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# The Valanginian to Aptian stages – current definitions and outstanding problems

Compiled by

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With 3 tables

## ABSTRACT

Current definitions of the Valanginian to Aptian Stages are reviewed and some of the outstanding problems outlined. Final recommendations on stage boundaries can be made only after much more stratigraphical work has been completed, as the eventual boundaries must have good international correlation potential. The Pre-Albian Stages Working Group is instigating study of selected sections in various parts of the world to provide an integrated framework of biostratigraphy and event stratigraphy.

## KURZFASSUNG

Ein Überblick über die gängigen Definitionen der Stufen vom Valangin bis zum Apt wird gegeben und einige wichtige Probleme hervorgehoben. Endgültige Empfehlungen zu Stufengrenzen sind z. Zt. noch nicht möglich. Dazu sind noch weitere stratigraphische Untersuchungen erforderlich, denn die festzulegenden Grenzen müssen international korrelierbar sein. Die Pre-Albian Stages Working Group regt an, ausgewählte Profile in verschiedenen Teilen der Welt zu untersuchen, um so den allgemeinen Rahmen für eine Neudefinition der Stufen auf der Grundlage der Biostratigraphie und der Event-Stratigraphie zu schaffen.

## 1. INTRODUCTION

This review has been compiled on behalf of the Pre-Albian Stages Working Group of the Subcommission on Cretaceous Stratigraphy. The primary role of the working group is to clarify, and to improve where necessary, the definition and boundaries of the Valanginian to Aptian Stages. This cannot be achieved simply by describing a stratotype and selecting boundaries because such a procedure takes no account of the international correlation potential of the stages so defined. Hence at its first meeting in Hannover in 1977 (see the group's Newsletter 2), the working group agreed on the following priorities:

1. "To establish inter-regional correlation more precisely than before, using all possible methods (macro- and microfossils, event stratigraphy, etc.)"
2. "As a result of more accurate correlation, to clarify (and if necessary to improve) the definition of stages and stage boundaries and to improve the usage of stage names in regions away from stratotype sections."

Thus our fundamental philosophy is first to make objective correlations between regions and only then to redefine stages and their boundaries.

As a first step towards priority 1, several key sections were identified in western Europe. At its second meeting (Münster 1978, see Newsletter 3), the group agreed to concentrate initially on investigating correlation of Hauterivian strata across Europe, in collaboration with the re-investigation of the Jura Hauterivian by a research group co-ordinated by Dr. J. Remane. It is intended that first results on the investigation of key sections will be given at a meeting of the Subcommission on Cretaceous Stratigraphy in Copenhagen in 1983. In the meantime it seems appropriate to summarise current definitions of the Valanginian to Aptian Stages and to demonstrate some of the outstanding problems. For the sake of using a common "language", we hope that fellow workers will continue to use stage names in the current sense (Table 1) until im-

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proved definitions are agreed. Specialists who insist on using them in a different sense are urged to explain their different usages.

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# II. EARLY CRETACEOUS BIOGEOGRAPHY AND THE STRATOTYPE AREAS

| STAGE | ZONE | |
|---|---|---|
| | FRANCE | ENGLAND/NORTH GERMANY |
| UPPER BARREMIAN | Colchidites sp.<br>Heteroceras astieri<br>Hemihoplites feraudi<br>"Emericiceras" barremense | Parancyloceras bidentatum & P. scalare<br>Simancyloceras stolleyi<br>"Ancyloceras" innexum & Simancyloceras pingue<br>Paracrioceras denckmanni |
| LOWER BARREMIAN | Moutoniceras sp.<br>Pulchellia compressissima<br>Spitidiscus hugii | Paracrioceras elegans<br>"Hoplocrioceras" fissicostatum<br>Paracrioceras raricostatum |
| UPPER HAUTERIVIAN | Pseudothurmannia angulicostata<br>Plesiospitidiscus ligatus<br>Subsaynella sayni | S. (C.) variabilis / S. (S.) marginatus → Simbirskites (Craspedodiscus) discofalcatus<br>S. (Craspedodiscus) gottschei<br>S. (Milanowskia) speetonensis/staffi |
| LOWER HAUTERIVIAN | Lyticoceras nodosoplicatus<br>Olcostephanus jeannoti<br>Crioceratites loryi<br>Acanthodiscus radiatus | Simbirskites (Speetoniceras) inversum<br>Endemoceras regale<br>Endemoceras noricum<br>Endemoceras amblygonium |
| UPPER VALANGINIAN | Neocomites (Teschenites) callidiscus<br>Himantoceras trinodosum<br>Saynoceras verrucosum | Olcostephanus spp.<br>Dicostella tuberculata<br>Dichotomites bidichotomoides<br>Dichotomites triptychoides<br>Dichotomites crassus<br>D. (Prodichotomites) polytomus<br>D. (Prodichotomites) hollwedensis |
| LOWER VALANGINIAN | Thurmanniceras campylotoxus<br>Thurmanniceras pertransiens<br>Thurmanniceras otopeta | Polyptychites sphaeroidalis<br>Polyptychites clarkei<br>Polyptychites multicostatus<br>Polyptychites pavlowi<br>Platylenticeras involutum<br>Platylenticeras heteropleurum<br>Platylenticeras robustum |

