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Chloritoid schists from the Uppony and Szendrő Paleozoic (NE Hungary): implications for Alpine structural and metamorphic evolution

BALÁZS KOROKNAI[1], PÉTER HORVÁTH[2], TIBOR NÉMETH[2] & PÁL PELIKÁN[3]

[1]Geological Research Group, Hungarian Academy of Sciences,H-1088 Budapest, Múzeum krt 4/A.
E-mail: koroknai@iris.elte.hu
[2]Laboratory for Geochemical Research, Hungarian Academy of Sciences, H-1112 Budapest Budaörsi út 45.
E-mail: phorvath@sparc.core.hu, ntibi@sparc.core.hu
[3] Geological Institute of Hungary, H-1143 Budapest Stefánia út 14.

Abstract. Two new chloritoid schist occurrences from the low-grade Uppony and Szendrő Paleozoic (NE Hungary) will be described from mineralogical-petrological and structural points of view.

Both occcurrences consist of idiomorphic, lath-shaped, often twinned, posttectonic chloritoid porphyroblasts of 0.2–2 mm in high modal content (20–30%). Chloritoid is especially frequent in the originally more pelitic rocks, while quartz-rich lithologies contain no or much less chloritoid demonstrating the crucial importance of bulk chemistry during the formation of metamorphic minerals.

XRD investigations show that chloritoid from the Uppony Paleozoic belongs to the triclinic structure polytype. Microprobe investigations display Fe-rich composition with slightly increasing Mg/(Mg+Fe) zoning from the core towards the rims suggesting prograde metamorphic conditions during the growth of chloritoid.

Outcrop-scale and microstructural observations reveal two foliation generations in these rocks: the first one is parallel to bedding (S_{0-1}); the second foliation cuts it at high angle and forms axial plane foliation (S_2) of F_2 folds. The post-tectonic character of chloritoid with respect to S_2 foliation indicates that it was formed after the major Alpine (Cretaceous ?) folding of these Lower Paleozoic sequences.

Keywords: Chloritoid, Alpine metamorphism, deformation, Uppony and Szendrő Paleozoic, NE Hungary.

Introduction

Low-grade Paleozoic and Mesozoic sequences in NE Hungary generally lack characteristic metamorphic index minerals. Two new chloritoid schist occurrences from the Uppony resp. Szendrő Paleozoic represent exceptions that allow us to put constraints on the tectonometamorphic evolution in these units.

From the Uppony Paleozoic sequence, chloritoid was first reported by Noske-Fazekas (1973) in the Rágyincs-valley Sandstone (Ordovician-Silurian?). She argued for its detrital origin, while Árkai et al. (1981) and Ivancsics & Kisházi (1983) regarded it as newly formed, metamorphic mineral. During recent field work a new chloritoid schist occurrence was found in the classical outcrop (Rágyincs-valley) of this chloritoid-bearing metasandstone.

Chloritoid has never been described from the Szendrő Paleozoic, although previous investigations suggested even higher metamorphic conditions than in the Uppony Mts. (Árkai, 1983). Dark phyllite with light, thin metasandstone intercalations (mm-scaled) was exposed below Tertiary sediments by a water prospecting borehole at Kazincbarcika in 1999. This rock – that lithologically can be correlated with the Szendrő Phyllite Fm. (Middle Carboniferous) or eventually the Irota Fm. (Lower Devonian?) – consists of idiomorphic chloritoid also in surprisingly large quantity. Therefore, this work is a first report of chloritoid from the Szendrő Mts., at the same time.

In this contribution we will briefly characterize these two new chloritoid schist occurrences from petrographical-petrological and (micro)structural points of view.

Geological setting

The Szendrő and Uppony Mountains in NE Hungary form two smaller, pre-Tertiary basement exposures in the so-called Gemer-Bükk region which comprises the innermost tectonic units in the Western Carpathians. The known stratigraphic range of these Early Paleozoic sequences extends from the Middle Devonian to the Middle Carboniferous including mostly platform and pelagic carbonates and a flysch-like sequence (Szendrő Mts.), furthermore clastic rocks of unknown age (Ord-Sil?) and strongly altered, basic volcanics and volcano-sediments. (For a more detailed stratigraphical and lithological description see Kovács, 1992.)

