Aalenian (Middle Jurassic) ammonites and stratigraphy of the Geisingen clay pit (SW Germany)

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Abstract

An account is given of the old clay pit at the Wartenberg Hill near Geisingen (SW Germany). A section ranging from the "Comptum" Subzone (Opalinum Zone, Lower Aalenian) to the Upper Aalenian/Lower Bajocian transition is described. Seven ammonite faunal horizons can be distinguished; four of them new for SW Germany. The Gigantea Subzone of the Bradfordensis Zone (Middle Aalenian) yields three faunal horizons. The ammonites of the family Graphoceratidae Buckman, 1905 are described in detail. Two new species of *Brasilia*, *B. geisingensis* and *B. decipiformis*, are introduced.

Keywords: Ammonites, Graphoceratidae, Aalenian, biostratigraphy, SW Germany.

1. Introduction

Since the 1970s Middle Jurassic clays have been exploited for cement production at the foot of the Wartenberg hill, close to the village of Geisingen, where the Danube River starts to cut through the mountains of the Swabian Alb (Fig. 1). The now abandoned clay pit exposed a lithological section ranging from the "Oberer Opalinuston" up to the "Unterer Wedelsandstein". A unique feature of this exposure is the occurrence of a chamosite-oolitic bed (0.6–0.8 m) representing parts of the Middle Aalenian Gigantea Subzone of the Bradfordensis Zone. This bed is especially rich in well preserved ammonites and has therefore attracted the attention of numerous amateur collectors. Thousands of specimens mainly belonging to the family Graphoceratidae occur besides rarer hammatoceratids and scarce lytoceratids, phylloceratids and erycitids. Many specimens are housed in private and institutional collections. Despite its key role in our understanding of the ammonite faunas and stratigraphy of the Middle Aalenian in southwestern Germany there exist only few short accounts and unpublished reports dealing with this key site (Schreiner 1976; Dietl & Rieber 1980; Dietze 1989; Albersdörfer 1992; Dietl 1997; Furze et al. 2010). Gastropods of the Geisingen section were recently described by Gründel et al. (2011). In Rieber's (1963) revision of the "Braunjura ß" of the Swabian Alb the author was unable to describe these strata and their ammonite assemblages as at the time no exposure existed there. This study will now add this missing data some half a century later.

The identifications of the ammonites are purely morphological, except for those coming from the chamosite-oolitic bed. We broadly follow the systematics of Howarth (2013). Where possible, species have been named by comparison to the type specimens.

Abbreviations: IFGT = Institut für Geowissenschaften der Universität Tübingen, Germany; LGRB = Landesamt für Geologie, Rohstoffe und Bergbau im Regierungspräsidium Freiburg, Germany; PIMUZ = Paläontologisches Institut und Museum der Universität Zürich, Switzerland; SMNS = Staatliches Museum für Naturkunde Stuttgart, Germany. [M] = macroconch specimen, [m] microconch specimen, HT = Holotype. dp = diameter of phragmocone, d = largest preserved diameter, wp = width of umbilicus at end of phragmocone, w = largest width of umbilicus, wbp = whorl breadth at end of phragmocone, wb = whorl breadth at largest preserved diameter, whb = whorl height at end of phragmocone, wh = whorl height at largest preserved diameter; - = measurement impossible.

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2. Material

This study is based primarily on specimens housed in the SMNS (mostly collected bed-by-bed in the 1980s by M. Rieter and collections donated by R. & T. Chiarini, and W. Auer). Other key collections for this study are

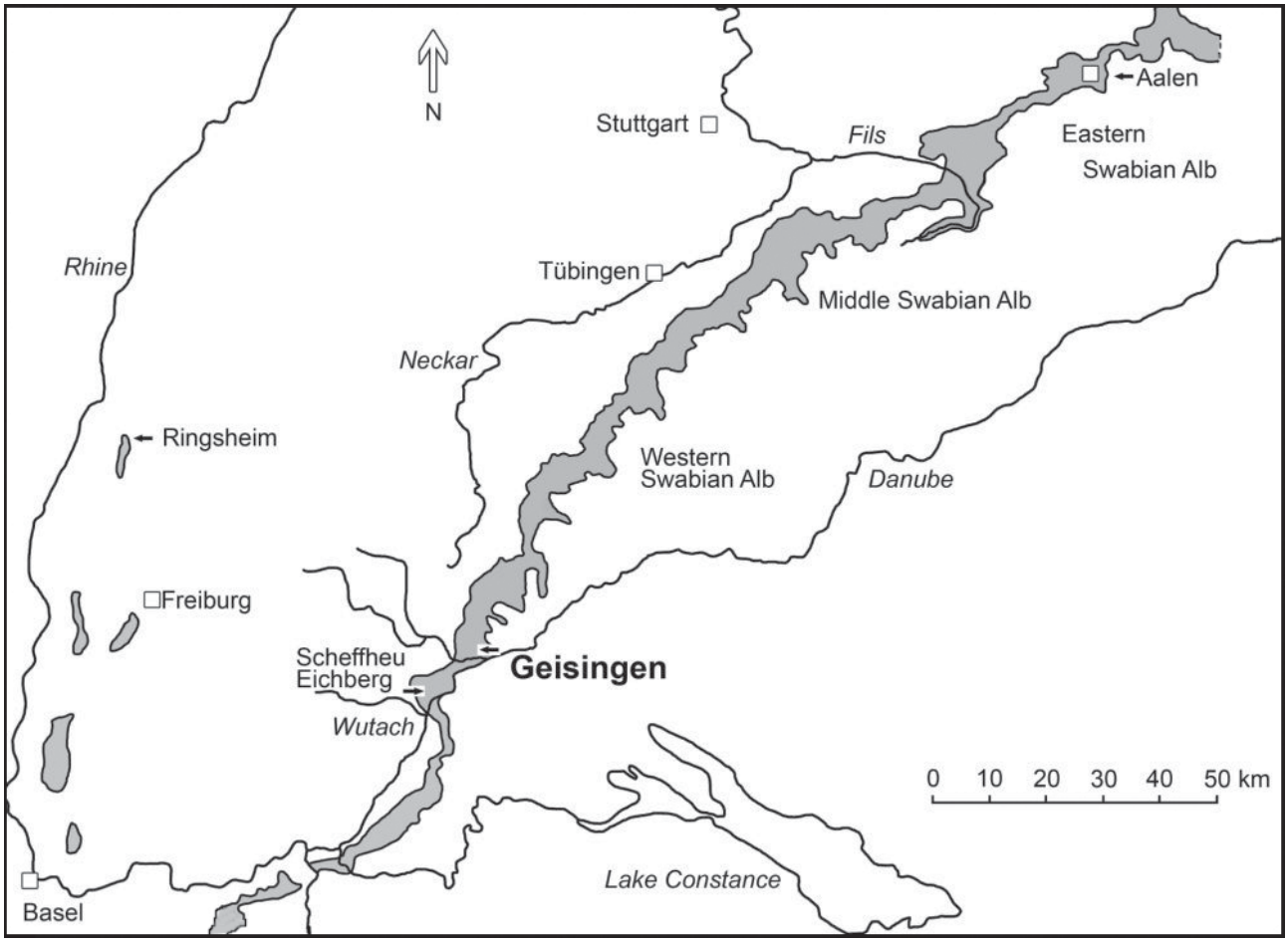

Fig. 1. Location of the section studied in the Swabian Middle Jurassic.

housed in the PIMUZ (mainly collected by H. Rieber) and in the LGRB.

3. The section of the Wartenberg clay pit

Our results are based on a number of previous accounts made over the years by H. Rieber in 1976, M. Rieter in 1978, M. Franz & D. Reimer in 1996 (Tongrube Schabel, Breisgauer Portland-Zementfabrik, R 34 11 100, H 53 71 515) and by W. Auer. The lithostratigraphical terminology follows Franz & Nitsch (2009). The sections were measured at different times and locations within the clay pit and therefore represent a composite profile.

Opalinuston Formation,
Zillhausen Member

• ?Wasserfallbänke/?Zopfplatten: A core drilling record (Franz 1996, unpubl.) identified that at five meters below the "Comptum" Bank there is a 0.4 m thick light grey colored, hard limestone bed. Below follow 1.1 m of bioturbated marly mudstones and a second 0.25 m thick limestone bed. The next 1.05 m downwards consist of bioturbated marly mudstones followed by two beds of hard limestone of 0.1 m and 0.15 m, respectively, separated by 0.2 m of marly mudstone. This part of the succession has a remarkable content of fine sand and muscovite and may represent the "Zopfplatten" and "Wasserfallbänke" beds (Franz & Nitsch 2009). The Zillhausen Member extends 14.3 m below the "Comptum" Bank.

• Laminated mudstone (ca. 5 m): This bed consists of grey laminated mudstones in which four horizons with septarian nodules occur. Immediately below the overlying "Comptum" Bank there is a band of calcareous nodules (0.03 m). Ammonites have not been recorded from this interval.

Achdorf Formation

• "Comptum" Bank (0.05–0.2 m): Calcareous marls, sometimes with pebbles and locally cemented, forming a hard limestone bed.

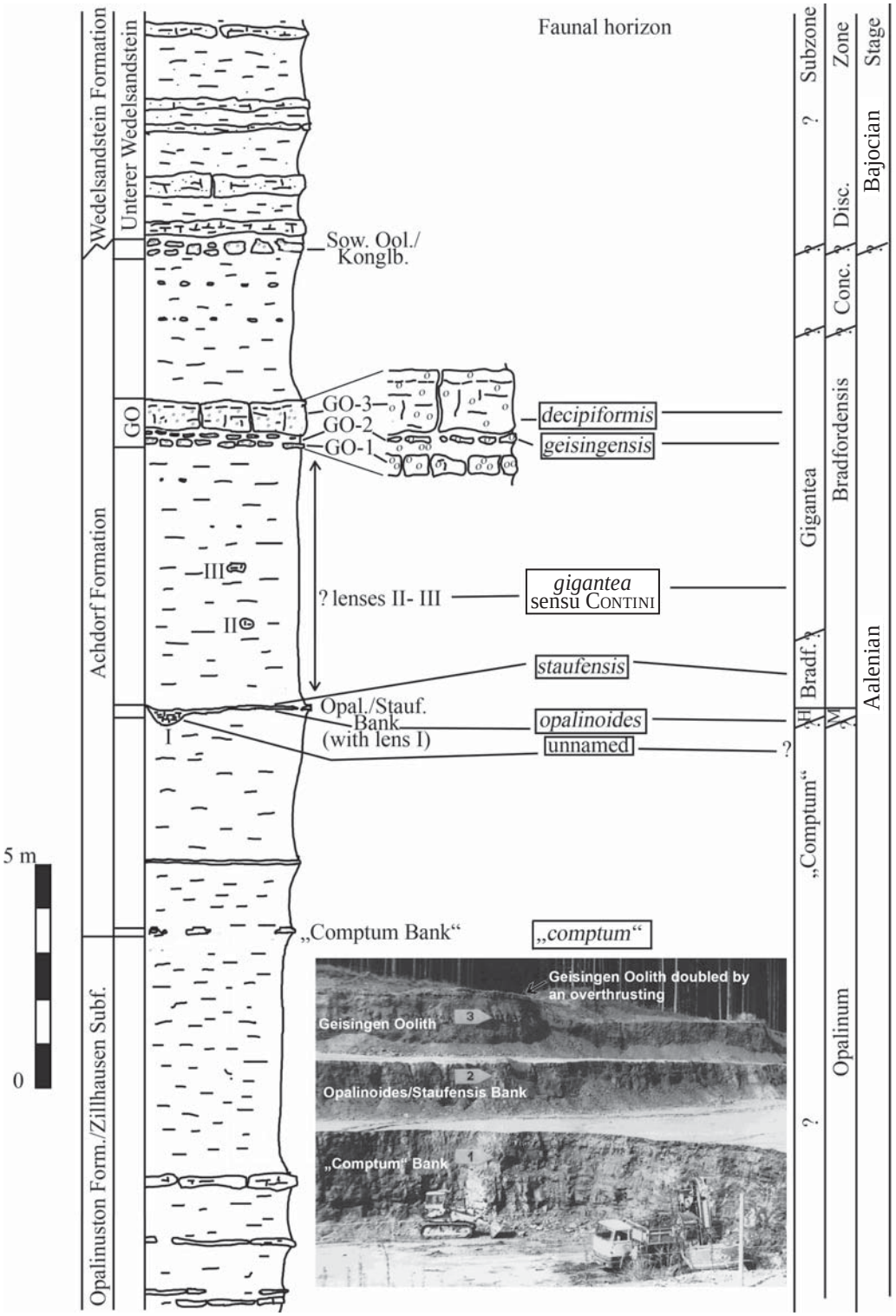

Fig. 2. Section of the Aalenian and ?Lower Bajocian outcrop in the Geisingen clay pit. Abbreviations: H = Haugi, M = Murchisonae, Bradf. = Bradfordensis, Conc. = Concavum, Disc. = Discites, GO = Geisingen Oolith, Sow. Ool. = Sowerbyi Oolith, Konglb. = Konglomeratbank. Diagonal lines with question marks: boundaries not exactly known. The photograph shows the section in 1978; at this time the Geisingen Oolith was at one small area doubled due to a tectonic overthrust (arrow 1: “Comptum” Bank; arrow 2: Opalinoides/Staufensis Bank; arrow 3: Geisingen Oolith).

Ammonites: *Leioceras "comptum"* auct. [non Reinecke = *Pleydellia* sp.] (Pl. 1, Figs. 2–7)
L. crassicostatum Rieber (Pl. 1, Figs. 1, 8)

• Mudstone (1.35–1.7 m): Mudstones with horizons of argillaceous ironstone concretions.

• Limestone bed (0.03–0.07 m): Limestone sometimes containing muddy pebbles, their surfaces partly encrusted with pyrite.
Ammonites: *Ancolioceras opalinoides* (Mayer) (Pl. 1, Fig. 9)

• Mudstone (3.0–3.5 m): Mudstone with some layers of septarian nodules.
Ammonites*: Ancolioceras opalinoides* [0.4 m from bottom; ca. 0.3 m below Opalinoides/Staufensis Bank]

• Opalinoides/Staufensis Bank (0.05–0.20 m; locally this bed thickens due to the presence of sediment-filled troughs up to 0.6 m). This bed displays considerable variations in thickness and contains one, two or even three horizons of irregular, nodular limestones recorded at different points. In the lower part fine-grained septarian-like limestones with ammonites occur, which are often corroded and reworked. The upper level contains muddy pebbles, abundant pyrite and is sparsely chamosite-oolitic. Bivalves, gastropods, serpulids and belemnites are common. Ammonites are embedded at all angles. Stromatolite layers and small areas of serpulid-encrusted hardgrounds within the Opalinoides/Staufensis Bank provide evidence for hiatuses. In places only one horizon of pyritic, sparsely oolitic, nodular limestone is developed.

