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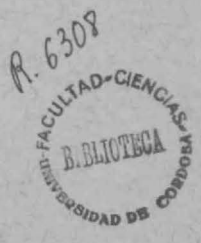

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THE BORMIDIAN STAGE AND THE BASE OF THE MIOCENE

ABSTRACT - The Bormidian Stage has a fauna of Zone N. 2 or late Zone N. 1 age near its base. The Aquitanian Stage type sections has a fauna of N. 4 age at its base. The type Rupelian appears to be almost entirely developed within Zone P. 19 and, by correlation *via* the Eochattian succession, the type Chattian may be developed within the interval of later Zone P. 19 and early Zone N. 1. The Eochattian succession at Doberg-bei-Bunde includes beds referable to latest Zone P. 19 and Zone N. 1 whilst the overying Neochattian succession includes beds referable to later Zone N. 1, Zone N. 2 and possibly Zone N. 3. However, the type Chattian is now thought to be entirely prior to most, if not all, of the Bormidian stratotype; it is certainly prior to that part of the stratotype subsequent to the base of Lorenz's bed 3 at Millesimo, Bormida. It is concluded that the Bormidian stage is not synonymous with either the Aquitanian or the Chattian.

Although the Bormidian probably covers much the same interval of time as the Neochattian, we recommend the use of the term Bormidian since this stage has priority of publication and yiedls less endemic faunas for world-wide correlation

INTRODUCTION

As a result of work by one of us (WHB) over the last decade into the stratigraphic distribution of planktonic foraminifera of the Cenozoic, a series of planktonic foraminiferal zones has been erected on the evidence of many land-based sections and many deep-sea core samples. The series of zones for the Neogene has been published in extract by BANNER & BLOW (1965) and the zones of the Oligocene have now been formally defined by BLOW in a paper presented to the « Planktonic Conference », Geneva, 1967. The planktonic foraminiferal zones erected by BLOW are being described in great detail in a large forthcoming work and it has

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been shown that these zones apply on a worldwide basis. Although the zones are most easily recognized in tropical and sub-tropical areas, the stratigraphical distribution of species of the Globigerinacea within them is now sufficiently clear to enable the zones to be distinguished, separately or severally in combination, in extra tropical localities such as Europe and New Zealand. BLOW's zonation has now been applied, in detail, to a study of many of the classical European and American stages. In this note we briefly record the results of studies of the distribution of planktonic foraminifera in the type Rupelian, Eochattian, Neochattian, Bormidian and Aquitanian strata of Europe. We also note that the Bormidian covers an interval of the geohistoric record which is represented in the interval of the later part of Zone N. 1, Zone N. 2 and Zone N. 3.

THE RUPELIAN

Our examination of material from the Boom Clay of Belgium and the Rupelton of the Mainz basin shows that the Rupelian is developed largely, if not entirely, within Zone P. 19. The lower part of the Boom Clay appears to be slightly subsequent to the base of Zone P. 19 and there is little doubt that a significant interval of time exists between the top of the Eocene (as currently undestood) and the horizon at the base of the Boom Clay. This interval is represented by Zone P. 18 (and probably the latest part of Zone P. 17) which is developed in the lower part of the Vicksburg Group of the U.S.A., in the marls of Lattorf and especially in the beds developed at Poudřany, Czechoslovakia. The Rupelian of Europe is, therefore, not to be considered as being « lowest Oligocene » and a significant biostratigraphic interval separates its base from the top of the Eocene in both Europe and America (Zone P. 18 and? part of Zone P. 17). On the other hand, the youngest horizons preserved in the Boom Clay and associated strata are also referable to Zone P. 19 so that from the record of the European stratotype the Rupelian consists only of one planktonic foraminiferal zone. In contradistinction to this, the Vicksburgian extends from Zone P. 18, throughout all of Zones P. 19 and N. 1. In passing we would say that perhaps the term « Vicksburgian » might be best employed in the stage terminology of the Oligocene.

