Abu Dhabi – 8 Million Years Ago

Late Miocene Fossils from the Western Region

Edited by Mark Beech and Peter Hellyer
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FOREWORD

In the arid landscape and climate that now characterise the United Arab Emirates, it is difficult to comprehend that once this country was a land of fertile plains, rather like today’s East African savannahs. The plains had large rivers flowing through them, with a wide variety of animals like elephants, horses, giraffes, gazelles, hyaenas, sabre-toothed cats, apes, ostrichs and other birds, on land and, in the rivers, hippopotami, crocodiles, turtles and large fish.

Yet six to eight million years ago, during the Late Miocene period, the Western Region of Abu Dhabi looked much like this.

The discovery of the fossil bones and landscapes that tell of this ancient past has been the result of nearly twenty years of painstaking scientific investigation, both by fossil experts (palaeontologists) from overseas institutions like the Natural History Museum in London and Yale University, in the United States, and by local bodies like the Abu Dhabi Islands Archaeological Survey, ADIAS, and the Department of Antiquities and Tourism in the Diwan of the Ruler’s Representative in Abu Dhabi’s Eastern Region.

This short book is designed to bring knowledge of those discoveries to a wider audience, and is published to coincide with the inauguration of a special exhibition of some of the larger and more dramatic fossil finds, like the tusk of an elephant that is over two and a half metres long discovered by ADIAS at Ruwais in 2002, as well as the elephant fossils discovered by the Natural History Museum team at Shuweihat in the 1990’s which included a skull, pair of jaws and leg bone.

It is our hope that, together, the book and the exhibition will introduce residents of the Emirates, in particular the younger generation, to this fascinating aspect of the country's past.

In times such as these, when the United Arab Emirates is developing at a breathtaking pace and is enjoying all of the benefits of modern technology and services, it is appropriate that we should take the time to remember the country’s past - for it is from there that we derive our roots, and from there that the environment of today has evolved. Without knowledge of our past heritage, both human and natural, we cannot fully appreciate the benefits of today, and those to come in the future.

Mohammed Bin Zayed Al Nahyan  
Crown Prince of Abu Dhabi  
Patron, Abu Dhabi Islands Archaeological Survey (ADIAS)
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CHAPTER 1

The Impact of Archaeology on the Paleontology of the Western Region of Abu Dhabi: the History of Palaeontological Research

Dr Walid Yasin Al Tikriti (Department of Antiquities and Tourism, Al Ain, UAE)

Introduction

Archaeological research in the United Arab Emirates is relatively recent, although it preceded by at least two decades the beginning of palaeontological research. The first archaeological work was initiated by a Danish team in 1959, and concentrated on the island of Umm an-Nar, adjacent to Abu Dhabi island, and in the Al Ain area of the Eastern Region of Abu Dhabi.

Further surveys were carried out by Iraqi teams between 1970 and 1975, mainly in coastal and inland areas of the Northern Emirates. A team from CNRS (Paris) has excavated at several sites in and around Al Ain since 1977, while a number of other foreign teams have worked throughout the Northern Emirates since the mid-1980s. Their work has been concentrated mainly along the western foothills of the Hajar Mountains and adjacent plains, the coastal zone between Dubai and Ra’s al-Khaimah, and in Fujairah, on the Gulf of Oman coast of the UAE.

If we exclude the reconnaissance by an Iraqi surveying team, headed by the late Mohamed Ali Mustafa, to Jebel Dhanna in 1971 (1) and the short exploration of the island of Dalma by another Iraqi archaeological team in 1975, the Western Region of the Emirate of Abu Dhabi remained terra incognita until March 1983 when the first survey was undertaken by the Department of Antiquities and Tourism in Al Ain. On behalf of the Department, a survey team of five archaeologists (five from Germany and two from Al Ain) surveyed parts of the coast of the Western Region (2).

The survey extended for around 150 km along the coast, but a lack of facilities and transport meant that the offshore islands were not visited. However, islands connected by causeway to the coast, like Thumayriyah, were visited. Sites ranging in date between the 3rd and the 1st millennium B.C and several Late Islamic sites were identified.

Before this survey, the Western Region had been considered to be peripheral to past occupation of the Emirate. The results of the 1983 work by the Al Ain Department of Antiquities team (3), however, not only indicated the importance of the area from an archaeological point of view, but also showed that it was of palaeontological importance (4). Apart from the archaeological sites located by the Al Ain team, a large and very interesting collection of fossilised bones of Miocene date was discovered. Among the bones were a lower mandible of a jaw belonging to a hippopotamus, large elephant bones, several bones that were at first unidentified and fossilised plants.

The discovery of the fossils was then announced locally (5). Further investigations were then undertaken by specialist palaeontologists, as described below.

Palaeontology

Following the discovery of the fossils by B. Vogt and his team, the present writer recognised their significance, and commenced a search to find specialists to study both the fossils themselves and the geological strata in which they were present. Initial contact was made with Dr. Hans-Peter Uerpmann, who was then studying the animal bones from Hili 8, a Bronze Age site in the Eastern Region of Abu Dhabi, and Uerpmann promised to assist in identifying an appropriate specialist.
While visiting New York, Uerpmann met Dr. Andrew Hill of Yale University and informed him of the discovery of the Abu Dhabi fossils. The latter, then involved in similar research in Kenya, expressed interest, and was invited to the UAE by the Department of Antiquities and Tourism in 1984. Hill and the writer examined the collection. Hill immediately recognised the importance of the fossils, being able to identify the presence of crocodiles, turtles, ostrich, bovids, *Hexaprotodon* and a gomphothere proboscidean. Fossil wood was also present.

Hill confirmed the initial identifications made by Vogt and his team but also recognised the presence of other species among the collection. Hill and Yasin then visited the areas where the collection had been made, to collect other material that had been left *in situ*. This included a mandible of a small *Hipparion* and some turtle bone. They also undertook further survey, and identified new fossil-bearing areas.

On his way back to the United States Hill discussed the discoveries with other paleontologists at the Natural History Museum in London and realised that Peter Whybrow, who was involved in similar work in Saudi Arabia and Qatar, had been to Jebel Barakah (a location west of Jebel Dhanna that had already yielded fossils) only two weeks before Hill and Yasin’s visit to the region. Hill also found that Whybrow had previously visited Jebel Barakah in 1979, and had found a proximal ulna of a bovid. In collaboration with the United Arab Emirates University, UAEU, Whybrow had also visited Jebel Barakah in 1981 and had discovered two equid teeth.

Although he had undertaken a considerable amount of research on the geology of eastern Arabia, Whybrow’s activities in the Western region of Abu Dhabi prior to the 1983 survey by Vogt and his team had been restricted to the Jebel Barakah area. In 1984, however, just before the Hill and Yasin visit, he and Peter Andrews, Professor of Geology at Cambridge University, had re-examined Jebel Barakah and a number of new areas, finding more fossils.

In 1986 Whybrow and M.A. Bassiouni (a professor of geology from Ain Shams and Qatar Universities) published a more comprehensive review of the Arabian Miocene, a result of the cooperation between Whybrow and the Emirates University. At around the same time, while the current writer was visiting Whybrow at the Natural History Museum in London, he was shown the specimens he had collected from the Western Region, in association with the Emirates University. Three years later, on 1st January 1989, a new and comprehensive phase of research on the palaeontology of the Western Region began under the aegis of the Al Ain Department of Antiquities and Tourism, and involving Hill, Whybrow and the present writer (Figs. 1-2). That day, Site JD-1, with eleven stone cairns of Third Millennium BC date, were visited by Hill and Yasin, while the next day, Sites JD-1, JD-2 and JD-3, which had yielded fossils when first examined in 1983, were visited, while a new fossil-bearing site, later called JD-5, was identified. A visit to the Hamra area found fossilised plant remains.

On 3rd January, the island of Shuwaihat, west of Jebel Dhanna, was visited, with a number of large fossils, including fossils of crocodiles and elephants, being located along the western foothills of its eastern ridge. Inspection of Jebel Tarboosh and other localities south of the main Abu Dhabi to Sila’a road failed to find any further fossils, although a poorly-preserved elephant tusk was found at Dubayah.

