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Tertiary to recent oblique convergence and wrenching of the Central Dinarides: Constraints from a palaeostress study

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Abstract

The late Eocene to Neogene tectonic evolution of the Dinarides is characterised by shortening and orogen-parallel wrenching superposed on the late Cretaceous and Eocene double-vergent orogenic system. The Central Dinarides exposes NW-trending tectonic units, which were transported towards the Adria/Apulian microcontinent during late Cretaceous–Palaeogene times. These units were also affected by subsequent processes of late Palaeogene to Neogene shortening, Neogene extension and subsidence of intramontane sedimentary basins and Pliocene–Quaternary surface uplift and denudation. The intramontane basins likely relate to formation of the Pannonian basin. Major dextral SE-trending strike-slip faults are mostly parallel to boundaries of major tectonic units and suggest dextral orogen-parallel wrenching of the whole Central Dinarides during the Neogene indentation of the Apulian microplate into the Alps and back-arc type extension in the Pannonian basin. These fault systems have been evaluated with the standard palaeostress techniques. We report four palaeostress tensor groups, which are tentatively ordered in a succession from oldest to youngest: (1) Palaeostress tensor group 1 (D_1) of likely late Eocene age indicates E–W shortening accommodated by reverse and strike-slip faults. (2) Palaeostress tensor group 2 (D_2) comprises N/NW-trending dextral and W/WSW-trending sinistral strike-slip faults, as well as WNW-striking reverse faults. These indicate NE–SW contraction and subordinate NW–SE extension related to Oligocene to early Miocene shortening of the Dinaric orogenic wedge. (3) Palaeostress tensor group 3a (D_{3a}) comprises mainly NW-trending normal faults, which indicate early/middle Miocene NE–SW extension related to syn-rift extension in the Pannonian basin. The subsequent palaeostress tensor group 3b (D_{3b}) includes NE-trending, SE-dipping normal faults indicating NW–SE extension, which is likely related to further extension in the Pannonian basin. (4) Palaeostress tensor group 4 (D_4) is characterised by mainly NW-trending dextral and NE-trending sinistral strike-slip faults. Together, with some E-trending reverse faults, they indicate roughly N–S shortening and dextral wrenching during late Miocene to Quaternary. This is partly consistent with the present-day kinematics, with motion of the Adriatic microplate constrained by GPS data and earthquake focal mechanisms. The north–north-westward motion and counterclockwise rotation of the Adriatic microplate significantly contribute the shortening and present-day wrenching in the Central Dinarides.
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1. Introduction

A key question of the geological evolution of the Alpine orogenic system of south-eastern Europe is the timing and nature of collisional processes which finally

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led to the double-vergent arcuate orogenic system (Fig. 1). These collisional processes followed the late Jurassic emplacement of the Dinaric ophiolite nappe and the Palaeogene closure of the Penninic oceanic domain (Burchfiel, 1980; Channell and Kozur, 1997; Pamić et al., 1998, Stampfli and Mosar, 1999; Stampfli et al., 2002; Neubauer, 2002; Pamić, 2003). The Austroalpine–Carpathian–Balkan strand of the orogen is affected, during late Cretaceous–Tertiary times, by Europe-directed shortening, folding and thrusting (Burchfiel, 1980; Dallmeyer et al., 1996). Deformation of the Southalpine–Dinaride–Hellenide strand was directed towards the Adriatic Sea, i.e. towards the eastern Mediterranean Sea (e.g., Dimitrijević, 1997; Pamić et al., 1998; Robertson and Karamata, 1994). The double-vergent orogen has been affected by subsequent orogen-parallel strike-slip motion along the Adriatic margin (Picha, 2002), lateral extrusion of the tectonic units from the Eastern Alps towards the Carpathian arc (Ratschbacher et al., 1989; Csontos et al., 1992; Csontos, 1995) and back-arc extension of the Aegean Sea (Jolivet et al., 2003; Fig. 1).