THE CHATTIAN, EOCHATTIAN AND NEOCHATTIAN

The history and present knowledge of the type Chattian beds has been ably summarised by ANDERSON (1961). Association of the Kassel

Sands with the later part of the Rupelton dates back to BEYRICH's (1854) work but these beds are only the lower part of a complex of sands that outcrop mainly to the north and distinguished as the Eochattian and Neochattian. They also carry a fauna dominated by *Pecten spp.* On the molluscan faunas, all these beds can be divided into three horizons viz: A, B and C. At Doberg, intervals A and B have been called « Eochattian » and interval C called « Neochattian ». The total Eochattian-Neochattian sequence is believed to represent a significantly greater stratigraphic interval than that represented by the « Chattian » near Kassel; HUBACH (1957) suggested that the lower and middle parts of his unit *B* only (*i.e.*, the lower and middle parts of the Middle Eochattian) were equivalent to the Chattian of Kassel. When the pectenid faunas were revised by ANDERSON, that author abandoned HUBACH's biostratigraphical divisions and proposed that the sequence could be divided into three zones only: he named then « A », « B » and « C » (which are not to be confused with the *A, B, C,* etc., of HUBACH), as follows

Zone « C »: Zone of *Pecten semistriata*, with *P. hofmanni*
Zone « B »: Zone of *Chlamys hausmanni* (*s.s.*)
Zone « A »: Zone of *Pecten bifidus, C. decussata*, etc.

ANDERSON was only able to indicate that he thought the equivalents of the Kassel sands (Chattian stratotype) were *within* the interval of his Zone « A » of the Doberg Eochattian succession and, thus, could not further refine HUBACH's suggested correlation. ANDERSON included beds 1 to 26 (of HUBACH) in his Zone « A » so that on his correlation, the Chattian stratotype was equivalent to the Doberg succession only within these limits. However, HUBACH was more explicit suggesting that, approximately, beds 7 to 16 of the Doberg succession were equivalent to the stratotype Chattian at Kassel. These correlations were based on the occurrences of six pectinid species in common between Kassel and Doberg and disregarded the occurrences of othe molluscan and echinoid species. If HUBACH's correlations are taken as being unwarrantably too precise and that ANDERSON was being properly realistic in his boader, less explicit correlation, then an important biostratigraphical point becomes available for discussion. Thus, ANDERSON's Zone « A » is « open » at its lower part, there being no determinable biostratigraphic base to the « zone », since the whole of the lower Doberg succession from bed 1 upwards was ascribed to the « zone ». Further, bed 1 is the lowest bed ever to be exposed at Doberg and, thus, the lowest bed considered in the biostratigraphic recognition of the « zone ». Once this is realised, it becomes apparent that the Kassel sands of the type

Chattian could even be older than the theoretical extension of the isochron defined at the base of bed 1 of the Doberg succession.

As pointed out above, the highest biostratigraphical horizon so far recognized by us in the Boom clay of Belgium (Rupelian) is entirely within the interval of Zone P. 19, but the planktonic foraminiferal fauna, believed to come from a level below HUBACH's bed 10 of the Doberg Eochattian succession, is also referable to a horizon high in Zone P. 19. Therefore the type Chattian, on HUBACH's correlation, seems to occupy the interval of the latest parts of Zone P. 19 and the earlier parts of Zone N. 1 (=P. 20). On the other hand, it might well be that the Chattian does not extend above the top of Zone P. 19 and that Zone N. 1 (=P. 20) is entirely above the level of the top of the type Chattian. However, we are left with the conclusion that the Chattian does not extend above Zone N. 1 (=P. 20) for even the fauna of bed 26 seems to be referable to a horizon within the later parts of Zone N. 1 (=P. 20). We must emphasize that since ANDERSON's Zone « A » is « open-ended » (*i.e.*, without a biostratigraphically determinable base either at Kassel or Doberg), then purely on ANDERSON's correlation the type Chattian could correlate anywhere within the limits of Zone « A » and also be below the level of bed 1 at Doberg. If this is the case, the Chattian and Rupelian may both be covered by the interval of Zone P. 19. Thus, the possibility exists that part of the type Chattian may be lateral equivalent to the later part of the Rupelian, but in any case, even on HUBACH's correlation, the Chattian is only a little younger than the Rupelian.

