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Tectonostratigraphic models of the Alpine terranes and subduction history of the Hellenides

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ABSTRACT

The tectonostratigraphy of the Hellenic terranes is related to their paleogeodynamic and paleogeographic evolution, which comprises three major stages: (i) Continental rifting in the northern margin of Gondwana, characterised by volcanosedimentary complexes of Late Paleozoic–Triassic. (ii) Continental drifting and contemporaneous oceanic opening of Tethyan basins in between the continental terranes during Triassic–Paleogene with shallow-water carbonate platforms on the continental terranes and ophiolite suites interlayered with pelagic sediments within the Tethyan basins. (iii) Accretion of the tectonostratigraphic terranes with docking along the active European margin, characterised by flysch/melange sedimentation along the trenches from ?early Jurassic to Neogene. Two tectonostratigraphic models can be distinguished: one for the continental terranes/carbonate platforms and another for the oceanic basins. The duration of each geodynamic stage for each terrane is obtained from the chronology of the tectonostratigraphic facies change. The general trend is younger ages observed in the southern terranes and older ages towards the northern terranes. The two alternative tectonostratigraphic models are applied in the two groups of terranes and the chronology of the geodynamic–paleogeographic stages is estimated. The Hellenic subducted slab as shown in the seismic tomographic images is correlated to the terrane paleogeography using the estimated widths and the average subduction rates. The upper 1700 km of the slab correspond to the three southern more external terranes whereas the remainingpart of the slab may represent the other more internal terranes. A palinspastic model of the Hellenides is presented taking into account the chronology of each stage for every terrane. Obduction of ophiolites over the southern platforms, is observed in all four oceanic basins. Blueschist exhumation, formation of core complexes and tectonic windows through extensional detachments occur after micro-collision of continental terranes/platforms and their isostatic uplift within the upper plate after their detachment from the subducting slab.

1. Introduction

The paleogeographic organisation of the Hellenides within the Tethyan system in the Eastern Mediterranean has been a matter of discussions and different views depending on the change of the general concepts of geotectonics. Thus, early syntheses following the geosynclinal concept have proposed the existence of a number of different paleoenvironments, both shallow neritic and deep pelagic, in a simplified model of alternating ridges and furrows forming isopic zones, which after their orogenic deformation, were transformed to geotectonic zones across the belt (Aubouin, 1959, 1965; Brunn, 1956, 1960; Philippson, 1898, 1959; Renz, 1940, 1955). After the development of geological models within the plate tectonics theory in the 1970s the paleogeography of the Hellenides has been revisited, focusing on the identification of the ophiolite suture zone(s) representing the lost oceanic basin(s) of Tethys and the attribution of the geotectonic zones to the northern/Eurasian or to the southern/African continental margin. However, this simple Atlantic type paleogeographic organisation could not be accepted because more than one ophiolite belt occurred within the pelagic sediments, alternating with shallow water carbonate platforms (Aubouin, 1976; Aubouin et al., 1977; Dercourt, 1970, 1972; Dewey et al., 1973; Dimitrievic, 1974; Jacobshagen, 1979; Le Pichon and Angelier, 1979; Smith, 1971).

Several tectonic and paleogeographic models of the Hellenides have been proposed involving a different number of oceanic basins along the belt and also different types of geodynamic settings, such as ophiolites formed within spreading centres along mid-ocean ridges, above supra-subduction zones, etc. (Biju-Duval et al., 1977; Dercourt et al., 1985; Dewey and Şengör, 1979; Garfunkel, 2006; Robertson, 2002, 2004; Robertson and Dixon, 1984; Robertson et al., 1991; Smith, 1993; Smith and Rassios, 2003; Stampfli and Borel, 2004). However, in between the ophiolite suture zones of the Hellenides outcrops of pre-Alpine continental crust of Pre-Cambrian and/or Paleozoic age covered by shallow-water carbonate platforms of Mesozoic–early Cenozoic age, were thought to represent microcontinents like the Cimmerian/Pelagonian blocks (Jacobshagen, 1986; Mountrakis, 1986; Papanikolaou,

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1984, 1986b; Robertson and Dixon, 1984; Sengor, 1979, 1984, 1989; Sengör et al., 1984b, 1988).

