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TEXTILINA MEXICANA (CUSHMAN) FROM THE WESTERN NIGER DELTA

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Abstract. This study of the foraminifer *Textilina mexicana* (Cushman) shows it to be a species with a perforated test wall, biserially arranged chambers, possibly an adventitious chamber, wall a mixture of mineral substances, mostly quartz and calcium carbonate, occasionally feldspar and other minerals, particularly ilmenite. Aperture quadrate, located at base of last chamber. Outer wall surface minutely perforate (ultrapores?). Principal components analysis is used to demonstrate that six dimensions of the test are not correlated with the size of the proloculus.

INTRODUCTION

Nørvang (1966) has recently shown that the widely accepted definition of *Textularia* is erroneous. In fact, as a result of his revision, only two of the multitude of species generally attributed to *Textularia* may be retained within that genus, the others now being referred to Nørvang's new genus, *Textilina.*

Textularia, as now defined on the grounds of the properties of the previously inadequately understood type species *Textularia sagittula* Defrance, comprises forms with the initial chambers planospirally arranged both in megalospheric and microspheric tests and subsequent chambers developed biserially; the wall of the test is a mixture of calcareous and arenaceous particles and it is imperforate. The aperture is interomarginal, without distinct lips.

Clearly, the new information on the structure of *Textularia* raises a problem about the validity of *Spiroplectammina,* which was claimed originally to be distinguishable from *Textularia* by the planospirally coiled initial chambers. Certain differences may possibly exist (Nørvang, 1966, p. 13) as the wall of the test is said to be arenaceous.

The properties of *Textilina* Nørvang are principally a biserial test, with an adventitious chamber adjacent to the proloculus in microspheric individuals and some megalospheric tests. The wall of the test is composed of calcareous and sandy particles and it is perforate. The aperture is interior-marginal (Nørvang, 1966, p. 6). The new genus is claimed to differ from both *Spiroplectammina* and *Textularia* in the structure of the first part of the test and in the distinct perforation of the cameral wall.

Loeblich and Tappan (1964, p. C 253) have also made a special study of *Textularia* and have arrived at a different result from Nørvang. They consider *Textularia sagittula* to be truly biserial, based on material from Siena, and that previous records of individuals of this species with a planispiral initial stage must be erroneous.

Le Calvez (1963) recorded the presence of "*Textularia mexicana* Cushman" in Recent sediment samples from the Ivory Coast. This form was originally described from sediments taken from the northern part of the Gulf of Mexico (Cushman, 1922, p. 17). The species was erected for compressed tests with ridge-like sutures, along which the texture of the test is coarsest.

DESCRIPTION

Provenance. The material covered in this report was obtained from three offshore localities in the western Niger Delta, notably, a station about 1 km off Lagos Harbor, a station about 1 km off the port of Forcados and a station roughly half way between these and about 5 km offshore, all at about a depth of 15 m.

Repository. Paleontological Museum, University of Uppsala; specimens Af 1–Af 11.

The test. The test is roughly trianguloid (kite-shaped) with well-rounded sutures. The sutures

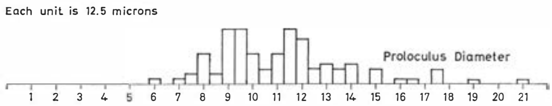

Fig. 1. Histogram of the diameter of the proloculus of *Textilina mexicana*.

are considerably thickened to form lateral ridges and a median ridge along the middle of the shell. The roofs of the chambers are flat. The aperture is rectangular and rimmed, located at the base of the chamber.

A plot of the diameter of the proloculus (Fig. 1) indicates that the distribution is bimodal; hence there is no clear partition into microspheric and megalospheric individuals.

The shell substance. The test is colored pale yellow and has a clearly sandy texture. Occasionally grains of darker minerals are to be seen. The major chemical constituents and their distribution in the test were investigated by means of the electronic microprobe of the Geological Department of the University of Uppsala. This investigation was mainly aimed at determining the dark minerals. The analysis was carried out by sweeping over the shell with electron rays and analysing the main constituents with the spectrometer of the instrument. The most common elements were found to be Si, Al, Fe, Mn, K, Ca, Ti. Magnesium also occurs but in a lesser amount. Sulfur could not be detected. The sutures are more compact than the cameral walls; they contain mainly Ca, Si, Al and subordinately K and Fe. The chamber walls contain mainly Si and a certain amount of Al. The dark mineral contains Ti and Fe (+some Mn) and would appear to be ilmenite. The distributions of these elements are shown in Pl. 2, Figs. 1–6.

