PETROCHEMISTRY AND AGE OF THE ŽDRALJICA OPHIOLITIC COMPLEX (SERBIA)

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Abstract: Ophiolites of Ždraljica (ŽOC) consists of both tholeiitic MORB- and calc-alkaline VA-affinity suites. Granitoids of VA-character (with pre-collision geotectonic setting) crystallized during Middle/Upper Jurassic (168.4-145.2 Ma). Their consolidation is roughly contemporaneous or slightly pre-dates the crystallization of the tholeiitic magma. Over-step sequence of Upper Jurassic flysch that covers the complex, indicates emplacement of the ŽOC.

Key words: Ophiolites, Middle/Upper Jurassic, Radiometric age, Over-step sequence, Collision/compression, Ždraljica, Serbia

INTRODUCTION

The Ždraljica Ophiolitic Complex (hereafter ŽOC), located on the northeastern slopes of the Gledići Mts, near Kragujevac (Central Serbia), represents a part of the oceanic crust of the ancient Vardar Ocean. This complex is recently situated at the eastern branch of the Vardar zone composite terrane (Karamata et al, 1994; Resimić-Šarić et al., 2000). It is associated with the assemblage of diabase-chert formation of Middle/Upper Jurassic age.

PETROCHEMISTRY

The ŽOC consists of two petrogenetically different rock suites: (1) suite of tholeiitic MORB-affinity and (2) suite of calc-alkaline VA-affinity (Resimić, 2001). The first group is represented by serpentinised cumulitic peridotites, massive and layered gabbros, diabases (occurring as dykes or irregular bodies) and plagiogranites, all of them metamorphosed under conditions of greenschist, rarely amphibolite facies. The suite of VA-affinity is represented by quartzdiorite, quartzmoncodiorite, granodiorite and leucocratic granite, all mostly intruding the unit of massive gabbros.

The tholeiitic group originated by melting of a depleted mantle source of NMORB characteristics (Pearce, 1983), showing HFSE contents and ratios close to average NMORB (Zr/Y around 2.3 and Ti/Y around 245 – similar to recommended values given by Saunders and Turney, 1984). Geochemical modeling of modal partial melting revealed 25-30 % of partial melts of a MORB-like mantle source. Primary magma was principally modified by fractional crystallization of clinopyroxene, olivine and plagioclase. Plagiogranites are certainly co-magmatic with the tholeiitic magmas, but their evolution, for instance, via liquid immiscibility or extensive fractionation awaits more data to be explained in detail.

The calc-alkaline rocks of VA-affinity overlap with the MORB-rocks on many discrimination plots, e.g. Nb:Zr/4:Y (Meshede, 1986) and Ti:V plots (Shervais, 1982) using rock composition, as well as F_1:F_2 (Nisbet and Pearce, 1977) and Ca:Ti+Cr (Letterier et al., 1982) diagrams for clinopyroxenes. However, high LILE/HFSE ratios in totally fresh or slightly weathered rocks of this suite implies their calc-alkaline affinity and VA geotectonic setting in broad sense. Ratios Y+Nb:Rb and Y+Nb (Pearce et al., 1984) define the calc-alkaline group of granitoid rocks as VAG and VAG+synCOLG rocks, in contrast of plagiogranites that correspond to ORG. According to Rb/30:Hf:Ta*3 (Harris et al.,1986), calc-alkaline rocks have precollisional character.

AGE DETERMINATION

The age of the ŽOC was a subject of many investigations, but they were mainly dealing with members of the diabase-chert formation. Previously, the age of the diabase-chert formation was determined from the Archean to the Tertiary (Ćirić, 1955). Few authors wrote about the age of the ŽOC: Gočanin (1938) considered diabases of the Gledići Mts. as Jurassic, Terzić (1962) wrote that gabbros of the ŽOC are Hercynian in age and Marković et al. (1968) argued that magmatites of the ŽOC consolidated during the Upper Jurassic. None of these authors gave more details about methods used for age determinations. According to the presence of an Upper Jurassic over-step sequence, represented by sterile flysch sediments covering both diabase-chert formation and members of the ŽOC, it may be concluded that the emplacement of this ophiolitic slice occurred before the Upper Jurassic. The same time period points to the closure of the eastern branch of the Vardar Ocean.

