

## THE BRĂDET QUARRY IN ANINA AND ITS PALAEOONTOLOGICAL HERITAGE

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**Abstract.** The Brădet Quarry, also known as the Bibel Quarry, occurs in Anina, Brădet area, Caraș-Severin County, South Carpathians, outcropping the highly fossiliferous, nodular limestones of the Upper Kimmeridgian – Lower Tithonian Brădet Formation. The site includes a rich and well-preserved assemblage of ammonites, belemnites, brachiopods, echinoids, bivalves and corals, next to the stratotype of the Brădet Formation, being worthy of the status of a Site of Special Scientific Interest (SSSI).

**Keywords:** Invertebrates, Brădet Formation, Kimmeridgian-Tithonian, Anina, Site of Special Scientific Interest (SSSI).

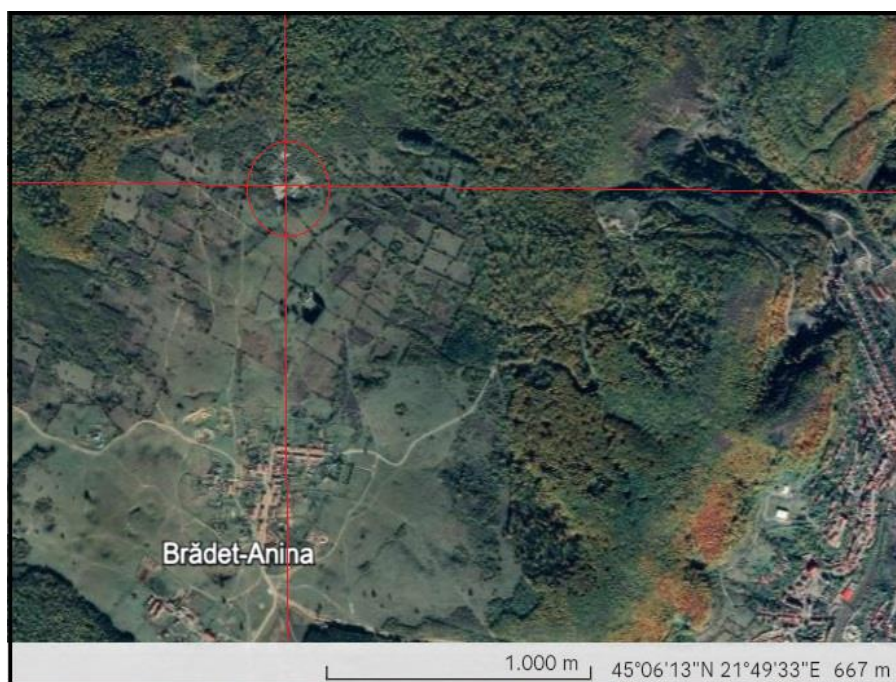
**Rezumat. Cariera Brădet din Anina, o propunere pentru o nouă rezervație paleontologică.** Cariera Brădet, cunoscută și sub numele de Cariera Bibel, se găsește în Anina, cartierul Brădet, Județul Caraș-Severin, Carpații de Sud și deschide Formațiunea de Brădet, o formațiune bogat fosiliferă, cu calcare nodulare Kimmeridgian superior – Tithonic inferior. Cariera include o asociație bogată și bine conservată de amoniți, belemniti, brachiopode, echinoide, bivalve și corali, alături de stratotipul Formațiunii de Brădet, necesitând statutul de rezervație paleontologică.

**Cuvinte cheie:** Nevertebrate, Formațiunea de Brădet, Kimmeridgian-Tithonic, Anina, rezervație paleontologică.

### INTRODUCTION

The Brădet Quarry, also known as the Bibel Quarry, occurs in Anina, Brădet (town district) area, along the Brădet Plateau (660 m altitude), Reșița area, Caraș-Severin County, in Banat region, South Carpathians (Fig. 1).

The quarry bears the name of its initial owner, Johann Bibel Sr. (1817-1900) who was involved in the design and building of the regional railways, also one of the first managers of the marble quarry from Ruschița (TODOR & SURD, 2015).



The Bibel Quarry outcrops the nodular, fossiliferous limestones of the Brădet Formation, Upper Kimmeridgian – Lower Tithonian in age (BUCUR, 1991, 1997).

Several research articles were published, starting with UHLIG (1881), followed by BÖCKH (1887), TELEGD (1906), TELEGD & HALAVATS (1911), HALAVATS & SCHRETER (1915). The contribution of UHLIG (1881) was the first and the most detailed analysis of the Brădet Formation, dealing with the local lithology and fossils.

Figure 1. Occurrence of the Brădet (Bibel) Quarry (outcrop), Google-Earth satellite image.

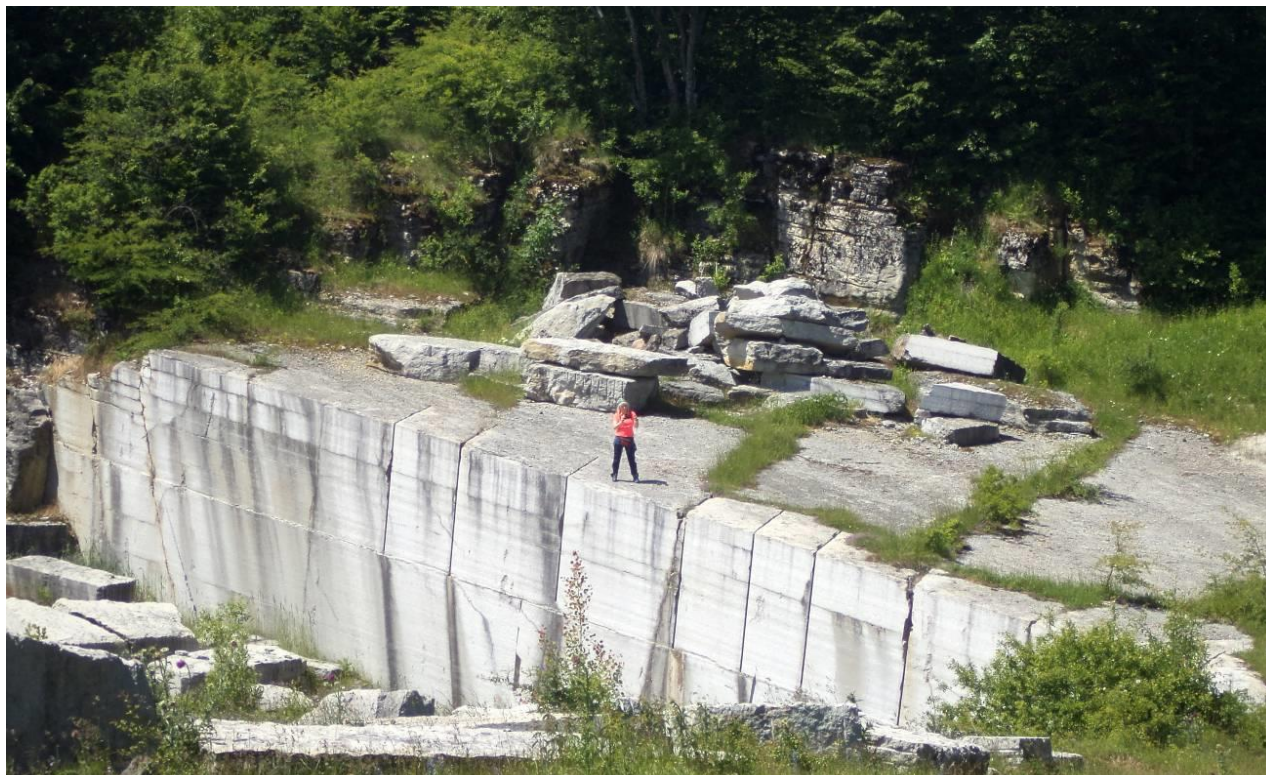


Figure 2. Main view of the Brădet (Bibel) Quarry; the modern and old quarries.

