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An Oligocene olistostrome with exotic clasts in the Silesian Nappe (Outer Ukrainian Carpathians, Uzh River Basin)

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In the Ukrainian part of the Silesian Nappe (Outer Carpathians, Uzh River Basin) the exotic clast-bearing Uzhok Olistostrome (up to 60 m thick) occurs within the Oligocene Krosno Formation and underlies the Pikui Sandstone (Otryt Sandstone in Poland). The Uzhok Olistostrome consists of debris/grain/mud flow deposits with clasts of schist and bioclastic limestone. These deposits contain redeposited pelagic sediments with planktonic foraminifers including *Parogloborotalia pseudocontinuosa* (Jenkins), *Ciperoella ciperoensis* (Bolli), *Globoturborotalita woodi* (Jenkins), *Chiloguembelina adriatica* Premec Fucek, Hernitz Kucenjak and Huber. The age of the Uzhok Olistostrome based on planktonic foraminifers correlates with the middle Oligocene within the middle O2–O5 zones. The source area for the Uzhok Olistostrome and Pikui Sandstone was a mid-Oligocene intrabasinal palaeouplift (the Pikui Ridge) interpreted as the fore-bulge located in the Silesian Sub-basin ahead the emerging Outer Carpathian accretionary prism (including the Dukla Nappe and other West Carpathian inner flysch nappes).

Key words: Ukrainian Carpathians, Silesian Nappe, Oligocene, olistostrome, foraminifers, biostratigraphy, palaeogeography.

INTRODUCTION

The Outer Carpathians consist of Upper Jurassic–Miocene deposits (mainly turbidites) locally containing olistostrome strata with exotic clasts and olistoliths of metamorphic, magmatic and sedimentary rocks that are the remnants of now-buried source areas. Exotic material was derived from the buried basin margins and intrabasinal uplifts (ridges) located in the Outer Carpathian sedimentary realm. Such material is an important source of information about the palaeogeography and geodynamic evolution of the Carpathians (e.g., Cieszkowski et al., 2009, 2012; Gawęda et al., 2019, 2021; Kowal-Kasprzyk et al., 2021 and references therein).

In the Ukrainian Carpathians, olistostrome deposits with exotics have been described in the Miocene molasse of the frontal Outer Carpathian Boryslav-Pokuttya Nappe (Kulchytskyi, 1977; Hnylko, 2014 with references therein), in the Cretaceous deposits of the Marmarosh Klippen Zone (Kruglov, 1965, 1986; Hnylko et al., 2015) and in the Oligocene flysch of the Silesian Nappe (Lozyniak and Temnyuk, 1971; Kulchytskyi, 1977). Small exotic debris is scattered throughout the Outer Ukrainian Carpathian flysch mass in many places (Tsar, 2018 with references therein).

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Olistostrome sedimentary lenses developed among the Oligocene deposits of the Silesian Nappe and located near the village of Uzhok in the Uzh River Basin are one of the most prominent exotics-bearing strata of the Outer Ukrainian Carpathians. They are made up of debris/grain-flow deposits containing clasts and olistoliths of exotic schist, bioclastic and micritic limestone as well as fragments of redeposited rock. In addition, these strata are enriched with micro- and macrofauna (unlike the surrounding flysch rocks depleted in fauna), which have long attracted the interest of Carpathian researchers (Table 1). These deposits (together with the surrounding strata) were first attributed to the "Sandstone from Uzhok" by Paul (1870) and subsequently to the "Uzhok Beds" by Temnyuk (1958). They have also been termed the "Uzhok faunistic horizon" (Danysh and Sovchik,1965), "horizon with fauna" or "horizon with debris and fauna" (Lozyniak and Temnyuk, 1971; Danysh, 1973; Kulchytskyi, 1977). It has been assumed (Danysh, 1973) that this "horizon" is an analogue of the "Bukowiec Horizon" described (Ślączka, 1961 with references therein) in the Polish Carpathians; as a result, this "horizon" was also marked by the same name of "Bukowiec Horizon" (Vialov et al., 1981) and "Bukowiec Olistostrome" (Hnylko, 2011a) in the Ukrainian Carpathians. In this article we use the name "Uzhok Olistostrome".

The Uzhok Olistostrome continues as sedimentary lenses to the north in the San River Basin (Polish Carpathians), where it was called the "Bukowiec Horizon" in the village of Bukowiec (Ślączka, 1961 and references therein). Ślączka (1961) first described the "Bukowiec Horizon" as a submarine slump containing a large bioclastic limestone block and pebbles of schist. In

Table 1

Historical overview of Uzhok Olistostrome studies

Author(s)	Remarks	Age significance of exotics-bearing strata in corresponding work
Vacek (1881)	Discovered fossiliferous strata in the upper reaches of the Uzh River and identified a mollusc fauna in a bioclastic limestone block located to the southeast of the Kinchyk Bukovskyi Mt. (Riszkania locality) on a mountain ridge between the Uzh and San River basins.	Oligocene based on mollusc fauna.
Wójcik (1905)	Found foraminifers, molluscs and brachiopods at the Riszkania locality and attributed this fauna to the Early Oligocene.	Early Oligocene based on benthic foraminifers, molluscs and brachiopods.
Andrusov and Hynie (1930)	Mapped the upper reaches of the Uzh River.	
Horusitzky and Wein (1939)	Published a detailed geological map of the upper reaches of the Uzh River and depicted the Uzhok Olistostrome as a narrow stongly compressed tectonic sheet.	
Temnyuk (1958)	Noted that exotics-bearing strata lie under the Holovets Limestone (Jasło Limestone in Poland, see Ciurej and Haczewski, 2012).	Early Oligocene based on molluscs which are similar in species composition to fossils in the Lattorfian sandstones of Northern Germany.
Zernetsky and Makarenko (1961)	Noted the presence of exotic limestone clasts containing Eocene nummulitids and suspected that these limestones may have been redeposited near the coastline.	Eocene based on mollusc fauna.
Maksimov (1959), Maksimov and Reifman (1963)	Believed that the mollusc fauna is located *in situ* in calcareous grey mudstone layers alternating with non-calcareous black mudstone layers exposed near Uzhok.	Early Oligocene based on mollusc fauna.
Dabagyan (1961)	Studied small foraminifers from the same rocks of the Uzhok Olistostrome, from which Maksimov (1959) studied molluscs. Assemblages of benthic foraminifers contain both Eocene and Early Oligocene species. Only one planktonic species, *Globigerina officinalis* Subbotina, has been found.	Boundary interval between the Eocene and Oligocene based on small foraminifera.
Danysh and Sovchyk (1965)	Assigned the deposits hosting the Uzhok Olistostrome to the Eocene.	Eocene on the basis of nummulitids (apparently redeposited into the Oligocene deposits).
Danysh (1973)	Studied the geological structure and mapped the area of the Uzh River Basin.	Boundary interval between Eocene and Oligocene based on small foraminifera (preliminary study).
Lozyniak and Temnyuk (1971), Smirnov (1975) and Kulchytskyi (1977)	Attributed the exotics-bearing "horizon with fauna" near Uzhok to submarine slump deposits. "Horizon with fauna" is located in Oligocene Krosno-like flysch, and the Eocene fauna is not in original position.	
Gruzman and Smirnov (1982, 1985)	Studied the stratigraphic distribution of the olistostromes in the Krosno Fm in both the Eastern and Western Carpathians.	
Gruzman and Smirnov (1985)	Assigned the "horizon with fauna" near Uzhok to upper part of the Krosno Fm., Early Miocene, though with no faunal evidence.	
Shakin (1976); Glushchenko et al. (1980); Kuzovenko (2003); Shlapinskyi et al. (2019)	Outlined the exotics-bearing "horizon with fauna" near Uzhok as part of a large olistostrome distributed among the Oligocene flysch.	
Jankowski et al. (2004)	Depicted chaotic complexes (olistostrome, melanges and broken formations) located ahead of the Dukla Nappe, though only schematically.	

Poland this horizon has been studied by many researchers (see Ślączka and Wieser, 1962; Mochnacka and Tokarski, 1972; Tokarski, 1975; Bąk et al., 2001; Ziemianin and Wolska, 2014; Haczewski et al., 2016a, b and references therein).

Thus, the geological setting, stratigraphic position and age of the exotics-bearing olistostrome located near the village of Uzhok remain debatable and not entirely clear (Table 1). Previous researchers noted finds of macrofauna and benthic foraminifers in these strata, while only one planktonic species *Globigerina officinalis* Subbotina was found here (Dabagyan, 1961). In this study we clarify the geological structure of the Silesian Nappe in front of the Dukla Nappe in the Uzh River Basin and detail the geologic/stratigraphic position and the age of the exotics-bearing Uzhok Olistostrome. Some of our mapping of this area has been published earlier (Hnylko, 2000; Hnylko and Hnylko, 2019). In order to determine the age, we analyzed planktonic foraminifers found mainly in the matrix of the olistostrome as well as in the deposits underlying and overlying the olistostrome.

GEOLOGICAL BACKGROUND

The Outer Carpathians are made up of a stack of the nappes thrusted over each other towards the north-east on the Miocene Carpathian Foredeep. The Outer Carpathian nappes consist of allochthonous Jurassic–Neogene, mainly flysch, rocks uprooted from their original position. The main nappes each have their own lithostratigraphy and tectonic structure and therefore are often considered as structural-facies units derived from different sub-basins separated by intrabasinal uplifts. The Outer Carpathians are described as a Cretaceous–Neogene

