

## 17. PLANKTONIC FORAMINIFERA FROM THE UPPER CRETACEOUS OF SITE 98, LEG 11, DSDP

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### INTRODUCTION

Site 98 was drilled in the Northeast Providence Channel in the Bahama Islands (lat. 25°22.95'N; long. 77°18.68'W) in a water depth of 2750 meters. The Upper Cretaceous was penetrated between 272 and 357 meters below bottom, of which 27 meters were cored and 5.1 meters recovered.

The composition of the planktonic foraminiferal assemblages from Cores 13 through 15 is fairly homogeneous. The cored intervals correspond roughly to the entire Campanian stage. Only at the base of Core 15 a few specimens of *Globotruncana* sp. aff. *G. renzi* and *G. sp.* aff. *G. arca* may indicate an older age. *Globotruncana calcarata*, present in Core 13, is typical of the topmost Campanian. The orbitoids in Core 13 and from the center bit between Cores 14 and 15 corroborate this attribution to the Campanian (see chapter by L. Hottinger in this volume).

*Globotruncana bulloides*, *G. stuartiformis*, *G. lineiana*, *G. fornicata*, *G. leupoldi* (= *G. stephensoni* Pessagno), and a few *G. lapparenti* are the dominant and stable components in the assemblages. The index species for the Campanian, *Globotruncana elevata*, and its numerous transitional forms to *G. stuartiformis* are present in Core 15 and disappear in Core 14. *Globotruncana stuartiformis* persists to higher levels, where it is associated with transitional forms to *G. subspinosa* and the first representatives of *G. tricarinata*. Typical *Globotruncana subspinosa* occurs in Core 13. The late Campanian age of this core is indicated by the presence of *Globotruncana calcarata*, *G. arca*, and *Globotruncanella havanensis*. In addition, a few representatives of *Globotruncana ventricosa* and *G. falsostuarti* are found.

In Cores 15 and 14, numerous specimens of a *Globotruncana* are present, which could not be identified with any described species. These specimens share with *Globotruncana stuartiformis* the shape of the chambers, but differ by their conical test. All transitions between the typically biconvex tests of *Globotruncana stuartiformis* and specimens with a completely flattened umbilical side can be observed. A new species, *Globotruncana atlantica* n. sp., is introduced to include these specimens with a spiroconvex test.

### REMARKS ON SOME SPECIES

A detailed list of the planktonic foraminifera and a few benthonic smaller and larger foraminifera found in the Upper Cretaceous at Site 98 is given on the distribution-chart. The following remarks are therefore restricted to the comments needed for the understanding of this chart and to a few ambiguous species.

*Globotruncana* sp. cf. *G. concavata* Brotzen

1934 *Rotalia concavata* Brotzen. Z. Deut. Ver. Palästinas, p. 66, pl. 3, fig. b.

1970 *Globotruncana concavata* (Brotzen), Kuhry. Lectotype. Revista Española de Micropaleontología, vol. 2, n. 3, pl. 11, fig. 16-18.

In Samples 98-15-1, 130 centimeters and 98-15-1, 116 to 119 centimeters, two fragments of this species are found. Excluding the possibility of contamination, the presence of *Globotruncana concavata* would indicate the proximity of the Upper Santonian.

*Globotruncana* sp. aff. *G. fornicata* Plummer  
(transitional forms between *G. renzi* and *G. fornicata*)

The specimens are still close to *Globotruncana renzi*, but the flexuosity of the spiral chamber surface is already well developed.

*Globotruncana* sp. aff. *G. arca* Cushman  
(transitional forms between *G. angusticarinata*  
and *G. arca*)

The two keels are not yet as strongly separated and vigorous as in typical *Globotruncana arca*.

The presence of *Globotruncana* sp. aff. *G. fornicata*, *G. sp.* aff. *G. arca*, and *G. sp.* cf. *G. concavata* point to an early Campanian to late Santonian age of Core 15.