At a few locations within the clay pit this bed displays a very different development. Small troughs appear to have been present on the ancient sea floor ranging in depth up to 0.6 m (pers. observ. W. Auer) over an area of about 1.5 m². One of these ammonite-bearing troughs we term "lens I". In these depressions a very hard, splintery limestone containing small shells is developed. The ammonites of lens I are jumbled throughout the bed.
Ammonites*:* Collection SMNS:
Specimens obtained in jumbled disorder or from the lower part of the bed:
Ludwigia haugi Douvillé (Pl. 3, Figs. 1–3, 6–7; Pl. 4)
Ancolioceras opalinoides (Mayer) (Pl. 5, Figs. 2–8, Pl. 6, Figs. 1–5)
Costileioceras sinon (Bayle) (Pl. 6, Figs. 6, 8–9)
Specimens from the upper part of the bed:
Brasilia ex gr. *bradfordensis* (Buckman) (Pl. 7, Figs. 3–5, 7–8)
Staufenia staufensis (Oppel) (Pl. 7, Figs. 1–2, 6) [Pl. 7, Figs. 1–4 are the specimens recorded by Dietl & Rieber 1980]
Specimens From "lens I" (coll. Auer, Fanzutti, now SMNS):
? *Ludwigia* n. sp. (Pl. 2, Figs. 1, 3)
Ancolioceras opalinoides (Mayer) (Pl. 1, Figs. 10–12)
? *A.* n. sp. (Pl. 1, Figs. 13–14)
? *Costileioceras* n. sp. (Pl. 2, Figs. 2, 4)

• Mudstone (5.6–6.1 m): Finely laminated mudstone with argillaceous ironstone concretions at different levels. At ca. 3.8 m above the base, a sandy limestone bed occurs (0.05–0.08 m). Two large ammonite-bearing lenses ("lens II", "lens III") were found ex-situ in the pit by the amateur collector E. Neisser. They must originate from somewhere in the section between the Opalinodes/Staufensis Bank and the Geisingen Oolith, The matrix of the ammonites from the lenses II and III is similar to that of the Opalinoides/Staufensis Bank.
Ammonites from "lenses II & III" (coll. Neisser, now SMNS):
Brasilia gigantea (Buckman) sensu Contini (Pl. 8, Fig. 2–4)
B. similis (Buckman) sensu Contini (Pl. 8, Fig. 1, Pl. 9, Figs 1–3)
B. aff. *rustica* (Buckman) sensu Contini (Pl. 9, Figs. 4–5)

• Geisingen Oolith (0.6–0.8 m): A chamosite-oolitic limestone bed, unweathered grey to green in color, weathering to a rusty brown. At its base (GO-1) a hard, sparsely chamosite-oolitic limestone bed (0.15 m) is intermittently developed. No ammonites have yet been recorded. A few centimeters of mudstone are succeeded by a nodular, fairly soft chamosite-oolitic limestone bed (GO-2). Ammonites are mostly crushed above nodules and some also occur below nodules but deformed. Above is a massive chamosite-oolitic bed (GO-3; 0.4–0.6 m) with abundant ammonites, belemnites and bivalves (mainly *Astarte* and *Cucullaea*) in its lower part.

At most places within the site two distinct levels with ammonites were observed, a lower one (Figs. 3–4; Pls. 10–14) in bed GO-2, sometimes reaching the bottom of bed GO-3 and an upper one (Figs. 5–6; Pls. 17–21) in the lowermost 0.1–0.15 m of bed GO-3, with most of the ammonites lying at about 0.05–0.15 m from the base. A third distinctive ammonite fauna (Pls. 15–16) occurs sporadically at the base and in the lowermost part of bed GO-3. At one location GO-2 was completely missing over few meters and bed GO-3 reached down to this level (pers. observation by W. Auer). Albersdörfer (1992) was of the opinion that the horizontal distribution of the Geisingen Oolith was more or less restricted to the area of the clay pit itself, because it was never seen elsewhere in the area (with the exception of an isolated occurrence near Öfingen, pers. observ. N. Wannenmacher).
Ammonites from bed GO-2:
Brasilia geisingensis n. sp. [interpreted as chronospecies (exhibiting different morphological varieties), see Chapter 4.3] (Figs. 3.1–3.2, 4.1–4.4; Pl. 10, Figs. 1–3, Pl. 11, Figs. 1–4, Pl. 12, Figs. 1–4, Pl. 13, Figs. 1–6, Pl. 14, Figs. 1–9)
Bredyia diadematoides (Mayer) and varieties
Abbasites gardincola (de Gregorio) [see Dietze et al. 2010]

Ammonites from the base of bed GO-3 [only locally]:
Brasilia platychora (BUCKMAN) (Pl. 15, Figs. 1–2, Pl. 16, Figs. 1–2, 5)
B. austera (BUCKMAN) (Pl. 16, Figs. 7–8)
B. nitens (BUCKMAN) (Pl. 16, Fig. 6)
B. deleta (BUCKMAN) (Pl. 16, Figs. 3–4)
B. spp.
Ammonites from bed GO-3 [0.05–0.15 m above the base; 1 specimen of *Brasilia*. *decipiformis* n. sp. from the top of this bed]:
B. decipiformis n. sp. (Figs. 5.1–5.2, 6.1–6.9; Pl. 17, Figs. 1–2, Pl. 18, Figs. 1–4, Pl. 19, Figs. 1–7, Pl. 20, Figs. 1–17, Pl. 21, Figs. 1–2, Pl. 22, Figs. 1–3)
Bredyia diadematoides (MAYER) and varieties
Abbasites aff. *abbas* BUCKMAN [see DIETZE et al. 2010]
Megalytoceras sp.
Costiphylloceras connectens (ZITTEL)

• Mudstone (2.6–3.1 m): mudstones with several levels of argillaceous ironstone concretions.
Ammonites*: Graphoceras* sp. [about 0.5 m above the top of the Geisingen Oolith]

• "Konglomeratbank/Sowerbyi Oolith": (0.2–0.35 m): When the clay pit was active in the late 1970s and 1980s, DIETL & RIEBER (1980) and RIETER and FRANZ (1986) observed two layers of chamosite-oolitic, calcareous nodules (each 0.1–0.2 m) separated by 0.15–0.2 m of mudstone. In the southern part of the pit, exploited only in later years, these two layers of nodules merged into one forming a hard, conglomeratic limestone bed (profile FRANZ & REIMER 1996, 0.2–0.3 m). It is pale grey to beige in color, feebly iron-oolitic and conglomeratic, containing bivalves and belemnites. The muddy pebbles within this bed are coated with microbial crusts, subsequently bored by bivalves and encrusted by oysters and serpulids. In contrast to the surrounding matrix these pebbles are not iron-oolitic. Although the boundary between the Achdorf and Wedelsandstein formations cannot be placed precisely, it must lie within these strata. From the north to the south of the clay pit the mudstones separating the two nodule layers within the "Konglomeratbank/Sowerbyi-Oolith" and between the "Konglomeratbank/Sowerbyi-Oolith" and the "Unterer Wedelsandstein", wedge out.
Ammonites: *Graphoceras* (*Ludwigella*) *latum* (BUCKMAN) (Fig. 7.5)
Hyperlioceras walkeri BUCKMAN (Figs. 7.3–7.4)
H. mundum (BUCKMAN)
Euaptetoceras infernense (ROMAN) (Fig. 7.1)
Eudmetoceras amplectens BUCKMAN (Figs. 7.2, 7.6)
Euhoploceras biplicatum (BUCKMAN) (Fig. 7.7)

Wedelsandstein Formation, Unterer Wedelsandstein

The "Unterer Wedelsandstein" is exposed in the new part of the clay pit in a thickness of over 4.9 m and shows the same sequence of alternating mudstones and limestones as in the old pit (see Fig. 2).

4. The ammonite fauna

4.1. General remarks

The predominant ammonites at Geisingen are graphoceratids. Due to their rapid evolution and abundance they can be successfully used for high resolution biostratigraphy. We therefore focus on this group. Graphoceratid ammonite assemblages in the Aalenian and lowermost Bajocian have been reported from SW Germany, central Switzerland, E France, S England, and N Spain (RIEBER 1963; CONTINI 1969; URETA GIL 1983; CALLOMON & CHANDLER 1990; CHANDLER 1997; CHRIST 1999). A revision of the Graphoceratidae is not possible based on the assemblages from Geisingen alone. However, we can add important new information about the phylogeny of this family, especially for the transition of the Opalinum –Murchisonae zones and for the Gigantea Subzone of the Bradfordensis Zone. Since the Geisingen section is stratigraphically incomplete, there are also gaps concerning the evolutionary record of the family. Moreover, in most beds ammonites are rare and often incompletely preserved, except those from the Geisingen Oolith. Nevertheless, the section contains lenses with two graphoceratid ammonite assemblages, which are new for SW Germany. The ammonite faunas from the Geisingen Oolith were never thoroughly described until now. A detailed investigation of the hammatoceratids, rare erycitids (DIETZE et al. 2010), phylloceratids and lytoceratids is beyond the scope of this study. Characteristic elements of these groups are identified in the faunal lists above, supplemented by short remarks. To describe the ammonite assemblage of lens I in detail is also beyond the scope of this study. These ammonites will be described elsewhere; hence we give here only some illustrations of the most significant elements of this assemblage (Pl. 1, Figs. 10–14, Pl. 2, Figs. 1–4), accompanied by some preliminary comments (see Chapter 4.3.2.).

4.2. Taxonomic concepts

The studies of HOFFMANN (1910, 1913), RIEBER (1963), CONTINI (1969), CHANDLER (1997), CHRIST (1999), CHANDLER & CALLOMON (2010) and CHANDLER et al. (2012) clearly showed that the evolution within the Graphoceratidae is gradual with very few branching events leading to new taxa around the Early/Middle Aalenian boundary. The usage of generic names (with the exception of *Ancolioceras*/*Costileioceras* – *Staufenia* – *Ludwigia*) is purely morphological and arbitrary due to the observed

Fig. 3. (1–2) *Brasilia geisingensis* n. sp.; holotype; Geisingen clay pit, Geisingen Oolith, bed GO-2; Middle Aalenian, Bradfordensis Zone, Gigantea Subzone, *geisingensis* horizon; (SMNS 70190/1). – x1, * = end of phragmocone.

intergradations between the distinguishable evolutionary trunks (see e.g., CHANDLER 1997; CHANDLER et al. 2012). We retain traditional names (CHANDLER 1997) for the description of the temporally succeeding transients at each level (= a chronocline) starting with the genus *Ludwigia* at the Comptum/Murchisonae zones boundary and ending in the Early Bajocian Discites Zone. We recognize four genera in the sense of "chronogenera": *Ludwigia* → *Brasilia* → *Graphoceras* → *Hyperlioceras*).

With the exception of two levels (Geisingen Oolith and lens I) we do not have enough material at our disposal and we therefore described most specimens morphospecifically.

The graphoceratid ammonite assemblages of the two newly described faunal horizons in the Geisingen Oolith (Gigantea Subzone) are interpreted as representing chronospecies. Chronospecies are temporal segments of a phyletic lineage, which can be distinguished from each other by morphological shifts of variation (for a detailed discussion of this chronospecies concept see e.g. WILLMANN 1985; DIETZE et al. 2005; CHANDLER & CALLOMON 2010). This concept was already applied to other Middle Jurassic genera: *Phlycticeras* (SCHWEIGERT & DIETZE 1998), *Sonninia* (DIETZE et al. 2005), *Strigoceras* (SCHWEIGERT et al. 2007) and *Leioceras* (CHANDLER & CALLOMON 2010). The time ranges of these chronospecies differ. In the case of *Leioceras*, a chronospecies is very close to a palaeo-biospecies (CHANDLER & CALLOMON 2010). But what is the "correct" name of an assemblage interpreted as a chronospecies with respect to the rules of the ICZN? There are few families of Jurassic ammonites with so many described nominal (morpho-)species as in the Graphoceratidae. Morphologically variable graphoceratid assemblages from Geisingen (*geisingensis* resp. *decipiformis* horizons) therefore include nominal morphospecies already described in the literature – as morphological variants – but either with unknown type horizons or coming from slightly older or younger strata, with significantly different ranges of variation of their assemblages, when compared to the two new horizons from Geisingen. The chronospecies concept requires a type specimen from exactly the time-interval of the chronospecies described. No nominal species has been described for graphoceratids coming from the exact time equivalent corresponding to the *geisingensis* and *decipiformis* horizons (see Chapter 4). This necessitates the introduction of two new (chrono-) species for these assemblages. We have carefully selected specimens as holotypes, which to date have not been described as a nominal morphospecies. If a specimen of a chronospecies is morphologically identical to an existing nominal morphospecies, its name may be used as a variant name; such infrasubspecific names do not fall under the restrictions of the ICZN (for details see DIETZE et al. 2005).

4.3. Description of two new ammonite species

Family Graphoceratidae BUCKMAN, 1905
Subfamily Graphoceratinae BUCKMAN, 1905
Genus *Brasilia* BUCKMAN, 1898

Brasilia geisingensis n. sp.
Figs. 3.1–3.2, 4.1–4, Pl. 10, Figs. 1–3, Pl. 11, Figs. 1–4, Pl. 12, Figs. 1–4, Pl. 13, Figs. 1–6, Pl. 14, Figs. 1–9.

? 1983 *Brasilia gigantea*. – URETA GIL, p. 301 [pars], pl. 15, fig. 2.
1997 *Ludwigia bradfordensis*. – DIETL, p. 43.
2010 *Brasilia similis maubeugei* CONTINI. – FURZE et al., fig. 5.

E t y m o l o g y : After the type locality, the village of Geisingen.

H o l o t y p e : Specimen figured on Figs. 3.1–3.2, SMNS 70190/1.

T y p e l o c a l i t y : Clay pit at the Wartenberg hill near Geisingen (SW Germany).

T y p e h o r i z o n : Bed GO-2 (Geisingen Oolith), Bradfordensis Zone, Gigantea Subzone, ammonite faunal horizon of *Brasilia geisingensis* n. sp.

M a t e r i a l : About 100 specimens from the SMNS and PIMUZ collections, about 50 specimens in private collections.

O c c u r r e n c e s : Geisingen; near Öfingen (ex coll. N. WANNENMACHER, now SMNS 70234).

D i a g n o s i s : Evolute species of the genus *Brasilia*, with ribbed inner whorls, later becoming smooth; fastigate venter becoming rounded at the end of the phagmocone; umbilical wall at least on the inner whorls relatively steep.

D e s c r i p t i o n : The holotype is a complete macroconch phragmocone with a diameter of 206 mm and lacking the test. The regular, initially dense and prorsiradiate, later more rectiradiate and distant ribs are clearly developed only within the umbilicus, then becoming flat and broad at the first quarter of the last preserved whorl. The relatively evolute umbilicus is surrounded by a steep umbilical wall. The umbilical edge is sharp. The slightly convex flanks continue to the beginning of the last preserved whorl. The venter develops from fastigate on the phragmocone to rounded on the body chamber. The whorls are high and moderately broad.

B. geisingensis is characterized by its consistently ribbed inner whorls, its evolute umbilicus, rounded body chamber and reduced whorl height, compared with *B. decipiformis* n. sp. The umbilical wall is relatively steep, but can develop a lower angle at the end of the phragmocone and on the body chamber. The umbilical edge is always well defined. The maximum diameter of the shell is approximately 280–300 mm (Pl. 10, Figs. 2–3; the last portion of the body chamber is missing). In most specimens, especially in the large-sized examples, the body chamber is smooth. Only in some strongly sculptured and

small-sized specimens the sculpture persists to the body chamber, forming ribs on the outer part of the flanks (Pl. 14, Figs. 5–6, 8–9). The ribbing style of this species shows a considerable variation. In some specimens only the innermost whorls are strongly ribbed (Pl. 10, Figs. 1–3; Pl. 12, Figs. 3–4; Pl. 13, Figs. 1–2, 5–6; Pl. 14, Figs. 5–6, 8–9). The primary ribs are first prorsiradiate until the lower/middle part of the flank and sometimes form small nodes. The secondaries are at first rursiradiate, later projecting forwards towards the outer flanks. The primary ribs can continue undivided or bifurcate. Occasionally intercalatory ribs occur. The ribbing does not reach the venter and weakens considerably before the end of the phragmocone. In most of the specimens studied the ribbing is weakly developed on the inner whorls but still clearly visible. These specimens normally become smooth distinctly before the end of the phragmocone (Fig. 3; Pl 10, Fig. 1; Pl. 11, Figs. 1–4; Pl. 13, Figs. 5–6; Pl. 14, Figs. 3–4). Rare morphologies exist at both ends of the variability of the assemblage. (a) Almost smooth, flat and relatively involute specimens (Pl. 13, Figs. 3–4; Pl. 14, Figs. 1–2) – already resembling the morphology of the genus *Graphoceras.* (b) Unusual specimens: one small example with the inner whorls strongly ribbed with ribbing persisting on to the body chamber (Pl. 14, Figs. 5–6). Other specimens develop strong secondaries that persist on almost the entire phragmocone (Pl. 12, Figs. 1–2; coll. Auer). The ribbing style of the specimen illustrated on Pl. 12, Figs. 1–2 closely resembles that of *Graphoceras fallax*.

