ON THE SO-CALLED DANIAN *s. l.* OR DANO-MONTIAN OF AUTHORS

by

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Abstract

The expansion of the term Danian to include the Montian as its upper substage in a Danian *s.l.*, a Montian *s.l.*, or a Dano-Montian stage is unwarranted and does not conform with the original definitions af these terms. The Montian, as originally defined by DEWALQUE (1868), is proved to be a junior synonym of the Heersian (DUMONT, 1851), and planktonic Foraminifera in the latter stage represent a particular evolutionary stage in the development of this group which necessitates its separate treatment.

DISCUSSION

The prolonged controversy surrounding the stratigraphical position of the Danian has been almost settled by its assignment to the base of the Tertiary system, as the oldest stage of the Paleocene series (see discussion by the present writer 1963, 1966 and by BERGGREN 1962, 1964). Nevertheless, the upper boundary of this stage is still much disputed, differently interpreted and difficult to decide. The difficulty has been mainly explained by the fact that the Danian, in its type region is separated from the overlying, younger Paleocene, greensands by a stratigraphical break. However, as viewed by the present writer, the confusion about the upper boundary of the Danian is mainly due to the fact that definite Danian strata in the other type sections of the Paleocene (e. g. in the Paris, Mons and Landen Basins) have been incorrectly dated. Therefore, these Danian beds were wrongly included within the overlying Montian or the underlying Maestrichtian, or even equated with either (see Lexique Stratigraphique International, Vol. I, Fasc. Aa VII, and EL-NAGGAR, in press).

The expansion of the term Montian to include typical Danian strata below (the "Tuffeau de Ciply" and the "Poudingue de la Malogne"), contrary to the original definition of the term, has masked the true stratigraphical relationship between the type Danian and the type Montian, and made it difficult to establish the boundary between these two stages. Similary, the assignment of strata of definite Danian age (in the Landen Basin) to the Montian has masked the relationship between the Danian and the Heersian on one side and between the Montian and the Heersian on the other, and has complicated matters further.

Following the traditional mistake of including the "Tuffeau de Ciply"

and the underlying "Poudingue de la Malogne" within the Montian, LOEBLICH and TAPPAN (1957a, b) equated the type Danian with the type Montian on the basis of the occurrence in the "Tuffeau de Ciply" of definite Danian planktonic Foraminifera. In a further attempt to justify this equation, they stated (1957 b, p. 1119): "the occurrence of the Cerithium fauna in the type Danian and the *Nautilus danicus* in Montian equivalents, the species of the *daubjergensis-compressa* faunal zone represented in both type Danian and type Montian and their equivalents over the world, the identical stratigraphic position of the Danian and Montian, each unconformable on the Cretaceous and underlying the Landenian sediments, and the fact that they were never found together, leads inescapably to the conclusion that the Danian and Montian are merely different lithologic and faunal facies of identical geologic age. We suggest that the term Danian be used to include the Montian also, inasmuch as the type Danian includes beds of both facies; the Danian should be used as a stage name within the Paleocene". This proposition was rejected by MOSKVIN & NAIDIN (1960) on the basis of the occurrence in the south-west Crimea of typical Danian strata conformably overlain with a succession characterised by a Montian molluscan and echinoid fauna. These authors *(op. cit.)* stated that "in sections of the territory discussed, between definitely Danian and Thanetian deposits, it is possible to distinguish Lower Paleocene rocks, which would approximately correspond to the Montian stage of Western Europe. Thus, the existing opinion regarding the complete conformity of the latter to the Danian stage is not confirmed by the material available".

MOSKVIN & NAIDIN *(op. cit.)* stated that the determination of the upper boundary of the Danian was rather difficult due to the incompleteness of its type section and to the different interpretations of more complete sections in Western Europe. Following the changes of the species populations in the full sections of the Crimea, the Caucasus and the Transcaspian region, these authors suggested two ways of determining the upper limit of the Danian stage: –

(a) Along the top of the layers with *Protobrissus tercensis, Coraster ansaltensis, Globigerina inconstans,* and the base of the beds with a mass appearance of *Globorotalia angulata* (WHITE). This position was said to correspond most likely to that established by Seunes in the Terci anticline and the nearby areas of the Pyrenean foreland region.

(b) Below the layers with *Protobrissus tercensis* and above the layers with *Cyclaster gindrei* and *Protobrissus depressus*. This boundary was described as coinciding with the vertical development of *Hercoglossa danica,* i. e. with the volume of the type Danian in Denmark.

