THE EARLY STAGES OF THE MALTESE PLEISTOCENE MAMMALIAN SEQUENCE
EVIDENCE FROM THE MAGHLAQ QUATERNARY DEPOSITS

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Introduction

Most works on the Maltese Pleistocene vertebrates have been either taxonomic studies (e.g. Bate 1935; Zammit Maempel & De Bruijn 1982) or purely descriptive (eg. Despott 1916, 1917, 1923; Zammit Maempel 1982). A holistic approach, whereby the deposits are viewed as a whole in order to establish a chronostratigraphy of the Pleistocene vertebrates of the Maltese Islands, has been conspicuous by its rarity, though a recent effort is that of Bonfiglio (1992). This preliminary study considers the mammal-bearing Pleistocene deposits of the Maghlaq region of the Maltese Islands and evaluates the evidence they contribute towards the establishment of the Maltese Pleistocene mammalian faunal succession. This is done against a background of the Sicilian mammalian stages.

Still extant quaternary sites in the Maghlaq area were visited and studied with special attention being made as to the presence or absence of vertebrate remains; for sites that have long since been destroyed, reliance had to be placed on the published descriptions, especially Adams (1870).

Geology

The Maltese stratigraphic succession consists of five marine formations - a basal Lower Coralline Limestone followed by the Globigerina Limestone, the Blue Clay, the Greensand and the Upper Coralline Limestone capping the sequence - which span a time interval from the Oligocene (Chattian) to the Miocene (Messinian) epochs. Pleistocene deposits are found as discontinuous veneers lying uncomfortably over rocks of the Tertiary succession, as well as fluvial deposits, beach-deposits, cave and fissure infills and several travertines (Pedley 1980; Pedley *et al.* 1976, 1978; Hunt 1997).

Tectonically, the Islands are riven by two systems of faults, each cutting across the entire succession: an older, extinct system oriented NE-SW which is crosscut by a younger NW-SE trending system active from the late Miocene to recent times (Reuther 1984; Pedley 1987). The most prominent fault of this latter system is the Maghlaq Fault lying off the western coast which has down-thrown the Upper Coralline to the south-west to at least 230 meters producing the south-western Lower Coralline sea-cliffs. In the Maghlaq region a preserved outlier of Upper Coralline forms a pediment (Paskoff 1985: 417, pl. 58-6) to the escarpment traced by the fault. Further geological and geomorphological details may be found in Alexander (1988), House *et al.* (1962), Illies (1981, 1982), Pedley (1987), Pedley *et al.* (1976, 1978), Reuther (1984), Reuther (1993), and Vossmerbaumer (1972). Quaternary reviews include those of Trechmann (1936) and Hunt (1997).

The Maghlaq Pleistocene Deposits

These deposits were described by A.L. Adams (1866, 1870), T.A.B. Spratt (1867), J.H. Cooke (1892), and C.T. Trechmann (1938).

The Maghlaq region, situated along the south-west coast of Malta **[Figure 1]**, held four major Pleistocene surface, cave and fissure deposits which were worked and described by T.A.B. Spratt and especially by A.L. Adams. The former gives a detailed account of the findings of a cave deposit (the "Crendi Cave", which Adams re-described as the "Malak Cave"). In addition the latter also thoroughly worked another cave and a fissure which he called the "Middle Cave" and the "Mnajdra Gap" respectively. These three deposits have since been destroyed. Both workers also described the deposits along the shore. Other descriptions were published by J.H. Cooke (1892: 122; 1896)

and C.T. Trechmann (1938: 6), who concentrated on the land-snails contained in the coastal deposit. In this paper the nomenclature as used by A.L. Adams (1870) is followed.

The Malak Cave

The infill, as described by Spratt and Adams, comprised a series of strata. The lowermost strata consisted of a well-cemented, poorly sorted conglomerate containing remains of large birds and of *Hippopotamus* sp. This extended outside the cave as a terrace deposit about twenty meters broad. A stalagmitic sheet containing abundant remains of glirids, fragments of bird bones and land-shells sealed the conglomerate. This was followed by a "*calcareous grey sinter and small bands of a dark brown loam*" (Adams 1870: 203,204, fig. 2) containing land-shells, birds bones, some of a large size, and a glirid. A superficial layer of dripstones terminated the sequence.

