46.2. COMPARISON BETWEEN FORMATIONS DRILLED AT DSDP SITE 372 IN THE WESTERN MEDITERRANEAN AND EXPOSED SERIES OF LAND

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ABSTRACT

Formations penetrated at Site 372 are compared with series cropping out on land in the Balearic Islands, Southern Spain, and Sardinia. The comparison is extended to wells drilled in the Gulf of Lion. The margin at Menorca and the North Balearic Provençal Basin appear to be at least of Burdigalian age. The entire Miocene is undisturbed at Site 372 in contrast to Mallorca and continental Spain where important tectonic events occurred during middle and upper Miocene.

INTRODUCTION

Because DSDP Site 372 is located only 40 km from the Balearic Islands, it is logical to compare the series penetrated at the site with land equivalents, particularly with those on the island of Menorca. As will be demonstrated below, time-equivalent series on the Balearic Islands are characterized by a shelf facies and do not correspond to the pelagic marls penetrated in the Hole 372. The comparison will be extended to the wells drilled by the Compagnie Française des Pétroles in the Gulf of Lion, and then to Sardinia and southern Spain. Finally, the study of a 3-meter core taken south-west of Site 372 will complete our interpretation.

Comparison with Menorca Island

Bourrouilh (1973) demonstrated that the island of Menorca can be divided into two geological provinces, a tectonically disturbed northern and northeastern region, the "Tramuntana," and a platform area to the south-southwest, consisting of post-tectonic molasses, the "Mindjorn."

In the former area, the oldest outcrops range in age from Devonian to Keuper. The Keuper is unconformably overlain by lacustrine conglomerates, the cement of which contains charophytes indicating a late Oligocene to early Miocene age. Reworked components of the conglomerate are from Jurassic to late APTian age.

By comparing these rocks with those of Mallorca, Bourrouilh considered the age of tectonism to be middle Miocene. This conclusion is questionable considering that at Site 372 the entire Miocene is undisturbed.

In the latter area (Figure 1A) the series is undisturbed except for recent faulting. The sediments are a chalky facies, cropping out in the south-southwestern part of the island. The carbonate formations are often rich in algae; echinoderms, pectens, and, locally, corals are also present. The foraminifers are essentially benthic with outer shelf (Amphistegina, Heterostegina) and inner shelf genera (Borelis). This shallow water facies was determined by Bourrouilh and Colom (1968) to be middle Miocene (Vindobonian) in age. In the southern part of the island near San Thomas, some planktonic foraminifer assemblages (Globorotalia humerosa Zone, Bizon et al., 1973) indicate that late Miocene sediments are present. Beyond the outcrops just mentioned, the Vindobonian molasses are, in fact, rather poorly dated, but are generally thought to range in age from Langhian to Tortonian.

To the southeast of Menorca, on Rey Island, at the contact between the tectonically disturbed and post-tectonic series and at the base of the Vindobonian molasses (Bourrouilh, 1973, p. 467), Miogypsina (sp. undet.) has been found in a dolomitic facies. Their presence, if they occur in situ (and there is no evidence
of reworking), would indicate that the Menorca molasse began locally in the Burdigalian.

Late Miocene evaporites are not known from outcrops. A new marine transgression began at the end of the Pliocene or at the beginning of the Pleistocene which deposited littoral limestones containing *Amphistegina*, *Miliolidae*, and other benthic foraminifers (Bourrouilh and Magne, 1963). In summary, shelf facies dominated on Menorca during the Miocene and Pliocene-Pleistocene, and consequently a direct correlation with the pelagic facies encountered in the formations penetrated at Site 372 is not possible.

Comparison with Mallorca Island (Figure 1B)

The complex geological framework of Mallorca is rather well known, as a result of investigations by Fallot, (1930) Rangheard, (1969) and Bourrouilh, (1973). It comprises:

1) The Sierra Norte in the north-northwest in which Mesozoic and lower Miocene rocks were thrust to the north-northwest resulting in imbricate structures.
2) A central region with outcrops of the “Vindobonian molasse” and, locally, some inliers in which older formations appear.
3) The Sierra de Levante, an intensely imbricated Mesozoic, Paleogene, and lower Miocene series.

The Tertiary outcrops are discontinuous, poorly exposed, and badly faulted; precise age determinations of the series is difficult.

