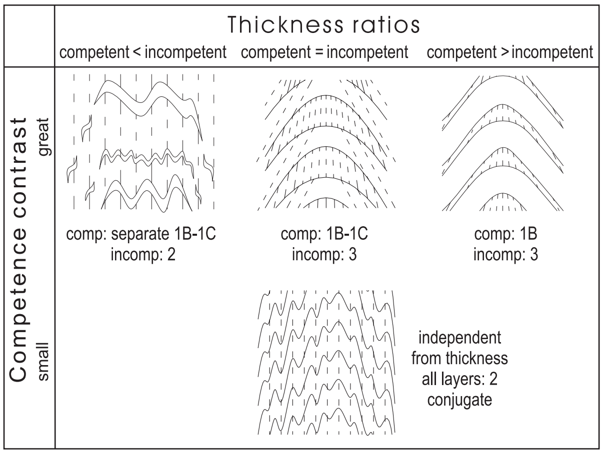

Fig. 1. Typical multilayer fold geometries with given thickness ratios and competence contrast. Dashed lines indicate cleavage.

the hinges and simple shear on the limbs. The multilayer fold geometry depends on the thickness ratio and the competence contrast between the layers as shown in fig. 1. In other cases, the small-scale folding is absent and the deformation patterns correspond to the flexural slip model; this style can also characterize folds of later deformation events. There are such outcrops too, where the layers were folded passively in similar folds with sharp hinges, according to the passive shear model.

In a considerable part of the limestones no folds are observable on the outcrop scale due to the lack of bedding or other foliations predating the early phase deformation. However, other deformation structures, such as cleavage and lineations developed in them like in other bedded successions. So it seems very likely that they have been sheared strongly on limbs of large-scale folds, but these folds are not mappable because the later (mainly brittle) deformations have divided them up.

The occurrence of different textural patterns is influenced partly by the same factors as the macroscopic style. Additionally, the predeformational grain size plays an important role. The main deformation mechanism in the fine-grained matrix was the pressure solution which resulted in a shape preferred orientation. Conversely, the crystal aggregates of more than 20-30 µm grain size show signs of dynamical recrystallization which leads in some cases as far as to the development of milonitic texture and strong lattice preferred orientation. The intensity of the deformation depends also on the position inside a fold: it is relatively weak in the hinge zones and strong on the limbs.

The spatial style differences of the same rock types provide a base to define tectofacial units in the eastern part of the Bükk Mts. The borderlines of these units are zones of large-scale movements (strike-slip faulting) developed during later deformation phases.

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Position of the Marmarosh Flysch (Eastern Carpathians) and its Relation to Magura Nappe (Western Carpathians)

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The Magura nappe is the innermost tectonic unit of the Western Carpathians and is linked with the Rheno-Danubian flysch of the Eastern Alps. Towards the east this unit runs as an arc from the Wienerwald (Austria) through Moravia (Czechia) and Poland, then narrows in Eastern Slovakia before disappearing beneath the Miocene volcanic rocks east of Uzhhorod (Trans-Carpathian Ukraine). The oldest Jurassic-Lower Cretaceous rocks are known from the peri-Pieniny Klippen Belt (PKB) in Poland and a few localities in Southern Moravia. The youngest (Early Miocene) deposits of the Magura Nappe are known from Poland. The Magura Nappe is separated from PKB by a sub-vertical Miocene strike-slip boundary, and is flatly thrust at least 50 km towards the north over its foreland. The Magura Nappe is subdivided into four structural subunits: Krynica, Bystrica, Rača and Siary. These subunits coincide, to a large extent, with the corresponding facies zone.

In the Ukrainian Carpathians, SE of the Latorica River, the position of the Magura Nappe is occupied by the Marmarosh Flysch Zone (Smirnov, 1973). This zone is bound from the NE by the Marmarosh Klippens and further to SE by the Marmarosh Massif, which are thrust over the Lower Cretaceous flysch by the Rakhiv and Porkulets units. The two facies-tectonic units have been distinguished in the Marmarosh Flysch Zone – the external Vezhany and the internal Monastyrets' units (Smirnov, 1973). The basal part of the Vezhany succesion is built up of olistostrome, up to 500–600 m thick and composed of blocks and klippens of Mesozoic carbonates, serpentinites, basic volcanites, granitoides and metamorphic rock. The olistostroma is followed by a 500 m thick sequence of Albian-Cenomanian basinal turbidites (Soimul Fm.), 100 m of Cenomanian-Turonian, Puchov type pelagic red marls and 50 m of the Maastrychtian – thin-bedded flysch with intercalations of red shales (Dabagyan et al., 1989).

