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First record and correlation value of *Aulacostephanus* cf. *subundorae* (Pavlow) (Ammonoidea, Upper Jurassic) from SW Germany

Günter Schweigert and **Lothar H. Vallon,** Stuttgart

With 7 figures and 1 table

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Abstract: *Aulacostephanus* cf. *subundorae* (Pavlow) is recorded for the first time from the Upper Jurassic Brenztaltrümmerkalk Member in Eastern Swabia (SW Germany). Together with *Gravesia irius* (d'Orbigny), this ammonite species of Subboreal origin is indicative of the youngest Late Kimmeridgian Autissiodorensis Zone. The co-occurring ammonites from this formation have a Submediterranean origin. Hence, a correlation is possible between the Subboreal and the Submediterranean zonation around the Kimmeridgian/Tithonian boundary.

Zusammenfassung: Die subboreale Ammonitenart *Aulacostephanus* cf. *subundorae* (Pavlow) wird erstmals aus der Brenztaltrümmerkalk-Subformation im Oberjura der östlichen Schwäbischen Alb nachgewiesen. Zusammen mit *Gravesia irius* (d'Orbigny) kennzeichnet die Art die Autissiodorensis-Zone des jüngsten Kimmeridgium. Die begleitende Ammonitenfauna ist der Submediterranen Faunenprovinz zuzurechnen. Hierdurch wird eine Korrelation zwischen der subborealen und der submediterranen Zonengliederung im Kimmeridgium/Tithonium-Grenzbereich ermöglicht.

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1. Introduction

In the eastern part of Swabia, the Brenztaltrümmerkalk is a locally developed bioclastic deposit in the higher part of the Upper Jurassic. The Brenztaltrümmerkalk has a maximum thickness of about 100 meters and is mainly restricted to the near surroundings of Heidenheim and Schnaitheim, where it was quarried for several centuries as an important building stone. Today, the quarries are all abandoned, but some have been preserved by geoconservation legacy. When the quarries were being actively worked, many fossils were recorded, including vertebrate remains of marine turtles, together with bones and teeth of marine crocodiles, sharks and holocephalans. In his fundamental study of the Brenztaltrümmerkalk, MUSPER (1920-1921) provided an exhaustive list of all fossils known at that time. Subsequently, BERCKHEMER (1924), followed by GEYER (1953), and, more recently LAUXMANN (1991), relisted the taxa without adding further data.

The Brenztaltrümmerkalk was mapped as a formation or as a member, but by most recent convention it is defined as a member. KREMER (1953) and REIFF (1958, 1988, 1991) studied the correlation of the Brenztaltrümmerkalk with neighbouring members and formations. REIFF (1991) also presented microfacies analysis and suggested that its deposition was influenced by tides, but a reliable environnmental reconstruction is still missing. For such a reconstruction precisely dated time equivalent successions are needed. This is difficult because of the overall scarceness of biostratigraphically relevant fossils in these shallow water deposits. In his diploma-thesis, L. VALLON has attempted a new reconstruction of the geometry of the Brenztaltrümmerkalk and contemporaneous Upper Jurassic deposits in eastern Swabia, using a microfacies analysis and high resolution analysis of macrofossils both stratigraphically and geographically. Here we present important finds from this area (Fig. 1).

2. Ammonites from the Brenztaltrümmerkalk Formation

Ammonites from the Brenztaltrümmerkalk are very rare and usually poorly preserved because of the high energy depositional environment and the coarse-grained lithology. However, during the time of active quarrying several better preserved ammonites were recorded. The determinations of ammonite taxa provided by MUSPER (1920), later again cited by LAUXMANN (1991), are of little worth because at that time the knowledge of ammonites from the higher part of the Upper Jurassic was in its infancy. As far back as 1953 GEYER had some doubts about the former determination of a perisphinctid ammonite (Fig. 6) from the Brenztaltrümmerkalk as "*Perisphinctes* cf. *vimineus* SCHNEID". The latter species, if correctly identi-

