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The Babín Klippen – a peculiar branch of the Orava sector of the Pieniny Klippen Belt (Slovakia)

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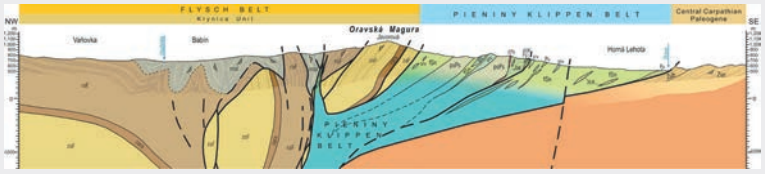
Abstract: The Pieniny Klippen Belt (PKB) is a narrow, approx. 5 – 8 km wide zone at the boundary of the External and Internal Western Carpathians. The zone of the Babín Klippen, which is the main subject of this study, represents northerly situated branch of the PKB located at the NW slopes of the Oravská Magura Mts. SE of Babín and Lokca villages (Námestovo district) in the northern Slovakia. The paper presents the results of geological mapping and lithostratigraphic investigation of the area. The PKB rocks are surrounded by sandstones of the Zábava Fm. and claystone-rich Malcov and Racibor fms. belonging to the Krynica Unit of the Flysch Belt. The soft matrix between the rigid klippen is represented mainly by the quartz-carbonate sandstones of the Snežnica and Sromowce fms. and red marls or shales of the Púchov Fm. Locally also red Malinowa-type shales of the Pavláškova skala Fm. were identified. The klippen rocks represented mainly by the limestones of the Pieniny Fm., locally also radiolarites of the Czajakowa Fm. and spotted limestones of the Allgäu Fm. are correlated with the Orava succession. The Jurassic crinoidal limestones of the Smolegowa and Krupianka fms. and red nodular limestones of the Czorsztyn Fm. are part of the Czorsztyn succession. The whole zone is intensively deformed and brecciated. The additional deformation can be interpreted as a consequence of backthrust and incorporation of the PKB successions inbetween the thrust sheets of the Krynica Unit, which is consistent with some older opinions.

Key words: Western Carpathians, Orava succession, Czorsztyn succession, Šariš succession, Backthrust

Graphical abstract



Highlights

- The Babín Klippen is approx. 8 km long and 200 m wide and extremely deformed zone of the Pieniny Klippen Belt (PKB) on the northern slopes of the Oravská Magura Mts.
- The studied area is composed of the Orava, Czorsztyn and Šariš successions of the Oravic units.
- The Babín Klippen Zone formed due to SE-vergent backthrust of the Krynica Unit of the Flysch Belt.

Introduction

The Pieniny Klippen Belt (PKB) is a narrow tectonic unit, approximately 0.5–8 km wide, located at the boundary between the External and Internal Western Carpathians (Andrusov, 1938; Andrusov & Scheibner, 1960; Scheibner, 1967; Mišík, 1997; Bezák et al., 2008; Plašienka, 2018). The PKB is characterized by its "klippen" structure, which consists of rigid limestone lenses (traditionally termed klippen), usually of Jurassic to Early Cretaceous age, located within a less competent formations composed of Upper Cretaceous flysch or marlstones (Andrusov, 1938; Plašienka, 2018). The internal structure of the PKB is highly complicated due the considerable lithofacies diversity and intensive compressional and transpressional deformation, related to the extreme convergence of lithotectonic units. Additionally, the interpretation of the PKB structure is hampered by insufficient exposures.

Despite the internally complicated structure, the PKB is confined to a coherent fault bounded zone, without significant outliers. The well-known exceptions are the Čakanov Klippen in the Vlára river Valley NW of Nemšová town, Mestečko Klippen NW of Považská Bystrica town and Mariková klippen in the western sector of the PKB (Mello et al., 2005; Plašienka et al., 2010; Pešková et al., 2021; Teťák, 2024).

A similar isolated structure formed by the PKB rocks surrounded by flysch sequences of the Krynica Unit of the Magura group of nappes of the Flysch Belt occurs in a narrow zone on the northern slopes of the Oravská Magura Mts. The PKB rock sequences form an independent strip on the NW slopes of the Prípor Hill (1,105.8 m), SE of

Babín and Lokca villages (Námestovo district, Fig. 1). The occurrences were discovered already by Andrusov (1931) and are also shown on later geological maps (Potfaj et al., 1981; Potfaj, 1979, 1983; Bezák et al., 2008; Káčer et al., 2024). Although some authors take these occurrences into account in regional interpretations (e.g., Marschalko, 1986; Vozár et al., 1999), the more detailed description and analysis of this PKB zone have not been available in English, especially for the international audience.

The zone of klippen south of Babín and Lokca villages was originally termed the Babín sector of the PKB (in Slovak: *babínsky úsek bradlového pásma;* Potfaj, 1983). A shorter name the Babín Klippen (in Slovak: *babínske bradlá*) is proposed for the zone after the nearby Babín village.

The earliest reference to the PKB rocks in this area is a pre-WW II 1:25,000 geological map by Andrusov (1931), who marked the occurrence of limestones of the Pieniny Fm. surrounded by the marlstones of the Púchov Fm. in the Skalnatý potok Stream and further north on the ridge. Other occurrence of the Pieniny Fm. has been shown further to the northeast, on the slope of the Rúbane locality. In the northeast, in the stream north of Šubovka Hill, another occurrence of the Púchov and Pieniny fms. is indicated. The PKB rocks are surrounded by the Paleogene formations of the Krynica Unit of the Carpathian Flysch Belt.

Potfaj et al. (1981) extended the known occurrences of the PKB facies in the unpublished manuscript of 1:25,000 map sheet Trstená to the Stodoly area, the right branch of

