

New Biostratigraphic Data from the Kimmeridgian/Tithonian Boundary Beds of SW Germany

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Abstract: An overview is given on the state of biostratigraphic refinement of the Upper Kimmeridgian and lowest Tithonian in SW Germany. The ammonite faunal horizons of the Upper Kimmeridgian Ulmense Zone and the succeeding Lower Tithonian Hybonotum Zone are briefly characterised. The *eigeltingense* horizon is proposed to represent the oldest faunal horizon of the Hybonotum Zone (Riedense Subzone). It is possible to make long-distance correlations of this local/regional biohorizon by the co-occurrence of *Euvirgalithacoceras eigeltingense*, *Subplanites postrueppellianus* and *Hybonotoceras pseudohybonotum*. The existing outcrops, however, do not provide a possible GSSP candidate section; such an exposure must be sought elsewhere.

The Search for a Reference Section of the Kimmeridgian/Tithonian Boundary

Recently, several members of the Tithonian working group have been looking for a possible GSSP for the Kimmeridgian/Tithonian boundary which lies, in biochronostratigraphic terms, at the lower boundary of the lowest standard zone of the Tithonian, the Hybonotum Zone. However, most of the sections in Europe are incomplete, or condensed, or still lacking a modern and detailed biostratigraphic investigation. One of the areas which could provide possible reference sections or auxiliary stratotype sections is the Upper Jurassic of SW Germany (Fig. 1).

Kimmeridgian/Tithonian Lithostratigraphy in SW Germany

The Upper Jurassic in SW Germany has been one of the classical areas of ammonite research and biostratigraphy since the times of Quenstedt and Oppel. This area is part of the Submediterranean Faunal Province, which is characterised by a dominating stock of Tethyan faunal elements along with minor faunal influx from several other areas, especially France (Paris Basin). The lithostratigraphic sequence around the Kimmeridgian/Tithonian boundary consists mainly of micritic limestones ("Liegende Bankkalke Formation", "Hangende Bankkalke Formation"), marly limestones ("Zementmergel Formation") and interfingering massive spongiolithic limestones (Fig. 2). In the middle and eastern part of the Swabian Jurassic small coral reefs occur. The famous locality of Nattheim, known since the last century with its fine silicified preservation of the coral fauna, lies within this interval. In the western part of Swabia, lithographic limestones occur in small outcrops near the village of Nusplingen ("Nusplingen Lithographic Limestone Formation").

Some Remarks on Oppel's *Ammonites ulmense*

Since the time of Oppel, *Lithacoceras ulmense* (Oppel) has often erroneously been thought to represent a typical Lower Tithonian ammonite species - even by Oppel himself, who changed his original specific concept of *Ammonites ulmense* (Oppel, 1858) in his later paper of 1863 by including specimens from Franconia (Solnhofen area) in his type series. Unfortunately, Schneid (1914) interpreted *Lithacoceras ulmense* in a way which was not according to the IRZN, and was followed by Arkell (1937, 1956), by taking a specimen of Schneid as "lectotype" of the species. Later, Arkell (1946) proposed an "Ulmense Zone" within the Tithonian succession of southern Franconia following an erroneous correlation of Roll (1933) between the Swabian and Franconian

Upper Jurassic. *Lithacoceras ulmense* and allied lithacoceratids are very common in the interval between the Setatum Subzone and the base of the Tithonian, so that an Ulmense Subzone was re-established and re-defined as the youngest subzone of the Late Kimmeridgian Beckeri Zone (Schweigert and Zeiss, 1994; Zeiss, 1994). Its index species, *Lithacoceras ulmense* (Oppel), was often misinterpreted because of the different species concepts mentioned above, so that a revision of this important species became urgently necessary. The revision was mainly based on newly discovered complete specimens from the Nusplingen Lithographic Limestone (Schweigert and Zeiss, 1998b).

