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Provenance of Tertiary volcanoclastic sediment in NW Thrace (Bulgaria): Evidence from detrital amphibole and pyroxene geochemistry

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ABSTRACT

Detrital heavy mineral and bulk rock geochemistry and a review of sandstone petrographic data have been used to investigate the post-collisional effusive magmatism that followed the closure of the Vardar Ocean and the generation of volcanic sediments in a complex and compositionally variable volcanic region. Available petrographic data gives evidence of contributions from three key source areas corresponding to the three main tectonic units: the structurally lower Gneiss–Migmatite Complex (Byala Reka-Kechros and Kesebir-Kardamos domes) and the upper Variegated (Kimi) Complex, both fringed by the low-to-medium-grade Mesozoic rocks of the Circum-Rhodope Belt. Besides the deposition of siliciclastic material, volcanic contributions from both, intermediate and acid products represent an important source of sediment in the area. Despite dominant intermediate to acid volcanic products, volcanic lithic fragments in sandstones (microlithic, lathwork and brown vitric textures) indicate main inputs from intermediate and basic-intermediate products generating questions on the interpretation of volcanic detritus in reconstruction of provenance. Detrital amphibole and pyroxene chemistry is used to characterise the supply of volcanic material as well as the dispersal mechanisms and understand the role played by each of the volcanic centers present in the area in the infill of the north-western Thrace basin. Amphibole chemistry reveals high compositional heterogeneity according to both compositional variability of the numerous volcanic centres active at the time of deposition and presence of metamorphic amphibole. ^{4}Al and Al_T apfu values indicate that most of the amphiboles from the NERZ are not of volcanic origin and their presence can only be attributed to the numerous amphibolite facies metamorphic rocks abundantly documented in the area. Detrital amphibole compositions from the ZKVS indicate major contributions from the Iran Tepe and Zvedzel volcanoes. Analysed detrital clinopyroxenes from the NERZ are mostly diopside–augite, with no hedenbergite or Fe–augite detected. The $^{4}Al/^{6}Al$ ratio is comparable with compositions of volcanic pyroxenes from the Momchilgrad–Arda (ZKVS) region and products from the pre-caldera phase of the Borovitza.

1. Introduction

Provenance analysis aims at revealing the information recorded in sediments derived from the evolution of orogens and magmatic arcs, and identifying the lithologies producing sediments and the processes they underwent from source to sink.

Besides traditional approaches as sandstone petrography (e.g. Dickinson, 1970, 1985) and bulk-rock geochemistry (Bathia, 1985; Bathia and Crook, 1986; McLennan, 1989; McLennan et al., 1993; Rollinson, 1993; von Eynatten, 2003; Armstrong-Altrin and Verma, 2005; Kutterolf et al., 2008), the provenance toolbox for basin analysts consists of a variety of techniques remarkably increasing the accuracy of data interpretation. The relationships between tectonic setting, orogenesis and associated basin systems can be determined integrating standard techniques with radiometric dating of single detrital minerals (e.g. Sircombe, 1999; von Eynatten and Wijbrans, 2003; Danišík et al., 2008; Andò et al., 2014) and heavy minerals analyses (Raman spectroscopy, ICP-MS and microprobe single grain geochemistry; Mange-Rajetzky, 1983, 1995; Mange and Morton, 2007; Garzanti et al., 2007; Triebold et al., 2007; Frei and Gerdes, 2009; Meinhold, 2010; Andò et al., 2011; von Eynatten and Dunkl, 2012; Andò and Garanzanti, 2014); quartz and feldspar cathodoluminescence (Augustsson and Reker, 2012 and this volume). Single-grain analytical techniques focus on within mineral phase variability, thus allowing the attribution of detrital grains to the rocks from which they were originated (e.g., Morton, 1991; von Eynatten and Gaupp, 1999; Zack et al., 2004b; von Eynatten and Dunkl, 2012; Andò et al., 2014; Limonta et al., 2014).

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Volcaniclastic sediments are generally clastic deposits derived from the transport, deposition and/or reworking of the products of volcanic activity (Manville et al., 2009).

Volcanic and volcanoclastic layers preserved in sedimentary successions are of critical importance in provenance analysis when reconstructing the evolution of sedimentary basins as they represent key and potentially well dated events (Garzanti, 1985; De Rosa et al., 1986; Marsaglia, 1992; Critelli and Ingersoll, 1995; Caracciolo et al., 2011, 2012). Volcanic sediment can be treated like non-volcanic sediment, but the close association of tectonism and volcanism provides an added dimension to the analytical importance of this type of sediment.

Volcanic-generated sediments have often been disregarded because of the intrinsic complexity of the fragmentation, transport and depositional processes controlling volcanic-influenced environments (Manville et al., 2009). Conversely, most of the attention has traditionally been directed to primary volcanic processes occurring prior and subsequent eruptive events. The main consequence of magmatic processes (e.g. lithospheric doming above the mantle plume; volume of emitted products) is the alteration of local and regional drainage networks (Cox, 1989), influencing basin evolution and accommodation space and consequently sediment dispersal pathways and hence sediment compositional signatures.

