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The Braunjura (Brown Jurassic) in Southwest Germany

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With 7 plates, 14 figures, and 1 table.

1. Introduction

The Middle Jurassic in Southwest Germany is built up mainly by fine, sandy clays and intercalated limonitic, calcareous sandstones and ferruginous oolites. Some rocks of this series are remarkably brown coloured and gave the whole sequence the name „Brauner Jura“ or „Braunjura“ („Brown Jurassic“). The layers of the Braunjura form especially the foot of the northern escarpment of the Swabian Alb.

Ferruginous oolitic limestones and marls of the middle Braunjura form steep escarpments in the region between the Donau and Balingen (Southwestern Alb). Similar escarpments are formed by the sandstones of the lower Braunjura in the region between Balingen and Geislingen (Middle Alb) and between Geislingen and Bopfingen (Eastern Alb).

In the area of Tuttlingen a. d. Donau and in the Fils Valley near Geislingen a. d. Steige the layers of the Braunjura are opened by erosion far into the valleys of the Swabian Alb.

Good exposures in the Braunjura are rare. Mostly the rocks of the Braunjura are not opened very well, because their outcrops are often covered by loams and screes. Only far in the southwest where the Wutach and their tributaries have cut very steep valleys by rapid erosion, the layers of the Lower and Middle Jurassic are opened very well.

The average thickness of the Braunjura amounts to 150–280 meters along the Swabian Alb (150–200 meters along the Eastern Alb, 200–270 meters along the Middle Alb, and 200–260 meters along the Southwestern Alb).

In the Franconian Alb the geological situation is similar. Only towards the edge of the Bohemian Massif the thickness of the Middle Jurassic decreases. About the Middle Jurassic of the Franconian Alb see ZEISS (1977).

The Braunjura of the Upper Rhine Valley differs from the facies of the Swabian Braunjura mainly by its marine calcareous oolites in its middle part. It will not be treated in this paper.

The Braunjura does not correspond exactly with the Middle Jurassic (Dogger) because it also includes the lower and some parts of the middle Oxfordian.

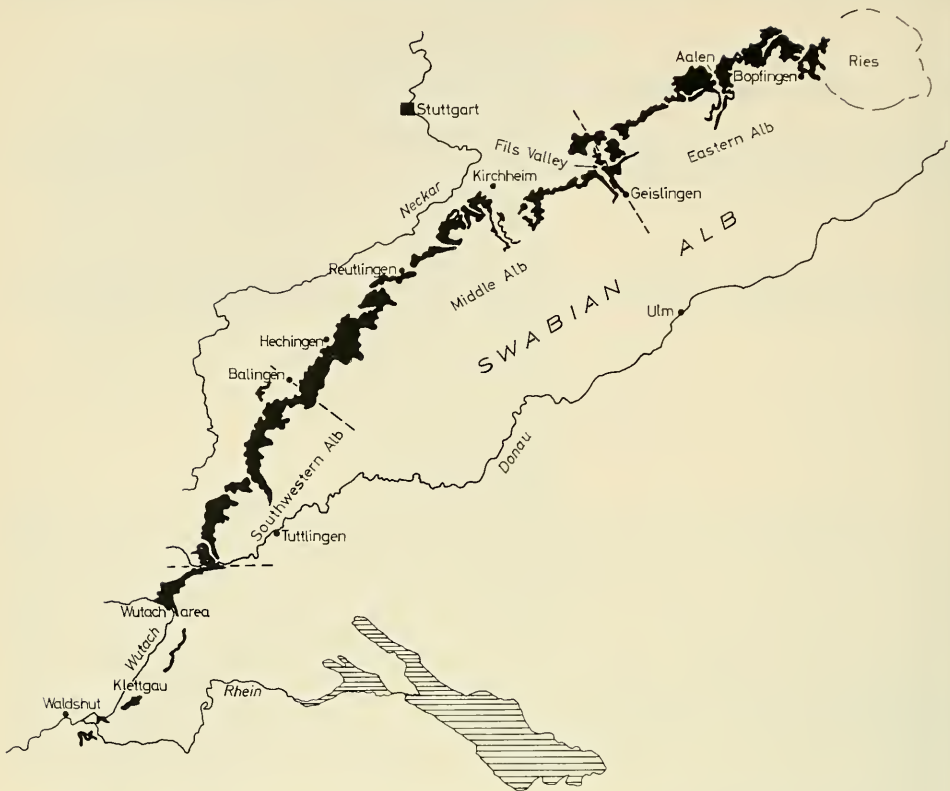


Fig. 1. Braunjura outcrops along the Swabian Alb, of the Wutach area, and of the Klettgau.

2. Subdivision *sensu* QUENSTEDT and its later usage

2.1. Swabian Alb and Wutach region

QUENSTEDT (1843; 1858; 1886/87) was the first who studied the lithostratigraphic sequence of the Braunjura of Württemberg in detail. He subdivided the Braunjura in six lithologic units characterized by fossils; for their designation he used the greek letters *a* to *ζ*. Only in the Middle Alb and in some parts of the Southwestern Alb these subdivisions are being used commonly. For the middle and the upper Braunjura of the Eastern Alb, the westernmost part of the Southwestern Alb, and the Wutach region they can be used only with difficulties.

Braunjura *a*

The Braunjura *a* is also called „Opalinus-Ton“ after its common, often still white-shelled fossil *Leioceras opalinum*. It is mainly built up by dark clays and shales. The base layer of the Opalinus-Ton is named „Torulosus-Schicht“ (QUENSTEDT 1843; 1858, p. 306; OPPEL 1856–58).

The Opalinus-Ton is a very thick and with regard to petrography and paleontology a rather monotonous sequence, which contains scattered nodules of pyrite, of marly limestone, of clay ironstone, and thin calcareous layers with cone-in-cone

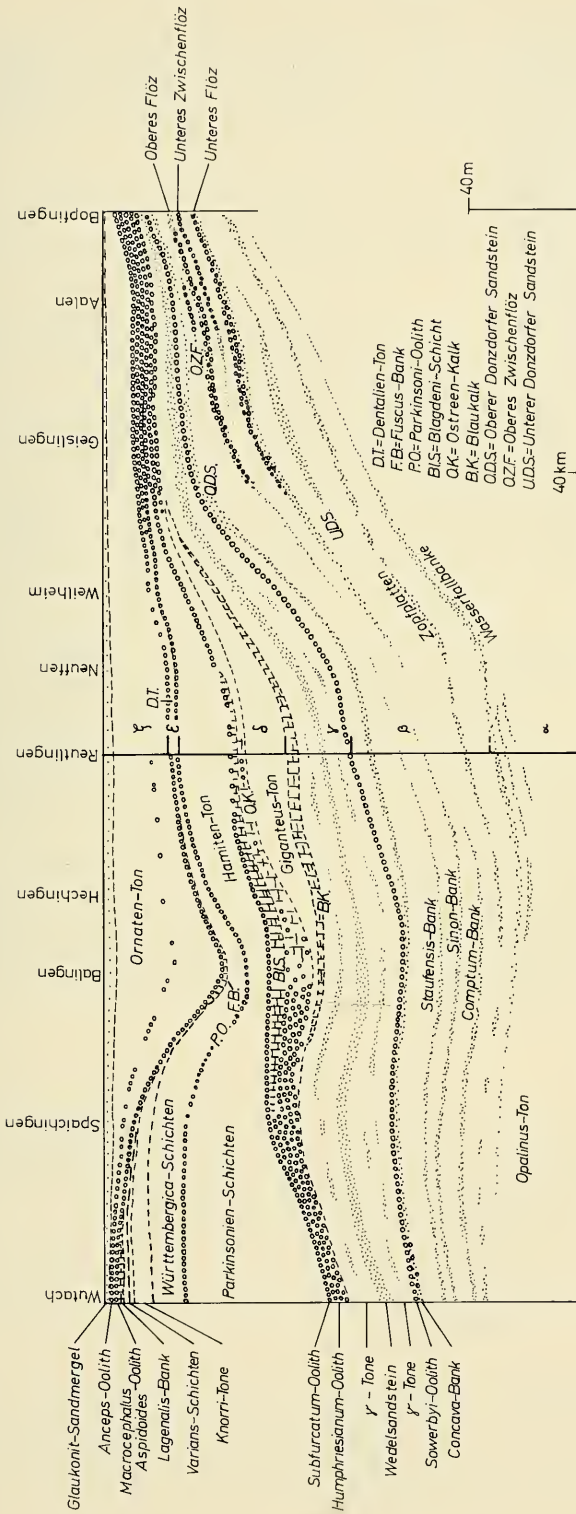


Fig. 2. Profile section of the Braunjura from the Wutach area to Bopfingen (Eastern Alb). (Adapted from GEYER & GWINNER 1968)

structure. The lower part of the Opalinus-Ton, especially in the region of Göppingen, is very rich in fossils, e. g. in white-shelled, but mostly compressed ammonites and bivalves. In the upper part the Braunjura α becomes sandy more and more. So the upper part of the Opalinus-Ton is built up by sandy marl benches, the so-called „Wasserfallbänke“.

The lithologic subdivision of the Opalinus-Ton in a Lower-, Middle- and Upper- α (ENGEL 1908) is useless for stratigraphy (KOBLEK 1972).

The thickness of the Opalinus-Ton is fairly constant 85—120 meters.

Braunjura β

QUENSTEDT (1843; 1858) has never fixed an exact limit between the Braunjura α and the Braunjura β . He rather described a „Gränzregion α/β “ („Boundary Region α/β “) (QUENSTEDT 1858, p. 329) which corresponds with the Wasserfallbänke. In the region between Reutlingen and Gosheim above the Wasserfallbänke layers are found which contain remarkably numerous fragments of belemnites, called „Belemnitenbreccie“. According to LÖRCHER (1934; 1939) the „Belemnitenbreccie“ still belongs to the Braunjura α , and the Braunjura β begins just above these layers. North of Reutlingen and south of Gosheim the Braunjura β begins above the Wasserfallbänke, because the „Belemnitenbreccie“ is absent there. In the region of the Wutach even the Wasserfallbänke are absent. This is the reason why there are difficulties in fixing the limit α/β as given by QUENSTEDT (1843; 1858).

In the Eastern Alb the limit Braunjura α/β is placed at the top of the Wasserfallbänke. In the area of Aalen only one „Wasserfallbank“ is developed (WEBER 1964). The „*Pholadomya triquetra*-Bank“, chosen by O. FRAAS (1871) as the limit-bench between Braunjura α and β in the region of Aalen, was interpreted in different ways by later authors, because there are several benches with *Pholadomya triquetra*. This term should be used no longer (WEBER 1964, p. 18).

Along the Swabian Alb the Braunjura β is separated into three regions of different facies. About the Braunjura β in the area of Aalen (Eastern Alb) see WEBER (1964) and DIETL & ETZOLD (1977). About the Braunjura β in the region of Balingen-Rottweil (Southwestern Alb) and farther southwest in the region of the Wutach see RIEBER (1963; 1977).

Braunjura γ

QUENSTEDT has never fixed an exact limit between Braunjura β and γ . Where the limit was drawn by later authors, is shown in a survey given by RIEBER (1963, table p. 18). According to this survey the so-called Sowerbyi-Oolith is considered as being the base of the Braunjura γ by most of the authors.

The „Sowerbyi-Oolith“ is a thin, partly iron-oolitic marly limestone horizon which is developed along the whole Swabian Alb. West of Balingen the Sowerbyi-Oolith is joined closely with the „Concava-Bank“. The intercalated layers, e. g. the „Gryphaeen-Bank“ of the Hechingen area, are absent there (see also RIEBER 1963, p. 17).

The „Wedelsandstein“ follows above the Sowerbyi-Oolith along the whole Swabian Alb. This unit mainly consists of sandy marl and calcareous sandstone. The sandstone contains a characteristic trace fossil (*Cancellolophycus scoparius*), whose shape („Wedel“) gave the name to this unit.

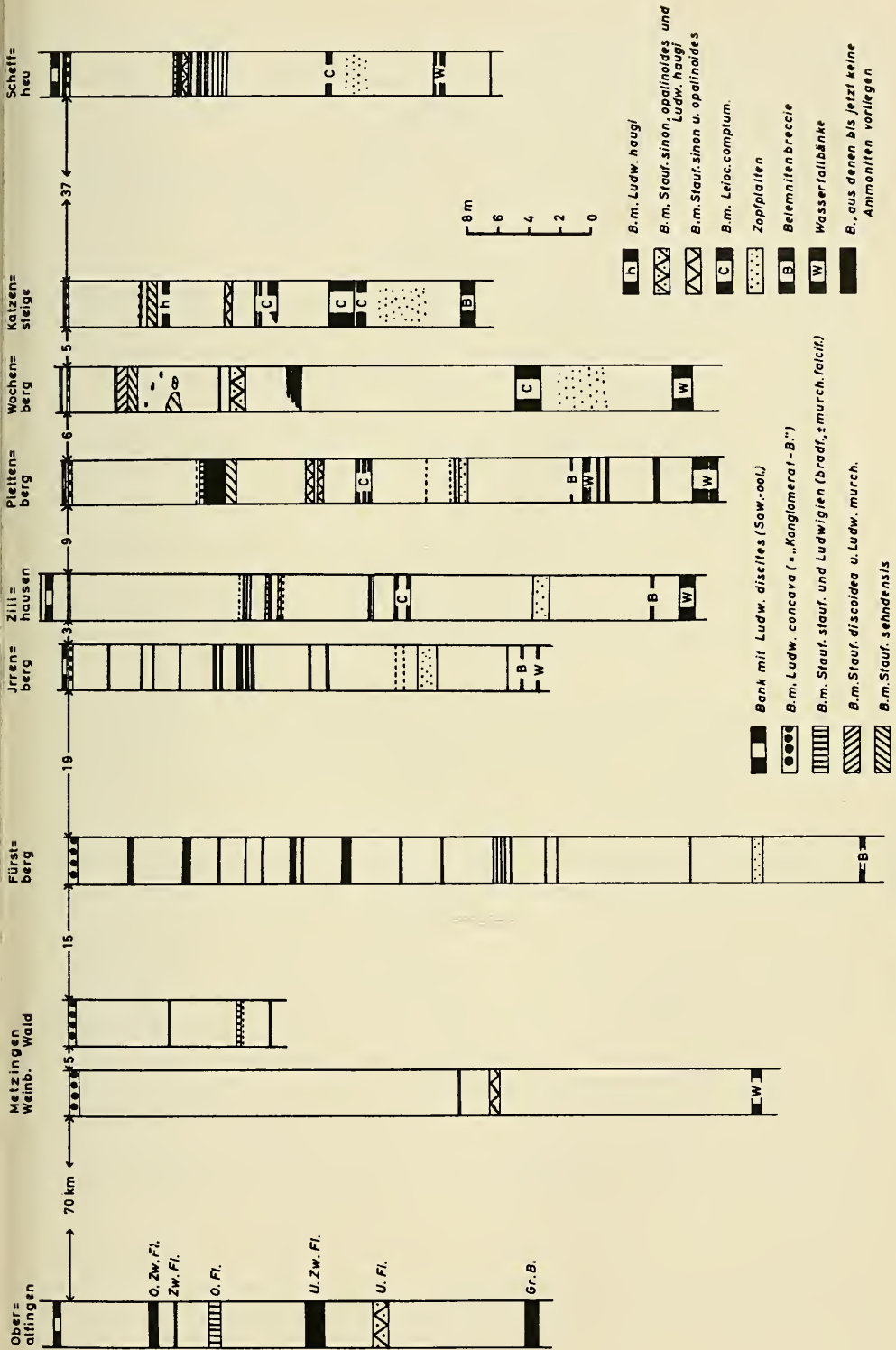


Fig. 3. Sections of the Braunjura β along the Swabian Alb. (RIEBER 1963)

In some regions clay horizons called „ γ -Tone“ (γ -clays) are intercalated between Sowerbyi-Oolith and Wedelsandstein or/and Wedelsandstein and Blaukalk.