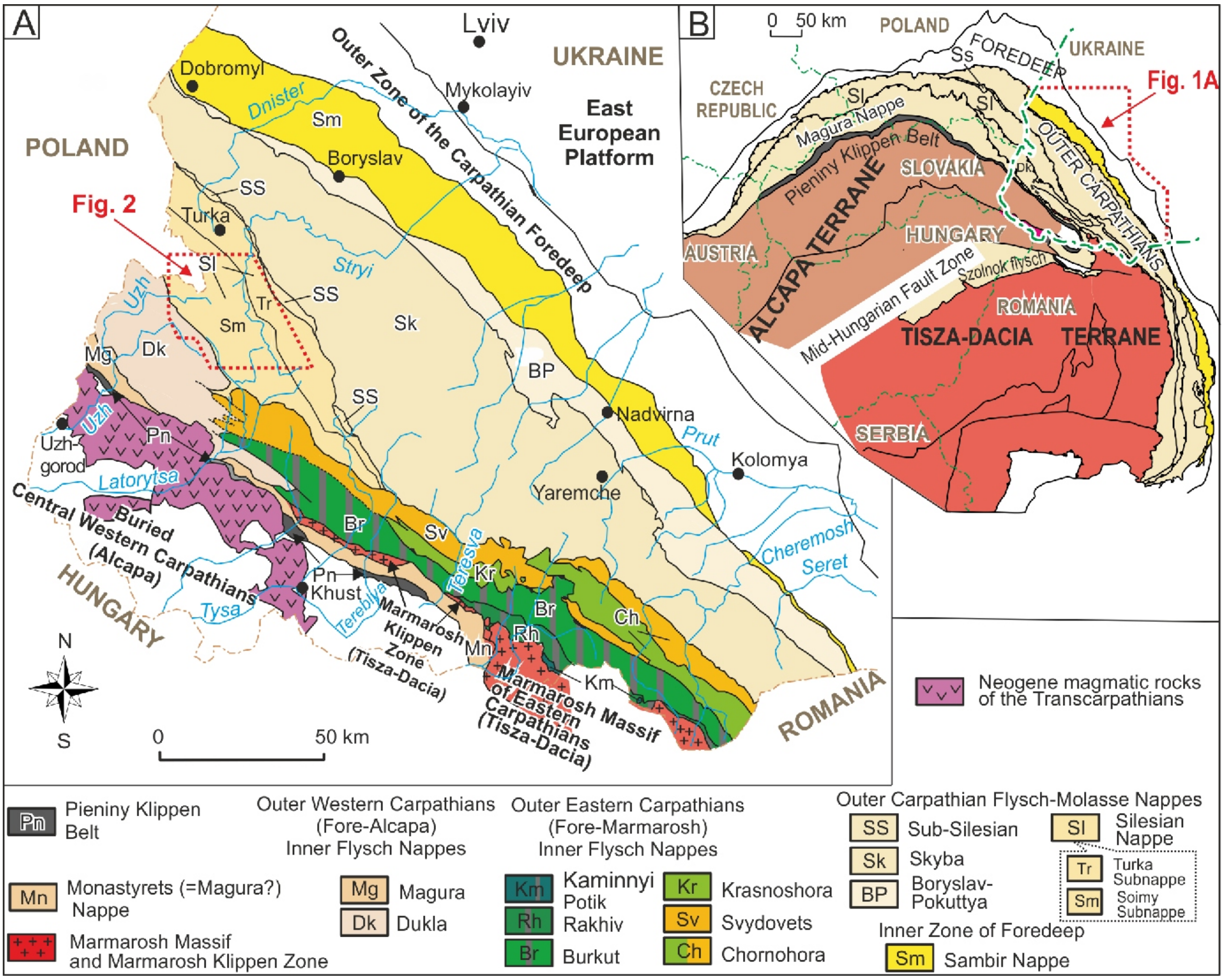

Fig. 1A – main tectonic units of the Ukrainian Carpathians (after Hnylko, 2012, 2017, 2019, modified); B – tectonic setting of the Ukrainian Carpathians, position of the terranes and main geological boundaries (after Csontos and Vörös, 2004; Kováč et al., 2016, 2017; Schmid et al., 2020: simplified, partly modified)

accretionary prism formed as a result of subduction of the Carpathian sedimentary flysch basin beneath the Alcapa and Tisza-Dacia (micro)continental terranes, which are now located in the Central Carpathians. The remnant Carpathian flysch basin was situated between the Eurasian passive margin and the active edges of these terranes (Csontos and Vörös, 2004; Golonka et al., 2006, 2019; Horvath and Galacz, 2006; Oszczypko, 2006; Golonka, 2011; Hnylko, 2011b, 2012; Kováč et al., 2016, 2017; Schmid et al., 2020; Fig. 1).

In Ukraine, the two nappe systems (accretionary palaeoprisms) located in the Outer Western Carpathians and Outer Eastern Carpathians adjoin "laterally" (Horvath and Galacz, 2006; Hnylko, 2011b, 2012). The first system, represented by the Outer Western Carpathian Inner Flysch nappes (Fore-Alcapa inner accretionary prism: Magura and Dukla nappes), was built in the foreland of the Alcapa Terrane during the Paleogene. The second one, comprising the Outer Eastern Carpathian Inner Flysch nappes (Fore-Marmarosh inner prism: Kamyanyi Potik, Rakhiv, Burkut, Krasnoshora, Svydovets and Chornohora nappes), was formed in front of the Tisza-Dacia Terrane during the Cretaceous–Paleogene. The nature of conjunction and boundaries of these inner palaeoprisms are still not quite clear (see Hnylko, 2012, 2017 and references therein). The Outer Carpathian Silesian, Sub-Silesian, Skyba, and Boryslav-Pokuttya flysch-molasse nappes were incorporated within amalgamated inner accretionary prisms, and were developed as the outer part of the newly formed combined accretionary prism ahead of both the Alcapa and Tisza-Dacia conjugate terrains. Finally, the combined prism was thrusted onto the Carpathian Foredeep in the Miocene (Hnylko, 2012, 2014; Fig. 1).

The Silesian Nappe (Unit) is located between the more external Sub-Silesian and Skyba nappes and the more internal Dukla Nappe. The stratigraphic succession of the Silesian Nappe in Ukraine includes Lower Cretaceous and Paleocene–Lower Miocene flysch deposits. Oligocene–Miocene deposits are widespread and pre-Oligocene strata are exposed locally (Vialov et al., 1981; Hnylko and Hnylko, 2019; see Fig. 2). Lower Cretaceous rocks (Shypot Fm.) are exposed in only one location outside of the study area in the Vicha River basin near Volovets. Upper Cretaceous deposits in the Ukrainian segment of the Silesian Nappe are not well-constrained.

Typical pre-Oligocene deposits are composed mainly of Eocene black shales (the Soimy Fm.) and developed in the central parts of the Silesian Nappe (Fig. 2). The top part of the Soimy Fm. contains the Globigerina Marl (up to a few metres of

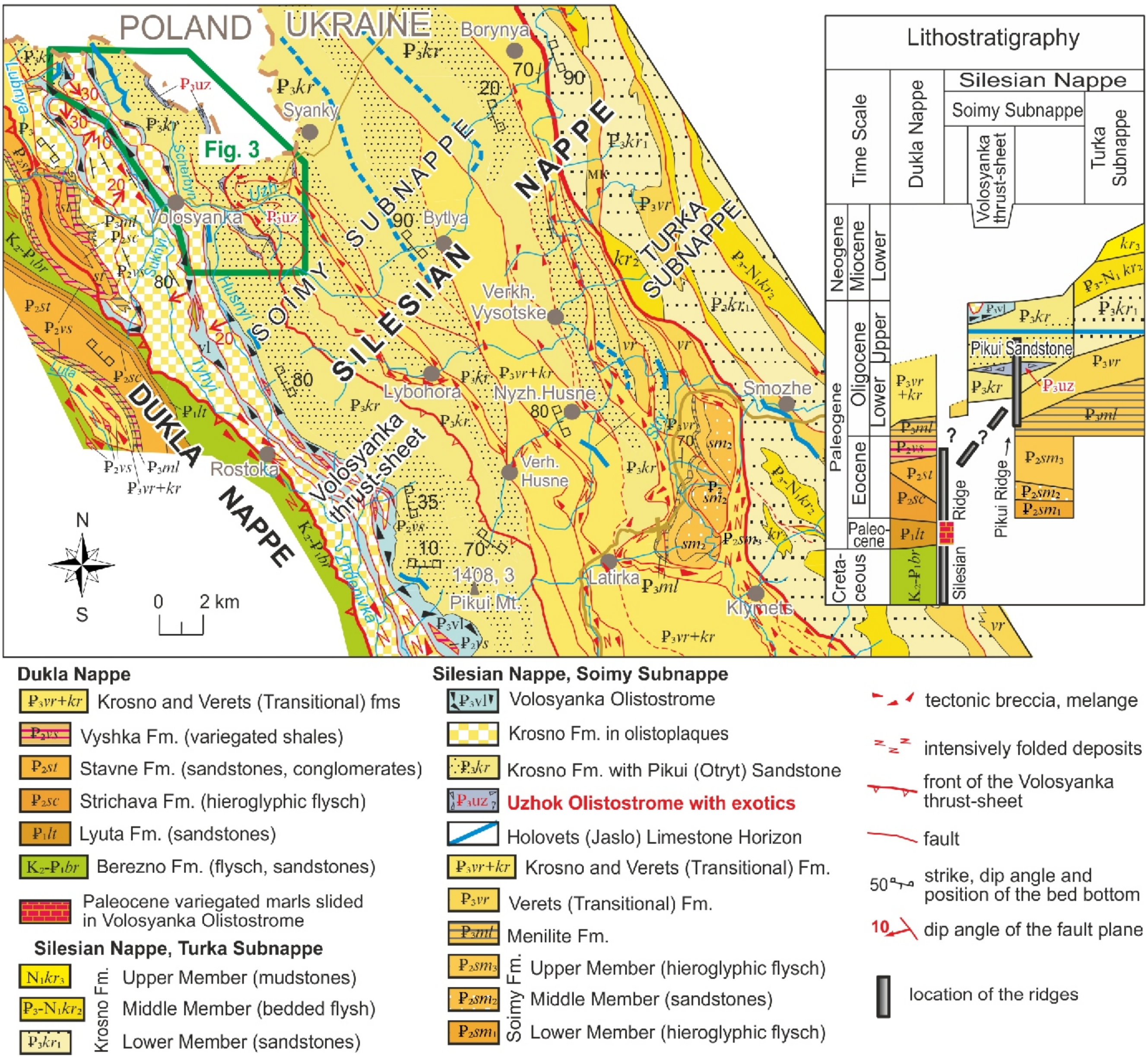

Fig. 2. Geological map of the Ukrainian part of the Silesian Nappe near the Polish-Ukrainian boundary and position of the area studied

Compiled on the basis of mapping by Hnylko and Vashchenko (partly published: Hnylko, 2000), and earlier maps (Danysh, 1973; Shakin,1976; Kuzovenko, 2003; Jankowski et al., 2004)

thickness) which is regionally distributed in the Carpathian region. In Ukraine, these (hemi)pelagic marls were named as the Sheshory Horizon (Vialov, 1988 and references therein). Paleocene–Eocene variegated shales are exposed in the frontal part of the Silesian Nappe in places, although these variegated shales may belong to the Sub-Silesian Nappe (Hnylko and Hnylko, 2019 with references therein).

The Silesian Nappe is subdivided into the outer (northern) Turka Subnappe and inner (southern) Soimy (Bitlia) Subnappe (Vialov et al., 1981). These subnappes are characterized by different Oligocene–Miocene sedimentary successions and tectonic styles.

