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Early Jurassic (Late Sinemurian–Early Pliensbachian) Ammonites from the Limestone Boulders of Bodrak River Basin, Southwest Crimea

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Abstract—Ammonites from two separate limestone blocks in the Bodrak River basin (Southwest Crimea) are described. The assemblage from the first boulder (on Tatyana's Hill) is represented by the Echioceratidae ammonites (genera *Orthechioceras* and *Echioceras*). The ammonite complex from the second boulder (in the Ammonite Ravine) is represented by one species of *Calliphylloceras* (family Phylloceratidae), one species of *Uptonia* (family Polymorphitidae), and three species of the genus *Tropidoceras* (family Tropidoceratidae). A new species *Tropidoceras komarovi* is described. For the first time for the Lower Jurassic of Crimea, a sequence of biostratigraphic units is proposed within each of the studied boulders. These units are correlated with biostratigraphic units (zones, subzones, and biohorizons) of the Sub-Mediterranean scale. Within the first boulder, the following units (bottom to top) are established: (1) Biohorizon Orthechioceras edmundi; (2) Biohorizon Echioceras rhodanicum; (3) Biohorizon Echioceras raricostatoides and (4) Biohorizon Echioceras crassicostatum, which correspond to the Raricostatum Zone and Densinodulum and Raricostatum subzones of the upper Sinemurian of Europe. Within the second block, the following units are established (from bottom to top): (1) Biohorizon Uptonia cf. jamesoni and (2) Biohorizon Tropidoceras erythraeum, corresponding to Jamesoni Zone (Jamesoni Subzone) and the bottom of the Ibex Zone (Masseanum Subzone) of the lower Pliensbachian of Europe. It is shown that the studied blocks in Bodrak River basin are composed of limestones of different ages, which, in turn, are different from the age of enclosing rocks.

Keywords: Crimea, Lower Jurassic, ammonites, Sinemurian, Pliensbachian

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INTRODUCTION

Blocks of Lower Jurassic limestones in the Bodrak River basin are products of tectonic fragmentation. Piles of such blocks of different composition and size (from tens of centimeters up to hundres of meters across), separated by a crushed matrix, compose Simferopol melange, a zone of tectonic brecciation identified by Yudin (1993). This largest mixtite of Mountainous Crimea is traced along the entire southern slope of the Second (Internal) Ridge of the Crimean Mountains and is a regional polymictic tectonic melange (Yudin, 1993, 2000, 2011, 2018; Yudin and Zaitsev, 2020).

In the English-language literature, the Simferopol melange in conjunction with the Marta melange, also identified by Yudin (2000), is known as "Eskiorda Formation" (Kotlyar et al., 1999) or "Eskiorda tectonic complex" (Kozur et al., 2000) and is characterized as "a composite and dismembered tectonic complex, that lies north of the Taurida flysch s.s." (Kozur et al., 2000, p. 224). The term "Eskiorda Formation," however, was put into use by the Crimean geologist Moiseev (1932) to define the stratigraphic unit previously assumed in the valleys of the Salgir, Alma, and Bodrak rivers (the stratotype was first identified by Shalimov (1969, p. 92)). Thus, hereinafter we use the terminology of Yudin, who identified the Simferopol melange as a regional chaotic complex of endogenous origin (Yudin, 1993, 2000, 2011). Note that the presence of fragments of chaotic complexes (olistostromes with olistolites, melange Mender strata, with a local outcrop 0.2 × 9 km, as part of a stratified complex) and foliation, localized at least in some areas within the so-called Eskiorda straton, was noted earlier (Zaika-Novatsky and Soloviev, 1986, 1988), including the area under study (Koronovsky and Mileev, 1974; Mileev et al., 1989, p. 16, Fig. 4).

Existing differences in views on the geological history and structure of Crimea (Koronovsky and Mileev, 1974; Muratov, 1969; Panov et al., 1994; Permyakov et al., 1991; Yudin, 1993, 2011; etc.) and the scarcity of the reported finds of Early Jurassic ammonites (as a rule, these are isolated specimens or collections from talus, without any stratigraphic reference) make any new information on the Early Jurassic ammonoids of the Crimea relevant.

The material for this work was a collection of ammonites gathered by the author from two limestone blocks in the basin of the Bodrak River south of the village of Trudolyubovka. In total, about 200 ammonite samples were collected from these blocks. The position of the finds in a particular interval within the blocks was recorded. This made it possible to establish separate ammonite complexes, confined to different stratigraphic intervals within each block, which was briefly reported earlier (Zaitsev, 2020). The collection of the samples studied is stored in the Central Geological Research Museum (TSNIGR Museum, St. Petersburg) under the number 13351.

GEOLOGY OF THE STUDIED AREA

Limestone blocks in the melange zone in the basin of the Bodrak River contain fossil fauna of an extremely wide age range: from the Serpukhovian of the Early Carboniferous (Miklukho-Maklai and Porshnyakov, 1954) to the Early Jurassic (late Toarcian). From the Lower Jurassic limestone boulders in the study area the Sinemurian, Pliensbachian and Toarcian fossil fauna was noted (Ippolitov et al., 2015; Kazakova, 1962; Panov, 1994; Repin, 2017).

The age relationships between the different boulders, as well as with the host terrigenous rocks, are still debatable (Komarov et al., 2012; Mileev et al., 2009; Panov, 1994, 2002; Yudin, 2011; etc.). The fossil fauna, reliably known from the melange matrix and blocks of terrigenous rocks (sandstones, mudstones, flysch fragments), characterizes the stratigraphic interval from the Middle Triassic (Ladinian Stage) (Astakhova, 1976) to the upper Toarcian (? lower Aalenian) (Ippolitov et al., 2015). Early Jurassic ammonites from the terrigenous rocks of the Bodrak river basin were mostly collected by by teachers and students of Moscow and St. Petersburg State Universities in the upper reaches of the Ammonite Ravine in different years (Kazakova, 1962; Zaitsev and Arkadiev, 2019). Here, in the greenish gray mudstones and the siltstone fragments an ammonite complex of the Obtusum Zone–Lower Raricostatum Zone of the upper Sinemurian was established (Fig. 1, locality 4). An isoated find of ammonite, typical of the lower Sinemurian–base of the upper Sinemurian of Europe, was described from foliated mudstones on the eastern slope of the Mount Konskiy on the left side of the Mender Ravine (Zaitsev and Arkadiev, 2019) (Fig. 1, locality 1).

Boulders of Lower Jurassic carbonate rocks in this area are believed to be fragments of the former carbonate massif (carbonate platform) that were brought up from the underthrust to the melange surface (Yudin, 2011). Detailed study of these boulders could help to determine their origin, as well as to clarify the nature of carbonate sedimentation in the Early Jurassic and its further evolution in the area under consideration.

HISTORY OF THE LOWER JURSIAN LIMESTONE STUDY IN THE BODRAK BASIN

Blocks of Lower Jurassic limestones in the Bodrak River basin were first mentioned at the beginning of the twentieth century in the reports of the Geological Committee (Report..., 1911, p. 169; Report..., 1913, p. 29). The limestones composing these blocks have been dated for a long time based on the finds of brachiopods (Moiseev, 1925, 1934; Mukhin, 1917), since in the previously studied collections, "other groups, such as bivalves, gastropods, belemnites, ammonites, and crinoids, in terms of the number of species and specimens, played an extremely insignificant role and were represented by very fragmentary material" (Komarov et al., 2012, p. 4).

Limestone blocks on Tatyana's Hill and in the Ammonite Ravine were studied in detail by the Crimean geologist Moiseev and assigned to the "Early–Middle Lias" on the basis of the analysis of brachiopod assemblages (Moiseev, 1925, 1934). Describing the cephalopods collected from these two blocks (nautiloids, ammonites, and belemnites), Moiseev emphasized the fragmentation of the material and the impossibility of its precise determination (Moiseev, 1925, p. 985).

More complete ammonite collections from the Bodrak River basin were described by Kazakova (1962). She had several samples from a limestone block of Tatyana's Hill, as well as ammonites of the Schlotheimiidae family collected from terrigenous rocks in the Ammonite Ravine. All specimens were attributed by Kazakova to the Lotharingian Stage (late Sinemurian). Similar ammonites "from clayey shales ... south of the Bodrak limestone block" were studied earlier by Krymgolts, who originally misattributed them to the end of the Hettangian–early Sinemurian (Miklukho-Maklai and Porshnyakov, 1954, p. 209).

The discovery of ammonite *Crucilobiceras* cf. *densinodum* (Quenstedt) from a limestone block in the Ammonite Ravine was reported later by Panov et al. (1994). *Crucilobiceras densinodum* as well as ammonites previously described by Kazakova (1962) are indicative on the upper Sinemurian of Europe (Raricostatum Zone) (Schlegelmilch, 1992). Therefore, it was concluded that the ammonite complexes from all Lower Jurassic limestone boulders in the Bodrak River basin (in particular from Ammonite Ravine and Tatyana's Hill) have the same age, coinciding with the age of the complexes from the host terrigenous rocks (Panov et al., 1994). This served as one of the principal arguments favoring the assumption that the bodies of carbonate rocks in the Bodrak River basin are "lenses, rather than blocks, or tectonic wedges" (Panov, 2002, p. 18).

Then Komarov et al. described an ammonite found in a limestone block in the Ammonite Ravine (Komarov et al., 2012, Figs. a, b), and assigned it to the species *Ptycharietites* (*Ptycharietites*) sp., characteristic of the Obtusum Zone (Stellare and Denotatus subzones) of the

