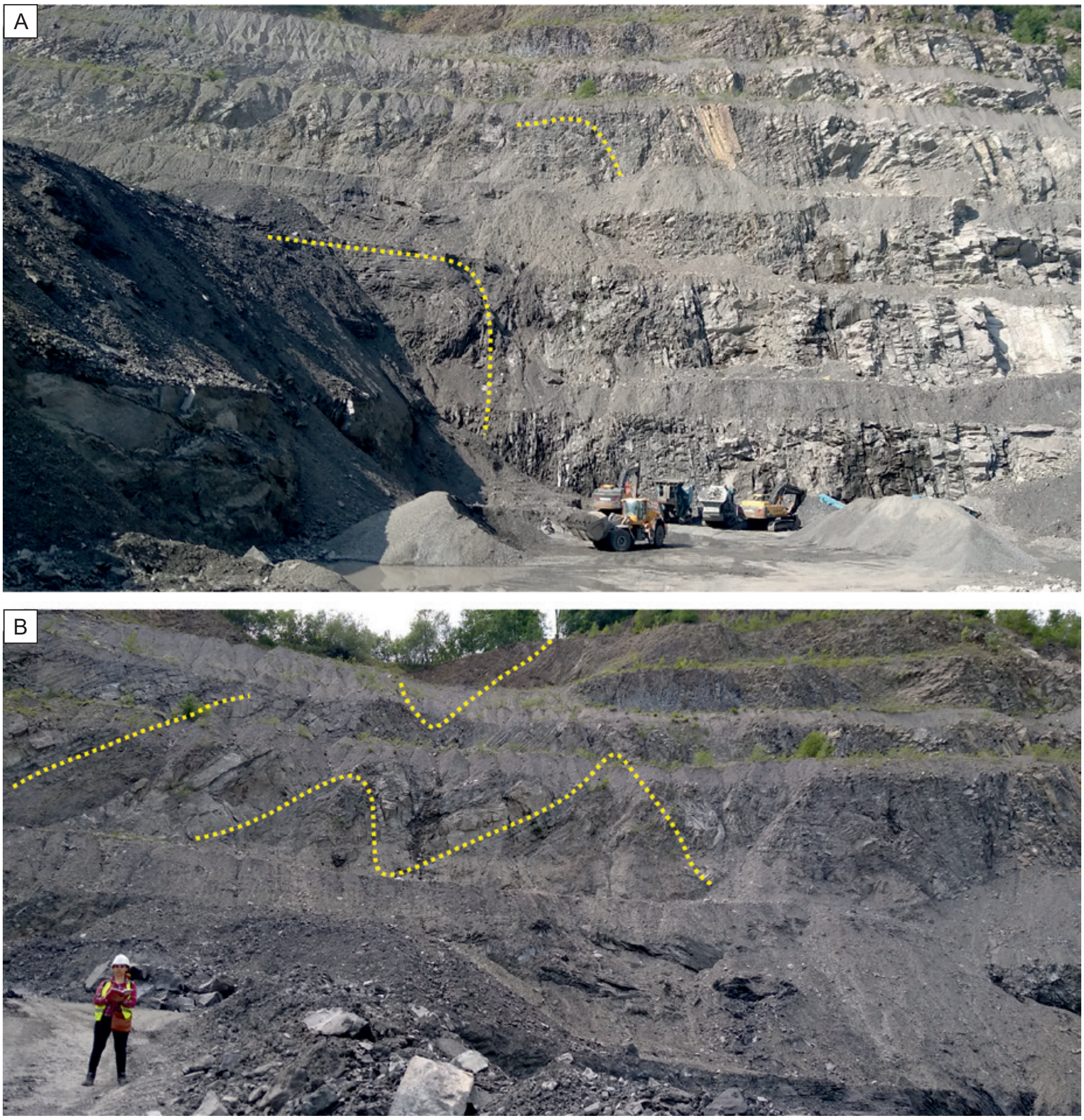

Fig. 28. Tectonic deformations formed at the front of the southern thrust sheet within the Godula Subunit: A – lower part of the Wisła Quarry; B – upper levels of the Quarry

