47. THE PLIOCENE RECORD IN DEEP-SEA MEDITERRANEAN SEDIMENTS

PREFACE

The dream of having a single continuous column of pelagic marine sediment from the Mediterranean region which goes back more than five million years has now been realized. The results of coring hundreds of meters below the floor of the present sea during Leg 13 of the Deep Sea Drilling Project (August-October, 1970) will allow the writing of a more complete geological history of this area. With the recovery of core materials has come an obligation to disperse this new information to our interested colleagues in the scientific community as rapidly, directly, and accurately as possible.

In the five subchapters that follow, Neri Ciaranfi and A. Longinelli have collaborated with our shipboard paleontologist specializing in planktonic foraminifera and myself to undertake the task of reporting the preliminary observations concerning the stratigraphic record of the Pliocene. As was the case in the previous chapter on the Quaternary record, this report is in some ways provisional. It is anticipated that it may simply serve as a guide for the deciphering of the complex sedimentary history of the time period considered.

Deep-sea sections of the Pliocene are now available from the western Alboran Basin, Valencia Trough, Balearic Rise, Balearic Abyssal Plain, Tyrrhenian Rise, Mediterranean Ridge, Hellenic Trench, and Strabo Mountains (Figure 1). The cataloguing of these cores can be found in the various site chapters of Part I of this volume. A summary of the biostratigraphic observations appears in Chapter 40.

Some of the sections, though not continuously cored, and at times in provinces with significant terrigenous contributions, have allowed us to recognize the same repeated biostratigraphic events by means of different fossil groups and to establish certain lithostratigraphic bases with time equivalence, such as episodes of brief but synchronous deposition under euxinic conditions, widespread showers of volcanic ash, and so forth.

In this chapter, a new stratigraphic framework is introduced with an awareness of the numerous previous attempts at a biostratigraphic zonation for the time period considered. We find that many of the former criteria used to recognize biostratigraphic levels cannot be readily applied to the deep-sea record. This is not to say that the existing subdivisions have not been productive. We merely point out that many of them, worked out in strata deposited in shallow environments on ancient shelves, appear to be based on faunal criteria whose dependence on ecological changes has not been satisfactorily worked out. In others, appreciable gaps in sedimentation are present. Since these marine sequences are the ones which outcrop on land, they are obviously necessary as convenient reference sections. The cores obtained by the *Glomar Challenger* will never replace the land sections. An objective of this chapter is to point out how the reading of the Pliocene record on the ocean floor, layer by layer, should be able to help us recognize some of the inconsistencies, miscorrelations, and misunderstandings that exist in the literature today. Hopefully, our preliminary work and the detailed investigations which will follow in the future will make the Neogene outcrops more useful.

We have discovered, beneath the floor of the Mediterranean, a layer of salt which can be correlated beyond any doubt with the Messinian "crisis of salinity". The finding of the evaporites, not only beneath the abyssal plains, but throughout the entire Mediterranean, sheds a whole new light on the origin of these deposits. It has provided us with an insight into the problem of the Miocene/Pliocene boundary which, as established by Mayer-Eymar at the basal conglomerate in the Tabiano section, is correlatable with the terminal flooding of desiccated Mediterranean basins.

The deluge is discussed in this chapter. With the establishment of an open communication with the Atlantic, the movement of marine waters through the Mediterranean basins could, at times, have interrupted the deposition of calcareous oozes, or at other times even been vigorous enough to remove them from the top of the evaporite layer. Since we believe there is good evidence that this has occurred, it is not so much the age of the first pelagic sediment on top of the evaporite in a given locality which establishes the true age of the boundary, but the age of the first sedimentation in the Mediterranean after connection with the Atlantic.

The change at a sedimentation contact from deposition on desiccated playas and in alkaline lakes with brackish-water faunas to a true open marine pelagic sedimentation is certainly worthy of a series boundary and should almost always be easy to recognize in an outcrop in the field or in a core. The reestablishment of normal marine conditions conditions would be expected to have influenced the entire Mediterranean realm.

