The oldest Oxfordian radiolarites occupy the topmost part of Mt. 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 multicolored (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 10 – Haligovce/Lipnik – Paleocene reefs after C/P mass extinction event (Fig. 42)

(*Michał Krobicki, Jan Golonka*)

In the vicinity of the villages of Haligovce and Lipnik, within the Paleogene flysch, there are large blocks of Paleocene olistolithic limestones, the oldest deposits of the so-called of the Pieniny Paleogene (Scheibner, 1968; Potfaj, 2002; Krobicki *et al*., 2004; Buček & Köhler, 2017). Their palaeontological and microfacial analysis showed the presence of numerous corals, red algae and foraminifera as well as bryozoans, serpulids, fragments of bivalves, brachiopods, echinoderms, sponges, and sporadically sponge spicules. Analysis of small fragments of coral colonies revealed the presence of scleractinians (*Asirocoenia*, ?*Acropora*, *Goniopora*, *Actinacis*, *Rhizangia*, *Orbignygyra*, *Favites*, *Oculina*, and ?*Rabdophylliopsis*) (Krobicki *et al*., 2004). Corals are often coated by the red algae Corallinaecae (the most numerous) and Peyssonneliaceae (*Polystrata alba*), with detritus being the most common in the carbonate matrix. Foraminifera are represented by large forms of encrusting agglutinating foraminifera (e.g. *Haddonia* sp.) and calcarous. General taxonomic composition of the corals most closely resemble the Paleocene corals from Slovenia. According to the palaeogeographic evolution of this area in the Paleocene time, the PKB was closed as a result of the collision of the Central Carpathians terrains with the Czorsztyn Ridge (Birkenmajer, 1986, 1988). The terrains of Adria, the Eastern Alps and the Inner Carpathians continued their movement northward. The Paleocene subsidence of the Magura Basin was associated with the shift of the subduction zone north of the Czorsztyn Ridge. In the Paleocene, the Alcapa superterrain was formed by combining the blanks of the Eastern Alps, the Tisza, the Inner Carpathians and other small terrains. At the same time, the aforementioned Paleocene reefs (Mišík & Zelman, 1959; Andrusov, 1969; Scheibner, 1968; Samuel *et al*., 1972; Köhler *et al*., 1993; Buček & Köhler, 2017) were formed in the shallowest zones of the basin, today's isolated occurrences of which can be found from the Eastern Alps (near Kambühel near Ternitz in Austria, the stratotype of the so-called Kambühel limestones, Tollmann, 1976; Faupl *et al*., 1987; Tragelehn, 1996; Müller, 2004) through western Slovakia (Mišík & Zelman, 1959; Scheibner, 1968; Köhler *et al*., 1993) to vicinity of Haligovce (Scheibner, 1968; Potfaj, 2002; Krobicki *et al*., 2004; Buček & Köhler, 2017). Identical limestones have also been found to be exotic within the boundaries of the Strihov and Proč strata of Western Slovakia (Miśik *et al*., 1991a, 1991b).

Stop 11 – Czorsztyn Castle (Jurassic-Cretaceous deposits of the Czorsztyn Succession) (Fig. 43)

(*Michał Krobicki*)

The Czorsztyn Castle klippen are one of the most famous geological site of the PKB with full sequence of Czorsztyn Succession from the Middle Jurassic up to Upper Cretaceous deposits, rich in invertebrate fossils such as: ammonites, brachiopods, crinoids, calpionellids, foraminifers, described and illustrated by numerous authors since beginning of the XIX century (e.g., S. Staszic, L. Zejszner, E. Suess, M. Neumayr, K. A. Zittel, V. Uhlig and others) (Uhlig, 1890a; Birkenmajer, 1963, 1977, 1979, 1983; Barczyk, 1972a, 1972b; Głuchowski, 1987; Krobicki, 1994, 1996b; Wierzbowski & Remane, 1992; Wierzbowski *et al*., 1999). Unfortunately, the water of present Czorsztyn lake covered the great part of this sequence (lowermost – lower part of the Middle Jurassic and upper part – Upper Cretaceous) and only Bajocian-Berriasian interval is available to study (partly by means of boat).

