

## The Zasadne Section of the Magura Nappe (Western Outer Carpathians, Poland) and its relation to the Rhenodanubian Flysch (Eastern Alps, Austria)

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*Upper Cretaceous  
Flysch  
Biostratigraphy  
Sedimentology  
Paleogeography*

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### Das Zasadne-Profil der Magura-Decke (Westliche Äußere Karpaten, Polen) und seine Beziehungen zum Rhenodanubischen Flysch (Ostalpen, Österreich)

#### Zusammenfassung

Aus der Bystrica-Teildecke der Magura-Decke wird ein oberkretazisches Flyschprofil beschrieben, das bemerkenswerte facielle Ähnlichkeiten zu altersgleichen Profilen aus dem Rhenodanubischen Flysch der Ostalpen zeigt. Von besonderem Interesse ist das Auftreten einer 100m mächtigen Abfolge von campanian Helminthoideen-Flysch (Haluszowa-Formation), die im Liegenden und Hangenden von bunten tonsteinreichen Abfolgen begleitet wird. Das Ende des Profils bildet der dickbankige Szczawina-Sandstein aus dem Maastricht. Die Fazies und stratigraphischen Einstufungen der Formationen dieses Profils sind vergleichbar mit jenen der Seisenburg-Formation, der Zementmergelserie, der Perneck-Formation und der Altengbach-Formation im Rhenodanubischen Flysch. Die stratigraphischen und lithologischen Übereinstimmungen beider Profile sind ein weiterer Hinweis darauf, daß die Magura-Decke die östliche Fortsetzung des Rhenodanubischen Flysches ist.

#### Abstract

From the Bystrica Subunit of the Magura Nappe a flysch section of Upper Cretaceous age is described which shows remarkable similarities in facies to coeval sections of the Rhenodanubian flysch of the Eastern Alps. Particularly interesting is the occurrence of a 100 m thick sequence of Helminthoid flysch (Haluszowa Formation) of Campanian age which is sandwiched between variegated shales. The younger shales are overlain by the coarse-grained Szczawina Sandstone of Maastrichtian age. The facies and stratigraphic position of the formations of this section are equivalent to the Seisenburg Formation, the Zementmergelserie, the Perneck Formation and Altengbach Formation of the Rhenodanubian Flysch. The striking stratigraphical and lithological correspondence of both sections support the assumption that the Magura nappe is the eastward continuation of the Rhenodanubian Flysch.

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## 1. Introduction

The Alpine Flysch Zone is separated from the Carpathian flyschzone by the Miocene pull-apart structure of the Vienna Basin. Across this large area without any flysch outcrops it is very difficult to carry out unequivocal correlations of flysch units. For such correlations it is essential to find marker formations which occur in the Alpine as well as in the Carpathian flysch.

In the Upper Cretaceous of the South-Penninic flysch deposits of the Eastern and Western Alps (e. g. CARON et al., 1981) Helminthoid-flysch presents a distinct facies-type, which is essentially composed of lime-mud turbidites which alternate with thin, predominantly greenish claystone layers. These hemipelagic claystones indicate deposition below carbonate compensation depth (CCD). By contrast, the source area of the turbidites must have been located above CCD. Their low content of terrigenous material and the absence of shallow water debris point to coeval existing intrabasinal elevations and slopes where pelagic carbonate mud accumulated. Thus, basin topography seems to be an important factor for the development of Helminthoid flysch, which got its name due to a characteristic ichnofacies with common grazing traces such as *Helminthoida* (= *Nereites*) and *Phycosiphon*.

In contrast to the ubiquitous occurrence of Helminthoid-flysch in the Alps, no equivalents of this facies were known to date from the Carpathian Flysch Zone. It was known only from isolated tectonic slices within the Grajcerek group of the Pieniny Klippen belt (Haluszowa Formation, BIRKENMAYER 1977). Recently within the frame of the Szczawa tectonic window (Fig. 1) Helminthoid facies were discovered in exposures along a small stream in the southwestern part of the village of Zasadne where the Haluszowa Formation is in stratigraphic contact with other formations. These outcrops belong to the Magura nappe which is the biggest and innermost unit of the Western Outer (=Northern) Carpathians in Poland. It is suggested that the Magura nappe is the continuation of the Rhenodanubian Flysch of the Eastern Alps (e.g. ELIAS et al., 1990; SCHNABEL, 1992) where Helminthoid flysch is known as the "Zementmergelserie". Our paper presents the first stratigraphical and sedimentological data from the Zasadne-section which give additional evidence for a palinspastic correlation of the Magura Nappe with the Rhenodanubian flysch.

