

The region is also a subject of vivid development of geothermal sites, where, for instance, in 2023–2024, the deepest geothermal well, designed to be 7 km, in Szaflary is currently being drilled (which has reached over 5 km (www1)). The factors mentioned above justify the need for seismological monitoring in the region, which will be further discussed in a short stop during the field trip.

**Stop 16 –
Sromowce, Macelowa –
Upper Cretaceous *Scaglia Rossa*
with clastics
(Figs 11, 35, 48, 49)**

(Michał Krobicki, Jan Golonka)

One of the major attraction of the PKB region is the rafting through the Dunajec River Gorge (Golonka & Krobicki, 2007; see also Alexandrowicz & Alexandrowicz, 2004). The rafting trip on the Dunajec River, which starts at Sromowce Kąty harbour, takes geotourist through the Dunajec Gorge to Szczawnica. The Dunajec offers magnificent view of the cliffs sculptured in the Pieniny Mountains by the tectonic activity and river's erosion. It offers also the close view of the outcrops of Jurassic and Cretaceous rocks of the Pieniny Succession and complex tectonics of the PKB.

Strongly folded Jurassic-Cretaceous strata are visible along the road from Sromowce Wyzne to Sromowce Niżne, close to the Dunajec River, on the southern slope of Mount Macelowa, where the Pieniny Succession rocks lie in an overturned position. The oldest Oxfordian radiolarites occupy the topmost part of Mount Macelowa (on its northern slope), gray cherty limestones of the *Maiolica* facies (Pieniny Limestone Formation) occupy the transitional position and in the lowest (topographically) position are the Late Cretaceous *Globotruncana*-bearing marls of the *Scaglia Rossa*-type (Birkenmajer, 1977; Bąk K., 1998, 2000). Figure 15 depicts the Birkenmajer & Jednorowska (1987a, 1987b) ideas about the Cretaceous lithostratigraphy of the Pieniny Mountains. Red marls and marly limestones of pelagic deposits with grayish intercalations of calcareous sandstones and siltstones of distal turbiditic origin predominate in this outcrop. This is the youngest part of the multi-colored (green-variegated-red) globotruncanid marls of the so-called Macelowa Marl Member of the Jaworki Formation, with good foraminiferal Upper Cretaceous biozonation (*Dicarinella concavata* – *D. asymmetrica* foraminiferal zones of the Upper Coniacian-Santonian) (Bąk K., 1998, 2000). These deposits originated during the final episode of the evolution of the PKB, when the unification of sedimentary facies took place within all the successions. Widespread in the Late Cretaceous Tethyan Ocean, the *Scaglia*

Rossa-type facies (= *Couches Rouge* = *Capas Rojas*) represented by the Jaworki Formation – which were widespread in the Late Cretaceous Tethyan Ocean – indicates open connections throughout the Northern Tethys.

**Stop 17 –
Sromowce-Szczawnica,
Dunajec River rafting –
uppermost Jurassic/Lower Cretaceous
Maiolica limestones
(Figs 9, 11, 35, 48)**

(Jan Golonka, Michał Krobicki)

The rafting through the Dunajec River Gorge belongs to the major geotouristic attractions of Poland. It offers magnificent views of the cliffs sculptured in the Pieniny Mountains both by the tectonic activity and river erosion. It offers also the close view of outcrops of Jurassic and Cretaceous rocks as well as an insight in to the complex tectonics of the Pieniny Klippen Belt. Therefore, it serves as the site of the fieldtrips for the international conferences held in southern Poland. Additionally, in near future the Dunajec River Gorge could be the main object of trans-bordering PIENINY Geopark (Golonka & Krobicki, 2007). The trips on the Dunajec River have started in 19th century and are still very popular nowadays. The boats are run by licensed local guides living in the Pieniny Mountains villages and towns: Sromowce Wyzne and Niżne, Czorsztyn, Szczawnica and Krościenko. Originally, the boat starting point was in Czorsztyn, just beneath the castle hill. After the Dunajec River dams at Czorsztyn and Niedzica were constructed, the new harbor was built in Sromowce Kąty. Each Dunajec River boat carries 10 tourists and the pilot-guide. The boats are specially design in order to enable the easy maneuvering on the treacherous whitewaters of Dunajec. The route partly follows the state border of Poland and Slovakia. Slovaks also offer their own rafting trips although somewhat shorter route.

