

## On the age and nature of the so-called Zázrivá Beds (Pieniny Klippen Belt, Western Carpathians)

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(Received 2 September 2003, revised version 21 November 2003)

### Abstract

The Zázrivá Beds, a black shale unit originally attributed to the Sinemurian sequence of the Kysuca Unit, has been revisited. Recent finds of bivalves *Bositra buchii* and a graphoceratid ammonite at the type locality near Zázrivá-Končítá provide correction of the age to be most probably Aalenian. The previous age determination has been based just on palynomorphs and seeming superposition. In this sense, the beds actually correspond to the Skrzypny Shale Formation (former "Murchisonae Beds") and their further use as an independent lithostratigraphic unit is no longer necessary. An atypical feature which does not usually occur in the Skrzypny Formation is the occurrence of the blocks of black bituminous limestones, calcarenites, spotted limestones (some with numerous belemnites) and spongolites. They form olistoliths in the black shales and were formerly considered to be the boudins and limestone intercalations. The spotted limestones, occurring in contact with the black shales occur also as blocks in the shales. Formerly, they were erroneously considered as the overlying formation of Lotharingian age. In fact, they are older than the Zázrivá Beds. An origin of the blocks via tectonic boudinage is unlikely, as they cannot be traced in dissected rows but they are mostly isolated. The blocks have commonly sharp rectangular form and lack tectonic lense shapes that would be attained by tectonic deformation.

**Key words:** Jurassic, lithostratigraphy, Pieniny Klippen Belt, Aalenian, black shales, olistoliths

### Introduction

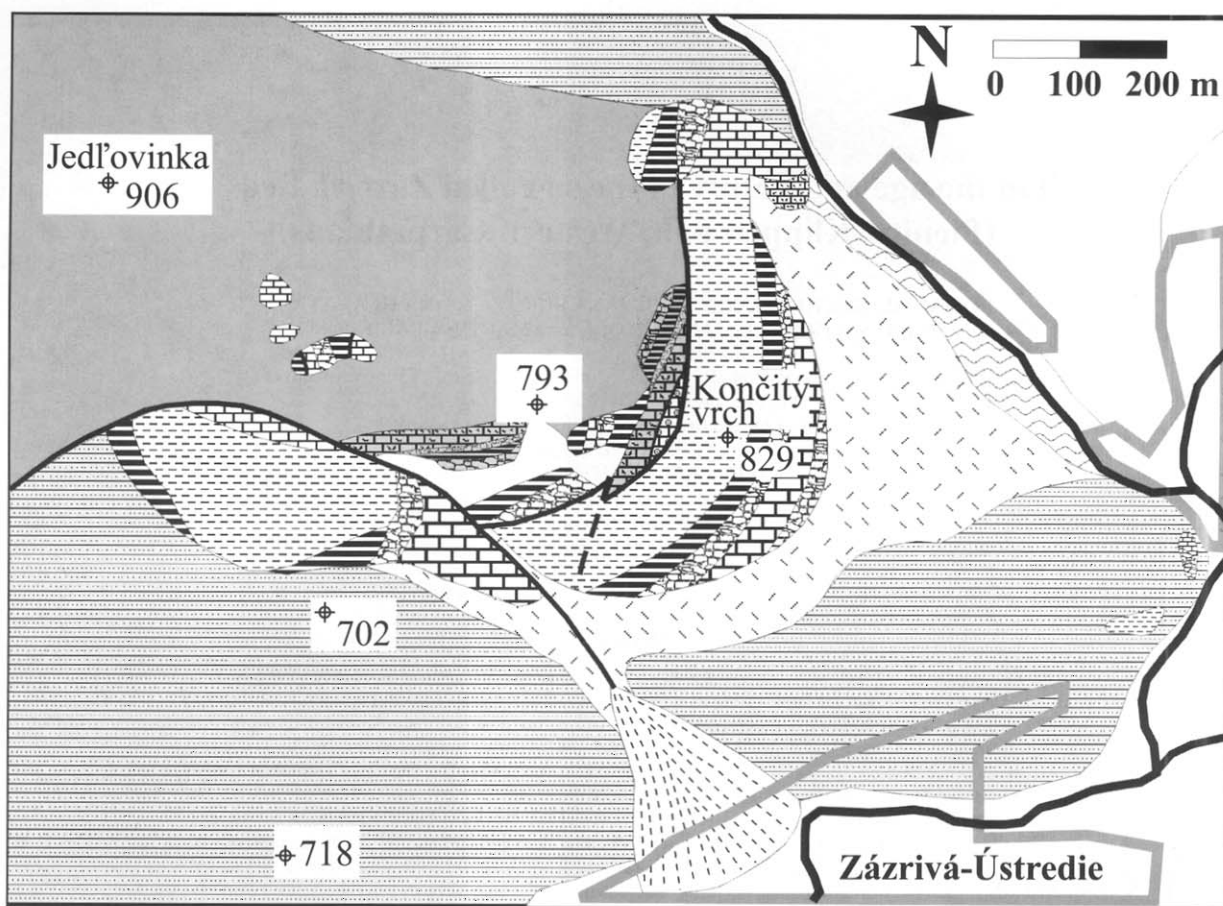
The Zázrivá Beds were distinguished by Haško and Planderová (1977) on the erosional bank of Končítý Creek near the Zázrivá-Končítá village, in Orava section of the Pieniny Klippen Belt. The beds were defined as "... dark-grey to black marly laminated limestones, dark shaly claystones with presence of oil and asphalt intercalations...". Haško and Planderová (l. c.) correlated them with similar Sinemurian marlstones found by Andrusov (1931) near Orava castle ("Spiriferina Marls"). The Zázrivá Beds were estimated to be of the Sinemurian age, mostly on the basis of palynological taxa, with maximum overlap in Liassic and on the presence of Lotharingian ammonite *Echioceras raricostatum* in the "overlying" spotted limestones.