Above the Wedelsandstein begins the „Blaukalk“, which is best developed in the region of Reutlingen (thickness 4 meters). It is absent in some regions, e. g. in the area of Aalen (pers. commun. A. ETZOLD, Freiburg).

In the Eastern Alb the Braunjura γ has a thickness between 3 and 15 meters, in the Middle Alb between 15 and 30 meters, and in the Southwestern Alb between 25 and 40 meters.

Braunjura δ

Mainly in the Middle Alb clays and marls are dominating in the whole Braunjura δ . In the Southwestern Alb the lower part of the Braunjura δ is formed as a mainly ferruginous oolitic, marly limestone horizon (= „Humphriesianum-Oolith“). In the Eastern Alb (e. g. area of Bopfingen) the whole Braunjura δ is only a few meters thick and built up only by ferruginous oolitic, calcareous marls.

Because the Braunjura δ shows a facies quite different from one region to the other in Swabia numerous designations of layers have been proposed and used [see the list of GEYER (in GEYER & GWINNER 1962)] which partly have only a local stratigraphic importance.

Mainly for the Middle Alb QUENSTEDT (1843; 1858; 1886/87) described the limits of the Braunjura δ and its sequence of layers. Because the facies of the Braunjura δ is quite different in the Eastern and in the Southwestern Alb, it is very difficult there to use the definition of the lower and the upper limit of the δ given by QUENSTEDT.

QUENSTEDT described the sequence of layers between the Blaukalk (Braunjura γ) and the „Bifurcaten-Schicht“ (= „Subfurcatum-Oolith“) for the Middle Alb as follows: „Giganteus-Ton“ (including the „Abraumschicht“ at the base), „Ostreen-Kalke“, and „Coronaten-Schicht“.

But even in the region of the Middle Alb this sequence of units has only a limited local stratigraphic value. Names as Giganteus-Ton and Ostreen-Kalke characterize rather the facies of the rocks than their stratigraphic position. Therefore quite different horizons were identified with these units of QUENSTEDT. GUSMANN (in ENGEL 1908, section p. 326) e. g. has described a clay horizon above the Coronaten-Schicht as Giganteus-Ton in the area of Eningen unter Achalm. According to KOERNER (in ETZOLD, HAHN & KOERNER 1975, p. 134), in the Zollernalb region (near Balingen) the Giganteus-Ton follows above the Humphriesianum-Oolith, representing the base of the Braunjura δ in this region. Farther southwest, in the area of Gosheim, the Giganteus-Ton is overlain by a thick horizon of ferruginous oolites, the so-called Humphriesianum-Oolith (= „Humphriesi-Schichten“ sensu WEISERT 1932). WEISERT (1932, p. 185) equated his Humphriesi-Schichten with the Ostreen-Kalke. The layer between the Humphriesi-Schichten and the Subfurcatum-Oolith is called „Blagdeni-Schicht“ by WEISERT. This Blagdeni-Schicht shall be the equivalent horizon to the Coronaten-Schicht sensu QUENSTEDT (WEISERT 1932, p. 185).

The Subfurcatum-Oolith is well developed along the whole Swabian Alb. Only in the region between Glems and Reutlingen it is very thin (thickness about 20 cm) and highly clayey. The ooids of the Subfurcatum-Oolith are much bigger than those of the „Parkinsoni-Oolith“ and the „Macrocephalus-Oolith“.

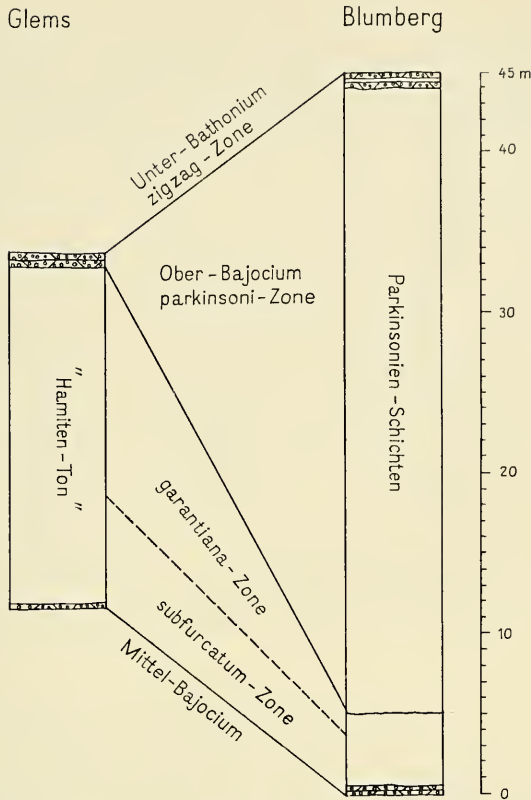


Fig. 4. Comparison of thicknesses of the Upper Bajocian between Glems (Middle Alb) and Blumberg (Wutach area). (HAHN, BUCK & SCHÄDEL 1966)

The so-called „Hamiten-Tone“ above the Subfurcatum-Oolith in the Middle and in the Southwestern Alb are typical stillwater sediments contrary to the Subfurcatum-Oolith. They are the best developed (thickness 12–20 m) in the area between Kirchheim and Reutlingen.

In contrast to his earlier opinion (1843; 1858) QUENSTEDT (1886/87) placed the Hamiten-Ton into the Braunjura δ . Already in 1858 he described the ammonite fauna of the Hamiten-Ton in the chapter about the Braunjura δ . More about this problem is said in the following chapter („Braunjura ϵ “).

In the Wutach area it is impossible to fix the limit δ/ϵ sensu QUENSTEDT (1886/87), because the clayey „Parkinsonien-Schichten“ (BUCK, HAHN & SCHÄDEL 1966, text-fig. 5) which are nearly 40 m thick are situated between the Subfurcatum-Oolith and the Parkinsoni-Oolith. These Parkinsonien-Schichten are no stratigraphic equivalent of the Hamiten-Ton. In the Eastern Alb the Subfurcatum-Oolith passes over into the Parkinsoni-Oolith without any clear separation. Here it is also difficult to fix the limit δ/ϵ .

The aggregate thickness of the Braunjura δ (without the Parkinsoni-Oolith) is changing in the Swabian Alb from east to southwest as follows: Bopfingen 8 m, Stuifen 23 m, Reutlingen 44 m, Balingen 30 m.

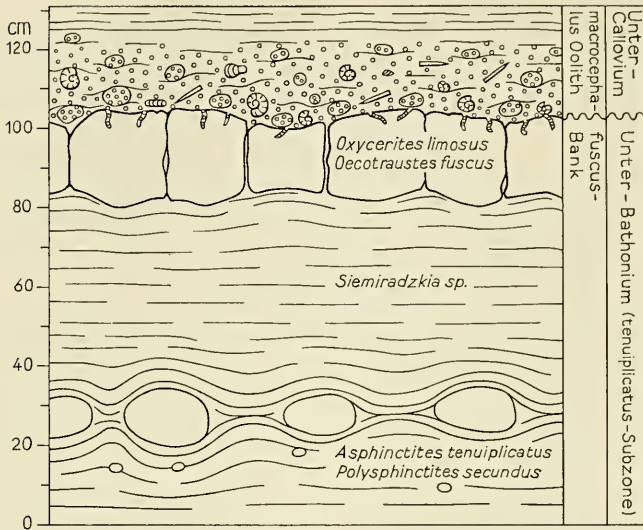


Fig. 5. Bathonian/Callovian boundary (Braunjura ϵ) at the eastern slope of the Plettenberg near Dotternhausen (Southwestern Alb). (HAHN 1970)

Braunjura ϵ

According to the definition given by QUENSTEDT (1886/87) and taken over by ENGEL (1908), the Braunjura ϵ comprises two horizons of ferruginous oolites: at the bottom the Parkinsoni-Oolith and at the top the Macrocephalus-Oolith. In the Wutach area it is difficult to define the base of the Braunjura ϵ , because the Parkinsoni-Oolith of this region is only partly equivalent to the Parkinsoni-Oolith of the Middle Alb. Clays and marls with a thickness of about 30 m are following in the Wutach area above the Parkinsoni-Oolith (BUCK, HAHN & SCHÄDEL 1966). These clays and marls are subdivided into a lower part called „Württembergica-Schichten“, a middle one called „Knorri-Tone“, and an upper one called „Varians-Schichten“ which are already more calcareous. In the Wutach region two additional horizons are distinguished immediately below the Macrocephalus-Oolith: the „Aspidoides-Oolith“ and the „Lagenalis-Bank“. Between Balingen and Reutlingen the „Fuscus-Bank“ lays immediately below the Aspidoides-Oolith. This Fuscus-Bank cannot be equated with the Lagenalis-Bank of the Wutach area. In some regions the Aspidoides-Oolith is developed as a calcareous marl bed without any ooids and therefore called Aspidoides-Bank. In the Eastern Alb between Schwäb. Gmünd and Bopfingen the facies is quite different. There the whole sequence is reduced to 2–4 meters and built up only by ferruginous oolites.

The stratigraphy of the Braunjura ϵ is full of problems. The great differences of facies from east to west make it more difficult to parallelize the different horizons which often have only a local stratigraphic importance.

The differences in fixing the lower and the upper limit of the Braunjura ϵ are the cause of further problems in the stratigraphy of this stage. The different ways of using the definitions of the limit δ/ϵ and of the top of the Braunjura ϵ given by QUENSTEDT (1843; 1858; 1886/87) shall be discussed in the following context:

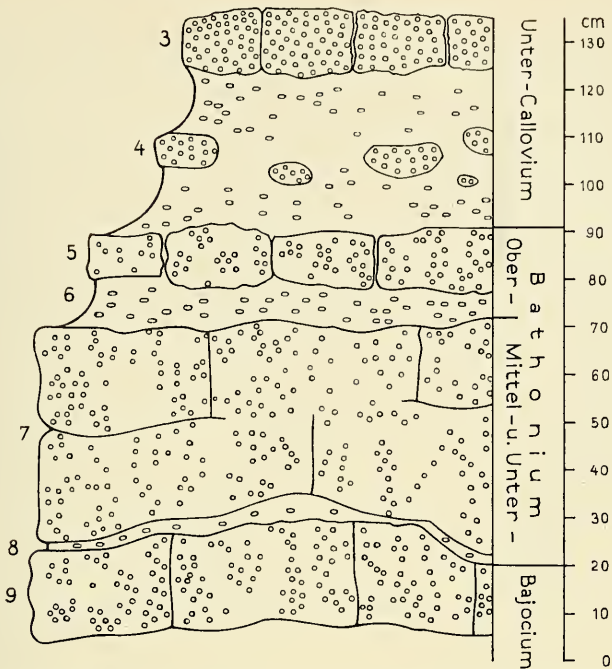


Fig. 6. Section of the Bathonian from the Ipf near Bopfingen (Eastern Alb). (HAHN 1968)

1. According to QUENSTEDT (1843) the Braunjura ε begins with a sequence of clays, the „Parkinsoni-Tone“. The typical development of these layers is described by him especially for the Middle Alb. There these clays are limited at the top by the *Macrocephalus-Oolith*. According to QUENSTEDT, the *Macrocephalus-Oolith* still belongs to the Braunjura ε . In contrast to QUENSTEDT, GEYER (in GEYER & GWINNER 1962) placed the *Macrocephalus-Oolith* into the Braunjura ζ to adjust the limit ε/ζ to the limit Bathonian/Callovian.

2. QUENSTEDT (1858, table p. 555) subdivided his Parkinsoni-Tone into a lower part „Schwefelkieston“ (= Hamiten-Ton) and into an upper part „Dentalien-Ton“. The separating horizon between both is the Parkinsoni-Oolith (QUENSTEDT 1858, p. 461). This subdivision is used for the region of the Middle Alb (especially the area of Reutlingen) until today.

3. QUENSTEDT (1886/87) changed his opinion about the lower limit of the Braunjura ε . He placed the „Clavellaten-Schicht“ (first mentioned by QUENSTEDT 1886/87, p. 523) which is the uppermost part of the Hamiten-Ton, into the Braunjura δ . [ENGEL (1883, p. 161) described *Trigonia clavellata* as the common fossil of the upper Hamiten-Ton.] ENGEL (1911) also placed the Hamiten-Ton in the Braunjura δ . According to the changed opinion of QUENSTEDT (1886/87), the Braunjura ε begins with the Parkinsoni-Oolith. ENGEL (1908; 1911) and FISCHER (1913) e.g. use the new definition of the Braunjura ε . Other authors (e.g. FRANK 1939, p. 369) continue the older definition of QUENSTEDT. FRANK (1945, p. 3) shows the different stratigraphic positions of the Hamiten-Ton in a table, in which the Hamiten-Ton of the Kirchheim-Reutlingen area is placed into δ and the Hamiten-Ton between Balingen and Hechingen into ε .

Most recently GEYER (in GEYER & GWINNER 1962) places the Parkinsoni-Oolith into the Braunjura δ to adjust the limit δ/ε to the limit Bajocian/Bathonian.