The quarry was later studied and discussed in wider, regional contributions such as RĂILEANU et al. (1957), MUTIHAC (1959), BĂDĂLUȚĂ-NĂSTĂSEANU (1965), NĂSTĂSEANU & SAVU (1968, 1970), NĂSTĂSEANU et al. (1968), BĂDĂLUȚĂ (1975), POP (1974, 1976), BUCUR et al. (1982), and BUCUR (1991, 1997). The studies detailed the micro- and macro-faunal fossil assemblages, leading to a better calibration and dating of the Brădet Formation. PATRULIUS et al. (1976) synthesized the age of the formation in a larger framework related to the Jurassic-Cretaceous boundary.

POPA (2001, 2005 and 2009) and POPA et al. (2009) addressed the palaeobotanical heritage of the Anina area, related to the Early Jurassic (Hettangian-Sinemurian) plants collected from underground mining works and from sterile dumps.

## MATERIALS AND METHODS

The Brădet Formation was carefully sampled in Brădet (Bibel) Quarry for documenting fossil invertebrates and their stratigraphical and palaeoecological context. The fossil material was collected by the authors in a series of field trips spanning the last 34 years, now curated at the Geological Museum of the Geological Institute of Romania, and in the Laboratory of Palaeontology, Faculty of Geology and Geophysics, University of Bucharest. The collected material was supplemented by hand specimens collected by previous authors, already curated in both institutions. The material was mechanically prepared, described, identified, and photographed.

## GEOLOGIC FRAMEWORK

Anina is located in the middle of the Reșița-Moldova Nouă sedimentary Zone, an area also known as the Reșița Basin, unconformably overlying the metamorphic basement of the Getic Nappe, part of the tectonic structure of the South Carpathians (CODARCEA, 1940; CODARCEA et al., 1961; SĂNDULESCU, 1984).

The basin is strongly tectonized, with a series of NE-SW oriented synclines and anticlines, the local structures being represented by the Anina Anticline with a central position, and the Brădet Syncline with a western position. The Anina Valley opens the Permian sandstone deposits in the area of the city of Anina, the oldest sedimentary deposits in the region.

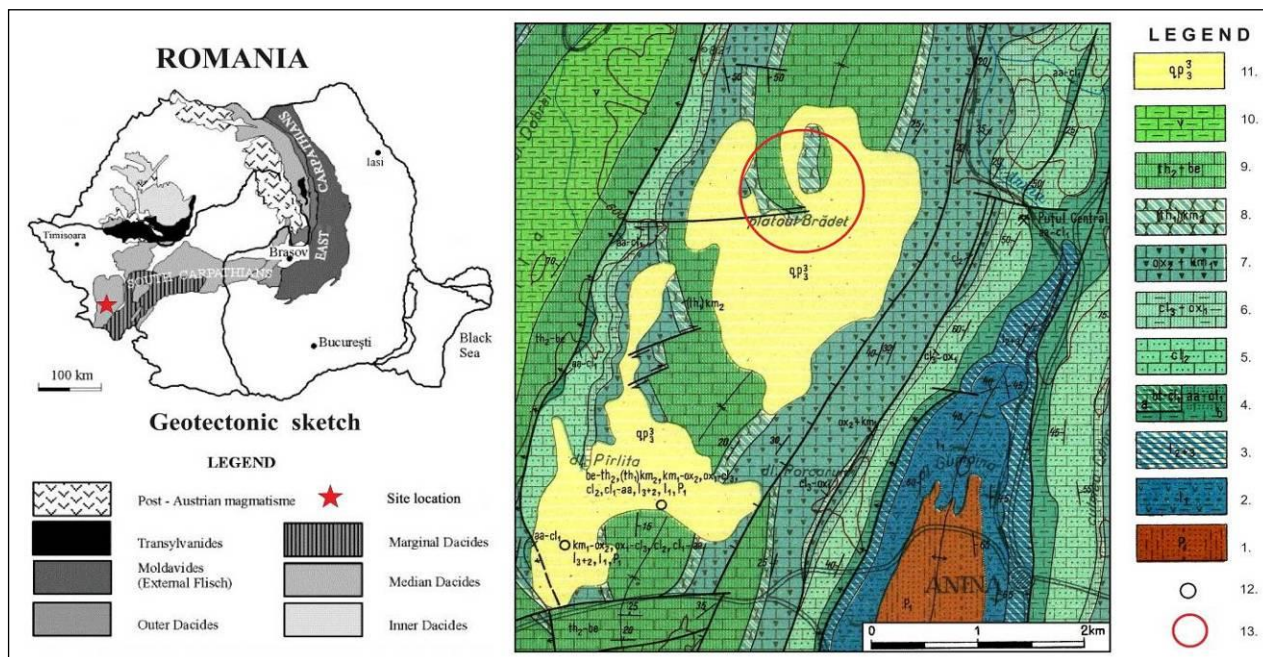


Figure 3. The Brădet (Bibel) Quarry and outcrop of Brădet Formation, occurrence on the geological map 1:50.000 (Anina sheet by NĂSTĂSEANU & SAVU, 1970). Caption: 1. Conglomerates, sandstones, red clays, continental facies – Lower Permian; 2. Conglomerates, sandstones, refractory clays with coals – Lower Liassic; 3. Bituminous clays with sphaeroidites- Middle-Upper Liassic; 4. Sandstone and marls – Bathonian/Lower Callovian; 5. Sandy Limestone of Gumpina Formation - Middle Callovian; 6. Marls of Tămașa Formation – Upper Callovian/Lower Oxfordian; 7. Limestone with cherts of Anina Formation – Upper Oxfordian/Lower Kimmeridgian; 8. Nodular limestone of Brădet Formation – Upper Kimmeridgian/Lower Tithonian; 9. Limestones of Marila Formation – Upper Tithonian /Berriasian; 10. Marls of Crivina Formation-Valanginian; 11. Red clays-Late Pleistocene; 12. Geological wells; 13. Quarry location.

The Reșița Basin includes sedimentary formations (Fig. 3) ranging from the Hettangian up to the Albian (BUCUR, 1991, 1997; POPA, 2009). The coal bearing Steirdorf Formation (Hettangian-Sinemurian) unconformably cover the Getic basement or Palaeozoic formations, conformably overlain by the Uteriș Formation with black shales (Pliensbachian-Middle Toarcian). They are followed by the Middle Jurassic deposits, represented by the Dealul Zânei Formation (with fossiliferous marls, Upper Toarcian - Aalenian - Lower Callovian) and the gritty-siliceous limestones of the Gumpina Formation (Middle Callovian), while the Upper Jurassic - Lower Cretaceous deposits are represented by the Tămașa Formation (Upper Callovian - Lower Oxfordian), followed by the Valea Aninei Formation (allodapic limestones with silicolite interlayers, Middle Oxfordian – Lower Kimmeridgian), by the Brădet Formation (nodular limestones, Upper Kimmeridgian – Lower Tithonian), overlain by the Marila Formation (Upper Tithonian – Middle Berriasian) and by the Crivina Formation (marls, Upper Berriasian - Lower Valanginian). The basin is strongly



Figure 4. Brădet (Bibel) Quarry views – a. detail of limestone extraction front; b. less desirable aspects.