Nevertheless, they stated that "the similarity of the faunistic composition of these adjacent layers, under conditions of uniform facies raises, however, the question of the independence of the Montian stage", and added "it seems to be more correct, following MUNIER-CHALMAS, LAPPARENT (1893, 1897) and CONGE (1935) to preserve this subdivision only as the upper substage of the Danian stage".

VOIGT (1960) also followed the traditional mistake of including the

"Tuffeau de Ciply" within the Montian. Therefore, he mentioned that the bryozoa of the Montian in Belgium and Holland show very close relationship with the bryozoan fauna of the Danian, but added that there is still a possibility for the "Lower Montian" "Tuffeau de Ciply", to be younger than Upper Danian.

HOFKER (1961) recorded the occurrence of *Globorotalia pseudomenardii* BOLLI, *G. ehrenbergi* BOLLI and *G. pusilla laevigata* BOLLI in the "Tuffeau de Ciply", and thus equated the Montian with the *G. pusilla pusilla* and the *G. pseudomenardii* zones of BOLLI (1957). Therefore, he considered the Montian to be of Middle Paleocene age, and introduced a "Lower Paleocene" stage between the Danian and the Montian, correlating it with the Seelandian of Sweden.

BERGGREN (1964, 1965a, b) quoted MOSKVIN & NAIDIN (1960) and stated that correlation of the Danian and Montian stages *in toto* is impossible as claimed by LOEBLICH & TAPPAN (1957*b*), but the similarity in fauna under uniform facies conditions questions the validity of the Montian as an independent stage in Paleocene stratigraphy. Following MOSKVIN & NAIDIN (*op. cit.*) he suggested the inclusion of the Montian as the upper substage of the Danian stage in a Danian *s. l.* or a Dano-Montian stage, and stated (1964) that "the relationship between the upper part of the Montian, "Calcaire de Mons", with the upper Danian remains uncertain. By extrapolation, it is probable that the upper part of the Montian is correlative in part with the upper Danian and, in part, younger than known, exposed Danian in Denmark. ... It is also possible that subsurface younger Danian in Denmark may fill the missing void in our information and allow confirmation of one of the two alternatives suggested by MOSKVIN & NAIDIN (1960)."

BERGGREN (1965*b* pp. 283–285) suggested that "... it would seem *a priori* impossible to determine the exact time stratigraphic limits of the Danian. With this demonstration that strata with a Montian fauna actually overlie strata with a Danian fauna and the recent demonstration by WIENBERG RASMUSSEN (1962) that the "Tuffeau de Ciply" (Lower Montian *s. l.*) corresponds to at least Lower and Middle Danian, the suggestion of MOSKVIN & NAIDIN (1960) appears to be a suitable compromise. It will take an act of the international committee of stratigraphic nomenclature to legalise this alteration of the concept of the Danian stage, but it would appear worthy of consideration. The term Dano-Montian would serve amply for the *"G. uncinata Zone"* in the meanwhile for those unable to take a definite stand at the present."

However, a detailed study of the planktonic Foraminifera of the type Paleocene sections in Western Europe (EL-NAGGAR, MS) has clearly shown that this proposition of enlarging the term Danian to include Montian strata, above, in a Danian *s. l.* or Dano-Montian stage, is unwarranted, and does not conform with the original definition of either the term Danian or the term Montian. Moreover, this does not agree with the evolutionary development of planktonic Foraminifera in both the type Danian and the type Montian.

Firstly, the expansion of the term Montian to include older strata

below, as suggested by RUTOT and VAN DEN BROECK (1885, 1886), by LERICHE (1937) and followed by several authors, is unjustified. Both the "Tuffeau de Ciply" and the underlying "Poudingue de la Malogne", which were wrongly attached to the base of the Montian, have been proved to contain typical Danian planktonic Foraminifera and are thus assigned to the Danian (EL-NAGGAR, in press).

Similarly, strata overlying the Upper Cretaceous chalk and underlying the Heersian, in north-eastern Belgium and in Holland were repeatedly assigned to the Montian. The discovery of the typical Danian planktonic Foraminifera of the "*Globorotalia compressa/Globigerina daubjergensis* Zone" throughout these so-called "Montian" strata (EL-NAGGAR, in press) proves their Danian age. It also proves the true stratigraphical position of the Heersian conformably overlying Danian strata and underlying the Landenian.

Secondly, the discovery of the Middle Paleocene planktonic foraminiferal fauna of the "*Globorotalia inconstans/Globorotalia angulata* Zone" in both the type Heersian and in Montian lateral equivalents (conformably overlying typical Danian strata and underlying the Landenian) (EL-NAGGAR, in press) proves the time stratigraphical equivalency of both the type Heersian and the type Montian. As the term Heersian (1851) had been introduced long before the term Montian (1868), it was suggested (EL-NAGGAR, in press) that the term Montian should be replaced by the term Heersian. The Heersian is regarded as the Middle Paleocene stage between the underlying Danian and the overlying Landenian.

