

## “Landslides in the Polish Carpathians as the Potential Educational Geosites“

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### *Abstract*

*In the last two decades, tourists around the world have been showing an increasing interest in geological and geomorphological attractions. They travel to places, often quite distant, where they can observe rare natural phenomena, such as tectonic faults, volcanoes or massive landslides. The landslides in the Polish Carpathians of various sizes are quite frequent, occupying large areas of slopes and often causing damage to buildings and infrastructure. However, they are not that common that they would be unnoticed by local residents or unattractive to tourists from other regions. As educational geosites, landslides can serve an educational purpose. They represent illustrative sites with significant explanatory potential with respect to the mass movement processes, their causes and effects. The objective of this paper is to present six landslides in the Polish Carpathians as educational geosites. These landslides are assessed from the perspective of their potential use in geotourism. The results allow comparing the selected landslides in terms of their attractiveness and also in terms of their suitability for different forms of geotourism.*

*Keywords:* educational position; geosides; geotourism; landslides; Rożnowskie Foothills, Spisko-Gubałowskie Foothills

*Paper Type:* Scientific paper

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## Introduction

Geotourism is a new section in tourism industry that promotes interesting geological and geomorphological sites, facilitates the appreciation of their priceless value and enhances their attractiveness by dissemination of “their stories” (information about their origins and evolution) to a greater audience. The growing demand of tourists for new types of destinations, especially in specialized tourism, and the increasing recognition of the importance of geological heritage has led to the spread of this form of tourism (Newsome, Dowling, 2010; Słomka, Mayer, 2011). The diverse geology of the Polish Carpathians predetermines their richness in count and variety of geological and geomorphological forms that are (or may be) used as geosites – geotourism destinations. Landslides are one of the most frequent types of these forms. However, they are not that common that they would

be unnoticed by local residents or unattractive to tourists from other regions. For example, the Polish Central Register of Geosites comprises about 1500 geosites and 16 of them have a landslide related genesis (<http://geoportal.pgi.gov.pl/portal/page/portal/geostanowiska>).

The main objective of this article is to provide valorization of six landslides located in the municipalities of Szczepanowice and Witów (Fig. 1). The method takes into account the educational and cognitive values of the landslides as well as their potential appropriateness for tourism purposes. The calculation of tourism valorization indicator allows for identification of the landslides with significant geotourism potential. This approach to valorization of geosites has not been applied to landslides before and thus it is a research problem that has not been addressed in Polish literature yet.

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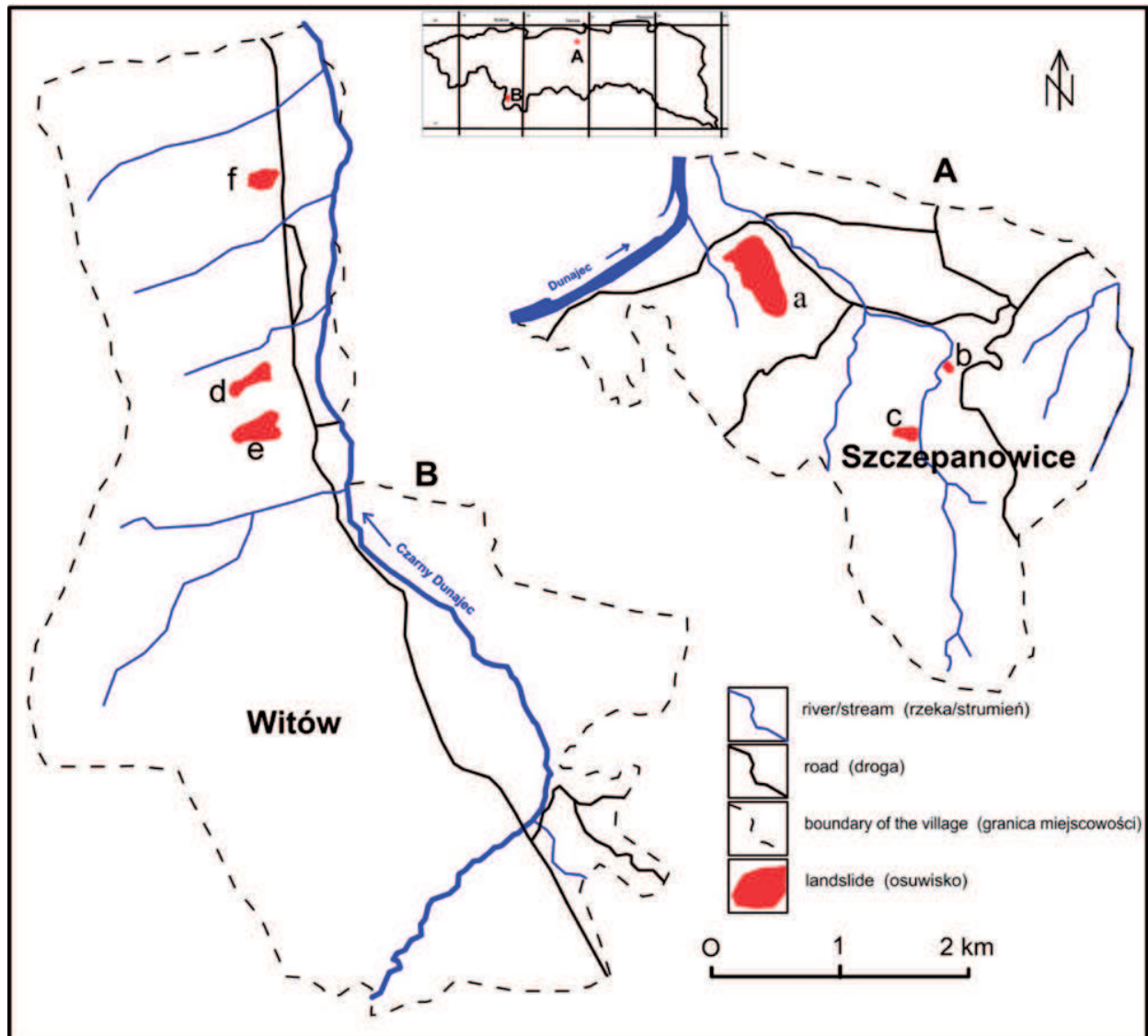


Fig. 1. Location of selected landslides; a – Tubendza landslide; b – Żabno landslide; c – Buczówka landslide; d – Nad kościołem landslide; e – Witów-ski landslide; f – Usypy landslide.

