Metamorphism and Exhumation Processes of the Shotur Kuh Metamorphic Complex, Semnan Province (Central Iran Zone)

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The Shotur Kuh Metamorphic Complex (SKMC) represents an E-W trending elliptical tectonic window (area 20 × 11 km), exposed within Jurassic–Eocen sedimentary sequences 260 km SE of Semnan city (Semnan province, Eastern Iran). The SKMC consists of banded sequence of orthogneisses (metagranite-metatonalite) and amphibolites. U-Pb data obtained by laser ablation ICP-MS analysis of zircon yielded a Cambrian age of ca. 520 Ma, which can be interpreted as corresponding to the protolith crystallization. The absolute age of pervasive amphibolite facies metamorphism is not established yet, but an indication of pre-Jurassic age of metamorphism is indicated by the presence of pebbles of gneisses and amphibolite in Jurassic basal conglomerates. The gneisses are formed mostly by plagioclase (An_{19-30}), biotite, (X_{Mg} = 0.47 or 0.67, regarding to the whole rock composition), in some cases also garnet (Alm_{58-70}, Grs_{24-36}, Py_{2-7}, Sps_{1-5}) and accessory amounts of allanite with epidote rim. Tonalitic varieties may additionally contain amphibole. Some quartz-rich mica schists have variable amounts of muscovite. Amphibolites are mostly formed by plagioclase (An_{18-20}) and ferropargasite (X_{Mg} = 0.34, Na^{M4} = 0.3), and locally also garnet (Alm_{56-61},Grs_{30-34},Py_{3-5},Sps_{1-5}). PT conditions of 520–560 °C and 6–8 kbar have been estimated using Grt-Bt, Grt-Amph thermometry and Grt-Amph-Pl barometry, in combination with thermodynamic calculations using the PTGIBS software. The amphibolite facies metamorphism was accompanied by strong deformation (D1) that resulted in formation of isoclinal syn-schistose folding of compositional layering and strong mineral foliation bearing stretching and mineral lineation trending in the E-W direction. All rocks are affected by variable degree of retrogression, mylonitization and brittle-ductile reactivation of the early high grade fabric. This late event was synchronous with very low-grade metamorphism and deformation (D2) developed in the adjacent Jurassic meta-sediments. Kinematic indicators, mainly asymmetrical buckling and asymmetrical boudinage of cherts in weakly metamorphosed limestones and dolomites suggest a N-S compression and top to the north shearing. Foliation in the Jurassic rocks which is parallel to mylonitic shear zones affecting the gneiss and amphibolite complex dips 60° to the north along the northern margin of the SKMC. However, in the southern and central parts of the complex the greenschist facies fabrics dip under 20–40° to the south. Cretaceous age of this tectonometamorphic process is inferred from the presence of pebbles of Jurassic slates and weakly metamorphosed carbonate rocks in the Upper Cretaceous basal conglomerates. In addition, late thin skinned deformation (D3) and N-S verging folding in the Eocene sediments date the yougest tectonometamorphic process in this area. This analysis clearly demonstrate that the exhumation of the Shotur Kuh Metamorphic Complex resulted from active buckling of the basement during a N-S directed Cretaceous to Tertiary compression and de-coupled thin-skinned tectonics of the Mesozoic cover. However, the age of main metamorphic event affecting the SKMC remains yet not constrained.

Emplacement Mechanisms of the Thrust Sheets in the Barrandian (Bohemian Massif)

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The Prague Synform (Teplá–Barrandian region, Bohemian Massif), referred in old papers as a Prague Basin, represents remains of Ordovician to Middle Devonian sedimentary units folded into a large synclinorium. The term Prague Basin was a consequence of geological interpretations of the Prague Synform as a relatively small and isolated sag of synsedimentary origin. The issue of older models is broad and complicated, further details are discussed in Melichar (2004).

First of three major faults under our study was the Tachlovice Fault. This fault is at least forty kilometres in length, strikes

in WSW–ENE direction, dips in 45 ° SE and could be traced from the surroundings of Beroun through Prague to Běchovice. Our research focused on fault accompanying structures which show a kinematic pattern in strong disagreement with the old models. The opposite sense of tectonic transport along the Tachlovice Fault, top-to-the SE ("normal" faulting) was documented by small-scale structures (fault-detachment folds, small ramps, S-C structures and others). If we examine the Tachlovice Fault on the map there are visible duplications of the rocks mainly of the Silurian and upper Ordovician age. A nice example is located e.g. in the surroundings of the Tachlovice village.

