Constraints on the evolution of the Central Srednogorie Zone and formation of world class Cu-Au deposits in the Panagyurishte ore region, Bulgaria

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The Panagyurishte region, east of Sofia, is characterized by amphibolite facies metamorphic basement rocks, overlain by Carboniferous to Late Cretaceous cover sequences, which together comprise the Central Srednogorie Zone. This succession is intruded by subvolcanic Cretaceous andesites, which are part of the so-called Banatite-belt and host world-class Cu-Au-deposits, as for instance Elatsite, Chelopech, and Medet. The goal of this study is (1) to constrain the age of the tectonometamorphic evolution of the basement, (2) to identify a possible age-trend of the intrusions, and (3) to reveal possible linkages between these intrusions and adjacent major ductile shear zones within the Central Srednogorie Zone.

The amphibolite facies metamorphic basement consists of two-mica gneisses, mica schists, ortho-amphibolites, small serpentinite bodies, and anatexites. The age of the basement rocks was believed to be Proterozoic, Archean, or as a Paleozoic "Balkanide type metamorphic complex", on the basis of their field relations with the Upper Carboniferous – Permian conglomerates. Our new $^{40}Ar/^{39}Ar$ ages presented in this study reveal a contrasting tectonothermal evolution for these basement units: White mica and biotite from southern and northern sectors of the Central Srednogorie tectonic unit show well-defined Late Paleozoic plateau ages of c. 317-311 Ma, which indicate a Variscan age for the (rapid) cooling after the last amphibolite facies metamorphic overprint. Biotite from the crosscutting Poibrene diorite, records an age of 261.4 ± 2.4 Ma. During the Cretaceous, the basement was affected by retrograde greenschist facies metamorphic overprint. The latter event is restricted to southern sectors along Alpine subhorizontal shear zones close to the confining, steeply N-plunging dextral, NW-trending ductile Maritsa shear zone. Muscovite and biotite samples from several ductile shear zone yielded consistent Cretaceous $^{40}Ar/^{39}Ar$ plateau ages of c. 100-106 Ma.

$^{40}Ar/^{39}Ar$ amphibole and biotite ages of the Banatites yielded varying ages displaying that magmatism lasted over a longer period ranging from ca. 92 to 80 Ma. A clear trend in ages is documented from north to south The northernmost sample has been taken from a monzonite dyke at the Elatsite deposit, where hornblende yielded an age of 90.78 ± 0.44 Ma, and biotite 91.72 ± 0.70 Ma. Further south, biotite from an andesite exposed in the valley NE Chelopech (neck of the Vosdol volcano) records an age of 89.95 ± 0.45 Ma. From a coarse-grained granodiorite exposed in the Medet mine a hornblende age of 85.70 ± 0.35 Ma has been obtained, and an age of 80.21 ± 0.45 Ma is recorded for hornblende from an andesite lava breccia exposed in the St. Nickola hills south of Panagyurishte.

The new $^{40}Ar/^{39}Ar$ ages clearly show that the last amphibolite facies metamorphic overprint on the Srednogorie basement rocks is of Variscan age. Furthermore, the data suggest that the subhorizontal shear zones are the result of early Late Cretaceous tectonothermal activity. The steep Maritsa shear zone and its splays towards the N (e.g. Iskar-Iavoritsa fault zone, Kamenitsa-Rakovitsa, etc.) can be regarded as a Cretaceous wrench corridor which was active under greenschist facies metamorphic conditions. Greenschist facies retrogression affected the basement mainly along basement-cover (Stefanian-Permian) contacts which are strongly sheared. The steep ductile shear zones possibly weakened the crust within the Panagyurishte region, thereby enabling the intrusion of andesitic magmas, which host the Cu-Au deposits.

The Sarmatian Brackish Water Environments – Fact or Fiction?

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The Sarmatian Stage of the Central Paratethys is generally interpreted as a transition from the marine Badenian sea towards the temperate-freshwater environments of Lake Pannon. This over-simplified story spanning 1.5 million years was mainly based on the comparison of the Sarmatian mollusc assemblages with modern, hemi-marine assemblages from the Caspian Sea. Foraminiferan, bryzoan and corallinacean assemblages, characteristic for the Middle and Late Sarmatian, however, were neglected in most environmental reconstructions. To re-evaluate this interpretation of the Sarmatian more than 20 outcrops were investigated along the western margin of the Sarmatian Sea, ranging from the Molasse Basin, the Northern Vienna Basin as far south as the Western Styrian Basin.