Since the time of definition, presence of the Zázrivá Beds was not reported from any other locality, either in the Pieniny Klippen Belt, or in the entire Western Carpathians. The classical type locality remained an only excursion locality, where this unique formation was frequently shown to students and to visitors interested in the Pieniny Klippen Belt.

The area of Zázrivá is for more than 20 years (with small interruptions) an object of the geological mapping courses organized by Comenius University, Bratislava. However, the Pieniny Klippen Belt on which Zázrivá is situated was mapped by students only since the year 2001. Since the very beginning, new data about the Zázrivá Beds appeared every year. Gathering of data culminated in 2003, when our mapping team, consisting of teacher and several students, for the first time discovered reliable macrofauna directly in the Zázrivá Beds. This paper brings evaluation of the new paleontological data, together with new sedimentological interpretation of the beds.

### Description and position of the type locality

The Zázrivá Beds are discontinuously outcropped in the Končítý creek in the length of about 500 m (Fig. 1), as far as the nearest small tributary, below Končítý vrch hill (829 m). The black shales that dominate the formation are easily eroded by the creek and the whole mass



### Explanations

#### Quaternary cover

alluvia and soils

debris

alluvial cones

#### Klape Succession

Santonian Flysch with hieroglyphs

#### Kysuca Succession

white *Calpionella* limestone  
Tithonian-Lower Cretaceous  
(Pieniny Limestone)

red to greyish nodular limestone  
Kimmeridgian  
(Czorsztyn Limestone)

green to red radiolarites  
Callovian-Oxfordian  
(Czajakowa Formation)

black shales with manganese  
Aalenian-Bajocian  
(Harcygrund Formation)

former Zázrivá Beds

flyschoid sandstones to  
quartzites, Sinemurian  
(Jedlovinka Formation)

#### Orava Succession

spotted to white micritic  
limestones, Lotharingian-  
Pliensbachian (Allgäu and  
Kozinec formations)

lower nodular limestone  
Toarcian (Adnet Formation)

green to grey spongolites to  
radiolarites, Aalenian-  
Oxfordian

upper nodular limestone  
Kimmeridgian (Czorsztyn  
Formation)

