Coordinated Miocene clockwise rotation of the Vardar Zone and the Drina-Ivanjica unit

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KOORDINISANA MIOCENSKA ROTACIJA U PRAVCU KAZALJKE NA SATU VARDARSKE ZONE I JEDINICE DRINA-IVANJICA

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Kao rezultat zatvaranja Neotetisa nastao je jako komplikovan tektonski domen, Vardarska zona. Zona obuhvata tektonske jedinice Jadranskog afiniteta i afiniteta stabilne Evrope; ostatke okeanske kore koji su obdukovani tokom kasne jure - rane krede i subdukovani tokom krede - paleogena; oligocensko-miocenske magmatske stene i neogene ili mlađe sedimente. Ovo istraživanje fokusirano je na jedinicu Drina-Ivanjica, preko koje je sa istoka navučena Zapadna vardarska zona. Podinu Drina-Ivanjica jedinice čine paleozojske metamorfne stene i sedimenti. Preko ovih formacija leže trijaski klastiti i karbonati; jurski krečnjaci i ofioliti (na zapadu) i gornjokredni fliš. Miocenska ekstenzija aktivirala je vulkanizam na tom području, što je dovelo do nastanka intruziva Golije i ekstruzivnih magmatskih stena. Paleomagnetni pravci za oligocensko - miocenske magmatske stene Zapadne vardarske zone (područje Kopaonika i Rudnika) su ranije publikovani. Nedavnim istraživanjem Istočne vardarske zone (magmatski kompleks Avale), izdvojeni su karakteristični paleomagnetni pravci za oligocenske dajkove. Oba ova istraživanja dokumentuju rotaciju od oko 30° u pravcu kazaljke na satu (CW), mlađu od 23 Ma. Postavlja se pitanje da li je i jedinica Drina-Ivanjica učestvovala u ovoj rotaciji oko vertikalne ose.

Za potrebe ovog istraživanja uzorkovane su plitke miocenske intruzije, dajkovi (granodioriti, kvarclatiti i daciti; 20,6-20,2 Ma; U-Pb starost) sa područja magmatskog kompleksa Golije, kao i bazaltne lave (23-21 Ma; K-Ar datiranje) iz zapadnog dela jedinice Drina-Ivanjica. Laboratorijska merenja su izvršena na 78 uzoraka izbušenih na 12 lokaliteta. Standardne paleomagnetne procedure dale su dobro definisane pravce sa 9 lokaliteta, i magnetit je u najvećem broju slučajeva identifikovan kao nosilac magnetizacije. Opšti srednji paleomagnetni pravac, dobijen na osnovu srednjih pravaca na nivou magmatskih lokaliteta ukazuje na rotaciju od oko 30° CW nakon 20 Ma, sa prilično velikim rasipanjem između individualnih pravaca. Jedan od mogućih razloga za značajno veliko rasipanje može biti sekularna varijacija magnetnog polja Zemlje. Da bi se ispitala ova mogućnost potreban je veliki skup podataka, stoga su kombinovani paleomagnetni rezultati iz jedinice Drina-Ivanjica i oligocensko-miocenske pravci iz Vardarske zone. Zaključak je da je rasipanje u našem skupu podataka veće nego što se može objasniti sekularnom varijacijom. Moguć razlog za ekstremno odstupanje nekih pravaca, od opšteg srednjeg paleomagnetnog pravca od tektonskog značaja, može biti posledica prisutva magnetnih komponenti koje se ne mogu razdvojiti. Ova interpretacija je potvrđena analizom krugova remagnetizacije. Ovo opravdava eliminaciju pravaca koji ekstremno izlaze iz skupine paleomagnetnih pravaca.

Statistički parametri opšteg srednjeg pravca za Drina-Ivanjica jedinicu su prihvatljivi nakon eliminacije podataka koji ekstremno ostupaju od grupe, a njegov pravac ukazuje na rotaciju od oko 30° CW. Prema tome, zaključujemo da paleomagnetni pravci oligocensko - miocenskih ekstruziva i intruziva Vardarske zone, i paleomagnetni pravci iz jedinice Drina-Ivanjica pokazuju skoro iste opšte srednje pravce, stoga mora da su rotirale zajedno u miocenu.

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As a result of the Neotethys's closure, a highly complicated tectonic domain developed, the Vardar Zone. The zone comprises tectonic units of Adriatic and stable European affinities; the remnants of the oceanic crust obducted during Late Jurassic–Early Cretaceous and subducted during Cretaceous–Paleogene; Oligocene–Miocene igneous rocks and Neogene, or younger sediments. This study focuses on the Drina-Ivanjica unit which is overthrusted from the east by the Western Vardar Zone. The basement of the Drina-Ivanjica unit is made up of Paleozoic metamorphic rocks and sediments. These formations are overlain by Triassic clastics and carbonates; Jurassic limestones and ophiolites (in the west) and Upper Cretaceous flysch. Miocene extension activated the volcanism in the area and resulted in the Golija intrusion and in extrusive magmatic rocks.

Earlier paleomagnetic directions had been published for Oligocene–Miocene igneous rocks from the Western Vardar Zone (Kopaonik and Rudnik areas). From the Eastern Vardar Zone (Avala magmatic complex) a recent study presented characteristic paleomagnetic directions for Oligocene dykes. These studies document about 30° clockwise rotation (CW) for the respective areas, after 23 Ma. The question was whether the Drina-Ivanjica unit took part in this vertical axis rotation.

For this study Miocene shallow intrusives, dykes (granodiorite, quartz latite, dacite; 20.6–20.2 Ma; U-Pb age) were sampled from the area of the Golija magmatic complex as well as basalt lavas (23–21 Ma; K-Ar dating) from the western part of the Drina-Ivanjica unit. The laboratory measurements were carried out on 78 rock samples from 12 sampling localities. Standard paleomagnetic processes resulted in well-defined directions for 9 sites, and the carrier of the remanent magnetization was identified in most cases as magnetite.

The overall-mean paleomagnetic direction based on the igneous locality mean directions suggests about 30° CW rotation after 20 Ma, with a high scatter between the individual directions. While the declinations are easterly and just slightly different, the inclination differences are significant. One possible reason for the large scatter could be the secular variation of the Earth magnetic field. To test this possibility a quite large data set is needed, therefore we combined the paleomagnetic results of the Drina-Ivanjica unit and the Oligocene–Miocene directions from the Vardar Zone. Our conclusion is that the scatter in our datasets is larger than explained by the secular variation. A feasible reason for the extreme deviation of some directions from the overall-mean paleomagnetic direction of tectonic significance can be non-separable magnetic components. This interpretation was confirmed by the analysis of remagnetization circles. This justifies eliminating the extreme outliers from the population of the paleomagnetic directions.

The statistical parameters of the overall-mean direction for the Drina-Ivanjica unit are acceptable after the elimination of outliers and points to about 30° CW rotation. Thus, we conclude that the Oligocene–Miocene extrusives and intrusives from the Vardar Zone, and the paleomagnetic directions from the Drina-Ivanjica unit exhibit almost the same overall-mean declinations, therefore they must have rotated together in the Miocene.

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