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Tracking the Adriatic-slab travel beneath the Tethyan margin of Corsica–Sardinia by low-temperature thermochronometry

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ABSTRACT

A new multi-thermochronological dataset from Corsica–Sardinia is here employed to constrain the Meso–Cenozoic evolution of the Western Mediterranean area and the problematic transition in space and time between the opposite-dipping Alpine (European) and Apenninic (Adriatic) subductions.

The dataset, including zircon and apatite fission track and apatite (U–Th)/He data, covers the whole Meso–Cenozoic time interval, and fits the theoretical age pattern that is expected in distal passive margins after continental break-up. This demonstrates that Corsica–Sardinia represents a fragment of the northern Tethyan margin still preserving the thermochronological fingerprint acquired during Middle Jurassic rifting. Mesozoic apatite (U–Th)/He ages from crustal sections located close to the Tethyan rift axis (i.e., central and eastern Sardinia) show that no European continental subduction took place south of Corsica since the Mesozoic. Along the Sardinia transect, post-Jurassic Adria–Europe convergence was possibly accommodated by Adriatic subduction, consistent with the onset of orogenic magmatism. In middle Eocene–Oligocene times, the northward translation of the Adriatic slab beneath the former Tethyan margin induced a coeval northward migration of erosional pulses at the surface, constrained by a trend of progressively decreasing fission track ages from southern Sardinia to NW Corsica. The Adriatic slab reached the Alpine wedge of Corsica by the end of the Oligocene without any breakoff of the European slab, and started retreating in Neogene times triggering the long-recognized basin opening in the backarc region.

1. Introduction

The Western Mediterranean tectonic puzzle is the result of a complex and still debated Meso–Cenozoic evolution at the boundary between the Eurasian and African plates (Dewey et al., 1989; Jolivet and Faccenna, 2000; Rosenbaum et al., 2002; Carminati et al., 2012). This plate-boundary area includes Cenozoic orogenic belts (Alps, Apennines, Betics and Pyrenées) related to different, possibly interacting, subduction zones (Jolivet et al., 2003; Vignaroli et al., 2008; Malusà et al., 2011a), and large Neogene backarc basins (Ligurian–Provençal and Tyrrhenian) that disrupt the original relationships between these belts, thus hindering a full understanding of several crucial steps of Mediterranean evolution (Fig. 1A). Half a century since the establishment of the plate tectonic paradigm, the problematic transition in space and time between the opposite-dipping Alpine (European) and Apenninic (Adriatic) subductions (Alvarez, 1991; Molli and Malavieille, 2011; Argnani, 2012), and the inferred southward extension of the Alpine orogenic wedge, are still open and heavily debated issues (Gueguen et al., 1997; Jolivet et al., 1998; Faccenna et al., 2001; Carminati et al., 2012; Turco et al., 2012; Vitale Brovarone and Herwartz, 2013). One end-member hypothesis (the so-called "young-Apennines" hypothesis, Fig. 1B) envisages the occurrence of a Cretaceous-to-Eocene Alpine subduction zone developed across the whole Western Mediterranean, later replaced, after the breakoff of the European slab, by a westward Apenninic subduction developed at the rear of the Alpine wedge since the Oligocene (e.g., Boccaletti et al., 1971; Doglioni et al., 1998, 1999; Handy et al., 2010). Another end-member hypothesis (the so-called "ancient-Apennines" hypothesis, Fig. 1B) envisages, in contrast, the occurrence of two coeval opposite-dipping subduction zones — the Alpine one to the north and the Apenninic one to the south (e.g., Principi and Treves, 1984; Rossetti et al., 2001; Argnani, 2009; Turco et al., 2012). But there is no general consensus about the location of the northern tip of the Apenninic subduction in Paleogene times (located either in front of Sardinia or in front of Corsica) and on the timing of its northward propagation (Jolivet et al., 2003; Vignaroli et al., 2008; Argnani, 2012; Advokaat et al., 2014).

The analysis of low-temperature geochronological systems in the Corsica–Sardinia continental block, a key area in terms of Alps–Apennines linkage located between the Ligurian–Provençal and Tyrrhenian basins (Fig. 1A), may provide useful data for shedding light