Braunjura ζ

The layers of the Braunjura ζ are built up mainly by dark clays and shales. These layers are usually named „Ornatenton“ because of the occurrence of *Kosmoceras „ornatum“*. But only the upper part of this series of clays should be

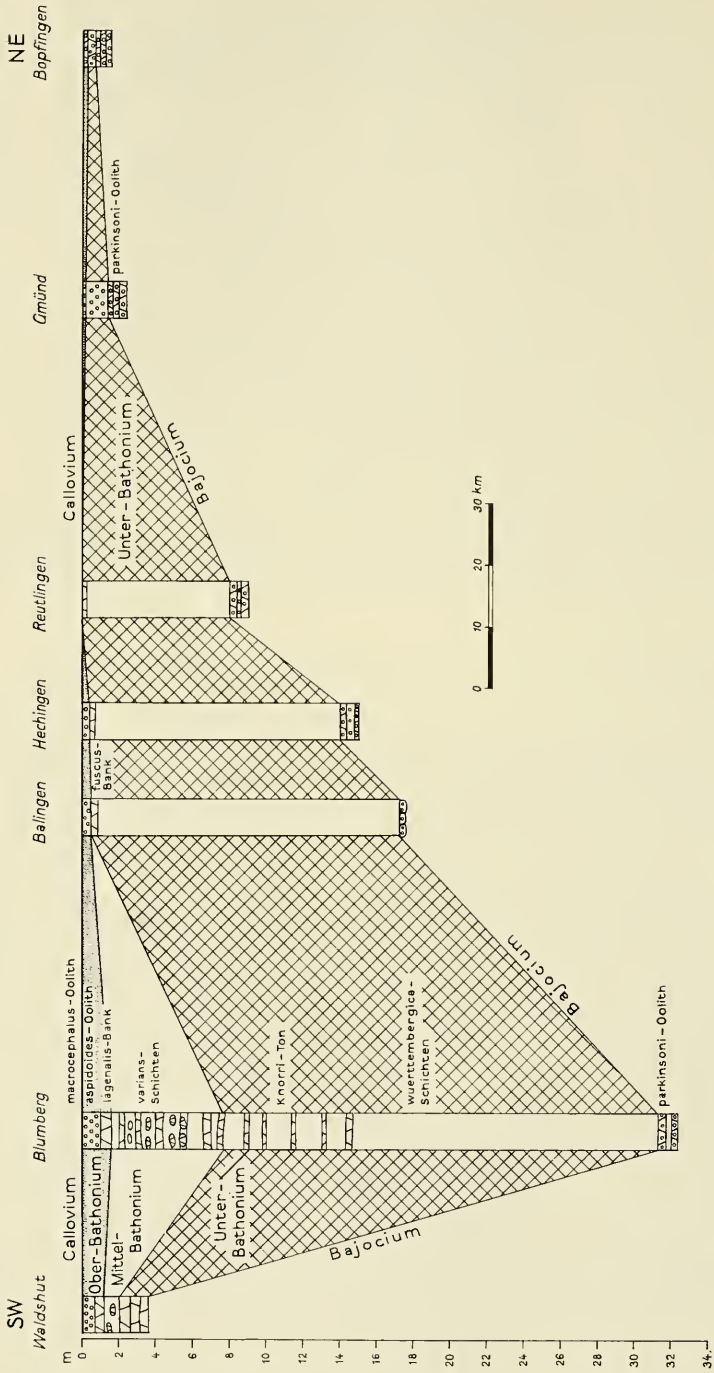


Fig. 7. Thickness and facies of the Bathonian in the region between the Klettgau and Bopfingen (Eastern Alb). (HAHN 1968)

called Ornatenton, because *Kosmoceras „ornatum“* can be found only in this level. The lower part of this series of clays contains ammonites of the genus *Macrocephalites* and therefore better should be called Macrocephalenton.

In the upper Ornatenton between Balingen and Spaichingen a very thin ferruginous oolite horizon is intercalated: the „Anceps-Oolith“. Perhaps this Anceps-Oolith is only a relic horizon of formerly thicker sediments in this level (HAHN & KOERNER 1971, p. 132). Further southwest, in the Wutach region, the Braunjura ζ (if there still can be spoken of a Braunjura ζ in the sense of QUENSTEDT) is very thin and mostly iron oolitic. A „Graublaues Erzlager“, a „Violettes Erzlager“, and the „Grenzkalk“ may be distinguished there above the Macrocephalus-Oolith, also called „Rotes Erzlager“ in this region (see also ZEISS 1955).

At the top of the Ornatenton a very thin layer of phosphatic concretions occurs which is enriched by processes of submarine erosions and condensation. This layer, also called „Lamberti-Knollenlage“, is widely distributed from the Wutach region to Bopfingen in the easternmost part of the Swabian Alb. According to ZAKRZEWSKI (1887) and HAHN & KOERNER (1971), the horizon of the Lamberti-Knollenlage mostly shows the presence of glauconite, at least in the region between Balingen and Hechingen. Above the Lamberti-Knollenlage a fine sandy sequence of clay marls (only a few meters thick) follows which is also characterized by the presence of glauconite. This sequence is limited by the first calcareous layer of the „Transversarium-Bänke“ (= „Grenzbank“: FRAAS 1888) which is the beginning of the Weißjura α as used by QUENSTEDT (see also ZIEGLER 1977).

The thickness of the Braunjura ζ reaches its maximum in the region between Hechingen and Balingen (30–50 meters). To the southwest the layers are reduced to about 5 meters near Blumberg. Towards the east they are also reduced to 20 meters between Boll and Gammelshausen, to 12 meters near Aalen, and to only about 3 meters near Bopfingen.

2.2. Klettgau

In the region of the Klettgau the layers of the lower and the middle Braunjura are formed in Swabian facies. They can be subdivided in the categories of QUENSTEDT.

In contrast to this the upper layers of the Braunjura are quite different and partly developed in the so-called „Spatkalk“ facies. These Spatkalke, first named and described by MOESCH (1867), show their greatest distribution in the Argauer Jura (Switzerland). They are nearly free of pelecypods and built up by limestones, which are rich in remainders of echinoderms. Their thickness is about 3 meters near Dangstetten (Ldkr. Waldshut: HAHN 1966, Abb. 1). The top layers of the Braunjura (above the Spatkalke) are developed in the same facies (ferruginous oolite) as described by ZEISS (1955) from Blumberg.

3. Biostratigraphy

Among the fossils the ammonites are most suitable for the biostratigraphic subdivision of the Braunjura in Southwest Germany. Good index species are found in most of their genera. Other macrofossils, too, are used for biostratigraphy, but not

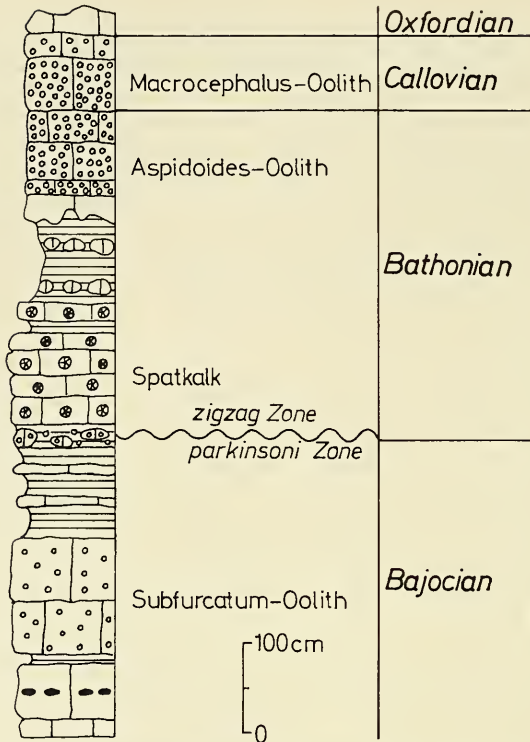


Fig. 8. Section of the middle and upper Dogger in the Berchenwald near Dangstetten (Klettgau). (Adapted from HAHN 1966)

with great success in any case. The foraminifera and ostracodes of the Swabian Braunjura are partly studied, but only the ostracodes are of stratigraphic value.

In contrast to the Weißjura (see ZIEGLER 1977, fig. 16–19) the vertical range of the most genera and species of ammonites is reduced in the Braunjura.

3.1. Swabian Alb and Wutach region Braunjura *a*

In the Swabian Braunjura the base of the Braunjura *a* is characterized by the occurrence of *Lytoceras* (*Pachylitoceras*) *torulosum* and therefore called Torulosum-Schicht. Beside *Lytoceras* (*P.*) *torulosum* also the first *Leioceratids* appear with two different species: *Leioceras opalinum* and *Leioceras costosum*. Both species persist throughout the whole Opalinus-Ton, and *Leioceras opalinum* is sometimes found even in the lowest part of the Braunjura *β* (see WEBER 1964, section 62). In the region of Boll the very rare *Tmetoceras scissum* occurs in the upper part of the Opalinus-Ton for the first time.

Only a few ammonites pass over the boundary Schwarzjura/Braunjura. These are some Hammatoceratids and *Pleydellia fluitans* which become extinct in the lowest part of the Opalinus-Ton.

Other macrofossils also used as index fossils are: „*Lucina*“ *plana* („Lucinen-Bank“), *Astarte* („Astarten-Schichten“), *Balanocrinus württembergicus* („Penta-

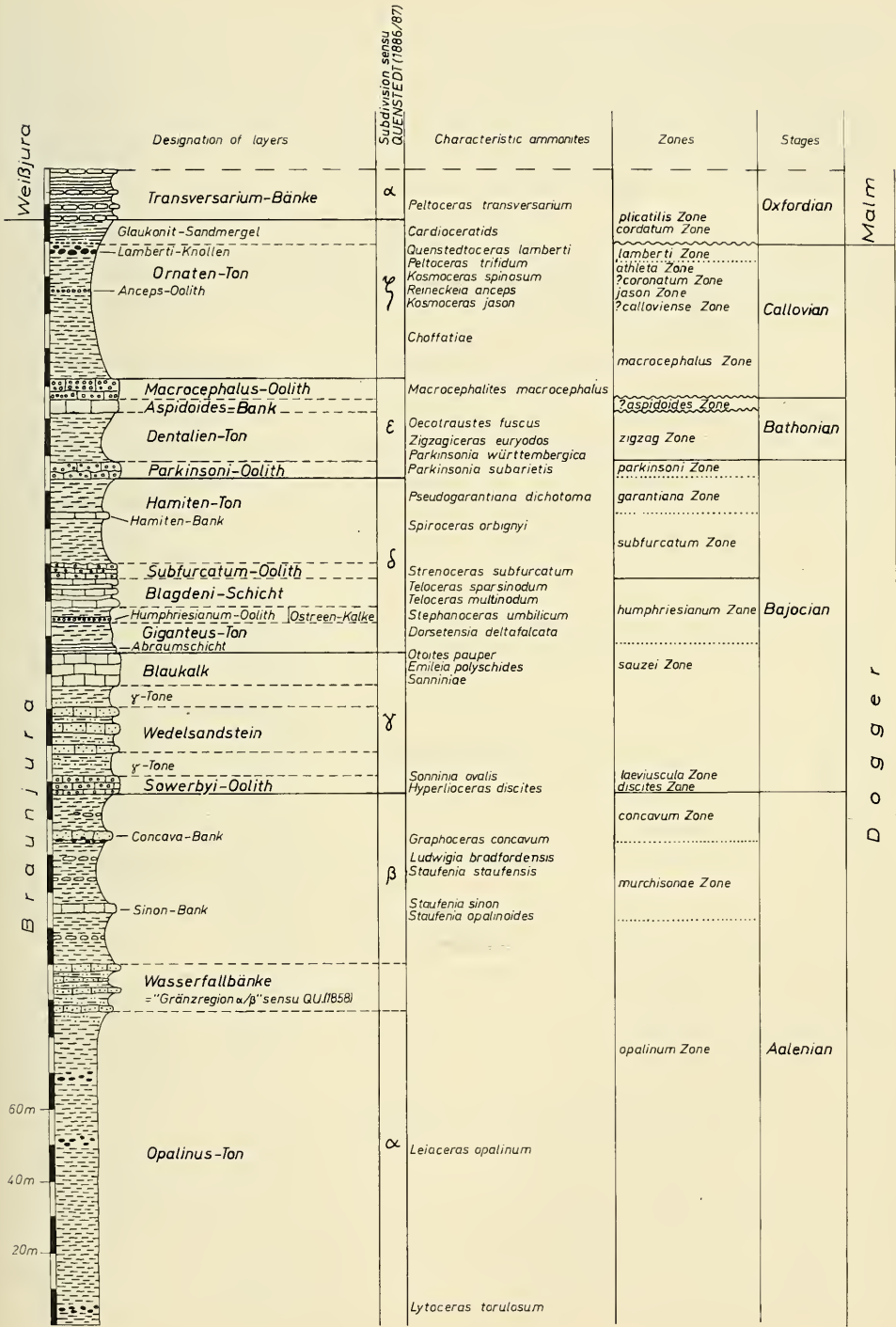


Fig. 9. Survey of the Braunjura and its characteristic ammonites of the Middle Alb. (Combined section adapted from RIEBER 1963, SCHOLZ 1966, and HAHN, BUCK & SCHÄDEL 1966)

criniten-Platte“), and *Trigonia navis* („Schichten der *Trigonia navis*“). Their stratigraphic value is restricted upon small areas.

The two ostracode species *Aphelocythere kuhni* and *Aphelocythere ramosa* occur at the boundary Schwarzjura/Braunjura (FISCHER 1961). The microfossils (ostracodes, foraminifera) of the Opalinus-Ton have been studied by KOBLE (1972) who merely described their ecological importance.

Braunjura β

The biostratigraphy of the Braunjura β will not be treated here because of its actual documentation by RIEBER (1977) for the Southwestern Alb and DIETL & ETZOLD (1977) for the region of Aalen.

Braunjura γ

Different species of the genus *Hyperlioceras* occur at the boundary Braunjura β/γ . Till now the occurrence of *Hyperlioceras* is only known from a few outcrops along the Swabian Alb. Its best investigated occurrence is the one in the Wutach Valley. There BAYER (1969) identified eight different species of this genus in a horizon called „Discites-Schichten“ with a thickness of less than one meter. These Discites-Schichten seem to be the lower part of the Sowerbyi-Oolith. In this level also the first *Sonninia* appear (BAYER 1969, fig. 1). *Sonninia* are found in the Sowerbyi-Oolith also in other regions along the Swabian Alb, but always as rarities. A famous locality of the Sowerbyi-Oolith, rich in fossils, is the area of Gingen an der Fils.

Typical *Sonninia* of the Sowerbyi-Oolith are the following: *Sonninia ovalis*, *Euhoploceras polyacantha*, *Euhoploceras adicra*. The *Sonninia sowerbyi* often mentioned for the Sowerbyi-Oolith (see also OECHSLE 1958) is unsuitable as an index fossil (PARSONS 1974, p. 160–161). *Sonninia sowerbyi*, the type specimen of which is quite indeterminable, is probably an inner whorl of a *Papilliceras* of the *mesacantha* group, which came from a higher horizon (*sauzei* Zone) (PARSONS 1974, p. 160–161). In the Swabian Braunjura γ also several species of the genus *Wittdellia* can be found, but they are very rare and no more treated since DORN (1935). Till now they have been never used as index fossils.

