Faunal density and faunal diversity in benthic Foraminifera on the floor of the Mediterranean Sea

by

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Abstract

The quantitative study of the foraminiferal assemblages contained in tops of gravity cores from the deeper parts of the Mediterranean revealed that both the faunal abundance and the faunal diversity decrease as a function of depth. The Western Mediterranean and the Eastern Mediterranean behave as different bioprovinces, the latter yielding poor, highly specialized faunas at depth. A tentative bathymetric zonation is proposed for the mesobathyal zone, with three zones (upper mesobathyal, 1000 to 1800 m; middle mesobathyal, 1800 to 2500 m, lower mesobathyal 2500 to 4000 m), based essentially on the B foraminiferal number, here defined as the number of benthic foraminifers per gram of sediment, and on the number of species present.

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Benthic foraminifers are commonly used as a tool to evaluate the depth of deposition of fossil sediments : the method is founded on the observation of their present day distribution and is quite successful for the shallower parts of the continental margins, a distinction of three to four depth zones being in most cases easy and immediate. Much more difficult is to subdivide the column beyond the outer limit of the continental shelf. In other words, while it is easy to say how shallow is a sediment on the basis of its fossil content, by far more difficult is to say how deep it is.

The depth zones recognized by the various authors are comparable, but not identical. PHLEGER [1960] bases his zones on the occurrence of characteristic assemblages. PARKER [1958] takes into account both the characteristic assemblages and the upper and lower depth limits of individual taxa; BANDY [1953] and BANDY & ARNAL [1960] essentially worked on the upper depth limit recorded for individual taxa. All these methods are qualitative. A further complication recorded in the Mediterranean derives from the peculiar conditions existing there, in terms of distribution patterns of temperature, salinity, oxygen content and nutrients at depth [MILLER *et al*, 1970]. In fact, the upper depth limit of a number of species has been found to be different in the Mediterranean and in California [BANDY & CHIERICI, 1966].

In order to quantify our observations, and to try a different approach on how to evaluate the depth of deposition of a basinal deposit in the Mediterranean, we oriented our investigation on the faunal abundance and faunal diversity, as recorded in the foraminiferal assemblages.

54 tops of gravity and/or piston cores from the Alboran, Balearic, Tyrrhenian, Ionian and Levantine Basins of the Mediterranean (1) have been investigated quantitatively and qualitatively. The sand-

(1) Most of the material investigated has been kindly provided by W.B.F. RYAN of Lamont-Doherty Geological Laboratory of Columbia University and is from the Vema Cruise n.9 and R. Conrad Cruise n.14. Five additional samples are tops of gravity cores taken during the Cruise Polymède 2 of the French Vessel *Jean-Charcot*.

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size fraction of the sediment, which usually consists of planktonic foraminiferal tests and of shells of pteropods, with minor amounts of benthic foraminifers, was found to be highly variable. In samples from depths in excess of 1000 m, which represent the large majority of the collection, both the highest and the lowest percentages of the sand-size fraction were found along with evidence of benthic faunas displaced from shallower slopes, sometimes selected by size. Partly allochthonous thanatocoenoses were found in 17 core samples, which were consequently discarded. In the remaining 37 cores (12 from the Levantine Basin, 16 from the Ionian Basin, 8 from the Balearic Basin and only one from the Tyrrhenian) we calculated the *B foraminiferal number*, here defined as the number of benthic foraminifers per gram of (dry) sediment, the *number of species* and the *diversity index*, calculated following VAN STRAATEN [1962] as the number of specimens/number of species.

The observational data have been grouped and are discussed for each major basin : in fact the oceanographic conditions of (parts of) the Ionian Basin and of the Levantine Basin are so different from those recorded in the Western Mediterranean that a general discussion would be confusing. While the Balearic Basin of the Western Mediterranean yields benthic assemblages normally diversified, comparable in their qualitative composition to those recorded from the open oceans, the Eastern Mediterranean bioprovince is characterized by a benthic fauna very restricted both in terms of density and of diversity. Foraminifers with arenaceous test and a pseudochitinous base are always dominant at depths in excess of 1800 m. They are apparently the only benthic forms recorded at the sediment/water interface where the clay minerals consist essentially of kaolinite, which suggests that supposedly high PH values result in the absence of foraminifers with calcitic tests, both imperforate and perforate.