The southern one represents the main part of the Subunit, including its complete succession from the lowermost part of the Godula Formation to the Oligocene in age Krosno Beds, and on the entire length it preserves undisturbed stratigraphic succession. Within the Wisła Quarry meso- and macrotectonic structures are observable that characterized the front of the southern thrust sheet (Fig. 28). For the Godula Subunit, a general decreasing character of the AFT age toward the north can be inferred. It is a typical AFT age pattern related to exhumation due to thrusting (Almendral *et al*., 2015), which supports the map-scale picture of the southern part of the Godula Subunit as a single block rotated due to reverse faulting.

Stop 6 – Janoszka stream in Kamesznica village sandy-to-gravelly debris flow deposits (Upper Cretaceous–Paleocene) (Figs 8, 13, 27–30)

(*Krzysztof Starzec*)

The Stop is located in the Kamesznica village along the Janoszka stream. The sequence of the Upper Cretaceous–Paleocene Istebna Formation is exposed along the stream

(Fig. 29). The rocks outcropped in this area belongs to the southern part of the Silesian Unit. They strike latitudinally about 2,5 km north of the thrust front of the structurally higher Fore-Magura Unit.

This formation was first described as the Istebna Beds by Burtan (1936) and characterized by Burtanówna *et al*. (1937). The Istebna Formation is spread from the Moravian-Silesian Beskids in the Czech and Slovak Republic through the Silesian Beskid, Mały Beskid, up to the Bieszczady Mountains area in the eastern part of the Polish Carpathians (see Żytko *et al*., 1989). This formation is best developed in the Silesian Beskid, reaching around 2000 m in thickness (e.g., Burtanówna *et al*., 1937; Unrug, 1963, 1968). The lower 1,500 m of this Formation belongs to the Lower Istebna Beds (represented by the Lower Istebna Sandstones), and over 400 m represents the Upper Istebna Beds that are subdivided into three members: the Lower Istebna Shale, Upper Istebna Sandstone and Upper Istebna Shale (Burtanówna *et al*., 1937; Burtan *et al*., 1956; Burtan, 1972, 1973). These subdivisions are clear foremost in the stratotype area of the Istebna Beds in the Silesian Beskid (Strzeboński, 2015), whereas more to the east of the Outer Carpathians, the Lower Istebna Shale and the Upper Istebna Sandstone pinch out locally, so the remaining subdivisions are merged and indistinguishable (Książkiewicz, 1951; Strzeboński, *et al*., 2017). In the Moravian-Silesian Beskids, in turn, a few to several principal lithological horizons are distinguished within the Istebna Formation, which are hard to correlate with the above-mentioned subdivisions from other areas (Strzeboński & Uchman, 2015).