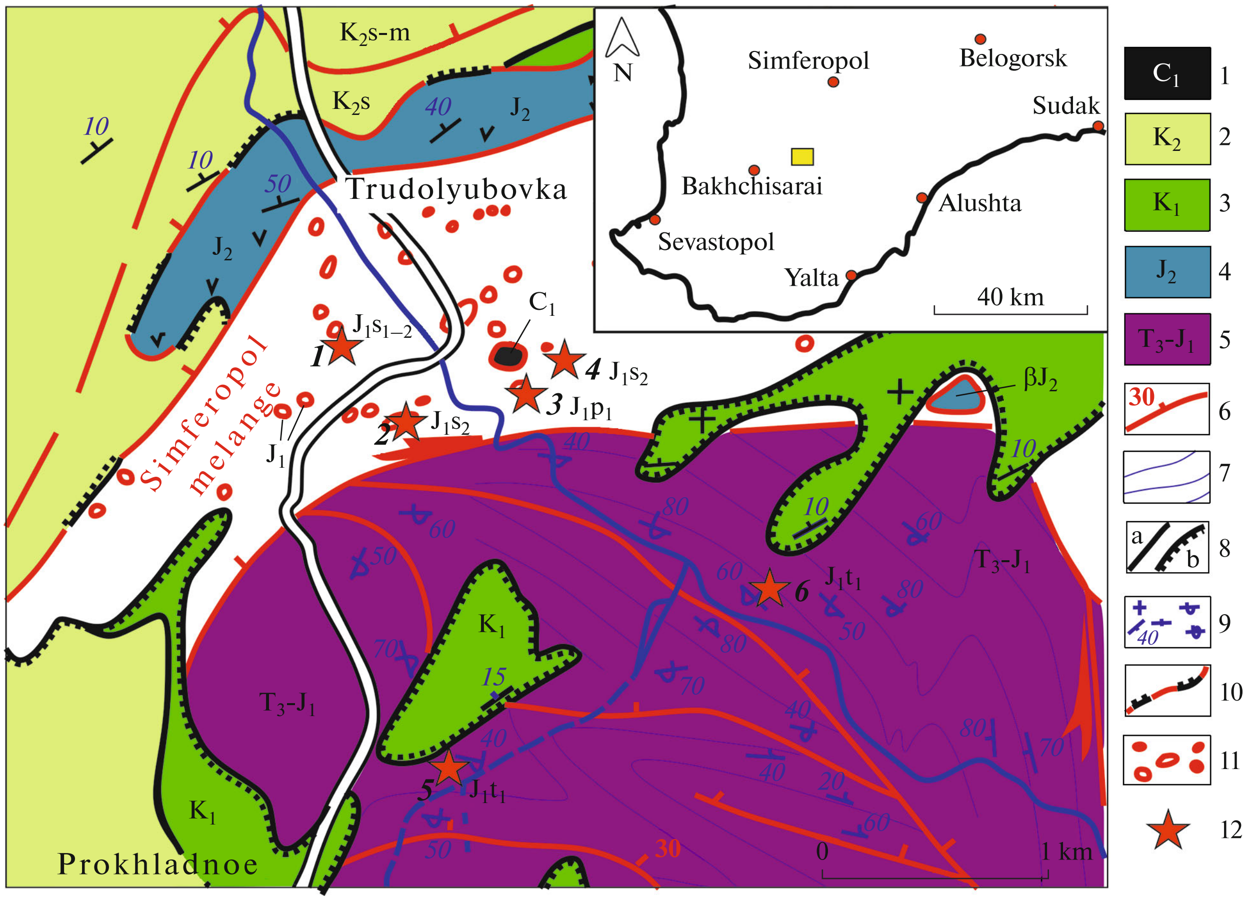


Fig. 1. Locations of Early Jurassic ammonites in the Simferopol melange of the Bodrak River basin on the geological map (modified from Yudin, 2018). (1) Lower Carboniferous: isolated limestone blocks in the melange; (2) Upper Cretaceous: marls, white porcelain-like limestones; (3) Lower Cretaceous: sandstones, conglomerates, limestones; (4) Middle Jurassic: tuff sandstones, tuff siltstones, basaltic andesites, and basalts; (5) Upper Triassic–Lower Jurassic (Taurida Formation (flysch)): thin-bedded sandstones, siltstones, mudstones; (6) thrusts and strike-slip faults; (7) strike of strata (according to aerial photographs); (8) stratigraphic boundaries, (a) conformable and (b) unconformable; (9) dip and strike of the rocks; (10) layer-by-layer breakdowns (flats); (11) boulders of rocks in melange; (12) localities of Early Jurassic ammonites: (*1*, *4*) in terrigenous rocks, (*2*, *3*) in the carbonate rock blocks, and (*5*, *6*) in the flysh of the Taurida series (*1*) Mount Konskiy, (*2*) limestone block on Tatyana's Hill, (*3*) limestone block in the Ammonite Ravine, (*4*) in mudstones and siltstones of the Ammonite Ravine, (*5*) Mangush Ravine, (*6*) foot of Mount Bolshoi Kermen.

upper Sinemurian (Dommergues et al., 2010). This contradicted the opinion of Panov that ammonite complexes in this limestone block should belong exclusively to the Raricostatum Zone of the upper Sinemurian. Later Ippolitov et al. (2015) published data on belemnites collected in a limestone block on the slope of Mount Bolshoi Kermen and from the terrigenous rocks on Tatyana's Hill (in the immediate vicinity of a Sinemurian limestone boulder). It was shown that, in both cases, the faunal assemblages are of late Toarcian (early Aalenian?) age. Ippolitov came to the conclusion that his data went against the concept of olistolite or sedimentation model of block formation (Ippolitov et al., 2015).

A small number of the Early Jurassic ammonites samples from the carbonate boulders was collected in the Bodrak River basin by the Ukrainian geologist Nerodenko before the early 1990s. Some of these ammonites were described by Repin (2017), who attributed them to the early–late Sinemurian and early Pliensbachian. Unfortunately, the exact location of these samples is unknown (Repin, 2017). Since none of the species identified by Repin was found in the course of this study, it can be assumed that all of them probably come from limestone blocks, which were not studied in this work.

All information on the finds of the Early Jurassic ammonites in the blocks of the Simferopol melange carbonate rocks of the Bodrak River valley are summarized in Table 1.

DESCRIPTION OF LOCATIONS

Limestone block in the Ammonite Ravine (coordinates: 44°46′46.10″ N; 34°00′06.19″ E; GPS altitude 278 m)

The large block (about 13 m long) is exposed in the middle part of the ravine, on its right slope. It is com-

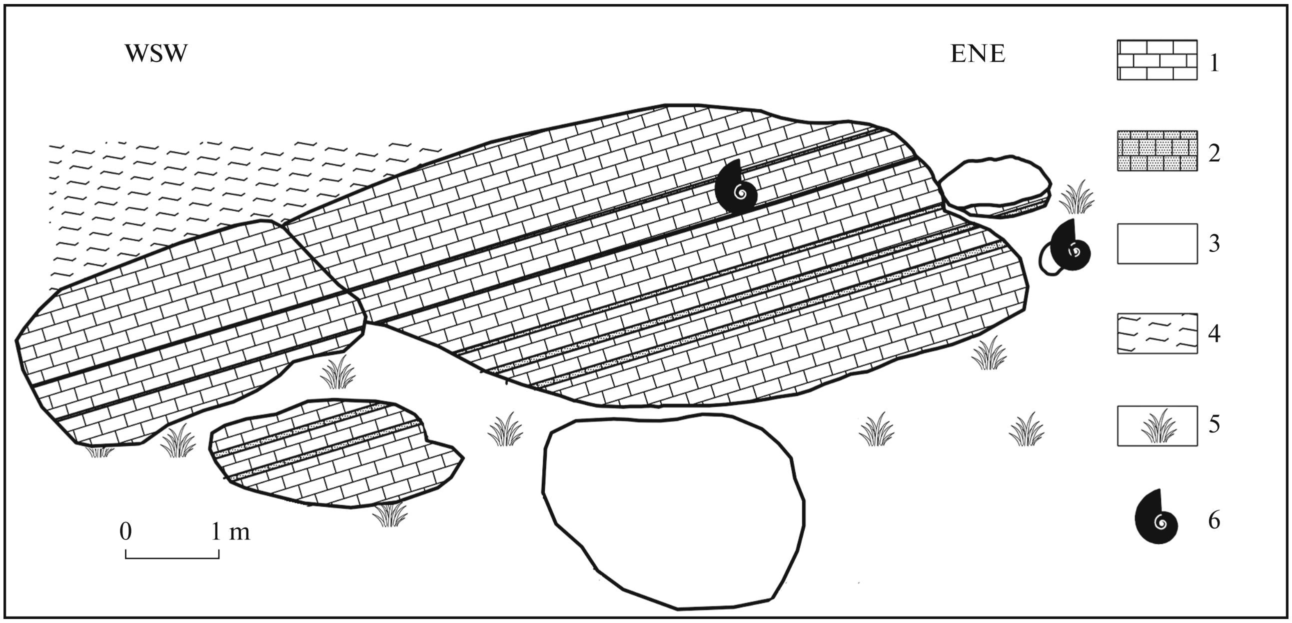


Fig. 2. Structure of the limestone block in the middle part of the Ammonite Ravine (view from the ravine side). (1) Yellowish gray brecciated micritic limestone (with inclusions of weakly rounded limestone fragments up to 3 cm in diameter); (2) interlayers of light greenish gray sandy limestone, (thickness 3–7 cm); (3) fragments of a boulder on the surface of the slope; (4) light brown foliated silty mudstone; (5) grass-covered slope; (6) sites of ammonite finds.

posed of yellowish gray micritic, brecciated limestone containing inclusions of weakly rounded limestone fragments up to 3 cm in diameter. They contain the interlayers of sandy limestone (3–7 cm), sometimes with brown ferruginous spots on the layer surface. The apparent thickness of the layers observed in the block is about 4 m. The layers dip to the northwest at an azimuth of 340° at an angle of 50°. Small (up to 30 cm in diameter) fragments of gray brachiopod limestone are observed 20 m northeast of the block, higher along the course of the ravine, at its bottom. The host rocks, observed above the block along the dirt road, are represented by silty, crushed, schistous mudstones. The right slope of the ravine below the block and around it is turfed (Fig. 2).

The limestones composing the block contain numerous fossil brachiopods (fragments and whole shells), as well as fragments of crinoid stems. Rare belemnite rostra and bivalve shells are found. Ammonoids are rare; all collected specimens are represented by internal casts and their fragments. According to Turov et al. (2020, p. 110), formation of the limestones composing the block took place in the upper continental slope "in an environment of active hydrodynamics and slumping of unlithified sediments."

Ammonite complex that was collected from the layer of dense limestone in the upper part of the block is typical for the basal part of the Ibex Zone of the lower Pliensbachian of the Sub-Mediterranean region (Alkaya and Meister, 1995; Géczy and Meister, 2007): *Tropidoceras semilaevis* Fucini and *T. erythraeum* (Gemmellaro). Ammonites *Uptonia* cf. *jamesoni* (J. de C. Sowerby), *Tropidoceras* sp. juv., *T. komarovi* sp. nov., and *Calliphylloceras* cf. *bicicolae* (Meneghini) were collected somewhat lower along the section and from a small separate fragment of limestone lying nearby. This older assemblage which can be matched with the Jamesoni Zone and Subzone of the lower Pliensbachian (Fig. 3). The presence of Sinemurian ammonites *Crucilobiceras* cf. *densinodum* (Quenstedt) reported by Panov et al. (1994, p. 22) was not confirmed. The specimen identified by Komarov et al. (2012) as *Ptycharietites* (*Ptycharietites*) sp. was assigned to the new species *Tropidoceras komarovi* sp. nov.

Limestone block on the northern slope of Tatyana's Hill (coordinates: 44°46′41.75″ N; 33°59′47.15″ E; GPS altitude 279 m)

The block is composed of gray, dense, brachiopod limestone, with the inclusion of gravel particles and small, well-rounded pebbles of milky quartz, with interlayers (up to 50 cm) of crinoid and crinoid-ammonite limestone. Its visible length is 17 m, and visible height is ~5 m. The lower part of the block is covered with talus and sod. Separate fragments of sandstone (up to 1.5 m in diameter) and mudstone (up to 1 m in diameter) are exposed to the southwest, at the side of the ravine (Fig. 4).

Outcrops of matrix rocks, represented by black, comminuted, strongly crushed argillites, with the inclusion of individual angular clasts of sandstone 10–30 cm in size, are observed north of the block, on the

Table 1. Ammonoid taxa found earlier in limestone blocks of the Bodrak River basin

Taxa	Location	Reference	Present name	Stratigraphic distribution in Europe
Phylloceras spp.	Limestone block in the vicinity of the village of New Bodrak (now Trudolyubovka)	Mukhin, 1917; Moiseev, 1925	*Phylloceras* spp.	–
Rhacophyllites sp.	———//———	Mukhin, 1917; Moiseev, 1925	Juraphillitidae gen. indet.	–
Oxynoticeras sp.	Presumably limestone block in the Ammonite Ravine	Moiseev, 1944, p. 31, 34	(?) Oxynoticeratidae gen. indet.	J_1s_2– J_1p_1 (Howarth, 2013)
Phylloceras ex gr. *tenuistriatum* Meneghini	———//———	Moiseev, 1944, p. 31	*Partschiceras* ex gr. *tenuistriatum* (Meneghini, 1868)	$J_1s_2 - J_1p_2$
Echioceras raricostatum (Zieten)	Limestone block on Tatyana's Hill	Kazakova, 1962, p. 45, Plate II, figs. 2–6	*Echioceras raricostatum* (Zieten, 1831)/*Echioceras raricostatoides* (Vadász, 1908)	J_1s_2, Raricostatum Zone, Raricostatum Subzone, Biohorizon *raricostatum/raricosta-toides* (Blau, 1998)
Paltechioceras edmundi (Dumortier)	———//———	Kazakova, 1962, p. 47, Plate II, fig. 1; Paryshev and Nikitin, 1981, p. 29, Plate 11, fig. 3	*Orthechioceras edmundi* (Dumortier, 1867)	J_1s_2, Raricostatum Zone, Densinodulum Subzone (Dommergues and Meister, 2017, p. 263)
Crucilobiceras cf. *densinodum* Quenstedt	Limestone lens in the Ammonite Ravine	Panov et al., 1994, p. 22	*Crucilobiceras* cf. *crucilobatum* Buck-man, 1919	J_1s_2, Raricostatum Zone, Raricostatum Sub-zone of Germany (Schlegelmilch, 1992)
Ptycharietites (*Ptycharietites*) sp.	———//———	Komarov et al., 2012; fig. on p. 7; Komarov, 2016, fig. on p. 58	*Tropidoceras komarovi* (sp. nov.)	J_1p_1, Biohorizon *Uptonia* cf. *jamesoni* of Southwestern Crimea
Arnioceras cuneiforme Hyatt	Limestone blocks in the Bodrak River basin	Repin, 2017, p. 180, Plate I, figs. 1, 14	*Arnioceras cuneiforme* Hyatt	J_1s_1, Semicostatum Zone (Guerin-Franiatte, 1966)
Eoderoceras sp.	———//———	Repin, 2017, p. 180, Plate I, figs. 3a, 3b	*Eoderoceras* sp.	J_1s_2, Oxynotum Zone–J_1p_1, bottom of Jamesoni Zone (Howarth, 2013)
Palaeoechioceras spirale (Trueman et Williams)	———//———	Repin, 2017, p. 180, Plate I, fig. 4	*Palaeoechioceras spirale* (Trueman et Williams, 1927)	J_1s_2, Oxynotum Zone, Oxynotum Subzone–bottom of Raricostatum Zone (Dommergues and Meister, 2017, p. 261)
Eoderoceras ex gr. *bispinigerum* (Buckman)	———//———	Repin, 2017, p. 180, Plate I, figs. 6, 12	*Eoderoceras* ex gr. *bispinigerum* (Buck-man, 1918)	J_1s_2, Oxynotum Zone–Raricostatum Zone, Densinodulum Subzone (Geczy and Meister, 2007, p. 191)
Paramicroderoceras fila (Quenstedt)	———//———	Repin, 2017, p. 180, Plate I, fig. 7	*Eoderoceras fila* (Quenstedt, 1884)	J_1p_1, Jamesoni Zone, Taylori–Polymorphus subzones (Donovan and Surlyk, 2003, p. 562)
Pseudophricodoceras?	———//———	Repin, 2017, p. 180, Plate I, fig. 8	(?) *Pseudophricodoceras*	J_1p_1, Jamesoni Zone (Howarth, 2013)
? *Juraphyllites* spp.	———//———	Repin, 2017, p. 180, Plate I, figs. 9, 10, 11	(?) *Juraphyllites* spp.	–
Plesechioceras cf. *regulare* (Trueman et Williams)	———//———	Repin, 2017, p. 180, Plate I, fig. 13	*Plesechioceras* cf. *regulare* (Trueman et Williams, 1925)	J_1s_2, Raricostatum Zone, Densinodulum Subzone (Blau et al., 2003, p. 422)
Pseuduptonia cf. *suessi* (Gugenberger)	———//———	Repin, 2017, p. 180, Plate I, fig. 15	*Pseuduptonia* cf. *suessi* (Gugenberger, 1929)	J_1p_1, Jamesoni Zone, upper part of Taylori Subzone–Polymorphus Subzone (Meister, 2010, p. 93)
Phylloceratida? gen.indet	———//———	Repin, 2017, p. 180, Plate I, fig. 2	Phylloceratida? gen. indet.	–
Lytoceras sp.	———//———	Repin, 2017, Plate I, fig. 5	*Lytoceras* sp.	–

