BIO-AND LITHOSTRATIGRAPHIC STUDY ON THE LOWER KIMMERIDGIAN OF THE SWABIAN AND FRANCONIAN ALB (GERMANY)

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Abstract. Correlation between Lower Kimmeridgian marly Lacunosamergel Formation of Swabia and the limestone-dominated Arzberg Formation of Franconia was recently carried out successfully. Correlation difficulties in the past were encountered in the Hypselocyclum Zone and in the Divisum Zone ("Baldcrum-Bank"). Base and top of the Hypselocyclum Zone, sensu Atrops: the Hippolytense Subzone and Perayensis horizon respectively, were correlated with numerous finds of Cymaceras guembeli (Oppel) on the base, and Ardescia perayensis Atrops on the top throughout Franconia and Swabia.

Introduction

The Upper Jurassic rocks of the Swabian Alb and the Franconian Alb covers an area of about 400 km in length and averages 30-40 km in width in S Germany (Fig. 1). Both regions are geographically divided in three parts each. The Swabian Alb in a Western, Central and Eastern and the Franconian Alb in a Northern, Central and Southern Alb (Fig. 1). In recent years the deposits of the Lower Kimmeridgian, Quenstedt’s "Weissjura γ", now renamed in Swabia as "Lacunosamergel-Formation" (Lm-Fm), were studied in more than 70 outcrops and quarries of the two neighbouring Albs. A large number of sections were recorded, accompanied with a bed-by-bed collection of ammonites. The study was carried out in the so called "Bankfazies", not in the siliceous sponge facies. Some of the results will be presented herein.

Lower Kimmeridgian rocks of the Lacunosamergel-Formation of the Swabian Alb vary in thickness from approx. 20 m to 70 m. In the Central Swabian Alb thickness is highest, whereas in the W Alb merely 20 m and in the E Swabian Alb 35 m are recorded. These beds consist mainly of marlstones with intercalated marly limestones, slightly nodular, and a few bedsets of more densely packed limestones (Geyer & Gwinner 1984).

Lower Kimmeridgian rocks of the Franconian Alb, there called "Malm γ", mount up to a maximum of approx. 30-35 (40) m in the N Alb, where marly facies dominates. Fazies and its stacking pattern are similar to those in the Swabian Alb. An even further increase in thickness in the "Dornig-Formation", of the northernmost Franconian Alb, is doubtful and, until now, not well documented (Hegenberger & Schirmer 1967; Freyberg 1967).
A major change of facies occurs in the Central and S Franconian Alb. Sedimentary rock consists mainly of thickly bedded limestones, slightly marly, with either thinly intercalated or completely missing marlstones. The series of evenly bedded limestones covers vast areas. It can be traced over tens of kilometres without much changing its facies or thickness. These limestone sections are interrupted at the base by the marly, 4-5 m thick "Platynota-Mergel", and in the upper third by the intercalated "Cruscoliensis-Mergel", measuring 1-2 m (Fig. 2). Thickness in the S Alb reaches up to approx. 28-32 m, whereas in the Central Franconian Alb thickness of the Malm y averages ~ 3-5 m less; it may even be reduced below 20 m (Kaulich et al. 2000; Meyer & Schmidt-Kaler 1992, 1995).

A reference section for the Lm-Fm has been established in the Central Swabian Alb, at the "Hausener Wand", nearby Hausen (Schick 1996). This marlstone-dominated section has a thickness of approx. 54-56 m (Fig. 2). About 12 m of the uppermost section is supplemented by a partial section of a nearby outcrop opposite the village of Drackenstein, because at the Hausener Wand this upper region is either not exposed or consists of spongiolithic limestones. The stacking pattern of this stratotype section houses a series of beds, bedsets and parasequences, which reflect most likely climatic changes ("Milankovitch-cycles"). These "Sedimentary Cycles" ("SC") allows a detailed subdivision, helping to improve resolution of the lithological framework (Fig. 2).