A few data are known from the late-orogenic Tertiary evolution of the Dinarides where Jurassic/Cretaceous emplacement of ophiolite nappes and subsequent shortening was directed towards the External Dinarides and the undeformed Adriatic microplate (e.g., Pamić et al., 1998; Pamić, 2003; Dimitrijević, 1997). The main stage of deformation of External Dinarides was during the Eocene when internal thrusting and folding occurred (Dimitrijević, 1997; Pamić et al., 1998 and references therein). Recently, Picha (2002 and references therein) suggested that Neogene north-westward motion of the Adriatic microplate is

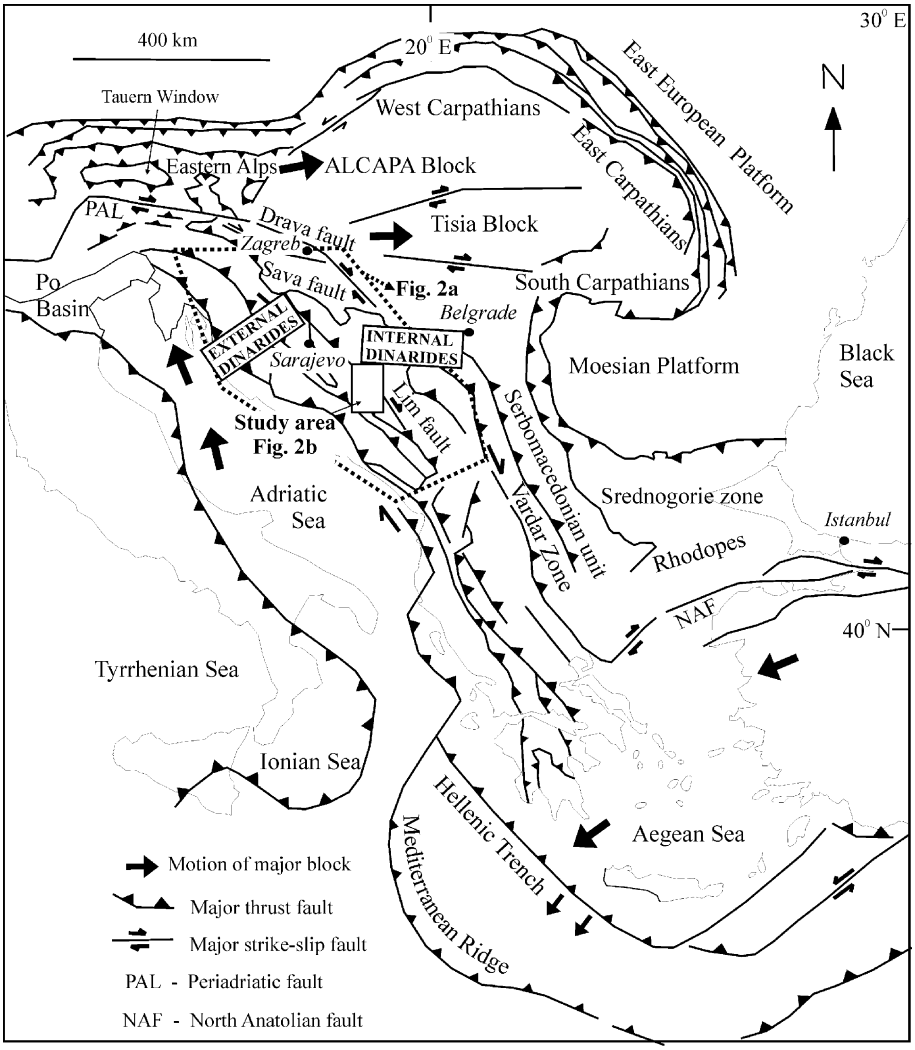

Fig. 1. Schematic tectonic overview over the Alpine orogenic system of southeastern Europe (modified after Royden, 1988).

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