The Wedelsandstein (middle γ) contains ammonites only as rarities. In contrast to this sequence the Blaukalk, especially in the region between Beuren and Eningen (Middle Alb), is rich in ammonites. Among others can be found: *Papilliceras mesacantha*, „*Sonninia*“ *patella*, *Kumatostephanus turgidulum*, *Otoites contractus*, *Otoites pauper*, and *Emileia polyschides*. Up till now the ammonite fauna of the Blaukalk has not been investigated in its modern biostratigraphic aspects.

In the Braunjura γ of Southwest Germany, e. g. near Aalen-Attenhofen, very small reefs of corals occur for the first time in the Braunjura more frequently: *Isastraera*, *Thamnastraera*. The corals of the Hohenzollern, described by QUENSTEDT out of the upper γ , belong to the lower δ according to FRANK (1945).

The trace fossil *Cancellolophycus scoparius* is a good facies indicator but useless for biostratigraphy.

Braunjura δ

In Swabia the beginning of the Braunjura δ is not well marked by ammonites. In the region of Hechingen the δ begins with the „Abraumschicht“ which is rich in

remainders of echinoderms and bivalves. The Giganteus-Ton, which follows above the Abraumschicht in this region, is named after the belemnite *Megateuthis giganteus* which is very common in this layer. But *Megateuthis giganteus* is no good index fossil, because occasionally it already occurs in the upper γ and extends up into the ε . Where the Giganteus-Ton contains nodular limestones and „Muschelknollen“ (nodules with bivalves), e. g. in the region of Hechingen, the first ammonites of the δ are found: *Dorsetensia romani*, *Dorsetensia deltafalcata*, *Dorsetensia liostraca*, and *Epalxites*, *Germanites*.

The bivalves *Lopha cristagalli* and *Ctenostreon pectiniforme* are typical fossils of the Ostreen-Kalke. But both fossils are not very important for the biostratigraphy, because they are typical facies fossils indicating deposits of shallow, wave-agitated water. The Ostreen-Kalke are best developed along the Middle Alb.

The Humphriesianum-Oolith following above the Giganteus-Ton in the region of Gosheim was investigated by WEISERT (1932) with regard to its biostratigraphy. According to WEISERT *Stephanoceras nodosum*, *Stephanoceras macrum*, and *Stephanoceras plicatum* characterize the lower part of the Humphriesianum-Oolith. The characteristic ammonites of the upper part are *Stephanoceras umbilicum* and *Stephanoceras rectecostatum*. Other ammonites accompanying *Stephanoceras* are more

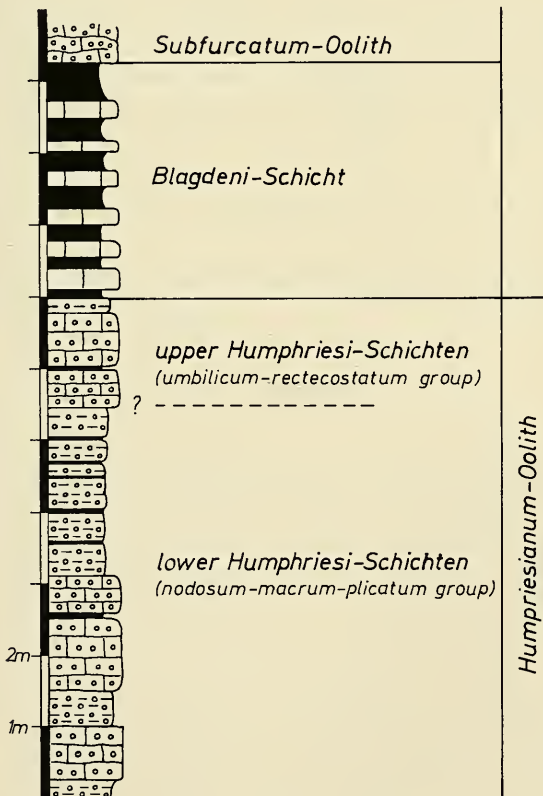


Fig. 10. Section of the Braunjura middle- δ near Gosheim (Southwestern Alb). (Adapted from WEISERT 1932)

frequent only in the top layers of the Humphriesianum-Oolith. Mainly these are different species of the genera *Normannites* and *Itinsaites* (in part may be *Stemmato-ceras*), *Dorsetensia*, and *Chondroceras*. Perhaps still in the Humphriesianum-Oolith of the Gosheim region the first Teloceratids appear. These dominate in the following Blagdeni-Schicht: *Teloceras sparsinodum*, *Teloceras multinodum*, and *Teloceras coronatum* (WEISERT 1932).

In the Subfurcatum-Oolith, following above the Blagdéni-Schicht (\approx Coronaten-Schicht), new groups of ammonites occur. In comparison with the lower δ the number of genera and species has increased enormously. The following genera are found: *Strenoceras*, *Garantiana*, *Oppelia*, *Bigotites*, *Leptosphinctes*, *Infraparkinsonia* (in part may be *Caumontisphinctes*), *Strigoceras*, *Lissoceras*, *Cadomites*, *Polyplectites*, and very rarely *Spiroceras*. For the lower part of the Subfurcatum-Oolith *Strenoceras subfurcatum*, *Garantiana baculata*, and *Infraparkinsonia* (in part may be *Caumontisphinctes*) are good index fossils. For the upper part, which is an iron oolite also near Bopfingen (Eastern Alb), different species of the subgenus *Subgarantiana* as well as the species *Garantiana* (G.) *dubia* and *Garantiana* (*Pseudogarantiana*) *dichotoma* are characteristic. The Hamiten-Ton of the area of Reutlingen is the stratigraphic equivalent deposit of nearly the whole Subfurcatum-Oolith of Bopfingen. BUCK, HAHN & SCHÄDEL (1966) investigated the biostratigraphy of the Hamiten-Ton in this region (Glems, Eningen). They found a sequence of ammonites equal to that of the whole Subfurcatum-Oolith of Bopfingen. In the section of Glems *Strenoceras subfurcatum* extends far up into the Hamiten-Ton. This species is replaced by *Garantiana* (*Pseudogarantiana*) *dichotoma* above the „Hamiten-Bank“ which is dividing the Hamiten-Ton in its middle part. The heteromorphs (*Spiroceras*) are typical ammonites of the Hamiten-Ton.

The ostracodes of the Braunjura δ were studied recently by BUCK (in BUCK, HAHN & SCHÄDEL 1966). *Procytheridea hoffmanni*, *Fuhrbergiella* (F.) *primitiva*, and *Fuhrbergiella* (*Praefuhrbergiella*) *horrida? horrida* are typical ostracodes of the Humphriesianum-Oolith. The Blagdeni-Schicht is characterized by the genus *Cytherella*. Besides *Pleurocythere regularis* the ostracodes *Glyptocythere regulariformis* and *Fuhrbergiella* (F.) *projecta* are typical index ostracodes of the Hamiten-Ton.

Braunjura ϵ

With the Parkinsoni-Oolith or the clayey Parkinsonien-Schichten the first Parkinsoniae appear. In these layers the most frequent Parkinsoniae are *Parkinsonia* (P.) *acris* and *Parkinsonia* (P.) *subarietis*. According to BENTZ (1924), they mark the lower Parkinsonien-Schichten in Württemberg. The „younger“ Parkinsoniae of the subgenera *Oraniceras* and *Gonolkites* follow above the „older“ Parkinsoniae in the condensed profile of the region of Bopfingen, as well as in the Dentalien-Ton of the Middle Alb and in the Württembergica-Schichten of the southwesternmost Alb. They indicate the upper Parkinsonien-Schichten, first described by WETZEL (1911) from Northwest Germany. *Parkinsonia* (*Oraniceras*) *württembergica*, *Parkinsonia* (*Oraniceras*) *gyrumbilica*, and *Parkinsonia* (*Oraniceras*) *valida* are especially common in the lower Braunjura ϵ and good index fossils of the upper Parkinsonien-Schichten. In association with them *Zigzagiceras euryodos* and *Morphoceras multiforme* still occur. In the Württembergica-Schichten only a few meters above the first occurrence of the „younger“ Parkinsoniae the following characteristic ammonite genera appear:

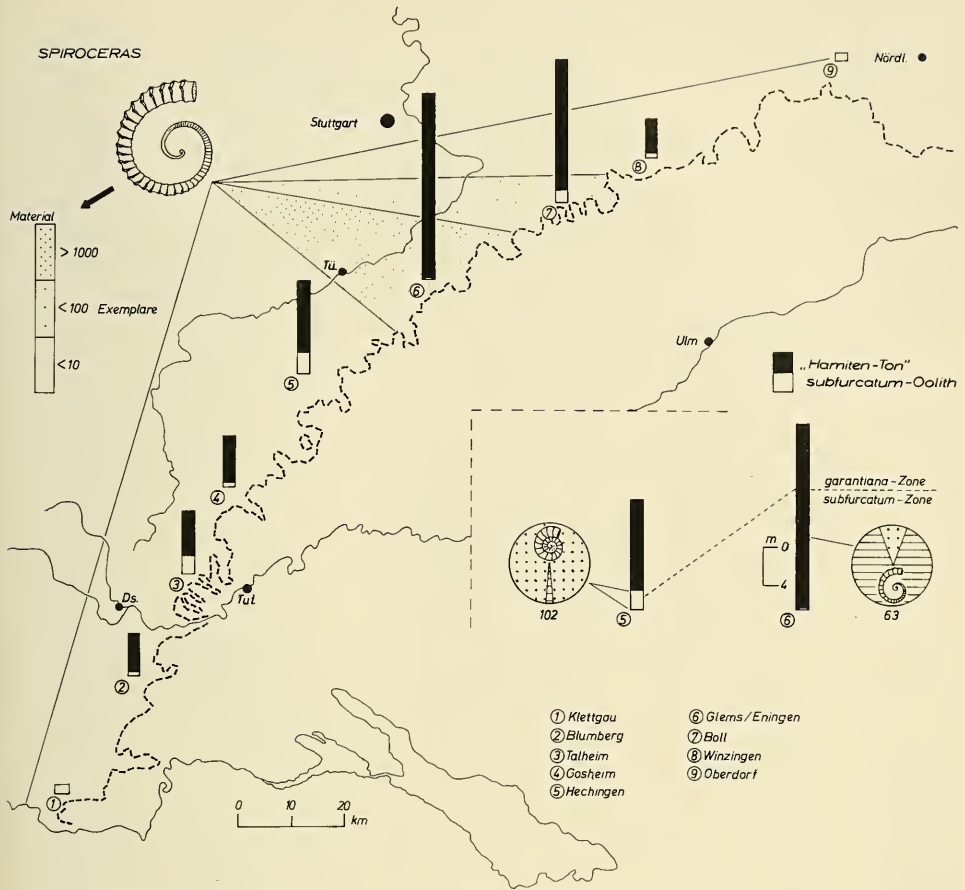


Fig. 11. Biotope dependence of the Dogger heteromorphs of the genus *Spiroceras* in the region of the Swabian Jurassic. (DIETL 1976)

Oecotraustes, *Oxycerites*, *Cadomites*, *Polyplectites*, *Ebrayiceras*, *Lissoceras*, *Siemiradzkaia*, and *Procerites*.

In the profile at the Eichberg near Blumberg (Wutach region) this ammonite association is replaced by other ammonites in the upper Württembergica-Schichten. Now the Oppeliae are dominating. The most common species of these is *Oecotraustes* (*Paroecotraustes*) *fuscus*. The genera *Parkinsonia*, *Zigzagiceras*, *Morphoceras*, and *Ebrayiceras* have disappeared.

The Fuscus-Bank of the region between Reutlingen and Spaichingen shows a similar ammonite fauna.

The Knorri-Tone above the Württembergica-Schichten in the region of the Wutach, named after a small oyster *Catinula knorri*, show a further change of the ammonite fauna. The Oppeliae are reduced to a lower frequency again. Besides *Polysphinctites* sp. the genus *Asphinctites* occurs for the first time here. In the Wutach region the Varians-Schichten, named after the brachiopod „*Rhynchonella varians*“ (= *Rhynchonelloidea alemanica*, occurring in crowds in these layers), follow above the Knorri-Tone. From these layers HAHN (1968) noted some ammonites:

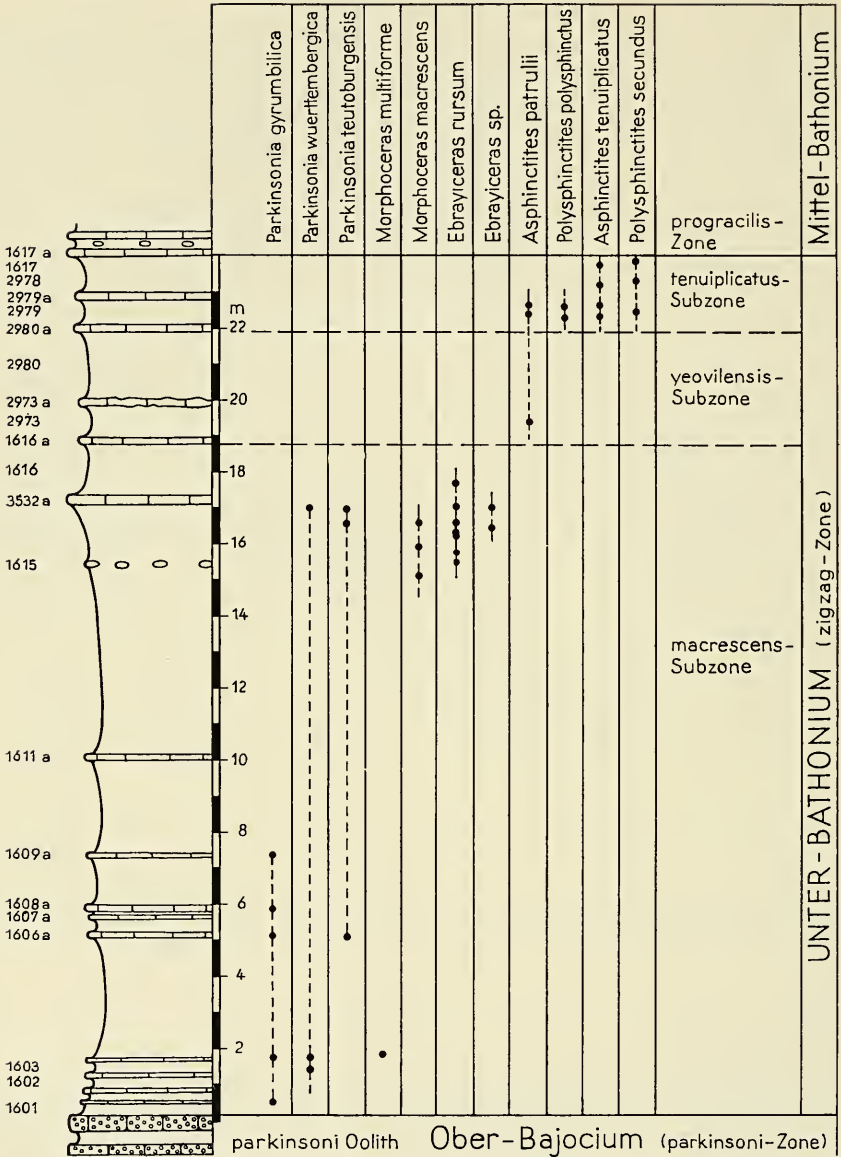


Fig. 12. Vertical distribution of the Parkinsoniidae and Morphoceratidae in the lower Bathonian of the western slope of the Eichberg near Blumberg (Wutach area). (HAHN 1970)

Procerites imitator, *Oecotraustes* (*Paroecotraustes*) cf. *splendens*, *Tulites modiolaris*, *Tulites subcontractus*, and different species of *Lycetticer*.