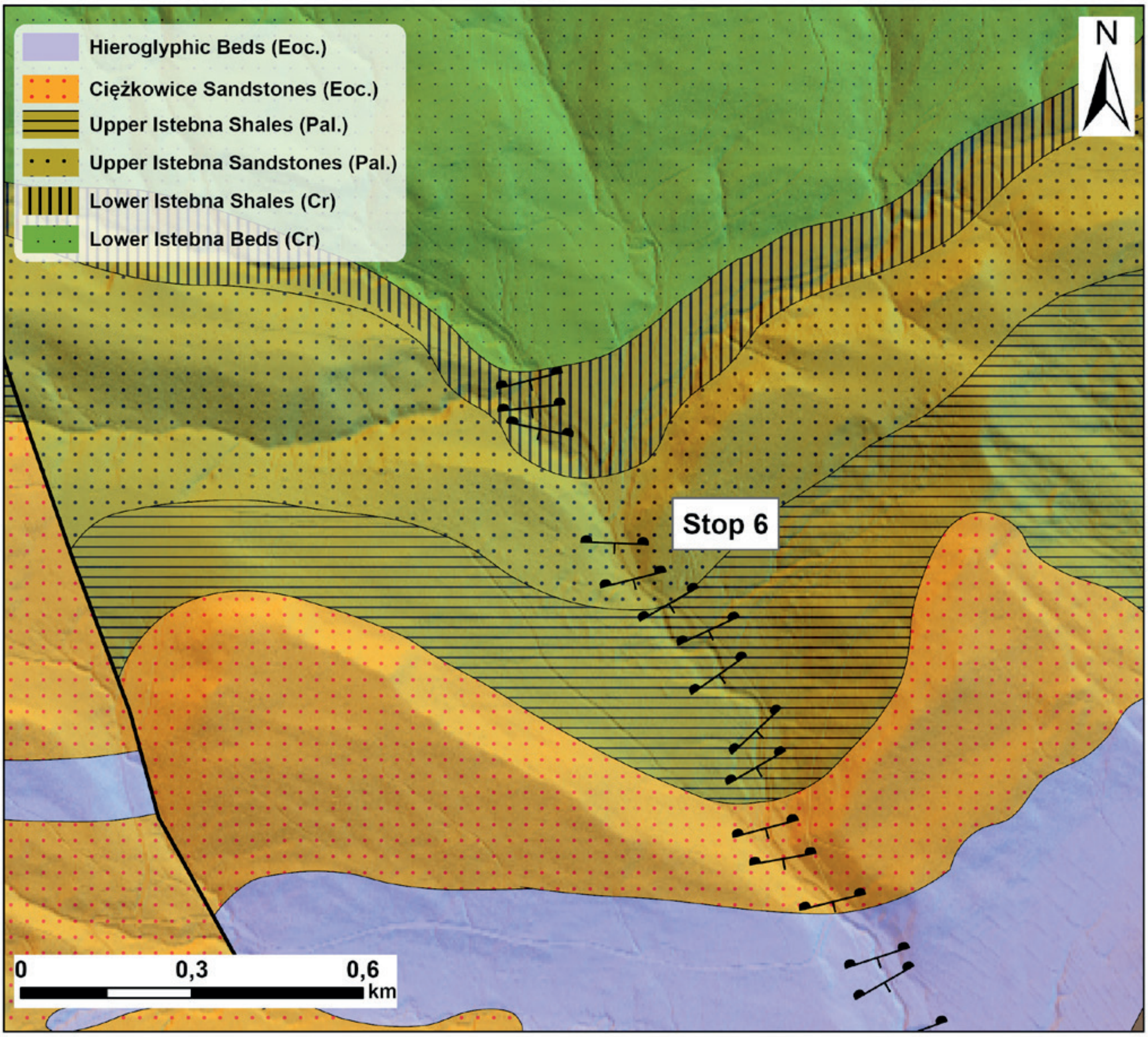

Fig. 29. Detailed geological map of the Kamesznica area. Stop 6 includes outcrops along the Janoszka stream

The Lower Istebna Beds is a sand-dominated lithostratigraphic unit. It consists mostly of thick-bedded, amalgamated, coarse-grained sandstones and granule/fine-pebble conglomerates with rare interbeds of shales or thin-bedded fine-grained sandstone-shale packets. They form the largest and highest part of the Silesian Beskid range.

The tripartite lithostratigraphical unit of the Upper Istebna Beds occupies a much smaller area. Its middle part is built of similar sandstones and conglomerates as in the lower member, and it is sandwiched between the lower and upper shale members represented by dark grey to black, very thin bedded mudstones, abundant in sphaerosiderites (Fig. 30). The sandstone complex reaches about 100 m in thickness, while the cumulative thickness of the mudstones complexes is about 300 m (Starzec *et al*., 2017), although their thickness, and as a consequence, the width of the outcrops, varies along the strike. This particularly holds true for the sandstone complex. The layers of both the lower and upper members of the Istebna Formation lie concordantly, being tilted to the south at an angle of about 22° (Fig. 29).