Former lithological frameworks, introduced by Aldinger (1945) and Geyer (1961a), are also shown in Fig. 2. Their resolution allows a rough orientation in the field, but is not high enough for detailed correlations. In fact, their subdivision centered around three major limestone-dominated "SC", such as "γ 1k", "γ 3k" and "γ 3b" (sensu Geyer). The central, marly dominated part (γ 3 of Aldinger), representing about 50% of the total thickness of the section, was regarded as not divisible by these authors. This means that the upper half of the Platynota Zone plus the entire Hypselocyclam Zone had no "bench marks". Ammonites collected in these beds

Reference section for the Lacunosamergel Formation (Lm-Fm) of the Swabian Alb

Fig. 1 - Upper Jurassic outcrops of the Swabian and Franconian Alb. Location map—underlined outcrops are mentioned in the text. Dotted lines mark geographic boundaries.

Fig. 2 - Complete Lower Kimmeridgian sections of Arzberg, (S Franconian Alb) and Hausen, (Central Swabian Alb), showing the different zonal schemes, lithological subdivisions and sedimentary cycles of Aldinger (1945), Atrops (1982), Geyer (1961a), Schick (1996), Schmidt-Kaler (1962), Zeiss (1977).
have had no "home address", they could not be traced back to a certain bedset, because no lithological subdivision existed. This deficiency does not exist any more thanks to the new subdivision. Most of these Sedimentary Cycles can be followed and correlated throughout the Swabian and N Franconian Alb from the Hypselocyclum Zone on upward (Fig. 2). Some flooding surfaces, e.g. such as the one atop the parasequence "γ 3k", allow even long-distance correlations, beyond Swabian and Franconian Alb and beyond the adjacent N Switzerland, down to the outcrops of the Ardèche region in SE France.

**Historical aspects of the recent zonal schemes**

The zonal scheme of the Lower Kimmeridgian, nowadays in use as a standard zonation of the Submediterranean Domain, was proposed by Geyer (1961a) to be employed in S Germany for the deposits of the Swabian and Franconian Alb. In the first place it was an attempt to combine litho- and biostratigraphic aspects. The problem was that the lithofacies of the Central Swabian Alb, where this scheme was established, is entirely different from that in the Central and S Franconian Alb (see above). This means that only the two calcareous sedimentary cycles of γ 1k and γ 3k could be correlated. As a result, the lithological concept of Geyer's scheme was hence not suitable for the application for most of the Franconian Lower Kimmeridgian deposits — and likewise for the westernmost part of the Swabian Alb too.

**Lithological framework for the Central and Southern Franconian Alb**

Amongst others, Streim (1961), Schmidt-Kale (1962) and Freyberg (1962) published various section of the Upper Jurassic of the Central and Southern Francconian Alb. Schmidt-Kale's subdivisions of Lower Kimmeridgian rocks considered primarily the lithological changes and secondarily the fossil content (see Fig. 2). Thus he integrated the marlstone-bedset with their natural boundaries in his framework-chart, producing a threefold subdivision too: γ 1 = "Platynota-Mergel", γ 2 = "Ataxioceraten-Schichten" and γ 3 = "Crussoliensis-Uhländi Schichten", which are ideally suitable for this region. The only problem was that they did not match the γ 1, γ 2, γ 3 of Geyer. None of these boundaries were coincidental, except the one at the base of γ 1, which also marks the Base of the Platynota Zone with the first occurrence datum.

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**Fig. 3** - Partial sections from Arzberg (S Franconian Alb) and Geisingen/Donau (W Swabian Alb), indicating the distribution of Aspidoceras (P.) uhlandi, Idoceras baldernum, Ardescia perayensis within the Divisum Zone.
of *Sutneria platynota* (Reinecke) (FOD) in the so called "Ammonitenbreccie". Until recently in SW Germany the Lower Kimmeridgian deposits of the two Albs were subdivided in three sections each, using the same abbreviations $\gamma 1$, $\gamma 2$, $\gamma 3$, but meaning partially different beds and bedsets. The *Platynota* Zone here was not identical with the *Platynota* Zone there.