Analysis of the planktonic Foraminifera in both the type Heersian and the type Montian proved their equivalency to the Middle Paleocene "*G. angulata Zone*" of the present author (EL-NAGGAR, 1963, 1966, in press and MS). The planktonic Foraminifera in this zone, as previously demonstrated by the present writer (1966), represent a particular stage in the evolutionary development of this group, which is clearly distinct from both the more primitive and the more advanced stages in the underlying and overlying strata respectively. This necessitates the treatment of the Middle Paleocene (Heersian) strata independently, as their inclusion within the underlying Danian does not conform with the original definition of the term or with the distribution of faunal assemblages in both the Danian and the overlying Heersian.

The detailed study of the planktonic Foraminifera in the Paleocene series (EL-NAGGAR, 1966, MS) showed clearly that three main assemblages follow one another in a continuous evolutionary sequence with clearly documented trends. These assemblages, which represent three successive natural units in Paleocene stratigraphy and the most logical divisions for this series, were described from the base upwards as follows: –

(1) A *Globigerina*/rounded *Globorotalia* assemblage.
(2) A *Globigerina*/truncated *Globorotalia* assemblage.
(3) A *Globigerina*/sharply keeled *Globorotalia* assemblage.

Characteristic species in each of these assemblages distinguished them as three successive zones from the base upwards as follows:

(1) The "*Globorotalia compressa/Globigerina daubjergensis* Zone".
(2) The "*Globorotalia angulata* Zone".
(3) The "*Globorotalia velascoensis* Zone".

The evolutionary development of the planktonic Foraminifera in these zones clearly demonstrates the main tendencies in the development of *Globorotalia* from the rounded, smooth forms into the sharply keeled and/or highly rugose ones, through slightly truncated and/or rugose forms. Similarly, it demonstrates the evolution of *Globigerina* from smooth to highly rugose forms. This may suggest that *Globorotalia* has evolved from *Globigerina* by the extension of the aperture to an extra-umbilical position and by the development of the truncated dorsal side and/or marginal keel. If this hypothesis is true, we would expect a zone younger than the Lower Danian in its type section, characterised by a flood of *Globigerina,* but with no *Globorotalia.* This may be substantiated by the fact that some forms of the genus *Globigerina* in the basal Danian, at its type section, are highly rugose. Indeed, both LUTERBACHER (1964) and LUTERBACHER and PREMOLI SILVA (1964) recorded the occurrence of a zone with *Globigerina* only at the base of the Tertiary succession in the Central Apennines. This zone was described as underlying their "*Globorotalia pseudobulloides/Globigerina daubjergensis* Zone"; it was named the "*Globigerina eugubina* Zone", and was included within the Danian.

LUTERBACHER (1964) stated that because of its reduced thickness this "*Globigerina eugubina* Zone" might be considered as the lowermost subzone of his "*Globigerina pseudobulloides/Globigerina daubjergensis* Zone", and included these, together with his "*G. trinidadensis* Zone", within the Danian. However, BERGGREN (1965c) questioned the possibility of the existence of two distinct zones within the Danian and added that the "*G. trinidadensis* Zone" of BOLLI (1957) can be correlated with the "*G. pseudobulloides/G. daubjergensis* Zone" of the boreal regions. He also added *(op. cit.)* that the occurrence of the "*G. eugubina* Zone", if correct, is an important link in our understanding of the development of planktonic Foraminifera at the Cretaceous-Tertiary transition period. However, he doubted the validity of the forms described by LUTERBACHER and PREMOLI SILVA (1964) in the "*G. eugubina* Zone" on the basis of their poor preservation, extremely small size and their resemblance to some Maestrichtian *Rugoglobigerina* and *Globigerinelloides* species. On the other hand, MOROZOVA (1960, 1961) recorded at the base of the Paleocene succession in the U. S. S. R. a zone "Zone I", distinguished by what she described as *Globigerina (Eoglobigerina) taurica,* and she considered this zone to be older than the lowest Danian in its type section. However, LUTERBACHER & PREMOLI SILVA *(loc. cit.)* and LUTERBACHER (1964) correlated their "*Globigerina pseudobulloides/G. duabjergensis* Zone" with the major part of the "*Eoglobigerina* Zone", and the "reticulate *Globigerina* Zone" of ALIMARINA (1963), with the "*G. pseudobulloides/ G. daubjergensis* Zone" of LEONOV & ALIMARINA (1961) and with the "*Rzehakina epigona* Zonule" of BOLLI (1957b). Nevertheless, it shold be