K/Ar ages on whole rock (w.r.) samples and mineral separates from the ŽOC (Table), discussed in this study, were carried out in the Institute for Nuclear Research of the Hungarian Academy of Sciences (ATOMKI) in Debrecen (Hungary). A wide variation of the data suggests that different processes were responsible for the evolution of the ŽOC and some of them may be radiometrically recorded: (1) the age of rock consolidation and (2) time of metamorphic processes or cooling which occurred after crystallization.

Table – K/Ar radiometric ages for rocks and minerals of the ophiolitic complex of Ždraljica

Rock type	Sample number	Analysed material	K (%)	$^{40}Ar_{(rad)}$ cm^3/g	$^{40}Ar_{(rad)}$ (%)	Age (Ma±σ)
gabbro	8-B	amphibole	0.0765	4.718x10^{-7}	26.8	152±21
		plagioclase	0.32	1.250x10^{-6}	19.5	97.8±7.3
diabase	E-550	w.r.	0.285	1.567x10^{-6}	58.7	136.2±7.7
		plagioclase	0.71	3.066x10^{-6}	68.3	107.8±4.5
quartzdiorite	V-306/7	magnesiohornblende	0.38	2.607x10^{-6}	62.8	168.4±6.7
		plagioclase	0.75	2.683x10^{-6}	54.0	90.03.7
quartzmonco-diorite	V-400a	feldspars	2.74	1.233x10^{-5}	83.1	112.3±4.3
		amphibole	1.30	6.725x10^{-6}	59.1	128.5±5.2
	V-353c	amphibole	1.249	7.340x10^{-6}	78.9	145.2±5.7
		feldspars	2.416	1.172x10^{-5}	68.5	120.7±4.8
leucocratic granite	V-306/6	w.r.	4.60	1.819x10^{-5}	94	99.0±3.8
	V-353b	K-feldspar	7.45	2.286x10^{-5}	89.0	77.3±3.6
		plagioclase	1.55	5.917x10^{-6}	79.0	95.6±3.8

The most important feature of K/Ar ages is that feldspar separates and whole rock samples are systematically younger than amphiboles. This is due to the lower closure temperature of feldspars. The feldspar ages range from 120.7 Ma to 77.3 Ma, suggesting that during the Late Cretaceous collision/compression events even the feldspars were only partly overprinted: the temperature of these events was near to the closure temperature of feldspars. Among the dated minerals K-feldspar loses Ar at the lowest temperature (130 ± 15 °C); this is in accordance with the youngest ages measured on the K-feldspar from the leucocratic granite. Plagioclase retains Ar better (~ 230 °C, according to Harland et al., 1990). It cannot be excluded, however, that the scatter of ages on feldspars from granitoids and gabbro is due to a prolonged cooling period.

The amphibole ages range from 168.4 Ma to 128.5 Ma. Excess Ar may cause great bias of age of low-K amphibole. The age of very low-K amphibole from gabbro 8-B is similar to the ages of high-K amphiboles, implying that excess Ar did not disturb significantly the K/Ar ages. According to the expectations the oldest age was measured on magnesiohornblende with lower K concentrations, since Mg-rich amphiboles preserve Ar at the highest temperature.

The Late Cretaceous events might have caused partial Ar loss from the amphiboles too, but the K content of the younger amphiboles is higher, > 1 wt%, therefore a prolonged crystallization of amphibole cannot be excluded. Ar-Ar investigations are planned to clear this question.

The age determinations ranging 168.4-145.2 Ma (Middle to Upper Jurassic) on magnesiohornblende from granitoids of VA-character likely indicate the crystallization age of these rocks. If these granitoids originated in a pre-collision geotectonic setting, which was suggested by Resimić-Šarić et al. (2000), then their consolidation is roughly contemporaneous or slightly pre-dates the crystallization of the tholeiitic magma.

On the other hand, from radiometric ages ranging between 136.2 Ma (diabase, w.r.) and 77.3 Ma (leucocratic granite, feldspars-lighter fraction) the time period of various metamorphic processes may be inferred. Anyway, the oldest ages (136.2-99.0 Ma – Early Cretaceous) could seem slightly younger than the age of the emplacement while the youngest radiometric ages (97.8-77.3 Ma – Late Cretaceos) are probably records of collision/compression events that subsequently occurred within the wide area, e.g. the closure of the western branch of the Vardar Ocean in the Upper Cretaceous (Karamata et al., 2000).

Acknowledgements:

K/Ar dating has been supported by the Hungarian Science Fund No. T029897. The Serbian Academy of Science and Arts, Geodynamic Project supported fieldwork of this study.

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