

# Representatives of the *Neocosmoceras* (Neocomitidae, Ammonoidea) Genus from the Berriasian of the Crimean Mountains and Their Stratigraphic Significance

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**Abstract**—The genus *Euthymiceras* is considered as the junior synonym of the genus *Neocosmoceras*. Four species *N. euthymi*, *N. cf. transfigurabilis*, *N. minutus* sp. nov., and *N. giganteus* sp. nov. from the Berriasian deposits of the Crimean Mountains are described for the first time. The biostratigraphic unit formerly termed the “*Euthymiceras*–*Neocosmoceras* Beds” is ranked now as the *Neocosmoceras euthymi* Subzone with a synonymous index species. The subzone is correlated to the following biostratigraphic units: the synonymous subzone of the northern Caucasus, the *Neocosmoceras*–*Septaliphoria semenovi* (upper part) and *Buchia volgensis* local zones of Mangyshlak, the upper part of the *Riasanites rjasanensis* Zone in the East European platform, and the *paramimounum* Subzone of the *boissieri* Zone in the standard zonation of the Tethyan ammonites.

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**Key words:** Crimean Mountains, Berriasian, ammonites, zonal biostratigraphy, correlation.

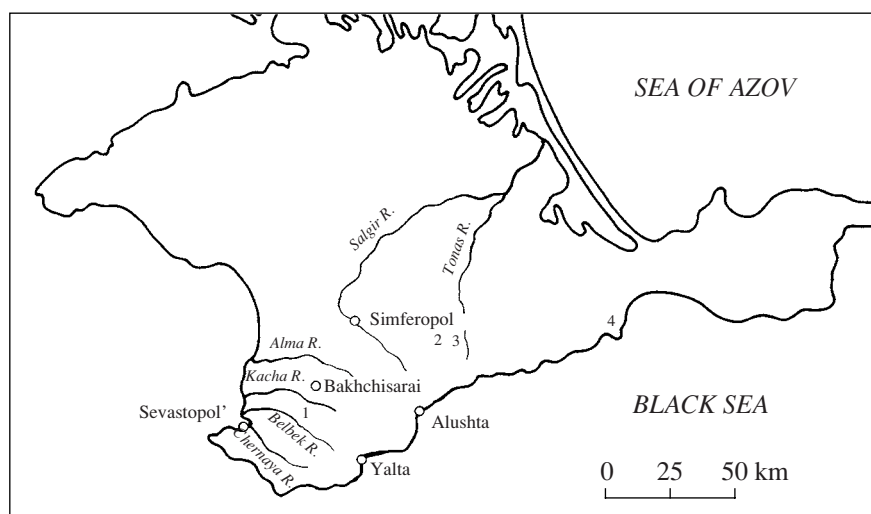
## INTRODUCTION

Ammonites of genera *Neocosmoceras* and *Euthymiceras* are of great significance for the zonal and infra-zonal subdivision of the Berriasian deposits. Many species of both genera have been originally described from the Berriasian of Western Europe (Mazenot, 1939; Le Hégarat, 1973; Nikolov, 1982; Tavera, 1985) and later on from concurrent deposits of Mangyshlak (Luppov et al., 1988) and northern Caucasus (Kalacheva and Sey, 2000). Klein (2005) attributed several species described by Uhlig (1910) from the Himalayas to the genus *Neocosmoceras*. In the opinion of Grigorieva (1938) and of Kalacheva and Sey (2000), certain ammonite species, in particular *Hoplites transfigurabilis*, initially described from the Ryazanian Horizon of the Oka River basin (Bogoslowski, 1895) belong to the genus *Euthymiceras*. Their opinion is very valuable in terms of the correlation beyond the Tethyan Realm, as it offers the opportunity to correlate the Berriasian deposits of the Crimean Mountains and the northern Caucasus with the concurrent sediments of the East European platform.

In the Crimea, representatives of the *Neocosmoceras* and *Euthymiceras* genera have been studied unsatisfactorily. Brief descriptions of several respective species are published in regional paleontological atlases (Druschits, 1960; *Atlas ...*, 1997) and in works by Kvantaliani (1999) and Arkadiev et al. (2000). Nev-

ertheless, ammonites of both genera have always been in consideration as index species during works on the zonal biostratigraphy of the Berriasian deposits in the Crimean Mountains. Kvantaliani and Lysenko (1979) were the first to recognize the *Euthymiceras euthymi* Zone in that region, which is mentioned in later work by Kvantaliani (1999). Bogdanova, who identified the *Neocosmoceras* ex gr. *rerollei* and *Euthymiceras* (?) ex gr. *euthymi* ammonites, discriminated the *Euthymiceras*–*Neocosmoceras* Beds above the strata with *Dalmasiceras* forms (Bogdanova et al., 1981). This biostratigraphic unit was included in the last stratigraphic chart of the Berriasian deposits in the Crimean Mountains (Arkadiev et al., 2006, 2008).

The collection of 80 ammonite specimens sampled in the 1950s–1970s by V.V. Druschits, B.T. Yanin, V.M. Nerodenko, T.N. Bogdanova, S.V. Lobacheva, and V.A. Prozorovskii has now been replenished with additional specimens collected by V.V. Arkadiev, Yu.N. Savel'eva, A.A. Fedorova, K.Yu. Chetverikova, and M.M. Sheker in 2004–2007. Two collections (nos. 12943 and 13175) are stored at the TSNIGR Museum of St. Petersburg and one (no. 330) at the St. Petersburg State Mining Institute (Technical University). In addition to the study of these collections, we reexamined ammonites sampled by Bogoslowski in the Oka River basin (collection no. 623), by Grigorieva in the Belaya River basin (collection no. 5661), by Kalacheva and



**Fig. 1.** Localities of the Berriasian section studied in the Crimean Mountains: (1) Belbek River, Kabanii Ravine, (2) Sary-Su River, village of Balki, (3) Tonas River, village of Alekseevka, (4) Feodosiya, Zavodskaya Balka.

Sey in the Uruk River basin, the northern Caucasus (collection no. 12950), and by Luppov and Bogdanova with their colleagues in the Mangyshlak region (collection nos. 6801 and 11104). Our objective was to get a deeper insight into the morphological features of ammonite genera and species considered in this work.

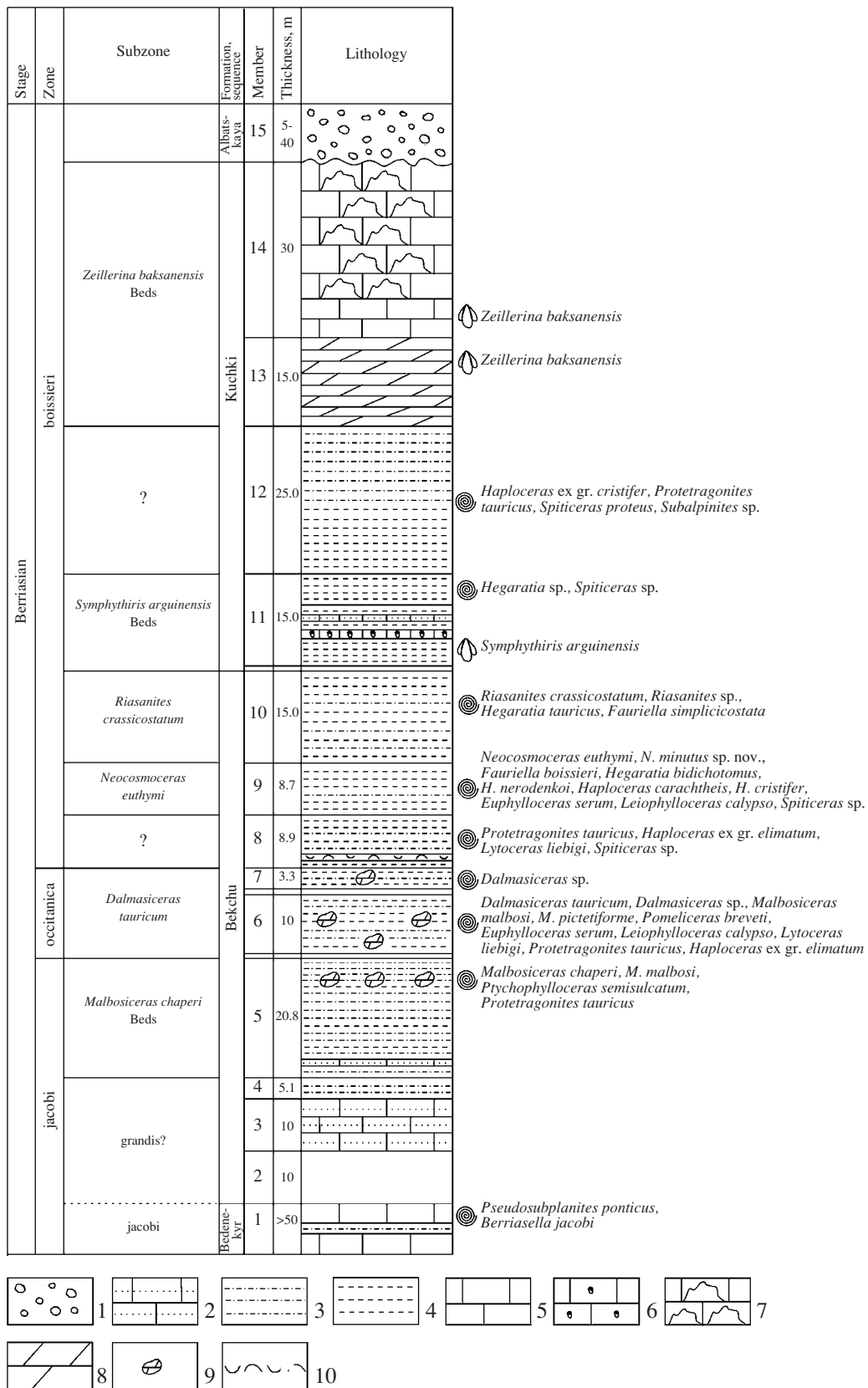
#### INVESTIGATION HISTORY OF THE *NEOCOSMOCERAS* BLANCHET, 1922, AND *EUTHYMICERAS* GRIGORIEVA, 1938 GENERA