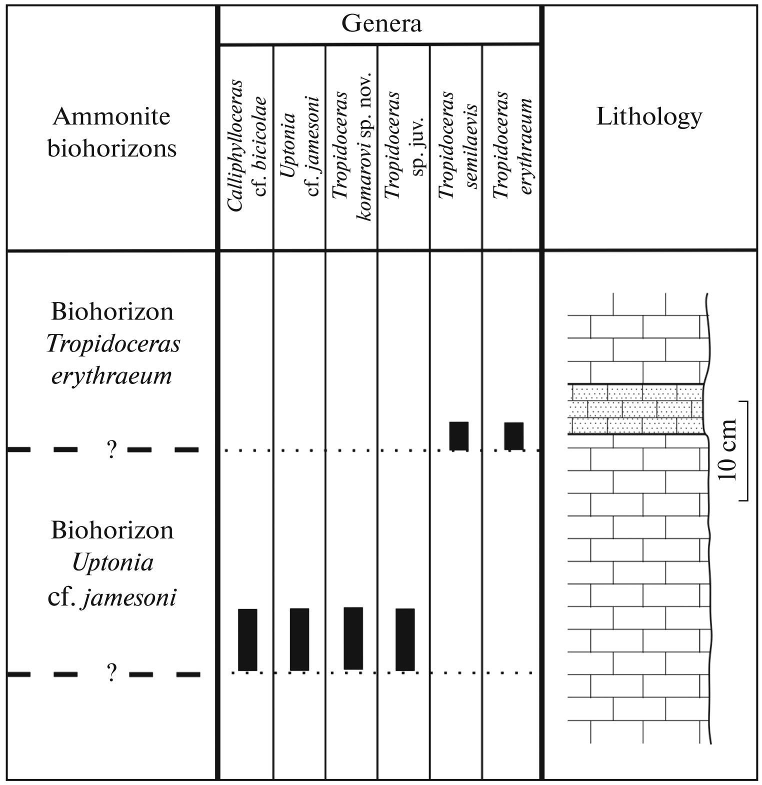


Fig. 3. Stratigraphic distribution of taxa and established biostratigraphic units in a limestone block from the Ammonite Ravine. See Fig. 2 for legend.

slope of Tatyana's Hill, in a gully along a dirt road. Herein late Toarcian belemnites were previously described by Ippolitov et al. (2015).

A less dense interlayer of bioclastic limestone composed of crinoid fragments and containing a large amount of ammonites (both fragments and whole shells) was encountered in the lower part of the block. The thickness of the interlayer was ~0.5 m. A pit (1.5 × 0.5 m along the perimeter and 0.7 m in depth) was dug in the southeastern part of the block along the interlayer of ammonite-crinoid limestone. Weakly expressed bedding of the limestone was exposed in the pit wall. The layers dip toward northwest along the azimuth of 285°–290°, at an angle of 35°–40°. The following layers were distinguished in the block:

(1) Gray, dense limestone, with brown spots and ferruginization surfaces, in places with brown oolites, with a few brachiopods and dissolved ammonite casts in the upper part of the layer. The exposed layer thickness is 0.2 m.

(2) Gray, crinoidal, bioclastic limestone, almost entirely composed of crinoid fragments, contains numerous fragments and whole ammonite casts. The abundance of ammonites and the presence of four separate ammonite complexes in the layer indicate an extremely low rate of sedimentation, which makes these limestones similar to the Ammonitico rosso facies. The layer thickness is 0.5 m.

(3) Dense, gray, brachiopod limestone; apparent thickness is 10 cm (Fig. 5).

According to Turov et al., the formation of limestones that compose the block occurred "at a distance from the coast, in the zone of currents and under conditions of wave impact on the sediment" (Turov et al., 2019; Turov et al., 2020, p. 110).

Layer-by-layer collection of ammonites from the limestones of the block allowed the following sequence of ammonite complexes to be established (from bottom to top): (A) *Orthechioceras edmundi* (Dum.), *O.* cf. *edmundi* (Dum.), *O.* cf. *viticola* (Dum.); (B) *Echioceras quenstedti* (Schafhäutl), *E. rhodanicum* (Buckm.); (C) *Echioceras raricostatoides* (Vadász), *E. raricostatum* (Zieten); (D) *Echioceras crassicostatum* T. et W., *E. raricostatum* (Zieten) (Figs. 5, 6).

The total number of ammonite specimens collected from the block was ~180; the vast majority of them originated from the crinoid-ammonite limestone interlayer (layer 2). Apart from that, several juvenile Echioceratidae shells, which could not be accurately identified, were found in the upper part of the block. All ammonoids collected in the block, with the exception of a small fragment Lytoceratidae indet.,

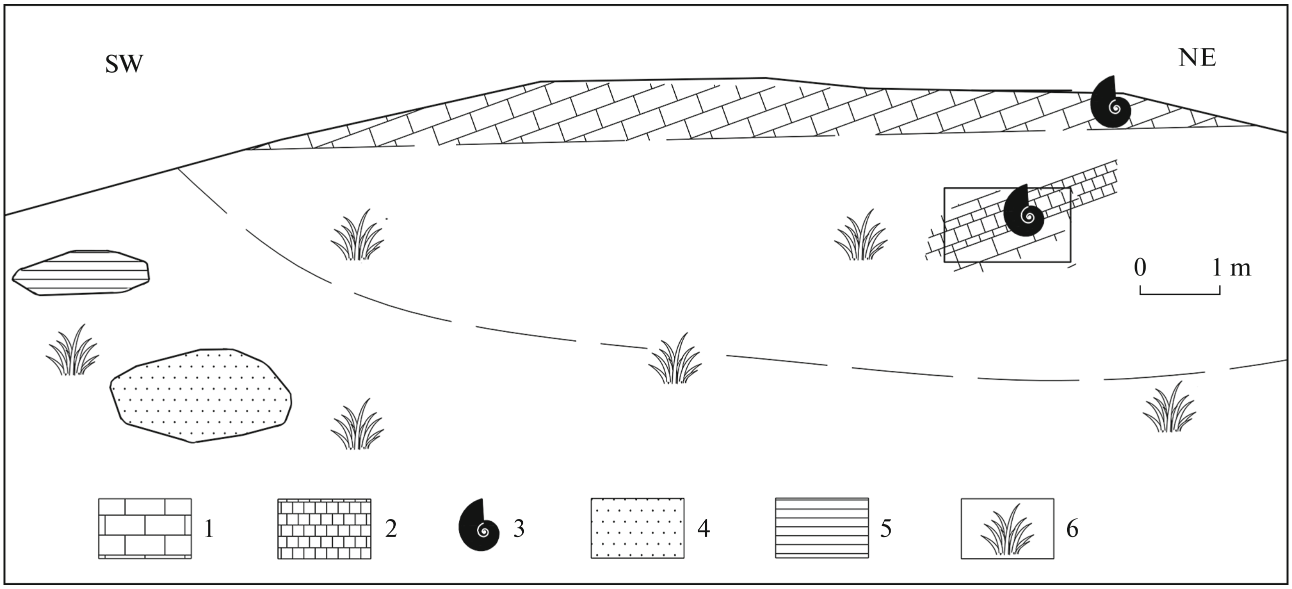


Fig. 4. Structure of a limestone block on Tatyana's Hill (view from the side of the ravine). (1) Brachiopod limestone; (2) crinoid and crinoid-ammonite limestone (thickness 0.4 m); (3) ammonite finds; (4) separately lying block of sandstone; (5) separately lying block of mudstone; (6) grass-covered slope.

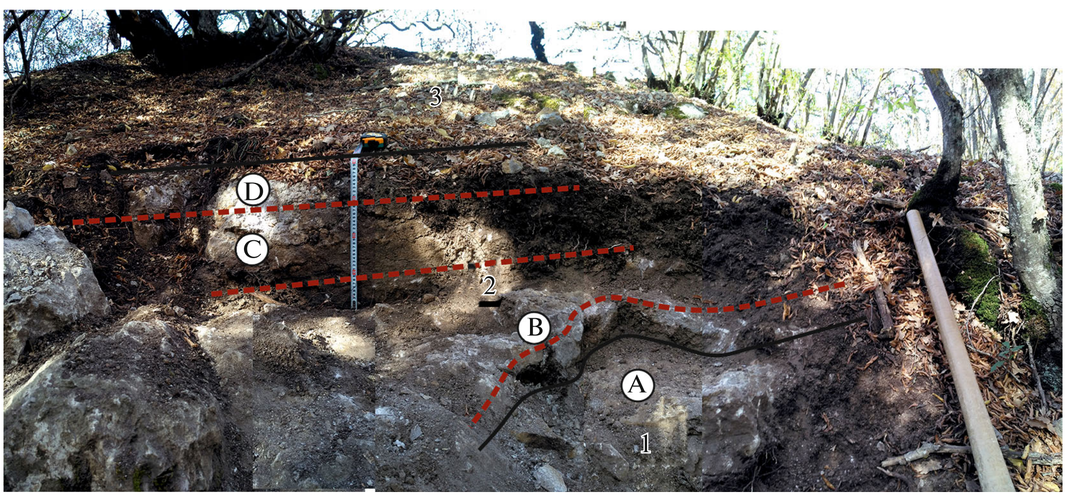


Fig. 5. Limestone block on Tatyana's Hill, view from the south (from the side of an unnamed ravine). Established fauna layers: (A) Biohorizon *Orthechioceras edmundi*; (B) Biohorizon *Echioceras rhodanicum*; (C) Biohorizon *Echioceras raricostatoides*; (D) Biohorizon *Echioceras crassicostatum*. Black lines show the boundaries of layers 1, 2, and 3, red dashed lines show the boundaries of biostratigraphic units.

belong to the Echioceratidae Buckman family. Most of the samples retained a shell; the chambers of the phragmocone are often filled with calcite crystals.

The study made it possible to confirm the presence of ammonites of the Echioceratidae family in the limestones composing the block (Kazakova, 1962), as well as to significantly supplement the information on their taxonomic diversity. A sequence of assemblages characteristic of the Echioceras raricostatum Zone (Densinodulum and Raricostatum subzones) of the upper Sinemurian of Europe was established for the first time.

