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Article

The Early Tithonian (Late Jurassic) ammonite genus *Virgatosimoceras* Spath (Ammonoidea: Simoceratidae) – revision and value for correlation

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With 8 figures

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Abstract: New findings of the Early Tithonian genus *Virgatosimoceras* Spath (Simoceratidae) from Hungary confirm the existence of a new chronospecies (*Virgatosimoceras dunaii* n. sp.) which fills the gap between *V. albertinum* and *V. rothpletzi*. The successive chronospecies demonstrate a well defined lineage through the Early Tithonian Darwini, Semiforme and Fallauxi zones, opening the possibility of enhancement of the time-correlation of the Submediterranean Province with adjacent regions. All figured records of *Virgatosimoceras* are revised. Micro- and macroconchs are tentatively distinguished for the first time. The similarities between *Virgatosimoceras* and some homoeomorphic perisphinctids are discussed. Based on the known records, is concluded that the genus was restricted to the western Tethys.

Key words: *Virgatosimoceras*, Lower Tithonian, revision, correlation, Hungary, southern Germany, palaeobiogeography.

1. Introduction

The most characteristic Late Jurassic Mediterranean ammonites belong to the family Simoceratidae (Cecca 1999; Schweigert et al. 2002). These ammonites are relatively frequent and conspicuous in the Apennines, southern Spain and some parts of Hungary, very evolute with large umbilicus, strongly ribbed in most cases on the adult body chamber but perisphinctoid on the phragmocone or at least on the nucleus. The most representative genera of the Simoceratidae are *Simoceras* Zittel, 1870, *Volanoceras* Geyssant, 1985, *Lytogyroceras* Spath, 1925, and *Virgatosimoceras* Spath, 1925. *Virgatosimoceras* is well represented in several regions of the Tethys: Southern Alps (Catullo 1855; Zittel 1870; Parona 1880; Del Campana 1905; Rossi 1984; Sarti 1986a, 1986b; Caracuel et al. 1998), ?SE France (Donze & Enay 1961: 117, holotype of *Subplanites concorsi,* pl. 17, fig. 3), Apennines (Cecca et al. 1983, 1985; Cecca & Santantonio 1988), Transdanubian Range (Vigh 1984; Főzy 1987, 1990, 1993b, and this study), Mecsek Mts. (Főzy 1993a, and this study), Pieniny Klippen Belt (Kutek & Wierzbowski 1986; Wierzbowski 1990), southern Spain (Enay & Geyssant 1975; Geyssant 1997; Olóriz 1978), southern Germany (Schneid 1915, 1916; Zeiss 1968; Barthel & Geyssant 1973; Geyssant & Zeiss 1978; Schlegelmilch 1994; Schweigert & Scherzinger 2004, and this study; Fig. 1).

The genus has also been reported, although sporadically, from outside Europe, but as discussed below in chapter 4, all these specimens seem to belong to other genera.

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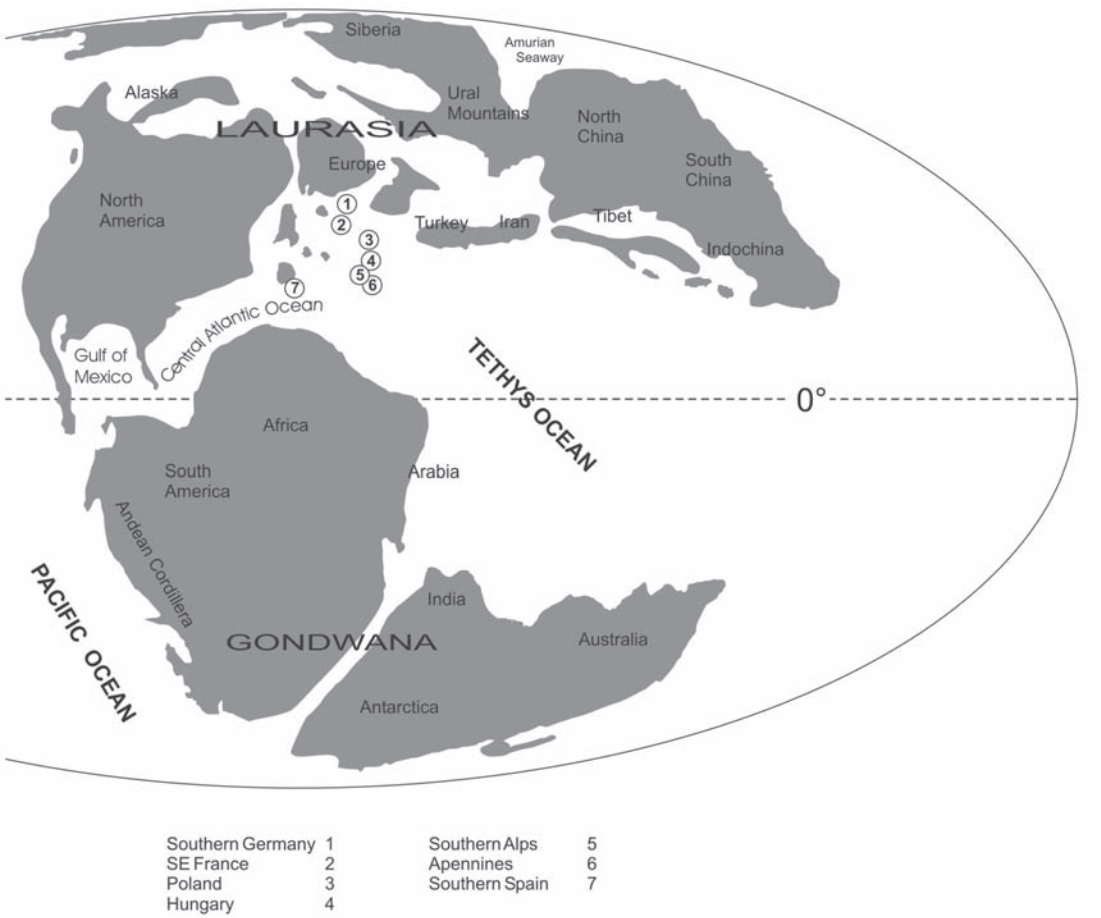

Fig. 1. Palaeobiogeographic distribution of *Virgatosimoceras* Spath, 1925 as indicated in the text. The genus is restricted to the western part of the Tethys. Global palaeogeography based on Scotese (2004).

Recent bed-by-bed collections in Hungary (Gerecse and Bakony Mountains) together with available specimens from southern Germany provided the opportunity to undertake a revision of the taxonomy and stratigraphic distribution of the genus *Virgatosimoceras*.

Once the taxonomy and chronostratigrapic succession are stabilized, the species became rather well-delimited and could be valuable tools for fine time-correlation based on their association with other characteristic ammonites.

Abbreviations: BSPM – Bayerische Staatssammlung für Paläontologie und Geologie, München, Germany; HNHM – Hungarian Natural History Museum, Budapest, Hungary; GMH – Geological Museum of Hungary, Budapest, Hungary; J – Material stored at the GMH (part of the inventory number); M – Material stored at the HNHM (part of the inventory number).

2. Account of references to *Virgatosimoceras* in historical context

The earliest known representative of the genus, *V. albertinum,* was described by Catullo (1855) from Rosso Ammonitico facies from Malcesine, near Verona, N Italy. Subsequently Zittel (1870) published two specimens of *V. albertinum* from Folgaria, N Italy. The exact stratigraphic levels of these specimens remain unknown. More recently, Sarti (1986a) and Caracuel et al. (1998) figured additional specimens of *V. albertinum* collected in the Darwini Zone (Enay & Geyssant 1975) of the Trento region.