Tectonically Disturbed Series

The oldest Tertiary formations known on Mallorca consist of conglomerates, unconformably overlying rocks of Cretaceous age, followed by Eocene nummulitic limestones; they outcrop near San Arboles, in the Sierra Levante, and near Santa Margarita, in the central part of the island.

The Oligocene is generally represented by continental red-beds, although marine intercalations are known from the central part of the island (Randa area). The Puig de Santa Gloria series, an overturned and faulted sequence, consists of lower Oligocene nummulitic limestones, middle Oligocene *Lepidocyclina* limestones and marls with *Almaena* sp., *Globigerinoides primordius* and *Globorotalia kugleri* of Aquitanian age. The lower Miocene (Burdigalian) series rests unconformably on the tectonically disturbed Aquitanian series. The lower Burdigalian rocks, containing *Miogypsina*, grade into a pelagic facies of Langhian age (*Praeorbulina glomerosa* Zone) in the Santa Margarita section in the center of the island. This marine series in turn grades gradually into brackish and lacustrine formations which contain laminated limestones. The Charophyta, *Planorbis*, and fresh-water ostracodes and diatoms are present in some intervals. The formations, accurately described by Colom (1967) are conformably overlain by the “Vindobonian molasses.” In the Sierra Norte and in the Sierra Levante, Burdigalian-Langhian marls are strongly affected by tangential tectonics.

Post-Tectonic Series

The “Vindobonian molasses” are shelf sediments comprising white chalks with oysters, pectens, and echinoderms. Benthic foraminiferal faunas consist mainly of near shore genera (*Borelis, Amphistegina, Heterostegina, Miliolids*). In 1947, G. Colom described highly diversified benthic foraminifers from the Vindobonian of Mallorca. These earlier investigations need
peripheroronda) contain too few specimens for adequate correlation with the formations penetrated at Site 372, where planktonic foraminifers are abundant. Large benthic outer shelf foraminifers occur in Tramontane 1 and Autan 1 which indicates the presence of sediments of Aquitanian age. These overlie in Autan 1, red-brown clays which cannot be easily dated. These shelf deposits were not found at Site 372 where the lowest core from the well contained a pelagic microfauna of lower Burdigalian age.

Comparison with Sardinia (Figure 2)

The Monte Santo section (Pomesano-Cherci, 1970) in the northwestern part of Sardinia shows a stratigraphic succession that is similar to the one observed at Site 372, ranging in age from Burdigalian, with Globigerinoides bisphericus to Serravallian, with Globorotalia praemenardii and Globorotalia miozea. The middle Miocene seems incomplete towards the top and the author does not mention the interval with abundant Globigerinoides obliquus which generally characterizes the top of middle Miocene in the Mediterranean. The marls with Globorotalia praemenardii are overlain by neritic limestones and by basalt flows.

The facies of the Burdigalian, Langhian, and Serravallian are generally sandy with neritic limestone intercalations, again indicating shallow water deposits and differentiating them from the deeper water facies encountered at Site 372.

Comparison with Southern Spain (Figure 2)

Lower and middle Miocene deposits exist to the northwest of Alicante, near Alcoy (Montenat, 1973). Here the planktonic microfauna is similar to that at Site 372. The sequence consists of white, silty marls with more calcareous intercalations, ranging in age from late Burdigalian (Globigerinoides bisphericus) to Langhian (Orbulina suturalis and Globorotalia fohsi peripheroronda). The Serravallian overlies this sequence with an angular unconformity and consists, as for the lower series, of silty marls with more calcareous intercalations. Globorotalia praemenardii occurs at the base of this sequence. At the top, planktonic foraminiferal assemblages are similar to those observed in Core 13 at Site 372. The sequence ends with a neritic limestone bed.

Although the planktonic foraminiferal assemblages found at Alcoy and at Site 372 are similar, the environment of deposition is definitely different. The Alcoy beds are always rich in benthic foraminifers which constitutes about 50% of the total benthos + plankton. The genera Elphidium and Amphistegina indicate sediments laid down on the outer shelf; the planktonic foraminifers although sometimes abundant, are often badly preserved. Fragments of echinoderms and pelecypods abound.

