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Additional Tethydian ammonites from the lower Neuburg formation (Middle Tithonian, Bavaria)

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With 5 figures in the text

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Summary: There are two peaks of Tethydian influence in the Unterhausen member of the Neuburg formation: at the base and at the top. Four faunal elements of Tethydian provenience are described: phylloceratid, lytoceratid, haploceratid, and simoceratid ammonites. The fauna restricts the Middle Tithonian to the Unterhausen member.

Key words: Ammonoidea, Tithonian, biofacies, Tethys; SW German Mountains.

Résumé: De nouvelles ammonites qui confirment une nette influence téthysienne à la partie inférieure des couches de Unterhausen de la formation de Neuburg, ont été découvertes à Neuburg et sont décrites: *Phylloceras* cf. *kochi* (OPP.), *Protancyloceras* sp., *Haploceras elimatum* (OPP.) et plusieurs espèces de *Virgatosimoceras*. Une deuxième pénétration, moins importante, d'éléments mésogéens est mise en évidence à la partie supérieure des couches de Unterhausen. Le Tithonique moyen est limité faunistiquement aux couches de Unterhausen.

Zusammenfassung: Einige zusätzliche Funde von Ammoniten, die den Tethys-Einfluß in den Unterhausener Schichten der mitteltithonischen Neuburger Folge weiter betonen, werden behandelt: *Phylloceras* cf. *kochi* (OPP.), *Protancyloceras* sp., *Haploceras elimatum* (OPP.), *Virgatosimoceras* cf. *albertinum* (CATULLO), *broilii* (SCHNEID), *rothpletzi* (SCHNEID), sp. indet. Ein zweiter, schwächerer tethydischer Einschlag zeigt sich in den obersten Unterhausener Schichten. Faunistisch ist das Mittel-Tithon auf die Unterhausener Schichten beschränkt.

Introductory note: Neuburg formation became widely known when TH. SCHNEID published his 1915 report on the ammonites found in these thick bedded limestones. The exact stratigraphic position within the Tithonian remained discussed until bed by bed quarrying operations uncovered Middle Tithonian faunal elements (BARTHEL, 1962). Further field operations in 1963/1964 provided data evaluated in BARTHEL 1969 and, with some exceptions, the specimens discussed below. Neuburg formation is extending into the Upper Tithonian with the top part of its Oberhausen mem-

ber. The basal Unterhausen member is enclosing the bulk of the ammonite fauna.

For locality names, stratigraphic details, bed numbers, and other information we refer to the papers cited above.

Synonymies are given in reduced form.

J. R. GEYSSANT is responsible for treatment of the simoceratids, K. W. BARTHEL for description of the remaining specimens, and both have joined for elaboration of the conclusions.

Phylloceratina ARKELL 1950
Phylloceratacae ZITTEL 1884
Phylloceratidae ZITTEL 1884
Phylloceras SUESS 1865
Phylloceras (Calliphylloceras ?) cf. *kochi* (OPPEL, 1865)

Fig. 1 a, b

cf. v* 1865 *Ammonites Kochi* Opp. — OPPEL, Tithon. Etage, 550.

cf. v 1868 *Phylloceras Kochi* Opp. sp. — ZITTEL, Stramberg, 65, pl. 6, fig. 1; pl. 7, figs. 1, 2.

cf. v 1870 *Phylloceras Kochi* Opp. — ZITTEL, Ält. Tithonbildungen, 159.

1871 *Phylloceras Kochi* Opp. sp. — NEUMAYR, Jurastudien 3, 337, pl. 15, f. 4.

cf. 1961 *Calliphylloceras kochi* (OPPEL). — DONZE & ENAY, St. Concors, 37.

v *1968* Phylloceratide — ZEISS, Cephalopoden Untertithon d. Frankenalb, 145.

Measurements (in mm, taken from plaster cast):

