±5.1 Ma). Samples from the western part of the Desná dome (the staurolite zone), shows cooling ages on muscovites from 260 to 302 ±4.4 Ma. In the Keprník nappe (staurolite-sillimanite zone) K-Ar method yields ages on muscovites from 285 to 300 ±4.5 Ma while in the western part affected by syn-extensional magmatism the youngest age was depicted (300 ±4.5 Ma, muscovite). Micaschists from the Velké Vrbno unit provide information about the earliest increments of synconvergent exhumation (331 ± 4.5 Ma, on biotite). Samples for monazite dating cover all units of wedge and inclusions of monazite in garnet and monazites in matrix were measured separately. In the Desná dome and in the Keprník nappe, both types of monazites yield similar ages ranging 250 Ma to 297 ±30 Ma. However, the samples from the Velké Vrbno unit exhibit two generations of monazites: in the garnet porphyroblasts the average ages correspond to 340 ±30 Ma, while in the matrix average age of 302 ±30 Ma was depicted. In order to correlate the K-Ar ages with the exhumational P-T path, the conditions of trapping of fluid inclusions in quartz and quartz –andalusite bearing tensional gashes were studied. In andalusite are identified ambigeous primary inclusions, while in quartz are observed primary and secondary inclusions. Primary incluisons of quartz were trapped from a homogeneous fluid phase. Interval of trapping is 280 to 380 °C at 2–2.8 kbar and consequently the ages of exhumation 282–293 Ma determined from K-Ar dating on micas are related to this event. In conclusion, the burial of continental crust occurred around 340 Ma, followed by synconvergent exhumation at 330 Ma and the up-doming of the crustal wedge accompanied with intrusion of large scale granite and final extensional collapse at about 300 Ma.

Tectonic Position of the Latest Triassic–Jurassic Sequences of Rudabánya Hills, NE Hungary – The First Steps in a Puzzle

Szilvia KÖVÉR[1], László FODOR[2], Katalin JUDIK[3], Péter OZSVÁRT[4], Péter ÁRKAI[3], Sándor KOVÁCS[1] and György LESS[5]

[1] Geological Research Group of the Hungarian Academy of Sciences, Pázmány P. sétány 1/C, H-1117, Budapest, Hungary
[2] Hungarian Geological Institute, Stefánia út 14., H-1143, Budapest, Hungary
[3] Institute for Geochemical Research, Hungarian Academy of Sciences, Budaörsi út 45., H-1112, Budapest, Hungary
[4] Hungarian Academy of Sciences – Hungarian Natural History Museum Research Group for Paleontology, P. O. Box 137, H-1431 Budapest, Hungary
[5] Department of Geology, Miskolc University, Egyetemváros, H-8515, Miskolc, Hungary