The Czorsztyn Castle klippen (more precisely – so-called Sobótka klippe) is a stratotype for the Czorsztyn Limestone Formation (red nodular limestone of the *Ammonitico Rosso* type facies; uppermost Bajocian-Tithonian in age) (Birkenmajer, 1977; see also Birkenmajer, 1963). In this section the oldest are grey crinoid limestones of the Smolegowa Limestone Formation. These are well-bedded grainstones and the youngest beds are cross-bedded well recorded shallow marine origin of these limestones. Gastropod trace fossils found in the base of these limestones supported such idea (Krobicki & Uchman, 2003). There follow thin-bedded reddish crinoid limestones of the Krupianka Limestone Formation with considerable amount of hematite-marly matrix. The ammonites are very rare and poorly preserved but brachiopods are rather common: *Capillirhynchia brentoniaca* (Oppel), *Septocrurella* ? *defluxa* (Oppel), *S. kaminskii* (Uhlig), *Linguithyris curviconcha* (Oppel), *Karadagella zorae* Tchorszhevsky et Radulović and *Zittelina* ? *beneckei* (Parona). The geological age of the crinoid units is Bajocian: the basal part of the Smolegowa Limestone Formation in the Sobótka Klippe of the Czorsztyn Castle klippes yielded ammonites – *Dorsetensia* (*Dorsetensia*, *Nannina*), *Pelekodites*, *Stephanoceras*