## 2. Lithology and stratigraphy of the Zasadne section

The section forms the hangingwall of an internal overthrust within the Bystrica Subunit of the Magura Nappe. In this lower part of the section (Fig. 2), red shales of the Malinowa Formation are exposed. They attain a thickness of approximately 40 m and display an increasing number of intercalated thin-bedded siltstones towards their top. In the classification scheme of PICKERING et al. (1986) the rocks of the Malinowa Formation can be attributed to facies E1.2 (varicoloured muds without sedimentary structures), facies E2.1 (graded muds) and in the upper part to facies D2.3 (thin silt laminae in mud). These facies are interpreted as hemipelagites and low-concentration turbidites. According to MALATA & OSZCZYPKO (1990) the foraminiferal assemblages of the Malinowa Formation consist exclusively of agglutinated benthic taxa. The common appearance of *Uvigerinammina jankoi* MAJZON and the absence of *Hormosina ovulum gigantea* GEROCH indicate an age from Late Turonian to Santonian. In the uppermost part of the Malinowa Formation red marly shales contain badly preserved and poor calcareous nannoplankton assemblages. The most important species for biostratigraphic zonation is *Lucianorhabdus cayeuxii* DEFLANDRE which proves an age of Late Santonian for the top of the formation (nannozone CC16 after SISSINGH, 1977).

The Malinowa Formation is overlain by the 100m thick Haluszowa Formation which is characterized by the predominance of thin layers (up to 10 cm) of graded calcareous marls. Occasionally, these marls display calcareous greywackes with incomplete BOUMA sequences (Tbc, Tc) at their base. Very rare complete BOUMA sequences were observed. In the lower part of the Haluszowa Formation the hemipelagic intervals ( $T_e$ ) are formed of red shales, in the upper part the proportion of green shales is gradually increasing. According to the classification of PICKERING et al. (1986) the Haluszowa Formation represents predominantly facies C2.3 (thin-bedded sand-mudstone couplets) and facies D2.1 (graded stratified siltstones) which are both interpreted as deposits from low-concentration turbidity currents. Flute casts indicate paleoflow directions from SE to NW. The heavy mineral assemblages of the greywacke-beds (two samples) are composed of tourmaline (28 %), zircon (24 %), apatite (21 %), rutile (15 %) and garnet (12 %). In comparison to samples from the coeval Zementmergelserie of the Rhenodanubian Flysch the high contents of biotite and chlorite are remarkable.

The shales in the lower part of Malinowa Formation already contain common *Hormosina ovulum gigantea* GEROCH and *Rzehakina inclusa* (GRZYBOWSKI) indicating Campanian age. Calcareous nannoplankton assemblages from the turbiditic marls are badly preserved and poor. *Aspidolithus parcus* was observed 20 m below the top of the formation which proves Campanian age (nannozone CC 18). At the very top of the Haluszowa Formation marly brownish-red shales appear. Besides *Aspidolithus parcus* (STRADNER) they contain *Ceratolithoides aculeus* (STRADNER), *Reinhardtites anthophorus* (DEFLANDRE) and *Eiffellithus eximus* (STOVER) as biostratigraphic important species. This nannoflora is indicative