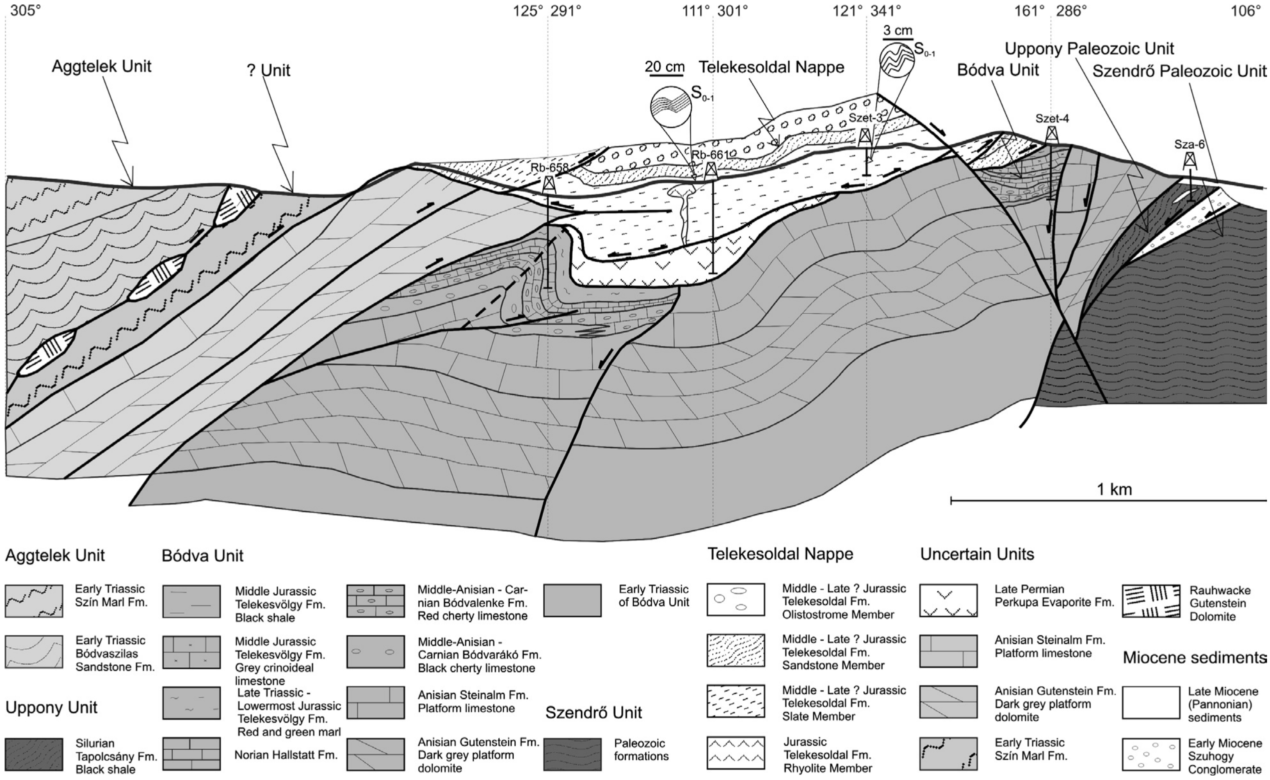
The Jurassic rocks of the Rudabánya Hills have been studied since the middle of the 19th century. However, our knowledge on their tectonic position, the number of the tectonic units, the history of their deformation, their exact age, their Triassic basement, and anyway, the correct order of the formations are not satisfying, yet. On the other hand, the Jurassic age of these formations was generally accepted only about 15 years ago, based on the works of Grill, Kozur and Dosztály.

The previous researchers divided the Jurassic rocks into two sequences by right of lithological and paleontological data (Grill and Kozur 1986, Dosztály 1994). The Telekesvölgy Formation (TV Fm.) starts with red and green clay marl, containing limestone olistholites and redeposited beds . This sub-unit likely has latest Triassic age, according to the Conodont fauna of the olistholites and redeposited limestone beds. Although the contact or transition is not clearly outcropping, the green and red marl is followed by grey crinoideal limestone and marl with no exact age, and finally, by black shale, with Bajocian – Bathonian radiolarians (Grill 1988, Dosztály 1994).

The Telekesoldal Formation (TO Fm.) contains silicified slate and marl with subvolcanic rhyolite bodies, black shale with sandstone olistholites (reinterpreted here as sandstone turbiditic layers) and a sub-unit of olistostromes with varying clast composition (limestones, rhyolite). From the sedimentary rocks, the only age we have, is Bajocian by right of the radiolarian fauna of the lowermost slate–marl member (Grill and Kozur 1986, Dosztály 1994). Radiometric age of the rhyolite was estimated with Rb/Sr (158 ±34 Ma) and K/Ar (120 ±6 Ma) methods (Grill 1988). The first method gives a wide age interval for magma intrusion; the other one may reflect the Early Cretaceous metamorphic event thus the exact formation age of the rhyolite remains poorly constrained.

In our work we made field works and measurements, thin sections, illite Kübler index measurements and radiolarian investigations, and re-examined several borehole material. The rocks of TO Fm. have a bedding-parallel foliation (S_1); in the olisthostroms foliation is connected to strong layer-perpendicular shortening (flattening of clasts). Rarely the bedding and the foliation intersect each other at an oblique angle. In this case, the foliation is an axial plane cleavage (S_2), connected to closed folds. The bedding-parallel foliation was overprinted by a folding phase, resulting in small-scale kink folds (F_3), at the transition of brittle-ductile deformation field. The effects of such ductile phases cannot be determined neither on the members of the TV Fm., nor on the Triassic rocks of Bódva series (Middle Triassic platform carbonate, red, basin facies limestones and chert from Middle Anisian to Middle Norian).

According to the radiolarian investigations, and the illite Kübler index data, measured on the rocks of TV Formation correspond to the diagenetic zone (Árkai 1982, Árkai and Kovács 1986), and contains poor Middle - Jurassic (Bajocian – Upper Bathonian) radiolarian fauna with the dominance of Nassellarians (deeper water) (Do-



■ **Fig. 1.** Geological cross section of the central part of Rudabánya Hills, NE Hungary.

sztály 1994, Ozsvárt pers. comm.). In contrast with it, the rocks of TO Formation suffered ductile deformation, in most cases show anchimetamorphic illite Kübler index values (Árkai 1982, Árkai and Kovács 1986), contains Bajocian radiolarian with the dominance of Spumellarians (shallower water) (Dosztály 1994, Ozsvárt).