Blanchet (1922) was the first to identify the *Neocosmoceras* genus among the ammonites collected from the Berriasian sediments of southeastern France. Later on, Grigorieva (1938) described *Euthymiceras* and *Renngarteniceras*, two subgenera of the composite genus *Protacanthodiscus*. Diagnoses of both subgenera published by Grigorieva are very similar and close to the diagnosis of the genus *Neocosmoceras* distinguished earlier. Soon afterward, the subgenus *Renngarteniceras* was defined as a synonym of the *Neocosmoceras* genus, whereas *Euthymiceras* was ranked as an individual genus (*Principles of Paleontology*, 1958; Druschits, 1960), although not all the researchers shared the latter viewpoint. In his early works (Le Hégarat, 1965; Le Hégarat and Remane, 1968), Le Hégarat regarded taxon as a subgenus of the *Neocosmoceras* genus and admitted its individual status only in a later work (Le Hégarat, 1973). As it was not included in the first edition of the *Treatise on Invertebrate Paleontology* dedicated to ammonoids (Arkell et al., 1957), the genus *Euthymiceras* is ranked in the same monograph on Cretaceous ammonites (Wright et al., 1996) as a junior synonym of the *Neocosmoceras* genus.

The uncertain taxonomic rank of the *Euthymiceras* genus adversely affected the status of its *E. euthymi* type species, which is included in that genus in some works (Grigorieva, 1938; Druschits, 1960; Le Hégarat, 1973; Khimshiashvili, 1976; Nikolov, 1982; Sakharov, 1984; Kvantaliani, 1999; Kalacheva and Sey, 2000; Mitta, 2002) and into the *Neocosmoceras* genus in others (Roman, 1938; Mazenot, 1939; Le Hégarat, 1965; Le Hégarat and Remane, 1968; Wright et al., 1996). Kalacheva and Sey (2000), who studied representative ammonite specimens from sections of the northern Caucasus noted the doubtless similarity between the *Euthymiceras* and *Neocosmoceras* genera, but, nevertheless, regarded them as separate taxa. After the examination of many pertinent ammonite specimens from the Crimean Mountains, collections of other researchers, and reproduced figures, we arrived at the conclusion that they possess iterative morphological features, and that there are many ammonites of transitional morphology as compared to those of type species representing the *Neocosmoceras* and *Euthymiceras* genera. Suture lines in species of both genera are identical as well. Accordingly, we regard the *Euthymiceras* genus as a junior synonym of the *Neocosmoceras* genus.

#### STRATIGRAPHY

Ammonites of the *Neocosmoceras* genus are irregularly distributed in sections of the Crimean Mountains. They are abundant in the central Crimean section (near the village of Balki) but rare (single specimens) in the Belbek River basin of southwestern Crimea and in the Feodosiya area of eastern Crimea (Fig. 1). Ammonites from predominantly clayey, comparatively deep-water deposits of central Crimea are represented by small ( $D = 1.5\text{--}2.0$  cm) ferruginate casts of completely substituted shells, while fragments of their larger speci-



**Fig. 2.** Composite succession of Berriasian deposits in the central Crimea, The Enisarai Ravine, the village of Balki, the Sary-Su and Burulcha rivers (compiled by V.V. Arkadiev based on personal observations and data of Bogdanova et al., 1981): (1) quartz conglomerate, (2) calcareous sandstone, (3) siltstone, (4) clay, (5) limestone, (6) sponge limestone, (7) coral-algal limestone, (8) marl, (9) marl nodules, (10) coquina.

mens ( $D = 5.0\text{--}6.0$  cm) are rare. The *Neocosmoceras euthymi* (Pictet) and *N. minutus* Arkadiev et Bogdanova sp. nov. species have been identified in these deposits. In the sandy shallow-water Berriasian deposits of the Belbek River basin, only fragments of shells up to 20 cm in diameter, which are defined as *Neocosmoceras* cf. *transfigurabilis* (Bogoslawski) and *N. giganteus* sp. nov., have been discovered. Being found in association with species of the *Malbosiceras* (*M. malbosi*) genus, these ammonites from the Belbek River basin characterize the *boissieri* Zone (Arkadiev et al., 2007). The *Neocosmoceras euthymi* (Pictet) and *N. minutus* Arkadiev et Bogdanova sp. nov. species occur in sections of the Tonas River basin. As is reported in separate works (Sazonova and Sazonov, 1974; Druschits, 1975), ammonites of the *Euthymiceras* and *Neocosmoceras* genera also occur in the Feodosiya section of eastern Crimea. Although this information was not confirmed for a long time, Arkadiev, who studied the Berriasian section of the Zavodskaya Balka locality in the northern suburbs of Feodosiya in 2008, found a well-preserved specimen of *Neocosmoceras euthymi* in this area.

The most complete section of the Berriasian deposits with a distinct biostratigraphic level of *Neocosmoceras* forms typical of the *boissieri* Zone was found near the village of Balki in central Crimea (Kvantaliani and Lysenko, 1979; Bogdanova and Kvantaliani, 1983; Arkadiev et al., 2007). The distribution of ammonites in that section is shown in Fig. 2. Taking into account the fact that the *Euthymiceras*–*Neocosmoceras* Beds (Bogdanova et al., 1981; Arkadiev et al., 2008) are recognizable everywhere in the Crimean Mountains and bearing in mind new determinations of *Neocosmoceras* forms, we suggest ranking the former beds as the *Neocosmoceras euthymi* Subzone, in the form of an index.

## SYSTEMATIC DESCRIPTION

### FAMILY NEOCOMITIDAE SALFELD, 1921

#### SUBFAMILY BERRIASSELLINAE SPATH, 1922

#### Genus *Neocosmoceras* Blanchet, 1922

[= *Octagoniceras* Spath, 1924; *Euthymiceras* Grigorieva, 1938; *Renngarteniceras* Grigorieva, 1938]

**Type species.** *Hoplites sayni* Simionescu, 1899; Berriasian of southeastern France.

**Diagnosis.** An evolute shell, predominantly medium size, with wide initial whorl sections that remain either wide as before or turn into trapezoidal ones stretched along its height in older whorls. Its narrow to moderately wide outer side is flat or convex and its umbilicus wide and shallow. Sculpturing is represented by solitary main and doubled short insert ribs, and by three rows of tubercles, the umbilical, lateral, and outer ones. The lateral and outer tubercles are most embossed; the latter ones appear spiny and are sometimes posteriorly curved. As they are interrupted on the outer side, the ribs form a smooth band here, although on the living

chamber they remain uninterrupted sometimes. In the outer segment, the suture line consists of external and lateral lobes, which are identically deep and slightly decreasing in dimensions toward the suture of the umbilical lobes.

