Geochronology of Permian–Triassic tectono–magmatic events from the Inner Western Carpathian and Austroalpine units

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Abstract: This contribution reviews published and our new geochronological data on the Permian–Triassic tectono–magmatic events determined from the researched areas of the Slovak Inner Western Carpathians (IWC) and the Austrian Austroalpine (AA) units by zircon U–Pb SIMS. Most of the dated rocks bear the signatures of the superimposed Late Jurassic and/or Cretaceous tectono–metamorphic overprinting in the greenschist (from the IWC Infratatric, Veporic and Gemeric basement complexes), greenschist and blueschist (from the IWC Meliata Unit) or greenschist to eclogite facies (from the Upper AA units) conditions. The reported Permian to Middle Triassic ages constrain a global extension event focused into an equatorial zone thus roughly tracing the accretion zone of the Gondwana-derived Late Variscan basement complexes (~Early Paleozoic basement of the IWC Gemericum, Transdanubicum, Southern Alps of the Pelsó or Noric terranes) to the Early Variscan (~Early Paleozoic to Proterozoic) basement complexes of the Armorican or Galatian affinity following the Devonian Paleotethys closure and the Carbonifeous to Early Permian Pangea supercontinent assembly. The Pangea break-up was accompanied by the crust–mantle lithosphere thinning, overheating, melting and formation of the Permian to Middle Triassic magmatic complexes within the rifted shelf areas developed on the thinning Variscan basement. The westward propagation of the Neotethys oceanic rift spreading and the Meliata(–Hallstatt) oceanic basin opening indicate a continuous transition of Late Permian to Early Triassic continental rifting into Middle to Late Triassic Neotethyan oceanic rifting.

Study area and methodology

Zircon U–Pb SIMS geochronological method was used to determine the Permian and Triassic tectono-magmatic events from the Inner Western Carpathian and some Austroalpine units. We investigated these events in the northern Austroalpine–Inner Western Carpathian (AA–IWC) Block of the Cenozoic ALCAPA microplate (Neubauer et al. 1992) which is separated from the southern Pelsó Block by the Periadriatic–Rába–Hurbanovo–Diósjenö Fault (e.g. Janik et al. 2011). The IWC Orogen can be traced from the Neotethys closure-related Late Jurassic–Early Cretaceous Meliatic–Gemeric–South Veporic (ME–GE–SVE) accretionary wedge in the S to the Atlantic (Alpine) Tethys closure-related Late Cretaceous–Eocene North Veporic–Tatric–Infratatric (NVE–TA–IFTA) accretionary wedge in the N (Putiš et al. 2019 and references therein).

Here we dated a gabbro-dolerite dyke crosscutting the Devonian meta-volcanics at the Harmónia village in the Tatric basement, rhyolitic (Bacúch, Závadka n.H.-Burda pass) and A-type granitic (Hrončok) rocks from the Veporic basement and its Permian volcano-sedimentary cover successions, and A-type (Turčok) granite and specialized S-type granites from the Rudník and Zlatá Idka localities in the Gemeric basement.

The GE and SVE units of the IWC can be correlated with the Upper Austroalpine (UAA) structural complexes of the Eastern Alps (sensu Schuster et al. 2004 or Schmid et al. 2004), both representing the inferred Meliata(–Hallstatt) Basin northern passive continental margin (cf. Putiš 1991). The investigated Austroalpine eclogitic complexes represent mostly the Variscan basement that underwent the Permian extension/overheating and the Cretaceous eclogite-facies metamorphism (e.g. Thöni & Jagoutz 1993; Schuster et al. 2004). Granitic orthogneisses from the UAA hanging wall Sieggraben eclogitic complex and the Grobgneis and Wiesmath type meta-granites from the LAA complex were dated in the eastern Austroalpine margin.

The SIMS dating was performed in Beijing and St.-Petersburg. Measurements of U, Th, and Pb isotopes were made by Cameca IMS-1280HR SIMS at the Institute of Geology and Geophysics, Chinese Academy of Sciences

in Beijing; the complete instrument description and analytical procedure were published by Li et al. (2009). In situ U–Pb analyses of zircon from Gemeric granites were performed on a SHRIMP-II in the Centre of Isotopic Research (CIR) at VSEGEI, St.-Petersburg, applying a secondary electron multiplier in peak-jumping mode following the procedure described by Williams (1998) and Larionov et al. (2004).

Review of published geochronological data

Both the IWC wedges are quite rich in the Permian mainly calc–alkaline and less A-type acidic to basic volcanic, subvolcanic, lamprophyric or plutonic (mainly granitic) magmatic products (Kotov et al. 1996; Uher and Broska 1996; Poller et al. 2000; Putiš et al. 2000, 2016; Vozárová et al. 2009, 2012, 2015, 2016; Radvanec et al. 2009; Demko & Hraško 2013; Pelech et al. 2017; Spišiak et al. 2018; Ondrejka et al. 2018). All these rock zircon U–Pb SIMS (SHRIMP) ages fall into interval of ca. 280 to 255 Ma. Typical rift-related continental tholeiites occur only in the IWC Hronic Unit Permian succession (Vozárová & Vozár 1988) overlying the Fatric and Tatric units as a rootless nappe. The Permian overheating was determined also by the EPMA monazite ages from the IWC North-Veporic Unit (Jeřábek et al. 2008).

