THE U–Pb AND Sm–Nd DATING OF THE MAIN LITHOTECTONIC ASSEMBLAGES OF THE EAST CARPATHIANS, ROMANIA

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Abstract: For a better constrain of the East Carpathian metamorphics evolution, we have selected six representative granite units from the major lithotectonic assemblages (Bretila, Rebra, Negrişoara and Tulgheş), for U-Pb zircon dating, and a suite of 24 samples for Sm-Nd whole rock T_{DM} model ages. Bretila includes the ca. 465 Ma Hăghimaş granitoid, and the ca. 468 Ma Mândra granitoid; Rebra includes the Nichitaş ortogneiss with a possible emplacement age of ca. 460 Ma; Negrişoara and Tulgheş include the ca.485 Ma old Pietrosu granitoid and Brezuța metaigneous layer, respectively. The T_{DM} model ages range between 1.56 and 2.07 Ga.

Keywords: East Carpathians, metamorphics, granites, geochronology, Caledonian

INTRODUCTION AND GEOLOGICAL SETTING. The Carpathian orocline belongs to the central European belt of complex Mesozoic and Cenozoic terrane accretion. The East Carpathians segment of the orogen consists from east to west of a fold-and-thrust belt, an imbricated basement and a magmatic arc. This paper is focused on the pre-Alpine tectonic evolution of EC basement. In an attempt to better constrain the geological evolution of the basement rocks in the EC and to inspire more comprehensive tectonic models we have undertaken an isotope study of igneous and metamorphic rocks. The approach has been to date the magmatic events in each major lithotectonic assemblage using the U-Pb abraded zircon technique and to compare the Sm-Nd signature of representative igneous and metamorphic units. The samples selected for study were collected from the most distinctive and representative rock units of the five metamorphic successions separated along the East Carpathians (Rodna, Bretila, Tulgheş, Negrişoara, and Rebra) (Kräutner, 1988, Balintoni, 1997).

The Bretila lithotectonic assemblage includes plagiogneiss, microclinic gneiss, augen gneiss, amphibolite and minor micaschist. The Hăghimaş granodiorites form the most extensive and least deformed igneous rock exposed. The Mândra granitoids were separated as highly sheared granitoid pods within a matrix of foliated rocks. The Bretila lithotectonic assemblage was interpreted as a sequence metamorphosed within an accretionary wedge and Hăghimaş and Mândra granitoids as remnants of a subduction arc.

The Rebra lithotectonic assemblage is dominated by thick carbonate layers and amphibolite within a matrix of staurolite, kyanite and/or sillimanite-bearing plagiogneiss, micaschist, subordinate microcline gneiss white quartzite and black graphite-bearing quartzite. The Nichitaş ortogneiss is a good meters to tens of meters thick lithological marker over tens of kilometers at the upper part of the Rebra assemblage. A premetamorphic passive continental margin setting was inferred from the locally mineralized carbonate units similar to Mississippi Valley type deposits.

The Negrişoara lithotectonic assemblage is a relatively thin and interrupted sequence of biotite plagiogneiss with thin and discontinuous intercalations of carbonate, amphibolite, microcline gneiss, overlain by an extensive layer of variably sheared granodiorite, known as the 'Pietrosu porphyroid gneiss' (Balintoni et al., 1983). The Negrişoara succession may be included in the upper part of the Rebra sequence or may be genetically unrelated to this.

The Tulgheş lithotectonic assemblage is a highly strained generally low-grade metamorphic succession dominated by white and black graphitic quartzite, and quartzo-feldspathic layers within a matrix of variably chloritic and phengitic schists(Kräutner, 1988). The association of graphite quartzite and iron-manganese ore is interpreted as a deep basin depositional environment. The metallic sulfide ore bodies are considered Kuroko type and their association with acidic metavolcanic rocks is interpreted as a subduction-related magmatic arc.

