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FLUVIAL FORMS AND PROCESSES IN NATURAL AND ENGINEERED RIVERBEDS: GEOTOURISTIC POTENTIAL OF MOUNTAIN RIVER VALLEYS (GEOFLUVIOTOURISM) – EXAMPLES OF ZUBRZYCA, SYHLEC AND LIPNICA STREAMS IN THE POLISH ORAVA (DANUBE BASIN)

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ABSTRACT

Aim of the study
The paper presents a study on geomorphological processes and forms in mountain streambeds, which may be attractive for tourists interested in geotourism. In such case we propose in the paper a new name of such geotourism: geofluviotourism).The authors focused on the description of river erosion and accumulation in the context of potential geosites. Fluvial processes and forms were demonstrated in three streambeds in Orava region that run almost parallel to each other, although are under different anthropopression. Such selection of watercourses allowed to show the processes and forms of fluvial geomorphology in a valley with natural streambed and with artificial hydraulic structures.

Material and methods
The paper was based on field research. The first stage involved observing the fluvial processes and forms in the Zubrzyca, Syhlec and Lipnica streams. Then the analysed streambeds and related fluvial forms and processes were mapped.

Results and conclusions
Fluvial processes and the resulting forms of terrain may interest tourists who want to learn about a given region. However, such geomorphological geosites require appropriate tourist-oriented development. Initially, it may be limited to placing information boards next to hydrotechnical objects, marking a path to the geosites or a tourist route. Similar projects can also be undertaken in the Polish Orava in the vicinity of Zubrzyca, Syhlec and Lipnica streams.

Keywords: accumulation, erosion, fluvial geomorphology, Orava, geofluviotourism

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INTRODUCTION

Geotourism is a form of recreation that focuses on learning about geological values of the visited region. Geomorphological geosites are typical geotourist attractions that present fluvial forms and processes to sightseers. They may be interesting for people who want to learn about sculptural activity of flowing waters. Especially in regard to mountain areas, where the impact of water on a riverbed is more intensive than in the lowlands. Whereas in areas with smaller relative heights, rivers and streams have a smaller drop, thus eroding their banks and accumulating carried rock material. This type of fluvial processes and forms can be found in Polish Orava. The northern and central parts of this Tatra region are mountainous and belong to the Beskids, while the southern fragments – located in the Orava-Nowy Targ Basin – are almost flat.

The authors attempted in this study to show fluvial processes and forms as geotouristically valuable. Thus includes various sites drawing attention to biodiversity, geomorphic diversity and hydrodiversity, for instance (Miśkiewicz et al., 2007). As part of geotourism, we include exploring rivers, mountain streams and their fluvial forms called geofluviotourism. This new concept – according to the authors – describes more precisely the geotourism concerned with geosites related to watercourses.

Riverbed geological diversity is clearly visible in a river valley. Three mountain streams from the Polish part of the Danube basin – Zubrzyca, Syhlec and Lipnica were selected for the analysis (see: Fig. 1). The streams, the right tributaries of the Black Orava, run parallel to each other. However, in effect of both natural forces and anthropopressure each has different geometry of riverbeds. Syhlec and Lipnica are slightly transformed by human activity, and Zubrzyca was built up with a number of rock thresholds, which are designed to reduce the speed of water runoff. Small thresholds are made according to different construction types. For their erection – in addition to concrete – various rocks (even from outside Orava) were used, including sandstones and granite pebbles. Some banks of Zubrzyca were also regulated in this watercourse, and the stream itself, as a result of human activity, reduced its curvature. Artificial thresholds also make a good place to show tourists the mechanism of headward erosion and water motion in the event of a sudden collapse of terrain. Syhlec and Lipnica streams, in turn, flow within natural beds. Syhlec waters wash over several-meter-long fluvial terraces. Some of them expose the geological structure of the streambed, in which even a small thickness of the brown coal layer can be seen. Lateral erosion occurs in the lower sections of the Syhlec and Lipnica streams.

Stagnation or speed loss of water causes accumulation. These are mainly convex edges of meanders and sites with a slight decrease in the longitudinal profile of a streambed. In the almost-straight Zubrzyca stream the accumulation processes take place below or just above a number of thresholds separating the bed.

Therefore, those interested in geotourism can get acquainted with the destructive and formative activity of water flow, river erosion as a factor contributing to the formation of geological exposures, fluvial processes and terrain microforms that are created by them in the vicinity of the Lipnica, Syhlec and Zubrzyca streams. In addition, tourists visiting the described watercourses may have the opportunity to compare the natural streambed and related processes with a stream under anthropopressure. All this can be a proposal to use rivers and mountain streams in geotourism and geoeducation.