DESCRIPTION OF AMMONOIDS

The following notation was adopted in the description: *—the first valid description of the species, D—shell diameter, Du—umbilicus diameter, H—height of the last whorl of shell, W—width of the last swhorl of shell. The lobe line in most cases is not preserved or is poorly preserved.

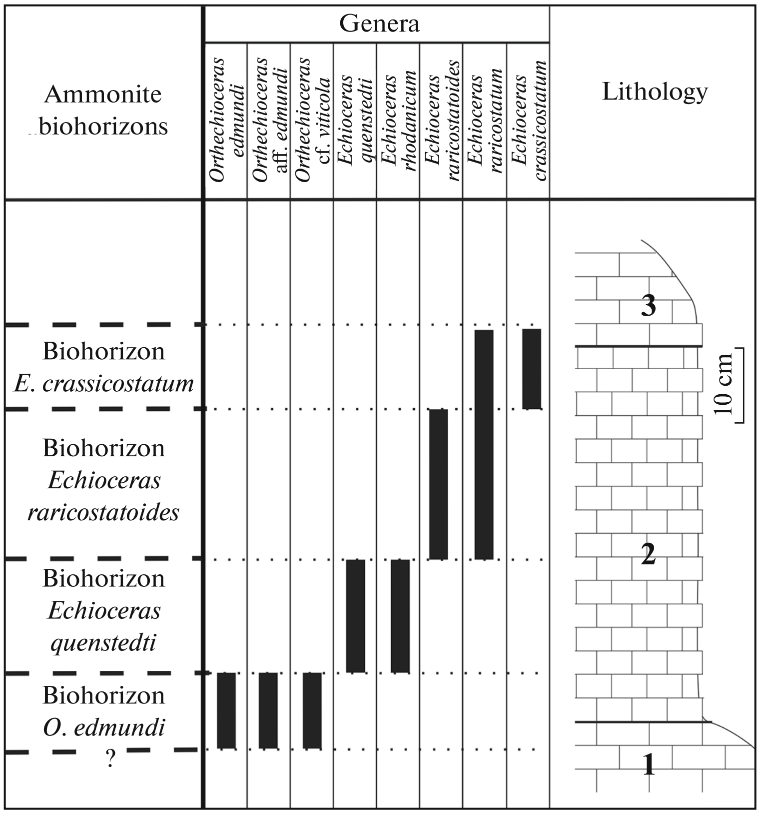


Fig. 6. Stratigraphic distribution of ammonites in the section of a block found on Tatyana's Hill and identified biostratigraphic units.

FAMILY PHYLLOCERATIDAE ZITTEL, 1884

SUBFAMILY PHYLLOCERATINAE ZITTEL, 1884

Genus *Calliphylloceras* Spath, 1927

***Calliphylloceras* cf. *bicicolae* (Meneghini, 1874)**

Plate I, fig. 8

S h a p e. The shell is involute, with a very narrow funnel-shaped umbilicus. The whorls have subelliptic cross section. The largest width of shell is observed approximately in the middle of the whorl height. The lateral sides are convex, gradually turning into a uniformly rounded ventral side.

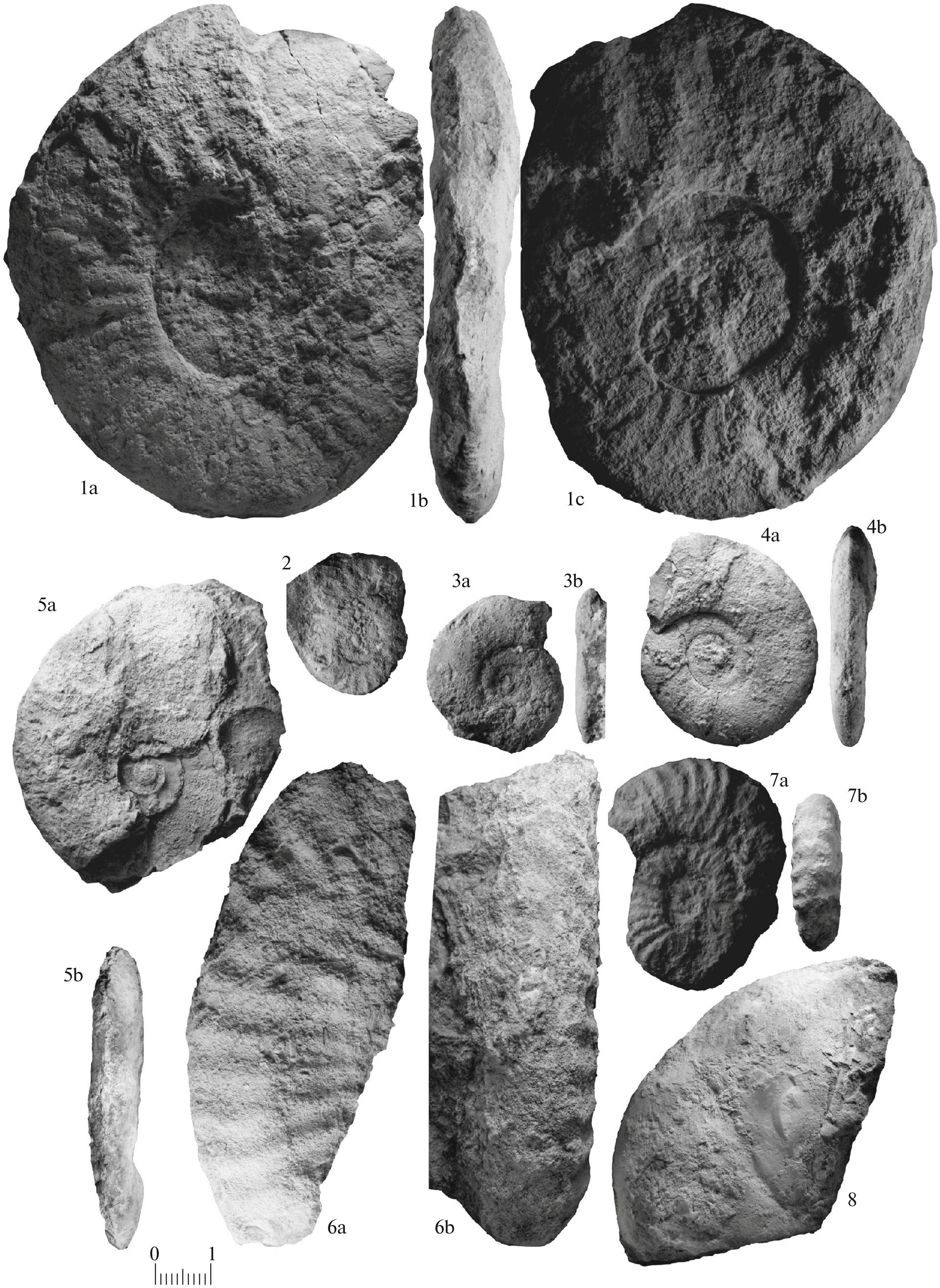
S c u l p t u r e. The specimen studied has a slight prorsiradiate constriction that begins in the area of the umbilical margin. The constriction keeps bending forward passing the ventral side.

C o m p a r i s o n a n d r e m a r k s. Alkaya (1983, p. 68) united at least five nominal species under the name of *Calliphylloceras bicicolae* (Meneghini, 1875). Those are *C. bicicolae* (Meneghini, 1875), *C. alomtinum* (Gemmellaro, 1884), *C. geyeri* (Bonarelli, 1895), *C. emeryi* (Bettoni, 1900), and *C. bettonii* (Del Campana, 1900), which differ both in the shape of the whorl cross section and the frequency of constrictions. The grounds for unifying them all into one species was provided by the statistical analysis performed on a sample of more than 100 specimens collected layer by layer from the deposits of the upper Sinemurian and lower Pliensbachian of Turkey. A similar point of view is shared by Meister, who pointed out that, of all the species of the genus *Calliphylloceras* occuring in this stratigraphic interval, apart from *C. bicicolae* (Meneghini), perhaps only *C. dubium* (Fucini) and *C. stoppani* (Meneghini) were independent species (Meister and Böhm, 1993, p. 172).

The specimen described is practically indistinguishable from *C. bicicolae*; however, its preservation makes it possible to define it only in open nomenclature. It dif-

Plate I. Early Pliensbachian ammonites from a limestone block in the Ammonite Ravine. Hereinafter, all images, except those specially noted, are shown in actual size. (1) *Tropidoceras komarovi* sp. nov., specimen no. 1/13351: (1a, 1c) side view, (1b) ventral view; Biohorizon *Uptonia* cf. *jamesoni*; (2) *Tropidoceras* sp. *juv*., specimen no. 2/13351, side view, Biohorizon *Uptonia* cf. *jamesoni*; (3, 4) *Tropidoceras erythraeum* (Gemmellaro): (3) specimen no. 3/13351, (3a) side view, (3b) ventral view; (4) specimen no. 5/13351, (4a) side view, (4b) ventral view; Biohorizon *Tropidoceras erythraeum*; (5) *Tropidoceras semilaevis* Fucini, specimen no. 7/13351: (5a) side view, (5b) ventral view; Biohorizon *Tropidoceras erythraeum*; (6, 7) *Uptonia* cf. *jamesoni* (J. de C. Sowerby): (6) specimen no. 10/13351, (6a) side view, (6b) ventral view; (7) specimen no. 9/13351, (7a) side view, (7b) ventral view; Biohorizon *Uptonia* cf. *jamesoni*; (8) *Calliphylloceras* cf. *bicicolae* (Meneghini), specimen no. 11/13351, side view, Biohorizon *Uptonia* cf. *jamesoni*.

Plate I



fers from *C. stoppani* (Meneghini) in less prorsiradiate and slightly more concave constrictions; it differs from *C. dubium* (Fucini) in higher and more compressed whorls, as well as in a narrower ventral side.

Distribution. The species *C. bicicolae* occurs in the upper Sinemurian–lower Toarcian stratigraphic range of North Africa (Algeria, Tunisia), Italy, Spain, Austria, Hungary, Turkey, Georgia, Switzerland, and France. Biohorizon *Uptonia* cf. *jamesoni* occurs in the lower Pliensbachian of Southwestern Crimea.

Material and location. Fragment of a shell (specimen no. 11/13351) from a limestone block in the Ammonite Ravine (Biohorizon *Uptonia* cf. *jamesoni*).

ECHIOCERATIDAE BUCKMAN FAMILY, 1913

Genus *Orthechioceras* Trueman et Williams, 1925

[=*Homechioceras*: Trueman et Williams in Buckman, 1925b, pl. 609; *Echioceratoides*: Trueman et Williams, 1925, p. 706]

Orthechioceras edmundi (Dumortier, 1867)

Plate II, figs. 1a–1b

Ammonites edmundi: Dumortier, 1867, p. 163, pl. XXXIX, figs. 3, 4.

Paltechioceras edmundi: Kazakova, 1962, p. 47, pl. II, fig. 1; Paryshev and Nikitin, 1981, p. 29, pl. 11, fig. 3.

"Echioceras" edmundi: Dommergues, 1982, p. 380, pl. I, figs. 8, 9; 1993, pl. IV, fig. 7.

"Echioceras" cf. *edmundi*: Dommergues, 1982, p. 380, pl. I, figs. 5–7.

Paltechioceras (Orthechioceras) edmundi: Taylor et al., 2001, pl. 8, figs. 5–6.

Holotype (by monotype). Sample shown in (Dumortier, 1867, pl. XXXIX, figs. 3, 4). Comes from Nolay (Burgundy, France), lost (Getty, 1973, p. 23).

Shape. The shell is evolute, medium-sized ophiocone, consisting of 6 or 7 whorls. The whorls are slowly expanding, compressed, have subrectangular cross section, and slightly convex ventral and flattened lateral sides. The umbilicus is very wide, shallow, and bowl-shaped. The umbilical wall is convex.

Sculpture. The ventral side bears a low blunt ventral keel flanked with narrow weak sulci. The ribs are prorsiradiate, slightly concave; at the ventrolateral margin, they have a very smooth forward bend and, passing to the ventral side with a loss of strength, disappear before reaching the ventral sulci. The width of the intercostal spaces is approximately 1.5 times the width of the ribs. The rib frequency gradually increases with growth on the outer and middle whorls.

