

14. UPPER APTIAN AGGLUTINATED FORAMINIFERS FROM DSDP HOLE 402A

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Forty meters of hard black shale obtained from Hole 402A, Cores 30-33, contained upper Aptian agglutinated benthic foraminifers. Found nowhere else in Leg 48 Bay of Biscay cores, they are similar to the primitive agglutinates described by Bartenstein (1974) from sediments obtained on Leg 27. The first appearance of these primitive agglutinates was in Sample 33,CC, where they occurred together with a calcareous benthic shelf fauna and planktonics belonging to the lower Gargasian *Schackoina cabri* Zone. The agglutinated fauna consists of: *Ammodiscus tenuissimus*, *Glomospira gordialis*, *Hyperammina gaultina*, *Hyperammina* sp., *Trochammina minuta*, and others, many of which are poorly preserved and too nondescript to identify. The calcareous benthic fauna includes: *Cornuspira cretacea*, *Epistomina spinulifera*, *Gavelinella barremiana*, *Gavelinella* cf. *G. barremiana*, *Gyroidinoides primitiva*, *Lenticulina heiermanni*, lenticulinids, dentalinids, and nodosariids. The planktonic fauna is dominated by *Schackoina cabri* and *S. pustulans*.

Samples 30,CC, 31,CC, and 32,CC also contain this mixture of calcareous species and primitive agglutinates in their benthic foraminiferal fauna. The calcareous fauna includes: *Epistomina caracolla*, *E. spinulifera*, *Gavelinella barremiana*, *Gavelinella* cf. *G. barremiana*, *Hoeglundina chapmani*, *Lenticulina heiermanni*, *L. spinosa*, *Lenticulina* spp., and *Spirillina minima*. The agglutinated fauna consists of: *Ammobaculites fisheri*, *Ammodiscus tenuissimus*, *Glomospira charoides*, *G. gordialis*, *G. irregularis*, *Hyperammina gaultina*, *Hyperammina* sp., and many others. The planktonic fauna is dominated by the upper Aptian species *Hedbergella trochoidea*.

The environment of deposition of the agglutinated benthic foraminifers poses a problem in interpretation. An almost identical fauna described by Bartenstein (1974) on Leg 27 from the southwest Indian Ocean was interpreted as being deposited below the CCD in samples where they appeared alone, or just above the CCD in samples where they are mixed with a calcareous fauna. *Hyperammina gaultina*, *Glomospira charoides*, and especially *G. gordialis* are usually considered indicators of deep water, lower bathyal or abyssal. Working on samples of slightly younger age from Leg 27, Scheibernova (1974) described a benthic foraminiferal fauna containing some of the same agglutinated species, including *G. gordialis*, and interpreted the environment of deposition as shallow water (less than 100 m), in a basin with poor water circulation, depleted O₂, a low pH, and high H₂S content. Calcareous forms were partly or completely dissolved in the sediment soon after deposition or during early diagenesis. Moorkens (1975) constructed a model to explain the occurrence of Paleogene "agglutinated-foraminifer-facies" found in the Paris Basin,

Belgium, the Netherlands, northern Germany, and the North Sea. As the agglutinated assemblages from these areas occurred in greatly different environments as far as salinity and bathymetry were concerned, the model called for the necessity of three physico-chemical parameters of the surface layers of the sediment and in the deepest bottom waters: "(1) Clayey or muddy sediments, relatively rich in slowly decaying organic matter, as mainly occurring under stagnant or poorly circulating bottom waters. (2) Low pH values, which are either low alkaline (pH less than 7.8) or slightly acidic; such low pH values are mainly the result of a high CO₂ content (a) derived from *in-situ* decaying organic matter or (b) occurring in cold, deep waters, where it is induced by low temperatures and high hydrostatic pressures. (3) Negative or low positive Eh values; such low redox-potentials occur together with O₂ depletion in and under stagnant bottom waters. Agglutinating foraminifers have been observed in Recent sediments, living under anaerobic conditions."