SIGNIFICANCE OF DATA. Because the new U-Pb zircon data from granitoids of the East Carpathians basement are discordant and do not always allow unequivocal distinction between Pb-loss and inheritance effects we prefer to quote age bands for the igneous activity instead of precise concordia intercept ages as protolith ages. The new data are critical since they point to Early Paleozoic, post-Cadomian and pre-Variscan protoliths (Table1).

Surprisingly, in spite of clearly documented Variscan tectonism in the basement rocks of the East Carpathians , no evidence of a major Variscan magmatic event has been identified yet in this segment of the orogen. East Carpathians basement may represent a slice of crust that was situated at some distance from a Variscan plate margin.

The variably deformed granitoids of the East Carpathians yielding Early to Middle Ordovician ages do not conform to either Cadomian or Variscan geodynamic models. The lithotectonic assemblages discussed herein probably were formed and evolved in an active Early Paleozoic tectono-magmatic setting. The lack of relevant faunal, paleomagnetic, stratigraphic, and structural data precludes the reconstruction of a well-constrained tectonic framework or a plausible "Caledonian" plate tectonic scenario. But we can suggest a model mainly derived from the interpretation of the intermediate igneous rocks as supra-subduction magmatism, and of the Rebra-Negrişoara and Tulgheş lithologies as passive margin and back-arc successions, respectively. Closure of a seaway between the Rebra-Negrişoara and Bretila crustal fragments somewhere along the northern Gondwana resulted in the ca. 485 Ma Pietrosu magmatic arc. Contemporaneous development of the Tulgheş back arc basin was accompanied by the deposition of volcanic rocks including the ca. 485 Ma Brezuța layer.

The U-Pb zircon data can be correlated with the Sm-Nd information (Fig.1). The most negative $\varepsilon Nd_{(0)}$ and the oldest T_{DM} obtained from both, carbonate and carbonate-free lithotectonic assemblages suggest a creation of a relatively homogenous crust at about 2 Ga. This hypothesis is in agreement with the concordia upper interception of the 1.8 – 1.9 Ga, provided by Pietrosu granite-biotite and Nichitaş granite Chl + F respectively (Table 1).The less negative $\varepsilon Nd_{(0)}$ and the younger T_{DM} of some lithologies are in the same range as the associated granites. This may indicate that juvenile material was locally added to the originally homogenous crust. This supposition is supported by 1.1 Ga and 1.3 – 1.4 Ga concordia upper interceptions (Table 1).

Finally, the all Sm-Nd granite data indicate the recycling of a Precambrian crust during the Lower Paleozoic granite emplacement.

DISCUSSION. The Early Paleozoic geological evolution of central and northwestern Europe is dominated by the view of some terrane interactions during post-Cambrian to pre-Late Devonian times as a part of Caledonian orogeny (e.g., Oliver et al., 1993). In this plate tectonics scenario, Baltica, Laurentia and Gondwana continental plates interacted on the large scale, with the consumption of the intervening thousands of kilometers wide Iapetus Ocean and Tornquist Sea. Faunal provincialism and paleomagnetism indicate that the Tornquist Sea separated Bohemian

Gondwana from Baltica and the Poland non-metamorphic Caledonides during the Cambrian-Ordovician times (Bergstrom, 1990; Tuckey 1990). At least 2000 km of oceanic crust was consumed during the Ordovician and another 1000 in the Silurian. As the Tornquist Sea disappeared by Silurian times, a collision zone of major importance consisting of a collage of exotic Lower Paleozoic oceanic, volcanic arc and continental margin terranes developed between Baltica and Gondwanaland.

Several such terranes were described by Oliver et al. (1993), in Poland, along the Tornquist suture zone. We hypothesize that the EC lithotectonic assemblages can represent the southern prolongation of these terranes. In the eastern part of Romania, the non-metamorphic Poland Caledonides are continued by the Scytic platform (Săndulescu, 1984). The Tornquist suture zone should be searched at the western boundary of the Scytic platform.

