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## SHORT NOTE

# NEW EVIDENCES FOR TRIASSIC MORB MAGMATISM IN THE NORTHERN MIRDITA ZONE OPHIOLITES (ALBANIA)

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## INTRODUCTION

A succession of mid-ocean ridge basalts (linked at their base to serpentinite slivers) with intercalations of chert levels of Middle and Late Triassic, as well as Early and Middle Jurassic ages have recently been found in the Argolis Peninsula, Greece (Bortolotti et al., 2001; 2002a; 2003; Saccani et al., 2004a). This succession shows the same lithostratigraphic and tectonic setting of the Triassic basalts of the “Volcano-sedimentary Formation” at the top of the “Rubik Complex” of the Mirdita Ophiolitic Nappe in Albania (Bortolotti et al., 1996; 2002b; 2004). Moreover, Argolis and Mirdita ophiolites belongs to the same ophiolitic belt, which extends from Mirdita to Pindos, Vourinos, Othrys and Argolis.

The “Volcano-sedimentary Formation” was previously interpreted by Kodra et al. (1993) as an Upper Jurassic sequence, which “precède de peu ou accompagne le début de l’ouverture (océanisation) proprement dite du domaine ophiolitique de Mirdita” (p. 66). Bortolotti et al. (1996) confirmed this interpretation (“the sequence can be interpreted as a product of syn-rift, subalkaline magmatism associated with thinning of the continental margin during the Middle Triassic”; p. 5). Thus, on the bases of the radiolarian stratigraphy, this sequence has been retro-dated to the Middle and Late Triassic times (Bortolotti et al., 1996; 2002b; Chiari et al., 1996).

The aim of this paper is to assess the petrology and tectono-magmatic significance, with respect to the age of formation, of basalts from this complex in the northern Albania Mirdita zone, to provide new data for a more detailed reconstruction of the Triassic tectono-magmatic events related to the formation of the Tethys oceanic basin in the Dinaric-Hellenic area.

## GEOLOGICAL BACKGROUND

The Mirdita Ophiolitic Nappe tectonically lies on the eastern margin of the Adria plate (on the Krasta-Cukali Unit on the west and on the Pelagonian Units on the east), and pertains to the Pindos Ocean according to some authors (e.g., Robertson and Shallo, 2000, and references therein), or to the unique (Vardar) Ocean according to other authors (Bortolotti et al., 2004). This palaeogeographic - palaeogeodynamic problem is behind the objective of this paper.

This Nappe consists of a pile of three main tectonic units: a) the Rubik Complex at the base of both the Western Ophiolite belt (b) and the Eastern Ophiolite Belt (c).

a- The Rubik Complex mainly consists of huge slices of Triassic - Malm carbonate rocks and subordinate slices of serpentinised lherzolites, and polimict breccias set in a shaly matrix (sedimentary mélange). Basalts with thin intercalations of Triassic cherts constitute the “Volcano-sedimentary Formation” (VSF) which, being always at the top of the Rubik Complex, can be identified as the independent “Porava Tectonic Unit” (PU).

b- The Western Ophiolite belt consists of mantle lherzolites, ultramafic-mafic cumulates and, at the top, a basalt sequence, covered, in turn, by a chert level (Kalur Cherts) of late Bajocian/early Batonian - late Bathonian to late Bathonian/early Callovian age. These ophiolites have been interpreted as a mid-ocean ridge product.

c- The Eastern Ophiolite belt consists of mantle harzburgites, ultramafic and mafic cumulates and, at the top a basalt, basaltic andesites, andesites, dacites and rhyolites sequence covered by thin chert levels of the same age of the cherts at the top of the Western belt. These chert levels also occur as thin intercalations in the volcanic sequence.

The two ophiolite belts are unconformably covered by a mélange (Simoni Mélange) which grades upwards to a Tithonian - late Valanginian flysch (Firza Flysch).

Barremian to Senonian carbonatic deposits seal the relationships among the three ophiolitic units.