Thus, there is evidence that benthic agglutinated foraminifers occur in a variety of depth habitats. Further evidence for multi-depth habitats for some of the species involved comes from distribution of *Glomospira charoides* and especially *G. gordialis*, which is usually considered a lower bathyal to abyssal species. These two species have persisted through time and are extant today. Parker (1954) records *G. charoides* from depths shallower than 200 meters in the northeastern Gulf of Mexico. Cushman (1918) lists the shallowest occurrence of *G. gordialis* in the Atlantic Ocean as 167 fathoms (308 m). All calcareous benthic foraminifers from Cores 30-33 indicate an open shelf environment of deposition. A deep-water origin for the primitive agglutinates, therefore, seems untenable. Also, the high percentages of planktonic foraminifers, (lowest, 46 per cent in Core 32), argue against a very shallow water origin. Since the calcareous forms, both benthic and planktonic, show little evidence of dissolution, there must have been little alteration after burial. The presence of calcareous forms, especially the high percentages of planktonics, requires a somewhat different interpretation than either of the two environments of deposition or the model discussed above.

Hole 402A was drilled in a canyon in a basin behind the crest of a tilted fault block. The crest of the fault block represents the sill of the basin. The 40 meters of upper Aptian black shales recovered in Cores 30-33 are the sediments which infilled the basin up to sill depth. The total amount of sediment is estimated to have been at least double the 40 meters of the compacted, drilled sequence. Poorly circulating bottom water, an oxygen neutral zone (indicated by pyrolysis data), and terrestrially derived organic matter

being deposited in the basin provided the habitat for the formation of the primitive agglutinates. Although the organic carbon content in Cores 30-33 was the highest of any of the Biscay cores (2-3 per cent), and the presence of the primitive agglutinates correlates exactly with this interval, pyrolysis data indicate the organic debris was highly oxidized prior to deposition. Thus it appears that the environment of deposition during the part of the upper Albian that produced the primitive agglutinated foraminiferal fauna was neither oxidizing nor reducing, but rather an oxygen neutral zone (Mélières, this volume), a departure from the model mentioned above. At Hole 402A, however, there is clearly a correlation between organic carbon content and the presence of the primitive agglutinated fauna. Its first appearance in Sample 33,CC marks the first in any of the cores that the organic carbon content exceeded 2 per cent. The fauna continued its presence through Sample 30,CC, after which the organic carbon content fell below 2 per cent and the agglutinated fauna never reappeared. Even though the depositional environment was in outer shelf depths, it was still near shore, as indicated by abundant terrestrially derived trachoidal and cuticular organic debris and the first appearance of the peridinacean dinocyst, *Ovoidinium diversum*, in Sample 32-7, 0-4 cm. The planktonic foraminifers and nannoplankton indicate oceanic conditions, or at least oceanic water influx, in the waters above the basin.

Some event in the lowermost upper Aptian, perhaps movement along the tilted fault block, restricted circulation in the basin, and organic debris began to accumulate marking the onset of conditions favorable for the formation of the primitive agglutinated fauna. Evidence for the beginning of these conditions is the first appearance of the primitive agglutinates and the rise of organic carbon content above 2 per cent in the sediments in Sample 33,CC. Benthic fauna comprised only 2.3 per cent of the total foraminiferal fauna and contained many calcareous shelf species. The sediments in Samples 32,CC and 31,CC, deposited somewhat later when the basin was partially infilled, contained around 54 per cent benthic fauna of which over 90 per cent were primitive agglutinates. By the time represented by the sediments in Sample 30,CC, the basin must have been practically infilled up to sill depth and circulation was no longer, or only partially, restricted. Benthic forms made up only 18 per cent of the total foraminiferal fauna, and the abundance of calcareous shelf forms increased. Above Core 30 no primitive agglutinates were found and organic carbon content dropped below 2 per cent, indicating complete infilling of the basin.

Calcareous benthic and planktonic species showed no signs of dissolution so typical of agglutinated facies found elsewhere. Although there is no evidence that reducing conditions were prevalent, for which the model for the formation of agglutinated foraminiferal facies calls, there almost certainly was an oxygen neutral zone. This oxygen neutral zone and the rapid deposition of oxidized organic material probably restricted, but did not completely inhibit, formation of calcareous forms, and in turn provided a favorable habitat for the agglutinated fauna allowing them to compete successfully in the benthic niche. There is also no evidence for post-depositional dissolution. Almost all foraminifers contain an organic sheath covering the calcareous test and protecting it somewhat from the external environment. (It is

this mechanism that allows many calcareous forms to exist in depths below the CCD in modern oceans.) The presence of this protective sheath and rapid burial (sedimentation rate for the Albian is 34 m/m.y.) could preserve the calcareous fauna almost intact.

SYSTEMATICS

Only the most numerous of the agglutinated fauna are listed below and figured in Plate 1.

Ammobaculites fisheri Crespin

(Plate 1, Figures 1, 2)

Ammobaculites fisheri Crespin, 1953. *Cush. Lab. Foram. Res., Contrib.*, v. 4, p. 42, fig. 1f.