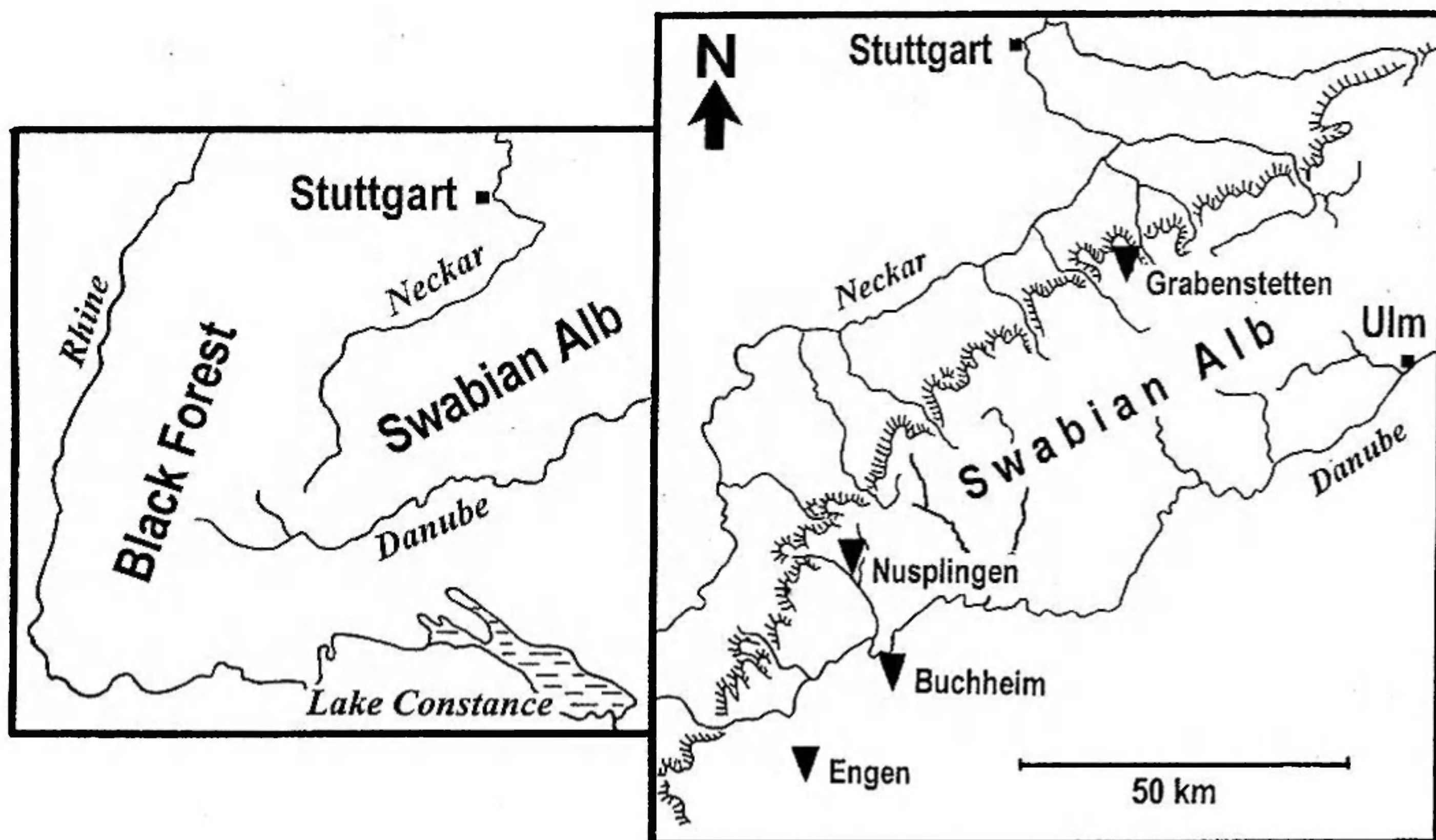


Figure 1. Location of important sections of Kimmeridgian/Tithonian boundary beds in SW Germany.

The Base of the Tithonian

The base of the Tithonian is not yet defined by a GSSP, but there is agreement that it should be at the base of the Hybonotum Zone. Hence, we have to investigate the succession of ammonite faunas. The assumed boundary is arbitrary, at a level selected by consensus of the Jurassic Subcommittee and the members of the boundary working group. A criterion for defining the boundary might be, for example, the first occurrence of *Hybonoticeras* of the *H. hybonotum* group or of some other taxon characteristic of the true Tithonian. Additionally, the ammonite faunal horizon which is defined as representing the base of the Tithonian should be characteristic enough to allow long-distance correlations. Hence, selection of an ammonite horizon with high endemism for the base of the Tithonian stage should be avoided.