The lobes, especially the lateral lobe with three main accessory lobes directed backwards, are long and deeply incised (Pl. 10, Fig. 2; Pl. 11, Fig. 3; Pl. 12, Figs. 1, 4; Pl. 13, Figs. 2, 6; Pl. 14, Fig. 7).

Microconchs: The corresponding microconchs show a similar variation as the macroconchs: slender shells with less strong ribbing (Figs. 4.1–4.2) and strongly ribbed shells with a more rounded whorl section (Figs. 4.3–4.4).

Comparisons: *Brasilia geisingensis* n. sp. differs from all other nominal species described from comparable strata in Southern England (Buckman 1887–1907, 1909–1930; see Chandler 1997, tab. I) or elsewhere (Quenstedt 1886–1887; Althoff 1940; Géczy 1967; Contini 1969) especially by the whorl section and ribbing on the inner whorls. *B. gigantea* (Buckman), *B. decipiens* (Buckman), *B. limatum* (Buckman) and *B. platys* (Buckman) are more involute, with higher whorl section and exhibit some weak ribbing on the inner whorls. The specimens figured by Contini (1969, pl. 20, figs. 1–6) as *B. gigantea* seem to be representatives of a slightly older fauna with a more "*B. bradfordensis*" like character, comparable to the ammonites from the lenses II and III of Geisingen. The type specimen of *B. rustica* (Buckman) is more involute at comparable diameters than similar specimens from the *geisingensis* horizon; it is the sculptured variant of a slightly older assemblage (Contini 1969). The closely related *B. platychora* (Buckman) mainly differs by its higher whorls and a smaller umbilicus; the ribbing is generally weaker, but persists longer on the outer flanks of the body chamber. *B. austera* (Buckman) lacks the rounded whorl section of *B. geisingensis* n. sp. *B. austera* is based on a small phragmocone, which cannot be interpreted satisfactorily. Interpretation of *B. effricata* Buckman and *B. pinax* (Buckman) is also difficult due to the incomplete illustrations of the types. None of our specimens of *B. geisingensis* n. sp. are as smooth on the inner whorls as *B. effricata*. *B. geisingensis* n. sp. is more involute at comparable diameters. The

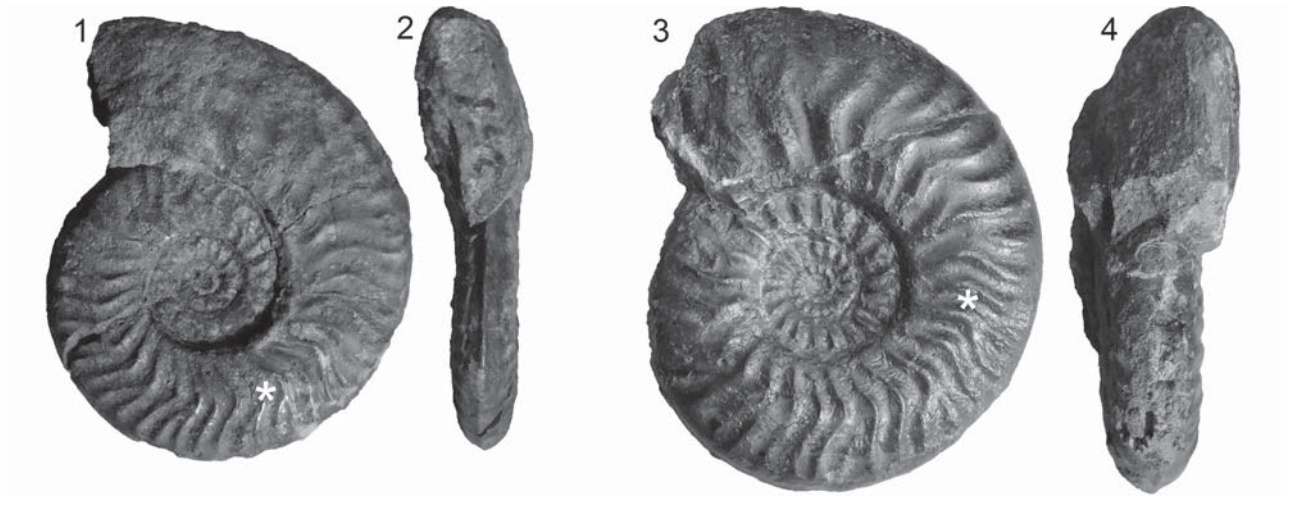

Fig. 4. (1–4) *Brasilia geisingensis* n. sp. [m]; Geisingen clay pit, Geisingen Oolith, bed GO-2 [**1–2**: less sculptured, slender variant; **3–4**: coarsely ribbed, broad variant]; Middle Aalenian, Bradfordensis Zone, Gigantea Subzone, *geisingensis* horizon; **(1–2)** (SMNS 70190/2), **(3–4)** (SMNS 70190/3). – x1, * = end of phragmocone.

Fig. 5. (1–2) *Brasilia decipiformis* n. sp. [M]; Holotype; Geisingen clay pit, Geisingen Oolith, bed GO-3 [0.05–0.10 m above base]; Middle Aalenian, Bradfordensis Zone, Gigantea Subzone, *decipiformis* horizon; (SMNS 70189/1). – Scale bar: 100 mm. * = end of phragmocone.

same characters distinguish the new species from *B. ambigua* (BUCKMAN), which also has no rounded whorl section. *B. nitens* (BUCKMAN) differs by possessing more sinuous ribs. None of the specimens assigned to *B. geisingensis* n. sp. of similar size and sculpture exhibit such an evolute umbilicus. *B. baylii* (BUCKMAN) and *B. bradfordensis* (BUCKMAN) differ by their less broad whorl sections; *B. bradfordensis* exhibits also a more involute umbilicus. *B. bradfordensis* and *B. baylii* are typical elements of the Bradfordensis Subzone.

Brasilia planata (QUENSTEDT) shows a more quadrate whorl section; it comes from older strata of the Bradfordensis Zone. *B. falcifera* (ALTHOFF) differs from the holotype of *B. geisingensis* n. sp. by a more involute umbilicus; it comes from the Bradfordensis Subzone (see Chapter 6). *B. latecostata* (ALTHOFF; pl. 3, fig. 1 [pl. 2, fig. 5 is a microconch]) shows considerably higher whorls and a smaller umbilicus as the holotype of *B. geisingensis* n. sp. at comparable diameters. The holotype of *B. maubeugei* CONTINI [= *B. helvetica* MAUBEUGE, 1967, fig. p. 79] is too small for a reasonable interpretation. However, it differs from *B. geisingensis* n. sp. by feebler and denser ribs. *B. fueloepi* (GÉCZY) shows similarities with the specimen figured on Pl. 14, Figs. 5–6, but is still more evolute and shows a lower height of the whorls. The very coarsely ribbed *B.*? *nalivkini* (GÉCZY) differs by a different, more quadrate whorl section and its extraordinarily strong ribs persisting on the body chamber. The whorl section of the type specimen of *B. schindewolfi* (GÉCZY) is more slender compared to *B. geisingensis* n. sp.

Measurements (in mm):

	d(p)	d	w (p)	w	wb(p)	wb	wh(p)	wh
Pl. 10, Figs. 2–3	~220	~265	83	105	-	-	-	-
Pl. 10, Fig. 1	210	267	68	98	-	-	79	92
Fig. 3.1–3.2 (HT)	206	206	61	61	~40	~40	84	84
Pl. 11, Figs. 1–2	192	204	54	57	-	-	79	80
Pl. 12, Figs. 1–2	175	175	48	48	37	37	74	74
Pl. 11, Figs. 3–4	160	205	47	64	35	-	67	75
Pl. 13, Figs. 1–2	157	157	49	49	31	31	61	61
Pl. 13, Figs. 5–6	~135	168	37	55	29	38	59	70
Pl. 14, Figs. 3–4	123	123	31	31	25	25	54	54
Pl. 14, Figs. 8–9	~115	~115	34	34	-	-	~45	~45
Pl. 13, Figs. 3–4	~113	~113	24	43	-	-	52	67
Pl. 14, Fig. 7	107	107	25	25	27	27	51	51
Pl. 14, Figs. 5–6	96	126	30	38	24	~27	42	51
Pl. 14, Figs. 1–2	~64	95	15	21	15	21	34	43

Brasilia decipiformis n. sp.

Figs. 5.1–5.2, 6.1–6.11; Pl. 17, Figs.1–2, Pl. 18, Figs. 1–4, Pl. 19, Figs. 1–7, Pl. 20, Figs. 1–17, Pl. 21, Figs. 1–2, Pl. 22, Figs. 1–3.

1980 *Ludwigia gigantea* (S. BUCKMAN). – DIETL & RIEBER, p. 55.
1980 *Graphoceras concavum* (SOW.). – DIETL & RIEBER, p. 55.
v 1989 *Ludwigia decipiens*. – DIETZE, p. 124, fig. top left.
1997 *Graphoceras concavum*. – DIETL, p. 43.
1997 *Ludwigia decipiens*. – DIETL, p. 43.
v 2010 *Brasilia decipiens* (BUCKMAN). – FURZE et al., fig. 11.
2010 *Graphoceras decorum* BUCKMAN. – FURZE et al., fig. 6.

Etymology: For its similarity with *Brasilia decipiens.*

Holotype: Specimen figured on Figs. 5.1–5.2, SMNS 70189/1.

Type locality: Clay-pit at the Wartenberg near Geisingen (SW Germany).

Type horizon: Bed GO-3 (Geisingen Oolith), Bradfordensis Zone, Gigantea Subzone, ammonite faunal horizon of *Brasilia decipiformis* n. sp.

Material: About 300 specimens from the SMNS and PIMUZ collections, more than 500 specimens in various private collections.

Occurrence: Geisingen.

Diagnosis: Large-sized, initially involute species of the genus *Brasilia* with high whorls and *Graphoceras*-like nucleus; inner whorls more or less ribbed, later becoming smooth, forming a shoulder on the ventral area.

Description: The holotype is a macroconch phragmocone with nearly half a whorl of the body chamber, mostly without test, the body chamber preserved with test. The preserved diameter is 296 mm. The small *Graphoceras*-like umbilicus shows distant, weak ribs, which disappear at a small diameter. At the beginning of the last two and a half preserved whorls the umbilical seam egresses, producing more evolute coiling and a wider umbilicus. The umbilical wall is steep and concave at first with a sharp umbilical edge, later decreasing in angle with a more rounded umbilical edge. With the exception of dense radial growth lines, the ammonite is smooth. In oblique light smooth and raised areas are visible across the venter. At the mid flank irregular bulges are discernible. The higher, less broad whorls are principally bound outwards with the greatest whorl-width at about half of the whorl-height. At the end of the phragmocone the lower third of the flanks has a concave indentation.

Specimens of *B. decipiformis* n. sp. show a considerable variation in their adult end-sizes (Pl. 17, Figs. 1–2 towards Pl. 20, Fig. 4), the ribbing style of the innermost whorls (Pl. 20, Figs. 1–17) and the shape and height of the umbilical wall. A particular character is the *Graphoceras*-like development of the umbilicus, which is fairly consistent. In larger specimens the umbilicus may become evolute at an early stage (Pl. 18, Figs. 2, 4) or much later (Pl. 18, Figs. 1, 3). Slender variants exist (Pl. 17, Figs. 1–2, Pl. 19, Figs. 2, 4, 7) as also variants with broader whorl section (Pl. 19, Figs. 1, 3, 5– 6). All these features occur in a plexus of variability and it is impossible to figure every variation. We have illustrated the most characteristic morphologies and selected a holotype, which shows a morphology at the middle of the range. Small-sized specimens generally remain slender with a less evolute umbilicus (Pl. 20, Figs. 4, 16–17). On the specimen figured on Pl. 21 the inner whorls were prepared on the reverse side to show that the inner whorls of the large-sized specimens are similar to the small ones, the latter are just missing the final

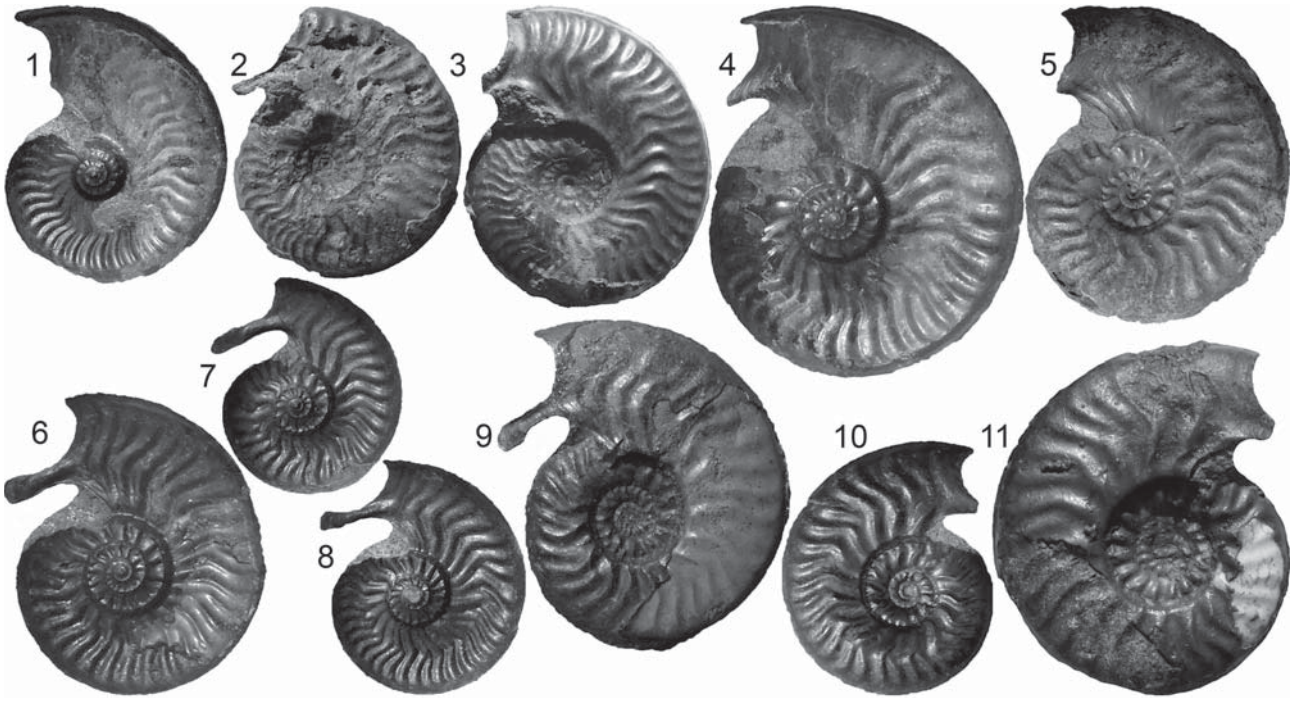

Fig. 6. (1–11) *Brasilia decipiformis* n. sp.; **(1)** juvenile macroconch; **(2–11)** microconchs [showing a range from involute, slender and weakly sculptured variants to evolute, broad and coarsely ribbed variants]; Geisingen clay pit, Geisingen Oolith, bed GO-3 [lowermost 0.15 m]; Middle Aalenian, Bradfordensis Zone, Gigantea Subzone, *decipiformis* horizon; **(1)** (SMNS 70189/2), **(2)** (SMNS 70189/3), **(3)** (SMNS 70189/4), **(4)** (SMNS 70189/5), **(5)** (SMNS 70189/6), **(6)** (SMNS 70189/7), **(7)** (SMNS 70189/8), **(8)** (SMNS 70189/9), **(9)** (SMNS 70189/10), **(10)** (SMNS 70189/11), **(11)** (SMNS 70189/12, leg. R. & T. CHIARINI). – x1.

smooth and evolute stage, some of them are most likely immature. The long and deeply incised lobes are close to those of *B. geisingensis* n. sp. (Fig. 5.1; Pl. 19, Fig. 2; Pl. 21, Fig. 1).