On 7th January 1989, Hill met Whybrow and Phil Crabb, (a photographer from the Natural History Museum) at Abu Dhabi Airport, and the next day, joined by Yasin, the team returned to Jebel Dhanna. More field work was undertaken, with collected specimens including a deinothere tooth fragment (Hamra 5) and a mandible of a mustelid, the first to be found in Arabia. The results of this short season were so promising that another season was arranged for December 1989 and January 1990, with the team being joined by Ernie Hailwood and Sally McBrearty. This lengthy season was also fruitful, with areas from Kihal in the east to Ra’s Ghumeis in the west being visited. One major find was a fossil of the first sabre-tooth cat yet to be found in Arabia and
another being a proboscidean skeleton on Shuwaihat. A well-preserved proboscidean tooth was found by the present author on Ra’s Dubay’ah (Fig. 3).

The discovery of this tooth coincided with a visit by former UAE President His Highness Sheikh Zayed bin Sultan Al Nahyan to Jebel Dhanna and Whybrow, Hill and the author were able to show the tooth to him on 1st January 1990, and to explain to him the significance of the finds and the evidence that an ancient river had once flowed through the area. The source of the river, which had not yet been determined, was discussed with the President at some length. In 1991, as a result of events in the Gulf region, only Whybrow visited, finding a *Hipparion* mandible (Fig. 4). The growing collection of specimens encouraged Whybrow to organise a small exhibition at the Natural History Museum in London, entitled “Hot Fossils from Abu Dhabi”, this being supported by the UAE Government.

Fieldwork then continued for several further seasons, with the sponsorship of the Abu Dhabi Company for Onshore Oil Operations, ADCO, whose general manager, Dr., Terry Adams, was himself a palaeontologist, and that of the Abu Dhabi National Oil Company, ADNOC. The proboscidean skeleton on Shuwaihat was excavated, and ADCO sponsored the production of a television documentary on the work entitled “Abu Dhabi – the Missing Link”.

Several academic papers were published by Whybrow, Hill and others on their research, while in 1995, ADCO and the UAE Ministry of Higher Education and Scientific Research sponsored a major conference on the Arabian Miocene at Jebel Dhanna, attended by around 30 scientists. The papers were later edited by Whybrow and Hill and were published as *Fossil Vertebrates of Arabia*, by Yale University Press, in 1999. By this time, the fieldwork undertaken by Whybrow, Hill and Yasin had come to an end.

However, in 1998, the Abu Dhabi Islands Archaeological Survey, ADIAS, identified further fossil sites in the coastal area during a survey for ADCO, and in subsequent years, further work has been undertaken by ADIAS. In 2002, during a survey for TAKREER, another member of the ADNOC Group, important fossils, including a complete elephant tusk and the lower mandibles of another elephant were identified by P. Hellyer, S. Aspinall and M. Beech, and were subsequently excavated. These are discussed further in Chapter 3. Further finds have also been made, while the area containing Late Miocene fossils has now been shown to extend as far east as Rumaitha, around 40 km, south-west of Abu Dhabi.

In accordance with an agreement between ADNOC and Abu Dhabi’s Environmental Research and Wildlife Development Agency, ERWDA, the fossil collections made by Whybrow and Hill during their ADCO-sponsored work have now been returned to Abu Dhabi, where they are curated and stored by ADIAS, in association with ERWDA. Discoveries continue in the field. The early phases of detailed work in 1989 and 1990, however, laid the groundwork for what was to follow – proving that the Late Miocene fossil vertebrate fauna of the Western region of Abu Dhabi was of international importance.

**Footnotes**

(1) Mohamed Ali Mustafa identified a group of graves later referred to as JD 1 by Vogt and others (see below). Mustafa was also shown a sulphur mine by ADCO officials and he attributed it to the presence of the Portuguese in the region (*pers. comm.*). It has been mistakenly mentioned elsewhere that Munir Taha was head of the team when the mine was shown to Mustafa although Taha, in fact, never visited Jebel Dhanna. The mine(s) were recently studied by the Abu Dhabi Islands Archaeological Survey, ADIAS, with a book being published, edited by G.R.D. King, *Sulphur, Camels and Gunpowder*, published by ADIAS and ADCO. P. Hellyer and G.R.D. King
however, mention in this book that “local people and oil industry personnel knew of the mines at least 25 years before the ADIAS team first identified the sites at Jebel Dhanna.”

(2) These short excavations were carried out at a late Islamic site. Although not published, the excavators partly uncovered a house built of some stone and gypsum with some potsherds and a limited amount of other material, including an incomplete glass goblet. Prior to this visit, Jabir Khalil, head of the Iraqi team, and Walid Yasin, then already a member of the Al Ain Department of Antiquities and Tourism, visited the island by helicopter in early 1975, but were able to spend only 40 minutes there, during which they identified some small stone cairns, of possible prehistoric date, and the structure later excavated by the Iraqi team.


(4) Since the early 1990s the Abu Dhabi Islands Archaeological Survey, ADIAS, has undertaken extensive surveys of the offshore islands, as well as along the coastline and further inland, identifying numerous sites, dating from the Fifth Millennium BC to the Late Islamic period. Several sites have subsequently been excavated. For more details see the following website: www.adias-uae.com

(5) The discovery was announced in the local media and a lecture was given by the author to the Emirates Natural History Group in Abu Dhabi a short time after the discovery.
Figure 1. Peter Whybrow and Walid Yasin Al-Tikriti holding an elephant scapula outside Al Ain Museum in 1989.

Figure 2. Peter Whybrow, Andrew Hill and Walid Yasin Al-Tikriti (from left to right) inspecting the crocodile skull at Shuwaihat in 1989.
Figure 3. Tooth, Lower third molar, from the primitive elephant species, Stegotetrabelodon syrticus, found at Ras Dubay’ah.

Figure 4. Jaw from the three-toed horse, Hipparion. Scale is a one dirham coin.
CHAPTER 2

Miocene Geology and Fossils of Abu Dhabi

Dr John R. Stewart (Biology Department, University College London, U.K.)

The Miocene

The Miocene Epoch lasted for nearly 20 million years, between 23.8 and 5.3 million years ago. This span of time was one when global temperatures were warmer than in the preceding epoch (the Oligocene) or the one which followed (the Pliocene). The Miocene was arguably the beginnings of our modern era, since many aspects of the global environment and its biota first appeared at this time, while the precursors of the ocean currents responsible for our climate system today were established. This was largely influenced by the fact that the continents had more or less assumed their present relative positions. For example, India had moved north, colliding with the rest of the Asian continent, thus forcing up the Himalayas. The initiation of such mountain ranges may have eventually helped cause a global climate cooling, leading to the Ice Ages.

Perhaps the most important development during this period was that of a new major terrestrial ecosystem, the grassland. The first appearance of such grasslands was probably caused in part by the higher temperatures which dried the continental interiors. This new ecosystem was particularly important in moulding the faunas discovered in Abu Dhabi in recent years. In fact, it can be argued that the existence of such grasslands was a prerequisite for the eventual evolution of an upright primate such as ourselves. Most of all, however, it saw the appearance of the first grass-eaters, such as horses, rhinos, camels, giraffe, cattle, deer, and antelopes, as well as a diversification of rodents and carnivores in the dog, cat, hyena and weasel families to take advantage of them.

Arabia, as part of the Eurasian continent, stood then, as now, at the crossroads of Africa and Eurasia, albeit for the first time. As a result, it was the region through which the sharing of animals between the two continents took place. At this time, even-toed hoofed mammals like pigs, deer, antelope and giraffe moved into Africa from Eurasia, while members of the elephant family and apes and old world monkeys spread in the opposite direction. By the time of the Late Miocene, the period covered by the fossils from Western Abu Dhabi, this exchange had been completed as seen by the inclusion of Stegotetrabelodon elephants and the old-world monkey that had originated in Africa.

