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19. We thank Mrs. Dorothy Rutherford and Mrs. Helen Hunt for their excellent technical assistance.

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Orbitolina, a Cretaceous Larger Foraminifer, from Flemish Cap: Paleoceanographic Implications

Abstract. *The Tethyan larger foraminiferal genus* Orbitolina *has been found in the easternmost part of the western North Atlantic continental shelf at 46°30′N. All other known occurrences of the genus in North America are south of 33°N. The species is* Orbitolina conoidea *Gras; its abundance in a grain-supported limestone indicates a tropical neritic environment and precludes the influence of Arctic waters in the Flemish Cap region in Early or Middle Cretaceous times.*

Flemish Cap is the easternmost element of the Atlantic continental margin of North America. Although it is separated from the Grand Banks of Newfoundland to the west by the deep water channel of Flemish Pass, the water depth over the central part of the cap is less than 150 m (Fig. 1). Dipping sedimentary strata have been detected on the flanks of Flemish Cap. A fragment of fossiliferous limestone dredged from the southern slope of Flemish Cap (*X* in Fig. 1) contains abundant *Orbitolina conoidea* Gras, a Lower Cretaceous larger foraminifer of unquestionable Tethyan affinity.

The limestone was dredged from a depth of approximately 1480 m during a cruise of the C.S.S. *Hudson* in 1967 (*1*). The dredge haul consisted mainly of large angular slabs of limestone and well-rounded cobbles and pebbles of granite and gneiss. On the southern slope of Flemish Cap, limestone has been recovered in quantity only in dredge hauls from depths greater than 270 m (*2*), where seismic profiler results and bottom photographs indicate outcrops of layered rocks. The ubiquitous occurrence of well-rounded specimens of igneous rocks indicates an ice-rafted origin for this fraction of the samples.

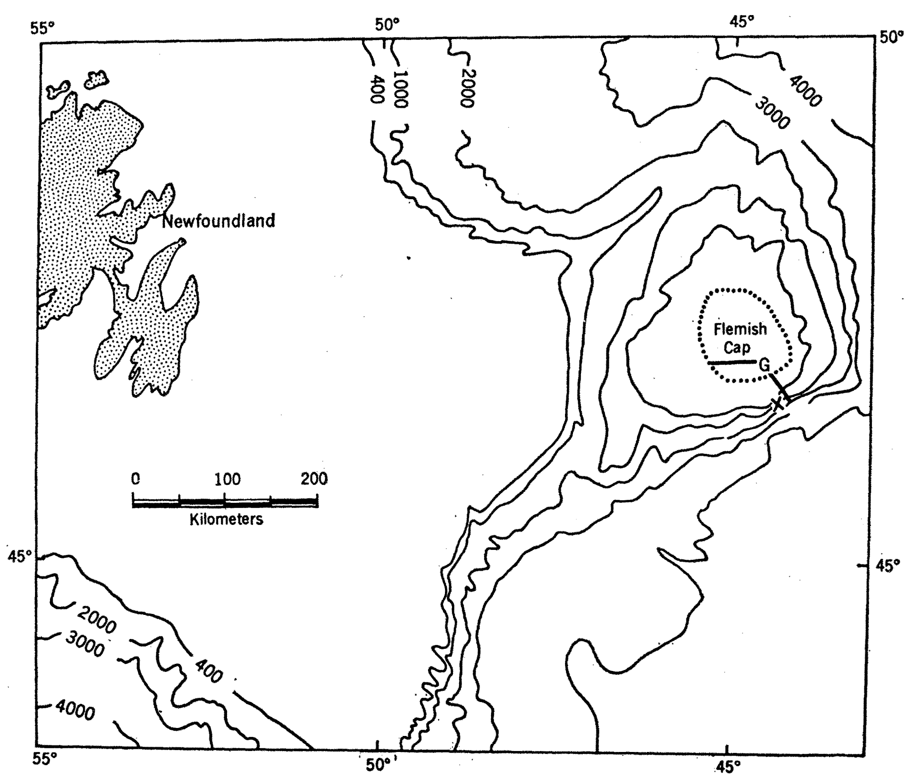

Fig. 1. Bathymetric map of the Flemish Cap area; isobaths are in meters. Letter *X* indicates sample location. Line *G* denotes the location of the seismic cross section in Fig. 2.