Microconchs: The corresponding microconchs (Figs. 6.1–6.11) show a variation from nearly smooth and involute to strongly ribbed, evolute forms, similar to the juvenile whorls of the macroconchs (see Pl. 20, Figs. 1–17, Pl. 21, Figs. 1–2). Because later the macroconchs exhibit smooth, high whorls this results in a different appearance for macro- and microconchs. The main differences are a smaller adult size, a continuation of the ornament to the end of the ontogeny, an egression of the last whorl, and the possession of lappets.

Comparisons: Some of the species introduced by BUCKMAN 1887–1907, 1909–1930) are close, but must be set apart on both morphological and stratigraphical criteria. The holotype of *B. gigantea* (BUCKMAN) differs from the holotype of *B. decipiformis* n. sp. by its much broader and more oval whorl section (Pl. 22, Figs. 1, 3), the more evolute and less *Graphoceras*-like umbilicus, the flat flanks that lack ornamentation except radial lines and its smaller end-size. Its type horizon is slightly older (see CHANDLER 1997); the assemblage of the Southern England faunal horizon Aa-11 *B. gigantea* as a whole is more like the Geisingen assemblage in the lenses at the base of bed GO-3 (Pls. 15–16). *B. platys* (BUCKMAN) lacks *Graphoceras*-like and relatively involute umbilicus of the holotype of *B. geisingensis* n. sp., and the flanks are more parallel and absolutely smooth. The venter is more rounded and the whorls are lower compared with the holotype of *B. decipiformis* n. sp. *B. effricata* (BUCKMAN) is more evolute with a lower whorl height; the flanks are smooth in contrast to the holotype of *B. decipiformis* n. sp. *B. decipiens* (BUCKMAN) is close to *B. decipiformis* n. sp. and has a *Graphoceras*-like umbilicus, as far as this can be judged from BUCKMAN's figures. Nevertheless, differences exist between *B. decipiens* and *B. decipiformis* n. sp. The holotype of *B. decipiens* exhibits more parallel flanks (Pl. 22, Figs. 1, 3), whereas the flanks of *B. decipiformis* n. sp. are more arched, the broadest point of the whorl section can be clearly recognized at about half of the whorl height or slightly below (Fig. 5.2, Pl. 18, Figs. 2–3, Pl. 19, Fig. 3). Chorotypes (= specimens from the same horizon, but neighboring locality) of *B. decipiens* (CHANDLER 1997, pl. 7, fig. 1; CHANDLER et al. 2012, pl. 3, figs. 1–2) show that this species misses also the typical concave depression on the lower part of the flanks and exhibits a different whorl

section. Some specimens (Pl. 19, Figs. 4, 7) are very close to the holotype of *B. decipiens* but differ in possessing a different whorl section and stronger ornamentation.

Remarks: In this assemblage small specimens occur (Pl. 20, Figs. 1–17), which could already be placed in *Graphoceras.* These specimens are significantly smaller than the macroconchs comprising the rest of the fauna. However, since all sizes and morphologies intergrade, we refrain from separating these from each other.

Measurements (in mm):

	d(p)	d	w (p)	w	wb(p)	wb	wh(p)	wh
Pl. 17, Figs. 1–2	372	471	67	103	~78	-	166	207
Fig. 4.1–4.2 (HT)	235	290	43	65	~54	~60	116	134
Pl. 18, Figs. 1, 3	228	228	31	31	~53	~53	119	119
Pl. 18, Figs. 2, 4	-	184	-	42	-	~37	-	83
Pl. 19, Figs. 1, 5	-	165	-	35	-	42	-	81
Pl. 19, Figs. 4, 7	-	156	-	25	-	32	-	76
Pl.19, Figs. 3, 6	128	128	22	22	~31	~31	65	65
Pl. 20, Fig. 1	-	116	-	21	-	28	-	59
Pl. 20, Figs. 2–3	-	101	-	16	-	21	-	51
Pl. 20, Fig. 4	-	83	12	13	12	15	27	40
Pl. 20, Fig. 5	-	91	-	15	-	-	-	46
Pl. 20, Figs. 6	-	100	-	19	-	18	-	50
Pl. 20, Figs. 7–8	-	110	-	15	-	29	-	58
Pl. 20, Figs. 14–15	~104	~104	19	19	26	26	-	50
Pl. 20, Figs. 16–17	72	93	13	14	17	22	40	47
Pl. 20, Fig. 9	-	77	-	15	-	-	-	39
Pl. 20, Fig. 13	-	90	-	18	-	19	-	42
Pl. 20, Fig. 10	-	75	-	13	-	17	-	41
Pl. 20, Figs. 11–12	-	63	-	12	-	~14	-	31

4.4. Description of the succeeding graphoceratid faunas from Geisingen

4.4.1. Graphoceratidae of the "Comptum" Bank

The leioceratids (Pl. 1, Figs. 1–8) exactly match with the assemblage that Rieber (1963) described as "Artengruppe des *Leioceras comptum*" from the western Swabian Alb.

4.4.2. Graphoceratidae of the Opalinoides/Staufensis Bank (including lens I)

The Graphoceratidae from this level ("unnamed horizon") belong to the genera *Ancolioceras*, *Costileioceras*, *Ludwigia*, *Brasilia*, and *Staufenia*.

Opalinum Zone, "Comptum" Subzone

The important new ammonite assemblage from "lens I" consists of about 50 ammonites. Because a thorough investigation and description of this assemblage requires a detailed comparison especially with the assemblage of the "Unteres Flöz" of Aalen and comparable faunas of the Murchisonae Zone from SW Germany and S England, it is impossible to describe these ammonites and their stratigraphy here in detail. For completeness of this work, we figure here some of these specimens (Pl. 1, Figs. 10–14, Pl. 2, Figs. 1–4) with some short remarks.

A small number of these specimens, here provisionally named as ?*Ludwigia* n. sp. (Pl. 2, Figs. 1, 3) show the lateral aspect of *Ludwigia*. They do not show the typical subquadrate whorl section; the whorl section is more rounded than seen in *Ludwigia* and is more *Leioceras*-like. Similar specimens were placed by Buckman (1899) into his genera *Hyattina* (Suppl. pl. 13, figs. 7–9), comparable in lateral view, and *Hyattia* (Suppl. pl. 12, figs. 5–8), comparable whorl section. One specimen, ?*Costileioceras* n. sp. (Pl. 2, Figs. 2, 4), is close to *Costileioceras sinon*, but differs in its whorl section, especially its broader, more rounded venter on the body chamber. Most of our specimens (Pl. 1, Figs. 10–12) are close to *Ancolioceras opalinoides* (for the variability see Horn 1909, pls. 9–10). Another form, ?*Ancolioceras* n. sp. (Pl. 1, Figs. 13–14), resembles *Staufenia sehndensis* (Hoffmann). However, the *S. sehndensis* from SW Germany (SMNS, coll. Dietze, Wannenmacher) and most of the specimens from N Germany (Hoffmann 1913) differ by showing a more acute whorl section.

Murchisonae Zone, Haugi Subzone

The *Ludwigia*, *Costileioceras* and *Ancolioceras* assemblages of the Haugi Subzone of Geisingen are identical to those described by Horn (1909) and Rieber (1963) from the nearby Wutach area. They show a strong affinity to ammonites described mainly by Quenstedt (1849, 1858, 1886–1887) from the "Unteres Flöz" of Aalen-Wasseralfingen (Eastern Swabian Alb).

- Genus *Ludwigia* Bayle, 1878

- *Ludwigia haugi* (Douvillé, 1885): We follow Rieber (1963) in the interpretation of this species. One incomplete phragmocone (Pl. 3, Figs. 3, 7) is a close match for the holotype (lost) from Aalen-Wasseralfingen (Quenstedt 1849, pl. 7, fig. 12; refigured herein in Pl. 3, Figs. 5–6). The specimen figured on Pl. 3, Figs. 1–2 is relatively stout and coarsely ribbed but still falls within the variability of the species. Other specimens (coll. SMNS) match with those figured by Horn (1909, pl. 12) as *L. obtusa* and *L. obtusiformis.* One example (Pl. 4) displays coarse ribs with basal nodes that weaken towards the end of the phragmocone, a feature resembling *L. crassa* Horn, 1909 [Lectotype from Aalen-Wasseralfingen: Horn 1909, pl. 13, fig. 2; refigured by Chandler et al. 2012, pl. 2, Fig. 1]. However, due to the occurrence of intermediate specimens from the Wutach area in the Auer collection we include this extreme variant also in *L. haugi*. The estimated end-diameter of this specimen, which has lost part of the body chamber is more than 300 mm. Thus it is the largest specimen so far known.

- Genus *Ancolioceras* Buckman, 1899

Following Contini (1969) we include the specimens described by Horn (1909) as *Lioceras acutum* (Quenstedt) and by Rieber (1963) as *Staufenia (Costileioceras) opalinoides* (Mayer) under the name *Ancolioceras opalinoides* (Mayer).

- *Ancolioceras opalinoides* (MAYER, 1864) [Lectotype by its somewhat sandy matrix either comes from the "Donzdorf Sandstein" or most likely from a sandy patch within the "Unteres Flöz" of Aalen-Wasseralfingen, where this species is common; here refigured on Pl. 5, Fig. 1]. This species exhibits a broad morphological variability. Various morphs have been described in the literature as different species, subspecies, morphs or varieties. Some of them have long stratigraphical ranges. We figure smooth morphs with dense, fine ribbing (like the LT) on Pl. 5, Figs. 2–4. Such examples were described by HORN (1909) as *Lioceras acutum* and *L. acutum* var. *sublaeve*, and by BUCKMAN (1899) as *Ancolioceras substriatum*. The species name *A. acutus* (QUENSTEDT) is preoccupied and thus cannot be used (RIEBER 1963). One specimen from Geisingen (Pl. 5, Figs. 6, 8) has irregular ribbing and resembles *Ancolioceras capillare* BUCKMAN but is slightly more evolute. Specimens with stronger, well-defined ribbing (Pl. 6, Figs. 1–5) were described by HORN (1909) as *Lioceras acutum* nov. var. *costatum* [with no reference to the similar *Lioceras* var. *costatum* BUCKMAN]. Where the test is preserved the typical fine and extremely dense ribs of the ancestral leioceratids are evident (Pl. 5, Figs. 5, 7). Similar specimens of *A. opalinoides* with extremely dense, fine, irregular growth-lines were figured by CONTINI (1969, pl. 10, figs. 1, 4) and HORN (1909, pl. 9, fig. 7).

• Genus *Costileioceras* MAUBEUGE, 1950

Following HOWARTH (2013) we keep the coarsely ribbed forms of the assemblage of this level (Pl. 6, Figs. 6, 8–9) with simple suture lines separate from both *Ancolioceras* and *Staufenia*. The morphogenus *Costileioceras* possibly just includes the extreme variants of *Ancolioceras opalinoides*, or it is the root of a separate lineage leading to *Staufenia*. A decision regarding this matter requires further research including a study of topotypes of *A. opalinoides* and *C. sinon* (Aalen, Eastern Swabian Alb). *Costileioceras sinon* (BAYLE, 1878) [LT: BAYLE 1878, pl. 83, fig. 4, designated by MAUBEUGE 1950: 386 comes from the "Unteres Flöz" of Aalen-Wasseralfingen]. We figure two specimens, a small phragmocone (Pl. 6, Fig. 6) and a larger fragment (Pl. 6, Figs. 8–9).

Bradfordensis Zone, Bradfordensis Subzone

Two fragmentary *Staufenia staufensis* (OPPEL) (Pl. 7, Figs. 1–2, 6) and three *Brasilia* ex gr. *bradfordensis* (Pl. 7, Figs. 3–5, 7–8) were found in the upper part of the Opalinoides/Staufensis Bank (= *staufensis* horizon).

4.4.3. Graphoceratidae of "lenses II & III" and of the Geisingen Oolith

The Graphoceratidae from "lenses II & III" and from the Geisingen Oolith belong to the (morpho-)genus *Brasilia* BUCKMAN, 1889.

Bradfordensis Zone, Gigantea Subzone

Five specimens of the genus *Brasilia* from "lenses II & III" (*gigantea* horizon sensu CONTINI, ex coll. NEISSER). Thousands of specimens of the genus *Brasilia* have been collected from two different levels within the Geisingen Oolith (*geisingensis* horizon resp. *decipiformis* horizons).

• *Brasilia gigantea* horizon sensu CONTINI:

Because our specimens match well with the range of Graphoceratidae described by CONTINI (1969, pl. 18, fig. 6; pl. 20, figs. 1–6) from his horizon à *Gigantea*, we identify our examples according to his interpretation of the species *Brasilia gigantea*, *B. similis* and *B. rustica*.

- *B. gigantea* (BUCKMAN) sensu CONTINI (Pl. 8, Figs. 2–4). A range of specimens close to our material was figured by CONTINI (1969, pl. 18, fig. 6; pl. 20, figs. 1–6). The finely ribbed *Brasilia eschense* (MAUBEUGE) also falls within the variation of this species.

- *B. similis* (BUCKMAN) sensu CONTINI (Pl. 8, Fig. 1, Pl. 9, Figs. 1–3) is characterized by its fine ribbing on the inner whorls, which tend to fade on the body chamber.

- *B.* aff. *rustica* (BUCKMAN) sensu CONTINI (Pl. 9, Figs. 4–5). The coarsely ribbed variant of the group, which was regarded by CONTINI (1969, table 12) as a separate branch [genus *Welschia*] in contrast to the chronocline *Ludwigia* → *Brasilia* → *Graphoceras* → *Hyperlioceras*. Illustrated here is a specimen that resembles *Graphoceras caduciferum* from the Concavum Zone.

4.4.4. Graphoceratidae of the Geisingen Oolith

Bradfordensis Zone, Gigantea Subzone

• *Brasilia geisingensis* horizon:

- *B. geisingensis* n. sp. (Figs. 3.1–3.2, 4.1–4.4; Pl. 10, Figs. 1–3, Pl. 11, Figs. 1–4, Pl. 12, Figs. 1–4, Pl. 13, Figs. 1–6, Pl. 14, Figs. 1–9). For a description of the fauna see Chapter 4.3.