The continuous sequence of the Upper Istebna Beds can be traced in the Janoszka riverbed and banks. The sequence includes contact between the shale and sandstone/conglomerate members in which a distinctive and abrupt change of facies is visible, i.e., the complex of black sandy shales, with only occasional intercalations of thin sandstone layers, is overlain by very thick-bedded, coarse-grained sandstones and conglomerates (Fig. 30). The latter contain pebbles and even boulders up to 70 cm in diameter. The sandstone-conglomerate layers are characterized mostly by massive or graded structure. The sedimentary structures are especially well visible within the rocky sandstone landforms that are scattered throughout the area. Within the tors south of the Stoczek, i.e., a hamlet of the Istebna village, the sedimentary sequence begins with a thick conglomerate layer that reveals normal grading (Fig. 31). Quartz and different crystalline lithoclasts form the main body of the conglomerate, with maximum size reaching about 4–6 cm. In the middle part of the layer shale clasts and more often caverns after these clasts occur (Fig. 31). The caverns are elongated, usually disc-shaped, and sometimes contain only remnants of the material that once filled them. Shale clasts are interpreted to have formed when already lithified shaly deposits were torn from the underlying beds by gravity currents. The fragments of shales were subsequently, deposited with coarse-grained material (Stadnik & Waśkowska, 2015). The conglomerate layer reveals a sharp top surface markinga distinctive border with another conglomerate. Within the lower part of the latter one, a thirty-cm thick interval with reverse grading occurs, passing to the top into normal grading. The normal graded interval starts with granules, reaching about 1 cm to 6 cm in diameter, and changes to the top of the layer into medium to fine gravel. At about 1.3 m above the bottom of the layer, the large crystalline boulders are enclosed. The biggest boulder reaches 70 cm. They have different shapes from angular to well rounded.

The conglomerate is followed by a sandstone layer of ca. 1.7 m thickness. This sandstone reveals rather poorly defined normal grading with dispersed fine gravel-sized grains. Within some parts of the layer a through cross-stratification can be recognized, the origin of which is unclear. This kind of structure has been interpreted as a sedimentary structure (Ślączka & Thompson, 1981; Dziadzio *et al*., 2006), but recently Leszczyński *et al*. (2015) described it as a tensile fracture. Moreover, the sandstone contains isolated, lenticular gravel pockets (Fig. 32), up to 80 cm in length and 20 cm in thickness that are irregularly distributed within the layer. The top contact of the sandstone with the overlaying conglomerate is sharp, but highly uneven. It is a result of the loaded erosional base of the conglomerate with large load-flame structures. The lithology and sedimentary features of deposits correspond to the sequence described by Lowe (1982) (Fig. 31). Within individual layers, the R2-R3-S1 or R3-S1 divisions can be recognized, i.e., very coarse and coarse-grained conglomerate with reverse grading (R2), upwards with normal grading (R3), turning into to coarse-grained sandstone with lenses of pebbles (S1).

Siliciclastic material of these deposits was accumulated in the Silesian Basin within a slope-apron depositional environment, mainly by sediment gravity-driven processes (Fig. 33). Initially, the material was chaotically redeposited from edge of a shelf-margin by mass-wasting processes (slides, slumps) and mass flows (avalanche, different types of debris flows) in the form of elongated tongues, which formed covers of a proximal slope apron. During further downslope redeposition, these slumps or debris flows were frozen or partly transformed into turbulent fluid-sediment gravity flows, including turbidity currents (e.g., Unrug, 1963; Strzeboński, 2015, 2022). Later, structural changes of these sediments and final accumulation could took place under the influence of in-situ liquidization, bottom current reworking with tractional deposition and hemipelagic sedimentation also occurred in the background.

The palaeotransport directions in the upper Istebna sandstones indicate the south-to-north direction of the material's supply, i.e., the hypothetical Silesian Ridge (cordillera) was the source area for the crystalline clasts. The Silesian Ridge represented an elevated fragment of the sea floor developed along the south edge of the North European Platform. Initially, during Jurassic and Cretaceous times, the Silesian Ridge separated the Magura and Severinic-Moldavidic (Protosilesian) basins. It formed a barrier between the Silesian and Fore-Magura basins after the Late Cretaceous geotectonic reorganization (e.g., Golonka *et al*., 2005, 2006a, 2006b, 2013). It was later destroyed in the process of expansion of the Carpathian accretionary prism and now is known only from olistolits and exotics.