The Geological Setting of the Fossils

The vertebrate fossils from Western Abu Dhabi all come from some fluvial sediments (sands and gravels) called the Baynunah Formation (Fig. 5). The deposits are the youngest in a series of Miocene sediments starting with a limestone formed under marine conditions (the Dam Formation) followed by a series of wind-blown sands and evaporitic sediments characteristic of a desert much like Abu Dhabi today (the Shuwaihat formation). Evaporitic sediments are ones partially produced by the evaporation of water leaving behind dissolved calcium carbonate and gypsum. Next, there was a much wetter phase with greater evidence for plants in the form of root casts and structures indicative of river deposition (the Baynunah Formation). These deposits contain the various animal fossil bones discovered by the Whybrow and Hill team in the 1980s and early 1990s, as well as those found during later fieldwork conducted by the Abu Dhabi Islands Archaeological Survey, ADIAS. Sites with Miocene fossil faunas are distributed in Abu Dhabi emirate from Jebel Barakah in the far west of Abu Dhabi to Rumaitha in the east (Fig. 6). Many of the animals confirm a riverine origin such as the freshwater mussels, crocodiles, turtles,
fish and hippopotami. The lusher environment supporting the other large herbivores is also indicated by soil formation seen in various sediment profiles. The rivers depositing the sands and gravels were evidently quite large with multiple channels covering a wide area, no doubt with vegetated sections between channels. One such fossil river bed near Mirfa has been estimated to have been over 100 metres wide.

The age of the Baynunah Formation has been estimated as 6 – 8 million years old, based in part on a technique called palaeomagnetic dating (Fig. 7). This uses the evidence in the rocks for the former magnetic field of the earth which has changed relative orientation through time due to factors including the movement of the continental landmasses by continental drift.

The Fossils

Plants

Plant are well represented in the Baynunah Formation but, since their fossils are mostly root casts, it is not possible to say in any detail what plants they belonged to. Acacia and palm have been tentatively identified on the basis of mineralised wood.

Invertebrates

The invertebrates found include molluscs, most of which are swan mussels, and small microscopic crustacea called ostracods. The swan mussels are freshwater bivalves and are relatively common, confirming the fluvial nature of the deposits from which they come. They also emphasise the greater amount of water available at the time. Two species were found that seem to indicate that they lived in flowing water, as their shape is relatively simple and flattened. The mussels lived partly buried in the riverbed, feeding on small particles of food carried by the water. The fossils found are either the shells themselves or moulds of the insides of the shells. The other mollusc that has been found is a mould of a small land snail that presumably lived on the banks of the river. The ostracods are small free-swimming shelled animals, allied to the shrimps and crabs, and are common components of a river fauna, although different species live in a variety of types of water, including the sea, today.

Fish

The presence of fish fossils are a further indication that the deposits of the Baynunah Formation were laid down by rivers. Three types of fish have been found so far, including two catfish (Clarias and Bagrus shuwaensis) and a member of the carp family, a barbel (Barbus). These are all freshwater fish and are often found in relatively gentle flowing rivers.

Reptiles

Crocodiles, tortoises and turtles are all found in the Miocene of Abu Dhabi. Of these, the crocodiles consist of both the true crocodiles (Crocodylus) as well as the more slender-jawed gharial crocodiles (Gavialis). The latter are rarer in the Baynunah Formation and feed almost exclusively on fish, and especially catfish, very common in these sediments. The shape of their rostrum (jaws) allows for greater speed in the water when pursuing fish. The more robust jaws of the true crocodiles allow them to hunt a broader range of prey, including terrestrial mammals with a degree of defensive abilities and strength. The existence of these two types of crocodiles is slightly unusual and may imply that they occupied different habitats or a kind of territorial behaviour not seen today. The most common fossils found of these creatures are isolated teeth and bony scutes from their skin, although mandible and skull fragments have also been found (Fig. 8).
The terrestrial tortoises and freshwater turtles are generally found as fragments of their bony shells or carapaces. The tortoise is a large species (Geochelone) which is herbivorous but can withstand very arid conditions. Included among the turtles are Trionyx which is a good swimmer and is generally found living in wide open rivers and lakes. Mauremys, on the other hand, is a turtle that prefers more ephemeral habitats including muddy waters and is not a very competent swimmer. Both the turtles are principally carnivorous

**Birds**

The presence of large numbers of eggshell fragments of an extinct member of the ostrich family signifies that bird fossils are relatively common. However, only three confirmed fossil bird bones have been found from the Miocene of Abu Dhabi, two of which were found during the Whybrow and Hill field work and another from the more recent work of ADIAS. The only bird identified from the earlier excavations was that of an egret (Egretta), possibly the great white egret, which is still a winter visitor to the Emirates today. The other bird identified is a darter or snakebird (Anhinga) found today in most relatively warm parts of the world (Central and South America, India, Africa and Australasia). It is also present in the marshes of southern Iraq. Both these birds are associated with water and eat fish.

**Mammals**

Mammals are the best represented group of vertebrates in the Baynunah Formation. A very obvious feature of this mammalian fauna is that it is disproportionately made up of large megafaunal elements. Mammals with a body mass lower than 40 Kg are almost absent. This is undoubtedly due in part to the methods used by both the Whybrow/Hill team and by ADIAS to recover the fauna, which was mostly surface collecting. The greater mechanical strength of the bones of larger mammals also probably played a role. The elephant family was mostly represented by Stegotetrabelodon syrticus, known predominantly from Africa. They had tusks in both upper and lower jaws. Those of the upper jaws were larger and measured up to 2.5 metres in length while those in the lower jaws were less than two thirds of that length. Stegotetrabelodon is the best known elephant from Abu Dhabi with finds of an incomplete skeleton found at Shuwaihat (Fig. 9). This skeleton is made up of a skull, lower jaw, many parts of the vertebral column, ribs and elements of both the forelimbs and hindlimbs. The smallest bones, such as those of the feet, were missing. Other finds include a lower jaw without teeth and various isolated teeth. The ADIAS excavations at Ruwais have yielded further remains of this elephant including two tusks 2.54 and 1.94 metres in length respectively, an almost complete pair of mandibles, a fragmentary mandible with an unerupted tooth seen in the jaw and some ribs. These finds are described in more detail in the following chapter.

The other elephants found, albeit in smaller numbers, were a type of Mastodon and a Deinothere. The Mastodon were a primitive group of elephants with lower crowned teeth adapted to browsing. The Deinothere on the other hand were a group of elephants that lacked upper tusks although possessed lower ones and instead of having a trunk like a modern elephant they had a large overhanging muscular structure similar to tapirs.

The odd-toed ungulates include two Hipparion species (one now named Hipparion abudhabiensis) and a rhinoceros. The Hipparions were three-toed horses of the last few million years, the immediate precursors to the modern true horses in the genus Equus (Fig. 10). The two Hipparion species differed in size. The most common, Hipparion abudhabiensis, was a small to medium sized horse, probably a grazer, with a wide muzzle, while the rarer type (an unnamed Hipparion species) was larger. The rhinoceros is known from sparse remains and none have been identified to species.
The largest group of mammals is the even-toed ungulates. These include the pigs, hippopotami, cattle, antelopes, gazelle and giraffe. The pigs belonged to two types and confirm the connections with both Africa and Asia. One type *Propotamochoerus* is of Asian affinity and occurs in the Siwaliks, a pushed together Tertiary sediment succession at the southern edge of the Himalayas, located within the political boundaries of Pakistan, India, Nepal, and Bhutan, while the other *Nyanzachoereus* is restricted to Africa. The hippopotamus in the Baynunah Formation is *Hexaprotodon*, a smaller animal than the common African hippopotamus *Hippopotamus amphibius* which was formerly found as far afield as northern Europe. Two well-preserved jaws were found during the Whybrow and Hill field work, one of which belonged to an immature individual with only partially-erupted permanent teeth. The giraffes from the Abu Dhabi Miocene include possible *Palaeotragus* and *Bramatherium* as well as unidentified giraffe-like bones. The two identified giraffes are *Sivatheres*, short-necked giraffes, which are well-known browsers in the late Miocene. The other even-toed ungulates are in the bovid family and include the cattle, antelope and gazelle. These include *Tragoportax cyrenaicus*, represented by a partial skull with the twisted horn cores preserved, and *Pachyportax latidens* another type of cattle. Spiral-horned antelopes are represented by *Prostrepsiceros* and the gazelle (*Gazella*), known only from poorly preserved material. The ruminants as a whole seem to suggest that the environment in the late Miocene was parkland that was unlikely to be very dry.