*Globotruncana arca* Cushman  
(Plate 2, Figure 2 a-c)

1926 *Pulvinulina arca* Cushman, pl. 3, figs. 1 a-c.

Biconvex test with a well developed inter-rim area separating the two keels. This good index species occurs in Core 13 together with *Globotruncana calcarata*.

DISTRIBUTION OF FORAMINIFERA IN THE UPPER CRETACEOUS-SITE 98

CORED INTERVAL ( in m. subbottom)				RECOVERY ( in m.)		BARREL		SECTION		INTERVAL ( in cm)		PLANKTONIC FORAMINIFERA		BENTHONIC FORAMINIFERA		ZONE	AGE	
272 - 281		311 - 318		Center bit between 14 and 15		348 - 357		GLOBOTRUNCANA		OTHERS		GLOBOTRUNCANA		OTHERS				
13	1	13	1	15	1	15	1	15-22	<i>G. cf. G. conovata</i> (Bretzen)	<i>Heterohelix striata</i> (Shrenberg)	<i>Reussella eschscholae</i> (Orstöm)	<i>G. cf. G. conovata</i> (Bretzen)	<i>Neofalsella gibbosa</i> (Wiedekind)	<i>Reussella eschscholae</i> (Orstöm)		Globotruncana formicata - G. stuartiformis assemblage zone (PESSAGNO, 1967)	LATE CAMPANIAN	
13	1	13	1	15	1	15	1	116-119	<i>G. venizi</i> → <i>G. formicata</i>	<i>Heterohelix planata</i> (Cushman)	<i>Orbitoides tisseroti</i> (sensu von Rintze 1966)	<i>G. venizi</i> → <i>G. formicata</i>	<i>subsp. a. Hiltnermann &amp; Koch</i>					EARLY CRETACEOUS
13	1	13	1	15	1	15	1	130-132	<i>G. angustiorinata</i> → <i>G. arva</i>	<i>Heterohelix planata</i> (Cushman)	<i>Leptodorbicoides</i> sp. cf. <i>L. minor</i> Schlumberger	<i>G. angustiorinata</i> → <i>G. arva</i>						
13	2	14	1	15	1	15	1	62-64	<i>G. apparenzi</i> Bretzen	<i>Heterohelix navarroensis</i> Loublich	<i>Torresina torrei</i> Palmer	<i>G. apparenzi</i> Bretzen						
13	2	14	1	15	1	15	1	99-101	<i>G. bulloides</i> (Vogler)	<i>Heterohelix globulosa</i> (Ehrenberg)	<i>Smuttna</i> sp. cf. <i>S. bermudezi</i> Cole	<i>G. bulloides</i> (Vogler)						
13	2	14	1	15	1	15	1	131-133	<i>G. formicata</i> Plummer	<i>Pseudostuzaria elegans</i> (Rzehak)	<i>Vaughanina subensis</i> Palmer	<i>G. formicata</i> Plummer						
13	2	14	1	15	1	15	1	core	<i>G. sinnetiana</i> (d'Orbigny)	<i>Globigerinoides bolivi</i> Pessagno	<i>Vaughanina barbari</i> Bromminann	<i>G. sinnetiana</i> (d'Orbigny)						
13	2	14	1	15	1	15	1	catcher	<i>G. Leopoldi</i> Bolli (= <i>G. stephensoni</i> Pessagno)			<i>G. Leopoldi</i> Bolli (= <i>G. stephensoni</i> Pessagno)						
13	2	14	1	15	1	15	1		<i>G. falsostuarti</i> Sigal			<i>G. falsostuarti</i> Sigal						
13	2	14	1	15	1	15	1		<i>G. ventricosa</i> White			<i>G. ventricosa</i> White						
13	2	14	1	15	1	15	1		<i>G. atlantica</i> n. sp.			<i>G. atlantica</i> n. sp.						
13	2	14	1	15	1	15	1		<i>G. elevata</i> (Bretzen)			<i>G. elevata</i> (Bretzen)						
13	2	14	1	15	1	15	1		<i>G. elevata</i> → <i>G. stuartiformis</i>			<i>G. elevata</i> → <i>G. stuartiformis</i>						