Dimensions (mm) and ratios (%):

No.	D	H	Du	W	H/W
12/13351	≈81	15.5	53.3	14	11

Comparison and remarks. Only one sample from this work was assigned to *O. edmundi* s.s. It was found at the base of the sequence of biostratigraphic units at Tatyana's Hill. Since there is little published data on the intraspecific variability of this species, it may also include specimens identified here as *O.* cf. *edmundi* (Dumortier) (Plate II, figs. 2a–2d, 4a–4b) and distinguished by a wider cross section (especially of the inner whorls) and by wider and deeper ventral sulci.

The species described differs from *O. viticola* (Dumortier, 1867) in the presence of ventral sulci bordering the keel, less coarse and more prorsiradiate ribs, and denser ribbing on the inner whorls; it differs from *Plesechioceras delicatum* (Buckman, 1914) in a wider cross section and more distant and coarser ribbing; it differs from *Echioceras quenstedti* (Schafhäutl, 1847) in less coarse, more prorsiradiate ribs, denser ribbing on the inner whorls, and flattened lateral sides; it differs from *Paltechioceras tardecrescens* (Hauer, 1856) in the sculpture of the ventral side: the presence of one weak single keel bounded by weak ventral sulci. In addition, it is distinguished by a significantly lower frequency of ribs (about 40 in total) on the outer whorl and a lower convexity of the lateral sides.

Distribution. The lower part of the Raricostatum Zone (Biohorizon *edmundi*) of the upper Sinemurian of Eastern France. Edmundi Subzone (Harbledownense Zone) of the upper Sinemurian of North America. Upper Sinemurian Biohorizon *Orthechioceras edmundi* of Southwestern Crimea.

Material and location. One incomplete sample (no. 12/13351) and several fragments from the limestone block at the Tatyana's Hill (Biohorizon *Orthechioceras edmundi*).

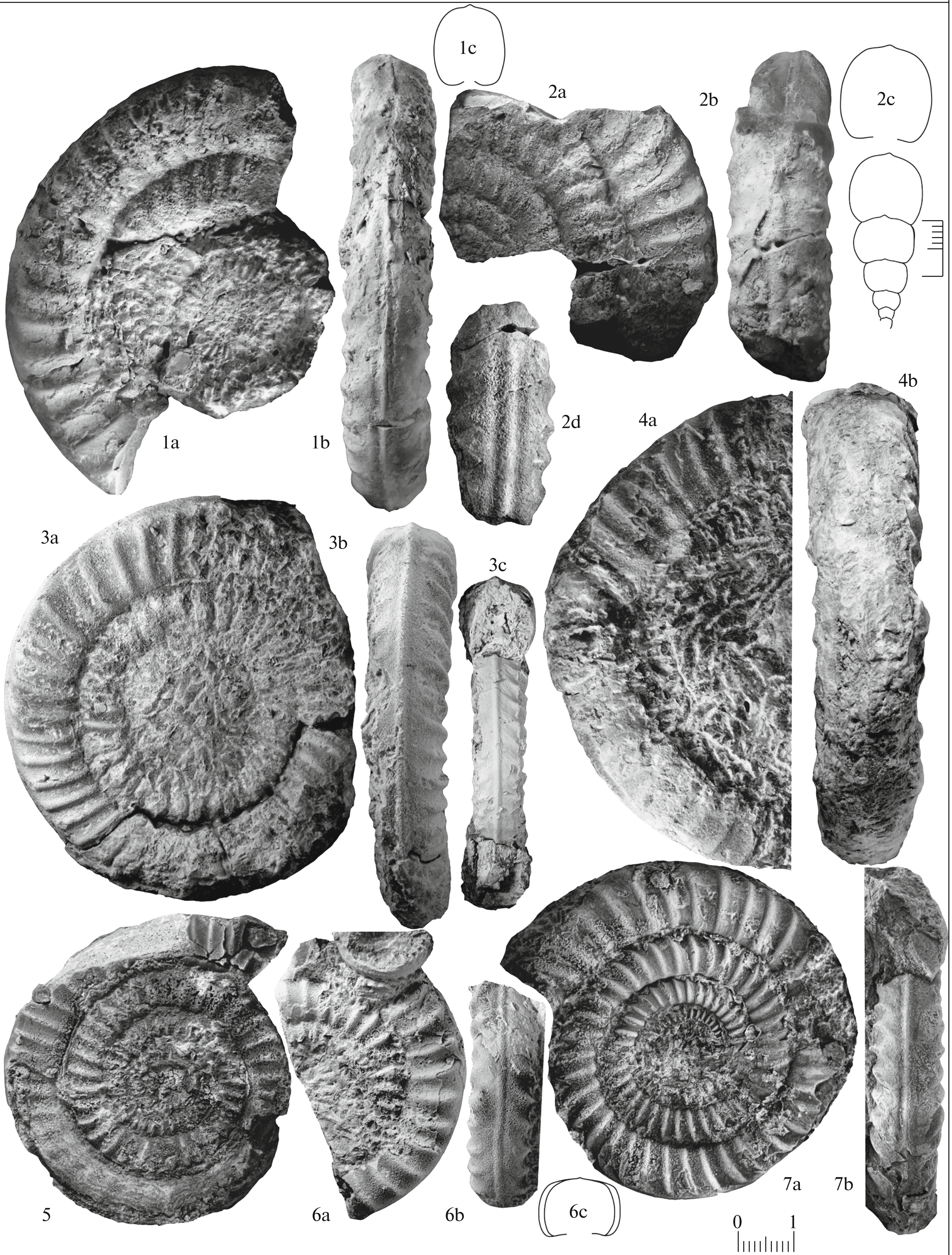
Orthechioceras cf. *viticola* (Dumortier, 1867)

Plate II, figs. 3a–3c, 5

Shape. Medium-sized, ophioconic, evolute, and flattened shell consisting of 7–8 whorls. The whorls are slowly expanding and have a rounded-square sec-

Plate II. Late Sinemurian ammonites from a limestone block from Tatyana's Hill. (1) *Orthechioceras edmundi* (Dumortier), specimen no. 12/13351: (1a) side view, (1b) ventral view, (1c) cross section; Biohorizon *Orthechioceras edmundi*; (2, 4) *Orthechioceras* cf. *edmundi* (Dumortier): (2) specimen no. 13/13351, (2a) side view, (2b) ventral view, (2c) cross section of internal whorls; (2d) a fragment of the external whorl of the same specimen, ventral view; (4) specimen no. 14/13351, (4a) side view, (4b) ventral view; Biohorizon *Orthechioceras edmundi*; (3, 5) *Orthechioceras* cf. *viticola* (Dumortier): (3) specimen no. 17/13351, (3a) side view, (3b) ventral view, (3c) mouth view; (5) specimen no. 18/13351, on the side; Biohorizon *Orthechioceras edmundi*; (6) *Echioceras rhodanicum* (Buckman), specimen no. 16/13351: (6a) side view, (6b) ventral view, (6c) cross section; Biohorizon *Echioceras rhodanicum*; (7) *Echioceras quenstedti* (Schafhäutl), specimen no. 21.2/13351: (7a) side view, (7b) ventral view; Biohorizon *Echioceras rhodanicum*.

Plate II



tion and a slightly fastigiate venter. The umbilicus is very wide, shallow, and bowl-shaped. The umbilical wall is convex.

S c u l p t u r e. The ventral side has a strongly developed blunt keel without sulci. The lateral sides are covered with rectiradiate or slight prorsiradiate ribs, smoothed at the ventrolateral bend; the ribs weaken and slightly bend forward at the ventral side of the inner whorls (Plate II, fig. 3c). On the outer whorl, the number of ribs increases sharply in comparison with the previous whorl.

D i m e n s i o n s (mm) and ratios (%):

No.	D	H	Du	W	H/D	W/D	Du/D	H/W	Ribs per 1/2 whorl
17/13351	73	14	46	14	19.2	19.2	63	100	22
18/13351	61.5	12.5	42	–	20.3	–	68.3	–	21

C o m p a r i s o n a n d r e m a r k s. This species is very close to *Orthechioceras viticola*. It also has a fastigiate venter, characterized by the absence of sulci and coarse ribs that do not pass to the ventral side (at least on the inner and middle whorls). However, since the type specimen has been lost (Getty, 1973, p. 22), and there are few published data on the intraspecific variation of *O. viticola* (Trueman and Williams, 1925; Dommergues and Meister, 1987; Dommergues, 1993), the species is identified here in open nomenclature. The *O. viticola* holotype has not been established; the storage location of the type series is unknown. Since the work of Buckman (Buckman, 1914 in Buckman, 1909–1930), as a rule, only the smaller one specimen of the two depicted by the author of the taxon was attributed to this species (Dumortier, 1874, pl. XXXI, figs. 12–13).

This species differs from the closely related *O. edmundi* (Dumortier, 1867) in a wider cross section, a fastigate venter, and more distant ribbing on the inner whorls, as well as the absence of ventral sulci and the absence of the ribs at the ventrolateral margin; it differs from *O. regulare* (Trueman and Williams, 1925) in denser ribbing and less fastigate venter; it differs from *Echioceras quenstedti* (Schafhäutl) in denser ribbing and fastigate ventral side, as well as in a sharp increase rib frequency with growth (on the middle and outer whorls).

D i s t r i b u t i o n. The species *O. viticola* indicates the Biohorizon *edmundi* (Densinodulum Subzone, Raricostatum Zone) of the upper Sinemurian of France. It was also found in the upper Sinemurian Biohorizon *Orthechioceras edmundi* in Southwestern Crimea.

M a t e r i a l a n d l o c a t i o n. Two specimens (nos. 17–18/13351) from a limestone block on Tatyana's Hill (Biohorizon *Orthechioceras edmundi*).

Genus *Echioceras* Bayle, 1878

[=*Ophioceras*: Hyatt, 1867, p. 75, obj. syn.; *Pleurechioceras*: Trueman et Williams, 1925, p. 706; *Pleurechioras*: Roman, 1938, p. 92, nom. null.]

Echioceras quenstedti (Schafhäutl, 1847)

Plate II, figs. 7a–7b; Plate III, figs. 7a–7c, 11

Ammonites quenstedti: Schafhäutl, 1847*, s. 810; 1851, s. 143, taf. 17, abb. 24.

Ammonites raricostatus: (pars) Dumortier, 1867, p. 173, pl. XXV, figs. 4, 5.

Echioceras quenstedti: Getty, 1973, p. 188, pl. 2, fig. 7; Wierzbowski et al., 2012, p. 37, pl. 1, figs. 7–9; Lukeneder and Lukeneder, 2018, p. 102, fig. 8c.

L e c t o t y p e. Schafhäutl, 1851, taf. 17, fig. 24. Identified and reimaged by Getty, 1973, p. 20, pl. 2, fig. 7. Comes from the Raricostatoides Subzone of Bavaria (Germany).

S h a p e. The shell is medium-sized ophiocone with 6–7 whorls. Whorls are slowly expanding and have suboval (to round) cross section. The outer whorls are usually extended in height. The weakly convex lateral sides smoothly pass into the convex ventral side. The umbilicus is wide and shallow. The umbilical wall is convex.

S c u l p t u r e. Ribs are coarse, slightly prorsiradiate (or less often rectiradiate). Rib frequency decreases gradually with growth, with the exception of the last whorl, where it may slightly increase. The ventral side bears a strong keel, sometimes bordered on the outer whorls by barely noticeable sulci.

D i m e n s i o n s (mm) and ratios (%):

No.	D	H	Du	W	H/D	W/D	Du/D	H/W	Ribs per 1/2 whorl
19/13351	66	14.5	40.5	12.5	22	18.9	61.4	116	–
21.2/13351	72	15.5	47	13	21.5	18.1	65.3	119	19
21.1/13351	–	11.5	38.5	–	–	–	–	–	–
20/13351	73	–	49	–	–	–	67.1	–	–
25/13351	59	11	38	–	18.6	–	64.4	110	16

C o m p a r i s o n. This species differs from *E. raricostatoides* (Vadász, 1908) in the absence of swelling on the ribs at the ventrolateral margin, more distant ribbing on the outer whorls, and also a higher and more compressed whorls; it differs from *E. rhodanicum* (Buckman, 1914) in more compressed whorls and a more convex ventral side.

D i s t r i b u t i o n. Biohorizon *quenstedti* of the Raricostatum Subzone of the Raricostatum Zone of the upper Sinemurian of Slovakia, Austria, Western Ukraine, Great Britain, Eastern France, and Southern Germany. Upper Sinemurian Biohorizon *Echioceras rhodanicum*, Southwestern Crimea.

