Tectonophysics 665 (2015) 218–235

Contents lists available at ScienceDirect

Tectonophysics

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

Kinematics of Cretaceous subduction and exhumation in the western Rhodope (Chalkidiki block)

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ARTICLE INFO

Article history:
Received 5 June 2015
Received in revised form 1 September 2015
Accepted 30 September 2015
Available online 6 November 2015

Keywords:
Aegean
Chalkidiki
Rhodope
Extension
Thrusting
Exhumation

ABSTRACT

In the Chalkidiki Peninsula of northern Greece a thrust complex made of a basement (Vertiskos Unit), a cover (Circum–Rhodope belt) and arc/back-arc units (Chortiatis Magmatic Suite and eastern Vardar Ophiolites) is exposed in the Chalkidiki Peninsula of northern Greece. The complex forms the western part of the Rhodope Metamorphic Province and lies on the hanging-wall of the Kerdylion Detachment, the structure responsible for the exhumation of the Southern Rhodope Core Complex and the most prominent and visible ductile structure related to the Tertiary Aegean extension. The Chalkidiki thrust complex arguably preserves a complete record of Cretaceous deformation and related fabrics. In this contribution we describe the geometry of foliation, stretching lineation and shear sense(s) on a regional scale. The regional foliation strikes NW–SE and displays different patterns in the three studied units: (i) dominantly dipping at low angle in the Vertiskos Unit, (ii) affected by upright folding in the Circum–Rhodope belt and (iii) systematically steeply dipping to the NE in the Chortiatis Magmatic Suite. Stretching lineation trend dominantly SW–NE in the three mentioned units. On the basis of new mapping, neglecting local perturbations and deformation related to Tertiary extension, we infer the regional kinematics of Cretaceous syn-metamorphic thrusting and subsequent exhumation of the metamorphic units. Thrusting took place toward the SW (in present-day coordination) and the related fabrics are recorded throughout the metamorphic pile. On the contrary, exhumation-related fabrics are related to shear toward the NE and are preferentially recorded in the uppermost part of the metamorphic pile suggesting that extension was more localised and of less finite intensity compared to thrusting.

1. Introduction

The Hellenides are part of the Alpine–Himalayan mountain chain and were formed during the Mesozoic–Cenozoic convergence between the South European margin and northward-driven Gondwana-derived continental blocks (e.g., Dercourt et al., 1993; Stampfli and Borel, 2002). They consist of three continental fragments, namely the Rhodopia, Pelagonia and the External Hellenides, arranged in a SW-verging stack from NNE to SSW in the order listed, and two intervening oceanic domains now forming, from north to south, the Vardar–Axios and the Pindos Suture Zones, respectively (Papanikolaou, 2009, 2013; Robertson, 2002; van Hinsbergen et al., 2005) (Fig. 1). The Mesozoic convergence phase is recorded in the innermost part of the Hellenides known as the North Aegean Domain. Subsequent early Cenozoic extension affected the North Aegean Domain, soon after suturing of the Pindos oceanic domain (Brun and Sokoutis, 2010; Jolivet and Brun, 2010), in a process intrinsically connected to the southward retreat of the Hellenic subduction (Dewey and Sengör, 1979; Jolivet and Faccenna, 2000; Le Pichon and Angelier, 1979, 1981; McKenzie, 1978; Mercier et al., 1979; Mercier, 1981); the Aegean Sea corresponds to the most stretched part of the Hellenic domain.

The present contribution deals with the Mesozoic tectonic history of the North Aegean Domain. We have selected the Chalkidiki block that largely coincides with the so-called Serbo-Macedonian Domain as the best witness of the Mesozoic deformation in terms of recorded ductile fabrics and related kinematics. The latest Cretaceous–early Cenozoic apatite fission-track ages from the Chalkidiki block, which predate the corresponding ages from the adjacent parts of the North Aegean Domain, attest for a minimum degree of post-metamorphic thermal overprint (Kydonakis et al., 2014a). Thus, the Chalkidiki block largely escaped thermal and tectonic overprint during the Cenozoic extension contrary to the counterpart units further to the northeast. The present paper, after a review of previous works, describes the Cretaceous syn-metamorphic deformation pattern of the Chalkidiki block through (i) description of strain markers and superposition of fabrics, (ii) maps of regional foliation, stretching lineation and associated shear sense,

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http://dx.doi.org/10.1016/j.tecto.2015.09.034
0040-1951/