LOCATION OF THE ZUBRZYCA, SYHLIEC AND LIPNICA CATCHMENT AREAS

The streams of Zubrzyca, Syhlec and Lipnica are located in the Polish Carpathians, in the Polish Orava (see: Fig. 1), on the border of the Western Outer Carpathians and the Western Inner Carpathians. Their sources are situated in the Żywiec Beskids, and they flow south almost parallel to each other through the Orava-Jordan Foothills. At its southern edges, Zubrzyca runs away, while Syhlec and Lipnica flow further south into the Orawsko-Nowotarska Basin (Balon et al., 1995). In a straight line, the distance from the source to the mouth of Zubrzyca is about 13 km, Syhlca – less than 15 km, and Lipnica – about 7.5 km.

These streams are right tributaries of the Black Orava, which is the largest river of Polish Orava. It debouches on the Polish-Slovak border into the Orava reservoir. The river that leaves this artificial reservoir is called Orava and is a right-bank tributary of the

Fig. 1. Hydrographic network of the Polish part of Orava

Váh. And the Váh flows into the Danube from the left. The analysed streams – Zubrzyca, Syhlec and Lipnica – therefore belong to the Black Sea catchment area.

In administrative terms, the discussed watercourses run through the municipalities of Jabłonka and Lipnica Wielka, which are situated in the western part of the Nowy Targ poviat, in the Małopolskie Voivodeship. Zubrzyca flows from Zubrzyca Górna and passes through Zubrzyca Dolna to Jabłonka, where it connects its waters with Black Orava. Syhlec has its sources in the vicinity of the Polana Krowiarki and initially runs on the border between Lipnica Wielka and Zubrzyca Górna. Below the Rajsztag road, it falls within the village of Lipnica Mała. Both the lower sections of Syhlec and its estuary into Black Orava are in the Jabłonka village. Lipnica is formed from the merger of the streams of Babia Góra, Lipniczanka and Kiczorka in Lipnica Wielka. The stream under study then flows through this village to the south and on the border between Lipnica Wielka and Jabłonka in the vicinity of the Orava reservoir it flows into Black Orava.

MEASUREMENT METHODOLOGY

The work was based on field research. The first stage consisted in observing the fluvial processes and forms in the Zubrzyca, Syhlec and Lipnica streams. Hydrodynamic measurements were also carried out in the field using the Valeport Model 801 Flat EM Flow Meter. This device allows to measure the instantaneous velocity of flow at any point of the watercourse cross-section and at any depth. This allows the tachoid of velocity in the hydrometric vertical to be crossed out from the measured values. Having measured instantaneous velocity values, it is possible to calculate: average velocity depending on the filling in a watercourse (Czetwertyński and Szuster, 1978*)*, forces acting on a streambed in a form of tangential stress (Gordon et al., 2007; Radecki-Pawlik, 2014), Reynolds number and Froude number (Graf, 2001; Sundborg, 1956).

In addition, the Wolman method (1954) can be used to determine grain size of bed material in a watercourse, which requires collecting 100 pebble grains in a straight line and measuring their length (axis a), width (axis b) and height (axis c). Then, from the obtained geometrical data of grains, a substitute diameter of pebble can be calculated (Plesiński, 2018). This methodology was employed by the authors to better understand water flow in the studied streams. Water movement has its impact on geomorphological processes occurring at the bed and on the banks of watercourses. These factors affect terrain formation (Allen, 2000*)*. Both morphological processes as well as resulting forms of shaping the earth's surface in Zubrzyca, Syhlec and Lipnica can be applied to develop geotourism (in that case geofluviotourism) in the Polish Orava.

RIVER EROSION

Morphological activity of rivers is known to have a particularly large role in shaping the earth's surface. Forms caused by the activity of watercourses are observed on all continents and in all climatic zones. The activity of rivers consists mainly in transforming – dismembering the forms created by internal forces. Destructive nature of rivers, called erosion, can be divided into four types: deep, bed, lateral and backward. All types can be found in the studied streams.