Among the finds made by Spratt was a small canine or incisor tooth of a carnivore the size of a fox, while Adams also notes his finding a similar tooth (Adams 1870: 204, 205). Adams also claimed to have discovered a solitary molar of a pygmy elephant. This molar was actually found by C.A. Wright, who in an annotation in his copy of Adams' book commented that the specimen had not originated from this site but from amongst the debris of the Mellieha Cave (Zammit Maempel 1989a: 192, fn 36). Adams, on the basis of the rounded pebbles and fragmented *Hippopotamus* bones, considered the lowermost level of the Malak Cave floor to have been deposited by running waters. This period was followed by a drier period which allowed the conglomerate to become sealed with a stalagmitic sheet and the overlying strata to accumulate. The fossils of this drier period were considered by Adams (1866, 1870) to have possibly been deposited by predators.

Mnajdra Gap

This was characterised by a lower series of sterile layers overlain by an upper series of fossiliferous beds making up a sequence of horizons, typically including rounded stones deposited by the action of flowing water. The fossil content of these upper layers was similar throughout and included chiropteran remains, *Leithia melitensis* (Adams), *Leithia cartei* (Adams), *Maltamys gollcheri* (De Bruijn), *Palaeoloxodon*[1] *falconeri* (Busk), *Palaeol. mnaidriensis* (Adams), *Geochelone robusta* (Adams) and several species of birds - *Grus grus, Grus melitensis, Cygnus falconeri, Cygnus equitum* as well as raptors and small birds. Land shells were abundant. It should be emphasized that **no** *Hippopotamus* fossils were found in this deposit.

The Middle Cave

This infill was in contrast to the previous ones comparatively rather poor in fossil remains. The mode of deposition of the entire sequence was assessed by Adams to have been that of a gradual accumulation of soil, derived from infiltration into the cave via fissures and from weathering of the cave walls and roof. Dripstones and flowstones were also present. The upper layer consisted of red earth devoid of fossil remains. The middle layers contained remains of glirids (? *Leithia melitensis*), fragments of *Anseres sp (? Cygnus sp.),* other smaller birds and an abundance of land shells. The lower layers contained only remains of *Arvicola pratensis* (=*Pitymys sp.*; cfr. Zammit Maempel 1989a), frog bones fragments of bird bones and those of fish. No megamammals were recorded for the entire deposit. There were also two well-abraded Miocene *Carcharocles megalodon (Agassiz)* teeth. It should be noted that its physical location precluded its being reached by flowing waters, hence its complete lack of high-energy beds (Adams 1866, 1870; Parker in Bate 1935).

Physical relationship of these deposits

It is very important that the topographic relationship between these three deposits be clearly established (Cooke 1892; Adams 1866, 1870). All three were intimately associated. The Middle Cave was some 3.5 metres below Mnajdra Gap and c.18 metres SE of the terrace-deposit continuous with the *Hippopotamus* conglomerate of the Malak Cave, which in

[1] We follow G. Haynes (1991: 8) and treat *Palaeoloxodon* as a full genus rather than as a sub-genus of *Elephas*.

turn was located some 60 metres ("*less than a stone's throw*") west of Mnajdra Gap, and so closer to Wied Maghlaq. Both caves opened on the same terraced cliff, either in the uppermost part of the free face of the escarpment or just above, since the Middle Cave was apparently easily accessible. Mnajdra Gap would thus have the three deposits are shown very close together indeed.

