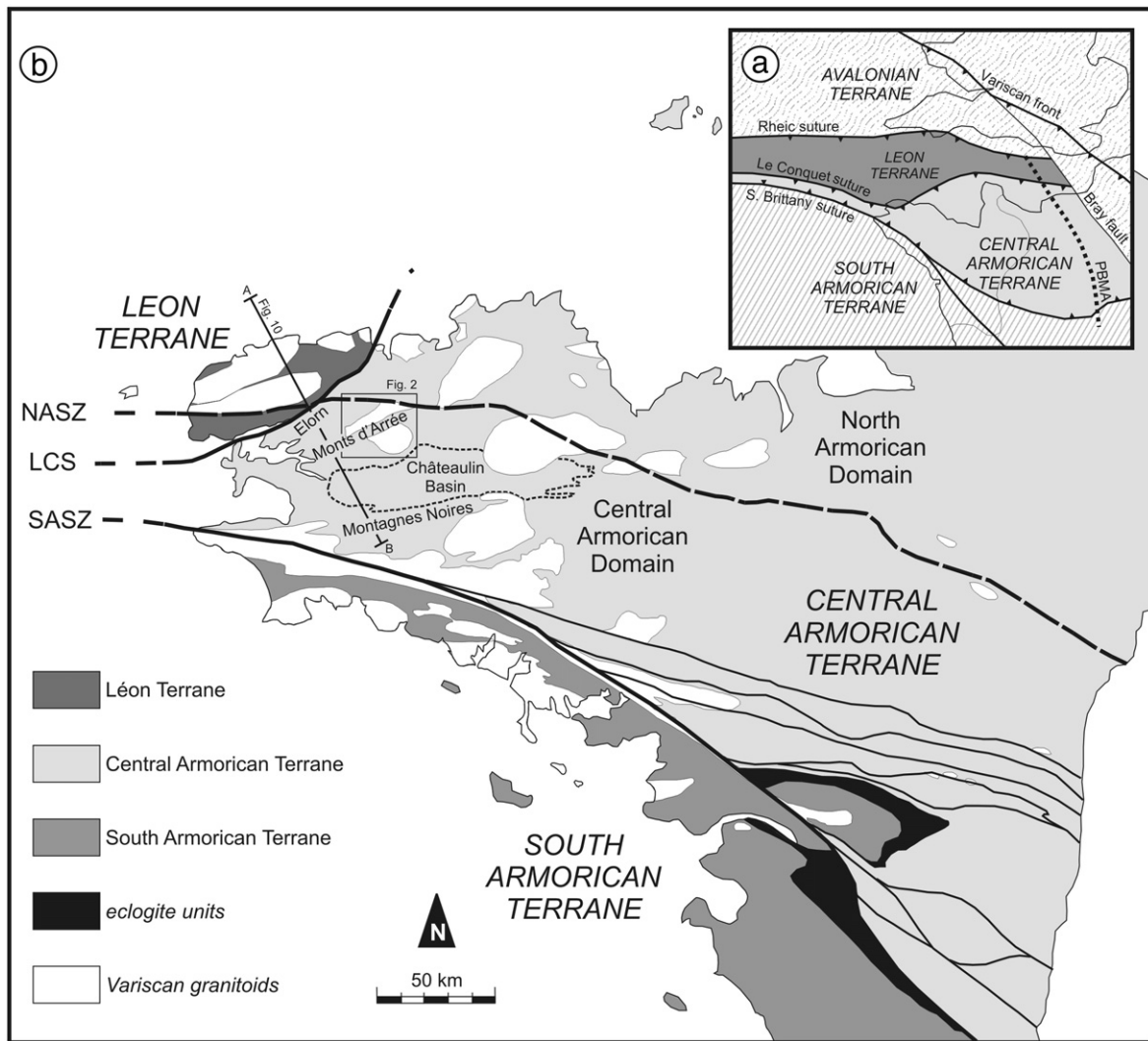
The contrasting geodynamics seems to suggest the presence of a major tectonic break between the wrench-dominated CAT and the contraction-dominated LT. In this respect the LT is considered an exotic terrane, juxtaposed against the CAT by large strike-slip displacements along major shear zones (Balé and Brun, 1986; Le Corre et al., 1989).