The process and extent of river erosion depend on many factors. Among them is water flow rate, which is largely determined by water volume, as well as the gradient and type of bed. The greater the gradient and water volume, the stronger the erosion. The type of water motion also has a great impact on its course and size. Erosion is much stronger with turbulent motion than with calm motion, which is confirmed by the Reynolds number. Quantity and quality of carried material and its displacement frequency are also important in the discussed morphological process. The more hard and sharp-edged fragments are dragged to the bed during high water, the stronger the erosion. Bed strength is also significant from a geological point of view. Bedrocks are more resistant to erosion than alluvial beds. Attention should also be paid to the compactness and hardness of rocks that build the bed and the banks of the riverbed. Bedrock sealing is another crucial element. Riverbed geometry forms, its gradient and course are among the factors influencing both the process and extent of erosion. Narrow beds with a large gradient are subject to faster deepening than wide beds with a small drop. Similarly, banks of winding channels are undercut more than banks of straight channels (Allen, 2000; Klimaszewski, 1978; Plesiński and Radecki-Pawlik, 2018; Przedwojski, 1998; Radecki-Pawlik, 2014; Gradziński et al., 1986; Charlton, 2008; Leopold et al., 1995). Thus, in the analysed streams, banks of winding channels of Lipnica and Syhlec undergo more intense erosion than an almost straight-line Zubrzyca.

In these catchments – Zubrzyca, Syhlec and Lipnica – tourists interested in geotourism can see the effects of processes and different pace of erosion and accumulation. Taking visitors to places where they can observe destruction or formation of beds and banks as well as geosites with erosion or fluvial accumulation processes will allow them to see sculptural activity of rivers and streams. However, these geosites should be properly developed for tourists wanting to learn about such phenomena. They can also more fully understand the changes in a river environment that occurred in ancient geological eras. Tourists can also learn about the impact of lithology of a bed and its resistance to water flow (see: Fig. 2). Therefore, the issues discussed in the paper complement adequately the knowledge about the impact of geological structure on terrain and related morphological processes in the aquatic environment.

RIVER BED EROSION AND DEEP EROSION

River bed erosion means washing and removing alluvial deposits previously left by a river. Whereas deep erosion consists in deepening the bed by carrying out elements of the bedrock. It includes three main processes – eversion, abrasion and cavitation – that shape the bed. Evorsion is the deepening of bed due to vortex motion of water (horizontal and vertical vortices) loaded with thick debris. In result, it creates giant's kettles and potholes. They occur especially below water thresholds and in meanders. Numerous natural rock as well as artificial concrete thresholds can be found in the Zubrzyca streambed. They provide excellent opportunities for showing tourists the swirling motion of water in developing giant's kettles. Evorsion potholes are also visible at longer shores of

Fig. 2. Syhlec waters eroding the Magura flysch layers, photo K. Miraj

river bends, where water erodes the bed and shore with greater force. Such processes can be observed in many places of the lower section of Syhlec and Lipnica, especially below the built-up areas of Lipnica Mała and Lipnica Wielka.

Abrasion is when dragged material hits the bedrock of a riverbed. Either gutters are formed in places with low rock resistance or thresholds in places with high rock resistance. This process is therefore related to the impact that the geological structure has on the formation of riverbeds, and sometimes even on some parts of valleys. In such places tourists can learn about the effects that water flow and gravity have on lithology. A good spot for observing such a phenomenon can be the upper and middle section of the Lipnica stream, where there are rock outcrops, gutters and potholes caused by the destructive activity of water flow. Such a facility is easily accessible for tourists in Lipnica Wielka at Rola Małkuchów, just below the bridge. There, water erodes the Magura sandstones of the Łącko facies (see: Fig. 3).

And cavitation is the removal of clasts in the zone of reduced pressure accompanying a high-speed water flow. This process can be seen in mountain streams around fords or anthropogenically transformed sites. Tourists might find interesting the effects of waters flowing into the lithosphere. This is particularly impressive because cavitation occurs on sections with high run-off velocity. A compelling issue for geotourism in such geosites is to demonstrate rock resistance to the destructive activity of surface water flow. Tourists can see cavitation in the area of hydrotechnical constructions in the regulated section of the Zubrzyca streambed (see: Fig. 4). This is the lower and middle section of this watercourse.

LATERAL EROSION

Lateral erosion consists in undercutting the base of the banks, which leads their collapse (see: Fig. 5). In alluvial beds it is a complex process. This is due to the fact that the material from banks is often more diverse than

Fig. 3. Natural rock thresholds in the source section of the Lipnica stream, photo K. Miraj

Fig. 4. Hydrotechnical construction of the Zubrzyca stream – one of few ramps in Poland with increased roughness of the Peterka type, photo: K. Miraj

Fig. 5. Lateral erosion of the Syhlec stream, photo: K. Miraj

from the bed. Even in mountain streams fine-grained material can be found such as silt or clay, which ensures that banks have a certain degree of consistency. Resistance to lateral erosion may also improve the root system of vegetation growing on the banks (slopes) of a riverbed. The reasons for loss of stability of bank slopes can be divided according to soil type.