This species was found in only Samples 31, CC, and 32, CC, where the agglutinated fauna reached its greatest abundance.

Ammodiscus tenuissimus (Guembel)

(Plate 1, Figure 3)

Spirillina tenuissima Guembel, 1862. *Wuerttemb. Natl. Jahrb.*, Jg. 18, p. 214, pl. 13, fig. 2.

This species occurred in Cores 30-33, but nowhere else at the Bay of Biscay sites.

Ammodiscus sp.

(Plate 1, Figure 4)

This species occurred only in Sample 32, CC. It is similar to *Ammodiscus cretaceus* (Reuss), but is almost always too poorly preserved for positive identification.

Glomospira charoides (Jones and Parker)

(Plate 1, Figures 5, 6)

Trochammina squamata var. *charoides* Jones and Parker, 1860. *Quart. J. Geol. Soc. London*, v. 16, p. 304.

One of three species of *Glomospira* in the agglutinated fauna that occurs both below and above Cores 30-33, and in cores from other sites in the Bay of Biscay.

Glomospira gordialis (Jones and Parker)

(Plate 1, Figures 7-9)

Trochammina squamata var. *gordialis* Jones and Parker, 1860. *Quart. J. Geol. Soc. London*, v. 16, p. 304.

This is the third most abundant species of the agglutinated fauna. It occurs above and below Cores 30-33, and in cores from other sites.

Glomospira irregularis (Grzybowski)

(Plate 1, Figures 10, 11)

Ammodiscus irregularis Grzybowski, 1898. *Rocz. Akad. mat.-prz.*, v. 33, p. 285, p. 11, fig. 2, 3.

This species is common in Samples 31, CC, and 32, CC, and is also found in other cores from the Bay of Biscay.

Hyperammina gaultina Tem Dam

(Plate 1, Figures 12-20)

Hyperammina gaultina Tem Dam, 1950. *Mem. Soc. Geol. France, Mem* 63, p. 5, pl. 1, fig. 2.

This is by far the most abundant species of the agglutinated fauna. The degree of agglutination of the test varies from specimen to specimen. Those that are lightly agglutinated usually have bilaterally compressed second chambers as described for the holotype by Tem Dam. Heavily agglutinated specimens have nearly round second chambers when viewed in cross-section. Without agglutination the test seems flexible, and the numerous lightly agglutinated tests with compressed second chambers are undoubtedly a result of compaction of the sediment. This species is limited to Cores 30-33, Hole 402A, in the Bay of Biscay.

Hyperammina sp.

(Plate 1, Figures 21-23)

This is the second most abundant species of the agglutinated fauna. It is similar to the species described as *Hyperammina* sp. 2 by Bartenstein (1974). It is limited to Cores 30-33, Hole 402A, in the Bay of Biscay.

Trochammina minuta Crespin

(Plate 1, Figure 24)

Trochammina minuta Crespa, 1953. *Cush. Lab. Foram. Res., Contrib.*, v. 4, p. 32, pl. 5, fig. 19a,b.

This species is limited to Sample 33, CC.

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PLATE 1

- Figures 1, 2 *Ammobaculites fisheri* Crespin. Sample 402A-33, CC.
1. $\times 45$.
2. $\times 90$.
- Figure 3 *Ammodiscus tenuissimus* (Guembel). Sample 402A-32, CC. $\times 45$.
- Figure 4 *Ammodiscus* sp. Sample 402A-31, CC. $\times 135$.
- Figures 5, 6 *Glomospira charoides* (Jones and Parker). Sample 402A-32, CC.
5. $\times 118$.
6. $\times 225$.
- Figures 7-9 *Glomospira gordialis* (Jones and Parker). Sample 402A-33, CC.
7, 9. $\times 90$.
8. $\times 145$.
- Figures 10, 11 *Glomospira irregularis* (Grzybowski). Sample 402A-33, CC. $\times 90$.
- Figures 12-20 *Hyperammina gaultina* Tem Dam. Sample 402A-32, CC.
12, 15, 20. $\times 45$.
13. $\times 58$.
14. $\times 90$.
16. $\times 68$.
17, 19. $\times 54$.
18. $\times 100$.
- Figures 21-23 *Hyperammina* sp. Sample 402A-33, CC.
21. $\times 90$.
22. $\times 85$.
23. $\times 72$.
- Figure 24 *Trochammina minute* Crespin. Sample 402A-33, CC. $\times 90$.

PLATE 1

