Tectonophysics 583 (2013) 164–182

Contents lists available at SciVerse ScienceDirect

Tectonophysics

journal homepage: www.elsevier.com/locate/tecto

Tectono-stratigraphic and kinematic evolution of the southern Apennines/Calabria–Peloritani Terrane system (Italy)

Stefano Vitale [a,*], Sabatino Ciarcia [a,b]

[a] Dipartimento Scienze della Terra, Università di Napoli Federico II, Largo San Marcellino 10, 80138 Napoli, Italy
[b] Dipartimento di Scienze per la Biologia, la Geologia e l'Ambiente, Università del Sannio, via dei Mulini 59/A, 82100 Benevento, Italy

ARTICLE INFO

Article history:
Received 3 March 2012
Received in revised form 30 October 2012
Accepted 3 November 2012
Available online 15 November 2012

Keywords:
Foredeep basin
Paleogeography
Tectonics
Thrust front migration
Wedge-top basin

ABSTRACT

Temporal controls such as sedimentation ages, in foredeep and wedge-top basins, combined with information about stratigraphic and metamorphic evolution, ages and characterization of magmatic rocks, deep structures, burial and exhumation histories, allowed us to obtain kinematic estimations of the southern Apennines/Calabria–Peloritani Terrane system evolution from the Late Oligocene to Recent. Calculated thrust front velocities suggest to subdivide the orogenic evolution in main five kinematic stages characterized by different velocity trends. Nine kinematic complexes (from A to I), i.e. sets of tectonic units deformed in the same time range, are determined according to foredeep ages. These complexes, bounded by main regional thrust faults, encompass one or more tectonic sub-units and successions of different paleoenvironment domains. Paleogeographic evolution model indicates, according to available paleomagnetic data, a counterclockwise rotation, with a mean angle of 60°, for the Apennine Platform carbonates, whereas a mean angle of 20° for the eastern sector of the Apennine Platform and western side of Apulian Platform. Shortening estimations for the Apennine successions show values ranging between 55% and 88% and a linear best fit indicating an increase from 60% (NW sector) to ca. 90% (SE sector). Such high values are consistent with a deformation dominated by a thin-skinned tectonics, on the contrary, the low value of 28% calculated for Mt. Alpi suggests an exhumation ruled by high-angle deep-seated structures characterized by limited displacements. Tectonic vergences, referred to Middle–Late Miocene, Late Miocene and Pliocene–Middle Pleistocene, when restored, indicate an average eastward tectonic transport. Finally, tectonic evolution is summarized in eleven schematic cross sections and corresponding paleogeographic maps.

1. Introduction

The fold-and-thrust belt of the southern Apennines, a segment of the Alpine system in the central sector of the western Mediterranean Sea (Fig. 1), is characterized by the tectonic superposition of several basin to platform successions (e.g., Bonardi et al., 2009; Casero et al., 1988; Catalano et al., 2004; Cosentino et al., 2010; Doglioni et al., 1996; Faccenna et al., 2001a, 2001b; Frizon de Lamotte et al., 2011; Mazzoli et al., 2008; Menardi Noguera and Rea, 2000; Mostardini and Merlini, 1986; Patacca and Scandone, 2007; Roure et al., 2012; Scrocca, 2010; Shiner et al., 2004). Temporal sequence of orogenic building up is ruled by the ages of foredeep basin deposits, progressively younger from top to bottom of the tectonic thrust pile. Unconformable wedge-top basin deposits, frequently sealing contacts between different tectonic units, may provide additional information about ages of orogenic pulses (e.g., Bonardi et al., 2009; Cosentino et al., 2003; Roure et al., 2012; Storti and McClay, 1995). The so obtained temporal sequence, combined with information about temporal and chemical patterns of magmatic rocks, metamorphism, deep structure of the orogenic system, as well as paleogeography reconstructions, allowed to provide several geodynamic evolution models (e.g., Accaino et al., 2011; Bonardi et al., 2009; Ciarcia et al., 2012; Lustrino et al., 2009; Patacca and Scandone, 2007; Scrocca and Tozzi, 1999; Vignaroli et al., 2009; Vitale et al., 2012). In the last years, numerous biostratigraphic and thermochronometric data provided more accurate ages for these deposits (e.g., Ciarcia et al., 2012; Cosentino et al., 2003; Mazzoli et al., 2008; Sgrosso, 1998), whereas structural data, on meso- and macro-scale deformation, clarified the tectonic transport and the geodynamic evolution, including oldest stages of the Apennine prism construction (Ciarcia et al., 2012; Vitale et al., 2010, 2011). Furthermore, recent studies about thermochronology (Corrado et al., 2002, 2005; Invernizzi et al., 2008; Mazzoli et al., 2008) yielded useful information on the burial history and subsequent exhumation of several tectonic units. Aim of this paper is provide a comprehensive geodynamic and kinematic scenario for the evolution of the southern Apennines/Calabria–Peloritani Terrane (CPT) system, within the framework of Central Mediterranean subduction zone. This is carried out by an effective integration of all available geological and geophysical constraints, and completed by a kinematic analysis of thrust front velocities, rotations, shortening

* Corresponding author. Tel.: +39 0812538124.
E-mail address: stefano.vitale@unina.it (S. Vitale).

