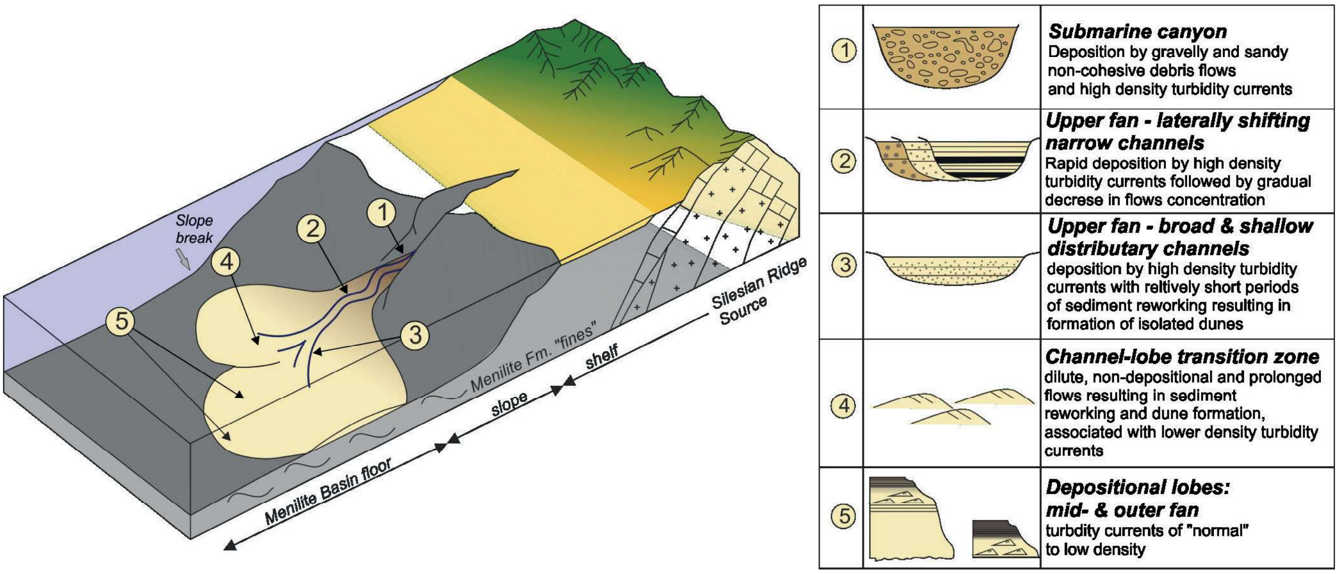

Fig. 26. Model of evolution of the Skrzydlna olistostrome to turbidite megasequence, interpreted in terms of Walther's Law of Facies as grading from proximal submarine canyon fill to distal small turbidite fan. Note five associations of facies, their palaeotopographic expression, and selected sedimentary features, deposition zones and the main controlling processes (1–5). Interpretation by Siemińska *et al*. (2018, 2020) and Wendorff *et al*. (2015)

Stop 2 – Skalski stream near Jaworki village (Late Cretaceous deposits with exotics) (Figs 27, 28)

(*Michał Krobicki, Barbara Olszewska*)

The Upper Cretaceous and Paleogene exotic-bearing gravelstones of the PKB are linked with flysch/flyschoidal sequences of the Sromowce Formation and the Jarmuta Formation, respectively (Birkenmajer, 1977, 1979, 1986). These exotic rocks are useful for reconstructing the basement and sedimentary cover of source areas (Birkenmajer, 1988). The present outcrop is located in the Skalski stream (below the lower station of ski lift – Birkenmajer, 1977, 1979, 1988; Birkenmajer & Lefeld, 1969; Radwański, 1978; Birkenmajer & Wieser, 1990; Birkenmajer *et al*., 1990). Lower Cretaceous Urgonian-type exotic rocks often occur within such gravelstones (Bukowiny Gravelstone Member – Birkenmajer & Lefeld, 1969) which represents a submarine slump, in the middle of the Sromowce Formation of the Niedzica Succession (Birkenmajer, 1977, 1979; Birkenmajer & Jednorowska, 1987b) (Fig. 28).