Biostatigraphic research in the Central and S Franconian Alb was also carried out by the above mentioned authors, about forty years ago. Streim (1961) had investigated in detail the $\gamma 3$ = Divisum Zone, plus parts of the "Treuchtlinger Marmor" in the Arzberg region. Schmidt-Kaler (1962) had sampled the "Treuchtlinger Marmor" (*Mutabilis* and *Endoxus Zones*) in the surroundings of Treuchtlingen. Schairer (1967, 1974) had studied the "Platynota-Mergel" in quarries of the Southern and Central Franconian Alb. His work revealed, amongst other results, that the total vertical occurrence of *Sutneria platynota*, the TRZ (Taxon Range Zone), was almost identical with the lithological unit of the "Platynota-Mergel", with a FOD in the "Ammonitenbreccie", and a last occurrence datum (LOD) just ~ 0.5 m below the more calcareous "Ataxioceraten-Schichten". Streim (1961) had accomplished the same results years before in Arzberg. Unfortunately, no one has studied in detail the *Hypselocyclum* Zone recently. Previous information is based on the work by Wegele (1929-1930) and Schneid (1939-1940, 1944), with the disadvantage that their described ammonite fauna was not collected "bed-by-bed".

### The relevance of studies outside SW Germany

Further research in the Lower Kimmeridgian deposits was done e.g. in France and Spain, resulting in the zonal charts by Atrops (1982) and Olóriz (1978), which had a direct impact on the studies here. Atrops (1982) took over the standard zonal scheme from Geyer (1961a, b) for the Lower Kimmeridgian in SE France and subdivided the three existing *Platynota, Hypselocyclum* and *Divisum Zones* furthermore to subzones and faunal horizons. The result was a shift in zonal boundaries too (Fig. 4).

The application of the zonation of Atrops (1982) in SW-Germany was not done in detail before. Doing so it reveals some corresponding and differing aspects in the Swabian and Franconian Alb. For example, the *Platynota* Zone sensu Atrops is a TRZ, therefore it has identical boundaries with the one in Franconia, but there is no conformity with the upper boundary in Swabia. Geyer (1961a) had laid the upper boundary of his *Platynota* Zone in a bed with a *Platynota* acme, once proposed by Veit (1936), and not above the LOD of *S. platynota*, hence its position lays several metres below (Fig. 2).

The same applies for the upper boundary of the *Hypselocyclum* Zone of Atrops, which is almost identical with the vertical extension of the $\gamma 2$ = "Ataxioceraten-Mergel" in Franconia, whereas in Swabia the boundary of Atrops lays several metres higher than the boundary introduced by Geyer (1961a). Geyer has laid his *Hypselocyclum-Divisum* boundary at the base of $\gamma 3k$, and Atrops (1982) lays it just above it. The best way out of all the

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**Fig. 4** - Zonal scheme of the Lower Kimmeridgian of the Ardèche region, SE France, Swabian and Franconian Albs, SW Germany and Zona Sub-berica, S Spain. Stippled frames contain the newly introduced zonal elements to the SW German Upper Jurassic.
zonation differences is to apply the Platynota and Hypselocyclum zonation sensu Atrops (1982) in SW Germany, because it serves best the lithological reality and the biostratigraphical data from Franconia and Swabia. Doing so, the Division Zone has to be defined newly, because the first occurrence of Crussolliceras divisum (Quenstedt) in Swabia lays even below the base of γ 3k.

Some further changes in the zonal scheme

The introduction of the Guembeli horizon

One of the problems in the search of unified boundaries can be solved by introducing the faunal horizon of Cymaceras guembeli in S Germany. In the sections of the Central Swabian Alb there is this prominent sedimentary cycle, named “D”, which occurs approx. one third up in the marly, central part of the section. The basal layer of “D” is more calcareous as the following layers and varies in thickness between 25 and 40 cm (Fig. 2). This distinctive sedimentary cycle and its prominent basal bed can be followed throughout the entire Franconian and Swabian Alb, only in the westernmost part of the W Alb it can not be traced. It has an erosive base and yields a considerable amount of ammonite fragments. Completely preserved specimens are rather rare. It contains reworked material, mostly of the subgenus Ardescia Atrops, 1982.

