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Zonation by ammonites and foraminifers of the Vraconnian-Turonian interval: A comparison of the Boreal and Tethyan domains (NW Europe / Central Tunisia)

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Abstract: Since the end of the 19th century the interval comprising the uppermost Upper Albian, the Cenomanian, the Turonian and the basal Coniacian has been subdivided, first into ammonite zones, then, beginning in the middle of the 20th century, into zones of planktonic foraminifera. These two groups, one macrofossil, the other microfossil, are particularly effective for bio-chronostratigraphy thanks to their rapid rates of evolution. But differences in the faunal makeup between the Boreal domain (northwestern Europe) and the Tethyan domain (Mediterranean) have for a long time hindered precise correlation of the two domains. Today, in a time interval covering about 16 million years, there are 29 ammonite zones in the Tethyan domain versus 24 in the Boreal one, of which 16 are common to both domains. For the planktonic foraminifera the Tethyan domain has 11 zones, the Boreal domain 10, with 7 in common.

Key Words: Cretaceous; Albian; Vraconnian; Cenomanian; Turonian; ammonites; foraminifers; zones; zonation; Tethys.

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Résumé : Zones d’ammonites et de foraminifères du Vraconnien au Turonien : Une comparaison entre les domaines boréal et téthysien (NW Europe / Tunisie centrale).- Depuis la fin du 19ème siècle, l’intervalle comprenant l’Albien supérieur élevé, le Cénomanien, le Turonien et le Coniacien basal a été subdivisé d’abord en zones d’ammonites puis, à partir du milieu du 20ème siècle, en zones de foraminifères planctoniques, deux groupes de macro- et de microfossiles particulièrement efficaces en bio-chronostratigraphie grâce à leur taux d’évolution rapide. Toutefois, des différences de compositions fauniques entre le domaine boréal (Europe du Nord-Ouest) et le domaine téthysien (Méditerranéen) ont longtemps empêché des corrélations précises entre ces deux domaines. Aujourd’hui, dans un intervalle de temps couvrant environ 16 millions d’années, on dénombre 29 zones d’ammonites en domaine téthysien contre 24 en domaine boréal parmi lesquelles 16 sont communes aux deux domaines. Pour les foraminifères planctoniques, on compte 11 zones en domaine téthysien et 10 en domaine boréal, dont 7 communes.

Mots-Clefs : Crétacé ; Albien ; Vraconnien ; Cénomanien ; Turonien ; ammonites ; foraminifères ; zones ; zonation ; Téthys.

Introduction

The biostratigraphic studies that we have undertaken for several decades in the Boreal and Tethyan realms have yielded a great amount of data, so here we synthesize the information about the ammonite and foraminiferous zones recognized in the "middle" Cretaceous of the two domains (Amédro, 1992, 2002, 2008; Amédro & Robaszynski, 2001 a-b; Amédro et alii, 2005; Robaszynski et alii, 1990, 1994). The results of a comparison of the several zones are shown on a table (Table) which provides a clear understanding of the choices made in its construction. Such a comparison of zones should not be taken as a purely academic exercise, but rather as an attempt to compare biostratigraphic intervals that should facilitate a more precise synchronization in the two domains of the events, lithologic, biologic, geochemical, eustatic that took place in the medial portion of Cretaceous times.

I – Choices made in constructing the table (Table)

The reference zonation was chosen to be that of the ammonites of Tunisia, in spite of the fact that for the middle Cretaceous two of the three stage boundaries are defined with a planktonic foraminifer and an inoceramid species. However, it appears that insofar as ma-
crofossil time-markers are concerned, ammonites are both the most abundant paleontologic material and the most determinative in indicating platform deposits, be they proximal or distal (AMÉDRO in ROBASZYNSKI et alii, 1990, 1994).

The number of ammonite zones in Tunisia is greater than those of the Boreal domain, for at least two reasons: (i) deposition of sediments was more continuous -thus more nearly complete- for it was taking place in a basin more subsident than those of the intracratonic basins of northwestern Europe, (ii) there, starting in Albian times, connections with North American and African provinces were established and immigrants from these provinces are associated with or replace Tethyan faunas.

In the table (Table), the zones recognized or created in Tunisia are in successive boxes of the same size, but this does not mean that they are all of the same time length. This form was chosen because, although the duration of several has begun to become known (CARON et alii, 1999), the length of many is far from being established. Probably the work on dating volcanic ash in company with detailed cyclostratigraphic studies will add a lot to the measurement of the length of zones.

The planktonic foraminiferal zones are placed in respect to the Tunisian ammonite zones in accordance with information obtained from records of their vertical ranges made in the same sections as those that furnished the ammonites (ROBASZYNSKI et alii, 1990, 1994).

