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PRELIMINARY CHARACTERIZATION OF MAGMATIC CLASTS FROM CONGLOMERATE WITHIN THE BOVEC FLYSCH (SLOVENIA)

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ABSTRACT

A Maastrichtian conglomerate related to the flysch beds of the Slovenian sedimentary basin and outcropping near Bovec is characterized by the presence of rare magmatic clasts, basaltic in composition. Petrographical features and major elements composition allow us to classify the few collected clasts as lavas or sub-intrusive High Allumina Basalts, rocks commonly related to compressive movements involving the subduction of oceanic plate(s). Incompatible element patterns support the hypothesis of a compressive geotectonic setting and suggest involvement of a continental source mantle in the genesis of the magmatic clasts.

Key words: conglomerate, Bovec, magmatic, HAB, Maastrichtian

CARATTERIZZAZIONE PRELIMINARE DEI CLASTI MAGMATICI PRESENTI NEL CONGLOMERATO FLYSCHOIDE IN PROSSIMITÀ DI BOVEC (SLOVENIA)

SINTESI

Il conglomerato Maastrichtiano di Bovec rappresenta il primo importante episodio sedimentario clastico del Bacino Sloveno ed è caratterizzato dalla presenza di rari clasti magmatici basaltici di derivazione effusiva o sub-intrusiva. Le caratteristiche chimiche degli elementi maggiori e le evidenze petrografiche, tipiche dei basalti con un alto contenuto in alluminio, fanno ipotizzare, per i clasti finora campionati, un' unica genesi relazionabile ad eventi compressivi coinvolgenti la subduzione di placca oceanica. L'andamento degli elementi incompatibili supporta l'ipotesi di un ambiente geodinamico compressivo e suggerisce inoltre il coinvolgimento di una sorgente di mantello continentale.

Parole chiave: conglomerato, Bovec, magmatico, HAB, Maastrichtiano

INTRODUCTION

The presence of unaltered and unmetamorphosed magmatic clasts in terrigenous sediments, deposited before the paroxysmal orogenic events (*i.e.* Dinaric and Alpine orogenesis), could provide important information on the sub-lithospheric mantle.

The main objective of this study is to give a first characterization of the few volcanic rocks collected from a conglomerate inside the Maastrichtian flysch conglomerate near Bovec to provide eventual information on the possible mantle source(s) involved, to evidence the presence of one or more magmatic events and to give first information about their possible geodynamic formation setting.

Geological and stratigraphical outlines

Bovec is located in NW Slovenia (Fig. 1A), between Mt. Rombon and Mt. Polovnik.

The stratigraphic succession of the area began in the Late Triassic (Lower Norian) with the very thick carbonate platforms of the "Main Dolomite" (dolomitic limestone) and "Dachstein" (limestone) formations originating on the Julian Platform (Buser, 1986; Ogorelec & Buser, 1996). These sequences are stratigraphically continuous with Rethyan successions represented by mudstones and limestones, typical of a neritic environment (Selli, 1947).

The Jurassic is represented by the Middle Liassic oolithic limestones (Buser, 1986; Jurkovšek *et al.*, 1988/89) and limestone breccias, the latter testifying an emersion of the area (Selli, 1947). The Julian carbonate platform was disintegrated in the Upper Lias due to compressive NE-SW movements, which led to a moderate and locally heavy folding of the area (Selli, 1947). In the surroundings of Bovec, there are typical dykes filled with red and grey crinoidal limestones. In the upper section, or at places directly on the Liassic neritic limestones, *nodular limestones (Rosso Ammonitico) occur. Close to* Bovec, manganese deposits, often in the shape of round manganese nodules, are occasionally present. During