Pelitic sedimentation predominates during the Early Sarmatian, limestones are mainly represented by reworked Badenian limestones and only rarely by autochthonous carbonate build-ups of serpulids and bryozoans. One of the typical Early Sarmatian sections - Hollabrunn in Lower Austria - represents a small and shallow embayment with a tidal environment settled by large populations of solenids. The narrow lough was probably strongly influenced by the waters of the surrounding drainage systems leading to polyhaline salinities. The occurrence of turritellids and naticids, however, excludes a drop of salinity far from polyhaline. A similar situation may be reconstructed for the fauna of Waldhof/Graz in Styria. Here the water of the Stallhofen Bay was affected by the drainage systems from the Alps whereas to the east the small sized depression was protected from the open Sarmatian Sea by the Sausal Swell, allowing the establishment of very calm conditions. The gastropod genus *Mohrensternia* flourished in these hyposaline coastal environments. After that phase, the genus vanishes nearly completely after its sudden acme. During the lower *Ervilia* Zone sedimentation switched from siliciclastic to carbonatic. This, together with the drastic increase in shell thickness of bivalves, reflects a change in mineralisation of the waterbody of the Sarmatian Sea. Higher energetic conditions along the W coast of the Paratethys led to the formation of up to 20 m of ooliths and thick coquina beds, indicating swift, agitated environments as well as carbonate-oversaturated waters. Middle to Late Sarmatian "gastropod-sediments" were formed by marine to hypersaline cerithiids. The shift from mixohaline to full marine during the Middle and Late Sarmatian is also strongly triggered by the ingression of marine waters from the Mediterranean. This ingression coincides well with the appearance of marine taxa (*Gibbula buchi*, *Jujubinus turricula*, *Pyrene agenta*) unknown from any earlier Sarmatian deposit. Correspondingly, the bryozoan-foraminiferan build-ups experience their optimum during the *Mactra* Zone, forming bioconstructions of up to 20 m width in the Eisenstadt-Sopron Basin. There is also a distinct shift in polychaete predominance observed during the Late Sarmatian (*Hydroides pectinata* prevalence in *Mohrensternia* and *Ervilia* Zones, *Janua heliciformis* dominance in *Mactra* Zone).

From these data it is obvious that the more than 100 year old interpretation of the Sarmatian Sea as a slowly freshening brackish basin has to be rejected. Hence, the Sarmatian falls apart at least into a short Early Sarmatian part with probably mixohaline conditions and a longer Middle to Late Sarmatian part with normal marine to partly hypersaline environments.

Quartärgeologie und Grundwasserreserven im Saalachtal zwischen Zeller See und Saalfelden

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Das für den inneralpinen Raum auffallend breite Tal zwischen Saalfelden im Norden und dem Zeller See im Süden verläuft senkrecht auf die dominierenden Ost – West gerichteten Strukturen des Alpenbogens im westösterreichischen Raum. Die Bildung des Tales wird als Resultat von Nord–Süd-verlaufenden Störungen interpretiert, die zu einer mehr oder weniger starken Gesteinszerrüttung geführt haben. In diesen Schwächezonen im Gesteinsverband griffen die Erosionsprozesse und vor allem der glaziale Tiefenschurf bevorzugt an, so dass sich das heutige Trogtal entwickeln konnte.

Neben der Tiefenerosion durch den Gletscher kam es aber auch zur Ablagerung von Moränen am Talboden und an den Flanken. Beim Eiszückzug entstanden kurzfristig Eisrandseen, die meist sehr rasch aufgefüllt wurden.

Nach der glazialen Ausräumung bzw. spätglazialen Wiederverfüllung lagerten die kleineren Zuflüsse aus den Seitengräben erhebliche Lockergesteinsmassen an den Grabenausgängen in Form mächtiger Schwemmkegel ab. Auch ist für die Talentwicklung wesentlich, dass der Saalach der Abfluss in Richtung Süden wahrscheinlich noch durch Eis versperrt war, so dass der Fluss vom Glemmtal kommend in Richtung Norden die Moränenhügel zwischen Bsuch und Pfaffenhofen durchschnitt.

Zur genetischen Zuordnung der Lockergesteinsablagerungen dienen allgemein im Untersuchungsraum die Komponentenzusammensetzung, während der Saalachschotter ausschliesslich aus Komponenten der Grauwackenzone besteht, ist die Zusammensetzung der fluvioglazialen und glazialen Ablagerungen weitaus bunter mit Komponenten vorwiegend zentralalpiner Herkunft (Granitgneise, Kalkglimmerschiefer etc.).

Im Bereich Kirchham/Mitterhofen-Haid wird die Morphologie durch eine flach hügelige Moränenlandschaft geprägt. Zahlreiche Vernässungen mit Hochmoorbildung zeugen stellenweise von abdichtendem Untergrund, abschnittsweise dürfte der Untergrund etwas