This basal layer represents not only a sedimentary transition between the most marly interval of the section and a more calcareous one, it also contains ammonites with changing ribbing-pattern. There is a change from tripartite and/or polygyrate ribbing into the polyplocoid pattern which means a transition from the genera Orthosphinctes/ Ardescia to Ataxioceras/Parataxioceras sensu Atrops (1982). This transitional fauna is not easy to determine, hence this work is only partly done so fare. But in the undetermined part of the fauna some specimens can be determined as Parataxioceras hibipolytense Atrops and Schmida lussasense Atrops, Ardescia inconditum (Fontannes) and Parataxioceras pseudooffrenatum (Wegele). Some of these ammonites mark the beginning of the Hippolytense Subzone within the Hypselocyclum Zone. Two layers above, Taramellliceras (Metabaploiceras) strombecki (Oppel) and Parataxioceras ex gr. lotbari (Oppel) are located. M. strombecki is another important guide fossil in the Mediterranean and Submediterranean realms. Kärve-Corvinus (1966) used it as an index fossil for her Strombecki Zone.

In the marly intercalation above the basal layer of the Sedimentary Cycle “D”, and in the following bed, the dimorph pair of Cymaceras (Cymaceras) guembeli (Oppel, 1863) and Cymaceras (Trachiskioceras) bidentosum (Quenstedt, 1857) has been located. Formerly, regarded as one of the rarest finds in the entire Swbian and Franconian Alb, it is nowadays found by the hundreds, thus the position of this “Cymaceras bed” is precisely known to collectors. When Oppel first described Ammonites guembeli in 1863, he could observe only 6 specimens altogether, which were collected in Franconian and Swabian Alb and N Switzerland. Wegele (1930) had still a small number of 31 specimens to work with, and Ziegler (1979) ~ 10 specimens of (Trachiskioceras) bidentosum. Latel Schlampp (1999) has collected about 400 specimens of Cymaceras exclusively in this one locality of Mantlack (Central Franconian Alb).

Not only the number of finds has increased, th knowledge of its geographical distribution also. Finds beyond the “classical region” of N Switzerland and S Germany are recorded as well. Geyer (1959) mentions a Cy maceras (?) guembeli find in Slovakia which is reported b Rakus (1959). Wendt (1971) found C. guembeli in Sicily: The knowledge of its exact stratigraphical position has gained on precision with the increasing number of out crops and careful sampling. Formerly, this was not very clear. Finds from the Platynota and from the Hypseloclum Zone were reported likewise. Thanks to the work of Schairer & Schlampp (1991, 2000), Schlampp (1998; 1991) and Gradl & Schairer (1997) in recent years, its stratigraphical position in the lowest Hypselocyclum Zone has been confirmed. I have found this dimorph pair over the past years in 12 different localities in the SA and Fi with its FOD always at the same position as described above, and never in the Platynota Zone.

The vertical range of Cymaceras may vary from a few centimetres to 20-30 cm, and the LOD lies very rarely up to ~ 60 cm above the FOD. Some of the find are seen in Plate I, Figs. 5-8. Trachiskioceras bidentosum bears lappets, if the specimen is complete, and is hence regarded as the microconch. It grows up to a size of about 10-12 mm (see Pl. 1, Fig. 2). From the macroconch o Cymaceras 3 species are distinguished: C. guembeli (Oppel, 1863), C. perundatum Wegele, 1930 and C. franziska Schairer, 1991. Their size can reach approx. 35 mm (P. 2, figs. 1, 3, 4).

Plate I

Fig. 1, 3, 4: Cymaceras (Cymaceras) guembeli, in different growth stages, showing intraspecific variations.
Fig. 2: Cymaceras (Trachiskioceras) guembeli. All specimens were collected in the Guembeli horizon at the Hausener Wann (Central Swabian Alb).
Fig. 5-8: Orthosphinctes (Ardescia) perayensis Atrops, 1982. Th Perayensis horizon of the W Swabian Alb yielded the shown specimen.
Fig. 5: microconch, D = 40 mm, Geisingen/D.; Fig. 6: macroconch, D = 80 mm; Fig. 7: D = 55, most likely macroconch; Fig. 8: likely macroconch, D = 45. All specimens (Fig. 1-8) housed at the SMNS (Stuttgart).
It was Veit (1936), who proposed for the first time, to use Cymaceras as an index fossil in the Lower Kimmeridgian. The present knowledge on Cymaceras and its wide geographical distribution justifies the introduction of the Guembeli horizon.