#### Czorsztyn Succession

white sandy crinoidal  
limestone, Bajocian  
(Smolegowa Formation)

tectonic boundaries

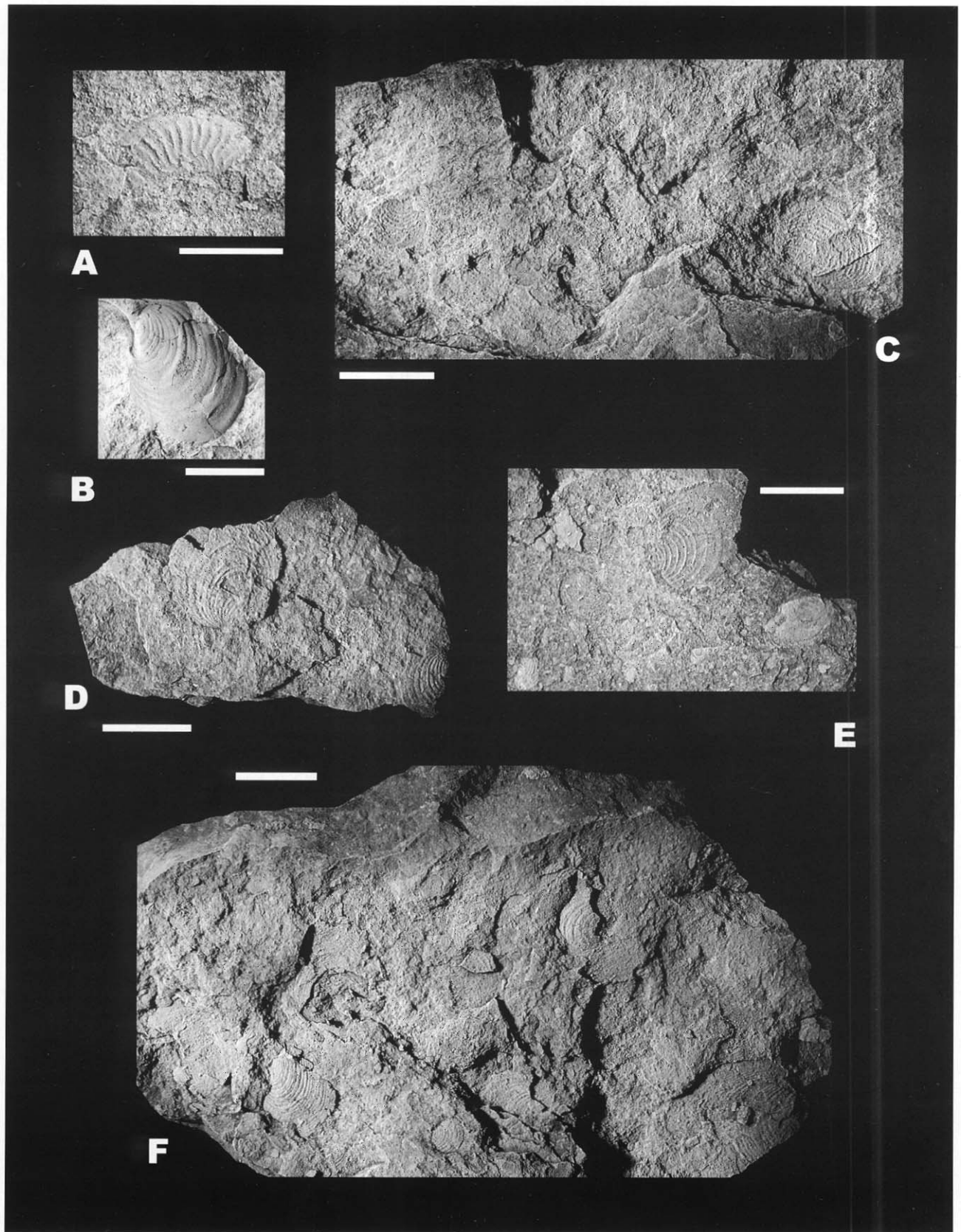
#### Topographic marks

streams

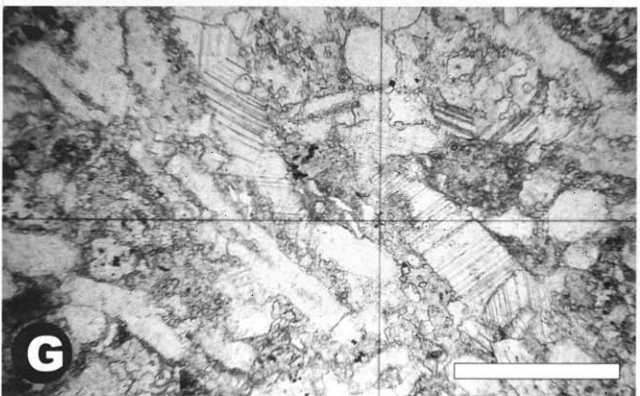
718 elevation points

settlements

Fig. 1. Geological map of the area near Zázrivá, compiled by the students in 2003 during their geological mapping course. Note also new occurrences of the Orava Succession NW from Končítý vrch hill that were not known so far.



Pl. I. A – Graphoceratid ammonite from the type locality of the Zázrivá Beds. B–F – Bivalves *Bositra buchii* (ROEMER) from the type locality of the Zázrivá Beds. The scales = 1 cm.





is slowly sliding down to the valley. Therefore, the morphology of the type locality changes from year to year. In the black shales, there are discontinuous layers and blocks of dark limestones which were also mentioned by Haško and Planderová (1977) but without any closer examination and interpretation.

### Fauna of the "Zázrivá Beds"

In the year 2000 a small but indeterminable ammonite was found by mapping students. In 2001, one of us (M. V.) has found a block of pale-grey, spotted marly limestone (probably olistolith in the black shales) in which numerous belemnites were found (Pl. II, H). This was the first macrofauna, although not directly from the black shales. In 2002, bivalves *Bositra buchi* (ROEMER) (Pl. I, B-F), together with graphoceratid ammonite (determined by S. Elmi, Lyon) (Pl. I, A) were found in the black shale matrix, suggesting most likely the Aalenian age of the black shales.

### Remarks to the sedimentological character of the "Zázrivá Beds"

Haško and Planderová (1977) defined the Zázrivá Beds as consisting of black marly limestones and claystones. In fact, our research showed that the formation mostly consists of black shales with uneven disintegration, in which, black laminated limestones (with asphalt impregnations in fractures) form just intercalations. Moreover, within the black-shale matrix, blocks of black bituminous limestones, calcarenites, spotted limestones (some with numerous belemnites) and spongolites occur (Pl. II, A-G). They form olistoliths in the black shales and were formerly considered to be boudins and limestone intercalations. Due to poor outcrops, the