maximum length preserved:	119,5
maximum width measurable:	70,0

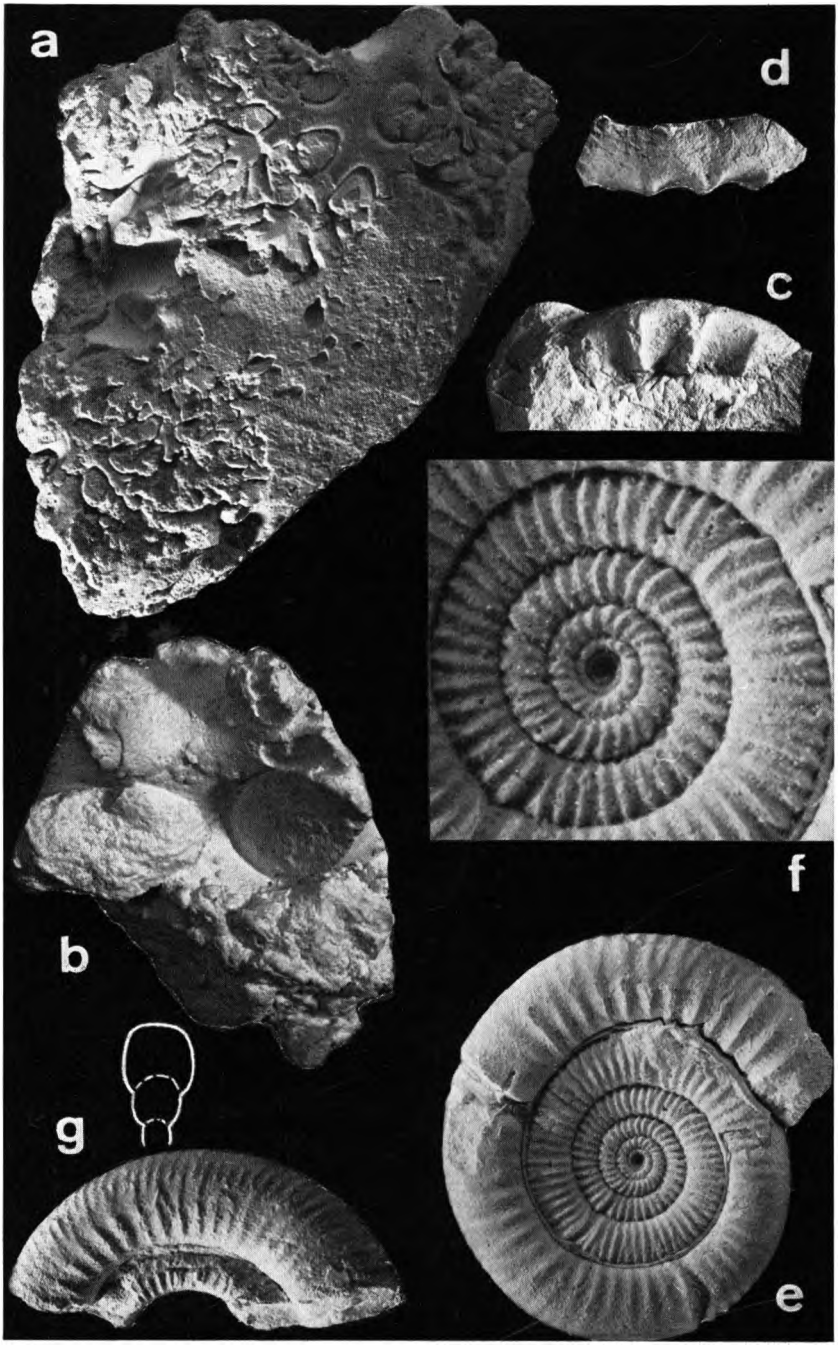
Locality: Quarries at the Unterhausen railway station; exact quarry unknown.

Bed: Neuburg formation, Unterhausen member, bed 22 (6) or 42 (26); comp. BARTHEL 1962, pl. 4.

Depository: L. KRUMBECK collection of the Geological Institute, Erlangen University; S 801.

This is but the exterolateral fragment of a large individual which must have reached twice the size of the specimen figured in ZITTEL 1868, pl. 6, fig. 1.

The fragment is exposing enough of the suture line, part of the whorl section, and imprints of the accretion lines to leave little doubt the specific allocation. Comparison with the originals of ZITTEL is supporting this. As in all large individuals of this species constrictions are absent on last whorls.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d
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e

One should hardly mention a mere fragment, were it not for the fact that this genus is very scantily represented in Upper Jurassic beds of the Franco-Suabian Alb.

Beside the more frequent *Sowerbyceras* of the Oxfordian and some solitary *Phylloceras* s. s. (QUENSTEDT 1887/88 pl. 97, f. 7; pl. 120, f. 15; pl. 121, f. 1; pl. 125, f. 14) from various zones of the Lower Kimmeridgian (sensu ARKELL) the further record is obsolete. It thus becomes obvious that the Middle Tithonian specimen is of some importance which is enhanced by its concurrence with other Tethydian elements during the deposition of the early Unterhausen member. The indicative value of *Ph. kochi* for detailed stratigraphy is, however, negligible since its range covers the entire Tithonian. The geographic distribution follows the Tethydian open-sea realms of Europe (Stramberg, Karpatian mts., Neuburg, Savoy, Southern Alps, Apennines a. o.).

The subgeneric attribution is tentative because the status of phylloceratid systematics in Jurassic forms is still not satisfactory.

Lytoceratina HYATT 1889
Ancyloceratacea MEEK 1876
Protancyloceratidae BREISTROFFER 1947
Protancyloceras SPATH 1924
Protancyloceras sp.

Fig. 2 a—f

Measurements (in mm):
D = diameter; U = umbilical diameter; W_h = whorl height; W_{th} = whorl thickness.

Fig. 1. a: *Phylloceras (Calliphylloceras ?)* cf. *kochi* (OPPEL), p. 19, fragment, lateral view. × 0,8.
b: *Phylloceras (Calliphylloceras ?)* cf. *kochi* (OPPEL), p. 19, fragment, septal view. × 0,8.
c: *Virgatosimoceras* cf. *albertinum* (CATULLO), p. 27, fragment, lateral view. × 1
d: *Virgatosimoceras* cf. *albertinum* (CATULLO), p. 27, fragment, external view (one side preserved only). × 1.
e: *Virgatosimoceras* sp. indet., p. 31, lateral view of immature specimen. × 1,6.
f: *Virgatosimoceras* sp. indet., p. 31, innermost whorls of specimen figured in 1 e. × 4.
g: *Virgatosimoceras broilii* (SCHNEID), p. 28, part of phragmocone. × 1,6; and whorl section (W_h = 8,9 mm). × 1.
All specimens are from the Unterhausen member, Neuburg formation; quarries at the Unterhausen railway station.
All specimens whitened by MgO fumes.