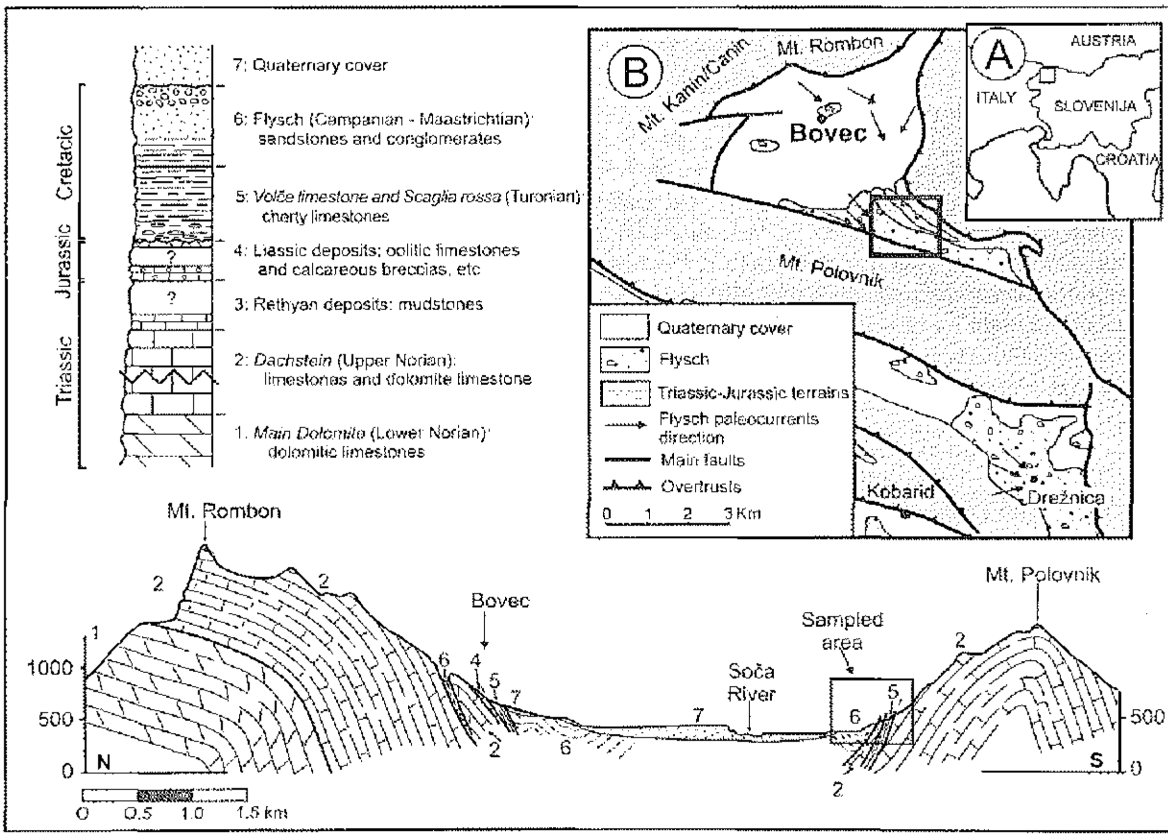

Fig. 1: Stratigraphic column of the stratigraphic section of Bovec basin with denoted position of studied conglomerate. A: Geographical location of Bovec basin; B: Sketch map showing the flysch outcrops (modified after Kuščer* et al., *1974 and Buser, 1974).

Sl. 1: Stratigrafski stolpec stratigrafske sekcije bovškega bazena z označenimi legami preučevanega konglomerata. A: geografska lega bovškega bazena; B: zemljepisna karta z vrisanimi flišnimi izdanki (prirejeno po Kuščer* et al., *1974 in Buser, 1974).

the Early Jurassic, Mt. Polovnik probably rose, which acted as a barrier during the Cretaceous marine ingression occurred in the sector between the Bovec area, located to north, and the Kobarid area, located to south. In the studied area, Cretaceous sediments are represented by thin bedded calcareous turbidites with chert of carbonate turbidities (Ogorelec *et al.*, 1974) that gradually developed in siliciclastic turbiditic sediments (Bovec flysch) during the Campanian – Maastrichtian (Aubouin, 1963; Cousin, 1970; Kuščer *et al.*, 1974; Pavšič, 1994).

The present paper focuses on the conglomerates located at the top of the Bovec flysch (Fig. 1B). The clasts are mainly composed of Dachstein limestones, Rethyan-Liassic brown limestones, red and black chert limestones of "Scaglia rossa" and Volče limestone, dark limestones with Raiblian fossils, volcanic clasts, few metamorphic clasts of probably Permic age, and plagioclase-rich sandstones (Selli, 1947; Kuščer *et al.*, 1974; Venturini & Tunis, 1992).

MATERIAL AND METHODS

Diffractometric analyses have been carried out at the "Dipartimento di Scienze della Terra" of the University of Trieste by means of powder diffractometer SIEMENS D500 (CuKα at 40 kV and 20 mA).