**Specific composition and distribution:** *Neocosmoceras acanthoptychum* (Uhlig), Berriasian of Himalayas; *N. ambiguum* (Mazenot), Berriasian of southeastern France and Italy; *N. ampanihyense* Collignon, Berriasian, *boissieri* Zone in Madagascar; *N. bituberculatum* Rossi, Berriasian of Italy; *N. breistrofferi* Mazenot, Berriasian, *occitanica* Zone (*privasensis* Subzone)–*boissieri* Zone (*paramimounum* Subzone) in southeastern France and Tunisia; *N. bruni* Mazenot, Berriasian, *boissieri* Zone, *paramimounum* Subzone in southeastern France and Bulgaria, Berriasian of Spain and Czechia; *N. concinnum* (Sakharov), Berriasian of the northern Caucasus; *N. crossi* (Anderson), Berriasian of North America; *N. euchrense* Imlay et Jones, Berriasian of North America; *N. euthymi* (Pictet), Berriasian, *boissieri* Zone, *euthymi* Subzone in the Crimean Mountains and northern Caucasus, Berriasian of Mangyshlak, Ryazanian Horizon of the East European platform, *boissieri* Zone, *paramimounum* Subzone in southeastern France, Bulgaria, and Poland; *N. flabelliforme* Le Hégarat, Berriasian, *boissieri* Zone, *paramimounum* Subzone in southeastern France, Poland, and Bulgaria; *N. giganteus* Arkadiev et Bogdanova, sp. nov., Berriasian, *boissieri* Zone, *euthymi* Subzone in the Crimean Mountains, *boissieri* Zone in southeastern France; *N. grigorievae* (Nikolov), Berriasian, *boissieri* Zone, *picteti* Subzone Bulgaria; *N. himalayanum* (Uhlig), Berriasian of Himalayas; *N. hoplophorum* Spath, Berriasian of Himalayas; *N. hospes* (Bogoslawski), Ryazanian Horizon of the East European platform; *N. hunevciense* Nikolov, Berriasian, *boissieri* Zone, *callisto* Subzone in Bulgaria; *N. kurdistanense* (Howarth), Berriasian, *boissieri* Zone, *paramimounum* Subzone in Iraq; *N. lamberti* Mazenot, Berriasian, zone *occitanica*, *privasensis* Subzone in southeastern France and Tunisia; *N. latouchei* (Uhlig), Berriasian of Himalayas and Tibet; *N. mazenoti* Nikolov, Berriasian, *occitanica* Subzone (*privasensis* Subzone)–*boissieri* Zone (*paramimounum* Subzone) in southeastern France, Bulgaria, and Tunisia; *N. mevludi* (Kvantaliani), Berriasian, *boissieri* Zone, *euthymi* Subzone the Crimean Mountains and northern Caucasus; *N. minutus* Arkadiev et Bogdanova, sp. nov., Berriasian, *boissieri* Zone, *euthymi* Subzone in the Crimean Mountains; *N. octagonoides* (Uhlig), Berriasian of Himalayas; *N. perclarum* (Matheron), Berriasian, *occitanica* Zone, *privasensis* Subzone in southeastern France and Romania, Berriasian of Mangyshlak (?); *N. perornatum* (Retowski), Berriasian of the Crimean Mountains northern Caucasus, Mangyshlak, and Iraq; *N. polyacanthum* (Uhlig), Berriasian of Himalayas; *N. prebalcanicum* Nikolov, Berriasian, *boissieri* Zone, *callisto* Subzone in southeastern France, Bulgaria, and Poland; *N. renngarteni* (Grigorieva), Berriasian of the

northern Caucasus; *N. rerollei* (Paquier), Berriasian, *occitanica* Subzone (*privasensis* Subzone)–*boissieri* Zone (*paramimounum* Subzone) in southeastern France and Tunisia, *boissieri* Zone, *euthymi* Subzone in the northern Caucasus; *N. salenskii* (Grigorieva), Berriasian of the northern Caucasus; *N. sayni* (Simionescu), Berriasian, *occitanicaone-boissieri* Zone (*paramimounum* Subzone) in southeastern France, Tunisia, Algeria, Bulgaria, Romania, Poland, and Czechia, Berriasian of Mangyshlak, northern Caucasus, Argentina, and Chili; *N. transfigurabilis* (Bogoslawski), Berriasian of Algeria, northern Caucasus, and Mangyshlak (?), Ryazanian Horizon of the East European platform, Berriasian, *boissieri* Zone, *euthymi* Subzone in the Crimean Mountains; and *N. zigzagum* (Sakharov), Berriasian of the northern Caucasus.

**Comparison.** As compared to the close genus *Tran-scaspites*, the taxon under consideration possesses higher whorls with flattened lateral sides and less embossed tubercles on young whorls.

*Neocosmoceras euthymi* (Pictet, 1867)

Plate I, Figs. 1–10; Plate II, Figs. 1–4

*Ammonites euthymi*: Pictet, 1867, p. 76, Plate 13, Fig. 3; 1868, p. 241, Plate 38, Fig. 7; non Pomel, 1889, p. 63, Plate 4, Figs. 1–4 (= *Neocosmoceras transfigurabilis*).

non *Hoplites euthymi*: Toucas, 1890, p. 605, Plate 18, Fig. 7 (= *Jabronella*).

*Neocosmoceras* cf. *euthymi*: Mazenot, 1939, p. 192, Plate 28, Fig. 8.

*Neocosmoceras* (*Euthymiceras*) *euthymi*: Le Hégarat, 1965, p. 125, Plate 1, Fig. 1, text-Figs. 1, 2; Le Hégarat, Remane, 1968, p. 23, Plate 2, Fig. 5.

*Euthymiceras euthymi*: Le Hégarat, 1973, p. 130; Khimshiyashvili, 1976, p. 108, Plate 20, Fig. 1; Nikolov, 1982, p. 166, Plate 60, Fig. 1 (solely); Sakharov, 1984, Plate 7, Fig. 1; Kalacheva and Sey, 2000, p. 79, Plate 17, Figs. 1–3, 5, 8, 9; Plate 18, Fig. 2; Plate 19, Fig. 5; Mitta, 2002, Plate 3, Figs. 4, 5; and non Druschits, 1960, p. 280, Plate 24, Fig. 3 [= *Neocosmoceras mevludi* (Kvantaliani)].

*Euthymiceras* cf. *euthymi*: Kvantaliani, 1999, p. 130, Plate 23, Figs. 4; Plate 24, Fig. 1; Plate 25, Fig. 3; Plate 28, Fig. 2.

*Euthymiceras* sp. nov. ex gr. *euthymi*: Luppov et al., 1988, p. 123, Plate 16, Fig. 2.