A single canine of a male monkey is the only evidence of old-world monkeys yet found in the Arabian Peninsula.

Remarkably a number of small mammals, rodents and an insectivores were found. These included the teeth of a new gerbil named *Abudhabia baynunensis*, a cane rat, a jerboa, an old world rat and an undetermined shrew. These were only found because of a sieving programme undertaken on gravel deposits from Shuwaihat in 1995. The biogeographic affinities of the small mammal fauna is a mixture of African and Asian on the basis of other Miocene finds of the animals. The Red Sea seems not to have formed a barrier to dispersal during the Miocene, as it does today.

Finally, there were also rare examples of carnivore fossils. These include a sabre-toothed cat (*Machairodon*), a couple of hyenas and a member of the weasel and badger family (*Plesiogulo*), ancestral to the today’s wolverine or glutton of more northern latitudes.

**Description of the Miocene Environment of Abu Dhabi**

Let us try to breath life into the 6 – 8 million year old geology and fossils from Abu Dhabi. Imagine a scene very much like the savannah grasslands of East Africa today. A broad river flows through this plain dotted with acacia trees (Fig. 11). In the river’s depths, catfish go about their business ploughing up the bottom in search of freshwater mussels, while further up the water column a shoal of young barbel glide by. Suddenly there’s a flash and the fish speed up and dart down stream as a snake bird, its neck outstretched, shoots through the water chasing them.

Further upstream in some muddy dead water beyond a wide bend, two young hippo cows are keeping cool during the midday sun whilst a number of large two metre long crocodiles bask on the bank. Nearby an egret wades in the shallows, eyes alert for fry.

There’s a sound coming from beyond the bushes a little further away. The egret takes flight and a herd of enormous beasts slowly appear, pushing their way through the undergrowth. These are *Stegotetrabelodon*, elephants with two sets of tusks, one set in their upper jaw and another shorter set in the lower. The matriarch leads the way to the water's edge causing the hippos to startle, half swimming, half running for a few metres. One of the crocodiles splashes into the water and disappears. The large female starts to probe into the water to help herself with her
trunk. Four others have followed her to the river. None had successfully reared young this year, so they have nothing to fear from the sabre-toothed-cat whose scent they had picked up from some scats by a nearby bush. An adult male cat had quenched his thirst there at day break.

Midstream was a small vegetated island surrounded by gravel bars against one of which the carcass of a *Stegotetrabelodon* had become mired. An adult male had succumbed to hunger some weeks earlier when summer was at its height, and had fallen into the river, being washed down to the shores of the island. Little remained of the animal’s flesh and its bones were being dispersed in an orderly fashion by the currents.

On the opposite bank, a few hundred yards away, some gazelle are drinking with a large antelope effectively keeping watch. A group of baboons who had just finished playing were sitting under a tree grooming each other.

Further out on the savannah, a large herd of some thirty or so horses were grazing. These were *Hipparion*, three-toed horses but like the horses of today in every other way. Some shrubs were being browsed by an ancient relative of the giraffe. Almost a giraffe but not quite, shorter and less ungainly. Two stoic buffaloes come into view. Unlike the elephants, they can be felled by the top predator of the day, the sabre-tooth cat, but show no sign of appearing worried.

A kilometre away, a female hyaena has brought the head of an antelope back to the lair where an excited group of youngsters come bounding out. They attempt to tear the dried flesh from the dessicated skull with little help from their mother. The exercise becomes a game rather than a serious attempt at feeding. One of the pups has noticed a large tortoise a little way off and, followed by two others, goes to investigate. They soon lose interest when they find the animal does not respond and simply plods on. Not very far away, a family of hogs are rooting around in an old waterhole left from recent rains and gradually drying up and becoming a dustbath. An abandoned nest of an ostrich-like bird excavated into a rise of ground lay beyond the waterhole. The area was covered in fragments of eggshell.

The sun is starting to cast long shadows as the evening draws nearer. The sun, whose relative position to the earth will some day change all this, is today sustaining it. The climate of the earth is driven by the sun and, depending on the configuration of this spinning and orbiting heavenly body around the sun, the climate will differ. The scene is familiar, and yet none of the animals and possibly few plants are truly modern. The savannah of Western Abu Dhabi and these organisms were all destined for extinction to be replaced by the desert dunes and *sabkhas* now found in Arabia and the wildlife that lives here. However, their descendants can still be seen living and dying in the great savannahs of today’s East Africa.
Figure 5. Cliff section at Jebel Barakah, with Peter Whybrow.

Figure 6. Map showing the location of fossil sites in the western region of Abu Dhabi.
Figure 7. Ernie Hailwood drilling at Jebel Barakah in 1990 taking palaeomagnetic dating samples. Peter Whybrow observing.
Figure 8. Crocodile (*Ikanogavialis*) jaw from Shuwaihat (Site S1, no.56).
Figure 9. Plan of the elephant excavation at Shuwayhat. Stippled area indicates carbonate gravel spread (after Whybrow and Hill 1999, Fig.24.8).
Figure 10. A saber-toothed cat tries to sink its teeth into the primitive 3-toed horse, *Hipparion*.

Figure 11. Abu Dhabi 8 million years ago – reconstruction painting by Gemma Goodall.
CHAPTER 3

The Late Miocene fossil site at Ruwais

Dr Mark Beech (ADIAS, Abu Dhabi, U.A.E.)

How do we find fossils?

"First experience helps. The cliché that the best palaeontologist is, amongst other things, the one who has seen the most fossils is true. Second, a knowledge of zoology helps a great deal because we are looking for shapes that are not minerals, not sedimentary structures nor weathered pebbles, but skeletal remains. A vertebra or rib just poking out of the rock has, to us, a recognisable form. Sometimes we are totally wrong. Field identifications, especially of bone fragments, can be suspect because comparative material is unavailable, and the bone is either attributed to the wrong animal or to the wrong part of the body. Finally, there is the search itself. A colleague once said that a search for fossils appears to consist of a lot of aimless wandering. We note the types of rocks exposed and try to imagine what the environment was like millions of years ago. In fact, clues are being looked for: this clay layer is no good for large fossils as it was deposited in very calm waters; this coarse-grained, bedded sandstone is no good as it seems to be river bed deposit. But here is a pocket of fine-grained sandstone that may have been a bar in a meander of the river. So, below where this sediment was exposed, we start to crawl up the slope with our eyes about 10 centimetres from the ground – not much fun in a high wind. Soon, recognisable shapes appear – tiny fish teeth, pieces of crocodile bone and complete rodent teeth all winnowed out of a fossil-bearing layer by recent erosion. After finding this layer, we must find how far it extends and, invariably because the sediments are river-channel deposits, it peters out into seemingly barren sandstones."


How did we find the fossil site at Ruwais?

In April 2002 a team from the Abu Dhabi Islands Archaeological Survey (ADIAS) was commissioned by TAKREER, the Abu Dhabi Oil Refining Company, (part of the Abu Dhabi National Oil Company, ADNOC, group of companies, to undertake an Environmental Impact Assessment of an area close to Ruwais where the BeAAT Central Environment Protection Facilities are to be built. The team comprised Peter Hellyer (Executive Director of ADIAS), Simon Aspinall (Director of ADIAS Environmental Studies) and Dan Hull (Archaeologist). The area to be surveyed lay just immediately south of the Tarif to Sila’a highway and east of the Ghiyathi junction.

The initial survey demonstrated that this was an area of very considerable palaeontological significance. An extensive spread of fossils was noted on the lower slopes of the barqat to the east of the area and on the slopes of areas of raised relief to the north-west of the area as well as in the core zone destined for the first phase of the TAKREER development (Fig. 12). A total of 19 fossil sites (RUW0001 – RUW0019) were recorded.

