

**MIGRATION OF MIOCENE ECHINOIDS BETWEEN THE
WEST INDO-PACIFIC AND THE MEDITERRANEAN REGIONS**

by

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Introduction. Since the earliest phases of the development of modern geologic sciences, the study of the migration of fossil fauna has been considered as one of the most important tools to decipher palaeogeographic conditions.

This paper deals with the study of the distribution of Early and Middle Miocene echinoids in the Eastern Mediterranean and the West Indo-Pacific regions as an attempt to understand the connection between those two main provinces and the mechanism of migration of the considered fauna.

In order to reach the proposed aim, the following points must be taken into consideration:

1 The palaeogeographic situation (distribution and extension of lands and seas) of the considered region should be determined. It is done by reviewing the available literature on plate movements during the Miocene in the area comprising Africa, the eastern Mediterranean lands and India.

2 The migration of marine organisms is influenced by many factors, which can be summarized as factors depending on the nature of the organism itself (its life habit, its life cycle, its ecological valency, etc. . .) and on the environmental conditions under which the organism lives and their suitability to help migration (distribution of lands and seas in which the organism is prone to migrate, existence of currents, existence of barrier to migration, etc. . .).

3 By reviewing previous literature care must be taken to use a unified scheme for defining the species, which are often differently evaluated and named by different authors. In general, it has been observed that many ancient authors tend to split too much taxonomic units. For example more than 139 species of *Clypeaster* have been recorded in the Middle Miocene of the Mediterranean region (ALI, 1983). This shows that a great effort should be undertaken to revise the taxonomy of echinoids in this part of the world. In the present work only the forms showing striking similarities in the different localities investigated have been taxonomically revised. Only publications with illustrations have been taken into consideration.

In the following paragraphs the first two mentioned points regarding the factors influencing the migration of marine organisms are dealt with briefly before presenting the discussion on the distribution of the echinoid faunas in the various Mediterranean and West Indo-Pacific occurrences and its implications regarding the migration mechanism of these faunas.

Palaeogeography of the Eastern Mediterranean and the West Indo-Pacific regions in Middle Miocene time

The maps of figure (1), show roughly the relative position of the various continental masses, marine bodies and sea ways during the Middle Miocene in the Eastern Mediterranean.

FELL (1967), explained the direction of the main marine currents acting in the Indo-Pacific. It is reasonable to suppose that the same causes which produce the movements of major marine currents in the seas on the northern and southern sides of the equator were also acting in the same way during the Miocene times. These forces create currents rotating in a clockwise direction and sweeping the equator from east to west in the northern hemisphere. Thus, during the Miocene, the main warm southern currents were coming from India towards Africa. The reverse movement being probably lost in the continental mass of the Arabian Peninsula and Asia.

Distribution of Early and Middle Miocene echinoids in the Mediterranean and in the coasts of the Indian Ocean

It is interesting before our discussion to give some informations about the stratigraphy of the Miocene successions which have yielded the echinoids in the localities chosen in the present study of the West Indo-Pacific region.

The most notable works of the Miocene echinoids in Somalia are the works of STEFANINI (1932) and SOCIN (1942, 1956). The faunas of this country have been collected from Hafun Peninsula, the most eastern point of Africa, coasts of N—E Somalia on the Indian Ocean. The Hafun Series which has yielded the echinoid faunas should therefore now be regarded as being of Middle Miocene age (EAMES and SAVAGE, 1975) and not Burdigalian as mentioned by SOCIN (1942 and 1956).

In Zanzibar, the Miocene echinoid faunas have been collected and described by STOCKLEY (1927), from Chake Chake Beds of the Pemba Series in Pemba Island. He assigned a Lower Miocene age to this series. EAMES and SAVAGE (1975), considered it to be Middle Miocene on the basis of Foraminifera.

