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Do We Know the Oldest Rock from the Western Carpathians at all?

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The oldest rocks on Earth found so far are the Acasta Gneisses in northwestern Canada near Great Slave Lake (4.03 Ga) and the Isua Supracrustal rocks in West Greenland (3.7–3.8 Ga), but well-studied rocks nearly as old are also found in the Minnesota River Valley and northern Michigan (3.5–3.7 Ga), in Swaziland (3.4 to 3.5 Ga), and in Western Australia (3.4–3.6 Ga). Indeed, these most ancient rocks are found exposed at the surface in parts comprising the Precambrian shield, a stable core of the continental landmass, very old rocks are found in the mobile – orogenic belts as well. Generally, the oldest rocks are known mainly from cratonic areas forming by greenstones and/or gneissic rocks, whereas in the young collisional belts are the older rocks present in the form of basement slivers. The basement areas in the modern collisional orogenic belts such as the Alps, Carpathians or Himalayas often comprise multistage metamorphic and magmatic events. It is common that within these young (Cretaceous–Cenozoic) orogenic belts locally survived relatively old rocks. The oldest orthogneissic rocks known from Himalayas are as old as 1850 Ma (Zeitler et al. 1989) although Late Proterozoic – Early Paleozoic (820–460 Ma) gneissic and granitic rocks are not so scarce there (Ahmad et al. 2003). However, the Proterozoic rocks are extremely rare within the basement of the Alps e.g. mantle related 1.72 Ga peridotite, 870 Ma gabbro from Central Alps (Gebauer 1993), and/or intermediate meta-igneous rocks 650–600 Ma from Eastern Alps (Thöni 1999). There are relatively more frequent only the products of the Cambrian and Ordovician magmatism (530–450 Ma) often sheared onto orthogneisses in the Alps (see review Schaltegger and Gebauer 1999). Due to missing of relevant isotopic dating the situation in the Carpathians is more or less obscured, indeed, scarce Late Proterozoic orthogneiss 770 Ma and granites 570 Ma in age were identified in the South Carpathians (Liégeois et al. 1996). As for almost all European basement territory, the Hercynian orogeny is dominant within the Western Carpathians basement (WCB) areas at the present erosion level. Available isotopic data (U/Pb, Rb/Sr, and Ar/Ar) support mainly the event between 360–340 Ma. The HT/MP metamorphism with concomitant widespread granitic magmatism has heavily overprinted basement precursors, and masked the polyorogenic history of the WCB. However, as observed in other European basement areas there exist some indication of older processes in the WCB. The oldest rocks identified so far in the Western Carpathians are metatrondhjemitic orthogneisses from layered amphibolites dated to be 514 ± 24 Ma (Putiš et al. 2001) and felsic Murán orthogneisses 470–450 Ma (Gaab et al. 2003) in age. Albeit, there exist some indications of older rocks on the basis of our reconnaissance study from the Patria crystalline complex – Branisko Mountains, suggesting for long multistage evolution. The northern part of the Branisko Mts. – Smrekovica massif is composed of a crystalline core – Patria complex consisting of magmatic rocks - including a biotite granodiorite to tonalite and felsic two-mica granite to granodiorite, from metamorphic rocks there are present

amphibolites and migmatitic biotite paragneisses as well as tonalitic gneisses. This gneissic – amphibolitic complex shows an anatectic overprint. The tonalitic gneisses have a "banded fabric" where the dark gneissic bands are composed of amphibole, plagioclase, biotite, quartz and an accessory mineral assemblage – zircon, apatite, ilmenite, epidote, titanite and/or ore minerals. The pale bands consist mostly of plagioclase and quartz. The bulk composition of the tonalitic gneisses is metaluminous (SiO_2 = 56–62 wt.%), A/CNK = 0.85–0.96 with CaO > 5.0 wt.%, TiO_2 = 0.4–0.6 wt.%, and MgO > 4.0 wt.%, low in Ba (270–320 ppm) and Sr (170–280 ppm). Generally moderate REE contents (with ΣREE ~150 ppm), moderate Eu anomaly and low to moderate La_N/Yb_N (8–10), but slightly enriched HREE indicate rather non-evolved rocks. Low Rb/Sr (0.2 to 0.3) ratios, with rather high $^{87}Sr/^{86}Sr_{(0)}$ ratio = 0.7130, and $\varepsilon Nd_{(0)} = -7.06$, together with low values of $\delta^{18}O_{(SMOW)} = 7.8$ ‰ and $\delta^{34}S_{(CDT)} = -0.11$ ‰ call for a lower crustal origin. The lower crustal provenance of these rocks is also indicated by their Pb isotopic compositions with $^{206}Pb/^{204}Pb$ = 18.439–18.724 and $^{207}Pb/^{204}Pb$ = 15.676–15.679. Several samples of tonalitic gneisses, gabbroamphibolites and various types of granites were collected for dating purposes from the Patria crystalline complex. A reconnaissance dating study were performed at the Open University – Milton Keynes (UK) – laser-probe $^{40}Ar/^{39}Ar$ analyses of samples using a focused CW Nd-Yag infrared laser combined with noble gas mass spectrometer MAP 215–50, and the Max Planck Institute of Chemistry – Mainz (D) – Pb/Pb isochrones of leached samples using a TIMS Finnigan MAT 261 mass spectrometer. The biotites in the Ar/Ar isotopic system from two tonalitic gneisses provide ages from 314 ±7 to 397 ±16 Ma, whereas amphiboles ages from identical samples ranges from 445 ±18 to 841 ±67 Ma. The pronounced scatter in amphibole ages and much younger biotite ages suggest that an earlier (ca. 750 Ma) metamorphic fabric has been overprinted by a ca. 350 Ma metamorphic/magmatic event. Curiously the identical results brought a preliminary Pb/Pb study because analyses from amphibolites and tonalitic gneisses fit an isochron with age 750 ±150 Ma, whereas Pb/Pb data from granitic and pale trondhjemitic parts of tonalitic gneisses fit an isochron with age 350 ± 10 Ma.

Field relations, petrography, and geochemistry demonstrate variegated character of the Patria crystalline complex – Branisko Mts. The whole Patria complex displays intensive anatectic overprint that is obvious in a new 5 km long highway tunnel. Our reconnaissance dating study exhibits that the last metamorphic/magmatic processes occurred during main meso-Hercynian period at ca. 350 – 340 Ma. However, systematic appearance of the older ages like the Late Proterozoic (ca. 750 Ma) indicates an activity of some older tectono-metamorphic events. Albeit, the indications of Panafrican (Cadomian – Avalonian) orogeny that occurred between 750–500 Ma are scarce in the Western Carpathians (mainly due to general lack of the modern isotopic data), we assume that these gneissic-amphibolitic rocks within the Patria crystalline complex represent partly reactivated remnants of this older orogeny and/or potentially the oldest rocks in the Western Carpathians.

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