The Maghlaq Coastal Deposit

(Ossiferous Breccias of Adams 1870)
The earliest stratum is found as patches infilling solution hollows in the karstic surface of the downthrown Upper

MALTA	SICILY	AGE
Absent	Monte Pellegrino fauna	Late Pliocene/Early Pleistocene
Palaeoloxodon falconeri fauna	Palaeoloxodon falconeri fauna	early Middle Pleistocene
Hippopotamus sp. Fauna	Absent	middle Middle Pleistocene
Carnivora fauna	P. mnaidrensis/ H. pentlandi fauna	late Middle Pleistocene early Late Pleistocene

Table 1. Correlation of the earlier Pleistocene Siculo-Maltese faunas

Middle Cave	???	*Malak Cave*	Maghlaq Coastal Deposit	Mnajdra Gap
			Birds' bones and two ruminant teeth	
		Glirids	Unconformity	
Glirids		Hippopotamus	Unconformity	
Pitymys sp. &c.		Lower Coralline Bedrock	P. falconeri G. robusta	P. falconeri P. mnaidrensis &c
Lower Coralline Bedrock			Pre-elephant deposit	Sterile series
			Lower Coralline Bedrock	Lower Coralline Bedrock

Table 2. Correlations of the vertebrate-bearing horizons of the Maghlaq Pleistocene deposits

lain in the convex zone. Spratt's (1867) description of Mnajdra Gap is unreliable, and his estimates of distance an exaggeration. His sea-view sketch of the area, depicting these deposits as being widely separated, is quite inaccurate. On the other hand the sketch published by Adams (1870) is quite precise. Landmarks such as boulders, rubble walls and *tafoni* depicted by the artist can all still be readily identified today. In this sketch, all

Coralline Limestone. This deposit, not described by previous workers, is extremely indurated, and appears to be devoid of vertebrate remains. These patches are obviously the remnants of a much thicker and more extensive deposit which was almost completely eroded away before the overlying beds were laid down. A long period may be inferred between deposition of this and the earliest overlying beds, an inference further

supported by its induration which is much more advanced than that of any of the overlying beds.

This deposit is followed by a fluvial series some 3.9 metres thick, which infills the lower part of a shallow palaeochannel incised by Wied Maghlaq in the Upper Coralline bed. Each stratum of this series consists of very poorly sorted rounded (only Globigerina) and angular (the Corallines and Globigerina) pebbles, cobbles and boulders embedded in Terra Rossa. Several discrete lenses of Terra Rossa are also present. Adams (1870) describes finding *Palaeoloxodon* remains in this sequence assigning these in 1870 to *Palaeoloxodon falconeri* and in 1874 to *Palaeoloxodon mnaidriensis.* Only *Palaeoloxodon falconeri* has been confirmed. Cooke (1890) also records finding a *Geochelone robusta* bone. However it should be recorded that Cooke also reports finding remains of *Palaeoloxodon mnaidriensis* in a similar deposit to the west of Wied il-Merhliet (Cooke 1896: 206). We were unable to locate this deposit.

Resting unconformably on these beds is another series which completes the burial of the palaeochannel and also extends laterally on both sides. Vertebrate remains in this series are extremely scarce. Adams (1870) refers only to fragmentary bird bones and two teeth of a sheep/goat-sized ruminant (*?Cervus elaphus siciliae* Pöhlig). This latter sequence strongly resembles the Ras il-Wardija deposit in Gozo which has been described as being of an aeolian origin (Hunt 1997).

It should be noted that *both* the two deposit sequences, besides exhibiting features indicative of water flow (e.g. channelling and imbrication), also show evidence of drier periods (e.g. caliche horizons and root-casts).