Though aware that the observational data are limited in number, we consider the results of our quantitative study so consistent and interesting as to motivate a bathymetric zonation, which is here proposed as tentative, and is expected to be improved by further investigations now in progress. Following HEDGEPETH's (1957) terminology, modified, we are not considering here the neritic zone (0-200 m) and the epibathyal zone (200-1000 m), which zones have been already subdivided on the basis of their (qualitative) foraminiferal assemblages in the Mediterranean by numerous authors, including PARKER [1958], CHIERICI, BUSI & CITA [1961] and BLANC-VERNET [1969]. Our interest is for the mesobathyal zone, extending beyond the isobath of 1000 m. According to the recent study by CIABATTI & MARABINI [1973] on the hypsography of the Mediterranean, inclusive of the Black Sea, 77 % of the Mediterranean is deeper than 200 m and 58.1 % is deeper than 1000 m, the average depth of the Mediterranean and Black Sea being 1485.6 m. The mesobathyal zone as here defined, viz. extending from 1000 to 4000 m, is the more extended large bathymetric zone of the Mediterranean : the areas deeper than 4000 m indeed represent only 0.6 % of the surface. All the so-called " abyssal plains ", including the Balearic, Tyrrhenian, Messina, Herodotus abyssal plains, fall within the mesobathyal zone. In this mesobathyal zone we consistently found that the faunal abundance and the faunal diversity decrease as a function of deepth both in the Western Mediterranean, where the trend is very clearly shown, and in the Eastern Mediterranean, where the general trend is complicated by locally anomalous physical conditions.

The mesobathyal zone is subdivided as follows [see also CITA & ZOCCHI, 1974] :

UPPER MESOBATHYAL (1000 to 1800 m)
- Western Mediterranean bioprovince
  - B foraminiferal number comprised between 21 and 29
  - number of species 65-92
- Eastern Mediterranean bioprovince
  - B foraminiferal number 3.9 to 12.2
  - number of species 11-64

MIDDLE MESOBATHYAL (1800-2500 m)
- Western Mediterranean bioprovince
  - B foraminiferal number 20 to 25
  - species present 46-65
  - *Uvigerina mediterranea* - *U. peregrina* assemblage, with abundance of costate uvigerinids
- Eastern Mediterranean bioprovince
  - B foraminiferal number 5 to 10
  - species present 4 to 8
  - *Glomospira charoides* s.str. or *Glomospira charoides-Gyroidina* assemblages

LOWER MESOBATHYAL (2500 to 4000 m)

Western Mediterranean bioprovince

B foraminiferal number less than 13
species present 20 to 40 (assemblage characteristic of the Balearic abyssal plain, including *Glomospira charoides*, *Gyroidina* spp., *Robertina translucens*, *Sigmoilina tenuis* etc.).

Eastern Mediterranean bioprovince

B foraminiferal number 0 to 10, often less than 2 species present no more than 8, usually less than 5 *Glomospira charoides-Gyroidina* assemblage.

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Discussion

Meulenkamp J. : You left out 17 samples which would contain displaced elements. What are the criteries used by you to distinguish between " autochthonous " and displaced foraminifera?

***M.B. Cita*:** The criteria I followed in order to distinguish in between " autochthonous " and displaced foraminifera are as follows (quoted after CITA & ZOCCHI, *in press*) :

"... Besides observations on the sedimentary characters, the strictly paleontological criteria followed to distinguish the displaced faunas was the finding — at depths in excess of 300 m — of one or more taxa known to be limited to the neritic zone of the continental shelf, with special reference to the Mediterranean (see PARKER, 1958; CHIERICI, BUSI & CITA, 1962; BLANC-VERNET, 1969). As characteristic species we considered *Astrononion stelligerum*, *Nonion granosum*, *Elphidium complanatum*, *E. crispum* and *Ammonia beccarii*. A secondary criterion was the occurrence — at depths in excess of 1000 m — of one or more of the following taxa, which according to PARKER *(op. cit.)* do not occur deeper than 500-700 m in the eastern Mediterranean : *Bolivina catanensis*, *Planorbulina mediterranensis*, *Textularia conica*, *T. sagittula* ".

Sonnenfeld P. : With regard to the data presented on temperature and nutrient distribution in the three mediterranean basins do they represent anormal averages or summer maxima?

M.B. Cita : The slides I projected, showing the distribution of temperature and nutrient and oxygen and salinity along three N-S cross sections in the Balearic, Ionian and Levantine Basin, are from MILLER, TCHERNIA & CHARNOCK [1970]. They represent neither annual averages nor summer maxima.

Profile 13 in the Balearic Basin has been constructed with the data collected during the Cruise ATLANTIS 263 : this cruise took place from February 4 to March 10, 1961.

Profile 35 in the Ionian Basin has been constructed with the data collected during the Cruise ATLANTIS 275, which cruise took place from February 1, 1962 to March 10, 1962.

Profile 57 in the Levantine Basin has been constructed with the data collected during the Cruise CHAIN 21, which cruise took place from October 18, 1961 to November 11, 1961.

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