Figure 5. Facies details in the Brădet (Bibel) Quarry; a1. Perisphinctid- juvenile ammonite; a2. *Laevaptychus* sp.; b. Siliceous nodules (chert) in the upper levels of the succession; c1-3. Ammonites and c2 *Pygope janitor*.



tectonized, with a series of NE-SW oriented synclines and anticlines, the local structures being represented by the Anina Anticline with a central position, and the Brădet Syncline with a western position.

#### SITE DESCRIPTION

The old Bibel Quarry and the new, larger quarry are confined to an area approximately 2.25 ha (Fig. 7).

In the large quarry, the limestone was extracted in large slabs for use in construction works (Fig. 10). Several steps open vertical walls, 2.5-5 m in height and 20-35 m in length. The steps are quasi-horizontal (5°-10° ESE), open the structural (layer) surfaces, providing an excellent image for understanding the limestone sedimentology and for the distribution of fossils (Figs. 5 and 6). The modern quarry is located in the southern half of the initial, large quarry area, outcropping the upper part of the Brădet Formation and the lower part of the Marila Formation. The entire succession of the Brădet Formation can be therefore studied, while the contact with the Anina Formation also occurs in the southwestern end of the large quarry. The transition from the nodular limestones of the Brădet Formation to the limestones with siliceous nodules and marls of the Marila Formation is traceable both in the smaller and larger quarries.

The nodular limestones of the Brădet Formation are thick and massively layered, with a pale, greenish marly material generating thin discontinuity surfaces, tapered in cross-section, generating a false centimetre stratification.

Figure 6. Structural (bed) surface of nodular limestone in the Brădet (Bibel) Quarry, with the facies and distribution of fossils, grey nodules of limestone in a mass of light green marl.

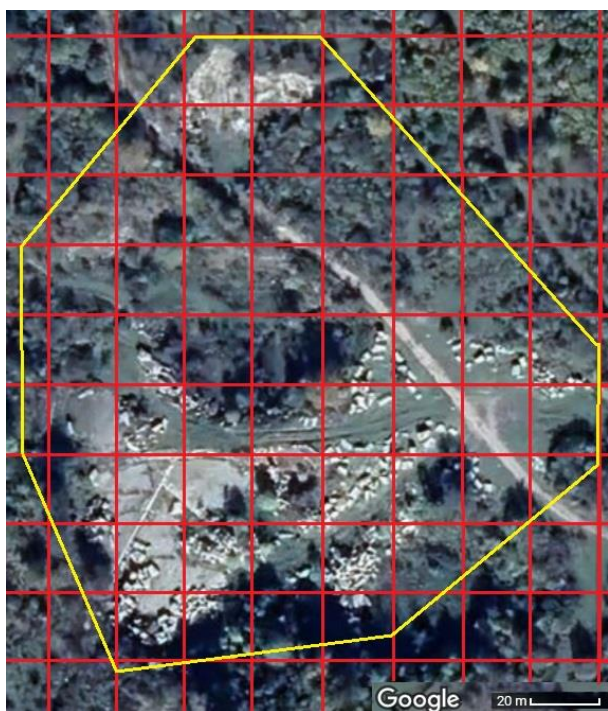


Figure 7. Perimeter of the future SSSI, including the Brădet Quarry.

The discontinuity surfaces marked by very thin marl layers are rare throughout the succession of the nodular limestone package, and they are visible especially at the base and top of the Brădet Formation. The nodular limestones include micrites, sparites, biosparites, biomicrites, biopelmicrites and nodular cherts, (BUCUR et al., 1982; BUCUR, 1997; and POP, 1976; Fig. 8b).

The stratotype of the Brădet Formation should belong to the large Brădet Quarry.

The Brădet Formation can be correlated with the Greben Formation (POP et al., 1997; GRIGORE, 1998) or with the Upper Nodular Limestone (RĂILEANU, 1953) according to STĂNOIU (2002-Lithostratigraphic Lexicon of Romania, [formatiunigeologice.igr.ro/formatiune/1384](http://formatiunigeologice.igr.ro/formatiune/1384)). Among all the occurrences and outcrops of Tithonian formations, such as the Prăpăstii Quarry from Pietra Craiului (AVRAM, 1988, 1996; GRIGORE, 2002), the Ghilcoș Formation outcrops from Hăghimaș (GRIGORE, 2000, 2002, 2011), or the Greben Formation with the new outcrops along the Danube Gorges (GRIGORE, 1998; CRUȘOVEANU and GRIGORE, 2022), the Brădet Quarry is the most representative in Romania.

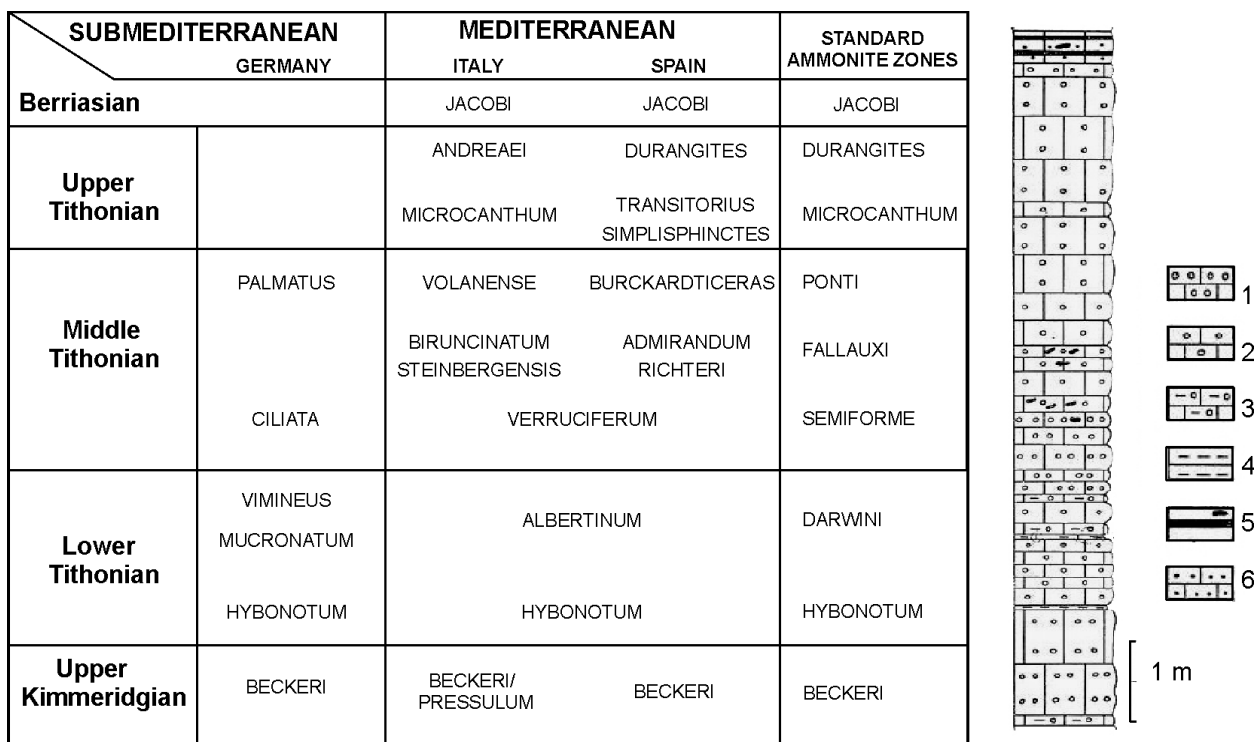


Figure 8. Tithonian ammonite zones of the Tethys realm (a) and (b) lithology of Brădet Formation (after POP, 1976). Legend: 1) nodular limestone; 2) nodular micrite and biomicrite; 3) marly nodular limestone; 4) marl; 5) banded or nodular chert; 6) biopelsparite.