A high resolution ammonite biostratigraphy based on the concept of ammonite faunal horizons has been recently established (Schweigert, 1993; 1996; 1998; Schweigert and Zeiss, 1994; 1998; 1999; Schweigert et al., 1996; Zeiss et al., 1996). In Swabia, the ammonite faunal horizon which yields one of the oldest *Hybonoticeras* species of the *H. hybonotum* group is represented by the *eigeltingense* horizon. This ammonite horizon is always found in the lowermost part of the "Hangende Bankkalke Formation", just above a prominent disconformity, where the lithofacies changes from marls or heavily bioturbated detrital carbonates to pure micritic limestones. The *eigeltingense* horizon is part of the Riedense Subzone, the oldest Subzone of the Hybonotum Zone.

Whether or not to accept the base of the *eigeltingense* horizon, as proposed herein, for the base of the Tithonian, will have to be agreed upon by the Tithonian working group and the Subcommittee.

Besides the index, *Euvirgalithacoceras eigeltingense*, and its antidimorph, *Subplanites postrueppellianus*, the *eigeltingense* horizon yields strange, simple ribbed perisphinctids (*Berckhemeria scherzingeri* [m] pl. 2.6 – *Presimoceras heteromorphum* [M]) which may represent the root stock of the Tithonian heteromorphs (Schweigert and Zeiss, 1998). The occurrence of *Euvirgalithacoceras/Subplanites* together with *Hybonoticeras pseudohybonotum* enables correlations to be made with other Submediterranean areas (SE France, Atrops, pers. comm.; and E Spain, Atrops and Meléndez, 1994) as well as with the Tethyan realm.

The faunal horizons just below the *eigeltingense* horizon should be placed in the Upper Kimmeridgian Beckeri Zone (Ulmense Subzone, respectively), because the *Hybonoticeras* species characteristic of this unit is markedly different from the younger *H. hybonotum* group (*H. pseudohybonotum*, *H. hybonotum*, *H. robustum*) having characteristic keels lacking dorsal spines (Pl. 2.4; for more details on the *Hybonoticeras* lineage see Schweigert et al., 1996). Ammonites known from higher ammonite faunal horizons of the Lower Tithonian in Swabia are listed in Schweigert (1996).

Faunal horizons	Age			Formations
<i>eigeltingense</i>	R.	Hyb.	T.	
<i>rebouletianum</i>	Ulmense	Beckeri	Late Kimm.	
<i>hoelderi</i>				
<i>zio-wepferi</i> β				
<i>zio-wepferi</i> α				

Figure 2. Biostratigraphic subdivision of the Kimmeridgian/Tithonian boundary beds in the Upper Jurassic of Swabia by ammonite faunal horizons. L = Liegende Bankkalke Formation; Z = Zementmergel Formation; N = Nusplingen Lithographic Limestone; H = Hangende Bankkalke Formation; R = Riedense Subzone; T = Tithonian.

The Ammonite Faunal Horizons Around the Kimmeridgian/Tithonian Boundary

In Swabia, the Ulmense Subzone can be subdivided into 4 ammonite faunal horizons. They are recorded in numerous outcrops all over Swabia. Two well exposed outcrops, located along a road near the village of Grabenstetten in the middle part of the Swabian Alb (see Berckhemer and Hölder, 1959: fig. 1) can serve as reference sections for this succession. The ammonite fauna of the *hoelderi* horizon was exhaustively described from the Nusplingen Lithographic Limestone sections (Schweigert, 1998).

zio-wepferi Horizon α

Taramelliceras wepferi Berckhemer [M] (Pl. 1.1) – very common, *Ochetoceras zio* (Oppel) [M] (Pl. 1.3), *Lithacoceras hillebrandti* Schweigert and Zeiss [M], *Silicisphinctes paraboliferus* (Berckhemer and Hölder) [m] (Pl. 1.4), *Lithacoceras* aff. *ulmense* (Oppel) [M], *Silicisphinctes oxypleurus* (Herbich) [m], *Glochiceras* cf. *Lens* Berckhemer [m], *Lingulaticeras nodosum* (Ziegler) [m], *Euvirgalithacoceras albulum* (Berckhemer and Holder non Quenstedt) [M], *Aspidoceras hystricosum* (Quenstedt) [M], *Hybonoticeras extraspinum* Berckhemer and Holder [M],