Following the initial visit to the site in April 2002, a further brief visit in June 2002 was undertaken by Simon Aspinall and Dr. Mark Beech (ADIAS Senior Resident Archaeologist). An inspection of previously-identified sites was undertaken and a strategy for further survey work and excavation was discussed and planned.
Following the obtaining from TAKREER of further information on plans for the area, the second phase of the survey took place in October 2002. Three people took part in the survey, Simon Aspinall, Dr. Mark Beech and Ingrid Barcelo (Field Assistant). The survey began at the north-west corner of the proposed area being developed by TAKREER, near the sign marked “ADNOC Hazardous Waste Treatment Facility” (location: N 24.08189, E 52.75806). Transects were made by 4-wheel drive car across the initial area marked for development of the hazardous waste treatment plant. This was an area of 694 X 632 metres (0.44 square km). Regular stops were made to check all likely deposits for fossil remains. All three personnel then walked on foot around fossiliferous deposits collecting all visible fossil remains, with the exception of very small fragments which were unlikely to be identifiable to species. A further 19 fossil sites were discovered (RUW0020 – RUW0038).

The third phase of survey at the core zone of the TAKREER site took place in November 2002, once again with support from TAKREER. A number of rich fossil-bearing sites discovered during the October survey were re-visited to search for further fossil specimens for collection. Other areas not previously examined were also visited, inspection being undertaken by walking transects. An additional 22 fossil sites were discovered (RW39-60). This work was done by a team comprising Dr. Mark Beech, Peter Hellyer, Dr. Geoffrey King (Academic Director, ADIAS) and Ingrid Barcelo, with the help of volunteers from the Emirates Natural History Group, Abu Dhabi, as well as John Newby, Director, Terrestrial Environment Research Centre, TERC, of the Environmental Research and Wildlife Development Agency, ERWDA. During this particular weekend a fossil specimen of major international importance was discovered at the locality named RUW0044. This was an almost complete tusk of a Proboscid (elephant).

The fourth phase of fieldwork on the site took place in December 2002. This work involved preliminary conservation of and lifting of the elephant tusk in order to bring it back to the ADIAS/ERWDA storage facility near Maqta bridge in Abu Dhabi. The team for this work consisted of Dr. Mark Beech, Will Higgs (Honorary Research Fellow, Department of Archaeology, University of York, U.K.), Simon Aspinall and Sarah Wood (School of World Art and Museology, University of East Anglia, U.K.). A report on this, entitled ‘Fossils Research at Ruwais’, by Dr. Mark Beech and Peter Hellyer was then submitted to TAKREER.

The fifth and final phase of fieldwork on the site took place in March 2003. This work involved the excavation and removal of three remaining major clusters of fossil specimens, and their transportation to Abu Dhabi. This work was carried out by Dr. Mark Beech and Will Higgs.

**How do we know the age of the fossils?**

The fossils are deposited within the remains of a geological stratum which has been dated to the Late Miocene period, ca. 6-8 million year ago. Previous palaeontological studies have shown that the formation, which has the scientific name of the Baynunah formation, has the most significant assemblage of Late Miocene terrestrial vertebrate fauna anywhere in the Arabian peninsula (Whybrow and Hill 1999; cf. ADIAS Miocene fossil website: www.adias-uae.com/fossils).

The underlying Shuwaihat Formation is revealed by marine erosion at the base of many sea cliffs in the Western Region of Abu Dhabi. This was deposited about 13 million years ago when Abu Dhabi had a desert climate not unlike the present day – dunes, *sabkha* and very little rainfall. The overlying Baynunah formation was laid down at a time of improved climatic conditions. A river then eroded away most of the Shuwaihat Formation and deposited its sediments in numerous channels separated by low sandbanks. The river itself may have been an ancestral extension of the present day Tigris/Euphrates delta, or perhaps more likely, the eastern part of a Saudi
Arabian system that flowed north-eastwards along the area that now forms part of the Sabkhat Matti.

**How do we record fossil sites?**

The locations of all the fossil concentrations at Ruwais were recorded during the survey using a handheld GPS. Co-ordinates were taken using decimal degrees and minutes latitude and longitude, the datum being WGS84. The fossil site locations were then superimposed on a satellite image of the area (Fig. 13).

Where important clusters of fossils were discovered, we sometimes decide to undertake a proper excavation. First of all the edges of the trench are marked out. A map is made of the surrounding area to record the original contours of the ground surface. Excavation then slowly proceeds. The excavators squat or lie close to the ground and use hand trowels, small hand shovels and brushes to gradually remove the sediment from within the trench. All the removed sediment should be sieved, if possible, to recover the smallest fossil fragments. The excavator looks for subtle changes in the colour and consistency of the sediment that is being removed. Each different natural layer of sediment is given a different number, so any fossil finds lying within that particular sedimentary layer receive the same number, its context number. Whereas a fossil survey might be carried out in the course of a day, a few days or a few weeks, excavations can last for weeks, months or even years!

When fossils are discovered in particular layers, a plan is made of the precise location of all the specimens. Photographs are made with a signboard describing the site location, a north arrow and scale being placed next to the fossil specimen. Once this has been done, the fossil may be lifted. How this is done depends on the size and status of the fossil in question. Smaller well-preserved fossil fragments are generally simply picked up and placed into small sealable plastic bags, the relevant details being written on the outside of the bag, as well as on a label inside the bag. Larger, more fragile, fossil specimens may require special treatment. This was the case for some of the fossils from the Ruwais site (see below).

**What types of fossils did we find at Ruwais?**

Fossils collected at Ruwais included the remains of fossil wood (acacia), freshwater clams, catfish, turtle, crocodile, ostrich, hyena, elephant, horse, hippopotamus, pig and antelope (Fig.14). This is a very similar range of material to the earlier fossils discovered by the Natural History Museum and Yale University teams at other sites in the western region of Abu Dhabi.

The most spectacular fossils from the Ruwais site were several large bones from primitive elephants. These are described in more detail as follows:

**The big elephantid tusk – Site RUW0044**

This was discovered during the November 2002 visit to the Ruwais fossil site. It was an almost complete upper tusk from a primitive elephant species called *Stegotetrabelodon syrticus*. This is a type of primitive elephant which had four tusks, two longer upper quite straight tusks and two shorter lower parallel tusks. The Ruwais tusk measured 2.54 metres in length from its base to its tip (Fig.15). *Stegotetrabelodon* lived in Abu Dhabi around 6 to 8 million years ago. Other fossils from this species have been discovered at a number of sites in the western region of Abu Dhabi such as Shuwaihat and Jebel Barakah.

The Ruwais tusk was, in fact, not one complete tusk but thousands of fragile fragments, bound together by its surrounding sediment. It was necessary, therefore, to undertake some conservation treatment on the tusk before it could be fully excavated and removed from the site.
Nigel Larkin, a UK-based expert on the conservation of fossil specimens, acted as an advisor and provided detailed advice, including what methods and materials would be useful to employ, and sources for these materials (see Chapter 4).

The excavation team comprised Dr Mark Beech (ADIAS Senior Resident Archaeologist) and Will Higgs (who at that time was based at the Department of Archaeology, University of York, UK). The work was carried out between 16-18 December 2002.

The tusk was first consolidated in the field with Paraloid B72 in acetone. Paraloid B72 is a very stable methacrylate co-polymer which is used by museum conservators all around the world due to its stability and because it is easily reversed by applying acetone. It can be used with acetone as a consolidant, a sort of thin glue which can penetrate into permeable fossils and is therefore useful for fieldwork. It is generally used as a consolidant between 5 to 20% in acetone, weight to volume.

The specimen was covered in tissue paper and foil and then plaster of Paris was used to make a rigid covering and support for the tusk as it was excavated. However, the plaster hardened too rapidly in the desert conditions, and there were worries about the specimen ultimately being too heavy to move. Therefore, expanding polyurethane foam was used to make a lighter, but nevertheless rigid, jacket around the remaining areas of the specimen and the hardened sand matrix surrounding it (Fig.16). Some of the tusk (roughly the second quarter from the proximal end) unavoidably suffered collapse during this tricky stage of excavation, as the interior of the tusk was a sandy material which the consolidant had not reached.