### FOSSIL ASSEMBLAGE

The fossil association includes ammonites, aptychus, belemnites, brachiopods, bivalves, echinoids, corals and microfossils (*Saccocoma* fragments, calpionellids, etc.). The ammonites and aptychus are frequent, while the rest are rare.

The distribution of fossils varies between 1/m<sup>2</sup> to 4/dm<sup>2</sup> (FigS. 6 and 5c). The fauna cited by previous authors, in a few cases illustrated and less described, is introduced in Table 1 (X - cited; Y - also illustrated).

Table 1. Cited fossil species from the Anina quarry in literature.

Species	Revised species	Uhlig 1881	Bădăluță 1975	Patrulus & al 1976	Bucur & al. 1982	Bucur 1988	Ammonite Zones Age
<i>Physodoceras cycloatum</i>	<i>Schaileria neoburgensis</i> (OPPEL, 1863)	X	X	X			<i>Hybonotum</i> - <i>Burckhardticeras</i>
<i>Subplanitoides contiguous</i>	<i>Subplanites contiguous</i> (Catullo, 1846)	X	X	X	X		<i>Beckeri</i> - <i>Hybonotum</i>
<i>Parapallasiceras praecox</i>	<i>Parapallasiceras praecox</i> (Schneid, 1915)		X	X	X		?Middle Tithonian
<i>Berriassella</i> sp. gr. <i>B. nitida</i>	<i>Berriassella nitida</i> Schneid, 1915				X		Middle Tithonian
<i>Lemencia adeps</i>	<i>Lemencia adeps</i> (Schneid, 1915)		X	X			Middle Tithonian
<i>Lemencia praerichter</i>	<i>Lemencia praerichter</i> Donze et Enay, 1961		X	X			Middle Tithonian
<i>Lemencia subrichter</i>	<i>Lemencia subrichter</i> (Retowski, 1894)		X				Upper Tithonian
<i>Lemencia</i> sp. gr. <i>L. parvula</i>	<i>Lemencia parvula</i> Donze et Enay, 1961				X		Middle Tithonian
<i>Virgatosimoceras rothpletzi</i>	<i>Virgatosimoceras rothpletzi</i> (Schneid, 1915)		X	X			<i>Rothpletzi</i>
<i>Virgatosimoceras broilii</i>	<i>Virgatomorphites broilii</i> (Schneid, 1915)			X			<i>Albertinum</i>
<i>Parastreblites circumnodosum gaetanoi</i>	<i>Parastreblites circumnodosum gaetanoi</i> (Fontannes)		X	X			Lower Tithonian
<i>Parastreblites</i> sp. gr. <i>P. hoelder</i>	<i>Parastreblites hoelder</i> Donze et Enay, 1961		X				Lower Tithonian
<i>Neochetoceras</i> sp. gr. <i>N. steraspis</i>	<i>Neochetoceras steraspis</i> (Oppel, 1863)		X	X			Lower Tithonian
<i>Perisphinctes transitorius</i>	<i>Paraulacosphinctes transitorius</i> (Oppel, 1865)	X					<i>Transitorius</i>
<i>Perisphinctes</i> cf. <i>pseudocolubrinus</i>	<i>Kuteceras pseudocolubrinum</i> (Kilian, 1895)				X		<i>Richteri</i>
<i>Haploceras elimatum</i>	<i>Haploceras elimatum</i> (Oppel, 1865)	X	X				<i>Hybonotum</i> - <i>Albertinum</i>
<i>Haploceras staszycii</i>	<i>Haploceras staszycii</i> (Zeuschner, 1846)	X					<i>Hybonotum</i> - <i>Albertinum</i>
<i>Haploceras tithonium</i>	<i>Haploceras tithonium</i> (Zittel, 1868)	X					<i>Verruciferum</i> - <i>Andreaei</i>
<i>Haploceras carachtheis</i>	<i>Haploceras carachtheis carachtheis</i> (Zeuschner, 1846)		X				<i>Albertinum</i> - <i>Jacobi</i>
<i>Haploceras</i> sp. gr. <i>H. leiosoma</i>	<i>Haploceras carachtheis leiosoma</i> (Zittel, 1868)				X		<i>Verruciferum</i> - <i>Jacobi</i>
<i>Sublithacoceras pseudojubatum</i>	<i>Sublithacoceras pseudojubatum</i> Donze et Enay, 1961				X		Middle Tithonian
<i>Phanerostephanus</i> sp. gr. <i>P. allobrogicus</i>	<i>Phanerostephanus allobrogicus</i> Donze et Enay, 1961				X		Middle Tithonian
<i>Laevaptychus obliquus</i>	<i>Laevaptychus obliquus</i> (Quenstedt, )		X	X			Kimm. - Tithonian
<i>Lamellaptychus beyrichi</i>	<i>Beyrichilamellaptychus beyrichi</i> (Oppel, 1865)		X	X			<i>Richteri</i> - <i>Jacobi</i>
<i>Lamellaptychus lamellosus</i>	<i>Lamellaptychus lamellosus</i> (Parker, )			X			Lower Tithonian
<i>Hoplisuslaevaptychus</i> sp.	---				Y		-
<i>Meneginiilaevaptychus</i> sp.	---				Y		Lower Tithonian
<i>Brevislaevaptychus</i> sp.	---				Y		-
<i>Lamellaptychus</i> group A	---				Y		<i>Andreaei</i>
<i>Lamellaptychus</i> group B	---				Y		-
<i>Pygope janitor</i>	<i>Pygope janitor</i> (Pictet, 1867)		X			Y	Tithonian
<i>Terebratula</i> sp.	---		X				?
<i>Stolmorhynchia</i> sp.	<i>Stolmorhynchia</i> sp.		X				?Jurassic
<i>Hibolites semisulcatus</i>	<i>Hibolites semisulcatus</i> (Münster, 1830)		X				Tithonian
<i>Polydiadema</i> cf. <i>karakachi</i>	<i>Polydiadema karakachi</i> Weber, 1934					Y	Jurassic-Cretaceous
<i>Hinnites</i> sp.	---		X				-

The faunal association is specific for the upper part of the Lower Tithonian (=Middle Tithonian), with some species marking the lower part as well, as noted by BĂDĂLUȚĂ (1975) and PATRULIUS et al. (1976). The occurrence of the Upper Tithonian in Brădet Formation was not demonstrated with a marker association until now, but only with a few debatable index fossils: *Perisphinctes transitorius* (UHLIG, 1881), *Lamellaptychus* sp. gr. A (BUCUR, 1982).

The systematic work is in progress, while some of the previously recorded species are now confirmed, but also some new species for the region, marked with an asterisk (Table 2), listed with their synonyms (Table 2). Some of the cited species are now confirmed, possibly also as new species for the region (marked with an asterisk, Table 2).

The ammonite assemblage is dominated by haploceratids, lysoceratids and perisphinctids, phylloceratids and lycoceratids are rare, as well as other oppelids, confirming the middle Tithonian (=upper half of the lower Tithonian), with the *Verruciferum* Zone being the best represented. Species marking the lower Tithonian (*Hybonotum* - *Albertinum* zones) also occur; the lower part of the Upper Tithonian, with the base of the *Transversarius* Zone (?*Djurjericeras*), should also be represented, as UHLIG (1881) noted the occurrence of the index species.

The fauna association is also completed by some specimens of *\*Duvalia* sp. (Fig. 9h), *Lamellaptychus* sp. (Fig. 9i), and *Laevaptychus* sp. (Fig. 5a).