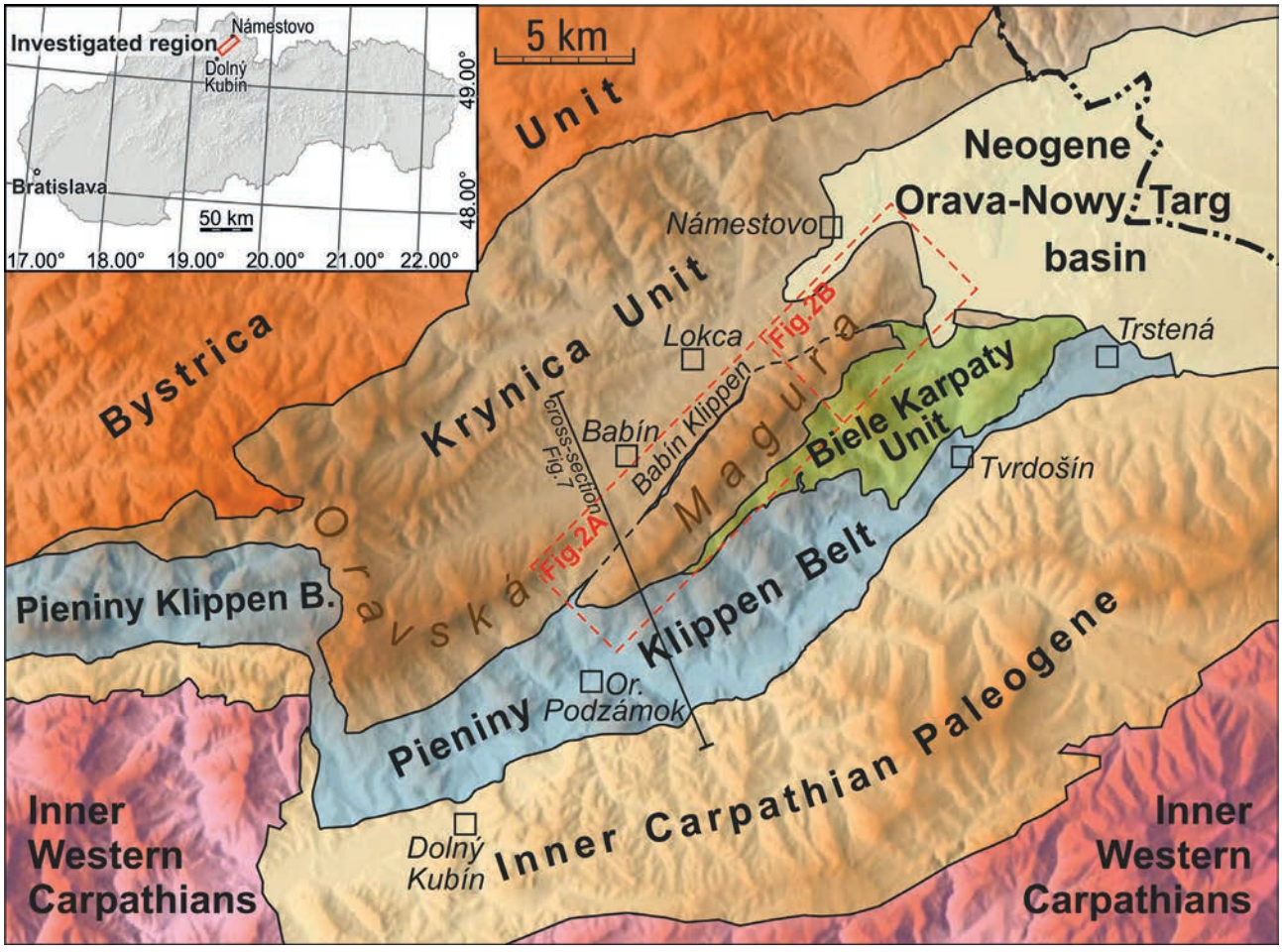
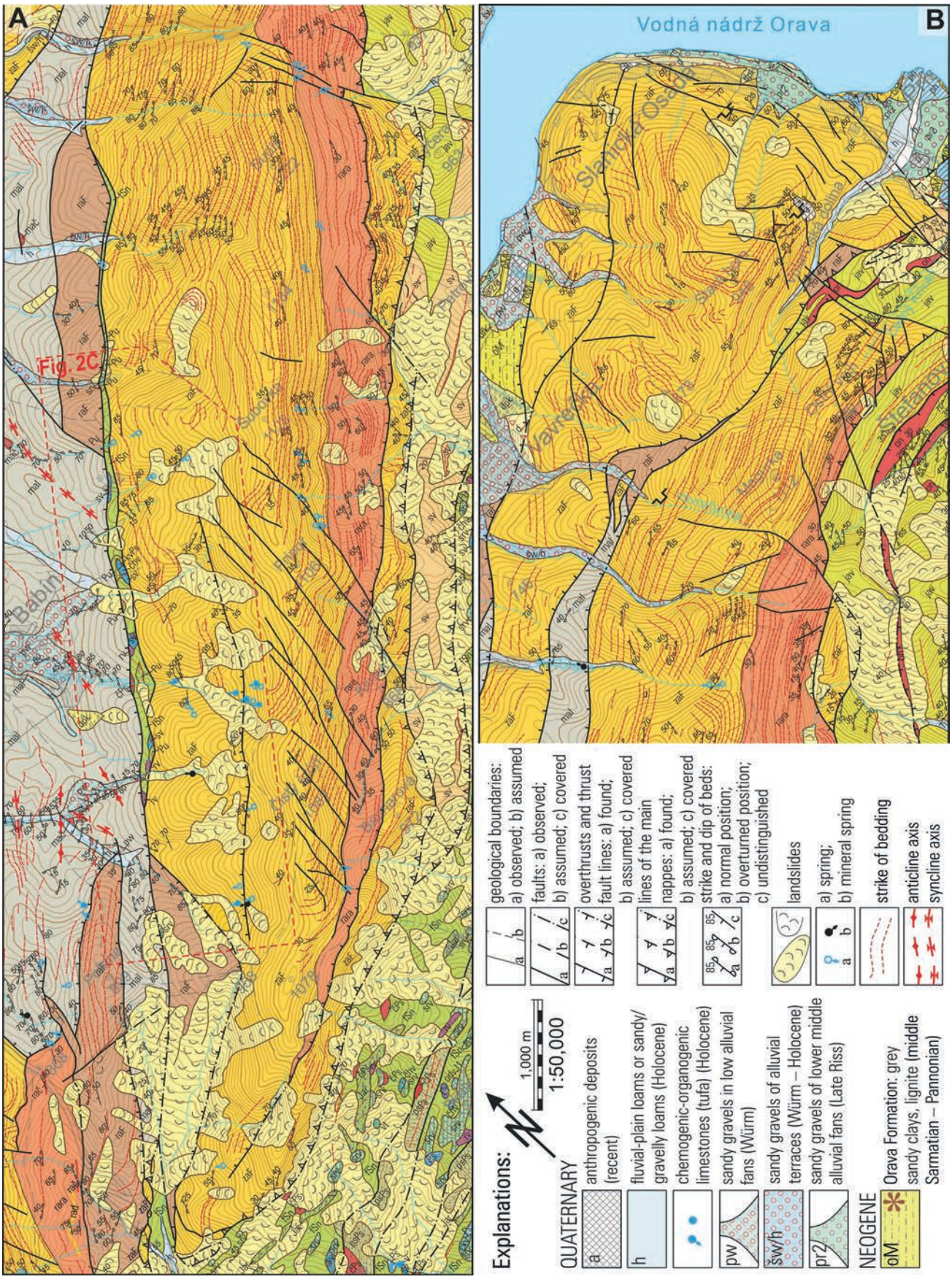


