cover which fill the Orava Basin (Chrustek and Golonka 2005). Moreover, the DEM allows determining the present image of the Orava Basin, relationship between ambient elevations and the Orava depression and effects of southern fringes uplift and northern fringes subsidence.

The geological research is in preliminary phase and hasn't been done yet in the whole investigated area. The tectonic deformations are represented by ductile and brittle faults which appear with breccias and also mixed faults in the north and south margins of the Orava Basin. The mentioned dislocations are longitiudinal and obligue faults. Moreover, most of them have strike-slip character. The field research allows determining places where the largest deformations are located as well. They are situated along south-east in the neighbourhood of the Pieniny Klippen Belt and north margin of the Orava Basin. The south-east fringe forms a steep scarp made up of Neogene gravels containing fractured clasts. The orientation of fracture sets observed in several outcrops from Domański Wierch to Stare Bystre in this area determines NE and NNE stress direction. According to Tokarski and Zuchiewicz (1998) these outcrops reflect dislocations in the basement. Probably these dislocations are active nowadays because along south-east fringe of the Orava Basin runs active zone called Myjava lineament (Bac-Moszaszwili 1993) or the Orava transforming fault (Baumgart-Kotarba *et al*. 2004). Besides, there are known earthquakes which had compressional character according to Baumgart-Kotarba (2001). In the northern part of the Orava Basin occur local overthrusts. In the border of thrust are reverse faults with overturned strata of the Magura series. These faults must have formed during compressional regime.

Directions of morpholineaments and faults founded in the investigated area are similar. It means that the faults situated on the surface are reflected by the morpholineaments distinguished on the basis of the DEM analysis.

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References

BAC-MOSZASZWILI M., 1993. Structure of the western termination of the Tatra massif. *Ann. Soc. Geol.*, 63: 167-193.

BAUMAGART-KOTARBA M., 2001. Continuous tectonic evolution of the Orawa Basin (Nothern Carpathians) from Late Badenian to the present-day? *Geologica Carpathica*, 52 (2): 103-110.

BAUMGART-KOTARBA M., MARCAK H. and MÁRTON E., 2004. Rotation alog transverse transforming Orava strike-slip fault: based on geomorphological, geophisical and paleomagnetic data (Western Carpathians). *Geologica Carpathica*, 55 (3): 219-226.

CHRUSTEK M. and GOLONKA J., 2005. Carpathian tectonics in the making – deformations and earthquakes in the Stare Bystre area (southern Poland). In: M. DOKTOR and A. WAŚKOWSKA-OLIWA (Editors), Geotourism – new dimensions in XXI century tourism and chances for future development. 2nd International Conference Geotour 2005, 22–24 September 2005, University of Science and Technology AGH, Krakow, pp. 16-18.

TOKARSKI A.K. and ZUCHIEWICZ W., 1998. Fractured clasts in the Domański Wierch series: Contribution to structural evolution of the Orawa Basin (Carpathians, Poland) during Neogene through Quternary times. *Prz. Geol.*, 46 (1): 62-66.

Olistostroms as Indicator of the Geodynamic Process (Northern Carpathians)

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Existence and transformation of the accretionary wedge in the southern in the Northern Carpathians are documented by occurrence of olistostroms. During the detail mapping and lithofacies investigations of deposits in a few main tectonic units of the Outer (Flysch) Carpathians the olistostroms has been identified. In Poland, Czech and Slovak Republic the olistostroms are known from the Cretaceous, Paleocene, Eocene, Oligocene and Miocene flysch deposits of a few main tectonic units. Those units are the Skole, Subsilesian, Silesian, Dukla and Magura nappes as well as Pieniny Klippen Belt.

The term olistostrome is derived from the ancient Greek and means «slide-layer» (Cieszkowski and Golonka 2005). An olistostostrome is a sedimentary deposit consisting of blocks of diverse origin that are immersed in a matrix. The Northern Carpathians this matrix consist of clay, mud, sand or their mixture forming turbidity package. The blocks in olistostrome are named olistolites. The size of olistolites varies, from centimeters to kilometers. Very large blocks could slide independently into the basin with no easily distinguishable matrix. The matrix in this case is the flysch sequence or even entire sedimentary-tectonic

unit. The olistostroms formed in Northern Carpathians as debris flows during the different stages of the development of flysch basins, from rift trough post-rift to the orogenic stage.

In the southern Part of the Polish Northern Carpathians as well as in the adjacent part of Slovakia the olistostroms are known from the Cretaceous-Paleocene flysch deposits of the Pieniny Klippen Belt Złatne Unit and in Magura Nappe marking an early stage of the development of the accretionary prism. The most spectacular olistostroms have been found in the vicinity Haligovce village in Pieniny Klippen Belt and in Jaworki village in the border zone between the Magura Nappe and Pieniny Klippen Belt. The olistolites and large clasts are represented by igneous rocks including possible ophiolite basalts as well as a variety of carbonate rocks of Triassic - Paleogene age. This material represents the former PKB basinal and ridge sequences as well as Inner Carpathian terrane sequences. The Haligovce Klippen and Homole block represent largest Pieniny Klippen Belt olistolites (Golonka et al. 2005).