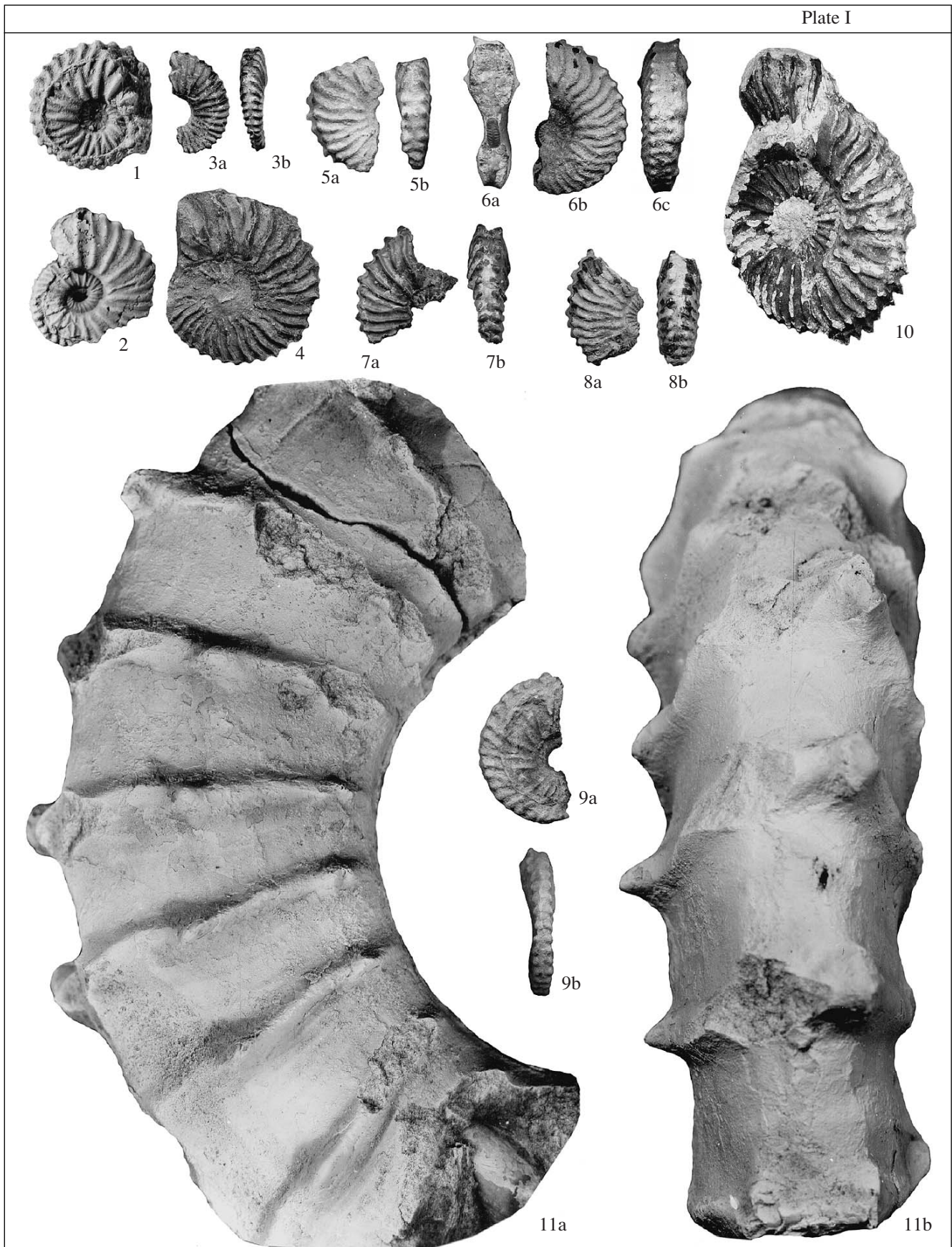
*Euthymiceras* (?) ex gr. *euthymi*: Arkadiev et al., 2000, p. 103, Plate 4, Figs. 3–5.

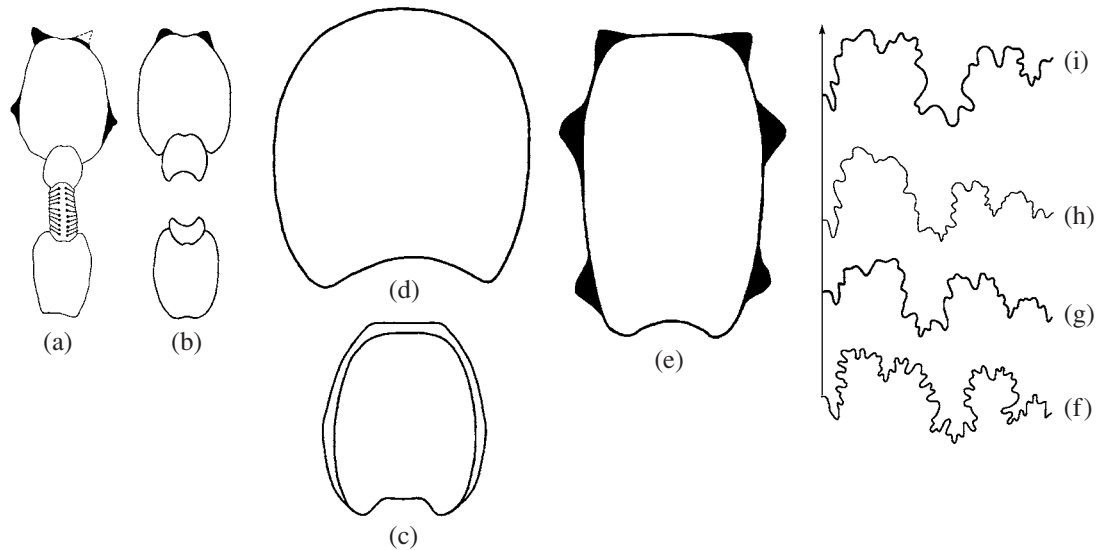
**Shape.** When  $D = 4.0$  mm, young whorls have an oval cross section, whose width is greater than its height (Figs. 3a, 3b). Convex lateral sides gently grade into a widely rounded outer side. In whorls having  $D = 6.0$  mm, the cross sections are rounded-quadrate with equal height and width, while the lateral and outer sides became somewhat flattened. When  $D = 20.0$  mm, the lateral sides are almost flat and parallel to each other, slightly narrow in the upper part of the whorls and pass via a distinct inflection into the narrow and flattened outer side. At this stage, the whorls have trapezoidal cross sections that are stretched in height. When  $D = 25.0$ – $30.0$  mm and the shell is discoid, having a flattened outer and slightly convex lateral sides, semi-evolute coiling is observable. In an umbilical with gently sloping walls, the umbilical inflection is almost indistinguishable. Judging from available fragments, the adult shells were up to 50–60 mm in diameter, discoid in shape, compressed from lateral sides, and having a narrow and flattened outer side.

**Sculpturing.** Shells are smooth up to  $D = 3.0$  mm. Later, when the diameter is about 4.0 mm, their sculpturing begins with the appearance of the solitary main and insert ribs. Doubled ribs appearing somewhat later terminate at the outer tubercles, which border a narrow smooth belt on outer side. At this stage, the bifurcation of ribs takes place close to the umbilicus. The appearance of lateral tubercles at the bifurcation points is characteristic when  $D = 25$ – $30$  mm or slightly later. The lateral sides become decorated simultaneously with the solitary main, doubled and insert ribs, all of them embossed and falcate. The branching of the ribs is not always clearly seen. Embossed tubercles on the outer side are prick-shaped and curved posteriorly on some shells. Judging from whorl fragments, the umbilical

Dimensions (mm), dimensional ratios, and amount of ribs per half of whorl.

Specimen no.	D	H	W	$D_u$	H/D	W/D	$D_u/D$	Amount of ribs per half of whorl	
								umbilical	outer
1/13175	17.7	7.3	6.2	5.0	0.41	0.35	0.28	11	20
2/13175	19.3	8.8	6.1	5.4	0.46	0.32	0.28	13	21
3/13175	21.5	9.0	7.3	5.7	0.42	0.34	0.27	10	17
1/12943	23.8	11.1	8.2	5.8	0.47	0.34	0.24	10	18
4/13175	24.0	10.5	8.7	5.5	0.44	0.36	0.23	–	–
2/12943	26.5	11.2	9.9	7.3	0.42	0.37	0.28	11	–
5/13175	27.5	11.5	7.3	6.8	0.42	0.27	0.25	11	17
6/13175	28.3	12.0	9.5	6.5	0.42	0.36	0.23	12	18
7/13175	28.5	11.3	8.4	8.0	0.40	0.29	0.28	–	–





**Fig. 3.** Cross sections (a–e) and suture lines (f–i) of studied *Neocosmoceras* species: (a, b) *N. euthymi* (Pictet): (a) Specimen 6/13175,  $\times 1.8$ , (b) Specimen 2/13175,  $\times 2.4$ , central Crimea, village of Balki, *boissieri* Zone, *euthymi* Subzone; (c) *N. transfigurabilis* (Bogoslowski), Specimen 64/623,  $\times 1$ , holotype (from work by Bogoslowski, 1895), East European platform, village of Shatrishchi, Ryazanian Horizon; (d) *N. cf. transfigurabilis* (Bogoslowski), Specimen 57/13175,  $\times 0.75$ , southwestern Crimea, Belbek River, Kabanii Ravine, *boissieri* Zone, *euthymi* Subzone; (e) *N. giganteus* Arkadiev et Bogdanova sp. nov., Specimen 79/13175,  $\times 0.8$ , the same locality and age; (f–h) *N. euthymi* (Pictet): (f) Specimen 11/13175, H = 10.0 mm,  $\times 3$ , (g) Specimen 36/13175, H = 6.0 mm,  $\times 5.5$ , (h) Specimen 8/13175, H = 7.0 mm,  $\times 4.7$ ); (i) *N. minutus* Arkadiev et Bogdanova sp. nov., Specimen 63/13175, H = 6.0 mm; (f–i) central Crimea, village of Balki, *boissieri* Zone, *euthymi* Subzone.

tubercles of adult shells up to 50–60 mm in diameter were likely less embossed.

**Suture line** (Figs. 3f–3h). When H = 6.0–7.0 mm, the external segment of the suture line includes the outer, lateral, and two umbilical lobes. When H = 10.0 mm, the lobes and saddles are finely serrate.

