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THE TYPE CAMPANIAN AND THE CAMPANIAN-MAASTRICHTIAN BOUNDARY IN EUROPE

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ABSTRACT

In his description of the type Campanian Coquand mentioned two localities in which his Campanian unit occurs. Later investigations showed that the two sections are not exact time equivalents. As a result controversies arose whether the one or the other unit should be the type Campanian. The simplest solution is to consider both units as Campanian stratotypes, one representative for the lower part and the other for the upper part, the more so as this agrees quite well with usage outside France.

Between the top of the upper Campanian type section and the base of the Maastrichtian type section a time gap exists. In this time gap the boundary between the geochronologic units Campanian and Maastrichtian has to be drawn. It is suggested to adopt the boundary of Seitz (1952) because this boundary is commonly used and because its use is in accordance with the priority principle.

INTRODUCTION

Two different views exist on the position of the type Campanian. Especially Séronie-Vivien (1959, 1970) and van Hinte (1965) are recent opponents in this question. As a result of this controversy, views regarding the position of the Santonian-Campanian and especially of the Campanian-Maastrichtian boundary vary considerably in the literature. An attempt is made to find the cause of this disagreement and to analyse some o the classifications of the uppermost Cretaceous.

THE TYPE CAMPANIAN

The name Campanian was introduced by Coquand in 1857 for the 'Craie à *Ostrea vesicularis*', a rock-unit of chalks and marls with oysters and white chert, which had been described more extensively in an earlier paper (1856, p. 84-94). This rock-unit occurs in the Grande Champagne, an area about ten kilometers south of Cognac, where the grapes for the Grande Champagne cognac are grown (department of Charente, SW France, geologically the northern border of the Aquitanian basin). According to Coquand (1856) this unit is also well exposed in Aubeterre, a village about eighty kilometers southeast of Cognac and from this locality he describes a section of Campanian, underlain by 'Santonian' and overlain by his type Dordonian. This dual description is the reason for the present-day confusion about the type Campanian because later investigations of Arnaud showed the Campanian of Aubeterre (zones P3, Q and probably partly R of Arnaud) to be younger than the Campanian of the Grande Champagne (zone P of Arnaud). The 'Santonian' at the base of the Aubeterre section would be time equivalent to the Campanian of the Grande Champagne and younger than the type Santonian, based on strata between Cognac and Saintes (Arnaud, 1879, p. 82).

Following Arnaud, French geologists, Abrard, Neumann, Séronie–Vivien, etc.) consider the unit of the Grande Champagne to be the type Campanian because this was primarily mentioned by Coquand. Others (van Hinte, Goharian) take the Aubeterre profile for type Campanian because this is the only locality from which an actual section has been described by Coquand. In any case Coquand must have meant by Campanian all strata between his type Santonian (stratotype between Cognac and Saintes) and his type Dordonian (stratotype at the top of the Aubeterre section), both of which were described in the same papers. So the simplest solution as to what Coquand meant to be the type Campanian is to consider both the Campanian of the Grande Champagne and the Campanian of the Aubeterre section as type Campanian: the first as representative for the lower part and the second for the upper. Moreover this conception of the Campanian agrees much better with the views on the Campanian outside France, as will be shown later.

In his detailed zonation of the Northern Aquitanian Upper Cretaceous Arnaud (1877) used the stage names of Coquand, but lowered the Campanian-Dordonian boundary to a level in the lower part of the Aubeterre profile, where *Orbitoides media* begins to occur in large numbers. This is at the boundary between his zones P and Q and corresponds with the boundary between the zones G and F of the Aubeterre Campanian of Coquand (see fig. 1). Although Arnaud had good arguments for this, De Grossouvre (1901, pp. 377-378) objects quite rightly that this is against the priority principle. The latter takes the Campanian-

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Dordonian boundary of Coquand as the only valid one. However, de Grossouvre probably makes a small mistake by equalizing Coquand's Campanian-Dordonian boundary with the boundary between Arnaud's zones Q and R. It is more likely that this is situated somewhere within Arnaud's zone R ('Dordonien moyen'). Nevertheless Arnaud's classification has been in general use in the area. The name Dordonian has later been replaced by Maastrichtian. As a result the French conception of Maastrichtian is too comprehensive and all or most 'Maastrichtian' in the Campanian type region may be Campanian.

THE TYPE MAASTRICHTIAN

The 'système Maestrichtien' was introduced by Dumont in 1849. Uncertainties exist about the downward extension of the stratotype. The question is whether the type Maastrichtian is restricted to the Maastricht Tuff Chalk (Ma up to Md) or whether parts of the underlying formations should be included. For reviews of this question and descriptions of the stratigraphy in the type region, see Visser (1950), Jeletzky (1951), van der Heide (1954), Voigt (1956), Calembert (1957), Romein (1962, 1963), Deroo (1966).