Major and trace element concentrations were determined using PW 1404 XRF spectrometer and the procedures of Philips® (1994) for the correction of matrix effects. Major element abundances were recalculated to 100 wt% on a volatile-free basis. The analytical uncertainties were estimated at less than 5% and 10% for major and trace elements, respectively. The samples have been analysed before and after the leaching procedure (Petrini *et al.*, 1987) in order to remove the secondary carbonates.

RESULTS

Petrographical features, classification and nomenclature

The volcanic clasts have main sizes diameter variable from 1-3 cm. The dimension of magmatic clasts and the roundness factor of carbonate and metamorphic clasts (roundness factor is not indicative for basaltic clasts, since their morphology is due to onion skin exfoliation) suggest a fluvial transport and a relative proximity to the erosion area. Petrographical analyses showed that higher glass contents recrystallized only partially into clay minerals. The texture ranges from subophitic-intersertal to microporphiric. Rare feno- and microfenocrystals of anplagioclase, augite, opaques and occasional olivines have been observed, secondary calcite plagues are often present. Due to the abundant plagioclase, these rocks have been optically classified as andesitic basalts.

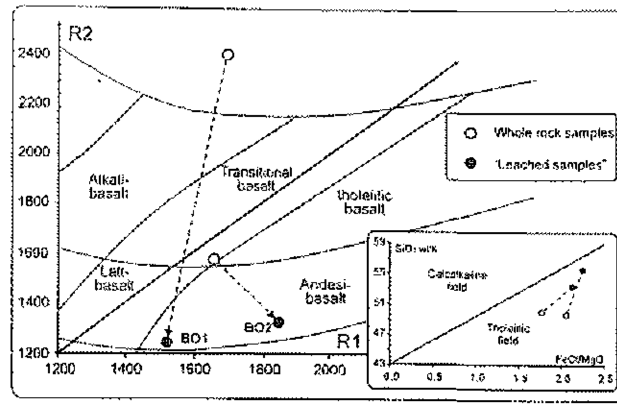

Fig. 2: Distribution of the Bovec volcanic clasts in R1-R2 classification diagram of De La Roche* et al. *(1980) as modified by Bellieni* et al. *(1981). Inset: SiO_2 vs. FeO_t/MgO diagram for basic sub-alkaline rocks (Miyashiro, 1974).

Sl. 2: Razširjenost bovških vulkanskih delcev v klasifikacijskem diagramu R1-R2 po De La Roche* et al. *(1980) in modificiranem po Bellieni* et al. *(1981). V okvirčku: diagram SiO_2 vs. FeO_t/MgO za bazične subalkalinske kamnine (Miyashiro, 1974).

The studied samples have been classified (Fig. 2) according to De La Roche *et al.* (1980), and Bellieni *et al.* (1981). Note that after the leaching procedure all the samples plot in the Andesi-basalt field, are in agreement with their optical features. Finally, the samples fall (inset of Fig. 2) in the tholeiitic field for the SiO_2 – FeO_t/MgO relationships (Miyashiro, 1974).

Diffractometrical data

The analyses obtained from a representative volcanic clast (e.g. sample BO1; Fig. 3) revealed the presence of augite, plagioclase, calcite and minor clay amounts, supporting the optical features.

Geochemistry

The CIPW norm has been calculated in dry conditions with $Fe_2O_3/FeO = 0.15$. Among the normative minerals, quartz (6-10 wt %), hyperstene (8-11 wt %), and occasional corindone (0-0.5 wt %) were present. These features, together with the high SiO_2 and Al_2O_3 (> 53 and > 18.5 wt %, respectively) and low MgO (< 4.5 wt %), associate the studied volcanics to the High-Allumina Basalt (HAB; James *et al.*, 1986), usually related to compressive geotectonic conditions (island-arc tectonic environment). These features contrast with the SiO_2 – FeO_t/MgO relationships of Miyashiro (1974). The authors of the article believe that the scarcity of SiO_2 may possibly be connected with natural leaching due to the glass alteration in clay minerals and in colloidal phases.

