Geologia Croatica	57/1	81–85	5 Figs.	1 Tab.		ZAGREB 2004

Jabuka Shoal, a New Location with Igneous Rocks in the Adriatic Sea

Mladen **JURAČIĆ**[1], Anđelko **NOVOSEL**[2], Darko **TIBLJAŠ**[1] and Dražen **BALEN**[1]

Key words: Gabbro, Magmatism, Fault zone, Jabuka Shoal, Adriatic Sea, Dinarides, Croatia.

Abstract

Petrographic and XRF analyses of the magmatic rock from Jabuka Shoal, 2300 m west of Jabuka Islet (central Adriatic Sea) revealed that the rock is gabbro. This new location of magmatic rocks in the Adriatic confirms their linear arrangement, and indicates the presence of an important fault line which predisposed the occurrences of magmatic rocks.

1. INTRODUCTION

The central part of the Adriatic Sea is situated between the western coast of Croatia and the eastern Italian coast, and its shape is characterised by the surrounding Alpine mountains. Two mountain chains, the Apennines and the Dinarides, mark its edges, predetermine its nature, and separate it from the western Mediterranean, and from the Eastern Alps and the Pannonian Basin, respectively. In the Adriatic Sea area, occurrences of igneous rocks are exceptionally rare at the surface but have been observed since the 18th century (DONATI, 1750) and recognised since the end of the 19th century and later (HAUER, 1882; KIŠPATIĆ, 1892; TUĆAN, 1953; BARIĆ, 1961; GOLUB & VRAGOVIĆ, 1975; BALOGH et al., 1994). The igneous rocks from the western part of Vis Island were classified as augite-porphyry and melaphyre (HAUER & STACHE, 1862). CARELLA (1961) named them augite-andesite and augite basalt. GOLUB & VRAGOVIĆ (1975) determined them as extrusive types with augite-andesite, spilite-keratophyre and spilite. In contrast, the rocks that form the entire Brusnik and Jabuka islets, to the west of Vis Island are regarded as intrusive rocks because of their texture and were classified as augite-diorite (FOULLON, 1883), and diorite (PELLERI, 1942). KIŠPATIĆ (1892) and RAFFAELLI (1977) found diabasic texture in these rocks and named them diabase and quartz-diabase. GOLUB & VRAGOVIĆ (1975) considered them to be subvolcanic augite-diabase, VRKLJAN (1979) named the Jabuka Islet rocks as augite diabase and spilitized augite diabase, whereas BALOGH et al. (1994) as medium-grained gabbro. Recently, GARAŠIĆ et al. (2001), described dolerite from the islet of Brusnik. The main difference between rocks found on the Jabuka and Brusnik islets is in their appearance. Jabuka Islet is probably a core of a small magmatic body while Brusnik Islet is partially built up of conglomerate with pebbles up to 50 cm in diameter (CRNJAKOVIĆ, 1998).

The radiometric ages (K–Ar 215–200 Ma, and Ar–Ar 200 Ma) measured on gabbro from Jabuka Islet reflects the latest stage of crystallization after the intrusion, since negligible rejuvenating processes due to syn- and postmagmatic hot fluids circulation have been inferred (BALOGH et al., 1994). This age corresponds to the Triassic–Jurassic boundary and could be interpreted as a late stage of rift-related magmatism.

The aim of this paper is to present a new locality with igneous rocks in the Adriatic Sea, provide basic petrographic and geochemical data, and discuss their significance.

2. RESULTS AND DISCUSSION

Nautical maps reveal few shoals in the region near to the Jabuka and Brusnik islets and we presumed that some of the shoals might also have igneous rocks. Research in the summer of 2001 concentrated on the shoal approximately 2300 m WNW of Jabuka Islet, as indicated/mapped on the coastal chart (HHI, 2000) 100–22 Jabuka–Vis, Scale 1:100,000. The location of the Jabuka Shoal is 43°06'06"N, 15°26'21"E. The top of the shoal is located 6 m below sea level. Its location and relationship to other islands in the region is presented in Fig. 1 (after HHI, 1980). No precise map of the Jabuka Shoal exists.