Fig. 1. Location of the investigated region within Slovakia marked by the red polygon

Fig. 2. Geological map of the Babín Klippen and their surroundings (Geological map of Oravská Magura: Teťák et al., in press)


A
B
Fig. 2C
Vodná nádrž Orava
Babín
Slanická Osada
Vavrečka
Stefanov
Explanations:
1,000 m
1:50,000
QUATERNARY
a anthropogenic deposits (recent)
h fluvial-plain loams or sandy/gravelly loams (Holocene)
chemogenic-organogenic limestones (tufa) (Holocene)
pw sandy gravels in low alluvial fans (Würm)
šw/h sandy gravels of alluvial terraces (Würm – Holocene)
pr2 sandy gravels of lower middle alluvial fans (Late Riss)
NEOGENE
oM Orava Formation: grey sandy clays, lignite (middle Sarmatian – Pannonian)
geological boundaries: a) observed; b) assumed
faults: a) observed; b) assumed; c) covered
overthrusts and thrust fault lines: a) found; b) assumed; c) covered
lines of the main nappes: a) found; b) assumed; c) covered
strike and dip of beds: a) normal position; b) overturned position; c) undistinguished
landslides
a) spring; b) mineral spring
strike of bedding
anticline axis
syncline axis

FLYSCH BELT – KRYNICA UNIT

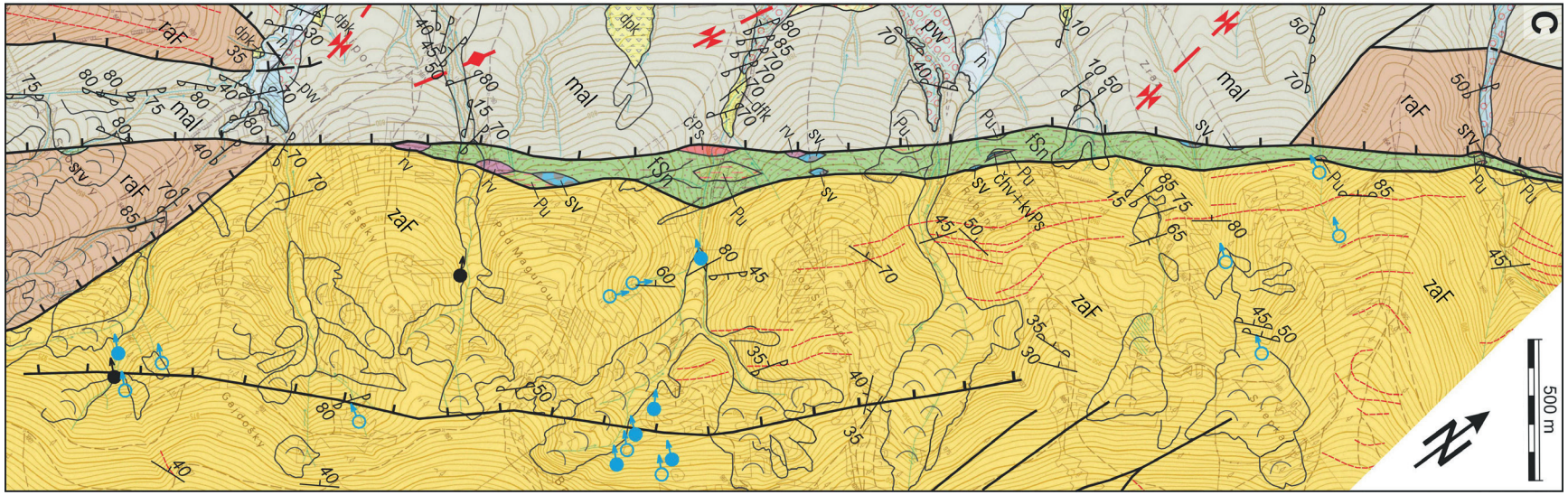
- mal mač — Malcov Formation: light claystones, chaotically bedded sandstones to claystones; mač – layer of red claystones (Latest Eocene – Oligocene)
- raF — Racibor Formation: thick grey claystones and thin beds of sandstones, thick Magura type greywacke sandstones (Middle Eocene – Early Oligocene)
- rara — Racibor Formation – Račová Member: thick grey claystones, thin beds of laminated sandstones (Middle Eocene)
- zaF — Zábava Formation: thick Magura type greywacke sandstones and thin-bedded flysch (Late Paleocene – Middle Eocene)

BIELE KARPATY UNIT – Štefanov Nappe

- sv — Svodnice Formation: massive calcareous claystones, quartz-carbonate sandstones (Paleocene – Early Eocene)
- svp — Svodnice Formation: thick-bedded massive greywacke sandstones
- jav — Lopeník Formation – Javorina Member: quartz-carbonate sandstones: thin-bedded flysch deposits (Late Campanian – Maastrichtian)
- on — Lopeník Formation – Ondrášovec Member: thin-bedded flysch, red and grey-green claystones (Middle Campanian – Late Maastrichtian)

KLIPPEN BELT

- Jar — Jarmuta-Proč Formation: quartzy-carbonate sandstones, conglomerates, organodetritic and reef limestones (Campanian? – Maastrichtian – Early Eocene?)
- psPs — Pavláškova skala Formation: massive quartzy-wacke sandstones (Turonian – Campanian)
- čPs — Pavláškova skala Formation: thin-bedded flysch: red claystones, grey-green quartzy-carbonate sandstones
- Pu — Púchov Formation: Púchov-type marlstones: red, green and grey marlstones to limestones with intercalations of sandstones (Cenomanian – Maastrichtian)
- fSn — Snežnica-Sromowce Formation: quartzy-carbonate sandstones, claystones, sporadically conglomerates (Turonian – Santonian)
- čhv — Czorsztyn and Niedzica limestones: red nodular limestone of "ammonitico rosso" facies (Toarcian, Bathonian – Callovian, Kimmeridgian – Tithonian)
- srv — Pieniny Formation: grey to white locally spotted thin-bedded limestones with cherts (Tithonian – Barremian)
- rv — Czajakowa Formation: red and green radiolarites and radiolarian limestones (Oxfordian)
- Ps — Posidonia and Supra-Posidonia mbs.: dark-grey shales, dark-grey limestones (Aalenian – Bajocian)
- odvJ1 — Lúty potok Formation: sandy, sandy-crinoidal limestones and quartzy conglomerates (Sinemurian – Pliensbachian)
- sv — Allgäu and Dolný mlyn Formation: black calcareous silty shales, spotty calcareous shales (Flacenmergel), spotty and grainy limestones (Fleckenkalk), intercalations of crinoidal limestones (Sinemurian – Pliensbachian)
- Gr — "Gresten Beds": grey to brown quartzy sandstones, locally grey claystones (Sinemurian)



the Bučníkový potok Stream, and above the Zraz locality. In addition to the spotted siliceous limestones with cherts and red marlstones of the Púchov Fm., already described in the previous work (Andrusov, 1931), new occurrences of Jurassic radiolarites and Upper Cretaceous PKB flysch formations were reported. At the documentation point D-365 (approx. at the locality Pod Magurou, N 49.3160398°, E 19.3909382°) a rich foraminifera assemblage from red marlstones of the Púchov Fm. indicated the Coniacian age (Gašpariková in Potfaj et al., 1981).