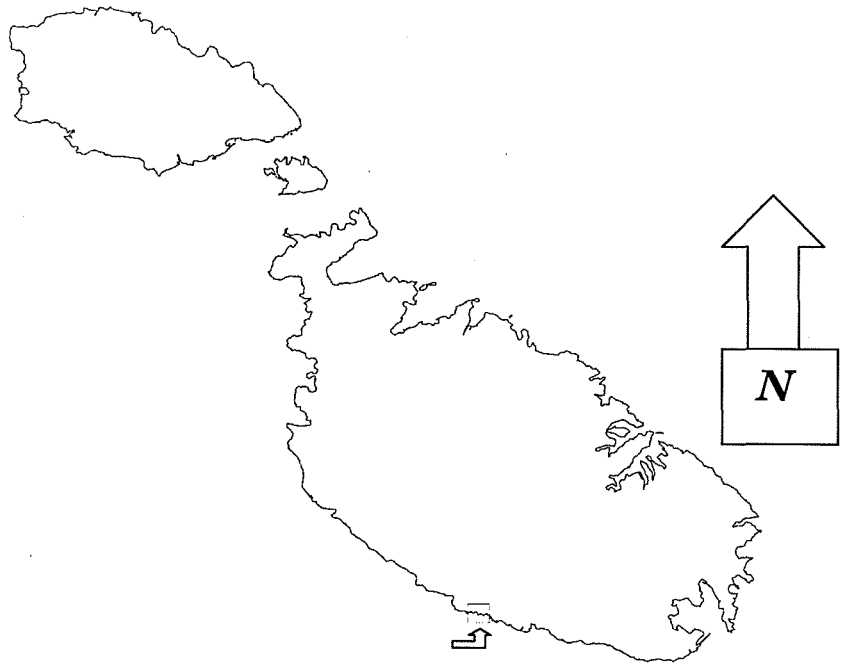
Discussion

The Pleistocene deposits in the Maghlaq region can be interpreted as representing three, possibly four, faunal stages. The earliest stage would be the ***Palaeoloxodon falconeri stage*** (cfr. Spratt 1867) represented by the beds of the Maghlaq Coastal Deposit and of Mnajdra Gap bearing *Palaeoloxodon falconeri* (Busk) and its associated fauna, which shows a high degree of endemism. On the basis of the very strong faunal similarities, this stage can with confidence be assigned to the Sicilian *Palaeoloxodon falconeri - Leithia melitensis* stage of the early Middle Pleistocene, which has been dated to about 500 Ka by amino acid racemisation (Bada *et al.* 1991).

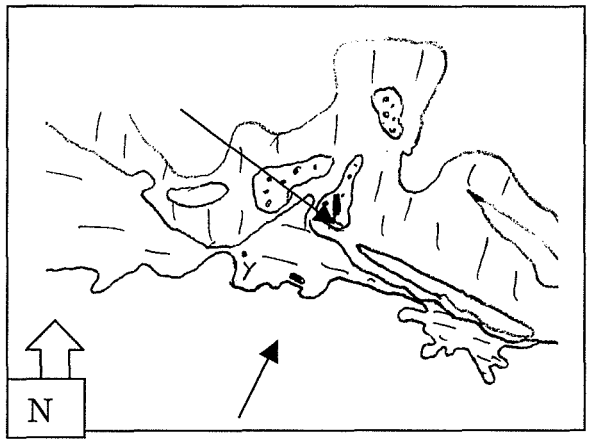
It has traditionally been held or implied - e.g. Adams (1870: 205, 208), Pedley (1976: 335), Northcote (1981-83: 6), Zammit Maempel (1989b) - that the *Hippopotamus* sp. and the *Palaeoloxodon falconeri* fauna were sympatric and merely occupied separate niches. However it is inconceivable that such an ecological separation should have been so sharp that it only allowed *Hippopotamus* to accumulate in the Maghlaq Cave, while the *Palaeoloxodon falconeri* fauna only accumulated in the Mnajdra Gap just a few metres away. The evidence presented by the Maghlaq Pleistocene deposits points towards a *temporal* rather than an ecological or depositional separation. A temporal separation suggests two distinct stages in the Pleistocene mammal sequence.

The second stage (cfr. Bonfiglio 1992) would thus be the *Hippopotamus*[2] stage represented by the basal conglomerate of the Maghlaq Cave and apparently characterised by the occurrence of *Hippopotamus sp.* as the dominant megamammal. The exact stratigraphic provenance of the two incisors / canines of small carnivores from the Maghlak Cave is unclear and the find of the solitary *Palaeoloxodon* molar is open to interpretation. In any case their occurrence in this stage would not alter materially this inference. This faunal stage may possibly represent the *Leithia cartei (= Eliomys sp.)* stage of G. Storch described from Ghar Dalam (Storch, 1974; Storch in Savona-Ventura & Mifsud 1998).