The specimen and its encasing rigid jacket were underpinned by a specially-made and ingenious wooden and steel framework, to which the rigid field jacket was securely attached (Fig.17). The tusk, in its protective jacket, was removed from the desert on the wooden framework to the ADIAS laboratory and storage facility at Maqta, Abu Dhabi.

Despite the size and fragility of the specimen and the weakness of the surrounding sediment the excavation was a great success. Nigel Larkin, the UK-based conservator, who had provided us with initial advice, subsequently made two visits to the UAE in February and October 2003 to work on the conservation and preparation for display of the Ruwais fossils (see Chapter 4 for more details).

**Elephantid jaws – Site RUW0013**

Another important discovery at the Ruwais site was a pair of jaws from another elephantid. These were found at site RUW0013, located to the south of the area being developed for the Waste Disposal Plant (Fig.18). The fossil specimens here were found just below the present-day ground surface, buried in a loose sandy matrix. They were heavily encrusted with gypsum so it was difficult to see the surface details on the jaws. An important feature which was visible, however, was traces of the lower tusks *in situ* (Fig.19). The poor preservation conditions had unfortunately led to the destruction of the teeth, only small splinters and fragments being recovered from the surface layers around the specimen. Preliminary examination suggests that they belong to *Stegotetrabelodon syrticus*. They are very similar in appearance to the earlier specimens collected by Peter Whybrow’s team from Shuwaihat site S6 (Tassy 1999; Whybrow and Hill 1999).

**Elephant Hill – Excavations at Site RUW0048**

Site RUW0048 was discovered by ADIAS during the survey carried out in late November 2002. An old abandoned rusty bicycle lay on the surface of a mound adjacent to what appeared to be a
large scatter of elephant bones. Large fossil fragments were eroding out of the surface and sides of the mound. The site was originally given the nickname “Bicycle Hill”, although it was later to be renamed “Elephant Hill” after excavations were initiated and the first discoveries were made. A trench 9 x 7 metres was excavated at RUW0048. All fossils were excavated stratigraphically. Notes, photographs and, where necessary, samples, were taken during the excavation to ensure maximum retention of data about the position and sedimentary environment of each specimen. A series of unique specimen numbers were allocated to each major fossil, each large piece within the surface scatter, and to each group of small fragments closely associated with a fossil (Fig.20). Excavation normally proceeded in the following stages:

1. Location of a probable large fossil near the surface from the scatter of white fragments eroding on the surface.
2. Exposure of a small portion of the upper surface of the fossil by gentle brushing, followed by immediate consolidation of the exposed area. This normally allows tentative identification of the fossil and assessment of its quality and importance.
3. When a decision has been taken to excavate, the sediment layers are removed in stratigraphic order. Often it is necessary to clean an area around each fossil specimen to allow the excavator more room for working.
4. This operation leads to the fossil being exposed so that it eventually stands on a pedestal of sediment. The excavator then carefully exposes one side of the fossil, constantly consolidating exposed parts and supporting sediment until it is clear that the full depth of the bone has been exposed and partially undermined.
5. The fossil is then wrapped in conservation grade acid-free tissue paper, followed by aluminium foil, before a coating of gypsum plaster or expanding foam is applied to provide rigidity and protection. The same process is carried out along the other side to complete the protective coat before removal.

Miocene fossils in the Baynunah Formation of Abu Dhabi are nearly always extremely fragile, probably due to weathering and salt computerized on during their sojourn near the desert surface. Consequently, it is necessary to excavate them with great care, immediately consolidating any exposed pieces and also consolidating surrounding sediment attached to the fossil with acrylic resin solution (Paraloid B72) diluted in acetone. Subsequently this consolidant may be removed by reversing the process through the application of more acetone.

Site RUW0048 proved to be extremely interesting. A series of large fossil specimens were excavated from the site, the majority of which appeared to be from elephantids (Fig.21). A tusk which measured 1.94 metres from its base to tip was the most spectacular find (Fig.20, no.3 and Fig.22). The tip of this was extremely well preserved. Other parts of elephants uncovered included an incomplete cranium (no. 15-17, 29, 50-51), a fragment of mandible with associated tusk cast fragments including a cross-section (no. 5 and 36), the very fragmentary remains of two other tusks (no. 39 and 46), one large complete rib (no. 45) and four large rib fragments (no. 4, 27, 33 and 40). Of particular note was the stone cast of a freshwater bivalve (no. 52). This was located resting up against the NE end of an elephant rib fragment (no. 33). This cast appears to belong to a swan mussel (Unionidae) which can only live in running freshwater, providing evidence that the deposits here were laid down by river currents (Fig.23).

Site RUW0048 bears a striking resemblance to the situation revealed by the earlier excavations carried out by the British Natural History Museum team at Site S6 at Shuwaihat. The bones here too lay on a pea-gravel type surface and appeared to have been water-deposited. An elephant must have died nearby and then its skeleton became disarticulated and distributed down the river channel until it settled on a gravelly bank. Even the orientation of some of the fossils and composition of bones remaining from the elephant skeleton was similar.
Fossil Study

Once the fossils have been excavated, recorded and removed in the field, that is not the end of it. On the contrary, it is just the completion of the first stage of the work. The laborious task of then cataloguing all the fossil material in the form of a computerized database begins (Fig.24). A preliminary database of the more than 7000 fossil specimens from the Ruwais site was made in November 2003 by ADIAS associate, Dr John Stewart.

The real scientific study can then begin. Each fossil piece must be examined in detail, so it can be properly identified and recorded. All the fossils should be catalogued in full within a database with linked images to key specimens. The ultimate aim of the work should be to prepare a formal publication in the form of an article in a scientific journal dedicated to palaeontology. Secondly, a more popular publication should be prepared making good use of colour photographs and drawings for the general public, and thirdly, the overall results of the work could then be disseminated via the ADIAS website. This present book, exhibition and new information on the ADIAS website go some way towards achieving some of these aims.

Fossil Curation

What happens to the fossils once they have been studied? An important part of fossil research is the curation of material so that it is accessible for future study to the international scientific community.

In accordance with an agreement between ADNOC and Abu Dhabi’s Environmental Research and Wildlife Development Agency, ERWDA, the fossil collections made by Whybrow and Hill during their ADCO-sponsored work are now back in Abu Dhabi, where they are curated and stored by the Abu Dhabi Islands Archaeological Survey (ADIAS), in association with ERWDA. All of these fossils, as well as other material discovered by ADIAS, are sorted by zoological type and are housed in the ADIAS storage facility in Abu Dhabi (Fig.25).

Specialists wishing to study any material in the existing collections can obtain permission to do so by applying to the Abu Dhabi Islands Archaeological Survey (ADIAS), P.O. Box 45553, Abu Dhabi, United Arab Emirates, submitting a copy of any application to the Secretary-General, Environmental Research and Wildlife Development Agency (ERWDA), P.O. Box 45553, Abu Dhabi, United Arab Emirates.

The application should state clearly the purpose of their visit, which material they would like to examine, and what will be the outcome of the research, i.e. specifying where the results will be published. In almost all cases researchers will only be given permission to study the material within the ADIAS-ERWDA storage facilities in Abu Dhabi.

Fossil Display

Some of the most important fossils collected during this and previous work are now on public display in the exhibition “Abu Dhabi 8 million years ago – Fossils from the Western Region”. The exhibition, co-sponsored by TAKREER, ADCO, BP, ADIAS and ERWDA, is housed permanently in the foyer of the headquarters of the Environmental Research and Wildlife Development Agency (ERWDA) in Abu Dhabi. A more detailed description of the fossils on display is provided in Appendix 1.
The fossils on display only represent a small fraction of the total collection of fossils existing from the Western Region, although a much more comprehensive display of the geology, natural sciences, including palaeontology, and archaeology of the United Arab Emirates may be created in future.