Hybonotoceras harpephorum (Neumayr) [M]; extremely rare: *Tolvericeras murgense murgense* Hantzpergue. [M].

zio-wepferi Horizon β

Ochetoceras zio (Oppel) [M] – very common, *Taramelliceras wepferi* Berckhemer [M], *Lithacoceras* aff. *onukii* Takahashi [M], *Lithacoceras* aff. *ulmense* (Oppel) (Pl. 2.1), *Silicisphinctes keratinitiformis* Schweigert [m] (Pl. 1.6), *Silicisphinctes oxypleurus* (Herbich), *Glochiceras politulum* (Quenstedt) [m], *Sutneria rebholzi* Berckhemer [m] – very common, *Physodoceras nattheimense* Schweigert [M], *Hybonotoceras harpephorum* (Neumayr) [M]; extremely rare: *Aulacostephanus jasonoides* (Pavlow) [M], *Sarmatisphinctes* cf. *fallax* (Ilovaisky and Florensky) [m+M] (Pl. 2.2), *Tolvericeras murgense katroliforme* Hantzpergue [M].

hoelderi Horizon

Lithacoceras ulmense (Oppel) [M], *Silicisphinctes hoelderi* (Sapunov) [m] (Pl. 1.5), *Lithacoceras fasciferum* (Neumayr) [M], *Silicisphinctes russi* Schweigert [m] (Pl. 1.7), *Ochetoceras* aff. *zio* (Oppel) [M], *Neochetoceras subnudatum* (Fontannes) [M], *Lingulaticeras pseudopercevali* Schweigert [m] (Pl. 1.2), *Physodoceras nattheimense* Schweigert [M], *Sutneria* cf. *rebholzi* Berckhemer [m], *Aspidoceras catalaunicum* (Loriol) [M]; extremely rare: *Gravesia lafauriana* Hantzpergue [M], *Streblites* cf. *zlatarskii* (Sapunov) [M], *Hybonotoceras* cf. *extraspinum* Berckhemer and Holder [M] (Pl. 2.3), *Hybonotoceras harpephorum crassicostatum* Olóriz.

rebouletianum Horizon

"*Lithacoceras*" *pseudoulmensis* (Furlani) [M], *Neochetoceras rebouletianum* (Fontannes) [M] (Pl. 2.5), *Lingulaticeras planulatum* Ziegler [m], *Sutneria bracheri* Berckhemer [m], *Physodoceras eligmoptychum* (Fontannes) [M], *Hybonotoceras "interlaevigatum"* Berckhemer mscr. [M] (Pl. 2.4), *Aspidoceras catalaunicum* (Loriol) [M]; extremely rare: *Aulacostephanus autissiodorensis* (Cotteau), ?*Gravesia irius* (d'Orbigny) [M].

In Swabia, the following association indicates the basal Tithonian, in accordance with the proposal above to take the *eigeltingense* horizon as the lowermost faunal horizon of the Hybonotum Zone:

eigeltingense Horizon

Euvirgalithacoceras eigeltingense (Ohmert and Zeiss) [M], *Subplanites postrueppellianus* Ohmert and Zeiss [m], *Lithacoceras riedense* (Ohmert and Zeiss) [M], *Silicisphinctes siliceus* Schneid non Quenstedt, *Neochetoceras praecursor* Zeiss [M], *Lingulaticeras* cf. *solenoides* (Quenstedt) [m], *Physodoceras episum* (Oppel) [M], *Sutneria* cf. *apora* (Oppel) [m], *Berckhemeria scherzingeri* Schweigert and Zeiss [m] (Pl. 2.6), *Presimoceras heteromorphum* (Quenstedt) [M], *Hybonotoceras pseudohybonotum* Vigh [M].