The Subcommission on the Upper Cretaceous stratigraphy of the International Geological Congress has recommanded to restrict the Maastrichtian stratotype to the Maastricht Tuff Chalk and has proposed a type section in the ENCI-quarry south of Maastricht, The Netherlands (Thiadens, 1970).

According to Hofker (1962, 1966 and many other papers) the Maastricht Tuff Chalk and the type Danian of Denmark are time equivalents. As the name Danian is older than the name 'Maestrichtien', the type Maastrichtian would be of Danian age. This possibility will not be considered here because it has convincingly been shown by several authors that the type Maastrichtian is older than the type Danian (Loeblich and Tappan, 1957, Berggren, 1962 and Moorkens, 1971 based on planktonic foraminifera, Voigt, 1960 based on belemnites, bryozoa and on other arguments, Bramlette and Martini, 1964 based on coccoliths and finally Wilson, 1971 based on dinoflagellate cysts).

THE TIME GAP BETWEEN THE CAMPANIAN AND MAASTRICHTIAN STRATOTYPES

Correlations with the aid of microfossils prove the existence of a time gap between the top of the Campanian stratotype (Aubeterre) and the base of the Maastrichtian Stratotype (Romein, 1963, van Hinte, 1966ab, 1967, 1968b and Freudenthal, 1969). To include this time interval in the geologic time scale we can:

A. *Create a new stage between the Campanian and Maastrichtian*

If a new stage is erected for this time interval we might use the name Dordonian of Coquand because the (type-) Dordonian directly overlies the type Campanian and because this probably agrees best with the priority principle. There are however numerous objections against this:

- the Dordonian has been designated by Coquand for chalks, which are very rich in rudists and corals. In the type description three localities are mentioned, one of them is at the top of the Aubeterre section. Later investigations (Arnaud, 1879, Goharian, 1971) showed that these rudist chalks do not occur as a consistent zone at the top of the Cretaceous in the type area, but as isolated reefs in the marly chalk, which is lithologically indistinguishable from the underlying Campanian. So it is not certain whether the three Dordonian localities of Coquand occur at the same level and which of the three should be considered to be the type Dordonian;
- the Dordonian of Coquand is very thin and probably represents only the lowermost part of the time gap between the Campanian and Maastrichtian stratotypes;
- because of its exceptional fauna, interregional correlations with this Dordonian are very difficult;
- the name Dordonian has subsequently been used in a meaning which differs from the original description of Coquand (Arnaud and others);
- although the type Maastrichtian is younger than the type Dordonian, the idea that these stages are time equivalents is widespread.

Another name which can be considered is the Aturian. This name has been proposed by Kühn and Zinke (1939) for a new stage between the Campanian and Maastrichtian stages. However, their Aturian probably partly overlaps the Campanian of Coquand. Moreover the name Aturian has frequently been used for the stages Campanian and Maastrichtian together (Munier–Chalmas and de Lapparent, see Sornay, 1957). Reintroduction of one of the names mentioned above would probably bring more confusion than clarity, so if a new stage is to be created for this time gap, it would be preferable to give it a new name. A stratotype would then have to be designated. However, before this can be done, a lot of additional research is required because the present knowledge about the extension of the time gap is rather poor.

B. *Extend the Campanian and/or Maastrichtian stage(s)*

If no new stage is to be created, the boundary between the geochronologic units Campanian and Maastrichtian can be drawn at any point in the time gap by extending the Campanian age upward or the Maastrichtian age downward or both. This has the advantage that the familiar succession Campanian-Maastrichtian in the geologic time scale is maintained. If we draw this boundary at a level which can easily be recognized biostratigraphically, the determination of the