The detailed analysis of unusual sedimentary constituents of the shell of an agglutinating foraminifer may be utilized for the reconstruction of the immediate sedimentary history of a microenvironment. By selecting individuals of the same size class that were alive at the time of capture, and studying the variation in mineralogy for each chamber, it is possible to reconstruct the shifts that took place in the mineral availability during the growth of the foraminifers.

The investigation of the shell structure by standard electron-microscopic methods indicates the wall to be composed of an aggregate of grains of quartz and calcium carbonate (Pl. 4, Figs. 3–5). This accords with Nørvang's observations made on etched sections. Thus, just as fine as well as coarse grains of quartz may occur, fine and coarse grains of calcium carbonate contribute to the test. As shown by Pl. 2 Figs. 3 and 6, the distributions of the points for Ca and Si approximate closely to each other, which is a result of their intimate mingling in the substance of the shell. The concentration of Si in the center of the test and the stronger Ca reactions in the last chamber, for example, suggest that the grains of quartz and calcium carbonate are not selected in a constant proportion but according to the relative abundance of these minerals in the sediment at the time of formation of the chamber.

The texture of the septal walls is shown in Plate 1, Figs. 6, 7, 10, 11. The structure of a fine-grained groundmass in which coarse crystals are embedded is shown clearly in Figs. 10 and 11.

The distribution of the pattern of points for Ti and the large agglomerations for Fe coincide, as is only to be expected if the dark grains are ilmenite.

The texture of the sutures and external wall in this section are shown in Pl. 1, Figs. 6, 7, 10, 11. The photographs of the thin section were taken in polarized light on Kodachrome II film. What appears to be a small adventitious chamber lies below the first chamber and may be difficult to locate (Pl. 1, Fig. 6). In addition to fine grains of quartz, the cameral outer walls and roofs contain very large grains of quartz (Pl. 1, Fig. 7) and, less frequently, grains of feldspar (Pl. 1, Fig. 10). The occurrence of feldspar in the test explains the presence of aluminium and potassium.

The external texture of the test was studied with the stereoscanning electronic microscope. The overall habitus of the test is shown in Pl. 2, Fig. 7 and Pl. 4, Fig. 1. The higher magnifications disclose two things about the surface texture. The first of these concerns the way in which the grains of calcium carbonate occur in the test. Pl. 3, Figs. 2, 4 show that embedded grains of calcite? are dispersed at irregular intervals in the shell. Calcite also occurs as a cementing medium (Fig. 4) in addition to some organic binding agent, perhaps tectine (Nørvang, 1966, p. 5). Fig. 4 shows calcite enclosing a feldspar crystal (cf. microprobe analysis). The material studied by Nørvang left him with the impression that the coarse grains in the shell are mostly calcite, few being quartz. In *T. mexicana* the large grains are mostly quartz. The second point arising from the stereoscanner investigation concerns the perforations of the wall. Coarse pores of the kind figured by Nørvang (cf. 1966, Pl. 2, Figs. 2, 3, 4) for *Textilina* were not identified in any of our material. However, the presence of external perforations is disclosed at high magnification (× 5000, × 10,000). This observation raises the question as to whether any *Textilina* are imperforate. Nørvang (1966, p. 9) was puzzled by the apparent absence or rarity of perforations in the wall and septa of the apertural end of *Textilina conica* (d'Orbigny) and it is conceivable that this species may also possess ultrapores. There is a possibility that ultrapores may occur in *Textularia* s.str. and *Spiroplectammina.*

Morphologic variation

Some examples of shell forms in the material from the Forcados locality are given in Fig. 2. The figured individuals comprise both pronouncedly microspheric and pronouncedly megalospheric individuals. The general shape is trianguloid but with straight to concave sides. Cushman's type has convex-outwards sides and represents a morphovariant that appears to be rare in the Niger Delta, but common in the coastal waters of the Ivory Coast. Some representatives of this morphovariant from the Ivory Coast are shown in Pl. 1, Figs. 1–3.