The stability of banks built of cohesive materials is reduced by: a sudden drop in water level, liquefaction or slipping of the soil under water saturation conditions, a significant height of banks and greater susceptibility to the effects of erosion mechanisms. Tourists can observe stable slopes of banks and lateral erosion processes in the Zubrzyca streambed in the lower parts of Zubrzyca Górna, in the middle and lower section of the Syhlec in Lipnica Mała and the lower section of Lipnica in Lipnica Wielka. Banks consisting loose soil have less stability because of changes in: flow rate in riparian zones (rate and variability of tangential stress), flow frequency, impact of undulation and filtration). Lateral erosion processes taking place on loose banks can be seen in the lower meander section of Syhlec and Lipnica (see: Fig. 6). These are already the bed areas of the Orava-Nowy Targ Basin.

The banks consisting of stratified soils are subject to erosion as a result of complex mechanisms which cause a variety of effects depending on bank construction. An important role here is played by the geological base and rock resistance to the destructive activity of flowing waters.

BACKWARD EROSION

Backward erosion contributes to deepening of riverbed, causing sources and waterfall thresholds to recede. This type of erosion can take many forms, for example: waterfall moving up the river, backward deepening of riverbed, receding of sources and river capture.

Waterfall moves up the river due to vortices and large eroding forces of falling water with large rock blocks. The bases of waterfalls are particularly vulner-

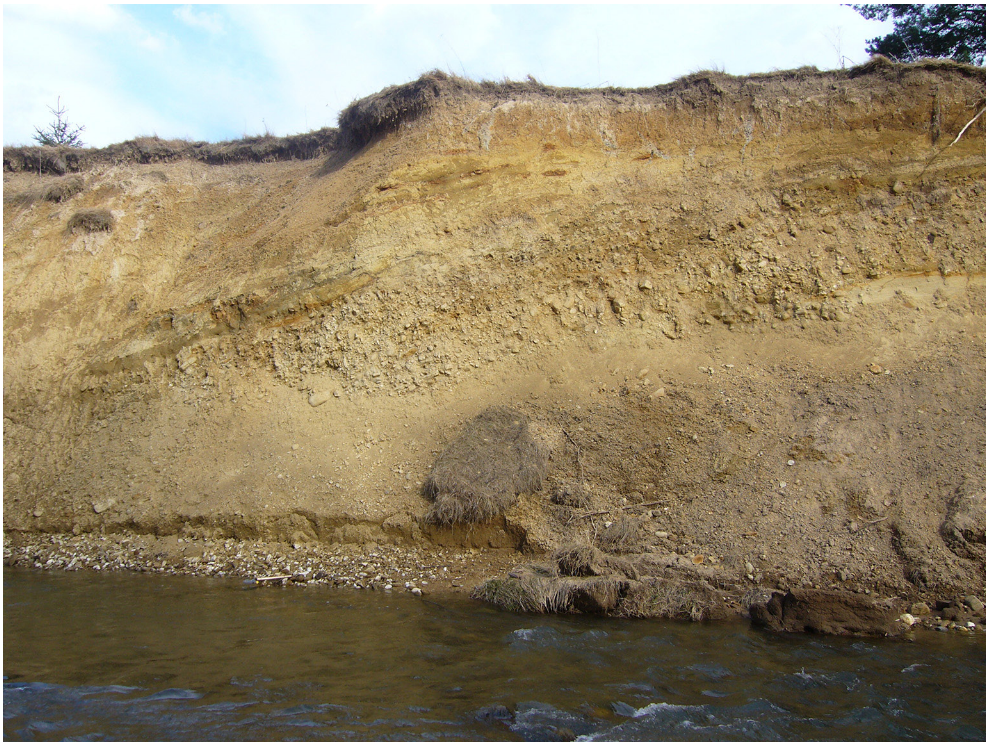

Fig. 6. Slope above the Syhlec stream exposing layers of Pleistocene gravel, photo: K. Miraj

able to destruction, because of constant washing they undergo, which ultimately causes the wall of waterfall to collapse. This phenomenon can be more visible and accessible at the thresholds of Zubrzyca (see: Fig. 7). Although they are of an anthropogenic origin, falling water has a similar morphological effect as in natural waterfalls.

Backward deepening of a riverbed causes it to move upstream. Fissures and cracks in rocks facilitate this process, as the point bars washed along them subside easier. This phenomenon can be observed on the mountain tributaries of the studied streams, where a large longitudinal slope of a streambed and very thick rubble lying in the bed form a cascade system. One of its features is the formation of small waterfalls, where water overflowing the stone boulders falls into a deepening.