The Urgonian (named after the village Orgon, east of Tarascon, France) is a characteristic shallow-water carbonate facies that accumulated along the Tethys northern shelf from the Barremian to the Late Albian. The facies encloses hard, light-coloured limestones with foraminifers and pachyodonts, marls with *Orbitolina* (foraminifers) and transitional sediments – detrital or siliceous limestones (Foury, 1968). Characteristic fossils of the facies are bivalves (rudists), corals, hydrozoans, bryozoans, small and large foraminifera and algae. The origin of the Urgonian facies is connected with the Barremian rearrangement of the world ocean (Renard, 1986). The Barremian regression uncovered large parts of the shelves on which abundant shallow-water communities proliferated until the mid-Aptian transgression caused, locally, their emersion and destruction (Scott, 1995). In the Inner Carpathians, the Urgonian facies is represented in the Hightatric units of the Tatra Mts (Lefeld, 1974, 1988; Masse & Uchman, 1997) and the Manín Unit of the Váh valley (Andrusov, 1953; Mišík, 1990). In the PKB, the Urgonian-like facies occurs in the Haligovce Nappe (Birkenmajer, 1959; Haligovce Limestone Formation – Birkenmajer, 1977) and as exotic pebbles in the Upper Cretaceous Sromowce Formation and the Upper Cretaceous–Paleocene Jarmuta Formation (Birkenmajer & Lefeld, 1969; Birkenmajer, 1970, 1977, 1979, 1986; Birkenmajer & Wieser, 1990). In the Outer Carpathians, the Urgonian-type limestones occur exclusively as exotic pebbles in younger deposits (Birkenmajer, 1970, 1973, 1977; Birkenmajer & Lefeld, 1969; Oszczypko, 1975; Burtan *et al*., 1984). Micropalaeontological investigations of these limestones were so far limited to determination of orbitolinids, without full documentation of other foraminifers typical for the Urgonian facies (except for remarks by Mišík, 1990; Krobicki & Olszewska, 2004). Foraminiferal assemblages of the Early Cretaceous Urgonian-type limestones contain many stratigraphically significant species of