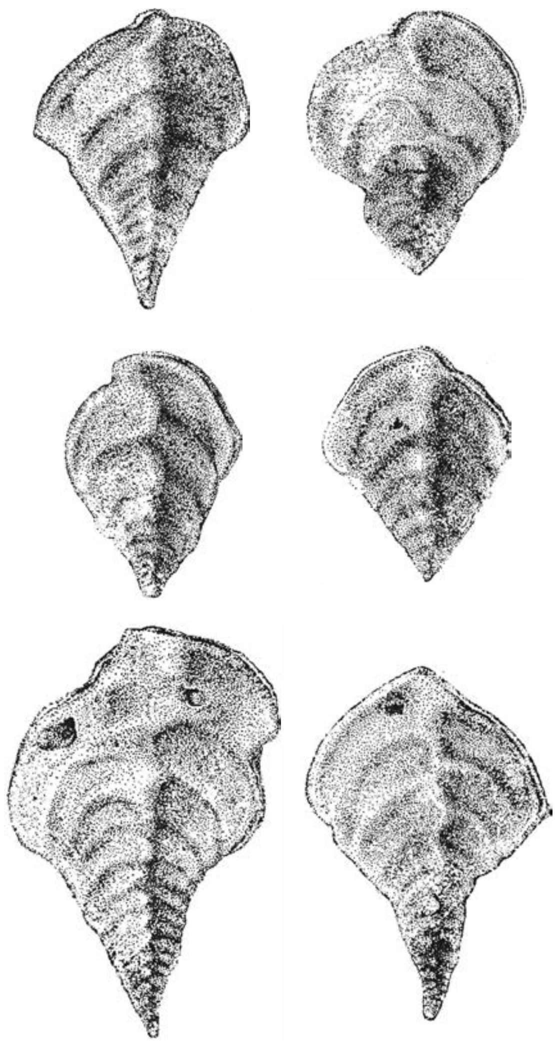

Fig. 2. Form variation in the test of *Textilina mexicana.* Specimens collected from Forcados, Niger Delta (× 45).

MORPHOMETRIC ANALYSIS

The variables selected for analysis are maximum breadth of test (x_1), maximum length of test (x_2), diameter of proloculus (x_3), breadth of last chamber (x_4), height of last chamber (x_5), length from initial tip of test to midpoint of rounding of last chamber (x_6), length from tip of test to midpoint of rounding of second last chamber (x_7). The unit of measurement for these variables is 40 units = 1 mm.

Owing to the presence of deviations from univariate normality in some of the variables all were logarithmically transformed. The standard deviations for all variables are not greatly different for the samples from Forcados and Lagos Harbor. The sample from the Midwestern Delta agrees for six variables, but x_4 is unusually small.

The nonsignificant correlations in Tables I, III and V are marked by an asterisk. These are between length of test and diameter of proloculus, breadth of last chamber and diameter of proloculus, and height of last chamber and diameter of proloculus. Generally, the significant correlations of the diameter of the proloculus with other dimensions are low. The first principal component (Table II) (cf. Reyment, 1966) represents variation in all variables with the diameter of the proloculus playing the least important part.

Variables x_1, x_2, x_5, x_6, x_7 are the dominant participants in this component. The second principal component is very interesting for it discloses the independence of the size of the pro-

Table I. *Basic statistics for Textilina mexicana (logarithms)*
Locality: Off Forcados (N = 93)

	x_1	x_2	x_3	x_4	x_5	x_6	x_7
Mean vector	1.4076	1.5542	0.7376	0.9460	0.9485	1.4206	1.3656
Standard deviations	0.0926	0.0986	0.1018	0.0861	0.1024	0.1089	0.1120
Covariance matrix	**0.00858**	0.00801	0.00184	0.00456	0.00740	0.00821	0.00824
(upper triangle)	0.8772	**0.00973**	0.00266	0.00465	0.00768	0.00967	0.00976
and	0.1954*	0.2648	**0.01037**	0.00105	0.00162	0.00238	0.00262
Correlation matrix	0.5717	0.5473	0.1192*	**0.00742**	0.00525	0.00401	0.00370
(lower triangle)	0.7801	0.7600	0.1557*	0.5951	**0.01049**	0.00830	0.00756
	0.8144	0.8998	0.2147	0.4279	0.7440	**0.01187**	0.01038
	0.7949	0.8836	0.2292	0.3839	0.6585	0.8507	**0.01255**

Table II. *Eigenvalues and eigenvectors for Textilina mexicana*
Locality: Off Forcados

Eigen-values	Confidence interval	Per-centage of total variation	Eigenvectors I	II	III	IV	V	VI	VII	
0.04810	0.03736–0.06750	67.76	0.3887	−0.0767	0.0628	0.0342	0.2941	−0.8239	−0.2696	x_1
0.00977	0.00759–0.01371	13.76	0.4331	−0.0019	−0.0890	0.1723	0.1057	−0.1163	0.8661	x_2
0.00633	0.00492–0.00889	8.92	0.1345	0.9802	0.1274	−0.0568	−0.0066	−0.0048	−0.0406	x_3
0.00292	0.00227–0.00410	4.11	0.2358	−0.1061	0.7703	0.5154	0.1353	0.1960	−0.1317	x_4
0.00165	0.00128–0.00232	2.32	0.3988	−0.1423	0.3487	−0.7600	−0.2259	0.2607	0.0499	x_5
0.00152	0.00118–0.00213	2.14	0.4626	−0.0431	−0.2703	−0.1129	0.7686	0.0295	−0.3267	x_6
0.00070	0.00054–0.00098	0.99	0.4632	0.0011	−0.4288	0.3315	−0.4922	0.4477	−0.2215	x_7