13	2	14	1	15	1	15	1		<i>G. stuartiformis</i> Dalb'ies			<i>G. stuartiformis</i> → <i>G. subspinoosa</i>						
13	2	14	1	15	1	15	1		<i>G. subspinoosa</i> Pessagno			<i>G. subspinoosa</i> Pessagno						
13	2	14	1	15	1	15	1		<i>G. tricarinata</i> (Quereau)			<i>G. tricarinata</i> (Quereau)						
13	2	14	1	15	1	15	1		<i>G. arva</i> (Cushman)			<i>G. arva</i> (Cushman)						
13	2	14	1	15	1	15	1		<i>G. calcarata</i> Cushman			<i>G. calcarata</i> Cushman						
13	2	14	1	15	1	15	1		<i>G. rosetta</i> (Carrey)			<i>G. rosetta</i> (Carrey)						
13	2	14	1	15	1	15	1		<i>Globotruncanella navarroensis</i> (Voorwijk)			<i>Globotruncanella navarroensis</i> (Voorwijk)						
13	2	14	1	15	1	15	1		<i>Achanaeoglobigerina blaut</i> Pessagno			<i>Achanaeoglobigerina blaut</i> Pessagno						
13	2	14	1	15	1	15	1		<i>Heterohelix striata</i> (Shrenberg)			<i>Heterohelix striata</i> (Shrenberg)						
13	2	14	1	15	1	15	1		<i>Heterohelix planata</i> (Cushman)			<i>Heterohelix planata</i> (Cushman)						
13	2	14	1	15	1	15	1		<i>Heterohelix navarroensis</i> Loublich			<i>Heterohelix navarroensis</i> Loublich						
13	2	14	1	15	1	15	1		<i>Heterohelix globulosa</i> (Ehrenberg)			<i>Heterohelix globulosa</i> (Ehrenberg)						
13	2	14	1	15	1	15	1		<i>Pseudostuzaria elegans</i> (Rzehak)			<i>Pseudostuzaria elegans</i> (Rzehak)						
13	2	14	1	15	1	15	1		<i>Globigerinoides bolivi</i> Pessagno			<i>Globigerinoides bolivi</i> Pessagno						
13	2	14	1	15	1	15	1		<i>Neofalsella gibbosa</i> (Wiedekind)			<i>Neofalsella gibbosa</i> (Wiedekind)						
13	2	14	1	15	1	15	1		<i>subsp. a. Hiltnermann &amp; Koch</i>			<i>subsp. a. Hiltnermann &amp; Koch</i>						
13	2	14	1	15	1	15	1		<i>Reussella eschscholae</i> (Orstöm)			<i>Reussella eschscholae</i> (Orstöm)						
13	2	14	1	15	1	15	1		<i>Orbitoides tisseroti</i> (sensu von Rintze 1966)			<i>Orbitoides tisseroti</i> (sensu von Rintze 1966)						
13	2	14	1	15	1	15	1		<i>Leptodorbicoides</i> sp. cf. <i>L. minor</i> Schlumberger			<i>Leptodorbicoides</i> sp. cf. <i>L. minor</i> Schlumberger						
13	2	14	1	15	1	15	1		<i>Torresina torrei</i> Palmer			<i>Torresina torrei</i> Palmer						
13	2	14	1	15	1	15	1		<i>Smuttna</i> sp. cf. <i>S. bermudezi</i> Cole			<i>Smuttna</i> sp. cf. <i>S. bermudezi</i> Cole						
13	2	14	1	15	1	15	1		<i>Pseudostuzaria elegans</i> (Rzehak)			<i>Pseudostuzaria elegans</i> (Rzehak)						
13	2	14	1	15	1	15	1		<i>Vaughanina subensis</i> Palmer			<i>Vaughanina subensis</i> Palmer						
13	2	14	1	15	1	15	1		<i>Vaughanina barbari</i> Bromminann			<i>Vaughanina barbari</i> Bromminann						

*Globotruncana atlantica* n. sp.  
Text-figure 1 a-c (holotype), 2 a-c  
(paratype); plate 1, fig. 5 a-c (paratypes).