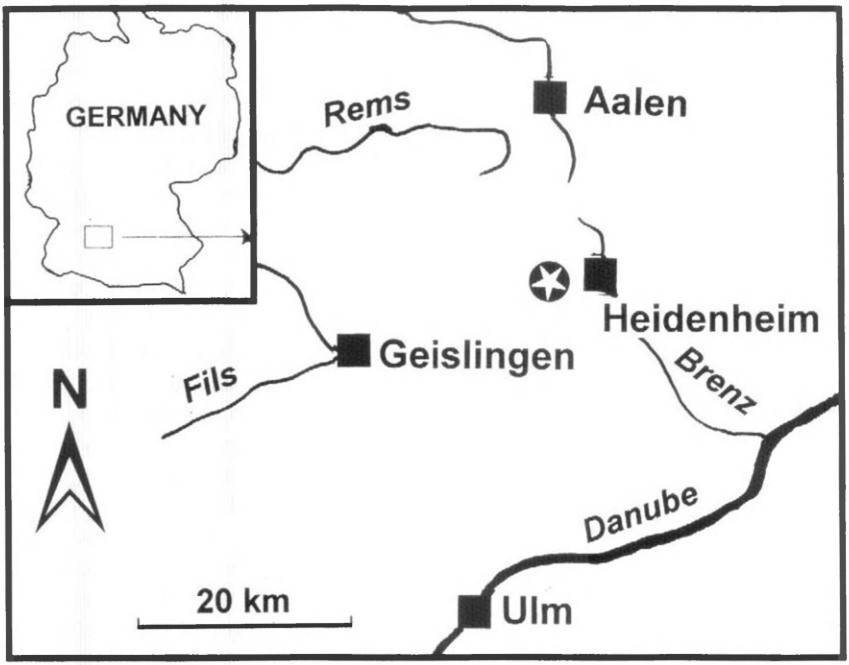

Fig. 1. Location of the *Aulacostephanus* find in SW Germany.

fied, would have pointed to a Tithonian age much younger than the famous Solnhofen Lithographic Limestones of southern Franconia. This identification as *Franconites vimineus* – now proved to be erroneous – together with other misleading data provided by ROLL (1933), gave rise to an incorrect correlation between the Swabian and the Franconian Upper Jurassic (e.g. HENNIG 1943; FESEFELDT 1962: table 1).

KREMER (1953) studied the relationship between the Brenztaltrümmerkalk and neighbouring formations. He recognized that the Brenztaltrümmerkalk interfingers both with Zementmergel, massive spongiolithic limestones (now: Oberer Massenkalk) and locally developed coralliferous limestones, and that it represents the topmost formation of the Upper Jurassic of eastern

Swabia. In contrast to interpretations given in some older geological maps of the area (MEDINGER 1935; GWINNER et al. 1987), it became obvious that the Tithonian is completely eroded (SCHWEIGERT 1996). REIFF (1991) showed that very locally the Brenztaltrümmerkalk interfingers with older micritic mudstones which he attributed to the Liegende Bankkalk Formation. These beds are Late Kimmeridgian (Beckeri Zone, Ulmense Subzone) in age, proved by typical ammonites such as *Taramelliceras wepferi* (BERCKHEMER), *Ochetoceras zio* (OPPEL), and various lithacoceratids. Recently in the study area the Liegende Bankkalke and Zementmergel formations were united in the Mergelstetten Formation (SCHWEIGERT & FRANZ 2004; for lithostratigraphic frame see Fig. 2).

The only reliable biostratigraphic data were provided by BERCKHEMER (1922, 1924). Several identifyable ammonites collected from the Brenztaltrümmerkalk allow a relatively precise biostratigraphic dating of this unit. The records of *Gravesia irius* (D'ORBIGNY) and *Gravesia irius transiens* HANTZPERGUE from the Brenztaltrümmerkalk (SCHWEIGERT 1993a, pl. 16, figs. 1-2) are fundamental to the biostratigraphy of the higher part of the Upper Jurassic of SW Germany. These ammonites are indicative of the youngest Kimmeridgian, when using the Subboreal zonation (HANTZPERGUE 1989). In contrast, no ammonites of Tithonian age were found at all in eastern Swabia, north of the Danube valley. This preliminary observation has since been substanciated and refined by the construction of ammonite faunal horizons (SCHWEIGERT 1996, 2000; SCHWEIGERT et al. 1996; SCHWEIGERT & ZEISS 1998, 1999).

Ammonites from the Brenztaltrümmerkalk Formation are stored in the collections of the Geologisch-Paläontologisches Institut und Museum der Universität Tübingen (GPIT) and of the Staatliches Museum für Naturkunde Stuttgart (SMNS). Besides some juvenile or fragmented perisphinctids which were too small or incomplete for a closer identification, we determined the following ammonite species:

Aulacostephanus cf. *subundorae* (PAVLOW) (Fig. 3)
Lithacoceras aff. *ulmense* (OPPEL) (Fig. 6)
Silicisphinctes paraboliferus (BERCKHEMER)
Silicisphinctes sp. (Fig. 7)
Gravesia irius (D'ORBIGNY) (Fig. 5)
Gravesia irius transiens HANTZPERGUE
Physodoceras nattheimense SCHWEIGERT