Present day confines of the Pieniny Klippen Belt are strictly tectonic reflecting its Paleogene-Neogene evolution when (sub)vertical faults and shear zones developed and a strong reduction of space of the original sedimentary basins took place. The NE–SW striking faults accompanying the Klippen Belt have the character of lateral slips. It is indicated by the presence of flower structures on the contact zone of the Magura Unit and the Klippen Belt, or by the structural asymmetry of the Inner Carpathian Paleogene Basin. The tectonic character of the Polish section of the PKB is mixed. Both the strike slip and thrust components occur here (e.g., Książkiewicz, 1977; Golonka & Rączkowski, 1984; Birkenmajer, 1986; Nemčok & Nemčok, 1994; Jurewicz, 1997, 2005; Golonka *et al.*, 2005).

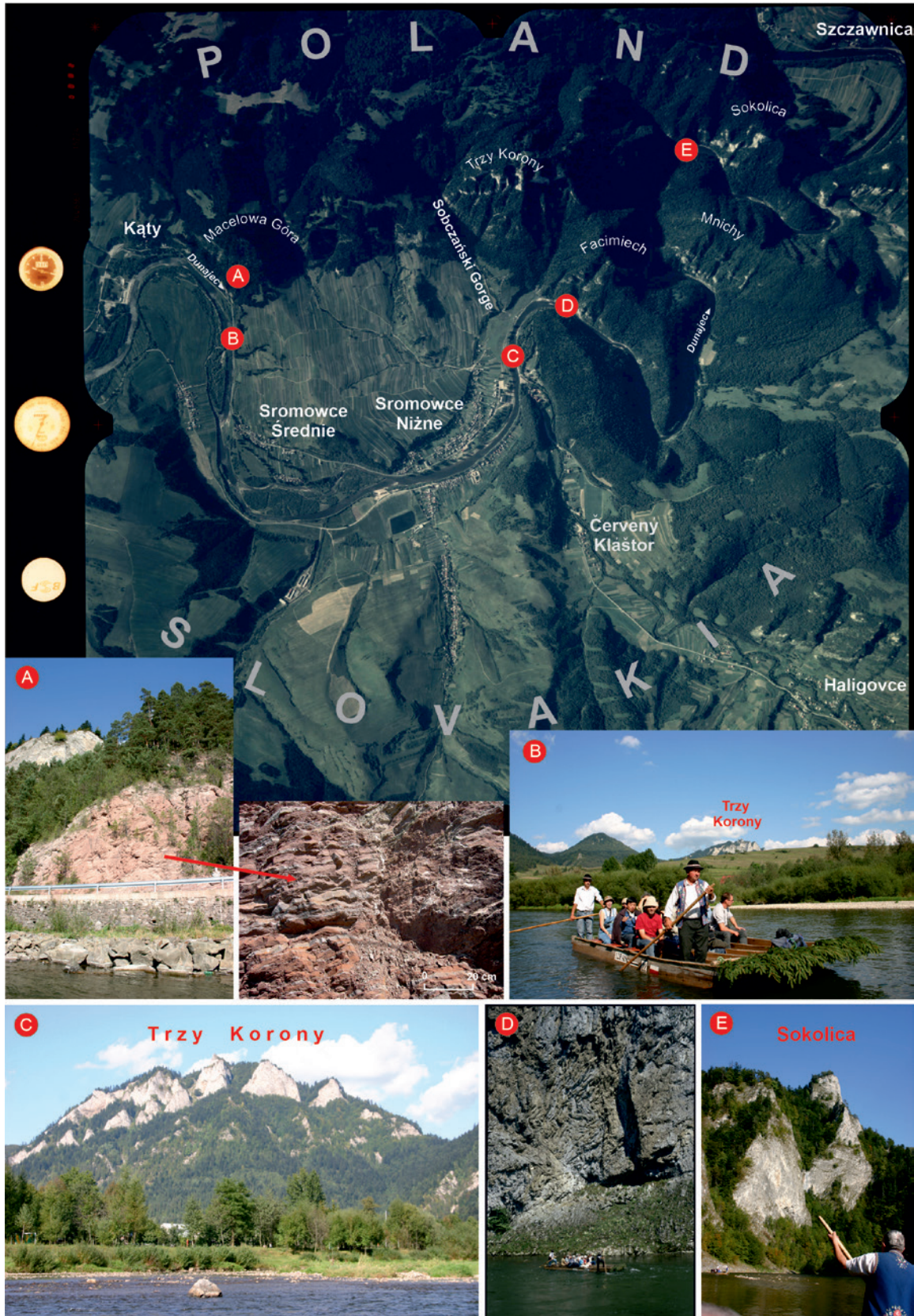


Fig. 48. Aerial view of the central Pieniny Mountains and Dunajec River Gorge with points of photos: A – Upper Cretaceous red marls of the *Scaglia Rossa*-type facies of the Macelowa Marl Member of the Jaworki Formation (Macelowa Mount); B – close to beginning of the rafting in Sromowce-Kąty harbor in the Pieniny Mts., boat full of tourists; C – Trzy Korony Mountain built of *Maiolica*-type well-bedded cherty limestones of the Pieniny Limestone Formation, usually strongly tectonically folded (D); E – Sokolica Mt. over the Dunajec River Gorge (after Krobicki & Golonka, 2008 and Krobicki, 2023)