## Characteristic of study areas

### Szczepanowice

Three of the six analyzed landslides are in the municipality of Szczepanowice, the Tarnów district. From the geomorphology viewpoint, the northern part of this area belongs to the Nadwiślańska Plain mesoregion and the southern part to the Rożnowskie Foothills (Kondracki, 2010). The geological composition of the region is very diverse. While the northern part of Szczepanowice lies within the fringe of the Carpathian Foredeep formed by rocks of miocene age (zglobicka unit), the southern part is located in the Carpathians built from flysch (skolska unit). The zglobicka unit comprises skawińskie layers (mostly mudstones and tuffites), Wieliczka formation layers (anhydrites, gypsum, salt stone and claystones), Chodnicki layers (claystones and tuffites), and Grabowiec layers (clay-sandy layers with Bogucice sands inserts) (Oszczypko, 1999). Skolska

unit is composed of alternating and strongly corrugated layers of sandstones, shales and marls (Kozarski, 1964).

The terrain of the respective part of the Rożnowskie Foothills is a consequence of a deep cut of the rolling hill surface (Czepe, 1976). The denudated hills in the southern part of the study area reach about 200 m above the Dunajec River. The slopes located in the southern part of Szczepanowice (the Carpathians) have a considerable gradient which is largely determined by the geological structure (resistant sandstones). On the contrary, the slopes of the Carpathian Foredeep fringe are formed of less resistant rocks and therefore they have smaller gradient.

Szczepanowice are located in the temperate-warm zone (Hess, 1965). The average annual rainfall in 1987-2012 at the station in Tarnów (12 km from the study area) amounts at 717 mm. In 2012, a number of landslides in the Carpathians were activated by long-term and intense rainfalls totaling 1223 mm.

The terrain in Szczepanowice is under a strong anthropogenic influence. On the surface of 10.7 km<sup>2</sup>, there are 309 residential buildings inhabited by 1476 people (Raport ... 2007). A significant portion of the area of primary forests growing on the slopes of the village was removed for cultivation purposes. At present, the cultivated land forms approximately 50% and forests about 36 % of the area of Szczepanowice.

### Witów

The second study area, the municipality of Witów, belongs to the western part of the Podhale region. The examined landslides are located on the western slopes of the Czarny Dunajec River valley (Ryc.1). Geologically, this area consists of Podhalań flysch – alternating layers of sandstones and shales (Mastella, Mizerski, 1977). The most important layers are formed by clays with pseudoxotics, which are especially susceptible to mass movement (Gołąb, 1954). Landslides in this area are caused mainly by heavy rain falls. Any tectonic movements, which could contribute to their formation, are rare and they represent continuation of the Pleistocene movements (Mastella, 1976). Recent major earthquakes in this area took place in March 1966 close to Zakopane area (Mazur, 1968) and in November 2004 in the Czarny Dunajec area. The Spisko-Gubałowski Foothills are characteristic by latitudinal course and asymmetric slopes. The foothill landscape of this region is largely determined by moderately modeled and leveled rolling hills with relative height differences between 100 m and 250 m and deeply cut river valleys of the Czarny Dunajec River tributaries – the Skoruszów, Magurski and Grekow streams (Klimaszewski, 1952).

The Podhale Region, including the municipality of Witów, belongs to the mountain climate zone (Wit, Ziemońska, 1960),

more specifically to the moderate cold belt (Hess, 1965). The climate of the area is considerably influenced by the proximity of the Tatra Mountains and the openness of the terrain towards west. A relatively frequent occurrence of heavy rain falls, totaling about 1000 mm a year on average (Ziemońska, 1966), is related to the polar maritime air masses dominating in this area. The two types of rain essentially related to the mass movement initiation include the following: the prolonged and intense rain falls occurring in May and June and torrential heavy rain falls occurring in June and July. On 28 June 2009, for example, the daily rainfall reached 140 mm (Długosz, 2009) and initiated about 50 new landslides (Chrobak, 2010).

Most of the area threatened by landslides is covered by forests, meadows and pastures, and therefore no significant damage has been caused to buildings. However, there are some exceptions, such as minor harm to the ski station and the church and parsonage in the municipality of Witów, which are located on one of the landslides.

### The landslides in Szczepanowice

Szczepanowice area is heavily transformed by landslides. The major factors include complex geological structure, significant vertical terrain dissection, small-stream erosion and intense human activity. There are 187 landslides located on the total surface area of Szczepanowice (10.7 km<sup>2</sup>), which is about 17.5 landslides per 1 km<sup>2</sup> on average (Cebulski, 2013). In the spring of 2010, dozens of landslides have been activated, in some cases destroying buildings, roads, transmission networks (high and low voltage and telephone lines, gas pipelines) and arable land.