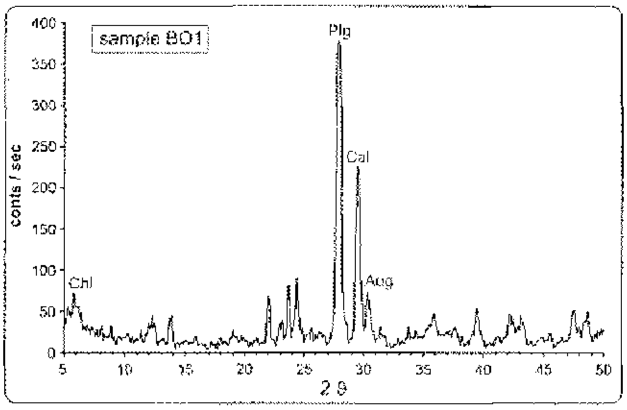

Fig. 3: Diffractometric analyses of the BO1 sample (volcanic clast). Chl: chlorite; Plg: plagioclase; Cal: calcite; Aug: augite.
Sl. 3: Difraktometrične analize vzorca BO1 (vulkanski delec). Chl: klorit; Plg: plagioklaz; Cal: kalcit; Aug: avgit.

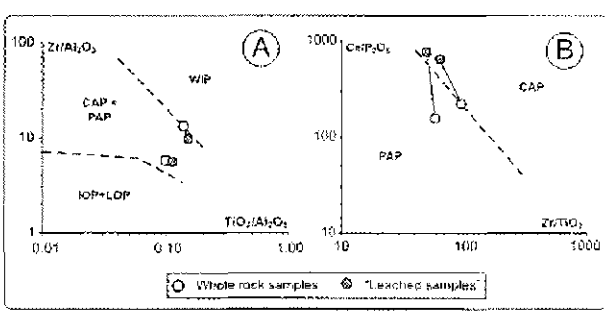

Fig. 4: Zr/Al_2O_3 vs. TiO_2/Al_2O_3 and Ce/P_2O_5 vs. Zr/TiO_2 tectonomagmatic diagrams (Müller et al., 1992). CAP: Continental Arc; IOP: Initial Oceanic Arc; LOP: Late Oceanic Arc; PAP: Postcollisional Arc; WIP: Within Plate.
Sl. 4: Tektonomagmatska diagrama Zr/Al_2O_3 vs. TiO_2/Al_2O_3 in Ce/P_2O_5 vs. Zr/TiO_2 (Müller et al., 1992). CAP: celinski lok; IOP: začetni oceanski lok; LOP: zadnji oceanski lok; PAP: pokolizijski lok; WIP: znotraj plošče.

In the tectonomagmatic diagram of figure 4A (Müller *et al.*, 1992), the selected samples plot into the orogenic field of continental - postcollisional arc basalts. After the leaching procedure (Fig. 4B; Müller *et al.*, 1992), the samples plot into the field of continental arc basalts.

Considering the trace elements, samples (Fig. 5) are characterized by strong negative Nb anomaly (indicative of crustal contamination or involvement of eclogitic layers in mantle source) and by a negative Sr anomaly (related to plagioclase fractionation). The collected samples show, except for the Nb anomaly, patterns and mean incompatible elements (IE) concentrations (Fig. 5) comparable with Upper Cretaceous - Paleogene tholeiitic basalts from the Pannonian basin (Belak *et al.*, 1988), but differ from the Triassic basic magmatism (shoshonitic in composition) from the Alps (not shown).

The studied samples have now been also compared (Fig. 6) with the younger volcanics of Cenozoic age from Ljubac (Croatia; Lugović *et al.*, 1998), which are certainly related to the compressive geotectonic environment. These samples show patterns similar to the

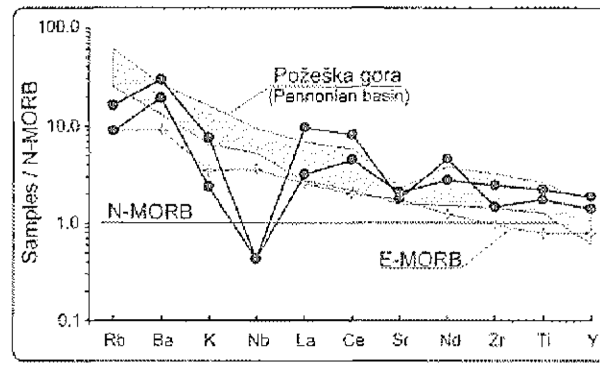

Fig. 5: Incompatible element patterns of Bovec volcanic clasts normalised to N-MORB (Normal Middle Oceanic Ridge Basalt; Sun & McDonough, 1989). E-MORB: Enriched Middle Oceanic Ridge Basalt (Sun & McDonough, 1989); Požeška gora: Upper Cretaceous – Paleogene tholeiitic basalts of the southern margin of the Pannonian Basin (Belak et al., 1988).
Sl. 5: Nezdružljivi vzorci elementov bovških vulkanskih delcev, normaliziranih na N-MORB (navadni srednjeoceanski grebenski bazalt; Sun & McDonough, 1989). E-MORB: obogateni srednjeoceanski grebenski bazalt (Sun & McDonough, 1989); Požeška gora: zgornja kreda – paleogenski toleiitski bazalti na spodnjem robu panonskega bazena (Belak et al., 1988).