Between the well-defined beds of the *B. geisingensis* n. sp. and *B. decipiformis* n. sp. horizons occasionally there occurs in lenses ammonites (Pl. 15–16), which are morphologically transitional between the *B. geisingensis* n. sp. and *B. decipiformis* n. sp. assemblages. The umbilicus is slightly more involute as in *B. geisingensis* n. sp., but they lack the typical, involute *Graphoceras*-like umbilicus of *B. decipiformis* n. sp. In this level a mixture of several features leads also to various morphologies. We illustrate the following morphospecies to give an impression of the range of variation:

- *Brasilia platychora* (BUCKMAN) (Pl. 15, Figs. 1–2, Pl. 16, figs. 1–2, 5).

- *B. deleta* (BUCKMAN) (Pl. 16, Figs. 3–4)

- *B. nitens* (BUCKMAN) (Pl. 16, Fig. 6)

- *B. austera* (BUCKMAN) (Pl. 16, Figs. 7–8)

Fig. 7. (1) *Euaptetoceras infernense* (Roman) [M] (SMNS 70214/1, leg. H. Rieber). **(2, 6)** *Eudmetoceras amplectens* Buckman [M] (SMNS 70214/2, leg. D. Schreiber). **(3–4)** *Hyperlioceras walkeri* (Buckman) [M] (LGRB E 1755). **(5)** *Graphoceras (Ludwigella) latum* (Buckman) [m] (SMNS 70214/3, leg. H. Rieber). **(7)** *Euhoploceras biplicatum* (Buckman) [M] (SMNS 70214/4, leg. R. & T. Chiarini). **(1–7)** Geisingen clay pit, "Konglomeratbank/Sowerbyi-Oolith"; Upper Aalenian (Concavum Zone) or Lower Bajocian (Discites Zone). – x1.

• *Brasilia decipiformis* horizon:

- *B. decipiformis* n. sp. (Figs. 5.1–5.2, 6.1–6.9; Pl. 17, Figs. 1–2, Pl. 18, Figs. 1–4, Pl. 19, Figs. 1–7, Pl. 20, Figs. 1–17, Pl. 21, Figs. 1–2, Pl. 22, Figs. 1–3). For a description of the fauna see Chapter 4.3.

4.4.5. Graphoceratidae of the "Konglomeratbank/Sowerbyi-Oolith"

Two poorly preserved specimens of the *genus Hyperlioceras* [*Hyperlioceras walkeri* (Buckman) (Fig. 7.3–7.4); *H. mundum* (Buckman)] and a microconch *Graphoceras* [*Graphoceras (Ludwigella) latum* (Buckman) (Fig. 7.5] were found.

4.5. The ammonite fauna excluding Graphoceratidae

Over the years hundreds of specimens of the family Hammatoceratidae Buckman, 1887 were collected from the Geisingen Oolith, especially from the *decipiformis* horizon (bed GO-3). Rare microconchs bearing lappets occur [*Sonninia (Poecilomorphus) boweri boweri* of Rieber (1963, Pl. 8, Fig. 4)] from beds of about the same age as Kappishäusern near Metzingen. These are micro-

conch hammatoceratids, not sonniniids. They are found with more or less spinose/ribbed specimens up to a diameter of 350 mm. One of them, now in the SMNS, was misidentified by DIETL & HAAG (1980) as an *Euhoploceras*. In fact it is a *Bredyia diadematoides* **(**MAYER**)**, as are probably most if not all of the macroconchiate hammatoceratids from the *decipiformis* horizon. We provisionally follow the opinion of SCHWEIGERT (1996), who stated that *Ammonites subinsignis* OPPEL (= type species of *Pseudammatoceras* ELMI, 1963) from the Torulosum Zone of the Upper Toarcian was the ancestor of *Ammonites diadematoides* MAYER and that the genus *Pseudammatoceras* is a junior subjective synonym of the genus *Bredyia* BUCKMAN, 1910 (type species: *Burtonia crassornata* BUCKMAN, 1910). SENIOR (1977) had previously synonymized *A. subinsignis* and *B. crassornata*.

Abbasites gardincola (DE GREGORIO) (from bed GO-2) and *A.* aff. *abbas* BUCKMAN (from bed GO-3) verify the presence of members of the family Erycitidae SPATH, 1928 (DIETZE et al. 2010).

The family Phylloceratidae ZITTEL, 1884 is represented by extremely rare specimens of *Costiphylloceras connectens* (ZITTEL); the family Lytoceratidae NEUMAYR, 1875 by similarly rare *Megalytoceras* sp.

5. Bio- and chronostratigraphy

5.1. Aalenian

5.1.1. Opalinum Zone

"Comptum" Subzone: As discussed by CHANDLER & CALLOMON (2010) the lectotype of "*Nautilus*" *comptus* REINECKE has been recently rediscovered (E. MÖNNIG, Coburg). It is a *Pleydellia* of the uppermost Toarcian and not a *Leioceras* of the Opalinum Subzone. A final solution to this problem with the index-species of the "Comptum" Subzone occurring in another stage is still to be addressed. Here "Comptum" Subzone is therefore placed in quotation marks.

- Horizon of *Leioceras* "*comptum*"

There appears to be no difference between the leioceratid assemblage of the "Comptum" Bank of Geisingen and that described by RIEBER (1963) from the "Schichten mit *Leioceras comptum*" of the western Swabian Alb.

OHMERT (1993) stated for SW Germany that the next older faunal horizon (= *lineatum-costosum* horizon) below that of *L.* "*comptum*" is dominated by *Leioceras* "*costosum*" [name preoccupied and invalid, see CHANDLER & CALLOMON 2010: 128] accompanied by *L.* ex gr. *lineatum*. The whorl section of *L.* "*costosum*" is oval, slender and sharper keeled compared to *L.* "*comptum*".

- "unnamed" horizon

"Lens I" is just a downward thickening of the Opalinoides/Staufenis Bank. We did not find any of the typical ammonites of the *opalinoides* horizon in the top of "lens I", hence the relative positions of this "lens I" and the *opalinoides* horizon is unclear. However, some observations favor our view that "lens I" is biostratigraphically older than the *opalinoides* horizon: (1) Specimens of ?*Ludwigia* n. sp. with typical prorsiradiate ribbing on the venter which persists up to the keel (CHANDLER 1997); typical of the genus *Ludwigia* in the Haugi Subzone and also discernible in *Ludwigia praecursor* RIEBER (1963, pl. 4, figs. 2, 10) from the "*comptum*" horizon. The whorl section is notably slender, fastigate and never as broad and quadrate as in typical *L. haugi*. The venter becomes rounded on the body chamber, a feature which is not observed in the genus *Ludwigia* of the Haugi Subzone, but is seen in specimens from older levels (RIEBER 1963; CHANDLER & CALLOMON 2010). The final adult diameter of such specimens is generally smaller than in specimens of *Ludwigia* from the Haugi Subzone. (2) Specimens of ?*Ancolioceras* n. sp. and ?*Costileioceras* n. sp. show this rounded venter on the body chamber, which is developed neither in *Staufenia sehndensis* nor in *Costileioceras sinon*. ?*Ancolioceras* n. sp. (Pl. 1, Figs. 13–14) already resembles *Staufenia sehndensis*, which starts in beds younger than the *opalinoides* horizon, but shows a clearly less acute and more fastigate whorl section compared to *S. sehndensis*. ?*Costileioceras* n. sp. differs from *C. sinon* by a more fastigate and rounded whorl section on the body chamber and a less acute whorl section on the phragmocone. Therefore we interpret the graphoceratid fauna of "lens I" as morphologically intermediate between the genus *Leioceras* and younger taxa, and younger than the assemblage of faunal horizon Aa-3b in England. The next older biohorizon described in the literature, the "*comptum*" horizon, can be easily distinguished. The ammonites are considerably smaller and the whole style shows a still more "leioceratid" character, with a rounded body chamber (see RIEBER 1963, pl. 1, figs. 1–16, pl. 2, figs. 1–8).

5.1.2. Murchisonae Zone

Haugi Subzone:

- Horizon of *Ancolioceras opalinoides*

Despite its reworked character, most of the Opalinoides/Staufensis Bank represents a short time interval and belongs to this faunal horizon (= Schichten mit *Staufenia sinon* in RIEBER 1963). It is characterized by the occurrence of *Ancolioceras opalinoides* together with the first frequent *Ludwigia* of the *L. haugi* group.

The subadjacent faunal horizon is either the "unnamed horizon" of "lens I" or another undescribed horizon sampled by DIETL (2013) in the Aichelberg section of the

Middle Swabian Alb (coll. SMNS). The latter is characterized by frequent late *Leioceras*, early *Ancolioceras*-like ammonites and very rare *Ludwigia*. Further investigations must clarify if the faunas from the "Unteres Flöz" and the "Unterer Donzdorf-Sandstein" of Aalen (Quenstedt 1846–1849, 1858, 1886–1887) have the same age as the *opalinoides* horizon of Geisingen .

Murchisonae Subzone

Ammonite evidence for the Murchisonae Subzone (*sehndensis* and *discoidea* horizons [= Schichten mit *Staufenia sehndensis* resp. *S. discoidea* in Rieber 1963], is missing in Geisingen. The occurrence of stromatolites and hardgrounds in the Opalinoides/Staufensis Bank indicates an interruption of sedimentation, which could correspond to this interval.

5.1.3. Bradfordensis Zone

Bradfordensis Subzone

Rare specimens of *Brasilia* ex gr. *bradfordensis* and *Staufenia staufensis* in the top of the Opalinoides/Staufensis Bank are indicative of this subzone.

Gigantea Subzone

- Horizon of *Brasilia gigantea* sensu Contini

Few specimens collected by E. Neisser in the "lenses II and III" include *Brasilia gigantea* sensu Contini, *B. similis* sensu Contini and *B.* aff. *rustica* sensu Contini. *B. gigantea* sensu stricto is the inflated form typical of stratigraphically early representatives, but ranges in Dorset to the end of the Gigantea Subzone (Chandler 1997, tab. 1). Due to the rarity of specimens and the uncertainty of the exact position of "lenses II and III" we refrain from naming this horizon, moreover, confusion with the *gigantea* horizon in the British sense seems possible.

The stratigraphically older *staufensis* horizon (= Schichten mit *Staufenia staufensis* of Rieber 1963) is characterized by frequent *S. staufensis* and a *Brasilia* assemblage centered around *B. bradfordensis* (Rieber 1963). Specimens of *S. staufensis* and *B.* ex gr. *bradfordensis* from the Opalinoides/Staufensis Bank may represent this horizon. It is noteworthy that *S. staufensis* has never been found in Britain.

- Horizon of *Brasilia geisingensis* n. sp.

This faunal horizon is characterized by *B. geisingensis* n. sp., as described above. Compared to specimens of the next older *gigantea* horizon sensu Contini the specimens are larger and lack the dense, fine ribbing at the ventral area, which is a common feature of representatives of the genus *Brasilia* from the Bradfordensis Subzone (Pl. 8, Figs. 2, 4; Pl. 9, Figs. 3–4).

- Occasional lenses between the *geisingensis* and *decipiformis* horizons

At some places in the clay pit ammonites morphologically intermediate between *B. geisingensis* n. sp. and B. *decipiformis* n. sp. occurred at the base and sometimes in the lowermost parts of bed GO-3 (Pl. 15–16). This may indicate a faunal horizon similar in age to the faunal horizon Aa-11 (*gigantea* horizon sensu Chandler 1997), situated between the *geisingensis* and *decipiformis* horizons. Due to the scarcity of these ammonites we refrain from erecting a name for this level as we cannot exclude condensation or reworking processes.

- Horizon of *Brasilia decipiformis* n. sp.

Typical of this horizon are extremely large and smooth examples of *Brasilia decipiformis* n. sp., the smaller specimens including both juveniles and small adults and inner whorls already resemble representatives of *Graphoceras* (Callomon & Chandler 1990). The graphoceratid fauna of the older *geisingensis* horizon is an assemblage with more evolute and often stronger ribbed specimens, especially on their inner whorls. The whorls of *B. decipiformis* are considerably higher. None of the ammonites from the *geisingensis* horizon of our sample exceeds 300 mm, while the largest ammonites from the *decipiformis* horizon reach maximum sizes of over 450 mm. In Southern England the genus *Abbasites* has not been published from beds younger than those of the Gigantea Subzone (Callomon & Chandler 1990).

5.1.4. Concavum Zone

The ammonite assemblage of the Konglomeratbank/Sowerbyi-Oolith is too poor for an exact determination of its age. The presence of the hammatoceratids *Eudmetoceras eudmetum*, *Euaptetoceras infernense* and the sonniniid *Euhoploceras biplicatum* indicate an age of Formosum Subzone at the earliest, but these taxa persist into the Early Bajocian (Chandler & Sole 1996; Contini et al. 1997; Rioult et al. 1997). Time diagnostic representatives of Graphoceratidae have not been found to date.

5.2. Bajocian

The assemblage is not sufficiently diagnostic to date the Konglomeratbank/Sowerbyi-Oolith either in the Formosum Subzone or the Discites Zone.

6. Correlation

Southern Germany: The "*comptum*" horizon can be observed from the Wutach area (Rieber 1963) to the

eastern Swabian Alb (DIETZE et al. 2007) and in the Franconian Alb (DORN 1935). It is best developed in the western Swabian Alb (RIEBER 1963). The "unnamed horizon" is new for Southern Germany and is situated most likely between the "*comptum*" and *opalinoides* horizons (see Chapter 5.1.1). In SW Germany the *opalinoides* horizon is best developed in the Wutach area (HORN 1909; RIEBER 1963). It has to be clarified whether the "Unteres Flöz" from Aalen-Wasseralfingen (BAYLE 1878; QUENSTEDT 1846 –1849, 1886–1887; DIETL & RIEBER 1977) is exactly of the same age. The *staufensis* horizon is widespread in SW Germany and well-documented from the Wutach area (HORN 1909; RIEBER 1963) and from the surroundings of the Plettenberg Hill near Balingen (RIEBER 1963), but also occurring at Ringsheim in the Upper Rhine Valley (REICHENBACH 1998). Ammonites in old collections from the former iron mines of the Eastern Swabian Alb near Aalen and Geislingen an der Steige (SMNS, Tübingen; DIETL & RIEBER 1977) seem to come from the top of the Bradfordensis Subzone, from beds yielding still *B. bradfordensis* and related forms, but lacking or with only very rare *Staufenia staufensis*. Ammonites from the Gigantea Subzone are figured from Ringsheim in the Upper Rhine Valley (REICHENBACH 1998, figs. 32–35; BOSCH 2006). These ammonites need further study; however, they seem to come from the base or middle part of the Gigantea Subzone. In any case they are older than the *decipiformis* horizon of Geisingen. The amateur collector N. WANNENMACHER found ammonites (now in SMNS) of the *geisingensis* horizon in an identical chamosite-oolitic matrix as at Geisingen in a locality near Öfingen (western Swabian Alb). One of us (V.D.) recorded a large *B.* ex gr. *gigantea* together with *B.* ex gr. *decipiens* in the Hofwald section near Kappishäusern (RIEBER 1963). At least lenticular sediments of the Gigantea Subzone seem to be preserved in that area. Another *B.* ex gr. *decipiens* from the Gigantea Subzone from nearby Metzingen (ex coll. U. BAYER) is stored in the collection of the SMNS.