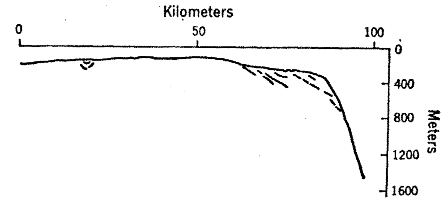

Fig. 2. Seismic cross section derived from records along line *G* of Fig. 1.

Seismic profiling was conducted over Flemish Cap in 1969 from C.S.S. *Hudson* and C.N.A.V. *Sackville* (*2*); a single-channel recording system was used, in conjunction with an air-gun energy source. The seismic profiler results show that the top of Flemish Cap is a smooth erosional surface, with a central area of seismically "hard" basement encircled by a zone of outward-dipping strata. The inferred extent of the central basement area is indicated by the dotted line in Fig. 1. One of the seismic profiler traverses, line *G* (Figs. 1 and 2), is in the vicinity of our sample station. A seismic cross section derived from the records along this line is shown in Fig. 2. The bottom profile is smooth, except for a minor step at the contact between the truncated strata and the basement media. Truncation of the layered rocks is also obvious on the slope of Flemish Cap.

The thin sections illustrated in this report (Fig. 3) were cut from a fossiliferous limestone specimen, which measured approximately 10 by 7 by 1.5 cm. This grain-supported limestone is extremely rich in specimens of the larger foraminifer *Orbitolina conoidea* Gras (*3*). In the thin sections examined, the density of tests is often about 40 per square centimeter. The form is generally conical. The very distinct marginal zone is about 0.04 mm thick. The radial zone is narrow and, at base, does not generally cover more than one-third of the diameter. The thick central reticulate zone includes a small amount of fine detrital particles. Calcite eyes are not seen. The megalospheric embryonic apparatus is apical and is surrounded by a number of periembryonic chambers. Because of the random orientation of the specimens of *O. conoidea* in the rock sections, few measurements could

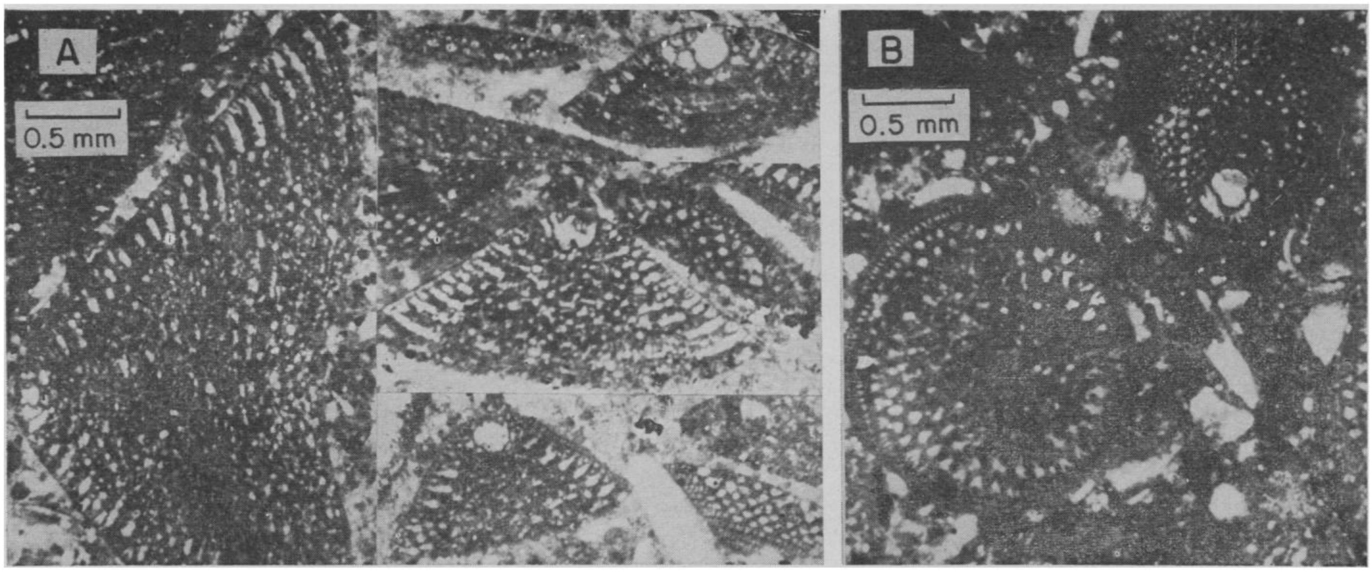

Fig. 3. *Orbitolina conoidea* Gras in grain-supported limestone from Flemish Cap. (A) Axial, near-axial, and oblique sections. (B) Near-basal and oblique sections.

be made of axial sections of individuals. The measurements of seven megalospheric and seven microspheric specimens are summarized in Table 1.