Thickly bedded, bioclastic limestones cropping out between the towns of Heidenheim and Nattheim, which represent the distal equivalent of the Brenztaltrümmerkalk, yielded a fragment of the body chamber of *Tolveri-*

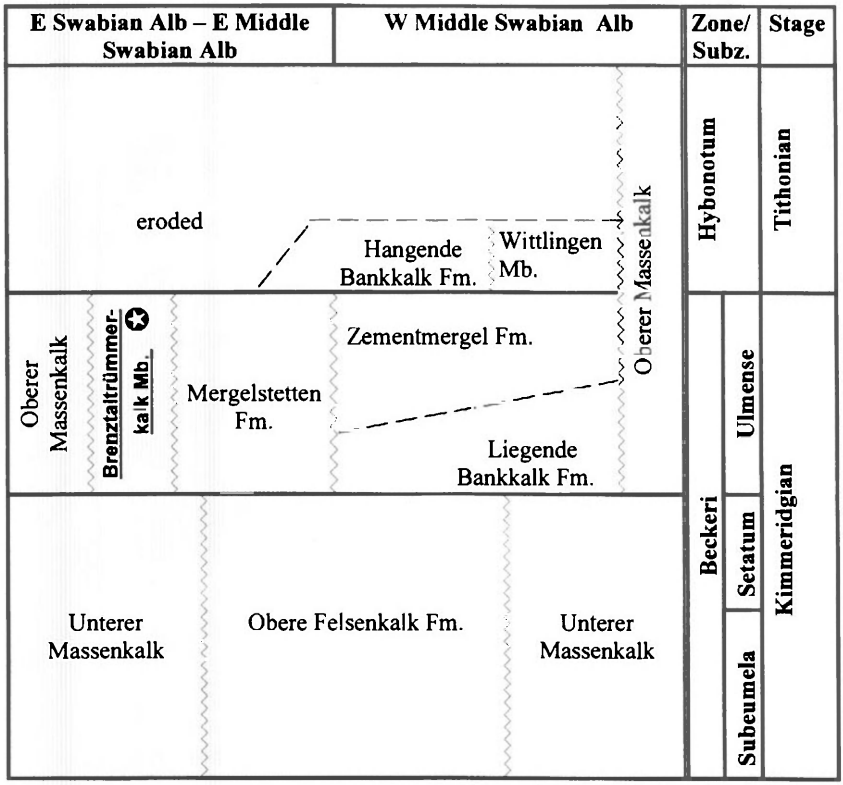

Fig. 2. Lithostratigraphic frame of the uppermost Jurassic in eastern Swabia (after Schweigert & Franz 2004). Finding level of *Aulacostephanus* cf. *subundorae* is marked by an asterisk.

ceras murogense katroliforme Hantzpergue (see Schweigert 1993a, pl. 18, fig. 1).

Most likely, the large *Phylloceras* specimen from the surroundings of Schnaitheim described by Quenstedt (1888) also comes from the Brenztaltrümmerkalk. The matrix of this specimen consists of a pale grey mud-

Table 1. Important records of *Aulacostephanus* from the younger Kimmeridgian of Swabia (after BAIER & SCHWEIGERT 2001 and this study).

Species	Record in Swabia
Aulacostephanus cf. *subundorae* (PAWLOV)	uppermost *ulmense* Subzone
Aulacostephanus autissiodorensis (COTTEAU)	uppermost *ulmense* Subzone,
Aulacostephanus cf. *volgensis* (VISCHNIAKOFF)	*ulmense* Subzone, *zio-wepferi* horizon β
Aulacostephanus yo (D'ORBIGNY)	*subeumela* Subzone, younger part
Aulacostephanus contejeani (THURMANN & ETALLON)	*subeumela* Subzone, *kiderleni* horizon
Aulacostephanus plataulax (BUCKMAN)	*subeumela* Subzone, *kiderleni* horizon

stone, a lithology which is sporadically intercalated with the bioclastic limestones.

3. The ammonite genus *Aulacostephanus* in the Upper Jurassic of Swabia

In the Upper Jurassic of Swabia, the Subboreal ammonite genus *Aulacostephanus* is almost restricted to the Kimmeridgian "Untere Felsenkalk" Formation ("White Jurassic Delta" in older publications). From higher up in the section, very few specimens have been recorded over the last few decades (HOLDER 1971; SCHWEIGERT 1992, 1993b; SCHWEIGERT & SCHERZINGER

Fig. 3. *Aulacostephanus* cf. *subundorae* (PAWLOV), lateral and ventral views. Out of situ find from Bad Überkingen originating from the Brenztaltrümmerkalk, Upper Kimmeridgian, uppermost part of *ulmense* Subzone. SMNS no. 64921 (Colln. Pistl). – Scale 2 cm.