spotted limestones were considered to belong to younger formation of the Lotharingian age. The blocks are mostly isolated and do not form dissected rows; hence, they do not represent tectonic boudins. They have commonly sharp rectangular edges (Pl. II, A, B). If considering them to be tectonic boudins, one would expect to meet lensoid shapes of the blocks that would be attained by tectonic deformation. In fact, such shapes occur very rarely (Pl. II, E). Although the composition of the blocks is oligomict, they show some variability that indicates that they do not belong to the black-shale formation. The rocks that compose the blocks originated not only in true anaerobic environment as did the black shales of the matrix. The spotted limestones are product of at least dysaerobic to aerobic environment and they represent an allochthonous element in the black shales. Therefore, the Zázrivá Beds appear to have an olistostrome character.

### Interpretation and conclusions

By its character and by the discovered fauna, the formation is very close to the Skrzypny Shale Formation (Aalenian-Lower Bajocian, Birkenmajer, 1977) that was formerly designated as the "Murchisonae Beds". Although the formation is also similar to the Aalenian-Bajocian Harcygrund Shale Formation (formerly known as the "Posidonia Beds"), the latter differs by regular platy shale disintegration, lack of sphaeroiditic concretions, lack of strong pyritization etc. We consider necessary to reject the Zázrivá Beds as an independent formation, as its originally defined age was erroneous and as the formation is practically indistinguishable from the Skrzypny Shale Formation. The Skrzypny Shale Formation was not reported from the area of Zázrivá so far but a very similar lithological unit was mapped at numerous places as the Harcygrund Shale Formation. It is typical by uneven disintegration of the black shales and by numerous small manganese deposits. According to information from local settlers, in the area of Zázrivá-Kozinská, similar deposits locally contain rich pyritized ammonite fauna. The fauna of pyritized ammonites, collected by local people from this still unknown locality, is very similar to that described by Scheibner (1964) from the Skrzypny Shale Formation near Litmanová village in the eastern Slovakia.