Note that all ammonite faunal horizons yield both hybonoticeratids and subboreal ammonites. These faunal elements are important for long-distance correlations between SW Germany, the Tethyan realm (Betic chains of Spain, Italy, Hungary) and adjacent areas (SE France, W France, E Spain, N Germany, Dorset, Poland, Russia). For example, the upper part of the Subboreal Autissiodorensis Zone coincides well with the Tethyan Ulmense Subzone (Kutek and Zeiss, 1997). Moreover, it is possible to recognise some of the Swabian faunal horizons of the Ulmense Subzone, especially the *zio-wepferi* horizon at the base and the *rebouletianum* horizon at the top, in SE France. In Franconia, however, the stratigraphic record of the Ulmense Subzone seems to be very incomplete, and the Torleite section in the classical Solnhofen area does not cross the Kimmeridgian-Tithonian boundary as previously thought, but only the boundary between the Setatum Subzone and a very reduced Ulmense Subzone.

A Possible GSSP for the Base of the Tithonian in SW Germany?

The succession of faunal horizons in Swabia listed above was mainly compiled from a number of isolated outcrops, but unfortunately there is no section which provides a continuous profile and could be proposed as a GSSP candidate section for the Lower Tithonian boundary. The best conditions in this area are around the village of Grabenstetten (middle part of the Swabian Alb) or near the town of Engen NW of the Lake Constance (Fig. 1). Concerning the first section, the ammonite fauna of the *eigeltingense* horizon has been found in an abandoned quarry which lies about 10 meters above the youngest limestones exposed along the road. In the section near Engen,

the *eigeltiense* horizon is well developed, but the underlying strata are extremely poor in ammonites. Even the Grabenstetten sections have to be studied in more detail, but there is no doubt as to their value as reference sections for the succession of ammonite faunal horizons of the Ulmense Subzone in SW Germany. Another section in which both the *rebouletianum* horizon and the *eigeltiense* horizon are exposed is located in a large quarry near Buchheim (Danube valley area). There, the boundary lies within a succession of massive spongiolithic limestones.

The higher parts of the Lower Tithonian Hybonotum Zone can be studied in the western part of Swabia, but most fossiliferous strata are only temporarily exposed. Magnetostratigraphic investigations have still not been done. An alternative biostratigraphic zonation across the Kimmeridgian/Tithonian boundary based on dinoflagellate cysts was not very successful for preservational reasons. Nevertheless, the biostratigraphic data obtained from Swabia should be kept in mind when looking for a GSSP candidate section in SE France or elsewhere.