Table III. *Basic statistics for Textilina mexicana (logarithms)*
Locality: Off Lagos Harbor (N = 32)

	x_1	x_2	x_3	x_4	x_5	x_6	x_7
Mean vector	1.3072	1.4257	0.2076	0.8426	0.8564	1.2805	1.2462
Standard deviations	0.0870	0.0806	0.1178	0.0713	0.0723	0.0810	0.1099
Covariance matrix	**0.00756**	0.00640	0.00351	0.00278	0.00295	0.00594	0.00668
(upper triangle)	0.9137	**0.00649**	0.00320	0.00275	0.00333	0.00608	0.00660
and	0.3431*	0.3377*	**0.01387**	−0.00095	0.00182	0.00262	0.00031
Correlation matrix	0.4475	0.4794	−0.1133*	**0.00509**	0.00165	0.00303	0.00311
(lower triangle)	0.4689	0.5708	0.2136*	0.3204*	**0.00523**	0.00263	0.00292
	0.8439	0.9316	0.2746*	0.5247	0.4497	**0.00656**	0.00665
	0.6988	0.7457	0.0238*	0.3960	0.3669	0.7470	**0.01209**

Table IV. *Eigenvalues and eigenvectors for Textilina mexicana*
Locality: Off Lagos Harbor

Eigen-values	Per-centage of total variation	Eigenvectors I	II	III	IV	V	VI	VII	
0.03172	55.75	0.4513	0.0150	−0.0211	0.1518	−0.5053	−0.6639	−0.2767	x_1
0.01394	24.50	0.4367	−0.0043	−0.0795	0.0176	−0.3066	0.1954	0.8188	x_2
0.00447	7.86	0.2513	0.9136	0.0781	0.0792	0.2991	−0.0177	−0.0071	x_3
0.00335	5.89	0.2060	−0.2250	−0.5725	0.5455	0.5124	−0.1307	0.0446	x_4
0.00211	3.70	0.2341	0.0242	−0.5869	−0.7585	0.0802	0.0003	−0.1355	x_5
0.00105	1.85	0.4238	−0.0520	−0.0214	0.2090	−0.2182	0.7025	−0.4822	x_6
0.00026	0.46	0.5154	−0.3336	0.5608	−0.2318	0.4946	−0.1012	−0.0079	x_7

Table V. *Basic statistics for Textilina mexicana (logarithms)*

Locality: Off Midwestern Delta (N = 30)

	x_1	x_2	x_3	x_4	x_5	x_6	x_7
Mean vector	1.3910	1.5242	0.4596	0.8786	0.8935	1.3872	1.3609
Standard deviations	0.0799	0.0875	0.0886	0.0469	0.0714	0.0980	0.1031
Covariance matrix	**0.00639**	0.00629	0.00277	0.00152	0.00357	0.00651	0.00734
(upper triangle)	0.9002	**0.00765**	0.00256	0.00084	0.00381	0.00802	0.00874
and	0.3917*	0.3308*	**0.00785**	0.00068	0.00296	0.00253	0.00292
Correlation matrix	0.4042*	0.2033*	0.1624*	**0.00220**	0.00162	0.00088	0.00094
(lower triangle)	0.6244	0.6100	0.4675	0.4837	**0.00510**	0.00347	0.00427
	0.8312	0.9355	0.2908*	0.1919*	0.4949	**0.00961**	0.00895
	0.8911	0.9692	0.3192*	0.1940*	0.5802	0.8856	**0.01063**

