

Middle Cenomanian ammonites from the type section of the Sanandinovo Formation of northern Bulgaria

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ABSTRACT:

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The type section of the Sanandinovo Formation between the villages of Sanandinovo and Novachene in northern Bulgaria has yielded numerous ammonites from packages 7-9 of the sequence recognised by previous authors. The assemblage is: *Tetragonites subtimotheanus* WIEDMANN, 1962, *Puzosia (Puzosia) mayoriana* (D'ORBIGNY, 1841), *Acanthoceras jukesbrownei* (SPATH, 1926), *Protacanthoceras tuberculatum tuberculatum* THOMEL, 1972, *Calycoceras (Newboldiceras) asiaticum asiaticum* (JIMBO, 1894), *C. (N.) asiaticum spinosum* (KOSSMAT, 1897), *C. (N.) planecostatum* (KOSSMAT, 1897), *Calycoceras (Proeucalycoceras) picteti* WRIGHT & KENNEDY, 1990, and *Scaphites equalis* J. SOWERBY, 1813. The assemblage indicates the upper Middle Cenomanian *Acanthoceras jukesbrownei* Zone of Western Europe. We have seen no evidence for either older or younger Cenomanian ammonite zones from the sequence.

Key words: Ammonites, Cenomanian, Bulgaria.

INTRODUCTION

The Sanandinovo Formation is a 78 m thick sequence of marls with rarer interbeds of marly limestone that has a type section between the villages of Sanandinovo and Novachene in northern Bulgaria (JOLKIČEV, 1987, 1989; JOLKIČEV & *al.* 1988; Text-fig. 1). The formation overlies glauconitic sandstones assigned to the Upper Albian *Stoliczkaia dispar* Zone, and is in turn overlain by glauconitic sandstones of the Belobardo Formation, the base of which is assigned to the Upper Turonian on the basis of the occurrence of *Subprionocyclus hitchinensis* (BILLINGHURST, 1927) and other fossils. It is divided into six sediment packets (Text-fig. 2), following JOLKIČEV & *al.* 1988, as follows:

- glauconitic sandstones (Belobardo Formation–Upper Turonian – Lower Campanian)

————— erosional contact —————
Packet 10-gray, indistinctly bedded, clayey marls with extremely rare interbeds of fine-bedded (10-15 cm) clayey limestones – 36.00 m
Packet 9-gray, indistinctly bedded, clayey marls with extremely rare interbeds of fine-bedded (10-20 cm) microgranular clayey limestones – 15.00 m
Packet 8-marls, slightly aleuritic, yellowish, indistinctly bedded with frequent limonite concretions – 5.00 m
Packet 7-marls (opposite the bridge on the Osam River), gray, massive, commonly including muscovite flakes – 5.00 m
Packet 6-marls, gray, indistinctly bedded, locally slightly aleuritic – 10.00 m
Packet 5 -marls, grayish-whitish, indistinctly bedded, clayey, at the base slightly arenitic, with glauconite – 7.00 m
————— gradual transition —————
Packet 4-(Dispar Zone) – glauconitic sandstones

The microfaunas of the Formation were listed by JOLKIČEV & *al.* (1988), who also provided a preliminary listing of the ammonite faunas. On the basis of these records, and those of NIKOLOV & NACHEV (1962) in correlative sediments in the Pleven district, they recognised a Lower Cenomanian *Mantelliceras mantelli* Zone, to which they assigned packets 5 and 6, a Middle Cenomanian *Acanthoceras rhotomagense* Zone, to which they assigned packets 7, 8, and part of 9, and an Upper Cenomanian *Calycoceras naviculare* Zone, to which they assigned the upper part of packet 9, and packet 10.

The currently widely recognized ammonite zonation of the Cenomanian stage in Western Europe is as follows:

Substage	Zone	Subzone
Upper Cenomanian	{ <i>Neocardioceras juddii</i> <i>Metoicoceras geslinianum</i> <i>Calycoceras guerangeri</i>	
Middle Cenomanian	{ <i>Acanthoceras jukesbrownei</i> <i>Acanthoceras rhotomagense</i> <i>Cunningtoniceras cunningtoni</i>	{ <i>Turrilites acutus</i> <i>Turrilites costatus</i>
Lower Cenomanian	{ <i>Mantelliceras dixonii</i> <i>Mantelliceras mantelli</i>	{ <i>Mantelliceras saxbii</i> <i>Neost. carcitanense</i>

Ammonite evidence for a Lower Cenomanian date for the lower part of the Sanandinovo Formation is lacking in the material studied here. NIKOLOV & NACHEV (1962) recorded *Mantelliceras mantelli* (J. SOWERBY, 1814) and *Mantelliceras martimpreyi* (COQUAND, 1862) from the correlative of package 5 in the Pleven district. We have been unable to examine these specimens; their *M. mantelli* (1962, pl. 1, figs 1, 2) is generically indeterminate from the figures. Their *M. martimpreyi* (1962, pl. 1, fig. 3) does not belong to that species, which is a junior synonym of *Mantelliceras saxbii* (SHARPE, 1857), and is again generically indeterminate from the figure.

At the type section, ammonites are present from the basal part of package 7 to the upper part of package 9. The assemblage is: *Tetragonites subtimotheanus* (WIEDMANN, 1962) *Puzosia* (*Puzosia*) *mayorana* (D'ORBIGNY, 1841), *Acanthoceras jukesbrownei* (SPATH, 1926), *Protacanthoceras tuberculatum tuberculatum* THOMEL, 1972, *Calycoceras* (*Newboldiceras*) *asiaticum asiaticum* (JIMBO, 1894), *C. (N.) asiaticum spinosum* (KOSSMAT, 1897), *C. (N.) planecostatum* (KOSSMAT, 1897), *Calycoceras* (*Proeucalycoceras*) *picteti* WRIGHT & KENNEDY, 1990, and *Scaphites equalis* J. SOWERBY, 1813. The range and occurrence of all of these species is documented in detail by WRIGHT & KENNEDY (1984, 1987, 1990, 1995, 1996), and the assemblage can be confidently assigned to the upper Middle Cenomanian *Acanthoceras jukesbrownei* Zone. We have seen no evi-



Fig. 1. Locality map showing the position of the type section of the Sanandinovo Formation, which is between the villages of Sanandinovo and Novachene, in northern Bulgaria

dence for either older or younger Cenomanian ammonite zones.

SYSTEMATIC PALAEOONTOLOGY

All dimensions are given in millimetres as follows: D = diameter; Wb = whorl breadth; Wh = whorl height; U = umbilicus. Figures given in parentheses are dimensions expressed as a percentage of diameter. Repositories of specimens are indicated as follows: GPSU: Department of Geology and Geography, University of Sofia; BMNH: The Natural History Museum, London; OUM: Oxford University Museum of Natural History.

Order Ammonoidea ZITTEL, 1884
Suborder Lytoceratina HYATT, 1889
Superfamily Tetragnostaceae HYATT, 1900
Family Tetragnostidae HYATT, 1900
Genus *Tetragnostes* KOSSMAT, 1895

TYPE SPECIES: *Ammonites timotheanus* PICTET, 1847, p. 295, pl. 2, fig. 6; pl. 3, figs 1, 2, by original designation.

Tetragnostes subtimotheanus WIEDMANN, 1962
(Pl. 1, Figs 1-3; Pl. 5, Fig. 5)

1973. *Tetragnostes subtimotheanus maclearni* WIEDMANN, p. 595, pl. 4, fig. 1; pl. 5, figs 1-3; text-fig. 3.
1984. *Tetragnostes subtimotheanus subtimotheanus* WIEDMANN, 1962; WRIGHT & KENNEDY, p. 40, pl. 1, figs 3, 4; text-fig. 1g (with synonymy).
1987. *Tetragnostes subtimotheanus maclearni* WIEDMANN; THOMEL, p. 16, pl. 2, figs 5, 6; pl. 3, fig. 2; pl. 4, figs 1-3, 8-10; pl. 5, figs 1, 2, 6-8 (with synonymy).
1988. *Mesogaudryceras leptonema* (SHARPE); JOLKIČEV & *al.*, p. 27.
1988. *Mesogaudryceras cf. leptonema* (SHARPE); JOLKIČEV & *al.*, p. 27.
1994. *Tetragnostes subtimotheanus* WIEDMANN, 1962a; KENNEDY, p. 217, pl. 2, fig. 15; pl. 4, figs 5, 6, 9-14, 18-22.

TYPE: The holotype, by original designation, is the original of KOSSMAT (1895, pl. 17(3), fig. 13), from the lower part of the Utatur Group of south India, and is probably of Cenomanian age.

MATERIAL: GPSU 2603, 2612.

DESCRIPTION: 2612 (Pl. 5, Fig. 5) is a very laterally crushed individual 51 mm in diameter, with U = 26% of diameter. 2603 (Pl. 1, Figs 1-3) is less crushed, 50.7 mm in diameter, with the following dimensions: D = 50.7(100);

Wb = -(-); Wh = 36.7(45.5%); U = 19.3(23.9). The specimen retains a 240° sector of body chamber, and shows eccentric coiling over the last half of the outer whorl, suggesting it may be adult. The umbilicus is deep, with a flattened, subvertical wall, and narrowly rounded umbilical shoulder. The flanks are flattened and subparallel, the ventrolateral shoulders broadly rounded, and the venter very feebly convex. The compressed whorl section (Pl. 1, Figs 1, 3) is a result of the post-mortem crushing. There are an estimated four constrictions on the half whorl that comprises the adapertural end of the phragmocone and the adapical end of the body chamber. The constrictions are narrow, faint, markedly prorsiradial, very feebly concave on the inner to middle flank, broadly convex on the outermost flank and ventrolateral shoulder, sweeping backwards, and crossing the venter in a relatively deep concavity. The constrictions are accompanied by growth lines and striae, and ill-defined adapical collars, most obvious on the ventrolateral shoulders. There is a faint, low, rounded mid-ventral ridge.

DISCUSSION: See WIEDMANN (1973) and THOMEL (1987).

OCCURRENCE: The total stratigraphic range of *T. subtimotheanus* and its subspecies is upper Lower Albian to Upper Cenomanian. The geographic range extends from SE France to southern England, Bulgaria, Crimea, Zululand (South Africa), Madagascar, south India, Alaska, Oregon and British Columbia.