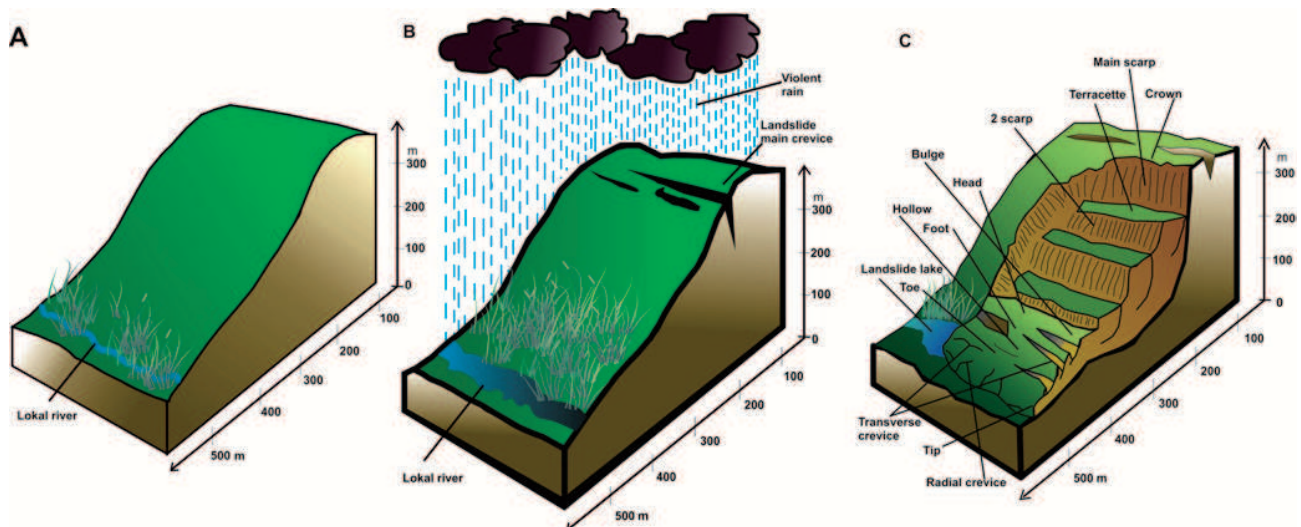


Fig. 2. Landslide development: A – slope before landslide, B – slope during heavy rainfall, C – slope with landslide

### Tubendza landslide

Tubendza landslide was formed on the north-eastern slope descending to the Dunajec valley in the holocen age. Its north-eastern part was reactivated as a result of rainfall in the spring of 2010. The active part of the landslide covering 16.4 hectares developed

in the loess deposited in the Dunajec valley probably in Miocene and Cretaceous (Raczkowski, Nescieruk, 2012). In the upper part, there is a landslide niche, a steep slope closing with a maximum height of 6 m (Fig. 2). The endorheic depression (with no outflow) immediately below the main escarpment usually gets filled



by rain water in spring, forming a small shallow lake. The area of the landslide is abundant in ditches and humps. The landslide foot slipped onto the Dunajec Holocene terrace and formed a distinct threshold. Originally, four houses were located on the surface of the landslide, of which three were completely destroyed and one

severely damaged (Cebulski, 2012). In addition, two outbuildings, a recreational building, high and low voltage transmission lines and telephone lines were also destroyed. The asphalt road located in the area of the landslide was severely deformed, preventing access to the destroyed houses and agricultural fields.

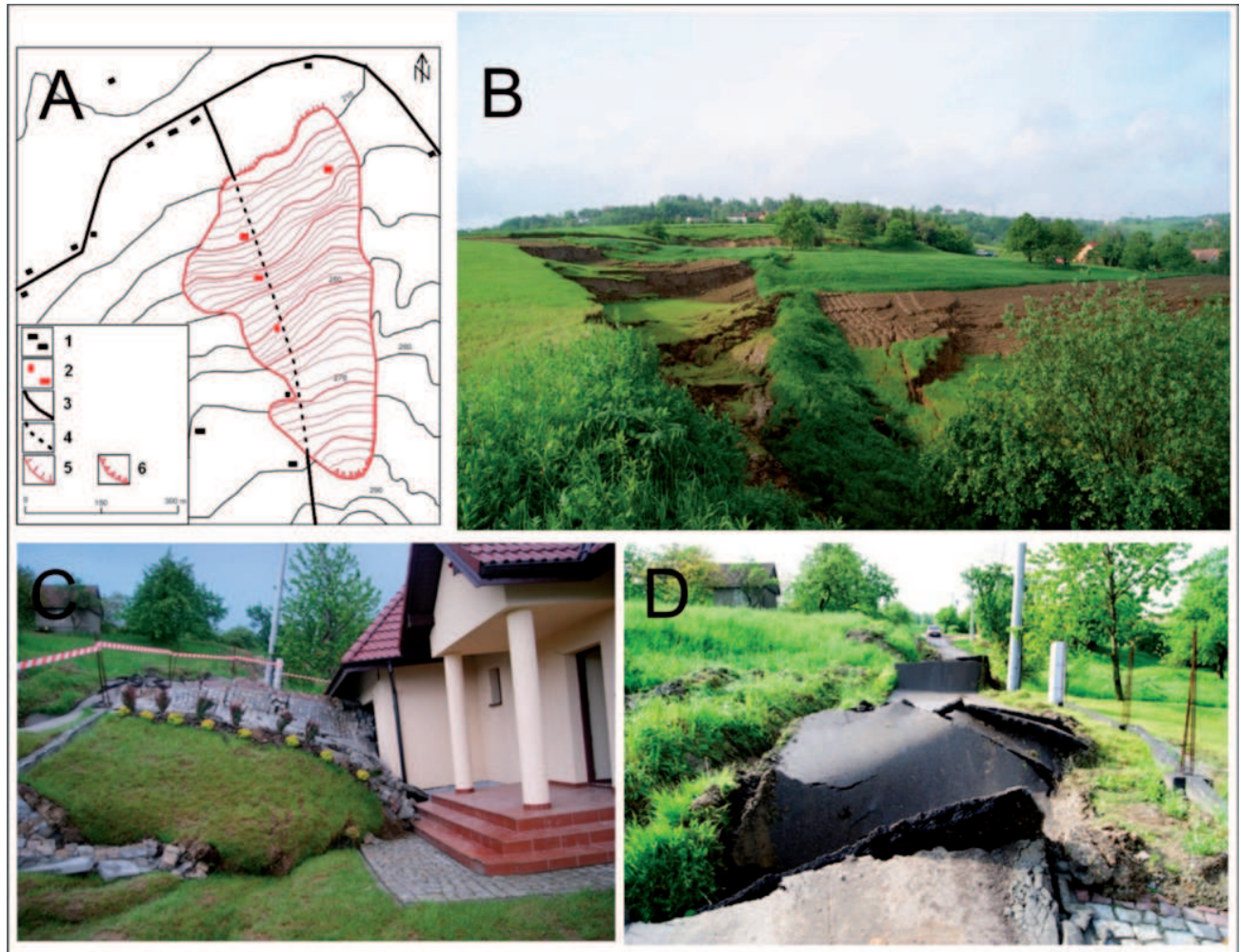


Fig. 3. Tubendza landslide; A – location on the map, B – landslides niches, C – damaged building, D – damaged road.