Upper Miocene sediments (Globorotalia acostaensis and Globorotalia humerosa zones) are represented in several areas of southern Spain (Montenat, 1973). In the Venta la Virgen section, marly beds belonging to the Globorotalia acostaensis and Globorotalia humerosa zones (600 m) are overlain by near shore sediments with Ostrea, Elphidium, and Ammonia (Bizon et al., 1972). Several tectonic disturbances are known to have affected these rocks between upper Serravallian and lower Tortonian times, but the boundary between Globorotalia acostaensis and G. humerosa zones is always conformable and represented by continuous open marine sediments.

A type of sediment similar to the laminated interval which occurs in the upper part of Core 9, Section 2,
Figure 2. Comparison between Site 372 other drill sites and exposed series on land.
and in the lower part of Core 9, Section 1, is known in
the Guadalquivir Basin in the Valenzuela present
(Globorotalia acostaensis Zone, Tjalsma, 1971) and
Chaves (lower and middle Miocene, Verdenius, 1970)
formations. Laminated limestones are also known in
from the upper-most Miocene of the Murcia-Alicante
basin where they contain coccoliths and diatoms. These
younger sediments are generally barren of any
foraminifers.

Comparison with Piston Core FOM 69
A piston core recovered on the continental shelf,
east of Menorca, south-southwest of Site 372, reveals
the presence of marine marls with a planktonic micro-
fauna of late Miocene age (Globorotalia humerosa
Zone, Globorotalia mediterranea Subzone), with inter-
calation of dolomitic beds (Bizon et al., 1975). Similar
beds occur in the upper part of Core 4, Section 2, at
Site 372, above the evaporites. Marine Quaternary
sediments overlie these beds in Core FOM 69, with
reworked lower Pliocene and upper Miocene micro-
fauna.

CONCLUSIONS
The pelagic marls of Miocene age, at Site 372 were
certainly deposited in a deeper marine environment
than on Menorca or Mallorca where shelf facies pre-
dominate. Towards the east, in Sardinia, the lower
middle Miocene becomes sandy and toward the west,
the sequence becomes more calcareous. To the north,
in the Gulf of Lion, the Miocene series is rich in
benthic foraminifers, indicating an environment of
deposition in water shallower than at Site 372. Thus,
the margin at Menorca and the North Balearic Pro-
venal Basin appears at least as old as Burdigalian and at
that time the basin was deeper. Furthermore, in spite of
more or less well-defined gaps or condensed sequences
in sedimentation recorded in the hole, the entire
Miocene is undisturbed at Site 372. This may also be
true in Menorca where Miocene tectonism is not
definitely proven. In contrast, Mallorca and continental
Spain were affected by significant tectonic events during
middle and upper Miocene time (see Biju-Duval et al.,
this volume).

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REFERENCES
Bizon, G. Bizon, and J. J., Bourrouilh, R., and Massa, D.,
1973. Présence aux îles Baléares (Méditerranéenne occi-
dentale) de sédiments "messiniens" déposés dans une
mer ouverte à salinité normale: C. R. A.A Sci., Paris, 277,
p. 985-988.
Miocène terminal et de Pliocène inférieur au large de
Minorque (Baléares, Espagne): IFP, XXX, v. 5, p. 713-
727.
terminal dans le Levant espagnol (Provinces d' Alicante
et de Murcia): Rev. IFP, XXVII, v. 6, p. 831-863.
Bourrouilh R., 1973. Stratigraphie, sédimentologie et tec-
tonique de l’île de Minorque et du Nord-Est de Majorque
Pliocène supérieur et du Quaternaire sur la côte Nord de
l’île de Minorque (Baléares): B.S.G.F., v. 7 p. 298.
Colom, G., 1947. Les foraminifères de las margas vindobo-
nienses de Mallorca: Est. Geol. III, p. 113-180.
sondages du Golfe du Lion: stratigraphie, sédimentologie:
C.F.P., Notes & Mémoires, v. 11, p. 209-274.
Fallot, P., 1930. Etat de nos connaissances sur la structure
Montenat, C., 1973. Les formations néogènes et quaternaires
du Levant espagnol (provinces d’Alicante et de Murcie):
Pomesano-Cherchi, A., 1970. Microfaune planctoniche di
alcune serie mioceniche del Logudoro (Sardegna): Secondo
Rangheard, Y., 1969. Etude géologique des îles d’Ibiza et de
Tjalsma, R. S., 1971. Stratigraphy and foraminifera of the
Neogene of the eastern Guadalquivir basin (southern
Verdenius, J. G., 1970. Neogene stratigraphy of the western
Guadalquivir basin (southern Spain): Utrecht Micropal.