References

Balintoni, I., (1997), *Geotectonica terenurilor metamorfice din România*, Ed. Carpatica, Cluj Napoca, 176p.

Balintoni, I., Gheuca, I., Vodă, Al., (1983), *Alpine and Hercynian Overthrust Napps from Central and Southern Areas of the East Carpathians Crystalline Mesozoic Zone*, An. Inst. Geol. Geofiz., LX, 15-22, Bucureşti.

Bergstrom, S.M., (1990), *Relations between conodont provincialism and changing paleogeography during the Early paleozoic.* In: McKerow, W.S., Scotese, C.R., (eds) *Paleozoic Paloegeography and Biogeography*, Geological Society, London, Memoir 12, 105-121.

Kräutner, K.G., (1988), *East carpathians.* In: Zoubek et al. (eds.), *Precambrian in Younger Fold Belts*, 625-638, Wiley.

Oliver, G.H.J., Corfu, F., Krogh, T.E., (1993), U-*Pb ages from SW Poland: evidence for a Caledonian suture zone between Baltica and Gondwana*. Jour. Geol. Soc. London, 150, 355-369.

Săndulescu, M. (1984): *Geotectonica României*. Ed.Tehnică, Bucureşti, 336p.

Tuckey, M.E., (1990), *Biogeography of Ordovician bryozoans*. Paleogeoraphy, Paleoclimatology, Paleoecology, 77, 91-136.