In the Turka Subnappe, the Oligocene–Miocene stratigraphic succession is represented by the Menilite Fm. (black shales), the Verets Fm. (transitional from the Menilite to Krosno formations) and the Krosno Fm. (grey flysch). The Krosno Fm. is subdivided into the Lower (sandstone), Middle (medium-bedded flysch) and Upper (mudstone and thin-bedded flysch) members (Vialov et al., 1981, 1988, with references therein). The Holovets Limestone (Jasło Limestones in Poland; Ciurej and Haczewski, 2012 and references therein) is located in the top of the Verets Fm. or in the bottom of the Krosno Fm.

In the Soimy Subnappe, the Oligocene stratigraphic succession (Miocene is not proven here) also contain the Menilite, Verets and Krosno formations. The Krosno Fm. is subdivided here into lower, middle and upper members by O. Hnylko (in the present study). However, these three members are significantly different in age and composition from the Lower, Middle and Upper members of the Krosno Fm. recognized in the Turka Subnappe. The lower and upper members consist of thin-bedded flysch-like deposits, and the middle member, containing the Pikui Sandstone, continues into the adjacent Polish territory (Hnylko, 2000), where it is known as the Otryt Sandstone (Bąk et al., 2001 and references therein). The Pikui Sandstone is characteristic of the Soimy sedimentary succession and lies stratigraphically below the Holovets Limestone according to our mapping (Fig. 2). This sandstone unit was depicted stratigraphically above the Holovets Limestone in previous geological maps (Shakin, 1976; Kuzovenko, 2003).

The Volosyanka Olistostrome overlaps the Krosno Formation and completes the Soimy sedimentary succession in the Uzh River Basin. It includes large flysch olistoliths and does not contain exotic metamorphic rocks (Hnylko, 2000, 2011a; Hnylko and Hnylko, 2019).

As mentioned above, the stratigraphic position of the exotics-bearing Uzhok Olistostrome as well as the geological structure of the area of its distribution in the Uzh River Basin are controversial (Lozyniak and Temnyuk, 1971; Danysh, 1973; Shakin, 1976; Kulchytskyi, 1977; Glushchenko et al., 1980; Kuzovenko, 2003; Shlapinskyi et al., 2019). The geological characteristics and lithostratigraphy of this area are given below, according to the lead author's geological mapping (published partly in Hnylko, 2000).

Continuation of the Uzhok Olistostrome to the south-west beyond the Uzh River Basin is possible. Paul and Tietze (1879), Vacek (1881), Wójcik (1905), Danysh (1973), Kulchytskyi (1977) and Glushchenko et al. (1980) pointed the presence of strata with molluscs and exotics in the Verhni Vorota area (Latorytsia River Basin, located south-east of the Uzh River Basin). However, we did not find these strata while mapping, probably due to poor exposure.

The Uzhok Olistostrome continues to the north in the San River Basin (Polish Carpathians) where, as noted above, its probable analogue is known as the "Bukowiec Horizon" (Ślączka, 1961, 2005). Farther north and north-west, Oligocene deposits with exotics have been described in the Silesian Nappe of the Polish Carpathians (Ślączka and Wieser, 1962; Mochnacka and Tokarski, 1972; Tokarski, 1975; Bąk et al., 2001; Ziemianin and Wolska, 2014 with references therein). The position of this olistostrome in the Upper San drainage basin was illustrated in two sheets of the Detailed Geological Map of Poland at 1: 50,000 scale (Ustrzyki Górne Sheet and Dźwiniacz Górny Sheet: Haczewski et al., 2016a, b, 2017a, b).

MATERIALS AND METHODS

Geological mapping at 1:25,000 scale, and sedimentological and tectonic documentation of the upper part of the Uzh River Basin was carried out by O. Hnylko during fieldwork in 1999–2000 (Fig. 3). Detailed field mapping identified localities with olistostromes and large olistoliths. Particular attention was paid to the study of the exposed contact between the turbidite-type strata and the olistostrome bodies. In 2019, the section along the Little Polonynka Stream (lower reaches) as well as individual exposures along the Little Polonyka Streem (upper reaches) section and the Husnyi Streem section were investigated by S. Hnylko, L. Generalova and M. Tsar.

Micropalaeontological studies were carried out on 27 400-g-samples collected during 1999–2000 and 2019 (Fig. 3). Processing of the samples was performed in the micropalaeontological laboratory of the Institute of Geology and Geochemistry of Combustible Minerals of the National Academy of Science of Ukraine, Lviv. Planktonic and small benthic foraminifers, and small (0.3–2 mm) molluscs and ostracods occurred in the samples. In addition, visible macroscopic remnants of gastropods, brachiopods, and other broken shells can be seen in the limestone clasts of the Uzhok Olistostrome. In this study we analyzed only the planktonic foraminifers.

Planktonic foraminifers found in 15 samples were analyzed by S. Hnylko. A significant number of specimens cannot be determined due to heavy pyritization and/or deformation of the tests. A total of 17 species of planktonic foraminifer were identified in the samples studied. Specimens identified are both non-pyritized (intervals C and E) and pyritized to varying degrees (intervals A, B and D and individual exposures). In some only the inner part of tests is pyritized. In exotics-bearing deposits of the Silesian Nappe in the Outer Polish Carpathians, pyritized planktonic and benthic foraminifers are considered as autochthonous (Bąk et al., 2001). Therefore, this assumption may be true for the Uzhok Olistostrome and the pyritized foraminifers from the intervals A, B, D and individual exposures are autochthonous or retransported from more shallow parts of the same basin. However, in the intervals C and E, non-pyritized Oligocene foraminifers have well-preserved fragile white tests indicating their deposition *in situ*. We consider these planktonic foraminifers to be autochthonous here.

Preliminary petrographic study of the exotic rocks was carried out in several thin-sections by M.Tsar.

LITHOSTRATIGRAPHY

The study area is located in the southwestern part of the Ukrainian Silesian Nappe (Soimy Subnappe) in the upper part of the Uzh River Basin (Fig. 3) and is bounded to the south-west by the Dukla Nappe. Several thrust-sheets are mapped here. The Volosyanka thrust-sheet is the largest one, and contains a synclinal fold. The syncline limbs are filled with the Oligocene Krosno Fm., and the syncline core is composed of the Volosyanka Olistostrome. This olistostrome contains large olistoliths (including olistoplaques) filled with Cretaceous–Oligocene flysch similar to the flysch of the Dukla Nappe (Hnylko, 2000; Hnylko and Hnylko, 2019).

The Volosyanka thrust-sheet is thrusted onto several small tectonic sheets developed in the Uzhok Pass area. These sheets comprise Oligocene Krosno deposits locally strongly deformed to tectonic melange.

Comparison of the compiled geological maps (Figs. 2 and 3) with geological maps of the adjacent Polish Carpathians (Ustrzyki Górne Sheet and Dźwiniacz Górny Sheet: Haczewski et al., 2016a, b, 2017a, b) suggests that the Volosyanka thrust-sheet is not a continuation of the Fore-Dukla Zone (*sensu* Świdziński, 1953) located in adjacent Polish territory. The Volosyanka thrust-sheet continues westwards into the Otryt part of the Silesian Unit, while the Fore-Dukla Zone continues into Ukrainian territory in the Lubnya Stream, where it forms a thin tectonic thrust-sheet directly in front of the Dukla Nappe. The Lubnya thrust-sheet probably ends near the Uzh River. The Volosyanka Olistostrome filling the syncline core into the Volosyanka thrust-sheet wedges out westwards due to the uplift of this syncline near the Ukrainian-Polish border.

In the upper part of the Uzh River Basin, the Silesian Nappe (Soimy Subnappe) is composed of the Oligocene Krosno Fm. subdivided into three members overlapped by the Volosyanka Olistostrome. These deposits are best represented in the Volosynka thrust-sheet and exposed along the Uzh River and its tributaries (Figs. 3 and 4).

The Lower member of the Krosno Fm. (up to 400 m thick) is developed in the frontal part of the Volosynka thrust-sheet; its lower surface is cut by faults. It begins the Silesian sedimentary succession and is represented by mainly thin-bedded alternat-

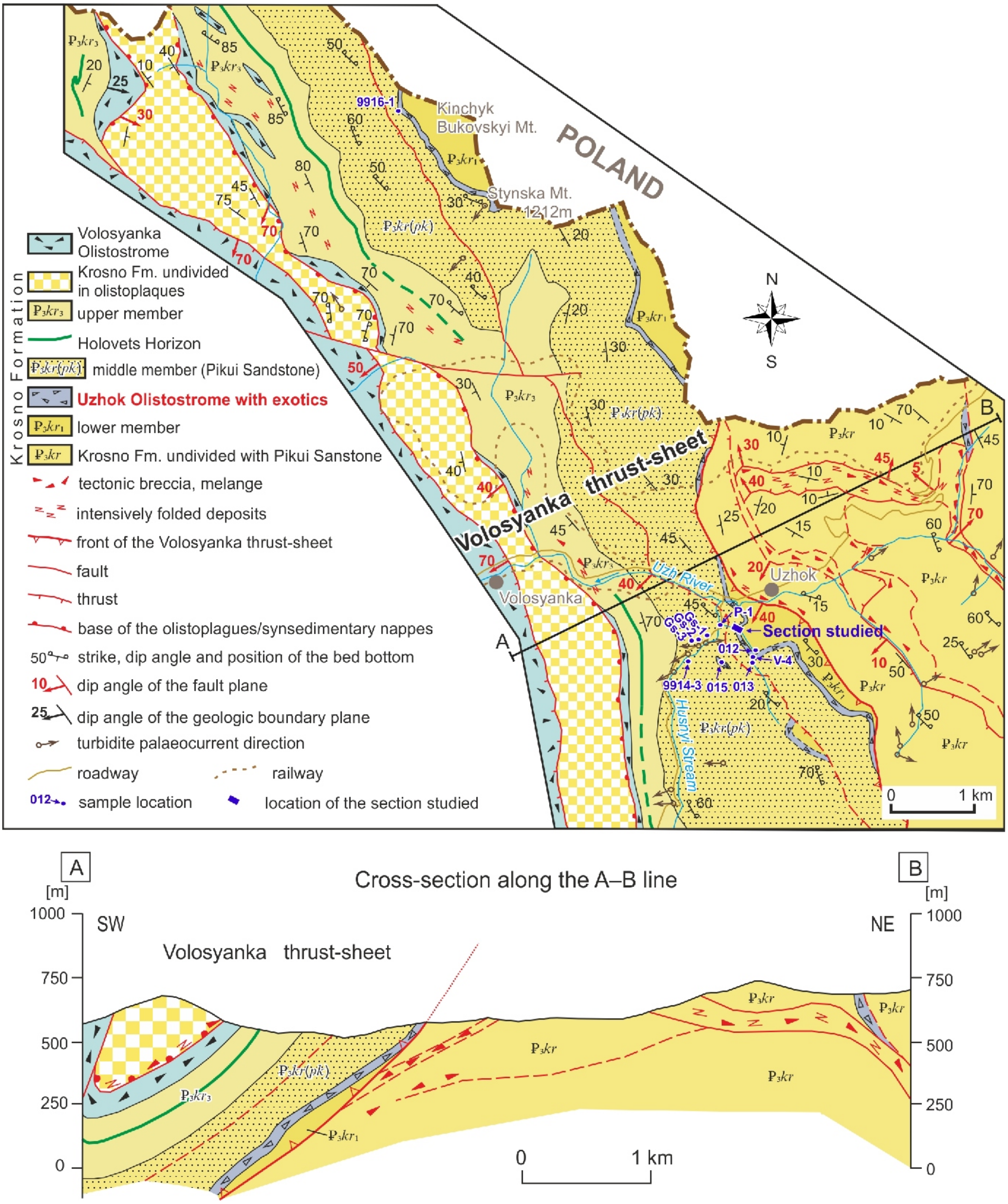

Fig. 3. Geological map of the area studied (upper part of the Uzh River Basin); compiled by O. Hnylko