Table 1. Valanginian to Barremian standard zones of south-east France, and the approximate correlation with the north-west European "boreal" Valanginian and Hauterivian. (Correlation after Kemper et al., 1981). No correlation between Barremian zones is intended.

During the Early Cretaceous there were two distinct faunal realms in the northern hemisphere, the Tethyan and Boreal. It is difficult to attempt a global summary of Early Cretaceous biogeography because many taxonomic groups have not been investigated adequately, but KAUFFMAN (1979) has given a general review, and for bivalves (KAUFFMAN, 1973) and ammonites (RAWSON, 1981) subdivision of the realms can be attempted. Valanginian to Aptian biostratigraphy is based primarily on ammonites. As in the Tithonian and Berriasian, the Valanginian to earliest Barremian boreal ammonites are clearly distinct from Tethyan ones, but during most of the Barremian and Aptian there were no distinctively boreal subfamilies and in the rare marine sections the northerly faunas were only depauperated versions of the Tethyan ones.

The historical type areas of the Valanginian to Aptian Stages are in the Swiss Jura and south-east France, and are characterised predominantly by Tethyan ammonites. Thus the main problem in Early Cretaceous stage definition lies in trying to correlate with the Boreal Realm. Primary clues come from areas of faunal overlap (e. g. parts of Europe). The biostratigraphy of areas outside the type regions of the stages is beyond the scope of this paper, but in Table 1 we give the approximate correlation of the Valanginian to Barremian Tethyan zones with the north-west European "boreal" zones to illustrate the nature of the problem. The correlations achieved so far suggest that some of the classic stage boundaries are of no inter-regional correlative value and therefore need to be altered if they are to be equally applicable to both realms.

# III. DEFINITION OF STAGES

## THE VALANGINIAN STAGE

Author: DESOR 1854

Stratotype: The Seyon Gorge near Valangin, Neuchâtel, Switzerland.

Hypostratotype: Roadside section near Angles (Alpes-de-Haute Provence, south-east France); Barret-le-Bas (Hautes-Alpes, south-east France) provides a complementary reference for the Lower Valanginian (BUSNARDO et al., 1979).

Original definition: DESOR (1854, p. 175) regarded all the "Neocomian" beds beneath the "Marnes de Hauterive" as corresponding with Campiche's "Neocomien inférieur", and for this subdivision proposed (p. 177) the stage name "Valangien" ("Valanginien" in the title of the paper). Thus the Valanginian embraced all the post-Jurassic rocks to the base of the "Marnes de Hauterive".

There are three important points to note with reference to the definition of the boundary between the Valanginian and Hauterivian Stages:

1. In terms of local lithostratigraphic units, DESOR's definition is very vague. He indicated (p. 174) that the "calcaires jaunes à *Ammonites astierianus*" lay beneath the "marnes bleues de Haute-Rive" and hence by defining the Valanginian stage to include all the units beneath the "marnes de Hauterive" apparently implied that beds containing "*Ammonites astierianus*" (= *Olcostephanus)* were Valanginian. Unfortunately it is impossible to decide whether the "calcaires jaunes à *Ammonites astierianus*" are equivalent to the "Marnes à *Astieria*" (= "*Astieriamergel*"), a critical bed at the Valanginian-Hauterivian boundary which was first described by DE TRIBOLET (1859). Hence one cannot say how far the phrase "un étage à part, inférieur aux marnes de Hauterive" (DESOR, 1854, p. 175) has to be taken literally.
2. The first clear definition of the Valanginian was only given by DESOR and GRESSLY (1859, p. 40). From top to bottom, the stage was intended to include:

a) La limonite ou calcaire ferrugineux
(= "calcaire roux" in actual usage)
b) Le calcaire compact ou marbre bâtard.
c) Les marnes et brèches marneuses grises et bitumineuses.