Further specimens of *V. albertinum* were mentioned also from red nodular limestones by Parona (1880), Del Campana (1905), Ramaccioni (1939), Cecca et al. (1983) – this specimen was figured and er-

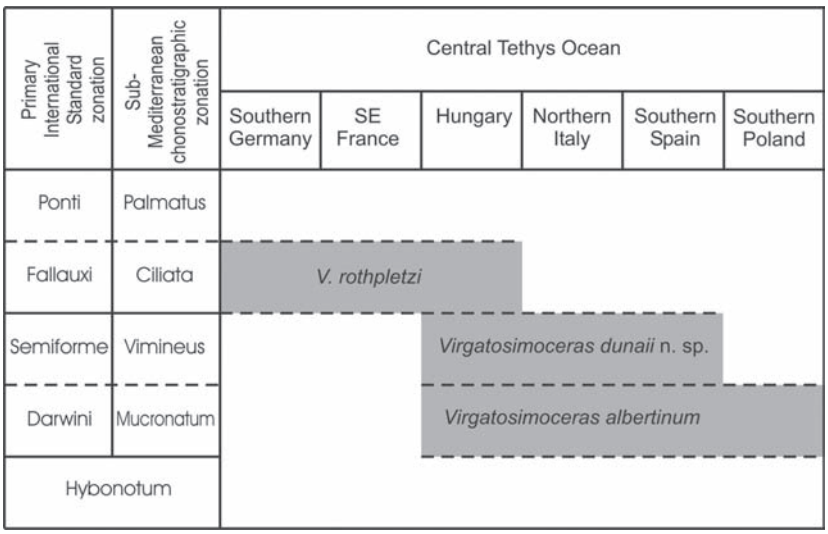

Fig. 2. The phylogenetic lineage of the successive three *Virgatosimoceras* species. Zonal names used in this paper follow the zonal scheme of Enay & Geyssant (1975), which may be compared with that published by Olóriz (1978).

roneously identified as *V. rothpletzi* – and Cecca & Santantonio (1988). Rossi (1984) figured well-preserved specimens from the Apennines (Umbro-Marchigiano), but most part of his material is herein reinterpreted (discussion below).

V. albertinum was also cited by Enay & Geyssant (1975) from the Darwini Zone of the Subbetic Cordillera (southern Spain). From the same region and in a similar stratigraphic level (Albertinum Zone) Olóriz (1978) described additional specimens together with two most likely junior synonyms: *V. uniformis* Olóriz, 1978 and *V. micrum* Olóriz, 1978 (discussion below). The Spanish specimens were collected from Rosso Ammonitico facies but with a good stratigraphic control.

De Wever et al. (1986: pl. 2, fig. 1) figured a poorly preserved specimen coming from condensed Rosso Ammonitico beds of Sicily under the name *Virgatosimoceras siculum* n. sp.. This ammonite species seems to be identical to *V. albertinum.*

From the Darwini Zone of the Pieniny Klippen Belt, southern Poland, *V. albertinum* was cited by Kutek & Wierzbowski (1986) and Wierzbowski (1990). Although the material is fragmentary there are no doubts about the determinations of the specimens (A. Wierzbowski, pers. comm. 25-09-08).

Recent records of *Virgatosimoceras*, including *V. albertinum*, were reported from the bed-by-bed sampled sections of the Bakony and Gerecse Mts., Hungary (Vigh 1984; Főzy 1988, 1989, 1990, 1993b).

The often cited species *V. rothpletzi* was introduced by Schneid (1915) on the basis of three specimens, collected from Unterhausen, near Neuburg a. d. Donau, Franconia, southern Germany. Schneid collected obviously most of his ammonites by himself (Schneid 1915: 308), but unfortunately he gave no information about the exact stratigraphic position.

Later, Barthel & Geyssant (1973) published new data and new ammonites from the locality of Schneid (1915) and confirmed the occurrence of *V. rothpletzi* in the basal beds 22 and 24 of the Neuburg Formation at Unterhausen. Based on the similarity between the characteristic features of local facies and the matrix of the specimens collected by Schneid (1915), it became clear that the type material of *V. rothpletzi* came also from bed 22. However a crushed fragment of an ammonite from bed 116 was also assigned to *Virgatosimoceras*, but this specimen actually belongs to the genus *Danubisphinctes* (see Schweigert & Scherzinger 2004).

Geyssant & Zeiss (1978) described a single, finely preserved ammonite collected in the bed 28 of Unterhausen, under *V. rothpletzi virgulifer* Geyssant & Zeiss, 1978.

3. Systematic palaeontology

Family Simoceratidae Spath, 1924
Genus *Virgatosimoceras* Spath, 1925

Type species: *Simoceras rothpletzi* Schneid, 1915, by OD

Diagnosis (Arkell 1957: 341): Evolute, perisphinctid-like, with prominent, distant, biplicate and triplicate ribs; constrictions bordered adorally by a conspicuous collar;

Fig. 3.1 – *Virgatosimoceras* aff. *dunaii* n. sp. – M 2008.262, Szomód, Bed 13, Lower Tithonian, Semiforme Zone. **2** – *Virgatosimoceras* sp. – M 92.578, Kárász, Mecsek Mts., Lower Tithonian. **3** – *Virgatosimoceras albertinum* (CATULLO, 1855) – J 10365, Hárskút II, Bed 64, Lower Tithonian, Darwini Zone, original in FŐZY (1990: pl. 5, fig. 3), re-figured here. Ventral (a) and lateral (b) views. Asterisk marks last septum.

venter with median groove, becoming smooth and ungrooved on outer whorl.

Remark: The median groove on body chamber or last whorl of phragmocone is absent in several specimens as shown below, thus most likely depending on preservation.

Virgatosimoceras albertinum (CATULLO, 1855)
Figs. 3.3a, b, 4.4, 5.1-5.3

* 1855 *Ammonites Albertinus* CATULLO. – CATULLO, p. 208, pl. 2, fig. 3a, b.
v 1870 *Perisphinctes Albertinus* CATULLO. – ZITTEL, p. 222, pl. 34, fig. 1a-d (re-figured here, Fig. 5.1, 5.3).
non 1890 *Simoceras* aff. *Albertinus* CATULLO. – BOGDANOWITCH, p. 143, pl. 5, fig. 5.
1925 *Virgatosimoceras albertinum* (CATULLO). – SPATH, p. 131.
v non 1973 *Virgatosimoceras* cf. *albertinum* (CATULLO). – BARTHEL & GEYSSANT, p. 27, figs. 1c, d, 4.
1978 *Virgatosimoceras albertinum* (CATULLO). – OLÓRIZ, p. 206, pl. 18, fig. 1a, b.
1978 *Virgatosimoceras micrum* nov. sp. – OLÓRIZ, p. 208, pl. 17, figs. 3-4.
1978 *Virgatosimoceras uniformis* nov. sp. – OLÓRIZ, p. 209, pl. 18, fig. 4a, b.
1984 *Katroliceras inornatum* n. sp. – ROSSI, pl. 32, fig. 6.
1984 *Virgatosimoceras albertinum* (CATULLO). – ROSSI, pl. 32, figs. 12-13.
1984 *Virgatosimocers simplicicostatum* n. sp. – ROSSI, pl. 35, fig. 4.
1984 *Virgatosimoceras* cfr. *rothpletzi* (SCHNEID). – ROSSI, pl. 35, fig. 8.
1984 *Virgatosimoceras* cfr. *albertinum* (CAT.). – VIGH, p. 162.
1986 *Virgatosimoceras albertinum* (CATULLO). – SARTI, p. 511, pl. 7, fig. 1.
1986 *Virgatosimoceras albertinum.* – SARTI, pl. 1, fig. 4.
? 1986 *Virgatosimoceras siculum* nov. sp. – DE WEVER et al., p. 164, pl. 2. fig. 1.
v 1990 *Virgatosimoceras* cf. *rothpletzi* (SCHNEID). – FŐZY, p. 327, pl. 5, fig. 1 (re-figured here, Fig. 4.4).
v 1990 *Virgatosimoceras* cf. *albertinum* (CATULLO). – FŐZY, p. 327, pl. 5, fig. 3 (re-figured here, Fig. 3.3a, 3.3b).
v 1993b *Virgatosimoceras* sp. – FŐZY, p. 453, fig. 8, 457, fig. 11.
1997 *Virgatosimoceras albertinum* (CATULLO). – GEYSSANT, pl. 25, fig. 4.
1998 *Virgatosimoceras rothpletzi* (SCHNEID). – CARACUEL et al., pl. 2, fig. 2.