Table VI. *Eigenvalues and eigenvectors for Textilina mexicana*

Locality: Off Midwestern Delta

Eigen-values	Per-centage of total variation	Eigenvectors I	II	III	IV	V	VI	VII	
0.03534	71.47	0.3986	0.0109	−0.1483	−0.3780	0.4235	−0.6961	−0.1104	x_1
0.00726	14.68	0.4558	0.1459	0.0664	0.1357	0.0126	0.0461	0.8636	x_2
0.00339	6.86	0.2132	−0.8876	0.3871	−0.1008	0.0032	0.0794	0.0192	x_3
0.00158	3.20	0.0747	−0.1156	−0.5747	−0.6513	−0.0672	0.4599	0.1031	x_4
0.00120	2.43	0.2597	−0.3047	−0.6567	0.5658	−0.2323	−0.1468	−0.1127	x_5
0.00053	1.07	0.4853	0.2270	0.2332	−0.2020	−0.7366	−0.0643	−0.2666	x_6
0.00015	0.30	0.5285	0.1816	0.0882	0.2083	0.4685	0.5194	−0.3837	x_7

loculus from the morphologic variables. The same result is yielded by the other two samples. In one respect, at least, this is to be expected on *a priori* grounds as the dimensions of the proloculus are unaffected by the growth relationships pertaining after the formation of this chamber. It is, however, not obvious that the dimensions attained by a test are largely independent of the phase in the generative cycle to which it belongs, as reflected in the size of the proloculus. The third principal component is also instructive; it is dominated by variable x_4, the breadth of the final chamber, whose shape is connected with the height of the last chamber and inversely with the length achieved by the test at the formation of the second last chamber. This interesting pattern is exactly repeated for the sample from off Lagos Harbor (Table IV), whereas the smallest of the three samples from the Midwestern Delta confirms only the interrelationship between variables x_4 and x_5. In all samples the first eigenvalue accounts for the greatest portion of the total variation.

The means for the three samples differ rather much from each other. The most surprising divergency is for the diameter of the proloculus. The mean for the Forcados sample is almost twice that of the Lagos sample, which in its turn is roughly twice that of the Midwestern sample. This would appear to indicate that the proportion of gamontic to schizontic individuals in a population of *T. mexicana* at any point in time is not anywhere near fixed.

The plot of the first two transformed variables of the component analyis of the largest sample is shown in Fig. 3. The points clearly do not form a single ellipsoidal pattern but seemingly two, and this would seem to be an outcome of morphologic differences occurring in the shells of gamonts and schizonts. A similar observation was made by the author (Reyment, 1966) for a Paleocene foraminifer.