According to KING (1953), the echinoid faunas of Zululand, northeast of South Africa, is contemporaneous with that from the Chake Chake Beds of the Pemba Island. Its age therefore should be Middle Miocene not Burdigalian as it was cleared by KING (1953).

The Dam Formation crops out near the coast of the Arabian Gulf in north-eastern Saudi Arabia. This formation is Middle Miocene according to POWER et al. (1966). But KIER (1972), and ADAMS et al. (1983), considered it as Burdigalian.

Table (1), shows the distribution of the echinoid species found in both the Mediterranean and West Indo-Pacific regions during the Miocene in the investigated localities. These species and their distribution have been recognized from published data on echinoids.

The Middle Miocene echinoid forms of East Africa and the Arabian Gulf region were compared to these from the Early and Middle Miocene in the Mediterranean. As it is known that the connection between the Indian Ocean and the Mediterranean was severed in the Early Miocene (Burdigalian) time (ALI, 1983 and ADAMS et al., 1983), it is not likely to find in sediments of this age species that would be common to both areas (EAMES and SAVAGE, 1975). This means that the Early Miocene echinoids of the Mediterranean show a great deal of endemism.

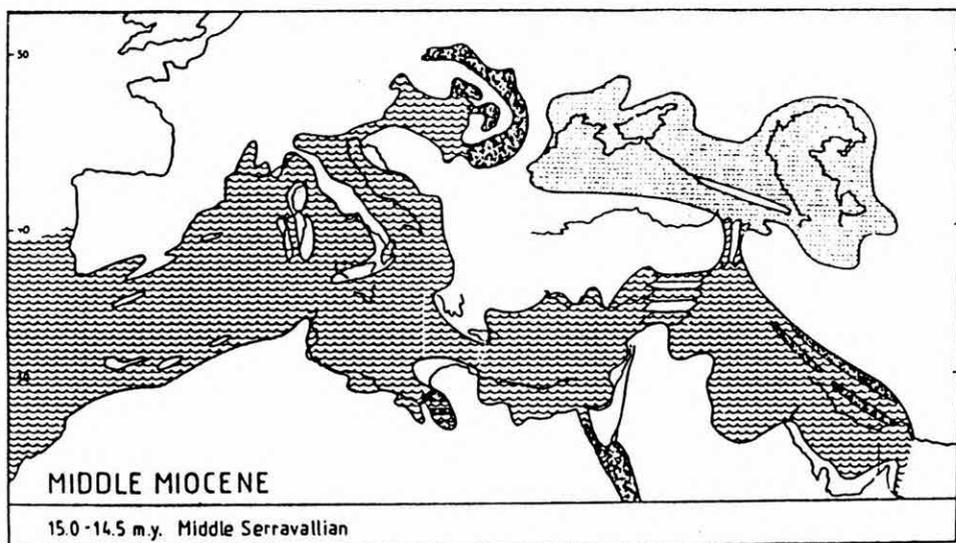
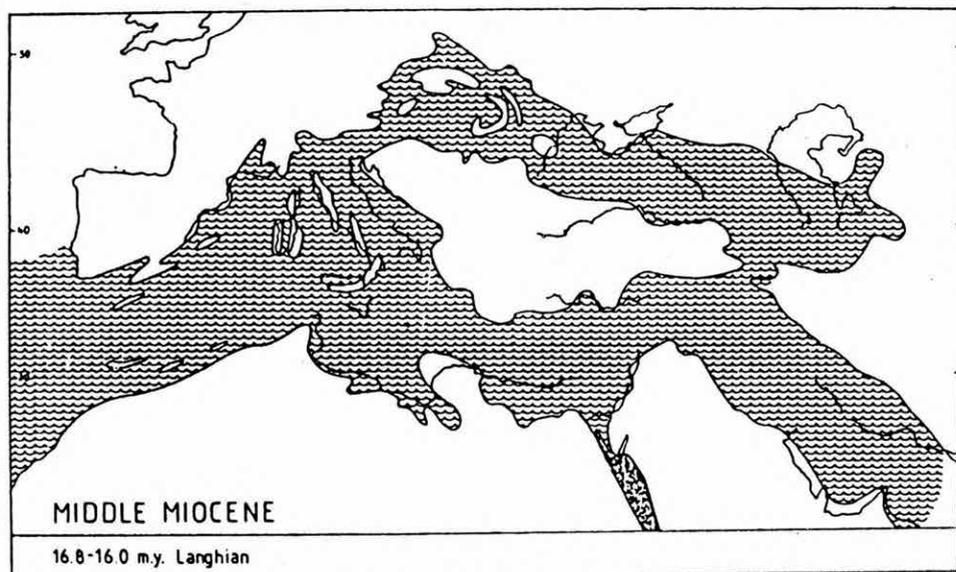