Holotype (by monotypy): The specimen figured by CATULLO (1855: pl. 2, fig. 3a, b), housed in the Museo di Geologia e Paleontologia Padova, Italy (Nr. 6916v).

Type locality: Malcesine (Verona), Northern Italy.

Type horizon: Rosso Ammonitico lithofacies of Venetian Alps; Lower Tithonian, Darwini/Albertinum Zone.

Studied material: Four specimens from the Margit Hill, Hárskút, and Lókút sections (Gerecse and Bakony Mts, Hungary), (HNHM: M 2008.263, M 92.748; GMH: J 10365, J 10367 [cast]). The Hungarian specimens are relatively well-preserved, but fragmentary internal moulds of adult or subadult specimens, except the specimen from the Szilas-ravine, which is a natural impression of a subadult shell. The specimens from Margit Hill and Hárskút are slightly deformed. These ammonites were figured or listed by FŐZY (1993b, 1990) and VIGH (1984) respectively (see synonym list). Two specimens from Folgaria (northern Italy) (BSPM: 1868 X 517), described and figured by ZITTEL (1870) are re-figured herein in Fig. 5.1 and 5.3.

Description: The specimen of Lókut (Fig. 5.2) shows a suboval whorl section. The innermost whorls can not be observed. At a diameter of about 30 mm, the ribs bifurcate high on the flank, below the umbilical wall. In a subsequent growth stage the ribs may trifurcate – this feature is well seen on the specimen from Hárskút (Figs. 3.3a, 4.4a). On the outermost whorl (body chamber?) the ribbing is again bifurcate. Constrictions occur from the innermost preserved whorls. The Lókút ammonite (Fig. 5.2) is probably adult, showing the complete aperture which is simple. The specimens from Margit Hill (HNHM: M 2008.263) and Hárskút (Figs. 3.3a, b, 4.4) show a cross section slightly higher than wide.

Remarks and comparisons: The species was described in detail by CATULLO (1855) and ZITTEL (1870). *Ammonites tortatilis* CATULLO, 1855 could be a synonym of *Ammonites albertinum* CATULLO (ZITTEL 1870: 222). Unfortunately the specimen was not figured. Innermost whorls of *V. albertinum* are perisphinctid-like, rather densely ribbed by bipartite ribs. *V. rothpletzi* is also densely ribbed, but the style of ribbing is of slightly prosocline primaries, somewhat weaker, bifurcating on the ventrolateral shoulder and passing to weaker ventral ribs.

Closer resemblance with *V. albertinum* is shown by *V. dunaii* n. sp. (described below). The dense bipartite stage is longer in *V. albertinum* (up to 40 mm in diameter or more), and the widely spaced, bipartite and triplicate ribs on the outer whorls may be slightly falcoid. The ribbing of *V. albertinum* is denser and more regular than that of *V. rothpletzi.* This progressive differentiation is the main evolutionary trend observable throughout the lineage, thus a valuable feature when attempting to identify the species of *Virgatosimoceras*.

The bulk of the published records of *Virgatosimoceras* (commonly under *V. rothpletzi*) from the Darwini Zone seem to belong to *V. albertinum.* An illustrative example is the specimen of the Darwini Zone of Trento Plateau, Italy figured as *V. rothpletzi* by CARACUEL et al. (1998: pl. 2, fig. 2). This specimen indeed shows some resemblance with the type material of *V. rothpletzi;* nevertheless, its bipartite ribbing style on the inner whorls is more widely spaced and

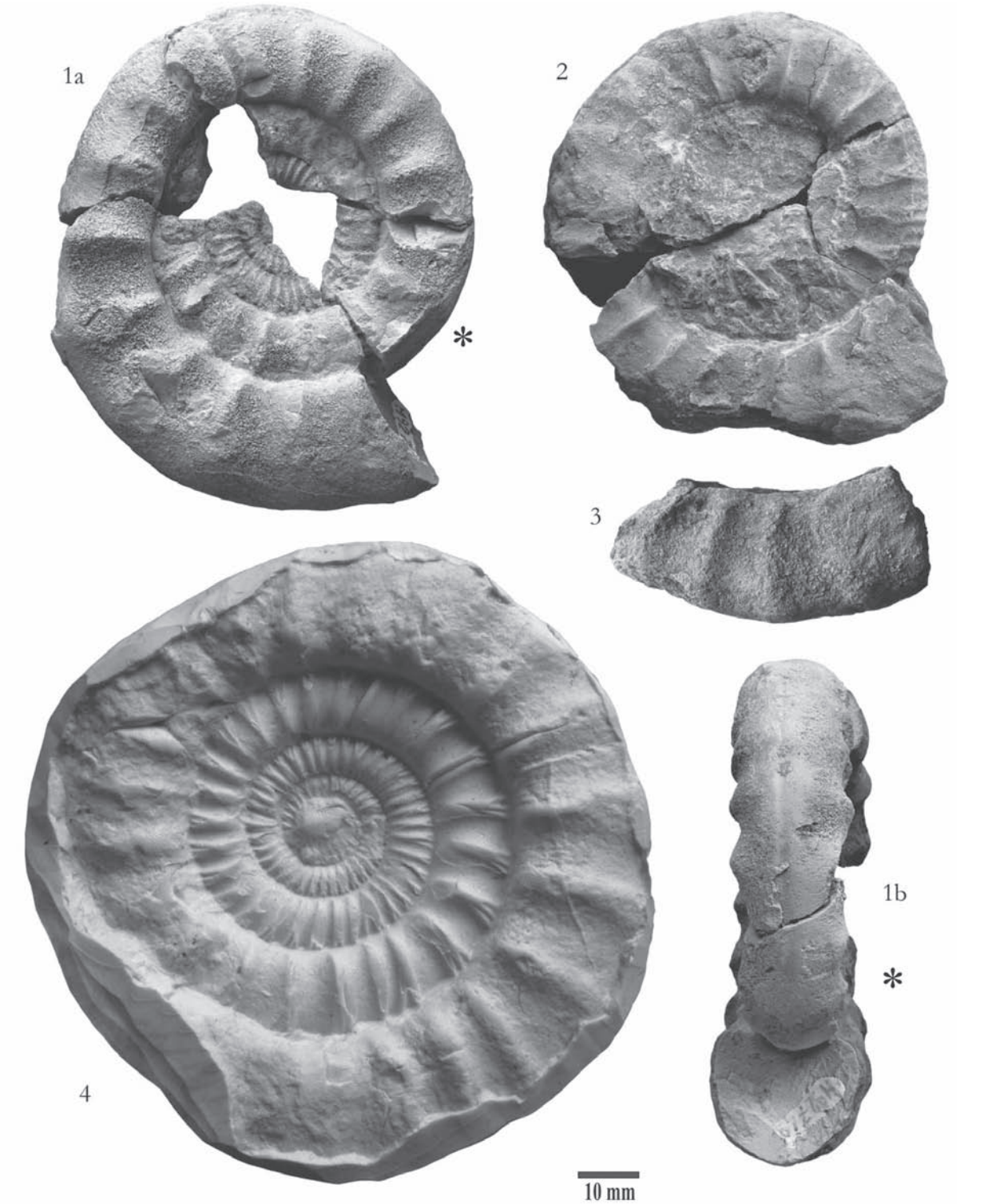

Fig. 4. 1 – *Virgatosimoceras dunaii* n. sp. – M 92.749 (holotype), Lókút, Bed 47, Lower Tithonian, Semiforme Zone. Ventral (a) and lateral (b) views. Asterisk at last septum. **2** – *Virgatosimoceras* aff. *dunaii* n. sp. – M 2008.261, Tölgyhát, Bed 19, Lower Tithonian, Semiforme Zone. **3** – *Virgatosimoceras* aff. *dunaii* n. sp. – M 2008.260, Tölgyhát, Bed 19, Lower Tithonian, Semiforme Zone. **4** – *Virgatosimoceras albertinum* (Catullo, 1855) – J 10367 (cast), Hárskút II, Bed 63, Lower Tithonian, Darwini Zone. Re-figured after Főzy (1990: pl. 5, fig. 1).

coarser than what is seen in *V. rothpletzi.* On the other hand, this specimen from the Trento Plateau is almost identical to the specimen of *V. albertinum* from the Darwini Zone of the same area figured by Sarti (1986a: pl. 7, fig. 1). The different interpretations may have been rooted in the poor knowledge of the holotype of *V. albertinum* and/or the stratigraphic distribution of the successive species of the lineage, but, of course, it mainly depends on the classification criteria adopted. However, specimens transitional between *V. albertinum* and *V. rothpletzi* through *V. dunaii* n. sp. (described below), may be sometimes difficult to place in one or another species following strictly morphological criteria. This is well in accord with the linear chrono-cline structure we favour for this genus, composed by a succession of chronospecies within which the different morphotypes (morphospecies) may persist through time as part of the spectrum of their variability.