## SAMPLE LOCATION AND AGE

The new samples have been collected in six areas located on the western, eastern and central parts of the ophiolitic belts (Fig. 1). In five localities (a-f), samples were taken from the Volcano-Sedimentary s.s. body, whereas in one area (g) samples represent small blocks in the Simoni Mélange s.s.

### a- Rubik

In the Rubik neighboroughs (Fig. 1), the tectonic pile includes the Rubik Complex, overlying the Krasta-Cukali Tectonic Unit, and bearing at its top a thick level of the VSF (Bortolotti et al., 1996 and 2004 and references therein).

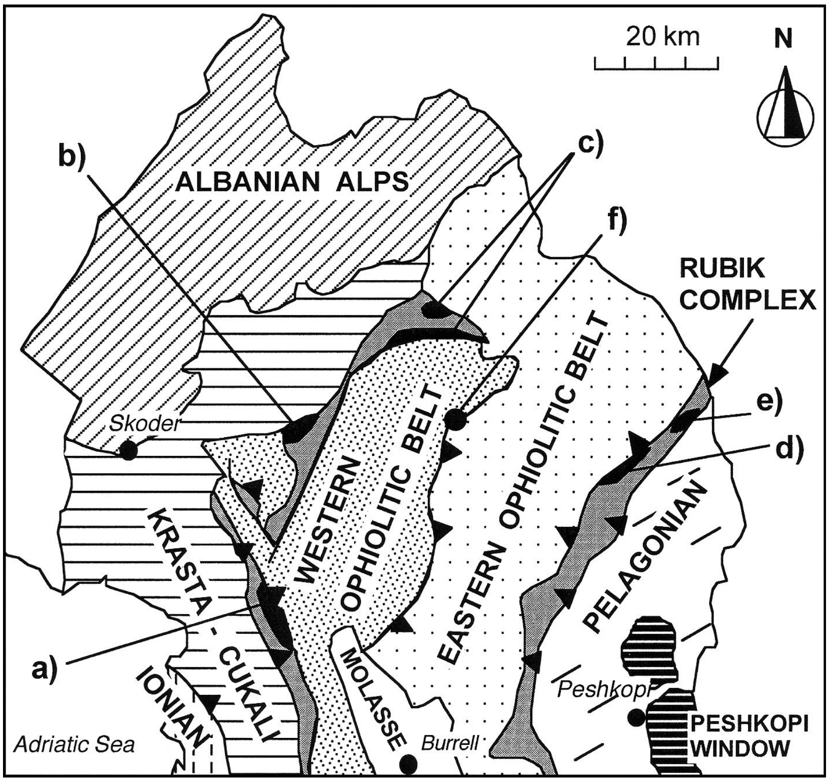

Fig. 1 - Schematic geological setting of the northern Albania (modified from Bortolotti et al., 2002b). Both Western and Eastern Ophiolitic Belts include ophiolitic sequences and their sedimentare covers. The Volcano-Sedimentary Formation (Porava Unit) outcrops investigated in this paper are represented in black and identified with letters according to the text: a) Rubik; b) Karma; c) Porava-Miliska; d) Surroj; e) Gjegjani; f) Fushe Arrez.

We sampled the basalts of the very thick Volcano-Sedimentary Fm. cropping out near the town (samples 02-AL11; 02-AL12), where Chiari et al. (1996) found thin intercalations of cherts which yielded radiolarian assemblages of Carnian-Norian age. The new sampling (02-AL9) yielded a Middle - Late Triassic age for the presence of *Oertlispongus* sp.

### b- Road to Komani Dam

Along the road to the Komani Dam, near Karma (Fig. 1), the tectonic pile includes a level of VSF, on top of the Rubik Complex, and emerging under the serpentinite massif of Terbuni - Kaçinari. We sampled, along the road, the basalts (02-AL1; 02-AL2; 02-AL5) and some samples of cherts (02-AL3; 02-AL4; 02-AL7; 02-AL8) from very thin levels intercalated or at the top of the basalts.

The chert sample 02-AL3 yielded a Middle - Late Triassic age, due to the presence of *Oertlispongus* sp.*;* the samples 02-AL7 and 02-AL8, yielded a Middle Triassic age, due to the presence of *Oertlispongus inaequispinosus* and *Baumgartneria* sp.