Table 2. Synonymies of the new ammonite species found now.

Species	Synonymy
<i>Haploceras</i> cf. <i>verruciferum</i> (ZITTEL, 1869) (Pl.1, Fig. 5) Verruciferum Zone	Sarti, 2020- p. 82, pl. 3/3,4; Sarti, 1986- p. 490, pl.1/6; Fözy & Scherzinger, 2013- p. 216, pl. 4/1,2, pl. 5/6, 7, 8, 9, 12.
<i>Pseudolissoceras</i> sp. aff. <i>P. olorizi</i> FOZY, 1988 (Pl. 1, Fig. 6) Verruciferum Zone	Sarti, 2020- p. 94, pl. 5/1; Oloriz, 1978- p. 38, pl. 2/11; Fozy, 1988- p. 65, pl. 4/1, 2.
<i>Pseudolissoceras planiusculum</i> (ZITTEL, 1870) (Pl. 1, Fig. 7) Verruciferum Zone	Sarti, 2020- p. 93, pl. 4/9, 10, 11; Oloriz, 1978- p. 35, pl. 2/10.
<i>Subplanites</i> cf. <i>contiguus</i> (CATULLO, 1853) (Pl.1, Fig. 1; Fig. 9e) Beckeri – Hybonotum zones	Donze & Enay, 1961- p. 111, pl. 16/3; Sarti, 1986- p. 502, pl. 5/1; Sarti, 1993- p.90.
* <i>Pseudosubplanitoides</i> cf. <i>pseudocontiguus</i> Donze, 1961 (Fig. 9d) Albertinum Zone	Sarti, 2020- p. 126; Cecca, 1990- p. 45, pl. 1/3; Sarti, 2017- p. 47; Donze&Enay, 1961- p. 110, pl. 16/1,2; Zeiss, 1968- p.108, pl. 19/5, 21/1; Oloriz, 1978- p. 546; Sato&Yamada, 2005- p.271, Fig. 3.
<i>Kutekiceras</i> cf. <i>pseudocolubrinum</i> (KILIAN, 1895) (Pl. 1, Fig. 3; Fig. 9f) Albertinum – Steinbergensis zones	Sarti, 2020- p.118, pl.13/2, 14/1,2; Sarti, 1986- p.500, pl.3/4; Donze&Enay, 1961- p. 180; Oloriz, 1978- p. 476, pl. 55/8, 9, 10; Tavera, 1985- p. 56, pl. 5/3; Vasicek & Al., 2017- p. 590, Fig. 6; Zeiss, 2001- p. 45, pl. 10/1–4; Fözy&Scherzinger, 2013- p. 233, pl. 16/1, 2, 6.
* <i>Richterella richteri</i> (OPPEL, 1865) (Pl. 1, Fig. 4; Fig. 9a) Richteri Zone	Cecca, 1986- p. 38, pl. 1/1-12; Vasicek&Skupien, 2016- Fig.7D; Avram, 1974- p. 18, pl. 2/3, 4, 5.
* <i>Torquatisphinctes proximus</i> (STEUER, 1921) (Pl. 1, Fig. 2) Semiforme (Verruciferum) Zone	Parent, 2003- p. 159. Figs. 9,13; Leanza, 1980- p. 44, pl. 6/2, 4, 5; Yin & Enay, 2004- Fig. 3/4.
<i>Kutekiceras</i> sp. aff. <i>K. pseudocolubrinum</i> (KILIAN, 1895) (Fig. 9f) Albertinum – Steinbergensis zones	aff. <i>K. pseudocolubrinum</i> (Kilian, 1895) syn.
*cf. <i>Djurjiceras</i> sp. (Fig. 9b) Transitorius Zone	cf. Sarti, 2020- p. 154, pl. 27/6.
<i>Lemencia</i> sp. (Fig. 9c) Middle Tithonian	? Donze&Enay, 1961- p. 164, pl.22/2 ( <i>L. ciliata</i> Schneid).
<i>Pygope janitor</i> (PICTET, 1867) (Fig. 9g, Fig. 5c2) Tithonian	Kazmer, 1993- p. 63; Bujtor & Al., 2021- p. 91, Fig. 8.

## CONCLUSIONS

The proposed preserved site (Site of Special Scientific Interest, SSSI) includes two quarries in Anina, the Brădet (large) and Bibel (smaller, older) quarries, with national and international significance for Tithonian biostratigraphy. A detailed, integrated biostratigraphic study is still necessary to establish a detailed biozonation and for correlating the macro- and micro-fauna. The studies carried out up to this date justify the classification and protection of this site, from paleontological, litho- and biostratigraphic points of view, and as a stratotype for the Brădet Formation. The site completes and increases the heritage of a proposed geopark in the area, part of a future geotouristic trail.

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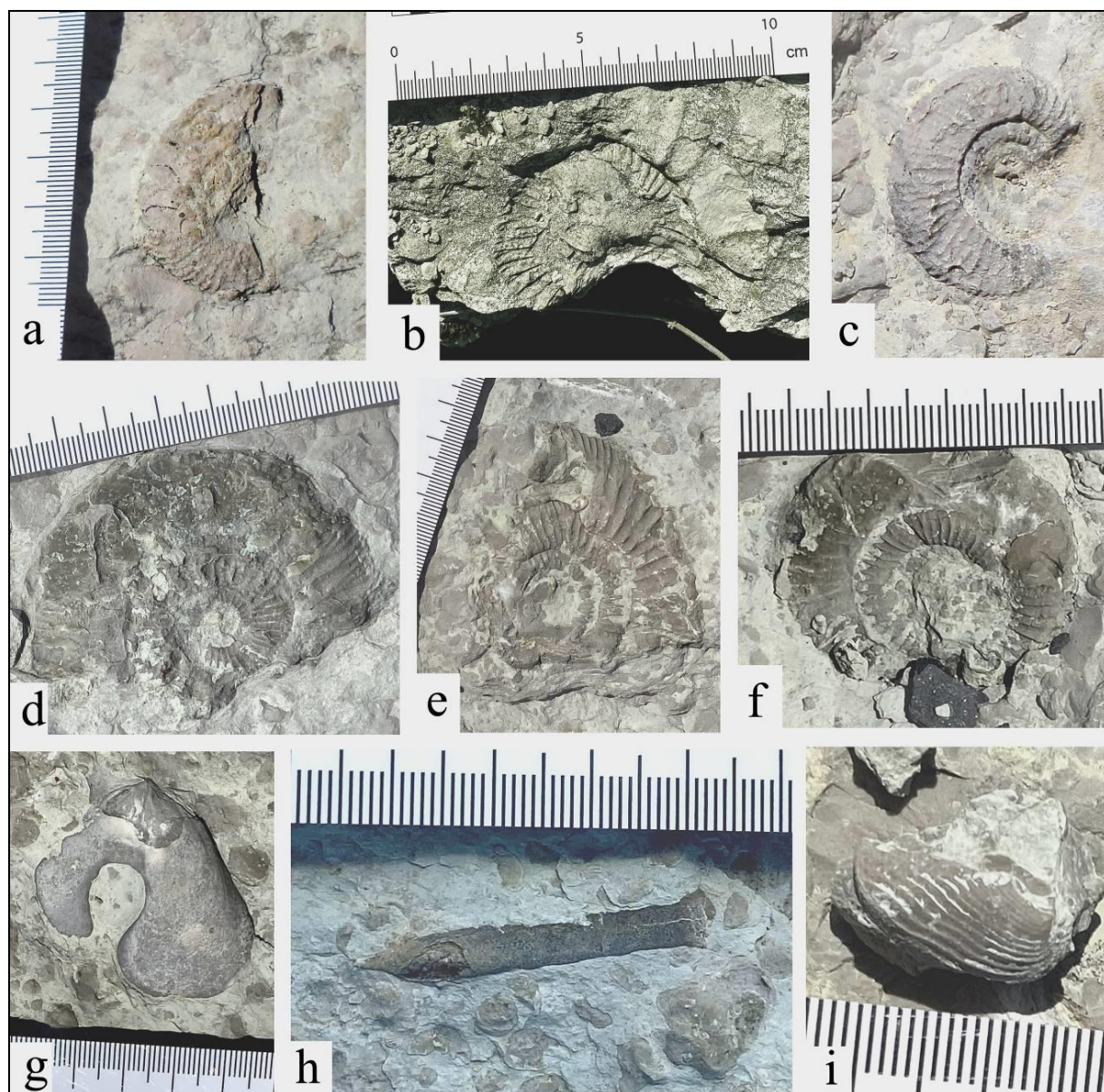