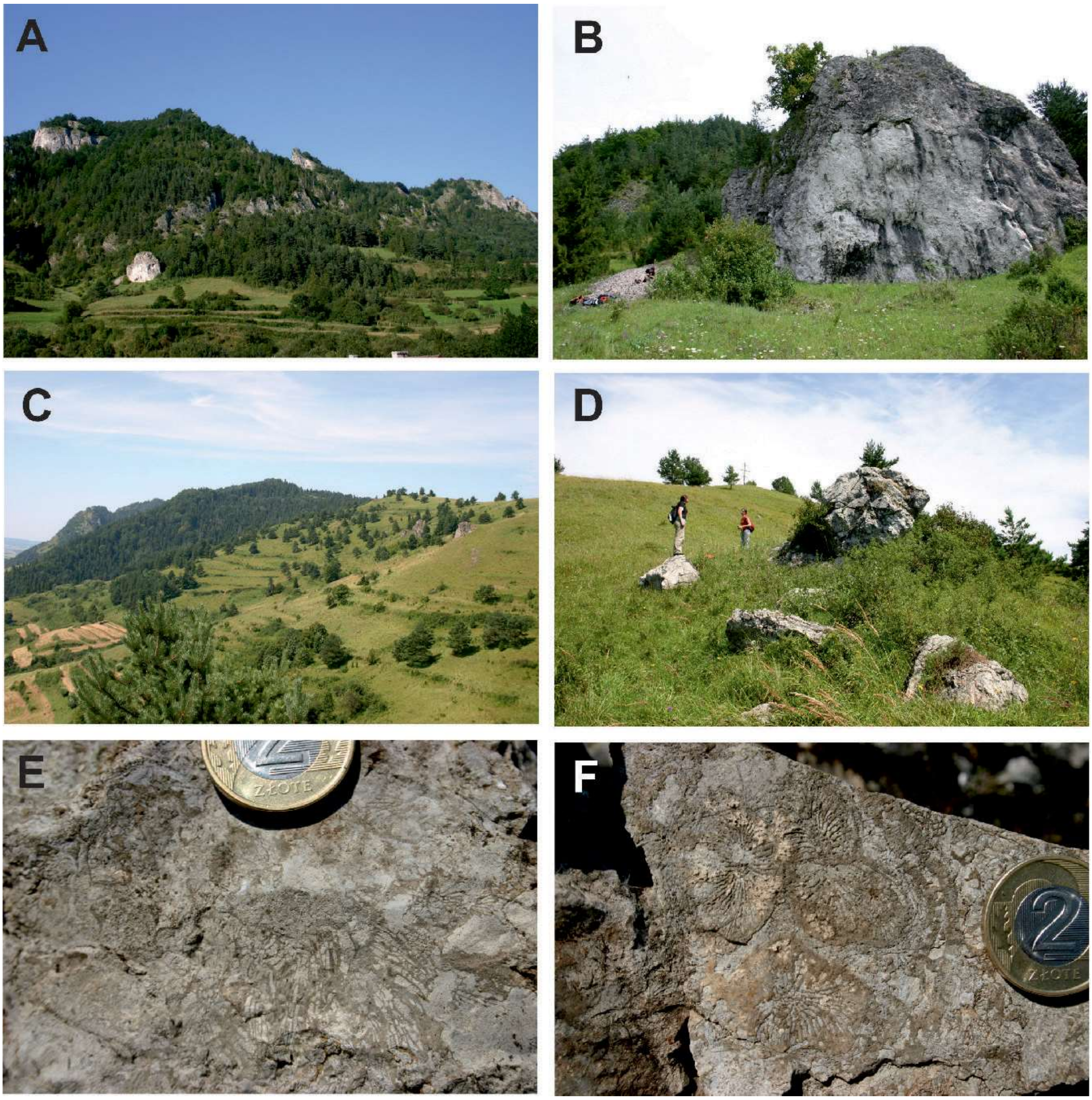

Fig. 42. View of Haligovce Klippen (A–C) and Lipnik Klippen (C, D) with olistoliths of Paleocene coral-bearing limestones (E, F) of the so-called Kambühel limestones (after Krobicki, 2022d)