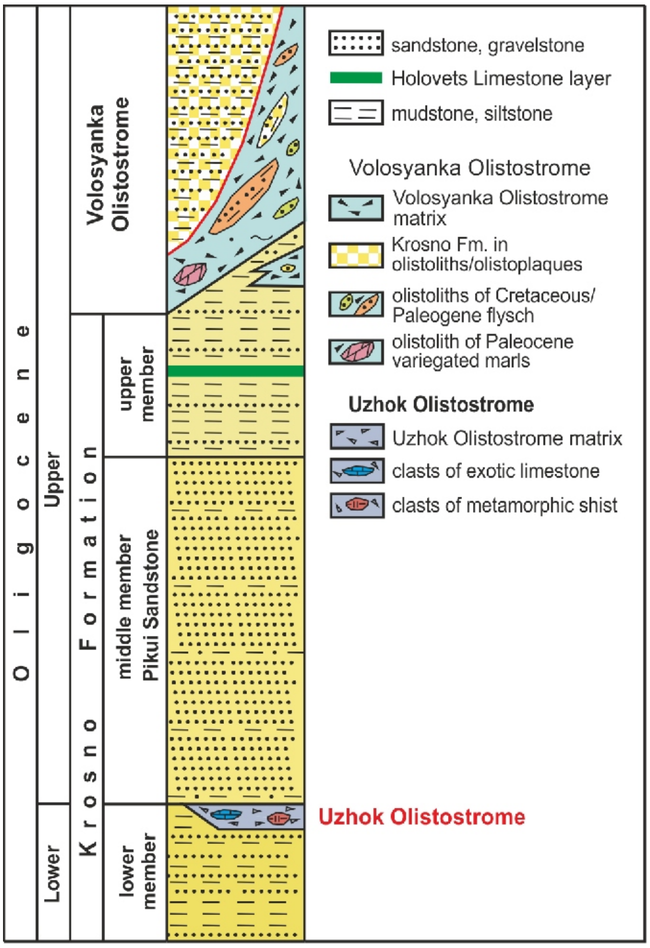

Fig. 4. Synthetic lithostratigraphic column of the Volosyanka thrust-sheet; compiled by O. Hnylko

ing grey marls, siltstones and sandstones as well as black Menilite-like shales. The deposits are characterized by Bouma divisions T_{cde}, T_{bcde}, T_{abcde} (Fig. 5A).

The Uzhok Olistostrome (up to 60 m thick) is confined to the top of the lower member of the Krosno Fm. It is made up of the debris-, grain-, and mud-flow deposits with a muddy-sandy matrix and clasts and olistoliths of flysch rocks (including Menilite-like black shales) as well as of the exotic micritic and bioclastic limestones and schists (Fig. 5B–D). The Uzhok Olistostrome stretches along the frontal part of the Volosyanka thrust-sheet and is also found near the Uzhok Pass (Fig. 3). This olistostrome is 8–10 km away from the Dukla Nappe front. It probably wedges out laterally in places.

The Middle member of the Krosno Fm. is represented by the **Pikui Sandstone** (up to 1000 m thick). There are medium- and thick-bedded and massive polymictic sandstones with Bouma divisions T_a, T_{abc}, T_{abcde} (Fig. 5E, F). The Pikui Sandstone contains clasts of schist and shallow shelly limestone similar to the exotics in the Uzhok Olistostrome. It also contains redeposited nummulitids. The sandy deposits were produced by high-density turbidity currents, grain-flows and debris-flows. The palaeotransport directions are from the NE in the deposits of the Volosyanka thrust-sheet and from the SW in the sandy flysch located ahead of the front of the Volosyanka thrust-sheet (Fig. 3).

These sandstones make up the Pikui mountain chain on the border of Lviv and the Transcarpathian regions and extend into neighbouring Poland in the Bieszczady Mountains (Hnylko, 2000) where they are known as the Otryt Sandstone (Bąk et al., 2001; Haczewski et al., 2016a, b, 2017a, b with references therein).

The Upper member of the Krosno Fm. (up to 700 m thick) is composed of thin-bedded grey marly mudstones, siltstones and sandstones. Sedimentary lenses of debris-flow deposits characterized by the presence of the blocks filled with Krosno-like flysch and a lack of exotics are developed here. In the middle part of the upper member, the Upper Oligocene Holovets Limestone horizon represented by thinly laminated pelagic limestone up to 4 m thick is present. The Upper member of the Krosno Fm. completes the Silesian stratigraphic succession outside of the Volosyanka thrust-sheet.

The Volosyanka Olistostrome (up to 1000 m thick) overlaps the Krosno Fm. in the Volosyanka thrust-sheet and completes the Silesian stratigraphic succession. The matrix of the olistostrome is represented by grey semi-lithified clay-sandy deposits with chaotic and weakly layered textures. Olistoliths are composed of Cretaceous–Oligocene flysch rocks. Olistoliths (including large olistoplaques) made of Krosno-like flysch are dominated (Figs. 2 and 3). They do not contain the Pikui Sandstone and consist of deposits similar to equivalent deposits of the Dukla Nappe (Hnylko, 2000).

UZHOK OLISTOSTROME

Sections of the Uzhok Olistostrome in the village of Uzhok, where palaeontological studies were carried out by Temnyuk (1958), Maksimov (1959), Dabagyan (1961), Zernetsky and Makarenko (1961), Danysh (1973), Gruzman and Smirnov (1982), are poorly exposed now. The Uzhok Olistostrome and some surrounding deposits were investigated, including sampling for microfaunal analysis in the section exposed along the first (counting from below) right tributary of the Hysnyi Stream and in individual exposures (Fig. 3). The name used for this right tributary herein – Little Polonynka – is used in this study but has not been used on published maps. Hysnyi Stream is pictured on published maps, it is a left tributary of the Uzh River and has a mouth below the village of Uzhok (Fig. 3). The Uzhok Olistostrome is relatively well-exposed in the lower reaches of the Little Polonynka Stream. Calcareous clayey rocks suitable for foraminiferal analysis make up a significant portion of the matrix here. Numerous planktonic Oligocene foraminifers were found here in the sample 99/18 collected during mapping in 1999. However, large blocks of metamorphic rock and bioclastic limestone, which had been observed along the streambed in 1999, are no longer visible.

The section studied (Figs. 3 and 6) is located in the lower reaches of the Little Polonynka Stream. The beginning of the section (N48°58'48.39"; E22°51'12.89") is placed 200 m upstream from the mouth of the Little Polonynka Stream. The base of the Uzhok Olistostrome is located here. Weakly lithified and poorly stratified grey siltstones and sandstones underlying the Uzhok Olistostrome are exposed 2 m upstream (sample 2019-406). Typical rocks of the lower member of the Krosno Fm., represented by thin-bedded flysch composed of grey polymictic sandstones, siltstones, mudstones with black shale intercalations, is exposed 50 m upstream (Fig. 5A). The sedimentary succession of the Uzhok Olistostrome is exposed downstream from the beginning of the section along the Little Polonynka and comprises several intervals which, however, have minor lithological differences (Fig. 6).

The stratigraphically lowermost sedimentary interval A is represented by dark grey to black non-layered weakly lithified calcareous silty mudstones with homogeneous and chaotic tex-

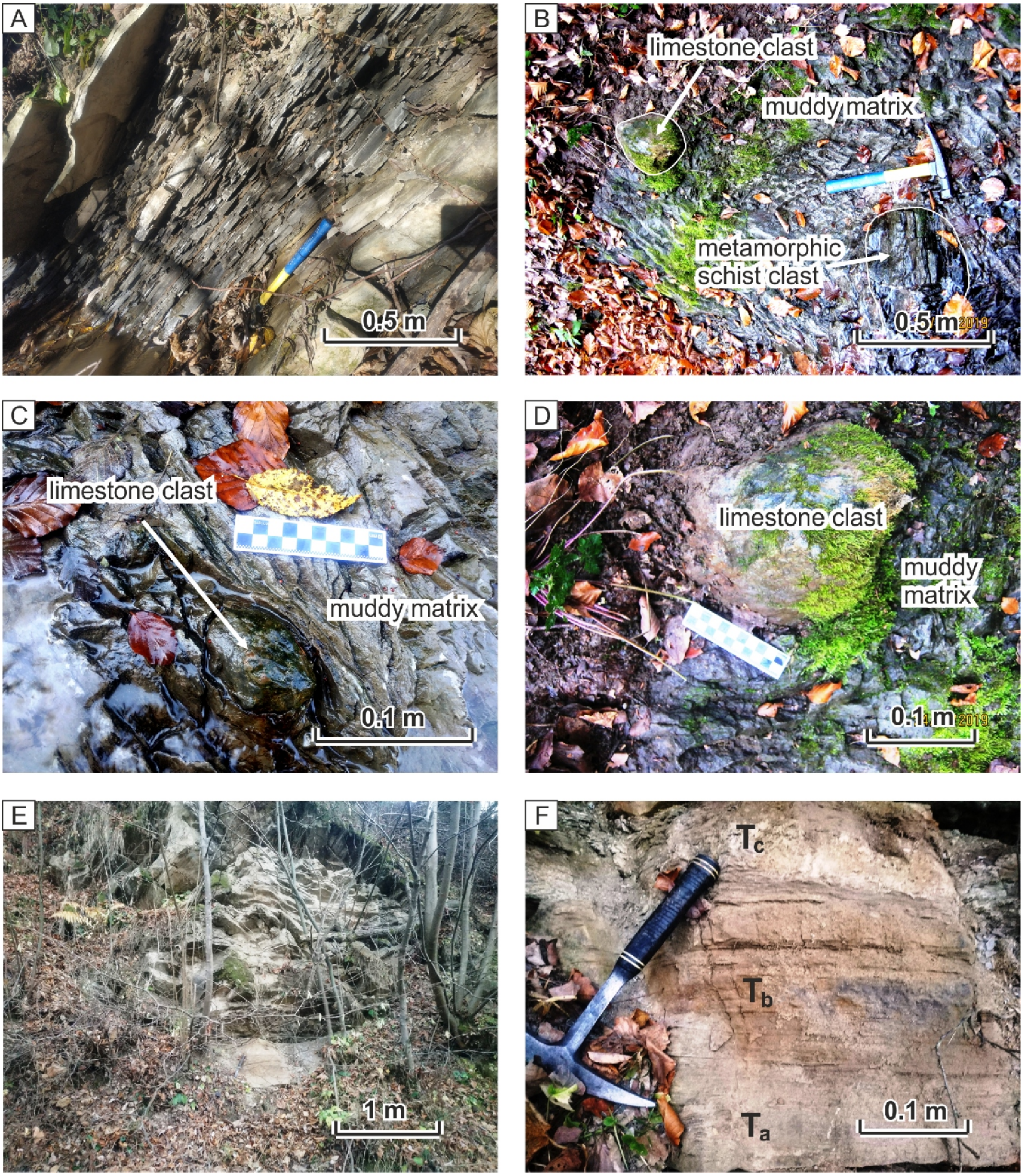

Fig. 5. Oligocene lithofacies units in the area studied (Volosyanka thrust-sheet of the Silesian Nappe, Fig. 4)