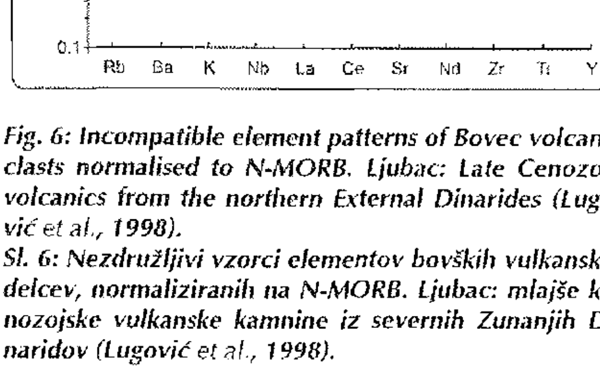

Fig. 6: Incompatible element patterns of Bovec volcanic clasts normalised to N-MORB. Ljubac: Late Cenozoic volcanics from the northern External Dinarides (Lugović et al., 1998).
Sl. 6: Nezdružljivi vzorci elementov bovških vulkanskih delcev, normaliziranih na N-MORB. Ljubac: mlajše kenozojske vulkanske kamnine iz severnih Zunanjih Dinaridov (Lugović et al., 1998).

studied volcanics including the Nb negative anomaly, but present lower mean IE contents for comparable grade of evolution.

DISCUSSION

In general, the morphology of all clasts suggests that rivers probably supplied them and that the source area was probably quite close. As regards the magmatic clasts, they are quite scarce and their abundance does not appear compatible with a large volcanic apparatus closer than 100-150 km to the deposition area. Their frequency and petrographical features suggest that these clasts may be derived from the erosion of magmatic structures as sills or dykes. Actually it is impossible to attribute a certain age to the magmatic clasts, but chemical features suggest that they belong to a magmatic event related to an orogenic geotectonical setting.

Moreover, the trace elements indicate a source mantle enriched in incompatible elements with respect to the younger Cenozoic magmatism of the area. This suggests a more important involvement of a continental mantle source (in a compressive setting) comparable in many aspects with that of Pannonian volcanics.

CONCLUSIONS

We can summarise the results as follows:

The studied magmatites are tholeiites one pyroxene-bearing (augites) characterized by subophitic-intersertal to micro porphiric texture.

The major elements associate the studied magmatites with the high allumina-basalts.

As far as the genesis of these tholeiites is concerned, the tectonomagmatic diagrams suggest a continental arc geodynamic environment.

The IE chemistry supports the major elements constrains and suggests involvement of a crustal component (crustal contamination or subducted eclogitic slab) in the tholeiites genesis.

Finally, the similitudes among the studied magmatites and those from the Ljubac and Pannonian basins suggest evolution of a common litospheric mantle source.

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PREDHODNA OPREDELITEV MAGMATSKIH DELCEV FLIŠNEGA KONGLOMERATA V BLIŽINI BOVCA

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POVZETEK

Avtorji so ob preučevanju redkih magmatskih, po sestavi bazaltnih delcev poskušali opredeliti maastrichtski konglomerat v povezavi s flišnimi plasti slovenskega sedimentarnega bazena, ki prihajajo na površje v bližini Bovca. Petrografske značilnosti in sestava iz poglavitnih elementov so jim omogočili, da so nekaj redkih zbranih delcev opredelili kot delce lave ali subintruzivnega bazalta z visoko vsebnostjo aluminija. Te kamnine so ponavadi povezane s kompresijskimi gibanji v subdukciji oceanskih plošč. Nezdružljivi vzorci elementov potrjujejo hipotezo o geotektonskem stiskanju in namigujejo, da je v nastanek magmatskih delcev vpleteno delovanje celinskega plašča.

Ključne besede: konglomerat, Bovec, magmatski delci, HAB, Maastricht

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