In order to locate sampling points the Jabuka Shoal was measured and a sketch of the top of the shoal was produced (Fig. 2a and b). Transects where rock sampling was performed, at different depths on the flanks ("cliffs") are also presented. A large part of the shoal is covered with algae (fucus) and it was rather difficult to sample the source rock. In appearance it is interesting

[1] University of Zagreb, Faculty of Science, Department of Geology, P.O.Box 332, HR-10002 Zagreb, Croatia;
e-mail: mjuracic@geol.pmf.hr

[2] Institute of Geology, Sachsova 2, HR-10000 Zagreb, Croatia.

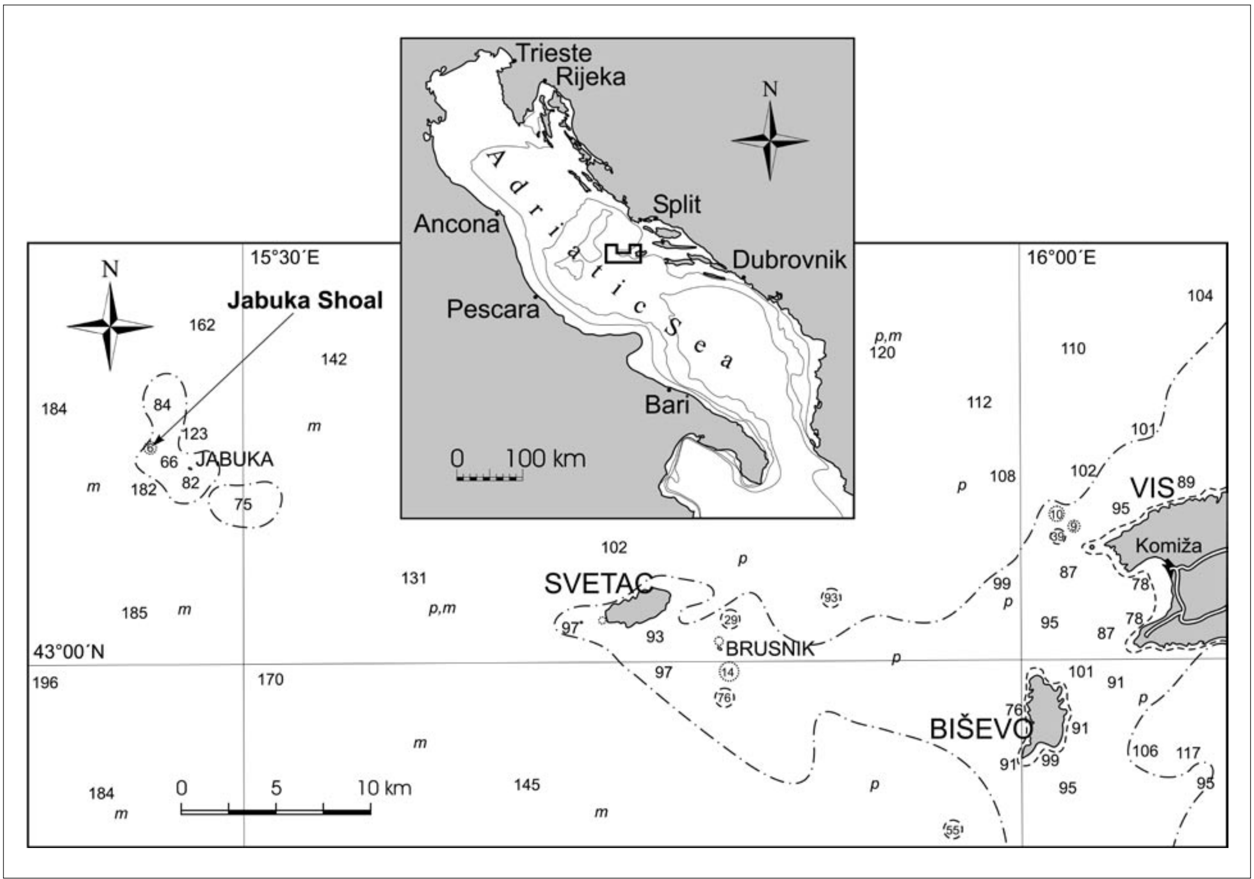

Fig. 1 Location of the Jabuka Shoal and Jabuka Islet in the Adriatic Sea. After Nautical chart 300–33 Pescara–Split (HHI, 1980).

that at the Jabuka Shoal a massive (monolithic rock) along with cobbles and pebbles (conglomerate) is present, a combination of the way the rock appears at Brusnik Islet.