The crystalline blocks represent magmatic, metamorphic, and rarely sedimentary rocks with domination of varied white-grey gneisses.

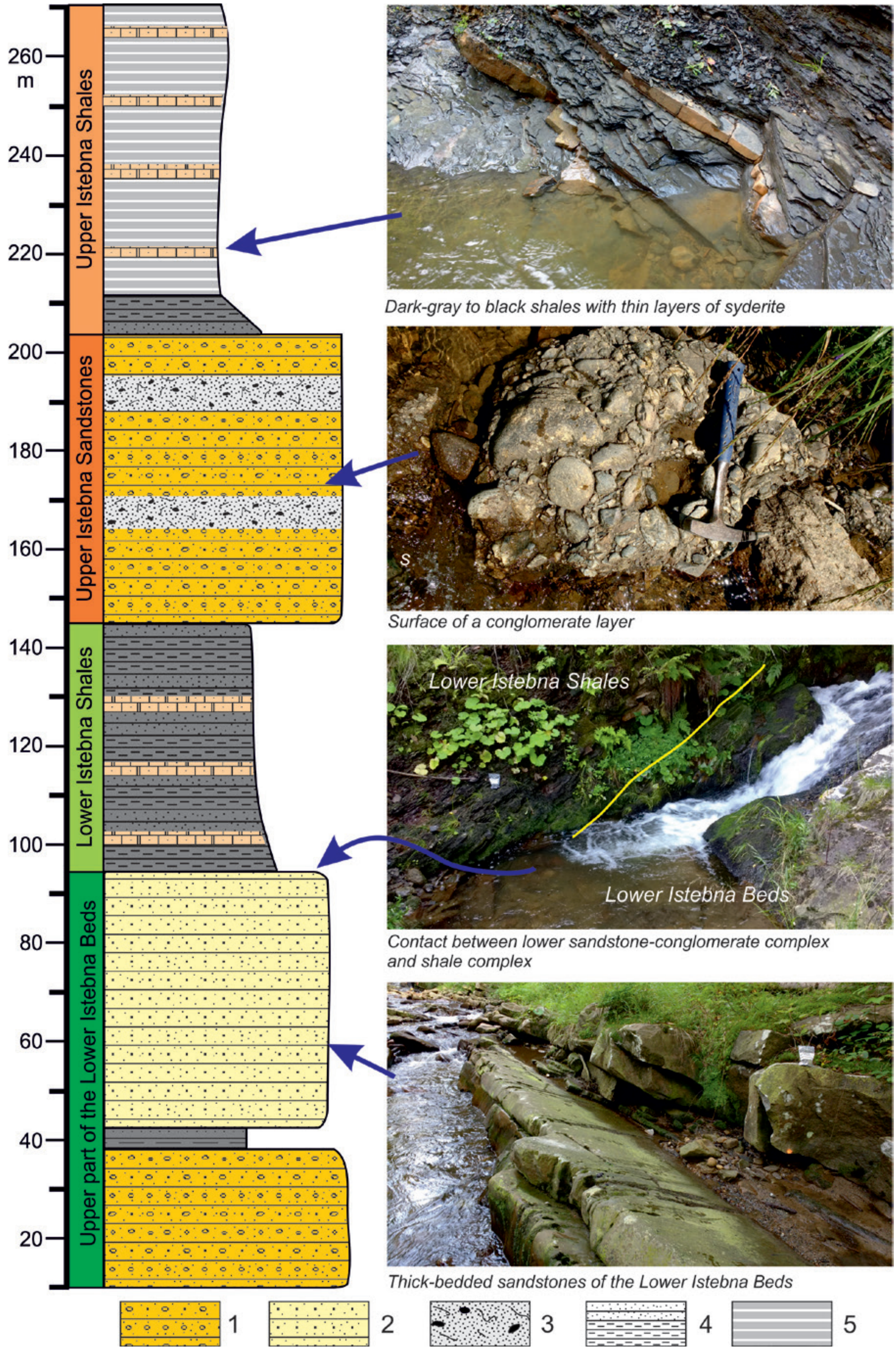

Fig. 30. Schematic lithological log of the upper part of the Istebna Formation. 1 – thick-bedded conglomerate and sandstone, 2 – thick-bedded, mainly coarse-grained sandstone, 3 – gravelly mudstone, 4 – sandy mudstone intercalated by thin-bedded sandstone and siderite, 5 – mudstone with thin-bedded siderite