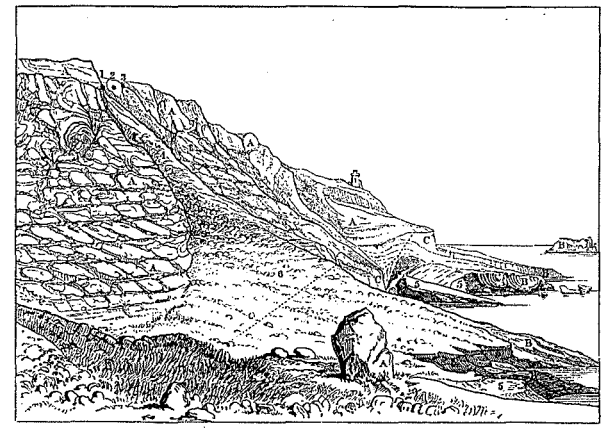
[2] *Hippopotamus pentlandi* Meyer and *Hippopotamus melitensis* Major are treated together.



A. The Maltese Islands showing the location of the Maghlaq Area



B. The Maghlaq area
Vertical hatching - Lower Coralline
Horizontal hatching - Upper Coralline
Dotted patches - Quarries
Unornamented patches - Globigerina
Upper arrow - Middle, Maghlaq Caves, Mnajdra Gap.
Lower arrow - Maghlaq Coastal Deposit.



C. Leith Adams 1870: 174. Looking eastward along the coast from point y in B.

Figure 1: The Maghlaq Region

The relationship between the *Palaeoloxodon falconeri* faunal stage and the *Hippopotamus* faunal stage cannot be determined on the evidence of the Maghlaq Pleistocene deposits. The presence of glirid remains above the *Hippopotamus*-containing layer in the Maghlaq Cave may suggest that the *Hippopotamus* stage preceded the *Palaeoloxodon falconeri* stage for this faunal stage. This observation contrasts with the evidence from Sicily. Absolute dating of fossil remains from Sicily confirms that the *Palaeoloxodon* stage preceded the *Hippopotamus pentlandi* stage (Bada *et al.* 1991). In addition, the evidence from Sicily suggests that glirids were associated with both the *Palaeoloxodon falconeri* faunal stage and also with the *Hippopotamus pentlandi* - *Palaeoloxodon mnaidriensis* faunal stage. Other Maltese Pleistocene deposits provide unequivocal evidence for the ***Hippopotamus faunal stage*** - a stage which is as yet unrecognised in Sicily, though it has been hesitatingly postulated (Caloi *et al.* 1986: 249).

In Sicily, *Hippopotamus pentlandi* and *Palaeoloxodon mnaidriensis* form an association characterising a continental European affinity fauna, containing carnivores as well as other herbivores. This association ranged from the late Middle Pleistocene to the early Late Pleistocene. This Sicilian *Hippopotamus* - *Palaeoloxodon* faunal stage has a Maltese equivalent - the ***Carnivora stage*** (= *Pitymys melitensis* stage of Storch, 1974) as described for Ghar Dalam (Savona-Ventura & Mifsud 1998).

Two *Hippopotamus* immigrations into the Maltese Islands are clearly indicated, with the proposed ***Hippopotamus - only faunal stage*** being the older. This was followed by the ***Hippopotamus - Palaeoloxodon faunal stage***. Absolute dating of Sicilian *Hippopotamus pentlandi* and *Palaeoloxodon mnaidriensis* molars has given ages of 200 Ka by amino-acid racemisation from various sites (Bada *et al.* 1991) and an ESR (Electron Spin Resonance) date of 88 Ka - 146.8 Ka for a series of molars of both taxa from Contrada Fusco, in Syracuse (Rhodes 1996).