2.1. Petrography

Samples from Jabuka Shoal (Fig. 3) are mostly medium-grained rocks of hypidiomorphic holocrystalline texture having a massive structure. However, some portions of rock characteristically resemble ophitic texture while other parts rarely contain spherulites, amygdales and fissures, filled with non-oriented needles of prehnite.

Their mineral composition comprises clinopyroxenes and plagioclase, with subordinate amphibole (uralite), chlorite and opâque minerals.

The most common mafic minerals are clinopyroxenes (pale green and brown monoclinic pyroxene). The first one is slightly zoned and shows weak pale green pleochroism. The distribution of fine-grained opâque minerals marks zoning in the clinopyroxene. Uralitization altered clinopyroxene and produced secondary green amphibole. In these mineral aggregates chlorite is also present as a product of a later alteration process. The plagioclase commonly displays weak zoning with a more basic core and an acidic rim. Usually plagioclase contains sericite flakes and non-oriented opâque mineral inclusions (poikilitic texture). Also it shows polysynthetic twins. Accessories are opâque mineral(s) and apatite.

All of the primary minerals are altered to various degrees. In spite of the fact that the rock suffered changes up to prehnite–pumpellyite facies, the presence of small amounts of newly-formed minerals mean that the rock is still determined as gabbro.

Petrographic data reveal that the samples from Jabuka Shoal have similar structural, textural and compositional features compared to the ~2 km distant Jabuka Islet as described in detail in BALOGH et al. (1994).

2.2. Geochemistry

Major and trace element contents of rock sample PJ 2/18 from the Jabuka Shoal, analyzed by the XRF method in the Activation Laboratories Ltd., Canada, along with a sample from Jabuka Islet (JA01/4) and data from BALOGH et al. (1994) and from GOLUB & VRAGOVIĆ (1975) are given in Table 1. The low content of MgO (3.49 wt. %), low magnesium number (41.0) and also the low content of Ni and Cr (8, <5 ppm, respectively) show that the magma was not primitive in its nature.

