THE INDO-PACIFIC AFFINITY OF SOME MALTESE TERTIARY FOSSILS

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ABSTRACT:

A review of the Maltese fossil record reveals an unsuspected marked Indo-Pacific affinity, suggesting a biostratigraphic link between the central Mediterranean and the Indo-Pacific in mid-Tertiary times. The family and sometimes even the genus of some Maltese Oligo-Miocene fossils still survive in the Indo-Pacific province after having become completely extinct from the Mediterranean region.

The fossils reviewed in this paper are the Cidaridae (which are also revised to reveal the presence of *Prionocidaris* and *Phyllacanthus*), *Coelopleurus, Echinoneus, Laganum, Apatopygus, Clypeaster, Tomistoma, Trionyx, Trilasmis, Kuphus,* and *Nautilus* — all of which have an Indo-Pacific affinity.

The survival of such a fauna in the Indo-Pacific region is attributed to two main factors: the former connection of Tethys to the Indo-Pacific, thereby allowing eastward migration of the central Mediterranean fauna into this Ocean, and climatic and other ecological conditions prevailing in the central Mediterranean region during mid-Tertiary times having been analogous to those now prevailing in the Indo-Pacific.

GEOGRAPHICAL CONSIDERATIONS

Most of the fossils collected from the Oligo-Miocene deposits of the Maltese Islands show a striking similarity to the shallow-water marine fauna of the Indo-Pacific region. The Maltese Islands are situated in the central Mediterranean at latitude 36°N. and longitude 14-15°E., while the Indo-Pacific region lies thousands of miles away and covers a very extensive area. It includes the Red Sea, Gulf of Aden, Persian Gulf, Gulf of Oman, Arabian Sea, Bay of Bengal, Andaman Sea, Indonesia, China Sea, Australian region, the lowest part of the Gulf of California, the Bay of Panama, the Tropical Pacific and the Indian Ocean north of 26°S. (Wells, 1956).

The Mediterranean is but the western end of ancient Tethys whose former extension over present-day Turkey, Syria, Iran (Persia) and Afghanistan established direct communication with the Indo-Pacific province. Such connection allowed eastward migration of central Mediterranean faunas into the Indo-Pacific region. The warmer climate and waters of mid-Tertiary times explain the presence of recent Indo-Pacific genera and families among the Oligo-Miocene rocks of the Maltese Islands.

The sea began to withdraw from the Near and Middle East towards the end of the Oligocene (Savage, 1967) and the Mediterranean became effectively sealed off from the Indo-Pacific and the Atlantic by the end of the Middle Miocene (Berggren, 1972, Brassier, 1975, pp. 893, 897). This in turn initiated a sequence of events which ultimately ended up in the desiccation of the Mediterranean and in the "Messinian crisis" of late Miocene times. By correlating and calibrating continental and marine chrono-stratigraphic units, Berggren presented in 1973 a revised time scale for the late Miocene. This provided a chronological framework within which to interpret the later stages of the evolution of the Mediterranean region. The late Miocene desiccation phase (Messinian) of the Mediterranean was apparently relatively of brief duration, less than 2m.y., at about 7-5 m.y. ago (p. 17.)

A REVIEW OF THE FOSSIL RECORD:

The present paper reviews the fossil record of the Maltese Islands and deals with some of the fossils having Indo-Pacific affinity. Such affinity was first recorded in the case of a crocodile skull belonging to the genus *Tomistoma*.

i. REPTILES: *Tomistoma* and *Trionyx*.

In a paper read to the Geological Society of London in 1885, Lydekker reviewed the gavial-like skulls from "Division C" of the Globigerina Limestone of Malta and Gozo respectively (Cooke, 1896, p. 504). Both specimens were once in the collection of the British Museum (Nat. Hist.) bearing registration no. BM/? and BM/41151 respectively. Owen, who had originally examined the above-mentioned specimens, thought they both belonged to the same species and labelled both skulls *"Melitosaurus champsoides"*. As the fossils were never described or figured, the name which Owen had given them must necessarily remain a "label" or "manuscript" name, (*Nomen in Collectione*), without any firm right of survival in scientific literature. This however, was not to be, as several years later, Hulke carried out a detailed study of the two skulls and realised that they represented two different species. These he described in 1871, calling the Gozo fossil, (now not traceable in BMNH), *Crocodilius gaudensis* sp. nov. and the 13 inch rostrum from Malta (BMNH/41151, presented to the BMNH by Captain Strickland R.N. in 1868), *"Melitosaurus champsoides* Owen". By his courtesy in thus preserving Owen's original label-name, Hulke recognised that name and made it scientifically valid. Strictly speaking, therefore, the binomial name *"Melitosaurus champsoides"* should be ascribed to Hulke and not to Owen, since label/manuscript names without the backing of a description are not scientifically valid. Owen's name however became still more deeply entrenched in scientific literature when, in 1886, Lydekker (p. 22) referred to Hulke's specimen as *"Tomistoma champsoides* (Owen)".