Description: Test high trochospiral, spiral side strongly convex, umbilical side flat to slightly convex; equatorial periphery slightly lobulate, with a single keel. Last whorl with six to seven chambers which increase slowly in size. Sutures on spiral side angular to curved in the youngest chambers, on the umbilical side angular, forming disjointed chevrons. Umbilicus narrow, shallow, covered by a spiral system of tegilla.

Type locality: Northeast Providence Channel, Bahamas Islands; Site 98 of Leg 11, DSDP, Sample 98-14-1, 65 to 67 centimeters.

Age of type-level: Campanian, lower part of *Globotruncana fornicata*-*G. stuartiformis* assemblage-zone (in Pessagno 1967).

Deposition of types: Naturhistorisches Museum Basel, C26628 (holotype), C26629 (paratypes).

Remarks: *Globotruncana atlantica* n. sp. shares with *G. conica* the conical outline of the test in lateral view,

but differs by the shape of the sutures which are almost always angular on the umbilical and the spiral side.

*Globotruncana atlantica* n. sp. is separated from *G. stuarti* by the shape of the chambers, which are often triangular on the spiral side, and by the conical outline.

*Globotruncana stuartiformis* is very close to *G. atlantica* n. sp. on the basis of the identical shape of the chambers on the spiral and the umbilical sides, but typical representatives of the two species can be readily distinguished by their different aspect in lateral view. However, transitional forms between the two species are frequently observed. In Text-Figure 3., the biconvex test of a typical *Globotruncana stuartiformis* (b) is opposed to the almost conical test of a typical *G. atlantica* n. sp. (c).

*Globotruncana calcarata* Cushman

1927 *Globotruncana calcarata* Cushman, pl. 23, figs. 10 a-b.

At the base of Core 13, a few transitional forms point towards an evolution of *Globotruncana calcarata* from

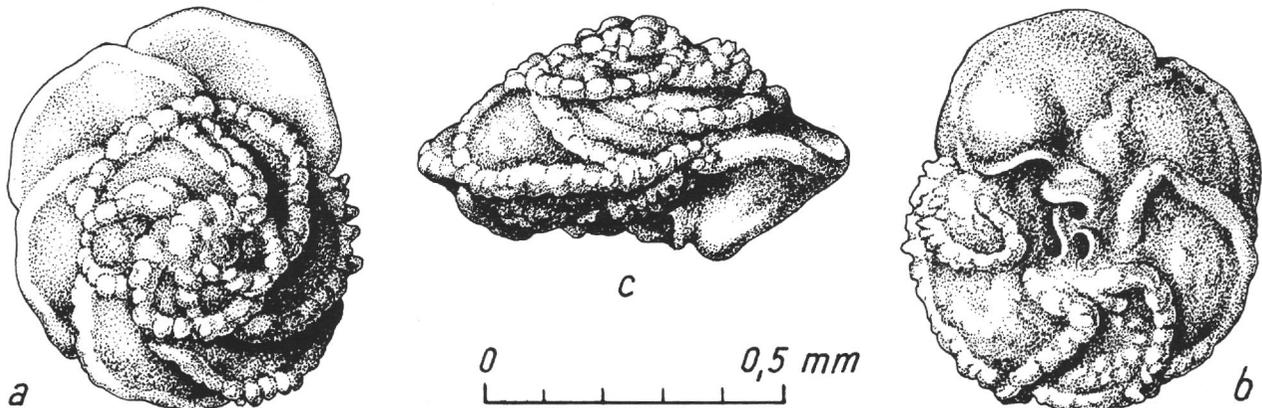


Figure 1 a-c. *Globotruncana atlantica* n. sp., holotype; 98-14-1, 65-67 cm.