The advantage of the Guembeli horizon is obvious, this index fossil is easy to determine, amongst the Ataxioceratina in transition, it is of limited vertical range, and it is quite common at least in SW Germany.

The confirmation of the Perayensis horizon in S Germany

Orthosphinctes (Ardescia) perayensis was chosen by Atrops (1982, p. 115) as an index fossil for his Perayensis horizon in SW Franc. It represents the uppermost horizon of the Hypselocyclum Zone. This small ammonite bears lappets and is therefore regarded as a microconch. In size it ranges between 40 and 50 mm in diameter (see Plate 1, figs. 5,6,7). Ardescia perayensis was encountered by Atrops also in S Germany in a few outcrops. In many outcrops of the Swabian Alb it is very abundant. It occurs on top of Sedimentary Cycle γ 3k, which is the thickest marly limestone bedset within the Lower Kimmeridgian of the Swabian Alb, a true parasequence sensu Kamola & van Wagener (1995). In Franconia this ammonite is not too frequent, but in the N Alb it occurs already in the marlstone bed intercalating γ 3k and the thicker bed above. In the Central and S Franconian Alb it appears in an identical position, although no intercalating marlstone beds separate the thinly bedded, slightly marly limestones atop γ 3k. Ardescia perayensis is also found in the Lower Kimmeridgian of N Poland (Matyja & Wierzbowski 2000). It supports there the correlation between the lowermost part of the Mutabilis Zone of the Boreal realm sensu Birkelund et al. (1983) and the uppermost part of the Hypselocyclum Zone of the Submediterranean realm sensu Atrops (1982).

Not too often one finds a microconch with its lappets (Pl. 1, fig. 5). Adult macroconchs are even rarer. I have collected various specimens of macroconchs in the W Swabian Alb at Geisingen and Mahlstetten. Unfortunately not one single specimen bears an undamaged body chamber (Pl. 1, fig. 6, D = 80 mm). The Perayensis horizon in Swabia is often condensed. It also yields echnoids, brachiopods, belemnoids, pelecypods, etc., and a great number of other ammonite genera too, such as: Terebrites, Taramelliceras, Glochiceras, Creniceras, Prorasenia, Eurasenia, Nebrodites, Crussoliceras, Garniersphinctes, Aspidoceras. This remarkable bed, the present Perayensis horizon, was already known to famous Swabian geologists/paleontologists in the 19th Century: Quenstedt, Engel, Fraas and others, under the name „Monotisbank“. Note: at certain spots the Monotisbank may yield mass occurrences of the bivalve Aulacomyella similis (formerly named Monotis similis).

The Subzone of Aspidoceras uhlandi and the horizon of Idoceras balderum

Notes on Orthaspidoceras uhlandi versus Pseudbimalayites uhlandi. Schweiger (1997, p. 8) explains plausibly that the type species of the genus Orthaspidoceras (Ammonites orthocera d’Orbigny) is an ammonite which possesses a row of large tubercles near the umbilicus, but no ribs at all. The morphological features of Aspidoceras uhlandi are quite different. A. uhlandi bears pronounced ribs and a row of lateral tubercles on the flanks, hence it belongs to a rib-bearing group of Aspidoceras. Schweiger suggests the genus Pseu dhimalayites Spath, 1925.