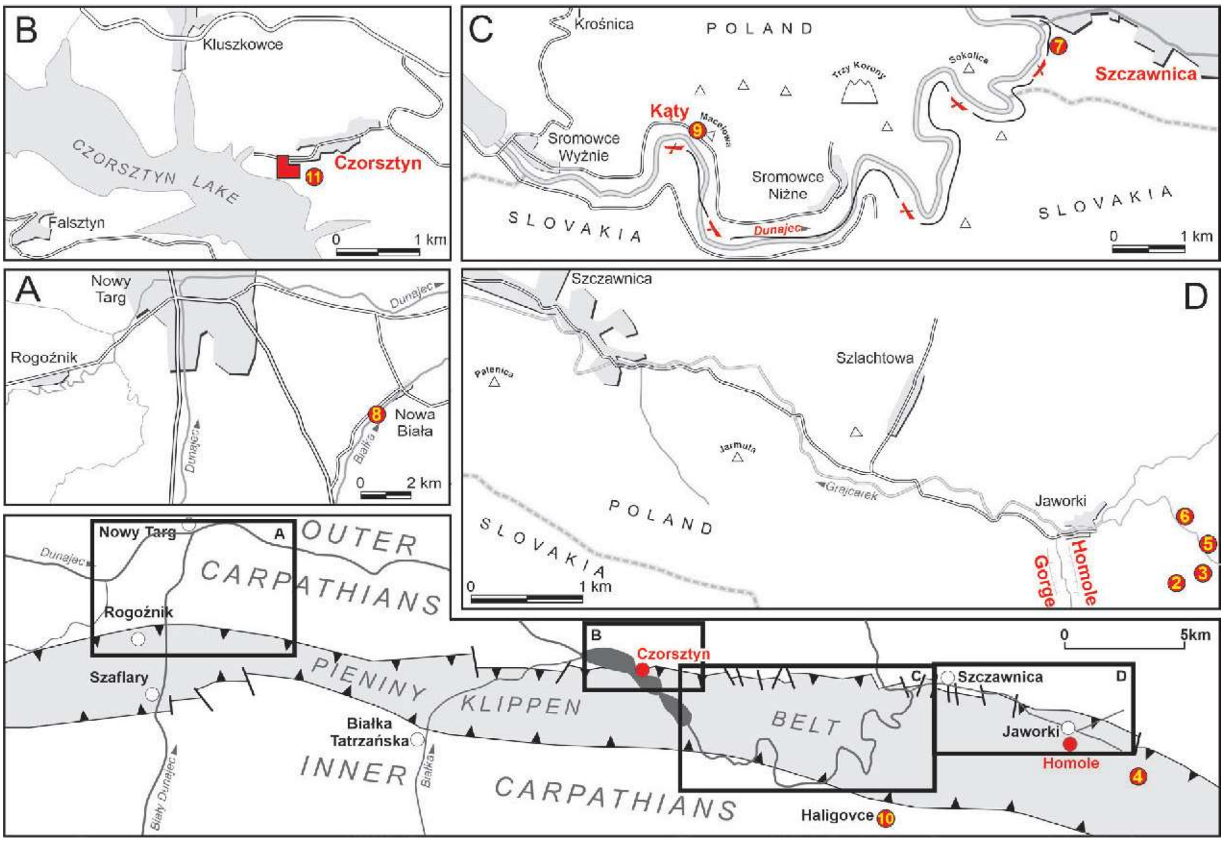

Fig. 27. Polish part of the Pieniny Klippen Belt and locations of visited outcrops – stop points