Order Ammonitina HYATT, 1889
Superfamily Desmocerataceae ZITTEL, 1895
Family Desmoceratidae ZITTEL, 1895
Subfamily Puzosiinae SPATH, 1922
Genus *Puzosia* BAYLE, 1878
Subgenus *Puzosia* BAYLE, 1878

TYPE SPECIES: *Ammonites planulatus* J. DE C. SOWERBY (1827, p. 134, pl. 570, fig. 5) (*non* SCHLOTHEIM, 1820, p. 59 = *Ammonites mayorianus* D'ORBIGNY, 1841, p. 267, pl. 79, figs 1-3). WRIGHT & KENNEDY (1984, p. 54) clarify the name of the type species.

Puzosia (Puzosia) mayoriana (D'ORBIGNY, 1841)
(Pl. 1, Figs 4-6)

1827. *Ammonites planulatus* J. DE C. SOWERBY, p. 597, pl. 570, fig. 5 (*non* SCHLOTHEIM, 1820, p. 59).
1841. *Ammonites mayorianus* D'ORBIGNY, p. 267, pl. 79, figs 1-3.
1984. *Puzosia (Puzosia) mayoriana* (D'ORBIGNY, 1841); WRIGHT & KENNEDY, p. 55, pl. 3, figs 1, 2, 4, 6, 9-12; pl. 4, figs 1, 2,

- 5-7; text-figs 1a, b; 2c, h, m; 3n-r; 4a-e (with full synonymy).
 1985. *Puzosia* (*Puzosia*) cf. *subplanulata* (SCHLÜTER, 1871); IMMEL & SEYED-EMAMI, p. 91.
 1987. *Puzosia* (*Puzosia*) *mayoriana* (D'ORBIGNY, 1841); COOPER & KENNEDY, p. 106, figs 1-7, 9, 10.
 1987. *Puzosia* (*Puzosia*) *mayoriana* (D'ORBIGNY, 1841); WRIGHT & KENNEDY, p. 142, pl. 47, fig. 4.
 1991. *Puzosia* (*Puzosia*) *mayoriana* (D'ORBIGNY, 1841); DELAMETTE & KENNEDY, p. 442, fig. 8.26.
 1994. *Puzosia* (*Puzosia*) *planulata* (D'ORBIGNY, 1841); KENNEDY, p. 220, pl. 2, figs 10-12, 18; pl. 5, figs 1-9.
 1996. *Puzosia* (*Puzosia*) *mayoriana* (D'ORBIGNY, 1841); KENNEDY in GALE & al., p. 552, figs 10f; 11k, l; 14h-n.
 1996. *Puzosia* (*Puzosia*) *mayoriana* (D'ORBIGNY, 1841); KENNEDY, BILOTTE & HANSOTTE, p. 312, Pl. 39, Figs 4, 5 (with additional synonymy).
 1998. *Puzosia* (*Puzosia*) *mayoriana* (D'ORBIGNY, 1841); KAPLAN & al., p. 71, pl. 1, figs 12, 13; pl. 9, figs 1, 11, 12; pl. 10, figs 3-5.
 1998. *Puzosia mayoriana* (D'ORBIGNY, 1841); LEHMANN, p. 15, pl. 1, figs 3, 4, 6; pl. 2, fig. 7.

LECTOTYPE: By the subsequent designation of WRIGHT & WRIGHT, 1951, p. 35): BMNH C9381, from the Lower Chalk of Hamsey near Lewes, Sussex. This specimen was designated lectotype of *planulatus* of J. DE C. SOWERBY for which D'ORBIGNY proposed *mayorianus* as replacement name.

MATERIAL: GPSU 3955.

DESCRIPTION: GPSU 3955 is a well-preserved, laterally crushed composite mould. The dimensions are, D = 107.3(100); Wb = 24.6(22.9); Wh = 41.1(38.3); U = 31.1(29.0). Coiling is moderately involute, with 77% of the previous whorl covered. The umbilicus is shallow, with a low, flattened, outward-inclined umbilical wall. The umbilical shoulder is very narrowly rounded. The whorl breadth to height ratio (modified by compaction) is 0.6, with very feebly convex, flattened, subparallel flanks, and narrowly arched, rounded venter. There are 7 widely separated constrictions on the outer whorl. They are straight and prorsiradial on the inner flank, convex on the mid-flank region, flexing back and concave on the outer flank, and sweeping forwards to cross the venter in a marked convexity. The edges of the constrictions are strengthened into narrow collar ribs, the adapical more prominent than the adapertural. The constrictions are weak on the flanks but strengthen and become very prominent (notably the adapical one) across the venter (Pl. 1, Fig. 6). There are 9-13 ribs between the collared constrictions. They parallel the constrictions, are very weak on the inner flank, but strengthen across the outer flanks, and are at their most prominent on the ventrolateral shoulders and venter.

DISCUSSION: See WRIGHT & KENNEDY (1984, p. 87), and COOPER & KENNEDY (1987, p. 106).

OCCURRENCE: Upper Albian to Upper Cenomanian, Europe, Africa, South India, Japan.

Superfamily Acanthocerataceae DE GROSSOUVRE, 1894
 Family Acanthoceratidae DE GROSSOUVRE, 1894
 Subfamily Acanthoceratinae DE GROSSOUVRE, 1894
 Genus *Acanthoceras* NEUMAYR, 1875

TYPE SPECIES: By the subsequent designation of DE GROSSOUVRE (1894, p. 27) *Ammonites rhotomagensis* BRONGNIART (1822, p. 83, 391, pl. 6 fig. 2).

Acanthoceras jukesbrownei (SPATH, 1926)
 (Pl. 2, Figs 9-12; Pl. 3, Fig. 12)

1926. *Protacanthoceras jukesbrownei* SPATH, p. 82.
 1984. *Acanthoceras jukesbrownei* (SPATH); KAPLAN & al., pl. 6, fig. 2.
 1986. *Acanthoceras jukesbrownei* (SPATH); KENNEDY, pl. 7, figs 3, 4.
 1987b. *Acanthoceras jukesbrownei* (SPATH, 1926a); WRIGHT & KENNEDY, p. 191, pl. 49, figs 2-4; pl. 50, figs 1-5; pl. 51, figs 1-7; text-figs 55-62; 64c, 65e, f, h-j, l, m; 66e; 67h-l (with full synonymy).
 1988. *Acanthoceras jukesbrownei* (SPATH, 1926a); LEHMANN, p. 143, figs 12-15.
 1988. *Acanthoceras rhotomagensis* (BRONGNIART); JOLKIČEV & al., p. 27.
 1992. *Acanthoceras jukesbrownei* (SPATH); THOMEL, pl. 34, figs 1, 2; pl. 35, pl. 37, figs 3, 4.
 1994. *Acanthoceras jukesbrownei* (SPATH); KENNEDY, p. 225, pl. 9, figs 11, 12.
 1996. *Acanthoceras jukesbrownei* (SPATH, 1926a); KENNEDY & al., p. 313, pl. 40, fig. 5.
 ?1997. *Acanthoceras* cf. *jukesbrownei* (SPATH); WILMSEN, pl. 19, fig. 4.
 1997. *Acanthoceras jukesbrownei* (SPATH); WILMSEN, pl. 38, fig. 1.
 1998. *Acanthoceras jukesbrownei* (SPATH, 1926a); KAPLAN & al., p. 144, pl. 48, figs 3, 4; pl. 49, fig. 1; pl. 50, figs 1, 2; pl. 62, fig. 3.
 1998. *Acanthoceras jukesbrownei* (SPATH, 1926a); LEHMANN, p. 25, pl. 4, fig. 2.

MATERIAL: GPSU 3942, 2651

TYPE: Holotype, by monotypy, is BMNH 50162, the original of SHARPE (1855, pl. 17, fig. 2) [reillustrated by WRIGHT & KENNEDY (1987, pl. 50, fig. 3)] from the basement bed of the Lower Chalk at Man O'War Cave, Dorset, England.

DESCRIPTION: 3942 is a nucleus, deformed into an ellipse with a maximum preserved diameter of 32 mm (Pl. 2, Figs 9-12). The coiling appears to have been moderately evolute, the whorl section depressed trapezoidal in intercostal section, and depressed polygonal in costal section. There are an estimated 21 ribs on the outer whorl. Primary ribs arise at the umbilical seam, and strengthen into coarse bullae, perched on the umbilical shoulder. These give rise to coarse, straight, prorsiradiate ribs that link to strong, subspinose inner ventrolateral tubercles. A coarse rib links to weaker outer ventrolateral clavi, and passes straight across the venter, bearing a subequal siphonal clavus. Primaries are separated by single intercalated ribs that arise both low and high on the flanks and have no, or only a weak inner ventrolateral tubercle. These ribs strengthen to match the primaries, and bear equal outer ventrolateral and siphonal clavi. GPSU 2651 (Pl. 3, Fig. 12) comprises a 240° sector of juvenile body chamber with an estimated original diameter of 124 mm. Coarse primary ribs arise at well-developed umbilical bullae, and are straight and prorsiradiate on the flanks, linking to coarse conical-clavate inner ventrolateral tubercles. These ribs are separated by single intercalated ribs that arise low on the flank and link to similar inner ventrolateral tubercles. A low, broad rib links these tubercles to long outer ventrolateral clavi, and a very broad rib that is wider than the interspaces links to a weak, effacing siphonal clavus (Pl. 3, Fig. 12).

DISCUSSION: As noted by WRIGHT & KENNEDY (1987, p. 192), juveniles of *A. jukesbrownei* differ from those of *A. rhotomagense* in the presence of one or several secondary ribs between primaries with weaker or no inner ventrolateral tubercles, rather than regularly alternate long and short ribs with equal inner ventrolaterals. In middle growth short ribs persist to 120 mm at least in early forms of *jukesbrownei*, and persist to maturity in late forms.

OCCURRENCE: Upper Middle Cenomanian, index of the *A. jukesbrownei* Zone. Recorded from southern England, the Münster Basin in Westphalia, Germany, Boulonnais, Haute Normandie, Sarthe, and Provence in France, Poland, Bulgaria (the present records), and Kopet Dag, Turkmenistan.

Genus *Protacanthoceras* SPATH, 1923

TYPE SPECIES: *Ammonites bunburianus* SHARPE (1853, p. 25, pl. 9, fig. 3) by original designation by SPATH (1923, p. 144).

Protacanthoceras tuberculatum tuberculatum THOMEL, 1972 (Pl. 2, Figs 1, 2, 5-8)

1972. *Protacanthoceras tuberculatum* THOMEL, p. 101, pl. 32, figs 9-12.