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Initial cataloguing and quantification of the Ruwais fossil remains was undertaken by Dr. Mark Beech, with assistance from Ingrid Barcelo and Mohammed Hasan. A more comprehensive database was then made by Dr John Stewart.
Figure 12. Searching for fossils at Ruwais.

Figure 13. Map of the location of fossil sites at Ruwais. Red line marks the area of the Takreer development. Blue square indicates the core development area.
Figure 14. Types of Fossils represented at Ruwais.
Figure 15. Measuring the elephant tusk at site RUW0044, Ruwais, in November 2002.

Figure 16. Will Higgs prepares the Polyeurathane foam jacket around the tusk to help protect it.
Figure 17. Top: the elephant tusk is now sitting completely on its wooden and steel supporting frame and its polyurethane foam jacket is complete. Bottom: Takreer provides a crane and lorry to transport the tusk to Abu Dhabi.
Figure 18. Dr Mark Beech examines the elephant jaws prior to excavation at site RUW0013. Scale = 1 metre.

Figure 19. The elephant jaws at site RUW0013. Scale = 1 metre.
Figure 20. Plan of the fossils excavated at 'Elephant Hill', site RUW0048, Ruwais.
Figure 21. View of the excavations at ‘Elephant Hill’, site RUW0048, Ruwais. Note the four elephant ribs visible in the foreground.

Figure 22. The 1.94 metre long elephant tusk discovered at ‘Elephant Hill’, site RUW0048, Ruwais. From left to right: Sulaiman Daoud Al Siksek and Mohammed al-Yabhouni (TAKREER), Will Higgs (ADIAS).
Figure 23. Swan mussel (Unionidae) found at ‘Elephant Hill’, site RUW0048, Ruwais.

Figure 24. ADIAS Database of Late Miocene Fossils from the western region of Abu Dhabi.
Figure 25. Dr John Stewart examining fossil specimens in the ADIAS research laboratory, Abu Dhabi.
CHAPTER 4

Conservation of Late Miocene fossils from Abu Dhabi

Nigel Larkin

Fossils arrive on the conservator’s workbench via a multitude of pathways, both physical and chemical, through which they were first preserved, then changed to stone, and then exposed again at the surface. Some fossils are hard, almost indestructible pieces of sandstone or limestone, while others are soft and crumbly. Furthermore, any fossil or archaeological specimen may deteriorate in storage due to attack from water vapour, oxygen or other chemicals present in the immediate environment. The task of the conservator is to anticipate and prevent change from physical or chemical processes, stabilising the fossil for long-term storage.

The main problem with most of the Miocene fossils from Abu Dhabi is their extremely fragmentary state. The fossil may appear to be a complete bone or tusk, but upon closer inspection it can be seen to consist of hundreds of fragments still in their original positions, but liable to disintegrate at the slightest movement. The main cause of this shattering is almost certainly the cyclic deposition of salt crystals within the fossil, particularly during the time it spent near the desert surface, where rain and evaporation cause cycles of dissolution and recrystallisation.

I worked for a number of years in the Paleontology Department in the Natural History Museum in London. My job involved the conservation and preparation of fossil specimens for display, and during the 1990s, I was fortunate enough to have the opportunity to work on the important Late Miocene fossils collected from Abu Dhabi’s Western Region by the late Peter Whybrow, beginning my association with the palaeontology of the United Arab Emirates. This included work on the Proboscidian (early elephant) skull and jaws from the species Stegotetrabelodon syrticus which had been found at Shuweihat (see Appendix 1).

In February 2003 I was invited by the Abu Dhabi Islands Archaeological Survey (ADIAS) to work on a very fragile and friable six to eight million year old tusk found lying in loose sediment at Ruwais in the Western Region of Abu Dhabi. Over 2.5 metres long, this is the largest fossil ever to have been found in the Arabian peninsula. The very long, straight tusk belonged to the same early elephant, Stegotetrabelodon syrticus, I had worked on in London. Further remains were found nearby.

This tusk seems to have suffered damage (probably wind erosion and maybe some trampling) at some point during its history and, like most fossil material found in the deserts of the Emirates, was in an extremely fragmentary and fragile condition. It was, in fact, a tusk-shaped pile of hundreds of thousands of tiny shattered pieces of fossil ivory held in place by the weight of surrounding sand. Most pieces were small enough to have been blown away by a medium strength wind once exposed. It is a testament to the dedication and the ingenuity of the excavators that the tusk was recovered almost completely and in a recognisable form, chiefly by use of a permanent wooden frame designed by Kelly Brookes constructed around it in the field.

Conservation work began by removing the temporary polyurethane foam jacket put around it in the field (Fig.26), the fragile specimen then being consolidated with Paraloid B72, and some damage from the excavation process repaired. Some areas of the tusk needed modeling work to disguise repairs, and some hollow areas needed infilling to make the specimen more robust and less prone to further damage. A secure permanent support was needed under the whole length to hold the tusk and matrix in place when being moved, and this was made with a combination of plaster of Paris and Jesmonite resin (Fig.27a,b). This support was then painted with a mixture of
clean sand and glue to disguise it for display purposes. It is important to note that all the processes and materials used were fully reversible.

In October 2003 I returned again to Abu Dhabi to work on a number of other fossil specimens from the Ruwais site. These were all from the early elephant, *Stegotetrabelodon syrticus*.

There were three major specimens, one of which was a 1.94 m length of tusk from site RUW48. The tusk had been collected in the field in the same manner as the mandibles, having been consolidated with Paraloid B72 in acetone and jacketed with polyurethane foam. The upper portion of the field jacket was removed and excessive consolidated sand was removed very carefully with very small amounts of acetone. The whole tusk was a length of shattered splinters of tusk material, but with its overall morphological integrity intact. The tip in particular had a relatively good and recognisable surface area, and the mid-section seemed curiously contorted but nevertheless quite well preserved. This damage must have happened very early on in the burial process, it certainly wasn't recent or the whole specimen, particularly the surface of this damaged area, would have lost its morphological integrity.

The foam having been removed to expose half of the thickness of the tusk along its entire length, the tusk fragments were then consolidated with Paraloid B72 in acetone. Once this had set, a new, permanent, supporting jacket for the (temporarily) upper half of the tusk was made using Moistop barrier foil and 4mm thick Plastazote foam. Several layers of Jesmonite acrylic resin were applied to this covering, with accompanying quadraxial glass fibre matting. Strengthening splints made from 1.5m lengths of wood were attached to either side of the specimen to strengthen it, providing a new permanent supportive storage structure (Fig.28).

The other two specimens were a relatively complete mandible and a mandible fragment of *Stegotetrabelodon*. These specimens required removal of the top half of their polyurethane foam jackets, and consolidation of friable areas with Paraloid B72 in acetone. A new permanent support was made as described above, but without the strengthening splints, and once turned over, all the fossils were in their original orientation as found in the field.

**Glossary:**

*Paraloid B72* - a reversible methacrylate co-polymer

*Plastazote foam* - a white, chemically inert, archival standard, low density, closed-cell, cross-linked polyethylene foam
Figure 26. Removing the polyeurathane jacket from the elephant tusk.
Figure 27. Top: Nigel Larkin working on the conservation and preparation for display of the elephant tusk from site RUW0044, Ruwais. Bottom: Section through the tusk and platform to show the supporting plaster and jesmonite base.
Figure 28. Nigel Larkin working on the conservation of the elephant tusk from ‘Elephant Hill’, site RUW0048, Ruwais. Note the elephant jaws from site RUW0013 in the right foreground.
The Fossil Trackway at Mleisa

Will Higgs

In Abu Dhabi’s Western Region, between the low dunes south of the Baynunah Forest Plantation, a group of white, stony plains are visible on satellite photographs (Fig.29). Though rather unremarkable to look at, these plains hold a fascinating secret – the fossilised footprints of animals which lived here about eight million years ago. The first of these spectacular fossil sites was drawn to the attention of ADIAS in 2001 by Mubarak al-Mansouri, who works at the Jebel Dhanna terminal of the Abu Dhabi Company for Onshore Oil Operations, ADCO. During fieldwork by ADIAS at Jebel Dhanna, Mubarak persuaded the ADIAS team of Dan Hull and Steve Rowland to come out with him into the desert to look at what he said were possible ‘dinosaur footprints’, which had long been known to his family.