Table 1. *Conventional Concordia Data*

Sample, fraction	207Pb /235U	1s %err	206Pb /238U	1s %err	rho	207Pb /206Pb	1s %err	Fractions Calculated	Isoplot solution	UI (Ma)	LI (Ma)	MSWD/PF
21. Brezuta, mylon-chl granite, Tughes												
1 z	0.52688	0.235	0.06813	0.214	0.91	0.05609	0.097	1,2,5,6,7,8	M. Carlo	486+62/-26	218+120/-150	
2 z	0.49337	0.459	0.06433	0.213	0.52	0.05563	0.393	1,2,5,6,7,8	Model 1	486±44	218±130	0.84/0.550
3 z	0.55436	0.244	0.06658	0.222	0.93	0.06039	0.088	1,2,5,6,8	M. Carlo	500+79/-34	264+100/-130	
4 z	0.63604	0.268	0.07600	0.210	0.84	0.06070	0.148	1,2,5,6,8	Model 1	500±62	264±120	0.14/0.94
5 z	0.64411	1.272	0.08193	0.224	0.34	0.05702	1.215	1,2,6,8	M. Carlo	511+100/-49	286+180/-140	
6 z	0.53741	0.256	0.06930	0.205	0.84	0.05624	0.140	1,2,6,8	Model 1	511±88	286±130	0.068/0.93
7 z	0.51801	0.345	0.06684	0.237	0.73	0.05621	0.235					
8 z	0.53261	0.303	0.06881	0.218	0.78	0.05614	0.192					
7. Haghimas, granitoid, Bretila												
1 z	0.54502	0.226	0.06915	0.190	0.86	0.05717	0.116	1,2,3,4,5,6		732±430	391±210	79/0.000
2 z	0.56406	0.227	0.07218	0.200	0.93	0.05668	0.082	2,4,5	M. Carlo	1141±78	435.4+3.4/-4.2	
3 z	0.56312	0.223	0.07196	0.199	0.95	0.05676	0.070	2,4,5	Model 1	1141±78	435.4±3.8	0.070/0.79
4 z	0.56041	0.424	0.07184	0.190	0.53	0.05658	0.362	2,3,4,5	M. Carlo	1122+72/-77	433.3+2.9/-3.5	
5 z	0.64619	0.294	0.07877	0.177	0.68	0.05950	0.216	2,3,4,5	Model 1	1122±75	433.3±3.3	1.5/0.21
6 z	0.63158	0.222	0.07941	0.189	0.59	0.05768	0.189	2,6	M. Carlo	572+58/-41	354+36/-57	
								2,6	Model 1	572±50	354±45	0.000/1.000
8-Pietrosu-Chlor, sheared granite, Negrişoara												
1 z	0.64901	0.254	0.08039	0.185	0.77	0.05855	0.161	1,2,3,4,5		527±?	159±?	202/0.000
2 z	0.54334	0.363	0.06716	0.292	0.83	0.05868	0.202	3,4	M. Carlo	444+51/-34	± inf	
3 z	0.55854	0.239	0.07207	0.191	0.85	0.05620	0.128	3,4	Model 1	2297±?	444±470	0.000/1.000
4 z	0.56246	0.303	0.07257	0.185	0.82	0.05621	0.185					
5 z	0.62415	0.621	0.07905	0.247	0.49	0.05727	0.543					
20-Pietrosu granite-biotite, Negrişoara												
1 z	0.77950	0.231	0.08733	0.215	0.95	0.06474	0.069	1,2,3,4		none	none	
2 z	0.64026	0.216	0.08036	0.189	0.95	0.05779	0.071	1,2,3,4,5,6,7		1433±540	399±280	3207/0.000
3 z	0.50106	0.395	0.06478	0.258	0.70	0.05610	0.282	2,6	Model 1	521.5±3.2	-2±12	0.000/1.000
4 z	1.00447	0.255	0.11091	0.184	0.78	0.06569	0.161	2,3	Model 1	545±11	271±42	0.000/1.000
5 z	1.34650	0.320	0.13871	0.181	0.65	0.07041	0.245	2,7	M. Carlo	1835.4+7.6/-8.1	493.4±2.1	
6 z	0.28534	3.587	0.03578	3.574	1.00	0.05783	0.294	2,7	Model 1	1835.4±7.7	493.4±2.1	0.000/1.000
7 z	2.13799	0.235	0.16407	0.188	0.85	0.09451	0.123	2,4,5	Model 2	1039±180	487±130	5.2/0.022
19- Nichitas, layered granite chl+F, Rebra												
1 z	0.48766	0.253	0.06126	0.196	0.85	0.05773	0.135	1,2,3,4		1772±840	363±130	743/0.000
2 z	0.58541	0.217	0.06411	0.190	0.94	0.06623	0.076	3,4	M. Carlo	1917±35	406.5+6.7/-7	
3 z	1.12848	0.363	0.10008	0.192	0.59	0.08178	0.293	3,4	Model 1	1917±34	406.5±6.9	0.000/1.000
4 z	0.50742	1.074	0.06592	0.222	0.32	0.05583	1.024	2,3	M. Carlo	3048+160/-130	376±2	
								2,3	Model 1	3048±140	376.4±2.1	0.000/1.000
18- Mandra, chl-mylonite white clasts, Bretila												
1 z	0.60589	0.217	0.07682	0.194	0.96	0.05720	0.065	1->6	Model 2	679±?	393±?	57/0.000
2 z	0.61906	0.222	0.07770	0.188	0.89	0.05778	0.101	1,2,3	M. Carlo	1330+250/-230	468.0+3.4/-5.2	
3 z	0.58794	0.411	0.07536	0.188	0.52	0.05658	0.351	1,2,3	Model 1	1330±270	468.0±3.2	1.18/0.28
4 z	0.76652	0.684	0.09289	0.458	0.70	0.05985	0.492					
5 z	0.57928	0.580	0.07417	0.382	0.69	0.05665	0.421					
6 z	0.63947	0.397	0.07710	0.214	0.59	0.06016	0.321					