M a t e r i a l a n d l o c a t i o n. Numerous fragments and 5 whole shells (specimens nos. 19–21, 25/13351) from a limestone block on Tatyana's Hill (Biohorizon *Echioceras rhodanicum*).

***Echioceras rhodanicum* (Buckman, 1914)**

Plate II, figs. 6a–6b

Ammonites raricostatus: (pars) Dumortier, 1867, p. 173, pl. XXV, figs. 4, 5.

Echioceras rhodanicum: Buckman, 1914*, p. 96c (= nom. nov. pro Dumortier, 1867, pl. XXV, figs. 4, 5); Dommergues, 1993, p. 133, pl. 7, fig. 1.

H o l o t y p e: Dumortier, 1867, pl. XXV, figs. 4, 5 (quoted in Buckman, 1914, p. 96c).

S h a p e. The shell is small ophiocone, consisting of 5 whorls of a rounded-square section, with the greatest width in its center. The lateral sides are slightly convex; the ventral side is wide and flattened. The umbilicus is wide, shallow, and bowl-shaped.

S c u l p t u r e. The ventral side has a very low keel without sulci. Ribs are coarse, rectiradiate, slightly prorsiradiate on the outer whorl. On the ventral side, the ribs are far less pronounced and acquire a noticeable forward bend. The ribs disappear slightly before reaching the ventral keel.

D i m e n s i o n s (mm) and ratios (%):

No.	D	H	Du	W	H/D	W/D	Du/D	H/W
16/13351	44	9.5	28.5	10.0	21.6	22.7	64.8	95

C o m p a r i s o n. This species differs from *E. quenstedti* (Schafhäutl) in a lower rib frequency (especially on the outer whorls), wider, rounded-square whorl section, wider flattened ventral side, and a more angular ventrolateral margin; it differs from *E. raricostatoides* (Vadász) in a rounded-square section and more flattened ventral side of whorls.

D i s t r i b u t i o n. Biohorizons *quenstedti* (Mediterranean scale) and *rhodanicum* (Northwestern European scale) of the Raricostatum Subzone of the Raricostatum Zone of the upper Sinemurian of Great Britain, France, and Romania. Upper Sinemurian Biohorizon *Echioceras rhodanicum*, Southwestern Crimea.

M a t e r i a l a n d l o c a t i o n. One incomplete shell (specimen no. 16/13351) from a limestone block on Tatyana's Hill (Biohorizon *Echioceras rhodanicum*).

***Echioceras raricostatoides* (Vadász, 1908)**

Plate III, figs. 1a–1c, 2a–2b, 10

Ammonites raricostatus (pars): Dumortier, 1867, p. 173, pl. XXV, figs. 6, 7.

Echioceras rarecostatum: Bayle, 1878, pl. LXXVII, figs. 2, 3; Roman, 1938, p. 91, pl. IX, fig. 84; Krymgolts and Nutsubidze, 1958, p. 67, Plate XXVI, fig. 1; Gotsannyuk and Leschukh, 2002, Plate II, fig. 2; Plate IV, figs. 3–8.

Ammonites raricostatus costidomus: (pars) Quenstedt, 1885, p. 188, Table 23, fig. 20.

Arietites raricostatoides: Vadász, 1908*, p. 373, text-fig. 26; Tomas and Pálfy, 2007, p. 247, figs. 5g, 5h, 5j–5k.

Echioceras sparsicostatum: Trueman and Williams, 1925, p. 713, pl. II, fig. 8

Echioceras fulgidum: Trueman and Williams, 1925, p. 717, pl. I, fig. 12.

Echioceras raricostatum (pars): ? Kazakova, 1962, p. 45, Plate II, fig. 2.

Echioceras ex gr. *raricostatum* (pars): Dommergues and Meister, 1987, p. 319, pl. 3, figs. 1, 2, 4; Meister, 1991, p. 231, pl. 1, figs. 6, 7.

Echioceras raricostatoides: Getty, 1973, pl. 1, fig. 12; Schlatter, 1991, s. 35, taf. 2, figs. 5–6; Schlegelmilch, 1992, s. 56, taf. 21, fig. 11; Dommergues, 1993, p. 134, pl. 7, figs. 2, 4; Guerin-Franiatte in Fischer et al., 1994, p. 55, pl. 20, figs. 7a, 7b, 8a, 8b (= Ammonites raricostatus: d'Orbigny, 1844, p. 213, pl. 54, fig. 14); Blau, 1998, s. 206, taf. IV, figs. 3–8; Howarth, 2002, p. 127, Table 4, fig. 2; 2013, p. 29, figs. 21, 4d, 4e, 4f; Tibuleac, 2005, pl. III, fig. 2; Wierzbowski et al., 2012, p. 37, pl. 1, figs. 2–5; Howarth, 2013, figs. 21, 4d–4f; Lukeneder and Lukeneder, 2018, p. 102, text-figs. 8a, 8b, pl. 5.

L e c t o t y p e. Two poorly preserved specimens presumably described in the work (Vadász, 1908) were reimaged in (Tomas and Pálfy, 2007, figs. 5g, 5h, 5j–5k). These authors defined the bigger sample (5918 (a)) as a lectotype and noted that the identification of the samples was based on their description. Samples come from the Lower Jurassic olystoliths in the vicinity of the village of Alsorakos in Romania. Diagnostic features are poorly distinguishable in the lectotype; therefore, most researchers base their perception of the taxon, relying on the neotype proposed by Getty (Getty, 1973, pl. 1, fig. 12).

S h a p e. The shell is evolute medium-sized ophiocone. The whorls are slowly expanding, evolute. The whorl section is nearly round (W ≈ H). The lateral sides are highly convex; the ventral side is convex. The ventral margin is rounded. The umbilicus is wide, shallow, and stepped. The umbilical wall is convex.

S c u l p t u r e. The ventral side has a low, well-pronounced blunt keel without a sulci. The lateral sides bear coarse rectiradiate ribs with a slight swelling at the ventrolateral margin. The inner whorls are densely ribbed; the rib frequency decreases with growth, while on the outer whorl the width of the intercostal spaces is approximately twice the width of the ribs. On the ventral side, the ribs slightly bend forward, then disappear near the ventral keel, forming an acute (slightly less than 90°) angle with the keel. The ribs on the outer whorls become wide and rounded.

D i m e n s i o n s (mm) and ratios (%):

No.	D	H	Du	W	H/D	W/D	Du/D	H/W	Ribs per 1/2 whorl
22/13351	77.5	14.8	54.8	14.5	19.1	18.7	70.7	102	14
23/13351	68.8	11.5	46.8	12.5	16.7	18.2	68.0	92	15
24/13351	–	11	40.5	10.5	–	–	–	105	–

C o m p a r i s o n a n d r e m a r k s. The differences between closely related species *E. raricostatum* (Zieten) and *E. raricostatoides* (Vadász) are most clearly shown by Schlegelmilch (1992, p. 56). They include a different shape of the whorl section, which is narrower and almost round in *E. raricostatoides* (Vadász). The species differs from *E. raricostatum* (Zieten) in less pronounced "raricostate ribbing" (gradual thinning of the rib frequency with growth from internal to middle whorls), as well as in the ribs approaching the keel on the ventral side at an acute angle instead of a right angle. On the other hand, the described species differs from *E. quenstedti* (Schafhäutl) in a wider cross section, more distinct "raricostate ribbing" (with noticeably sparse ribs in the middle whorls), and also slight swelling at the ventrolateral bend of the ribs.

D i s t r i b u t i o n. Biohorizon *raricostatum/raricostatoides* in the lower part of the Raricostatum Subzone (Raricostatum Zone) of the upper Sinemurian of Romania, Western Ukraine, Slovakia, Austria, Italy, Germany, Switzerland, Lorraine, and Great Britain. Upper Sinemurian Biohorizon *Echioceras raricostatoides* of Southwestern Crimea.

M a t e r i a l a n d l o c a t i o n. Numerous fragments and three almost complete shells (specimens nos. 22–24/13351) from a limestone block on Tatyana's Hill (Biohorizon *Echioceras raricostatoides*).

***Echioceras raricostatum* (Zieten, 1831)**

Plate III, figs. 3a–3b, 4a–4b, 5, 6a–6b, 9a–9b

Ammonites raricostatus: Zieten, 1831* (in 1830–1833), s. 18, taf. XII, fig. 4.

Ammonites raricostatus robustus: Quenstedt, 1856, s. 106, taf. XIII, fig. 17.

Echioceras robustum: Getty, 1973, pl. 2, fig. 4 (=neotype *Ammonites raricostatus robustus* Quenstedt, identifed by Getty, 1973).

Ammonites raricostatus zieteni: Quenstedt, 1884, p. 189, taf. XXIII, figs. 27–31.

Echioceras zieteni: Trueman and Williams, 1925, p. 711; Getty, 1973, pl. 2, fig. 3.

Ammonites raricostatus costidomus: (pars) Quenstedt, 1885, s. 188, taf. XXIII, fig. 21.

Echioceras raricostatum: Topchishvili, 1990, p. 11, Plate I, figs. 3–4; Schlegelmilch, 1992, s. 56, taf. 21, fig. 10; Edmunds et al., 2003, p. 72, fig. 6.2; Wierzbowski et al., 2012, p. 37, pl. 1, figs. 6a–6b; Howarth, 2013, figs. 21, 4a–4c.

Echioceras raricostatum (pars): ? Kazakova, 1962, p. 45, Plate II, figs. 3–5, 7; Blau et al., 2000, s. 261, figs. 3.9–3.10 [non Fig. 3.6–3.7 (=? *Echioceras crassicostatum* Trueman et Williams)]; Topchishvili et al., 2006, Plate 3, fig. 5 [? non Plate 3, fig. 6 (= *Echioceras* cf. *raricostatoides* (Vadász)].

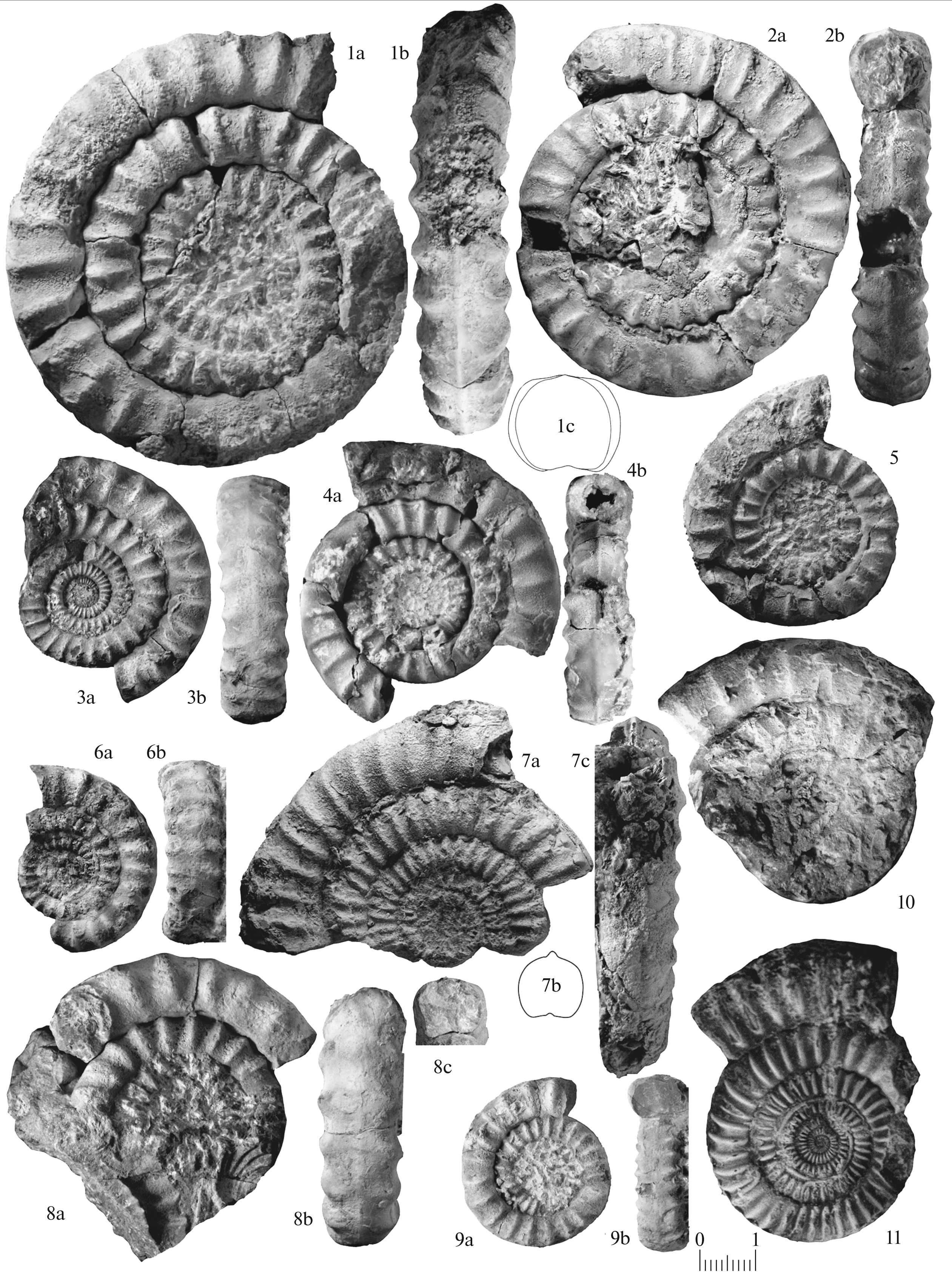
N e o t y p e. Established by Getty (1973, pl. 1, fig. 7) owing to the loss of the type series (Donovan, 1958, p. 18). It comes from the Raricostatum/Raricostatoides Subzone in the vicinity of Pliensbach (Baden-Württemberg, Germany). Stored at the Geologische-Paläontologische Institut der Universität, Stuttgart, Germany, Allmendinger collection, sample without number. Reimaged in (Howarth, 2013, figs. 21, 4a–4c).