The "Marnes à *Astieria*" were explicitly placed in the "Neocomian" (which became the Hauterivian of RENEVIER, 1874) by DESOR and GRESSLY (1859, p. 36).
It is also interesting to note that the first detailed description of the succession at the type locality did not appear until the end of the century (BAUMBERGER and MOULIN, 1899).

3. Logically, RENEVIER therefore included the "Marnes à *Astieria*" in his Hauterivian Stage. It is only since BAUMBERGER (1901, p. 21) that it has become general usage to place them in the Valanginian.

Development of the concept of the Valanginian Stage: The early Cretaceous sediments of the Jura Mountains accumulated on a shallow shelf. Some lithological units are thin, condensed and laterally discontinuous, especially those lying between the "Calcaire Roux" and the "Marnes de Hauterive". Early biostratigraphic correlation was based primarily on echinoids, and ammonites are generally rare. This, coupled with the incompleteness of the sequence, means that both the Valanginian and the Hauterivian stratotypes have a very limited correlation potential. Because of the rarity of ammonites KILIAN and other French workers preferred to define both stages according to the succession of ammonite zones established in the vocontian facies of south-east France. It should be noted that KILIAN paid little attention to the correlation between the French zones and the original stratotype successions when drawing his boundaries.

In 1871, COQUAND proposed the Berriasian for the limestones of Berrias, regarding it as a substage for the lower part of the Valanginian. LORY (1898) and PAQUIER (1900) then restricted the Valanginian to exclude the Berriasian and recognised lower and upper divisions of the restricted Valanginian. KILIAN (1910) reverted to an extended Valanginian, his lower Valanginian corresponding to the Berriasian and his middle Valanginian to the lower Valanginian of LORY and PAQUIER. A similar tripartite division was applied in north Germany (e. g. STOLLEY, 1925).

Mainly because of MAZENOT's (1939) work, the Berriasian began to be used as a stage, and this was ratified by the 1963

Lyon colloquium, when the overlying Valanginian was divided into:

| substage | zone |
|---|---|
| Upper Valanginian | *Saynoceras verrucosum* |
| Lower Valanginian | *Kilianella roubaudiana* |

At the Colloquium, the principle of establishing a new stratotype in the vocontian facies was approved. A hypostratotype was formally proposed in 1979 by Busnardo et al. The Angles section and a complementary section for the Lower Valanginian at Barret-le-Bas were measured and sampled bed-by-bed and the ranges of ammonites, belemnites, ostracods, nannofossils, calpionellids and foraminifera were established. Some new zones were proposed (Table 2). The ammonite zones proposed by Busnardo and Thieuloy (in Busnardo et al., 1979) represent the culmination of many years of work on all the main French sections and are traceable across the whole vocontian trough. The zones (Tables 1, 2) are assemblage biozones, in which the index species reached its acme within the nominate zone. Some of the zones have been recognised in Tunisia (Memmi, 1981) but still require testing in other Tethyan areas.

Base of the Valanginian: The boundary between the Berriasian and the Valanginian has been placed between the *boissieri* and *roubaudiana* Zones since these were introduced by Kilian (1888). The base of the Valanginian was effectively marked by the appearance of *Kilianella*. The palaeontological boundary was believed to coincide with the lithological boundary between the "Calcaires de Berrias" and the "Marnes valanginiennes". However, Le Hegarat (1965) showed that the highest part of the "Calcaires de Berrias" contained a distinctive early Valanginian fauna, for which he later (in Le Hegarat and Remane, 1968) introduced the *pertransiens* Subzone. This subzone has priority over the *lucensis* Zone, introduced by Wiedmann (1968) for the same fauna in the same beds.

Le Hegarat (1973, p. 295) believed the faunal change from Berriasian to Valanginian was abrupt. However, Busnardo and Thieuloy (in Busnardo et al., 1979) suggested that faunas of the lower part of Le Hegarat's *pertransiens* Subzone represented a mixture of Berriasian and Valanginian forms, generally poorly known species. This intermediate fauna between the "classic" Berriasian and Valanginian was known to Mazenot. For this fauna the *otopeta* Zone was proposed. The lower part of the overlying *pertransiens* Zone coincides with the remainder of Le Hegarat's *pertransiens* Subzone (see Busnardo and Thieuloy's table 3, p. 62). As the distinctive *Kilianella* species of the old *roubaudiana* Zone first appear within the *pertransiens* Zone, Busnardo and Thieuloy have effectively lowered the base of the Valanginian compared with previous definitions.