By 1885, the two Maltese crocodile skulls had attracted the attention of Lydekker who noted that they both possessed 4-5 premaxillary teeth, a very

slender rostrum, and an elongated premaxilla that articulated with the long slender nostrils. As these features characterised the genus *Tomistoma* Mueller, 1846, and as the above-mentioned Maltese Tertiary reptilian remains were both closely related to the existing Indo-Pacific crocodile *Tomistoma schlageli* (Strauch) of Borneo, Lydekker referred both fossil forms to the genus *Tomistoma*. He called the Gozo specimen *Tomistoma gaudensis* Hulke) and the Maltese specimen (BMNH/41151) *Tomistoma champsoides* (Owen), adding that the two fossils represented "one more instance of the survival of Middle and Upper Tertiary genera in the oriental region" (Lydekker, 1886, p. 22).

Cooke's "Division C" of the Globigerina Limestone, the "fine-grained bluish freestone" which yielded the gavial-like skulls referred to above, is said to have yielded also "a portion of a skull of *Tomistoma champsoides* with teeth in situ and with two vertebrae imbedded by the side of it". The latter specimen, said to have been presented to the University Museum by the Dock Engineer (Cooke, 1886, p. 506), cannot now be traced in the National Museum of Natural History Collections at Mdina, where the unlabelled and unregistered collection of the University Museum ended up.

It should be noted that the genus *Tomistoma* has been recorded in beds ranging from Eocene to Pliocene in North Africa and from Eocene to Miocene in Europe (Romer, 1968, p. 605).

Another reptile recovered from the Maltese Tertiary and known to have Indo-Pacific affinities is the large chelonian *Trionyx*. The anterior part of the carapace of this turtle was discovered in the Globigerina Limestone quarry at Luqa (Cooke, 1886, p. 504). As all building-stone quarries at Luqa involve only the lower division of the Globigerina Limestone formation, it is presumed that the carapace was recovered from this division.

When Dr. John Murray of the "Challenger" expedition visited Malta in 1890, he managed to acquire the specimen and in July of that same year presented it to the British Museum (Natural History) of London, where it is registered as "R.1795". In 1891 Lydekker described and figured the specimen as a new species which he called *Trionyx melitensis*. It is the only species of turtle known from the Maltese archipelago and is undoubtedly the same specimen recorded and figured anonymously (?Gulia) in 1843 (pp. 77-78, fig.). The species is allied to the existing Indian species *Trionyx gangeticus*, *T. leithi* and *T. hurium* with which it is said to agree in having the characteristic two neural bones (division of the first neural) between the first pair of costals, other members of the family having only one first neural bone (Boulenger 1889, p. 244; Lydekker 1891, p. 37). The genus *Trionyx*, which, during the Globigerina Limestone times, found the warm shallow seas of the Maltese area adequate for its survival, has now completely disappeared from the Mediterranean region and is confined to Indian waters.

ii. SHARKS

Fossil sharks' teeth are extremely abundant in Maltese Tertiary deposits and though formerly thought to be limited to only three of the five local geological formations (Globigerina Limestone, Clays, Greensand), they have lately been collected also from the other two formations. Menesini (1974) has recorded *Odontaspis acutissima* Ag. from the Upper Coralline Limestone of Gozo, and the present author has collected *Isurus hastalis* (Ag.) from the same formation at Lippia, Malta, and *Carcharodon megalodon* Ag. from the base of the *Scutella* bed at Dwejra, Gozo, and *Odontaspis* sp. from the *Kuphus* bed in the Lower Coralline Limestone at Attard, Malta.