1987. *Protacanthoceras tuberculatum* THOMEL, 1972; WRIGHT & KENNEDY, p. 206, pl. 46, fig. 5; pl. 54, figs 1-4; text-fig. 82A, C, H; text-fig. 84A-C (with full synonymy).

1988. *Protacanthoceras compressum* (JUKEB-BROWNE); JOLKIČEV & al., p. 26, 27.

TYPE: The holotype, by monotypy, is the original of THOMEL (1972, pl. 32, figs 9-12), no. 17525 in the THOMEL Collection, housed in the Collections of the Faculté des Sciences, Nice, from the lower Upper Cenomanian of Peille, Alpes-Maritimes, France.

MATERIAL: GPSU 2579, 2645.

DESCRIPTION: GPSU 2579 (Pl. 2, Figs 5-8) is a well-preserved, laterally crushed composite mould with the following dimensions at D = 28.0 (100); Wb: -(-); Wh: 12.2(43.6); U: 7.4(26.4); the original diameter was over 31 mm. Coiling is moderately involute, the umbilicus of moderate depth, with a flattened subvertical wall and narrowly rounded umbilical shoulder. The whorl section is compressed, as a result of post-mortem crushing, with flattened subparallel flanks. Primary ribs arise at the umbilical seam, and strengthen across the umbilical wall, developing into weak to strong bullae, perched on the umbilical shoulder, six in all on the outer half whorl. They give rise to single straight, prorsiradiate, coarse, feebly convex ribs, with single ribs intercalated between, in some cases tenuously linked to the umbilical bulla. All ribs bear strong conical to feebly clavate inner ventrolateral tubercles. A broad strong rib connects to strong outer ventrolateral clavi, linked across the venter by a strong transverse rib, bearing a subequal siphonal clavus. It is interpreted as an incomplete macroconch. GPSU 2645 (Pl. 2, Figs 1, 2) is an incomplete individual preserved to a diameter of 28 mm, associated with a juvenile *Calycoceras* (*Newboldiceras*) sp. Ornament is coarser, with more widely separated ribs than in GPSU 2579, while at the largest preserved diameter, the inner ventrolateral tubercles are lost and the last two ribs crowd, suggesting the specimen to be a near-complete microconch.

DISCUSSION: The representatives of the genus *Protacanthoceras* were comprehensively reviewed by WRIGHT & KENNEDY (1980, 1987), who discuss differences between *P. tuberculatum mite* and other subspecies.

OCCURRENCE: Middle and lower Upper Cenomanian, southern England, France, and Bulgaria (the present records).

Genus *Calycoceras* HYATT, 1900, p. 589
(ICZN Generic Name No. 1352)

TYPE SPECIES: By designation under the Plenary Powers (ICZN Opinion No. 557) *Ammonites navicularis* MANTELL (1822, p. 198, pl. 22, fig. 5) (ICZN Specific name).

Subgenus *Calycoceras* (*Newboldiceras*) THOMEL, 1972

TYPE SPECIES: By original designation by THOMEL (1972, p. 105) *Acanthoceras newboldi* KOSSMAT, 1897, p. 5(112), which is a junior synonym of *Acanthoceras rhotomagense* var. *asiaticum* JIMBO, 1894, p. 177, pl. 20, fig. 1 (WRIGHT & KENNEDY, 1990, p. 239).

Calycoceras (*Newboldiceras*) *asiaticum asiaticum* (JIMBO, 1894)

(Pl. 3, Fig. 1; Pl. 4, Figs 6, 7; Pl. 5, Figs 1-4)

1865. *Ammonites Rotomagensis* DEFRANCE; STOLICZKA, p. 66 (*pars*), including *typicus* (p. 68) (*pars*) and var. *subcompressus* (p. 68), pl. 34, figs 3, 4; pl. 35, fig. 1; pl. 36, fig. 1; pl. 37, figs 1, 2.
1894. *Acanthoceras rhotomagense* var. *asiatica* JIMBO, p. 177, pl. 20, fig. 1.
1897. *Acanthoceras Newboldi* n.sp. (Typische form) KOSSMAT, p. 5 (112), pl. 1 (12), figs 2, 3; pl. 3 (14), fig. 2.
1972. *Newboldiceras* (*Newboldiceras*) *newboldi* (KOSSMAT); THOMEL, p. 106 (*pars*), pl. 40, figs 1-3; *non* pl. 34, figs 1-3; pl. 38, figs 1, 2; pl. 39, figs 1-3; pl. 41; ?pl. 42, figs 3, 4.
1988. *Mantelliceras* cf. *mantelli* (SOWERBY); JOLKIČEV & al., p. 27.
1988. *Calycoceras* (*Cal.*) *multicostatum* (COLLIGNON); JOLKIČEV & al., p. 27.
1988. *Calycoceras* cf. *paucinodatum* (CRICK); JOLKIČEV & al., p. 27.
1990. *Calycoceras* (*Newboldiceras*) *asiaticum asiaticum* (JIMBO, 1894); WRIGHT & KENNEDY, p. 239, pl. 58, fig. 1; pl. 64, figs 1, 2; pl. 65, figs 1-3, 5, 7; pl. 72, fig. 3; text-figs 87a-c; 88f; 97; 98 (with full synonymy).
1994. *Calycoceras* (*Newboldiceras*) *asiaticum asiaticum* (JIMBO, 1894); KENNEDY, p. 227, pl. 7, figs 7, 8; pl. 8, figs 1, 2.
1997. *Calycoceras* (*Newboldiceras*) *asiaticum asiaticum* (JIMBO); WILMSEN, pl. 16, fig. 1.

TYPE: The holotype by monotypy is the original of JIMBO (1894, pl. 20, fig. 1), no. 1-105 in the Collections of the Geological Institute, Tokyo University, from the Middle Cenomanian *Trigonia* Sandstone of the Ikushumbets, Hokkaido, Japan.

MATERIAL: GPSU 2630, 2649, 2662, 3950.

DESCRIPTION: GPSU 2649 (Pl. 5, Figs 1-4) is a well-preserved juvenile, with a maximum preserved diameter of 48.3 mm. Coiling is moderately evolute; the umbilicus comprises 26% approximately of the diameter. The whorl section has been modified by post-mortem compaction but appears to have been trapezoidal in intercostal section, and polygonal in costal section.

There are an estimated 40 or more ribs on the outer whorl. On the adapical half whorl, primary ribs arise at the umbilical seam, and strengthen into prominent sharp bullae, perched on the umbilical shoulder. Straight, prorsiradiate ribs strengthen across the flanks and venter, and bear strong subspinose inner ventrolateral tubercles, and smaller outer ventrolateral and siphonal clavi. The primary ribs are separated by one or two long or short intercalated ribs with no or weak inner ventrolateral tubercles, plus outer ventrolateral and siphonal clavi that are equal in strength to those on the primary ribs. On the adapertural half of the outer whorl, bullate primary ribs are separated by up to 3 long or short intercalated ribs. The inner ventrolateral clavi decline and are lost, the outer ventrolateral clavi persist, while the siphonal clavi decline. These changes suggest the specimen may be a small microconch.

GPSU 2662 (Pl. 4, Figs 6, 7) is a slightly deformed individual 147 mm in diameter. The penultimate whorl bears crowded bullate primary ribs with one, rarely two long or short intercalated ribs between. There are an estimated 42-44 ribs on the outer whorl. Primary ribs arise at the umbilical seam, and strengthen into prominent bullae perched on the umbilical shoulder, which give rise to relatively coarse, straight, prorsiradiate ribs, usually singly, occasionally in pairs, with one or two long or short intercalated ribs between. At the adapical end of the outer whorl there are blunt inner ventrolateral tubercles and well developed small outer ventrolateral and siphonal clavi, borne on a coarse transverse rib. As size increases, the ribbing coarsens, inner and outer ventrolateral tubercles persist, but the siphonal clavi are lost, leaving a broad, feebly convex venter.

DISCUSSION: *Calycoceras* (*Newboldiceras*) *asiaticum asiaticum* and *C. (N.) asiaticum spinosum* (KOSSMAT, 1897) are closely allied, and linked by occasional passage forms. They differ in the much more robust tuberculation of the latter, well-seen in the present collection (compare Pl. 4, Figs 1-5 and Pl. 4, Figs 6, 7).

OCCURRENCE: Middle and upper Middle Cenomanian, rarer in the lower Upper Cenomanian. Southern England, northern and southern France, Spain, Romania, Bulgaria, Tunisia, Zululand (South Africa), Madagascar, south India, and Japan, with possible records from Poland, Israel, and China.

Calycocheras (Newboldiceris) asiaticum spinosum
(KOSSMAT, 1897)

(Pl. 3, Figs 7, 10, 11; Pl. 4, Figs 1-5; Pl. 5, Figs 6-11)

1897. *Acanthocheilus Newboldi* var. *spinosa* KOSSMAT, p. 7 (114), pl. 2 (13), figs 2, 3; pl. 3 (14), fig. 1.
1972. *Newboldiceris (Newboldiceris) spinosum* (KOSSMAT); THOMEL, p. 110, pl. 42, figs 1, 2; pl. 46, figs 1-3.
1988. *Acanthocheilus rhotomagense* (BRONGNIART); JOLKIČEV & al., p. 27.
1988. *Calycocheras (Cal.) boulei* (COLLIGNON); JOLKIČEV & al., p. 27.
1988. *Eucalycocheras* sp.; JOLKIČEV & al., p. 27.
1988. *Mantelliceras (Promantelliceras) picteti* cf. *densecostata* THOMEL; JOLKIČEV & al., p. 27.
1990. *Calycocheras (Newboldiceris) asiaticum spinosum* (KOSSMAT, 1897); WRIGHT & KENNEDY, p. 249, pl. 64, fig. 3; pl. 65, figs 4, 6; pl. 66, figs 3, 4; pl. 69, fig. 1; pl. 70, fig. 3; text-figs 87a-c; 88d, l; 99; 100; 102; 107k (with full synonymy).
1994. *Calycocheras (Newboldiceris) asiaticum spinosum* (KOSSMAT, 1897); KENNEDY, p. 228, pl. 9, figs 1-3, 7-9; pl. 10, figs 12, 13.
1997. *Calycocheras (Newboldiceris) asiaticum spinosum* (KOSSMAT); WILMSEN, pl. 12, fig. 1; pl. 20, fig. 1.