Northern Germany: The abandoned clay pits of Sehnde and Gretenberg were described by HOFFMANN (1910, 1913) and correlated by HÖLDER (1964) with the Swabian Alb. ALTHOFF (1940) investigated the clay pits of Bielefeld. An overview was given by KUMM (1952) and a new zonal subdivision was proposed by SPIEGLER (1966), whose palaeontological and stratigraphical results are doubtful and have not been taken into account. Although modern interpretations are missing, a reasonable correlation is possible with the well documented beds of the "Obere Ludwigienschichten", subdivided by bed-by-bed ammonite collections, of the clay pits of Bethel, now part of Bielefeld (ALTHOFF 1940). The "Obere Ludwigienschichten", overlying the "Mittlere Ludwigienschichten" with the *staufensis* Zone at their top, are subdivided into the "Murchisonae-", "Concava-" and "Disciteszone". Hence, the top of the Opalinoides/Staufensis Bank of Geisingen can be correlated at least with parts of the "Staufensiszone" of Bethel. In a modern interpretation the "Murchisonaezone" of ALTHOFF (1940) is part of the Bradfordensis Zone and different from the Murchisonae Zone in its present usage (Fig. 8). ALTHOFF's (1940) "Untere Murchisonaezone" [beds 1–6] and "Obere Murchisonaezone" [beds 11–20] represent nothing else but faunal horizons. ALTHOFF's (1940) "Untere Murchisonaezone" can be located between the *staufensis* and *geisingensis* horizons of Geisingen. The figured ammonites from Bethel include typical finely ribbed ammonites with slender whorl sections (ALTHOFF 1940, pl. 1, figs. 1–2, 4; pl. 3, figs. 2–4; pl. 4, figs. 1–4; pl. 5, figs. 1–8) besides more coarsely ribbed specimens (pl. 2, figs. 2–3), the latter resembling *B. geisingensis* n. sp. ALTHOFF (1940: 3) already noticed, that "… bis in Einzelheiten hinein, gleiche Formentypen in verschiedenen Zonen ausgebildet werden…", a fact that can also be observed in SW Germany (RIEBER 1963). The few diagnostic ammonites illustrated from the "Obere Murchisonaezone" (ALTHOFF 1940, pl. 1, figs. 5–6; pl. 2, fig. 5; pl. 3, fig. 1) may come from somewhere around the Bradfordensis/Gigantea subzonal boundary.

The correlation with the long abandoned clay pits near Sehnde is more difficult. After HOFFMANN (1910, 1913) the beds from the uppermost Toarcian up to the "Staufensis Subzone" – characterized by numerous *Staufenia staufensis* – consist only of represantatives of a "Staufensis-Linie" (a chronocline from *"Grammoceras" aalense* → *"Ludwigia" opalina* → *"L." costosa* → *"L." sinon* → *"L. tolutaria"* → *"L." sehndensis* → *"L." discoidea"* → *"L." staufensis"*), whereas the following beds in Sehnde (= Obere Ludwigienschichten sensu ALTHOFF 1940) contain a chronocline (= "Discites-Linie") starting with the sudden appearance of *L. murchisonae* → *"L." concava* → *"L." discites"*. We have doubts, if HOFMANNS' interpretation of *"L." sinon* and *"L." tolutaria* (= *Ancolioceras opalinoides*) were correct or if his figured specimens are late leioceratids of the uppermost Opalinum Zone. Therefore a correlation of the Sinon and Tolutaria Subzones sensu HOFFMANN and the Haugi Subzone of Geisingen is doubtful. The upper part of the Opalinoides/Staufensis Bank can be correlated with part of the Staufensis Subzone sensu HOFFMANN. A correlation with the Murchisonae Subzone sensu HOFFMANN is impossible, because most of his material came from old museum collections and was imprecisely collected.

Switzerland: The Aalenian of central Switzerland was subdivided by CHRIST (1999) into "Ammoniten-Biohorizonte", mainly based on the old collections of LIEB/BODMER in the Naturhistorisches Museum Basel. Hence, the allocation of these ammonites to special beds must be considered with some caution. The "*comptum*" horizon of Geisingen matches best with CHRIST's Fauna 4 (*comptum – uncinatum*); the *opalinoides* horizon can be correlated with

Upper Aalenian	Concavum	Formosum	yet to be worked out	?Geisingen, Ringsheim
		Concavum	yet to be worked out	Wutach, Ringsheim, Kappishäusern, Metzingen [Rieber 1963]
Middle Aalenian	Bradfordensis	Gigantea	*decipiformis*	Geisingen
			?	Geisingen
			geisingensis	Geisingen, Öfingen
			gigantea sensu Contini	Geisingen, Wutach (condensed)
		Bradfordensis	yet to be worked out	Aalen, Kuchen, Geislingen, Wutach (condensed)
			staufensis	Swabian Alb, Wutach [Rieber 1963], Geisingen, Ringsheim
	Murchisonae	Murchisonae	*discoidea*	Wochenberg [Rieber 1963]
			sehndensis	Wochenberg, Plettenberg, Gosheim [Rieber 1963]
		Haugi	*opalinoides*	Geisingen, Wutach, ?Aalen, Wochenberg [Rieber 1963]
Lower Aalenian	Opalinum	"Comptum"	yet to be worked out	Aichelberg [Dietl 2013]
			unnamed	Geisingen
			"comptum"	Swabian Alb, Wutach [Rieber 1963]
		Opalinum	*lineatum-"costosum"*	Middle Swabian Alb [Ohmert 1993]
			partitum	Middle Swabian Alb [Ohmert 1993]
			opaliniforme	Middle Swabian Alb [Ohmert 1993]
			misera	Wittnau [Ohmert 1993; non Schulbert 2001], Swabian Alb

Fig. 8. Recorded ammonite faunal horizons (shaded) in the Aalenian of the Geisingen clay pit and other faunal horizons (Rieber 1963; Ohmert 1993) in the Aalenian of SW Germany. The relative positions of the two upper faunal horizons within the "Comptum" Subzone is tentative.

his Fauna 5 (*sinon – opalinoides*). The faunal horizons from the Gigantea Subzone of Geisingen seem to be included, at least partly, in his Fauna 11 (*gigantea – similis*).

France: Based on the investigations of CONTINI (1969), CONTINI et al. (1997) subdivided the French Aalenian into "horizons". The horizon à *crassicostatum*, characterized by the occurrence of *Leioceras crassicostatum*, can be correlated with the "*comptum*" horizon of Geisingen. The horizon à *haugi* is equal to the *opalinoides* horizon of SW Germany. The horizon à *gigantea* is older than the *geisingensis* horizon and is recorded in Geisingen in the "lenses II and III".

Southern England and Scotland: Aplethora of genera and species of Aalenian ammonites, especially graphoceratids, were described by S.S. BUCKMAN (1887–1907, 1909–1930). It is the merit of CALLOMON & CHANDLER (1990), CHANDLER & SOLE (1996) and especially CHANDLER (1997), that this bulk of information was put into a modern stratigraphical order. The "*comptum*" horizon of Geisingen is older than the *comptocostosum* horizon (Aa-3a) of Dorset; whereas our "unnamed horizon" (Fig. 8) seems to lie between the British *comptocostosum* (Aa-3a) and *opalinoides* (Aa-4) horizons, but still in the Opalinum Zone. The *opalinoides* horizon (Aa-4) of Southern England and the *opalinoides* horizon of Southern Germany are more or less coeval. The correlation of the *gigantea* horizon sensu CONTINI ("lenses II and III") from Geisingen is difficult due to the small number of ammonites, but is probably slightly younger than Aa-10 (horizon of *B. bradfordensis*, *similis*). The *geisingensis* horizon is slightly older than the horizon of *B. gigantea* (Aa-11) from Dorset. In general, the assemblage of the *geisingensis* horizon from Geisingen shows more evolute shells compared to the *gigantea* horizon sensu CHANDLER (Aa-11). Ammonites from rare lenses in the bottom of GO-3 belong to a horizon of about the same age as Aa-11 (horizon of *B. gigantea*) in Dorset. The newly introduced *decipiformis* horizon lies between the horizons of *B. decipiens* (Aa-12) and *B. cavatum* (Aa-13), but still in the Gigantea Subzone. The assemblage shows already slightly more placements into the genus *Graphoceras* as the *B. decipiens* horizon (Aa-12) from Dorset.

A summary of the Aalenian of Bearraraig Bay (Isle of Skye, Scotland) was provided by MORTON & HUDSON (1995). The lower part of the Opalinoides/Staufensis Bank (= *opalinoides* horizon) corresponds with beds O1–O3, assigned to the Haugi Subzone. Strata of higher parts of the Murchisonae Zone, well documented from Bearraraig Bay (beds O4–O11), are missing in Geisingen. Characteristic ammonites from for the Bradfordensis Zone have not been published until now.

Rest of the NW Tethys: An assemblage very close to that of the *gigantea* horizon sensu CONTINI was recently described by GUÉRIN-FRANIATTE & WEIS (2010) from near Rumelange in Luxembourg. GÉCZY's (1967) revision of the Jurassic ammonites from Csernye (Bakony Mountains, Hungary) is unfortunately based on rather poorly preserved specimens, allowing only an approximate correlation. The "*comptum*" horizon lies in GÉCZY's zone à *Leioceras comptum*; the Geisingen *opalinoides* horizon in the lower part of the Hungarian sous-zone à *Costileioceras opalinoides* (GÉCZY 1967: 258). The *staufensis* horizon lies somewhere in the sous-zone à *Ludwigia bradfordensis*, whereas the correlation of the *gigantea* horizon sensu CONTINI, the *geisingensis* horizon and the *decipiformis* horizon is difficult. The occurrence of *Ludwigia* n. sp. aff. *wilsoni*, *L. bradfordensis depressa* and *L.*? *nalivkini* in the zone à *Graphoceras concavum* of Csernye indicate that GÉCZY (1967: 259) has included strata into the Hungarian *concavum* zone which are assigned elsewhere in Europe into the Gigantea Subzone. TOPCHISVILI (2009) recently summarized the knowledge of the Aalenian deposits of the Caucasus in Georgia, Azerbaijan and Russia. He subdivided the Aalenian into an Opalinum Zone with nearly exactly the same fauna as in SW Germany, a Murchisonae Zone which includes also typical ammonites from the *opalinoides* and *staufensis* horizons, and the Concavum Zone. He cited also *B. gigantea*, which is a characteristic ammonite of the Gigantea Subzone in SW Germany. The Aalenian of the Pieniny Klippen Belt and the Tatra Mountains was studied by MYCZYŃSKI (2004). *Leioceras comptum* and *L. crassicostatum* give evidence for Lower Aalenian beds comparable to the "*comptum*" horizon; *Ludwigia crassa* and *Ancolioceras opalinoides* for the existence of beds of similar age as the *opalinoides* horizon. The overlap of typical ammonites of the Bradfordensis Zone and several *Graphoceras* (MYCZYŃSKI 2004, tab. 5) may indicate that these strata belong at least partly to the Gigantea Subzone. Further investigations with a focus on Graphoceratidae and Aalenian stratigraphy in the NW Tethys are by VACEK (1886), CALLOMON et al. (1994) (Southern Alps, Italy); URETA GIL (1983) (Cordillera Ibérica, Spain); HENRIQUES (1992) (Portugal), and SADKI (1996) (Morocco).

7. Conclusions

The Geisingen section is like most other Aalenian outcrops in SW Germany and elsewhere, biostratigraphically highly incomplete. Furthermore, the faunal horizons of Geisingen represent only short time intervals. The successive graphoceratid assemblages clearly differ in their variation from each other, showing evolutionary steps and not gradual changes of variation as we would expect in continuous deposits. The section of Geisingen is an important addition to the biostratigraphy of the Aalenian in SW

Germany, especially in two stratigraphical intervals: (1) at the transition Lower/Middle Aalenian with an until now unknown assemblage of Graphoceratidae, and (2) in the Gigantea Subzone of the Bradfordensis Zone (Middle Aalenian), with three faunal horizons (*gigantea* horizon sensu Contini, *geisingensis* and *decipiformis* horizons).

Each of the rich graphoceratid assemblages from the *B. geisingensis* and *B. decipiformis* horizons shows a typical assemblage with a considerable variability, however, the different variants merge with each other. Therefore the material from Geisingen supports the idea that only a single phyletic lineage exists leading from *Ludwigia* to *Hyperlioceras.* It is best to subdivide such assemblages into horizontal sections (= chronospecies) rather than into vertical morpho-genera (Chandler & Callomon 2010; Chandler et al. 2012). Hoffmann (1913) had previously used this concept in his description of the assemblages from Sehnde: "… dass alle Formen desselben Lagers, soweit sie durch gemeinsame Merkmale verbunden, sich durch diese Merkmale von dem Formenkomplex eines höheren oder tieferen Lagers unterscheiden einer einzigen Art angehören d.h. Variationen einer Art darstellen." In a more morphologically oriented taxonomy as used here, at least in the *decipiformis* horizon a further separation into the morphogenera *Brasilia* and *Graphoceras* would be necessary.

The juvenile ontogeny ("first stage") of the macroconch specimens from the *geisingensis* horizon start with a more or less extended evolute and ribbed stage (Pl. 10, Fig. 3), which corresponds to the adult whorls of the microconchs (Fig. 4). The macroconchs have higher and smooth whorls up to the adult peristome ("second stage"). In the *decipiformis* horizon, the ontogenetic stage, where macroconchs and microconchs are very similar, is followed in the macroconchs by a stage with a very narrow, deep and *Graphoceras*-like umbilicus with steep umbilical wall, which is still missing in the specimens of the older *geisingensis* horizon. In a third stage, corresponding to the second ontogenetic stage of the *geisingensis*-assemblage, the whorls of the ammonites of the *decipiformis*-assemblage evolve, keep high and smooth and the umbilical wall becomes flatter. In the large-sized adults of *B. decipiformis* the three ontogenetic stages are developed. Some of the specimens do not develop the latest, *Brasilia*-like stage and become adult in the *Graphoceras*-stage. In later Concavum Zone strata the Graphoceratidae reach only the *Graphoceras*-stage – therefore the largest specimens do not have diameters much in excess of 200 mm. Another evolutionary trend is that the lateral and umbilical lobes and especially the incision at the saddle between the external and the lateral lobe become more complicated in stratigraphical younger specimens (see Pl. 3, Figs. 1, 3, 6–7, 7; Pl. 4 versus Pl. 11, Fig. 3; Pl. 13, Fig. 2; Pl. 16, Figs. 2, 7; Pl. 19, Fig. 2). Our results strongly suggest that the evolution of the Graphoceratidae as pointed out by Contini (1969, tab. 12) is principally correct, with the exception, that the "*Welschia*" strand must be re-connected with the "*Ludwigia →Brasilia→Graphoceras→Hyperlioceras* "strand. In this chronocline the morphological variation within each horizon is large with members of each assemblage merging vertically and horizontally into one another.

8. References

Albersdörfer, R. (1992): Environment einer Sonderfazies im Braunen Jura beta von Geisingen/Baden und die Einbettungsvorgänge ihrer Cephalopoden. Teil 1. – Unpublished Diploma Thesis, Institut für Paläontologie der Universität Erlangen/Nürnberg, Germany, 88 pp.

Althoff, W. (1940): Die Ammonitenzonen der oberen Ludwigienschichten von Bielefeld. – Palaeontographica, (A), **92**: 1–44.

Bayle, E. (1878): Fossiles principaux des terrains. Service de la Carte géologique détaillée. – Explication de la Carte Géologique de la France **4/1** (Atlas, 158 pls.); Paris (Imprimerie Nationale).

Bosch, K. (2006): Geologie und Fossilien. – In: Zweckverband Abfallbehandlung Kahlenberg (Ed.): Blickpunkt Kahlenberg, 25–50.