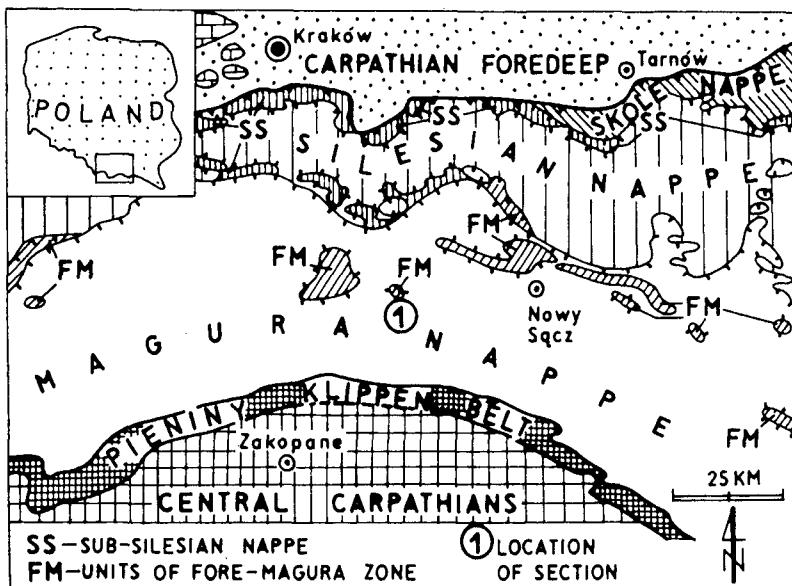


Fig. 1.  
Location of the studied section.

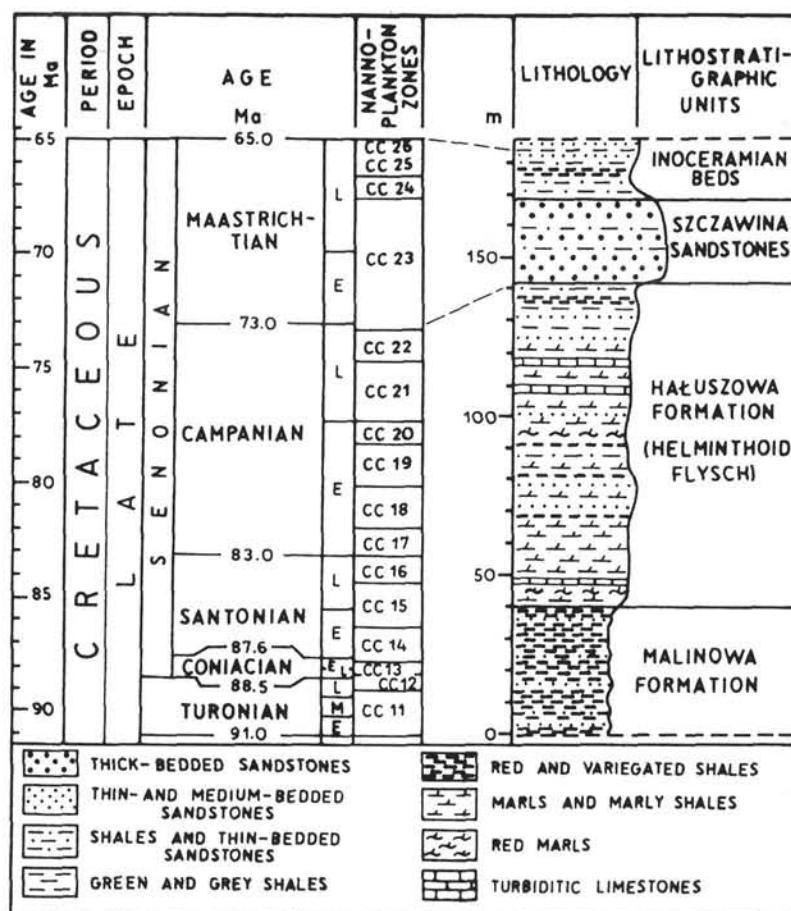


Fig. 2.

Stratigraphic position of the Helminthoid flysch (Haluszowa Formation) within the Upper Cretaceous deposits of the Magura nappe, Bystrica subunit.

for the middle to upper Campanian (nannozone CC20 or younger). The following trace fossils were described by UCHMAN (1991) from the Zasadne-section: *Helminthoida labyrinthica* HEER (= *Nereites irregularis* (SCHAFFHAUTL)), *Chondrites intricatus* (BROGANIART), *Chondrites affinis* (BROGANIART), *Sabularia simplex* (KSIĄZKIEWICZ), *Planolites ichnosp.*, *Phycosiphon ichnosp.*. This facies (=Nereites facies) occurs mainly in deep-sea environments (UCHMAN, 1992), whereas *Planolites* lived in the uppermost part of Te, *Phycosiphon* and *Nereites* inhabited the upper part of Td and *Chondrites* penetrated also the dee-per part of Td.