Fig. 1. Explanation of the relative position of the various continental masses, marine bodies and sea ways during the Middle Miocene in the Eastern Mediterranean (after STEININGER and RÖGL, 1984)

1 Marine realms, 2 reduced salinity realms, 3 evaporitic realms

The distribution of some Miocene echinoid species found in the Mediterranean and West Indo-Pacific regions

Table 1

Species	Mediterranean region	West Indo-Pacific region
<i>Clypeaster martini</i>	Aqui. and Burd.: Italy and France M. Miocene: Libya, Egypt and Sardinia	M. Miocene: Somalia, Zanzibar and Zululand
<i>C. latirostris laganoides</i>	Langh.: Libya and Italy M. Miocene: (Hel.): Italy, Lybia, Portugal and Sardinia	M. Miocene: Somalia
<i>C. marginatus</i>	M. Miocene: Malta, Italy, Portugal, France, Algeria, Spain and Egypt	M. Miocene: Zanzibar
<i>Lagammm depressum</i>	Tor.: Malta	Burd.: Saudi Arabia M. Miocene: Zululand
<i>Echinolampas complanata</i>	M. Miocene: Syria	Burd.: Iran
<i>Schizaster eurynotus</i>	Burd.: Malta Langh.: Malta, Italy, France and Libya M. Miocene: Italy, France, Greece, Egypt, Libya and Portugal	M. Miocene: Somalia
<i>S. parckisnoni</i>	Aqui.: Malta Langh.: France, Spain and Italy M. Miocene: Malta and Italy	M. Miocene: Somalia
<i>S. desori</i>	Helv.: Corsica	M. Miocene: Somalia
<i>S. baylei</i>	Burd.: Sardinia and Corsica	M. Miocene: Somalia
<i>S. valabrequei</i>	Aqui.: France	M. Miocene: Somalia
<i>Pericosmus latus</i>	Burd.: Libya and Egypt Langh.: Malta M. Miocene: Egypt, Malta and Libya	M. Miocene: Somalia
<i>Macropneustes sahelensis</i>	Helv.: Italy Tor.: Algeria	M. Miocene: Somalia

Aqui. = Aquitanian, Burd. = Burdigalian, Langh. = Langhian, Helv. = Helvetian, M. = Middle, Tor. = Tortonian.

Here, also it can be found that some species of the Early and Middle Miocene of the Mediterranean region are found in the Middle Miocene of Somalia, Zanzibar and Zululand. Thus attesting for a migration of some Early and Middle Miocene echinoids from the Mediterranean region towards the West Indo-Pacific during the Middle Miocene.

Common Middle Miocene echinoid species are also found between East Africa, India and Pakistan. However, no common species whatever have been found between India or Pakistan and the Mediterranean region. These peculiarities were controlled by current circulation as shown here under.