Potfaj (1979) described the occurrence of the PKB rocks along the line Príslop saddle (808 m) – Kubička locality – Vavrečka village as: *"strongly crushed belt with tectonic breccia up to 80 m thick. Apart from the Paleogene sandstones and claystones, breccia contains fragments of Tithonian clayey limestones, green radiolarites, 'exotic' conglomerates with similar pebble composition as conglomerates near Krivá village, tectono-sedimentary breccias of 'Záskalie-type' with Campanian – Maastrichtian age and brick-red claystones with Turonian microfauna. Based on the field measurements the line is dipping 80–85° to the SE"*. Potfaj (1983) stated that *"the Magura sandstone complex is tectonically separated from the Malcov Formation at the northern foot of the Oravská Magura and meets the Malcov Formation through a 20 to 200 m wide tectonic zone, along which fragments, lenses, and breccias of rocks from the sedimentary sequences of the Pieniny Klippen Belt are brought to the surface"*.

Apart from the cited works, the Babín Klippen area has not been studied or properly discussed. During the new geological mapping, it was possible to verify and accurately locate most of the known sites and several new sites were discovered. The present paper is aimed on a revision and description of the geological structure of the Babín Klippen.

Methods

The area was mapped using the standard methods of geological mapping according to the *Directive of the Ministry of Environment of the Slovak Republic No. 4/1996-3.1. for the compilation of basic geological maps and explanatory notes at the scale 1:25,000 and regional geological maps at the scale 1:50,000*. Additionally, the standard geological mapping was enhanced thanks to LiDAR assisted base maps using DTM 5.0 with accuracy of ~0,2 m (Liščák et al., 2022; Leitmannová & Gálová, 2023). The accuracy of the GNSS devices used for field navigation was within 5 m. The mapping was based mainly on the occurrence of rock fragments in a scree. Better outcrops were found only in the Skalnatý potok Stream and in the Rúbane section after the riverbed was washed out by an extreme storm in April 2025.

Results

The Babín Klippen form a 20 to 250 m wide and about 8 km long continuous zone, consisting mainly of the Upper Cretaceous Snežnica and Sromowce flysch formations composed of claystones and quartz-carbonate sandstones. Structurally, we can follow the Babín Klippen Zone south-westward to the spur of the PKB in the Račová Stream valley, and north-eastward to the spur of the Biele Karpaty Unit, although rocks of the PKB are not exposed in the area (Fig. 2). The Babín Klippen structure follows the morphological break of the slope at a distinct

Tab. 1

Important studied localities with WGS coordinates mentioned in the text

Number	Locality	WGS X (N) [°]	WGS Y (E) [°]	Description
1.1	Skalnatý potok Stream, SE of Babín village	49.3218442	19.3951113	cut of the stream, contact of Malinowa-type shales with grey shaly mélange
1.2		49.3213092	19.3951895	cut of the stream, Pavláškova skala Fm.
1.3		49.3215107	19.3965051	dirt road cut, Púchov, Allgäu and Czajakowa fms.
1.4		49.3211137	19.3958103	cut of the stream, brecciated Pieniny Lmst.
2.1	Šubovka, ESE of Vasiľov village	49.3414387	19.4171408	cut of the stream, toe of the landslide, Púchov Fm.
2.2		49.3409803	19.4177868	debris in the stream, Pieniny Fm.
2.3		49.3414679	19.4172501	debris in the stream, Pieniny Fm.
3	Rúbane section, E of Babín village	49.3286451	19.4037086	outcrop in dirt road and its surroundings, Púchov Fm. with Smolegowa and Czorsztyn fms. klippen

tectonic contact between the sandstone-rich Zábava Fm. (Ypresian – Lutetian) and the claystone-rich Malcov or Racibor formations (middle Eocene – Oligocene) of the Flysch Belt. The Flysch Belt formations are strongly tectonically reworked and often brecciated at the contact with the Babín Klippen (locality no. 1.1, N 49.3218442°, E 19.3951113°). The area is poorly exposed, covered by Quaternary deluvial sediments and soils with sandstone debris from the topographically higher exposed Zábava Fm. The continuation of the Babín Klippen to the SW and NE is manifested by distinct tectonic jointing and even brecciation of the rocks of the Flysch Belt. In the Skalnatý potok Stream valley (locality no. 1.1, Tab. 1), a tectonic mélange was observed, consisting mainly of debris of the Snežnica and Sromowce fms. The klippen cover rocks are broken into blocks and breccia of grey claystones, laminated fine-grained sandstones, massive medium-grained sandstones, and grey claystones (Fig. 4A, B, and 4F). The sandstones are fine-grained quartz-carbonate and well-sorted. The limestone material can be found as cm to dm clasts and boulders either in-situ in outcrops or as alluvial deposits in the stream (Figs. 4G and 4H).

Especially in the northern margin of the section red clays accompanied by green laminated fine-grained Malinowa-type sandstones with biotite and muscovite occur (locality no. 1.2, N 49.3213092°, E 19.3951895°). They are interpreted as the part of the Pavláškova skala Fm. The Pavláškova skala Fm., a name originally proposed by Potfaj in Bezák et al. (2009) as an informal name for occurrences of flysch strata with red claystones in the Zázrivá area, whose age was not satisfactorily determined at that time. Plašienka et al. (2021) have correlated this lithostratigraphic unit with the Turonian – Campanian Malinowa and Haluszowa formations and assigned them to the Grajcarek or Šariš successions, which should represent the structurally lowermost Šariš Unit of the PKB in the Orava sector of the PKB. The lithostratigraphic classification of the Pavláškova skala Fm. is, however, beyond the scope of this paper. For further discussion see Teťák et al. (2025).