The purpose of this paper is to demonstrate that the contraction-dominated 'Bretonian' thrust tectonics affected the entire CAD, and can be linked to the early Variscan tectonic development of the LT. By doing so, new evidence is presented in favour of the models that refute the exotic nature of the LT and place the LT within the suture zone along the northern margin of Armorica, hence relating the 'Bretonian' event to the closure of the Rheic Ocean (Faure et al., 2005; Ballèvre, 2007; Schulz et al., 2007).

The results presented are based primarily on an extensive structural analysis in the Monts d'Arrée (Fig. 1). van Noorden et al.

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**Fig. 1.** Geodynamic setting of the Armorican Massif (Brittany, France). (a) Variscan terrane map of NW Europe (after [Matte, 2001](#); [Faure et al., 2005](#)). NASZ = North Armorican Shear Zone; SASZ = South Armorican Shear Zone; LCS = Le Conquet Suture; PBMA = Paris Basin Magnetic Anomaly. (b) Terrane map of the Armorican Massif in Brittany, with the indication of the different domains and major tectonic elements (after [Matte, 2001](#); [Gumiaux, 2003](#); [Faure et al., 2005](#)).

(2007) give a detailed account of the kinematic model explaining the deformation observed in the Monts d'Arrée. In this paper we make an attempt to place the conclusions of [van Noorden et al. \(2007\)](#) in a broader geodynamic framework, by adding evidence from a more regional survey of the deformation of the Pridolian to Lochkovian Plougastel Formation across Central Armórica.

## 2. Geodynamic setting

The Armorican Massif, situated in Brittany and Normandy (France), exposes a particular segment of the Pan-European, late Palaeozoic, Variscan orogen. It forms the northern branch of the Ibero-Armorican Arc (e.g. [Matte, 1991](#); [Dias and Ribeiro, 1995](#)), the curvature of which is related to the progressive indentation of a Gondwanan promontory during the Variscan orogeny (e.g. [Matte, 1986](#); [Matte, 1991](#); [Ribeiro et al., 2007](#)). The resulting lateral escape caused significant wrenching, particularly evident in the Armorican Massif ([Fig. 1](#)). The South Armorican Shear Zone (SASZ) ([Gapais and Le Corre, 1980](#); [Jégouzo, 1980](#)) formed during this localised dextral wrenching. The SASZ, moreover, coincides with the tectonic boundary (i.e. South-Brittany Suture; [Fig. 1](#)) that resulted from suturing of the Armorica microplate (e.g. [Tait et al., 1997, 2000](#); [Robardet, 2003](#)) and Gondwana ([Ribeiro et al., 2007](#)) following the closure of the Galicia-Southern Brittany Ocean (e.g. [Autran et al., 1994](#); [Matte, 2001](#); [Matte, 2002](#); [Stampfli and](#)

[Borel, 2002](#)). To the south, a high-grade metamorphic domain, the South Armorican Terrane (SAT) ([Fig. 1](#)), belonging to the internal parts of the Variscan orogen, contains the evidence of continental subduction (370–350 Ma) and orogenic collapse (320–300 Ma).

To the north, a low-grade middle- to upper-crustal domain, the CAT ([Fig. 1](#)), represents a part of the Perigondwanan microcontinent Armorica, rifted off the northern margins of Gondwana during early Ordovician times (e.g. [Matte, 2001](#); [Robardet, 2003](#); [Ribeiro et al., 2007](#)). The CAT consists of a Neoproterozoic, Cadomian cratonic basement, reflecting Pan-African geodynamics (e.g. [Strachan et al., 1989](#); [Strachan and Roach, 1990](#); [Strachan et al., 1996](#); [Ballèvre et al., 2001](#); [Chantraine et al., 2001](#)), and its late-Proterozoic to Palaeozoic metasedimentary cover. This metasedimentary cover sequence starts with the Brioverian deposits (late Proterozoic to Cambrian) ([Cogné, 1962](#)), composed of the erosional products of the early phases of the Cadomian orogen ([Guerrot et al., 1992](#)). The Palaeozoic sequence ranges in age from Arenig to Namurian ([Guillocheau and Rolet, 1982](#)) ([Fig. 3](#)). The Grès Armoricain Formation, a white, predominantly arenitic sequence, forms the base of the Ordovician transgressive sequence. The predominantly terrigenous sedimentation evolved from continental platform conditions during the Siluro-Devonian towards more restricted syn-orogenic flysch basins during the Carboniferous (e.g. the Châteaulin Basin; [Figs. 1 and 3](#)) ([Rolet and Thonon, 1979](#)). The CAT is cross-cut by a more diffuse dextral strike-slip

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