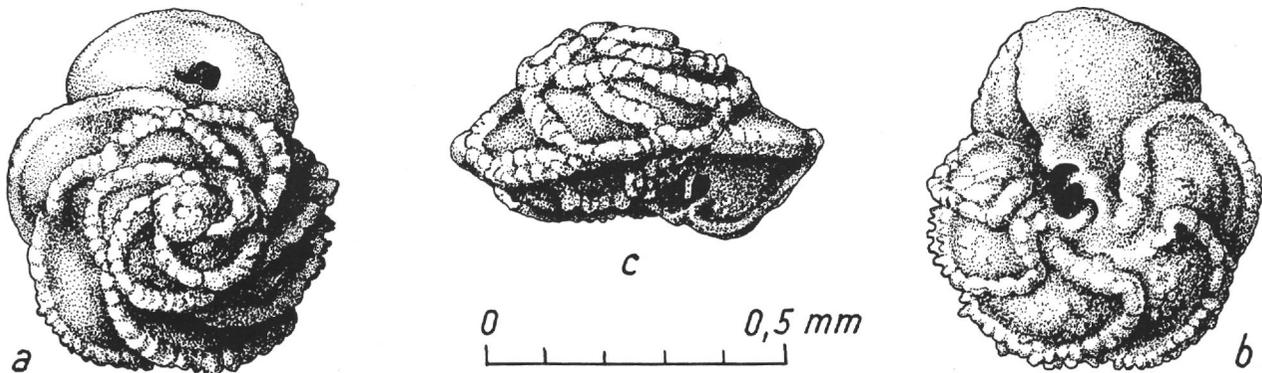


Figure 2 a-c. *Globotruncana atlantica* n. sp., paratype; 98-15-1, 130-132 cm.

*G. subspinosa*. In the same samples, *Globotruncana calcarata* is also represented by typical specimens, which indicate a late Campanian age.

*Globotruncana elevata* (Brotzen)  
(Plate 1, Figure 1)

- 1934 *Rotalia elevata* Brotzen, p. 66, pl. 3, fig. c.  
 1955 *Globotruncana (Globotruncana) elevata elevata* (Brotzen), Dalbiez, p. 171, text-fig. 9 a-c.  
 1960 non *Globotruncana elevata* (Brotzen) = *Globotruncana subspinosa* Pessagno, in Pessagno, p. 336.  
 1970 *Globotruncana elevata* (Brotzen), Kuhry, plate 1, fig. 1-3, lectotype.  
 1970 non *Globotruncana elevata* (Brotzen) = *Globotruncana elevata stuartiformis* Dalbiez, Kuhry, p. 294.  
 1970 non *Globotruncana elevata* (Brotzen) = *Globotruncana subspinosa* Pessagno, Kuhry, p. 294.

A recent revision of *Globotruncana elevata* based on the reexamination of the type-material by Kuhry (1970) demonstrates that the supposed holotype of the species would be a *Globotruncana concavata carinata*. Since Brotzen did not formally designate a holotype in his original paper, Kuhry selected a lectotype and gave a good illustration of it. This lectotype is a form with a single keel and a plano-convex outline; the chambers are rounded on the spiral side and strongly inflated on the umbilical side. We agree with this judicious selection of a lectotype, but we reject the inclusion of *Globotruncana stuartiformis* and *G. subspinosa* in *G. elevata*. Kuhry (and Pessagno, 1967) argue that these three species are linked by continuous series of transitional forms and would therefore represent a single species. Any planktonic foraminiferal species is linked to others by transitional forms, whenever sufficiently rich and well-preserved assemblages are examined.

The typical differences between *Globotruncana elevata* and *G. stuartiformis* are: *G. stuartiformis* is biconvex and has triangular chambers on the spiral side. *G. elevata* is plano-convex and has rounded chambers on the spiral side.

(The outlines in lateral view of the two species are compares in Text-figure 3 a-b.) *Globotruncana elevata* appears already in the late Santonian, whereas *G. stuartiformis* is restricted to the Campanian.

