sliced into blocks, which were incorporated into the Alpine (nappe and/or terrane) complexes and subsequently uplifted to a different degree during the Alpine collisional tectonic events. This polyorogenic history makes the reconstruction of the Hercynian structures rather difficult, but provides excellent exposure of various levels of the Hercynian crust. The Hercynian granitic rocks occur in all three superunits of the CWC (the Tatricum, Veporicum and Gemericum) in various positions. In response to different geotectonic settings, different genetic types of granites were formed in the Western Carpathians over the time interval of 100 million years (360–250 Ma). Lower Carboniferous crustal thickening, Upper Carboniferous delamination, and Permian transtension resulted in S-, I- and A-type granite-forming events, respectively (Petrík and Kohút, 1997).

A reconnaissance ammonium study was carried out on 40 selected representative Hercynian granitic rocks from the Western Carpathians. Ammonium was separated by distillation, using the classical method of Urano (1971), and its contents were determined at Philips TU 8670 VIS/NIR spectrophotometer. Although ammonium content of the Western Carpathians granites is rather variable, our research confirmed the commonly accepted opinion that the content of ammonium increases from more basic to more felsic granitic rocks, with the following mean values: diorites 17.8 ± 3.8 ppm, I-type granites 25.4 ± 8.7 ppm, S-type granites 36.0 ± 17.6 ppm. Not surprisingly, muscovite-bearing leucogranites within the Western Carpathians S-type granites have the highest values of ammonium (47.2 ± 18.4 ppm). However, most of the NH_4^+ data overlap and a general dividing line between I- and S-type granitic rocks cannot be drawn. Noteworthy are the local differences within independent Core Mountains, e.g., ammonium content in granites of the Velká Fatra Mts. is generally low (11–36 ppm, aver. 19.5 ppm) but rather high in the Malé Karpaty Mts. (40–57 ppm, aver. 47.7 ppm). Interestingly, no principal differences were found between I/S type rocks albeit all ammonium values within each pluton are either low or high. Hall (1999) suggested that there is no significant correlation between NH_4^+ and any individual major and trace element, although some correlation with alumina saturation index (ASI) exists. This was fully confirmed by our research, where metaluminous granites yielded low ammonium contents and strongly peraluminous ones are dominated by higher values of NH_4^+, although an overlap within subaluminous and mildly peraluminous I/S-type granites is obvious. However, the wide variability of data can be also explained by the fact that additional ammonium was derived from the country rocks via assimilation processes.

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Oblique Collision and the Evolution of Large-Scale Transcurrent Shear Zones in the Neoproterozoic Kaoko Belt (NW Namibia)

Jiri KONOPASEK[1], Stephan KRÖNER[1], Shawn-Leslie KITT[2], Cees PASSCHIER[1], Alfred KRÖNER[1] and Karl-Heinz HOFMANN[2]

[1] Institut für Geowissenschaften – Tektonophysik, Universität Mainz, Becherweg 21, 55099 Mainz, Germany

[2] Geological Survey of Namibia, P.O. Box 2168, Windhoek, Namibia

The Kaoko orogenic belt represents a NNW–SSE-trending branch of the Damara orogenic belt system, which probably developed as a result of Neoproterozoic (ca. 550 Ma) collision between the Congo and Kalahari cratons of the present Africa, and the Rio de la Plata craton of the present South America. The most prominent structure of the Kaoko belt is the ~400 km long Puros shearzone (PSZ), which can be traced from southern Angola up to the Atlantic coast in central Namibia. In the central part of the Kaoko belt, the PSZ separates two units with distinct metamorphic and structural evolution. East of the PSZ, the tectonic evolution is characterized by medium-pressure (MP) and medium-temperature (MT) metamorphic conditions associated with the development of main metamorphic foliation. The area west of the PSZ is characterized by low-pressure (LP) and high-temperature (HT) metamorphism associated with melting, intense post-metamorphic deformation and syntectonic intrusion of granitoids.