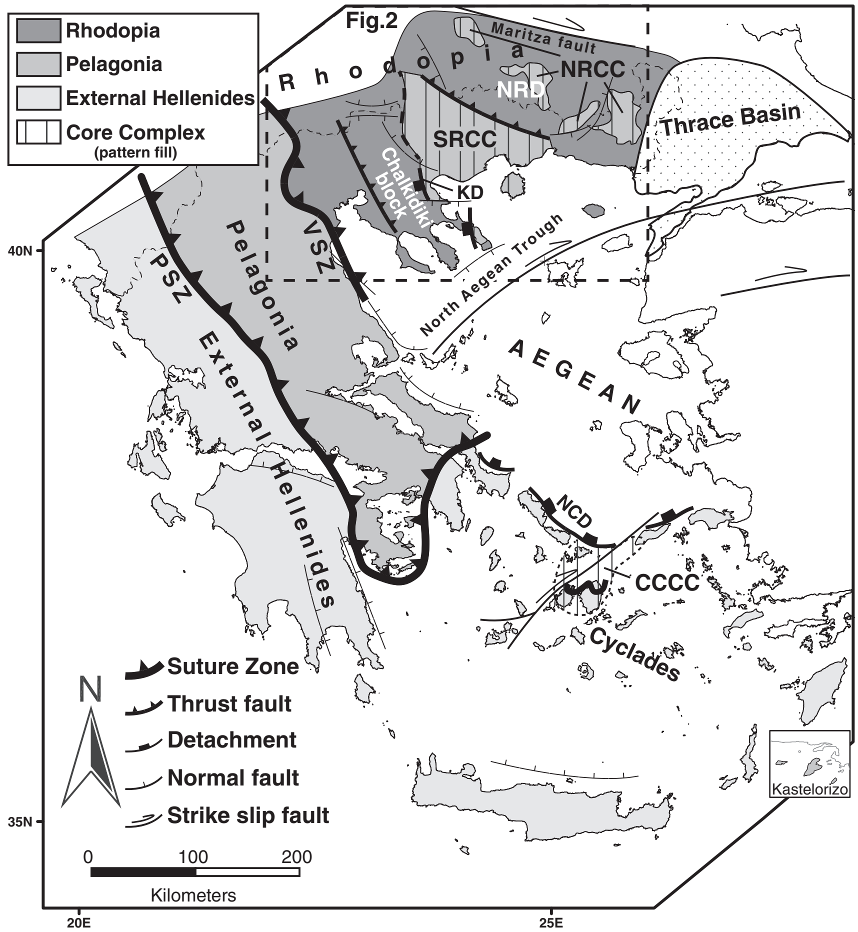

Fig. 1. Simplified geological map of the Hellenides. The Hellenides are made, from north to south, of three continental blocks (the Rhodopia, Pelagonia and the External Hellenides) and two intervening sutured oceanic domains (Vardar and Pindos Suture Zones). The study area is located to the hinterland of the Hellenides, in the Rhodope. NRD: Northern Rhodope Domain, NRCC: Northern Rhodope Core Complex, SRCC: Southern Rhodope Core Complex, CCCC: Central Cyclades Core Complex, KD: Kerdylion Detachment, NCD: North Cycladic Detachment.

(iii) folding pattern and (iv) kinematic description of thrust- and exhumation-related kinematics.

2. Geological setting

The North Aegean Domain covers a large part of northern Greece and forms the hinterland of the Hellenides (Fig. 2). It is bordered to the north by the Maritza dextral strike–slip fault (Naydenov et al., 2013) and to the south by the Vardar–Axios Suture Zone defined by obducted ophiolites on the Pelagonia continental block (see Papanikolaou, 2009; Robertson et al., 2013; and references therein). In the mainland of northern Greece and southern Bulgaria, the North Aegean Domain is divided into three sub-domains with different tectono-thermal histories that are, from northeast to southwest, the *Northern Rhodope Domain*, the *Southern Rhodope Core Complex* and the *Chalkidiki block* (Fig. 2).

Evidence of Mesozoic crustal thickening has been reported from various units exposed at the North Aegean Domain (e.g., Burg et al., 1990, 1995, 1996; Ricou et al., 1998). Large-scale extension affected the area since the middle Eocene as a response to gravity spreading of the previously formed thick and weak crustal-scale orogenic wedge (Kydonakis et al., 2015a). The formation of an array of four extensional gneiss domes within the Northern Rhodope Domain (Chepinska, Arda, Kardamos–Keshebir and Kechros–Biela-Reka; see review in Burg, 2012) pre-dates and partly overlaps with the formation of the Southern Rhodope Core Complex (Brun and Sokoutis, 2007; Dinter and Royden, 1993; Sokoutis et al., 1993); formation of the extensional domes was accompanied by widespread syn-extensional plutonic and volcanic activity (e.g., Jones et al., 1992; Kolocotroni and Dixon, 1991; Marchev et al., 2004, 2013). The development of the Southern Rhodope Core Complex separated the Chalkidiki block from the Northern Rhodope Domain to the northeast and southwest, respectively (Brun and Sokoutis, 2004, 2007; see also Kydonakis et al., 2015a). Before separation, these two domains shared a similar tectono-metamorphic history and arguably participated in the same Mesozoic crustal-scale southwestward piling-up event (see Kydonakis et al., 2015b and discussion therein).

2.1. The Northern Rhodope Domain

The *Northern Rhodope Domain* (NRD) is the northeastern part of the Rhodope (Fig. 2). Gneisses exposed there are locally turned into mylonites and ultra-mylonites and record intense, close to plane strain, non-coaxial ductile deformation (Burg et al., 1990, 1993). A regional NNE-trending stretching lineation associated to a top-to-SW sense of shear developed during thrusting (Barr et al., 1999; Burg et al., 1990; Kilias and Mountrakis, 1990) under amphibolite-facies conditions (Burg et al., 1996). Evidence of UHP conditions is demonstrated by the presence of micro-diamond inclusions in metapelites (Mposkos and Kostopoulos, 2001; Perraki et al., 2006; Schmidt et al., 2010) that indicate a minimum local pressure of 3.0 GPa (for 600 °C). Jurassic and Cretaceous zircon metamorphic ages (circa 150 and 75 Ma) from both garnet-kyanite gneisses and amphibolitised eclogites have been reported (Bauer et al., 2007; Liati et al., 2011; and references therein). Metamorphic conditions for the HP event recorded in mafic rocks are estimated at 1.9 GPa/700 °C (Liati and Seidel, 1996) and for the regional