Both units suffered low-grade metamorphism (Árkai, 1983) and intensive folding. K-Ar ages on illite-muscovite are mostly in the range of 130–110 Ma indicating

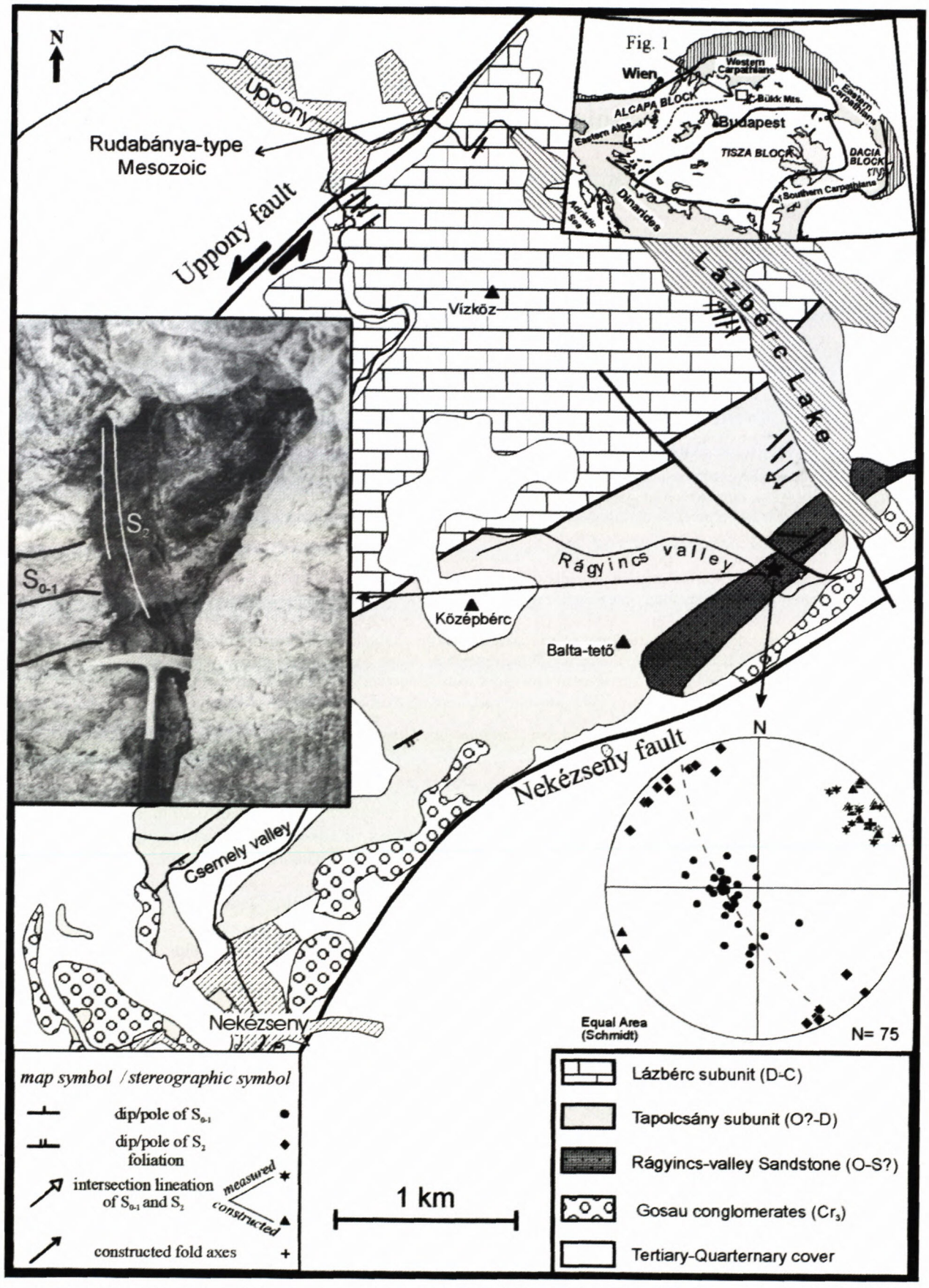


Fig. 1 Simplified geological map of the Uppony Mts. with the main bounding faults (parts of the Darnó fault zone) and subunits (modified after Kovács, 1983). The symbol „★" indicates the found locality of the chloritoid schist in the Rágyincs-valley Sandstone with its photo (S_{0-1} resp. S_2 are indicated). Stereogram shows the orientation of the different foliation-generations, furthermore measured and constructed intersection lineations, and fold axis.

Eoalpine metamorphism (Árkai et al., 1995). Until now there is no isotope geochronological evidence of a pre-Alpine metamorphic event.

The Uppony Paleozoic sequence is covered by Upper Cretaceous, Gosau-type conglomerates in the south (Clifton et al., 1985) that contains low-grade metamorphic pebbles of the Uppony Paleozoic proving its uplift and exhumation during the Late Cretaceous.

Results

Structural features

Both field observations and microstructural investigations indicate that two foliations were formed in the chloritoid schists and the surrounding rocks: the first one is parallel to bedding (S_{0-1}) developed due to deep burial (sedimentary and/or tectonic). The second foliation (S_2) cuts it at high angle (Figs. 1, 2b) resulting many times in characteristic wedge-shaped splitting of the rocks.