Rossi (1984) figured well-preserved specimens of *Virgatosimoceras* from the Umbria-Marche Apennines. Unfortunately these specimens were not collected under close stratigraphic control. Beside typical *V. albertinum* (Rossi 1984: pl. 32, figs. 12-13), he described *V. simplicicostatum* Rossi (1984: pl. 32, fig. 4). The bipartite ribbing shows very close resemblance with *V. albertinum* (more or less dense, regular bipartite ribbing on the innermost whorls, long duration of this ontogenetic stage up to a diameter of about 40 mm). Therefore we consider *V. simplicicostatum* as a junior synonym of *V. albertinum.*

The specimen described as *V.* cf. *rothpletzi* by Rossi (1984, pl. 32, fig. 8) is incomplete, only the outer whorls are visible. The regular, dense bipartite ribbing in this specimen closely resembles that of *V. albertinum.* Differences between both species are discussed below.

Simoceras aff. *albertinum* in Bogdanowitch (1890) from the Chemiran Mountains, north of Teheran, Iran, does not belong to *Virgatosimoceras* because of its very different style of ribbing: irregular, with several intercalatory ribs.

Furlani (1910: 77) cited the occurrence of *"Simoceras albertinum Catullo"* from the Lemes-Schichten in Dalmatia based on a single specimen which was said to fit in all characters with the specimen described by Catullo (1855), but unfortunately the specimen was not figured and it seems that it was destroyed during World War II (pers. comm. I. Zorn, 19-09-08).

The small-sized *V. micrum* and *V. uniformis* described by Olóriz (1978) from material of southern Spain are morphologically very close to each other and show close resemblances with *V. albertinum.* The holotypes of both species come from the Albertinum Zone, which is time-equivalent to the Darwini Zone.

Zittel (1870) already realized the typical variation within the species. He figured two specimens which show most of the spectrum of variation assumed for this species: a widely ribbed portion of body chamber and a more densely ribbed, almost complete specimen (Fig. 5.1, 5.3).

Further citations are in Parona (1880: 10), Del Campana (1905: 61), Furlani (1910: 77), Ramaccioni (1939: 197), Kutek & Wierzbowski (1986: 307), Cecca & Santantonio (1988: 534) and Wierzbowski (1990: fig. 2), but all lacking illustrations.

Occurrence: After discussion above, *Virgatosimoceras albertinum* (Catullo) is restricted in the Darwini Zone of southern Spain (Subbetic Cordillera), Italy (Southern Alps and Apennines), Hungary (Bakony and Gerecse Mts.), Poland (Pieniny Klippen Belt). This distribution (see Fig. 1) shows the species confined to the Mediterranean Province of the Tethys.

Virgatosimoceras dunaii n. sp.
Fig. 4.1a, b.

1978 *Virgatosimoceras* sp. gr. *rothpletzi* (Schneid). – Olóriz, p. 205, pl. 17, fig. 1.
? 1978 *Virgatosimoceras* sp. 1. – Olóriz, p. 211, pl. 17, fig. 2.
v 1984 *Virgatosimoceras* sp. (nov. sp.?). – Vigh, p. 165.
v 1993b *Virgatosimoceras* sp. – Főzy, p. 446, fig. 3, p. 457, fig. 11.

Holotype: The specimen M 92.749 (HNHM), a moderately well-preserved internal mould).

Etymology: In honour of our colleague and friend, Mihály Dunai, who collected excellent Tithonian ammonite specimens from the Gerecse Mountains.

Type locality: Lókut Hill, Transdanubian Range, Hungary.

Type horizon: Lókút section, Bed 47, Lower Tithonian, Semiforme Zone. The section and its fauna was described by Vigh (1984).

Studied material: The holotype. Three additional specimens from the Semiforme Zone of the Szomód and Tölgyhát sections (Gerecse Mts, Hungary) are tentatively assigned to this species and hereafter referred as *V.* aff. *dunaii* (see below; Figs. 3.1, 4.2- 4.3).

Diagnosis: Medium-sized, inflated serpenticone with dense ribbing on the middle whorls, up to 30-40 mm in diameter; body chamber round in whorl section with strong, well-spaced primaries fading out on the venter.

Description: The holotype is a subadult specimen with part of its body chamber; the innermost whorls are lost. The maximum diameter and the umbilical width are 82 and 45 mm, respectively. Moderately evolute, whorl section rounded, slightly wider than high, with maximum width on the lower third of the flank. Umbilical wall low; venter rounded, bearing a shallow, weak siphonal groove on the early part of the last whorl of the phragmocone. The ribbing is strong and rather irregular. At about 20 mm in diameter, most of the ribs seem to be simple, only few are bifurcate. The middle whorls bear also strong primary ribs. On the last whorl, the ribs are fading on the venter, which is consequently nearly smooth, except for the fine median groove. Constrictions occur, at least, from the innermost whorls.