Structural investigations west of the PSZ revealed three phases of deformation. The D1 phase is associated with the development of the westward-dipping S1 foliation, and the L_1 stretching lineation plunging in the same direction. The S_1 foliation was later refolded into km-scale F_2 folds or completely reworked into NW–SE-striking, subvertical S_2 foliation. The L_2 stretching lineation is mostly subhorizontal, suggesting transpressional regime of deformation. Intrusion of the Amspoort-type granite seems to be coeval with the D2 deformation and its solid-state deformation (D3) indicates continuous deformation during decreasing temperature.

As suggested by structural data, the early stage of tectonic evolution in the area is characterized by oblique northwestward underthrusting of the western margin of the Congo craton, resulting in its MP–MT metamorphism. On the other hand, slow oblique exhumation caused LP–HT metamorphism and partial melting of the upper plate, and resulted in its strong weakening. The development of a substantial rheological contrast prevented further underthrusting of the western margin of the Congo craton, and allowed the formation of the HT Puros shearzone as a result of localized transpressional deformation along the contact with the weak LP–HT unit. Intense deformation associated with transcurrent movement is observed in the whole LP–HT unit where the former flat-lying metamorphic foliation is almost completely reworked into subvertical fabric. This subvertical fabric was later intruded by syntectonic Amspoort-type intrusion. Late tectonic evolution of the area is characterized by localization of transpressional deformation in the Amspoort-type intrusion, probably during cooling of the whole orogenic belt. Intense low-temperature deformation of the Amspoort granite and surrounding rocks suggests that this intrusion represented weak inhomogeneity which overtook the role of the PSZ in late stages of the evolution of the Kaoko belt. We suggest that differential movements along these first-order shearzones are responsible for the final pattern of the Kaoko orogenic belt.

U-Pb Dating of Detrital Zircons by Laser Ablation ICPMS for Sedimentary Provenance Studies

Jan KOŠLER[1,2,3] and Hege Cathrine FONNELAND[2]

[1] *Ústav geochemie, Universita Karlova, Albertov 6, Praha 2, 128 43, Czech Republic*
[2] *Institutt for geovitenskap, Universitetet i Bergen, Allégaten 41, 5007 Bergen, Norge*
[3] *Department of Earth Sciences, Memorial University of Nfld, 300 Prince Philip Drive, St John's, NF A1B3X5, Canada*

Age dating of detrital zircon has proven to be a useful tool for stratigraphic correlations, identification of sediment sources and transport and depositional histories. Laser ablation ICPMS and ion probe (SIMS) have been successfully used to resolve the provenance of sediments in a variety of geological settings worldwide. Comparison of results from dating the same samples of detrital zircons by SIMS and LA-ICPMS (Košler et al. 2002) has demonstrated that both techniques are equally accurate and suitable for U-Pb dating of zircon for provenance studies. The advantages of SIMS are slightly more precise ages, less damage to samples and better spatial resolution. LA-ICPMS is the more cost-effective technique with the potential to analyse 3–5 times as many samples in a given time compared to SIMS.

Elemental fractionation of Pb and U has always been an important source of error in U-Pb dating of zircon by LA-ICPMS. There is, however, a variety of sampling techniques that suppress this fractionation, and several correction methods that can be used, resulting in accuracy and precision of age data that are sufficient for sedimentary provenance studies. They include external calibration by matrix-matched standards, use of special cell design, short ablation time (large laser pit diameter/depth ratio), laser beam rastering and mathematical methods of correction for elemental fractionation.

The laser ablation ICPMS method of age dating has been successfully applied to study the provenance of Cretaceous to Paleocene sandstones from the Norwegian Sea (Fonneland 2002). It can be demonstrated that material derived from east Greenland contains both Archean (3800–2500 Ma) and early Proterozoic rocks (ca 2000 Ma) while sediments derived from the Norwegian landmass are significantly younger (1600–1000 Ma). The changes in detrital zircon age spectra interpreted as a result of progressive change of sedimentary sources has been documented from several places in the Norwegian Sea, where it can be correlated with elevation of the Baltic margin in Coniacian to Maastrichtian times.

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