Largest diameter measurable:		
	U:	8,9 (61 %)
	W_h:	3,2 (22 %)
	W_{th}:	2,9 (20 %)
Number of ribs:		29
Measurements of plastic core:		
	D:	11,5
	U:	7,5 (65 %)
over ribs	W_h:	2,5 (22 %)
over ribs slightly crushed	W_{th}:	2,4 (21 %)
Number of ribs:		30
Innermost whorl at	D:	7,6
	U:	5,5 (73 %)
	W_h:	1,3 (17 %)
	W_{th}:	1,2 (16 %)

Number of ribs (count under immersion): 47

The measurements of the plastic core give slightly smaller values because the natural mold shows an over-all coating of tiny calcite crystals.

Locality: Smaller quarry at the Unterhausen railway station.

Bed: Neuburg formation, Unterhausen member, bed 22 (6).

Depository: Bayer. Staatssamml. Paläont. hist. Geol., Munich, 1957 VI 4424.

This third representative of uncoiled ammonites from the Neuburg formation consists of a partial living chamber (core) and an almost complete phragmocone (mold). The mold permitted preparation of a plastic cast.

Two slightly elliptic coils are preserved. Whorl height is slowly increasing and the umbilicus, consequently, is wide. The excentric protoconch is missing and supposedly has broken off. The minuteness of the initial part allows the assumption to estimate the length of the absent part to a quarter or at most half a whorl up to the protoconch. Similar conditions are found in other leptoceratid ammonites.

The two coils are in close approximation but do not touch. The whorl section is slightly compressed but must have been approximately circular before compaction of the sediment.

The number of ribs decreases with age (47 to 29). Extern and intern sides are crossed without interruption in the inner whorl, the ribs being some prorsocostate. On the living chamber they are almost recticostate and progressive interruption becomes observable at the venter. "Chevroning" is barely visible. Ribs are distinct, sharp, and thicken toward the extern side.

The interior tour has a compaction-induced siphonal crest and in some spots the sipho itself is distinguishable on the cast (Fig. 2 f).

The original shell material of the living chamber was replaced by crystalline calcite. This circumstance enabled partial preparation by the sandblast method. Preservation of that type, however, is unfavourable for the only possibility to recognize the suture line: the rear wall of the living chamber consists of fairly large calcite crystals which have grown into the void of the phragmocone mold. Viewed under immersion a rough E-L-U-I lobe pattern can be made out.

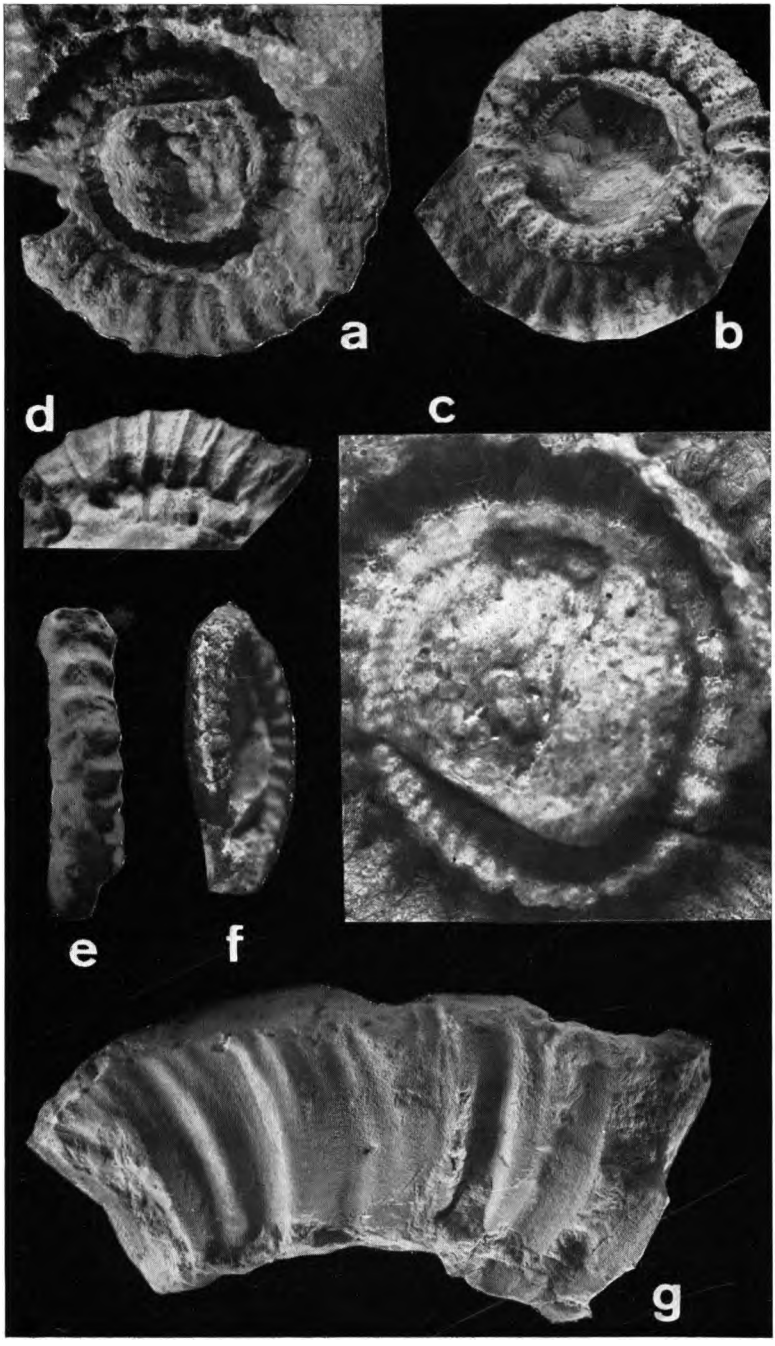
Relationship: Generic attribution of the specimen meets some handicaps. This is due to paucity of Tithonian material, the imperfect state of preservation, and a high degree of intraspecific variation.

