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How tectonics controlled post-collisional magmatism within the Dinarides: Inferences based on study of tectono-magmatic events in the Kopaonik Mts. (Southern Serbia)

Ana Mladenović *, Branislav Trivić, Vladica Cvetković

Faculty of Mining and Geology, University of Belgrade, Đušina 7, Belgrade 11000, Serbia

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ABSTRACT

In this study, we report evidence about coupling between tectonic and magmatic processes in a complex orogenic system. The study focuses on the Kopaonik Mts. situated between the Dinarides and the Carpatho-Balkanides (Southern Serbia), and a perfect area for investigating tectono-magmatic evolution. We combine a new data set on tectonic paleostress tensors with the existing information on Cenozoic magmatic rocks in the wider Kopaonik Mts. area. The paleostress study revealed the presence of four brittle deformational phases. The established link between fault mechanism and igneous processes suggests that two large tectono-magmatic events occurred in this area. The Late Eocene–Early Miocene tectono-magmatic event was generally characterized by transpressional tectonics that provided conditions for formation of basaltic underplating and subsequent lower crustal melting and generation of I-type magmas. Due to predominant compression in the first half of this event, these magmas could not reach the upper crustal levels. Later on, limited extensional pulses that occurred before the end of this event opened pathways for newly formed mantle melts to reach shallower crustal levels and mix with the evolving I-type magmas. The second event is Middle–Late Miocene in age. It was first associated with clear extensional conditions that caused advancing of basaltic melts to mid-crustal levels. This, in turn, induced the elevation of geotherms, melting of shallow crust and S-type granite formation. This event terminated with transpression that produced small volumes of basaltic melts and finally closed the igneous scene in this part of the Balkan Peninsula. Although we agree that the growth of igneous bodies is usually internally controlled and can be independent from the ambient structural pattern, we have strong reasons to believe that the integration of regional scale observations of fault kinematics with crucial petrogenetic information can be used for establishing spatial–temporal relationships between brittle tectonics and magmatism.

1. Introduction

The relationship between brittle tectonic and magmatic events belongs to the hot topics in modern geology (see Saint Blanquat et al., 2011, and references therein). The existing opinions range from those that invoke a close relationship and even two-way tectono-magmatic links (e.g., Bons et al., 2008; Grocott et al., 2009; Hollister and Crawford, 1986; Tikoff and Teyssier, 1992), to those arguing that magmatic and tectonic processes operate at different time scales, and that it is very difficult to establish a direct relationship between, for instance, pluton construction and external regional deformation (e.g., Nyman et al., 1995; Paterson and Tobisch, 1992; Saint Blanquat et al., 2011). The latter opinion of such a tectono-magmatic misfit, i.e., the view that the growth of igneous bodies is mainly controlled by internal factors independent from the ambient tectonic regime, was mainly derived by correlation studies of the structural pattern of individual plutons and deformation fabric of the surrounding rocks (Cruden, 1998; Cruden and McCaffrey, 2001; Petford et al., 2000). On the other hand, regional-scale studies that combine brittle fault kinematic and igneous petrology data are rare or they are restricted to granite pluton emplacement mechanisms (e.g., Hutton and Reavy, 1992; Paterson and Tobisch, 1988; Weinberg et al., 2004).

This study is aimed at establishing the relationship between brittle deformation and magmatism in the Kopaonik Mts. area, which is situated near the contact between the Dinarides and the Carpatho-Balkanides (Southern Serbia, Central Balkans). The Dinarides represent the deformed margin of Adria and are structurally in the lower plate position in respect to the Carpatho-Balkanides, which in the studied area correspond to the Europe-derived Dacia Mega-Unit (Schmid et al., 2008). The Dinarides and the Carpatho-Balkanides together represent a complex double-vergent orogen system (Fig. 1). It formed as a result of the Mesozoic subduction of the Vardar ocean and subsequent Late Cretaceous–Neogene collisional and post-collisional phases, which gave rise to the thrusting of the Dinaric orogenic wedge, post-collisional magmatism, and the formation of core-complexes and

* Corresponding author. Tel.: +381 11 3219 273.
E-mail address: ana.mladenovic@rgf.bg.ac.rs (A. Mladenović).