The red-brownish shales at the top of the Haluszowa Formation are overlain by the siliciclastic Szczawina Sandstone which therefore should be Upper Campanian and Maastrichtian in age. Usually the coarse-grained beds display complete BOUMA sequences and occasionally they even show massive nongraded intervals at their basal parts. In the classification scheme of PICKERING et al. (1986) these rocks belong to facies C2.1 (thick-bedded sandstone-mudstone couplets) and C2.2 (medium-bedded sandstone-mudstone couplets) which are assigned to high-concentration turbidity currents. Flute casts are common and again indicate paleoflow directions from SE to NW. The heavy mineral assemblages are composed of garnet (24 %) and apatite (23 %), zircon (21 %), tourmaline (19 %) and rutile (12 %). In comparison to the samples of the Haluszowa Formation the higher content of garnet is remarkable which is probably a consequence of the coarser grainsizes of the Szczawina

sandstone. The heavy mineral data from the Haluszowa Formation and from the Szczawina Sandstone fit well into the Magura IVc group of WINKLER & SLACZKA (1992, 376). These authors suggest two major source terrains for the West Carpathian flysch sediments depending on the presence or absence of staurolite. Material devoid of staurolite is derived from an area in the south of the Magura basin which is in accordance with our observations.

### 3. Discussion

Within an extensive flysch basin, long-range correlations of lithostratigraphic units are difficult to assess if there are no continuous exposures. Generally, the tools for establishing such correlations are biostratigraphic age determinations and comparisons of flysch facies and sediment petrography, especially of the composition of heavy mineral assemblages. It is unlikely, however, that the composition and topography of the source areas were uniform along their whole extension. For example, the Upper Cretaceous of the Rhenodanubian Flysch displays remarkable amounts of carbonate whereas the coeval sediments of the Magura flysch are often devoid of carbonate. This is probably an effect of a change of basin morphology and not an argument for two separated basins. Consequently, petrographic composition of rocks is of minor value for long distance correlations. Flysch facies can change quickly at the same stratigraphic level as a

consequence of different depositional environments. However, facies can also reflect global events such as eustatic sea level changes and climatic changes or regional tectonic events which can affect the entire orogen. In both cases facies changes may appear coeval in a vast area with different sedimentary basins.

Summarizing these facts, we can conclude that different facies and different petrographic compositions of two formations at the same stratigraphic level do not necessarily mean, that these formations originate from two different basins. On the other hand, it will be very difficult if not impossible to find arguments that they were deposited in the same basin. The only argument for such an assumption is the complete or almost complete conformity of two sections.

The lithological and stratigraphical characteristics of the Zasadne section show close similarities to the section of the Rhenodanubian Flysch between Salzburg and Vienna. The Malinowa Formation seems to be an equivalent of the Seisenburg Formation which displays several meters of red shales at its base and an increasing number of interbedded siltstone turbidites in its upper part. The age of the top of the Seisenburg Formation is determined as oldest Campanian (EGGER, 1993). The Seisenburg Formation is overlain by the Helminthoid-flysch of the Zementmergelserie which toward the north (Salzburg facies, EGGER 1992) in its younger part is interfingering with varicoloured shales of the Perneck Formation. The latter is Upper Campanian in age and is overlain by coarse-grained arenitic sandstones (Roßgraben

Member – EGGER, 1995) of the Altengbach Formation. The striking stratigraphical and lithological correspondence of both sections support the assumption that the Magura nappe is the eastward continuation of the Rhenodanubian Flysch.

Differences occur in the composition of heavy mineral assemblages and in the patterns of paleoflow directions. The heavy mineral assemblages of the Roßgraben Member are highly dominated by garnet (usually more than 70 %) and always contain a significant portion of staurolite. The source area of the terrigenous material is assumed to have been a middle grade metamorphic terrain north of the flysch basin. This is consistent with the results of WINKLER & SLACZKA (1992) concerning the position of the source areas of the Carpathian flysch where staurolite-bearing assemblages are derived from the north as well. However, paleoflow-directions and heavy mineral assemblages of the Szcza-wina sandstone indicate a sediment supply from the south. Hence, the correlation of Szcza-wina Sandstone and Altengbach Formation is not straightforward. Additionally, the heavy mineral assemblages of the Haluszowa Formation show high values of biotite and chlorite which are not known to that extent from the Zement-mergelserie. In the latter the pattern of paleoflow directions is predominantly from west to east, whereas the flute casts of the Haluszowa Formation indicate transport directions from southeast to northwest. In the Rhenodanubian Flysch similar directions are only known from the Kahlenberg Formation (MÜLLER 1987, 154). This formation is a time equivalent of the Zementmergelserie consisting of calcareous turbidites, however, without the typical marls of this unit. Nevertheless, Kahlenberg Formation is a clear indication for carbonate producing areas east of the Alpine flysch. Most heavy mineral assemblages from the Kahlenberg Formation are dominated by garnet, only individual samples show prevailing zircon depending on grain sorting effects. A high content of apatite (up to 15 %) is noteworthy, which is similar to that of the Haluszowa Formation.