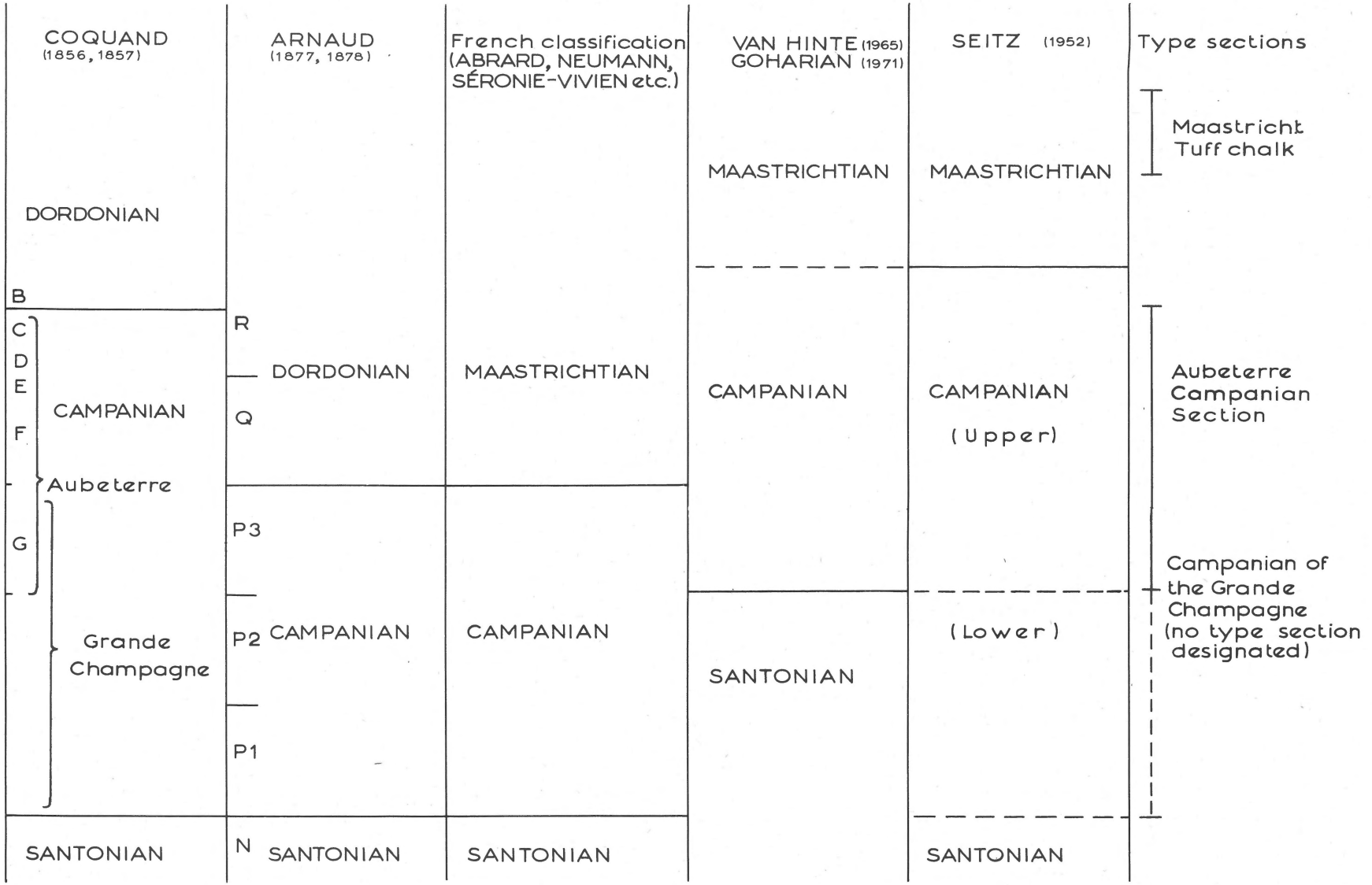

Fig. 1
Correlation of some classifications of the uppermost Cretaceous. Interrupted lines indicate the estimated position of the boundary concerned. Vertical intervals not to scale.

position of this boundary in Upper Cretaceous rock sequences is facilitated. In reality the definition would then be biostratigraphic instead of chronostratigraphic. However, for the moment this seems to be the most practical solution and this will be elaborated in the next chapter.

THE CAMPANIAN-MAASTRICHTIAN BOUNDARY

Before agreeing upon a suitable position for the boundary between the geochronologic units Campanian and Maastrichtian, it is necessary to check what the current views on this boundary are in the literature. Wherever the position of this boundary is discussed, this is usually based on the classification of Seitz (1952), who applied the stage names Coniacian, Santonian, Campanian and Maastrichtian to biozones, characterized by ammonites and belemnites. As advocated by Jeletzky (1951) the Campanian-Maastrichtian boundary is defined by the first occurrence of *Belemnella lanceolata* (SCHLOTH.) and *Scaphites constrictus* SOW.. This biostratigraphic definition proved to be very useful and this boundary has been applied in many other biozanations, especially in the so-called Boreal Upper Cretaceous province. We may mention biozonations based on foraminifera (Bettenstaedt, Hiltermann, Hofker, except in Hofker, 1959, where the classification of Arnaud is used, Koch, Küpper, Papp, Wicher, etc.), belemnites (Birkelund, Jeletzky, Naidin, Schmid), echinids (Ernst, Meijer), inocerams (Seitz), bryozoa (Voigt), ostracods (Deroo), coccoliths (Vangerow and Schloemer), etc.

What now is the relation of this Campanian-Maastrichtian boundary of Seitz with the stratotypes of these stages? With the aid of a number of fossilgroups an attempt will be made to determine the position of this boundary with regard to the stratotypes.