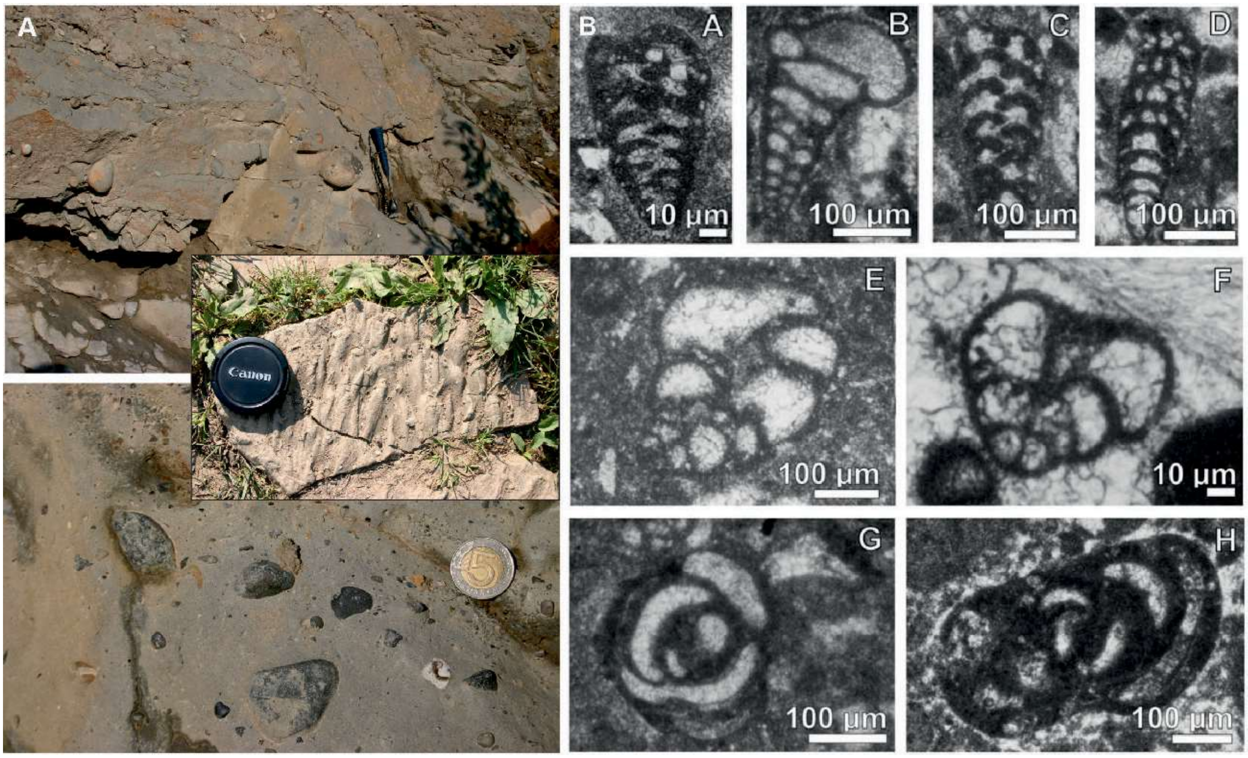

Fig. 28. View of the Bukowiny Gravelstone Member and Sromowce Formation in Skalski stream (A) and foraminifers of the Urgonian limestones (B): A – *Praechrysalidina infracretacea* Luperto Sinni (vertical section); B – *Praedorothia praeoxycona* (Moullade) (longitudinal section); C, D – ?*Pseudotextulariella scarsellai* (de Castro) (longitudinal sections); E – *Pfenderina* cf. *janae* Neagu (longitudinal section); F – *Pfenderina aureliae* Neagu (vertical section); G – *Pseudonummuloculina aurigerica* Calvez (oblique section); H – *Pseudonummuloculina aurigerica* Calvez (sub-axial section) (after Krobicki & Olszewska, 2022, modified)

both larger and smaller foraminifera. They cover the time span of Hauterivian–Albian, predominantly the Barremian to Early Aptian. Sporadic planktonic organisms, such as planktonic foraminifera (*Hedbergella*, *Heterohelix*, *Favusella*), tintinnids (*Colomiella* cf. *recta* Bonet) and calcareous dinocysts ("Calcispheres") [*Crustocadosina semiradiata* (Wanner)] have also been observed. Tintinnids (*Colomiella* cf. *recta* Bonet) and planktonic foraminifera [*Heterohelix* aff. *moremani* (Cushman)] suggest that the age of some assemblages may be younger than the earliest or even Late Albian (Reháková & Michalík, 1997; Nederbragt *et al*., 1998).

Additionally, magmatic/sub-volcanic exotic pebbles occur here, which are very well rounded. The exotics are represented by granitic and andesitic-type rocks (mainly andesite, basaltic andesite, basaltic trachyandesite, trachyandesite and rhyolitic pebbles, and rare dacite, tephrite, trachybasaltic and basaltic pebbles). Radiometric dating of these exotics (by U-Pb SHRIMP 206Pb/238U method) are following: 266.0 Ma ±1.6 Ma, 266.4 Ma ±1.8 Ma, 268.8 Ma ±1.9 Ma and 269.7 Ma ±1.8 Ma (Middle Permian; Guadalupian) (Poprawa *et al*., 2013; Krobicki *et al*., 2018). Additionally, such features suggest origin of these exotics from the same source area (Inner Carpathians the most probably) and have been connected with the Middle Permian oceanic crust subduction and origin of magmatic arc mentioned above, presumable connected with southern margin of Laurusia with subduction of oceanic crust of the Palaeotethys (proto-Vardar Ocean?). In conclusion, results of SHRIMP data and geochemical character of investigated exotics excluded their Barremian-Albian age of subduction and the Early Cretaceous age of oceanic crust (Birkenmajer, 1986, 1988), and existence of so-called Exotic Andrusov Ridge as well, postulated earlier in several papers (e.g., Birkenmajer, 1977, 1986, 1988).