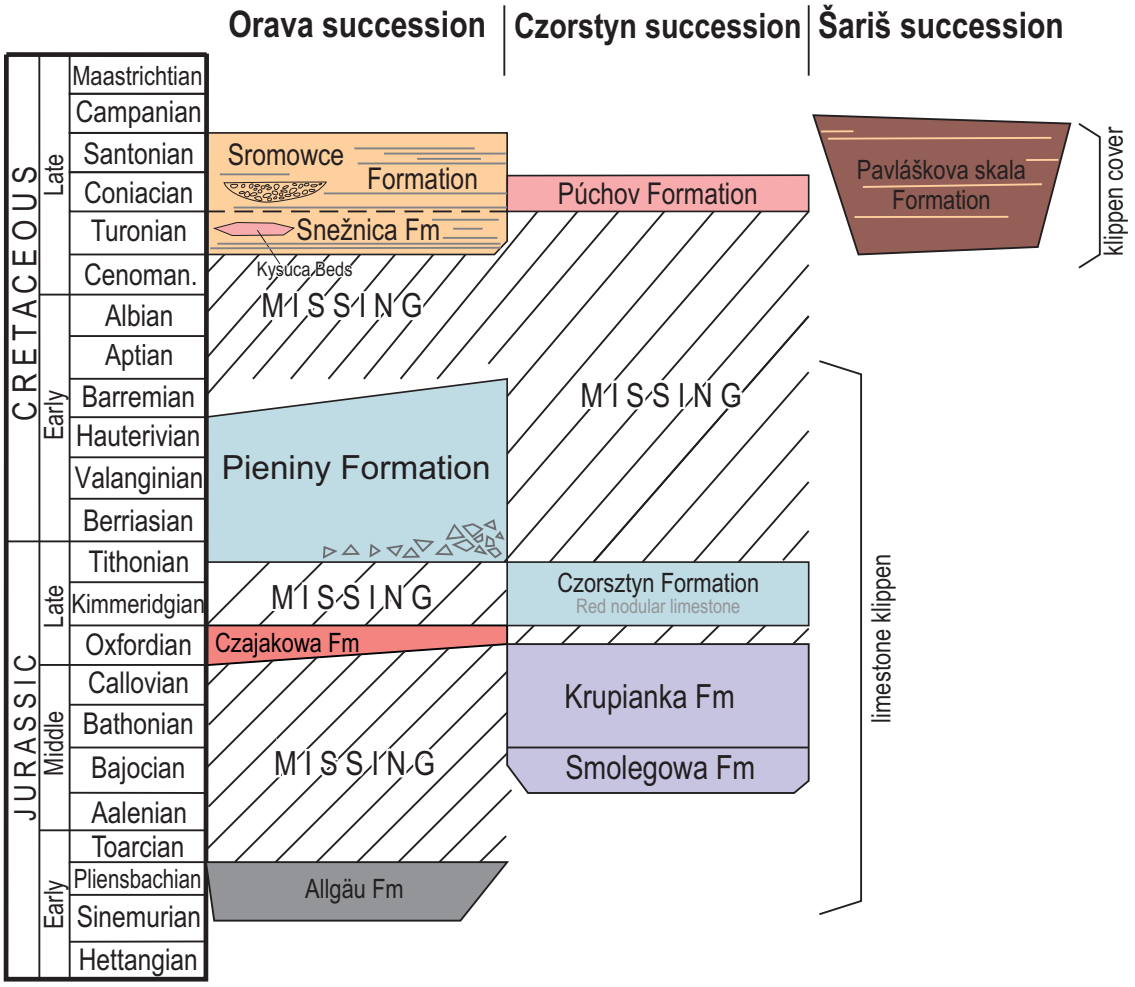


Fig. 3. Lithostratigraphic scheme of the PKB successions in the studied area of the Babín Klippen

Fig. 4. A – Fleckenkalk-type limestone with *Teichichnus* isp. from the right slope of the Skalnatý potok Stream valley, locality 1.3; B – Grey spotted radiolarite, SE of the Babín village; C – Grey brecciated limestone of the Pieniny Fm., SE of Vasiľov village; D – Detail of the limestone breccia from the same locality; E – Outcrop of grey and pink crinoidal limestone of the Smolegowa Fm., the Rúbane section, loc. 3; F – Red nodular limestone of the Czorsztyn Fm., the Rúbane section, loc. 3; G – Block of grey quartz-carbonate sandstone of the Snežnica or Sromowce Fm.; H – Pebbly mudstone with exotic blocks and pebbles at the Skalnatý potok Stream locality.