The species *Globotruncana subspinosa* is characterized by the shape of the spiral face of the chambers in the youngest whorl. The rounded chambers in *Globotruncana elevata* may tend to become triangular as in *G. stuartiformis* or to extend backward into a "pseudospine" as in *G. subspinosa*. Equally, all transitional forms can be observed from the plano-convex outline of *Globotruncana elevata* to the outline of *G. subspinosa*, and finally to the biconvex outline of *G. stuartiformis*.

The stratigraphic ranges of *Globotruncana elevata* and *G. subspinosa* are different. *Globotruncana elevata* appears during the late Santonian and was phased out toward the middle of the Campanian at approximately the level at which *G. subspinosa* makes its appearance.

*Globotruncana falsostuarti* Sigal

- 1952 *Globotruncana falsostuarti* Sigal, p. 43, text-fig. 46.

Test biconvex, with a double keel which, in places, may become fused and have a sinuous shape as in *Globotruncana leupoldi*. Further investigations may demonstrate that the two species are synonymous. We would prefer to maintain *Globotruncana falsostuarti* as a separate species, since it appears later than *G.*

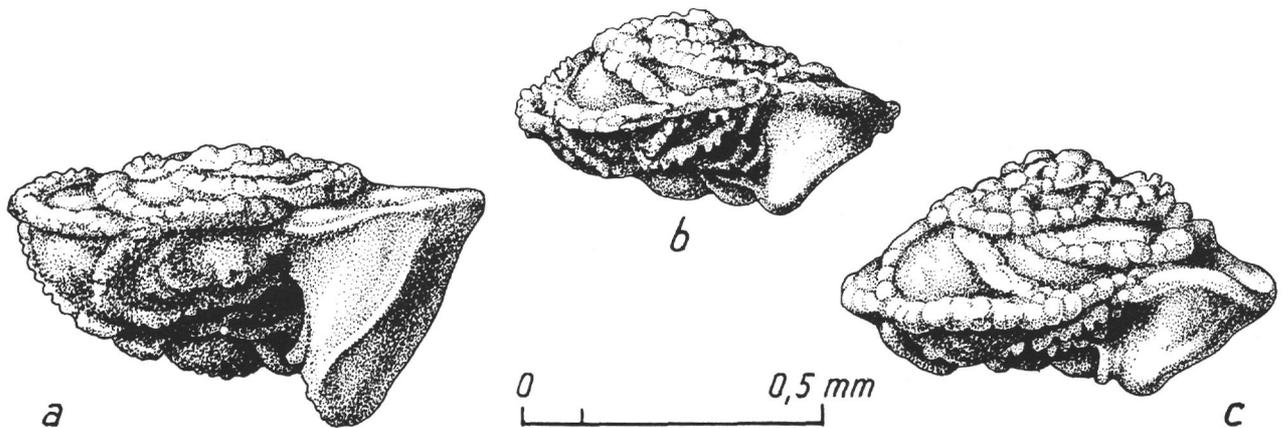


Figure 3. Comparison in lateral view of  
 a - *Globotruncana elevata* (Brotzen); 98-15-1, 148-150 cm.  
 b - *Globotruncana stuartiformis* Dalbiez; 98-15-1, 148-150 cm.  
 c - *Globotruncana atlantica* n.sp., holotype; 98-14-1, 65-67 cm.

*leupoldi* (at the top of the Campanian). *Globotruncana falsostuarti* is strictly biconvex, whereas *G. leupoldi* is somewhat dissymmetrical.

*Globotruncana leupoldi* Bolli  
(Plate 2, Figure 1 a-b)

- 1945 *Globotruncana leupoldi* Bolli, p. 235, lam. 17 (holotype).  
1967 *Globotruncana stephansonii* Pessagno, plate 69, fig. 1-7; plate 96, fig. 5-6.  
1968 *Globotruncana leupoldi* Bolli, Longoria, lam. 1, fig. 4-6; lam. 9, fig. 1-4; lam. 19, fig. 2.