Tab. 1. Morphometric values of selected landslides

Name	Area (ha)	Length/Width (m)	Inclination (°)	Height Niches/Scarps (m)	Undercutting Erosion
Tubendza	16,4	614/320	7,5	6	No
Żabno	0,22	60/24	10	1,5	Yes
Buczkówka	0,52	115/35	27	2	Yes
Nad Kościołem	6,6	500/160	9	10	No
Witów - ski	1,7	250/70	8	5	No
Usypy	3,06	250/160	8	2,5	Yes

### *Żabno landslide*

Large sums of precipitation and strong lateral erosion in the spring of 2010 led to the activation of a small landslide (0.22 ha) in the Szczepanowicki Creek valley (Fig. 1). It is a translational landslide formed on a perimeter of loess formations with a distinct scarp 1.5 m high (Tab. 1). The bottom part of the sliding colluviums dammed the creek, thus forming

a small lake (Fig. 3), which filled with material carried by the stream shortly afterwards (Cebulski, 2013). At present, there are still small mudflows on the landslide surface, particularly active in spring and after heavy rainfall. The landslide area is covered by meadow vegetation and to a small extent also by forest vegetation.

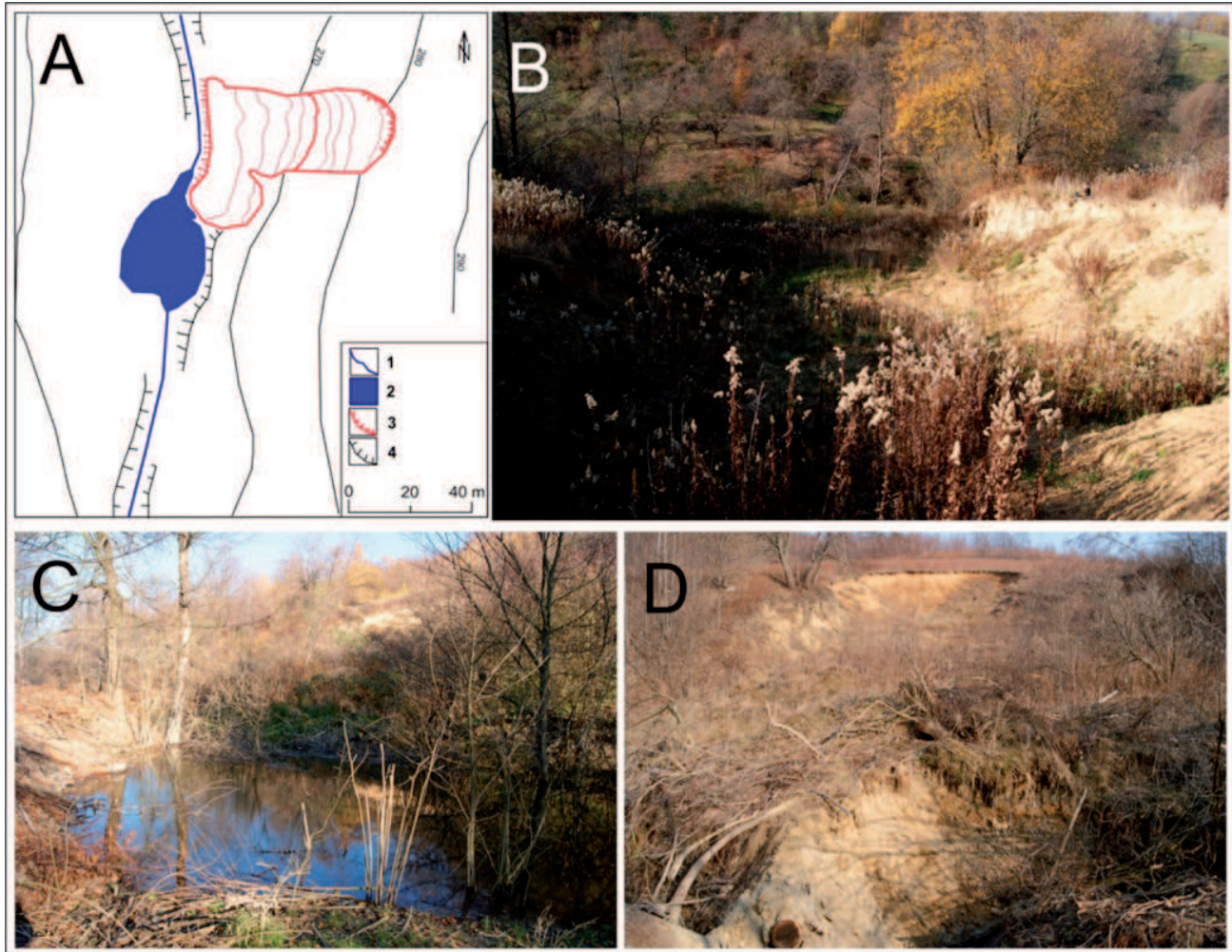


Fig. 4. Żabno landslide; A – location on the map, B – landslide body, C – landslide dam lake, D – landslide front scarp.

### *Buczkówka landslide*

Like Żabno landslide, Buczkówka landslide was also formed in the spring of 2010 in the Szczepanowicki Creek valley (Fig. 1). The main factor of its activation was a large precipitation total, which caused soaking of the slope material. The strong lateral erosion of Szczepanowicki Creek represented an addi-

tional stimulus. Also, the considerable slope inclination of 27° (Tab. 1) played an important role. The sliding of the large area of the slope to the bottom of the valley dammed the creek, forming a small, but quite deep lake (Cebulski, 2013). Since the area was covered by a beech forest, the landslide led to the complete destruction of the timber.