Some of the genera represented in Maltese rocks, particularly *Hemipristis* and *Carcharodon,* have a marked Indo-Pacific affinity. Teeth of *Hemipristis* sharks are abundant in the Globigerina Limestone "Nodule beds" and in the Greensand, but have now completely disappeared from the Mediterranean and survive only in tropical waters thousands of miles away.

The artificial connection established in 1869 between the warm Indian Ocean and the Mediterranean by way of the Red Sea and the Suez Canal, is gradually restoring the former physical conditions of the Mediterranean area with consequent gradual changes in the central Mediterranean fauna. Warm-water members of the Indian Ocean, finding the Mediterranean basin congenial to them, are migrating westward and becoming gradually established in the Mediterranean. Records show that the White Shark of the Indian Ocean, whose ancestor, the Giant White Shark *Carcharodon megalodon* Ag., is very richly represented in Maltese Tertiary rocks, is making a come back to the Mediterranean. Dr. Giovanni Gulia editor of *Il Naturalista Maltese* narrates in that journal (1890, p. 11-12) how two men were swallowed by a large fish off Marsaxlokk, Malta, and records that a *Carcharodon* shark, known locally as *Silfjun* or *Ħuta tax-Xmara,* was thought to have been responsible. One year later, Cooke (1891, p. 76) reported the capture of a White shark, by British sailors during the Royal Navy manoeuvers of 1891. The fish measured 33 feet in length and weighed four tons. In recent years, a man-eating Great White Shark has been held responsible for the sudden disappearance of an English swimmer in Maltese waters. The unlucky man was snatched away from the surface while swimming with a Maltese companion across St. Thomas Bay (S.E. Malta) in the summer of 1956 (*Times of Malta,* July 20, 1956).

iii. CIRRIPEDES: *Trilasmis.*

In 1953, Withers founded a new species of cirripede on a right tergum (lacking base) from the Upper Globigerina Limestone (Division A of Cooke) of Marsaxlokk. Cooke's Division A refers to 4.5 — 9 meters of fawn coloured clayey limestone with small concretions of hematite and clay ironstone. The

specimen which Withers called *Trilasmis* (*Temnaspis*) *melitense* was collected and presented to the British Museum (Nat. Hit.) by the late Dr. J. G. Baldacchino in June 1957, and is now registered in that Museum as INV. 35920. The species has marked Indo-Pacific affinities for it resembles in many ways the Recent *Trilasmis* (*Temnaspis*) *excavatum* (Hoek) occurring in the Malay Archipelago at a depth of 289-304 meters. (See Withers 1953, pp 95, 342-343, fig. 104).

iv. MOLLUSCS: *Kuphus* and *Nautilus*.

At about 30 meters beneath the *Scutella* bed, the Lower Coralline Limestone (formerly considered Lower Miocene, Aquitanian, and now thought to be Upper Oligocene, Chattian), may reveal a 1-3m thick bed of more-or-less vertically aligned tube fragments embedded in a rubbly or marly matrix (Zammit-Maempel, 1977, p. 15). The tubes belong to the mud-boring teredinid mollusc *Kuphus* Guettard, whose modern representative *Kuphus polythalamia* (L.) is restricted to the mangrove swamp areas of the Indo-Pacific (Turner, 1966, p. 73), with records from such places as Sumatra, Java, Celebes, Philippines, Moluccas and the Solomon Islands.

During Oligocene and Lower Miocene times the animals became very widely distributed and have been recorded from the East and West Indies, Madagascar and southern France. Comparable fossil tubes have been found also in the Eocene of the Khirthar beds of N.W. India and in the Pliocene of Italy and Java (Cox, 1927, p. 63). In the Catania Museum of Palaeontology the author examined (1964) several tube fragments from the Miocene of Sicily and they were very closely similar to the Maltese specimens.

In Malta and also elsewhere, the tubes were formerly mistaken for worm tubes, but the concentric laminations of their wall and the division of the narrow end of each tube into two separate siphonal canals, reveal their real nature. Specific identification of this teredinid is based chiefly on its internal structures, which have never been recorded in the fossil state (Cox et al., 1969, p. N740). The stalks of pallets and the moulds of valves of the Maltese *Kuphus* discovered by the present writer reveal that it is very similar to the Indo-Pacific *Kuphus polythalamia* (L) but is actually a new species (Zammit-Maempel, in preparation).