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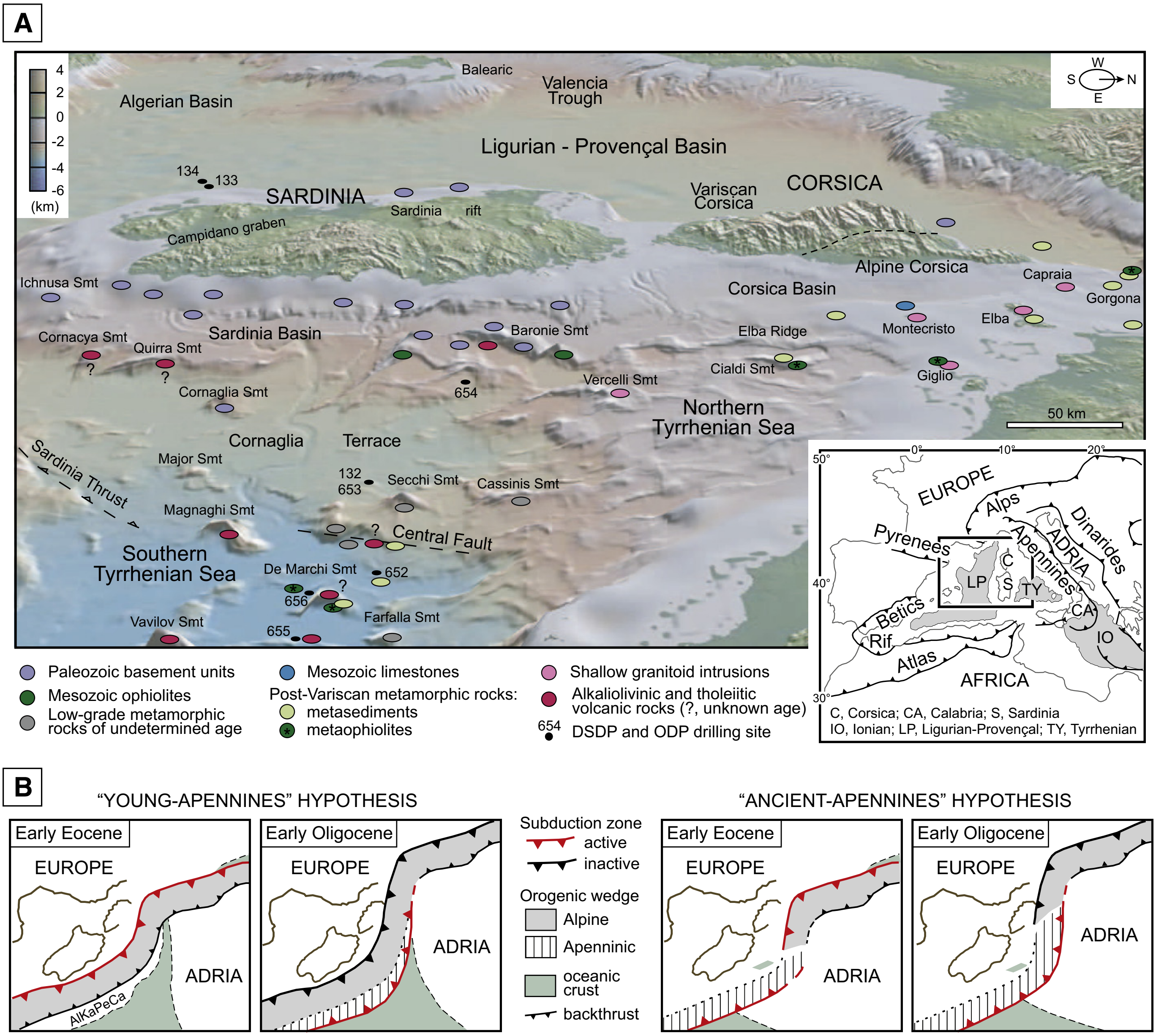

Fig. 1. A: Tectonic map of the Mediterranean area (bottom right) and digital topographic-bathymetric model of Corsica–Sardinia and adjoining basins looking west (after http://www.virtualocean.org; 10/1 vertical exaggeration, location in the inset). The elevation of the wedge-shaped Corsica–Sardinia block gradually decreases from north to south. Note the contrasting physiography between the northern and southern Tyrrhenian basins, and the drastic change in basement lithology across the Central Fault (circles indicate rocks exposed or found by drilling, compiled after Colantoni et al., 1981; Sartori, 1986; Schreider et al., 1986; Bigi et al., 1991, 1992; Sartori et al., 2004). B: Paleogene evolution of the Western Mediterranean according to the young-Apennines (left) and ancient-Apennines (right) hypotheses (based on Doglioni et al., 1999; Jolivet et al., 2003; Molli and Malavieille, 2011; Argnani, 2012; Carminati et al., 2012). In the former case, Sardinia is located in a lower plate position during most of its evolution, and the northern distal margin of Tethys is subducted beneath the Adriatic plate. In the latter case, Sardinia is located in an upper plate position from the Mesozoic, and the distal Tethyan margin is possibly preserved. Note that paleotectonic reconstructions consistent with the ancient-Apennines hypothesis may locate the Paleogene northern tip of Adriatic subduction either in front of Sardinia (e.g., Argnani, 2009) or in front of Corsica (e.g., Jolivet et al., 2003).

on the timing of subduction propagation, and fundamental constraints to discriminate between the end-member reconstructions illustrated in Fig. 1B. In fact, according to the ancient-Apennines hypothesis, Sardinia would be located in an upper plate position since the Mesozoic, and may thus preserve the thermochronological imprint acquired during Tethyan rifting by the distal European passive margin. According to the young-Apennines hypothesis, in contrast, Sardinia would be located in a lower plate position during most of its evolution, and the European distal margin would be no longer preserved because of subduction beneath the Adriatic plate.

In spite of its key position and the favorable widespread exposure of granites, Sardinia is relatively unexplored in terms of thermochronological work (Zattin et al., 2008). In this study, we provide the first full spatial coverage of Sardinia by three low-T thermochronometers, namely zircon and apatite fission track (ZFT and AFT), and apatite (U–Th)/He (AHe). The new data, combined with literature datasets from Corsica (e.g., Zarki-Jakni et al., 2004; Fellin et al., 2006; Danišík et al., 2007; 2012), allow us to constrain the thermal evolution of the whole Corsica–Sardinia block during rifting and subduction, in a temperature range between ~240 °C and ~70 °C. Results are discussed within the framework of available onshore and offshore geological constraints, providing fundamental pinpoints to the Meso–Cenozoic tectonic evolution of the Western Mediterranean area.