From the Caravaca region of south-east Spain, Hoedemaeker (1982) has proposed a subzone of *Tirnovella alpillensis*, which he correlates with the *callisto* Subzone of Le Hegarat and Remane (1968). However, while the French *callisto* Subzone contains Berriasian ammonites, its Spanish equivalent contains Valanginian forms too, and thus Hoedemaeker places the *alpillensis* Subzone in the Valanginian. If the correlations are correct, this would suggest that the French *callisto* Subzone should be placed in the Valanginian.

While further work is clearly required, neither definition allows the base of the Valanginian to be recognised in the Boreal Realm. In the West European Province the first appearance of *Platylenticeras* is taken to mark the base of the Valanginian (Kemper, 1973), because early species occur also in France, at approximately the base of the old *roubaudiana* Zone. In the modern zonation this horizon is at about the base of the *pertransiens* Zone, and thus the *otopeta* Zone may correlate with the highest Ryazanian of the boreal sequence.

Base of the Upper Valanginian: The old *Saynoceras verrucosum* Zone spanned the whole of the Upper Valanginian. However, Moullade and Thieuloy (1967) showed that the index species had a very short range, and restricted the zone to embrace only the lowest part of the Upper Valanginian. The sudden appearance of *Saynoceras verrucosum* and

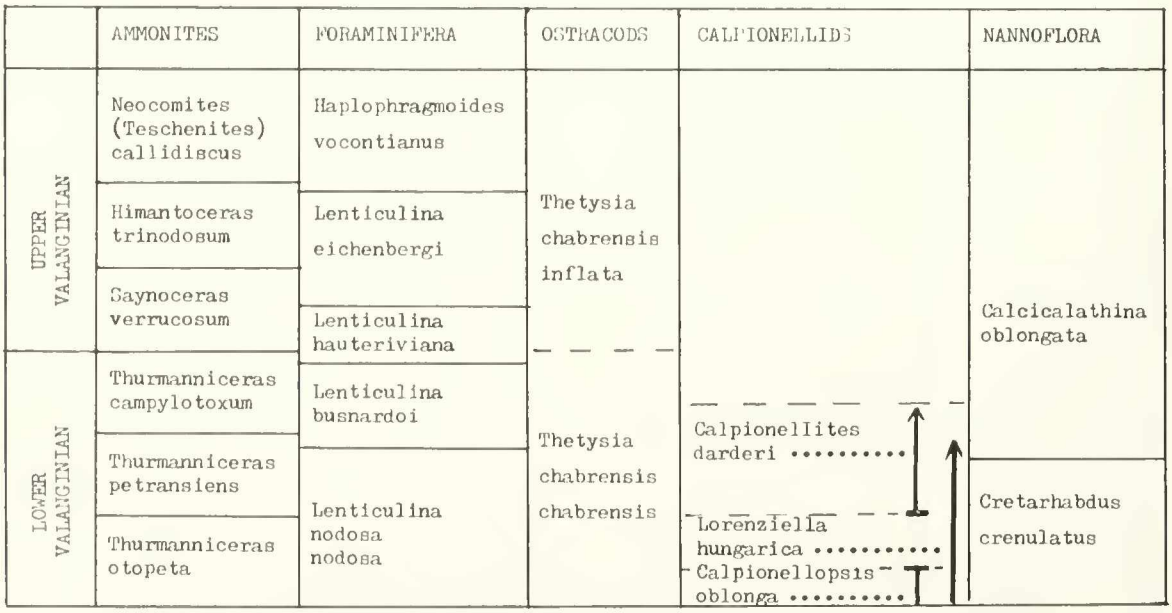


Table 2. Biostratigraphic subdivision of the French Valanginian (after Busnardo et al., 1979).

some associated species (e. g. *Valanginites nucleus, Neohoploceras submartini* and *Karakaschiceras* spp.) in north-west Europe marks a major faunal migration horizon (and transgression) which can be traced in the Polish Furrow, north Germany and eastern England (Kemper, Rawson and Thieuloy, 1981, p. 259). The same fauna occurs also in Tunisia (Memmi, 1981).