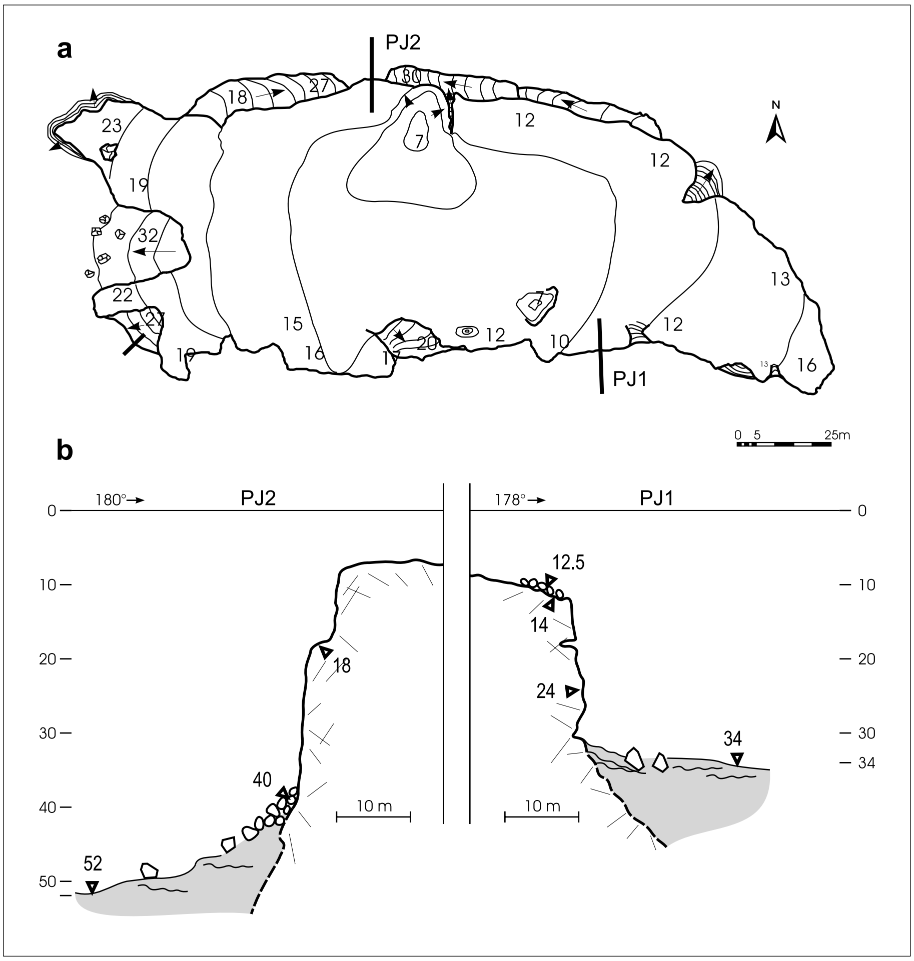

Fig. 2 (a) Sketch of the top of the Jabuka Shoal with transect locations PJ1 and PJ2; depths in m; (b) schematic transects with sampling locations.

The major element content of Jabuka Shoal rocks is similar with those of the nearby Jabuka Islet magmatic rocks. Figure 4 – TAS classification diagram (LE BAS et al., 1992) shows that both the Jabuka Shoal and the Jabuka Islet rock samples plot in a relatively narrow area overlapping the basaltic andesite and basaltic trachyandesite fields. The trace elements distribution reflects the major element content.

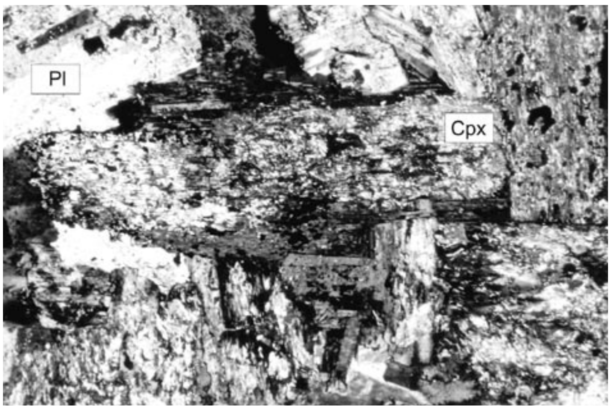

Fig. 3 Detail of gabbro texture – pyroxene (Cpx) and plagioclase (Pl) grains with alteration products; sample PJ2 Jabuka Shoal, depth 18 m, plane polarized light, crossed polars, picture width 1.6 mm.

A diagram after WINCHESTER & FLOYD (1977) based on immobile trace elements (Fig. 5) shows that the samples chemically correspond to the basalt/andesite field.

The presented results indicate that magmatic melts moved upwards along fractures into the overlying continental crust. In the newly formed "magma chambers", various differentiation and crystallization processes took place and finally produced gabbro.

The position of three known localities (Jabuka, Brusnik and Komiža) together with the new Jabuka Shoal occurrence, 2300 m west of the Jabuka Islet, show a linear arrangement that can be set up as a superficial marker of fault system(s) which predisposed the occurrences of the magmatic rocks.

3. CONCLUSION

The main contribution of this research and the discovery of magmatic rocks on the Jabuka Shoal is that the linear arrangement indicates a structure connecting the Jabuka Shoal, Jabuka and Brusnik islets and Komiža. They may be regarded as an important superficial marker of a fault system(s) which predisposed the occurrences of magmatic rocks.

Sample	PJ2/18	JA–01/4	JA–BAL	JA–GV1	JA–GV2	JA–GV3	JA–GV4	JA–GV5
SiO_2	52.15	52.49	50.60	51.63	52.48	51.88	51.50	53.62
TiO_2	0.84	0.94	1.14	1.71	2.27	2.08	1.40	1.67
Al_2O_3	17.18	17.06	14.76	17.12	15.88	12.58	17.68	13.30
Fe_2O_3	9.95	10.63	13.80	4.26	6.69	9.55	3.94	7.06
FeO	0.00	0.00	0.00	5.07	4.52	4.78	7.12	6.37
MnO	0.13	0.19	0.20	0.06	0.05	0.13	0.16	0.11
MgO	3.49	3.36	5.34	3.83	1.44	4.70	3.31	3.28
CaO	7.27	7.67	7.51	8.42	8.03	7.61	7.71	5.18
Na_2O	5.22	3.35	2.95	4.21	5.42	2.87	3.30	6.48
K_2O	1.17	1.66	1.21	1.43	1.27	0.85	1.45	0.22
P_2O_5	0.18	0.20	0.18	0.15	0.25	0.20	0.18	0.36
H_2O	2.54	2.53	2.32	2.12	2.06	2.53	2.32	2.28
Total	**100.12**	**100.08**	**100.01**	**100.01**	**100.36**	**99.76**	**100.07**	**99.93**
Mg #	41.0	38.5	43.4	43.4	19.6	38.5	35.6	31.5
Ba	267	338	323					
Ce	0	0	26					
Co	25	27	0					
Cr	<5	<5	63					
Cu	107	106	241					
Ga	18	19	0					
La	0	0	14					
Nb	3	2	4					
Nd	0	0	14					
Ni	8	10	16					
Rb	28	51	29					
Sc	0	0	38					
Sr	250	336	336					
V	199	227	256					
Y	23	23	23					
Zn	41	63	238					
Zr	77	76	77					