If one is accepting THIEULOY's 1966 (p. 287) diagnosis of *Leptoceras* UHLIG the present form fits most characters except for absence of retrocostate ribbing, interrupted ribs on the living chamber, and slower increase of whorl hight. These latter properties are found in *Protancyloceras* SPATH, to which THIEULOY assigns "... formes à enroulement cyrtoconique très ouvert ...". Our specimen, on the other hand, exhibits the more regular and tighter coiling of *Leptoceras*. I was able to check this against six topotype specimens of *Leptoceras studeri* (OOSTER) (Mus. hist. nat. Paris, R 764).

Such mode of coiling was also present in *Protancyloceras* sp. (BARTHEL 1962, pl. 1, f. 6–10, p. 10) in which the whorls are in close contact and bear coarser ribbing (25 at 13,5 mm). It was considered a possible juvenile specimen of *P. guembeli* (OPPEL). With the new specimen the rib density becomes transitional to that of the uncoiled sections known as *P. gracile* (OPPEL) (BARTHEL 1962, pl. 1, f. 1–5).

Since in our realms finds are restricted to two species, *P. guembeli* and *gracile*, we may assume, with high probability, the association of the Neuburg juveniles with these. As *gracile* is fairly frequent, respective to *guembeli*, it seems reasonable to assign our early whorls to the first. *P. guembeli* is very similar to *P. kurdistanense* SPATH in living chamber ornamentation and possibly had also a dense prorsocostate ribbing, a point disregarded in 1962.

If we take the three Neuburg individuals as fragments belonging to the same species, *P. gracile*, the complete animal must have consisted of rather closely coiled initial whorls which then became quickly uncoiled to form moderately curved to almost straight rods. THIEULOY (1969, 415/416 in: ENAY et al.) has expressed similar views, but last evidence is still lacking. With this conch shape *P. gracile* would make an almost ideal predecessor of protancyloceratids and leptoceratids alike: one branch continuing narrow initial coiling, reducing the rod, and, loosening the entire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spire in the protancyloceratid main stock. We consider *guembeli* as an early off-shoot rather than the root-stock, as is done by THIEULOY (1966, f. 2).

SPATH (1950) and THIEULOY (1966) have surveyed the protancyloceratid and leptoceratid forms to some extent. Comments therefore pertain to close relatives of *P. gracile*. SPATH's 1950 pl. 9, f. 6 specimen seems to be the largest fragment of a living chamber known.

Another Kurdistan *P.* aff. *gracile* (SPATH 1950, pl. 9, f. 4) we would rather join with *P. hondense* (IMLAY). Comparison with casts of the Cuban species (IMLAY 1942, pl. 10, f. 10) reveals considerable rib density in both but the Kurdistan form differs by marked extern chevroning. On pl. 8 (figs. 13, 14) SPATH presents a protancyloceratid which is difficult to place. He correctly places pl. 6, figs. 13, 14, near *P. catalinense* (IMLAY). Since, however, *catalinense* and *hondense* are connected by transitional forms (IMLAY 1942, 1495) they should be united under the better known *hondense*. *P. hondense* is a close relative of *gracile* from which mature individuals are set off clearly by the regularly continuing spire. To our knowledge *hondense* is the only Tithonian species known by a large number of individuals.

Fig. 2. a: *Protancyloceras* sp., p. 21, original specimen, juvenile whorls, right lateral view. × 3,5.

b: *Protancyloceras* sp., p. 21, plastic cast of innermost whorls of Fig. 2 a, left lateral view. Coarse surface caused by replicas of calcite crystals. × 3,5.

c: *Protancyloceras* sp., p. 22, detail of incipient whorl of specimen figured in 2 a, to show mode of ribbing on right side (mold!). × 7.

d: *Protancyloceras* sp., p. 22, living chamber, left lateral view. Originally acute ribs partially dulled by sandblast operations to free object from sediment. × 3,5.

e: *Protancyloceras* sp., p. 22, external view of preserved part of living chamber. Same specimen as in 2 a. × 3,5.

f: *Protancyloceras* sp., p. 23, oblique external view showing siphuncle as preserved at about $^2/_3$ of the first whorl. Plastic cast as in 2 b. × 3,5.

g: *Virgatosimoceras* (?) *broilii* (SCHNEID)?, lateral view of crushed specimen; living chamber fragment. × 1. Top of Unterhausen member, larger quarry at the Unterhausen railway station, p. 29.

Specimen of Fig. 2 a—f recovered from the basal Unterhausen member, Neuburg formation; smaller quarry, Unterhausen railway station.

All specimens whitened by MgO fumes, except Fig. 2 c, which was taken with the object under alcohol immersion.

Middle Tithonian protancyloceratids had a Tethys-wide distribution (Cuba to Kurdistan) and thus are useful for approximate long-range correlation. These frail animals probably have reached distant places well camouflagend among floating plants like todays *Sargassum*. Their shell form would aptly mimikry bent and coiled plant parts.