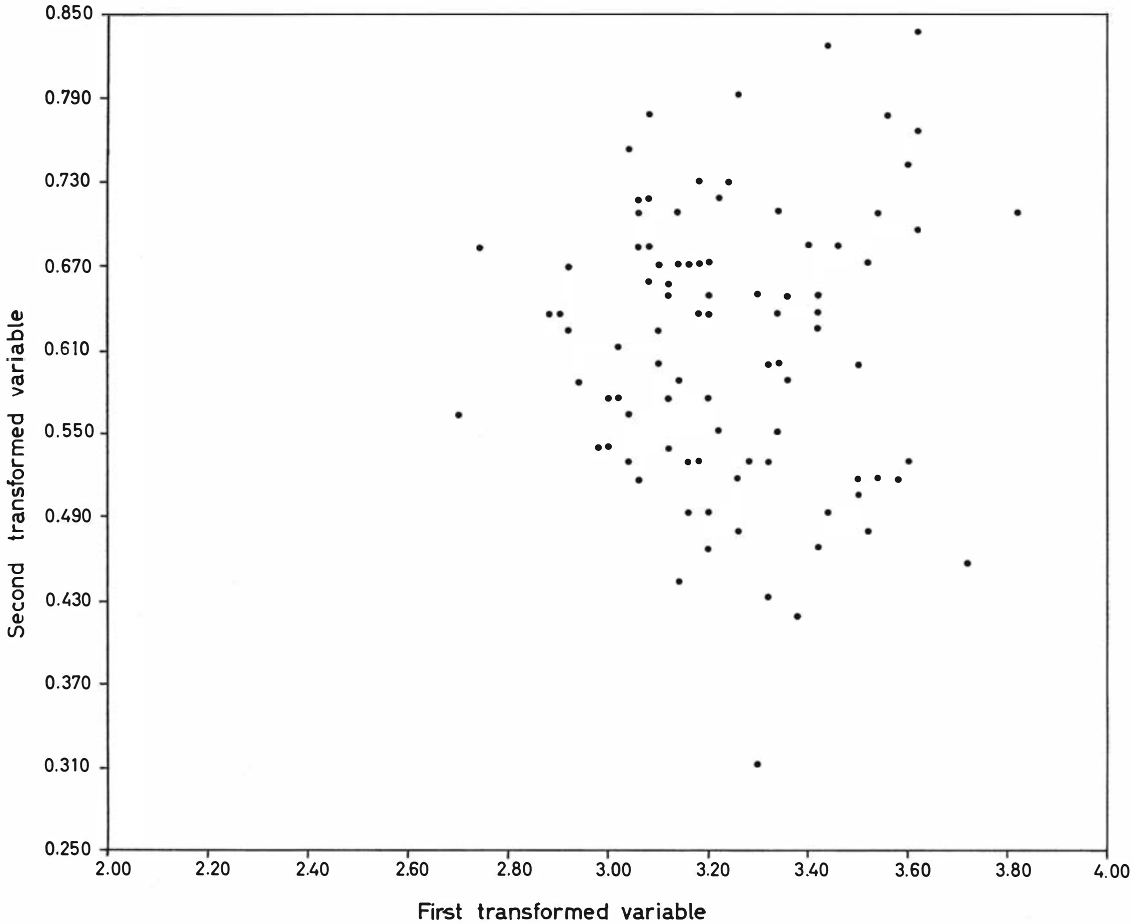

Fig. 3. Plot of the first two transformed variables of the principal components analysis.

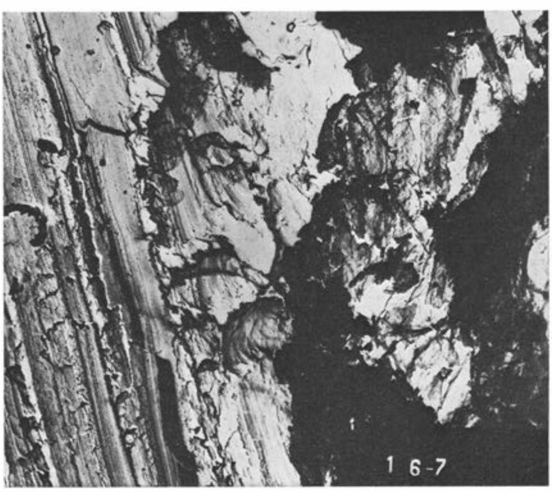

Fig. 4. Electron microscope picture of the wall of *Textilina* showing calcite cementing a grain of feldspar (× 1800).

ACKNOWLEDGMENTS

The conventional electron-microscopic pictures were made by Miss Ingrid Hallberg, University of Stockholm and the stereoscanner pictures by Jeolco Paris and by Statens Institut för Silikatforskning, Göteborg. The next figures were drawn by Mrs Ulla Karlsson, University of Stockholm and Mrs Inga Thomasson, University of Uppsala. The habitus photographs and the thin sections were made by Mr G. Andersson and the microprobe investigation by Dr. Marianne Dahl, both of the University of Uppsala. This investigation was supported by grant 2320-17/7242 from Statens Naturvetenskapliga Forskningsråd.