Stop 3 – Bereśnik hill near Jaworki village ("mid"-Cretaceous pelagic shell beds, Late Cretaceous deposits and inversion structure) (Fig. 29)

(*Michał Krobicki*)

Pelagic deposits of the Albian/Cenomanian transition occur mainly in the Kapuśnica and Jaworki formations. The Kapuśnica Formation (Upper Aptian-Albian) is represented by dark-grey shales, grey-blue and green marly shales with intercalations of light-grey pelitic spotty (also cherty) limestones, rare fine-grained turbidite sandstone intercalations, and a few layers of black radiolarian shale. Other fossils, i.e. belemnites, ammonites and pelecypods, are very rare (see Kokoszyńska & Birkenmajer, 1956). The shell beds described here occur in the Niedzica Succession and represent the late Upper Albian through early Lower Cenomanian (foraminiferal palaeobathymetric association B1 of Gasiński (Gasiński 1991; Birkenmajer & Gasiński, 1992). The Albian-Cenomanian shell beds discussed are exposed in a right tributary of the Skalski Stream, about 1.5 km southeast of the Jaworki village (Krobicki, 1995) (Fig. 29). A section 7.5 m thick is seen in the steep bank of the stream. The section exposes mostly green and green-grey hard marls, spotty marly limestones and shales (cherry red-grey at some places), with subordinate intercalations of green spotty pelitic limestones and shell beds from a few to 30 cm thick. Some beds are technically boudinaged. The shell beds occur as layers and lenses varying in thickness from about 0.5 cm to 20 cm. They are built almost exclusively of small thin-shelled bivalves of the genus *Aucellina*. The shells are dismembered and severly crushed, many are also deformed by compaction, as is shown by broken shells whose fragments remain in place. Unbroken shells are preserved in the lower parts of some shell beds. Abundant and very well preserved mainly planktonie foraminiferal tests are present together with the bivalve shells, other fossils are represented by small pieces of indeterminable bivalve shells with spines and fragments of echinodenns. The shell beds are nearly monospecific (paucispecific sensu Kidwell *et al*., 1986). Belemnites and single shells of the bivalve *Aucellina* sp. Are very rare in the accompanying marls and marly limestones which show the presence of abundant trace fossils. They are represented mainly by *Chondrites* and by *Zoophycos* and *Planolites*-like burrows in marls and pelitic limestones. Sedimentary features of the described deposits are indicative of deep water pelagic deposition. Soft-substratum conditions are suggested by body fossils (*Aucellina* shells) and trace fossils (deposit-feeders dominating), the latter indicative of low energy of the bottom water. The foraminiferal assemblages are characteristic of middle slope (Gasiński, 1991; Birkenmajer & Gasiński, 1992). The dominant sedimentary features of the Albian-Cenomanian pelagic marls and limestones, their foraminifers and the macrofauna, all indicate low energy of their depositional environment In contrast, the skeletal accumulations represent highenergy events. Wide occurrence of shell beds in different carbonate or mixed clastic/carbonate shallow-marine sediments, both ancient (e.g. Kreisa & Bambach, 1982; Aigner, 1985; Fürsich & Oschmann, 1986; Eyles & Lagoe, 1989; Johnson, 1989) and modem (e.g. Gagan *et al*., 1988; Davies *et al*., 1989) is well known. Most of the shell beds formed above the storm wavebase, and skeletal accumulations formed below it are rare (Kidwell *et al*., 1986: fig. 5). Pelagic bivalve turbidites occurring widely in the Alpine-Mediterranean region are an exception (e.g. Bernoulli & Jenkyns, 1974).

In the upper part of the Bereśnik hill we can see the Late Cretaceous *Scaglia Rossa* deposits again overlying by flysch-type of the Sromowce Formation with exotics in local inversion structure.