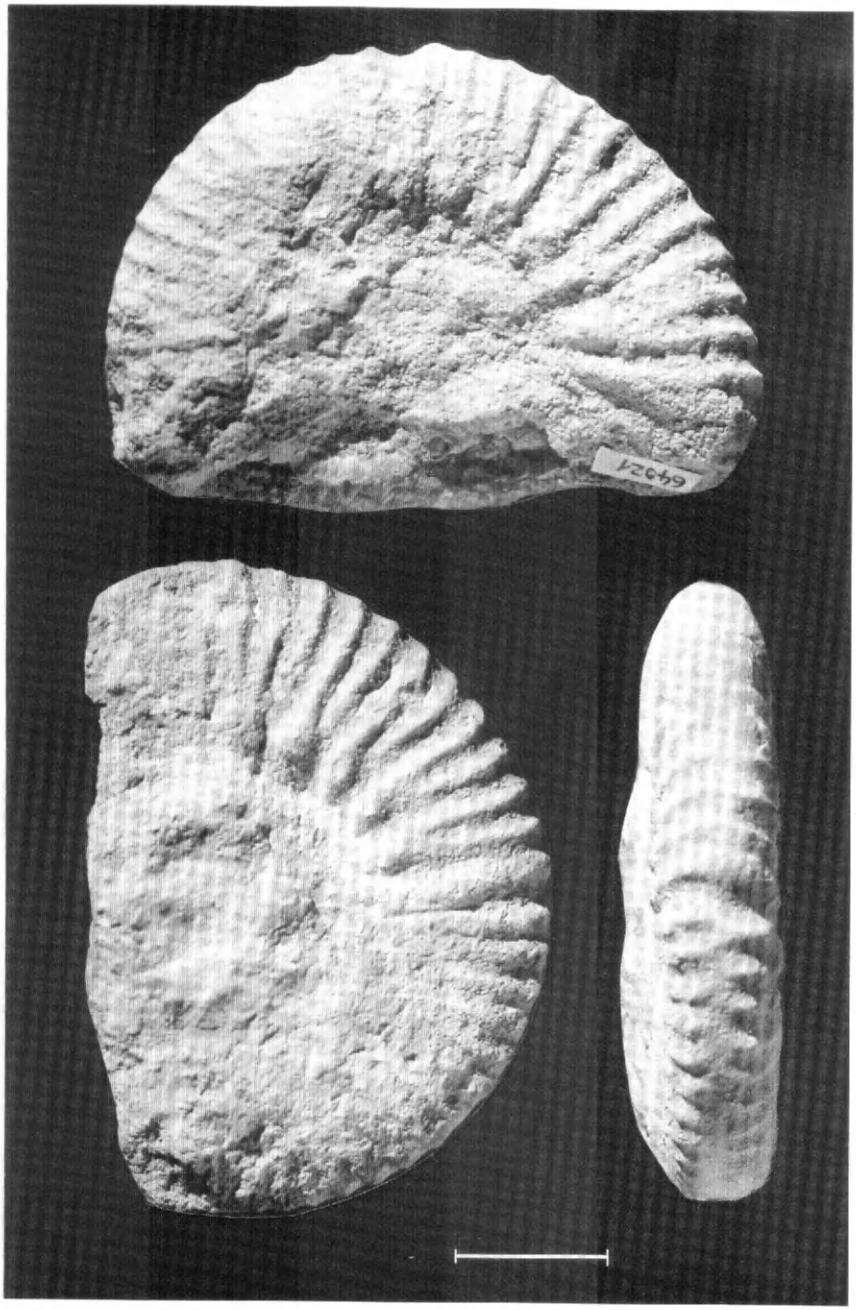

Fig. 3 (Legend see p. 70)

1997; BAIER & SCHWEIGERT 2001; Table 1). Despite this extreme rarity, these finds provide important correlation points between the upper part of the Subboreal Eudoxus and Autissiodorensis zones with the Tethyan Beckeri Standard Zone.