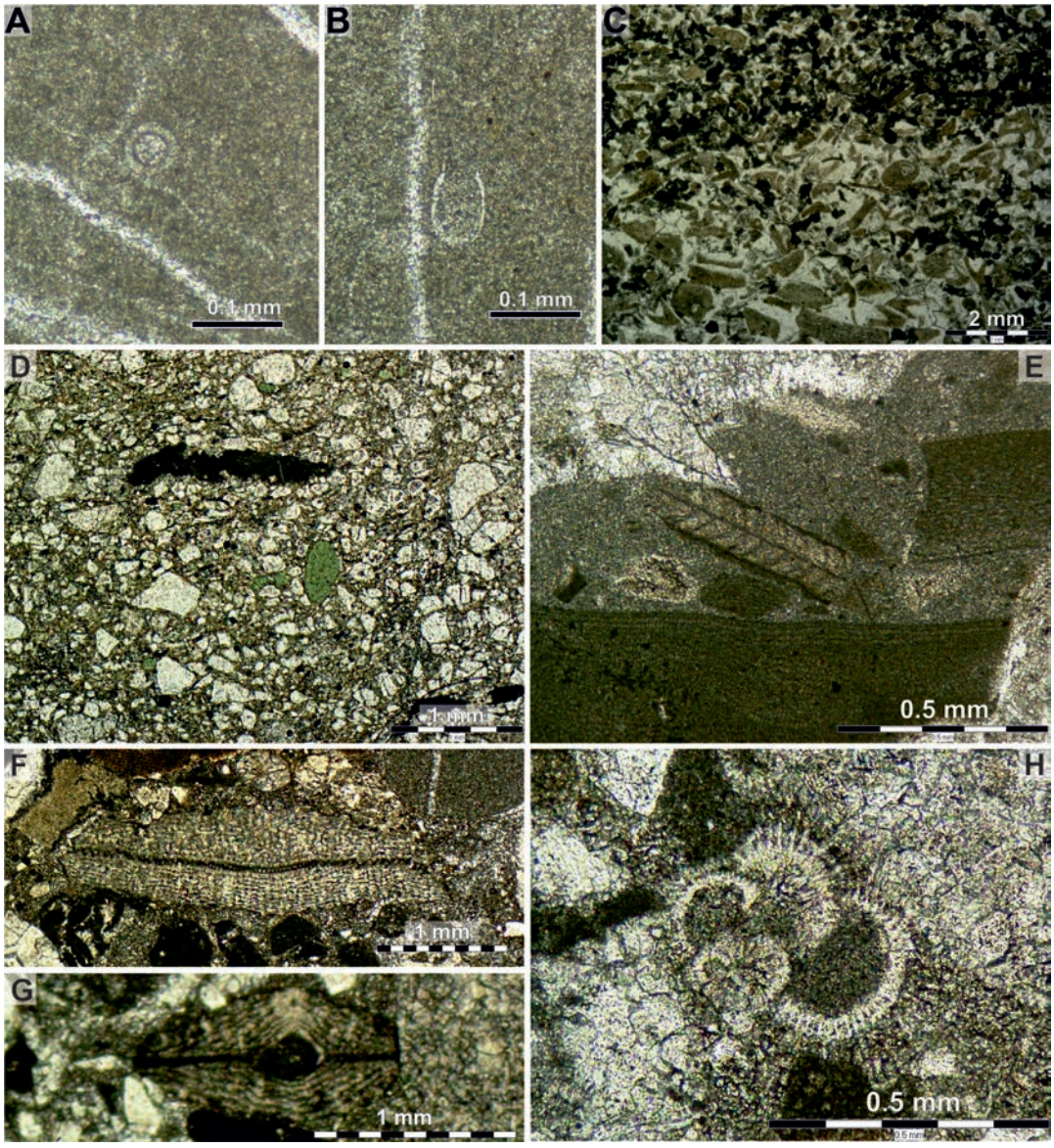


Fig. 5. A–B – Pieniny Formation, locality 1.4, sample OP1234OMa. A – *Colomisphaera minutissima* Nowak. B – *Calpionella elliptica* (Cadisch). C – Crinoidal grainstone microfacies of the Smolegowa Fm. (sample OP1239OM). D – Glauconitic sandstone with angular quartz clasts (sample OP1241OM); E–H – Organodetritic quartz-carbonate sandstone of the Eocene age (sample OP1234OMb). E – Feather-shaped algae *Districhoplax biserialis* (Dietrich). F–G – Fragments of larger benthic foraminifera *Discocyclina* sp. H – Planktonic foraminifera *Subbotina* cf. *yeguanensis* (Weinzierl & Applin).

The other klippen material represented by red and green radiolarites to radiolarian limestones of the Czajakowa Fm., white Biancone-type limestones of Pieniny Fm., brecciated Pieniny limestone with a dark matrix, and exotic polymictic conglomerates were observed in a tectonic mélange (Fig. 4H; locality no. 1.4, N 49.3211137°, E 19.3958103°). The mélange contains also grey crinoidal limestone blocks.

On the right slope of the Skalnatý potok Stream valley (locality no. 1.3, N 49.3215107°, E 19.3965051°), in the road track, numerous red claystones of the Púchov Fm. and spotted limestones of the Fleckenmergel-Fleckenkalk facies (Allgäu Fm.) accompanied with fine-grained quartz-carbonate sandstones occur as a debris in a scree (Fig. 4G). The Allgäu Fm. as well as the Czajakowa Fm. radiolarites occur to the south and north. The surrounding deluvium is rich in fragments of fine-grained (rarely coarse-grained) quartz-carbonate sandstones representing most likely flysch deposits of the Snežnica and Sromowce formations with red claystone interbeds, probably belonging to the

Púchov Fm. The klippen composed of Allgäu, Czajakowa, Pieniny, Snežnica and Sromowce formations could be correlated with the Orava or Kysuca successions (Fig. 3).

Apart from the quartz-carbonate sandstones of the klippen cover, sandstones clearly derived from the surrounding Flysch Belt also occur. These are represented by glauconitic sandstones (Fig. 5D) and organodetritic sandstones (locality no. 2, Šubovka ESE of Vasiľov village, N 49.3414387°, E 19.4171408°) with fragments of algae, larger benthic foraminifera and planktonic foraminifera (Figs. 5E–H).

In the Šubovka stream (ESE of Vasiľov, Tab. 1), red clays and fragments of red shales with calcite veins typical for the Púchov Fm., a tectonic breccia of Pieniny limestones with cherts (Fig. 4C, and 4D; locality no. 2.1, N 49.3409803°, E 19.4177868°), followed by fine-grained conglomerates with carbonate pebbles up to 15 mm (rarely up to 15 cm) and predominantly strongly tectonically brecciated laminated fine-grained quartz-carbonate sandstones, apparently from the accompanying flysch formations, were observed. The Pieniny limestone was transported with the toe of landslide (locality no. 2.2, N 49.3414679°, E 19.4172501°). The brecciated white Pieniny limestones occurring at this locality represent mudstone to wackestone with radiolarians. The limestones contain *Colomisphaera minutissima* Nowak and *Calpionella elliptica* (Cadisch) indicating early to middle Berriasian age (according to Reháková, 2000 and Reháková & Michalík, 1997; Figs. 5A and B). The studied limestone represents a lower part of the Pieniny Fm.

The only more-or-less geomorphologically manifested klippe can be found in the Rúbane section (locality no. 3, N 49.3286451°, E 19.4037086°). The Rúbane section is up to 70 m long sequence exposed in a dirt road, which consists of grey and pink crinoidal limestones of the Bajocian Smolegowa and Krupianka fms. The crinoidal Smolegowa limestones are coarse-grained and massive (Fig. 4E). Microstructurally the crinoidal limestones represent packstones to grainstones (Fig. 5D). The overall thickness of the grey and pink crinoidal limestone is approx. 10 m. The overlying thin-bedded red nodular limestones of the Czorsztyn Fm. contain sporadic ammonite and belemnite fragments (Fig. 4F). Their thickness is up to 5 m. The crinoidal and red nodular limestone klippe is surrounded by red claystones and marlstones of the Púchov Fm. The whole sequence at this locality could be correlated with the Czorsztyn succession (Fig. 3). The wider area is formed by klippen cover flysch formations, represented predominantly by darker grey claystones and fine- to medium-grained laminated quartz-carbonate sandstones, sporadically interbedded with red claystones or marlstones.

Discussion

In his 1938 geological cross-sections, Andrusov (1938, Tabs. XIII and XIV) had already shown the PKB extending into the footwall of the Oravská Magura Mts. in the Hruštínka valley. However, he interpreted the whole structure as inclined to the south, which is no longer the case, although numerous evidences of the south-vergent backthrust were provided already at the time (Andrusov, 1938). The presence of the PKB rocks in this area was mentioned by Marschalko (1986, p. 16) in the same context.