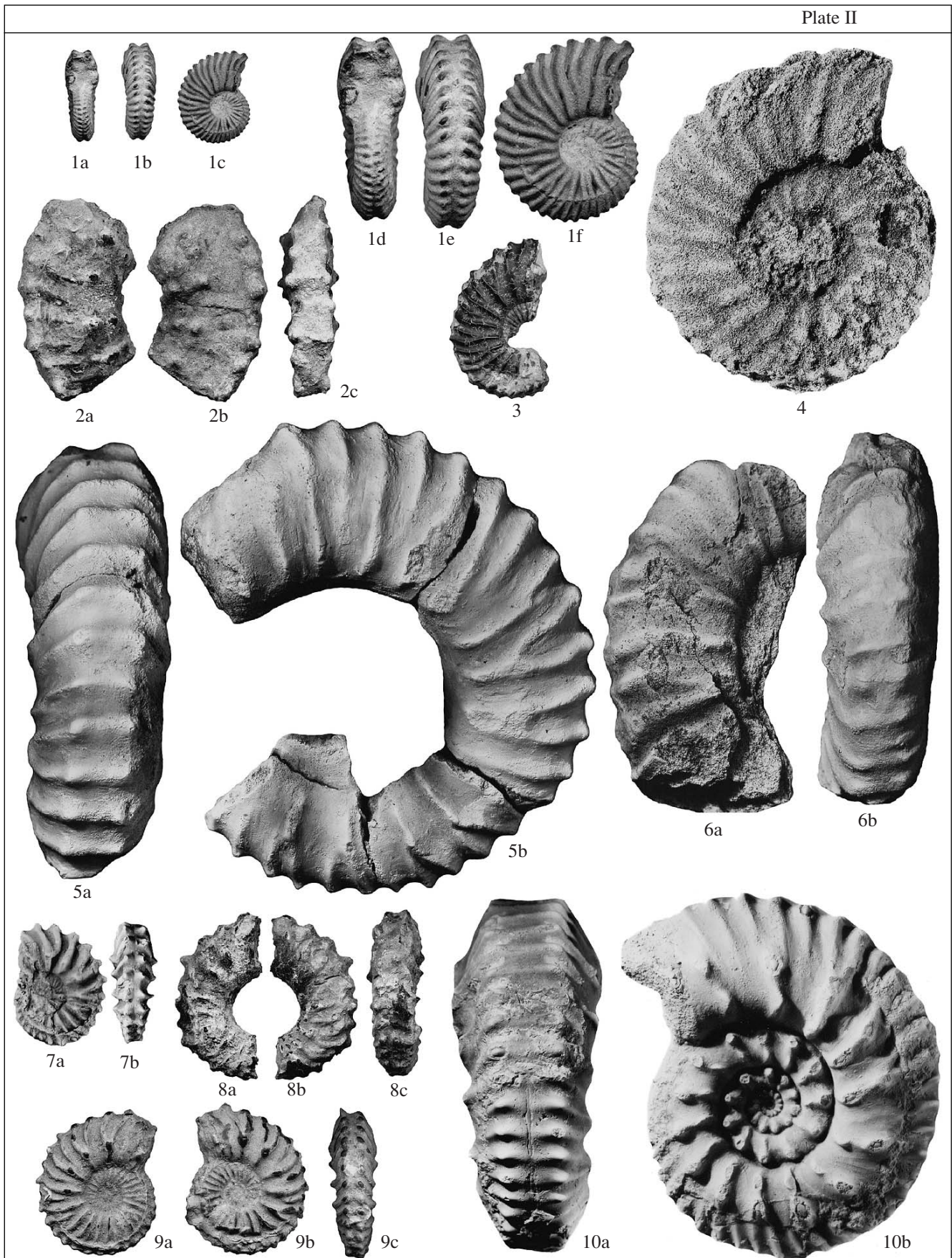
**Variability.** Kalacheva and Sey (2000), who studied ammonite specimens from the northern Caucasus, reported on a great variability of *euthymi* forms evident from the changing thickness and width of whorls variably overlapping one another, from differently convex lateral sides, and especially from the changeable extent of the embossment of the three tubercular rows. Our data confirm their observations. In the Crimean *euthymi* species, whorls are also of variable thicknesses and tubercles of different characters. The lateral tubercles,

usually appearing when D = 25–30 mm, may originate with some delay, and the outer ones are either prick-shaped, or curved posteriorly. The position of rib bifurcation points is unstable as well.

**Comparison and remarks.** It is difficult to compare the Crimean *euthymi* species, which are predominantly small, with the larger shells of the lost holotype (Pictet, 1867) and subsequently chosen neotype (Le Hégarat, 1965). Nevertheless, our specimens are identical with their counterparts described from the Uruk section of the northern Caucasus and figured in ontogeny at different stages (Kalacheva and Sey, 2000). As compared to its close species *N. transfigurabilis*, the *euthymi* species have higher, more flattened whorls and narrower external sides. Following Kalacheva and Sey (2000), we class the ammonites from the Berriasian of the eastern Karatau, which have been described as

**Plate I.** Ammonites of the genus *Neocosmoceras*:

(1–10) *Neocosmoceras euthymi* (Pictet): (1) Specimen 1/12943, lateral side,  $\times 1$ ; (2) Specimen 2/12943, lateral side,  $\times 1$ ; central Crimea, village of Balki, *boissieri* Zone, *euthymi* Subzone, collection of T.N. Bogdanova; (3) Specimen 8/13175: (a) lateral side,  $\times 1$ , (b) outer side,  $\times 1$ ; the same locality and age, collection of V.V. Arkadiev; (4) Specimen 9/13175, lateral side; Tonas River, village of Alekseevka, *boissieri* Zone, *euthymi* Subzone; collection of V.V. Arkadiev; (5) Specimen 10/13175: (a) lateral side,  $\times 1$ , (b) outer side,  $\times 1$ ; (6) Specimen 6/13175: (a) apertural side,  $\times 1$ , (b) lateral side,  $\times 1$ , (c) outer side,  $\times 1$ ; (7) Specimen 11/13175: (a) lateral side,  $\times 1$ , (b) outer side,  $\times 1$ ; (8) Specimen 12/13175: (a) lateral side,  $\times 1$ , (b) outer side,  $\times 1$ ; (9) Specimen 5/13175: (a) lateral side,  $\times 1$ , (b) outer side,  $\times 1$ ; (5–9) central Crimea, village of Balki, *boissieri* Zone, *euthymi* Subzone, collection of V.V. Arkadiev; (10) Specimen 80/13175, lateral side,  $\times 1$ , eastern Crimea, Feodisiya, Zavodskaya Balka, *boissieri* Zone, *euthymi* Subzone, collection of V.V. Arkadiev. (11) *Neocosmoceras giganteus* Arkadiev et Bogdanova sp. nov., Specimen 24/330, holotype: (a) lateral side,  $\times 1$ , (b) outer side,  $\times 1$ ; southwestern Crimea, Belbek River, Kabanii Ravine, *boissieri* Zone, *euthymi* Subzone; collection of V.V. Arkadiev.





*Euthymiceras* sp. nov. indet. ex gr. *euthymi* with the *euthymi* species (Luppov et al., 1988, Plate 16, Fig. 2, TSNIGRMuseum, Specimen 15/11104; see Plate II, Fig. 4 in this work). Intraspecific types of characteristics are considered by Luppov as discriminating these ammonoids from the *euthymi* species. Our examination of specimens stored at the TSNIGRMuseum showed them to be identical with some of the Crimean species.

**Distribution:** Berriasian, *boissieri* Zone, *euthymi* Subzone in the Crimean Mountains and northern Caucasus; Berriasian of Mangyshlak; Ryazanian Horizon of the East European platform; *boissieri* Zone, *paramimounum* Subzone in southeastern France and Bulgaria.

**Material:** 56 specimens (nos. 1–17/13175, 19–56/13175, 80/13175) from central (Sary-Su and Balka river basins) and eastern (Feodosiya, Zavodskaya Balka) Crimea; collections of V.V. Druschits, V.N. Nerodenko, T.N. Bogdanova, V.V. Arkadiev, Yu.N. Savel'eva, A.A. Fedorova, K.Yu. Chetverikova, and M.M. Sheker.

***Neocosmoceras* cf. *transfigurabilis* (Bogoslowski, 1895)**

Plate II, Fig. 6; Plate III, Fig. 3

*Euthymiceras* sp.: Atlas ..., 1997, p. 115, Plate 32, Fig. 4.