Buckman, S. S. (1887–1907): A Monograph of the ammonites of the Inferior Oolite Series. – Palaeontographical Society Monographs, ccixii + 456 pp.; London (The Palaeontographical Society).

Buckman, S. S. (1909–1930): Yorkshire Type Ammonites/Type Ammonites, 1–7, 790 pls.; London (Wheldon & Wesley).

Callomon, J. H. & Chandler, R. B. (1990): A review of the ammonite horizons of the Aalenian – Lower Bajocian stages in the Middle Jurassic of Southern England. – In: Cresta, S. & Pavia, G. (Eds.): Atti del meeting sulla stratigrafia del Baiociano. – Memorie descrittive della Carta Geologica d'Italia, **40**: 88–111.

Callomon, J. H., Cresta, S. & Pavia, G. (1994): A revision of the classical Aalenian succession in the Middle Jurassic of San Vigilio, Lake Garda, Northern Italy. – Géobios, Mémoires spécials, **17**: 103–110.

Chandler, R. B. (1997): The graphoceratid ammonite succession in the Aalenian and lowest Bajocian (Middle Jurassic) at Horn Park, Dorset, UK. – Proceedings of the Dorset Natural History and Archaeological Society, **118**: 85–106.

Chandler, R. B. & Callomon, J. H. (2010): The Inferior Oolite at Coombe Quarry, near Mapperton, Dorset, and a new Middle Jurassic ammonite faunal horizon, Aa-3b, *Leioceras comptocostosum* n. biosp. in the Scissum Zone of the Lower Aalenian. – Proceedings of the Dorset Natural History and Archaeological Society, **130**: 99–132.

Chandler, R. B., Dietze, V. & Auer, W. (2012): Die Graphoceratidae: *Leioceras* und seine Verwandten. – Fossilien, **2012** (2): 110–119.

Chandler, R. B. & Sole, D. T. C. (1996): The Inferior Oolite at East Hill Quarry, Bradford Abbas, Dorset. – Proceedings of the Dorset Natural History and Archaeological Society, **117**: 101–108.

Christ, H. A. (1999): Zur Stratigraphie und Ammoniten-Paläontologie des Aalenian im zentralen Schweizer Jura. – Eclogae geologicae Helvetiae, **92**: 451–465.

CONTINI, D. (1969): Les Graphoceratidae du Jura franc-comtois. – Annales scientifiques de l'Université de Besançon, série 3, Géologie, **7**: 1–95.

CONTINI, D., ELMI, S., MOUTERDE, R. & RIOULT, M. (1997): Aalénien. – In: CARIOU, É. & HANTZPERGUE, P. (Eds.): Biostratigraphie du Jurassique ouest-européen et méditerranéen. – Bulletin du Centre des Recherches Elf Aquitaine Exploration et Production, Mémoires **17**: 37–40.

DIETL, G. (1997): Extra-STOP: Am Wartenberg bei Geisingen a. d. Donau. Tongrube der Breisgauer Cement GmbH mit einer aufgeschlossenen Schichtenfolge vom höheren Unter-Aalenium bis zum tieferen Unter-Bajocium (oberer Opalinuston bis Unterer Wedelsandstein). – In: BLOOS, G., DIETL, G., SCHLATTER, R., SCHWEIGERT, G. & URLICHS, M.: Deutsche Subkommission für Jurastratigraphie, Jahrestagung 1997 in Blumberg-Achdorf, Wutachtal (7.5–10.5.1997). [Unpublished].

DIETL, G. (2013): Der Braunjura am Fuß der Schwäbischen Alb. – Fossilien, Sonderhefte, **2013**: 3–46.

DIETL, G. & HAAG, W. (1980): Über die „*sowerbyi*-Zone" (= *laeviuscula*-Zone, Unter-Bajocium, Mittl. Jura) in einem Profil bei Nenningen (östl. Schwäb. Alb.). – Stuttgarter Beiträge zur Naturkunde, (B), **60**: 1–11.

DIETL, G. & RIEBER, H. (1977): The Aalenian at the type locality. – Stuttgarter Beiträge zur Naturkunde, (B), **30**: 1–13.

DIETL, G. & RIEBER, H. (1980): Der Braune Jura der Westalb zwischen Balingen und Geisingen (Exkursion F1 am 10. April und Exkursion F2 am 11. April 1980). – Jahresberichte und Mitteilungen des oberrheinischen geologischen Vereins, Neue Folge, **62**: 57–69.

DIETZE, V. (1989): Die Westalb für Fossiliensammler. – Fossilien, **1989** (3): 122–127.

DIETZE, V., CALLOMON, J. H., SCHWEIGERT, G. & CHANDLER, R. B. (2005): The ammonite fauna and biostratigraphy of the Lower Bajocian (Ovale and Laeviuscula zones) of E Swabia (S Germany). – Stuttgarter Beiträge zur Naturkunde, (B), **353**: 1–82.

DIETZE, V., SCHWEIGERT, G., CALLOMON, J. H., DIETL, G. & KAPITZKE, M. (2007): Der Mitteljura des Ipf-Gebiets (östliche Schwäbische Alb, Süddeutschland). Korrelation der süddeutschen Ammoniten-Faunenhorizonte vom Ober-Bajocium bis zum Unter-Callovium mit Südengland und Frankreich. – Zitteliana, **A47**: 105–125.

DIETZE, V., SCHWEIGERT, G., DIETL, G., AUER, W., DANGELMAIER, W., FURZE, R., GRÄBENSTEIN, S., KUTZ, M., NEISSER, E. & SCHREIBER, D. (2010): Rare Middle Jurassic ammonites of the families Erycitidae, Otoitidae and Stephanoceratidae from Southern Germany. – Zitteliana, (A), **50**: 71–88.

DORN, P. (1935): Die Hammatoceraten, Sonninien, Ludwigien, Dorsetensien und Witchellien des süddeutschen, insbesondere fränkischen Doggers. – Palaeontographica, (A), **82**: 1–124.

DOUVILLÉ, H. (1885): Sur quelques fossiles de la zone à *Amm. Sowerbyi* des environs de Toulon. – Bulletins de la Société géologique de France, séries 3, **13**: 12–44.

ELMI, S. (1963): Les Hammatoceratidae (Ammonitina) dans le Dogger inférieur du Bassin Rhodanien. – Travaux du Laboratoire de Géologie de la Faculté des Sciences de Lyon, nouvelle série, **10**: 1–144.

FRANZ, M. & NITSCH, E. (2009): Zur lithostratigraphischen Gliederung des Aalenium in Baden-Württemberg. – LGRB Informationen, **20**: 123–146.

FURZE, R., HAVLIK, P. & AIGLSTORFER, M. (2010): Die Tongrube Geisingen: Fenster in den Mitteljura der Westalb. – Fossilien, **2010** (2): 92–99.

GÉCZY, B. (1967): Ammonoides jurassiques de Csernye, Montagne Bakony, Hongrie – Part II (excl. Hammatoceratidae). – Geologica Hungarica, Series Palaeontologica, **35**: 1–413.

GRÜNDEL, J., EBERT, M. & FURZE, R. (2011): Die Gastropoden aus dem oberen Aalenium von Geisingen (Süddeutschland). – Zitteliana, **A51**: 99–114.

GUÉRIN-FRANIATTE, S. & WEIS, R. (2010): Le passage Aalénien-Bajocien près de Rumelange: la série biostratigraphique dans le bassin d'Esch-sur-Alzette (Grand-Duché de Luxembourg). – Ferrantia, **62**: 73–96.

HENRIQUES, M. H. P. (1992): Biostratigrafi e Paleontologia (Ammonoidea) do Aaleniana em Portugal (Sector Setentrinal da Bacia Lusitaniana). – Ph.D Thesis, Centro de Geociencias da Universidade de Coimbra, Portugal, 301 + 7 pp.

HÖLDER, H. (1964): Jura. – 603 pp.; Stuttgart (Enke).

HOFFMANN, G. (1910): Stratigraphie und Ammoniten-Fauna des unteren Doggers in Sehnde. – PhD Thesis, Georg-August-Universität, Göttingen, 80 pp.

HOFFMANN, G. (1913): Stratigraphie und Ammoniten-Fauna des Unteren Doggers in Sehnde bei Hannover. – 202 pp.; Stuttgart (Schweizerbart).

HORN, E. (1909): Die Harpoceraten der Murchisonae-Schichten des Donau-Rhein-Zuges. – Mitteilungen der Grossherzoglichen Badischen Geologischen Landesanstalt, **6**: 251–323.

HOWARTH, M. K. (2013): Treatise Online 57. Part L, Revised, Volume 3B, Chapter 4: Psiloceratoidea, Eodoceratoidea, Hildoceratoidea. 1–139.

KUMM, A. (1952): Das Mesozoikum in Niedersachsen (Der Dogger). – Geologie und Lagerstätten Niedersachsens, **2**: 329–509.

MAUBEUGE, P. L. (1950): Nouvelles recherches stratigraphiques et paléontologiques sur l'Aalenien Luxembourgeois. – Archives Institut Grand-Ducal de Luxembourg, nouvelle série, **19**: 365–397.

MAUBEUGE, P. L. (1967): Catalogue des Ammonites du Jurassique inférieur et moyen (Hettangien à Bathonien) du Musée cantonal de Bâle-Campagne. – Tätigkeitsberichte der Naturforschenden Gesellschaft Baselland, **25**: 43–130.

MAYER, C. H. (1864): Déscription de coquilles fossiles des terrains jurassiques. – Journal de Conchyliologie, **12**: 368–378.

MORTON, N. & HUDSON, J. D. (1995): Field guide to the Jurassic of the Isles of Raasay and Skye, Inner Hebrides, NW Scotland. – In: TAYLOR, P. D (Ed.): Field Geology of the British Jurassic. – 286 pp.; Bath (The Geological Society Publishing House).

MYCZYŃSKI, R. (2004): Toarcian, Aalenian and Early Bajocian (Jurassic) ammonite faunas and biostratigraphy in the Pieniny Klippen Belt and the Tatra Mts, West Carpathians. – Studia Geologica Polonica, **123**: 7–131.

OHMERT, W. (1993): Zur Entwicklung der Grammoceratinae – Leioceratinae an der Toarcium-/Aalenium-Grenze Südwestdeutschlands. – Geologische Blätter für Nordost-Bayern und angrenzende Gebiete, **43** (1–3): 143–166.

OPPEL, A. (1856–1858): Die Juraformation Englands, Frankreichs und des südwestlichen Deutschlands. – Jahreshefte des Vereins für vaterländische Naturkunde in Württemberg, (**12–14**): 1–837.

QUENSTEDT, F. A. (1845–1849): Petrefactenkunde Deutschlands. 1. Cephalopoden. – 580 pp.; Tübingen (Fues).

QUENSTEDT, F. A. (1856–1857): Der Jura. – 842 pp.; Tübingen (Laupp).

QUENSTEDT, F.A. (1886–1887): Die Ammoniten des Schwäbischen Jura. 2. Der Braune Jura, p. 441–815; Stuttgart (Schweizerbart).

Reichenbach, B. (1998): Die Fossilien des Kahlenbergs – Teil A: Die Kopffüßer. – In: Reichenbach, B., Bosch, K., Gibis, G. & Schulte-Fischedick, W. (Eds.): Der Kahlenberg und seine Schätze, 77–166; Ringsheim (Zweckverband Abfallbeseitigung Kahlenberg).

Rioult, M., Contini, D., Elmi, S. & Gabilly, J. (1997): Bajocien. – In: Cariou, É. & Hantzpergue, P. (Eds.): Biostratigraphie du Jurassique ouest-européen et méditerranéen. – Bulletins du Centre des Recherches Elf Aquitaine Exploration et Production, Mémoires **17**: 41–54.

Rieber, H. (1963): Ammoniten und Stratigraphie des Braunjura β der Schwäbischen Alb. – Palaeontographica, (A), **122**: 1–89.

Sadki, D. (1996): Le Haut-Atlas cenral (Maroc). Stratigraphie et Paléontologie du Lias supérieur et du Dogger inférieur. Dynamique du bassin et des peuplements. – Documents des Laboratoires de Géologie Lyon, **142**: 1–245.

Schreiner, A. (1976): Hegau und westlicher Bodensee. – Sammlung Geologischer Führer, **62**: 1–93; Berlin & Stuttgart (Borntraeger).

Schulbert, C. (2001): Die Ammonitenfauna und Stratigraphie der Tongrube Mistelgau bei Bayreuth (Oberfranken). – Beihefte zu den Berichten der Naturwissenschaftlichen Gesellschaft Bayreuth e.V., **4**: 183 pp.

Schweigert, G. (1996): Seltene Ammoniten aus dem Opalinuston (Unter-Aalenium) des Schwäbischen Jura (Baden-Württemberg). – Stuttgarter Beiträge zur Naturkunde, (B), **244**: 1-17.

Schweigert, G. & Dietze, V. (1998): Revision der dimorphen Ammonitengattungen *Phlycticeras* Hyatt – *Oecoptychius* Neumayr (Strigoceratidae, Mitteljura). – Stuttgarter Beiträge zur Naturkunde, (B), **269**: 1–59.

Schweigert, G., Dietze, V., Chandler, R.B. & Mitta, V. (2007): Revision of the Middle Jurassic dimorphic ammonite genera *Strigoceras*/*Cadomoceras* (Strigoceratidae) and related forms. – Stuttgarter Beiträge zur Naturkunde, (B), **373**: 1–74.

Senior, J. R. (1977): The Jurassic ammonite *Bredyia* Buckman. – Palaeontology, **20**: 675–693.

Spiegler, W. (1966): Graphoceratidae des Ober-Aalenium (Jura, NW-Deutschland). – Mitteilungen aus dem Geologisch-Paläontologischen Institut der Universität Hamburg, **35**: 5–113.

Topchishvili, M. (2009): Zonal dissection of Aalenian deposits by ammonites of the Caucasus. – Bulletins of the Georgian National Academy of Sciences, **3** (2): 109–117.

Ureta Gil, S. (1983): Bioestratigrafia y Paleontologia (Ammonitina) del Aaleniense en el sector noroccidental de la Cordillera Iberica. – Unpublished Ph.D. Thesis, Madrid, VIII + 452 pp.

Vacek, M. (1886): Über die Fauna der Oolithe von Cap S. Vigilio. – Abhandlungen der königlich-kaiserlichen geologischen Reichsanstalt, **12**: 57–212.

Willmann, R. 1985. Die Art in Raum und Zeit. Das Artkonzept in der Biologie und Paläontologie. – 207 pp.; Berlin & Hamburg (Parey).

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Plate 1

(1, 8) *Leioceras crassicostatum* Rieber [M]. **(2 –7)** *L.* "*comtpum*" auct. [M] [non Reinecke]. **(9–12)** *Ancolioceras opalinoides* (Mayer) [M]. **(13–14)** ?*Ancolioceras* n. sp. [M]. **(1–14)** Geisingen clay pit; **(1–8)** "Comptum" Bank; Lower Aalenian, Opalinum Zone, "Comptum" Subzone, "*comptum*" horizon; **(9)** Mudstone ca. 1–3.5 m below Opalinoides/Staufensis Bank; Lower Aalenian, Opalinum Zone, "Comptum" Subzone, **(10–14)** "Lens I"; Lower Aalenian, Opalinum Zone, "Comptum" Subzone, "unnamed horizon". **(1)** (SMNS 70082/1), **(2)** (SMNS 70082/2), **(3)** (SMNS 70082/3), **(4–5)** (SMNS 70082/4), **(6)** (SMNS 70082/5), **(7)** (SMNS 70082/6), **(8)** (SMNS 70082/7), **(9)** (LGRB 10597), **(10–12)** (SMNS 70213/1), leg. W. Auer), **(13–14)** (SMNS 70213/2, leg. W. Auer). – x1, * = end of phragmocone.


