



Sympatric speciation of planktic foraminifera in response to environmental changes during the Cenomanian-Turonian interval in the Western Interior Basin

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Major oceanic changes occur during Cenomanian-Turonian period, including the global expansion of the oxygen minimum zone, are recognised involving the disappearance of *Rotalipora*, complex keeled foraminifera which previously occupied deep oceanic waters.

In the best documented Pueblo type section (Colorado), only two keeled species of *Rotalipora* are recorded: *R. cushmani* (Morrow) and *Rotalipora greenhornensis* (Morrow). Associated with these deepest-dwelling morphotypes, two forms of the genus *Anaticinella* occur. These inflated morphotypes are characterised by a discrete peripheral keel which sometimes is not expressed on each chamber or even totally absent. But they always present supplementary apertures as *Rotalipora*. The first species *Anaticinella multiloculata* (Morrow) has a great number of chambers in its last whorl (6.5 to 9). The second: *Anaticinella planoconvexa* (Longoria) has fewer chambers (5 to 6). *Anaticinella* preserves youthful characters (the development of the keel was truncated) but they remain the same size as *Rotalipora*. Such transformations during the ontogeny development agree with a heterochrony like neoteny *sensu* Gould (1977). Thus, *Anaticinella multiloculata* would derive from *R. greenhornensis* and *Anaticinella planoconvexa* from *R. cushmani* by simply losing their keels. This deterioration of the development corresponds to a modification of the growth speed. In the

case of *Anaticinella*, this one is slowed down. Even if *A. planoconvexa* remains a minority in planktonic assemblages, *A. multiloculata* proliferates a few tens of centimetres under the marker bed 63 to reach nearly 80% of the planktonic forms of large size. Thus, over tens of thousands of years, this species, plentiful in the Western Interior Basin, multiplies and predominates on *Rotalipora* before a progressive decline. It becomes extinct at the same time as *R. greenhornensis*. If *A. planoconvexa* constitutes a minor fraction of the planktic foraminiferal assemblages, nevertheless they survive, as atypical forms of *R. cushmani*, up to the bed 86 where the Cenomanian-Turonian boundary is placed according to the first occurrence of *Watinoceras devonense*.

These examples of sympatric speciation conduct to more general questions about the conception of a genus. Indeed, if for the Cretaceous times, keeled or globular forms (as for *Rotalipora*) are not classified in the same genus, different morphotypes may currently be regrouped in same genera by the micropalaeontologists for the Paleogene and Neogene (as for *Globorotalia crassaformis*/*Globorotalia ronda*).

Thin sections let us to accomplish a fine study of microfacies which are an evidence for the reconstitution of the degree of oxygenation on the seafloor. Two main types of microfacies have been defined. Oxidic microfacies are burrowed with a high diversification of planktic specialized foraminifera as *Helvetoglobotruncana helvetica* (Bolli), *Dicarinella* spp. or *Marginotruncana* spp. On the opposite, anoxic microfacies are characterised by rich organic carbon laminations; foraminifera are not so diversified with the predominance of inflated forms as large *Whiteinella*. Thus, at Pueblo and another nearby section, our observations in thin sections reveal that the highly oxygenated marker bed 86 contains the first occurrences of the complex keeled *H. helvetica*.

The relationship between *Anaticinella*/*Rotalipora* distribution and microfacies succession is not obvious even if the anaticinellids seem to be more abundant during hypoxic period. According to Eicher (1972) and Leckie (1985), the rotaliporids gave rise to anaticinellids by losing their keels in response to the OAE2. But, beyond the expanding of oxygen minimum zone, other oceanic changes must be considered as salinity and temperature variations which would also lead to the modification of other morphological criteria as the porosity of the test.

Toward north (South Dakota), our high resolution correlations indicate that transitional forms between *Whiteinella praehelvetica* (Trujillo) and *H. helvetica* are present in the terminal Cenomanian. Whereas the first chambers of these morphotypes are globular, the two or three last chambers of the final whorl show a peripheral keel. In term of taxonomy, transitional forms are difficult to attribute to such or such species because there is a continuum between *W. praehelvetica* and *H. helvetica*.

If transitional forms occur within anoxic microfacies whereas *H. helvetica* appears in highly oxygenated limestones (as bed 86), are morphological evolutions be systematically associated with oceanic changes? Indeed, transitional forms from *W. prae-helvetica* toward *H. helvetica* expand during the acme of oceanic anoxic event.

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Leckie, R.M., 1985. Foraminifera of the Cenomanian-Turonian boundary interval, Greenhorn Formation, Rock Canyon anticline, Pueblo, Colorado. In: Pratt, L.M., Kauffman, E.G., Zelt, F.B. (Eds.). *Fine-grained deposits of cyclic sedimentary processes*. SEPM Field Trip Guidebook. 4, pp. 139-149.