Orbitolina is fairly common in Lower Cretaceous limestones (Trinity Group) of the southern United States, but most of the species seem to be indigenous (*4*, *5*) and none of them resemble the Flemish Cap species *O. conoidea* Gras. To our knowledge, this is the first report of a North American *Orbitolina* north of 33°N. The species is locally abundant in other areas, especially in western Europe and the Middle East. The known distribution of *Orbitolina* is shown in Fig. 4; different species range from Neocomian to probable Maestrichtian, but the abundance of the genus is greatest in Aptian-Albian. The reported range of *O. conoidea* is Neocomian to Cenomanian, with the maximum development in Aptian. The restriction of *Orbitolina* to the Tethyan or Mediterranean biogeographic province will be obvious from Fig. 4. An association of *Orbitolina* with rudistan reefs has also been frequently reported (*5*–*8*).

Southwest of Flemish Cap, from the Grand Banks of Newfoundland, two subsurface sections with about 1445 m of Mesozoic and Cenozoic sediments have recently been described (*9*, *10*). The Lower and Middle Cretaceous sediments were interpreted as nearshore clastics containing few planktonic Foraminifera, which have been identified as primitive globigerinids, mostly of Tethyan affinity but with occasional boreal elements (*9*). Our Flemish Cap lime-

Table 1. Measurements (in millimeters) of *Orbitolina conoidea* Gras from Flemish Cap.

Value	Diameter	Height	Diameter / Height	Larger diameter of proloculus
	Megalospheric generation (seven specimens)			
Maximum	2.9	1.3	2.6	0.18
Minimum	0.9	0.4	1.7	0.12
Mean	1.6	0.8	2.1	0.16
Coefficient of variation	40.8%	40.2%	13.9%	13.6%
	Microspheric generation (seven specimens)			
Maximum	4.2	1.7	2.8	
Minimum	3.1	1.2	2.4	
Mean	3.5	1.4	2.6	
Coefficient of variation	11.8%	12.9%	4.8%	

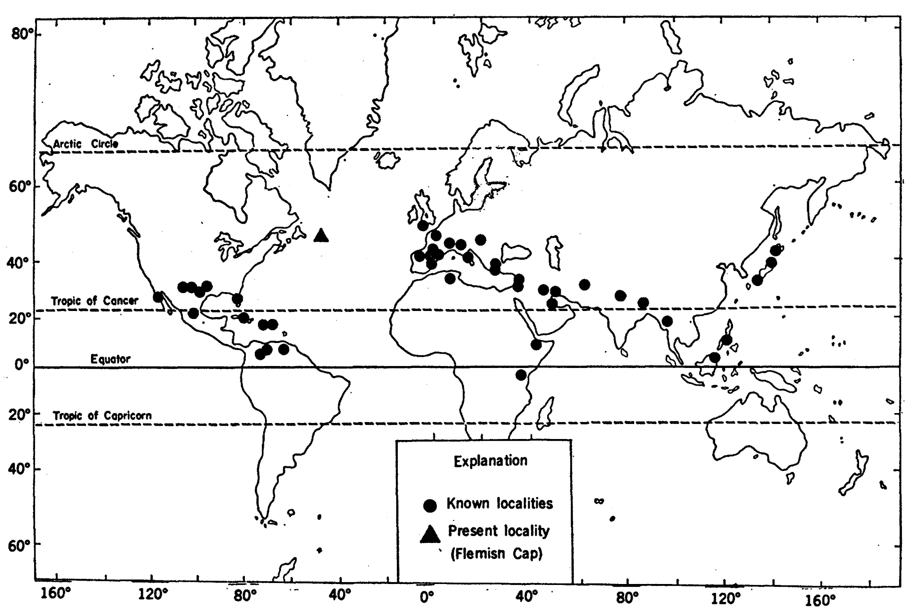

Fig. 4. Geographic distribution of *Orbitolina* [after Douglass (*4*), with additional data from Méhes (*5*)].

stone belongs to a different facies. Planktonic and smaller benthonic Foraminifera are rare and poorly preserved. The striking abundance of *Orbitolina* is, on the other hand, characteristic of a reef facies (*7*).