0040-1951/$ – see front matter
http://dx.doi.org/10.1016/j.tecto.2012.11.004

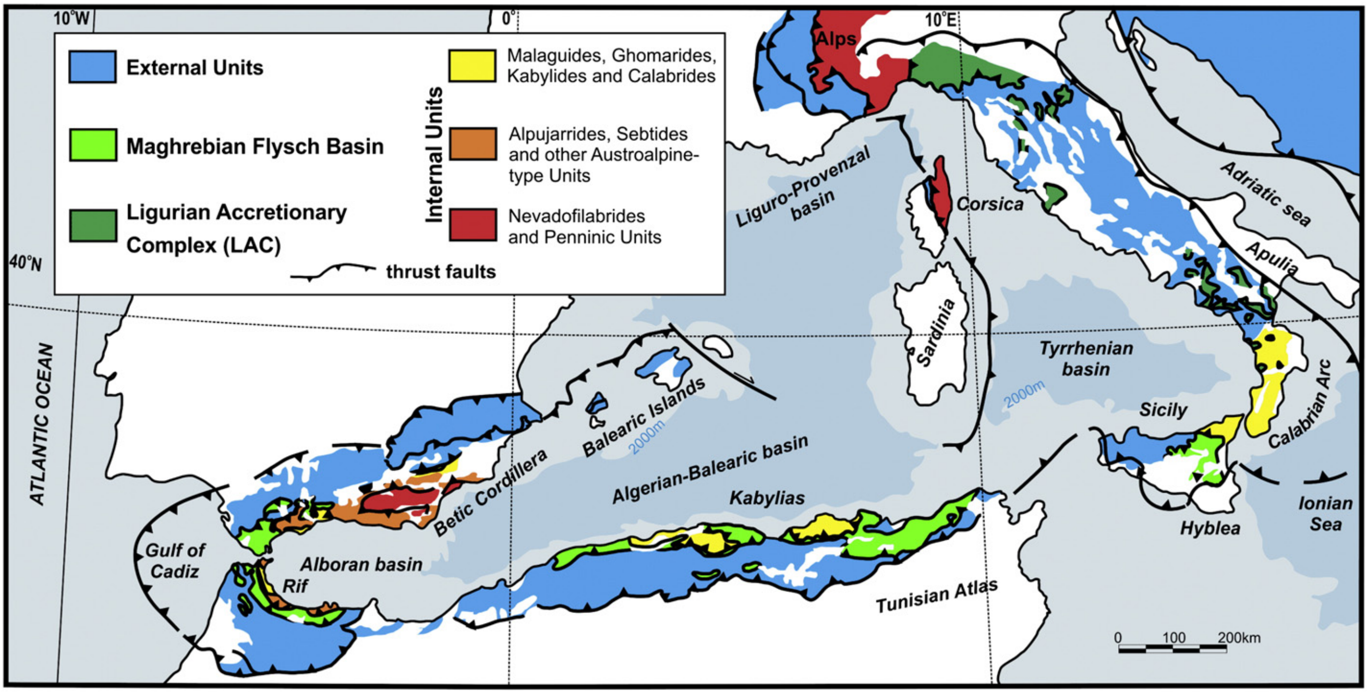

Fig. 1. Tectonic sketch of western-central Mediterranean orogenic belts (from Mazzoli and Martin-Algarra, 2011, modified).

estimations, tectonic vergences and paleogeographic and tectonic evolution models from the Late Oligocene (Chattian) to Recent.

2. Geological setting

The southern Apennines/CPT system is a part of a very long peri-Mediterranean orogenic belt running from the Alps, Italian Peninsula, Sicily, northern Africa, southern Spain, Balearic Islands and part of Corsica Island (Fig. 1). These chains are characterized by the superposition, from top to bottom, of tectonic units derived from: (i) internal domains (generally made of continental crust and more or less metamorphosed sedimentary covers); (ii) oceanic and thinned continental crust basin realms (Maghrebian Flysch Basin and Ligurian domain; e.g., Ciarcia et al., 2012; Guerrera et al., 2005; Knott, 1987); and (iii) external domains (African and European margin successions).