The scope of this chapter calls for a documentation of the postdiluvial record. Our preliminary report summarizes investigations in the fields of paleontology, oceanography, and isotope geochemistry. Chapter 47.1 deals with the problems of biostratigraphic zonations. Chapter 47.2 offers an interpretation of the paleomagnetic reversal record of the late Neogene, as deciphered in part from measurements of the continuously cored sections. Chapter 47.3 treats the faunal assemblages in terms of ecological adaptations to variations in the regional climate of the Mediterranean during the Pliocene. Chapter 47.4 reports measurements of the isotopic composition of oxygen and carbon in the preserved tests of the foraminifer *Orbulina universa* and discusses variations in the composition in terms of both changes in the ancient climates and the mixing of water masses between the various Mediterranean basins and the Atlantic Ocean. Chapter 47.5 provides a generalized time-scale for the Pliocene, correlatable with other published time-scales by means of the biostratigraphic horizons and the paleomagnetic reversal chronology. A general synthesis

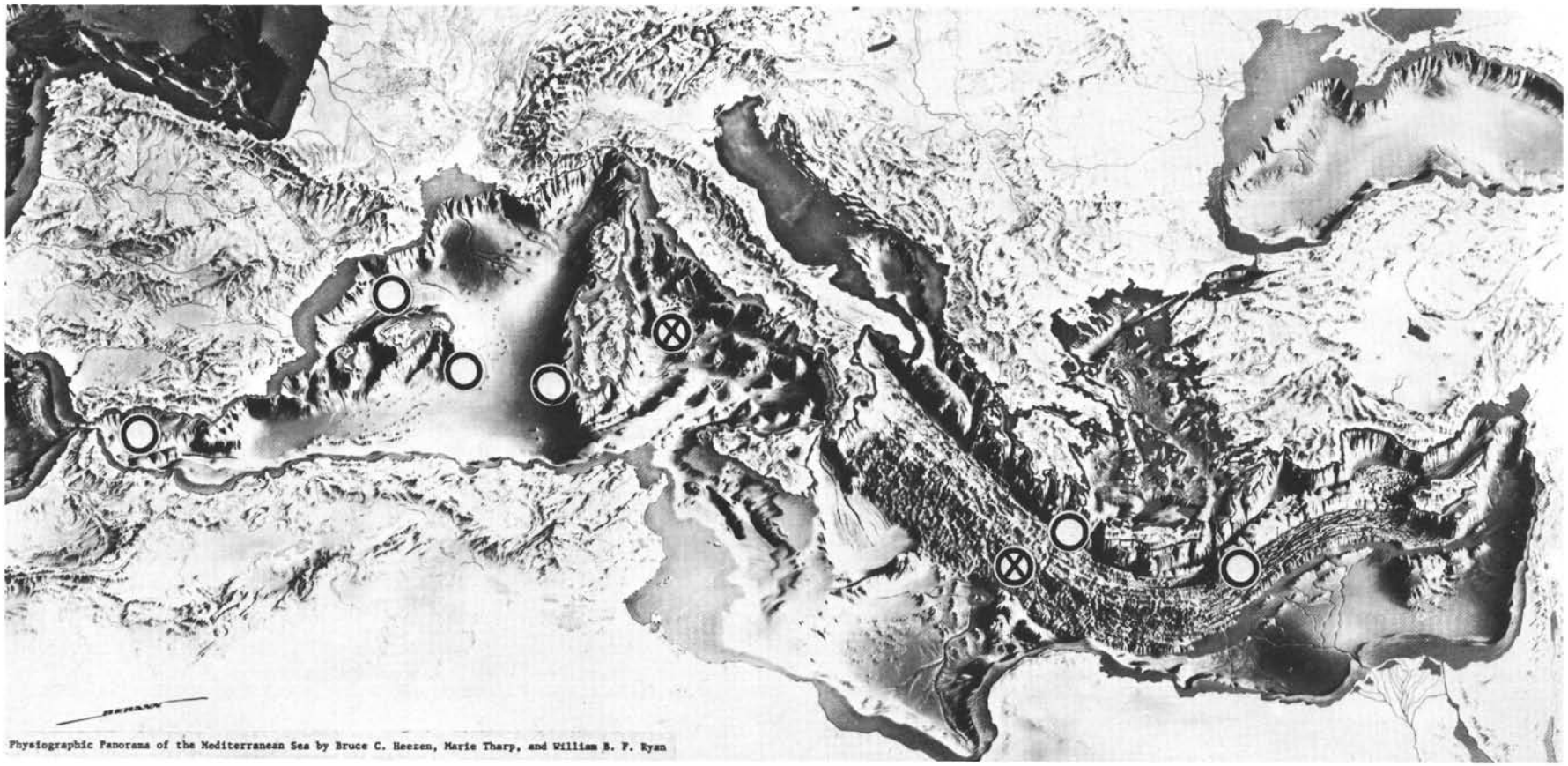

Figure 1. *The locations of drill sites in the Mediterranean Sea where Pliocene sediments were recovered. The circles with crosses denote the two sites with continuously cored sequences – Site 132 in the Tyrrhenian Basin and Site 125 on the Mediterranean Ridge in the Ionian Basin.*

of the evolution of marine sedimentation in the Mediterranean since the latest part of the Miocene is presented.