TYPES: Lectotype, designated by WRIGHT & KENNEDY (1990) is the original of KOSSMAT (1897, pl. 2 (13), fig. 2), from the Utatur Group of Odium, South India. Paralectotypes are the originals of KOSSMAT's [pl. 2 (13), fig. 3, and pl. 3 (14), fig. 1]. The paralectotype in STOLICZKA (1865, pl. 35, fig. 2) may not belong to this subspecies.

MATERIAL: 11 specimens, GPSU 2572, 2574, 2576, 2577, 2625, 2632, 2643, 2652, 3943, 3953, 6022.

DESCRIPTION: All specimens are crushed to varying degrees. Coiling is moderately evolute, with an umbilicus that ranges from 28% at a diameter of 73 mm in GPSU 2574 (Pl. 5, Figs 6-8) to 31% in GPSU 2572 (Pl. 5, Figs 9-11). The umbilicus of moderate depth, with a flattened wall and narrowly rounded umbilical shoulder. The whorl section is trapezoidal in intercostal section, and polygonal in costal section. Strong primary ribs arise at the umbilical seam, and develop into strong, subspinose to spinose bullae, perched on the umbilical shoulder. These give rise to strong prorsiradiate primary ribs, either singly, or in pairs, the second rib varying from strongly to weakly attached to the bulla. One or two long or short ribs intercalate between the bullate ribs. All ribs bear well-developed inner and outer ventrolateral clavi, the latter linked across the venter by strong rounded ribs. There are an estimated 46 ribs per whorl in GPSU 2574, and 48 in GPSU 2572. Siphonal claves are present at the smallest diameter seen (GPSU 6022; Pl. 3, Fig. 7). In GPSU 2643 (Pl. 4, Figs 4, 5), they have already disappeared by a whorl height of 18

mm, giving the characteristic ventral profile of adults of the species, with persistent inner and outer ventrolateral clavi, and an evenly arched venter between (KOSSMAT, 1897, Pl. 2 (14), Fig. 2b).

This, and other small specimens appear to be microconchs. In other specimens (GPSU 2572, 2574), the siphonal tubercles persist to diameters of up to 75 mm; these may be incomplete macroconchs.

DISCUSSION: Crowded ribbing, strong, persistent umbilical, inner and outer ventrolateral tubercles, and the distinctive arched venter without siphonal clavi make even fragments of this species readily identifiable (Pl. 4, Figs 1-5). See WRIGHT & KENNEDY (1987, p. 249) for further observations on the subspecies.

OCCURRENCE: Upper Middle and lower Upper Cenomanian, southern England, France, Spain, Romania, Bulgaria (the present record), Tunisia, Zululand (South Africa), Madagascar, South India, Tibet(?), Japan and California.

Calycocheras (Newboldiceris) planecostatum (KOSSMAT, 1897)

(Pl. 3, Figs 2-6, 8, 9)

1897. *Acanthocheilus Newboldi* var. *planecostata* KOSSMAT, p. 9(116), pl. 2(13), fig. 1.
1988. *Acanthocheilus (Ac.) rhotomagense* var. *subflexuosum* (SPATH); JOLKIČEV & al., p. 27.
1990. *Calycocheras (Newboldiceris) planecostatum* (KOSSMAT, 1897); WRIGHT & KENNEDY, p. 252, pl. 61, figs 2, 3; pl. 67, figs 1-4; text-figs. 101c-e (with full synonymy).
1994. *Calycocheras (Newboldiceris) planecostatum* (KOSSMAT, 1897); KENNEDY, p. 228, pl. 10, figs 2, 3.
1994. *Calycocheras (Newboldiceris) planecostatum* (KOSSMAT, 1897); KENNEDY & JUIGNET, p. 50, text-figs 1c; 18a-c; 19a-c.
1996. *Calycocheras (Newboldiceris) planecostatum* (KOSSMAT, 1897); KENNEDY & al., p. 314, pl. 40, fig. 3.
1998. *Calycocheras (Newboldiceris) planecostatum* (KOSSMAT, 1897); KAPLAN & al., p. 158, pl. 26, figs 9-11.

TYPE: Lectotype, by the subsequent designation of WRIGHT & KENNEDY (1990, p. 252), is no. 14842 in the Collections of the Geological Survey of India, the original of KOSSMAT [1897, pl. 2(13), fig. 1] (WRIGHT & KENNEDY 1990, text-fig. 101c-e), from the Utatur Group of Odium, south India.

MATERIAL: GPSU 296, 2578, 2623, 2632, 2646, 3952.

DESCRIPTION: Fragmentary juveniles (Pl. 3, Figs 2-6, 8) have whorl heights of up to an estimated 25 mm. The

coiling appears to have been moderately evolute, with convergent, feebly convex flanks, narrowly rounded ventrolateral shoulders, and a broad, feebly convex venter. Prorsiradiate primary ribs arise either singly or in pairs from narrow umbilical bullae, with one or two intercalated ribs between, both short and long, and in some cases extending to the umbilical shoulder as mere striae (Pl. 3, Fig. 2). Some juveniles have weak inner ventrolateral tubercles (Pl. 3, Fig. 2), but they are absent in others (Pl. 3, Figs 3, 4, 8). There are small but well-developed outer ventrolateral clavi on all ribs; and these are linked across the broad venter by strong transverse to feebly convex ribs.

GPSU 2623 (Pl. 3, Fig. 9) is part of the adult phragmocone of a macroconch that is referred to the species. The inner flanks are broadly convex, the outer flanks flattened and convergent, the ventrolateral shoulders broadly rounded, the venter broad, and feebly convex. Five well-developed umbilical bullae are present on the 120° fragment. They give rise to single ribs, or a second rib may be weakly attached to a bulla, with one or two long intercalated ribs between the bullate ones. They are straight and prorsiradiate on the inner flank, strengthening, broadening and flexing back and feebly convex at mid-flank, and feebly concave on the outer flank, where they link to a very effaced inner ventrolateral tubercle. A broad, flattened rib links to blunt outer ventrolateral clavi, and broad, ribbon-like ribs extend across the venter, separated by narrower interspaces.

DISCUSSION: Early loss of all but outer ventrolateral tubercles, crowded flattened ribs that are wider than the interspaces on the venter of the larger fragment, are characters that compare well with those of the type material and numerous topotype specimens we have studied.

OCCURRENCE: Upper Middle and lower Upper Cenomanian, south India, Madagascar, Zululand (South Africa), James Ross Island, Antarctica, Iran, Bulgaria (the present records), France, Germany and southern England.

Subgenus *Proeucalycoceras* THOMEL, 1972

TYPE SPECIES: By original designation *Calycoceras* (*Eucalycoceras*) *besairiei* COLLIGNON, 1937 (p. 37(13), pl. 3, figs 1-4; pl. 8, fig. 5), from the Cenomanian of Madagascar.

Calycoceras (*Proeucalycoceras*) *picteti* WRIGHT & KENNEDY, 1990
(Pl. 2, Figs 3, 4)

- ?1846. *Ammonites cenomanensis* D'ARCHIAC, pp. 62, 78 (*nomen nudum*).
1863. *Ammonites cenomanensis* D'ARCHIAC; PICTET, p. 28 [pars], pl. 3, fig. 2; inner whorls of fig. 1, pl. 4.
1969. *Calycoceras* aff. *choffati* (KOSSMAT); KENNEDY, pl. 18, fig. 4.
1971. *Calycoceras* aff. *newboldi ankomaensis* COLLIGNON; KENNEDY, p. 76, pl. 42, fig. 4.
1971. *Calycoceras* aff. *choffati* (KOSSMAT); KENNEDY, p. 75 [pars], pl. 38, fig. 5; pl. 39, fig. 1 only.
1972. *Acanthoceras* (*Acanthoceras*) aff. *cenomanense* (D'ARCHIAC); THOMEL, p. 141, pl. 68, figs 1, 2.
1972. *Acanthoceras* (*Acanthoceras*) aff. *cenomanense densecostatum* THOMEL, p. 143, Pl. 44, figs 3-5 (proposed as a variety: not available under the Rules).
- ?1972. *Calycoceras* (*Gentoniceras*) *subwiestii* (SPATH); THOMEL, p. 76 [pars], pl. 25, figs 1, 2.
1983. *Calycoceras cenomanense* (D'ARCHIAC, 1846); MOREAU & al., p. 324, Fig. 6.
1990. *Calycoceras* (*Proeucalycoceras*) *picteti* WRIGHT & KENNEDY, p. 264, pl. 54, fig. 2; pl. 64, fig. 4; l. 68, figs 1, 2; pl. 74, fig. 3; pl. 75, figs 2-6; text-figs 110d, g; 113; 114; 116a-d; 117; 119a-c.
1994. *Calycoceras* (*Proeucalycoceras*) *picteti* JUIGNET & KENNEDY, p. 471, figs 1a; 2a, b; 3a-d; 4a-d; 5a-d; 13a.
1998. *Calycoceras* (*Proeucalycoceras*) *picteti* WRIGHT & KENNEDY, 1990; KAPLAN & al., p. 164, pl. 51, figs 1-8; pl. 52, figs 1-6.
1998. *Calycoceras picteti* WRIGHT & KENNEDY, 1990; LEHMANN, p. 26, pl. 3, fig. 6.

TYPES: The holotype is OUM K22586 from the upper Middle Cenomanian fauna of the Chalk Basement at Storridge Hill, Chardstock, Devon; there are numerous paratypes, listed in WRIGHT & KENNEDY (1990, p. 264).

MATERIAL: GPSU 3944.

DESCRIPTION: GPSU 3944 (Pl. 2, Figs 3, 4) is a laterally crushed composite mould with a maximum preserved diameter of 63.6 mm. Coiling is moderately evolute, the whorl section compressed, as a result of post-mortem crushing. The inner flanks are feebly convex, the outer flanks convergent, the ventrolateral shoulders narrowly rounded, the venter broad, and flattened.

Crowded primary ribs arise from small, elongate bullae either singly or in pairs, and additional ribs intercalate below mid-flank. The ribs are straight and prorsiradiate, broadening progressively across the flanks and terminating in narrow outer ventrolateral clavi. These are linked across the venter by low, broad flattened ribs, separated by narrower interspaces. All bear feeble siphonal clavi.

DISCUSSION: Coiling, flattened flanks, lack of an inner ventrolateral tubercle, and the flat venter with broad, flattened ribbon-like ribs bearing feeble siphonal clavi sepa-

rate this specimen from all others in the collection. In these respects it finds a match in juvenile *Calycoceras* (*Proeucalycoceras*) *picteti* from the upper Middle Cenomanian and lower Upper Cenomanian of southern England and Sarthe, France, as figured by WRIGHT & KENNEDY (1987, pl. 75, figs 2-6; text-fig. 119A-C), such differences as are apparent being due to the dissimilar preservation of the material.

