Pre-Variscan metaigneous ROCKS of the Kłodzko Metamorphic Complex – a vestige of Cadomian subduction in the Central Sudetes, SW Poland

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The Kłodzko Metamorphic Complex (KMC) crops out in the Central Sudetes between the Góry Sowie Massif and the Orlica-Śnieżnik Dome. It comprises metasedimentary and various, mostly basic, metaigneous rocks and orthogneisses metamorphosed under greenschist to amphibolite facies conditions (Wojciechowska 1990; Kryza – Mazur 2001). These crystalline rocks form a NW-SE elongated outcrop (ca. 100 km^2) bounded in the south and west by the Upper Carboniferous to Lower Permian clastic sedimentary sequence of the Intra-Sudetic Basin. In the NE, the KMC is unconformably overlain by the unmetamorphosed Upper Devonian conglomerate and limestone, which form the basal part of the Bardo succession (Haydukiewicz 1990). The SE boundary of the KMC is defined by an intrusive contact with the Kłodzko-Złoty Stok granitoid of unknown, probably Early Carboniferous age.

The KMC was previously considered to represent a continuous volcano-sedimentary succession with a thickness of 1500–2000 m (Wojciechowska 1990; Narębski et al. 1988). Its age was interpreted as Silurian – Early Devonian, based on the stratigraphic record of a crystalline limestone from the lower part of the KMC. This fossil-bearing rock contains a fauna which was originally assigned to Upper Silurian (Gunia – Wojciechowska 1971), but subsequently the age was re-interpreted as Middle Devonian (Hladil et al. 1999). The upper time limit for the development of the KMC is provided by the presence of the Upper Devonian strata resting upon the eroded metamorphic series (Bederke 1924). According to Mazur – Kryza (1999), the KMC comprises a number of separate tectonic units and is built up, from base to top, by: (1) the Mały Bożków Unit comprising Givetian shelf sequence (Hladil *et al.* 1999), (2) a mélange body defining the Łączna Unit (Mazur – Kryza 1999), (3) Bierkowice Unit composed of mafic volcanics, (4) metagabbros of the Ścinawka Unit, (5) metagabbros and mafic volcanics of the Orla-Gołogłowy Unit intruded by granitoids and their subvolcanic equivalents, and accompanied by deep marine sediments, (6) distal flysch with basaltic lavas, associated with volcaniclastic sandstones and dacitic/andesitic tuffs, composing the Kłodzko-Fortress Unit. These tectonic elements, interpreted as thrust sheets, reveal contrasting metamorphic paths (Kryza – Mazur 2001) and differences in the geochemical characteristics of their metaigneous rocks, which suggest derivation from various plate tectonic settings (Kryza *et al*. 2003). Consequently, the existing stratigraphic evidence does not constrain the evolution of the whole KMC succession, but only refers to its lowermost section. Because the stack of thrust sheets can be stratigraphically inverted, new age data for the KMC turn out to be of particular importance for a correct understanding of the field relationships.

Published and new bulk compositional and Nd-isotope results show that the metabasic rocks of the NE part of the KMC (Łączna and Bierkowice Units) are of WPT-type, with εNd_{400} (assuming approximate youngest possible Silurian/Devonian age) of +6.8, typical of magmas derived from a relatively depleted mantle source. The Ścinawka, Orla-Gołogłowy and Kłodzko-Fortress Units in the SW and S part of the KMC are characterized by the association of peraluminous, calc-alkaline, felsic rocks with metagabbros and cumulates; these rocks display variable trace-element features, partly resembling N-MORB. The metagabbros of the SW part of the KMC range from slightly enriched to depleted rocks, and their εNd_{560} (assuming Neoproterozoic age) varies from +2.2 to +8.6. The intermediate and acidic rocks are peraluminous to metaluminous rhyolites, rhyodacites/dacites and andesites (and volcaniclastics), with trace-element patterns generally rather flat to slightly enriched in most-incompatible elements. Their εNd_{560} values, between +2.9 to +8.6 (mostly clustering around +5.5), within the same range as in the metagabbros, together with the lack of alkaline rocks, suggest a subduction-related environment.

Our geochronological studies focused on the two uppermost units of the KMC. Three samples (SCI, GPL and K-163) were collected from the Orla-Gołogłowy Unit and one sample (TKT) from the Kłodzko-Fortress unit. Samples SCI and K-163 represent the Ścinawka metagranite, which intruded into amphibolites; sample GPL is a plagioclase gneiss which occurs closely associated with metagabbros. Sample TKT corresponds to a rhyodacite/andesite tuff and was collected from a structural coherent layer within the volcano-sedimentary succession. Zircon measurements, based on the conventional multigrain U/Pb method, were carried out at the Universität Münster. Sample GPL yielded abundant high quality zircons. Their crystals are euhedral, transparent, colourless to light yellow, prismatic with magmatic oscillatory zoning. Four analysed zircon fractions from GPL yielded discordant results. The regression of data reveals an upper intercept age of 590 ± 10 Ma which is interpreted as the time of igneous crystallization of the protholith. Six grain-size fractions of zircon from SCI yielded discordant ages. The upper intercept age of 501 ± 6 Ma probably reflects the crystallization age of the granitic protholith for the Ścinawka gneiss. A similar age of 500 ± 5 Ma was obtained for zircons from K163, based on a 10-point isochron. The TKT sample contains a mixture of genetically different zircon grains. The youngest $^{207}Pb/^{206}Pb$ ages, which cluster at ca. 600 Ma, are interpreted to indicate the minimum depositional age of the tuffaceous component of the rock. From the position of data points on the concordia diagram it is reasonable to suggest that detrital zircons are derived from a source older than 2 Ga.

The overall geochemical variation in the KMC, combined with new age data, indicate the existence of rock assemblages representing a Pan-African active margin, juxtaposed with Palaeozoic rift volcanics and passive margin sequences. Our preliminary results indicate the presence of Proterozoic crust in the structurally higher parts of the KMC. The new data are in accord with a model that suggests a nappe structure for the KMC, with the Middle Devonian succession at the base and the Upper Proterozoic units at the top. Consequently, the KMC seems to represents a composite tectonic suture which juxtaposes elements of pre-Variscan basement against a Middle Palaeozoic passive margin succession. The latter is most likely related to the marine basin from which the Sudetic ophiolites are derived. The ages of detrital zircons from TKT indicate the incorporation of Proterozoic crust with Armorican affinities in the suture. The recognition of Neoproterozoic subduction-related magmatism provides new indications that equivalents of the Tepla-Barrandian domain are exposed in the Central Sudetes. The Neoproterozoic plutonic and volcano-sedimentary sequences in the SW part of the KMC can be interpreted, following Nance – Murphy (1996), as evidence for the subduction of an oceanic domain beneath the Gondwana active margin. In contrast, the metamorphosed volcanic and sedimentary successions of the NE part of the KMC, showing affinities to rifting and passive continental margin settings, may represent subsequent events related to the Palaeozoic break-up of Gondwana.

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