### c- Porava - Miliska

Along the Drin Valley (Fig. 1), on the southern side of the Lake, a large block of Triassic-Jurassic limestones, pertaining to the Rubik Complex, crops out between the Porava and Miliska villages. At the top of this block, to the north and south, a lens of mélange, from few to some hundred meters thick, supports the VSF. The tectonic pile ends with the harzburgitic massif of Tropoja. The VSF is cut by some minor thrusts, so the geometric thickness has increased to many hundred meters (till ~ 800). We sampled the basalts and the cherts of some very thin and disrupted intercalations (03-3a; 03-4) both on the northern (Porava, 03-2; 03-5; 03-6; 03-7) and the southern (Miliska, 03-8) side of the limestone block. The preservation of the radiolarians is very low: a possible Late Triassic? age can be inferred.

### d- Surroj

On the western side of the Drin, near Surroj (Fig. 1), along the lake, the Rubik Complex comprises a large block of Triassic-Jurassic limestones covered by a lens of mélange topped in turn by a level of VSF that is some tens of metres thick. The VFS is tectonically covered by the harzburgitic massif of Kukes, with a thick metamorphic sole at the base. We sampled the basalts (03-9b) and a 60 cm thick lens of shaly chert (03-9a). The preservation of the radiolarians is very low: a possible Triassic? age can be inferred.

### e- Gjegjani

Some kilometers east of Kukës (Fig. 1), near Gjegjani, an ancient copper mine was sited in a level of VSF. This volcanic sequence is tectonically sandwiched between the Rubik Complex (Simoni Mélange covering a large block of Triassic-Jurassic limestone), at the base, and the harzburgite massif of Tropoja, with its thin metamorphic sole, at the top. The deformation of all the sequence is intense and pervasive, and the beds of a chert level, which linked to the volcanites, are strongly streched.

We sampled the basalts (03-14a, 03-14b) and the cherts (03-15, 03-16). The radiolarians are completely recrystallised and deformed: no age determinations have been possible.

### f- Fushe Arrez

A few kilometers along the main road, north-east of Fushe Arrez (Fig. 1), the Simoni Mélange, at the top of the ophiolitic unit, includes some decametric blocks of basalt with metric chert intercalations. We collected samples from two of these blocks:

a- first block: 03-19, 03-20 the basalt; 03-18 the chert. The age of the cherts is Late Triassic, for the presence of *Capnodoce* sp and *Capnucosphaera* sp.

b- second block: 03-22 the basalt; 03-21 the chert. The age of the cherts is Late Triassic, for the presence of and *Capnucosphaera* sp. and *Pseudostylosphaera* sp.

## PETROGRAPHY, GEOCHEMISTRY AND TECTONO-MAGMATIC INTERPRETATION OF BASALTS

All studied samples display degrees of alteration ranging from moderate to severe. Alteration processes include transformation of groundmass minerals into chlorite, clinopyroxene into chlorite and tremolite, plagioclase into albite and calcite. Variably-sized veins filled by quartz or calcite are observed in many samples. Most of the studied basalts are aphyric, with fine-grained ophitic and sub-ophitic (rarely intergranular) groundmass, in which plagioclase (and rarely clinopyroxene) microlites are recognized. Very few samples display coarse-grained doleritic texture with euhedral plagioclase and sub-hedral clinopyroxene. Accessory phases are represented by interstitial Fe-Ti oxides.

Whole-rock major and trace (including REE) element analyses were performed at the Department of Earth Sciences of the University of Ferrara using an *ARL Advant XP* x-ray fluorescence spectrometer and a *VG Elemental Plasma Quad PQ2 Plus* inductively coupled plasma-mass spectrometer. Details on analytical procedures are reported in Saccani et al. (2004b), whereas chemical data are available from the corresponding authors upon request.