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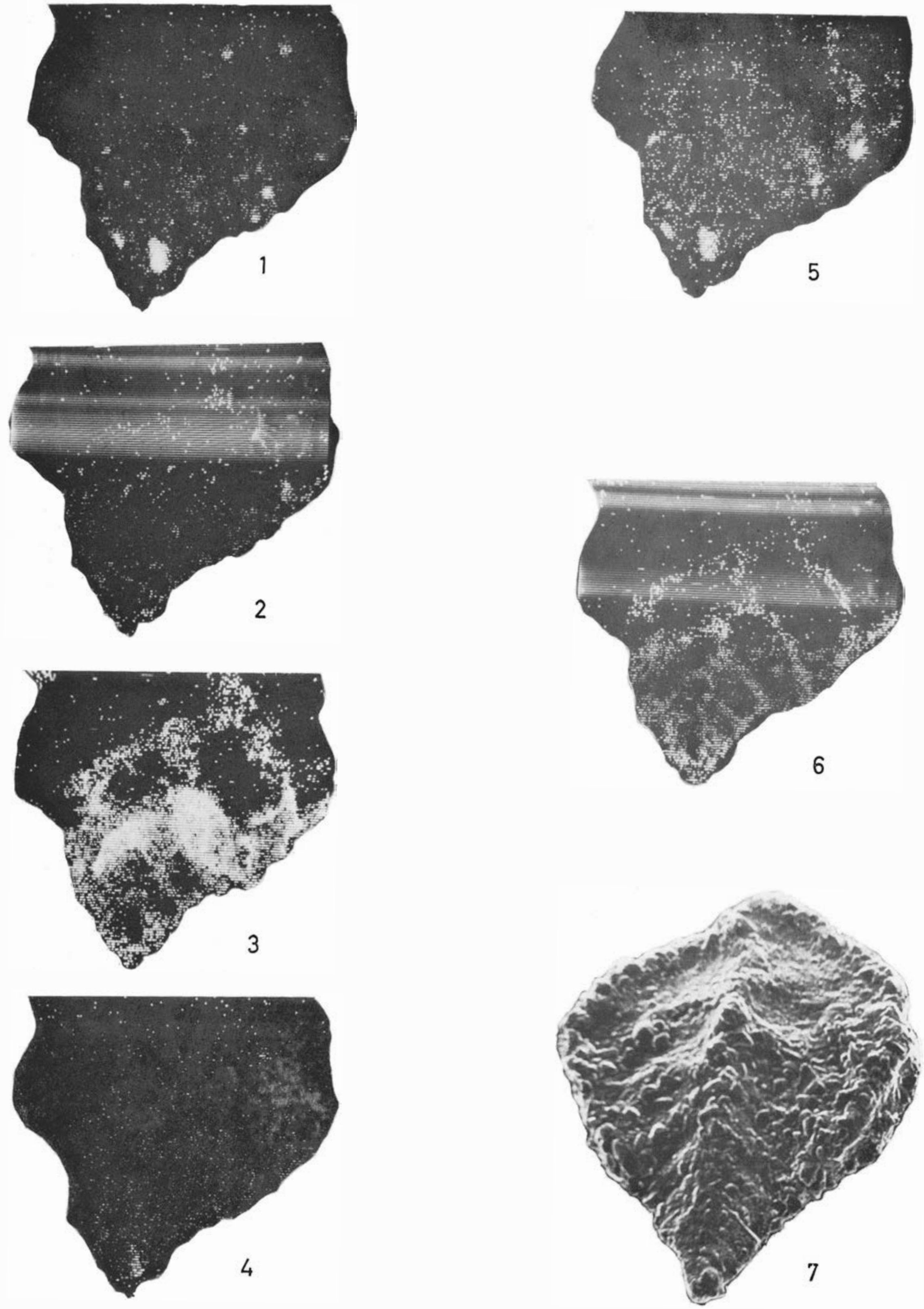
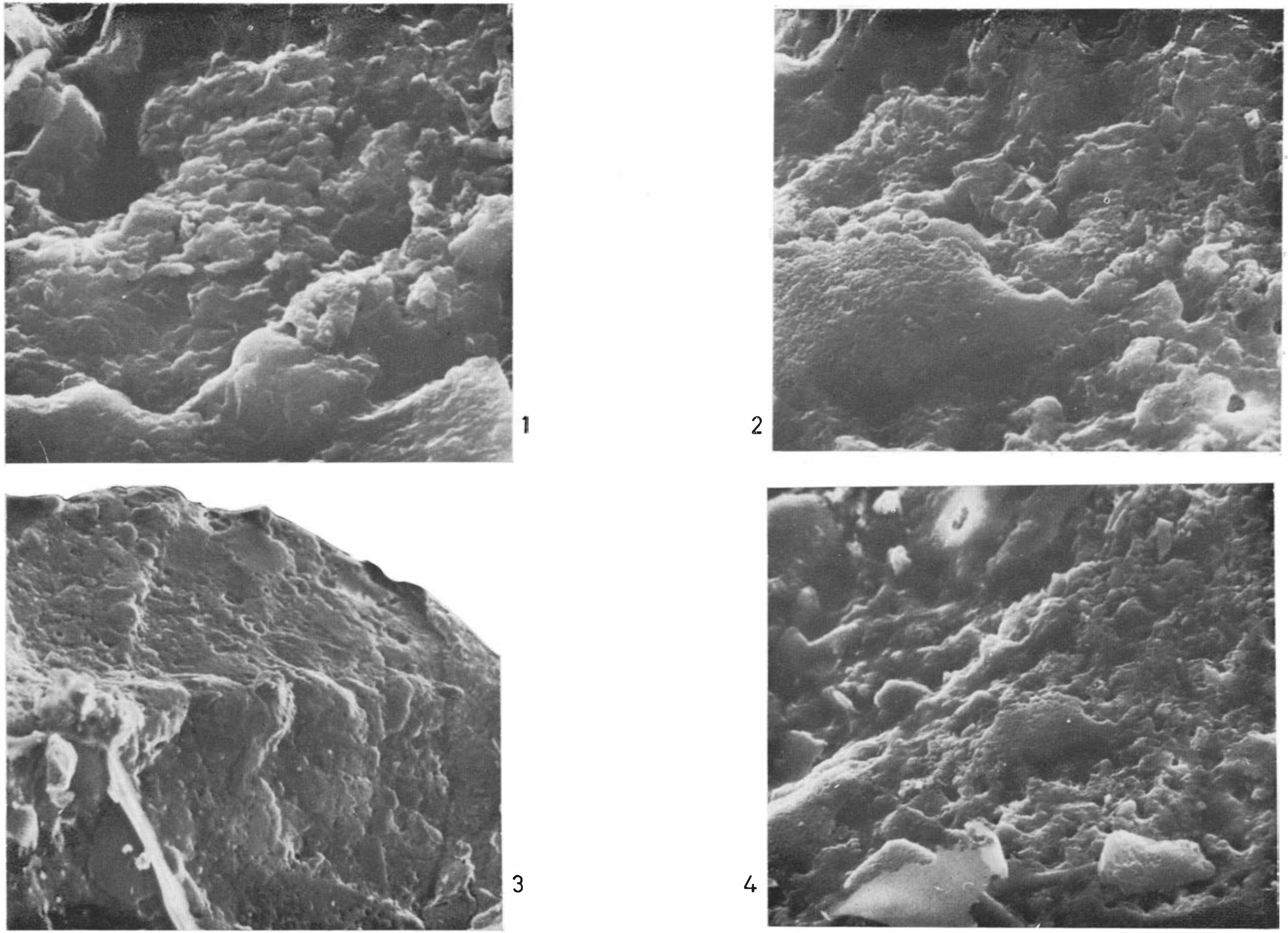
Figs. 1–3. Specimens of *Textilina mexicana* from off Bandama, Ivory Coast. Nos. Af 5, Af 6, Af 7 (× 60).
Fig. 4. Lateral view of test (× 60). No. Af 1.
Fig. 5. Oblique view of aperture (× 60). No. Af 2.