This species is often confused with *Globotruncana fornicata*, *G. arca*, and *G. falsostuarti*, because its holotype has been designated in a thin section. *Globotruncana leupoldi* has the same outline as *G. fornicata*, but the youngest chamber is always single-keeled. The spiral surface of the chambers is always flat and never flexuous. *Globotruncana leupoldi* differs from *G. arca* by its narrower inter-rim area. The two keels, which may be distinctly separated or become almost fused, form a sinuous line as in *Globotruncana falsostuarti*. The umbilical rim is always retracted below the spiral rim level and is always distinctly weaker; in places, it may be only faintly indicated.

*Globotruncana ventricosa* White  
(Plate 2, Figure 3 a-c)

- 1928 *Globotruncana canaliculata* var. *ventricosa* White, p. 284, pl. 38, fig. 5 a-c.

This rare but characteristic species is here restricted to the late Campanian.

*Globotruncana stuartiformis* Dalbiez  
(Text-figure 3b; Plate 1, Figure 2 a-c)

- 1955 *Globotruncana (Globotruncana) elevata stuartiformis* Dalbiez, p. 171, text-fig. 10 a-c.  
1967 *Globotruncana stuartiformis* Dalbiez. Pessagno, pp. 357-59, et pl. 92, fig. 1-3.  
1970 *Globotruncana elevata* (Brotzen), Kuhry, pl. 1, fig. 4-9.

Reference is made to the discussion of this species in the paragraph dealing with *Globotruncana elevata*. In *Globotruncana stuartiformis* the chambers are typically triangular on the spiral side, whereas they are petaloid in *G. stuarti*.

*Globotruncana subspinosa* Pessagno  
(Plate 1, Figures 3, 4 a-c)

- 1960 *Globotruncana (Globotruncana) subspinosa* Pessagno, pp. 101-102, pl. 1, figs. 1-9.

*Globotruncana subspinosa*, a species introduced by Pessagno in 1960, was placed by the same author in 1967 in synonymy with *G. elevata*. However, the very typical shape of the chambers on the spiral face in *Globotruncana subspinosa* and the fact that these forms appear later than *G. elevata* justify considering *G. subspinosa* as a morphologically well individualized and stratigraphically useful species (see also discussion of *G. elevata*).

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PLATE 1

- Figure 1 *Globotruncana elevata* Brotzen; 98-13, core catcher; X130.
- Figure 2 a-c *Globotruncana stuartiformis* Dalbiez; 98-15-1, 116-119cm; X120.
- Figure 3 *Globotruncana subspinosa* Pessagno; 98-13-1, 62-64cm; X120.
- Figure 4 a-c *Globotruncana subspinosa* Pessagno; a-c; 98-13-2, 99-101cm; b: 98-13-2, 131-133cm, b: X140.
- Figure 5 a-c *Globotruncana atlantica* n. sp., paratypes; a-b; 98-14-1, 65-67cm; c: 98-15-1, bottom of core; a-b: X130; c: X180.