Notwithstanding the arguments as to the relative position of the stratotype Chattian to a part of the lower Eochattian succession at Doberg delimited by ANDERSON's Zone « A » (= approximately HUBACH's beds 1 to 26), the planktonic foraminiferal fauna of a sample from bed 26 (sample FTB. 315) is referable to a horizon from *within Zone* N. 1 (=P. 20). Since a sample from a level below bed 10 yielded a high Zone P. 19 fauna, it seems clear that the type Chattian of Kassel includes horizons representative of Zones P. 19 and N. 1. On the other hand, the Bormidian of PARETO (1865), commences at a horizon within the later parts of Zone N. 1 (=P. 20) so that this zone probably includes part, at least, of the latest Oligocene *sensu* BEYRICH (1854) and the lowest part of the Miocene *sensu* PARETO. We have observed *Miogypsina septentrionalis* in the same sample which also yields the late Zone P. 19 planktonic foraminiferal fauna but this *Miogypsina* does not occur at Kassel which, if not a facies

exclusion, further tentatively suggests that the type Chattian occurs a little earlier in Zone P. 19.

At present the evidence available to us suggests that the type Chattian is in part, at least, prior to the Bormidian but we are unable to place exactly the geostratigraphic base of the Chattian on the planktonic foraminiferal scale used in this work. We can only suggest that it is within the later parts of Zone P. 19. In any case we consider the evidence is sufficient to warrant a presumption that it is prior to the geostratigraphic base of the Bormidian and that Zones P. 19 and N. 1 cover all the Chattian stage.

If HUBACH's correlation of beds 7-16 of the Eochattian with the type Chattian at Kassel is accepted, then beds 1 to 6 of the Eochattian succession at Doberg must, automatically, be accepted as being referable to the Rupelian stage since the geostratigraphic base of a succeeding stage (*i.e.*, Chattian in this case) must be taken as delimiting the upward extension of the prior stage (*i.e.*, Rupelian).

The planktonic foraminiferal faunas of the Neochattian, although poor, have yielded species indicative of Zones N. 2 and ? N. 3. In this regard Dr. W. A. BERGGREN has informed us (*pers. comm.* to WHB) that he has observed *Globorotalia* (*T.*) *opima opima* in the Neochattian beds which confirms that Zone N. 2 is certainly represented in the succession at Astrup. It would appear that the Neochattian succession commences either within the later part of zone N. 1 or the earlier part of zone N. 2.

ANDERSON considered that the Eochattian and Neochattian should all be considered as forming the Chattian stage. However, this has not been fully accepted and whether the Eochattian, or both the Eochattian and Neochattian, or neither, should be formally regarded as part of the Chattian is a matter for formal international decision. The sands from the Kassel sands to the interval C (Neochattian) evidently form one depositional unit and would be united in local stratigraphy in one Formation.

THE BORMIDIAN

The type section of the Bormidian stage is at Spigno Monferrato, valley of the Bormida de Spigno, N. Italy, VERVLOET (1966). It was originally named by PARETO (1856) who considered that it was referable to the Miocene. LORENZ (1964) studied sections at Millesimo and Lodola and gave a review of both lithology and fauna; LORENZ considered the series

of beds involved at both Lodola and Millesimo as « Aquitanian », *i.e.*, post-Oligocene.

The section at Millesimo commences with a substantial conglomerate which rests on eroded Triassic dolomites and evidently represents a major transgression. The significant faunal records of the Millesimo and Lodola sections are summarized below from LORENZ's work but it should be remembered that both sections are developed within coarsely arenaceous beds and that derivation of older material is common throughout the sequences.

In the Millesimo section LORENZ recorded the following significant forms.

i) Bed 3 *Miogypsina*

ii) Beds, 7, 10 and 11, yielded *Heterostegina papyracea gigantea* known previously from beds considered post-Oligocene (*i.e.*, so-called Aquitanian *auctt.*)

iii) Bed 12 yielded *Globigerinoides* sp.

iv) Bed 14 yielded *Globigerinoides* sp.

In addition to the forms listed above, bed 11 yielded *Spondylus bifrons*, a form known previously from late Eocene and Oligocene horizons and which seems to be derived from nearby « Stampian » horizons (see below).