All the analysed samples are represented by basalts with $SiO_2$ ranging from 42.55 to 52.06%, though values lower than 46% negatively correlate with high loss on ignition. CaO, $Na_2O$, $K_2O$, Rb, Sr, and Ba contents display considerable scatter, clearly related to secondary processes. Elements, which are considered to be relatively immobile during alteration processes (Pearce and Norry, 1979), indicate a clear mid-ocean ridge (MORB) affinity, with $TiO_2$ (0.88-2.08%), $P_2O_5$ (0.08-0.20%), V (192-444ppm), Zr (63-173ppm), Y (23-63ppm), Ti/V (22-38), and Zr/Y (2-4) that are in the range of typical high-Ti (MORB) ophiolitic basalts (Pearce and Norry, 1979). Nonetheless, on the bases

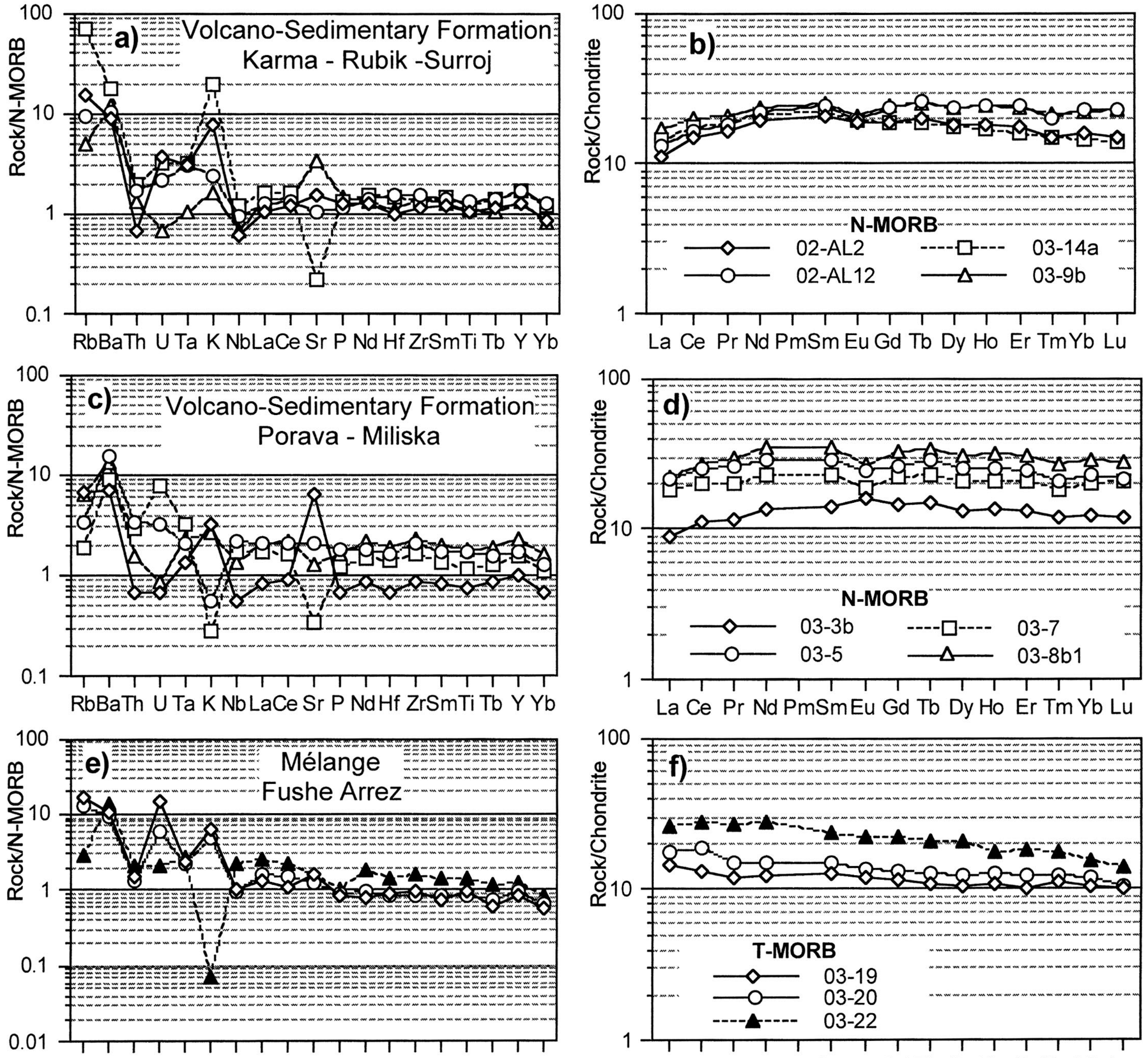

Fig. 2 - N-MORB normalized incompatible element compositions (a, c, e) and chondrite-normalized rare earth element compositions (b, d, f) for the basaltic rocks from the Volcano-sedimentary Formation of the Porava Unit. Normalization values are from Sun and McDonough (1989).

of high field strength element (HFSE) and rare earth element (REE) concentrations (Fig. 2), these basalts can be subdivided into two main groups.

The first group of basalts is found in the VSF from all the studied areas and display chemical compositions resembling those of normal-type MORBs (N-MORBs). They are characterised by flat HFSE patterns (Figs 2a, c) ranging from 0.7 to 2 x N-MORB composition (Sun and McDonough, 1989), coupled with REE patterns (Fig. 2b, d) slightly depleted in light REE (LREE) with respect to heavy REE (HREE). Medium and HREE concentrations range from 10 to 30 x chondrite abundance (Sun and McDonough, 1989), and the more evolved samples display Eu negative anomalies, reflecting early fractionation of plagioclase. These geochemical characteristics are consistent with a genesis of basalts from undepleted MORB-type mantle sources (Pearce and Norry, 1979).

The second group is represented by basalts from the mélange in the Fushe Arrez area. These are characterised by a rather uniform composition, slightly decreasing patterns, from Nb to Yb, of incompatible element abundance with respect to N-MORB (Fig. 2e), and REE abundance (Fig. 2f) from 10 to 30 x chondrite composition (Sun and McDonough, 1989). They