*Euthymiceras* (?) ex gr. *euthymi*: Arkadiev et al., 2000, p. 103, Plate 4, Fig. 2.

**Shape.** Notably swollen shells medium to large in size; when their diameter is close to 75 mm, the lateral sides are slightly convex, the outer side wide and flattened, and the whorl cross section rectangular-oval. When  $D = 200$  mm, the cross section is more rounded, and a little higher than it is wide (Fig. 3d). The transition between outer and lateral sides is smooth. The umbilical walls are steep within the intermediate whorls, but gently sloping within the adult ones.

**Sculpturing.** Simple ribs originate at the umbilical tubercles, bifurcate into two branches near the lateral tubercles, and then, after passing through the outer tubercles, cross the outer side at a right angle. When  $D = 200$  mm, the outer ribs are strong, resembling prick-shaped ridges extending along the ribs. In addition to the doubled ribs, there are rare solitary ribs.

Dimensions (mm) and dimensional ratios.

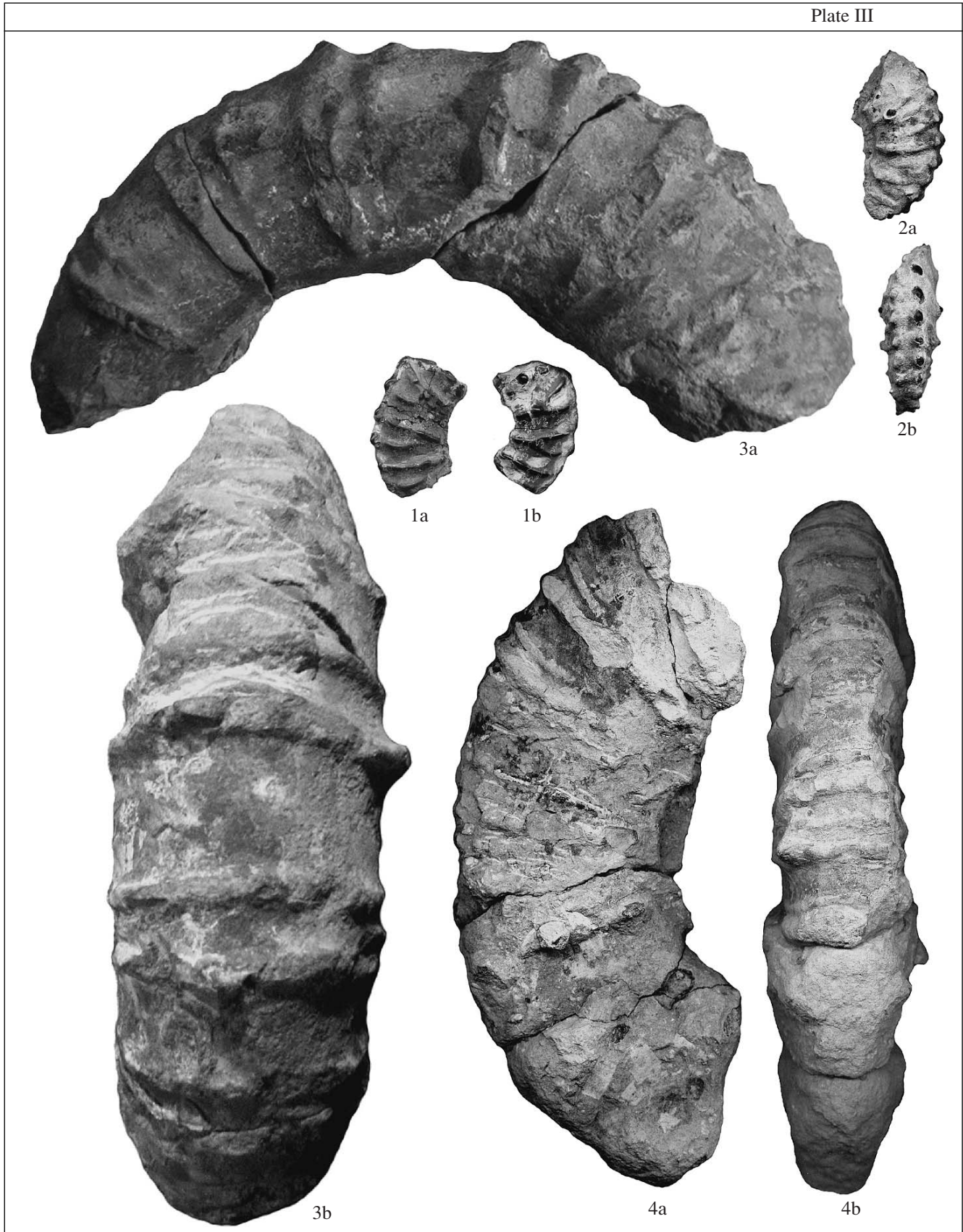
Specimen no.	D	H	W	$D_u$	H/D	W/D	$D_u/D$
23/330	85.0?	25.0	21.0	33.0?	0.29?	0.25?	0.39?
57/13175	210.0	59.0	47.5	99.0	0.28	0.23	0.47

**Comparison and remarks.** Precise identification is impossible for unsatisfactorily preserved specimens. Formerly, we classed Specimen 23/330 from the Crimean Mountains with *Euthymiceras* sp. (Atlas..., 1997) and later on with *Euthymiceras* (?) ex gr. *euthymi* (Arkadiev et al., 2000). Owing to its swollen shell shape with a wide outer side and embossed ribs, the specimen is very similar to the *transfigurabilis* species of Bogoslowski (1895, Plate 6, Fig. 3; see Plate II,

Fig. 5 in this work) from the Ryazanian Horizon. Kalacheva and Sey (2000) included Specimen 23/330 in the synonymous *transfigurabilis* species without sign of an open nomenclature. An examination of their collection stored at the TSNIGR Museum showed a clear similarity between the Crimean and Caucasian specimens, but in this work, we classify the specimen in open nomenclature, as it is preserved insufficiently well. The other specimen of our collection (no.

**Plate II.** Ammonites of genera *Neocosmoceras* and *Transcaspites*:

(1–4) *Neocosmoceras euthymi* (Pictet): (1) Specimen 1/13175: (a) apertural side,  $\times 1$ , (b) outer side,  $\times 1$ , (c) lateral side,  $\times 1$ , (d–f) ditto,  $\times 2$ ; (2) Specimen 13/13175: (a, b) lateral side,  $\times 1$ , (c) outer side,  $\times 1$ ; (3) Specimen 14/13175, lateral side,  $\times 1$ ; central Crimea, village of Balki, *boissieri* Zone, *euthymi* Subzone; (1, 2) collection of V.V. Arkadiev, (3) collection of V.V. Druschits; (4) Specimen 15/11104, lateral side,  $\times 1$  (from work by Luppov et al., 1988); eastern Karatau, Dzhakhsysauran Spring, Berriasian. (5) *N. transfigurabilis* (Bogoslowski), Specimen 64/623, holotype: (a) outer side,  $\times 1$ , (b) lateral side,  $\times 1$ ; East European platform, village of Shatrishchi, Ryazanian Horizon; (6) *N. cf. transfigurabilis* (Bogoslowski), Specimen 23/330: (a) lateral side,  $\times 1$ , (b) outer side,  $\times 1$ ; southwestern Crimea, Belbek River, Kabanii Ravine, *boissieri* Zone, *euthymi* Subzone; collection of V.V. Arkadiev. (7–9) *N. minutus* Arkadiev et Bogdanova, sp. nov.: (7) Specimen 58/13175: (a) lateral side,  $\times 1$ , (b) outer side,  $\times 1$ ; (8) Specimen 62/13175: (a, b) lateral side,  $\times 1$ , (c) outer side,  $\times 1$ ; (9) Specimen 60/13175, holotype: (a, b) lateral side,  $\times 1$ , (c) outer side,  $\times 1$ ; central Crimea, village of Balki, *boissieri* Zone, *euthymi* Subzone; (7) collection of T.N. Bogdanova, (8, 9) collection of V.V. Arkadiev. (10) *Transcaspites transcaspicus* (Luppov), Specimen 10/6801, holotype (from work by Bogdanova et al., 1985): (a) outer side,  $\times 1$ , (b) lateral side,  $\times 1$ ; Mangyshlak, Well Karasyaz, Berriasian; collection of M.V. Bayarnus.