The olistostrome character of the Zázrivá Beds is not very typical for the Skrzypny Shale Formation. It indicates a tectonic unrest in the sedimentary area, connected with bottom inclination and slumping. This feature corresponds well with the overall tectonic evolution of the Pieninic sedimentary area. In the Toarcian-Aalenian time, the first signs of rising Czorsztyn Swell are indicated by the Szlachtowa Formation that represents a black flysch, with detritic material transported from a rising elevation. Latest, yet unpublished results of the project KBN 6 P04D 022 21, show that in more eastern parts of the Pieniny Klippen Belt, even more shallow-water Toarcian-Aalenian deposits can be found. For instance, shallow-water ferruginous sandstones and conglomerates of Aalenian age, with carbonate pebbles commonly bored by bivalves most likely in the peritidal area, have been discovered in Vulkovchik valley; similar deposits were also found at Priborzhavskoe (both in the Ukrainian part of the Pieniny Klippen Belt), where they are already mixed with crinoidal limestones. Local Aalenian start of deposition of the crinoidal limestones (Smolegowa Limestone Formation) was also proved by ammonites at Beňatina locality (eastern Slovakia).

**Acknowledgements.** The authors are indebted to Dr. J. Michalík (SAV, Bratislava) for reviewing this article. The paper is a contribution to the project KBN 6 P04D 022 21 of the Polish State Committee for Scientific Research. Additional support was also provided by grants KEGA 3/0108/02 and VEGA 2/4095/04.

- ◀ **Pl. II.** A – Angular olistolith of spiculite in the black shales of the Zázrivá Beds in the stream of Končítý potok creek. GPS coordinates: N 49°17.281', E 19°09.816'; B – Closer view on the olistolith is in part A; C – Limestone olistolith in the Zázrivá Beds. Artificial outcrop behind the house at the main road from Zázrivá-Ústredie to Zázrivá-Kozinská, near the turn to Zázrivá-Končítá; D – A group of smaller olistoliths in the Končítý potok creek; E – Other group of smaller olistoliths; a rare example of lens-shaped blocks; F – Two smaller angular olistoliths (GPS coordinates: N 49°17.288', E 19°09.809') enveloped by black shales of the Zázrivá Beds; G – Microphoto of spiculite sample from the olistolith in parts A and B. Plane polarized light. Scale = 1 mm; H – Deformed belemnite guards from olistolith of grey spotted limestone. Scale = 1 cm.

## References

- Andrusov, D., 1931: Geologický výzkum vnútorného bradlového pásma v Západných Karpatoch. Časť I: Úvod, Časť II: Stratigrafie (trias a lias). *Rozpr. St. geol. Úst. Čs. Republ. (Praha)*, 6, 167.
- Birkenmajer, K., 1977: Jurassic and Cretaceous lithostratigraphic units of the Pieniny Klippen Belt, Carpathians, Poland. *Stud. geol. pol. (Kraków)*, 45, 158.
- Haško, J. & Planderová, E., 1977: Zázrivské vrstvy – nová litostratigrafická jednotka kysuckej série bradlového pásma. *Mineralia Slov.*, 3, 207–212.
- Scheibner, E., 1964: Contribution to the knowledge of the Murchisonae Beds in the Klippen Belt of West Carpathians in Slovakia. *Geol. Sbor.*, 15, 1, 27–55.

## O veku a charaktere takzvaných zázrivských vrstiev (pieninské bradlové pásmo, Západné Karpaty)

Zázrivské vrstvy vyčlenil Haško a Planderová (1977) na pravom brehu Končitého potoka v Zázrivej-Končitej na Orave (obr. 1). Definovali ich ako tmavé vápence a ílovce s asfaltovými impregnáciami. Podľa palynologických údajov a nálezu lotarinského amonita *Echioceras raricostatum* v predpokladaných nadložných škvrnitých vápencoch vrstvy zaradili do sinemúru a paralelizovali ich s tzv. spiriferinovými slieňmi Andrusova (1931) z oblasti Oravského zámku.