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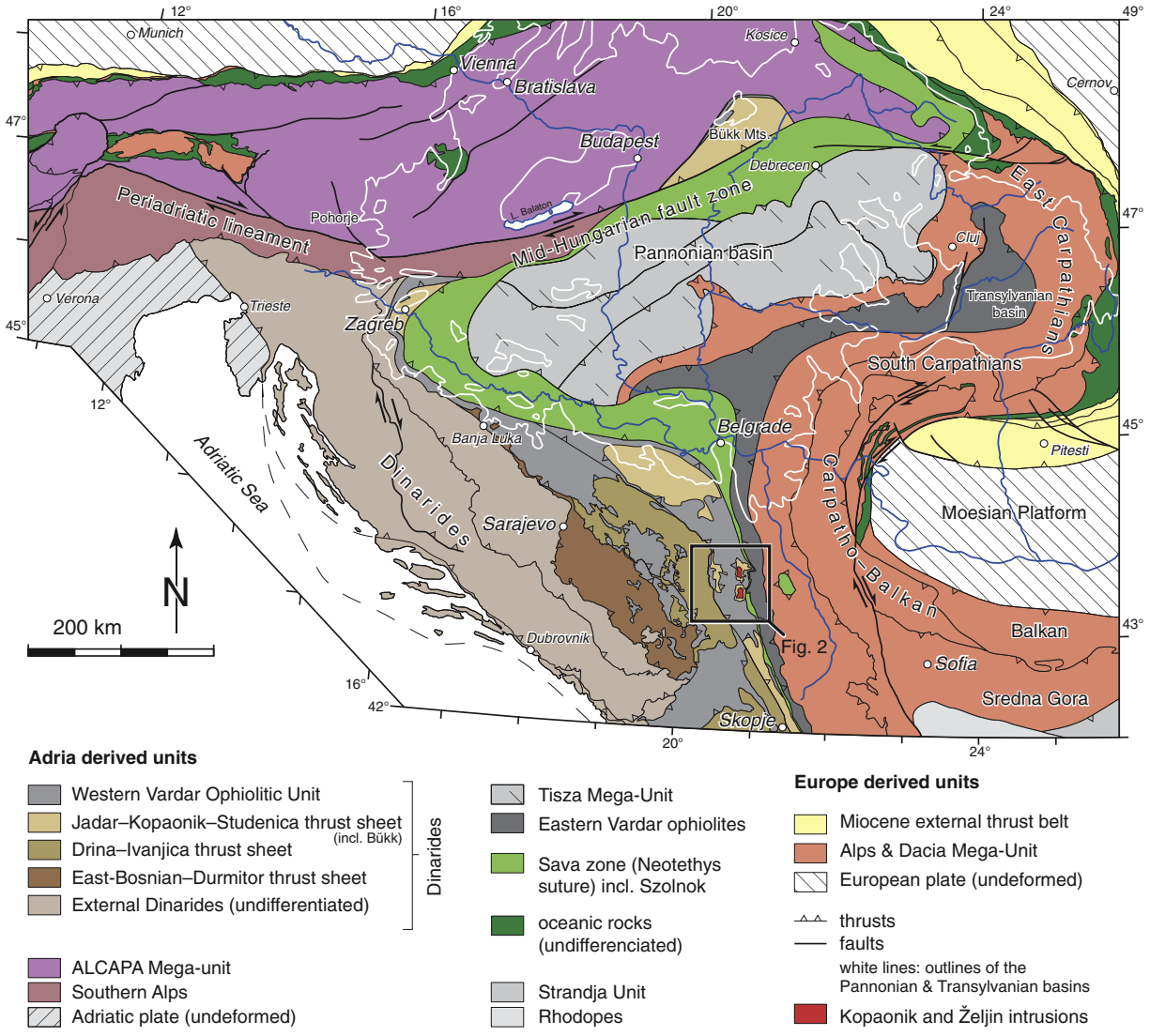

Fig. 1. Regional geotectonic position of the research area after Schmid et al. (2008).

sedimentary basins (e.g., Andrić et al., in press; Bada et al., 2007; Cvetković et al., 2004; Karamata, 2006; Schefer et al., 2011; Schmid et al., 2008).

The geotectonic position within the axial part of the Dinaric–Carpatho-Balkan double-vergent orogen system has very much conditioned the complex tectonic history of the Kopaonik Mts. Several recent studies (Schefer et al., 2010, 2011; Zelić, 2005; Zelić et al., 2010a,b) provided significant new data concerning ductile tectonic evolution of this region and recognized four ductile deformation phases. The first three phases are Cretaceous–Paleogene in age and were related to compression and closure of the Vardar branch of the Neotethys Ocean, whereas the youngest phase is related to the Miocene extension. This information shed more light to our present-day knowledge about the geodynamic conditions, which affected the internal part of the Dinarides and were active immediately after collision. These geodynamic conditions were also responsible for relatively long-lasting and polyphase magmatism that occurred from Late Eocene to Late Miocene time.

In this study, we focus on the Kopaonik Mts. in order to establish a link between brittle tectonics and magmatism in an unprecedented way in this region. We present and discuss new data on fault kinematics, which allows for distinguishing several brittle deformational phases operating in this area. We then try to link the results of this independent paleostress study to the known magmatic episodes that have occurred in this region. In this attempt, we include all relevant petrogenetic information, from the absolute and relative age to geodynamically significant petrochemical signatures of the occurring igneous rocks. Our results demonstrate that, although the relationship between brittle tectonic history and the episodes of igneous activity is indeed very complex, it is possible to establish significant tectonic factors that control magmatism, which may lead to better understanding of geodynamic evolution of the entire region.

2. Geological setting

2.1. Regional geology

The basement of the area of the Kopaonik Mts. and its surroundings is composed of two innermost nappes of the Dinarides—the Drina-Ivanjica and the Jadar-Kopaonik-Studenica (Fig. 1). In the latest Cretaceous and Early Paleogene, these tectonic units collided with the Dacia Mega-Unit as part of the Carpatho-Balkan orogen. The immediate contact between the Dinarides and the Carpatho-Balkan orogen is marked by the Sava zone, which runs through the central part of the Balkan Peninsula, representing the final suture of the Neotethys Ocean (Pamić, 2002; Karamata et al., 2005; Ustaszewski et al., 2009). Before collision in the Late Jurassic, most parts of the Vardar branch of the Neotethys Ocean, known as the Western Vardar Ophiolitic Unit, were