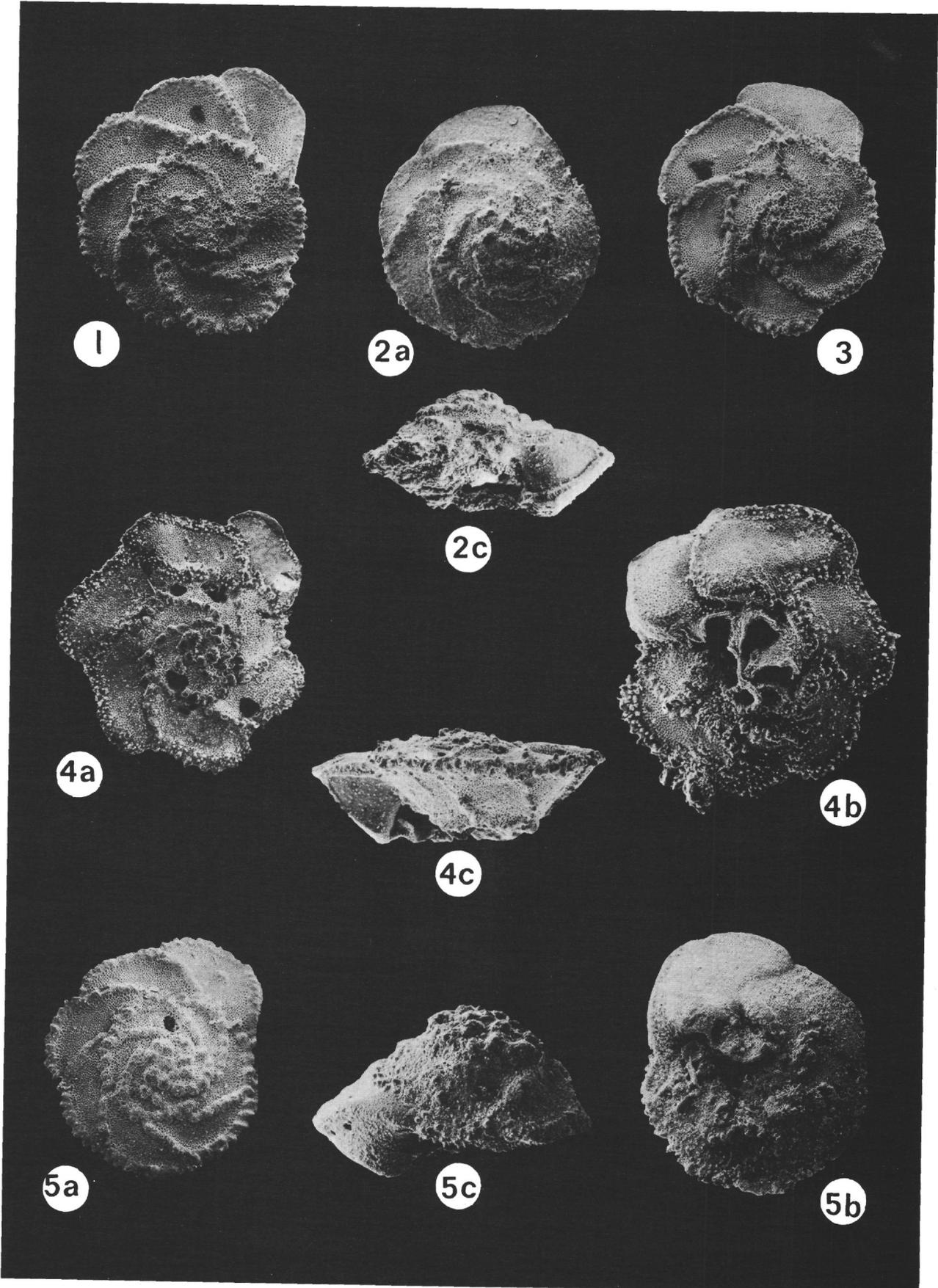


PLATE 2

- Figure 1 a-b *Globotruncana leupoldi* Bolli; 98-13-2, 131-133cm;  
X160.
- Figure 2 a-c *Globotruncana arca* (Cushman); a: 98-13-2, 62-64cm;  
b: 98-13, core catcher, c: 98-13-1, 118-121cm; X140.
- Figure 3 a-c *Globotruncana ventricosa* White; a-c: 98-13-2,  
99-101cm, b: 98-13-1, 118-121cm; X110.

PLATE 2



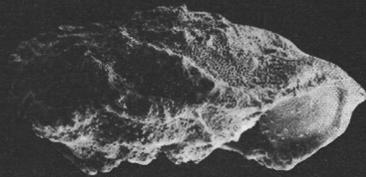
1a



1b



2a



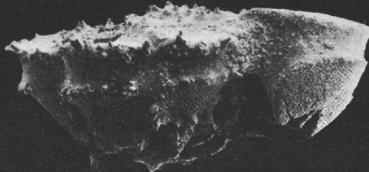
2c



2b



3a



3c



3b