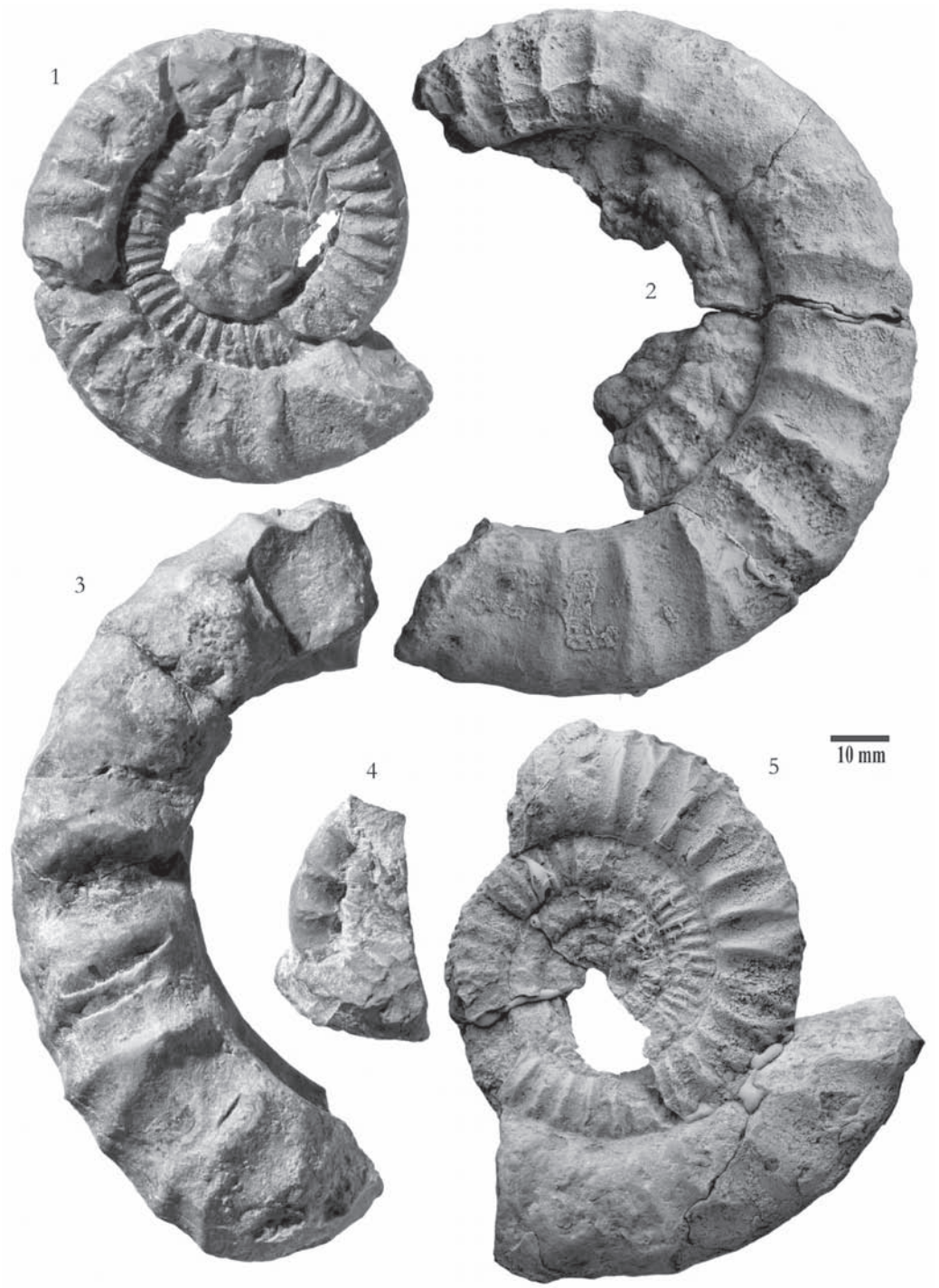

Fig. 5. 1, 3 – *Virgatosimoceras albertinum* (Catullo, 1855) – BSPM 1868 X 517, Folgaria (northern Italy), originals figured by Zittel (1870: pl. 34 (10), fig. 1), re-figured here for the first time. Lower Tithonian, Darwini Zone. **2** – *Virgatosimoceras albertinum* (Catullo, 1855) – M 92.748, Lókút, Bed 61, Lower Tithonian, Darwini Zone. **4** – *Virgatosimoceras rothpletzi* (Schneid, 1915) [M] – BSPM: 1957 VI 4426, fragment of an macroconch, bed 22, Unterhausen near Neuburg a. d. Donau, southern Germany, figured by Barthel & Geyssant (1973: figs. 1c, d, 4), refigured here. Lower Tithonian, Ciliata Zone, *Penicillatum* Horizon. **5** – *"Danubisphinctes"* sp. – M 2008.264, Tölgyhát, Lower Tithonian, (from loose blocks).

Remarks and comparison: *V. dunaii* n. sp. has perisphinctid-like innermost whorls, with dense ribbing. This dense ribbing stage ends at about 30-40 mm in diameter, earlier than what is observed in *V. albertinum* (Fig. 4.1a), and then followed by bipartite or triplicate, widely spaced ribs, very similar as in *V. rothpletzi.* The distance between the widely placed ribs in *V. dunaii* n. sp. is larger than in *V. albertinum* at comparable diameters, but similar to *V. rothpletzi.*

Occurrence: According to the original label of the holotype, the specimen was collected by Lajos Kocsis (technician of the Hungarian Geological Survey in 1963) from Bed 47 of the Lókút section. The ammonite association of this bed was partly described by Vigh (1984) and assigned to the "Middle Tithonian *Simoceras (Lytogyroceras) subbeticum volanensoides* Zone". In the Lókút section, the interval of beds 41-52 is represented by 234 cm of nodular limestones in which also the Semiforme Zone is represented with several characteristic ammonites. The succession of ammonites which are the most significant for time-correlation is as follows, from above:

Beds 37-44: *Simoceras admirandum*, and *Simoceras volanensoides* [Fallauxi Zone]
Beds 46-53: *Pseudhimalayites kondai* Vigh, 1984 (type material from bed 47), *Haploceras verruciferum* and *V. dunaii* n. sp. [Semiforme Zone]
Bed 62: *Hybonoticeras pseudohybonotum* Vigh, 1984 [Hybonotum Zone]

The holotype of *P. kondai* is very similar to the specimens figured by Checa (1985: pl. 20: figs. 3-5) as *P. steinmanni* (Haupt, 1907) which come from the Semiforme Zone of the southern Spain. *Haploceras verruciferum* (Zittel, 1869) is a typical and conspicuous ammonite of the Semiforme Zone (Főzy 1988) although it could range from the upper Darwini to the lower Fallauxi zones (Enay & Cecca 1986). Consequently it may be assumed that the holotype of *V. dunaii* n. sp. is Semiforme Zone in age.

V. dunaii n. sp. could occur in N Italy (Cecca & Santantonio 1988; Cecca 1990; but the material was not illustrated therein) and southern Spain (see synonymy in Olóriz 1978). These records are also mainly from the Semiforme Zone. Complete well-preserved specimens seem to be rare.

Virgatosimoceras rothpletzi (Schneid, 1915)
Figs. 5.4, 6.1-6.4, 7.1-7.2

*v 1915 *Simoceras rothpletzi* n. sp. – Schneid, p. 88, pl. 7, figs. 2-3.
v 1915 *Simoceras rothpletzi* n. sp. – Schneid, p. 88, pl. 4, fig. 1a, b.
v 1915 *Simoceras broilii* n. sp. – Schneid, p. 90, pl. 6, fig. 4a, b.
v 1916 *Simoceras rothpletzi* n. sp. – Schneid, p. 24 (190).
v 1948 *Virgatosphinctes (Katroliceras ? Dorsoplanites ?)* nov. sp. A. – Donze, p. 98.
v 1959 *Katroliceras (Virgatosimoceras) rothpletzi.* – Ziegler, p. 47.
v ? 1961 *Subplanites concorsi* nov. sp. – Donze & Enay, p. 117, pl. 17, fig. 3, fig. 31h.
v 1962 *Virgatosimoceras rothpletzi.* – Barthel, p. 24.
v 1968 *Dorsoplanitoides (D.) bavaricus* sp. n. – Zeiss, p. 94, pl. 16, fig. 2 (only).
v 1973 *Virgatosimoceras* cf. *albertinum* (Catullo). – Barthel & Geyssant, p. 27, fig. 1c, d.
v 1973 *Virgatosimoceras* sp. indet. – Barthel & Geyssant, p. 31, fig. 1e, f.
? 1976 *Virgatosimoceras rothpletzi* (Schneid). – Sapunov & Ziegler, p. 23, pl. 2, fig. 7.
v 1978 *Virgatosimoceras rothpletzi virgulifer* n. subsp. – Geyssant & Zeiss, p. 177, pl. 1, figs. 1-2, pl. 2, figs. 1-3.
non 1978 *Virgatosimoceras* sp. gr. *rothpletzi* (Schneid). – Olóriz, p. 205, pl. 17, fig. 1.
non 1979 *Virgatosimoceras rothpletzi* (Schneid). – Sapunov, p. 159, pl. 49, fig. 3.
? 1983 *Virgatosimoceras rothpletzi rothpletzi* (Schneid). – Cecca et al., p. 117, pl. 3, fig. 2.
v non 1990 *Virgatosimoceras* cf. *rothpletzi* (Schneid). – Főzy, p. 327, pl. 5, fig. 1.
non 1998 *Virgatosimoceras rothpletzi* (Schneid). – Caracuel et al., p. 244, pl. 2, fig. 2.
v 1999 *Virgatosimoceras rothpletzi* (Schneid) [M]. – Scherzinger & Schweigert, p. 5.
v 2004 *Virgatosimoceras rothpletzi* (Schneid) [M]. – Schweigert & Scherzinger, p. 313 f., pl. 1, fig. 1.