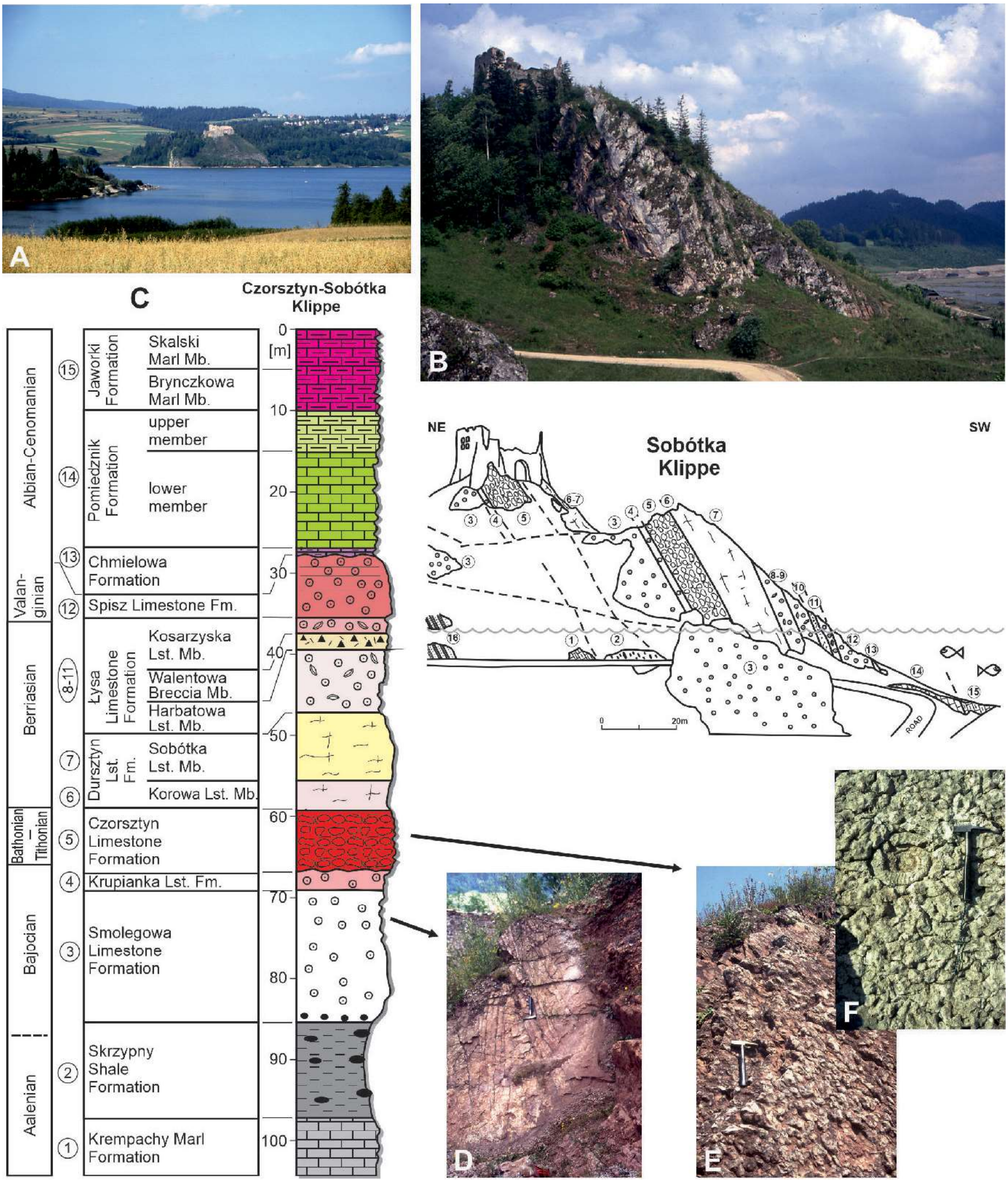

Fig. 43. Stratigraphical section of the Czorsztyn-Sobótka Klippe (A, B) with indication of position of the Walentowa Breccia Member of the Łysa Limestone Formation of the Czorsztyn Succession (C) (lithostratigraphy after Birkenmajer, 1977, slightly modified) (photo – state in 1992). Explanations of lithology: 1 – dark-grey/black marls/marly limestones; 2 – black spherosideritic shales; 3 – white cridoidal limestones (with phosphatic concretions in base – black dots); 4 – red/pink crinoidal limestones; 5 – red nodular limestones; 6 – pink micritic *Calpionella*-bearing limestones; 7 – creamy micritic *Calpionella*-bearing limestones; 8 – creamy brachiopodic- crinoidal limestones; 9 – limestone sedimentary breccia; 10 – pink-creamy brachiopodic-crinoidal limestones; 11 – cherry crinoidal limestones; 12 – violet-red marls; 13 – green marls, sometimes with cherts; 14 – green and variegated *Globotruncana*-bearing marls (formal litostratigraphical names of units – see Fig. 9) (after Krobicki *et al.*, 2010)

(*Stephanoceras*, *Skirroceras*) which are indicative of the upper part of the Lower Bajocian (upper Propinquans Zone, and the Humphriesianum Zone) – see Krobicki & Wierzbowski (2004), whereas the nodular limestones directly overlying crinoid limestones of the Krupianka Limestone Formation in the Czorsztyn Castle Klippe section yielded ammonites of the uppermost Bajocian (Wierzbowski *et al.*, 1999; Krobicki *et al*., 2006). The upper surface of the topmost bed of the red crinoidal limestones is corroded and covered with ferro-manganese crust, very typical feature for this boundary surface, known from several other outcrops in the PKB, both in Polish, Slovakia and Ukrainian part of the region. The overlying nodular limestones correspond already to the Czorsztyn Limestone Formation (red nodular limestone). The lowermost part of the nodular limestones of the Czorsztyn Limestone Formation exposed in the Czorsztyn Castle Klippe yielded the rich ammonite faunas. These ammonites are indicative to uppermost Bajocian, Bathonian, and Callovian up to Oxfordian. The whole uppermost Bajocian up to uppermost Callovian and/or Oxfordian interval does not exceed 2.0 meters, therefore the oldest part of the Ammonitico Rosso type limestones (of the Czorsztyn Limestone Formation) represents very condense sequence (Wierzbowski *et al*., 1999). The whole Cretaceous strata were visible previously (from Berriasian limestones up to Santonian marls), including very characteristic synsedimentary limestone breccias of the so-called Walentowa Breccia Member of the Łysa Limestone Formation (Berrisian in age) which indicates the earliest Cretaceous (Neo-Cimmerian) tectonic movements in this part of the Tethys.