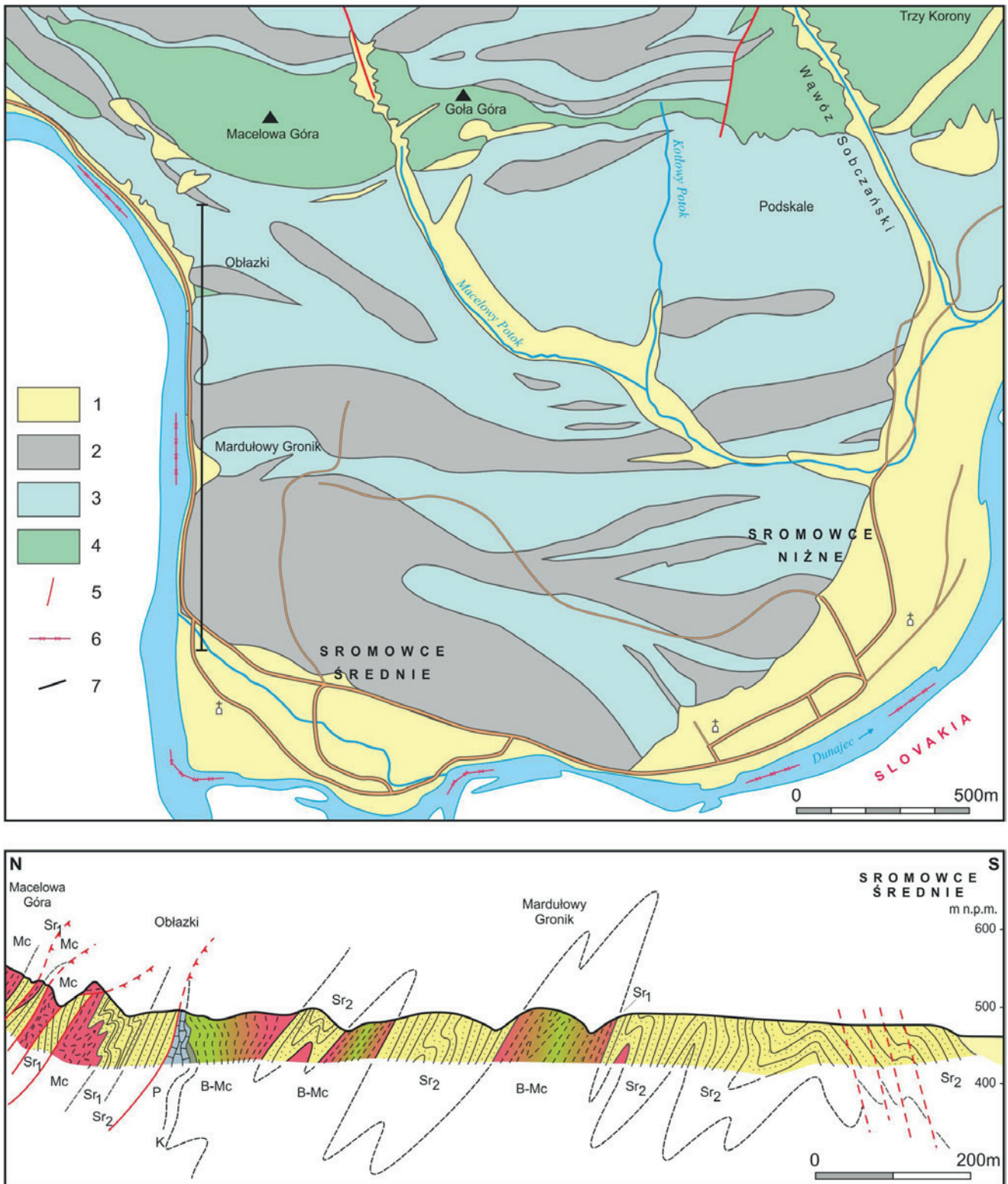


Fig. 49. Geological map of the vicinity of Sromowce (after Horwitz, 1963, Birkenmajer & Jednorowska, 1984, simplified) and geological cross-section: 1 – Quaternary; 2 – Sromowce Formation; 3 – Jaworki Formation, partly Kapuśnica Formation; 4 – Pieniny Limestone Formation, partly also Czajakowa Radiolarite Formation; 5 – faults; 6 – state border; 7 – geological cross-section (below); P – Pieniny Limestone Formation (grey cherty limestones); K – Kapuśnica Formation (green spotty marls); B-Mc – Jaworki Formation (Brynczkowa, Skalski and Macelowa Marl members – green, variegated and red marls respectively); Sr – Sromowce Formation (Sr₁ – Osice Siltstone Member; Sr₂ – flysch) (after Golonka *et al.*, 2018 and Krobicki, 2023)

In general the subvertically arranged Jurassic–Lower Cretaceous basinal facies display the tectonics of the diapir character originated in the strike-slip zone between two plates. The ridge facies are often uprooted and display thrust or even nappe character.

The origin of the Gorge is related to the neotectonic movements during the Neogene time. Following the Serravalian formation of the Outer Carpathian fold-and-thrust belt, the plate boundary was covered during the Neogene by at least 600–900 m of sand, silt and clay, which were deposited in the Orava–Nowy Targ Depression east of the Gorge (Chrustek & Golonka, 2005). The Dunajec River valley reached the mature stage during the latest Miocene–Pliocene time. This stage is indicated by numerous meandering bends of the river. The vertical uplift of the Pieniny Mountains followed the meandering stage of the Dunajec River. Faulting and uplifting played a tremendous role during the Neogene tectonic evolution. Dense and regular fault net is one of the characteristic features of the Carpathians. Brittle, mainly strike-slips faults combined with other dynamic tectonic boundaries allowed the propagation of individual, detached blocks to the realm of the future Carpathian region (Golonka *et al.