The Očkov Thrust is next important fault. It is nicely exposed in the old Na Kobyle Quarry near Koněprusy where the Lochkovian rocks were thrust over the Pragian ones, with an increased tectonostratigraphically distinct gap in close neighbourhoods (Silurian rocks of the Požáry Formation above the relicts of mid-Devonian Srbsko Formation). The Očkov Thrust is about forty-five kilometres long but of varying strike due to its curved shape. A longer part of the Očkov Thrust strikes similarly as the Tachlovice Fault in WSW–ENE direction but it dips to the NW and could be traced from the surroundings of Běchovice through Prague to the surroundings of Zadní Třebaň. There the fault changes its strike into W–E, going to Koněprusy where its further continuation is unknown. Looking on the Očkov Thrust in the map there is a visible three times repeating of the Silurian and upper Ordovician formations in the vicinity of Zadní Třebaň. The Koda Fault is last of the three major faults. It is located almost in the middle of the Prague Synform striking WSW–ENE and dipping to the NW. This fault is poorly exposed in the mouth of the Loděnice Creek (Kačák) into the Berounka River. It divides facially quite different Devonian and upper Silurian rocks and three times duplicates the Silurian Kopanina and Požáry formations and the Devonian Lochkov Formation near Radotín.

The folding style is characterized by brachyal folds (with wavelength greater than hundred metres) that are all connected in major faults. Almost everywhere they have steeper south oriented limbs against to the north verging limbs. There are relatively shallow and wide synclines and steep but tight anticlines. Average axis of the folds is oriented 243 °, but the orientation of folds is slightly changing to be in similar direction as a nearby lying fault. Small folds are abundant in less competent, mostly layered rocks and are very variable in shape and orientation of axis even in the scale of one outcrop. There is a wide variety of fold shapes. We can mention e.g. tight to isoclinals folds from the Srbsko village located on the left side of the Berounka River or isoclinals folds from the Jedlička Rock near Radotín. Disharmonic folding is known from the Budňany Rock in Karlštejn, Barrande Rock in Prague or Homolka Hill near Velká Chuchle. Kink style folds are less abundant except of the thin laminated siliciclastic Devonian Srbsko Formation. The vergence of folds is oriented mainly to the SE, with the exception of rarely occurring NW verging folds situated in the frontal parts of antiforms. Folds axes calculated from 177 folds show two very close maxima – 250/9 and 238/8 respectively.

Very interesting data were obtained from small ramp-and-flat faults which are often connected with intensive folding in accompanying rocks. A nice example can be traced in the Budňany Rock, just next to the parastratotype of the Silurian/Devonian boundary. Next examples are located in the Devonian Zlíchov Formation in the Mramorka Quarry near Chýnice and on the Tachlovice Fault near Beroun in the Silurian Liteň Formation. Small fold propagation folds are found rarely. A nice example is located on the Tachlovice Fault near Beroun in the Silurian Liteň Formation. All these structures are showing everywhere top-to-the SE sense of movement.

Our arguments are supporting top-to-the SE sense of the movement in the central parts of the Prague Synform. Large folds are related to major faults (e.g. the Amerika Anticline is related to the Koda Fault, Hradinov Hill Anticline is related to the Očkov Thrust). We suppose that this is caused by changes in geometry of faults (ramps) beneath the surface. There are great stratigraphic inversions and duplications along major faults (Silurian over Devonian, upper Ordovician over Silurian).We used a stratigraphic separation diagram (SSD) to prove that the Tachlovice Fault and the Očkov Thrust are faults with a ramp and flat geometry (Melichar 2004). We have arguments in support of thrusting of shallower Silurian facies (tuffs+limestones) over the Silurian graptolitic black shales as was proposed by Bouček (1941) and confirmed by Melichar (2004). Taking in mind top-to-the SE sense of tectonics movement and accepting allochthoneity of the shallower tuffitic Silurian facies of the Liteň and Kopanina formations we can assume at least 5 km transport of these rocks.

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Reference

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