M. CL. LORENZ very kindly sent his thin sections and foraminiferal preparations to us for examination from the Millesimo section. We can confirm the occurrence of *Miogypsina* in bed 3 and W. J. CLARKE has recognized the form as being close to *M. gunteri* although not fully conspecific and probably somewhat more phylogenetically primitive than the typical *M. gunteri*. We have also recognised specimens of *Austrotrillina* cf. *striata, Neoalveolina pygmaea* and *Lepidocyclina* (*Nephrolepidina*) cf. *tournoueri* from thin sections made from material of bed 3. Some planktonic foraminiefra are present in washings made from more marly horizons and the lowest of these yielded forms of *Globorotalia* cf. *siakensis* which are known elsewhere only in latest parts of Zone N. 1 and in Zone N. 2. Other samples from bed 3 yielded specimens referable to *Globorotalia* (*Turborotalia*) *opima* cf. *opima, G.* (*T.*) *opima nana, G.* (*T.*) cf. *siakensis, Globorotaloides suteri, Globigerinita unicava unicava, Globigerina* cf. *tripartita* and *Globigerina* cf. *venezuelana* (of BOLLI = *G. euapertura* of BLOW & BANNER, now renamed). This fauna is strongly suggestive of Zone N. 2 but a very late Zone N. 1 determination cannot be ruled out on the planktonic foraminifera alone. Considering the presence of the *Miogypsina* cf. *gunteri* in bed 3, we suggest that a horizon high in Zone

N. 2 is much more likely. Thus considering the conglomerates of beds 1 and 2 we suggest that the Bormidian transgression commenced at a time which is represented elsewhere by a horizon in the later parts of Zone N. 1 or the earlier part of Zone N. 2, at youngest. It is also evident from LORENZ's records of *Globigerinoides* in beds 12 and 14 that the Millesimo section extends into horizons at least as young as those in Zone N. 4 which seems to be the oldest horizon present in the type Aquitanian. Hence the Bormidian stratotype covers the interval of Zones N. 2 and N. 3 at least.

In the Lodola section, Bed 1 contains *Heterostegina papyracea gigantea* (Aquitanian); Bed 3 contains *Porites* cf. *collegniana* (Lower Miocene); Bed 6 contains *Heterostegina papyracea gigantea* (Aquitanian); Bed 7 contains *Heterostegina papyracea gigantea* (Aquitanian) and *Nummulites* cf. *fichteli* (Lower and Middle Oligocene) (AS DEBRIS); Bed 8 contains *Heterostegina papyracea gigantea* (Aquitanian); Bed 10 contains *Heterostegina papyracea gigantea* (Aquitanian); Bed 11 contains *Heterostegina papyracea gigantea* (Aquitanian); Bed 12 contains *Heterostegina papyracea gigantea* (Aquitanian); Bed 13 contains *Heterostegina papyracea gigantea* and *Echinolampas bathistoma* (Aquitanian), « *Globigerina quadrilobata* » and « *Globigerinoides trilobus* » (not below Miocene), as well as *Nummulites* cf. *intermedius* (Lower and Middle Oligocene), and the bivalvia *Chlamys biarritzensis, C. deleta, C. oligosquamosa* (Oligocene) and *C. spinicosta* and *Pecten vezzanensis* (Aquitanian). Is should be noted that Mongin did not find the Oligocene *Pecten arcuatus* recorded from the Oligocene of the area by ROVERETO (1910) (*teste* MONGIN in LORENZ, 1964).

LORENZ records that in the Lodola section *Nummulites* cf. *fichteli* is represented by one specimen in Bed 7 and by five specimens in Bed 13, and states that these forms *are abundant in the Stampian outcrops situated further east.*

ROVERETO (1910) while recording that the great extent of sandy beds with rare lepidocyclines covering the summit of the mountains between Millesimo, Cengio and Cairo Montenotte were of Aquitanian age, also recorded from the Millesimo area is a large Stampian fauna consisting of 15 species of foraminifera, 5 species of echinoids, 17 species of gastropoda, 1 species of scaphopoda, and 19 species of bivalvia. This latter fauna is evidently a composite list comprising faunas from more than one locality; forms such as *Lepidocyclina schlumbergeri, L. raulini, L. morgani* and *L. sumatrensis* are known from the Miocene, while the molluscan faunas are characteristically Oligocene. Furthermore, ROVERETO records

the presence of the Middle Eocene *Nummulites tchihatcheffi* and *N. contortus*, incorrectly refers *N. intermedius* to the Auversian and *N. fichteli*, *N. vascus* and *N. boucheri* to the Wemmelian. It is evident that, apart from errors of dating and/or identification, the fauna is a composite list.

From LORENZ and VERVLOET it now becomes apparent that the Bormidian Parastratotype and Holostratotype cover the interval of Zones N. 2, N. 3 and N. 4 and that the uppermost part of Zone N. 1 may be represented by the basal conglomerates. Some of these zones are present in the Neochattian succession.

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