also display LREE enrichments similar to those observed in transitional MORB (T-MORB). This feature is exemplified by the $La_N/Sm_N$ and $La_N/Yb_N$ ratios, which are 1.10-1.17 and 1.38-1.73, respectively. In addition, these T-MORBs can be distinguished from the N-MORBs of the VSF on the bases of their Ta/Yb (>0.15 in T-MORBs, <0.12 in N-MORBs) and Ce/Y (>0.35 in T-MORBs, <0.30 in N-MORBs) ratios. These features suggest an origin of T-MORBs from the Fushe Arrez mélange from an asthenospheric MORB-type mantle source slightly enriched by plume components.

## CONCLUSIONS

Late Permian-Triassic magmatic rocks are widespread throughout the Dinaride-Hellenide orogenic belt. According to Pe-Piper and Piper (2002, and references therein), they are represented by: 1) subalkaline series, possibly originating in a back arc setting; 2) high-K shoshonites and calc-alkaline andesites, originating in an extensional setting from a mantle source bearing inherited subduction-derived components; and 3) alkali basalts, referred either to oceanic island or rift settings. In addition, Saccani et al. (2004a) recently described MORBs associated with Triassic radiolarites (Bortolotti et al., 2001; 2002a; 2003) in the Argolis Peninsula (Greece).

The data presented in this paper indicate that Triassic MORBs also occur in the northern Albanian Mirdita zone. On the basis of chemical compositions, they can be subdivided into two distinct types: N-MORBs characterising the VSF of the PU, and T-MORBs found in the Simoni Mélange. These data have important implications for the evolution of the Albanian sector of the Tethyan oceanic basin. The extension between Adria and Europe plates resulted in the generation of high-K shoshonites, calc-alkaline andesites, and alkali basalts. Starting from the Middle Triassic, T-MORBs, reflecting the interaction between uprising MORB-type asthenosphere and OIB-type mantle source, and N-MORBs, with primitive asthenospheric geochemical characteristics, were produced. This implies that the oceanic spreading in the northern Mirdita sector had already reached at that time a steady state, involving only sub-oceanic mantle sources and their partial melt derivatives.

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