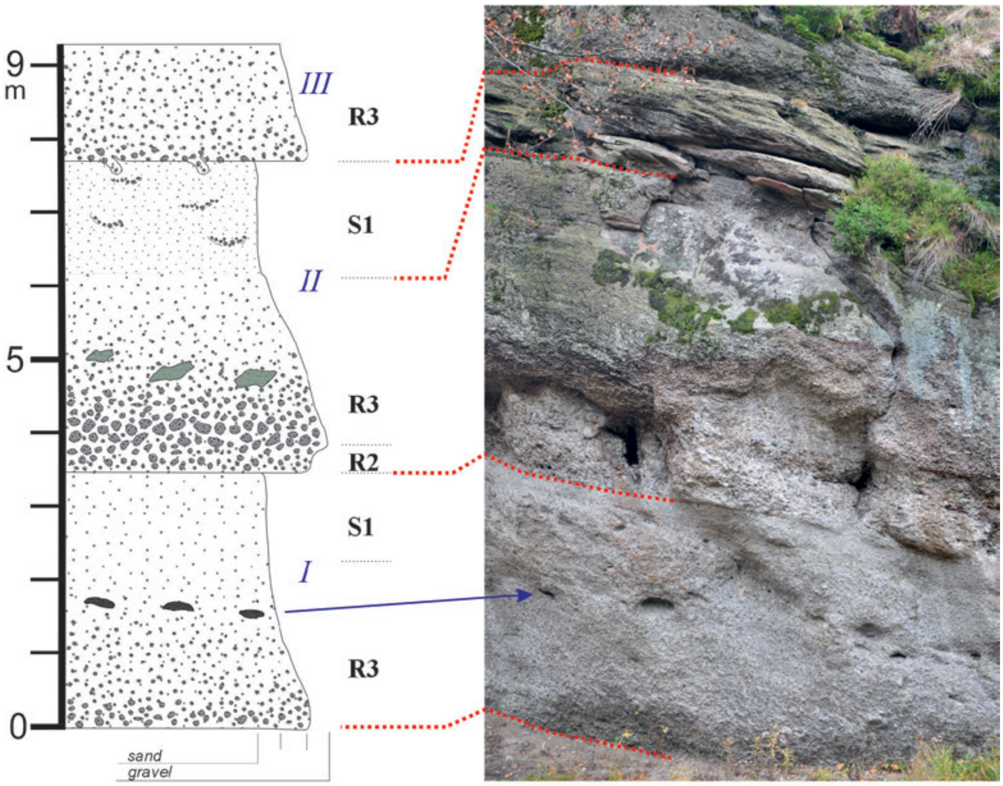

Fig. 31. Lithofacies profile of the part of the Upper Istebna Sandstones with the facies succession corresponding to Lowe's succession intervals; Bed I – very coarse and coarse-grained conglomerate displaying normal grading (R3) transiting to medium and fine-grained conglomerate (S1); Bed II – very coarse- and coarse-grained conglomerate with reverse grading (R2), upwards with normal grading (R3) and large gneiss blocks, transiting to coarse-grained sandstone with lenses of pebble; Bed III – coarse-grained conglomerate displaying normal grading (after Starzec *et al*., 2017)