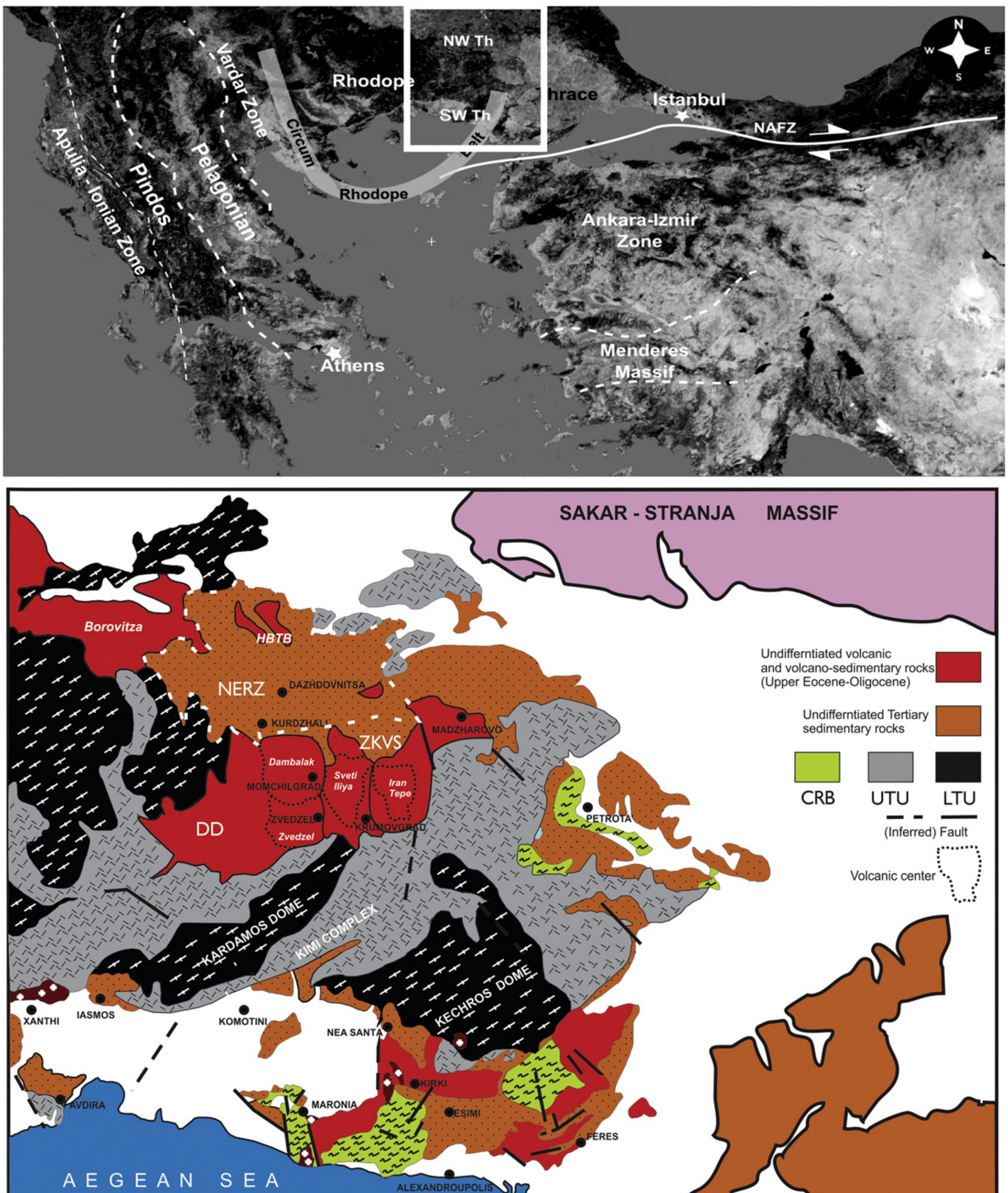

Fig. 1. a) The Thrace basin within the Eastern Mediterranean and Balkan regions. Main sutures and correspondent terrains are reported. NAFZ, North Anatolian Fault Zone (modified after Caracciolo et al., 2011); b) simplified geological map of the Rhodope massif and the western portion of the Thrace Basin incliding the three main Eocene–Oligocene depocentres (ZKVS, Zvedzel-Krumovgrad Volcanotectonic Structure; NERZ, North East Rhodope Zone; DD, Dzhebel Depression) and location of main volcanic centers. Modified after Caracciolo et al. (2012) and Kirchenbaur et al., 2012. CRB, Circum_Rhodope Belt, UTU, Upper Tectonic Unit, LTU, Lower Tectonic Unit.