Figure 9: a. *Richterella* cf. *richteri* (Oppel) Middle Tithonian (Richteri Zone); b. cf. *Djurjuriceras* sp. Upper Tithonian (?Microchantum Zone); c. *Lemencia* sp. Middle Tithonian (?Richteri Zone); d. *Subplanites* cf. *pseudocontiguus* Donze Middle Tithonian (Richteri Zone); e. *Subplanites* cf. *contiguus* (Catullo) Middle Tithonian (Zone); f. *Kutekiceras* cf. *pseudocolubrinum* (Kilian) Middle Tithonian (Verruciferum Zone); g. *Pygope janitor* (Pictet) Tithonian; h. *Duvalia* sp. Tithonian; i. *Lamellaptychus* sp. Tithonian. All pictures taken on the nodular limestone surfaces opened in the Brădet (Bibel).



Figure 10. Brădet (Bibel) Quarry and Brădet Plateau of Anina; view of the limestone quarry steps and blocks.



## REFERENCES

- AVRAM E. 1974. Position et valeur taxonomique du groupe << *Berriasella* >> *richteri* (OPPEL). *Dări de seamă*. (1972-1973). *Paleontologie*. Institutul Geologic. Bucharest. **60**(3): 11-22.
- AVRAM E. 1988. *The Upper Jurassic cephalopod assemblages in Romania and their paleogeographic distribution*. 2nd International Symposium Jurassic Stratigraphy. Lisboa. 609-622.
- BĂDĂLUȚĂ-NĂSTĂSENU A. 1965. *Geologia regiunii Anina cu privire specială asupra Jurasicului (Zona Reșița-Banat)*. Universitatea București. Teză doctorat (Autoreferat). București: 23 pp.
- BĂDĂLUȚĂ A. 1975. Biostratigraphie des formations du Tithonique Valanginien et de la limite Jurassique-Crétacé dans le Banat Occidental (Roumanie). *Mémoires du Bureau de Recherches Géologiques et Minières*. Paris **86**: 23-28.
- BÖCKH J. 1887. Adatok a Bozovicstól észak-nyugatra emelkedő hegység geologiai ismeretéhez. *Jahrbuch der königlich-ungarischen geologischen Anstalt*. Budapest: 117-144.
- BUCUR I. 1991. Proposition pour une nomenclature lithostratigraphique des Carpathes Méridionales, Roumanie. *Studia*. Universitatea Babeș-Bolyai. Cluj-Napoca. **36**(2): 3-14.
- BUCUR I. 1997. *Formațiunile mezozoice din zona Reșița-Moldova Nouă (Munții Aninei și estul Munților Locvei)*. Presa Universitară Clujeană. Cluj-Napoca: 214 pp.
- BUCUR I., BĂDĂLUȚĂ A., POPESCU O. 1982. Date noi privind biostratigrafia depozitelor jurasice și cretacice din partea mediană a Zonei Reșița (Banat). *Dări de Seamă*. Institut de Geologie și Geofizică. București. **66**(4): 21-51.
- BUJTOR L., ALBRECHT R., MARÓTI D., MIKLÓSY Á. 2021. Lower Tithonian and lower Berriasian brachiopods from the Márévár Limestone Formation, Zengővárkony (Mecsek Mountains Hungary), and remarks on their palaeoenvironment. *Paläontologische Zeitschrift*. Springer. Berlin. **95**: 85-95.
- CECCA F. 1986. Le genre *Richterella* Avram (Ammonitina, Périssphinctidés) dans le Tithonique inférieur de la bordure ardéchoise (sud-est de la France): dimorphisme et variabilité. *Geobios*. Elsevier. Amsterdam. **19**(1): 33-44.
- CECCA F. 1990. Étude des Périssphinctidés de la zone à Darwini (Tithonique inférieur) des Apennins des Marches (Italie): paléontologie et paléobiogéographie. *Atti II<sup>o</sup> Convegno Internazionale Fossili, Evoluzione, Ambiente*. Pergola. **87**: 39-55.
- CODARCEA A. 1940. Vues nouvelles sur la tectonique du Banat Méridional et du Plateau de Mehedinți. *Anuarul Institutului Geologic*. București. **20**(1): 1-74.
- CODARCEA A., RAILEANU G., PAVELESCU L., GHERASI N., NASTASEANU S., BERCIA I., MERCUS D. 1961. Privire generală asupra structurii geologice a Carpaților Meridionali dintre Dunăre și Olt. Congresul al V-a al Asociației Geologice Carpato-Balcanice. *Ghidul excursiilor C. - Carpații Meridionali*. 125-125 pp.
- CRUȘOVEANU S. & GRIGORE D. 2022. Three paleontological sites proposal as new national reserves in the Iron Gates National Park (Romania). *Oltenia. Studii și comunicări. Științele Naturii*. Muzeul Olteniei Craiova. **38**(1): 17-24.
- DONZE P. & ENAY R. 1961. Les Céphalopodes du Tithonique inférieur de la Croix-de-Saint-Concors pres Chambéry (Savoie). *Travaux du Laboratoire de Géologie de la Faculté des Sciences de Lyon*. **7**: 1-236.
- FÖZY I. 1988. Tithonian Ammonites (Oppeliidae, Haploceratidae and Simoceratidae) from the Transdanubian Central Range, Hungary. *Annales Universitatis Scientiarum Budapestinensis de Rolando Eötvös nominate, Sectio Geologica*. **28**: 43-119.
- FÖZY I. & SCHERZINGER A. 2013. Systematic descriptions of Tithonian ammonites of the Gerecse Mountains. In: Fözy, I. (Ed.) *Late Jurassic-Early Cretaceous fauna, biostratigraphy, facies and deformation history of the carbonate formations in the Gerecse and Pilis Mountains (Transdanubian Range, Hungary)*. Institute of Geosciences. University of Szeged. 207-292.
- GRIGORE D. 1998. Upper Kimmeridgian and Lower Tithonian sequence of the Greben Formation in the Șvinița area – SW of the South Carpathians. *Anuarul Institutului Geologic al României*. Bucharest. **70**: 81-86.
- GRIGORE D. 2000. Kimmeridgian and Lower Tithonian sequences from East and South Carpathians – Romania). *Anuarul Institutului Geologic al României*. Bucharest. **72**(2): 37-45.
- GRIGORE D. 2002. *Formațiunea cu Acanthicum din regiunea Lacu Roșu (Msv. Hăghimaș-Carpații Orientali) – posibil hipostratotip al limitei Kimmeridgian – Tithonic*. *Stratigrafie. Paleontologie*. Teză doctorat. Universitatea „Alexandru Ioan Cuza” Iași. 347 pp.
- GRIGORE D. 2011. Kimmeridgian – Lower Tithonian Ammonite Assemblages from Ghilcoș – Hăghimaș Massif (Eastern Carpathians – Romania). *Acta Palaeontologica Romaniae*. Societatea Paleontologilor din România. Editura Presa Universitară Clujeană. Cluj Napoca. **7**: 177-189.
- HALAVATS J. & SCHRETER Z. 1915. *Fehértemplom Szászabánya és Omoldovo kömyéke Magyarázatok – a magyar kőrországnak részletes geológiai térképéhez*. 26/27ov/XXv. oszlap Jelzesü, lap, (1:75.000), Budapest: 55 pp.
- KÁZMÉR M. 1993. Pygopid brachiopods and Tethyan margins. In J. Pálffy & A. Vörös (eds.): *Mesozoic brachiopods of Alpine Europe*. Hungarian Geological Society. Budapest. 59-68.
- KILIAN W. 1889. Études paléontologiques sur les terrains secondaires et tertiaires de l'Andalousie. Mission d'Andalousie. *Mémoires de l'Académie des Sciences de l'Institut National de France*. Paris. **30**: 601-750.
- LEANZA H. A. 1980. The Lower and Middle Tithonian ammonite fauna from Cerro Lotena, Province of Neuquen, Argentina. *Zitteliana*. Bayerische Staatssammlung für Paläontologie und Geologie München. **5**: 3-49.