OCCURRENCE: Upper Middle and lower Upper Cenomanian. *C. picteti* is common in the upper Middle Cenomanian in Sarthe, with numerous specimens from the Sables du Perche, as well as the Craie de Rouen. It characterizes a similar stratigraphic level elsewhere as in Charente-Maritime, Haute Normandie and Provence in France, the Münster Basin, Westphalia, Germany, Bulgaria (the present records), Dorset, Somerset and Devon in southern England. It ranges into the lower Upper Cenomanian in Dorset and Devon.

Suborder Ancyloceratina WIEDMANN, 1966
 Superfamily Scaphitaceae GILL, 1871
 Family Scaphitidae GILL, 1871
 Subfamily Scaphitinae GILL, 1871
 Genus *Scaphites* PARKINSON, 1811

TYPE SPECIES: *Scaphites equalis* J. SOWERBY, 1813, p. 53, pl. 18, figs 1-3, by original designation by MEEK, 1876, p. 413.

Scaphites equalis J. SOWERBY, 1813
 (Pl. 6, Figs 1-16)

1813. *Scaphites equalis* J. SOWERBY, 1813, p. 53, pl. 18, figs 1-3.
 1988. *Scaphites equalis* J. SOWERBY; JOLKIČEV & *al.*, p. 27.
 1996. *Scaphites equalis* J. SOWERBY, 1813; WRIGHT & KENNEDY, p. 394, pl. 116, figs 1-5, 7-11; pl. 117, figs 1-11; pl. 118, figs 1-13; text-fig. 129B, C (with full synonymy).
 1996. *Scaphites* (*Scaphites*) *bituberculatus* SANTAMARIA-ZABALA, 1992; WILMSEN & WIESE, p. 95, pl. 1, fig. 1.
 1998. *Scaphites equalis* J. SOWERBY, 1813; KAPLAN & *al.*, p. 224.
 1998. *Scaphites equalis* J. SOWERBY, 1813; LEHMANN, p. 41.

TYPE: The holotype, by the subsequent designation of WRIGHT & KENNEDY (1996, pl. 395), is BMNH 43986, the original of J. SOWERBY (1813, pl. 18, figs 1-3).

MATERIAL: 14 specimens, GPSU 2580, 2604-9, 2614, 2615, 2634, 2636, 2637, 2640, 2650.

DESCRIPTION: All specimens are crushed to varying degrees. Complete specimens vary from 22.3 to 27 mm

long. Coiling of the spire is very involute, with a tiny, deep umbilicus. Coarse crowded primary ribs arise at the umbilical seam and are straight and prorsiradiate on the inner to mid flank region. They increase by bi- and trifurcation on the outer flank, where additional ribs coarsen markedly on the adapical end of the body chamber and are linked across the venter by groups of two or three ribs, with additional ribs intercalated between. This coarsening continues on the remainder of the shaft and adapical part of the hook, with coarse distant flank ribs that strengthen into coarse to weak ventrolateral bullae. These are linked over the venter by groups of up to four ribs, with additional ribs intercalated between (Pl. 6, Figs 9-16). The bullae weaken on the adapertural part of the hook, and there is a short, completely smooth section of shell immediately preceding the adult aperture. This is marked by a strong constriction, markedly prorsiradiate on the flanks, and crossing the venter in a broad convexity (Pl. 6, Figs 8, 9, 11, 14, 16). One specimen referred to the species (GPSU 2607: Pl. 6, Fig. 5) has strong close-spaced flank ribs, but fails to develop ventrolateral tubercles.

Specimens regarded as microconchs have relatively slender body chambers, the umbilical wall of the body chamber concave, and barely concealing the umbilicus of the spire (Pl. 6, Figs 3, 4, 9, 10, 14, 15). None of the material can be assigned to the macroconch of the species with confidence, because of defective preservation.

DISCUSSION: *Scaphites equalis* is readily separated from *S. obliquus* J. SOWERBY, 1813 (see revision in WRIGHT & KENNEDY (1996, p. 390, pl. 114, figs 7-20; pl. 115, figs 1-17; pl. 116, fig. 6; text-figs 150F, K). The shell of *S. obliquus* is shorter, the ribs on the shaft are finer, denser, and markedly prorsiradiate; the shaft is constricted adorally of the mid-shaft lateral swelling; there are no, or only incipient ventrolateral tubercles. *Scaphites* (*Scaphites*) *bituberculatus* SANTAMARIA-ZABALA, 1992 (p. 247, pl. 2, fig. 9) is no more than an Upper Cenomanian intraspecific variant of *S. equalis*.

OCCURRENCE: Middle and Upper Cenomanian. Southern England, France, Germany, Poland, the Czech Republic, Ukraine, Bulgaria (the present records), the Caucasus, Turkmenia, Iran, Algeria, Tunisia, and south India.

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REFERENCES

- ARCHIAC, A.D'. 1846. Études sur la formation crétacée des versants sud-ouest, nord et nord-ouest du Plateau Central de la France (2e partie). *Mémoires de la Société Géologique de France*, (2), 2, (1), 148 p.
- BAYLE, É. 1878. Fossiles principaux des terrains. *Explication de la Carte Géologique de France*, 4, (1), (Atlas), 158 pls. *Mémoires du Service de la Carte Géologique détaillée de la France*, Paris.
- BILLINGHURST, S.A. 1927. On some new Ammonoidea from the Chalk Rock. *Geological Magazine*, 64, 511-518.
- BRONGNIART, A. 1822. Sur quelques terrains de Craie hors du Bassin de Paris. In: G. CUVIER & A. BRONGNIART, Description géologique des environs de Paris, 80-101, 3rd edn., 428 p. *Dufour et D'Ocagne*, Paris.
- COLLIGNON, M. 1937. Ammonites Cénomaniennes du sud-ouest de Madagascar. *Annales géologiques du Service des Mines de Madagascar*, 8, 29-72.
- COOPER, M.R. & KENNEDY, W.J. 1987. A revision of the Puzosiinae (Cretaceous Ammonites) of the Cambridge Greensand. *Neues Jahrbuch für Geologie und Paläontologie, Abhandlungen*, 174, 105-121.
- COQUAND, H. 1862. Géologie et paléontologie de la région de la Province de Constantine. *Mémoires de la Société d'Emulation de la Provence*, 2, 1-341.
- DELAMETTE, M. & KENNEDY, W.J. 1991. Cenomanian ammonites from the condensed deposits of the Helvetic Domain. *Journal of Paleontology*, 65, 435-465.
- GALE, A.S., KENNEDY, W.J., BURNETT, J.A., CARON, M. & KIDD, B.E. 1996. The Late Albian to Early Cenomanian succession at Mont Risou near Rosans (Drôme, SE France): an integrated study (ammonites, inoceramids, planktonic foraminifera, nannofossils, oxygen and carbon isotopes). *Cretaceous Research*, 17, 515-606.
- GILL, T. 1871. Arrangement of the Families of Mollusks. *Smithsonian Miscellaneous Collections*, 227, xvi + 49 p.
- GROSSOUVRE, A. de 1894. Recherches sur la craie supérieure, 2, Paléontologie. Les ammonites de la craie supérieure. *Mémoires du Service de la Carte Géologique détaillée de la France*. 264 p. (misdated 1893). *Imprimerie Nationale*, Paris.
- HYATT, A. 1889. Genesis of the Arietidae. *Smithsonian Contributions to Knowledge*, 673, xi + 239 p.
- 1900. Cephalopoda, pp. 502-604 in K.A. VON ZITTEL, 1896-1900, *Textbook of Palaeontology*, transl. C.R. EASTMAN, *Macmillan*; London & New York.
- IMMEL, H. & SEYED-EMAMI, K. 1985. Die Kreideammoniten des Glaukonitkalkes (0. Alb- 0. Cenoman) des Kolah - Qazi - Gebirges südöstlich von Esfahan (Zentral Iran). *Zitteliana*, 12, 87-137.
- JIMBO, K. 1894. Beiträge zur Kenntniss der Fauna der Kreideformation von Hokkaido. *Paläontologische Abhandlungen*, (N.S.) 2, 147-194.
- JOLKIČEV, N.A. 1987. [Lithostratigraphic units connected with the Upper Cretaceous Series in the central parts of the Moesian Platform. *Review of the Bulgarian Geological Society*, 48, 25-37.
- 1989. *Stratigraphy of the epicontinental type Upper Cretaceous in Bulgaria*. 184 p. *Kliment Ohridski University Press*, Sofia. [In Bulgarian]
- JOLKIČEV, N.A., JOVČEVA, P., DIMITROVA, E. & STOJANOV-VEGILOVA, M. 1988. Stratigraphy of the Campanian Stage north of Pleven and new microfaunistic data on its basement. *Review of the Bulgarian Geological Society*, 49, 25-36. [In Bulgarian]
- KAPLAN, U., KELLER, S. & WIEDMANN, J. 1984. Ammoniten - und Inoceramen - Gliederung des Norddeutschen Cenoman. *Schriftenreihe der Erdwissenschaftlichen Kommissionen Österreichische Akademie der Wissenschaften*, 7, 307-347.
- , KENNEDY, W.J., LEHMANN, J. & MARCINOWSKI, R. 1998. Stratigraphie und Ammonitenfaunen des westfälischen Cenoman. *Geologie und Paläontologie in Westfalen*, 51, 244 p.
- KENNEDY, W.J. 1969. The correlation of the Lower Chalk of south-east England. *Proceedings of the Geologists Association*, 80, 459-560.
- 1971. Cenomanian ammonites from southern England. *Special Papers in Palaeontology*, 8, v + 133 p.
- 1986. Ammonite biostratigraphy of the Albian to basal Santonian. *Physics and Chemistry of the Earth*, 16, 129-182.
- 1994. Cenomanian ammonites from Cassis, Bouches-du-Rhône, France. *Palaeopelagos*, Special Volume 1, 209-254.
- , BILOTTE, M. & HANSOTTE, M. 1996. Cenomanian ammonites from Pech de Foix (Ariège, France). *Géobios*, 29, 307-318.
- & JUIGNET, P. 1994. A revision of the ammonite faunas of the type Cenomanian. 6. Acanthoceratinae (*Calycoceras* (*Proeucalycoceras*), *Eucalycoceras*, *Pseudocalycoceras*, *Neocardioceras*), Euomphaloceratinae, Mammitinae and Vascoceratidae. *Cretaceous Research*, 15, 469-501.
- KOSSMAT, F. 1895-1898. Untersuchungen über die Sudindische Kreideformation. *Beiträge zur Paläontologie Österreich-Ungarns und des Orients*, 9, (1895): 97-203 (1-107); 11, (1897a): 1-46 (108-153); 11, (1898): 89-152 (154-217).
- LEHMANN, J. 1988. Die Ammonitengattung *Acanthoceras* im NW-deutschen Cenoman (untere Oberkreide). *Aufschluss*, 39, 129-145.
- 1998. Systematic palaeontology of the ammonites of the Cenomanian-Lower Turonian (Upper Cretaceous) of northern Westphalia, North Germany. *Tübinger Geowissenschaftliche Arbeiten*, A37, 2-57.
- MANTELL, G.A. 1822. The fossils of the South Downs; or illustrations of the geology of Sussex. xvi + 327 p. *Lupton Relfe*, London.
- MEEK, F.B. 1876. A report on the invertebrate Cretaceous and Tertiary fossils of the upper Missouri country. In: F.V. HAYDEN, *Report of the United States Geological Survey of the Territories*, 9, lxiv + 629 p.
- MOREAU, P., FRANCIS, I.H. & KENNEDY, W.J. 1983. Cenomanian