Podľa nálezov z nového výskumu, vykonaného spolu so študentmi v rámci kurzu geologického mapovania, sa podarilo nájsť prvú makrofaunu zo zázrivských vrstiev, ktorá vrhá nové svetlo na ich stratigrafické zaradenie. Faunu skladajúcu sa z rastier belemnitov mladších ako sinemúr nájdených v jednom z olistolitov v týchto vrstvách neskôr doplnil nález fragmentu grafoceratidného amonita (Pl. I, A) a lastúrnika *Bositra buchi* ROEMER (Pl. I, B–F). Táto fauna potvrdzuje, že zázrivské vrstvy sú v skutočnosti álenského veku a vyčleňovať ich ako samostatné nie je opodstatnené. Možno ich porovnávať so skrzypnianskymi vrstvami álenského veku (niekdajšie „murchisoniové vrstvy“), ktorým sa podobajú čiernou farbou, nepravidelným rozpadom, silnou pyritizáciou a výskytom sférosideritových konkrécií. Podobné harcyrundské bridlice (niekdajšie „posidóniové vrstvy“) sa vyznačujú pravidelným lístkovitým rozpadom, neobsahujú sférosideritové konkrécie a majú o niečo nižší obsah pyritu. Skrzypnianske vrstvy sa doteraz v okolí Zázrivej oficiálne nezistili, no mnohé z výskytov zmapovaných ako harcyrundské vrstvy v skutočnosti majú rad znakov skôr typických pre skrzypnianske vrstvy. Miestni obyvatelia v oblasti Zázrivej-Kozinskej dokonca našli faunu pyritizovaných amonitov podobnú faune, ktorú opísal Scheibner (1964) zo skrzypnianskych vrstiev z okolia Litmanovej.

Výskyt doteraz známy ako typová lokalita zázrivských vrstiev má však jednu zvláštnosť, aká sa v skrzypnianskych ani harcyrundských vrstvách nevyskytuje. V čiernych bridliciach sú totiž bloky čierneho bituminózneho vápence, kalkarenitov, škvrnitého vápence (odtiaľ je aj blok s belemnitmi) a spongolitov. Tieto bloky, ktoré sa v minulosti pokladali za vrstvy alebo tektonické budiny, interpretujeme ako olistolity (Pl. II, A–G). Často majú ostrý pravouholníkový tvar (Pl. II, A, B), lenže budiny by boli aspoň čiastočne modelované do tvaru tektonických šošoviek. Bloky nevytvárajú rady a nedá sa nájsť ich pokračovanie, čo je ďalší argument proti budinži. Litologická rôznorodosť blokov navyše signalizuje, že nevznikli v spoločnom sedimentačnom prostredí. V tomto zmysle skúmaný komplex interpretujeme ako olistostrómu. Jej prítomnosť zapadá do kontextu doterajších poznatkov o bradlovom pásme, poukazuje na tektonický nepokoj a nakláňanie dna v súvislosti so začiatkom rozčleňovania sedimentačnej oblasti pieninika. Z áleny je v bradlovom pásme známe szlachtowské súvrstvie, ktorého materiál zrejme pochádza z novovznikajúcej czorsztynskej kordiléry. Aj nové, doteraz nepublikované poznatky získané v spolupráci s poľskými geológmi z východnej časti bradlového pásma na Slovensku a Zakarpatskej Ukrajine potvrdzujú, že sa czorsztynská elevácia začala už v álene. Vo Vulkovčickej doline a na lokalite Priboržavskoje (Ukrajina) sa našli álenské sedimenty s prímiesou krinoidových článkov a klasty navŕtané lastúrnikmi v intertidálnej zóne. Na lokalite Beňatina na východnom Slovensku sa v spodných častiach krinoidových vápencov smolegovského súvrstvia našla fauna álenských amonitov.