The Neotethyan Meliata Unit mid-Triassic (Ladinian) silicites, interlayered with N-MORB, contain the youngest detrital zircon population of 247±4 Ma from an inferred (Anisian) acidic magmatic source (Putiš et al. 2011). The Triassic overheating of the Permian Gemeric granites up to the Carnian/Norian boundary (ca. 250–225 Ma) was determined by the EPMA ages of the magmatic monazite outer zones and newly-formed monazites (Radvanec et al. 2009).

A clinopyroxenite dyke crosscutting harzburgite was dated at 252±2 Ma from the UAA Sieggraben structural complex near Steinbach in Burgenland (Putiš et al. 2018). Permian U–Pb age of 286±14 Ma as an upper intercept age was dated on zircon by conventional method from a granitic orthogneiss of the UAA Sieggraben complex between the Sieggraben and Schwarzenbach villages (Putiš et al. 1994, 2000, 2002a). Similar ages of ca. 275 Ma (meta-gabbro) and 260 Ma (meta-pegmatite of Platengneis type) were determined by Grt–wr isochrons plot of whole rock and mineral Sm–Nd data (Thöni and Jagoutz 1993; Thöni & Miller 2000, 2003, respectively) from the UAA eclogitic complexes of Koralm and Saualm areas in Austria. Available Sm–Nd age data of garnet from metasediments (Wölz, Saualpe, Koralpe units) are restricted to a time interval, roughly between 280 and 260 Ma (Thöni & Miller 2009).

Results from the IWC units

Gabbro-dolerite dyke crosscutting the Devonian metavolcanics at Harmónia village in the Malé Karpaty Mts. Tatric basement yielded an age of 269±4 Ma (HAR-1 sample).

Rhyodacite body from the North-Veporic Permian volcano-sedimentary succession at the Bacúch village was dated at 267±2 Ma (BAC-1 sample).

Trachy-rhyolite dyke in the Permian South-Veporic siliciclastic cover from a quarry at the Burda pass, S of the Závadka n.H. village was dated at 267±2 Ma (BUR-1 sample) and 266±2 Ma (BUR-1 sample retested). The Hrončok A-type granite in the Veporic Variscan basement was dated at 267±2 Ma (HK-1 sample).

The Turčok A-type granite in the North-Gemeric basement was dated at 262±4 Ma (TU-3 sample). Specialized S-type granites from the southern part of the Gemeric basement were dated in interval from ca. 280 to 270 Ma at the locality of Rudník (276±5 Ma sample RUD-1; 277±2 Ma sample RUD-2; 271±4 Ma sample RUD-3; 269±3 Ma sample RUD-4; 281±3 Ma sample RUD-5). Granite at the Zlatá Idka village was dated to 265±2 Ma (sample ZLI-1).

The detrital zircon U–Pb SIMS Concordia ages of 247±4 Ma and 243±4 Ma from the Ladinian cherty shales of the Meliata Unit near the Jaklovce village in eastern Slovakia, and xenocryst zircon concordia age of 266±3 Ma from a 0.5m thick N-MOR basalt layer in these cherty shales, reveal a connection of the evolving oceanic basin to adjacent rifted continental margin Permian to Early/Middle Triassic zircon magmatic sources.

Remarkable are zircon rejuvenation Permian ages found from the North-Veporic Variscan (Ordovician originally) granitic orthogneisses.

Results from the Austroalpine units

The eclogitized continental crust fragments of the UAA Sieggraben structural complex contain Permian (256±3 Ma, sample GS-8) gneisseous granite veins between Gschorrholz and Steinbach in Burgenland, Austria. The underlying calc-alkaline Grobgneis meta-granite was dated at 265±2 Ma (sample GRG-1).

In contrast, characteristic Wiesmath A-type meta-granite from the LAA Wechsel complex is Ordovician (484±3 Ma, sample WTH-1 from a small quarry at the Wiesmath village). Surprising are also Triassic (246 and 240 Ma) ^{40}Ar–^{39}Ar white mica plateau ages from a granitic-pegmatitic orthogneiss of the Hochkreuz complex (Putiš et al. 2002b) in the Kreuzeck Massif S of the High Taurs (our unpublished data) which may suggest a Permian age of these pegmatite veins.

Discussion and conclusion

All these ages indicate a major Permian crust–mantle lithosphere extension, melting and overheating during the Pangea break-up and the Neotethys opening, thus tracing a period from the Permian–Early Triassic continental to the Middle Triassic Neotethys oceanic rifting stages.

The Gemeric basement in the southern part of the IWC underwent the most intensive Permian to Early Triassic extension and overheating, connected with the formation of anorogenic specialized S- and A-type granites and volcanites above the inferred Late Paleotethys subduction-related mantle plume zone ("hot lines" in Radvanec et al. 2009 and references therein). The low-grade metamorphics of the Variscan GE basement resemble the basement complexes of the Noric terrane (Frisch & Neubauer 1989; Neubauer & von Raumer 1993) exposed in the Transdanubian Range (Pelsó), Dinarides and Southern Alps, which are however dismembered between the Adria, Alcapia (ALCAPA), Tisia and Dacia Cenozoic microplates together with the Neotethys oceanic crust remnants, including the Meliata Unit. The input of 247–243 Ma old detrital zrn into the oceanic sediments of the Meliata Unit was accompanied by the Ladinian to Carnian ocean-floor N-MORB extrusions. A contemporaneous intra-shelf magmatic activity at 242–227 Ma was reported from the Southern Alps (e.g. Mundil et al. 1996) and the Transdanubian Range (Kövér et al. 2018; Dunkl et al. 2019) which still may belong to this major Permian–Triassic tectono-thermal-magmatic event.

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