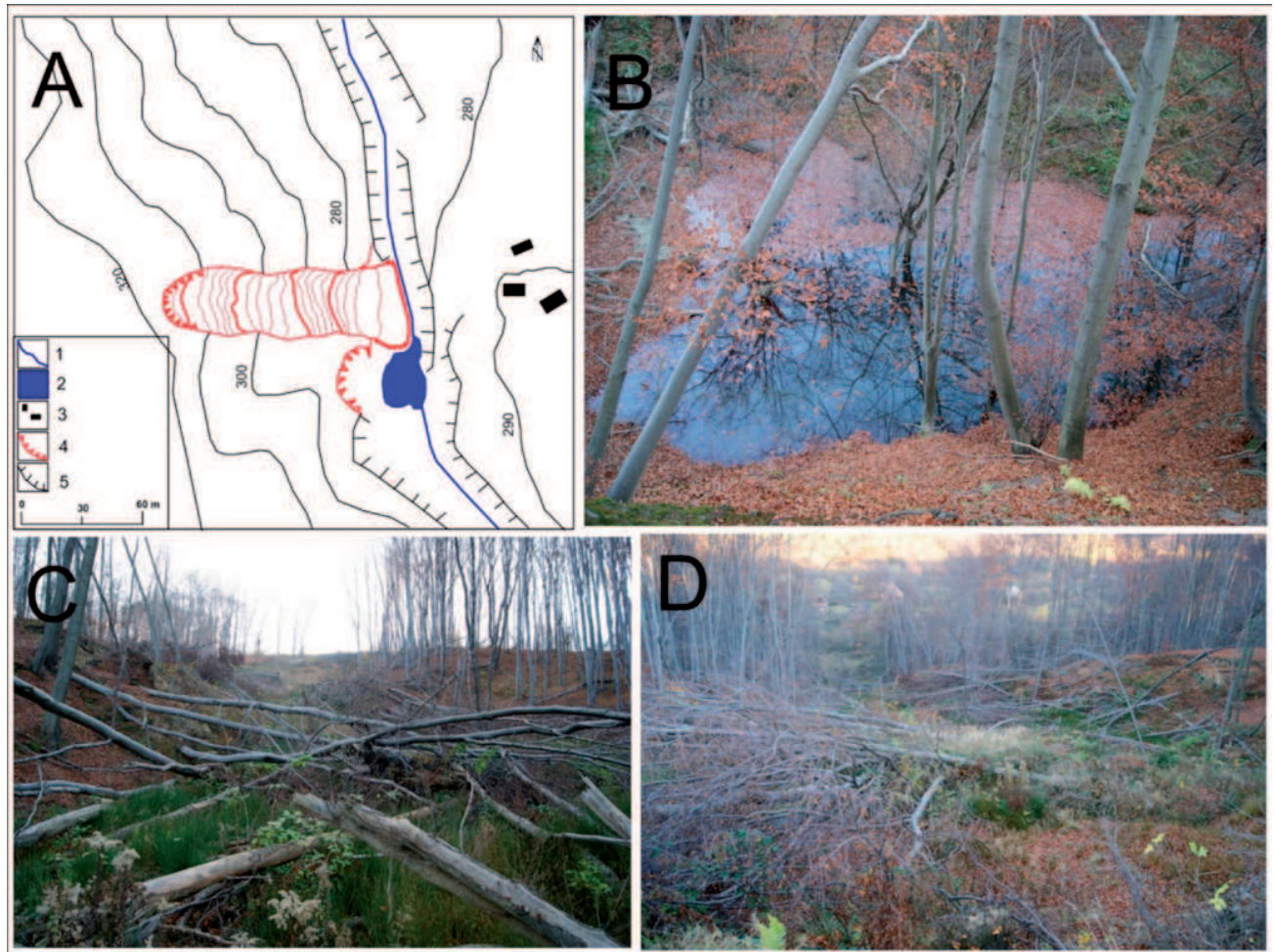


Fig. 5. Boczkówka landslide; A – location on the map, B – landslide dam lake, C – landslides scarps, D – damaged trees in the central part of the landslide

### *The landslides in Witów*

Slope mass movements are quite common phenomena in Witów, especially on the western slopes of the Czarny Dunajec River valley, reaching from Magura Witowska to Krowiarki. While the SOPO (System of protection against landslides) database maintained by the Polish Geological Institute - National Research Institute (PIG-PIB) contains 43 landslides in the area (<http://geoportal.pgi.gov.pl/portal/page/portal/SOPO>), 50 new ones developed within the lateral valleys of the Czarny Dunajec River after the rainfall on 28 June 2009, which have not been included into the system yet. Taking into account this large number of landslides and the relatively small area of the village (excluding the Tatra Mountains), the average density soars to 3.7 landslides per km<sup>2</sup>.

### *Nad Kościołem landslide*

The landslide is located in the central part of the municipality of Witów. Its main scarp is just 110 meters from the church (Fig. 1). It was formed in the early Holocene due to infiltration of rainwater into the flysch ground, which is susceptible to mass movements, and it is still active in its upper part after heavy rain falls. The last activity was recorded in May 2010. The landslide is of a subsequent rock-geest type (Fig. 2) and of a medium size (Tab. 1). After the recent activity, minor damage was induced to the church (broken pipes supplying water from the parsonage to the church), the parsonage (broken tiles) and the parking lot (small break-offs near the stream) (Fig. 6).