A Maltese *Hippopotamus pentlandi* molar from Ghar Dalam - dated by ESR and Uranium Series Disequilibria (USD)[1] by Bouchez *et al.* (1988) has been variously reported in the literature as 110 Ka - 130 Ka (Reese 1996) and as 190 Ka (Bonfiglio 1992). A discussion of this date is beyond the scope of this paper but it is quite likely that this molar came from the Carnivora layer (Galea Bonavia *et al.*, in prep). In any case, it falls within the time range of the Sicilian *Hippopotamus pentlandi* - *Palaeoloxodon mnaidriensis* faunal association of the late Middle / early Late Pleistocene. The evidence indicates an earlier age for the ***Hippopotamus - only stage***, possibly the middle Middle Pleistocene.

A third faunal stage, the ***Glirid stage,*** is suggested by the glirid beds of the Malak and Middle Caves; however the correlation of these deposits to the rest are by no means clear. The taphonomy of these beds is different from those containing the *Hippopotamus* and *Palaeoloxodon falconeri* faunas which are clearly of a flowing water origin. Adams (1866, 1870) suggests that the Glirid beds represent the food remains of predators, the glirids being taken selectively from a more diverse fauna and carried to the caves for consumption (1866, 1870). The lack of diversity exhibited by these remains of presumed prey is curious but Adams only records glirids and unfortunately the site no longer exists. A major problem in the correlation of these beds is the lack of knowledge of the specific identity of the glirid/s involved and the absence of megamammals which can be ascribed to the caves either having never been reached (Middle Cave) or having ceased to be reached, by flowing water (Malak Cave).

Certainly the stratigraphic location of the micromammal bed of the Malak Cave argues for a younger age for the glirid layer than the ***Hippopotamus - only stage.*** Its age can possibly be referred to that of the Wied Incita fissure where two glirids *Leithia aff. melitensis* and *Maltamys wiedincitensis* (Zammit Maempel & de Bruijn 1982) were present.

[1] It was not possible to obtain a copy of the original paper.

Both these glirids, as well as several elements of their associated fauna namely *Lacerta siculimelitensis* Bohme and Zammit Maempel, and *Ursus cf. arctos* L., have been found in an assemblage that included both *Hippopotamus pentlandi* and *Palaeoloxodon mnaidriensis* at Contrada Fusco and which was, as already mentioned, E.S.R-dated to 88 Ka - 146.8 Ka (Rhodes 1996), and which thus refers to a late phase of this stage.

Much more problematic to date are the micromammal layers of the Middle Cave since the lack of any of the megamammals does not provide any reasonable indication as to age. These beds can just as easily be assigned to any of the earlier or later stages, even though the glirid species from this cave has been identified as *Leithia melitensis* (see below).

The two teeth of a sheep or goat-sized ruminant (*?Cervus elaphus siciliae* Pöhlig) from the upper sequence of the Maghlaq Coastal Deposit point towards a fourth faunal stage, but the evidence of just two vaguely identified teeth is far too sparse to allow any firm conclusions to be drawn.

These deposits also highlight several problems relating to the mammalian faunal succession e.g. the clarification of the stratigraphic relationship between the two *Hippopotamus* spp., with its phylogenetic, palaeogeographical and other implications, which must be addressed before a reasonably accurate sequence can be worked out. Furthermore, a thorough revision of the Siculo-Maltese *Gliridae* is absolutely essential as this would define the mammalian stages involved more precisely and with a finer resolution (Kotsakis 1995).

Summary

Thus the Maghlaq deposits afford reliable evidence for the early part of the sequence of the mammalian faunal stages which may be summarised thus: the **first** stage (early Middle Pleistocene) is represented by the *Palaeoloxodon falconeri* fauna and corresponds to the Sicilian stage represented by a practically identical fauna; the **second** stage (? middle Middle Pleistocene) is represented by the *Hippopotamus* sp. only fauna which, to date, has no described Sicilian equivalent; the **third** stage is represented by the glirid beds which may possibly be referred to a late phase of the **Carnivora** stage of Ghar Dalam, which is equivalent to the Sicilian stage represented by the *Palaeoloxodon mnaidriensis* / *Hippopotamus pentlandi* fauna of the late Middle-early Late Pleistocene) ; a **fourth** stage may be represented by the two ruminant teeth but, in the absence of further details, no secure inferences may be made.