## THE HAUTERIVIAN STAGE

Author: Renevier 1874.

Stratotype: "Hauterive" (actually in Neuchâtel), Switzerland.

Original definition: Renevier included the "marnes à *Astieria*", the "marnes bleue de Hauterive" and the "Pierre Jaune de Neuchâtel".

Discussion: By including the "Marnes à *Astieria*" (= "Astieriamergel") in the Hauterivian Stage, Renevier placed the base of the Hauterivian to agree with Desor and Gressly's (1859) definition of the top of the Valanginian (see Valanginian discussion, above).

Development of the concept of the Hauterivian Stage: For reasons discussed above (see "Valanginian Stage") the Hauterivian of the type area proved to be of limited correlation potential. Hence Kilian and others again turned to the French sequence for a better standard, and here proposed four ammonite zones. The lowest was that of *Acanthodiscus radiatus,* which most subsequent workers (including Baumberger) accepted as marking the lowest Hauterivian. However, in the Jura *A. radiatus* occurs in the "Marnes de Hauterive" but not in the "Marnes à *Astieria*" beneath. Thus common usage has modified the Valanginian/Hauterivian boundary as defined by Renevier. It should also be noted that in the French scheme the Hauterivian Stage was extended upwards so that both the "Marnes de Hauterive" and the "Pierre jaune" are now Early Hauterivian.

Thieuloy (in Moullade and Thieuloy, 1967) has modified the zonation of the French successions (see Table 1), though further revision is in progress (by Busnardo and Thieuloy) and the sequence has still to be described in detail. No hypostratotype section has been described. Debelmas and Thieuloy (1965) recommended that one should be chosen in the Salérans region (Hautes-Alpes), but Thieuloy (herein) now believes that this alone would not be sufficient: several sections are useful, including La Charce, Sallerans, Barrème and Castellane.

The base of the Hauterivian: Thieuloy (1977, p. 125) has formally defined the base of the *radiatus* Zone at La Charce as the base of the Hauterivian. The base of the *radiatus* Zone itself is defined by the first appearance of *Acanthodiscus*. The use of *A. radiatus* as a zone fossil has been criticised because it is so rare in the vocontian facies, but despite this it is very useful because it allows an inter-realm correlation. Early Hauterivian strata are poorly known in the Boreal Realm (Rawson, 1981) but occur in north-west Europe. In north Germany, rare *Acanthodiscus* occur near the base of the *Endemoceras* beds and hence these are placed conventionally in the Hauterivian. In theory, the lowest beds could be latest Valanginian, but the area of uncertainty is small.

The base of the Upper Hauterivian: The separation of the Hauterivian into two substages, defined by the disappearance of the Neocomitinae and the appearance of *Subsaynella sayni,* is very clear, especially in Ardèche where the hemipelagic sequence is very expanded (Busnardo, herein). Thus the base of the Upper Hauterivian is defined by the base of the *Subsaynella sayni* Zone.

The boreal Upper Hauterivian is characterised by *Simbirskites* (with several subgenera) which occurs from California and Arctic Canada to north-west Europe and the Soviet-Union. Faunal mixing in north-west Europe shows that the base of the Tethyan Upper Hauterivian correlates with the upper part of the *Simbirskites (Speetoniceras) inversum* Zone (Kemper et al., 1981, p. 307).

## THE BARREMIAN STAGE

Author: Coquand 1861.

Stratotype: Angles, Basses-Alpes, France (designated by Busnardo, 1965b).

Original definiton: Coquand proposed the stage for beds characterised by *"Belemnites minaret, Ammonites ligatus, Scaphites yvanni,* etc.". Angles was one of the cited localities.

Development of the concept of the Barremian Stage: Although Coquand's original definition was not very precise, Busnardo (1965a) pointed out that it embraces both the Barremian and Upper Hauterivian of current usage. Present usage effectively dates from Kilian's (1888) work on the montagne de Lure: Busnardo (1965b) summarised subsequent ideas and tabulated the evolution of zonal schemes. We agree with him that despite historical priority it is best in the interest of stability to follow customary usage and limit the Barremian in Kilian's sense.