We specially investigated the contact of the carbonate-dominated and clastic-dominated latest Triassic to Jurassic formations, and the relationship of the two (latest Triassic–) Jurassic formations. In some borehole (P-74, Szet-4, Rb-658) we found, that the transition between the Hallstatt Limestone of the Bódva series and the red and green marl of the TV Formation is continuous, so we have indication that the Bódva series being the original Triassic basement of the TV sequence. The illite Kübler index (IK) data, measured so far (Árkai 1982, Árkai and Kovács 1986, and this study) confirm it, because both Triassic and Jurassic sequences have only diagenetic IK values. The relation between the Bódva-type Triassic and TO Jurassic is always tectonic – both in field and boreholes – and there is a considerable difference not only in the metamorphic grade, but also in the style of deformation. So the Jurassic TO Fm. cannot be related to the Bódva-type Triassic sequence, in contrast to previous interpretation (Grill 1988, Less et al. 1988). Superposition of the two latest Triassic–Jurassic formations was in fact penetrated by the borehole Rb-658, in which the TO Fm. is in upper position. The reinterpretation of Szet-4 borehole and its surroundings suggests their superposition, too (Fig. 1.).

We suggest that the TV Formation is the original Jurassic cover of the Triassic carbonate rocks of the Bódva series. The TO Formation is supposed to be a nappe, overlying the Bódva nappe (including TV Fm.). Because the upper "Telekesoldal nappe" is very probably slightly metamorphic, this juxtaposition would only be possible after metamorphism. This overthrust supposed to be a relatively early event, and was followed by several smaller-scale thrusts. We have not direct field data on the vergence of the main nappe emplacement so far. The most frequent dip directions of the formations are W or NW, so the transport direction can be from E to W (hinterland-dipping) or from W to E (foreland-dipping). The vergence of the younger reverse faults and fault propagation fold is to E or SE. This event can be connected to the deformation of the Alsótelekes gypsum-anhydrite body, located somewhat to the S (Zelenka et al. 2005).

There are normal faults among the observed brittle structures, too. Part of them supposed to be active even in the Middle and Late Triassic, causing considerable thickness variations of basinal formations. They can be more than 100 m thick, but in some outcrop it appears only as neptunian dykes in the underlying platform limestone (Steinalm Fm.) and as a few condensed beds. Some of them are reactivated during the Miocene.

According to our investigations and geological sections constructed (Fig. 1.) so far, the following deformation phases can be detected. The first S_{0-1} foliation of the TO Fm. was most probably formed due to deep tectonic burial (e.g. thrusting) under anchimetamorphic conditions, representing the first D_1 event. The S_2 axial plane cleavage of the D_2 folding phase can be observed only in few outcrops. The last phase of ductile deformation (D_3) is represented by kink folds (F_3), can be seen in the outcrops and borehole materials of the silicified slate of TO Fm. This kind of deformation could occur at shallower crust depth, at the transition of brittle-ductile deformation field. The influence of these ductile phases cannot be observed on the rocks of Bódva series (including TV Fm.). During the D_4 deformation event the anchimetamorphic „Telekesoldal nappe" thrust over the Bódva nappe. In the D_5 phase, characterized by NW-SE compression, SE verging reverse faults and fault-propagation folds were formed (Fig. 1.). The alternating dip values measured on the rocks of Bódva series and those of TO Fm. are probably the reason of a late folding phase (F_4), characterized by open folds with long wavelength. The semi-vertical dipping of the Late Triassic basinal limestones can be formed by movements along SE verging fault-propagation folds (F_5). The ongoing NW-SE compression resulted in SE verging thrusts. Among them, an uncertain unit of Gutenstein Dolomite, Steinalm Limestone and Early Triassic marl thrust upon the Bódva Unit. During this thrust the ramp fault might have not reach the surface, but connected to roof thrust of duplexes. The juxtaposition of Aggtelek Unit and Bódva Unit can be related to this phase, but it is more likely to be an older structure. Younger transpressive strike-slip and normal fault movements (D_6–D_7), connected to Darnó Zone, juxtaposed the Mezosoic formations of Rudabánya Hills and the Paleozoic rocks of Uppony and Szendrő Hills. Parts of these movements are Tertiary in age, indicated by the involved Szuhogy Conglomerate and Pannonian sediments (Szentpétery 1997). This model can be extended to the major part of Rudabánya Hills, because it has a great similarity to the previous investigations made in other part of the Rudabánya Hills (Fodor and Koroknai 2000, Kövér et al 2005)

Acknowledgement

The study was supported by the grant OTKA 48824 (Hungarian Research Found) and the Aggtelek National Park.