A – thin-bedded flysch of the lower member (beneath the Pikui Sandstone) of the Krosno Fm., Little Polonynka Stream – right inflow of the Husnyi Stream; **B, C** and **D** – exotics-bearing debris/mud-flow deposits of the Uzhok Olistostrome, Little Polonynka Stream – right inflow of the Husnyi Stream; **E** – Pikui Sandstone of the Krosno Fm., Husnyi Stream; **F** – T_{abc} Bouma divisions in the Pikui Sandstone bed, Hysnyi Stream

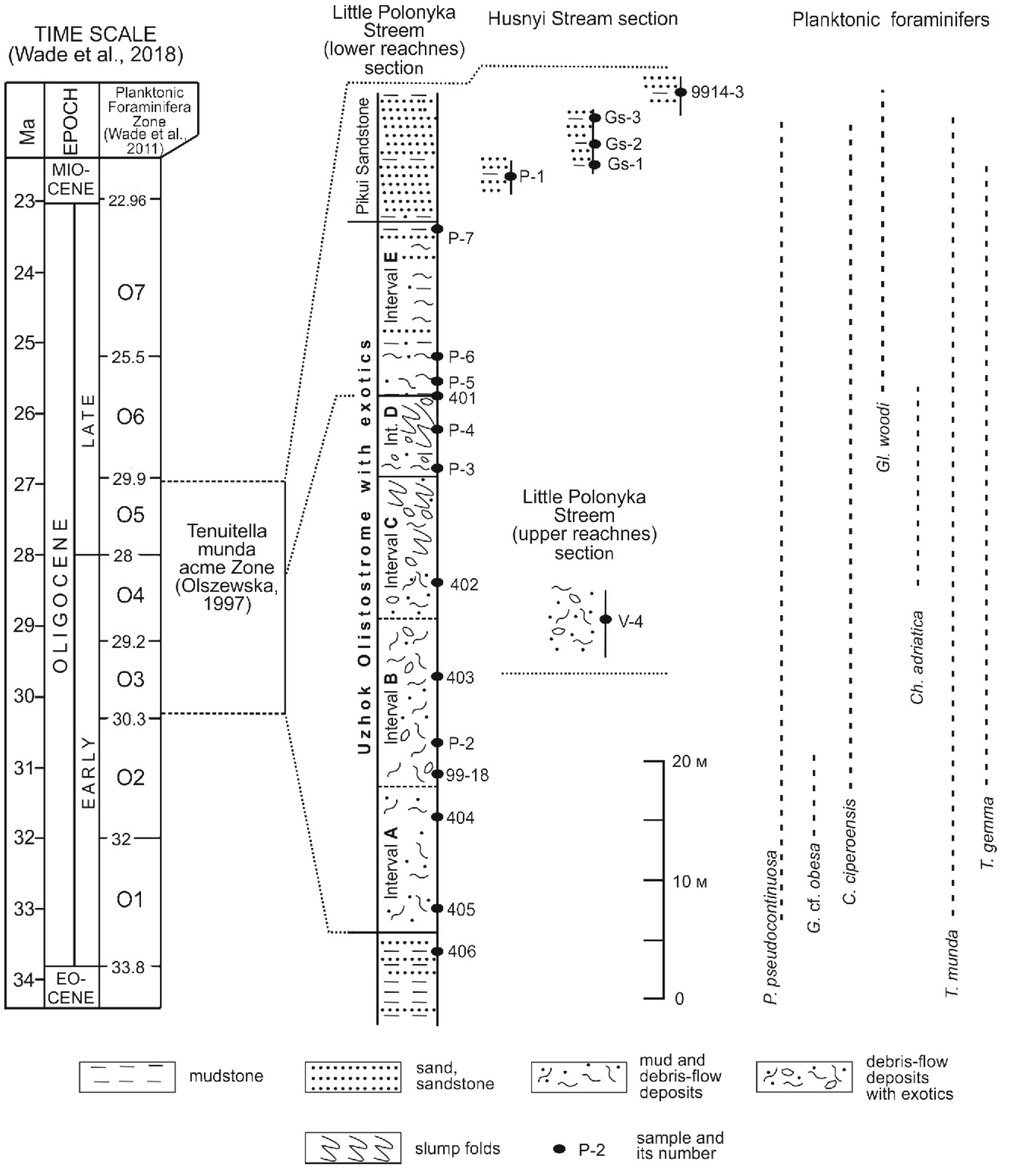

Fig. 6. Biostratigraphy of the sections studied (Fig. 4)

tures, deposited as mudflows. Only individual exposures of these deposits extend 13 m downstream from the beginning of the section studied. The stratigraphically higher interval B (up to 14 m thick) consists of dark grey to black calcareous clay and silty-clay chaotic deposits with scattered small pebbles of schist, which are easily recoverable from the poorly cemented matrix. These deposits are the products of mud- and debris-flows.

Interval C (up to 12 m thick) is composed by diffusely bedded dark grey to black silty mudstones with submarine slump folds. Fine (up to a few centimetres across) clasts of schist scattered in a clayey-silty matrix are found. Interval D (up to 9 m thick) is represented by poorly lithified structureless calcareous clay, silty clay and silty deposits. Alternating dark grey silty-dominated layers and light grey clay-dominated layers (2–3 m thick) are observed here. Inclusions of fine clasts of schist and grey micritic limestone as well as slump folds (up to 0.3 m across) are also present in this sedimentary interval.

The transitional interval E (up to 15 m thick) is represented by interbedded light grey and dark grey mudstones and grey sandstones. Layers of mudstone reach a thickness of 0.8 m, and sandstones 0.2 m. They were probably deposited by both mudflows and turbiditity currents. Intercalations of (hemi) pelagic deposit may be present. This sedimentary interval is the transition from the Uzhok Olistostrome to the overlying Pikui Sandstone (middle member of the Krosno Fm.). The end of the studied section is placed at the base of the Pikui Sandstone succession.

The Pikui Sandstone, expressed as polymictic medium-bedded grey sandstones with rare mudstone intercalations, is exposed along the Little Polonynka downstream up to its mouth (sample P-1) and on the banks of the Hysnyi Stream (samples Gs-1, Gs-2, Gs-3, 9914-3; Figs. 4 and 7).

Individual exposures of the Uzhok Olistostrome deposits were observed in the section along the upper reaches of the Little Polonynka Stream, 600–1000 m upstream from its mouth. The olistostrome is crossed by a stream here almost along the strike of the strata. The chaotic and unclearly layered matrix is mainly sandy-silty, rarely sandy-clayey and relatively well-cemented (sample V-4; Figs. 3 and 6). Olistoliths are represented by both redeposited flysch (sandstones, conglomerates with metamorphic debris, Menilite-like black shales) and exotic rocks (schist, quartz, micritic and bioclastic limestone). Many clast of the bioclastic limestone contain broken mollusc shells (Fig. 7A, B). Poorly rounded clasts of bioclastic limestone reach 0.8 m across, and schist up to 0.3 m. The exotic clasts often cohere strongly to the matrix. The flysch olistoliths are up to a few metres across. An olistolith filled with Menilite-like black shales reaching several metres across its short axis was found. The long axis of the olistolith is not completely exposed. Submarine slump folds of clayey rocks are also observed here.

Macroscopically, the metamorphic rock in the clasts located both along the section studied in the lower reaches of the Little Polonynka Stream and in its upper reaches represents grey-green crystalline schist, finely folded in places (Fig. 7C). Microscopically, this rock is seen as mica-quartz and mica-quartz-feldspar schists. The schistose structure takes the form of well-developed alternating laminae enriched in mica and laminae dominated by quartz grains (Fig. 7E, F). Subgrains and recrystallized quartz grains with undulatory extinction can be seen here (Fig. 7F). Garnet (Fig. 7D) and plagioclase (Fig. 7E) have been observed in these exotic schists.

Intermittent exposures of the Uzhok Olistostrome are present on the left bank of the Uzh River in the village of Uzhok, where blocks of bioclastic limestone, metamorphic rock and black Menilite shale are embedded in a dark grey sandy-clay matrix.

Examples of the Uzhok Olistostrome, with a mainly sandy matrix and bioclastic limestone blocks, were also locally observed in exposures located near the Uzhok Pass and around the Polish-Ukrainian border near the peaks of Kinchyk Bukovskyi and Stynska (see Fig. 3). In general, they are debris/grain-flow deposits.

Thus, the internal stratigraphic succession of the Uzhok Olistostrome is heterogeneous, being characterized by lithological differences including the presence of mud-flows products in its interval A, mud- and debris-flows deposits in interval B, and poorly expressed stratification in intervals C, D and E. This suggests the Uzhok Olistostrome accumulated as successive debris/grain/mud flows and slumping of soft weakly lithified sediments. The boundaries between the deposits of individual gravitational mass-flows, though, are not clearly visible due to poor exposure. It seems that these boundaries do not exactly coincide with the boundaries of the described intervals A–E.