Remains of the cephalopod mollusc *Nautilus* are abundant in the Maltese Tertiary, being most common in the Globigerina Limestone and in its phosphatic "Nodule beds." Over sixteen specimens were collected by the authors from this formation during excavation of Ta' Ġorni tunnels, St. Julians. *Nautilus* internal moulds are known also from the Upper Coralline Limestone (Zammit-Maempel, 1977, pl. 26), and through the genus has never been recorded from the Lower Coralline Limestone, one large specimen is known to have been collected from this formation in the region of Qalet Marku.

The Maltese nautiloids are very closely similar to those now thriving in the warm Indo-Pacific waters. Their sutures, however, are straighter than those of the modern *Nautilus* but not so straight as those of *Eutrephoceras*.

v. ECHINOIDS: *Ceolopleurus*, Cidaridae (*Prionocidaris, Phyllacanthus*), *Apatopygus, Laganum, Clypeaster, Echinoneus*.

Because of the warmer climate during mid-Tertiary times, Recent Indo-Pacific genera and families of echinoids are very abundant and geographically widely distributed in Miocene rocks (Glaessner, 1969).

The echinoid fauna of the Mediterranean neogene is essentially a sub-tropical one (Cottreau, 1914) and that of the central Mediterranean island of Malta is made up of a large number of genera, with many of the genera being represented solely by one species. Such for example, is the case with the genera *Coelopleurus, Apatopygus, Laganum* and *Echinoneus*.

Coelopleurus:

The genus *Ceolopleurus* was first recorded from the whole Mediterranean region by the present writer, from the uppermost limit of the Lower Coralline Limestone of Malta (Zammit-Maempel, 1969). It disappeared from the Mediterranean in Oligocene times (Mortensen, 1935) and now survives only at great depths (102-2419m) in the Indo-Pacific (Cottreau, 1914, p. 46). *Coelopleurus melitensis* Zammit-Maempel, however, must have lived at much lesser depths in the central Mediterranean as the Lower Coralline Limestone is a very shallow water deposit. Its Indo-Pacific affinity induced Dr. Stephenson of Keele University to search for similar affinities in other Maltese Tertiary echinoids. After examining the British Museum Nat. Hist. collections he concluded that a revision of the Cidaridae would also reveal a close Indo-Pacific affinity (Pers. comm. 8 May 1969). On learning that the present author was already working on this subject, Dr. Stephenson most courteously passed on to him (8 July, 1969) all the information he had obtained from the survey of Maltese echinoids in the Brit.Mus. (N.H.) collection.

Cidaridae: *Phyllacanthus, Prionocidaris*.

Six species of Cidaridae, pertaining to three genera, have been recorded from the Maltese Tertiary to date:

Cidaris adamsi Wright, *Cidaris melitensis* Wr., *Cidaris scillae* Wr., *Cidaris oligocenus* Gregory, *Cidaris sismondai* Mayer and *Cidaris avenionensis* Desmoulins, all of which with the possible exception of *Cidaris melitensis* Wr. have an Indo-Pacific affinity.

Cidaris melitensis Wr. which is abundant in the middle division of the Upper Coralline Limestone of some localities, seems to be the only Atlantic element in

the Maltese group. It is a *Stylocidaris* closely resembling *Stylocidaris affinis* (Philippi), the present-day Mediterranean species which lives on rocky and coral bottoms around the Island at depths of 80-to 120m. The species occurs also in the Atlantic Ocean. Referring to the North Atlantic cidaroid fauna, Fell (1966, p. U312) records that it too "seems to be a late derivative of a small Caribbean nucleus of genera derived from the Indo-Pacific".

Stefanini (1908, p. 440) considered the Mediterranean *Stylocidaris* a *Dorocidaris* (a synonym of *Cidaris* s.s.) on account of the "pronounced depression of its medium suture", whilst Tortonese (1965, p. 307) regarded the fossil as a *Stylocidaris* and a possible ancestor of *Stylocidaris affinis* (Philippi).