Lectotype: The specimen BSPM 1913 201b (Fig. 6.1, herein), a well-preserved internal mould. Beside the lectotype, designated by Spath (1925: 131) a plaster cast of a negative print of the same specimen exists (Geyssant & Zeiss 1978: 176, re-figured as Fig. 6.2). This was not realized by Schneid (1915: 88 [360]). Geyssant & Zeiss mentioned also different syntypes (syntypes A-D). Syntype D, not figured by Schneid (1915) is missing. Syntype B and C: B is the lectotype and C is the negative print of the same specimen (see above). Both were figured by Schneid (lectotype: 1915, pl. 7, fig. 3, 3a, b; mould: pl. 7, fig. 2). Barthel & Geyssant (1973: 30, fig. 4) figured both as "lectotype" but they gave no information why they did it. Syntype A: Schneid (1915, pl. 4, fig. 1a-c – re-figured as Fig. 6.3).

Type locality: Unterhausen near Neuburg/Donau, Bavaria, southern Germany.

Type horizon: Neuburg Formation; Lower Tithonian, Ciliata Zone, *Penicillatum* horizon.

Studied material: Eight specimens from Unterhausen, near Neuburg a. d. Donau (BSPM: 1913 IX 201a, b, c, 1913 IX 202, 1957 VI 4426, 1957 VI 4432, 1957 VI 4433, 1957 VI 4428, 1957 VI 4427).

Remarks and comparisons: A detailed description was given by Schneid (1915: 88 [390]). *V. rothpletzi* has

Fig. 6. 1 – *Virgatosimoceras rothpletzi* (Schneid, 1915) [M] – Lectotype, BSPM 1913 IX 201c, Unterhausen near Neuburg a. d. Donau, southern Germany, figured by Schneid (1915: pl. 23, fig. 3), re-figured here. Lower Tithonian, Ciliata Zone, *Penicillatum* Horizon. **2** – *Virgatosimoceras rothpletzi* (Schneid, 1915) [M] – BSPM 1913 IX 201b, plaster cast, Unterhausen near Neuburg a. d. Donau, southern Germany, figured by Schneid (1915: pl. 23, fig. 2), re-figured here. Lower Tithonian, Ciliata Zone, *Penicillatum* Horizon. **3** – *Virgatosimoceras rothpletzi* (Schneid, 1915) [M] – BSPM 1913 IX 201a, Unterhausen near Neuburg a. d. Donau, southern Germany, figured by Schneid (1915: pl. 20, fig. 1), re-figured here. Lower Tithonian, Ciliata Zone, *Penicillatum* Horizon. **4** – *Virgatosimoceras rothpletzi* (Schneid, 1915 [m] – BSPM 1957 VI 4428, bed 22, Unterhausen near Neuburg a. d. Donau, southern Germany, figured by Barthel & Geyssant (1973: figs. 1e, f, 4-5, 3 molded), re-figured here. Last whorl original, inner whorls reconstructed with plastic by molding. Lower Tithonian, Ciliata Zone, *Penicillatum* Horizon. Ventral (a) and lateral (b) views.

evolute and rounded-subcircular innermost whorls, densely ribbed by bipartite ribs rather radially arranged and bifurcated on the ventro-lateral shoulder, giving origin to weaker ventral ribs. The dense bipartite stadium ends at about a diameter of 20-25 mm, earlier than what is observed in *V. albertinum* and in *V. dunaii* n. sp., following by bipartite or triplicate, widely spaced ribs. The distance between the widely spaced ribs in *V. rothpletzi* is much larger than what can be observed in *V. albertinum* but similar as in *V. dunaii* n. sp. at comparable diameter.

Occurrence: All the well controlled records, safely attributed to the species, come from the *Penicillatum* horizon, Ciliata Zone at Unterhausen near Neuburg a. d. Donau and Ellenbrunn near Rennertshofen, both southern Germany and ?St. Concors, near Chambery, SE France. Latest findings from Unterhausen were collected from the same lithostratigraphic unit – beds 22, 24 and 28 (Barthel & Geyssant 1973; Geyssant & Zeiss 1978). An incomplete and poorly preserved specimen from the lower Fallauxi Zone from Szilas ravine, Hungary (bed 80, not figured) is stored at the HNHM.

Two additional citations in literature, without figuration, are from Romania (Badaluta 1975: 27) and Sicily (De Wever et al. 1986: 166).

Virgatosimoceras sp.
Fig. 3.2.

Material: A single specimen (HNHM: M 92.578) from the Kárász section of Mecsek Mts., southern Hungary.

Description: The specimen consists of a fragmentary portion of an outer whorl of possibly an adult ammonite, preserved as an internal mould. Coiling is very evolute, the whorl section is higher than wide. The ribbing consists of strong, distant, simple ribs, slightly curving forward on the ventro-lateral shoulder. The venter is smooth. Inner whorls are lost.

Remarks: The specimen has a special palaeobiogeographic importance, since it is the first representative of the genus from the Mecsek Mts. The assemblage of the Kárász locality was listed by Főzy (1993b).

Occurrence: The specimen was collected from a volcanoclastic succession, in which the ammonites cannot be collected bed-by-bed. The specimen was associated with some typical Early Tithonian ammonites like *Haploceras elimatum* and *Physodoceras* cf. *neoburgense*.

4. Ammonites recorded as *Virgatosimoceras* from outside Europe

Mexico: The occurrence of *Virgatosimoceras* in Mexico was suspected by Callomon (1992: 268) based on the great similarity of *Mazatepites* Cantú-Chapa, 1967. The resemblance is valid only between the paratype of *Mazatepites arredondense* (in Cantú-Chapa 1967: pl. 1, fig. 1) and *Virgatosimoceras rothpletzi* (Schneid, 1915). Nevertheless after new observations carefully made by A. Cantú-Chapa (pers. comm. 19-11-07) on the original material of *M. arredondense* it can be provisionally concluded that there is no generic identity with *Virgatosimoceras* based on: (1) the suture of *Mazatepites* is more complex with the lateral lobe deeper than the ventral/siphonal one; and (2) lack of virgatotome ribbing in *Mazatepites*. Also Lopez-Caballero et al. (2007: 247) cast doubts on the occurrence of *Virgatosimoceras* in Mexico.

Cuba: *Virgatosimoceras*? sp. was figured in Imlay (1942: pl. 3, figs. 8-10). In this case no relationships with *Virgatosimoceras* can be supported due to the poor and incomplete preservation.

Myczynski (1989) also listed *Virgatosimoceras*? sp. This author referred to the specimen of Imlay (1942) and described a further specimen under *Virgatosimoceras*? sp. (Myczynski 1989: 102, pl. 4: 5). Indeed, the figured fragment belongs to an ammonite with collared ribs which is hardly attributable to the genus.

Somalia: *Virgatosimoceras* sp. nov. in Spath (1925: 132, pl. 16, fig. 2a, b). These are two ammonites from the Upper Jurassic of Somalia. We consider these specimens belong to an endemic perisphinctid genus with distribution in eastern Africa. We agree with Cecca (1999: 16) who casted doubts on Spath's determination because of the poor preservation.

Ethiopia: Another specimen from Ethiopia was figured by Scott (1943: pl. 22, fig. 1) under *Virgatosimoceras* sp. ind. and said to be conspecific with the specimens of Spath (1925). Nevertheless the specimen is so poorly preserved that it can not be concluded if belongs to *Virgatosimoceras*.

Iran (Elburz): *Virgatosimoceras elbursense* Spath (1925: 132) does not belong to *Virgatosimoceras*. The ribbing is denser and the triplicate ribs are missing. This ammonite seems to belong to an un-described perisphinctid genus.