BIOSTRATIGRAPHY

The Uzhok Olistostrome succession contains planktonic foraminifers of stratigraphic significance. The biostratigraphic markers include:

– *Paragloborotalia pseudocontinuosa* (Jenkins) (Fig. 8C) is present in the both the Uzhok Olistostrome (intervals A, B, D, E: samples 405, 404, 99-18, P-4, 401) and Pikui Sandstone (sample Gs-3). The stratigraphic range is the Rupelian Zone O2 to Miocene (Leckie et al., 2018).
– *Ciperoella ciperoensis* (Bolli) (Fig. 8A, B) is present in the both sections studied (intervals B, D. samples 99-18, 403, P-4) and in an individual exposure of the Uzhok Olistostrome (sample V-4). This species also was found in the Pikui Sandstone (sample Gs-1). The stratigraphic range is upper Rupelian middle Zone O3 to lower Miocene Subzone M1a (Olsson et al., 2018).
– *Tenuitella gemma* (Jenkins) (Fig. 8T) is present in the both the Uzhok Olistostrome (samples 99-18, 402) and Pikui Sandstone (sample Gs-1). Its stratigraphic range is Eocene to the Oligocene/Miocene boundary (Pearson et al., 2018 with references therein).
– *Chiloguembelina adriatica* Premec Fucek, Hernitz Kucenjak and Huber (Fig. 8U) was found in the Uzhok Olistostrome (intervals C, E: samples 402, 401). Its stratigraphic range is uppermost Eocene to the lower Chattian Zone O5 (Premec Fucek et al., 2018).
– *Globoturborotalita woodi* (Jenkins) (Fig. 8L–P) is present in the uppermost part (transition to the overlying Pikui Sandstone) of the Uzhok Olistostrome (interval E: sample 401). This species was found also in the Pikui Sandstone (sample 9914-3). Its stratigraphic range is the uppermost Rupelian Zone O4 to Miocene (Spezzaferri et al., 2018).

Other characteristic planktonic foraminifers co-occur with the above species in the deposits studied (Figs. 6 and 9).

Turborotalia cf. *ampliapertura* (Bolli) and *Globoturborotalita ouachitaensis* (Howe and Wallace) were identified from deposits directly below the olistostrome (sample 406). *Globoturborotalita pseudopraebulloides* (Olsson and Hemleben), *Globoturborotalita ouachitaensis* (Howe and Wallace), *Paragloborotalia nana* (Bolli), *Dentoglobigerina galavisi* (Bermúdez) and *Tenuitella munda* (Jenkins) and poorly preserved tests of *Globigerinella* cf. *obesa* (Bolli), *Globoturborotalita* cf. *occlusa* (Blow and Banner), and *Turborotalia* cf. *ampliapertura* (Bolli) are present in the lower part of the Uzhok Olistostrome (interval A: samples 405 and 404). The co-occurrence of these species indicates an Oligocene age. The presence of *Paragloborotalia pseudocontinuosa* (Jenkins) indicates the Oligocene not older than the middle Zone O2.

The occurrence of *Ciperoella ciperoensis* (Bolli) characterizes intervals B–D. *Paragloborotalia pseudocontinuosa* (Jenkins), *Paragloborotalia nana* (Bolli), *Globoturborotalita pseudopraebulloides* (Olsson and Hemleben), *Globoturborotalita ouachitaensis* (Howe and Wallace), *Tenuitella munda* (Jenkins), *Tenuitella angustiumbilicata* (Bolli), *Tenuitella gemma* (Jenkins) and *Chiloguembelina adriatica* Premec Fucek, Hernitz Kucenjak and Huber together with poorly preserved *Globigerinella* cf. *obesa* (Bolli), *Globoturborotalita* cf. *occlusa* (Blow and Banner) and *Globoturborotalita* cf. *gnaucki* (Blow and Banner), are present here. The age of these deposits (intervals B–D) is not older than the upper Rupelian Zone O3.

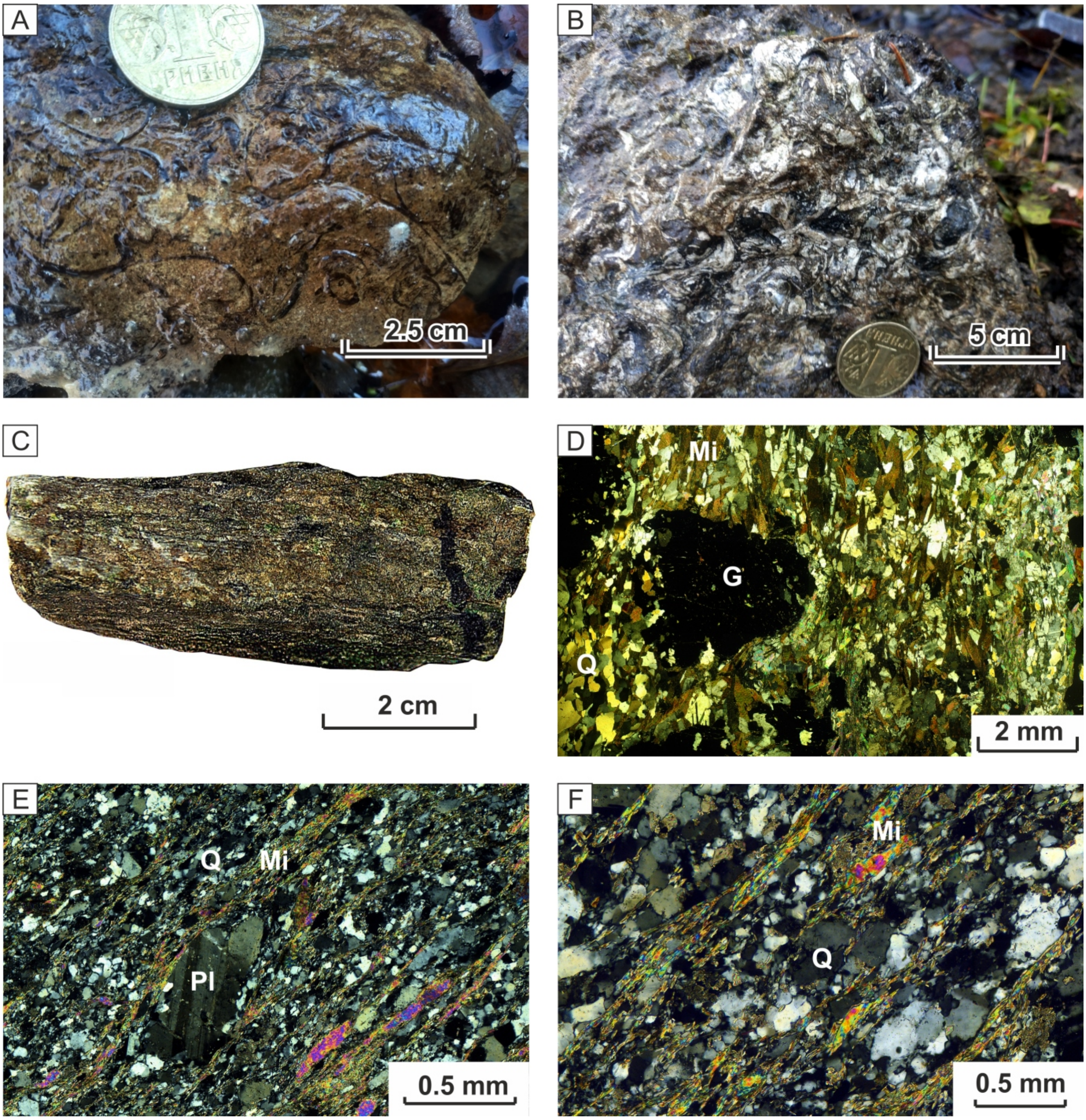

Fig. 7. Exotic clasts in the Uzhok Olistostrome: macroscopic (A–C) and microscopic (D–F) views (samples from the Little Polonynka Stream section – right inflow of the Husnyi Stream)

A – bioclastic limestone with broken shells, 700 m Little Polonynka upstream from its mouth; **B** – bioclastic limestone with many broken mollusc shells, 750 m Little Polonynka upstream from its mouth; **C** – grey-green crystalline schist, 750 m Little Polonynka upstream from its mouth; **D** – mica-quartz-feldspar schist with garnet, crossed polars, section studied along Little Polonynka Stream; **E**, **F** – mica-quartz schist with alternating laminae enriched in mica and with quartz grains, crossed polars, 760 m Little Polonynka upstream from its mouth; Q – quartz, Mi – mica, G – garnet, Pl – plagioclase

The occurrence of *Globoturborotalita woodi* (Jenkins) in interval E (sample 401) suggests that the age of these deposits is not older than Zone O4. The presence of *Chiloguembelina adriatica* Premec Fucek, Hernitz Kucenjak and Huber here, suggests an age not yonger than Zone O5. *Paragloborotalia pseudocontinuosa* (Jenkins), and *Globoturborotalita ouachitaensis* (Howe and Wallace) are also present here (sample 401).

Thus, the age of the Uzhok Olistostrome based on planktonic foraminifers in the section studied (intervals A–E) correlates with the middle Oligocene, within the middle O2–O5 zones. The biostratigraphic succession is marked mainly by the appearance of the species *Ciperoella ciperoensis* (Bolli) and *Globoturborotalita woodi* (Jenkins). The lower part of the Uzhok Olistostrome (interval A) containing *Paragloborotalia pseudocontinuosa* (Jenkins) is not older than the middle Zone O2. The