57/13175) from the same locality is much greater in diameter than the ammonite figured and described by Bogoslawski. Nevertheless, we identify it with the *transfigurabilis* forms based on the character of its sculptured and wide whorl cross sections. According to the same morphological features, the specimen from the Berriasian of Algeria described and figured by Pomel (1889, p. 63, Plate 4, Fig. 1) under the name *Ammonites euthymi* Pictet should be also attributed to the *transfigurabilis* species. The Crimean forms show a similarity with that ammonite as well.

The generic affinity of *transfigurabilis* forms remains debatable so far. Many researchers attributed them to the genus (or subgenus) *Euthymiceras* (Grigorieva, 1938; Druschits, 1960; Khimshiashvili, 1976; Kvantaliani, 1999; Kalacheva and Sey, 2000). In his publication on the Ryazanian Horizon of the East European platform, Mitta (2002, 2006, 2007) included the respective species into the genus *Transcaspiites*, however, without substantiation. Luppov distinguished the last genus among the ammonite specimens from the Berriasian Mangyshlak (see Bogdanova et al., 1985). In the last volume of "Treasure on Invertebrate Paleontology" (Wright et al., 1996), dedicated to Cretaceous ammonites, the genus *Transcaspiites* is regarded as synonymous with the genus *Neocosmoceras*. We reviewed specimens of the genus *Transcaspiites* from collections of the TSNIGR Museum and arrived at the conclusion that they are greatly different in morphological characteristics from ammonites of the genus *Neocosmoceras*. Low-evolute whorls with cross sections that are wider than they are high, clearly convex (not flattened) lateral sides, and very prominent prick-shaped lateral tubercles (up to 5–7 mm high) on the young whorls (Plate II, Fig. 10) are characteristic of the latter. These characteristics are untypical of all known species of the genus *Neocosmoceras*, and accordingly we regard the genus *Transcaspiites* as an individual taxon. The *Neocosmoceras polyacanthum* described by Uhlig (1910) from the Berriasian of the Himalayas is the only species that shows some similarity with the genus *Transcaspiites*. The specimen described by Uhlig also has prominent tubercles on inner whorls, but the sculpturing of its adult whorls is different from that of the *Transcaspiites* species. In our opinion, the above data imply that *transfigurabilis* species having the flattened lateral sides of intermediate whorls and lacking prom-

inent prick-shaped tubercles should be attributed to the genus *Neocosmoceras*.

**Distribution:** Berriasian, *boissieri* Zone, *euthymi* Subzone in the Crimean Mountains.

**Material:** two specimens (nos. 23/330 and 57/13175) from southwestern Crimea (Belbek River, village of Kuibyshevo, the Kabanii Ravine); collection of V.V. Arkadiev.

*Neocosmoceras minutus*  
Arkadiev et Bogdanova, sp. nov.

Plate II, Figs. 7–9; Plate III, Figs. 1, 2

**Etymology:** *minutus* (means small in Latin).

**Holotype:** Specimen 60/13175, TSNIGR Museum, St. Petersburg; Berriasian, *boissieri* Zone, *euthymi* Subzone, central Crimea, the Sary-Su River basin, the village of Balki.

**Shape.** These moderately evolute shells are small, rarely medium-sized, with narrow, slightly convex and flat outer sides. The trapezoid cross sections of the whorls are stretched in height. The moderately wide or wide umbilicus has low, gently sloping walls. The umbilical inflection is very smooth.

**Sculpturing.** The lateral sides of young whorls (with a diameter of less than 20 mm) are ornamented with outer tubercles and thin doubled or solitary main ribs. The bifurcation of the ribs originates at a low level, sometimes close to the umbilical inflection, however, it is sometimes not very distinct, in which case, this branch remains unclearly connected with the main rib and resembles the inserted rib. In addition, real inserted ribs originating at the bifurcation points of the main ribs are rarely observable. The ribs do not cross the outer side, leaving a narrow smooth belt there that is bordered by two rows of outer tubercles, which are sometimes posteriorly curved. Lateral tubercles appear at bifurcation points of doubled ribs or at the same level of the solitary ribs on older whorls approaching 20 mm in diameter. On adult shells with  $D = 30\text{--}35$  mm, the bifurcation points of ribs are displaced closer to the midline of the lateral sides, and small umbilical tubercles appear on the umbilical inflection. At this stage, the ribs are very prominent and wider spaced than at the early stages. The prick-shaped lateral and outer tubercles are well developed. On adult shells, the lateral tubercles are localized below the midline of the lateral sides very close to the umbilical tubercles.

**Plate III.** Ammonites of the genus *Neocosmoceras*;

(1, 2) *Neocosmoceras minutus* Arkadiev et Bogdanova sp. nov.: (1) Specimen 73/13175, (a, b) lateral side,  $\times 1$ ; central Crimea, village of Balki, Berriasian, *boissieri* Zone, *euthymi* Subzone; collection of V.V. Druschits; (2) Specimen 66/13175: (a) lateral side,  $\times 1$ , (b) outer side,  $\times 1$ ; the same locality and age, collection of V.V. Arkadiev. (3) *Neocosmoceras* cf. *transfigurabilis* (Bogoslawski), Specimen 57/13175: (a) lateral side,  $\times 0.75$ , (b) outer side,  $\times 0.75$ ; (southwestern Crimea, Belbek River, Kabanii Ravine, *boissieri* Zone, *euthymi* Subzone; collection of V.V. Arkadiev. (4) *Neocosmoceras giganteus* Arkadiev et Bogdanova sp. nov., Specimen 79/13175: (a) lateral side,  $\times 0.75$ , (b) outer side,  $\times 0.75$ ; the same locality and age.

Dimensions (mm), dimensional ratios, and amount of ribs per half whorl.

Specimen no.	D	H	W	D <sub>u</sub>	H/D	W/D	D <sub>u</sub> /D	Amount of ribs per half whorl	
								umbilical	outer
58/13175	22.0	8.4	6.4	7.6	0.38	0.29	0.35	7	11
59/13175	23.5	10.0	7.6	7.0	0.43	0.32	0.30	8	13
60/13175	27.5	10.2	8.0	8.7	0.37	0.29	0.32	9	17
Holotype									
61/13175	31.5	12.1	9.2	8.5	0.38	0.29	0.27	–	–

**Suture line** (Fig. 3h). When H = 6.0 mm, the external segment of the suture line includes outer and lateral lobes, as well as one umbilical lobe. The outer and lateral lobes are equally deep, whereas the umbilical lobe is two times shorter. The saddles are wider than the lobes, and the subordinate lobes dissect their apical segments in two parts. The serration of the lobes and saddles is weak.

**Comparison and remarks.** Bogdanova initially classed ammonites of the described morphology with *Neocosmoceras* ex gr. *rerollei* (Paquier) (Bogdanova et al., 1981; Arkadiev et al., 2007). An examination of new materials during this study implies that they exemplify a new species that is most close to *N. rerollei* Paquier (Paquier, 1901, p. 551, Plate 7, Fig. 3), one of all the known *Neocosmoceras* species. *N. minutus* is of a transitional morphology between the *rerollei* species and its *lamberti* variety distinguished by Kilian (1910) and figured by Mazenot (1939, p. 186, Plate 29, Figs. 5 and 6, Plate 31, Fig. 1). On the shells of the new species, the ribs are wider spaced than on the early whorls of the *N. rerollei* var. *lamberti* but more frequent than on the late whorls of *N. rerollei*, and their bifurcation points are situated lower. Whorls that are more swollen and the earlier appearance of lateral tubercles situated lower are distinctions of new species as compared to the *N. euthymi* (Pictet). The *N. minutus* is close to some extent to the *Neocosmoceras octagonoides* described by Uhlig (1910, p. 207, Plate 27, Figs. 1 and 2) from the Berriasian of the Himalayas, but its umbilical wall is less steep.

**Distribution:** Berriasian, *boissieri* Zone, *euthymi* Subzone in the Crimean Mountains.

**Material:** 22 specimens (nos. 18/13175, 58–78/13175) from central Crimea (the Sary-Su River basin, village of Balki) and the Tonas River basin; collections of

V.V. Druschits, T.N. Bogdanova, V.V. Arkadiev, Yu.N. Savel'eva, A.A. Fedorova, K.Yu. Chetverikova, and M.M. Sheker.

***Neocosmoceras giganteus* Arkadiev et Bogdanova, sp. nov.**

Plate I, Fig. 11; Plate III, Fig. 4

*Neocosmoceras* sp. indet.: Mazenot, 1939, p. 188, Plate 31, Fig. 8.