The contact between the Flysch Belt and the Pieniny Klippen Belt at greater depths was discussed by Potfaj (1983), who stated that *"The fold-and-thrust-belt style can be mapped along the aforementioned tectonic line on the northern slope of the Oravská Magura Mts. (i.e., the Babín sector of the PKB) and probably extends to the line of Námestovo-Žilina gravimetric minimum. From a structural point of view, we can shift the northern boundary of the PKB that far"*. This opinion can still be considered valid today.

The new mapping confirmed the lithology and precise location of the klippen mapped by Andrusov (1931). It has been found that the klippen mapped by Potfaj et al. (1981) are located up to 200 m further to the south. The presence of several klippen could not be confirmed due to poor exposure conditions, so we assume that there are more small broken blocks than Jurassic klippen shown on the map in Fig. 2. However, the extent of the Babín Klippen structure is reliably delineated by the occurrence of quartz-carbonate sandstones in Quaternary slope debris, as these are otherwise rare in this portion of the Krynica Unit.

The study of the Babín Klippen is important due to the fact, that the area is transected by the seismic profile 2T (Vozár et al., 1999; Tomek et al., 1989; Tomek, 1993). The interpretation of this profile, suggesting a north-dipping geometry of the PKB and a backthrust of the Flysch Belt, is supported by the recent geological investigations (Teťák et al., 2025). In contrast, the interpretation of the seismic profile 512/86 (Vozár et al., 1999), located slightly farther east, shows significant differences in the geometry of the PKB and the accretionary wedge of the External Western Carpathians. The main difference can be considered to be the absence of backthrust of the PKB. We would interpret the subsurface extent of the Internal Western Carpathian units (i.e. units south of the PKB) significantly further north, similar to profile 2T (Fig. 6).

The successions of the PKB are generally strongly tectonically deformed. However, the deformation in the Babín Klippen Zone is exceptionally intense. Approximately 1 km south of the Babín Klippen Zone, changes in the bedding dip of the Zábava Fm., together with a distinct change in morphology, are interpreted to reflect an additional (back-)thrust. This structure is further expressed by a high concentration of springs, several of which precipitate tufa, forming the most extensive accumulation of tufa-bearing springs in the region (N 49.314853°, E 19.403826°). Within this zone and in the Babín Klippen Zone, three

mineral springs enriched in H_2S occur. The association of tufas and mineral springs suggests deep groundwater circulation, likely facilitated by tectonic structures. In the PKB and the Biele Karpaty Unit of the Považie region, more than 100 tufa-forming springs have been documented (Pešková et al., 2021), many of which show a clear relationship to underlying fault systems.

Several issues in the examined area remain unsolved. Firstly, there is the unusual pebbly mudstone body that passes to the tectonic mélange in the Skalnatý potok Stream. Although not studied in detail, based on our field observations, we correlate it with the polymict conglomerate bodies of the Upper Cretaceous Sromowce Fm. (Fig. 4H). Secondly, we also draw attention to the occurrences of organodetritic sandstones ESE of the Vasiľov village (Fig. 5E–H), which cannot be correlated with any of the surrounding formations. The organodetritic sandstones with fragments of algae and foraminifera resemble organodetritic limestones from the Malcov Fm. of the Flysch Belt described by Potfaj (1983, p. 127), or possibly part of the Proč Fm. of the PKB.

extremely deformed exposure related to the backthrust of the External Western Carpathian accretionary wedge to the SE.

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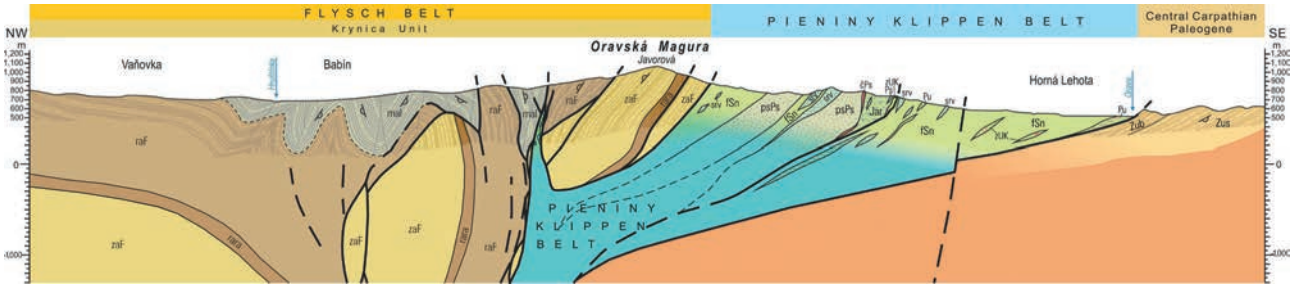

Fig. 6. The cross-section extending into the foothills of the Oravská Magura Mts. oriented approximately parallel to the line of the 2T seismic profile (based on Teťák et al., in press). For location of the profile see Fig. 1.

Conclusions

The narrow zone of the Pieniny Klippen Belt sandwiched inbetween the thrust sheets of the Krynica Unit of the Flysch Belt on the northern slopes of Oravská Magura Mts. is known as the Babín Klippen (Figs. 1, 2 and 6). The Babín Klippen form approximately 200 m thick and 8 km long strongly disintegrated zone of the PKB rocks SE of the Babín and Vasiľov villages (Námestovo district). The Babín Klippen Zone consists of the three different PKB sedimentary successions. From the paleogeographic point of view the Orava (or Kysuca) succession was the southernmost one (in present coordinates) and is represented by rocks of the Allgäu, Czajakowa, Pieniny, Snežnica and Sromowce fms. The second one is the Czorsztyn succession represented by rocks of Krupianka, Smolegowa, Czorsztyn and Púchov fms. The most northerly situated was the Šariš succession formed by the Pavláškova skala Fm. is represented to a lesser extent. The studied Babín Klippen represent unique

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Babínske bradlá – osobitý výbežok oravského úseku pieninského bradlového pásma (Slovensko)

Na viacerých starších geologických mapách je zobrazené vystupovanie bradlového pásma v úzkej zóne na severnom svahu Oravskej Magury nad Babínom (Andrusov, 1931; Potfaj et al., 1981; Potfaj, 1983). Potfaj (1979) charakterizuje babínske bradlá ako *„silne drvené pásmo s tektonickými brekciami o hrúbke až do 80 m. Okrem paleogénnych pieskovcov a ílovcov sú v brekcii aj úlomky titónskych kalových vápencov, zelených rádiolaritov, ‚exotické' zlepence s obdobným zložením valúnového materiálu, ako majú zlepence pri Krivej, tektonicko-sedimentárne brekcie ‚záskalského typu' s vekovým zaradením do kampánu až maastrichtu a tehlovočervené slieňovce s turónskou mikrofaunou. Podľa priebehu v teréne má línia 80-85° sklon k JV"*. Potfaj (1983) udáva, že *„komplex magurských pieskovcov je na sz. úpätí Oravskej Magury tektonicky odrezaný od malcovského súvrstvia a stýka sa cez 20 až 200 m širokú tektonickú zónu, pozdĺž ktorej sú na povrch vyvlečené útržky, šošovky a brekcie hornín z vrstevných sledov bradlového pásma"*.