Ammonitina Hyatt 1889
Haploceratacea Zittel 1884
Haploceratidae Zittel 1884
Haploceras Zittel 1870
Haploceras elimatum (Oppel, 1865)

v* 1865 *Ammonites elimatus* Opp. — Oppel, Tithon. Etage, 549.

v 1868 *Ammonites elimatus* Opp. — Zittel, Stramberg, 79—82, pl. 13, figs. 1—7.

v 1870 *Haploceras elimatum* Opp. — Zittel, Ält. Tithonbildungen, 11—12, pl. 27, fig. 7.

1961 *Haploceras elimatum* (Oppel). — Donze & Enay, St. Concors, 44.

v 1962 *Haploceras elimatum* (Oppel). — Barthel, Neuburger Bankkalke, pl. 1, figs. 12—17.

Measurements (in mm):

Maximum diameter:	52,5
D:	49
U:	13,8 (= 24 %)
W_h:	23 (= 44 %)
W_{th}:	13,5 (= 24 %)

Locality: Smaller quarry at the Unterhausen railway station.

Bed: Neuburg formation, Unterhausen member, bed 22 (6).

Depository: Bayer. Staatssamml. Paläont. hist. Geol., Munich, 1957 VI 4425.

The specimen is a steinkern consisting of living chamber and two phragmocone chambers. As in most Neuburg ammonites the interior whorls are without sedimentary filling and hence are preserved as voids. The cast of the living chamber is slightly compressed. Its flanks are covered with sigmoid accretion lines. Measurements and suture line are matching those given for the species. Of all the *elimatum* found in the Unterhausen member, so far, the specimen under consideration is the largest, rating with the average given by Zittel (1868, 80).

The time range of this frequent Tethydian species continues throughout the Tithonian into the Berriasian.

Perisphinctaceae STEINMANN 1890
Aspidoceratidae ZITTEL 1895
Simoceratinae SPATH 1924
Virgatosimoceras SPATH 1925
Virgatosimoceras cf. *albertinum* (CATULLO, 1853)

Fig. 1 c, d; 4

cf. v* 1853 *Ammonites Albertinus* Cat. — CATULLO, Calc. rosse ammon. Alpi venete, 208, pl. 2, f. 3 a, b.

cf. v. 1870 *Perisphinctes Albertinus* Catullo sp. — ZITTEL, Fauna ält. ceph. führend. Tithon., 222, pl. 34, f. 1 a—d.

cf. 1880 *Perisphinctes Albertinus* Cat. (sp.) — PARONA, Caprino e Longarone, 10.

cf. 1905 *Perisphinctes Albertinus* Cat. — CAMPANA, Sette comuni, 61.

cf. 1910 *Simoceras Albertinum* Cat. — FURLANI, Lemeš-Schichten, 77.

cf. *1925* *Virgatosimoceras ? albertinum* (Catullo) — SPATH, Somaliland, 131.

cf. 1939 *Perisphinctes Albertinus* (CAT.) — RAMACCIONI, Mte. Cucco, 197.

Measurements (in mm):

W_h	8,9	8,5
W_{th}	$\sim$ 11,8	$\sim$ 11,0
ratio W_{th}/W_h	$\sim$ 1,33	$\sim$ 1,29

Locality: Smaller quarry at the Unterhausen railway station.

Bed: Neuburg formation, Unterhausen member, bed 22 (6).

Depository: Bayer. Staatssamml. Paläont. hist. Geol., Munich, 1957 VI 4426.

But a small fragment of a rather evolute whorl-core has been recovered. It has a subquadrate section which is slightly wider than high between the ribs. Over the ribs width markedly exceeds height. Ribs are bifurcate, distantly spaced, strong, and acute. The primaries and the posterior secondaries are rectiradiate whereas the anterior secondaries become more or less prorsiradiate. Prominence of the primaries is lost in the secondaries which are fading and leave a smooth band on the extern side.

Relationship: Mode of coiling, whorl section and ribbing are those of the genus *Virgatosimoceras*. The specific characters justify approximation to *V. albertinum* from which it differs by less dense costulation, thicker whorls, and shorter external secondaries, at comparative diameters. The specimen is clearly discernible from inner whorls of *V. broilii* and *V. rothpletzi* also found at Unterhausen. This is the first record of an *albertinum*-type simoceratid from the extra-Alpine parts of southern Germany.

Virgatosimoceras broilii (SCHNEID, 1915)

Fig. 1 g, 3—4

v* 1915 *Simoceras broilii* n. sp. — SCHNEID, Ammonitenfauna Neuburg, 392, pl. 23, f. 1, 1 a; non pl. 22, f. 4, 4 b.

v 1916 *Simoceras broilii* n. sp. — SCHNEID, Fränk. Alb, 24 (190).

1925 *Virgatosimoceras broilii* (SCHNEID) — SPATH, Somaliland, 131.

1959 *Katroliceras (Virgatosimoceras) broilii* — ZIEGLER, Idoceras, 47.

v *1962* *Virgatosimoceras broilii* — BARTHEL, Neuburger Bankkalke, 24.