Reviewing *Report* No. 125 of the Royal Society of London written by the scientists on board the "Porcupine" during its 1870 expedition to the Mediterranean, Dr. Giovanni Gulia (1870, p. 40) recorded that "*Cidaris hystrix* seemed to them (the scientists) very abundant and that from a series of specimens of this species it resulted that *Cidaris hysrix, C. pabillata* and *C. affinis* are specifically identical". It is now known however, that there are two species of *Cidaris* in the Mediterranean: *Stylocidaris affinis* (Philippi) and *Cidaris cidaris* and that these can be distinguished from each other on the basis of their pedicillariae. As such structures are not preserved, it is consequently very difficult to distinguish the two species in the fossil state. Even the large-sized species of *Cidaris* encountered at surface on the southern part of the Island marking the Lower Coralline Limestone — Globigerina Limestone transition zone is attributed to the genus *Stylocidaris*.

Cidaris adamsi Wr. and *Cidaris scillae* Wr. originally described by Wright in 1864 from the Lower Coralline Limestone and Globigerina Limestone respectively, must be assigned to *Phyllacanthus* on the basis of the oval shape of their scrobicular tubercles. This genus is now limited to "Australia (5 or 6 species), Indo-Pacific" (Fell, 1966, p. U330). Cottreau (1914, p. 45) was aware of their systematic position as early as 1913, for he grouped both these echinoids (*C. adamsi* and *C. scillae*) under the subgenus *Leiocidaris* Desor, 1855, which is actually a junior synonym of *Phyllacanthus* Brandt 1835.

Under the subgenus "*Leiocidaris* Desor 1855", Cottreau (1914, p. 45) included also *Cidaris sismondai* Mayer. This was a new record for the Maltese Tertiary but Cottreau did not describe or figure the Maltese specimen referred to in his text. The original *Cidaris sismondai* Mayer is now known to be definitely a *Prionocidaris* another genus presently limited to the Indo-Pacific, excluding New Zealand (Fell, 1966, p. U330). Its presence in the Maltese Miocene however, has not been confirmed.

On account of the poor preservation of all specimens ascribed to "*Cidaris oligocenus* Gregory 1891" and *Cidaris avenionensis* Desmoulins collected so far from the Maltese Tertiary sediments, there is much debate as to their correct subgeneric position. It is interesting to remember that the species *Cidaris oligocenus* was founded by Gregory on an interambulacrum with attached ambulacrum

(BMNH/E.3401) and on broken spines (BMNH/3409) (Gregory, 1891, pl. 1 fig. 2-4; p. 589). Its scrobicular tubercles reveal that the specimen is a *Phyllacanthus*. This identification has been confirmed by Dr. Stephenson of Keele University who has examined the BMNH type material and has most kindly passed his comments to the author (Pers. comm. 8/5/69 and 8/7/69).

Cidaris avenionensis Desmoulins seems to be a *Prionocidaris*. It was first recorded from the Maltese Miocene in 1891 by Gregory (pp. 587-588, pl. 1 fig. 1a-c). His identification was based on only "half one sector with a few spines" from the Globigerina Limestone (BMNH/ E. 1957), but stated that "there can be little doubt" as to the correct identification of the species. Cottreau (1914, p. 79) recorded the species as a *Cyathocidaris,* and included under the same designation of *Cyathocidaris avenionensis* Desm., the large, sometimes cyathiform, spines from the Lower Coralline Limestone which Gregory (1891, p. 589) had attributed to *Cidaris oligocenus*.

The worn test of *Cidaris avenionensis* Desm. which Cottreau figured with long tapering spines attached (1914, p. 80 fig. 90) has been located in the "University Collection" (which now forms part of the National Museum of Natural History, Mdina, Malta). The specimen is however, so badly weathered and fragmented that it is not possible to identify the characteristic features.

Clypeaster

The genus *Clypeaster* achieved worldwide distribution from Upper Eocene times onwards but is now limited to the Indo-Pacific and to the tropical Atlantic. It is found locally in great abundance where it displays two main stocks (*C. altus* and *C. marginatus*) with varieties related chiefly to variations in external morphology of the test and in the shape of the petals. It occurs at the upper limit of the Lower Coralline Limestone (Oligocene), in Nodule Layer 2 (NL.2) of the Globigerina Limestone, in the Greensand and in the Upper Coralline Limestone (Tortonian).