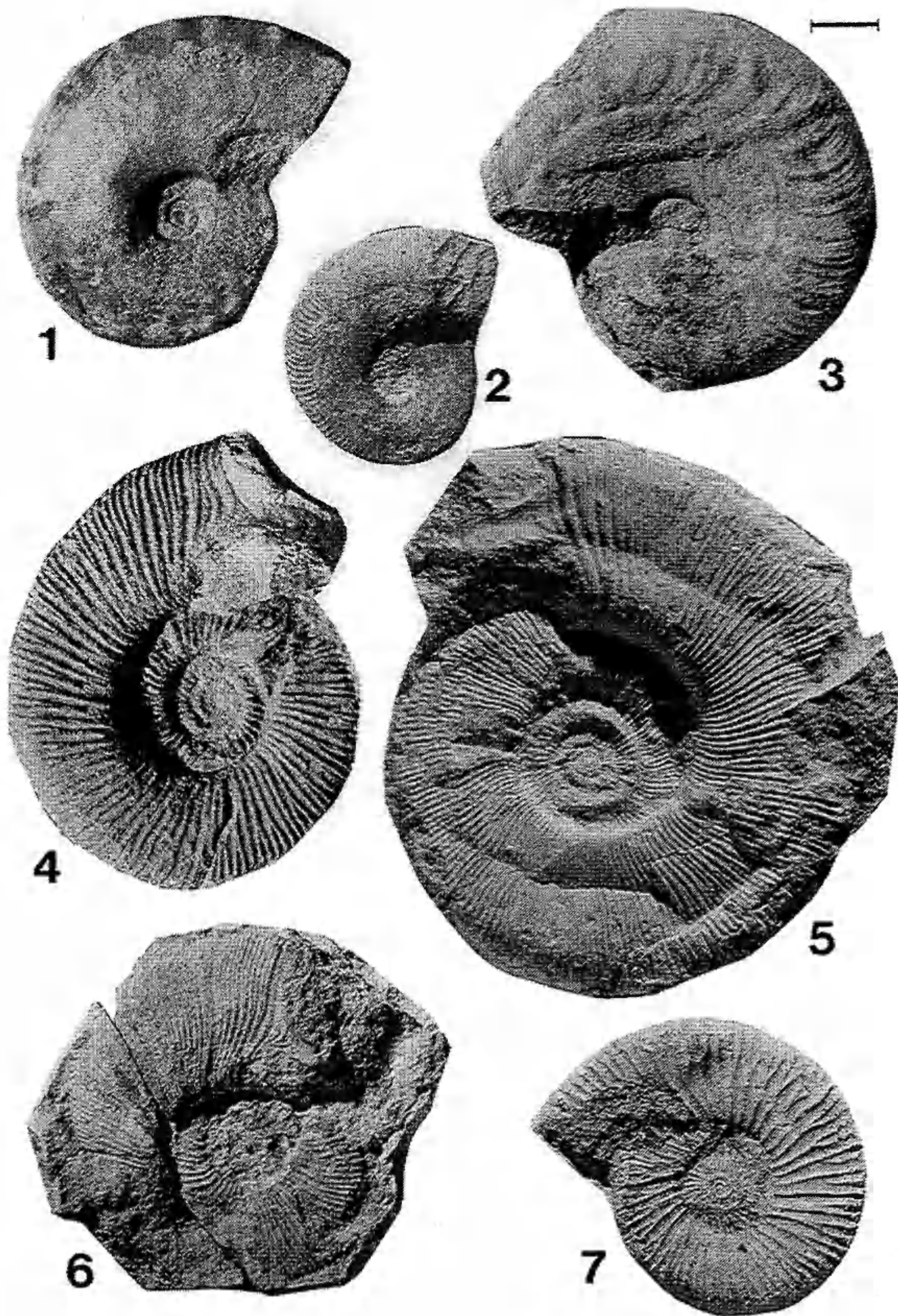
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Plate 1. 1. *Taramelliceras wepferi* Berckhemer. Beckeri Zone, Ulmense Subzone, *zio-wepferi* horizon α . Nusplingen, SW Germany. SMNS No. 63646; 2. *Lingulaticeras pseudopercevali* Schweigert. Beckeri Zone, Ulmense Subzone, *zio-wepferi* horizon β . Tuttlingen, abandoned Mattsteige quarry, SW Germany. SMNS No. 63079; 3. *Ochetoceras zio* (Oppel). Beckeri Zone, Ulmense Subzone, *zio-wepferi* horizon α . Tuttlingen, abandoned Mattsteige quarry. SW Germany. SMNS No. 63631/2; 4. *Silicisphinctes paraboliferus* Berckhemer in Berckhemer and Holder. Beckeri Zone, Ulmense Subzone, *zio-wepferi* horizon α , Gerhausen, SW Germany. SMNS No. 63345; 5. *Silicisphinctes hoelderi* (Sapunov). Beckeri Zone, Ulmense Subzone, *hoelderi* horizon. Neresheim, SW Germany. GPIT No. Ce 1101/43; 6. *Silicisphinctes keratinitiformis* Schweigert. Ulmense Subzone, *zio-wepferi* horizon β . Möhringen, Danube valley, SW Germany. SMNS No. 62646. 7. *Silicisphinctes russi* Schweigert. Beckeri Zone, Ulmense Subzone, *hoelderi* horizon. Neresheim, SW Germany. GPIT No. Ce 1101/49. Scale bar 1 cm.