In the Upper Jurassic of the Paris Basin and adjacent areas in northern France, together with the Upper Jurassic of Central Poland and Russia, aulacostephanids from beds younger than of the Eudoxus Zone are widely distributed (e.g. CALLOMON & COPE 1971; MESEZHNIKOV 1984; KRYMHOLTS et al. 1988; HANTZPERGUE 1989; HANTZPERGUE et al. 1997; KUTEK & ZEISS 1997). Palaeobiogeographic barriers, such as islands, hypersaline lagoons and shallow water areas that are unfavourable for ammonites hampered a continuous faunal exchange with more southern areas like SW Germany. Thus, the few finds are of enormous interest because they enable different correlation schemes in neighbouring areas to be correlated. According to the biostratigraphy provided by the horizon-resolution of ammonites of Subboreal origin in Submediterranean sections it is considered that the Eudoxus Zone as used as chronostratigraphic units in the French and British Jurassic (e.g. Paris and Aquitaine Basins) exhibits a remarkably longer duration than the stratigraphical range of this zone in southern Germany. However, in the Kimmeridgian type area in southern England, the exact position of the *eudoxus/autissiodorensis* zonal boundary is still uncertain (MORGANS-BELL et al. 2001). The younger part of the French Eudoxus Zone overlaps with the Beckeri Standard Zone. Therefore, it was recently suggested to replace the Eudoxus Zone of the Submediteranean Province by the Pseudomutabilis Zone (BAIER & SCHWEIGERT 2001).

The Autissiodorensis Zone is the youngest ammonite standard zone of the Subboreal Kimmeridgian. It is not only likely to represent the same period of time as the Submediterranean Ulmense Subzone, but most probably also includes part of the underlying Setatum Subzone. In this context, one of the most important finds was a single ammonite from the *subeumela* Subzone described by HÖLDER (1971) which was later identified as *Aulacostephanus contejeani* (SCHWEIGERT 1993b). In France, this ammonite species is very typical of the *Contejeani* faunal horizon of the Eudoxus Zone. But this horizon is not even the youngest faunal horizon of the Eudoxus Zone. The index species of the latter is *Aulacostephanus yo* (D'ORBIGNY). Thus it is not surprising that recently *A. yo* was recorded from beds of the *setatum* Subzone of SE Swabia (BAIER & SCHWEIGERT 2001).

The *Aulacostephanus* specimen described herein represents both the youngest find of this genus in eastern Swabia and the sole record from the Brenztaltrümmerkalk. However, it is also possible that the explicit citation of "*Ammonites humphriesianus* SOWERBY" from the "Coralrag" of Nattheim by ZIETEN (1833: 89) refers to a specimen of *Aulacostephanus autissiodorensis*

(COTTEAU) from the Brenztaltrümmerkalk that has since been lost, because *A. autissiodorensis* is the only homoeomorphic ammonite which could be confused with the Middle Jurassic *Stephanoceras humphriesianum*.

4. Systematic description

Family Perisphinctidae STEINMANN, 1890
Subfamily Aulacostephaninae SPATH, 1924
Genus *Aulacostephanus* SUTNER & POMPECKJ, 1896

Aulacostephanus (*Aulacostephanoceras*) cf. *subundorae* (PAVLOW) Fig. 3

cf. 1886 *Hoplites subundorae* sp. n. – PAVLOW, p. 21, pl. 5, figs. 1-2.
pars 1962 *Aulacostephanus* (*Aulacostephanoceras*) *volgensis* (VISCHNIAKOFF). – ZIEGLER, pl. 9, fig. 1, pl. 10, figs. 1-5.
pars 1962 *Aulacostephanus* (*Aulacostephanoceras*) *undorae* (PAVLOW). – ZIEGLER, pl. 6, fig. 10 [= lectotype of *A. subundorae* (PAVLOW)].
pars 1962 *Aulacostephanus* (*Aulacostephanoceras*) *rigdus* n. sp. – ZIEGLER, pl. 6, fig. 11.
cf. 1984 *Aulacostephanus* (*Aulacostephanoceras*) *undorae* (PAVL.). – MESEZHNIKOV, pl. 34, figs. 2-3.
pars 1997 *Aulacostephanus volgensis* (VISCHNIAKOFF). – KUTEK & ZEISS, p. 130, pl. 4, figs. 1-2; pl. 5, figs. 1, 3.
2002 Microconch of *Aulacostephanus autissiodorensis*. – MONKS & PALMER, pl. 13.