- MUTIHAC V. 1959. *Studii geologice în partea mediană a zonei Reșița - Moldova Nouă (Banat)*. Editura Academiei R. P. R. București. 106 pp.
- NĂSTĂSEANU S. & SAVU H. 1968. *Harta geologică a României, scara 1:200,000, foaia 31-Reșița. Notă explicativă*. Institutul Geologic. București. 44 pp.
- NĂSTĂSEANU S. & SAVU H. 1970. *Harta geologică a României, scara 1:50,000, foaia 121d-Anina*. Institutul Geologic. București.
- NASTASEANU S., STANCIU C., ILIE S. 1968. *Harta geologică a României, scara 1:200,000, foaia 31-Reșița*. Institutul Geologic. București.
- OLÓRIZ F. 1978. *Kimmeridgiense -Tithonico inferior en el sector central de las Cordilleras Béticas (Zona Subbética) - Paleontología, Bioestratigrafía*. PhD Tesis doctoral. Universidad de Granada. 758 pp.
- PARENT H. 2003. The ataxioceratid ammonite fauna of the Tithonian (Upper Jurassic) of Casa Pincheira, Mendoza (Argentina). *Journal of South American Earth Sciences*. Elsevier. Amsterdam. **16**(3): 143-165.
- PATRULIUS D., NEAGU T., AVRAM E., POP G. 1976. The Jurassic-Cretaceous boundary beds in Romania. *Anuarul Institutului de Geologie și Geofizică*. București. **50**: 71-126.
- POP GR. 1974. Les zones de Calpionellides tithoniques-valanginiennes du sillon de Reșița (Carpathes Méridionales). *Revue roumaine géologie, géophysique, géography. Géologie*. Académie de la République Socialiste de Roumanie. Bucarest. **18**: 109-125.
- POP GR. 1976. Origin of some basinal limestones from the Reșița zone (South Carpathians). *Anuarul Institutului Geologic al României*. Bucharest. **48**: 57-95.
- POP GR., MĂRUNȚIU M., IANCU VIORICA, SEGHEDI ANTONETA, BERZA T. 1997. Geology of the South Carpathians in the Danube Gorges (Romanian bank). International Symposium Geology of the Danube Gorges, Băile Herculane, September 23-26, 1997. *Field Guidebook*. Raport Fond Geologic I.G.R. 28 pp.
- POP GR., MĂRUNȚIU M., STĂNOIU I., GRIGORE D. 1997. *Raport geologic. Harta geologică a României, scara 1:50,000, foaia Svinecea Mare*. Raport Fond Geologic I.G.R. 21 pp.
- POPA M. E. 2001. Ponor SSSI (Site of Special Scientific Interest). Lower Jurassic Paleoflora. In Bucur I. I., Filipescu S., Săsăran E. (Eds.): *Algae and carbonate platforms in western part of Romania*. Field trip guidebook. "Babes-Bolyai" University. Cluj-Napoca. 167-171.
- POPA M. E. 2005. Aspects of Romanian Early Jurassic Palaeobotany and Palynology. Part VI. Anina, an exceptional locality. *Acta Palaeontologica Romaniaae*. Societatea Paleontologilor din România. **5**: 375-378.
- POPA M. E. 2009. *Late Palaeozoic and Early Mesozoic continental formations of the Reșița Basin*. Editura Universității din București. 197 pp.
- POPA E. M., KEDZIOR A., FODOLICĂ V. 2009. The Anina Geopark: preserving the geological heritage of the South Carpathians. *Revue Roumaine de Géologie*. Romanian Academy. Bucharest. **53-54**: 109-113.
- RĂILEANU G. 1953. Cercetări geologice în regiunea Svinița - Fața Mare. *Buletinul științific al Academiei Republicii Populare Române* (Secția Biologie-Agronomie-Geologie-Geografie). București. **5**(2): 307-409.
- RĂILEANU G., NĂSTĂSEANU S., MUTIHAC V. 1957. Cercetări geologice în regiunea dintre Anina și Doman (Zona Reșița-Moldova Nouă). *Buletinul științific al Academiei Republicii Populare Române*. București. **11**(2): 289-310.
- ROTH TELEGD L. 1906. *Krassova és környéke, Magyarázatok. A. M.: kóri Országainak Részletes Geológiai Térkép*. 25, zona/XXV -rovat, jelzés lap (1:75.000). Budapest: 43 pp.
- ROTH TELEGD L. & HALAVATS G. 1911. *Temescutas és Oravicobanya környéke. Magyarázatok. A. M.: kóri Országainak Részletes Geológiai Térkép*. 25 ov/XXV-ronat, jelzés lap (1:75.000). Budapest. 33 pp.
- SARTI C. 1986. Fauna e biostratigrafia del Rosso Ammonitico del Trentino centrale (Kimmeridgiano- Titoniano). *Bollettino della Società Paleontologica Italiana*. Milano. **23**(3): 473-514.
- SARTI C. 1993. Il Kimmeridgiano delle Prealpi Veneto-Trentine. Fauna e Biostratigrafia. *Memorie del Museo Civico di Storia Naturale di Verona. Sezione Scienze della Terra*. **5**: 204 pp.
- SARTI C. 2017. New ammonite genera from the Lower Tithonian (Upper Jurassic) of the Southern Alps (Northern Italy). *Studi Trentini di Scienze Naturali*. Museo delle Scienze. Trento. **96**: 33-61.
- SARTI C. 2020. Il Titoniano del Trento Plateau (Alpi Meridionali): faune ad Ammoniti, Stratigrafia e variazioni paleoambientali / Sea level change in the Tithonian and the Ammonite fauna and stratigraphy of Venetian Alps. (Northern Italy). *Studi Trentini di Scienze Naturali*. Museo delle Scienze. Trento. **99**: 37-314.
- SATO & YAMADA 2005. Early Tithonian (Late Jurassic) Ammonite Parapallasiceras newly discovered from the Itoshiro Subgroup (Tetori Group) in the Hida Belt, northern Central Japan. *Proceedings of the Japan Academy Serie B. Physical and Biological Sciences*. **81**(7): 267-272.
- SĂNDULESCU M. 1984. *Geotectonica României*. Editura Tencică. București. 336 pp.
- SCHNEID T. 1915. Die Ammonitenfauna der obertithonischen Kalke von Neuburg. *Donau Geologische und Palaeontologische Abhandlungen*. Bayerische Staatssammlung für Paläontologie und Historische Geologie. **13**(5): 1-114.
- STĂNOIU I. 2002. *Lexiconul litostratigrafic al României. Formațiunea de Brădet*. <https://formatiunigeologice.igr.ro/formatiune/1384>. (accessed: January 23, 2024).
- TAVERA J. M. 1985. *Les ammonites del Tithonico superior Berriasense de la Zona Subbética (Cordilleras Béticas)*. Tesis Doctoral. University of Granada. 381 pp.