The Upper part of the sequence, 200–300 m thick, is composed of dark shaley flysch and thick-bedded sandstones from the Metovo beds and finally overlapped by black marls and shales of the Luh beds (Smirnov, 1973). In the Terebla River section we found Eocene and Oligocene (Rupelian) calcareous nanoplankton in the Metovo and Luh beds, respectively. The Oligocene deposits in this section resemble Grybów/ Dusyno bituminous marls known from the Fore-Magura units in Poland and Ukraine. In our opinion the Vezhany succession could be regarded as the equivalent of the Fore-Magura thrust sheet in the Żywiec area of Poland. The Monastyrets Unit is composed of Coniacian-Early Santonian calcareous flysch with intercalations of red shales (Kalyna beds, Vialov et al., 1988) and followed by thin-bedded flysch and variegated shales from the Shopurka (Sushmanets) beds (Lower-Middle Eocene) and thick-bedded Drahovo sandstones (Middle-Upper Eocene). The Monastyrets succession, up to 2000 m thick (Smirnov, 1973) resembles the Rača development of the Magura Nappe in Poland and Slovakia (see also Żytko, 1999). The Monatyrets Unit makes contact along sub-vertical fault with the PKB. On Romanian territory the equivalents of the Monastyrets Unit are known as the Leordina and Petrova nappes. These units composed of the Maastrichtian-Chattian deposits are regarded as the prolongation of the Magura Nappe (Sandulescu, 1988, Aroldi, 2001). South of the Bohdan Woda fault this unit passes into the Wild Flysch Nappe. Between Botiza and the Wild Flysch nappe, the Poiana Botizei Klippens (Middle Jurassic-Oligocene) are edged. These klippens are regarded as the SE termination of the PKB (Aroldi (2001) or as the intra-Magura (like Hluk Klippe in Moravia) klippens (Bombita et al., 1992). The Magura Nappe and Marmarosh Flysch revealed not only the same geotectonic position but also a similar diachronic distribution of Eocene/ Oligocene facies in the basins. It makes possibly to regard some similarities between the Marmarosh Massif and buried Silesian Ridge (see Sandulescu, 1988, Oszczypko, 1992).

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Position of the Late Cretaceous – Palaeocene Source Areas of the Magura Basin – Evidence from Heavy Mineral Study

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The Late Cretaceous-Palaeocene deposits of the Magura Nappe in Poland are surrounded by the Hulina spotty marls (Albian-Cenomanian) at the base and variegated shales of the Łabowa Fm. (Early Eocene) at the top. The basal portion of the Upper Creteceous sequence is represented by variegated shales of the Malinowa Fm. Their upper boundary is diachronous – older in the Rača zone (Santonian) and younger in the Krynica zone (Campanian/ Maastrichtian). The variegated shales are followed by the Senonian-Palaeocene flysch deposits traditionally referred as the Inoceramian Beds. These deposits, 200–400 m thick, could be divided into several divisions: Kanina, Jaworzynka and Ropianka (Mutne) beds in the Rača zone, and Kanina, Szczawina Sandstones and Ropianka beds in the Bystrica zone. These deposits display paleocurrent directions from the NW and SE in the Rača and Bystrica zones respectively (see Książkiewicz (Ed), 1962). On the contrary, the variegated shales in the Krynica zone are overlapped by the Jarmuta (Maastrichtian/Palaeocene) and Szczawnica (Palaeocene/Lower Eocene) formations supplied from the south-eastern direction.

Heavy mineral assemblages occurring in these sediments are dominated by stable and ultrastable minerals. They are zircon, tourmaline and rutile, which are present in all the studied samples in various amounts. For heavy fractions of deposits deriving from NW great amounts of garnets are characteristic. In some samples of heavy fractions of the Jarmuta and Szczawnica fms considerable amounts of garnets are also occur. In the sediments deriving from the SE direction, except Szczawina Sds, significant amounts of chromian spinels have been counted. They comprise up to 13 % (in the Szczawnica Fm.) of the studied heavy mineral assemblages (Salata, 2002).

Analyses of chemical composition of the listed mineral groups displayed that tourmalines represent schorl-dravite series, deriving mostly from metamorphic rocks and in minor amounts from igneous rocks of granitoide type. In garnets composition the amount of Almandine end-member dominates over Pyrope, Grossularite, Spessartine and Andradite. Chemistry of these minerals indicated that they crystallized under low to medium grade metamorphic conditions. Therefore their pa-