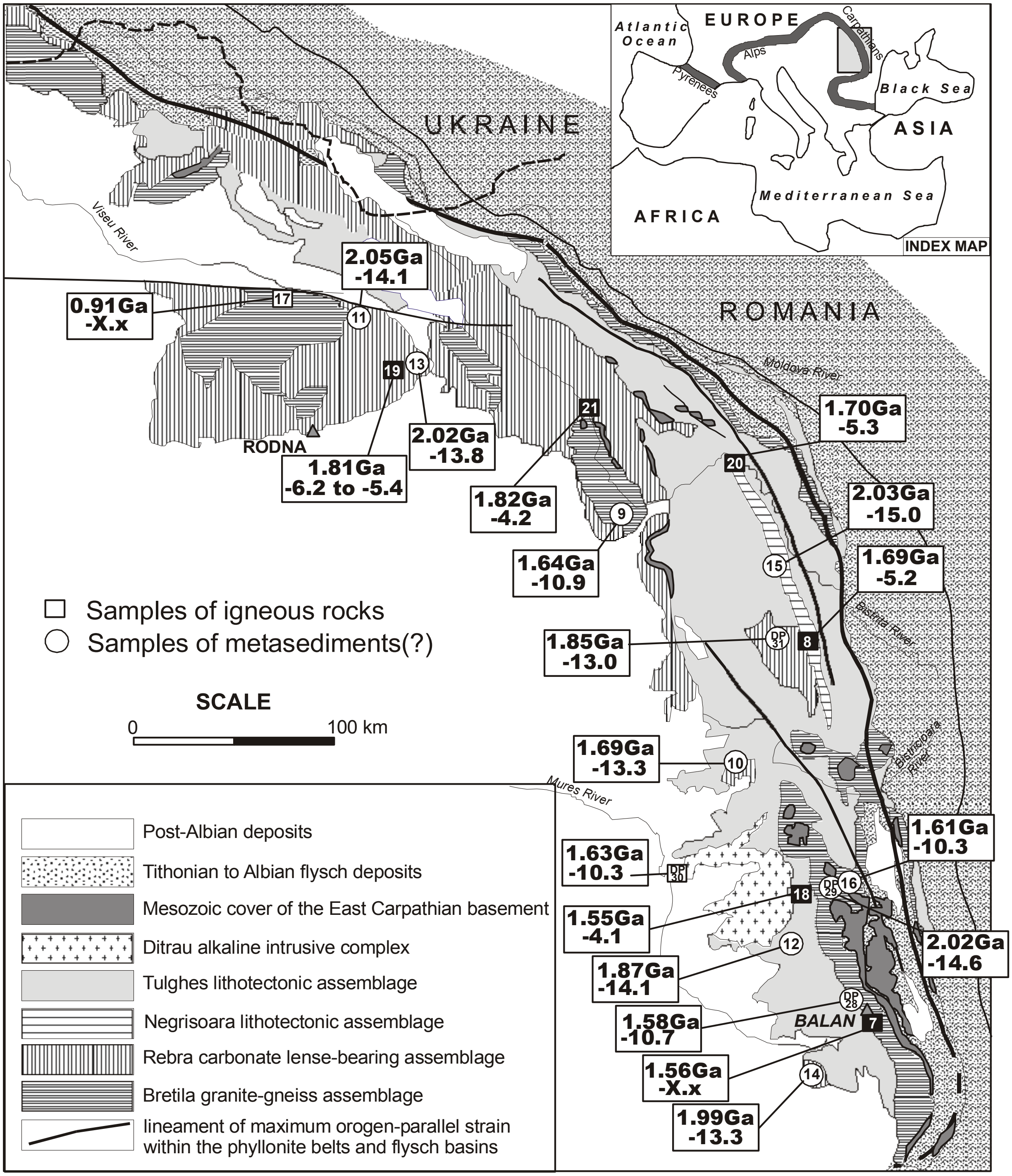

Figure 1. *Simplified sketch map of the East Carpathians illustrating the distribution of major basement lithotectonic assemblages and sample locations. Numbers in circles are samples from assumed metasediments; numbers in squares are samples from massive or foliated igneous rocks. Corresponding T_{DM} model ages and εNd values are in large boxes. Black squares are samples analysed for both Sm-Nd whole rock and U-Pb zircon dates (see Table 1).*