Yemen: Howarth (1998: pl. 16: 2) figured a rather poorly preserved ammonite from Wadi Arus, Yemen under *Virgatosimoceras broilii* (Schneid, 1915). The phragmocone up to about 50 mm in diameter is densely ribbed with prorsiradiate primaries and constric-

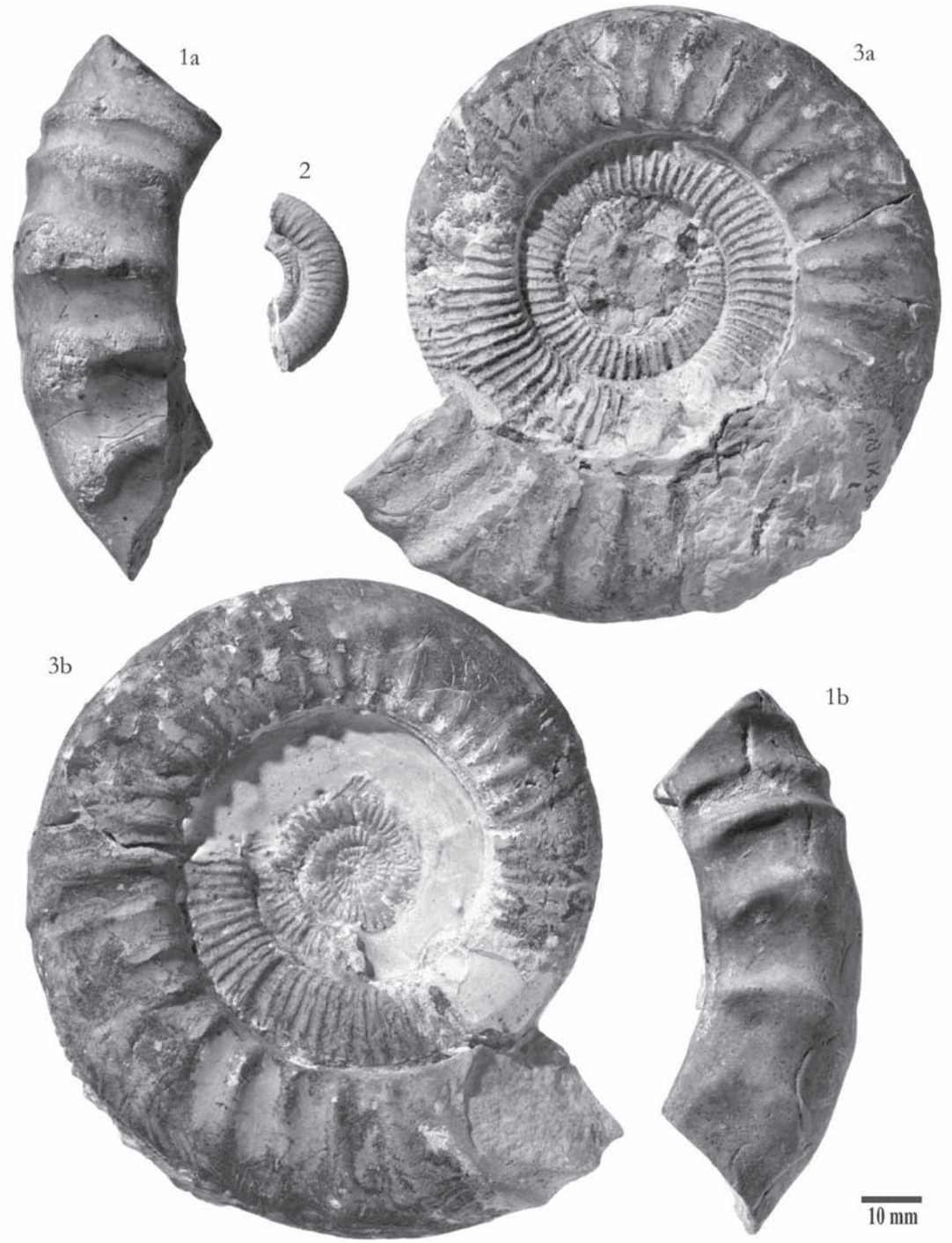

Fig. 7. 1 – *Virgatosimoceras rothpletzi* (Schneid, 1915) [M] – BSPM 1913 IX 202, Unterhausen near Neuburg a. d. Donau, southern Germany, figured by Schneid (1915: pl. 22, fig. 4), re-figured here. Lower Tithonian, Ciliata Zone, *Penicillatum* Horizon. Ventral (a) and lateral (b) views. **2** – *Virgatosimoceras rothpletzi* (Schneid, 1915) [m] – BSPM 1957 VI 4427, bed 22, fragmentary microconch, Unterhausen near Neuburg a. d. Donau, southern Germany, figured by Barthel & Geyssant (1973: figs. 1g, 3-4), re-figured here. Lower Tithonian, Ciliata Zone, *Penicillatum* Horizon. **3** – *"Dorsoplanitoides" broilii* (Schneid, 1915) [M] – Holotype, BSPM 1913 IX 504, Unterhausen near Neuburg a. d. Donau, southern Germany, figured by Schneid (1915: pl. 7, fig. 1), re-figured here. Lower Tithonian, Ciliata Zone, *Penicillatum* Horizon. Left (a) and right (b) lateral views.

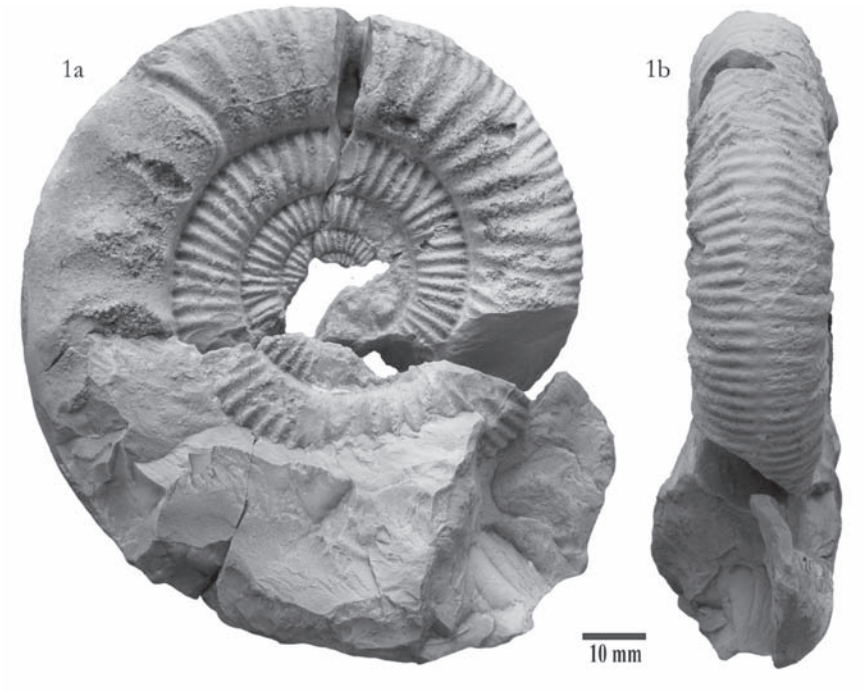

Fig. 8. 1 – *"Danubisphinctes"* sp. – M 2008.265, Hárskút, Lower Tithonian (from loose blocks). ?Semiforme Zone. Ventral (a) and lateral (b) views.

tions; the bodychamber is subrectangular in whorl section and variocostate, with strong prosocline and widely spaced primaries. The specimen of Yemen is confidently dated in the Late Tithonian Microcanthum Zone (Howarth 1998: 102) and could belong to an endemic genus. The ribbing of the inner whorls is different in *Virgatosimoceras* and the typical triplicates on bodychamber are absent. *"Simoceras" broilii* is different in morphology and sculpture (see below).

5. Homoeomorphic perisphinctids

Some ammonites in literature show more or less conspicuous resemblance with species of *Virgatosimoceras*. The most important of them are the following:

Holcostephanus (Virgatites) steindachneri Blaschke, 1911. – The holotype (by monotypy) comes from the famous limestone of Stramberg, Moravia. This ammonite is a macroconch perisphinctid unrelated with *Virgatosimoceras* as already pointed out by Olóriz (1978: 204). Vigh (1984: 123, pl. 2, fig. 1) figured a specimen from the Lower Tithonian of Paprét-árok, Gerecse Mountains, Hungary as *Virgatosimoceras steindachneri.* This specimen most likely belongs to a still un-described perisphinctid.