- TELEGD R. L. & HALAVATS G. 1911. *Temescutas és Oravicobanya környéke. Magyarázatok. A. M.: kóri Országainak Részletes Geológiai Térkép. 25 ov/XXV-ronat, jelzés lap (1:75.000)*. Budapest. 33 pp.
- TODOR D. R. & SURD V. 2015. History and Tourist Valorization of the Ruschița Marble Quarry (Caraș-Severin County, Romania). *Studia Universitatis „Babeș-Bolyai”. Geographia*. Cluj-Napoca. **60**(2): 97-122.
- UHLIG V. 1881. Zur kenntnis der Malm- und Tithonstufe in der Umgebung von Steierdorf im Banat. *Verhandlungen der kaiserlich-königlichen geologischen Reichsanstalt*. Wien. **3**: 51-52.
- VASÍCEK Z. & SKUPIEN P. 2016. Tithonian and early Berriasian perisphinctoid ammonites from the Stramberk Limestone at Kotouc Quarry near Stramberk, Outer Western Carpathians (Czech Republic). *Cretaceous Research*. Elsevier. Amsterdam. **64**: 12-29.
- VASÍCEK Z., REHÁKOVÁ D., SKUPIEN P. 2017. Some perisphinctoid ammonites of the Štramberk Limestone and their dating with associated microfossils (Tithonian to Lower Berriasian, Outer Western Carpathians, Czech Republic). *Geologica Carpathica*. Carpathian-Balkan Geological Association. **68**(6): 583-605.
- YIN J. & ENAY R. 2004. Tithonian ammonoid biostratigraphy in eastern Himalayan Tibet. *Geobios*. Elsevier. Amsterdam. **37**: 667-686.
- ZEISS 1968. Untersuchungen zur Paläontologie der Cephalopoden des Unter-Tithon der Südlichen Frankenalb. *Abhandlungen der Bayerischen Akademie der Wissenschaften, mathematischnaturwissenschaftliche Klasse*. **132**: 1-191.
- ZEISS 2001. Wenig bekannte Ammoniten aus dem Grenzbereich Oberkimmeridgium / Untertithonium der Südlichen Frankenalb. *Archaeopteryx*. **19**: 57-70.

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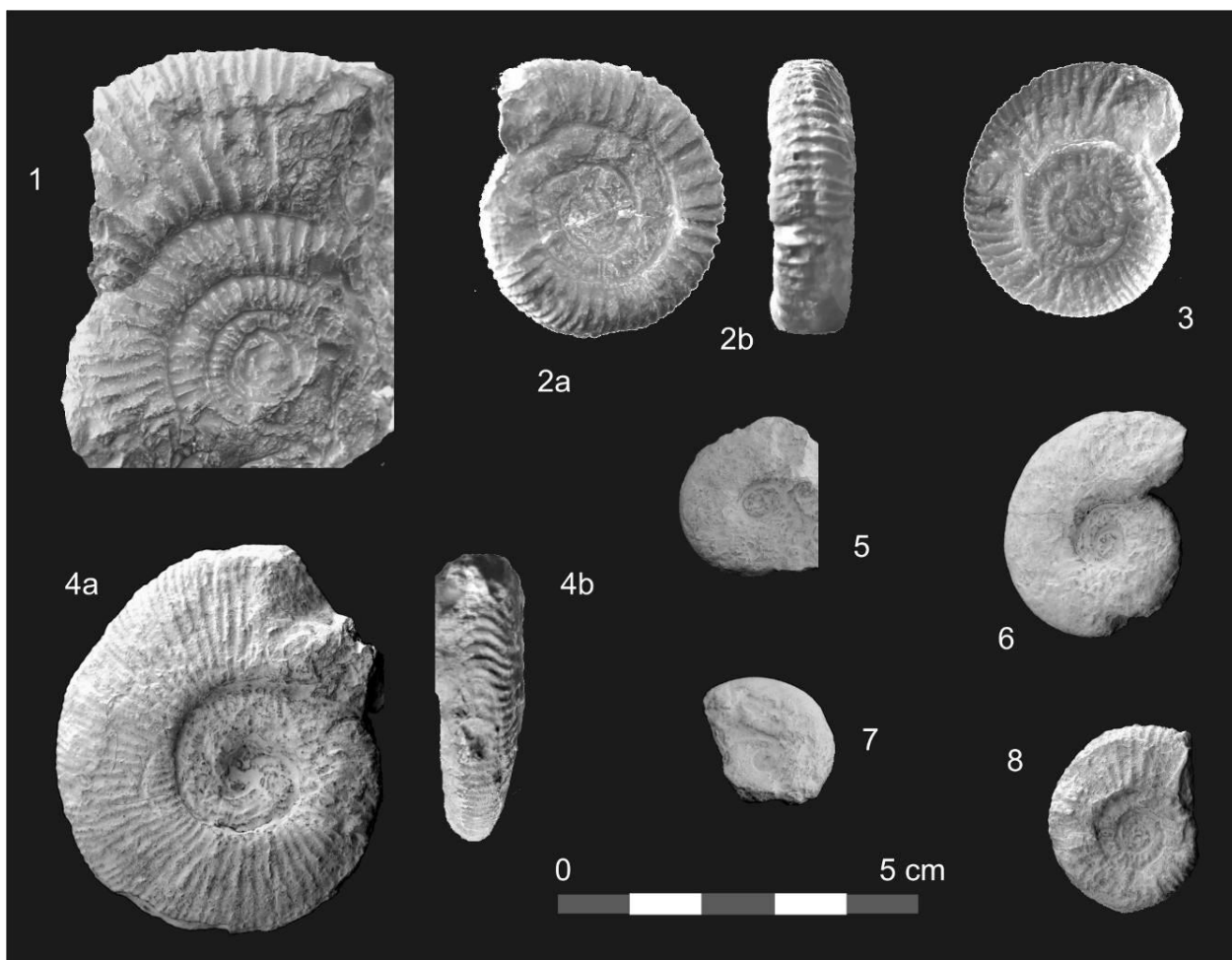
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## Plate 1



Figures: 1. *Subplanites cf. contiguus* (Catullo) Lower Tithonian (Hybonotum Zone); 2. *Torquatisphinctes proximus* (Steuer) Middle Tithonian (Richteri Zone); 3. *Kutekiceras* sp. aff. *K. pseudocolubrinum* (Kilian) Middle Tithonian (Verruciferum Zone); 4. *Richterella richteri* (Oppel) Middle Tithonian (Richteri Zone); 5. *Haploceras cf. verruciferum* (Zittel) Middle Tithonian (Verruciferum Zone); 6. *Pseudolissoceras* sp. aff. *P. olorizi* Fozy Middle Tithonian (Verruciferum Zone); 7. *Pseudolissoceras planiusculum* (Zittel) Middle Tithonian (Verruciferum Zone); 8. Perisphinctidae indet. Tithonian. All from Brădet Formation.