Stop 12 – Wżar Mt (Miocene andesites and panoramic view) (Fig. 44)

(*Jan Golonka, Michał Krobicki*)

The most famous outcrop (artificial one – abandoned quarry) of the Middle Miocene volcanism of the Pieniny Mts occur on the Wżar Mt, near Snozka pass, and is represented by two generation of intrusive dykes and sills. In half of the XX century several pioneer researches were done both geologically, mineralogically/petrographically and geophysically (e.g. Wojciechowski, 1950, 1955; Birkenmajer, 1956a, 1956b, 1958b; Kardymowicz, 1957; Małoszewski, 1957, 1958; Gajda, 1958; Kozłowski, 1958; Małkowski, 1958). The Neogene volcanic activity in Carpathian–Pannonian region was widespread. The Pieniny Andesite Line is an about 20 km long and 5 km wide zone, which cut both Mesozoic-Paleogene rocks of the PKB and Paleogene flysch of the Magura Nappe of the Outer Flysch Carpathians. Andesites occur in the form of dykes and sills. At the Wżar Mt two generations of andesitic dykes occur (Youssef, 1978). Numerous older dykes are sub-parallel to the longitudinal distribution of the PKB structure and younger are perpendicular to the first and are represented only by three dykes (Birkenmajer, 1962, 1979; Birkenmajer & Pécskay, 1999). Spatial distribution, temporal relationships, and geochemical evolution of magmas contribute to interpretation of the geodynamic development of this area (e.g., Birkenmajer, 1986; Kováč *et al*., 1998; Golonka *et al*., 2005a, 2005b).

The Wżar Mt represents the westernmost occurrence of andesites in the Pieniny region. Amphibole-augite and/or augite-amphibole andesites dominate in the Mt Wżar area. Numerous petrographical varieties were distinguished, based mainly on the composition of phenocryst assemblages (Michalik M. *et al*., 2004, 2005; Tokarski *et al*., 2006). The mainly Sarmatian age of first phase of andesite dykes from this quarry, which are parallel and subparallel with the northern boundary fault of the PKB, radiometrically determined as 12.5–12.8 Ma (K-Ar method) (Birkenmajer & Pécskay, 2000; Trua *et al*., 2006). The second, younger generation of dykes follows transversal faults, which cut the older generation (Birkenmajer, 1962) and is dated on 10.8-12.2 Ma (Birkenmajer & Pécskay, 2000; Birkenmajer, 2001). These calc-alkaline andesites interpreted by Birkenmajer (2001) as products of hybridization of primary mantle-derived magma over subducted slab of the North European Plate (Birkenmajer & Pécskay, 1999) connected with collision-related post-Savian tectonic, compression event. The newest results of andesitic rocks investigations indicate partial melting derived from an ancient metasomatized, sub-continental lithospheric mantle. Generation of the calc-alkaline magmas in the upper lithospheric mantle was effect of collision of the Alcapa block with southern margin of the European platform (Anczkiewicz & Anczkiewicz, 2016; see also Trua *et al*., 2006).

These andesitic rocks cut Upper Cretaceous and Paleogene flysch deposits of the autochthonous Magura Nappe (the Szczawnica, Zarzecze and Magura formations), which is the southernmost flysch tectonic unit of the Outer Carpathians – near northern strike-slip–type faults of the PKB. Near the entrance to this quarry contact metamorphism and hydrothermal activity within flysch sandstones are good visible (Birkenmajer, 1958b; Gajda, 1958; Małkowski, 1958; Michalik A., 1963; comp. Szeliga & Michalik, 2003). Two stages of magmatic activity resulted also in chemical variation in composition of surrounding sandstones (Pyrgies & Michalik, 1998). The similar Miocene volcanic activity is widespread within whole Carpathian-Pannonian region and can be use to geodynamic interpretation of syn-orogenic magmatic events of these regions (e.g., Kováč *et al*., 1997; Anczkiewicz & Anczkiewicz, 2016 with references cited therein).

Wżar Mt is one of the geological objects classified for the entry into the European network of GEOSITES (Alexandrowicz, 2006) and mining activity of prospecting and excavation of magmatic ore deposits connected with Pieniny andesites were known since beginning of the XV century (Małkowski, 1958).