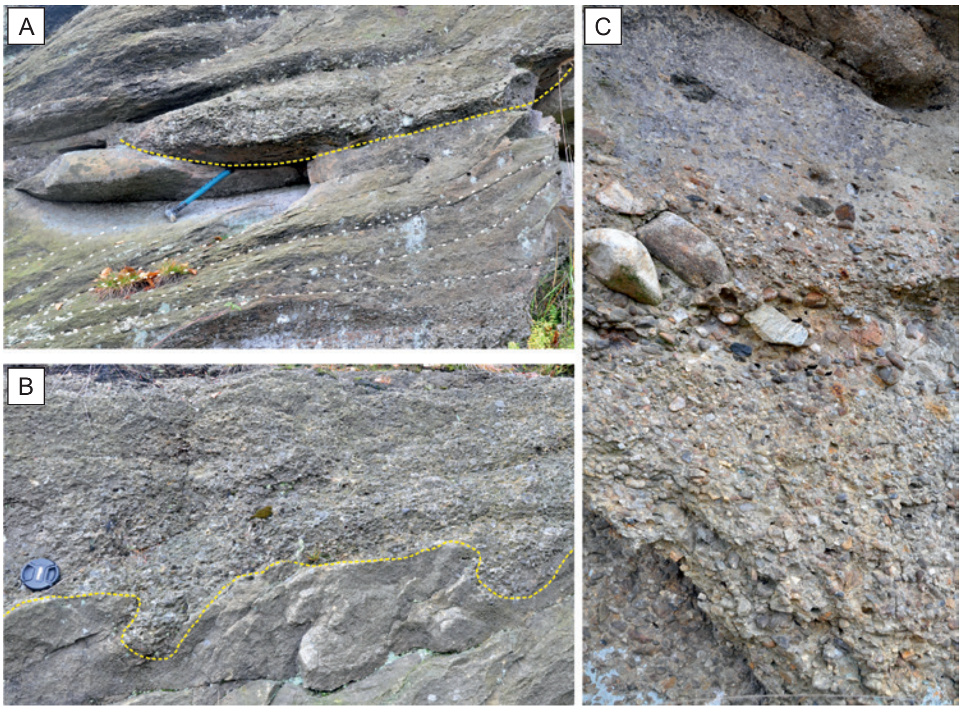

Fig. 32. Sedimentological features of the Istebna sandstones: A – fragment of sandstone bed with cross-bedded laminae marked by white lines and with lense-shaped conglomerates marked by yellow line laminae; B – loading deformations at the boundary of conglomerate and sandstone layers marked by yellow line; C – pebbles and cobbles of gneisses of various roundness constituting the basic components of conglomerate; photo K. Starzec