The olistostroms of different age are especially frequent in the Silesian Nappe. They have been created in some different stages of evolution of Silesian basin. Oldest are known from western-most part of Polish Outer Carpathians. In the Cieszyn beds olistostroms arrived during the Late Jurassic – Early Cretaceous extensional stage forming the Silesian basin. In the basal part of the Godula beds (Turonian – Campanian) represented by very thick-bedded sandstone turbidites a large flat blocks of the shales derived from the Lgota beds (Albian–Cenomanian) lies on slumped beds (Ślączka and al. 2005).

In area surrounding artificial Rożnów Lake a few olistostrome horizons are known from the Istebna beds (Maastrichtian–Paleocene) and from the Hieroglyphic beds (Middle-Late Eocene). There the large flat or plastically folded blocks of flysch deposits. Blocks of marls and occasionally limestones inhere in the debris-flow sandy-gravel matrix with pebbles. The pebbles represent different sedimentary, metamorphic and magmatic rocks.

During Late Paleogene final stage of the Silesian accretionary prism numerous olistostroms were deposited within the Oligocene-Early Miocene Menilite and Krosno Beds. In the abandoned quarry in Skrzydlna in the basal part of the Cergowa Sandstone in the Menilite beds (Oligocene) occur large olistostroms (Cieszkowski and Polak 2001) composed mainly of the Lower Cretaceous flysch deposits which represent Cieszyn beds, Hradiste beds and Verovice beds and minor addition of the Eocene gray or red marls and shales. The debris-flow deposits with pebbles of different sedimentary and crystalline rocks are frequent. The Silesian Ridge, which framed the Silesian Basin from south, was overridden by accretionary prism. Then, the ridge basement rocks, Paleogene deposits of the slope as well as older Cretaceous flysch deposits partly folded and thrust within the prism were slided northward toward the basin, forming the olistostrome.

The Sub-Silesian ridge deposits were partially included into the Subsilesian nappe, the ridge's basement rocks and part of its depositional form olistostroms and exotic pebbles within Menilite-Krosno flysch. The largest olistostroms were found in the vicinity of Andrychów and are known as Andrychów Klippen (Golonka et al 2005). The Fore-Magura and Silesian ridges were destroyed totally and are known only from olistolites and exotic pebbles in the Outer Carpathian flysch. They destruction is related to the advance of the accretionary prism. This prism obliquely overridden the ridges leading to the origin of the Menilite-Krosno basin. The Malcov Formation was deposited in the smaller piggy-back subbasin. During overthrusting the outer, marginal part of the advanced nappes was uplifted whereas in the inner part sedimentation persisted in the remnant basin. From that, uplifted part of the nappes big olistolites glided down into the adjacent, more distal basins. The nappes became detached from the basement and were thrust northward in the west and eastward onto the North European platform with its Miocene cover. Overthrusting movements migrated along the Carpathians from the west towards the east. The Outer Carpathian allochtonous rocks, as result of Miocene tectonic movements, have been overthrust onto the platform for a distance of 50 to more than 100 km.

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References

CIESZKOWKI M. and POLAK A., 2001. Stop C4 – Skrzydlna Yillage. In: K. BIRKENMAJER and M. KROBICKI (Editors), 12* meeting of the Association of European Geological Societies: 10–15 September 2001. Kraków: Carpathian palaeogeography and geodynaniics: a multidisciplinary approach: field trip guide. Polish Geological Institute. Kraków, pp. 121-126.

CIESZKOWSKI M.. GOLONKA J., POLAK.A., RAJCHEL J. and ŚLĄCZKA A.. 2003. Olistostroms in the deep water flyschdeposits in the Polish outer Carpathians. In: I. VLAHOVIC (Editors), 22nd I AS Meeting of Sedimentology – Opaltja 2003. Abstract Book, pp. 66

CIESZKOWSKI M. and GOLONKA J., 2005. Olistolites and olistostromes as geotouristic objects – examples from Northern Carpathians, Poland. In: M. DOKTOR and A. WAŚKOWSKA-OLIWA (Editors), Geotourism – new dimensions in XXI century tourism and cahnces for future development. 2nd Internat. Conference Geotour 2005, 22–24 September, Kraków: 21-23.

GOLONKA J., KROBICKI M., MATYSZKIEWICZ J., OLSZEWSKA B., ŚLĄCZKA A. and SŁOMKA T., 2005. Geodynamics of ridges and development of carbonate platform within the Carpathian realm in Poland. *Slovak Geol. Mag.*, 11: 5-16.

ŚLĄCZKA A., KRUGLOW S., GOLONKA J., OSZCZYPKO N. and POPADYUK I., 2005. The General Geology of the Outer Carpathians, Poland, Slovakia, and Ukraine. In: F.J. PICHA and J. GOLONKA (Editors), The Carpathians and their foreland: *Geology and hydrocarbon resources: AAPG Mem.*, 84: 221-258.