- ammonites from northern Aquitaine. *Cretaceous Research*, **4**, 317-339.
- NEUMAYR, M. 1875. Die Ammoniten der Kreide und die Systematik der Ammonitiden. *Zeitschrift der Deutschen Geologischen Gesellschaft*, **27**, 854-942.
- NIKOLOV, T. & NACHEV, I. 1962. Several fossil mollusks from the Cenomanian in the district of Pleven. *Travaux sur la Géologie de Bulgarie. Série Paléontologie*, **4**, 127-131. [In Bulgarian]
- ORBGINY, A. d'. 1840-1842. Paléontologie française: Terrains crétacés. 1. Céphalopodes. 1-120 (1840); 121-430 (1841); 431-662 (1842). *Masson*; Paris.
- PARKINSON, J. 1811. Organic remains of a former world, **3**. 479 p. *J. Robson*; London.
- PICTET, F.J. 1847. In: F.J. PICTET & W. ROUX, (1847-1854). Description des mollusques fossiles qui se trouvent dans les Grès Verts des environs de Genève. *Mémoires de la Société de Physique et d'Histoire Naturelle de Genève*, **11** (1847), 257-42; **12** (1849), 21-151; **13** (1852), 73-173; **14** (1854), 279-341.
- 1863. Mélanges paléontologiques. 4. Discussion sur les variations et les limites de quelques espèces d'Ammonites du groupe des *A. rotomagensis* et Mantelli. *Mémoires de la Société de Physique et d'Histoire Naturelle de Genève*, **17**, 15-39.
- SANTA MARIA-ZABALA, R. 1992. Los Ammonoideos del Cenomaniense superior al Santoniense de la plataforma nord-castellana y la cuenca navarro-cantabra. Parte 1. Bioestratigrafía sistemática: Phylloceratina, Ammonitina (Desmocerataceae y Hoplitaceae) y Ancyloceratina. *Treballs del Museu de Geologia de Barcelona*, **2**, 171-268.
- SCHLOETHEIM, E.F. VON 1820. Die Petrefaktenkunde auf ihrem jetzigen Standpunkte durch die Beschreibung seiner Sammlung lxii + 437 p. *Beckershe Buchhandlung*, Gotha.
- SHARPE, D. 1853-57. Description of the fossil remains of Mollusca found in the Chalk of England. I, Cephalopoda. *Palaeontographical Society Monographs*, **68** p., 1-26, (1853); 27-36, (1855); 37-68, (1857).
- SOWERBY, J. 1812-1822. The mineral conchology of Great Britain. *The author*, London.
- SOWERBY DE C. 1823-1846. The Mineral Conchology of Great Britain (continued). *The author*, London.
- SPATH, L.F. 1922. On the Senonian ammonite fauna of Pondoland. *Transactions of the Royal Society of South Africa*, **10**, 113-147.
- 1923. On the ammonite horizons of the Gault and contiguous deposits. *Summary of Progress of the Geological Survey of Great Britain and the Museum of Practical Geology* (for 1922), 139-149.
- 1926. On new ammonites from the English Chalk. *Geological Magazine*, **63**, 77-83.
- STOLICZKA, F. 1863-1866. The fossil cephalopoda of the Cretaceous rocks of southern India. Ammonitidae with revision of the Nautilidae etc. *Memoirs of the Geological Survey of India*, (1), *Palaeontologica Indica*, **3** (1), 41-56 (1863); (2-5), 57-106 (1864); (6-9), 107-154 (1865); (10-13), 155-216 (1866).
- THOMEL, G. 1972. Les Acanthoceratidae Cénomaniens des chaînes subalpines méridionales. *Mémoires de la Société Géologique de France*, (N.S.), **116**, 204 p.
- 1987. La famille des Tetragonitidae (Ammonoidea) dans le Cénomaniens du sud-est de la France. *Annales de Paléontologie (Vertébrés-Invertébrés)*, **73**, 241-272.
- 1992. Ammonites du Cénomaniens et du Turonien du Sud-Est de la France. **1**, 422 p.; **2**, 383 p. *Serre*, Nice.
- WIEDMANN, J. 1962. Ammoniten aus der Vascogotischen Kreide (Nordspanien). 1, Phylloceratina, Lytoceratina. *Palaeontographica*, **118A**, 119-237.
- 1966. Stammesgeschichte und System den posttriadischen Ammonoideen; ein Überblick. *Neues Jahrbuch für Geologie und Paläontologie Abhandlungen*, **125**, 49-79, **127**, 13-81.
- 1973. The Albian and Cenomanian Tetragonitidae (Cretaceous Ammonoidea), with special reference to the Circum-Indic species. *Eclogae Geologicae Helvetiae*, **66**, 585-616.
- WILMSEN, M. 1997. Das Oberalb und Cenoman im Nordkantabrischen Becken (Provinz Kantabrian, Nordspanien): Faziesentwicklung, Bio- und Sequenzstratigraphie. *Berliner Geowissenschaftliche Abhandlungen*, **E23**, x + 167 p.
- WILMSEN, M. & WIESE, F. 1996. The species *Scaphites bituberculatus* SANTAMARIA-ZABALA, 1992 (Cretaceous Ammonoidea) from the Upper Cenomanian of Tagle (Cantabria, northern Spain): geologic setting, paleontology, and stratigraphic position. *Acta Geologica Polonica*, **46**, 89-98.
- WRIGHT, C.W. & KENNEDY, W.J. 1980. Origin, evolution and systematics of the dwarf acanthoceratid *Protacanthoceras* SPATH, 1923 (Cretaceous Ammonoidea). *Bulletin of the British Museum (Natural History). Geology*, **34**, 65-107.
- & — 1984-1996. The Ammonoidea of the Lower Chalk. *Palaeontographical Society Monographs*, 319 p. (1-126 (1984); 127-218 (1987); 219-294 (1991); 295-319 (1995); 320-413 (1996)).
- WRIGHT, C.W. & WRIGHT, E.V. 1951. A survey of the fossil Cephalopoda of the Chalk of Great Britain. *Palaeontographical Society Monographs*, 1-40.
- ZITTEL, K.A. VON 1884. Handbuch der Paläontologie. 1, Abt. 2; Lief. 3, Cephalopoda, p.329-522. *R. Oldenbourg*; Munich & Leipzig.
- 1895. Grundzüge der Paläontologie (Paläozoologie), vii + 972 pp. *R. Oldenbourg*; Munich & Leipzig.

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PLATES 1-6

PLATE 1

Middle Cenomanian *Acanthoceras jukesbrownei* Zone ammonites from the Sanandinovo Formation at its type section between the villages of Sanandinovo and Novachene, in northern Bulgaria

1-3 – *Tetragonites subtimotheanus* WIEDMANN, 1962. GPSU 2603, from package 7.

4-6 – *Puzosia (Puzosia) mayoriana* (D'ORBIGNY, 1841). GPSU 3955, from package 9.