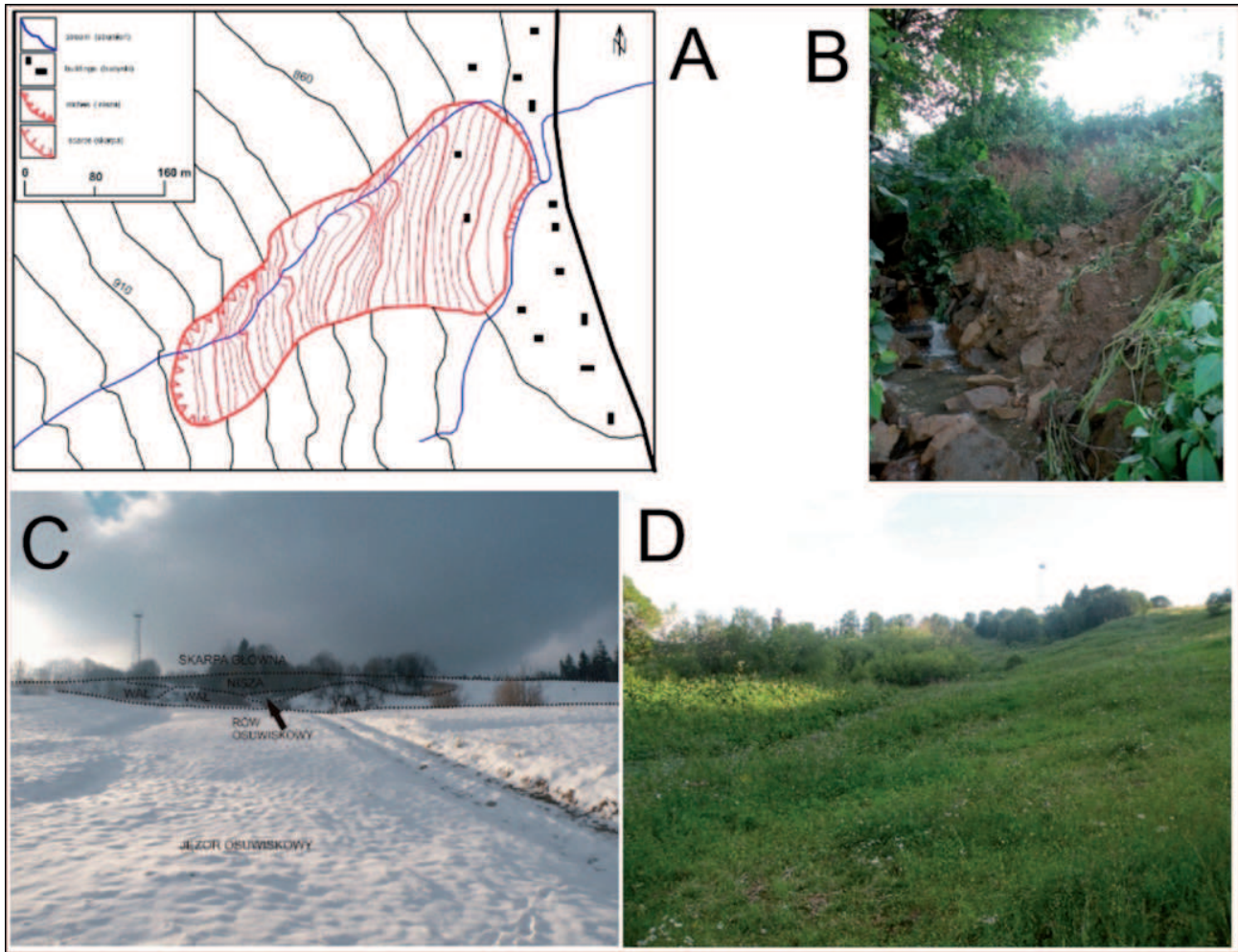


Fig. 6. Nad Kościołem landslide: A – location on the map, B – side scarp, C – different forms inside landslide, D – main scarp

**Witów-Ski landslide**

The landslide in the Witów-Ski area is located in the central part of the municipality of Witów, south of the landslides over the Church (Fig. 1). It was formed in the early Holocene, while the last of its notable activity took place in May 2010. However, since the development of the ski lift and snow park,

new exposure can be observed within the main scarp every year in spring. This implies a continuous, but small activity with no damage to the property. Just like in the previous case, this landslide is also of a subsequent rock-geest type (Fig. 2) and of a medium size (Tab. 1), (Fig. 7).

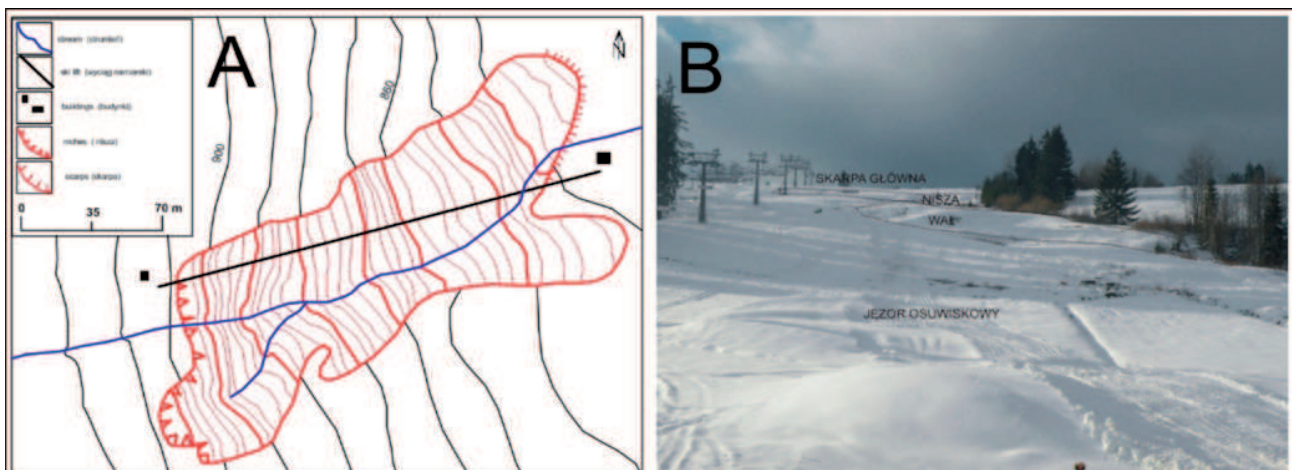






Fig. 7. Witów-ski landslide: A – location on the map, B – different forms inside landslide, C – snow park, D – snow park on the mail scarp

### Usypy landslide

The Usypy landslide is located in the lower part of the municipality of Witów. Like the other two landslides in Witów, it was established in early Holocene due to infiltration of rainwa-

ter into the flysch ground (Fig. 2). The latest activity took place in 2009. However, the latest significant damage that was caused by this landslide occurred in 2004, when it buried a roadside ditch and broke a local water pipeline (Fig. 8).