Busnardo (1965b) designated the Angles roadside section as stratotype because it is complete, readily accessible, sufficiently rich in ammonites and tectonically undisturbed. It is part of the same long exposure that has been selected as hypostratotype of the Valanginian. Busnardo gave a detailed lithic log and ammonite ranges, retained Kilian's division into Lower and Upper Barremian and proposed a zone for each substage. He also suggested a subzonal scheme, though that was incomplete because of gaps in the faunal sequence. Busnardo (1965a, p. 115) regarded his work as a first step in achieving a geographically widespread zonation, and indicated the problem of selecting suitable zonal and subzonal indices. Recently he has put forward a more detailed zonation (Busnardo in Roger, 1980, table) which is shown, with slight modification (Busnardo, herein) in Table 1. The zonation has yet to be formally described.

Elsewhere in the Tethyan Realm, the best-known faunas are probably in Colombia, where a detailed pulchelliid zonation has been established, and the Barremian divided into "lower", "middle" and "upper". In the Boreal Realm, Barremian faunas occur mainly in north-west Europe, where they are represented predominantly by heteromorphs and, in the basal Barremian, by the last *Simbirskites.* Some of the heteromorphs may be identical with Tethyan species, other are

endemic. STOLLEY (1925) recognised a tripartite division into "lower", "middle" and "upper" and proposed a zonal scheme which has been modified only slightly since (see IMMEL, 1979, table 5).

The base of the Barremian: At the stratotype section the passage from Hauterivian to Barremian was hidden by fallen rock, though faunas can now be collected. Species of *Pulchellia*, *Holcodiscus* and *"Emericiceras"* (= *Paracrioceras*) have been used by various authors to define the lowest zone. At present, BUSNARDO (herein) takes the appearance of *Raspailiceras* and *Barremites* to mark the base of the stage, though this limit will be refined eventually. There is a slight overlap between these forms and the last representatives of *Pseudothurmannia* (especially *P.* gr. *edouardi*). *Spitidiscus* (gr. *kiliani-hugii*) and *Nicklesia* appear several beds higher in the sequence.

In the Boreal Realm, the base of the north-west European Barremian lies approximately at the base of the English *variabilis* Zone and in the middle of the German *discofalcatus* Zone (KEMPER et al., 1981, p. 307).

The base of the Upper Barremian: BUSNARDO (herein) defines the base of the Upper Barremian by the appearance of *Heinzia* and of *"Emericiceras"* of the *barremense* group. This limit differs slightly from that published in ROGER (1980, table). However, it remains difficult to define in the stratotype, for want of sufficiently numerous fossils.

## THE APTIAN STAGE

Author: D'ORBIGNY 1840.

Stratotypes: The stage was named after Apt (Vaucluse) in south-east France. However, there is no single stratotype section: La Bedoule, Gargas (near Apt) and Clansayes are all reference sections for subdivisions of the Aptian though not all are satisfactory for correlation purposes.

Original definition: The stage was proposed rather loosely for strata containing an "Upper Neocomian" fauna, but D'ORBIGNY later modified his definition several times.

Development of the concept of the Aptian Stage: FLANDRIN (1965) and MOULLADE, TAXY and TRONCHETTI (1980a) have summarised the history of interpretation of the Aptian Stage and its subdivisions in France, and CASEY (1961) reviewed its interpretation in other European areas too. The 1963 Lyon Colloquium adopted the following division of the French Aptian (ANONYMOUS, 1965):

| | | |
|---|---|---|
| Upper Aptian | Clansayesian | *Diadochoceras nodosocostatum* |
| | Gargasian | *Epicheloniceras subnodosocostatum*<br>*Aconeceras nisus* |
| Lower Aptian | Bedoulian | *Deshayesites deshayesi* |

MOULLADE et al. (1980a, p. 113) pointed out that in terms of both stratigraphical nomenclature and logic a division into Lower and Upper Aptian was less satisfactory than BREISTROFFER's (1947) tripartite division into Lower Aptian or Bedoulian, Middle Aptian or Gargasian and Upper Aptian or Clansayesian Substages.

