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# Late orogenic collapse and thermal doming in the northern Gondwana margin incorporated in the Variscan Chain: A case study from the Ozieri Metamorphic Complex, northern Sardinia, Italy

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**Abstract**

A branch of the South European Variscan chain is noticeably exposed in Sardinia. The early stage of collision between the Northern Gondwana margin and the Armorica Terrane Assemblage (ATA) generated syn-metamorphic folding and thrusting. The evidences of such deformation are well preserved in the nappe zone, a structural domain characterized by stacking of different tectonic units under metamorphism of Barrovian greenschist facies. A late, post-nappe, shortening, under retrograde metamorphic conditions, gave rise to wide, upright, N120–N160 trending antiforms that control the trend of the chain. The structural analysis of the Ozieri Metamorphic Complex (OMC) shows evidence of an important phase of late-Variscan extensional tectonics. Deformation results in, the formation of oppositely dipping, normal shear zones, which developed at upper and middle structural level along the limbs of major regional antiforms causing fabric reactivation, crustal thinning, and exhumation of the OMC core. Within the OMC, the activity of the shear zones was coeval with HT-LP metamorphism as suggests the occurrence of syn-kinematic cordierite + andalusite ± sillimanite + biotite. Whereas syntectonic dykes and a tonalite body in the deeper part of the OMC indicate that early emplacement of melt along shear zones and/or in the antiform hinges possibly supplied the heat for the anomalous thermal gradient and triggered the exhumation of a core complex-like structure.


*Keywords:* HT-LP metamorphic complexes; Post-orogenic collapse; Sardinia; Extensional tectonics; Variscan chain

## 1. Introduction

Collisional tectonics and post-collisional collapse are complementary processes for the arrangement of crustal blocks (Van Bemmelen, 1972; Elliot, 1976; Platt and Vissers, 1989; Alonso et al., in press). In the more general case, collisional chains reach a post-collisional stress field through a gradual transition from compression to extension in concomitance with HT or UHT metamorphic conditions. Post-collisional deformation, involving exhumation of deep structural layers and development of core-complex-type structures, has been sufficiently constrained along the South European Variscan chain (Echtler and Malavieille, 1990; Malavieille et al., 1990; Faure, 1995). Throughout Sardinia island, a complete section of this chain is exposed. Carmignani et al. (1994) subdivide the chain into: i) non-metamorphic foreland, ii) low- to medium-grade metamorphic nappe zone, iii) migmatitic inner zone. The suture between the northern Gondwana margin and the Armorica Terrane Assemblage (ATA), with oceanic crust remnants, is exposed in the northern part of the island along the Posada–Asinara line (PAL since Cappelli et al., 1992). Although the collisional history of the Variscan chain of Sardinia, over the last decades, received the attention of several authors (Arthaud, 1970; Carmignani et al., 1994; Conti et al., 1998, 2001; Carosi and Oggiano, 2002), not much can be said about the late post-collisional evolution. The researches on this aspect of the Variscan Chain in Sardinia are restricted to few areas (Oggiano and Di Pisa, 1988; Ricci, 1992; Cortesogno et al., 1998; Conti et al., 1999) and the post-orogenic extension is still a matter of

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debate. In this article, the late orogenic structural evolution of the OMC, made up of the Ozieri Unit (OU) and the overlain Fiorentini Unit (FU – Oggiano, 1994), which are parts of the north Gondwana margin involved in the collisional frame, is discussed. Starting from the comparison between structural and micro-structural data, we focus on:

1) the kinematics of late deformation stages and the role of inherited collisional structures during the post-collisional extension;
2) their relationship with the HT-LP metamorphism and the emplacement of the plutons that finally stitched the north Gondwana margin and the ATA.