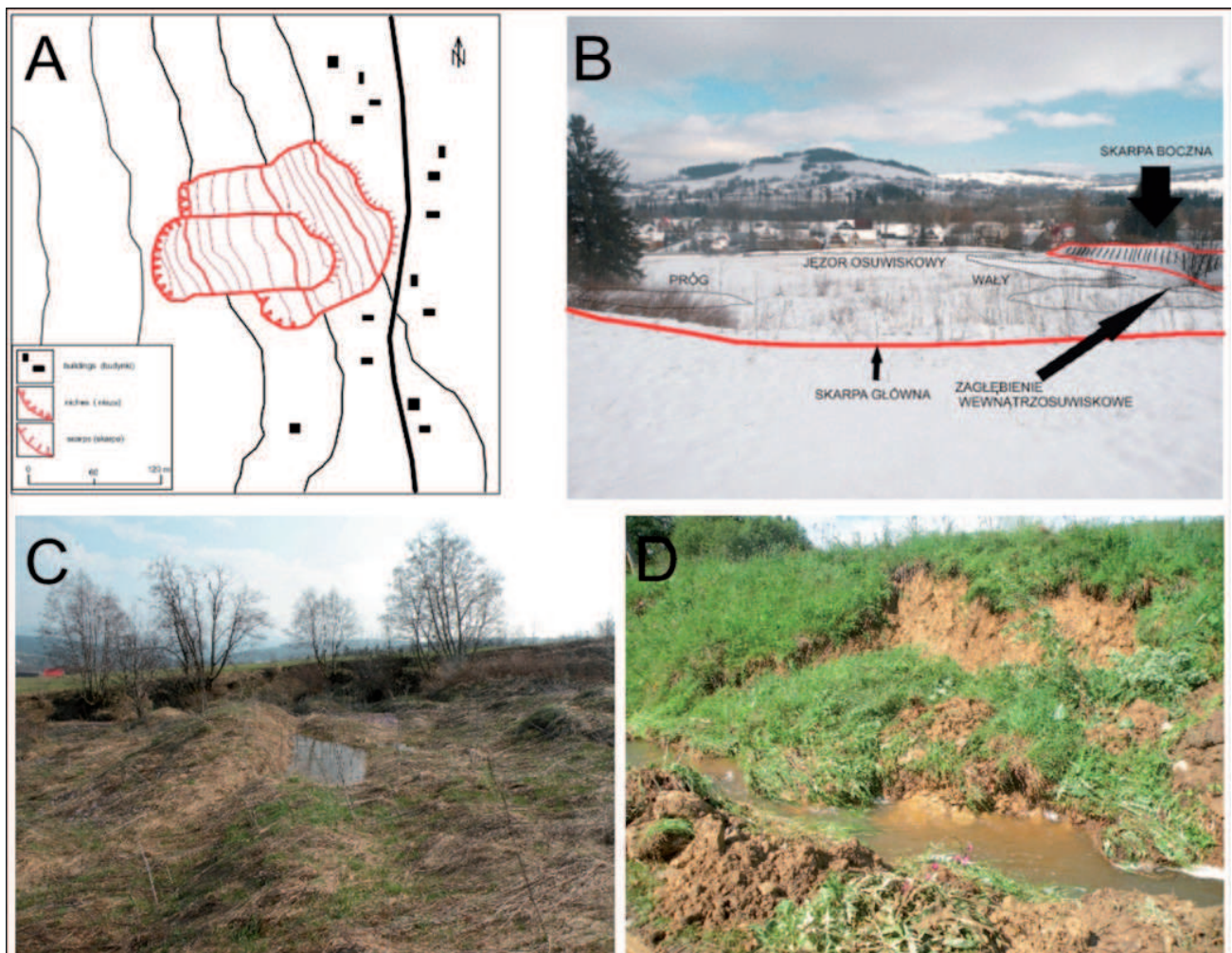


Fig. 8. Usypy landslide: A – location on the map, B – different forms inside landslide, C – lake inside landslide, D – reactivated part of the landslide after a heavy rainfall



## Methodology

The slopes in the municipalities of Szczepanowice and Witów are significantly transformed by landslides of different sizes, ages and conditions. Since many of the landslides are still active and since these areas are still being used for the development of residential and nonresidential buildings, roads and other infrastructure, there is a need for education of population. This could be achieved by information stands and notice boards with a geotourism content located at landslide sites. Obviously, not all the sites can or should be signposted. Therefore, criteria need to be found that can be evaluated and then used in the process of selection of landslides to be used in geotourism.

For the purpose of this contribution, a choice of three landslides in each village was made, which were subject to valorization method developed by Renard et al. (2007). The geotourism potential of each of them was then determined on the basis of several partial (analytical) marks evaluating different components, including scientific and educational value, additional value, tourism utility value, and state of conservation. Evaluation of each of the components consisted of several marks for different partial aspects of the component, which were rated on the scale from 0 to 1 using a 0.25 interval: the higher the value, the more suitable the site for geotourism. For example, the partial aspect called "presence of other interesting geological structure features" within the component named "scientific and educational value" was rated 0.25 when some of the colluvium was uncovered within the landslide. The higher value of 0.5 or 0.75 was assigned to this aspect when a smaller or larger outcrop of bedrock (respectively) was exposed. Another example of a partial aspect evaluated within the valorization method of Renard et al. (2007) is the partial aspect called "accessibility" within the component named "tourism utility value". For instance, when a landslide was accessible only by foot across fields, meadows or forests, it was rated 0.25. The higher value of 0.75 or 1 was assigned to this aspect when a landslide could be approached by a dirt road (e.g. by a terrain vehicle) or by a paved road (respectively).