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References

Adams, A.L. 1866. Maltese caves. Report on Mnaidra Cave. *Report of the British Association for the Advancement of Science* 1865: 257-263.

Adams, A.L. 1870. *Notes of a naturalist in the Nile Valley and Malta.* Edinburgh: Edmonston & Douglas.

Adams, A.L. 1874. On the dentition and osteology of the Maltese fossil elephants, being a description of the remains discovered by the author. *Transactions of the Zoological Society of London* 9: 1-124 + plates 1-22.

Alexander, D. 1988. A review of the physical geography of Malta and its significance for tectonic geomorphology. *Quaternary Science Reviews* 7: 41-53.

Bada, J.L., Belluomini, G., Bonfiglio, L., Branca, M., Burgio, E. and Delitala, D. 1991. Isoleucine epimerization ages of Quaternary mammals from Sicily. *Il Quaternario* 4 (1a): 49-54.

Bate, D. M. A. 1935. Two new mammals from the Pleistocene of Malta, with notes on the associated fauna. *Proceedings of the Zoological Society of London* 2: 247-264.

Bonfiglio, L. 1992. Middle and Upper Pleistocene mammal faunas in the islands of Sicily and Malta: analogies and palaeogeographic implications. *INQUA-MBSS Newsletter* 14: 52-56. [International Union for Quaternary Research – Subcommission on Mediterranean and Black Sea Shorelines].

Bouchez, R., Condomines, M., Faure, M., Guerin, C., Jeunet, A., Ma, J.L., Piboule, M., Poupeau, G., Rossi, A.M. and Sarcia, M.N.G. 1988. Radiometric dating of Hippopotamus pentlandi from the Ghar Dalam cave, Malta. *Proceedings: International Conference 'Early*

man in island environments' September 25 – October 2, 1988, Oliena, Sardinia, p.4.

Caloi, L., Kotsakis, T. and Palombo, M.R. 1986. La fauna a vertebrati terrestri del Pleistocene delle isole del Mediterraneo. *Geologica Romana* 25: 235-256.

Cooke, J.H. 1890. Notes on the reptiles of the Maltese Islands. *Il Naturalista Maltese* 1(2): 18-20.

Cooke, J.H. 1892. Observations on the Geology of the Maltese Islands: Part VII. *The Mediterranean Naturalist* 1(9): 120-133.

Cooke, J.H. 1896. Notes on the 'Pleistocene Beds' of the Maltese Islands. *Geological Magazine* (IV) 3: 201-210.

Despott, G. 1917. Excavations conducted at Ghar Dalam (Malta) in July, 1916. *Report of the Meeting of the British Association for the Advancement of Science* 86: 294-302.

Despott, G. 1918. Excavations conducted at Ghar Dalam (Malta) in the summer of 1917. *Journal of the Royal Anthropological Institute* 48: 214-221 + plates 17-19.

Despott, G. 1923. Excavations at Ghar Dalam (Dalam Cave), Malta. *Journal of the Royal Anthropological Institute* 53: 18-35 + plates 1-4.

Haynes, G. 1991. *Mammoths, mastodonts and elephants. Biology, Behaviour and the Fossil Record.* Cambridge University Press.

House, M.R., Dunham, K.C. and Wigglesworth, J.C. 1961. Geology and structure of the Maltese Islands. In Bowen Jones, H., Dewdney, J.C. and Fisher, W.B. (eds.) *Malta, a background for development.* pp.25-47. Durham: University Press.

Hunt, C.O. 1997. Quaternary deposits in the Maltese Islands: a microcosm of environmental change in Mediterranean islands. *GeoJournal* 41(2): 101-109.

Kotsakis, T. 1996. Anfibi e Rettili. In Basile, B. and Chilardi, S. (eds.), *Siracusa - Le ossa dei giganti,* pp.56-60. Siracusa: Arnaldo Lombardi.