## 2. Metamorphic Variscan basement (OU, FU) and late-Variscan plutons

The study area (Fig. 1) is located in the northernmost part of a narrow, N–S trending, ridge of Variscan basement that crops out in the Goceano district, east of the Tertiary Logudoro basin (Funedda et al., 2000), in central northern Sardinia. This region is part of a structural domain known as "Nappe zone" that partially coincides with a continental arc terrane derived from the north Gondwana margin (Central Sardinia Terrane since Carmignani and Oggiano, 1997). The Posada–Asinara Line separates this domain from a high-grade metamorphic complex that is supposed to be part of the ATA. At Goceano, the Variscan basement consists of the OU, best exposed in the northern part of the study area, and the FU, which is juxtaposed on the former by the 20-km extending, W–E oriented, S-directed Fiorentini thrust (Fig. 2). Two successive parageneses, associated to two different fabrics, have been observed in the OU metapelites. The former retains biotite + muscovite + chlorite mineral assemblage. It corresponds to the Barrovian phase documented elsewhere in the nappe zone and related to the collision tectonics (Franceschelli et al., 1990; Ricci, 1992). The biotite + muscovite + oligoclase + andalusite/sillimanite association indicates LP-HT amphibolite facies conditions. In contrast, the only mineral assemblages within FU metapelites (muscovite + albite ± biotite) indicate greenschist facies conditions. The FU lithostratigraphic sequence is an essentially metapelitic succession consisting of Cambrian–Ordovician metagraywackes, metasandstones, phyllites and rare black quartzites lenses. The OU starts with Cambrian–Early Ordovician poorly selected metasandstones, fine-grained meta-conglomerates and quartzites, overlain by thick continental-arc-related calc alkaline metavolcanic suite of Middle Ordovician age. The succession continues with Late Ordovician metagraywackes hosting alkaline metabasalts, Silurian black phyllites, and Devonian marbles, as observed elsewhere, into other sequences of the northern Gondwana margin (Martin et al., 2003; Oggiano and Mameli, 2006). Two distinct Late-Variscan plutons intruded discordantly across the metamorphic basement. The peraluminous monzogranite is a N–S trending dyke-shaped intrusion, partly exposed below tertiary covers west of Ozieri. The pluton, a few hundred meters wide, hosts several basement xenoliths and mafic aggregates. Farther east, a tonalite body intruded NW–SE. A NNW–SSE trending swarm of aplite dykes, mostly

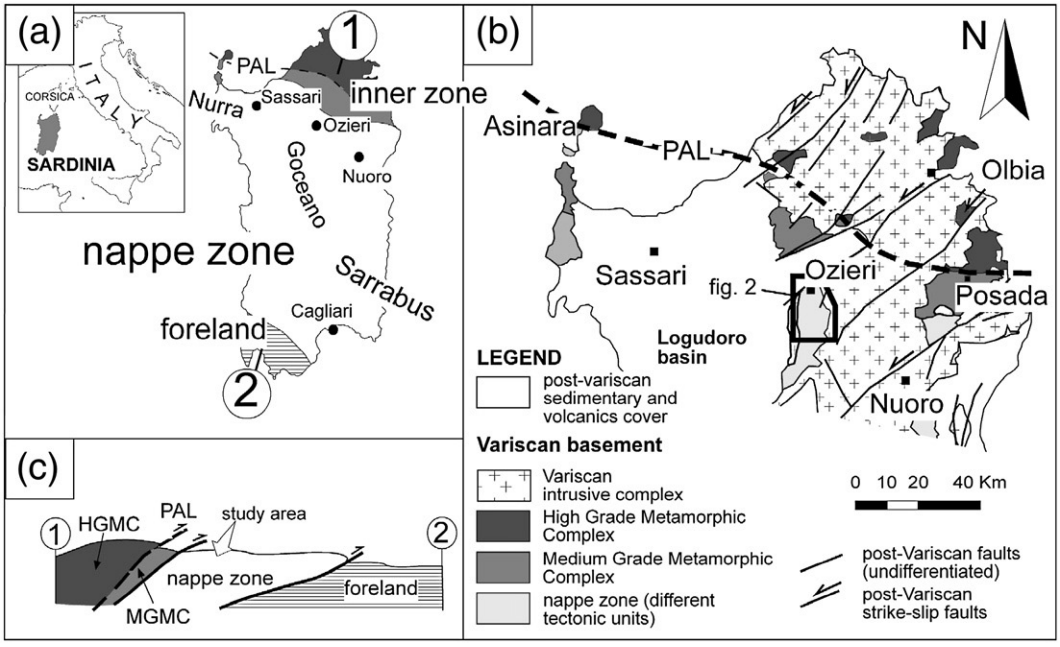


Fig. 1. Location of Sardinia and geological draft of the Variscan basement; a) Scheme of metamorphic/structural domains: the grey area in the north indicates the inner zone (dark-grey: High-Grade Metamorphic Complex, light-grey: Medium-Grade Metamorphic Complex); both complexes are separated by the dextral strike-slip zone PAL (Posada–Asinara Line, Cappelli et al., 1992). The white and the lined areas indicate, respectively, the nappe zone and the foreland; b) Schematic NNE–SSW profile across the whole Variscan basement of Sardinia. Contacts between structural domains (thick lines) are thrusts or, in the case of PAL, strike-slip shear zones; c) Schematic geological map of north Sardinia; the box indicates the location of the study area.