In the Uppony Mts. chloritoid schist forms blackish, dm-scale blocks or lenses (Fig. 1*)* that are strongly transposed into the anastoming S_2 foliation of the surrounding light-grey metasandstone. The first, subhorizontal to gently dipping foliation in the metasandstone is widely-spaced (in the range of c. 2–6 cm) and regarded to be parallel to the original bedding (S_{0-1}). The closely-spaced (mm-scale), steeply SE-dipping S_2 foliation is considered as axial plane foliation of gently NE (resp. SW) plunging folds. Constructed fold axis orientation agrees well with the observed and calculated intersection lineations (Fig. 1) assuming cylindrical fold geometry. This result is in very good accordance with the structural data of many outcrops in the Uppony Mts. (Fig. 1).

In the Szendrő Mts., the dip directions of these foliation generations could not be determined in the investigated drill core, but their presence (Fig. 2b) is also very pronounced, suggesting basically very similar deformation history. S_2 foliation is also regarded here as axial plane foliation of fold structures. This feature is very well-documented in many surface outcrops, especially in those of the Szendrő Phyllite Fm., where the relationship between the original sedimentary bedding and S_2 foliation is well-preserved despite of heavy ductile deformation.

Petrography and mineral chemistry

In microscopic scale, chloritoid forms randomly orientated porhyroblasts (0.2–2 mm) overgrowing the S_2 foliation recording its posttectonic character in both occurrences. It occurs both as single idiomorphic, lath-shaped, frequently polysynthetically twinned crystals or as rosettes (Figs. 2, 3) in a fine-grained matrix. It reaches surprisingly high modal content (approx. 20–30 %). The fine-grained matrix contains white mica, quartz and opaque minerals (pyrite, hematite), furthermore accessory zircone and tourmaline could be optically determined.

The rocks exhibit porphyro-lepidoblastic texture. On microscopic scale, the foliation is defined by the shape preferred orientation of white micas and occasionally quartz.

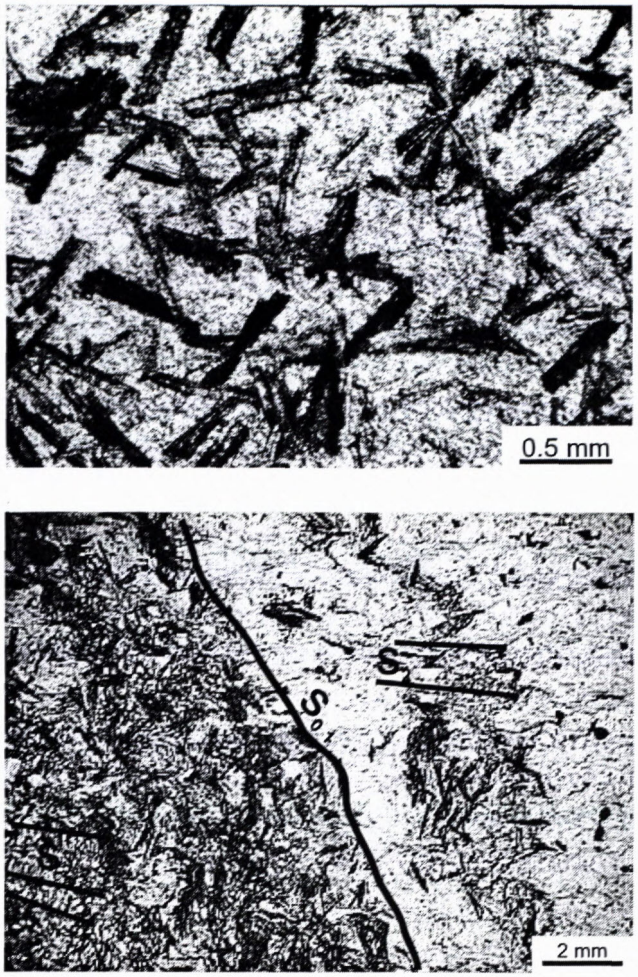
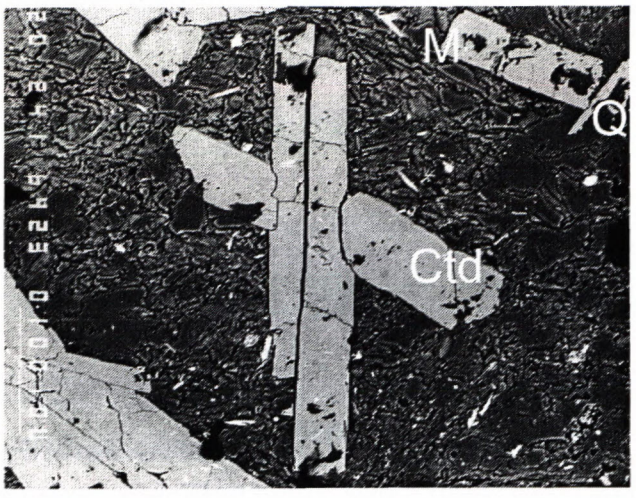