Table 1 Major (wt. %) and trace (ppm) elements for the Jabuka Shoal (PJ) and Islet (JA) samples; BAL – BALOGH et al. (1994); GV – GOLUB & VRAGOVIĆ (1975). Mg # = 100∗molar $MgO/(MgO+FeO_{tot})$.

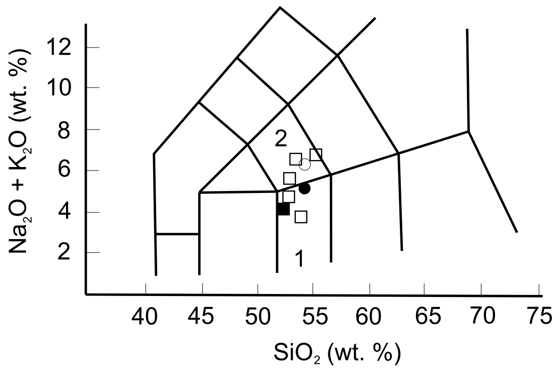

Fig. 4 Segment of the total alkali–silica (TAS) classification diagram (Le BAS et al., 1992) for igneous rocks of the Jabuka Shoal and Jabuka Islet (central Adriatic Sea): empty circle – Jabuka Shoal; full circle – Jabuka Islet, this work; full square – Jabuka Islet, BALOGH et al. (1994); empty square – Jabuka Islet, GOLUB & VRAGOVIĆ (1975). Numbers on diagram: 1 – basaltic andesite; 2 – basaltic trachyandesite.

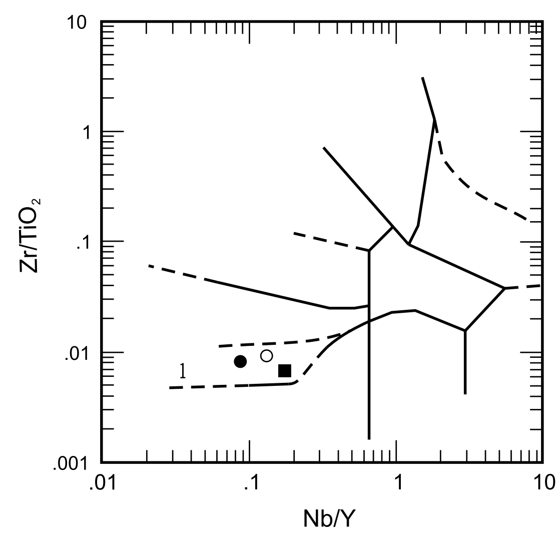

Fig. 5 Plot of Zr/TiO_2 against Nb/Y (WINCHESTER & FLOYD, 1977) for igneous rocks of Jabuka Shoal and Jabuka Islet (central Adriatic Sea): empty circle – Jabuka Shoal; full circle – Jabuka Islet, this work; full square – Jabuka Islet, BALOGH et al. (1994); 1 – range of andesite/basalt.

4. REFERENCES

BARIĆ, Lj. (1961): Wo kommen auf den süd- und mittel-dalmatinischen Inseln die Eruptivgesteine vor? [*Where igneous rocks come on south- and middle Dalmatian Islands?* – in German].– III kongres geologa Jugoslavije, 1, 343–355, Titograd.

BALOGH, K., COLANTONI, P., GUERRERA, F., MAJER, V., RAVASZ-BARANYAI, L., RENZULLI, A., VENERI, F. & ALBERINI, C. (1994): The medium-grained gabbro of the Jabuka Islet ("Scoglio del Pomo", Adriatic Sea).– Giornale di Geologia, ser. 3a, 56/2, 13–25, Bologna.