The Lagenalis-Bank (named after the terebratulid *Ornithella lagenalis*), following above the Varians-Schichten in the region of the Wutach, mainly contains large-growing Proceritids and Wagnericeratids. The Macrocephalitidae of the Varians-Schichten are no longer present. Moreover, in the Lagenalis-Bank *Oppeliae* of the genera *Oxycerites*, *Oecotraustes*, and *Prohecticoceras* are found as great rarities.

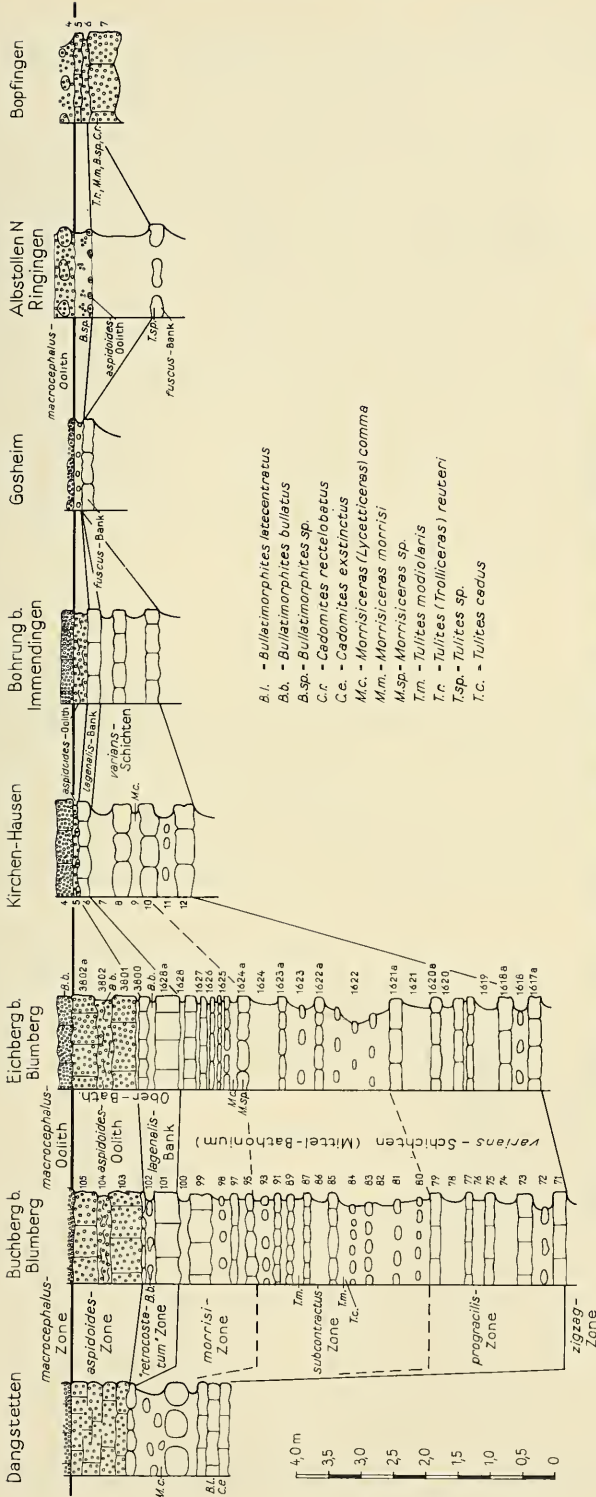


Fig. 13. Stratigraphic sections of the Middle and Upper Bathonian between the Klettgau and Bopfingen (Eastern Alb). (HAHN 1971)

In the Aspidoides-Oolith the most frequent and characteristic ammonite is *Oxycerites aspidoides*, accompanied for the first time by species of the genus *Choffatia* beside *Prohectioceras*. From the top of the Aspidoides-Oolith two specimens of *Clydoniceras discus* are known (OPPEL 1863; RIEBER 1961).

The Macrocephalus-Oolith, the upper layer of the ϵ , is very rich in fossils in contrast to the layers of the lower ϵ , where ammonites are partly very rare. The genera *Macrocephalites*, *Bullatimorphites*, *Cadoceras*, *Grossouvria*, *Choffatia*, „*Hectioceras*“, *Kepplerites* are particularly common. The ammonite fauna of the Macrocephalus-Oolith has been investigated no more since QUENSTEDT (1886/87).

In the profile of Glems near Reutlingen (BUCK & HAHN 1966) the ostracode *Pleurocythere connexa* appears for the first time in the Parkinsoni-Oolith. This common ostracode extends up to the base of the Aspidoides-Oolith. In the region of the Wutach (see also BUCK & HAHN 1966) *Oligocythereis* cf. *fullonica* occurs nearly in the middle of the Württembergica-Schichten, and *Fissocythere variabilis* a short distance higher in the stratigraphic column. In the Varians-Schichten *Pleurocythere* is dominating, and in the Aspidoides-Oolith *Lophocythere plena* is an index ostracode. With the beginning of the Macrocephalus-Oolith *Lophocythere cruciata* occurs (BUCK & HAHN 1966).

Braunjura ζ

Along the Swabian Alb the Ornaten-Ton is the most conspicuous sequence of layers of the Braunjura ζ . Its biostratigraphy is investigated by means of modern methods only in parts, although the pyritic ammonites of these layers have been collected since generations. The reason for this may be that the pyrite ammonites are only the inner whorls of much larger individuals in most cases and thus often difficult to determine. HAHN & KOERNER (1971) tried to solve this problem. Unfortunately these investigations were interrupted by the sudden death of W. HAHN in the year 1972.

In the artificial outcrops of the Braunjura ζ , opened by tunneling in the region of the Zollernalb, HAHN & KOERNER (1971) found a very wide vertical distribution for the ammonite genus *Macrocephalites*. *Kepplerites gowerianus* extends only a few meters above the Macrocephalus-Oolith, but *Macrocephalites* extends into the Anceps-Oolith. The layers containing *Macrocephalites* are about 21 meters thick in the Zollernalb (HAHN & KOERNER 1971).

Along the Swabian Alb the Anceps-Oolith is a horizon of high condensation. In large parts of the Middle and the Eastern Alb this horizon does not exist.

The sequence of the upper Ornaten-Ton following above the Anceps-Oolith is very rich in ammonites. The most frequent ammonites are Perisphinctids (*Grossouvria*, *Subgrossouvria*) and Oppeliids (*Distioceras*, *Horrioceras*, *Proscaphites*, *Lorioliceras*, *Hectioceras*). Apart from the Kosmoceratids, the Peltoceratids, and the Reineckeids are not rare in these layers. The upper part of these clays and shales is marked by *Quenstedtoceras*, which is particularly frequent in the layer of the Lamberti-Knollenlage, the top layer of this series. In the top layer of the Lamberti-Knollenlage the first ammonites of the genus *Cardioceras* occur. The glauconitic, sandy marls above also contain Cardioceratids. In the Zollernalb from the same horizon HAHN & KOERNER (1971) noted *Euspidoceras perarmatum*. The first

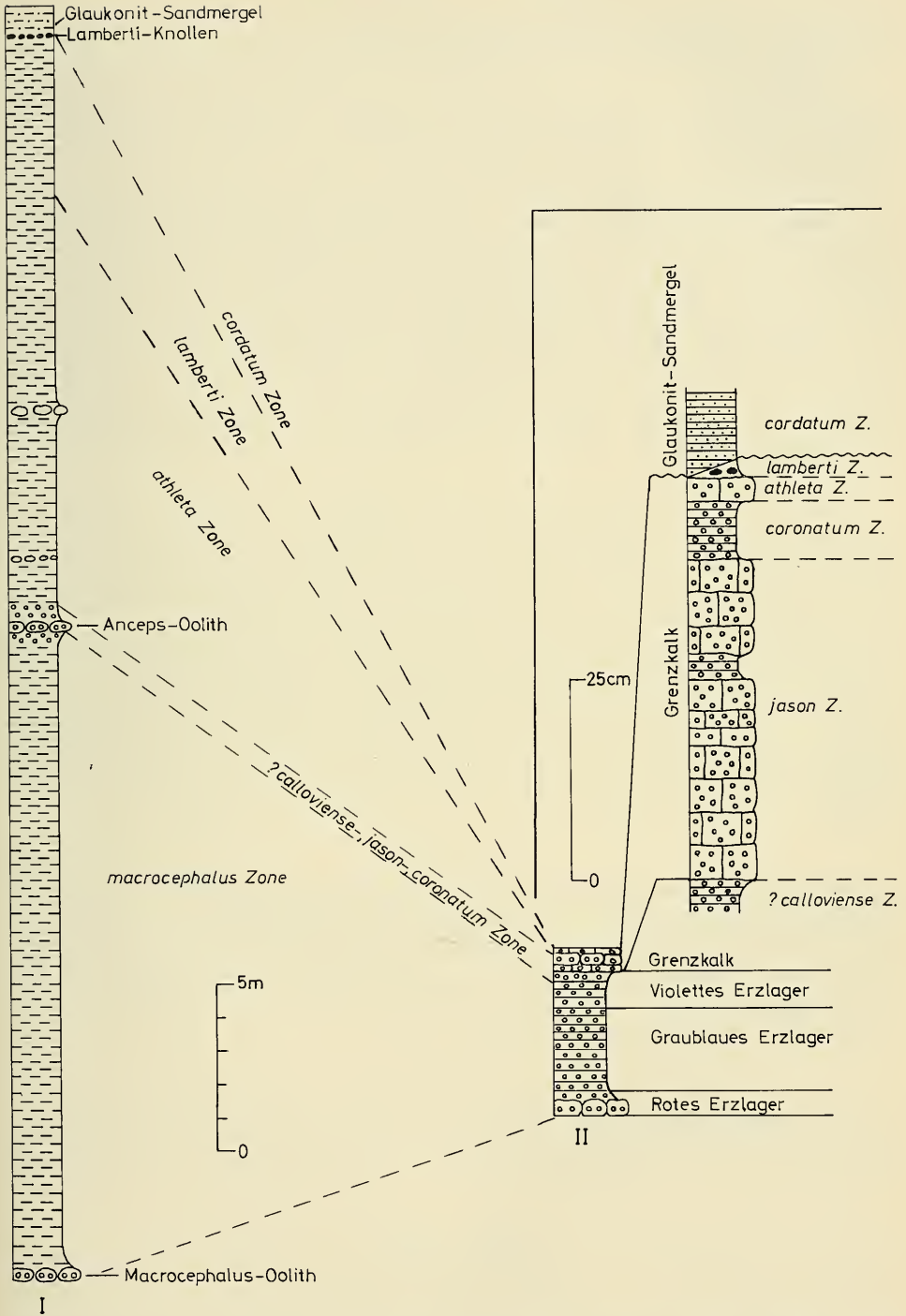


Fig. 14. Comparison of thickness and stratigraphy of the upper Braunjura between Talheim (I) near Tübingen (Middle Alb) and Blumberg (II) (Wutach area). (Section I adapted from HAHN & KOERNER 1971; section II with the Grenzalk in detail adapted from ZEISS 1955.)

calcareous layer of the Transversarium-Bänke which is following above the glauconitic, sandy marls is the beginning of the Weißjura.

The ostracodes cited by MALZ (in HAHN & KOERNER 1971) for the Ornaten-Ton of the Zollernalb are no good index-fossils. Only the ostracodes *Lophocythere flexicosta* ssp. and *Protocytheridea? gubleria* are of stratigraphic value and characteristic of the higher part of the Ornaten-Ton.

The condensed iron oolitic upper Braunjura of Blumberg (Wutach region) has been already investigated by ZEISS (1955; 1957). According to him, *Proplanulites*, *Parapatoceras*, and *Kepplerites* are the typical ammonites of the Graublaues Erzlager. The characteristic ammonites of the Violettes Erzlager are the Reineckeids. The thin layers above the Violettes Erzlager (the Grenzkalk) contain Erymnoceratids, Peltoceratids, Quenstedtoceratids, and Cardioceratids and show a sequence of ammonites similar to that one of Herznach/Switzerland (JEANNET 1951). Specimens of *Erymnoceras coronatum* which are very rare in the Swabian Jurassic have been found also near Bopfingen (Eastern Alb) where the layers of the upper Braunjura are highly condensed, too.

3.2. Klettgau

The succession of layers of the lower and middle Braunjura of the Klettgau has not been investigated recently. But it may be the same as in the Swabian Jurassic. Within the Spatkalke ammonites only occur in condensed layers as a rule (HAHN 1966). HAHN described a sequence of ammonites similar to that of the Eichberg near Blumberg for the Spatkalke. Only some characteristic ammonites are absent documenting a hiatus during high condensation. As a result of this condensation e. g. the „older“ and the „younger“ Parkinsoniids do not occur in different layers, but side by side in the same horizon. The ammonite fauna of the uppermost part of the Braunjura seems to be the same as given by ZEISS (1955; 1957) from Blumberg.

4. Chronology

In this chapter the local succession of the ammonite zones of the Swabian Braunjura will be compared with the international standard scheme. The basis is the scheme given by HALLAM (1975), which is not only based upon the conclusions and propositions of the two International Colloquiums on the Jurassic System in Luxembourg (1962; 1967), but includes also newest proposals as e. g. those of PARSONS (1974) on the so-called „sowerbyi Zone“.

Aalenian

The Aalenian will not be treated here, because of its documentation by RIEBER (1977) for the Middle and the Southwestern Alb and by DIETL & ERZOLD (1977) for the area of Aalen (Eastern Alb).

Bajocian

The basal zone of the Bajocian, the *discites* Zone, has been identified by the occurrence of *Hyperlioceras discites* at least in some parts of the Swabian Braunjura. The ammonite fauna of this zone has been investigated in detail by BAYER (1969) for the first time in the Wutach region. There, according to BAYER (1969, fig. 1), *Hyperlioceras discites* first occurs in the upper part of the Discites-Schichten (in part may

be the Sowerbyi-Oolith). The genus *Hyperlioceras* begins already in the upper Aalenian (*concauum* Zone). Even before the appearance of *Hyperlioceras discites* the genus *Sonninia* occurs (BAYER 1969, fig. 1).