Measurements (in mm):

Specimen A:	Maximum restored diameter	~ 35	
	number of primaries on last semi-whorl:	26	
	At restored D	~ 33	
	restored U	~ 18	(55 %)
	W_h	8,9	(27 %)
	W_{th}	8,4	(25 %)
	W_{th}/W_h ratio	0,94	
	number of primaries on last semi-whorl:	24	(at D ~ 33)
	Ratio W_{th}/W_h at W_h 8,0	0,99	
Specimen B:	Maximum restored diameter	~ 130	

Locality: Smaller quarry at the Unterhausen railway station.

Bed: Neuburg formation, Unterhausen member, bed 22 (6).

Depository: Bayer. Staatssamml. Paläont. hist. Geol., Munich; specimen A: 1957 VI 4427, specimen B: 1957 VI 4430.

Specimen A consists of part of a phragmocone cast. Umbilical width is considerable and the coils are hardly touching. Whorl section is varying from almost quadrate in the inner whorls to higher than wide in the younger coils. Flanks and external side are fairly flat (Fig. 1 g). Ribs are numerous, almost exclusively bifurcate, densely spaced (Fig. 4). Primary ribs are straight and recticostate, the weaker secondaries show moderate forward inflection. At the external side the secondaries are either interrupted or attenuated.

Suture line: E is of moderate width and deeper than the trifid L. E/L is also trifid with a deep intern incision and, as a whole, is large. Two U are visible on the flanks, an undivided U_1 lies on the intern side beside the narrow U_1/I and the slender deeply cut I. U_2 surpasses U_3 in size. Both are well developed and separated by a wide U_3/U_2 with two frontal incisions.

Specimen B is a partly preserved living chamber core which is fairly complete toward the aperture but fading into an imprint near the badly preserved phragmocone. At the aperture the ribs are simple. They possess a forward inclination. Their relief on the flanks is regular. Due to diagenetic compaction the whorl section is higher than wide.

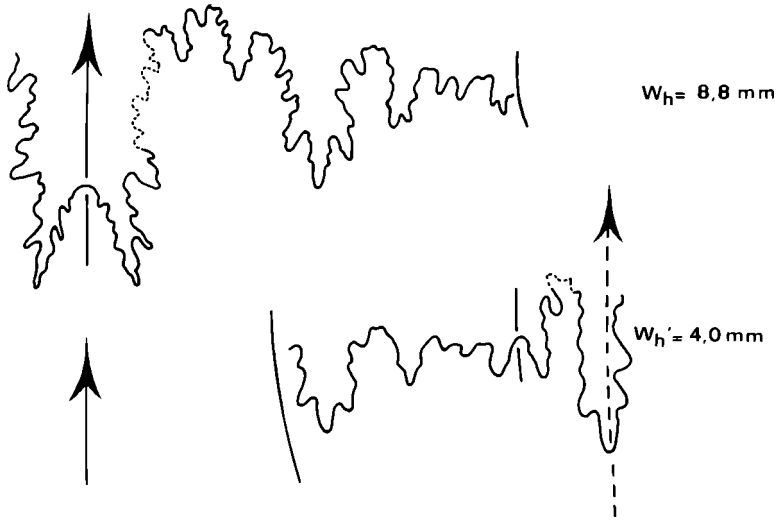

Fig. 3. *Virgatosimoceras broilii* (SCHNEID), suture line.

Relationship: Again, type of ribbing, slow increase of whorl height and wide umbilicus enclose the specimens in the genus *Virgatosimoceras*. Details in specimen A correspond with the species *V. broilii:* 1. Equal umbilical diameters (umbilical diameter in *rothpletzi* is wider). 2. Whorl section higher than wide and flattened flanks (wider than high, with vaulted flanks in *rothpletzi*). 3. Same rib frequency as in SCHNEID's specimens and predominance of bifurcated ribs. 4. Suture line identical with that of *broilii* but differing from the *rothpletzi* type. In specimen B rib pattern and whorl section are essentially as in *V. broilii*.

Though fragmentary, both specimens may be included, with a high degree of probability, in the species *broilii*.

Virgatosimoceras (?) *broilii* (SCHNEID, 1915)?

Fig. 2 g

For synonymy see p. 28

Measurements (in mm): Largest dimension: 88.

Locality: Larger quarry at the Unterhausen railway station.

Bed: Neuburg formation, Unterhausen member, bed 116 (89).

Depository: Bayer. Staatssamml. Paläont. hist. Geol., Munich, 1957 VI 4429.

Fossils found at the 116 (89) level are usually crushed. This is also the case with the living chamber fragment under discussion. W_h accordingly