The presence of the Tethyan larger Foraminifera indicates a "warm water" neritic environment for the Flemish Cap area during Early or Middle Cretaceous times. Paleomagnetic data support the conclusion that the North Atlantic Ocean (north of 40°N) was almost fully open by Middle Cretaceous time (*11*). The presence of a tropical Mediterranean (possibly forereef) fauna would, however, preclude the influence of Arctic waters and certainly the dominance of a cold current in the Flemish Cap region. The existence of a warm transoceanic gyre would, of course, be advantageous for the distribution of identical species of tropical larger Foraminifera along comparable latitudes on both sides of the North Atlantic. Thus, the water-mass distribution in the North Atlantic about 100 million years ago was very different from that of the present. The Labrador Current is a very significant component in the North Atlantic Ocean of today, and between 45° and 60°N the mean isotherms for surface water swing northward through several degrees of latitude from the western to the eastern side (*12*). Instead of this cold current, a northern branch of a Cretaceous "Gulf Stream" system might have been flowing in the Flemish Cap region. The idea of a major change in the water-mass relationships in this area after Middle Cretaceous times agrees well with the suggestion of Berggren and Hollister (*13*) that the North Atlantic region became linked with the Arctic region about 60 million years ago, at which time a boreal biogeographic province was established in the Atlantic Ocean.

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Eye Marks in Vertebrates: Aids to Vision

Abstract. *Lines leading forward from the eye may function as aiming sights in many small vertebrates. The chief evidence is the correlation of distribution and positions of eye-lines in various vertebrate groups with predatory feeding habits. Dark patches around the eye may serve to reduce glare in species in bright environments. Facial patterns often have multiple functions.*

Several functions have been suggested for the characteristic colors and markings of species, including camouflage (*1*, *2*), social signals (*3*), mimicry (*4*), and thermoregulation (*5*). We suggest that, in addition, the patterns of circles and lines about the eyes of vertebrates may enhance their vision and enable predaceous species to locate and capture prey more effectively.

Eye-lines are well-defined marks, usually very dark and narrower than the eye. The dorsal borders are usually more or less straight and uninterrupted (Fig. 1A). The ventral margins may be straight, but some are curved, demarcating a facial patch. The eye-lines extend from the margin of the eye or, more rarely, from or through an eye circle (Fig. 1B) toward, above, or below the bill tip or snout; sometimes they become narrower along their path. Some are positioned so that the line of sight is along the upper edge of the eye-line. However, often a line from the center of the pupil bisects the dark eye-line. Another frequent pattern is that of light over dark lines, which could be used as a line of sight in at least two ways; either the dark line or the line margins could be followed (Fig. 1B). The area above the eye-line might regulate light falling on the eye-line. Many birds lift the feathers above the eye-line forming an eye-brow (Fig. 1C). In birds with eye-lines the area above the line is frequently light in color. Increased light falling on the dark line from this area might increase visual acuity.

If the eye-lines serve as lines of sight in tracking and capturing swiftly moving prey, their presence, position, and type should be related to feeding habits. These lines should occur more frequently in species that feed on rapidly moving prey. We grouped North American songbirds by feeding habits in six categories, ranging from rank 1 in which more than 50 percent of the diet consisted of flying insects or other swiftly moving animal life. There was a + .94 rank-difference correlation between the presence of eye-lines and feeding on swiftly moving prey [see (*6*)]. Also we compared 50 species of insectivorous vireos and warblers with 44 species of granivorous and insectivorous sparrows (Emberizinae, closely related to warblers). We assigned all 94 species to categories based on the complexity of eye markings. We considered a dark line, as shown in Fig. 1A, simple; light over dark stripes with a broken or unbroken eye circle we considered complex (Fig. 1B). The most complex eye markings, as depicted in Robbins *et al.* (*7*), were found in all North American vireos and 32 out of 36 northeastern North American warblers, but in only four North American sparrows ($P < .01$).

Many species of birds having eye-lines show variations in the direction of the eye-line which are apparently