In the Maastrichtian type area the base of the Maastrichtian of Seitz (also called 'Maastrichtian s.l.' or 'Maastrichtian in the international sense') is found within a hiatus on top of a hardground in the Cr3b member of the Gulpen Chalk, which underlies the Maastricht Tuff Chalk, the stratotype; see Romein, 1962, 1963 and Schmid, 1967. These authors consider the Maastricht Tuff Chalk as Upper Maastrichtian.

As based on the distribution of cephalopods the Campanian of Seitz seems to agree well with the type Campanian (Grande Champagne and Aubeterre; see de Grossouvre, 1901, tabl. XVI). In the type region ammonites have been found in the P1 zone of Arnaud (lowest type Campanian), the first occurrence of which is used by Seitz to define the base of the Campanian: *Pachydiscus dulmensis* (SCHLÜT.), *Placenticeras bidorsatum* (ROEM) and *Scaphites aquisgranensis* SCHLÜT.. In the P3 zone, which corresponds with the base of Coquand's Aubeterre Campanian (zone G), ammonites have been found, the first occurrence of which is used by Seitz to define the Upper Campanian: *Hoplites vari* (SCHLÜT.) and *Scaphites gibbus* SCHLÜT..

The few belemnites found in the type region correspond with those found in the Campanian of Seitz as well: *Gonioteuthis quadrata* (BLAINV.) (Seitz Lower Campanian index fossil) in the P2 and P3 zones (Balland, 1948) and *Belemnitella mucronata* (SCHLOTH.) (Seitz Upper Campanian index fossil) in zone Q (Arnaud, B.S.G.F., 1896, vol. 24, p. 85 and Gillard, 1943).

Benthonic forminifera of the genus *Bolivinoides* have been studied by van Hinte (1967) in the Aubeterre section. The association *B.decoratus* JONES and *B.miliaris* HILTERMANN and KOCH can be placed in the Upper Campanian of Seith (see Hiltermann and Koch, 1962).

Papp (1955, 1956) has determined the position of the Campanian-Maastrichtian bboundary of Seitz with regard to the succession of evolutionary stages of the larger foraminifera *Orbitoides* and *Lepidorbitoides.* Increase in the number of epi-auxiliary chambers (sensu van Hinte, 1966a) is an evolutionary trend in *Orbitoides.* From Papp's figures it can be concluded that the Seitz boundary occurs in a level in which *Orbitoides* has an average of eight of these chambers. In the Aubeterre Campanian type section *Orbitoides* is somewhat more primitive and an average of eight of these chambers is only reached in the overlying (type-) Dordonian. On the basis of these data the position of the Campanian-Maastrichtian boundary of Seitz would lie above the top of the upper Campanian type section.

Lepidorbitoides occurs in the middle part of the Aubeterre section (Hofker, 1959, Goharian, 1971 and own findings) and almost always shows a primitive biserial arrangement of the peri-embryonic chambers(so the determination as *L.socialis* in Hofker, 1959 is incorrect). The Seitz boundary is drawn by Papp at the top of the quadriserial *Lepidorbitoides bisambergensis* zone. Unfortunately *Lepidorbitoides* did wot occur in our highest samples of the Aubeterre section, but the lack of any quadriserial specimens makes it probable that the Campanian-Maastrichtian boundary of Seitz is situated above the top of the Aubeterre Campanian type section.

Planktonic foraminifera are rare in the Aubeterre section. Acording to Van Hinte (1965, 1969) the base of the Aubeterre section probably belongs to the top of his *Globotruncana stuartiformis* zone, whereas the top of the section may reach into the *Globotruncana calcarata* zone. So the Aubeterre section would represent a middle to uppermost Campanian age in the planktonic foraminiferal zonation.

In Austria Küpper (1956), Bettenstaedt and Wicher (1956), Herm (1962) and Van Hinte (1963) found *Globotruncana calcarata* CUSHMAN, which is almost universally correlated with the uppermost Campanian, in a level just below the Campanian-Maastrichtian boundary sensu Seitz (estimated with the aid of benthonic foraminifera). This means that the frequently used boundary of Seitz concurs with the Campanian-Maastrichtian boundary which is used in the *Globotruncana* biozonation.

Considering these data we suggest to accept the view of Seitz (1952) on the Campanian-Maastrichtian boundary because:

- this is situated in the time gap between the type sections of the Campanian and Maastrichtian,
- such usage does not violate the priority principle,
- this agrees with usage outside France, including the Maastrichtian type region,
- this agrees with the biostratigraphy based on planktonic foraminifera.

As a result the 'Maastrichtian' of Douvillé, Neumann, Séronie-Vivien and other, for the greater part French workers, should be restricted because its lower part belongs to the Campanian.

Van Hinte's view on the Campanian is also to be amended and the stage should be extended downward. More in particular the association of *Orbitoides (Monolepidorbis) douvillei* and *Subalveolina dordonica* at Belvès (van Hinte, 1968a) should be assigned a Lower Campanian age

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