Receding source means that water flowing out of the source carries rock material from its vicinity. Therefore the source's orifice widens, which together with the accompanying processes of ripping and sub-siding of slopes, leads to receding of the source. It is possible to show this process to tourists in the highest parts of a catchment, where mountain streams take their origin.

River capture occurs as a result of backward erosion, when a bed of one stream takes over the waters of another stream. This mechanism can be demonstrated to tourists interested in geotourism only theoretically, because there was no capture in examined catchments. However, it would be interesting to simulate a capture of waters by one of the streams.

ACCUMULATION

Accumulation process is opposite to erosion. Accumulation is a fluvial process involving sedimentation of materials at the bed of a river referred to as alluvium. Depending on their size, these deposits can form various gravel and sand beds. For interested in geotourism, these alluviums can be found in all three streams: Lipnica, Syhlec and Zubrzyca.

Fig. 7. Anthropogenic thresholds in the Zubrzyca stream, photo: K. Miraj

Gravel bars comprise of accumulated rock rubble formed by alluviums. Forms of this type are most common in braided rivers, but they can also be found in meandering beds, including the lower sections of Syhlec and Lipnica (see: Fig. 8).

Gravel bars are rich in living organisms, both terrestrial above water table and aquatic below. Processes forming braided rivers (several channels separated by bars) and anabranches occur in rivers with significant kinetic energy of water flow, which combined with a large amount of rubble supplied to the bed by slope processes creates favourable conditions for such forms. They are natural in places where hydrodynamic parameters of water flow allow sedimentation and deposition of transported rock material. This process is related to decrease of water transportability of rock material. First fall the larger and heavier fractions, then the smaller and lighter ones. Due to decrease of flow rate, spaces between larger grains are filled with finer grains, forming a first layer. It gives a base for the next layer of the formation. The whole process continues until a large flow exceeds the limit forces, repeating loosening and transporting pebbles. We can distinguish the following types of gravel bars: bend (meandering), alternating, mid-channel, formed behind or in front of an obstacle, braided, irregular and sand cones formed on floodplains (see: Fig. 9). They can be observed in the lowest sections of the Lipnica and Syhlec streams, where there is a particularly large number of meanders in the river bends. The sand fraction often has a large part in their construction. Whereas, in the lower sections of beds, but slightly higher than the meandering sections, alternating and mid-channel gravel bars can be seen, as well as bars formed in front of and behind various obstacles, e.g. larger boulders or bridge pillars.

In geotourism, the analysis of granulometric material of river banks should be carried out primarily in geological terms. Tourists will certainly be interested in the morphological and biological aspects of such deposits in watercourses. They can be formed in a variety of ways and from materials of different fractions. Oversized grains, imbricated structures, ribbed transverse structures and sandy-gravel shadows can be distinguished. Learning about them in field will certainly enrich tourists' experience and geomorphological knowledge.

Fig. 8. Two types of beds in one cross-section: in the foreground: alluvial part with a gravel-bar, on the other side of the river: bedrock with rock outcrops

Oversized grains (see: Fig. 10) are pebble grains with a diameter several times larger than the diameter of grains forming bed cover. Their significance for aquatic organisms is crucial, because they create habitat conditions with shade, thereby reducing the temperature of water during day and providing shelter for fish. In engineering practice, grain elements with increased roughness have recently been used more often. The introduction of these elements improved the condition of sections of some rivers (e.g. Raba) by