S h a p e. The shell is evolute, from small to medium-sized, with moderately growing evolute whorls. The whorls are wide, depressed, with strongly convex lateral sides. The ventral side is wide, slightly convex. The umbilicus is wide and stepped.

S c u l p t u r e. The straight, rectiradiate, coarse ribs reach the maximum height near the ventrolateral margin, and then, upon transition to the ventral side, they weaken and disappear before reaching the ventral keel. The rib frequency decreases with growth; with the dense ribbed inner whorls. The width of the intercostal spaces at the middle and outer whorls significantly exceeds the width of the ribs. The low blunt ventral keel is present in all whorls and is not bordered by sulci.

Plate III. Late Sinemurian ammonites from a limestone block from Tatyana's Hill. (1, 2, 10) *Echioceras raricostatoides* (Vadász): (1) specimen no. 22/13351, (1a) side view, (1b) ventral view, (1c) cross section; (2) specimen no. 22/13351, (2a) side view, (2b) view from the mouth; (10) specimen no. 24/13351, side view; Biohorizon *Echioceras raricostatoides*; (3–6, 9) *Echioceras raricostatum* (Zieten): (3) specimen no. 26/13351, (3a) side view, (3b) ventral view; (4) specimen no. 27/13351, (4a) side view, (4b) view from the mouth; (5) specimen no. 28/13351, side view; Biohorizon *Echioceras raricostatoides*; (6) specimen no. 29/13351, (6a) side view, (6b) ventral view; (9) specimen no. 30/13351, (9a) side view, (9b) view from the mouth; Biohorizon *Echioceras crassicostatum*; (7, 11) *Echioceras quenstedti* (Schafhäutl): (7) specimen no. 19/13351, (7a) side view, (7b) cross section, (7c) ventral view; (11) specimen no. 21.1/13351, side view; Biohorizon *Echioceras rhodanicum*; (8) *Echioceras crassicostatum* Trueman et Williams, specimen no. 31/13351: (8a) side view, (8b) ventral view, (8c) view from the mouth; Biohorizon *Echioceras crassicostatum*.

Plate III



D i m e n s i o n s (mm) and ratios (%):

No.	D	H	Du	W	H/D	W/D	Du/D	H/W	Ribs per 1/2 whorl
27/13351	52.1	10.0	32.5	11.7	19.2	22.5	62.4	85.5	–
29/13351	35	7.0	22	10	20	28.6	62.9	70.0	13
30/13351	32.5	7.0	20.0	8.5	21.5	26.2	61.5	82.4	12
28/13351	43.4	9.5	27.2	–	21.9	–	62.3	–	12
26/13351	–	12.5	36.2	15.2	–	–	–	82.2	–

C o m p a r i s o n. The species described differs from *E. raricostatoides* (Vadász) in a wider and flatter ventral side, as well as in a wider, depressed whorl section; it differs from the closely related *E. crassicostatum* Trueman et Williams in less depressed external whorls, with a more convex ventral side, and also in less coarse and denser ribbing.

D i s t r i b u t i o n. Biohorizon *raricostatum* of the Raricostatum Subzone (Raricostatum Zone) of the upper Sinemurian of Germany, Czech Republic, Great Britain, Switzerland, Turkey, Western Ukraine, and Abkhazia. Upper Sinemurian Biohorizon *Echioceras raricostatoides* and Biohorizon *Echioceras crassicostatum* of Southwestern Crimea.

M a t e r i a l a n d l o c a t i o n. A large number of individual fragments and five well-preserved casts (specimen no. 26–30/13351) from a limestone block on Tatyana's Hill (Biohorizon *Echioceras raricostatoides* and Biohorizon *Echioceras crassicostatum*).

Echioceras crassicostatum Trueman et Williams, 1925

Plate III, figs. 8a–8c

Echioceras crassicostatum: Trueman and Williams, 1925*, p. 712; Buckman, 1925, pl. DLIII, figs. 12; Schlatter, 1991, s. 37, taf. 2, fig. 11; Cariou and Hantzpergue, 1997, pl. 5, figs. 5a–5b.

Echioceras raricostatum: (pars) Blau et al., 2000, s. 261, figs. 3.6–3.7 [non figs. 3.9, 3.10 (= *Echioceras raricostatum* (Zieten))].

H o l o t y p e. Described in (Trueman and Williams, 1925) with reference to the Buckman collection (see synonyms). The sample comes from the Kilmersdon Colliery coal mine, Radstock, Somerset, Raricostatum Zone, Raricostatum Subzone. Stored in the British Geological Survey (BGS), Sample no. GSM47560. It was first depicted by Buckman (1925, pl. DLIII, figs. 1, 2).

S h a p e. The shell is ophiocone and has moderately increasing whorls with a wide depressed cross section. The lateral sides are highly convex. The ventral side is wide. The umbilicus is wide and stepped.

S c u l p t u r e. The lateral sides have wide high ribs, much less frequent on the outer whorls than on the inner ones (raricostate ribbing). The intercostal spaces on the outer whorls exceed the width of the ribs by more than 2 times. Ribs are straight, rectiradiate, reaching maximum height at the ventrolateral margin. The ribs weaken and disappear on the venter, before reaching the keel. A low, blunt ventral keel is present on all whorls and is not bordered by sulci.

D i m e n s i o n s (mm) and ratios (%):

No.	D	H	W	H/D	W/D	H/W
31/13351	47	11	12.5	23.4	26.6	88

C o m p a r i s o n. The species described differs from the closest species *E. raricostatum* (Zieten) in more compressed section, wider ventral side, and wider and more distant ribbing of external whorls.

D i s t r i b u t i o n. Biohorizon *crassicostatum* of the Raricostatum Subzone of the Raricostatum Zone of the upper Sinemurian of Great Britain, Northwest Germany, Switzerland, and Eastern France. Upper Sinemurian Biohorizon *Echioceras crassicostatum* of Southwestern Crimea.

M a t e r i a l a n d l o c a t i o n. One well-preserved sample (specimen no. 31/13351) and several fragments from a limestone block on Tatyana's Hill (Biohorizon *Echioceras crassicostatum*).

FAMILY TROPIDOCERATIDAE HYATT, 1900

[=Acanthopleuroceratidae Arkell, 1950]

Genus *Tropidoceras* Hyatt, 1867

[=*Eremiticeras*: Faraoni et al., 2002, p. 223]

Tropidoceras semilaevis Fucini, 1899

Plate I, figs. 5a–5b

Tropidoceras flandrini var. semilaevis: Fucini, 1899*, p. 169, pl. XXII [IV], fig. 1.

Tropidoceras semilaevis: Alkaya and Meister, 1995, p. 158, pl. XI, figs. 1, 3.

H o l o t y p e. Depicted in (Fucini, 1899, pl. XXII [IV], fig. 1) (by monotype). Mountains of Monte Catria, Urbino, Italy. Lower Pliensbachian. Stored in the Museum of the University of Pisa. Collection of Prof. Cittel.

S h a p e. The shell is moderately involute, platyconic, medium-sized. The whorls are moderately growing, strongly compressed. The whorls are widest at the umbilical margin. The whorl section is oval, with a very narrow keeled ventral side. The lateral sides are slightly convex. The umbilicus is moderately wide, shallow, and bowl-shaped. The umbilical wall is convex.

S c u l p t u r e. The adult whorls are smooth. Weak ribs are present on the inner whorls. The ventral side has a well-developed keel.

D i m e n s i o n s (mm) and ratios (%):

No.	D	H	Du	W	H/D	W/D	Du/D	H/W
7/13351	58	25	17.5	8	43.1	13.8	30.2	31.3

C o m p a r i s o n. This species differs from most species of the genus *Tropidoceras* in the absence of ribbing on the adult whorls; it differs from the closely related *T. erythraeum* (Gemmellaro) in a much more involute shell; it differs from *T. mediterraneum* (Gemmellaro) and *T. flandrini* (Dumortier) in a more involute shell and reduction of ribbing on the lateral sides with growth.

D i s t r i b u t i o n. The Masseanum Subzone of the Ibex Zone (lower Pliensbachian) of Turkey; lower Pliensbachian of Italy. Lower Pliensbachian Biohorizon *Tropidoceras erythraeum* of Southwestern Crimea.

M a t e r i a l a n d l o c a t i o n. Two specimens: one whole cast and one fragment (specimen no. 7, 8/13351) from a limestone block in the Ammonite Ravine (Biohorizon *Tropidoceras erythraeum*).

Tropidoceras erythraeum (Gemmellaro, 1884)

Plate I, figs. 3a–3b, 4a–4b

Harpoceras erythraeum: Gemmellaro, 1884*, p. 204, pl. 5, figs. 10–16.

Tropidoceras erythraeum: Fucini, 1896, p. 248 [46], pl. XXV [2], figs. 22a, 22b; Levi, 1896, p. 274, pl. 8, fig. 10; Bremer, 1965, s. 187, text-fig. 2c; Braga and Rivas, 1985, pl. 1, figs. 1, 2; Meister and Friebe, 2003, p. 46, pl. 16, figs. 2–3; Géczy and Meister, 2007, p. 197, pl. XL, figs. 9–10.

Tropidoceras masseanum var. *inornata*: Kovács, 1941 (var. nov.), s. 191, text-figs. 101–102, taf. IV, figs. 3, 6.

Tropidoceras cf. erythraeum: Alkaya and Meister, 1995, p. 157, pl. X, figs. 5–6; pl. XI, figs. 2, 5.

[non *Tropidoceras erythraeum* Smith and Tipper, 1996, p. 38, pl. 10, figs. 4, 7 (=*Tropidoceras* sp.)].

L e c t o t y p e. Depicted in (Gemmellaro, 1884, pl. 5, figs. 10, 11). Established in (Bremer, 1965, p. 187). Comes from the Roche Rossa region, the Galati Mamertino commune in the province of Messina (Sicily, Italy). Stored in the Museum of Geology and Mineralogy of the University of Palermo.

S h a p e. The shell is small, platyconic, moderately evolute. The whorls are moderately growing, evolute, and have a strongly compressed suboval section. The lateral sides are flattened. The venter is narrow and angular. The ventrolateral margin is poorly defined. The umbilicus is wide, shallow, bowl-shaped; the umbilical wall is vertical or somewhat sloping.

S c u l p t u r e. The ventral side has a low, well-defined keel. The phragmocon in the outer whorls is completely devoid of ornamentation. Sample no. 3/13351 has weak ribs on the middle whorls, only distinguishable in some areas of the lateral sides. Ribs are barely visible, irregular, sigmoid, slightly concave in the near-umbilical third of the lateral side. In the subiphonal part of the lateral side, there are secondary ribs curved forward. In Sample no. 6/13351, these ribs disappear near the ventrolateral bend.