emphasised that the record between the uppermost Maestrichtian and the lowermost Danian, as known in their type sections, is incomplete. The discovery of new Tertiary fauna between these two limits should be clearly assigned to the Lower Danian without the necessity of creating a new stage or substage name. Contrary to this, the extension of the upper boundary of the Danian to include younger strata in a Danian *s. l.* or a Dano-Montian stage is unnecessary. In continuous Paleocene successions, strata with typical Danian planktonic Foraminifera and macrofauna are conformably overlain with beds containing characteristic planktonic Foraminifera of the Middle Paleocene "*G. angulata* Zone", and their lateral equivalents were found in different parts of the world (e. g. in the U. S. S. R.) to contain molluscan and echinoid fauna which were originally described from the type "Calcaire de Mons".

The time-stratigraphic equivalency of the type Heersian (1851) and the type Montian (1868) and their equation with the Middle Paleocene "*G. angulata* Zone" was clearly demonstrated by the present writer (EL-NAGGAR, in press). Moreover, the independent treatment of this zone as a distinct stage in the evolutionary development of Paleocene planktonic Foraminifera was also discussed (EL-NAGGER, 1966). This clearly indicates that the Danian in its type section and elsewhere should be equated with the Lower Paleocene "*Globigerina*/*Globigerina*-like *Globorotalia* assemblage. Its lower limit is defined by the extinction of the typical Cretaceous macrofauna (e. g. ammonites, belemnites, inocerami, rudistids; mosasaurus, dinosaurus, ichthyosaurus, pterodactyles etc.) and planktonic Foraminifera (e. g. *Globotruncana, Rugoglobigerina, Abathomphalus, Hedbergella, Trinitella, Plummerita, Globigerinelloides, Schackoina, Pseudotextularia, Pseudoguembelina, Gublerina, Planoglobulina, Racemiguembelina* and *Heterohelix* etc.). It is also marked by the first appearance of the typical Tertiary molluscan and echinoderm fauna, primitive placental mammals as well as the index Tertiary planktonic foraminiferal genera *Globigerina* and *Globorotalia.*

The upper boundary of the Danian, which has recently been much disputed, is clearly marked by the first appearance of the truncated *Globorotalia* assemblage. This assemblage, as reasoned above, represents a transitional stage in the development of this genus between the underlying rounded *Globorotalia* and the overlying sharply keelded ones. This is further substantiated by the fact that no truncated or keeled *Globorotalia* have yet been recorded from the type Danian section or from strata of definite Danian age elsewhere. Thus, the Danian is the Lower Paleocene, and is conformably overlain by the Middle Paleocene (= the Heersian). The Montian should be dropped from Paleocene stratigraphy and so should the Danian *s. l.,* the Montian *s. l.,* or the Dano-Montian stages suggested by the different authors.

SUMMARY AND CONCLUSIONS

The extension of the upper limit of the Danian to include younger strata above, in a Danian *s. l.,* a Montian *s. l.,* or a Dano-Montian stage, as

suggested by MUNIER-CHALMAS and de LAPPARENT (1893, 1897) CONGE (1935) and SIGAL (1949) and revived by MOSKVIN & NAIDIN (1960) and BERGGREN (1964, 1965a, b, c.) is unjustified. It neither conforms with the original definitions of these terms, nor with the stratigraphical analysis of continuous Paleocene successions elsewhere. It also contradicts the natural divison of the Paleocene series on the basis of the evolutionary development of its planktonic Foraminifera into a lower "*Globigerina*/ rounded *Globorotalia* Zone", a middle "*Globigerina*/truncated *Globorotalia* Zone" and an upper "*Globigerina*/ sharply keeled *Globorotalia* Zone". These three successive stages in the evolutionary development of Paleocene planktonic Foraminifera are clearly documented in different parts of the world and represent three natural divisions in Paleocene stratigraphy. Any division of this series which cuts across these natural units is very misleading.

The detailed study of the planktonic Foraminifera in the various type sections of the Paleocene, and a revision of the historical development of these stages and substages (EL-NAGGAR, in press, MS) has clearly proved that the Paleocene is divisible into three successive stages from the base upwards—a Lower "Danian", a Middle "Heersian" and an Upper "Landenian" stage. It has also proved that the commonly used stage and substage names in Paleocene stratigraphy, other than these three, are superfluous and very misleading.

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