Figs. 6, 7. Thin section of the test in polarized light (Fig. 6 × 160; Fig. 7 × 100). No. Af 8.
Fig. 8. Oblique view of aperture (× 60). No. Af 3.
Fig. 9. Oblique view of aperture (× 60). No. Af 4.
Figs. 10–11. Same section as figured in Figs. 6, 7.



Figs. 1–6. Electronic microprobe photographs. Fig. 1, distribution of Ti; Fig. 2, distribution of K; Fig. 3, distribution of Si; Fig. 4, distribution of Mn; Fig. 5, distribution of Fe; Fig. 6, distribution of Ca. No. Af 9. Fig. 7. Electronic scanning microscope photograph of obliquely oriented test (× 80). No. Af 10.



1 2 3 4

Scanning microscope photographs of the surface of the test of *Textilina mexicana*. Photographs taken by JEOLCO (Europe) S.A. with copper coating, voltage 25 KW. Fig. 1 (× 8000); Fig. 2 (× 2400); Fig. 3 (× 240); Fig. 4 (× 800). No. Af 11.

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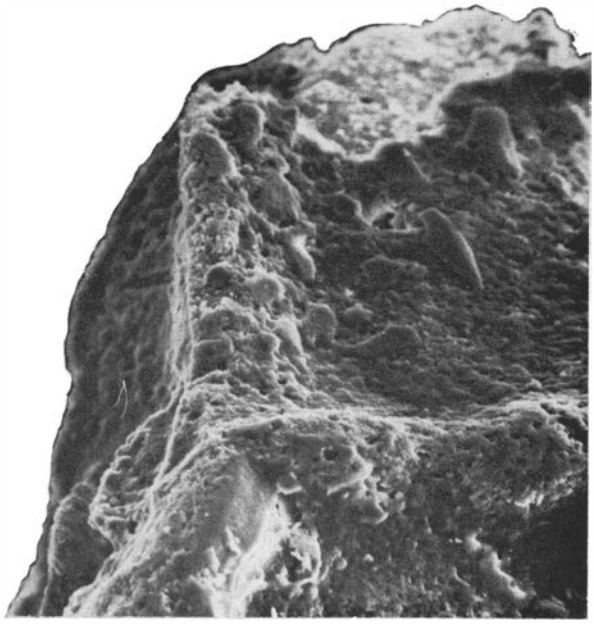

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Fig. 1. Electronic scanning microscope picture of the test in slightly oblique orientation (× 80). No. Af 11.
Fig. 2. Electronic scanning microscope picture of a ridged part of the test showing ultrapores (× 800). Same specimen as shown in Fig. 1.

Figs. 3–4. Electron microscope pictures of the wall of the test of the younger shell Fig. 3 (× 1500); Fig. 4 (× 6400); Fig. 5 (× 6400). The quartz grains show up as irregularly shaped bodies (cf. especially Fig. 3) and the calcareous grains as needles.