II - Characteristics and comparison of the two ammonite zonations of the middle Cretaceous

1 - NW Europe: Anglo-Paris Basin, Westphalia and southeastern France (Rhône valley and the Vocontian domain)

The ammonite zonation currently in use for the middle Cretaceous of NW Europe, an area that includes the historical stratotypes of the Albian, Cenomanian and Turonian stages, is one of the most precise known. Its examination calls for several remarks: (i) most of the markers of the zones have a broad geographic distribution; (ii) where it is possible, the species chosen are in the same phyletic lineage, for example in the Upper Albian-Vraconnian the succession is Mortoniceras with two tubercles per rib (M. pricei), then three (M. inflatum, M. fallax) and finally four tubercles per rib (M. perinflatum); (iii) except in the Vocontian domain (Mont Risou, KENNEDY et alii, 1996) an important gap in sedimentation marks a hiatus in the succession of ammonite faunas; (iv) in the Middle Turonian, while the chalk facies of the northern Anglo-Paris Basin and of Westphalia (KAPLAN et alii, 1996) contain a typically Boreal fauna with Collignoniceras, the "tuffeaux" (porous limestones) of the southern border of the basin (Saumur, Bourré, Poncé) and the sandstones of the Rhône valley (Uchaux) contain mixed faunas, rich in Kamerunoceras, then in Romaniceras. These intermediate areas form precious links between the Boreal and Tethyan domains.

2 - Central Tunisia

The ammonite zonation now used for the middle part of the Cretaceous succession has progressed in relation to the previous divisions recognized by PERVINQUIÈRE (1903, 1907) and DUBOURDIEU (1956). Its detail is often better to that obtained in the intra-cratonic basins of NW Europe, because of the continuous and thicker deposition, and an extraordinarily rich ammonite fauna at almost all the levels.

3 - Comparison

There are numerous kinships between the ammonite zones of NW Europe (Boreal and north Tethyan domains) and those of Tunisia (southern Tethyan domain). Nevertheless, several intervals have no direct correlation. These coincide in particular with the limits of stages (eustatic events, lowering of sea level). But on the other hand, at these levels there is the remarkable occurrence in Tunisia of the episodic occurrence of ammonites with North American affinities, successively: (i) at the limit between Albian (Vraconnian) and Cenomanian: Graysonites (AMÉDRO in ROBASZYNSKI et alii, 2007); (ii) in the Middle Cenomanian: Paraconlinoceras barcusi, Acanthoceras amphibolum; (iii) at the Cenomanian-Turonian boundary: Pseudaspidoceras pseudodosoides, Watinoceras sp., Pseudaspidoceeras flexuosum; (iv) in the Upper Turonian: Priocyclus novimexicanus, P. germari. These successive phases of migration are probably linked to eustatic events (Transgressive Intervals of 3rd order eustatic cycles). All of this demonstrates the existence of numerous relationships between the Boreal and Tethyan domains, not only between northwestern Europe and Tunisia but also, in a more ephemeral way, between the North-American continent and Tunisia.
### Table:

An attempt to correlate the zonation of ammonites and foraminifers in northwestern Europe (Boreal domain) with that of central Tunisia (Tethyan domain). The up- and down-pointing arrows indicate respectively the first and last appearances of the taxa concerned.

### III - Foraminiferal zonations

#### 1 - Central Tunisia

The sections were made in areas where sedimentation was intermediate between platform and basin. The Kalaat Senan region is in the outer platform domain, in a distal relationship to the coast, with deposits essentially argillaceous and marly in the Albian-Lower Albian.
have less significance for chronostratigraphy. Generally associated with planktonic forms but forms with agglutinated or calcareous tests are forms between species. Moreover, benthic forms with thick keels, with numerous transitional morphotypes have well-marked and globular morphotypes have well-marked and 0.7mm, sometimes up to 1mm), the non-thick keels, with numerous transitional forms between species. Moreover, benthic forms with agglutinated or calcareous tests are generally associated with planktonic forms but have less significance for chronostratigraphy.

In Tunisia, the zones recognized between the Vraconnian and the Coniacian are more or less the "standard zonation" that since the middle of the 20th century has been established and improved (BOLLI, 1966; SIGAL, 1987; ROBASZYNSKI & CARON, 1979; details in ROBASZYNSKI & CARON, 1995, and in GONZÁLEZ-DONOSO et alii, 2007), with the succession: Thalmanninella appenninica, T. globotruncanoides (= brotzeni), T. reicheli, Rotalipora cushmani, Whiteinella archaeopecteira, W. praehelvetica, Helvetoglobotruncanana helvetica, Marginotruncanana schneegansi, Dicarinella concavata.

Remarks

As Thalmanninella globotruncanoides has been chosen as the marker of the base of the Cenomanian, it implies that the last Stoliczkaia ammonites -among which is the index of the zone, that is Stoliczkaia (Shumarinia) africana- are not confined to the Albain (Vraconnian) but "climb" into the basal Cenomanian. For the two other limits of stages the planktonic foraminifers have no bioevents to serve as true markers. However, they can be used as "proxies": for example as regards the Cenomanian-Turonian boundary the first Whiteinella praehelvetica (very rare) with flattened chambers on the spiral side are already noted in the Pseudaplectoceras pseudodososoides Zone of the uppermost Cenomanian, but at the Turonian-Coniacian limit there is no major extinction or appearance of foraminifera.

Conclusions

- A comparison of the ammonite zones of the Boreal and Tethyan domains shows numerous affinities between the two domains: almost two-thirds are the same.

- In Tunisia, nearly a third of the zones are based on species with North American affinities, so constitute excellent guides for intercontinental correlation.

- Planktonic foraminifera have only a third of the number of zones provided by ammonites. This disadvantage is compensated for by the fact that foraminiferal zones are global and that they can be recognized in the subsurface, in wells for example.

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