## Results and discussion

The valorization revealed a considerable variation within the selected landslides from the viewpoint of their scientific, educational and additional value. The most attractive landslide from this point of view, the Tubendza landslide, obtained the

score of 5.25 out of the maximum possible score of 9 (Tab. 2). There are several factors that contribute to this. The first and most important factor is the high quantity and clarity of the individual elements of the landslide. It has a well preserved and clearly identifiable textbook-like niche, slots (transverse and longitudinal), tongue, as well as forehead markedly contributing to the overall terrain appearance. In several depressions without outflow within the landslide, small ponds are formed filled by accumulated water and thus they further increase the attractiveness of the site. The other two landslides in Szczepanowice also received high scores. This relates to the clarity of the individual elements of the landslides formed in 2010. The landslides in Witów were rated as less attractive than those in Szczepanowice. Since they are older and have not been reactivated recently, they do not have clearly visible renewed elements (except for the Usypy landslide), what makes their scientific, educational and additional value much smaller than the one of the landslides in Szczepanowice.

Beside the scientific, educational and additional value, the selected landslides were also assessed from the perspective of their tourism utility value and state of conservation (susceptibility to change) potential. The components included in the assessment of this perspective have a substantial impact on the overall score of the site. For example, the accessibility of the individual sites is one of them: the most accessible ones – located directly on the main road or with comfortable access to the landslide – received the highest score. The analysis of these components showed that the most attractive landslide is the Tubendza landslide (Tab. 2). However, the landslides in Witów were also highly rated. The reason for this is that these forms are already partly used in tourism and they are located in a reasonable proximity to a large number of accommodation facilities located in Witów, Kościelisko and Zakopane.

In the process of geotourism strategic planning, one of the most important steps is to choose the sites that are both accessible and attractive from the esthetic, scientific and educational point of view. Obviously, the preparation and marketing of the sites which follows is crucial. All the features included in Table 2 allow determining the overall geotourism potential of the individual sites and their comparison. From the landslides assessed in this study, the Tubendza landslide has the greatest geotourism potential (Tab. 2). The Usypy and Nad Kościołem landslides were also identified as geosites with a relatively high potential. After appropriate procedures, these sites may become adapted and well integrated in geotourism.

Tab. 2. The valorization of landslides (based on method of Renard et al., 2007).

Feature assessed	Nad Kościołem	Witów-ski	Usypy	Tubendza	Żabno	Buczkówka
SCIENTIFIC AND EDUCATIONAL VALUE						
Rarity in the region	0.25	0.25	0.25	0.25	0.25	0.25
Condition of the landslide	0.5	0.5	0.5	1	0.75	0.75
The representativeness of the geomorphological process and educational value	0.5	0.25	0.5	1	1	1

Presence of other interesting geological structure features	0.25	0.25	0.5	0.75	0.75	0.75
The degree of scientific recognition	0.75	0.75	0.75	0.5	0.25	0.25
Rarity in the country	0.75	0.75	0.75	0.75	0.75	0.75
ADDITIONAL VALUE						
Cultural value	0	0	0	0	0	0
Aesthetic value	0.5	0.5	0.5	0.5	0.5	0.5
Ecological value	0.5	0.25	0.5	0.5	0.25	0.25
Total scientific, educational and additional potential	4	3.5	4.25	5.25	4.5	4.5
TOURISM UTILITY VALUE						
Accessibility	0.75	1	0.75	1	0.25	0.25
Possibility of visual observation	0.5	0.75	1	1	0.75	0.75
Present use of the landslide in geotourism	0	0	0	0	0	0
Present use of other features of the landslide in tourism	0.25	0.5	0	0	0	0
State of legal protection and restrictions on use	0	0	0	0	0	0
Proximity to accommodation facilities	0.75	0.75	0.75	0.25	0.25	0.25
STATE OF CONSERVATION (SUSCEPTIBILITY TO CHANGE)						
Condition of the landslide	0.75	0.75	0.75	1	1	1
Sensitivity to anthropogenic pressure	0.75	0.75	0.75	0.75	0.5	0.5
Total tourism utility potential	3.75	3.5	3.5	4	2.75	2.75
Sum	7.75	7	7.75	9.25	7.25	7.25

## Conclusion

The valorization of landslides as geosites, i.e. the assessment of landslides from the perspective of their suitability for geotourism, is a new idea not yet considered in the Polish literature. The increasing interest in cognitive tourism in recent years generates demand for new tourism attractions, which may include landslides. The multitude of slope mass movements in the Polish Carpathians and their absence or rarity in the other parts of Poland makes them attractive points of interest for the visitors to the region. At the same time, they have the potential to diverge at least some of the large number of tourists coming to the region from the most overcrowded attractions in the Tatra Mountains. Therefore, there is a need for a better marketing and presentation of these forms to a larger number of tourists. Moreover, these geosites can be used to promote knowledge about slope mass movements as naturally occurring hazards, their causes and the risks associated with them with respect to lives and property of the affected population. Thus they become

the tools of education, especially to young people, who do not have much experience with the destruction power and potential of the natural phenomena such as landslides and therefore they need to acquire this experience to become better prepared to assess the risk and cope with the negative consequences of this type of threat if/when they face it later in their lives. Well thought-out and well planned construction projects – in consultation with geological survey services – may significantly reduce the risk of material losses resulting from this type of natural processes. The development of information stands, guides and educational trails should be entrusted to the local governments, which should cooperate closely with professionals in the field of geotourism. Also, local government representatives are usually well set to negotiate the terms of cooperation with the owners of the private properties, on which the landslides are located. As none of the evaluated geosites is located within a protected area, the property owners might be interested in preserving the landslides only under certain conditions and for a certain time



period. Thus, this type of geosites would be different from the more traditional long lasting geosites located in protected areas. However, the limited time span of this new type of geosites should not be inevitably perceived as an insuperable obstacle of their development or a reason for them to be seen as inferior-value geosites. In fact, the dynamic processes they represent and document makes them – in a sense – even more valuable and attractive.

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