Description: The studied specimen has a diameter of 87 mm. Its maximum width is approximately 17 mm, but the specimen is remarkably compressed. The body-chamber is completely preserved until the beginning of the apophysis. The phragmocone is filled with calcite spar. The matrix of the specimen consists of a packstone of rounded bioclasts, ooids and echinoid fragments, both very typical of this formation. Although the umbilicus could only partly be prepared, a large umbilical width and a relatively small height of the whorl section is visible. The sculpture is predominantly made up of coarse, slightly curved biplicate ribs which joint in nodular thickenings close to the umbilical edge. In addition, some secondaries and one simple rib are developed. In the posterior part of the body-chamber the ribs do not cross the venter. The ventral endings of the ribs of both flanks are slightly alternating. In the anterior part of the body-chamber, the ventral interrupting of the ribs diminishes due to the strong compaction the specimen has suffered probably during diagenesis.

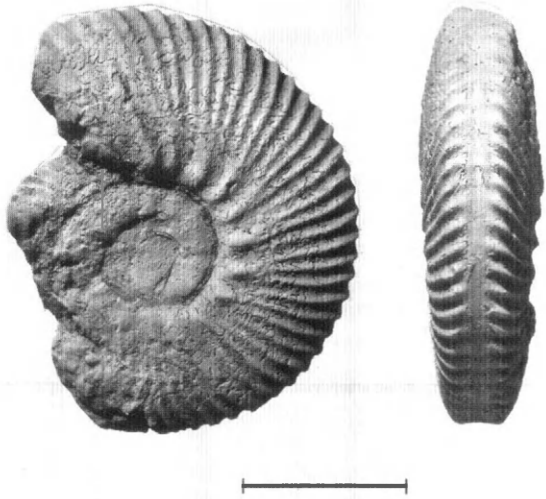

Fig. 4. *Aulacostephanus volgensis* (VISCHNIAKOFF), holotype, lateral and ventral views. Syzran, Kujbyschew area, Russia; Vernadsky Geological Museum, Moscow, no. VI-60/4 (photograph by courtesy of V. Mitta, Moscow). – Scale 2 cm.

Discussion: In the past, aulacostephanid forms like the present one have often been identified as *Aulacostephanus volgensis* (VISCHNIAKOFF). However, the holotype of *A. volgensis* (Fig. 4), which was recently re-discovered in the collection of the Vernadsky Geological Museum in Moscow, is densely ribbed and not necessarily comparable with the other specimens. Moreover, it is unclear if the type horizon of *A. volgensis* is located in the Autissiodorensis Zone, or in the Eudoxus Zone. The holotype of *A. volgensis* is a completely septate phragmocone which is very close to or even identical with inner whorls of *Aulacostephanus pseudomutabilis* (DE LORIOL), a macroconch species which was, according to ZIEGLER (1962), not yet recorded from Russia although the corresponding microconch *A. eudoxus* (D'ORBIGNY) was cited from the Russian platform (HANTZPERGUE et al. 1998a, 1998b). On the other hand, already PAVLOW (1886, pl. 4, fig. 2) identified a small involute inner whorl as belonging to *A. pseudomutabilis*. Inner whorls of some microconch aulacostephanids from the Autissio-

Fig. 5. *Gravesia irius* (D'ORBIGNY), same provenance as Fig. 3. Brenztaltrümmerkalk, Upper Kimmeridgian, uppermost part of *ulmense* Subzone. SMNS no. 65422 (Colln. Pistl). – Scale 2 cm.