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## References

- BIRKENMAYER, K. (1977): Jurassic and Cretaceous lithostratigraphic units of the Pieniny Klippen Belt, Carpathians, Poland. – *Studia Geol. Pol.*, **45**, 1–158, Warsaw.
- CARON, C., HESSE, R., KERCKHOVE, E., HOMEWOOD, P., STUIJVENBERG, J., TASSE, N. & WINKLER, W. (1981): Comparaison préliminaire des flyschs à Helminthoides sur trois transversales des Alpes. – *Eclogae geol. Helv.*, **74**, 369–378, Basel.
- EGGER, H. (1992): Zur Geodynamik und Paläogeographie des Rhenodanubischen Flysches (Neokom – Eozän) der Ostalpen. – *Z. dt. geol. Ges.*, **143**, 51–65, Hannover.
- EGGER, H. (1993): Zur Nannoplankton Stratigraphie der Seisenburger Schichten (?Coniac-frühes Campan) in der Rhenodanubischen Flyschzone (Ostalpen) östlich des Inn. – *Zitteliana*, **20**, 59–65, Munich.
- EGGER, H. (1995): Die Lithostratigraphie der Altengbach-Formation und der Anthering-Formation im Rhenodanubischen Flysch (Ostalpen, Penninikum). – *N. Jb. Geol. Paläont. Abh.*, **196**, 69–91, Stuttgart.
- ELIAS, M., SCHNABEL, W. & STRANIK, Z. (1990): Comparison of the Flysch Zone of the Eastern Alps and the Western Carpathians. In: MINARIKOVA, D. & LOBITZER, H. (Eds.): Thirty years of geological co-operation between Austria and Czechoslovakia, 37–46, Prague (Geol. Survey).
- MALATA, E. & OSZCZYRKO, N. (1990): Deep water agglutinated foraminifera assemblages from Upper Cretaceous red shales of the Magura Nappe/Polish Outer Carpathians. – In: HEMLEBEN, C. et al. (Eds.): Paleoecology, Biostratigraphy, Paleoceanography and Taxonomy of Agglutinated Foraminifera. – NATO ASI Ser. C, **327**, 507–521, Dordrecht.
- MÜLLER, A. (1987): Zur Lithofazies und Stratigraphie der Kahlenberger Schichten der Flyschzone des Wienerwaldes. – Unpubl. thesis univ. Vienna, 195p., Vienna.
- PICKERING, K., STOW, D., WATSON, M. & HISCOCK, R. (1986): Deep water facies, processes and models: a review and classification scheme for modern and ancient sediments. – *Earth Sci. Rev.*, **23**, 75–174, Amsterdam.
- SCHNABEL, W. (1992): New data on the Flysch Zone of the Eastern Alps in the Austrian sector and new aspect concerning the transition to the Flysch Zone of the Carpathians. – *Cret. Res.*, **13**, 405–419, Amsterdam.
- UCHMAN, A. (1992): An opportunistic trace fossil assemblage from the flysch of the inoceramian beds (Campanian – Paleocene), Bystrica Zone, of the Magura Nappe, Carpathians, Poland. – *Cret. Res.*, **13**, 539–547, Amsterdam.
- SISSINGH, W. (1977): Biostratigraphy of Cretaceous calcareous nanoplankton. – *Geol. Mijnbouw*, **56**, 37–65, Dordrecht.
- WINKLER, W. & SLACZKA, A. (1992): Sediment dispersal and provenance in the Silesian, Dukla and Magura flysch nappes (Outer Carpathians, Poland). – *Geol. Rdsch.*, **81**, 371–382, Stuttgart.