*Neocosmoceras* sp.: *Atlas...*, 1997, p. 114, Plate 33, Fig. 1; Arkadiev et al., 2000, p. 102, Plate 4, Fig. 6.

**Etymology:** *giganteus* (means great or huge in Latin)

**Holotype:** Specimen 24/330, Museum of the SPGGI (TU), St. Petersburg; Berriasian, *boissieri* Zone, *euthymi* Subzone in southwestern Crimea, the Belbek River, the Kabanii Ravine.

**Shape.** Very large shells whose whorl cross sections are rectangular (Fig. 3e). Their lateral sides are slightly convex and nearly parallel to each other. There is a distinct external inflection toward the narrow, almost flat outer side. The walls of the wide umbilicus are low and gently sloping. The umbilical inflection is smooth. It is impossible to judge the morphology of the young whorls based on the materials of our collection (two fragments of adult whorls).

**Sculpturing.** On the last whorl, the lateral sides are ornamented with rare prominent solitary or doubled ribs. Among three pairs of tubercles, the lateral and external ones are most prominent, extended respectively along and across the ribs. Straight ribs cross the outer side. Thinner intermediate ribs are observable in some interspaces between the main ribs of the lateral sides in the middle part of the latter.

Dimensions (mm) and dimensional ratios.

Specimen no.	D	H	W	D <sub>u</sub>	H/D	W/D	D <sub>u</sub> /D
24/330	200.0	59.0	43.0	90.0	0.30	0.22	0.45

**Comparison.** Crimean forms differ from all known species of the genus *Neocosmoceras* in their extremely

large size and represent most likely a new species. We include the specimen described by Mazenot (1939,

Correlation between the *Neocosmoceras euthymi* Subzone of the Crimean Mountains with concurrent biostratigraphic units of Western Europe, northern Caucasus, and the Russian plate

Standard zones of the Tethyan Realm (Reboulet et al., 2006)		Crimean Mountains (Arkadiev et al., 2008; this work)		Northern Caucasus (Sey and Kalacheva, 2000)		Russian plate (Mitta, 2007)				
Berriasian	<i>Fauriella boissieri</i>	<i>Thurmanniceras otopeta</i>	Valanginian	<i>Thurmanniceras otopeta</i>	?		?			
		<i>Thurmanniceras alpillensis</i>		?						
		<i>Berriasella picteti</i>	<i>Fauriella boissieri</i>		<i>Jabronella</i> cf. <i>paquieri</i> – <i>Berriasella callisto</i> Beds	<i>Fauriella boissieri</i>	<i>Jabronella</i> cf. <i>paquieri</i> – <i>Berriasella callisto</i> Beds		Ryazanian	
					?		<i>Riasanites rjasanensis</i> – <i>R. angulicostatus</i>			
					<i>Riasanites crassicoatum</i>					
		<i>Malbosiceras paramimounum</i>	<i>Fauriella boissieri</i>		<i>Neocosmoceras euthymi</i>	<i>Fauriella boissieri</i>	<i>Riasanites rjasanensis</i> – <i>Spiticeras cautleyi</i>		<i>Riasanites rjasanensis</i>	<i>Surites tzikwinianus</i>
	?			<i>Transcaspiites transfigurabilis</i>						
							<i>Riasanites rjasanensis</i>			

Plate 31, Fig. 8) and possessing large dimensions in contrast to the other *Neocosmoceras* forms as a synonymous example of the new taxon. The Crimean samples resemble this specimen in terms of their whorl outlines and very coarse rib characteristics.

**Distribution:** Berriasian, *boissieri* Zone, *euthymi* Subzone in the Crimean Mountains; the *boissieri* Zone in southeastern France.

**Material:** two specimens (nos. 24/330 and 79/13175) from southwestern Crimea (the Belbek River, village of Kuibyshevo, the Kabanii Ravine); collection of V.V. Arkadiev.

CORRELATION

The *Fauriella boissieri*, *Neocosmoceras euthymi*, *N. cf. transfigurabilis*, *N. minutus* sp. nov., *N. giganteus* sp. nov., *Hegaratia bidichotoma*, *H. nerodenkoi*, *Haploceras carachtheis*, *H. cristifer*, *Euphyloceras serum*, *Leiophylloceras calypso*, and *Spiticeras* sp. are ammonite species characterizing the *euthymi* Subzone in the Crimean Mountains. According to the occurrence of zonal index species *F. boissieri* and its position above the level with the *Dalmasiceras* forms, the *euthymi* Subzone can be correlated with the *paramimounum* Subzone of the standard Tethyan scale (Reboulet et al., 2006) (Table 1).

The Crimean species of the genus *Neocosmoceras* described in this work are different to some extent from their European counterparts, being more similar to forms from sections of the East European platform, northern Caucasus, Mangyshlak, and Himalayas.

Based on the occurrence of the *euthymi* and *transfigurabilis* species, the *euthymi* Subzone of the Crimea can be correlated most confidently with the synonymous biostratigraphic unit of the northern Caucasus (Sey and Kalacheva, 2000).

In the section near the village of Balki in central Crimea, there is a stratigraphic interval below the *euthymi* Subzone that is barren of guide ammonite species (Fig. 2, Member 8). As it was mentioned already (Arkadiev et al., 2008), this interval can be correlated with the *Riasanites rjasanensis*–*Spiticeras cautleyi* Subzone of the northern Caucasus recognized there below the *euthymi* Subzone as well. As the *euthymi* species occurs in Mangyshlak (Luppov et al., 1988), equivalents of the *euthymi* Subzone can be recognized in this region also. The most obvious equivalents of the subzone are the upper part of the *Neocosmoceras*–*Septaliphoria semenovi* local zone, where abundant *Neocosmoceras* forms have been found, and the *Buchia volgensis* local zone bearing ammonites close to the *euthymi* species. This interval of the Berriasian succession in Mangyshlak is correlative with the *parami-*

*mounum* Subzone of the *boissieri* Zone in southeastern France (*Zones ...*, 1989, p. 29).

It is more difficult to correlate the *euthymi* Subzone with biostratigraphic subdivisions established in sections of the East European platform. Sey and Kalacheva (2000) correlated the *euthymi* Subzone of the Caucasus with the upper part of the *Riasanites rjasanensis* Zone in the Oka River basin. Mitta (2002) portrayed the *Euthymiceras euthymi* species from deposits of the *rjasanensis* Zone in the Moscow region (we agree with his identification). On the other hand, Mitta (2005, 2007) omitted this species from consideration in his later works. In such a case, the occurrence of *transfigurabilis* forms is very important for correlation. In the *R. rjasanensis* Zone, Mitta (2007) distinguished the upper *Transcaspiites transfigurabilis* assemblage and correlated it with ammonite assemblages of the *euthymi* Subzone in the northern Caucasus, on the one hand, and with assemblages of the standard *paramimounum* Subzone on the other hand. Therefore, the *euthymi* and *transfigurabilis* species found in the Crimean Mountains suggest that the *euthymi* Subzone of the study region is correlated to the upper part of the *R. rjasanensis* Zone in the East European platform.

### CONCLUSIONS

1. The *Euthymiceras* genus is considered in this work as a junior synonym of the *Neocosmoceras* genus. Four species (*N. euthymi*, *N. cf. transfigurabilis*, *N. minutus* sp. nov., and *N. giganteus* sp. nov.) are identified in the Berriasian deposits of the Crimean Mountains and described for the first time.

2. The *Euthymiceras–Neocosmoceras* Beds formerly distinguished in the Crimean Mountains (Bogdanova et al., 1981; Arkadiev et al., 2006, 2008) can be ranked at present as the *Neocosmoceras euthymi* Subzone in the form of an index species. The reference section of this subzone is near the village of Balki in the central Crimea (Fig. 2). Bogdanova and Kvantaliani (1983) described successive beds of this section, including those of the *euthymi* Subzone.

3. Based on the occurrence of *euthymi* and *transfigurabilis* forms, the *euthymi* Subzone of the Crimean Mountains is correlated with a synonymous subzone in the northern Caucasus, with the *Neocosmoceras–Septaliphoria semenovi* (upper part) and the *Buchia volgensis* local zones in Mangyshlak, and also with the upper part of the *Riasanites rjasanensis* Zone in the East European platform. According to the *boissieri* index species found in the *euthymi* Subzone and the position of the latter above the *Dalmasiceras* Beds, the biostratigraphic unit under consideration is correlative with the *paramimounum* Subzone of the standard Tethyan scale.

Reviewers M. A. Rogov and V.A. Zakharov

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