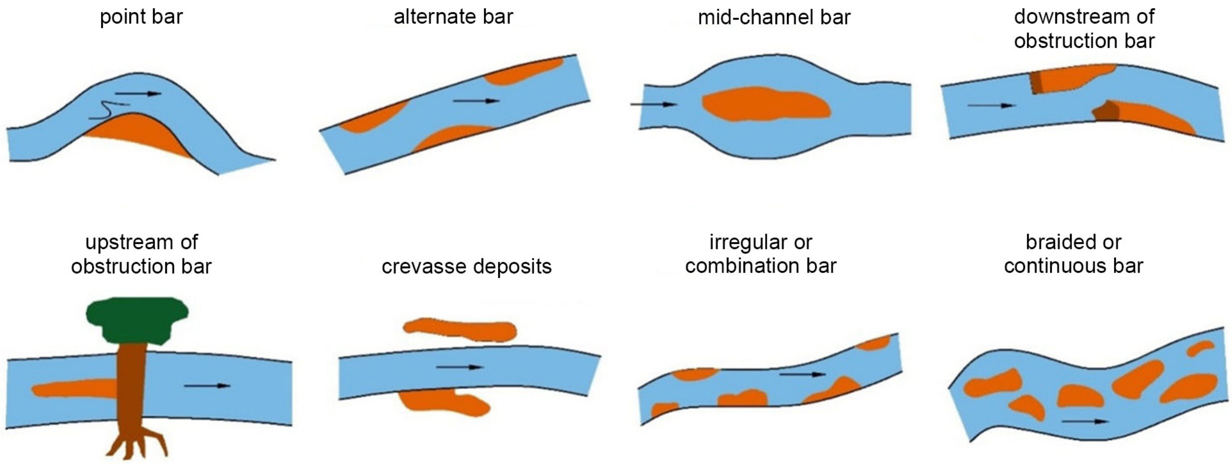

Fig. 9. Gravel bars (according to Radecki-Pawlik, 2001, 2014)

Fig. 10. Oversized grains in the source section of the Lipnica stream, photo: K. Plesiński

strengthening the bed due to the expansion of gravel bars above and below these structures. A large number of oversized grains occur in the middle and upper sections of the Lipnica stream.

Imbricated structures are built of several (from 3 to 6) grains arranged in a row, one by one, imbricating each other at an angle of 15–30 degrees. They do not need to be composed of larger fractions than those found in a gravel bar, but they are usually of a large diameter. Imbricated structures provide good information about the maximum fraction of rubble transported during high water.

Ribbed transverse structures are characteristic for sections of rivers with a small number of bends. They are formed in riverbeds with little filling, but with considerable speed and high transport capacity of the watercourse. Sand-gravel shadows, in turn, are formed behind boulders or other obstacles after small freshets.

The division and formation of gravel bars depends mainly on the flow and hydrodynamic conditions in the riverbed (see: Fig. 11). First, somewhat standard form of bed is flat. There, water flows at a very small rate, up to 0.45 ma^{-1}. The stresses at the bed are lower than the limit stress for individual grains, therefore rubble remains in its place. Froude number describing the impact of gravity on fluid flow plays an important role in the formation of bed forms. Its value at the lower flat bed is very small ($Fr << 1$), which indicates calm water motion. However, if this number's value is above one, then we are dealing with turbulent motion, during which water effervesces and foams, and water table is most often broken. When the depth or drop of a river starts to increase, individual grains of sand begin rolling and slipping. With a further increase in drop or depth, the bed material movement becomes more intense and foldings (also called ripplemarks) begin to form at the riverbed. The bed covered with ripplemarks is characterized by a group of regular fold. Their height is usually small compared to their length. Yang (1996) reports that the length of ripplemarks does not exceed 45 cm, height 3 cm, and their size is almost equal. The cross-section is approximately triangular, with a slight gradient from the current side, and a steep one from the off-current side. The gradient of foldings is 6–8 degrees from the upper water side, and from the lower water side up to 30 degrees. Ripplemarks travel down the watercourse at a much slower speed than the flow.

Grains with a smaller diameter, not exceeding 0.7 mm, do not form ripplemarks. Water table remains flat, and the Froude number is much smaller than $Fr << 1$. With a further increase in water velocity (2–2.5 times higher than in the previous phase), large asymmetrical ridges called river dunes are formed at the bed, their surface is initially covered with foldings, which slowly begin to disappear. The dunes are larger folds than ripplemarks. They are characterized by gentle decrease directed upstream and sharp, abrupt drops in downstream direction. The arrangement of sand dunes is irregular. Their height limit is determined by the depth of water above their ridge. At a speed of 2–3 $m \cdot s^{-1}$, the height of dunes increases above several dozen centimetres. In deep riverbeds, the length of dunes reaches up to several hundred meters. Dunes travel down a watercourse and their cross-section reveals traverse stratification. Shape of riverbed changes from flat to folded, and then dunes cause a rapid change in riverbed roughness. For such hydraulic conditions, the Froude number is still less than one, but is approaching it significantly ($Fr < 1$). If water velocity continues to increase, the dune system transforms, intervals between them lengthen and ridges flatten. Some dunes diffuse at a speed of 1.20 $m \cdot s^{-1}$. Further diffusing of dunes causes the bed to become almost flat and its roughness decreases compared to roughness of the previous form ($Fr \approx 1$). However, since there is further movement of river material, it is only a transient state to the next form of riverbed, if the depth or drop continues to grow.