The opinion of PARSONS (1974, fig. 3 and p. 173) that the Sowerbyi-Oolith only represents the *discites* Zone in Swabia has to be doubted. According to OECHSLE (1958), *Sonninia ovalis*, the index fossil for the *ovalis* Subzone which is the basal subzone of the *laeviuscula* Zone¹⁾, also appears in the Sowerbyi-Oolith. Therefore along the Swabian Alb the Sowerbyi-Oolith seems to comprise the *discites* Zone as well as sometimes still parts of the *laeviuscula* Zone. The Wedelsandstein is poor in ammonites. PARSONS (1974, fig. 3) places it into the *laeviuscula* Subzone, but until now the index fossil has not been identified surely in the Swabian Braunjura. The specimens, figured as *Witchellia laeviuscula* by DORN (1935, pl. 6, fig. 3, and pl. 14, fig. 2), have been determined wrongly. The correlation of the Blaukalk with the *sauzei* Zone presents no problems (PARSONS 1974, p. 172). But the index fossil for the *sauzei* Zone has not been identified with certainty in Swabia until now. Because the Abraumschicht still contains ammonites of the genus *Emileia* as a great rarity, the *sauzei* Zone still extends up into the lower Braunjura δ . Therefore the lower Bajocian is only approximately corresponding with the Braunjura γ .

In the Giganteus-Ton the *humphriesianum* Zone begins with the occurrence of *Germanites*, *Epalxites*, and *Dorsetensia romani* (*pinguis* Subzone and *romani* Subzone). The *romani* Subzone may be supposed also in the Ostreen-Kalke (\approx Humphriesianum-Oolith), and the *blagdeni* Subzone may be restricted to the Coronaten-Schicht (\approx Blagdeni-Schicht). In the Swabian Jurassic the index species *Stephanoceras humphriesianum* seems to be very rare or even absent. The specimen figured by WEISERT (1932, pl. 17, fig. 5) as *Stephanoceras humphriesianum* seems to be no true *humphriesianum*, and the specimen figured by WEISERT (1932, pl. 18, fig. 2) as *Teloceras blagdeni* seems to be no true *blagdeni*. The latter seems to be very rare. The Giganteus-Ton, the Ostreen-Kalke (\approx Humphriesianum-Oolith) and the Coronaten-Schicht (\approx Blagdeni-Schicht) are equal to the middle Bajocian because of their ammonite fauna.

The upper Bajocian begins with the zone of *Strenoceras subfurcatum* in the Subfurcatum-Oolith along the whole Swabian Alb. The index species is very common. The *garantiana* Zone following above is still placed in the Subfurcatum-Oolith in the Eastern Alb. In the Middle Alb (Kirchheim-Reutlingen area) the limit *subfurcatum/garantiana* Zone is situated nearly in the middle of the Hamiten-Ton (HAHN & SCHÄDEL 1966), above the Hamiten-Bank. In the Wutach area this limit is also placed in clayey layers, but these belong to the lower part of the Parkinsoni-Schichten (HAHN & SCHÄDEL 1966). The index species *Garantiana* (*G.*) *garantiana*, designated by ARKELL (1956), seems to be absent in Swabia. The beginning of the *garantiana* Zone is marked by the occurrence of *Garantiana* (*Pseudogarantiana*) *dichotoma*, the index species for the *dichotoma* Subzone (WESTERMANN 1967, table 1). Between Bopfingen (Eastern Alb) and Gosheim (Southwestern Alb) the *parkinsoni* Zone is characterized by the frequent occurrence of *Parkinsonia* (*P.*) *acris* and *Parkinsonia* (*P.*) *subarietis*. Both are typical Parkinsoniae of the *acris* Subzone at

¹⁾ According to the proposition of PARSONS (1974) the *sowerbyi* Zone is to be eliminated and must be replaced by the zone of *Witchellia laeviuscula*. The *laeviuscula* Zone comprises two subzones: the *ovalis* Subzone and the *laeviuscula* Subzone (PARSONS 1974).

the base of the *parkinsoni* Zone. In the Wutach area the *parkinsoni* Zone starts in the clayey Parkinsoni-Schichten with *Parkinsonia* (*P.*) *neuffensis* which occurs only in the upper part of the *parkinsoni* Zone. There the above following Parkinsoni-Oolith forms the top layer of the *parkinsoni* Zone!

B a t h o n i a n

The Bathonian begins with the *zigzag* Zone immediately above the Parkinsoni-Oolith in some regions, in others above the clayey Parkinsoni-Schichten. According to HAHN (1969 p. 36), *Zigzagiceras zigzag* is probably the junior synonym to *Zigzagiceras euryodos*. *Zigzagiceras euryodos* is very frequent in Swabia and documents the *macrescens* Subzone together with *Morphoceras macrescens*. In the Wutach area, where the Bathonian is best developed, HAHN (1968) has distinguished two additional subzones in the *zigzag* Zone: the *yeovilensis* Subzone (*Oxyerites yeovilensis*) and the *tenuiplicatus* Subzone (*Asphinctites tenuiplicatus*). The Fuscus-Bank from the area of Balingen is a horizon of condensation containing the ammonites of the *yeovilensis* Subzone as well as the ammonites of the *tenuiplicatus* Subzone. Consequently the Dentalien-Ton of the Middle Alb and the equivalent Württembergica-Schichten including the Knorri-Tone of the Southwestern Alb and of the Wutach area belong to the lower Bathonian.

The middle Bathonian is only known from the Wutach region. There it exists in the Varians-Schichten (HAHN 1968) and may be subdivided into the *progracilis* Zone, the *subcontractus* Zone, and the *morrissi* Zone. Their index species *Procerites progracilis*, *Tulites subcontractus*, and *Morrisiceras morrissi* are very scarce. Only 2–3 specimens of each index fossil have been found in Southwest Germany. A few ammonites of the middle Bathonian have been found also in the condensed Braunjura of the Eastern Alb. There they appear together with ammonites of the lower Bathonian in a highly condensed layer.

In contrast to the middle Bathonian the upper Bathonian is represented in the whole Swabian Alb. But only in the Wutach area a division into two parts is possible. In this area HAHN (1968) has distinguished a *retrocostatum* Zone in the Lagenalis-Bank and an *aspidoides* Zone in the Aspidoides-Oolith. The first mentioned zone is based on ammonites described by TORRENS (1965) in England and MANGOLD (1967) in France from this zone. Only two specimens of the index species *Prohcticoceras retrocostatum* have been found until today in Southwest Germany, one in the Upper Rhine Valley and the other one in the Aspidoides-Oolith (!) of the Wutach area. Two specimens of *Clydoniceras discus*, the index fossil of the uppermost zone of the Bathonian, were found by OPPEL (1857) and RIEBER (1961) in the top of the Aspidoides-Oolith. These two specimens of the Swabian Braunjura are no sure indication that the *discus* Zone is always included in the Aspidoides-Oolith. Perhaps this zone is absent in most parts of the Swabian Jurassic.

C a l l o v i a n

In whole Southwest Germany the lower Callovian begins with the Macrocephalus-Oolith following immediately above the Aspidoides-Oolith. The zone of *Macrocephalites macrocephalus* is extremely thick (21 meters) in the region of the Zollernalb and extends into the Anceps-Oolith (HAHN & KOERNER 1971). The *calloviense* Zone, which — according to MODEL (1935) — is believed to exist in the Ornaten-Ton

east of Reutlingen and to begin there only one meter above the upper limit of the Macrocephalus-Oolith, is absent in the region of the Zollernalb.

Near Balingen and in the Wutach area the whole middle Callovian and some parts of the upper Callovian are included in the condensed Anceps-Oolith (see also ZEISS 1955). HAHN & KOERNER (1971) did not find any ammonites of the middle Callovian in the region of the Zollernalb. Deposits of the *jason* Zone and the *coronatum* Zone seem to be condensed in the Anceps-Oolith and without any ammonites in this region. In other parts of the Swabian Alb at least *Kosmoceras jason* is very frequent. On the contrary *Erymnoceras coronatum* is always very rare. Near Blumberg an *Erymnoceras*-Bed is described by ZEISS (1955) within the Grenzkalk.

The lower part of the upper Callovian, the zone of *Peltoceras athleta*, is rich in ammonites and well developed in the whole region of the Swabian Braunjura. But the index species *Peltoceras athleta* seems to be very rare or absent. Neither PRIESER (1937), ZEISS (1955), nor HAHN & KOERNER (1971) mention *Peltoceras athleta*. On the contrary the index species of the *lamberti* Zone, *Quenstedtoceras lamberti*, is widely distributed in the Swabian Jurassic. In the Zollernalb area *Quenstedtoceras lamberti* occurs already 6 meters below the Lamberti-Knollenlage in the Ornatenton (HAHN & KOERNER 1971).

Oxfordian

The first Oxfordian ammonites of the genus *Cardioceras* appear in the top horizon of the Lamberti-Knollenlage. These Cardioceratids are typical for the *cordatum* Zone. The *mariae* Zone below seems to be absent in the Swabian Braunjura. In the glauconitic, sandy marls above the Lamberti-Knollenlage also Cardioceratids occur. Because of their bad preservation they do not give indications to which zone they belong. The *Euaspidoceras perarmatum* found by HAHN & KOERNER (1971, 137) in this horizon indicates, that the Braunjura includes at least still parts of the *plicatilis* Zone (middle Oxfordian).

4.2. Klettgau

The chronology of the Middle Jurassic of the Klettgau is not treated here, because it is similar to that one of the Wutach region.

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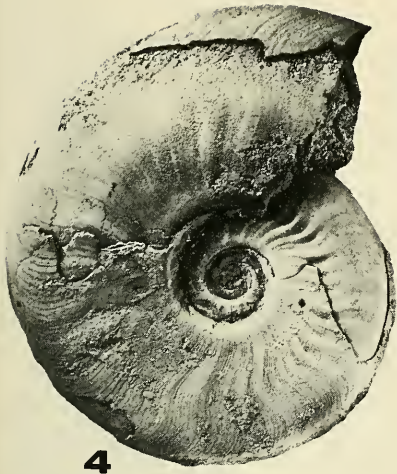
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Plate 1

- Fig. 1. *Lytoceras* (*Pachylitoceras*) *torulosum* (ZIETEN). Braunjura α , lower „Opalinus-Ton“, *opalinum* Zone; Ottenbach. Staatl. Mus. f. Naturk. Stuttgart, no. 21348. — x 1.
- Fig. 2. *Leioceras opalinum* (REINECKE). Braunjura α , „Opalinus-Ton“, *opalinum* Zone; Dürrwangen. Staatl. Mus. f. Naturk. Stuttgart, no. 23040. — x 1.
- Fig. 3. *Tmetoceras scissum* (BENECKE). Braunjura α , upper „Opalinus-Ton“, *opalinum* Zone; Grünbach. Staatl. Mus. f. Naturk. Stuttgart, no. 18859. — x 1.
- Fig. 4. *Leioceras comptum* (REINECKE). Braunjura β , *murchisonae* Zone; Weilen u. d. R. Staatl. Mus. f. Naturk. Stuttgart, no. 23045. — x 1.
- Fig. 5. *Staufenia* (*Costileioceras*) *sinon* (BAYLE). Braunjura β , „Unteres Flöz“, *murchisonae* Zone; Aalen-Wasseraltingen. Staatl. Mus. f. Naturk. Stuttgart, no. 23044. — x 2/3.
- Fig. 6. *Staufenia* (*Staufenia*) *staufensis* (OPPEL). Braunjura β , *murchisonae* Zone; Achdorf/Wutach. Staatl. Mus. f. Naturk. Stuttgart, no. 23042. — x 2/3.



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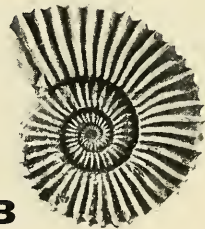
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Plate 2

- Fig. 1. *Ludwigia (Brasilia) bradfordensis* (S. BUCKMAN). Braunjura β , „Oberes Flöz“, *murchisonae* Zone; Aalen-Wasseralfingen. Staatl. Mus. f. Naturk. Stuttgart, no. 20374. — x 2/3.
- Fig. 2. *Ludwigia (Ludwigia) murchisonae* (SOWERBY). Braunjura β , *murchisonae* Zone; Weilen u. d. R. Staatl. Mus. f. Naturk. Stuttgart, no. 23043. — x 1.
- Fig. 3. *Staufenia (Ancolioceras) opalinoides* (MAYER). Braunjura β , „Unteres Flöz“, *murchisonae* Zone; Aalen-Wasseralfingen. Staatl. Mus. f. Naturk. Stuttgart, no. 23140. — x 1.
- Fig. 4. *Poecilomorphus boweri* (BUCKMAN). Braunjura β , *concauum* Zone; Balgheim. Staatl. Mus. f. Naturk. Stuttgart, no. 23154. — x 1.
- Fig. 5. *Graphoceras concauum* (SOWERBY). Braunjura β , *concauum* Zone; Metzingen. After RIEBER 1963, pl. 7, fig. 16, Geolog.-Paläont. Inst. Univ. Tübingen, no. Ce 1211/60. — x 1.