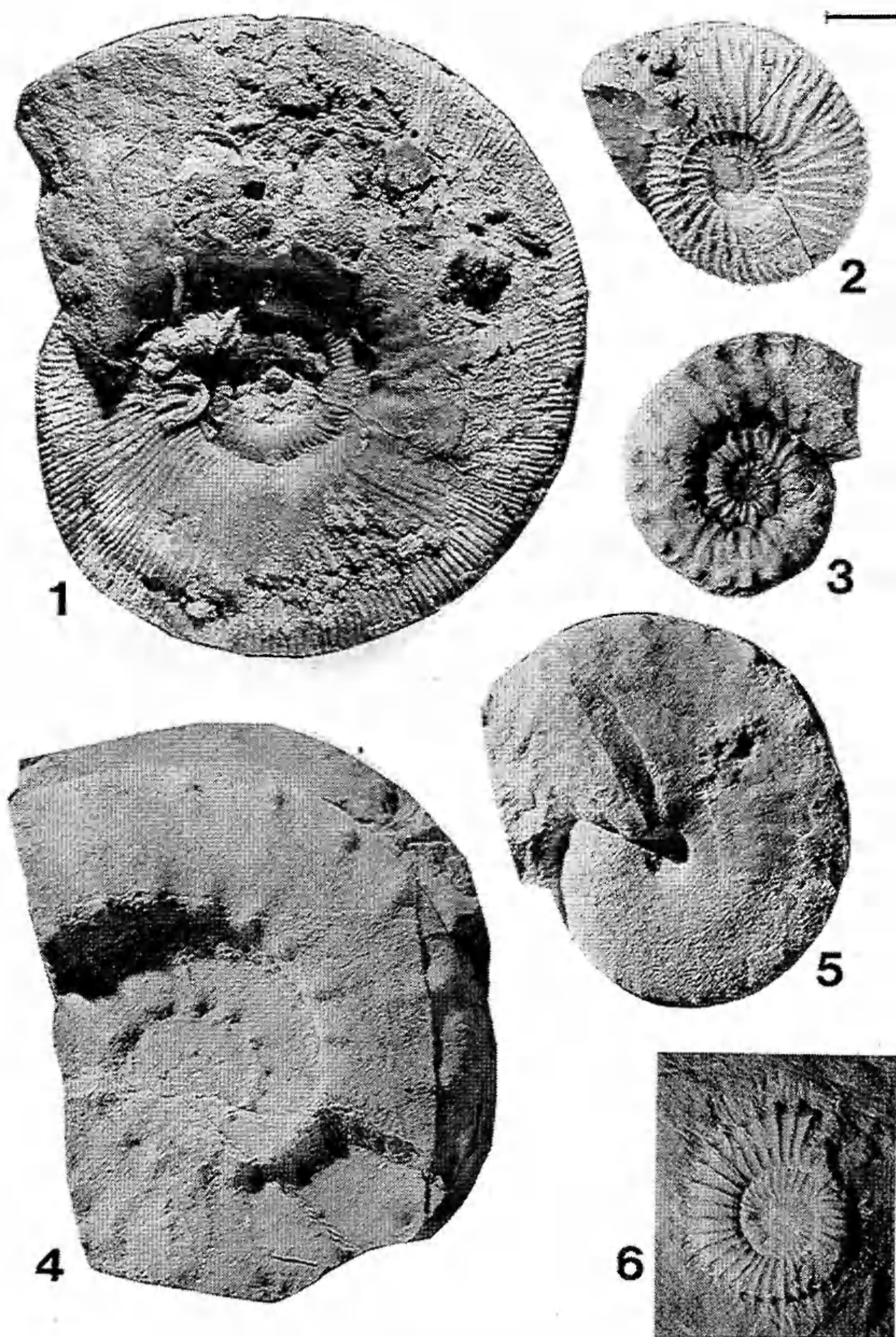


Plate 2. 1. *Lithacoceras* aff. *ulmense* (Oppel). Ulmense Subzone, *zio-wepferi* horizon β . Nattheim, SW Germany. SMNS No. 62520; 2. *Sarmatisphinctes* aff. *fallax* (Ilowaisky and Florensky). Ulmense Subzone, *zio-wepferi* horizon β . Gussenstadt, SW Germany. SMNS No. 63647; 3. *Hybonotoceras* cf. *Extraspinatum* Berckhemer and Holder. Beckeri Zone, Ulmense Subzone, *hoelderi* horizon, Fridingen, Danube valley, SW Germany. SMNS No. 19427; 4. *Hybonotoceras interlaevigatum* Berckhemer mskr. Ulmense Subzone, *rebouletianum* horizon. Münsingen Auingen, SW Germany. SMNS No. 14929, x 2/3; 5. *Neochetoceras rebouletianum* (Fontannes). Beckeri Zone, Ulmense Subzone, *rebouletianum* horizon. Buchheim, SW Germany. SMNS No. 63632; 6. *Berckhemeria scherzingeri* Schweigert and Zeiss. Hybonotum Zone, Riedense Subzone, *eigeltingense* horizon, Grabenstetten, SW Germany. SMNS No. 19466. Scale bar (except for Fig. 4) 1 cm.