*, 2006). At least some of the faults were still active during the Quaternary (Baumgart-Kotarba, 1996, 2001; Zuchiewicz *et al.*, 2002). The studies on the 1995 earthquake (Baumgart-Kotarba, 2001 and references therein) show the good agreement of focal model with the trends of vertical crustal movements. The recent vertical movements in the area are up to +0.5 mm per year (Vanko, 1988; Vass, 1998). During the

fault-related uplift the Dunajec River cut through the competent, Jurassic–Early Cretaceous cherty limestones, forming the magnificent cliffs of the Gorge. Most recently description of age and origin of the Dunajec River Gorge with the review of structural and geomorphological features of the Pieniny Mountains was published by Birkenmajer (2006, 2017).

The boat trip launches from Sromowce Kąty village within the Pieniny Klippen Belt (Fig. 48). The harbor is easily accessible by car or bus. Many travel companies offer the rafting trips combined with the coach transportation. The coaches bring tourist to the starting point and pick them up at the final destinations in Szczawnica or Krościenko.

Stop 18 – Szczawnica (“Orlica”) – history of the discovery of nappes in the Carpathians (Figs 35, 50–52)

(Michał Krobicki)

As a representative of the young French school of alpine tectonics, 33 years old Maurice Lugeon took part in a seven-day geological field trip to the Pieniny and Tatra Mountains (from 11 to 18 July 1903) as a part of the 9th International Geological Congress organized in Vienna.

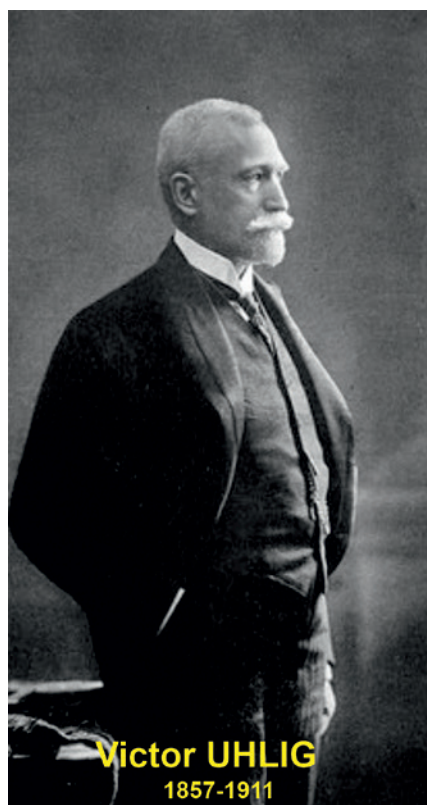


Fig. 50. Two prominent scientists – specialists of the Pieniny Klippen Belt geology (after Krobicki, 2023)