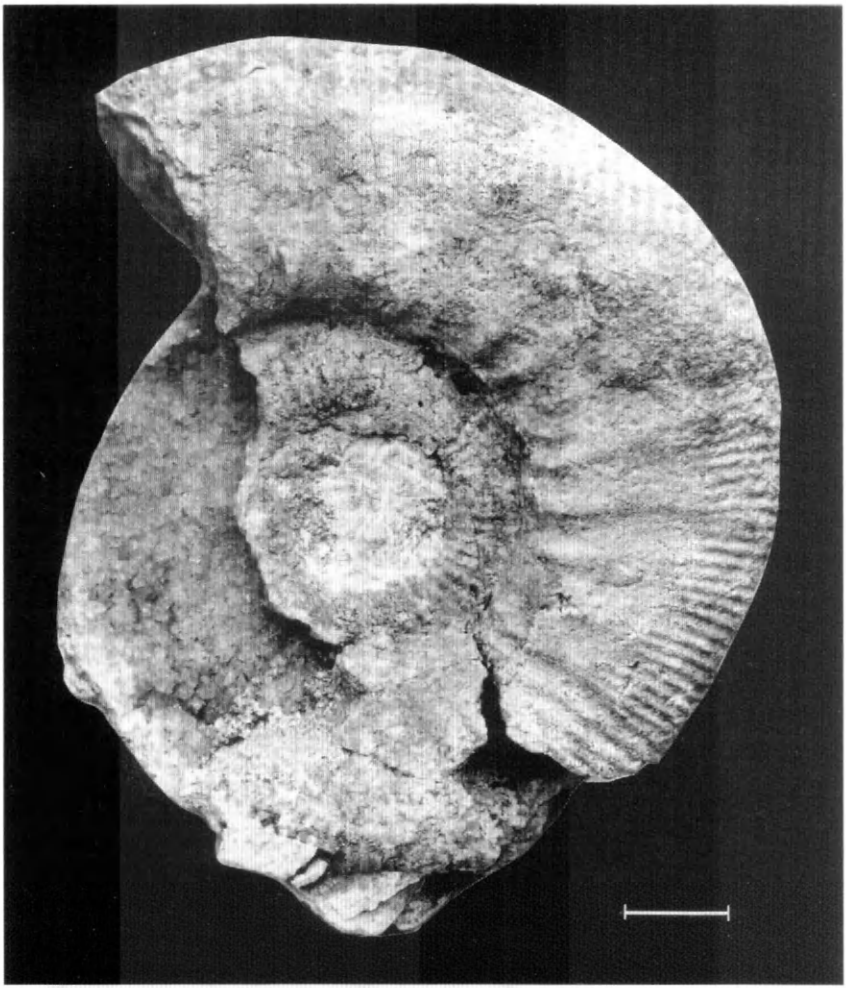

Fig. 6. *Lithacoceras* aff. *ulmense* (OPPEL). Specimen originally labelled as "*Perisphinctes* cf. *vimineus* SCHNEID". Schnaitheim, SW Germany, Brenztaltrümmerkalk, Upper Kimmeridgian, uppermost part of *ulmense* Subzone. GPIT no. 1900/1. – Scale 2 cm.

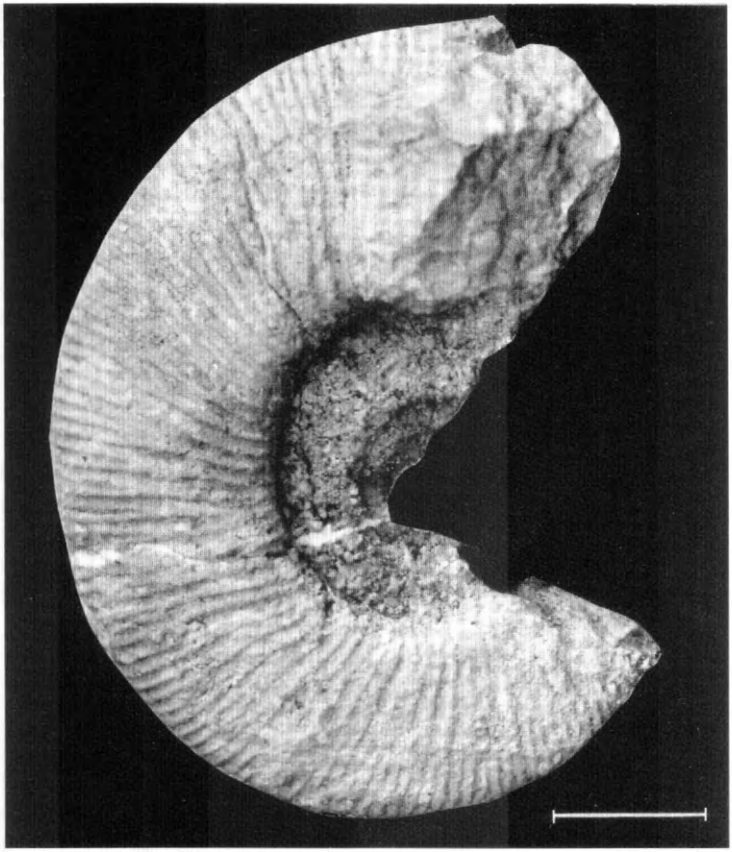

Fig. 7. *Silicisphinctes* sp.; Schnaitheim, SW Germany. Brenztaltrümmerkalk, Upper Kimmeridgian, uppermost part of *ulmense* Subzone. GPIT no. 1900/2. – Scale 2 cm.

dorensis Zone, however, strongly resemble the holotype of *A. volgensis*, mainly differing in a more evolute coiling and a little wider cross section at a comparable diameter. Thus, at the moment we cannot exclude the fact that the Eudoxus Zone may contain the type horizon of *A. volgensis*.