CARELLA, R. (1961): Nuove osservazioni sull'isola di Lissa (Vis) in Jugoslavia [*New observations on Vis Island in Yugoslavia* – in Italian].– Boll. Soc. Geol. Ital., 80, 27–37.

CRNJAKOVIĆ, M. (1998): Vulkani na Jadranskim otocima? [*Volcanoes on the Adriatic islands?* – in Croatian].– Hrvatski prirodoslovni muzej, 40 p., Zagreb.

DONATI, V. (1750): Della storia naturale marina dell'Adriatico [*Natural history of the Adriatic Sea* – in Italian].– Appresso Francesco Storti, 81 p., Venezia.

FOULLON, H. (1883): Der Augitdiorit des Scoglio Pomo in Dalmatien [*The augitdiorite of Jabuka Islet in Dalmatia* – in German].– Verhandl. der K.K. geol. R.-A., 1883, Wien, 283–286.

GARAŠIĆ, V., VRKLJAN, M., TADEJ, N. & MAJER, V. (2001): Dolerites from the islet of Brusnik (Adriatic Sea, Croatia).– Berichte der Deutschen Mineralogischen Gesellschaft, Beih. Z. Eur. J. Mineral., 13/1, 56.

GOLUB, L. & VRAGOVIĆ, M. (1975): Eruptivne stijene dalmatinskih otoka (Vis, Jabuka i Brusnik) [*Igneous rocks of the Dalmatian Islands (Vis, Jabuka and Brusnik)* – in Croatian].– Acta geologica, 8/4, 19–63, Zagreb.

HAUER, F. (1882): Der Scoglio Brusnik bei St. Andrea in Dalmatien [*Brusnik Islet near Sv. Andrija Island in Dalmatia* – in German].– Verhandl. der K.K. geol. R.-A., 1882, Wien, 75–77.

HAUER, F. & STACHE G. (1862): Aufnahmreise in Dalmatien [*Prospection in Dalmatia* – in German].– Verhandl. der K.K. geol. R.-A., 1861 und 1862, Wien, 257 p.

HHI (1980): Nautical chart 300–33, Pescara–Split, Scale 1:300000.– Hrvatski hidrografski institut, Split.

HHI (2000): Coastal chart 100–22, Jabuka–Vis, Scale 1:100000.– Hrvatski hidrografski institut, Split.

KIŠPATIĆ, M. (1892): Eruptivno kamenje u Dalmaciji [*Igneous rocks in Dalmatia* – in Croatian].– Rad JAZU, 111/15, Zagreb, 158–190.

LE BAS, M.J., LE MAITRE, R.W. & WOOLEY, A.R. (1992): The consideration of the total alkali–silica classification of volcanic rocks.– Mineral. Petrology, 46, 1–22.

PELLERI, L.C. (1942): Sulle rocce dioritiche degli scogli Pomo e Mellisello nel Mare Adriatico [*About diorite rocks of Jabuka and Brusnik islets* – in Italian].– Per. Mineral., 13/2, 191–199.

RAFFAELLI, P. (1977): Osnovna geološka karta SFRJ 1:100.000. Tumač za list Jabuka K33–31 (Basic Geological Map SFRJ 1:100 000. Geology of the Jabuka Sheet K33–31).– Institut za geološka istraživanja Zagreb (1968), Savezni geološki zavod, Beograd, 63–67.

TUĆAN, F. (1953): O istraživanju eruptivnih stijena otoka Jabuke, Brusnika i Visa [*About research on igneous rocks from Jabuka, Brusnik and Vis Islands* – in Croatian].– Ljetopis JAZU, 57, 215–225, Zagreb.

VRKLJAN, M. (1979): Neki mikroelementi u eruptivnim stijenama dalmatinskih otoka [*Some trace elements in igneous rocks of the Dalmatian islands* – in Croatian].– Geol. vjesnik, 31, 309–314.

WINCHESTER, J.A. & FLOYD, P.A. (1977): Geochemical discrimination of different magma series and their differentiation products using immobile elements.– Chemical Geology, 20, 325–343.

Manuscript received July 29, 2003.

Revised manuscript accepted May 04, 2004.