The concept of tectonostratigraphic terranes was applied in the Mediterranean mainly within the IGCP project 276, aiming to analyse the pre-Alpine basement rocks within the Mesozoic organisation of Tethys and to identify their provenance from Gondwana or Eurasia (Papanikolaou and Ebner, 1997; Papanikolaou and Sassi, 1989). In the Hellenides this project resulted with the distinction of nine terranes, five continental and four oceanic (Papanikolaou, 1989, 1997, 2009; Papanikolaou et al., 2004) (Fig. 1). Some authors have questioned the use of the terrane concept in favour of the term "microcontinent" and the use of the "tectonic facies" concept (Robertson, 2004). The main difference in the terminology and notion of the microcontinent concept from the terrane concept lies in the overall aspect, which is rather static in the microcontinent but highly dynamic in the terrane. In the first case, it is a paleogeographic element separating different parts of the Tethys ocean with extremely complex tectonic scenarios resulting from a variety of tectonic facies whereas in the second case it is a dynamically evolving element with differentiating tectono-stratigraphy following the entire movement and history from the break of the African margin through rifting in the early Mesozoic, to the drifting within the oceanic basins of the changing Tethys and the final accretion to the European margin in the late Mesozoic–Tertiary (Papanikolaou, 1989, 1997). Earlier events of terrane rifting, drifting and accretion can be detected within the continuation of the more internal part of the Hellenides north of Rhodope in the basement of the Balkanides and the Dinarides (Haydoutov, 2002; Haydoutov et al., 1997; Karamata et al., 1997; Yanev, 1993). Tectonostratigraphic terranes have also been described in the Pontides–Taurides with events ranging from the Variscan orogeny to the Late Cretaceous and Early Tertiary (Goncuoglu et al., 1997; Moix et al., 2008). Paleogeographic representations and stratigraphic columns of the Hellenic terranes show a continuous change both as far as their autonomous existence as microplates and their relative position in the Tethyan organisation are concerned. Thus, the nine terranes described in the Hellenides (H1 to H9) never co-existed, because by the time the younger ones in the south were drifted northwards and new oceanic basins were opened, the early ones in the north were already accreted to Europe and the older oceanic basins were closed. The tentative paleogeographic reconstruction of the Hellenic terranes (Papanikolaou, 1989, 2009) is an overall scheme which corresponds to a synthesis of paleogeographic schemes during different time intervals. Correlation of the pre-Alpine basement rocks with their usually detached sedimentary cover, made of shallow-water carbonate platforms, is the main tool for deciphering the Tethyan paleogeographic organisation of the Hellenides

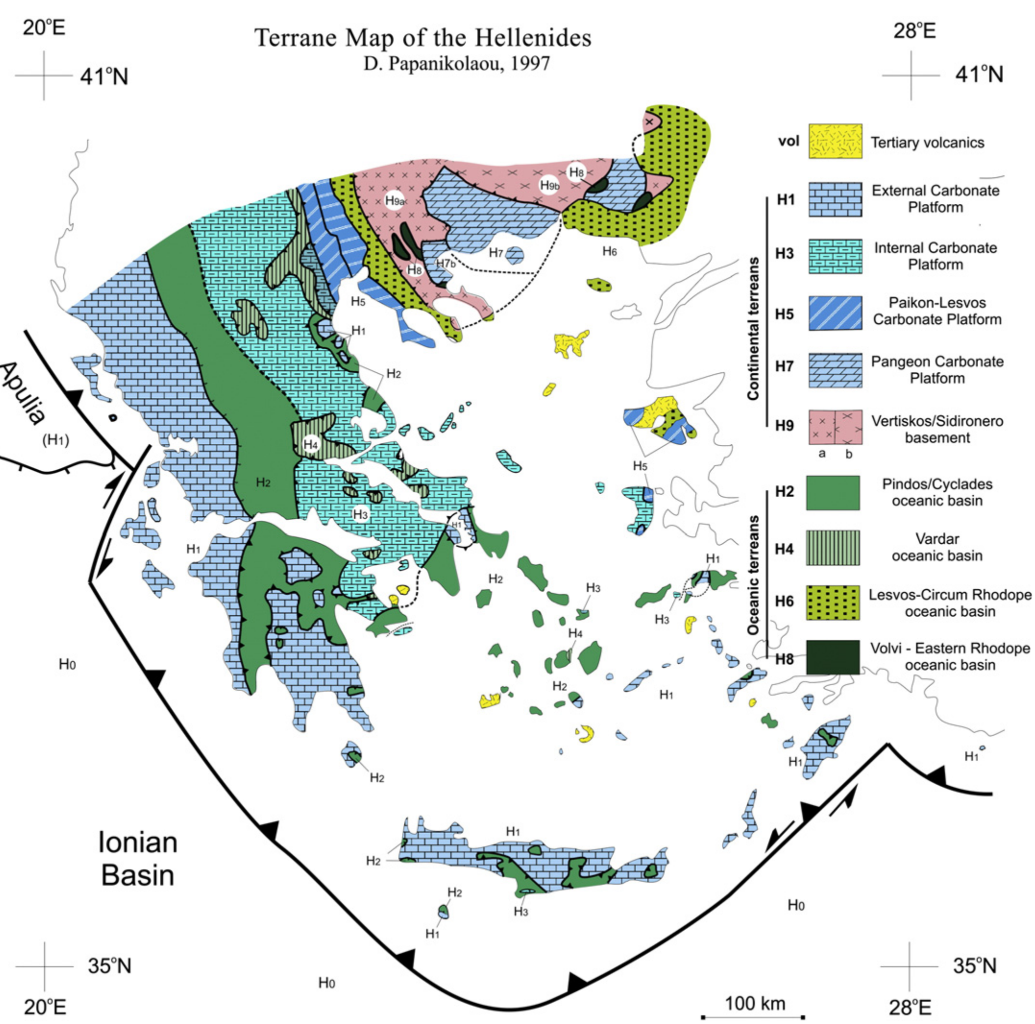

Fig. 1. Terrane map of the Hellenides (after Papanikolaou, 1997, modified). Continental terranes H1, H3, H5, H7 and H9 are drifted Gondwana fragments with Mesozoic carbonate platforms whereas oceanic terranes H2, H4, H6 and H8 are Mesozoic oceanic basins with ophiolites sutured and obducted within Jurassic–Oligocene. Apulia represents the still undeformed external part of the External Carbonate Platform of the Hellenides (H1) in front of the Northern Hellenides. The Ionian Basin, being part of the East Mediterranean Basin, is subducted since late Miocene beneath the Southern Hellenides and represents the last future terrane H0.