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Plate 2

(1, 3) *Ludwigia*? n. sp. [M] (SMNS 70213/3, leg. W. Auer). **(2, 4)** *Costileioceras*? n. sp. [M] (SMNS 70213/4, leg. W. Auer). **(1 –4)** Geisingen clay pit; "lens I"; Lower Aalenian, Opalinum Zone, "Comptum" Subzone, "unnamed horizon". – x1, * = end of phragmocone.


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Plate 3

(1–7) *Ludwigia haugi* (Douvillé) [M]; Middle Aalenian, Murchisonae Zone, Haugi Subzone, *opalinoides* horizon; **(1–3, 6–7)** Geisingen clay pit, Opalinoides/Staufensis Bank, **(1–2)** (SMNS 70081/1), **(3, 7)** (SMNS 70081/2), **(6)** (SMNS 70081/3); **(4–5)** illustration from Quenstedt 1849, pl. 7, figs. 12 a, b), Aalen-Wasseralfingen, Unteres Flöz. – x1.


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Plate 4

Ludwigia haugi (Douvillé) [M]; Geisingen clay pit; Opalinoides/Staufensis Bank, Middle Aalenian, Murchisonae Zone, Haugi Subzone, *opalinoides* horizon; (SMNS 70081/4). – x1.


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Plate 5

(1–8) *Ancolioceras opalinoides* (MAYER) [M]; Middle Aalenian, Murchisonae Zone, Haugi Subzone, *opalinoides* horizon; **(2–8)** Geisingen clay pit, Opalinoides/Staufensis Bank, **(2)** (SMNS 70081/5), **(3)** (SMNS 70081/6), **(4)** (SMNS 70081/7), **(5, 7)** (SMNS 70081/8), **(6, 8)** (SMNS 70081/9); **(1)** Aalen-Wasseralfingen, "Donzdorf Sandstein" or most likely from a sandy patch in the Unteres Flöz [lectotype; GPIT, without number]. – x1, * = end of phragmocone.


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Plate 6

(1–5) *Ancolioceras opalinoides* (MAYER) [M]; Middle Aalenian, Murchisonae Zone, Haugi Subzone, *opalinoides* horizon; Geisingen clay pit, Opalinoides/Staufensis Bank, **(1)** (SMNS 70081/10), **(2)** (SMNS 70081/11), **(3)** (SMNS 70081/12), **(4–5)** (SMNS 70081/13). **(6, 8–9)** *Costileioceras sinon* (BAYLE) [M]; Middle Aalenian, Murchisonae Zone, Haugi Subzone, *opalinoides* horizon, **(6, 8–9)** Geisingen clay pit, Opalinoides/Staufensis Bank, **(6)** (SMNS 70081/14), **(8–9)** (SMNS 70081/15); **(7)** *Costileioceras sinon* (BAYLE) [M], Aalen-Wasseralfingen, Unteres Flöz [illustration of lectotype, lost]. – x1, * = end of phragmocone.


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Plate 7

(1–2, 6) *Staufenia staufensis* (Oppel) [M]; **(3–5, 7–8)** *Brasilia* ex gr. *bradfordensis* (Buckman) [M]; Middle Aalenian, Bradfordensis Zone, Bradfordensis Subzone, *staufensis* horizon; Geisingen clay pit, Opalinoides/Staufensis Bank [**1–4** uppermost part]; **(1–2)** (SMNS 70081/16), **(3–4)** (SMNS 70081/17), **(5)** (LGRB E820), **(6)** (SMNS 70081/18, leg. M. Kutz), **(7–8)** (PIMUZ 21490). – x1, * = end of phragmocone.


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Plate 8

(1) *Brasilia similis* (Buckman) sensu Contini [M]; **(2–4)** *Brasilia gigantea* (Buckman) sensu Contini [M]; Middle Aalenian, Bradfordensis Zone, Gigantea Subzone, *gigantea* horizon sensu Contini; Geisingen clay pit, "lenses II & III" [embedded in the mudstone below the Geisingen Oolith]; **(1)** (SMNS 70215/1, leg. E. Neisser), **(2, 4)** (SMNS 70215/2, leg. E. Neisser), **(3)** (SMNS 70215/3, leg. E. Neisser). – x1, * = end of phragmocone.


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Plate 9

(1–3) *B. similis* (Buckman) sensu Contini [M]; **(4**–**5)** *Brasilia* aff. *rustica* (Buckman) sensu Contini [M]; Middle Aalenian, Bradfordensis Zone, Gigantea Subzone, *gigantea* horizon sensu Contini; Geisingen clay pit, "lenses II & III" [in Mudstone below Geisingen Oolith]; **(1–3)** (SMNS 70215/4, leg. E. Neisser), **(4–5)** (SMNS 70215/5, leg. E. Neisser). – x1.


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Plate 10

(1–3) *Brasilia geisingensis* n. sp. [M] [large sized specimens]; Geisingen clay pit, Geisingen Oolith, bed GO-2; Middle Aalenian, Bradfordensis Zone, Gigantea Subzone, *geisingensis* horizon; **(1)** (SMNS 70190/4) [smooth variant], **(2–3)** (SMNS 70190/5) [with coarsely ribbed inner whorls; (**3)** = nucleus from reverse side]. – Scale bar: 100 mm, * = end of phragmocone.


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Plate 11

(1–4) *Brasilia geisingensis* n. sp. [M]; Geisingen clay pit, Geisingen Oolith, bed GO-2; Midddle Aalenian, Bradfordensis Zone, Gigantea Subzone, *geisingensis* horizon; **(1–2)** (SMNS 70190/6, leg. W. Auer), **(3–4)** (SMNS 70190/7, leg. W. Auer). – Scale bar: 10 cm, * = end of phragmocone.


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Plate 12

(1–4) *Brasilia geisingensis* n. sp. [M] [variants with long stadium of coarse ribbing on phragmocone]; Geisingen clay pit, Geisingen Oolith, bed GO-2; Middle Aalenian, Bradfordensis Zone, Gigantea Subzone, *geisingensis* horizon; **(1–2)** (SMNS 70190/8, leg. W. Auer), **(3–4)** (SMNS 70190/9). – Scale bar: 10 cm, * = end of phragmocone.


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Plate 13

(1–6) *Brasilia geisingensis* n. sp. [M] [smooth variants of medium size]; Geisingen clay pit, Geisingen Oolith, bed GO-2; Middle Aalenian, Bradfordensis Zone, Gigantea Subzone, *geisingensis* horizon; **(1–2)** (SMNS 70190/10), **(3–4)** (SMNS 24474/4), **(5–6)** (SMNS 70190/11). – Scale bar: 10 cm, * = end of phragmocone.


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Plate 14

(1–9) *Brasilia geisingensis* n. sp. [M] [small sized specimens, (**1–4)** smooth variants,**(5–9)** coarsely ribbed variants]; Geisingen clay pit, Geisingen Oolith, bed GO-2; Middle Aalenian, Bradfordensis Zone, Gigantea Subzone, *geisingensis* horizon; **(1–2)** (SMNS 70190/12), **(3–4)** (SMNS 24474/11), **(5–6)** (SMNS 70190/13), **(7)** (SMNS 70190/14), **(8–9)** (SMNS 70190/15). – Scale bar: 10 cm, * = end of phragmocone.


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Plate 15

(1–2) *Brasilia platychora* (BUCKMAN) [M]; Geisingen clay pit, Geisingen Oolith, bed GO-3 [base]; Middle Aalenian, Bradfordensis Zone, Gigantea Subzone; (SMNS 70189/13). – Scale bar: 10 cm.


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Plate 16

(1–2, 5) *Brasilia platychora* (Buckman) [M], **(1–2)** (SMNS 70189/14), **(5)** (SMNS 24474/13); **(3–4)** *B. deleta* (Buckman) [M] (SMNS 70189/15, leg. K.-H. Spieth); **(6)** *B. nitens* (Buckman) [M] (SMNS 70189/16, leg. W. Auer); **(7–8)** *B. austera* (Buckman) [M] (SMNS 70189/17); Geisingen clay pit, Geisingen Oolith, bed GO-3 [base or lowermost part]; Middle Aalenian, Bradfordensis Zone, Gigantea Subzone. – Scale bar: 10 cm, * = end of phragmocone.


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Plate 17

(1–2) *Brasilia decipiformis* n. sp. [M] [extremely large sized specimen]; Geisingen clay pit, Geisingen Oolith, bed GO-3; Middle Aalenian, Bradfordensis Zone, Gigantea Subzone, *decipiformis* horizon; **(1–2)** (PIMUZ 12790). – Scale bar: 10 cm, * = end of phragmocone.


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Plate 18

(1–4) *Brasilia decipiformis* n. sp. [M] [medium to large sized specimens]; Geisingen clay pit, Geisingen Oolith, bed GO-3; Middle Aalenian, Bradfordensis Zone, Gigantea Subzone, *decipiformis* horizon; **(1, 3)** (SMNS 70189/18) [involute, broad variant]; **(2, 4)** (SMNS 70189/19) [evolute, slim variant]. – Scale bar: 10 cm, * = end of phragmocone.


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Plate 19

(1–8) *Brasilia decipiformis* n. sp. [M] [medium-sized specimens]; Geisingen clay pit, Geisingen Oolith, bed GO-3; Middle Aalenian, Bradfordensis Zone, Gigantea Subzone, *decipiformis* horizon; **(1, 5)** (SMNS 70189/20, leg. R. & T. Chiarini) [involute, broad variant], **(2)** (SMNS 70189/21, R. & T. Chiarini) [involute, slim variant], **(3, 6)** (SMNS 70189/22) [involute, broad variant], **(4, 7)** (SMNS 70189/23) [involute, slim variant; similar to *B. decipiens* (Buckman)]. – Scale bar: 10 cm, * = end of phragmocone.


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Plate 20

(1–17) *Brasilia decipiformis* n. sp. [M] [small sized specimens, already resembling *Graphoceras*]; Geisingen clay pit, Geisingen Oolith, bed GO-3; Middle Aalenian, Bradfordensis Zone, Gigantea Subzone, *decipiformis* horizon; **(1)** (SMNS 70189/24), **(2–3)** (SMNS 70189/25), **(4)** (SMNS 70189/26), **(5)** (SMNS 70189/27), **(6)** (SMNS 70189/28, leg. R. & T. Chiarini), **(7–8)** (SMNS 23980), **(9)** (SMNS 23290), **(10)** (SMNS 70189/29, leg. K-H. Spieth), **(11–12)** (SMNS 70189/30), **(13)** (SMNS 70189/31), **(14–15)** (SMNS 70189/32), **(16–17)** (SMNS 70189/33). – Scale bar: 10 cm, * = end of phragmocone.


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Plate 21

(1–2) *Brasilia decipiformis* n. sp. [M]; Geisingen clay pit, Geisingen Oolith, bed GO-3; Middle Aalenian, Bradfordensis Zone, Gigantea Subzone, *decipiformis* horizon; (SMNS 70189/34, prepared by Esther Premru); **(1)** lateral view of a large phragmocone, **(2)** reverse side, showing the inner whorls with a *Graphoceras*-like stage. – Scale bar: 10 cm, * = end of phragmocone.


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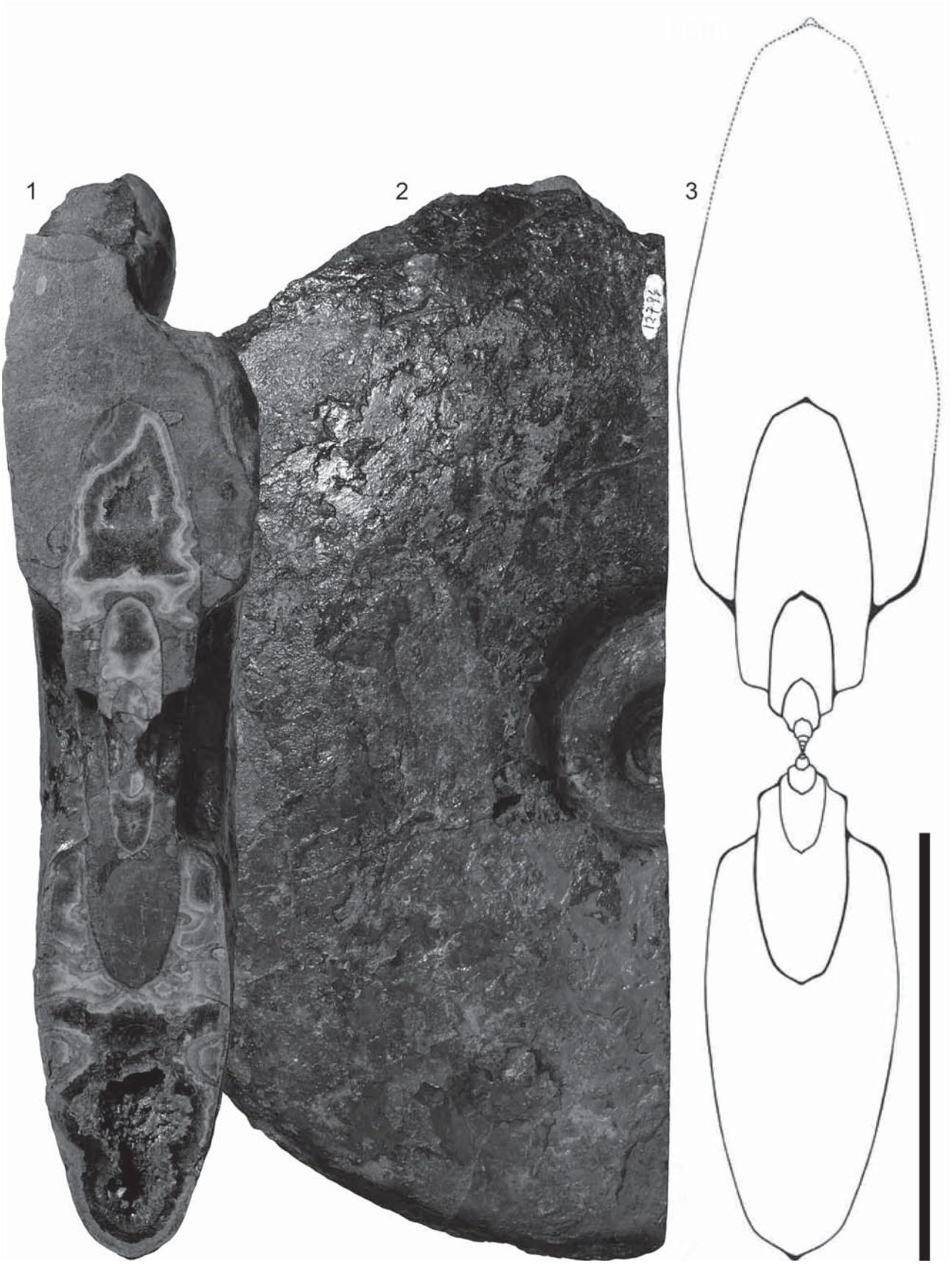
Plate 22

(1–3) *Brasilia decipiformis* n. sp. [M]; Geisingen clay pit, Geisingen Oolith, bed GO-3; Middle Aalenian, Bradfordensis Zone, Gigantea Subzone, *decipiformis* horizon; (PIMUZ 12794); **(1, 3)** whorl section, **(2)** lateral view. – Scale bar: 10 cm.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