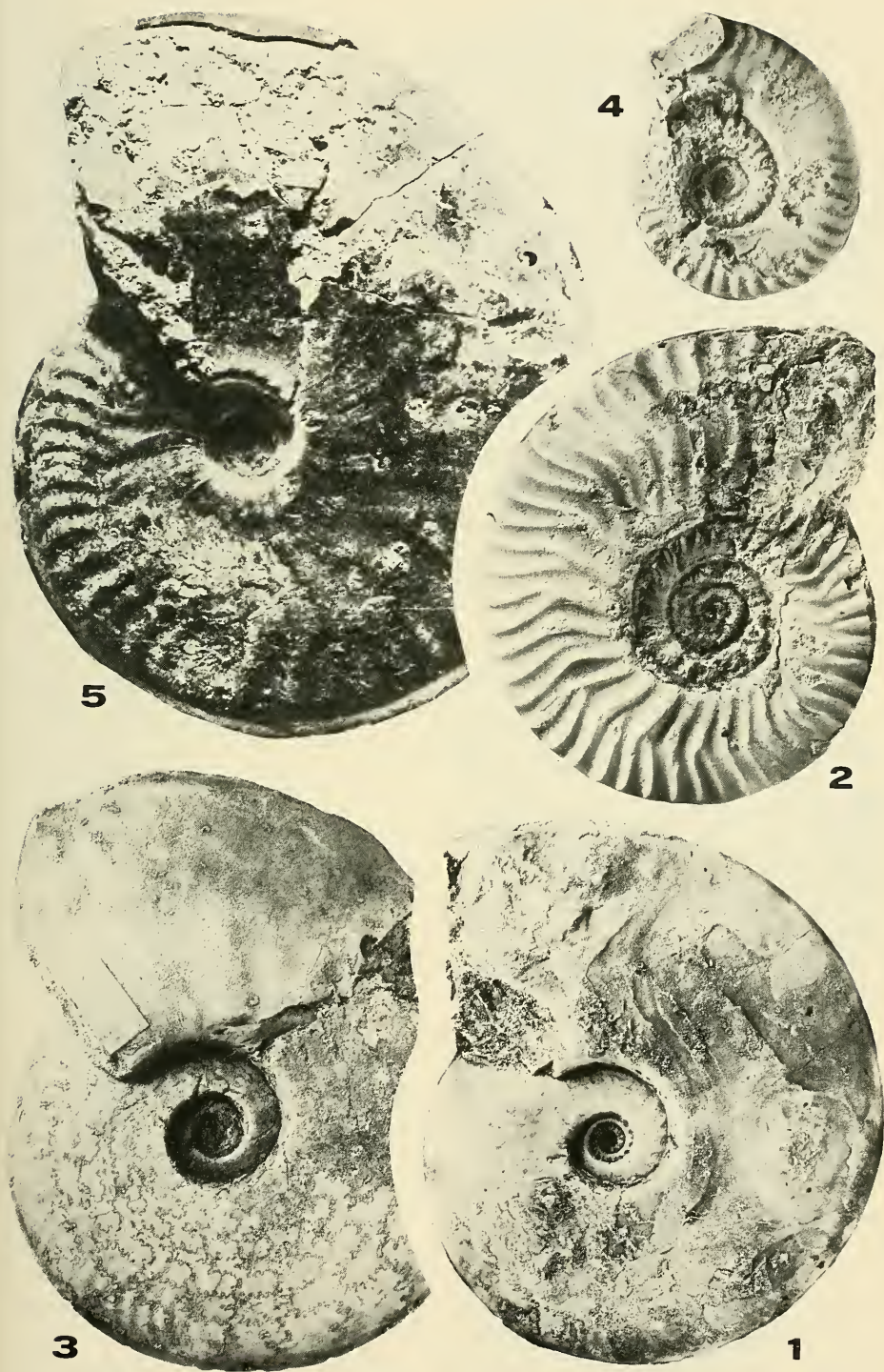


Plate 3

- Fig. 1. *Hyperlioceras discites* (WAAGEN) (inner worl). Braunjura β/γ , „Discites-Schichten“, *discites* Zone; Eschach/Wutach. Staatl. Mus. f. Naturk. Stuttgart, no. 20725. — x 1.
- Fig. 2. *Sonninia* („*Fissiloboceras*“) *ovalis* (QUENSTEDT). Braunjura γ , „Sowerbyi-Oolith“, *laeviuscula* Zone; Staufenek. Orig. DORN 1935: *Dorsetensia liostraca* (pl. 27, fig. 1). Staatl. Mus. f. Naturk. Stuttgart. — x 1/2.
- Fig. 3. „*Sonninia*“ *patella* (WAAGEN). Braunjura γ , „Blaukalk“, *sauzei* Zone; Laufen a. d. Eyach. Staatl. Mus. f. Naturk. Stuttgart, no. 5864. — x 1/2.
- Fig. 4. *Emileia polyschides* (WAAGEN). Braunjura γ , „Blaukalk“, *sauzei* Zone; Eningen unter Achalm. Staatl. Mus. f. Naturk. Stuttgart, no. 10028. — x 1/2.
- Fig. 5. *Otoites pauper* (WESTERMANN). Braunjura γ , „Blaukalk“, *sauzei* Zone; Balzholz. Staatl. Mus. f. Naturk. Stuttgart, no. 18976. — x 1.

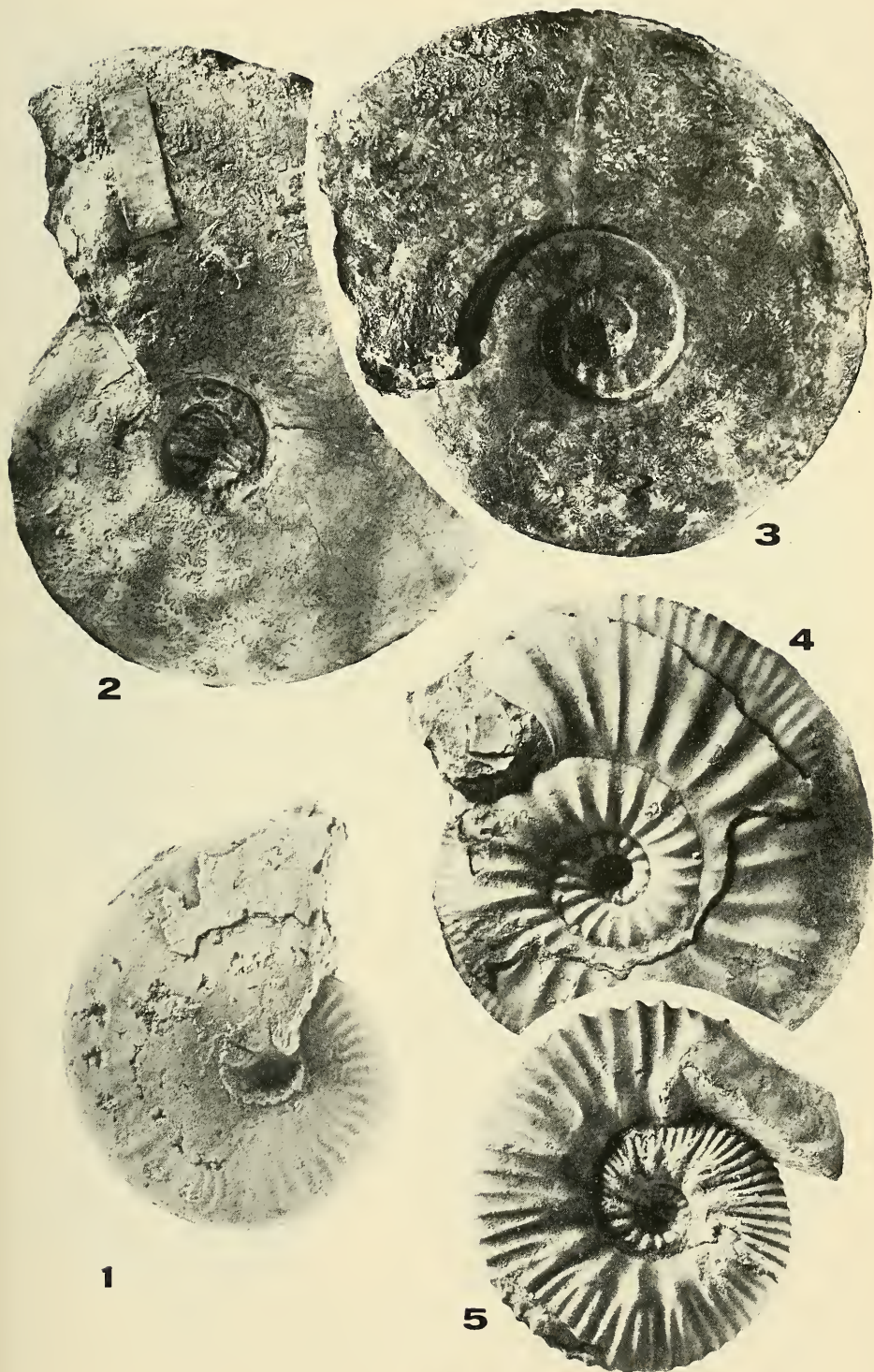


Plate 4

- Fig. 1. *Dorsetensia deltafalcata* (QUENSTEDT). Braunjura δ , „Giganteus-Ton“, *humphriesianum* Zone; Oeschingen; Staatl. Mus. f. Naturk. Stuttgart, no. 23050. — x 1.
- Fig. 2. *Stephanoceras nodosum* (QUENSTEDT). Braunjura δ , „Humphriesianum-Oolith“, *humphriesianum* Zone; Lautlingen. Staatl. Mus. f. Naturk. Stuttgart, no. 20695. — x 2/3.
- Fig. 3. *Teloceras sparsinodum* (QUENSTEDT). Braunjura δ , „Blagdeni-Schicht“, *humphriesianum* Zone; Beuren. Staatl. Mus. f. Naturk. Stuttgart, no. 23049. — x 2/3.
- Fig. 4. *Strenoceras subfurcatum* (SCHLOTHEIM). Braunjura δ , „Subfurcatum-Oolith“, *subfurcatum* Zone; Hohenstaufen. Staatl. Mus. f. Naturk. Stuttgart, no. 23051. — x 1.
- Fig. 5. *Spiroceras orbignyi* (BAUG. & S.). Braunjura δ , „Hamiten-Ton“, *subfurcatum* Zone; Eningen unter Achalm. Orig. QUENSTEDT 1856, pl. 55, fig. 3. Geolog.-Paläont. Inst. Univ. Tübingen, no. Ce 4/55/3. — x 1.
- Fig. 6. *Garantiana (Pseudogarantiana) dichotoma* BENTZ. Braunjura δ , „Subfurcatum-Oolith“, *garantiana* Zone; Oberdorf a. Ip. Staatl. Mus. f. Naturk. Stuttgart, no. 23052. — x 1.
- Fig. 7. *Garantiana (Orthogarantiana) schroederi* BENTZ. Braunjura δ , „Subfurcatum-Oolith“, *subfurcatum* Zone; Streichen. Staatl. Mus. f. Naturk. Stuttgart, no. 23047. — x 1.



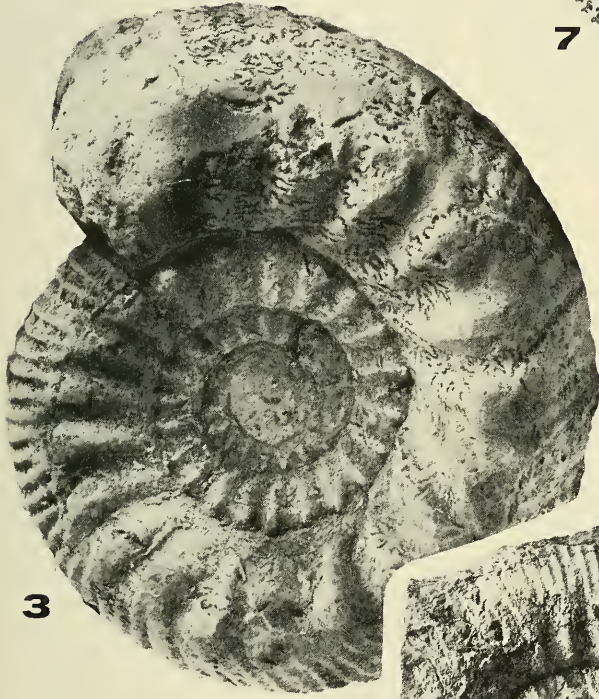
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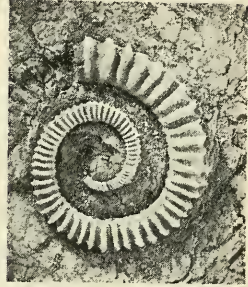
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Plate 5

- Fig. 1. *Parkinsonia* (*Parkinsonia*) cf. *parkinsoni* (SOWERBY). Braunjura ε , „Parkinsoni-Oolith“, *parkinsoni* Zone; Oberdorf a. Ipf. Staatl. Mus. f. Naturk. Stuttgart, no. 21801. — x 2/3.
- Fig. 2. *Zigzagiceras euryodos* (F. A. SCHMIDT). Braunjura ε , „Dentalien-Ton“, *zigzag* Zone; Beuren. Orig. HAHN 1969, pl. 2, fig. 4. Staatl. Mus. f. Naturk. Stuttgart, no. 21023. — x 1.
- Fig. 3. *Parkinsonia* (*Oraniceras*) *württembergica* (OPPEL). Braunjura ε , „Württembergica-Schichten“, *zigzag* Zone; Pffeffingen. Orig. HAHN 1970, pl. 3, fig. 4. Staatl. Mus. f. Naturk. Stuttgart, no. 21036. — x 1.
- Fig. 4. *Morphoceras macrescens* (S. BUCKMAN). Braunjura ε , „Württembergica-Schichten“, *zigzag* Zone; Lochen b. Balingen. Orig. HAHN 1970, pl. 5, fig. 13. Staatl. Mus. f. Naturk. Stuttgart, no. 21054. — x 1.
- Fig. 5. *Oxycerites yeovilensis* ROLLIER. Braunjura ε , „Parkinsoni-Oolith“, *zigzag* Zone; Oberdorf a. Ipf. Staatl. Mus. f. Naturk. Stuttgart, no. 21793. — x 1.
- Fig. 6. *Asphinctites tenuiplicatus* (BRAUNS). Braunjura ε , „Parkinsoni-Oolith“, *zigzag* Zone; Oberdorf a. Ipf. Orig. HAHN 1970, pl. 7, fig. 2. Staatl. Mus. f. Naturk. Stuttgart, no. 21050. — x 1.

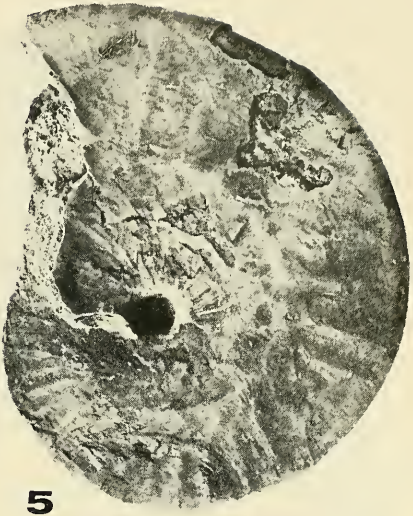
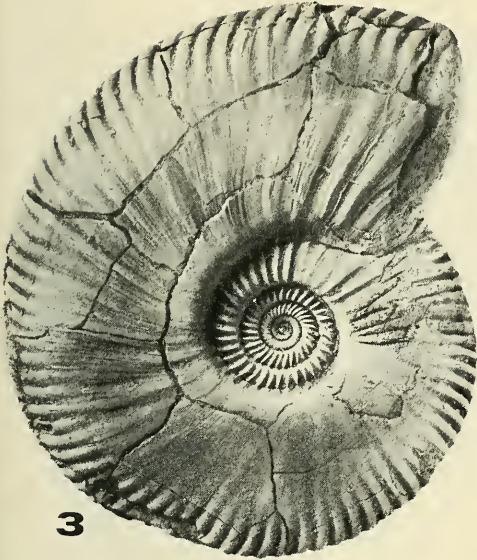


Plate 6

- Fig. 1. *Oecotraustes (Paroecotraustes) fuscus* (QUENSTEDT). Braunjura ε , Lower Bathonian; Oberdorf. Staatl. Mus. f. Naturk. Stuttgart, no. 23153. — x 1.
- Fig. 2. *Wagnericeras suspensum* (S. BUCKMAN). Braunjura ε , Middle Bathonian; Oberdorf a. Ipf. Staatl. Mus. f. Naturk. Stuttgart, no. 15097. — x 2/3.
- Fig. 3. *Oxyerites aspidoides* (OPPEL). Braunjura ε , „Aspidoides-Oolith“, *aspidoides* Zone; Blumberg. Staatl. Mus. f. Naturk. Stuttgart, no. 23054. — x 2/3.
- Fig. 4. *Bullatimorphites bullatus* (D'ORBIGNY). Braunjura ε , ? „Aspidoides-Oolith“, Upper Bathonian; Zollern. Staatl. Mus. f. Naturk. Stuttgart, no. 23055. — x 2/3.
- Fig. 5. *Macrocephalites macrocephalus* (SCHLOTHEIM). Braunjura ε , „Macrocephalus-Oolith“, *macrocephalus* Zone; Blumberg. Staatl. Mus. f. Naturk. Stuttgart, no. 22824. — x 1/2.