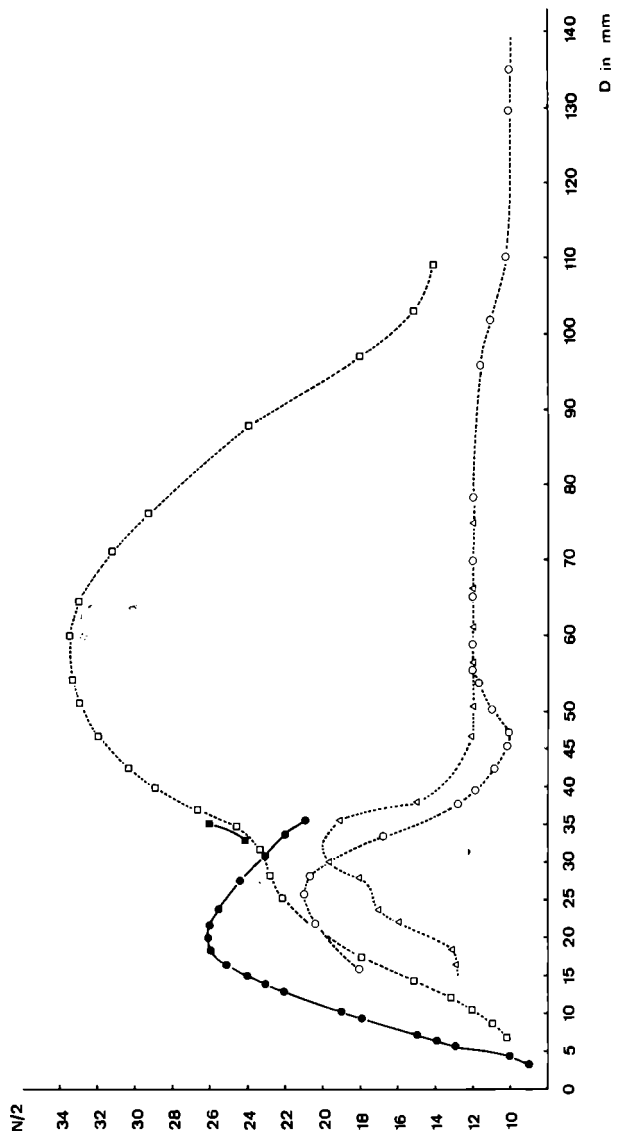

Fig. 4. *Virgatosimoceras* rib frequency curves. D = diameter; N/2 = number of ribs per semi-whorl; black squares = *V. broilii*; black circles = *V.* sp. indet.; white squares = *V. broilii*, lectotype (Munich 1913 IX 504); white circles = *V. rothpletzi*, lectotype (Munich 1913 IX 201 b, c); white triangles = *V. albertinum*, holotype (Padova 6.916 v).

is overstressed. The evolute relic bears distant ribs which bifurcate at about the exterior third of the flanks. One rib seems to be trifurcate but the third and last secondary is very weak. The secondaries are prosocline

and lower in relief than the primary ribs. Two deep constrictions exhibit the same prorsocostate trait as the anteriorly concave general ribbing.

With these characters the specimen may well belong to *V. broilii*.

Virgatosimoceras rothpletzi (SCHNEID, 1915)

v* 1915 *Simoceras Rothpletzi* n. sp. — SCHNEID, Ammonitenfauna Neuburg, 390, pl. 20, f. 1—1 c; pl. 23, f. 2, 3—3 b.

v 1916 *Simoceras Rothpletzi* n. sp. — SCHNEID, Fränk. Alb, 24 (190).

1925 *Virgatosimoceras rothpletzi* (Schneid). — SPATH, Somaliland, 131.

1959 *Katroliceras (Virgatosimoceras) rothpletzi.* — ZIEGLER, Idoceras, 47.

v *1962* *Virgatosimoceras rothpletzi.* — BARTHEL, Neuburger Bankkalke, 24.

Locality: Smaller quarry at the Unterhausen railway station.

Bed: Neuburg formation, Unterhausen member, bed 22 (6) specimens 1957 VI 4431, 4432 and bed 24 (8) 1957 VI 4433.

This species is represented by three living chamber fragments (cores) of various growth stages, with typical *V. rothpletzi* ribbing. The ribs commence retrocostate at the umbilical part of the flanks with a very pronounced relief, then they weaken considerably toward the middle. Approaching the flank-exterior, rib relief once more increases strongly and the secondaries become procline. There are single or bifurcate ribs.

Virgatosimoceras sp. indet.

Fig. 1 e, f; 4, 5

Measurements (in mm): At various diameters

D	U		W_h		W_{th}		W_h/W_{th}	ribs per semi-whorl
35,3	21,0	59 %	8,0	23 %	~ 9,6	~ 27 %	~ 1,20	20
33,8	19,9	59 %	7,7	23 %	8,9	26 %	1,16	21
30,6	17,8	58 %	7,0	23 %	8,1	26 %	1,16	23
27,3	16,3	60 %	6,7	25 %	7,7	28 %	1,15	24
25,5	15,2	60 %	6,4	25 %	7,6	30 %	1,19	25

Locality: Smaller quarry at the Unterhausen railway station.

Bed: Neuburg formation, Unterhausen member, bed 22 (6).

Depository: Bayer. Staatssamml. Paläont. hist. Geol., Munich, 1957 VI 4428.

Part of a juvenile living-chamber-cast and a phragmocone mold are available. A plastic cast has been gained from the mold. Very wide

umbilicus, slow increase in whorl height are significant "shell" characters. Whorl section is subcircular, width barely surpassing height.

Ribs are numerous, with maximum frequency at a diameter of about 20 mm (Fig. 4). They are either simple or bifurcate. The points of furcation lie close to the ventral shoulder, being almost covered by the subsequent coils. Prorsocostate primary ribs are encountered up to a diameter of 7 mm and thereafter are becoming progressively recticostate. Then the posterior secondaries continue in recticostate manner while the anterior secondaries have a forward slant. On the inner whorls the ribs are passing uninterruptedly across the venter. They are leaving, however, a smooth siphonal band on the last whorl's mid-venter. One notes uniform costal relief on coils below the 30 mm diameter. Above this diameter the primaries are increasing in strength.