References

ÁRKAI P., 1982. Report on the metamorphic petrological investigations of the Bükk and Aggtelek-Rudabánya Mts. Manuscript, Hung. Geol. Survey (in Hungarian).

ÁRKAI P. and KOVÁCS S., 1986. Diagenesis and regional metamorphism of the Mesozoic of Aggtelek-Rudabánya mountains (Northeast Hungary). *Acta Geol. Hung.* 29: 349-373.

DOSZTÁLY L., 1994. Mesosoic radiolaria investigations in NE Hungary. Manuscript, Budapest: pp. 108 (in Hungarian)

FODOR L. and KOROKNAI B., 2000. Ductile deformation and revised lithostratigraphy of the Martonyi Subunit (Torna Unit, Rudabánya Mts.), NE Hungary. *Geologica Carpathica*, 51 (6): 355-369

GRILL J., 1988. The Jurassic formations of the Rudabánya Hills. Annual report of the Hungarian Geological Institute, pp. 69-103. (in Hungarian)

GRILL J. and KOZUR H., 1986. The first evidence of the Unuma echinatus radiolarian zone in the Rudabanya Mts. (northern Hungary). *Geologisch - Palaeontologische Mitteilungen Innsbruck*, 13 (11): 239-275.

KÖVÉR Sz., FODOR L., KOVÁCS S., CSONTOS L., PÉRÓ Cs., 2005. Tectonic position of Torna s.s. and Bódva Units in the central part of Rudabánya Hills, NE Hungary. 7th Workshop on Alpine Geological Studies, Opatija, Abstracts book, In: B. TOMLJENOVIC, D. BALEN and VLAHOVIC I., Croatian Geological Society, Zagreb pp: 53-54.

LESS Gy., 2000. Polyphase evolution of the structure of the Aggtelek-Rudabánya Mountains, (NE Hungary), the southernmost element of the Inner Western Carpathians a review. *Slovak Geological Magazine*, 6: 260-268.

LESS S., GRILL J., RÓTH L., SZENTPÉTERY I., GYURICZA Gy. 1988. Geological map of the Aggtelek-Rudabánya-Mts., 1:25.000. *Hung. Geol. Inst.*, Budapest.

SZENTPÉTERY I., 1997. Sinistral lateral displacement in the Aggtelek-Rudabánya Mts. (North Hungary) based on the facies distribution of Oligocene and Lower Miocene formations. *Acta Geol. Hung*, 40: 265-272.

ZELENKA T., KALÓ J. and NÉMETH N. 2005. The structure of the gypsum-anhydrite dome at Alsótelekes. *Földtani Közlöny*, 135: 493-512.

Multiple Magmatic Fabrics in Episodically Emplaced Granites in Transtensional Setting: Tectonic Model Based on AMS Study and Numerical Modeling

Zuzana KRATINOVA[1], Karel SCHULMANN[2], Jean-Bernard EDEL[3], Urs SCHALTEGGER[4] and Josef JEZEK[5]

[1] Institute of Petrology and Structural Geology, Charles University, Prague, Czech Republic
[2] Centre de Geochimie de la Surface, EOST, Université Louis Pasteur, Strasbourg cedex, France
[3] Institut Physique du Globe, EOST, Université Louis Pasteur, Strasbourg cedex, France
[4] Département de Mineralogie, Université de Geneve, Geneve, Switzerland
[5] Institute of Applied Mathematics, Faculty of Sciences, Charles University, Prague, Czech Republic

The three successive sigmoidal sheet-like granite intrusions (Thannenkirch, Brézouard, Bilstein granites – BBT Complex) in the Central Vosges Mts. (France) separates medium to high grade (~700 to 800 °C, >9 kbar) gneiss and granulites to the north from low-pressure (~700 °C, ~4 kbar) anatectic migmatites to the south. The entirely compressional fabrics in the northern gneiss contrast with the pervasive extensional deformation in the south. This different structural record reflects the latest deformation event in the south