Another bed formation presents a set of symmetrical sand waves with equal gradients upstream and downstream. These waves change into asymmetrical folds called anti-dunes ($Fr > 1$) due to their inverse arrangement compared to dunes. In the last two forms water table is strongly rippling, except that with anti-dunes there are refractions and disturbances visible on crests of waves. Water reaches velocity of 1.70 $m \cdot s^{-1}$, when these formations develop. Anti-dunes exhibit cross-layering.

Gutters and overdeepenings are another form of bed. When these formations develop, water flows with enormous energy, with potholes and sites with intensive movement of bed material appearing in a riverbed. Froude's number is much greater than one ($Fr >> 1$), and waves begin to break very intensely (Radecki-Pawlik 2014; Florek et al. 2015).

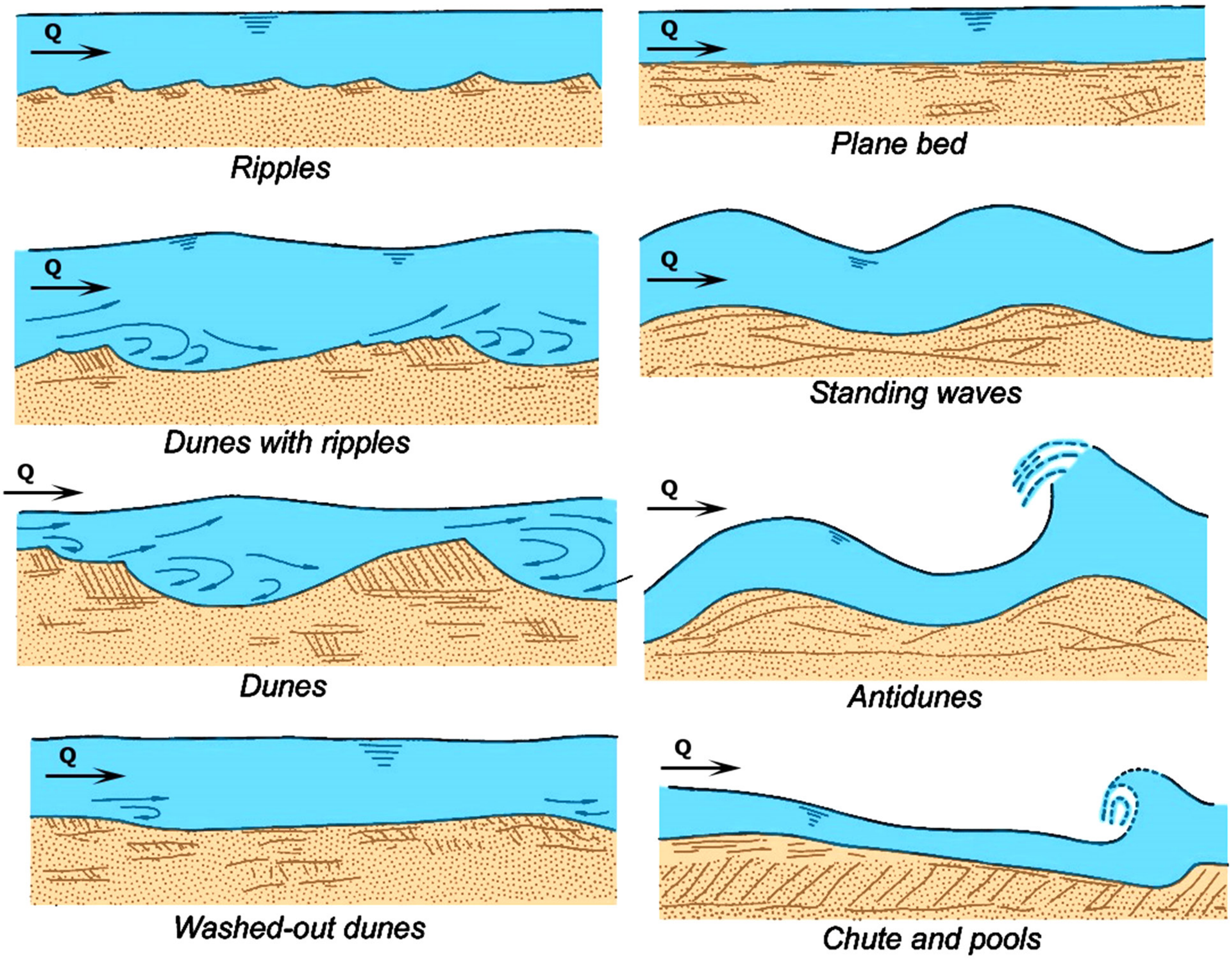

Fig. 11. Sand forms in the riverbed (according to Radecki-Pawlik, 2014)

CONCLUSION

Fluvial processes and related forms of terrain may interest tourists who want learn about a given region. However, the use of such geomorphological geosites requires appropriate development of tourist facilities. Initially, it may be limited to placing information boards next to hydrological objects, marking a path to the geosites or a tourist trail. Such projects can also be undertaken in the Polish Orava in the vicinity of the streams Zubrzyca, Syhlec and Lipnica. The terrains of these watercourses are relatively easily accessible, because the roads – the main axes of near villages – run almost parallel to them. Such land use also significantly facilitates the accessibility to geosites associated with hydrosphere.