There are two or three deep and forward-bent constrictions per whorl. A single suture line has been tolerably preserved at the adapical side of the

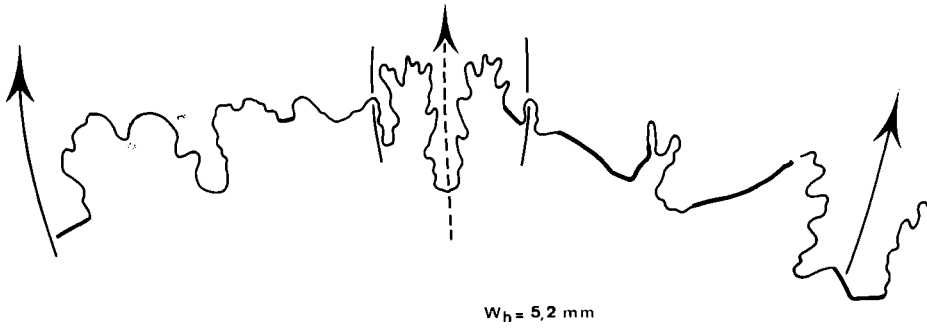

Fig. 5. *Virgatosimoceras* sp. indet., suture line.

living chamber. Three umbilical lobes seem to have existed. The undivided U_1 is the single intern umbilical lobe beside a narrow and deep I (Fig. 5).

Relationship: Generic attribution is indisputable. In general the specimen is comparable to young *V. broilii* and *rothpletzi*. Its rib frequency curve suggests closer affinity to *rothpletzi:* in *broilii* rib frequency is increasing up to the diameter of 55 mm (Fig. 4). From *rothpletzi,* however, the specimen is contrasting by recticostate ribbing as well as by possession of the single intern U element (U_1) in the suture line.

It may be stressed that the present *Virgatosimoceras* have been recovered from the basal beds (22, 24) of the Neuburg formation, excepting but one crushed specimen from bed 116.

Knowledge of local facies conditions and of SCHNEID's specimens permits retracing of most of his originals to bed 22. It is certain beyond doubt for the lectotypes of *V. rothpletzi* (type-species) and *broilii*. SCHNEID's additional specimens come with near-certainty also from bed 22, and definitely not from beds above 42 (26) (BARTHEL 1962, pl. 4). Such is also valid for the solitary *Simoceras volanense schwertschlageri* SCHNEID.

Thus the simoceratids were concentrated in the lower part of the Unterhausen member, i. e., at the base of the Middle Tithonian. We recovered fragments of six individuals from 18 m^2 of bed 22 during our operations.

Conclusions

The ammonites *Protancyloceras*, *Phylloceras* cf. *kochi*, *Haploceras elimatum*, *Virgatosimoceras* cf. *albertinum*, *V. broilii*, *V. rothpletzi*, and *V.* sp. indet. add further Tethydian elements to the Neuburg fauna. With the known specimens of *Protancyloceras gracile*, *Pseudolissoceras bavaricum* BARTHEL, *Glochiceras carachtheis* (ZEJSZNER), *Haploceras elimatum*, *Sutneria asema* (OPPEL) and SCHNEID's original simoceratids we can locate the Tethydian faunal peak at the base of the Middle Tithonian.

Together with some perisphinctids this peak signifies the strongest Tethydian influence not only within the Neuburg formation but in the entire Franconian Upper Jurassic.

Since 1962 we know that there is a second bed, 116 (89), with *Pseudolissoceras*. From this bed the 1963 field party extracted single specimens of *Sutneria* cf. *asema* and *Virgatosimoceras* (?) *broilii* (?) (see p. 29). We therefore may speak of a second, though much weaker Tethydian peak within the Unterhausen member.

Among the newly described specimens *Virgatosimoceras* cf. *albertinum* deserves special interest because it represents a frequent mediterranean species. Jointly with other simoceratids from Neuburg it seems to indicate a marker bed. *V. albertinum* and additional simoceratids are found at a similar stratigraphic position in sections of the Betic Cordillera (above the Hybonotum and below the Semiforme zones: ENAY & GEYSSANT, unpublished).

It is, however, difficult to establish exact correlation at present. Lower and Middle Tithonian are mostly condensed in regions within and in immediate vicinity of the former geosynclinal realm of Europe. For convenience, therefore, we often find the Middle Tithonian included in a lower Tithonian s. l.

The Middle Tithonian, on the other hand, is clearly discernible by its faunal content and it is well developed in other areas. *Pseudolissoceras*,

Protancyloceras and simoceratids are fairly frequent in these beds, and can be correlated, at large, from Cuba to Kurdistan (BARTHEL, 1962; ENAY et al., 1969).

Within the realms of the northern Tethys *Semiformiceras semiforme* (OPPEL) has been considered the index of the Middle Tithonian. The exact range of this ammonite is, however, largely unknown. So, presently, it seems preferable to use the above association as it occurs in the Neuburg section (opinion BARTHEL) to characterize the Middle Tithonian.

Of all ammonites the perisphinctid genus *Isterites* (BARTHEL 1969, 151) alone passes on into the Oberhausen Member. *Isterites* seems to be an endemic genus and thus we may consider the Unterhausen member (23 m) as the legitimate equivalent of the Middle Tithonian in extra-Alpine Bavaria (see also ZEISS 1968, 38). A large part of the Oberhausen member has been included in the Middle Tithonian by BARTHEL in 1969, taking the topmost *Isterites* finds in consideration.

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