The ammonite sequence in the French Aptian is still inadequately documented (see MOULLADE et al., 1980a) and at present the zonal division of the English (CASEY, 1961) and north German (KEMPER, 1976) sequences is much more detailed. Although there was still some faunal differentiation between the north-west European and French areas, it was not as well-

| | South-east France | Southern England | North Germany |
|---|---|---|---|
| UPPER APTIAN | Diadochoceras nodosocostatum | Hypacanthoplites jacobi | Hypacanthoplites jacobi |
| | | | Acanthohoplites nolani |
| | Epicheloniceras subnodosocostatum | Parahoplites nutfieldiensis | Parahoplites nutfieldiensis |
| | Aconeceras nisus | Epicheloniceras martinioides | Epicheloniceras tschernyschewi |
| | | | Tropaeum drewi |
| LOWER APTIAN | Deshayesites deshayesi | Tropaeum bowerbanki | Tropaeum bowerbanki |
| | | Deshayesites deshayesi | Deshayesites deshayesi |
| | | Deshayesites forbesi | |
| | | Prodeshayesites fissicostatus | Prodeshayesites tenuicostatus |

Table 3. Correlation of French, English and north German Aptian zonal schemes.

marked as earlier in the Cretaceous and broad correlation can be made (Table 3).

Rich ammonite faunas occur also in parts of the Soviet Union. Here, some recent workers have abandoned the long-established division into Lower and Upper Aptian in favour of a tripartite division.

The base of the Aptian: The appearance of the earliest deshayesitid ammonite, *Prodeshayesites*, marks the base of the north-west European Aptian, and this genus is now known from south-east France. It appears there immediately above latest Barremian *Colchidites*, as for example at La Bedoule (Busnardo, herein). Thus it appears to be a good marker over a wide area.

The Bedoulian "Substage": The Bedoulian was proposed by Toucas (1888) for the upper part of the limestones of La Bedoule, near Marseilles. The Lyon Colloquium recommended that the name be used in a broader sense, following Kilian (1907–13). Moullade, Taxy and Tronchetti (1980b) reviewed the sequence in the stratotype area, and a "Bedoulien" volume is to be published in the CNRS series "Les stratotypes français". This will include 7 ammonite zones, which can be correlated with Casey's (1961) English scheme. At present, only a single zone of *Deshayesites deshayesi* is recognised (Table 3).

The Gargasian "Substage": The Gargasian was proposed by Kilian (1887) for marls with *Aconeceras* near Gargas, but is now used in a more limited sense (see Moullade, 1980a). The Gargas section is of limited value for correlation and several sections have been investigated for selection as a parastratotype; nothing has yet been published (Moullade, 1980a, p. 122).

The Clansayesian "Substage": The Clansayesian was proposed by Breistroffer (1947) for about 5 metres of cross-bedded sands with beds of phosphatic nodules yielding a *Diadochoceras nodosocostatum* Zone fauna. Again the stratotype is poor, and a working group has chosen the Lioux section (Alpes-de-Haute-Provence) as a parastratotype though the decision is not yet published.

Moullade (1980b) has pointed out that of the three Aptian "substages" the Clansayesian is the thinnest and is often difficult to separate palaeontologically. It is thus often included in an enlarged Gargasian, or referred to informally as the "Clansayes horizon". At present the name is not used outside the south of France: in most other areas there is a two-fold division into Lower and Upper Aptian. Thus one of the outstanding problems to be resolved by the working group is whether the Clansayesian should be retained, and if so what status it should have.

## IV. CONCLUSIONS

Research over the last 150 years has resulted in a broad understanding of the world-wide distribution and correlation of rocks of Valanginian to Aptian age. For the stratotype areas of France and Switzerland the 1963 Lyon Colloquium (published 1965) summarised much useful information and stimulated further research, some now published. However, even in these areas few sections have been described in detail and most stage/substage boundaries are open to dispute. The present review shows a strong bias towards ammonite biostratigraphy because ammonites have been the main tools of correlation so far; yet many ammonite ranges are still poorly known and few other taxon ranges are adequately documented.

Most of the problems outlined in this brief review can be resolved only after much more field work. For the Valanginian Stage, and to some extent for the Barremian and Aptian Stages, detailed lithological/palaeontological logs have been produced for the stratotype sections, and these provide a starting point for the next phase of research. This will concentrate on:

1. Lithological/palaeontological logging of the remaining type sections.
2. Comparable logging of other key reference sections (some of which will serve as regional stratotypes) around the world.
3. Magnetostratigraphic logging of stratotypes and other key reference sections.
4. Chronostratigraphic logging of stratotypes and other key reference sections (O and C stable isotopes, rare elements, organic matter).
5. Search for radiometrically datable material in stratotypes and key reference sections.
6. Synthesis of all available data to provide:
   a) A definition of stage and substage boundaries that is valid for as broad an area as possible, ideally globally.
   b) A series of standard zonal schemes for individual faunal/floral regions.

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