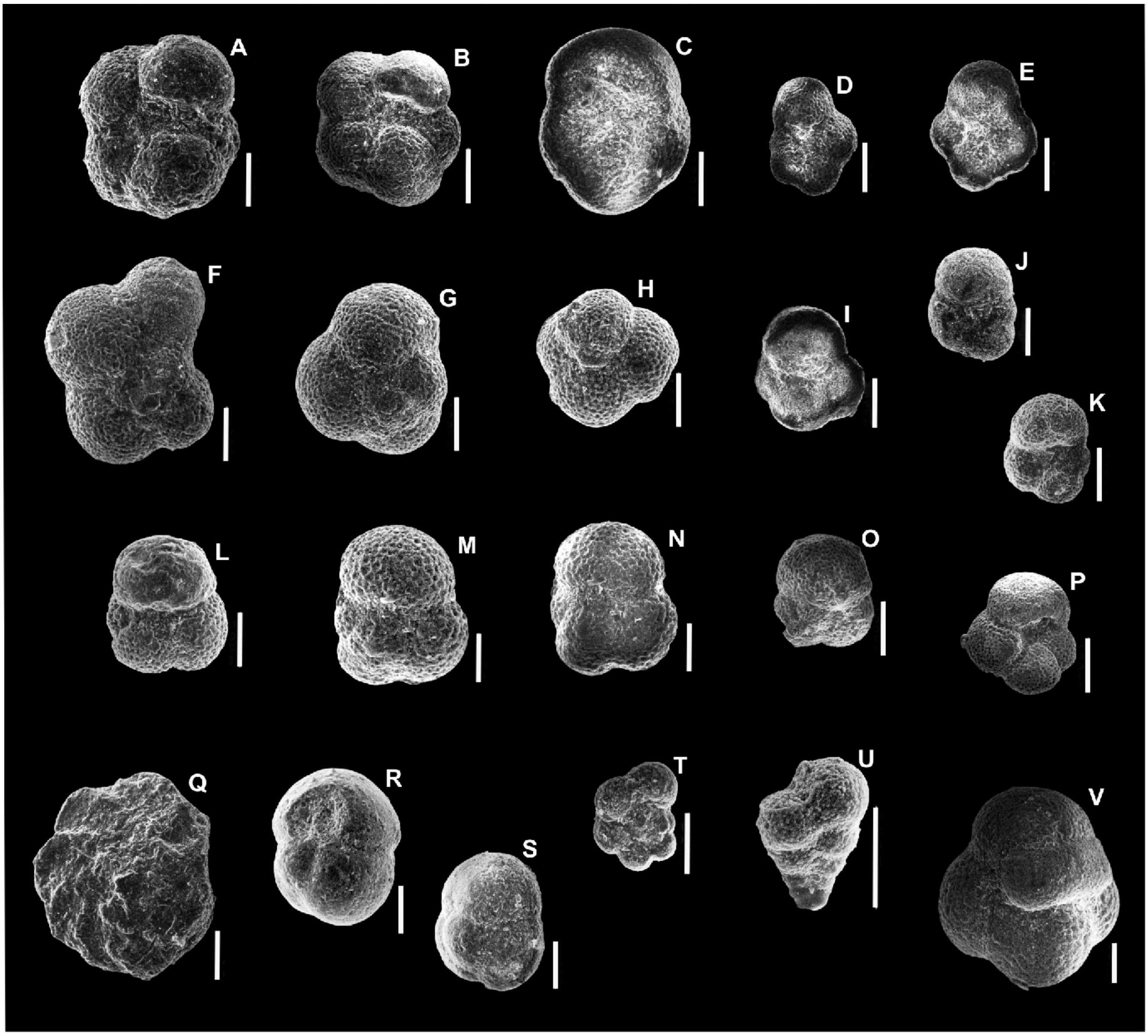

Fig. 8. Planktonic foraminifers from the Uzhok Olistostrome (A–K; M–S; U, V) and Pikui Sandstone (L, T)

A, B – *Ciperoella ciperoensis*, pyritized test (A – sample 99-18, B – (sample V-4); **C** – *Paragloborotalia pseudocontinuosa* (sample 401); **D, E** – *Paragloborotalia nana,* pyritized test (D – sample V-4, E – sample 403); **F** – *Globoturborotalita* cf. *gnaucki*, pyritized test (sample P-2); **G** – *Globoturborotalita pseudopraebulloides* (sample 402); **H** – *Globoturborotalita ouachitaensis* (sample 401); **I** – *Globoturborotalita* cf. *occlusa*, pyritized test (sample 404); **J, K** – *Turborotalia* cf. *ampliapertura* (J – sample 405, K – sample 406); **L–P** – *Globoturborotalita woodi* (L – sample 9914-3, M–P – sample 401); **Q** – *Globotruncana* sp., redeposited species (sample 404); **R**, **S** – *Globigerinatheka index,* redeposited species (sample 404); **T** – *Tenuitella gemma*, pyritized test (sample O-3); **U** – *Chiloguembelina adriatica* (sample 401); **V** – *Subbotina corpulenta,* redeposited species (sample 405); scale bar 100 µm

middle-upper part of the Uzhok Olistostrome (intervals B – D), characterized by the appearance of *Ciperoella ciperoensis* (Bolli), is not older than the middle Zone O3. The uppermost (transition) part (interval E), characterized by the appearance of *Globoturborotalita woodi* (Jenkins), is not older than Zone O4.

A similar Oligocene age has been assigned to the exotics-bearing layer beneath the Otryt Sandstone (Bąk et al., 2001) in the Polish part of the Silesian Nappe in the Bieszczady Mts. The nannoplankton Zone NP24 and foraminiferal middle Oligocene *Tenuitella munda* Zone (*sensu* Olszewska, 1997) are identified there (Bąk et al., 2001).

The co-occurrence of *Ciperoella ciperoensis* (Bolli) and *Tenuitella gemma* (Jenkins) in the Pikui Sandstone (samples Gs-1 and Gs-3) determines an Oligocene age not older than the upper Rupelian Zone O3. The presence of *Globoturborotalita woodi* (Jenkins) in the stratigraphically higher part of the Pikui Sandstone (sample 9914-3) suggest an age not older than the uppermost Rupelian Zone O4.

Some species of planktonic foraminifers redeposited from older sediments are found in the Uzhok Olistostrome matrix. A single test of s poorly preserved Upper Cretaceous *Globotruncana* sp. (Fig. 8Q) was found in interval A (sample 404).

		Section studied lower reaches of the Little Polonynka Stream										**Individual outcrops**				
			Uzhok Olistostrome with exotics											Pikui Sandstone		
			A		B			C	D		E					
		middle Oligocene														
Planktonic foraminifers \ Sample numbers		406	405	404	99-18	Pol-2	403	402	Pol-3	Pol-4	401	V-4	9916-1	Gs-1	Gs-3	9914-3
Globigerinella cf. *obesa*				⊙	●											
Paragloborotalia nana			⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙		⊙	⊙		⊙	
Paragloborotalia pseudocontinuosa			○	○	○					○	⊙					○
Ciperoella ciperoensis					○		○			○		⊙		○		
Globoturborotalita cf. *gnaucki*						○										
Globoturborotalita cf. *occlusa*			⊙	●	●	⊙	⊙		⊙	⊙						
Globoturborotalita ouachitaensis		○	●	●	●	⊙	⊙		⊙		○	⊙				
Globoturborotalita pseudopraebulloides				⊙	⊙			○								
Globoturborotalita woodi											⊙					○
Dentoglobigerina galavisi			○													
Turborotalia cf. *ampliapertura*		○	⊙	⊙												
Tenuitella angustiumbilicata						○				○			○			
Tenuitella gemma					⊙			⊙						○		
Tenuitella munda			⊙	⊙	⊙	⊙	⊙		⊙			⊙		●		
Chiloguembelina adriatica								⊙			⊙					
Globigerinatheka index	redeposited species		⊙	⊙	⊙	○				○						
Subbotina corpulenta			○	○			○	○								
Pseudohastigerina sp.								○								
Globotruncana sp.				○												

○ 1–3 specimens ⊙ 4–10 specimens ● >10 specimens

Fig. 9. Distribution of planktonic foraminifer specimens

A, B, C, D, E – the intervals of the Uzhok Olistostrome in the section studied (Fig. 6 and text)

This test is recrystallized and glazed. The Eocene species *Globigerinatheka index* (Finlay) (Fig. 8R, S) was found in units A, B and D (samples 405, 404, 403 and P-4). This species appears in the upper E9 Zone and disappears (at mid latitudes) at the E15/E16 boundary (Premoli Silva et al., 2006 with references therein). All tests are recrystallized and glazed.

Well-preserved yellow-white tests of *Subbotina corpulenta* (Subbotina) (Fig. 8V) are found in intervals A and B. *Subbotina corpulenta* (Subbotina) is first reported in Zone E7 but its extinction is not well-constrained (Wade et al., 2018). This species is known from the Eocene of the Polish and Romanian Carpathians (Bratu, 1985; Olszewska at al., 1996), and from the Eocene to lowest Oligocene of the Slovak Carpathians (Samuel and Salaj, 1968; Soták et al., 2007). Numerous specimens are found in the *Subbotina corpulenta* Acme Zone (Upper Priabonian) in the "Globigerina Marl" of the Ukrainian Carpathians (Dabagyan, 1987; Hnylko and Hnylko, 2016).

PALAEOGEOGRAPHY

Intrabasinal uplifted submarine and land areas (ridges or so-called "cordilleras"), built probably of continental crust, played an important role in the palaeogeography of the Outer Carpathian Basin. These ridges divided the Carpathian sedimentary realm into several sub-basins including the Silesian and Dukla sub-basins, and were one of the sources of the clastic material with exotics for the Outer Carpathian Basin (Danysh,1973; Vialov et al., 1981; Kruglov, 1986 and references therein; Golonka et al., 2019; Kowal-Kasprzyk et al., 2021 with references therein). The ridges' uplift is related to the convergence of the Tethys microplates and Eurasia and, as a result, to compression of the Outer Carpathian Basin's basement (Oszczypko, 2006; Cieszkowski et al., 2009, 2012; Golonka, 2011; Gawęda at al., 2019 with references therein).

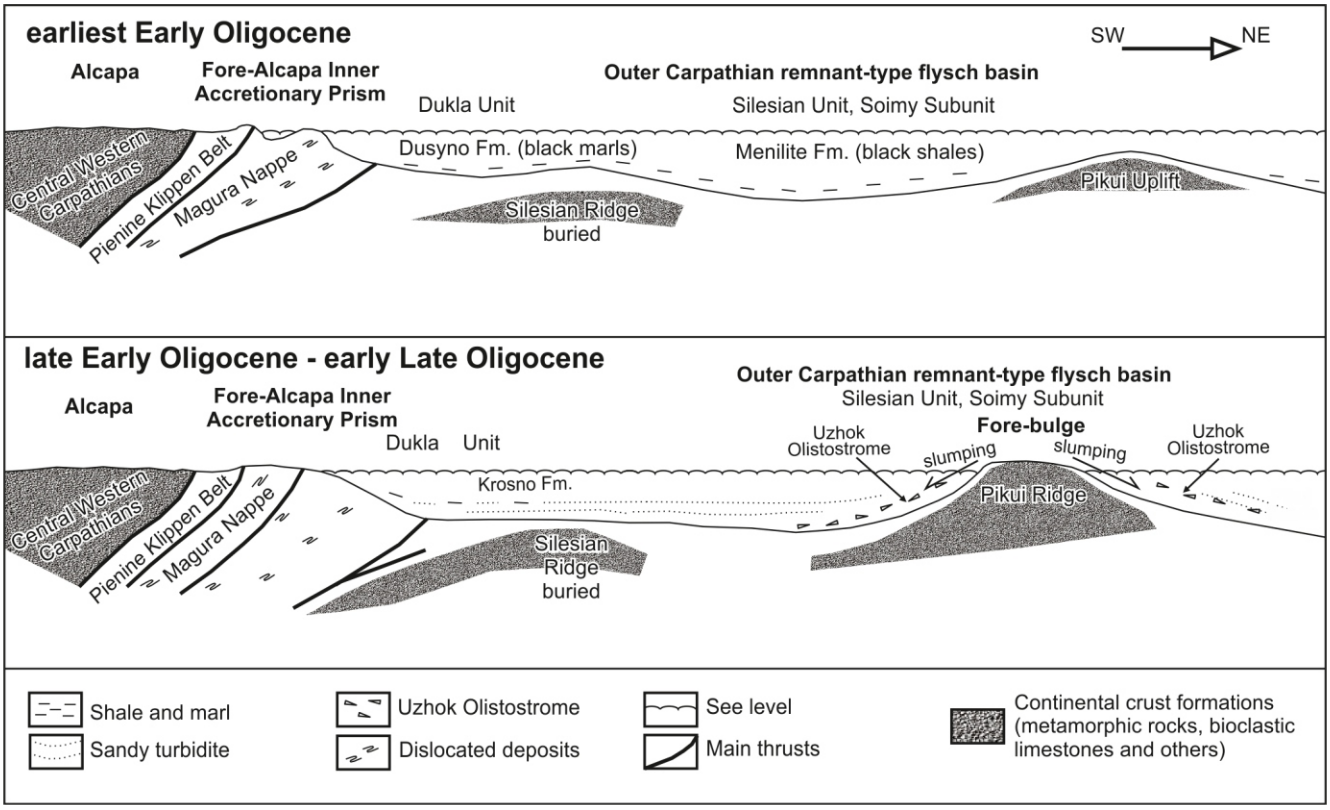

Fig. 10. Palinspastic reconstruction of the Oligocene Dukla–Silesian sedimentary realm ahead of the Fore-Alcapa accretionary prism (Western Ukrainian Carpathian segment).