Andrusov (1931) nad Babínom zaznamenal na mape viaceré výskyty titónsko-spodnokriedových pieninských vápencov pieninskej sukcesie, miestami obklopené púchovskými vrstvami. Bradlové pásmo na mape a v reze zobrazuje ako izolované vystupovanie hornín bradlového pásma, obklopené paleogénnym súvrstvím Oravskej Magury. Lokalizácia uvedených výskytov je presná a overili sme ju.

Potfaj et al. (1981) na mape listu Trstená rozšírili známe výskyty fácií bradlového pásma na časť Stodoly, pravú vetvu Bučníkového potoka a nad Zraz. Okrem škvrnitých slienitých vápencov s rohovcami a červených slieňov gbelianskych vrstiev, ktoré uvádza už Andrusov (1931), sa na viacerých miestach nachádzali aj výskyty rádiolaritov a flyšových súvrství bradlového pásma.

Okrem uvedených dvoch prác úsek babínskych bradiel nebol skúmaný a do novších prác boli informácie prevzaté. Pri novom geologickom mapovaní sa nám podarilo overiť a presne lokalizovať väčšinu známych lokalít. Zistili sme niekoľko nových lokalít (tab. 1, obr. 2). Nepodarilo sa overiť napr. vystupovanie v Bučníkovom potoku, no kvôli úplnosti preberáme aj neoverené výskyty.

Babínske bradlá tvorí súvislá, len 20 až 250 m široká a asi 8 km dlhá zóna tvorená prevažne flyšovým súvrstvím s ílovcami a kremenno-karbonátovými pieskovcami. Je lokalizovaná pod morfologickým lomom svahu na výraznom tektonickom kontakte zábavského súvrstvia s malcovským, prípadne raciborským súvrstvím. Spomínaný úsek je značne prekrytý sutinou z pieskovcov zábavského súvrstvia. Predmetom štúdia boli len výskyty horninových úlomkov, in-situ odkryvy boli pozorované len výnimočne. Výnimkou bolo jediné morfologicky vystupujúce bradlo v časti Rúbane.

V doline Skalnatého potoka bola pozorovaná tektonická melanž, ktorú tvoria flyšové sedimenty bradlového obalu rozbité na bloky až brekcie sivých ílovcov, laminované jemnozrnné pieskovce s patinou, masívne strednozrnné pieskovce a tenko vrstvený flyš so sivými ílovcami. Pieskovce sú jemnozrnné, kremenno-karbonátové. Bradlový materiál sa nachádza v podobe balvanov a úlomkov v potoku. Výrazné boli červené hliny, hojne sprevádzané zelenými laminovanými jemnozrnnými pieskovcami s biotitom a muskovitom, ktoré zaraďujeme do súvrstvia Pavláškovej skaly. V melanži sme pozorovali blok rádioláriového vápenca, bloky slienitého vápenca (aj škvrnité), početnú sutinu pieninského vápenca fácie biancone v brekcii s tmavým matrixom a množstvo obliakov exotických polymiktných zlepencov sromowského súvrstvia. V pravom svahu doliny v koľaji cesty je veľa červených slieňovcov a na pár metroch sú úlomky allgäuského súvrstvia s patinou, doplnené jemnozrnnými kremenno-karbonátovými pieskovcami. Aj vyššie na hrebienku vystupuje na dvoch miestach allgäuské súvrstvie. V okolí sú hojné jemnozrnné (vzácne až hrubozrnné) kremenno-karbonátové pieskovce reprezentujúce snežnické a sromowské súvrstvie a šmuhy červených hlín.

Najvýraznejšie bradlo vystupuje v časti Rúbane (lokalita č. 3, tab. 1). Je dlhé až 70 m. Na západnom konci ho tvoria hľuznaté čorštynské biomikritické vápence s amo-

nitmi aj belemnitmi, ktoré smerom na sever prechádzajú do ružových krinoidových vápencov. Bradlo sa končí v poľnej ceste sivými hrubozrnnými krinoidovými vápencami smolegowského súvrstvia. Je obklopené červenými slieňovcami púchovského súvrstvia a v širšom okruhu bradlovým flyšom snežnického a sromowského súvrstvia. Sú to prevažne tmavšie sivé ílovce sprevádzané jemno- až strednozrnnými laminovanými kremenno-karbonátovými pieskovcami, miestami s patinou, zriedka doplnenými šmuhou červených hlín/slieňovcov.

V potoku sz. od k. Šubovka v čele zosuvu vystupujú premiestnené červené hliny s úlomkami červených slieňovcov púchovského typu s množstvom kalcitových žiliek, pieninské vápence fácie biancone, miestami s rohovcami vo forme tektonickej brekcie, ale aj celistvý až béžový, miestami škvrnitý vápenec, drobnozrnné zlepence s obliačikmi karbonátov s veľkosťou do 15 mm (vzácne do 15 cm) a prevažne silno tektonicky drvené laminované jemnozrnné kremenno-karbonátové pieskovce, zrejme zo sprievodného bradlového flyšu.

V zóne babínskych bradiel môžeme vyčleniť tri sedimentárne sekvencie bradlového pásma. Z paleogeografického hľadiska bola oravská (resp. kysucká) sukcesia najjužnejšia (v súčasných súradniciach). Tvoria ju horniny allgäuského, čajakovského, pieninského, snežnického a sromowského súvrstvia. Druhou je čorštynská sukcesia reprezentovaná horninami krupianskeho, smolegowského, čorštynského a púchovského súvrstvia. Najsevernejšie sa nachádza šarišská sukcesia tvorená súvrstvím Pavláškovej skaly, ktoré vystupuje iba v plošne obmedzenej miere. Študované babínske bradlá predstavujú jedinečný, extrémne deformovaný výstup bradlového pásma súvisiaci so spätným prešmykom akrečného klina Vonkajších Západných Karpát smerom na juhovýchod.

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