All figures are $\times 1$

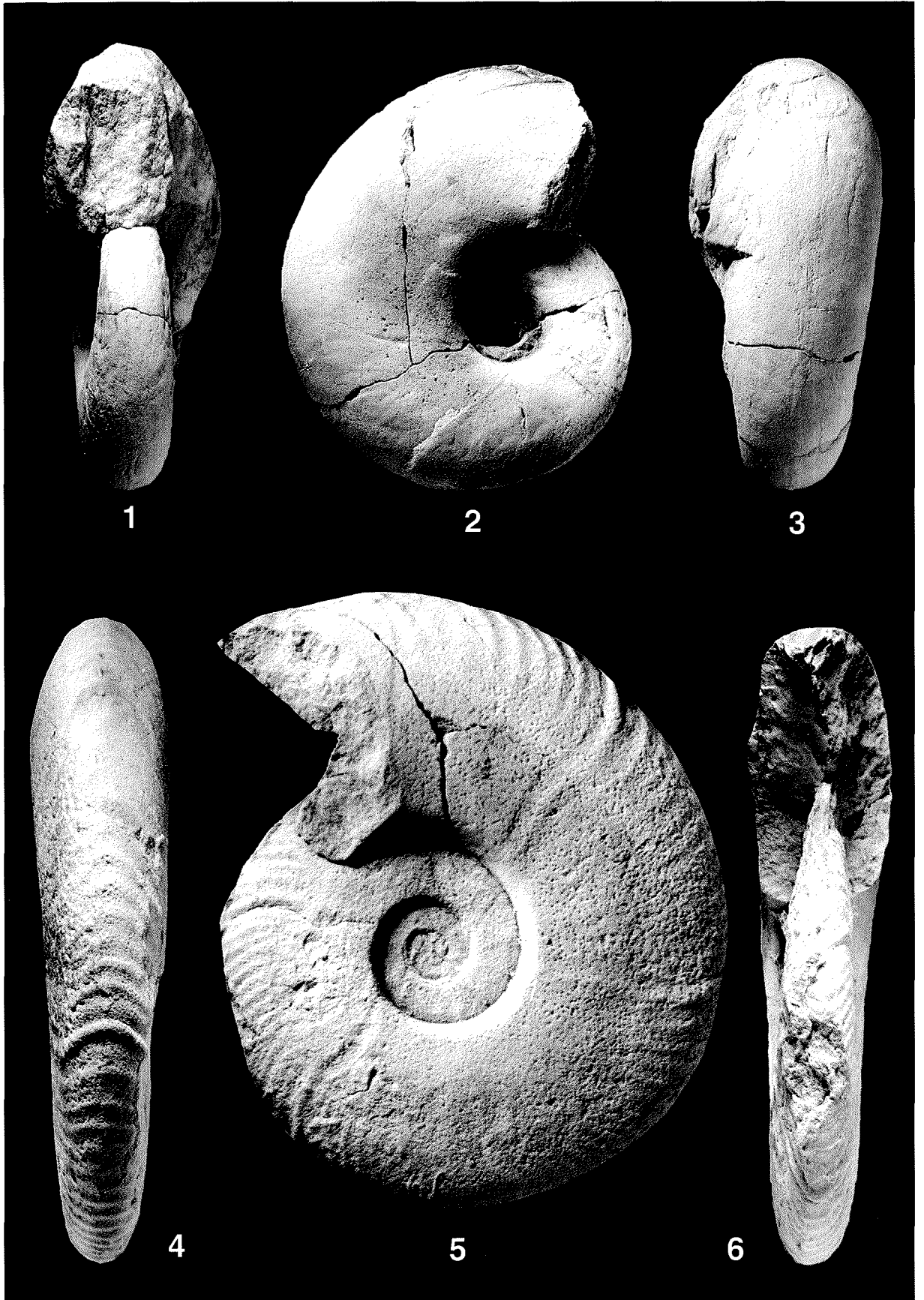


PLATE 2

Middle Cenomanian *Acanthoceras jukesbrownei* Zone ammonites from the Sanandinovo Formation at its type section between the villages of Sanandinovo and Novachene, in northern Bulgaria

- 1-2** – *Protacanthoceras tuberculatum tuberculatum* THOMEL, 1972, GPSU 2645 and *Calyco-ceras (Newboldiceras)* sp. juv., package 9.
3-4 – *Calyco-ceras (Proeucalyco-ceras) picteti* WRIGHT & KENNEDY, 1990. GPSU 3944, from package 7.
5-8 – *Protacanthoceras tuberculatum tuberculatum* THOMEL, 1972. GPSU 2579, from package 9.
9-12 – *Acanthoceras jukesbrownei* (SPATH, 1926). GPSU 3942, from package 7.

Figures 1, 6-8, 10-12 are $\times 2$; Figures 2-5, 9 are $\times 1$

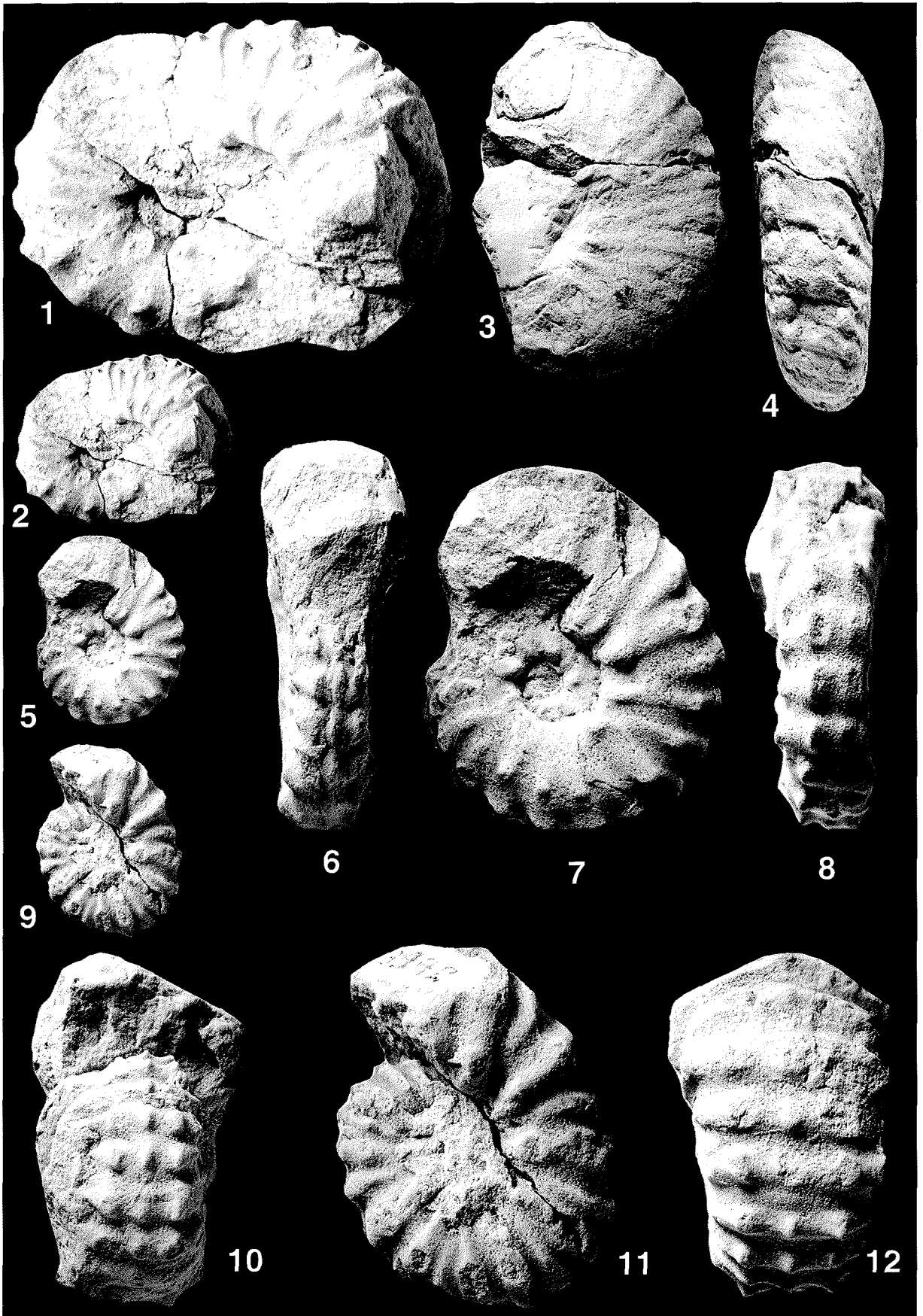


PLATE 3

Middle Cenomanian *Acanthoceras jukesbrownei* Zone ammonites from the Sanandinovo Formation at its type section between the villages of Sanandinovo and Novachene, in northern Bulgaria

- 1** – *Calycoceras (Newboldiceras) asiaticum asiaticum* (JIMBO, 1894). GPSU 3950, package 7.
- 2-6, 8-9** – *Calycoceras (Newboldiceras) planecostatum* (KOSSMAT, 1897). 2, GPSU 3952, package 7; 3, 4, GPSU 2646, package 9; 5, GPSU 296, package 10; 6, GPSU 2632, package 9; 8, GPSU 2578, package 9; 9, GPSU 2623, package 9.
- 7,10-11** – *Calycoceras (Newboldiceras) asiaticum spinosum* (KOSSMAT, 1897). 9, GPSU 6022, package 9; 10, 11, GPSU 2577, package 9.
- 12** – *Acanthoceras jukesbrownei* (SPATH, 1926), GPSU 2651, package 9.

All figures are $\times 1$

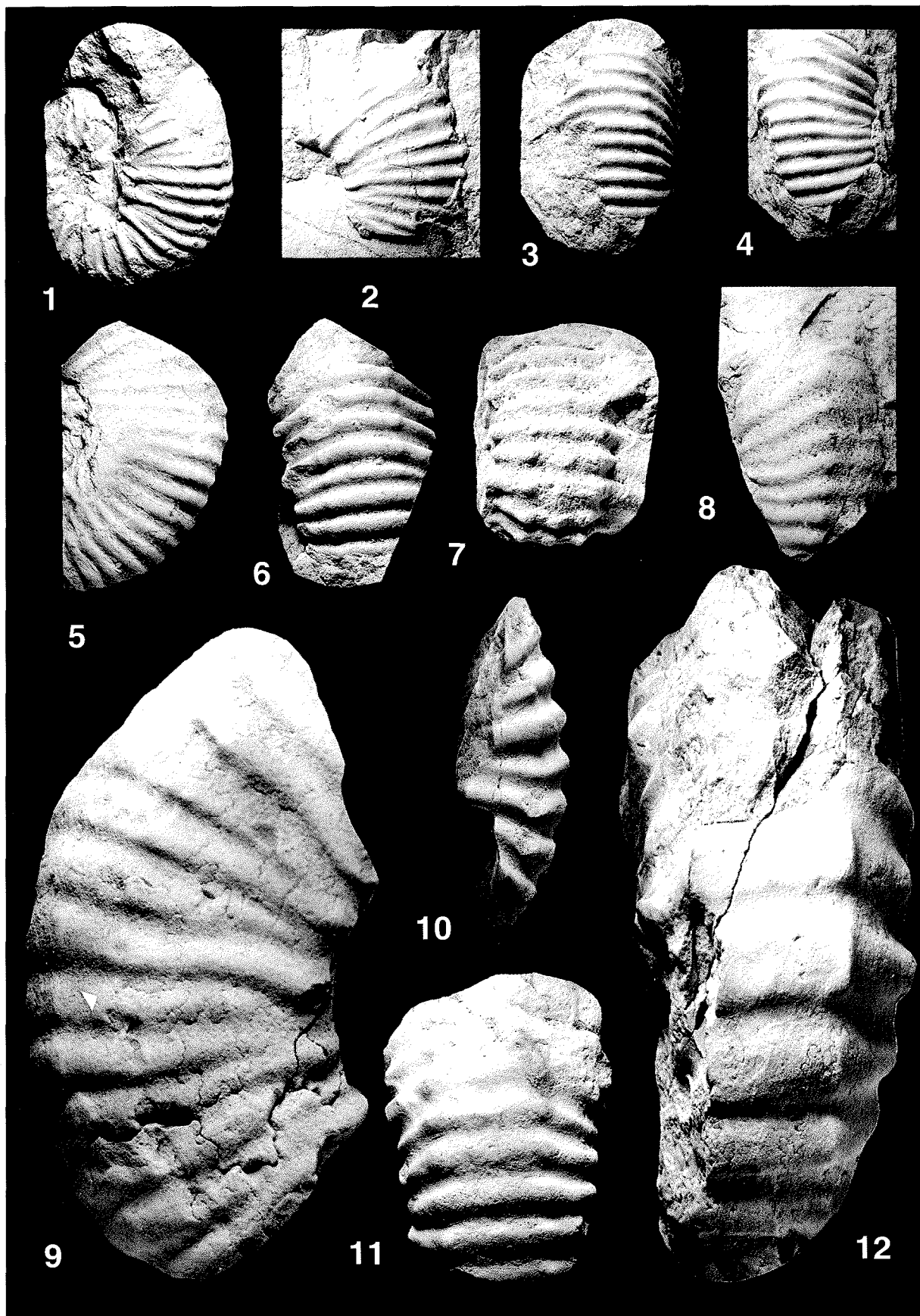


PLATE 4

Middle Cenomanian *Acanthoceras jukesbrownei* Zone ammonites from the Sanandinovo Formation at its type section between the villages of Sanandinovo and Novachene, in northern Bulgaria

- 1-5** – *Calycoceras (Newboldiceras) asiaticum spinosum* (KOSSMAT, 1897). 1, 2, GPSU 2576, package 9; 3, GPSU 3943, package 7; 4, 5, GPSU 2643, package 9.
6-7 – *Calycoceras (Newboldiceras) asiaticum asiaticum* (JIMBO, 1894). GPSU 2662, package 9.