Migration of echinoid species in the Mediterranean Sea and the Indian Ocean

Ten Early and Middle Miocene species recorded from the Mediterranean region (France, Portugal, Spain, Italy, Malta, Greece, Libya and Egypt), are also found in the Middle Miocene rocks of the Indian Ocean (Somalia, Zanzibar and Zululand) (Table 1) These are: *Clypeaster martini*, *C. latirostris laganoides*, *C. marginatus*, *Schizaster eurynotus*, *S. parkinsoni*, *S. desori*, *S. baylei*, *S. valabrequei*, *Pericosmus latus* and *Macropneustes sahelensis*. These similarities indicate west—east migration from the Mediterranean to the West Indo-Pacific region. At the same time, two species *Echinolampas complanata* and *Laganum depressum*, which are Early Miocene (Burdigalian) West Indo-Pacific forms (recorded from Iran and Saudi Arabia respectively), have been recorded from the Middle Miocene of Syria and Malta. This indicates east—west migration from Iran and the Arabian Gulf to the Eastern Mediterranean during the Middle Miocene time.

The general absence of common Miocene species between India and the Mediterranean region suggests that no migration path between these two areas existed at that time. However, common forms between East Africa and India are frequent (*Coelopleurus forbesi*, *Opechinus rosseaui*, *Clypeaster depressus*, *C. profundus*, *C. pulvinatus*, *Echinolampas spheroidal* and *Breynia carinata*). These phenomena may be explained as a result of the distribution and the currents direction shown by FELL (1967), which indicate that migration of larval planktonic echinoids between the two areas (India and East Africa), is more likely to have proceeded in an east—west direction, from India towards East Africa.

It is also interesting to notice here that *Laganum depressum*, which is an Early Miocene of the Eastern Saudi Arabia, is to be found in the Middle Miocene of Zululand and in the Tortonian of Malta (ZAMMIT-MAEMPEL, 1978). This suggests migration in two directions from the Arabian Gulf to East African coast on one hand, and towards the Mediterranean Sea on the other hand.

Conclusion

The analysis and discussion of published data on the distribution of echinoids in the Mediterranean and the West Indo-Pacific regions show that these two basins were connected by a passage way during the Middle Miocene time as represented by the occurrence of identical echinoids in both regions. This passage way permitted to these species to migrate from the Mediterranean towards the Indian Ocean and vice versa although the main trend was from west to east.

The Middle Miocene echinoid faunas of the Gulf of Suez in Egypt show definite Mediterranean affinities at the generic and specific level (ALI, 1984). On the other hand, the marine Miocene faunas of Iran have much in common with both the West Indo-Pacific and the Mediterranean (EAMES and SAVAGE, 1975), suggesting that the passage way between the two regions during the Middle Miocene existed through the region of the Arabian Gulf and Iran and not through the Gulf of Suez and the Red Sea.

Here, it is interesting to notice that ADAMS et al. (1983), consider that a land bridge existed in Langhian time between the Indian Ocean and the Eastern Mediterranean. They reached their conclusions through the study of the foraminifera and macrofossils in Iran, Iraq and Arabia and around the Arabian Gulf. These conclusions not necessarily contradict our findings. The chronostratigraphical subdivisions referred to in

the literature we used have not the degree of precision to decide if what is called Langhian in Arabian Gulf by ADAMS et al. (1983) corresponds to what is generally referred to as "Middle Miocene" in the present paper. It is well-known that the Early Langhian is considered by most Mediterranean Neogene geologists as related to the "Early Miocene" (HARLAND et al., 1982). In this case the Langhian of ADAMS et al. (1983), may be Early Miocene and a continuation of the period of separation of the West Indo-Pacific from the Mediterranean. The Middle Miocene of our discussion refers probably to the Late Langhian and Serravallian ages. However, if we accept the conclusions of ADAMS et al. (1983), about the Middle Miocene land bridge between the two regions, we suggest that there were several intervals of relatively high sea level during the Middle Miocene in which the land bridge was probably of low relief or in the form of island chains, so allowing for partial migration of some echinoid species between the Indian Ocean and the Mediterranean Sea by temporary connections between them.

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