D i m e n s i o n s (mm) and ratios (%):

No.	D	H	Du	W	H/D	W/D	Du/D	H/W
5/13351	40	14.5	15	6.8	36.3	17	37.5	213
3/13351	27.5	9	13	4.5	32.7	16.4	47.3	200

C o m p a r i s o n. The described species differs from most species of the genus *Tropidoceras* in a strongly reduced ornamentation on the lateral sides; it differs from *T. semilaevis* Fucini in a more evolute shell and wider umbilicus; it differs from the closely related *T. demonense* (Gemmellaro) in a smaller shell size and reduced sculpture on the lateral sides.

D i s t r i b u t i o n. Subzone Masseanum of the Ibex Zone of the lower Pliensbachian of Austria, Hungary, and Turkey. In Italy and southern Spain, it is probably also present in the upper part of the Jamesoni Zone of the lower Pliensbachian. Lower Pliensbachian, Biohorizon *Tropidoceras erythraeum*, Southwestern Crimea.

M a t e r i a l a n d l o c a t i o n. Four specimens: two complete casts, one juvenile specimen, and one fragment of two outer whorls (specimens nos. 3–6/13351) from a limestone block in the Ammonite Ravine (Biohorizon *Tropidoceras erythraeum*).

Tropidoceras komarovi Zaitsev, sp. nov.

Plate I, figs. 1a–1c

Ptycharietites (*Ptycharietites*) sp.: Komarov et al., 2012, fig. on p. 7; Komarov, 2016, fig. on p. 58.

S p e c i e s n a m e. After Vladimir Komarov.

H o l o t y p e. Sample no. 1/13351 in the Central Geological Research Museum (TsNIGR Museum, St. Petersburg). Comes from a limestone block in the Ammonite Ravine, Biohorizon *Uptonia* cf. *jamesoni*.

S h a p e. The shell is evolute, very flattened. The whorls are high, moderately expanding, strongly compressed from the sides, suboval section (reaching maximum width in the near-umbilical third). The lateral sides are flat or slightly convex. The ventral side is narrow, convex, without ribbing, and bears a well-developed keel. The umbilicus is wide, shallow, bowl-shaped, with a vertical wall.

S c u l p t u r e. The lateral sides have a gently rounded low-relief ribs, devoid of tubercles, which disappear in the ventrolateral margin. The ribs are rather thick, slightly narrower than the intercostal spaces, slightly sigmoid: they begin at the umbilical margin; in the near-umbilical third of the lateral side, they are slightly concave; and in the ventral part, they display a slight forward bent. With a large shell diameter, the ribs are almost straight. When D = 90–120 mm, there are about 16–17 ribs per half whorl. There are no secondary ribs.

Dimensions (mm) and ratios (%):

No.	D	H	Du	W	H/D	W/D	Du/D	H/W	Ribs per 1/2 whorl
1/13351	94	34.4	37.1	15	36.6	16	39.5	229	17

Comparison and remarks. This species includes a specimen described and depicted by Komarov et al. (2012) as *Ptycharietites* (*Ptycharietites*) sp. (Komarov et al., 2012). This specimen however cannot be assigned to the genus *Ptycharietites* Spath, as it has a much more compressed whorl section, a more convex ventral side, and no sulci bordering the keel. In addition, a sample with similar morphological features described in this work was found in the same locality together with *Uptonia* cf. *jamesoni*.

The species described differs from *T. demonense* (Gemmellaro) in a larger shell size and in higher and more compressed whorls. Unlike *T. flandrini* (Dumortier), the described species lacks rib tubercles and secondary ribs during all stages of ontogeny. The described species differs from *T. zitteli* Fucini in a significantly more compressed cross section; it differs from *T. masseanum* (d'Orbigny) in higher whorls, a narrower ventral side, and absence of secondary ribs; it differs from *T. mediterraneum* (Gemmellaro) in more compressed whorls and faster growing in height during ontogenesis.

Distribution. Biohorizon *Uptonia* cf. *jamesoni* of the lower Pliensbachian of Southwest Crimea.

Material and location. One specimen (no. 1/13351) from the limestone block in the Ammonite Ravine, Biohorizon *Uptonia* cf. *jamesoni*.

FAMILY POLYMORPHITIDAE HAUG, 1887

Genus *Uptonia* Buckman, 1898

***Uptonia* cf. *jamesoni* (J. de C. Sowerby, 1827)**

Plate I, figs. 6a–6b, 7a–7b

Shape. The shell is evolute and reaches a large size. The whorls are moderately expanding, of subrectangular cross section (with a narrow, slightly convex venter and flattened lateral sides). The ventral margin is rounded. The umbilicus is wide, stepped.

Sculpture. The lateral sides bear numerous ribs; on the inner whorls, they are rather thin and densely spaced. Ribs begin at the umbilical margin, bend forward in the ventral part of the lateral side, and thickening a little, reaching their maximum height at the ventrolateral bend. The ribs cross the ventral side with a weakening.

Dimensions (mm) and ratios (%):

No.	D	H	Du	W	H/D	W/D	Du/D	H/W
9/13351	40.5	14	17	8.3	34.6	20.5	42.0	169
10/13351	–	41.7	–	25	–	–	–	167

Comparison and remarks. Bremer (1965, s. 177) believed that the genus *Uptonia* "includes a number of closely related forms that can be considered as subspecies within a very variable species or as independent species connected by smooth transitions." One can confidently distinguish between them only if "the research is carried out on very rich material." Thus, the species is understood rather broadly and can only be described here in an open nomenclature.

Distribution. The species *U. jamesoni* (J. de C. Sowerby) is distributed within the Jamesoni Subzone (Jamesoni Zone) of the lower Pliensbachian of Great Britain, France, Germany, Hungary, Turkey, the Caucasus, etc. Lower Pliensbachian, Biohorizon *Uptonia* cf. *jamesoni* of Southwestern Crimea.

Material and location. One shell representing fragments of four whorls and one fragment of an adult whorl (specimens nos. 9, 10/13351) from a limestone block in the Ammonite Ravine, Biohorizon *Uptonia* cf. *jamesoni*.

BIOSTRATIGRAPHIC AND PALEOGEOGRAPHIC CONCLUSIONS

Ammonites collected from two studied blocks allowed the sequence of biostratigraphic units (biohorizons) to be established and correlated with units identified in different regions of Europe (Fig. 7).

Ammonite assemblages from the block at Tatyana's Hill can be correlated with the Echioceras raricostatum Zone of the upper Sinemurian of Europe. The sequence of biohorizons (*edmundi*, *rhodanicum*, *raricostatoides*, *crassicostatum*) is completely identical to that established in Burgundy (Central France; see Dommergues, 1993). Some of these biohorizons are more widespread, and some (Biohorizon *crassicostatum*) are included in the standard scale of Northwestern Europe (Page, 2003).

Two separate ammonite complexes were found in a boulder from the Ammonite Ravine. The lower one is proposed to designate as the Biohorizon *Uptonia* cf. *jamesoni*. It can be correlated with the upper part of

NW Europe (Page, 2003)					Sub-Mediterranean (Burgundy, Spain, Hungary) (Dommergues, 1993; Meister, 2010)	Crimea	
Stage	Substage	Zone	Subzone	Biohorizon	Biohorizons	Biostratigraphic subdivision	Block/section
Pleinsbachian	Lower	Tragophylloceras ibex (partially)	Valdani				
			Masseanum		Tropidoceras erythraeum	Biohorizon Tropidoceras erythraeum	Ammonite Ravine
		Uptonia jamesoni	Jamesoni		Uptonia jamesoni–U. bronni; Tropidoceras ex gr. flandrini	Biohorizon Uptonia cf. jamesoni	
			Brevispina				
			Polymorphus				
			Taylori				
Sinemurian	Upper	Echioceras raricostatum	Aplanatum	simplicicosta			
				romanicum			
				oosteri			
				aureolum			
			Macdonelli	macdonnelli			
				meigeni			
				liciense			
				favrei			
			Raricostatum	boehmi	Paltechioceras boehmi		
				cf. intermedium			
				crassicostatum	Echioceras crassicostatum	Biohorizon E. crassicostatum	Tatyana's Hill
				raricostatum	Echioceras raricostatum	Biohorizon E. raricostatoides	
				quenstedti	Echioceras rhodanicum	Biohorizon E. rhodanicum	
			Densinodulum	"Echioceras" sp. 3	"Echioceras" edmundi	Biohorizon Orthechioceras edmundi	
				radiatum			
				grp. armatum			
				bispinigerum			
				lymense			
				subplanicosta			
				delicatum	Plesechioceras delicatum		

Fig. 7. Correlation of biostratigraphic units established in this work with the European scale.

the Jamesoni Zone of the lower Pliensbachian of Europe, while the upper assemblage (Biohorizon *Tropidoceras erythraeum*) corresponds to the biohorizon of the same name in the lower part of the Ibex Zone or the terminal Jamesoni Zone of the standard scale of Northwestern Europe (Meister, 2010). This biohorizon is quite widespread in the Mediterranean and sub-Mediterranean parts of Europe (Spain, Italy, Hungary) and in Turkey.

Analysis of the ammonites described in this work and earlier (Kazakova, 1962; Repin, 2017; Zaitsev and Arkadiev, 2019) shows that early Sinemurian ammonoids of Crimea are mostly represented by the widespread species known from Western Europe, Mediterranean, Pacific coast of North America, and Southeast Asia. At the same time, the early Pliensbachian ammonoids are represented by species with a more limited distribution area (mainly Mediterranean taxa). These data are consistent with the idea of development of highly endemic ammonite fauna in the early Pliensbachian (Page, 2008), when the Western Tethys (Mediterranean) paleobiogeographic province was divided into three subprovinces: Mediterranean s.s., South Alpine, and Pontic (Dommergues et al., 2009). It is possible that the latter included the Crimean Mountains.

CONCLUSIONS

(1) The Early Jurassic ammonites *Calliphylloceras* cf. *bicicolae* (Meneghini), *Orthechioceras edmundi* (Dumortier), *O.* cf. *viticola* (Dumortier), *Echioceras quenstedti* (Schafhäutl), *E. rhodanicum* (Buckman), *E. raricostatoides* (Vadász), *E. crassicostatum* Trueman et Williams, *E. raricostatum* (Zieten), *Tropidoceras semilaevis* Furacini, *T. erythraeum* (Gemmellaro), *T. komarovi* sp. nov., and *Uptonia* cf. *jamesoni* (J. de C. Sowerby) were described from two separate blocks of carbonate rocks in the Simferopol melange zone in the Bodrak River basin.

(2) Ammonites of the genus *Tropidoceras* have been identified in Crimea for the first time. The species *T. erythraeum* and *T. semilaevis* were found for the first time in Russia. The presence of five species belonging to the Echioceratidae family, *Echioceras crassicostatum* T. et W., *E. quenstedti* (Schafhäutl), *E. rhodanicum* (Buckm.), *E. raricostatoides* (Vadász), and *Orthechioceras* cf. *viticola* (Dum.), has been established for the first time in Crimea.

(3) The following sequence of biostratigraphic units (bottom to top) is established in the limestone block on Tatyana's Hill: (1) Biohorizon *Orthechioceras edmundi*; (2) Biohorizon *Echioceras rhodanicum*; in this interval, one can also distinguish biohorizon *Echioceras quenstedti*, corresponding to the identical biohorizon on the Mediterranean scale (Page, 2003); (3) Biohorizon *Echioceras raricostatoides*; (4) Biohorizon *Echioceras crassicostatum*. In a limestone block in the Ammonite Ravine, the following units are distinguished: (1) Biohorizon *Uptonia* cf. *jamesoni*; (2) Biohorizon *Tropidoceras erythraeum* (Fig. 7).

(4) The correlation of the above ammonite complexes with the European scale (Meister, 2010; Page, 2003; etc.) shows that, contrary to the widespread opinion (Panov, 2002; Panov et al., 1994), limestones in different blocks have a different age, which does not coincide with the age of the host terrigenous rocks. Ammonites typical of the base of the Raricostatum Zone (Densinodulum–Raricostatum subzones) of the upper Sinemurian of Europe are found in the block on Tatyana's Hill, and ammonites typical of the boundary between the Jamesoni (Jamesoni Subzone) and the Ibex (Masseanum Subzone) zones of Turkey and Hungary are found in the block in the Ammonite Ravine (Alkaya and Meister, 1995; Géczy and Meister, 2007).

(5) Ammonites known from terrigenous rocks of the same region are more ancient. They are characteristic of the interval of Semicostatum–Oxynotum (? Raricostatum) zones of the Sinemurian Stage of Europe (Zaitsev and Arkadiev, 2019).

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