Fig. 2 Microfabrics of the chloritoid schists from the a) Uppony Mts. showing posttectonic chloritoid rosettes and single, lath-shaped grains in a fine-grained matrix. +N.
b) Szendrő Mts. with marking of the two foliation generations. Small, black neddles are chloritoid grains. Note the alternation of chloritoid-rich – originally pelitic (dark) – and chloritoid-poor – oroginally sandy (light) – layers, indicating importance of bulk chemistry during growth of chloritoid. 1N.

Semi-quantitative phase analysis of the XRD investigations (Uppony Mts.) suggests that the sample consists of quartz (c. 40–45 wt %), chloritoid (c. 20–35 wt %), 10 Ĺ phyllosilicate (sericite-muscovite, c. 10–15 wt%) and minor quantity of plagioclase (max. 5 wt%). Chloritoid belongs mainly to the triclinic polytype, however, the appearance of the peaks at 2.59A, 2.49A indicates that the monoclinic polytype can be present in subordinate quantity, too. Plagioclase reflects acidic composition. Considering the metamorphic grade of the studied rock, its composition most probably refers to albite. The subordinate presence of rutile is probable, as well.

Based on the 2.99A reflection, white mica probably belongs to the $2M_1$ polytype which is a very characteristic and frequent structure type of the higher temperature sericites (Velde, 1965). It is noteworthy that chlorite is not present in the assemblage although it appears in many of the surrounding rocks in both units.

Microprobe investigations reveal that analysed chloritoids are Fe-rich, with slightly increasing Mg/(Mg+Fe^{2+}) ratio from the core to the rim of the grains (Fig. 3a, b).



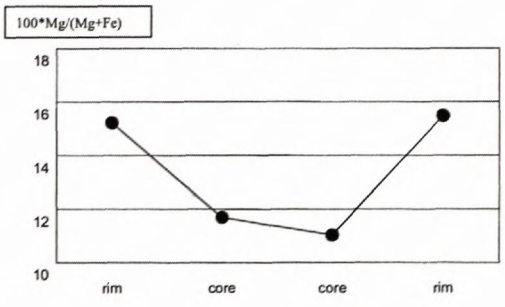


Fig. 3 a) BSE image of penetrating chloritoid (Ctd) twins (Uppony Mts.). (Qtz = quartz; M = mica; tiny, bright grains = opaque minerals) b) Zoning profile of a chloritoid grain with increasing Mg/(Mg+Fe^{2+}) ratio from the core towards the rims.

Conclusions

1. Outcrope-scale and microstructural observations record that the investigated rocks experienced essentially the same ductile deformation sequence: formation of bedding-parallel, first foliation (S_{0-1}) was followed by intense folding associated with a closely-spaced, axial plane foliation (S_2). The age of folding and accompanying low-grade metamorphism is inferred to be Cretaceous on the basis of geochronological data (Árkai et al., 1995) and microfabric studies.

2. Since post-tectonic growth (with respect to S_2 foliation) of chloritoid is probably roughly synchronous with the thermal climax of the Alpine (Cretaceous) metamorphism, it means that the major folding of the Szendrő and Uppony Paleozoic sequences must have occurred *before* peak metamorphic conditions were reached.

3. XRD investigation shows that chloritoid belongs to the triclinic polytype. This agrees well with the general observation that this structure polytype occurs predominantly in (very) low-grade metamorphic rocks. Zoning profiles with increasing Mg/(Mg+Fe^{2+}) ratio from core to rims of chloritoid crystals suggest prograde metamorphic conditions during its growth.

4. Crucial importance of bulk chemistry on metamorphic mineral growth is also emphasized by this study: originally sandy, quartz-rich lithologies contain no or only very few, generally badly-developed, skeletal chloritoid crystals reflecting its relatively Al-poor bulk chemistry, while Al-rich bulk chemistry of the more pelitic precursor made possible the formation of idiomorphic grains in large quantity.

5. The detailed petrographic-petrological investigations on the chloritoid schists from the Uppony and Szendrő Paleozoic clearly prove the metamorphic origin of chloritoid in accordance with the conclusions of Árkai et al. (1981) and Ivancsics & Kisházi (1983), but contradict to the former idea of Noske-Fazekas (1973).

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