Echinoneus

In 1864 Wright described a new species of echinoid from the Upper Coralline Limestone of Malta and called it *Amblypygus melitensis*. In 1929 Brighton, who figured and redescribed the species, attributed it to the genus *Echinoneus*, a "lineal descendant of the Cretaceous genus *Pyrina*". He considered the Maltese Miocene species very close to the modern *Echinoneus cyclostomus*. The *Pyrina — Echinoneus* line was described by Brighton (1929, p. 94) as being "almost static in evolution", so that it is not surprising that a species which is practically identical with the modern form existed already in the Miocene. Its modern representative, *Echinoneus cyclostomus*, is an exceedingly variable shallow water form with an unusually wide destribution in the Indo-Pacific and in the western Atlantic Ocean, but is now completely absent from the Mediterranean. In their

survey of the Key Largo Coral Reef Preserve, Florida, Kier & Grant (1965, p. 5) saw only a few specimens of the species *Echinoneus cyclostomus* and *Brissus unicolor* although all other species of echinoids were abundantly represented by living individuals. Its habitat was found to be broken rock bottoms associated always with *Brissus unicolor* at depths varying from 3 to 12m. Dead tests were also found on sandy rock bottoms (p. 7) and among debris eroded from the reef offshore at depths of 7-13m. Mortensen (1948, p. 78) reported the species as clinging to the undersurfaces of rocks at depths of 116m, but these observations could not be confirmed by Kier & Grant (1965, p. 26).

In Malta the author has collected only one crushed specimen (GZM/E.71) from the rubbly nodular middle division of the Upper Coralline Limestone on the north-west coast of Malta, and here too (as in Florida) the species was associated with a *Brissus* — (*Brissus oblongus*).

Apatopygus and *Laganum*

Early in 1965 two specimens belonging to the genus *Apatopygus* (GZM/E. 105 and E.683) were collected by the present author from the fragmented zone of the *Scutella* bed at Ix-Xgħajra, limits of Zabbar, Malta. Another broken specimen (GZM/E.725 was recovered from the Lower Coralline Limestone of the same region about 3m below the giant *Lepidocyclina* zone. The exposure has since been covered up by the construction of a new coast road.

In a paper presented to the Echinoid Conference, Smithsonian Institution 6-8 September, 1972 (Abstract of Paper), Dr. Rose recorded the find of rare specimens of *Apatopygus* from Gozo (Malta) and Derna (Libya) stating that the genus ranged stratigraphically from Middle Eocene to Recent and geographically from the Mediterranean to Australia — New Zealand regions, far more widely than formerly accepted (Kier, 1966, U522). The paper was apparently never published. In another study on the stratigraphical and facies distribution of irregular echinoids in Miocene Limestones of Gozo (Malta) and Cyrenaica (Libya) presented at the V Congress of the Mediterranean Neogene at Lyon, Sept. 1971 and published in 1974, Rose again *listed* the rare presence of "*Apatopygus* sp.nov." in the *Scutella* bed of the Maltese Islands (p. 353) and in 1975 (p. 79) from "Il Mara or Xlendi member" of the Lower Coralline Limestone.

The presence of a *Laganum* specimen in the Maltese Tertiary is being recorded by the present writer in a paper awaiting publication (Zammit-Maempel, in press). This genus, which is known from the Miocene to Recent of the Indo-Pacific region (Wyatt-Durham, 1966, p. U472) is presently restricted to the shallow waters of the Indo-Pacific. It is new to the Maltese Islands, but Klein in 1734 (p. 31) and Leske in 1778 (p. 24-25, 87) had wrongly attributed to this genus the *Scutella* of Malta which Scilla (1670, Tav. VIII, fig. I, III) had figured in his *La vana speculazione*. The Maltese *Scutella*, which is now known to be *Scutella subrotunda* (Leske), was by Klein called *Laganum scillae*.

The echinoids and other fossils reviewed in this paper have a marked Indo-Pacific affinity and suggest a biostratigraphic link between European Tethys and the Indo-Pacific during Upper Oligocene and Miocene times. The survival of such a fauna in the Indo-Pacific regions is attributed to two main factors: the former open connection by way of Tethys with the Indo-Pacific, which allowed eastward migration of the central Mediterranean fauna, and climatic and other ecological conditions which prevailed in the central Mediterranean region during mid-Tertiary times being analogous to those which now prevail in the Indo-Pacific.

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