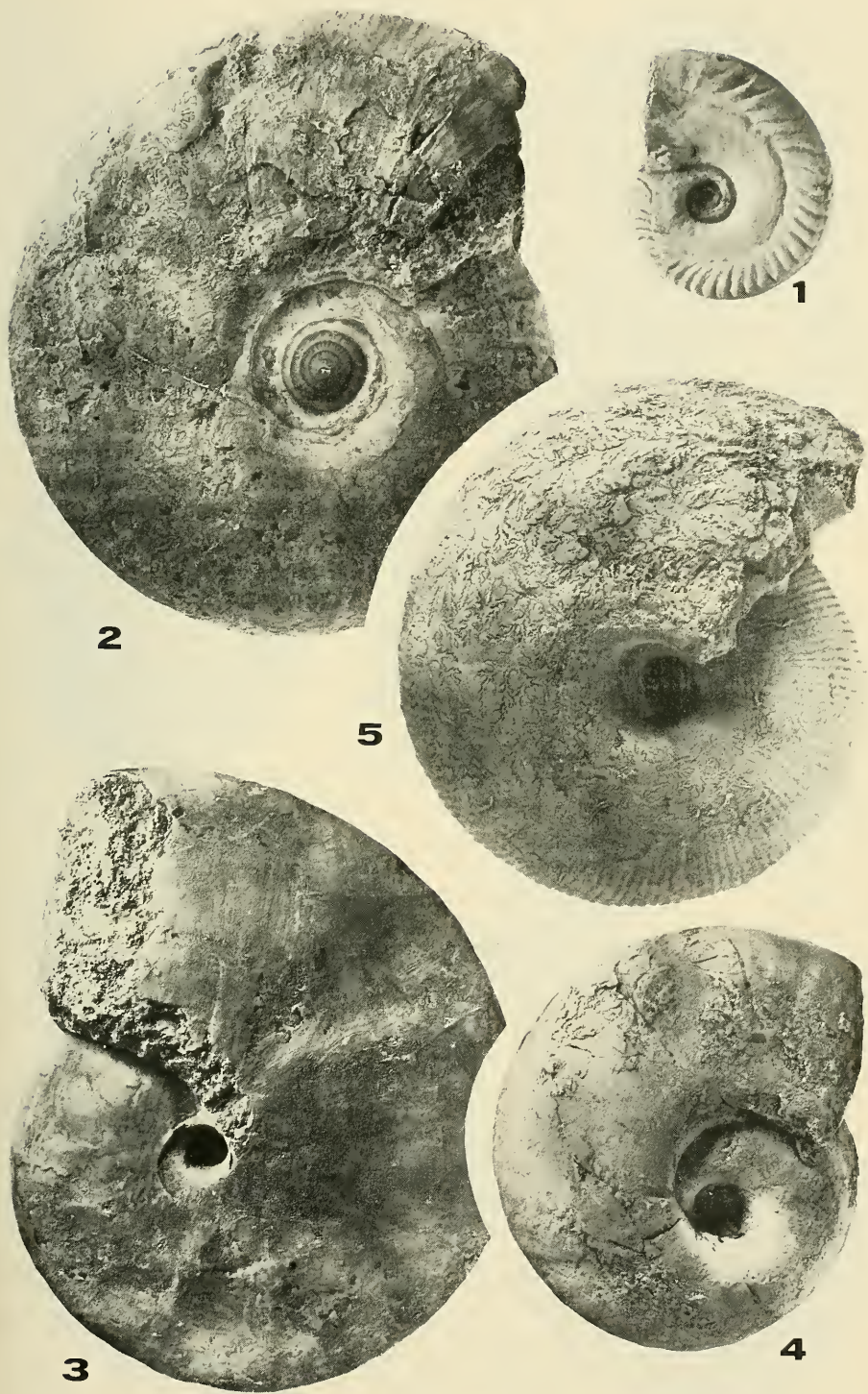
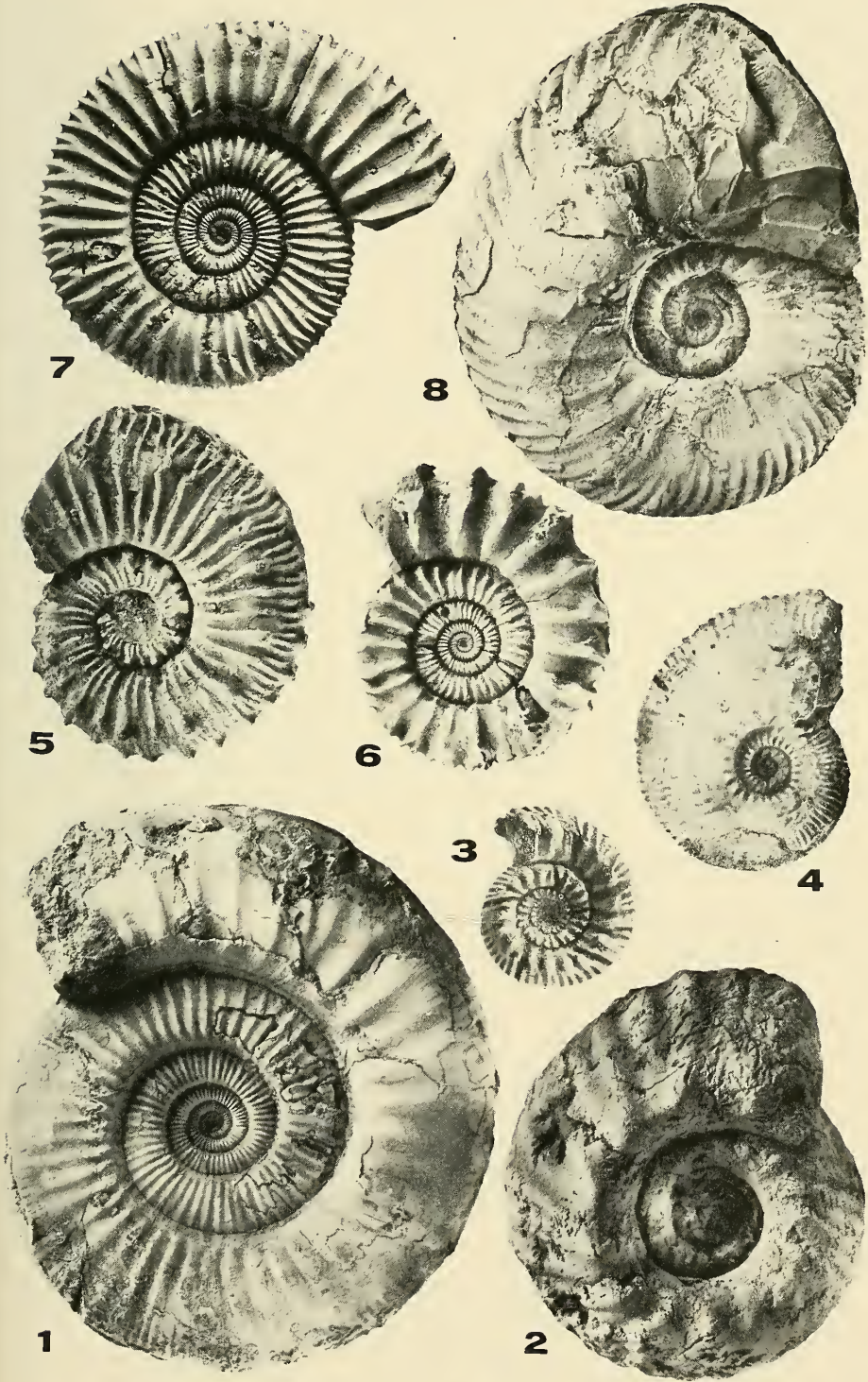


Plate 7

- Fig. 1. *Homoeoplanulites* (*Homoeoplanulites*) aff. *balinensis* (NEUMAYR). Braunjura ϵ , „Macrocephalus-Oolith“, Lower Callovian; Pfeffingen. Staatl. Mus. f. Naturk. Stuttgart, no. 23057. — $\times 2/3$.
- Fig. 2. *Erymnoceras coronatum* (D'ORBIGNY). Braunjura ζ , *coronatum* Zone; Bopfingen. Staatl. Mus. f. Naturk. Stuttgart, no. 20709. — $\times 1$.
- Fig. 3. *Reineckeia anceps* (REINECKE) (inner worl). Braunjura ζ , „Ornaten-Ton“, Middle Callovian; Oberalfingen. Staatl. Mus. f. Naturk. Stuttgart, no. 23058. — $\times 1$.
- Fig. 4. *Kosmoceras* (*Zugokosmoceras*) *jason* (REINECKE) (inner worl). Braunjura ζ , „Ornaten-Ton“, Middle Callovian; Boll. Staatl. Mus. f. Naturk. Stuttgart, no. 23060. — $\times 1$.
- Fig. 5. *Kosmoceras* (*Kosmoceras*) *spinulosum* (SOWERBY). Braunjura ζ , „Ornaten-Ton“, Upper Callovian; Laufen a. d. Eyach. Staatl. Mus. f. Naturk. Stuttgart, no. 23065. — $\times 1$.
- Fig. 6. *Peltoceras trifidum* (QUENSTEDT). Braunjura ζ , „Ornaten-Ton“, *athleta* Zone; Gammelshausen. Staatl. Mus. f. Naturk. Stuttgart, no. 23062. — $\times 1$.
- Fig. 7. *Peltoceras annulosum* (QUENSTEDT). Braunjura ζ , „Ornaten-Ton“, Upper Callovian; Gruibingen. Staatl. Mus. f. Naturk. Stuttgart, no. 23061. — $\times 1$.
- Fig. 8. *Quenstedtoceras lamberti* (SOWERBY). Braunjura ζ , „Lamberti-Knollen-Schicht“, *lamberti* Zone; Eningen unter Achalm. Staatl. Mus. f. Naturk. Stuttgart, no. 20732. — $\times 1$.



Weilburg	Malm	Stages	Zones	Subzones according to: BROUWER (1966) (HAYEN 1969) HAYEN (1969) PARSONS (1974), RIEDEL (1963, 1977) REE (1963, 1977) (* own results first mentioned herein)	Subzones of the Middle Jurassic in Germany proposed by WATKINS (1967) MAASS (1967)	
		Oxfordian				
B a u r n j u r a	C a l l o v i a n		<i>(vicatilis)</i> (3)			
			<i>(cordatum)</i> (1)			
			<i>(lauberti)</i> <i>(altilata)</i>			
			<i>(coronatum)</i>		<i>(obduratorum)</i>	
	B a t h o n i a n		<i>(sironi)</i>			<i>(enodatum)</i> <i>(callovitense)</i> <i>(loewigi)</i>
			<i>(callovitense)</i>			<i>(kamptus)</i>
			<i>(macrocephalus)</i>			<i>(macrocephalus)</i>
			<i>(discus)</i> (2)			<i>(aspidoides)</i> <i>(paradoxus)</i> <i>(dissecositas)</i>
			<i>(aspidoides)</i>			
			<i>(retrocostatum)</i>			
			<i>(morrisi)</i>			
			<i>(subcontractus)</i>			
			<i>(progracilis)</i>			
			<i>(zigzag)</i> (4)	<i>(tenophilus)</i> <i>(yeovlensis)</i> <i>(macrescens)</i>		
	B a j e c i a n		<i>(parkinsoni)</i>			<i>(frederici angusti)</i> <i>(parkinsoni)</i>
			<i>(acris)</i>			<i>(acris)</i>
			<i>(garantiana)</i>			<i>(seragona)</i> <i>(garantiana)</i>
			<i>(dichotoma)</i>			<i>(dichotoma)</i>
		<i>(subfucatum)</i>	<i>(bucinata)</i> (*) <i>(polygyris)</i> (*) <i>(blagdeni)</i>		<i>(sturoceti)</i> <i>(subfucatum)</i> <i>(phanta)</i>	
		<i>(humphreysianum)</i>	<i>(sironi)</i> <i>(pinguis)</i>		<i>(humphreysianum)</i> <i>(amblicum)</i> <i>(fredi)</i>	
		<i>(fianzei)</i>				
		<i>(laeviuscula)</i>	<i>(laeviuscula)</i>		<i>(laeviuscula)</i> <i>(polyschides)</i>	
		<i>(disctes)</i>	<i>(ovalis)</i>		<i>(sowerbyi)</i> <i>(disctes)</i>	
		<i>(concavum)</i>				
A a l e m a n		<i>(murdisonae)</i>	<i>(bradfjordensis)</i> <i>(discoida)</i> <i>(selindense)</i> <i>(sironi)</i>		<i>(bradfjordensis)</i> <i>(stansensis)</i> <i>(discoida)</i> <i>(selindense)</i>	
		<i>(opalinum)</i>	<i>(comptum)</i> <i>(opalinum)</i>		<i>(comptum)</i> <i>(opalinum)</i> <i>(beyridi)</i>	

Tab 1 Zones and subzones of the Braunjura in Southwest Germany (along the Swabian Alb, Würtach area, Klettgau).
 In brackets the zone only based on the ammonite assemblage (the index species is rare or missing).
 Without brackets the index species in wellknown in Southwest Germany.
 (1) non-sequence representing the *murrae* Zone.
 (2) only two specimens are known of the index species but within the highly condensed Aspidoides-Oolith.
 (3) the Braunjura includes at least parts of the *pluatilis* Zone.
 (4) according to HAYEN (1969) *Zigzagoceras zigzag* is the junior synonym to *Z. curvifolius*, which is very frequent in the Swabian Braunjura.

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