The analyzed sector (Fig. 2a) includes tectonic units derived from oceanic to transitional basin successions overlying a tectonic thrust pile formed by continental margin successions deposited on the Apulian (African) margin (e.g., Mazzoli et al., 2008). The orogenic wedge is capped by remnants of the overriding plate, including Paleozoic crystalline basements (Calabria–Peloritani Terrane, CPT; Bonardi et al., 2001).

Considering a geological transect from the northern sector of Calabrian Arc to the southern Apennines (Fig. 1), the orogenic architecture includes three main tectonic complexes: (i) tectonic units referred to the Paleozoic continental crust and relative Mesozoic covers characterized by different grades and ages of metamorphism (Sila, Castagna and Bagni Units; Amodio-Morelli et al., 1976; Bonardi et al., 2001) that we can refer as Internal Units in analogy with the Betic–Rifian–Kabilian Chain (e.g., Guerrera et al., 2005); (ii) HP–LT ophiolite bearing units (Diamante–Terranova, Malvito, Gimigliano and Frido Units, Amodio-Morelli et al., 1976; Bonardi et al., 2001; Liberi and Piluso, 2009; Liberi et al., 2006; Rossetti et al., 2001, 2004 and references therein) and unmetamorphosed basin deposits of the Ligurian Accretionary Complex (LAC) formed by Nord-Calabrese, Parasicilide and Sicilide Units (Fig. 1; Bonardi et al., 1988a; Ciarcia et al., 2009a; Ciarcia et al., 2012; Ogniben, 1969; Selli, 1962; Vitale et al., 2010, 2011); and (iii) External Units (Fig. 1), formed by the tectonic superposition of stratigraphic covers of the Apulian (African) block formed by Mesozoic to Neogene successions (Bigi et al., 1992; Bonardi et al., 1988b, 2009; Cosentino et al., 2003; D'Argenio et al., 1973; Patacca and Scandone, 1989, 2007) partially detached to their pre-Triassic basement (e.g., Casero et al., 1988; Cippitelli, 2007; Menardi Noguera and Rea, 2000; Shiner et al., 2004). The southern Apennines chain structure, at shallow levels (Fig. 2b), is dominated by low-angle tectonic contacts separating carbonate platform/slope successions of the so-called Apennine Platform (Mostardini and Merlini, 1986) in the hanging wall, from pelagic Lagonegro–Molise Basin successions (Scandone, 1967, 1972) in the footwall. On the contrary, at deep levels, the Apennine structure is characterized by high-angle faults affecting both the buried Apulian Platform and allochthonous successions (Fig. 2b). Only part of the inner margin of the Apennine Platform, cropping out in northern Calabria, is affected by HP–LT metamorphism (Lungro–Verbicaro Unit; Iannace et al., 2007; Vitale, 2005).

Similar major units occur along a geological transect from southern Calabrian Arc to Sicilian Maghrebides: (i) Internal Units, comprising Paleozoic continental crust and more or less metamorphosed Mesozoic covers (Bonardi et al., 2001); (ii) unmetamorphosed basin deposits of the Maghrebian Flysch Basin (Guerrera et al., 2005); and (iii) External Units, derived from the Hyblean (African) block including carbonate platform/slope and pelagic basin successions (e.g., Accaino et al., 2011; Catalano et al., 1996). In both belts, several Neogene wedge-top basin successions progressively covered the tectonic prism (Accaino et al., 2011; Bonardi et al., 2009; Roure et al., 2012).

Being the Late Cretaceous–Recent convergence rate between African and European plates relatively low (from 1–2 cm/yr on average in the last 80 Myr to few mm/yr in the last 20 Ma, e.g., Dewey et al., 1989; Faccenna et al., 2001b), most of the consumption of oceanic lithosphere was probably driven by its negative buoyancy, resulting in trench rollback (Faccenna et al., 1996; Malinverno and Ryan, 1986). Two main geodynamic phases characterize the construction of the southern Apennines/CPT system (Dewey et al., 1989; Faccenna et al., 2001a): (i) Late Oligocene–Middle Miocene trench migration, accompanied by opening of the Ligurian–Provençal back-arc basin and (ii) Tortonian–Pleistocene migration, with opening of the Tyrrhenian back-arc basin. Subduction of oceanic crust produced widespread orogenic volcanism since the Eocene–Oligocene (Savelli, 2002) with the maximum development in Miocene time (Lustrino et al., 2009).