Simoceras achiardii Del Campana, 1905. – The holotype is a very poorly preserved and incomplete specimen. The innermost whorls are missing and the outer ones are too poorly preserved for identification, thus we consider this species as a *nomen dubium.* Enay & Geyssant (1975) listed *Virgatosimoceras achiardii* from the Semiforme Zone of southern Spain, but unfortunately the material was not figured.

Simoceras broilii Schneid, 1915 (Holotype refigured herein, Figs. 7.3a, 7.3b). – This species, although classically assigned to *Virgatosimoceras*, shows no relationships with the type species *V. rothpletzi.* The sculpture corresponds to a small sized perisphinctid ammonite. Moreover, the suture is very different to that of *Virgatosimoceras*, being more complex, the lateral and umbilical saddles different in design and strongly retracted, so showing one more saddle on the umbilical shoulder. This suture closely resembles the structure typical of the Lithacoceratinae. We assign this species preliminary to the genus *Dorsoplanitoides* Zeiss, 1968. The holotype shows close resemblance with *D.*? *obscurum* (Zeiss) and *D.*? aff. *robustus* Zeiss

(1968, pl. 13, fig. 2). Also the microconchs *Ammerfeldia ammerfeldensis* Zeiss, 1968 and *A. subschaschkovae* Zeiss, 1968 in Scherzinger & Schweigert (2003) have the same regular and dense style of bipartite ribbing.

"Danubisphinctes" spp. – In literature on Mediterranean ammonites several *Virgatosimoceras*-like perisphinctids have been figured (e.g., Sarti 1986; Cecca 1990; Cecca & Enay 1991). In most cases these ammonites have been compared with *Danubisphinctes* Zeiss, 1968, but as already noted by Cecca (1990, 1999) they do not belong to this genus. These ammonites have a similar ontogeny, bifurcate passing to triplicate ribs, to that of *Virgatosimoceras* (examples see Figs. 5.5, 8.1a, b). However, many of these ammonites were assigned by Olóriz (1978) to *Pseudokatroliceras* Olóriz, 1978. They can be distinguished from *Virgatosimoceras* by the more involute coiling and wider and stouter whorls. *Danubisphinctes* s. str. and its corresponding microconch *Parapallasiceras* Spath, 1925 have a Subboreal to Submediterranean distribution. Both are homoeomorphic with several other perisphinctids from other palaeobiogeographic regions (e.g. southern Spain: Olóriz 1978; Argentina: Leanza 1980) and were hence often misidentified (Schweigert & Scherzinger 2004). A revision of all these ammonites is necessary.

6. Sexual dimorphism in *Virgatosimoceras*

There is no published information about sexual dimorphism in *Virgatosimoceras*. Geyssant & Zeiss (1978) figured a finely preserved specimen of *Virgatosimoceras rothpletzi* from Unterhausen near Neuburg a. d. Donau, Franconia. This specimen shows, close to the peristome, a flattening of the whorl section what is typical for adult macroconch perisphinctids. Up today there is no single specimen with lappets documented in *Virgatosimoceras*. Beside typical macroconchs there exist small sized specimens (*Virgatosimoceras* sp. indet. figured by Barthel & Geyssant, 1973; pl. 1, fig. 1e-f). The specimen figured in Fig. 6.4a, b is a complete small adult with about half whorl of the body chamber. This specimen shows its last whorl uncoiled, what is a diagnostic feature of adulthood. Its inner whorls are identical at comparable diameter, to those of the larger and best preserved specimen of *V. rothpletzi* (Fig. 6.1-6.2). These specimens are very rare and none of the studied ones have lappets. The constrictions and the sculpture are similar in all specimens at comparable diameter. The small, almost isocostate specimens should be microconchs, and the larger and variocostate specimens the macroconchs. A more complete characterisation of the sexual dimorphism of this species needs complete microconchs with complete peristome (which could bear lappets), but it can be assumed with few doubts that the species of the genus are sexually dimorphic. All ammonites were collected in the *Penicillatum* horizon (bed 22-28) of the Unterhausen Member, Neuburg Formation.

7. *Virgatosimoceras* as a tool for correlation

Already in 1973, Barthel & Geyssant proposed a correlation of the Neuburg section with the Tethyan standard chronostratigraphic scale, but some of their determinations have led to different, sometimes contradictory interpretations. The main difficulty has been the conclusion that the basal part of the Neuburg Formation starts somewhere in the Darwini (= Albertinum) Zone. This conclusion was based on a fragmentary specimen (Fig. 5.4) that these authors assigned to *V. albertinum,* but which is herein confidently reinterpreted as belonging to *V. rothpletzi* of the Ciliata Zone (time-equivalent of the Fallauxi Zone, see Schweigert & Scherzinger 2004).

Kutek & Zeiss (1988: 632) correlated the lower part of the Neuburg Formation (their "rothpletzi/penicillatum Beds") with the Semiforme and the lower part of the Fallauxi zones (Richteri Subzone). Later, Scherzinger & Schweigert (1999, 2003) and Schweigert & Scherzinger (2004) gave additional and well-documented information, including the description of faunal horizons. It is now well established that all the known specimens of *V. rothpletzi* from the Neuburg Formation, including the original material of Schneid (1915), Barthel & Geyssant (1973) and *V. rothpletzi virgulifer* Geyssant & Zeiss, 1978, come from the *Penicillatum* horizon of the Ciliata Zone. This conclusion indicates that the variability shown by the known material of *V. rothpletzi* from the *Penicillatum* horizon can be attributed to intraspecific variation within a single transient of the species.

The uppermost Rennertshofen Formation near Ellenbrunn, Franconia, southern Germany (see Zeiss 1968), only few kilometers away from Neuburg, has yielded an ammonite fauna which belongs to the

Penicillatum horizon of the Neuburg Formation. In addition to several perisphinctids, there were collected: *Physodoceras neoburgense* (Oppel), *Sutneria asema* (Oppel) (coll. Scherzinger & Röper, 2003) and the boreal bivalve *Loripes gerasimovi*, and a specimen of *V. rothpletzi*. This specimen was formerly assigned to *Dorsoplanitoides bavaricus* in Zeiss (1968, pl. 16, fig. 2).

The successive chronospecies, as interpreted above, appear well delimited morphologically. This pattern is mainly based on the extension of the densely ribbed early ontogenetic stage and the morphology and sculpture of the adult bodychamber (further discussed below). Under these conditions the lineage opens possibility of its use in refining the time-correlation between the Mediterranean and Submediterranen Province during part of the Tithonian.

8. Evolution of the *Virgatosimoceras* lineage

The present review demonstrates a rather discrete but consistent phylogenetic succession of three chronospecies: *V. albertinum* – *V. dunaii* n. sp. – *V. rothpletzi*, ranging from the Darwini (equivalent with the Albertinum Zone) to the Fallauxi (equivalent with the Ciliata Zone) zones (Fig. 1) – or in other words an anagenetic (gradual) mode of evolution of chronospecies.

The specimens described above as *V.* aff. *dunai* n. sp. (Fig. 4.2-4.3) could represent other species close or transient to *V. dunaii* n. sp. within the Semiforme Zone.

The main morphologic evolutionary change through the described lineage consists of a gradual displacement of the characteristic variocostate ribbing towards earlier stages in the ontogeny. The stage of finely and radial ribbed inner whorls is developed in *V. albertinum* up to about 30-50 mm in diameter, but at smaller sizes of about 35-40 mm in *V. dunaii* n. sp. and about 25-30 mm in *V. rothpletzi*. In terms of developmental heterochronies this pattern may be interpreted as a peramorphic cline, since the adult size is very similar in the three species. This pattern should have been produced by a persistent process of acceleration of the juvenile sculptural development (McNamara 1986).

Virgatosimoceras seems restricted to the western part of the Tethys and neighboring north-western shelf. The occurrence of representatives of the genus out of this area, as well known also for *Volanoceras* in Central and South America (Krantz 1926, 1928; Imlay 1942; Verma & Westermann 1973; Cantú Chapa 1990; reviewed by Schweigert et al. 2002) is disregarded for the time being.

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