Illies, J.H. 1980. Form and Formation of Graben Structures: the Maltese Islands. In Closs, H., Gehlen, K., Illies, J.H., Kuntz, E., Neunmann, J. and Seibold, E. (eds.) *Mobile Earth,* pp.160-184. Boppard: Boldt.

Illies, J.H. 1981. Graben Formation: the Maltese Islands - A Case History. *Tectonophysics* 73: 151-168.

Northcote, E.M. 1981-83. The giant Maltese swan. *Il-Merill* (Malta) 22: 6-8.

Paskoff, R.P. 1985. Malta In Bird, E.C.F. and Swarchz, M.L. (eds.) *The World's Coastline,* pp.431-437. New York: Van Nostrand Reinhold.

Pedley, H. M. 1980. The occurrence and sedimentology of a Pleistocene travertine in the Fiddien Valley, Malta. *Proceedings of the Geologists' Association* 91: 195-202.

Pedley, H.M. 1987. Controls on Cenozoic carbonate deposition in the Maltese Islands: review and reinterpretation. *Memorie della Societa Geologica Italiana* 38: 81-94.

Pedley, H.M. 1993. *Geological Map of the Maltese Islands.* Malta: Oil Exploration Directorate, Office of the Prime Minister.

Pedley, H.M., House, M.R. and Waugh, B. 1976. The Geology of Malta and Gozo. *Proceedings of the Geological Association* 87(3): 325-341.

Pedley, H.M., House, M.R. and Waugh, B. 1978. The Geology of the Pelagian Block: the Maltese Islands. In Nairn, A.E.M., Kanes, W.H. and Stehli, F.G. (eds.) *The ocean basins and margins*: (vol 4b) *The western Mediterranean,* pp. 417-433. London: Plenum Press.

Reese, D.S. 1996. Cypriot Hippo Hunters No Myth. *Journal of Mediterranean Archaeology* 9(1): 107-112.

Rhodes, E.J. 1996. ESR dating of tooth enamel. In Basile, B. and Chilardi, S. (eds.) *Siracusa – Le ossa dei giganti.* pp.39-44. Syracuse: Arnaldo Lombardi.

Reuther, C.D. 1984. Tectonics of the Maltese Islands. *Centro* B:1 (1): 1-20.

Reuther, C.D. and Adam, J. 1993. Neotektonic, Faciesentwicklung und Fragen der Angewanten Geologie auf den Maltesischen Inseln. *Geologische Gelandeubung,* Institut fur Geologie und Palaontologie, Techniche Universitat Berlin, 1-15 September 1993.

Savona-Ventura, C. and Mifsud, A. 1998. Ghar Dalam Cave: a review of the sediments on the cave floor stratigraphy. *Xjenza* (Malta) 3 (1): 5-12.

Spratt, T.A.B. 1867. On the bone caves near Crendi, Zebbug and Melliha on the island of Malta. *Quarterly Journal of the Geological Society, London* 23: 283-297.

Storch, G. 1974. Quartäre Fledermaus-faunen von der Insel Malta. *Senckenbergiana Lethaea* 55: 407-434.

Trechmann, C. T. 1938 Quaternary conditions in Malta. *Geological Magazine* (IV) 75: 1-26.

Vossmerbaumer, H. 1972. Malta: ein Beitrag zur Geologie und Geomorphologie des Zentral Mediterranen raumes. *Wurtzburger Geographie Arbeiten* 8: 1-213.

Zammit Maempel, G. 1982. A Maltese Pleistocene sequence capped by volcanic tufa. *Atti della Societa Toscana di Scienze Naturali. Memorie,* serie B, XLII: 225-240.

Zammit Maempel, G. 1989a. *Pioneers of Maltese Geology.* Malta: Mid-Med Bank.

Zammit Maempel, G. 1989b. *Ghar Dalam cave and deposits.* Malta: Dr G. Zammit Maempel.

Zammit Maempel, G. and De Bruijn, H. 1982. The Plio/Pleistocene Gliridae from the Mediterranean Islands reconsidered. *Proceedings of the Koninklijke Nederlandse Akademie van Wetenschappen* B85: 113-128.