At times, the last subchapter departs from the realm of objective nonpartisan reporting. We recognize some of the writing as speculative. We will be glad if the tale woven here elicits new avenues of attack on what is to us an intricate and fascinating history of the Mediterranean region.

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47.1. PLIOCENE BIOSTRATIGRAPHY AND CHRONOSTRATIGRAPHY

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INTRODUCTION

Pliocene sediments have been recovered in forty-two of the more than two hundred cores recovered during Leg 13 of the Deep Sea Drilling Project in the eastern North Atlantic and Mediterranean Sea. Fossiliferous Pliocene sediments were found at Sites 120 (Gorringe Bank), 121 (Alboran Basin), 122 and 123 (Valencia Trough), 124 (Balearic Rise), 127 (Hellenic Trench), 129 (Strabo Trench and Mountains), and 134 (Balearic Abyssal Plain). However, these sites were not continuously cored and the cored intervals were often widely separated. In some cases the material is allochthonous.

The best sections of the Pliocene were those continuously cored at Site 132 in the Tyrrhenian Basin and Site 125 in the Ionian Basin. In fact, at the latter site, the Pliocene interval was cored twice.

In the sedimentary sequence of Sites 132 and 125 the Pliocene is represented by highly calcareous deep-sea pelagic oozes with a low and constant rate of sedimentation. Planktonic foraminifera are by far the most abundant constituent of the sand-sized fraction of the sediment. Such material is ideally suited for biostratigraphic investigations. The thickness of the Pliocene section is 118 meters at Site 132, where the core recovery exceeds 86 per cent and is about 50 meters at Site 125A where the core recovery is unfortunately considerably lower, especially in the Lower Pliocene.

The planktonic foraminiferal zonation proposed here is new. To avoid duplication, reference is made to Chapter 40, Part II, point 10, for a discussion of its background and of the criteria used for the selection of the various zonal markers.

The zonation here proposed is fairly close to those recently defined for the Pliocene of Italy (Bertolino *et al.*, 1968), for the Pliocene of Greece (Bizon, 1967), for the Pliocene of Italy and other Mediterranean regions (Cati *et al.*, 1968) and can be correlated with them (see further below). The most important difference is that in the zonation here proposed for the deep-sea Mediterranean sediments we do not use as zonal markers either *Globorotalia aemiliana* (or *G. hirsuta aemiliana*, or *G. crassaformis aemiliana* or *G. crotonensis*), or *G. crassaformis*. Both taxa have been recorded in the DSDP cores, but their occurrence, especially that of *G. crassaformis* cum var., appears strongly controlled by some ecological factors (see range charts in Chapters 7 and 13).

Globorotalia crassaformis is a mesopelagic species, living in the present seas and known in fossil sediments as old as early Pliocene (Miocene according to Blow, 1969).

The frequency curve of *G. crassaformis* (group), based on thirty samples investigated from the Pliocene section continuously cored at Site 125, does not show a correlation with the inferred climatic curve based on the occurrence of a restricted number of epipelagic, temperature-sensitive species of *Globigerinoides*, whose distribution in the present seas is limited to the tropical or subtropical areas (see Cita and Ciaranfi, 1971, and Chapter 47.3). Therefore, the factor which controls the very irregular abundance of *G. crassaformis* is not the temperature of superficial waters in the photic zone, but possibly changes in the structure of the permanent thermocline, or other ecological factors.

Although ten months have been dedicated to the investigation of the Pliocene sections under discussion, the present study is still preliminary in some aspects. Shortage of space and time have prevented a thorough documentation of the foraminiferal faunas.

The taxonomy of some groups, including the *Globorotalia crassaformis* group, is provisional. No taxonomical notes will be included here, with the exception of the *Globorotalia margaritae* group, on which statistically oriented investigations have been done (see Section on statistical investigations on this group). We had to describe two new taxa, since one of them has been used as zonal marker. Two more new taxa recorded in the Mediterranean DSDP cores will be published elsewhere, as will further paleontological investigations.

In the present chapter only the aspects of Pliocene foraminiferal biostratigraphy considered of interest for the project will be examined.