The streams analysed in the article – Zubrzyca, Syhlec and Lipnica – differ in regard to the degree of anthropopressure. The bed of Zubrzyca has been largely redesigned by human activity. Its watercourse is more straightforward than that of Syhlec and Lipnica. A number of different speed thresholds were built there. Syhlec and Lipnica, on the other hand, are more natural, and the anthropogenic transformation of their banks and beds is small and limited to just a few spots. All this allows tourists to observe and learn about morphologically different streams. Therefore, people interested in these issues will learn about fluvial forms and processes in a broader context. They cannot be isolated from the geological structure of bed, as well as hydrographic or even climatic issues. In this paper, the authors propose to call this form of geotourism:-geofluviotourism. In addition, water steps and dams built in a riverbed can be a good motivation to learn about the hydrotechnical structures in the catchment and their functions. Hence, geosites in the valleys of mountain streams can enrich the tourist offer of the regions. This is also the case in Polish Orava, where geotourism can develop and coexist with other forms of tourism.

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FORMY I PROCESY FLUWIALNE W KORYTACH NATURALNYM I ANTROPOGENICZNIE PRZEKSZTAŁCONYM JAKO POTENCJAŁ GEOTURYSTYCZNY GÓRSKICH DOLIN RZECZNYCH (GEOFLUWIOTURYSTYKI) – PRZYKŁAD ZUBRZYCY, SYHLCA I LIPNICY NA POLSKIEJ ORAWIE (DORZECZE DUNAJU)

ABSTRAKT

Cel pracy

W artykule zaprezentowano procesy i formy geomorfologiczne występujące w korytach górskich potoków, które mogą być atrakcyjne dla turystów zainteresowanych geoturystyką. Autorzy skoncentrowali się na opisie procesów erozji i akumulacji rzecznej, powstałych za ich pośrednictwem form terenu w dolinie oraz ich ukazaniu w kontekście lokalizacji potencjalnych geostanowisk. W pracy zaproponowano nową nazwę dla tego typu geoturystyki: geofluwioturystyka. Omawiane formy i procesy fluwialne ukazane zostały na przykładzie trzech potoków płynących niemal równolegle względem siebie. Różnią się one jednak miedzy sobą stopniem antropopresji. Taki dobór cieków pozwala ukazać formy i procesy geomorfologii fluwialnej w dolinie cieków o naturalnie ukształtowanym korycie oraz zabudowanym szeregiem obiektów hydrotechnicznych.

Materiał i metody

Praca oparta została na badaniach terenowych. Pierwszym krokiem była obserwacja procesów i form fluwialnych w korytach Zubrzycy, Syhlca i Lipnicy. Następnie skartowano analizowane łożyska cieków wodnych i obserwowane w ich obrębie formy i procesy rzeczne. W terenie wykonano też pomiary hydrodynamiczne przy użyciu młynka elektromagnetycznego Valleport Model 801 Flat EM Flow Meter. Ponadto, w celu określania uziarnienia materiału dennego zalęgającego w korycie cieku można zastosować metodę Wolmana (1954), która polega na poborze 100 ziaren otoczaków w linii prostej i obmierzeniu ich długości, szerokości i wysokości. Metodyka ta służyła autorom do pełniejszego poznania przepływu wody w korytach badanych potoków.

Wyniki i wnioski

Procesy fluwialne i powstałe dzięki nim formy terenu mogą zainteresować turystów, którzy chcą poznać dany region. Wykorzystanie takich geomorfologicznych geostanowisk wymaga jednak odpowiedniego zagospodarowania turystycznego. Początkowo może ono ograniczać się do postawienia tablic informacyjnych przy obiektach, wyznaczenia ścieżki dojścia do geostanowiska czy wytyczenia szlaku turystycznego. Takie przedsięwzięcia można też podjąć na Polskiej Orawie w sąsiedztwie potoków Zubrzyca, Syhlec i Lipnica.

Słowa kluczowe: erozja, Orawa, akumulacja, geomorfologia fluwialna, geofluwioturystyka