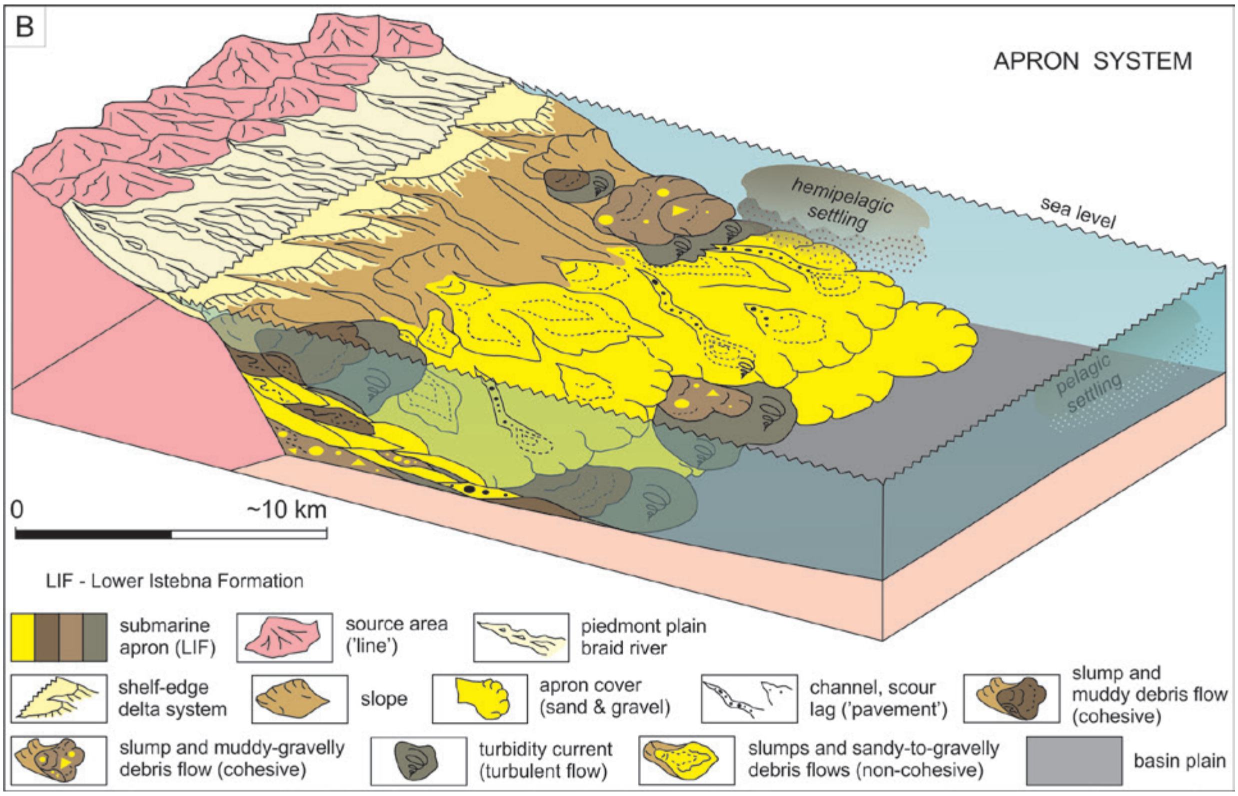

Fig. 33. Sedimentation model of the depositional system for the Istebna Formation – line-supplied slope resedimentation apron (after Strzeboński, 2022, with permission of author)

These gneisses together with schists, phyllites, pegmatites, milky or dark quartzites, pinkish granites, and sporadically dark limestones, represent the rocks inventory of the basement upon which the Carpathian basins, developed during Mesozoic and Cenozoic times. This, so far poorly known basement is customarily called the "Protocarpathians" (Gawęda & Golonka, 2011). The Protocarpathian exotic material plays a key role in palaeotectonic reconstructions. Data from the felsic crystalline clasts imply that the Silesian Ridge was an eastern prolongation of the Brunovistulia microcontinent (Gawęda *et al*., 2019).

Stop 7 – Klubina quarry – siliciclastic flysch (upper Eocene) (Figs 8, 13, 31–34)

(*Krzysztof Starzec*, *Jan Barmuta*, *Lothar Ratschbacher*, *Saeideh Asal Seyedi, Piotr Łapcik*)

The abandoned Klubina quarry is located in Slovak part of the Outer Carpathians, about 7 km south the Polish/Slovak border. This area belongs to the highest tectonic unit in the Western Carpathians, i.e., the Magura Unit (Nappe). The Unit forms a continuous belt along the Western Carpathian arc from the Vienna Forest in Austria to the Western Ukraine (Picha *et al*., 2006). The sedimentary succession of the Magura Unit includes mostly flysch type deposits that evolved during the Late Cretaceous and Paleogene at the convergent stage of the Carpathian area development (Picha *et al*., 2006).

Rocks exposed in the quarry represent the youngest (Late Eocene) stage of sedimentary infill of the Magura Basin. They are assigned to the Kýčera Member of the Zlín Formation of the Rača Subunit (Staňová *et al*., 2009), i.e., one of the large thrust units within the Magura Unit. The Zlín Formation is regarded as an equivalent of the muscovite sandstone facies of the Magura Formation distinguished in the Polish part of the Magura Unit. The Kýčera sedimentary succession in the Quarry is a representative of the entire belt of the Magura Unit, along which the youngest synorogenic flysch deposits are more or less similarly developed. These deposits mark the last phase of the Magura Basin evolution. Rocks making up the sedimentary succession in the quarry form a sandstone-mudstone sequence, although with distinctive domination of the first lithology (Fig. 34). The sandstones occur mostly in thin to thick layers, very thick beds are also quite often present, some of them shows amalgamation structures. Most sandstone beds have flat or slightly wavy bases, very often with flute casts or tool marks.