In contrast, the *Aulacostephanus* specimen from the Brenztaltrümmerkalk is much closer to specimens described in literature as *A. subundorae* or *A. rigidus* (PAVLOW 1886; ZIEGLER 1962). ZIEGLER (1962: 75) included *A. subundorae* (PAVLOW) in *A. undorae* (PAVLOW) despite its much higher whorl section and a denser ribbing of the body-chamber. Both syntypes figured by PAVLOW (1886, pl. 5, figs. 1-2) exhibit biplicate or simple ribs on the body chamber, but they are smaller than the specimen from the Brenztaltrümmerkalk. A new field study in Subboreal sections is necessary to bring light into the chronological succession of *Aulacostephanus* species and their sexual dimorphism. Preliminarily, we can state that the specimen from the Brenztaltrümmerkalk represents a microconch *Aulacostephanus* species which is close to *A. subundorae*. An almost identical specimen was recently figured – unfortunately without scale – by MONKS & PALMER (2002) from the Autissiodorensis Zone of England and therein termed as a microconch of the index species of this zone.

The specimen of *Aulacostephanus* cf. *subundorae* (PAVLOW) (Fig. 3) from the Brenztaltrümmerkalk Formation was found out of situ in a dump near Bad Überkingen, some tens of kilometers west of Heidenheim (Fig. 1), but its origin from the surroundings of Heidenheim is in no doubt because of its characteristic lithology. Together with *A.* cf. *subundorae* a well-preserved *Gravesia irius* (D'ORBIGNY) was also collected (Fig. 5), which exhibits an identical matrix and is thus assumed to originate from the same locality.

5. Position of the Kimmeridgian/Tithonian boundary

Before the final acceptance of a GSSP for the base of the Tithonian, the exact position of the Kimmeridgian/Tithonian boundary, i.e. the base of the Hybonotum Standard Zone needs to be determined. However, following the correlations of HANTZPERGUE (1989), the Upper Kimmeridgian of the Subboreal Province is characterised by species of *Aulacostephanus* accompanied by *Gravesia* species like *G. lafauriana* and *G. irius*, whereas in the Tithonian aulacostephanids became most probably extinct, and *Gravesia gigas* and *Pseudogravesia hahni* are abundant. In southern Germany, the latter two species have never been found lower than the Tithonian Hangende Bankkalk Formation or its time equivalents. Though, this formation is not preserved due to erosion, which are already eroded in the eastern part of Swabia. MAUBEUGE (1996) reported a single *Aulacostephanus* specimen from the "Couches à *Gravesia*" in the Paris Basin which he interpreted as a "Portlandian" (= equivalent to part of the Tithonian) representative of the genus. The fragmentary figured specimen looks similar to *A. kirghisensis* (D'ORBIGNY) (cf. ZIEGLER 1962, pl. 11, fig. 2) a species indicative of the

Autissiodorensis Zone, but it is not known whether this formation comprises Kimmeridgian deposits, containing *Gravesia* species morphologically intermediate between *G. irius* and *G. gigas*.

The study of the *Hybonoticeras* succession of the latest Kimmeridgian and of the Early Tithonian is in progress. In the Submediterranean zonal succession, the Ulmense Subzone is included in the latest Kimmeridgian. The basal Tithonian is characterised by a first acme of *Subplanites* and corresponding macroconch *Euvirgalithacoceras* within an ammonite faunal horizon yielding the enigmatic simple ribbed perisphinctid *Berckhemeria* (see SCHWEIGERT & ZEISS 1998). Hybonoticeratids, however, have never been recorded from the uppermost Jurassic deposits of eastern Swabia. Other aspidoceratids are not very significant, and poorly preserved, so that they contribute little to a precise dating. The perisphinctids of the Brenztaltrümmerkalk are represented by lithacoceratids (Figs. 6-7) typical of the uppermost Ulmense Subzone. Identical forms occur in the highest part of the Mergelstetten Formation of eastern Swabia (e.g. SCHWEIGERT & ZEISS 1999, fig. 6), co-occurring with *Gravesia irius* (D'ORBIGNY).

As a result it may be stated that the Brenztaltrümmerkalk ranges up to the youngest Kimmeridgian, but that the Tithonian boundary is located higher in the stratigraphy.

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Addresses of the authors:

Dr. G. SCHWEIGERT, Staatliches Museum für Naturkunde Stuttgart, Rosenstein 1, 70191 Stuttgart, Germany.
E-mail: schweigert.smns@naturkundemuseum-bw.de

Dipl.-Geol. L. H. VALLON, Institut für Geologie und Paläontologie der Universität, Herdweg 51, 70174 Stuttgart, Germany.
E-mail: lvallon@geologie.uni-stuttgart.de