All figures are $\times 1$

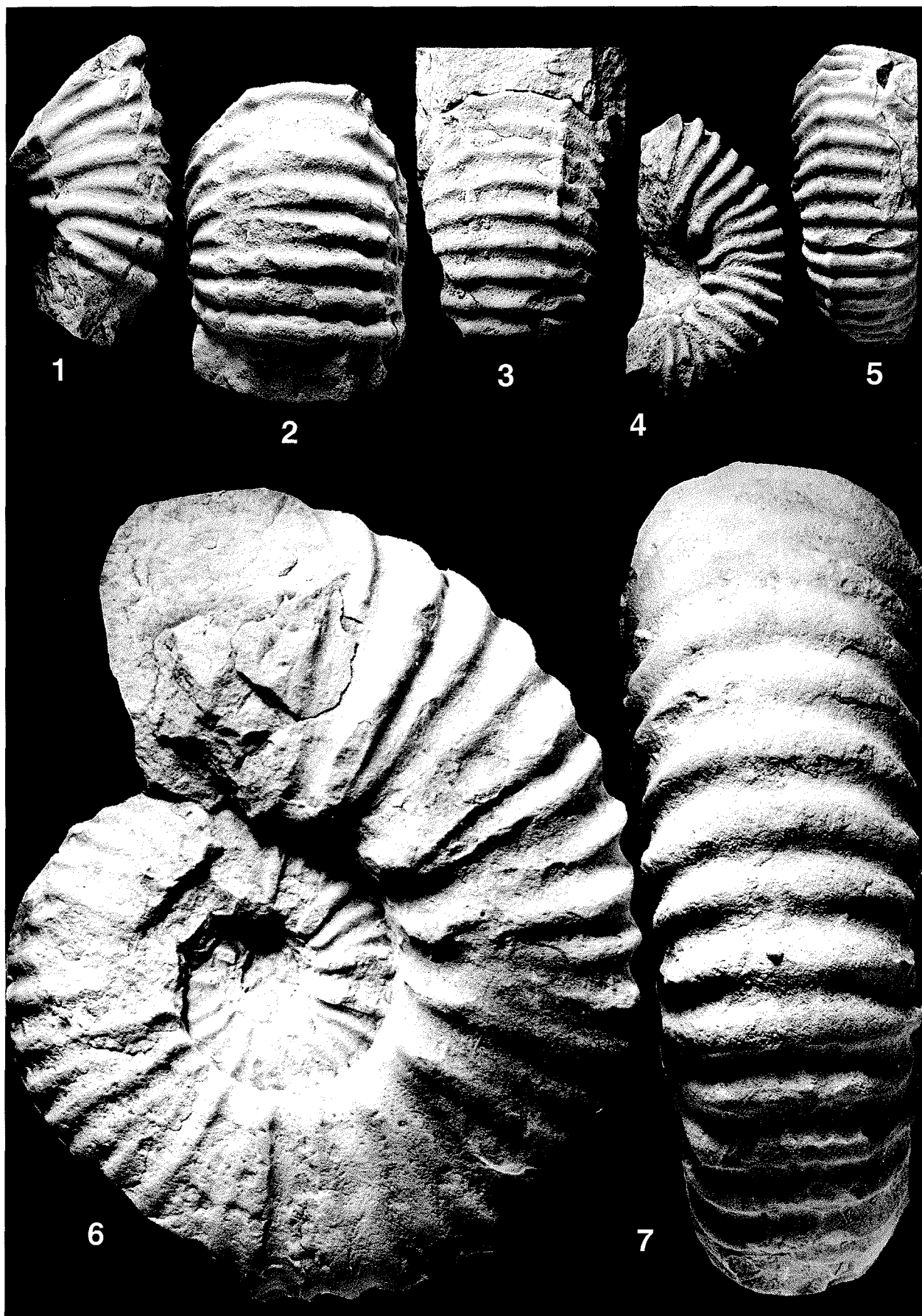


PLATE 5

Middle Cenomanian *Acanthoceras jukesbrownei* Zone ammonites from the Sanandinovo Formation at its type section between the villages of Sanandinovo and Novachene, in northern Bulgaria

- 1-4 – *Calycoceras (Newboldiceras) asiaticum asiaticum* (JIMBO, 1894). GPSU 2649, package 9.
5 – *Tetragonites subtimotheanus* WIEDMANN, 1962. GPSU 2612, package 7.
6-11 – *Calycoceras (Newboldiceras) asiaticum spinosum* (KOSSMAT, 1897). 6-8, GPSU 2574; 9-11, GPSU 2672, both from package 9.

All figures are $\times 1$

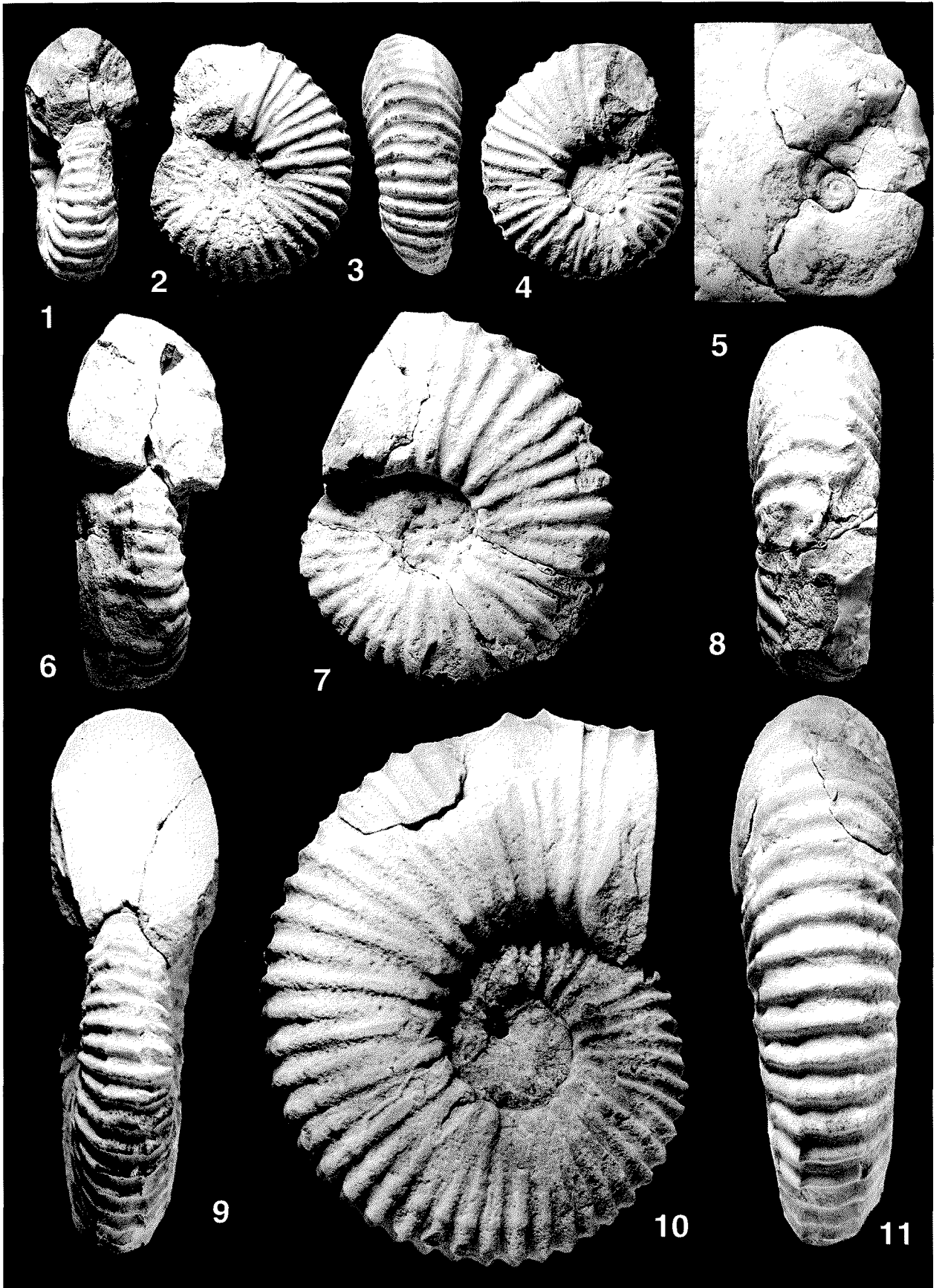


PLATE 6

Middle Cenomanian *Acanthoceras jukesbrownei* Zone ammonites from the Sanandinovo Formation at its type section between the villages of Sanandinovo and Novachene, in northern Bulgaria

1-16 – *Scaphites equalis* J. Sowerby, 1813. 1, 2, GPSU 2634, package 9; 3, 4, GPSU 2650, package 9; 5, GPSU 2607, 6, 7, GPSU 2606, 8, GPSU 6024, all from package 7; 9, 10, GPSU 2640, 11, 12, GPSU 2580, from package 9; 13, GPSU 2609, from package 7; 14, 15, GPSU 2637, 16, GPSU 2636, both from package 9.

All figures are $\times 2$