Idoceras balderum occurs in Swabia within the Divisum Zone in a prominent limestone bed or bedset called “Balderum-Bank” or “Balderum-Bänke” (BB). Its vertical range is rather limited, less than one metre. It appears in relative abundance in an acme in the upper part of the BB, but it can also be found a few decimetres below and/or above, in the “Balderum-Twin-Bank” (BTB) (Fig. 2, 3). These two outstanding bedsets, above the “Crussoliensis-Mergel”, can be followed throughout the Swabian Alb. Hence the index fossil I. balderum and the two bedsets are of outstanding correlation value. A few other genera, mostly fragmented, occur with the dominating I. balderum: Steroblites, Glochiceras, Cremiceras, Crussoliceras, Garniersphinctes, Aspidoceras.

In Franconia, especially in the Central and S Alb, where the majority of bedsets consists of densely packed limestones, the BB and BTB is not easy to detect. Furthermore the index fossil is rare. This lack of I. balderum finds made not only the correlation with the adjacent Swabian Alb difficult, but also within the Franconian Alb itself.

Yet, another index fossil was frequently found in these beds in question in Franconia: Aspidoceras (Pseudhimalayites) uhlandi. In Swabia it is the contrary, this species was not found too often in the Central Swabian Alb, where most of the research has been done. A. uhlandi finds were reported from below and within the Balderum-Bank, but never above (Oppel 1863, p. 225; Haizmann 1902, p. 513; Veit, 1936, p. 91; Aldinger 1945, p. 131; Zeiss 1964, p. 112). This “fact” has led in Franconia to the misleading conclusion that the LAD of Idoceras balderum and Aspidoceras uhlandi are coincidental. This idea was published by Streim (1961, p. 11) who had not succeeded in finding I. balderum in his Arzberg section. The relative frequency of A. uhlandi in Franconia and the lack of I. balderum finds there had made A. uhlandi to be employed as a stratigraphical “substitute” of I. balderum.

To prove his statement, Streim (1961, p. 11) employed the bed-by-bed correlation. He was convinced that his bed “371” could be correlated to the E Ries area, in the S Franconian Alb, some 70 kilometres to the West. There, in the presumed equal bed, had Weber (1941) encountered I. balderum. First doubts of this correlation practice was uttered by Herrle (1979) who had encountered several I. balderum beds, and the appropriate index fossil to it, in the N Franconian Alb (Thurnau), Central Franconian Alb.
Checa A. (1985) - Los Aspidoceratiformes en Europa (Ammonites balderum)


Gigy & Persoz (1986, tab. 2) better understood: therein this deduction is not only based on the /4, but also on more finds of Idoceras balderum in Franconian quarries, including the Arzberg quarry, the stratotype locality of the Arzberg Formation. For the distribution of these index fossils see Fig. 3.

The present knowledge about the distribution of these two important species Aspidoceras ublandi and Idoceras ashbalderum within the Divisum Zone in S Germany enables long-distance correlation to southern Spain. There, Olóriz (1978) has described the same situation concerning the vertical distribution of A. ublandi and I. balderum: Olóriz has distinguished a Ublandi Subzone within the Divisum Zone and in the middle of this subzone the Balderum horizon is placed. The stratigraphical distribution of A. ublandi in this region is also reported by Checa (1985), Olóriz & Rodríguez-Tovar (1993), Caracuel et al. (1998) and others.

To some extent the enlarged occurrence of A. ublandi in Swabia makes now the zonal chart of Switzerland by Gigg & Persoz (1986, tab. 2) better understood: therein the Ublandi subchron is positioned above the Balderum subchron, which means no ublandi finds were made there below the balderum horizon until now.

Conclusions

The influence of the Mediterranean Domain is clearly notable in SW Germany. The distributions of major index fossils are alike. Hence the concept of the Mediterranean zonal chart of the Divisum Zone of Olóriz (1978) can be applied also for the Swabian and Franconian Alb, since the chart of Atrops (1982) embraces ± Platynota and Hypselocyclum Zone, and not the deposits in between Perayensis horizon and Idoceras balderum bed and the layers above.

The detailed zonal chart of the Platynota Zone and Hypselocyclum Zone of Atrops (1982) can also be employed in SW Germany, but further research is necessary, for example, above the Ublandi subzone a diverse Progeronia and Discosphinctoides fauna is encountered. The exact occurrence of the Nebrodities and Mesosimoceras fauna in the SW should also be studied.

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