No scale; compiled by O. Hnylko using earlier reconstructions (Oszczypko, 2006; Ślączka and Golonka, 2006; Cieszkowski et al., 2009, 2012; Hnylko et al., 2015; Kováč et al., 2016; Golonka et al., 2019)

The Silesian Unit together with the Sub-Silesian, Skyba, Boryslav-Pokyttya, and partly Dukla units belonged to the remnant Outer Carpathian flysch basin placed on and/or near the Eurasian passive margin in the Oligocene. This Outer Carpathian flysch basin was limited along the south-west side by an accretionary prism composed of the Inner Flysch Nappes (Magura, partly Dukla ones and others; Fig. 1). The growth of the prism took place in front of the moving Alcapa and Tisza-Dacia terranes due to subduction of the substrate of the Outer Carpathian sedimentary basin beneath these terranes. Olistostromes were formed in consequence of the accretionary prism fold-thrust movements (Oszczypko, 2006; Jankowski, 2007; Cieszkowski et al., 2009, 2012; Hnylko, 2014; Gawęda et al., 2019 and references therein).

In the Oligocene, the Carpathian sedimentary realm belonged to the Paratethys, a partly isolated sea, which was connected with an open ocean via periodically opening seaways (Rögl, 1999; Kováč et al., 2016, 2017; van der Boon et al., 2018). A significant portion of the intrabasinal uplifts, including the Silesian Ridge probably located between the Dukla and Silesian sub-basins, were burried in the Oligocene (Vialov et al., 1981 with references therein) due to subduction and accretionary prism progradation (Oszczypko, 2006: Cieszkowski et al., 2012; Gawęda et al., 2019; Golonka et al., 2019 with references therein). As a result, a unification of sedimentation in the Outer Carpathian Basin occurred and most of the area was occupied by sedimentation of the Menilite and Krosno formations. But, at the same time, the Uzhok Olistostrome with exotic metamorphic rocks and bioclastic limestones accumulated.

The Uzhok Olistostrome is characterized by a biostratigraphic succession of foraminiferal assemblages succeeding each other in ordered fashion. This suggests the olistostrome accumulation occurred as several episodes succeeding wach other in time. As noted above, some sedimentological data, including the the presence of several mud- and debris-flows, also indicate multiple sedimentary episodes. Pelagic background deposits with planktonic foraminifers likely accumulated in the "peaceful" intervals between the gravity-driven mass flows. Probably, the background sediments were eroded and redeposited by gravity flows, and as a result were incorporated, together with the planktonic foraminifers, into the Uzhok Olistostrome matrix.

The presence of autochthonous or/and re-transported middle Oligocene planktonic foraminifers in all samples of the section studied indicates normal marine conditions during the accumulation of the deposits that subsequently became the matrix of the Uzhok Olistostrome. Probably, the pelagic sediments were initially enriched in plankton and subsequently were retransported. The high percentage (70–100%) and abundance of planktonic foraminifers (samples 99-18 and 401) suggests a bathyal pelagic environment in accordance with Murray (1976). Obviously, these environments were present on the slope of the intrabasinal uplift where infrequent mud- and debris-flows occurred in the middle Oligocene. Various exotic products of erosion of the intrabasinal uplift, including the bioclastic limestones and schists, as well as the redeposited foraminifers, were transported by these mass-flows too. In particular, the presence of planktonic foraminifers redeposited from the Eocene deposits and probably from the "Globigerina Marl" of the Eocene-

–Oligocene boundary was observed. This supports the inference by previous researchers (Lozyniak and Temnyuk, 1971; Smirnov, 1975; Kulchytskyi, 1977; Gruzman and Smirnov, 1985) of faunal redeposition.

An intrabasinal uplift composed of metamorphic rocks, biogenic limestones and pelagic deposits on its slopes may have been the source area for the Uzhok Olistostrome as well as for the Pikui (Otryt) sandstones containing metamorphic rock clasts and redeposited nummulitids. This uplift, named the Pikui Ridge in our study, should probably be compared with the previously distinguished Pikui Cordillera (Shulga,1965), Fore-Dukla Cordillera (Danysh, 1973) and Bukowiec Ridge (Ślączka, 2005; Ślączka and Golonka, 2006). The Pikui Ridge could be the eastern branch (one branch among several?) of the Silesian Ridge – the most prominent elevated area bounding to the north the Magura and probably Dukla sedimentary sub-basins (Golonka et al., 2019 and references therein), although the exact position of the Silesian Ridge among the Ukrainian Carpathian formations remains unclear.

The measured directions of palaeocurrents in the Oligocene strata (Fig. 3) suggest that the Pikui Range was located north of the main Silesian Ridge, at least in the study area. The Pikui Range was probably located in the Silesian Unit between the Oligocene local sub-basin, with sediments now forming the Volosyanka thrust-sheet (measured turbidite palaeocurrent directions are from the NE), and the local sub-basin, with sediments now located to the north-east ahead of this thrust-sheet (palaeocurrent directions are from the S and SW; Fig. 3), while the main Silesian Range was located on the southern margin of the Silesian Unit (Fig. 10).

Remnants of the Silesian Range may be the variegated (red and green) marls rich in Paleocene planktonic foraminifers within the olistolith in the Volosyanka Olistostrome (Hnylko and Hnylko, 2019). Olistoliths of variegated marls displaced from the northern slope of the Silesian Ridge have been described in the Silesian Unit of the Polish Carpathians (Waśkowska and Cieszkowski, 2014 and references therein).

Only further studies of the exotic metamorphic rocks as well as a more complete palaeontological analysis of the Uzhok Olistostrome, including of the bioclastic limestones, will allow reconstruction of the exact age, composition and palaeogeographic position of the Pikui Ridge and determine its relationship with the metamorphic basement and sedimentary cover of both the European Platform and Central Carpathians.

Thus in the earliest Oligocene, more or less uniform sedimentation covered the Outer Carpathian Basin including the Dukla and Silesian sub-basins. Mainly clay deposits of the Menilite Fm. and the lower part of the Krosno Fm. accumulated here (Fig. 10).

In the late Early Oligocene–early Late Oligocene, the Pikui Ridge had actively risen and become a source of clastic material for the Uzhok Olistostrome and Pikui Sandstone. This ridge is interpreted as a fore-bulge ahead the Dukla Nappe – frontal element of the Oligocene West Carpathian accretionary prism developed in front of the Alcapa Terrane (Fig. 10).

In the latest Oligocene, the Pikui Ridge was submerged due to subduction, as inferred from the cessation of the coarse clastic sedimentation and the accumulation of the clay-marl upper member of the Krosno Fm. including the Holovets pelagic limestones.

After the accumulation of the Holovets limestones, the Dukla Nappe front was uplifted due to accretionary prism progradation and became a source for the Volosyanka Olistostrome (Hnylko, 2000).

CONCLUSIONS

Oligocene exotics-bearing olistostrome deposits containing clasts and olistoliths of exotic schists, bioclastic and micritic limestones and fragments of redeposited flysch rocks are present in the inner part of the Silesian Nappe ahead the Duka Nappe in the Uzh River Basin, Ukraine. These deposits are assigned to the Uzhok Olistostrome located in the stratigraphic succession of the Soimy Subnappe. This succession in the Uzh River Basin includes the following lithostratigraphic units:

– Lower member of the Krosno Fm. (up to 400 m thick) represented by thin-bedded flysch;
– Uzhok Olistostrome (up to 60 m thick) situated at the top of the lower member and including debris-, grain- and mud-flow deposits containing exotic clasts of schist and limestone;
– Middle member of the Krosno Fm. represented by medium- and thick-bedded Pikui (Otryt in Poland) Sandstone (up to 1000 m thick);
– Upper member of the Krosno Fm. (up to 700 m thick) composed of thin-bedded grey flysch deposits and a unit of the pelagic Holovets Limestone (Jasło Limestone in Poland);
– Volosyanka Olistostrome (up to 1000 m in thick) overlapping the Krosno Fm. and containing olistoliths of flysch rocks.

The Uzhok Olistostrome accumulated as a succession of debris/grain/mud flows and by slumping of soft weakly lithified sediments. Pelagic background deposits with planktonic foraminifers accumulated in the “peaceful” intervals and periodically were redeposited by gravity flows and added to the Uzhok Olistostrome matrix.

The age of the Uzhok Olistostrome based on planktonic foraminifers correlates with the middle Oligocene within the middle O2–O5 zones.

The source area for the Uzhok Olistostrome as well as for the Pikui Sandstone may have been the intrabasinal Pikui Ridge. This was probably located in the Silesian Unit between the Oligocene local sub-basin with sediments now forming the Volosyanka thrust-sheet (measured turbidite palaeocurrent directions are from the NE) and the local sub-basin with sedimens now located to the north-east ahead of this thrust-sheet (palaeocurrent directions are from the S and SW; Fig. 3). The Pikui Ridge may be interpreted as the fore-bulge located ahead of the moving accretionary prism and supplied exotic clasts to the Silesian Sub-basin (Uzhok Olistostrome and Pikui Sandstone). The fore-bulge was situated ahead of the Dukla Nappe, which was a frontal element of the Oligocene West Carpathian accretionary prism developed in front of the Alcapa Terrane.

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