He took them to a plain at Mleisa (Fig.30) where there were, indeed, large fossilised footprints, later shown to be from a period long after the dinosaurs. Further visits were then made by ADIAS, and a detailed survey of the Mleisa site was carried out in 2003, when measurements were taken. This showed that the footprints are very large and roughly circular, some showing faint traces of toes (Fig.31). Given the Miocene age of the sediment, the only types of animal which could have made such footprints are elephants.

Why are these fossil footprints so interesting? All kinds of fossils are a valuable resource for palaeontologists trying to recreate past faunas and environments, but fossil bones are usually the only source of information about the animals of the time. As with most fossil bones, the remains of Abu Dhabi’s Miocene fauna are found in sediments which have been laid down by water, but many of the animal species are not aquatic, so their bones are found places where they did not actually live. Bones can be carried long distances in a river, or by predators, and this transport and accumulation of bones after death makes deductions about the habitat of the animal during life difficult. Fossil bones also provide very little information about the behaviour of the animals concerned.

The discovery of an extensive trackway of Proboscidean (Elephant family) footprints at Mleisa is, therefore, of great significance because it is an additional and alternative type of fossil evidence. Such fossils can only be preserved in the exact place where they were created. Fossil footprints preserve a snapshot of past animal behaviour, and show that we are looking at a preserved ancient ground surface. They also show that the animals chose to spend at least some of their time in that particular spot.

Many fossil footprints have been discovered in other parts of the world, but it is often difficult to link them to a contemporary animal. In the United States, for example, palaeontologists may find dinosaur bones at one site, and footprints which may have been made by that type of animal at another site hundreds of miles away. The link between the two must always remain tentative and is almost impossible to prove. At Mleisa, however, the footprints are close to the sites that have produced fossil elephant bones at Ruwais and Shuweihat and lie within the same well-defined geological formation. Finding footprints and the bones of the animals which may have created them in relatively close proximity is very unusual. As the overwhelming majority of Proboscidean bones recovered from the Baynunah formation have been from *Stegotetrabelodon syrticus* it is tempting to assign the footprints to that species, but small fragments of two other Proboscideans show that they too were present in this palaeoenvironment.
The footprints at Mleisa are on the light-coloured, level floor of an oval stony depression approximately 500m long among low dunes and outcrops of soft rock. The outcrops are of silty and sandy indurated water-lain sediments typical of the Baynunah Formation. (‘Indurated’ means sediment which has been cemented by salts such as gypsum or lime.) The surface containing the footprints is broken up into polygonal pieces, indicating that the original sediment had been wet, and had dried out. Around the edges of the depression other examples of similar whitish layers, with similar polygonal fracturing, can be seen up to one metre above the floor of the main depression.

Most of the footprints seem to have dislodged some of the surrounding polygonal fragments, showing that the elephants were not wading, they crossed the area after it had dried out. Was this surface a seasonal lake bed, a temporary pool of rain or flood water (such as may form in the desert today after heavy rain), or perhaps sabkha? Only further study by geologists will reveal the original nature of the deposit.

The Mleisa trackway consists of a group of up to 14 roughly parallel tracks, with one larger track crossing them. The main trackway can be followed for about 170 metres before it disappears under overlying sediment, while the visible portion of the larger track is 290 metres long. It seems that the elephants may have been crossing the area frequently, as some of the parallel tracks appear to run in opposite directions. Measurements of pace, stride and width of three tracks were made (Fig.32), showing that the single track crossing the main group was made by a much larger animal with a stride of over three metres, perhaps a lone male.

At first sight, the footprints are disappointing in that they are indistinct in shape, showing very little morphological detail, perhaps due to the muddy sediment flowing back into the depression after the foot was removed. Also, when walking slowly, most four-legged animals place the hind foot in exactly the same place as the front, creating a composite, rather messy imprint. A further complicating factor is the possibility that the Proboscideans may actually have been walking on an overlying layer of sediment, and what we see are blunt indentations punched through the surface by their great weight.

Pace, stride and track width measurements are, nevertheless, reliable indicators of the animals’ size, even if derived from indistinct footprints. In order to obtain some idea of the track-makers’ relative size, measurements were made of the tracks of modern Asian elephants at Blackpool Zoo, in Britain, for comparison (Fig.33a,b). The Mleisa track-makers were considerably larger than Asian elephants (Fig.34).

Much further work requires to be carried out at this site to map it at high resolution and make more elaborate measurements of the trackways. It can be seen from satellite images of the area that the white stone plain in which the footprints were found is only a small part of an extensive sweep of similar outcrops stretching many kilometres to the east and west. A brief survey of a nearby stony plain at Mleisa has revealed more Proboscidean footprints and the tracks of a cloven-hoofed animal like an antelope. To the west of Mleisa at Niqa isolated footprints of two types were observed at two locations on a fossilized mud plain. Three prints left by an animal with a five toed foot around 28cm across were noted (Fig.35).

Future scientific analysis of these trackways and their associated sediments will reveal much about past faunas, environments and climate change.
Figure 29. Location of the two Mleisa and Niqa trackway sites.
Figure 30. View of the plain at Mleisa.
Figure 31. View of the main trackway at Mleisa.
Figure 32. Basic measurements used to describe a track, after Thulborn (1990).
Figure 33. Top: Measuring the shoulder height of a modern Asian elephant at Blackpool Zoo. Bottom: Walking the elephant on raked sand to record measurements on its tracks.
<table>
<thead>
<tr>
<th>Track</th>
<th>Stride (cm)</th>
<th>Pace (cm)</th>
<th>Width (cm)</th>
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<tr>
<td>Mleisa track 1</td>
<td>306</td>
<td>173</td>
<td>128</td>
</tr>
<tr>
<td>Mleisa track 2</td>
<td>267</td>
<td>136</td>
<td>85</td>
</tr>
<tr>
<td>Mleisa track 3</td>
<td>264</td>
<td>137</td>
<td>94</td>
</tr>
<tr>
<td>Modern Asian elephant</td>
<td>241</td>
<td>127</td>
<td>77</td>
</tr>
</tbody>
</table>

Figure 34. Comparison of the track measurements between modern Asian elephants from Blackpool Zoo with three examples from the Mleisa site.

Figure 35. Footprint of a five-toed animal discovered at Niqa.
CHAPTER 6

Conclusion - the importance of Abu Dhabi’s Late Miocene fossil sites

Mark Beech and Peter Hellyer

The coastline of the Emirate of Abu Dhabi from As Sila in the west to Abu Dhabi city in the north-east is part of the Western Region of the Emirate of Abu Dhabi. It extends for some 300 km, forming the southernmost edge of the inner Arabian Gulf. In this area, a number of isolated, flat-topped hills (jebels) project a few tens of metres above the generally flat coastal plains. Although these hills are low, (between 40 and 60 metres) they contain enough outcrop, particularly in hills bordering the present-day sea, to provide collections of Miocene faunas unique to Arabia and sedimentary successions that allow the environments of deposition to be interpreted. Sites with Miocene fossil faunas are distributed from Jebel Barakah in the far west to Rumaitha in the east.

The importance of these sites to the cultural and scientific heritage of the United Arab Emirates lies in the fact that they are the only locations in Arabia where the remains of fossil animals and plants have been recovered that are of international significance. The Baynunah Formation crops out in an area of about 1800 sq km, the fossils identified so far only come from a 560 sq km area, and that has not been yet surveyed in detail. More work therefore still needs to be done.

Around 18 million years ago, the broad seaway between the Mediterranean Sea and the Indian Ocean closed. The Arabian peninsula, for the first time, formed a bridge between Africa and Asia. Elephant-like animals and primates (apes) moved northwards and rhinos came in from Eurasia. Such exchanges occurred repeatedly during the Miocene. Sometimes the land bridge was blocked by short-lived marine connections between the Indian Ocean and the Mediterranean or the Black Sea. Consequently, the Arabian Peninsula has been the important cross-roads for faunal exchanges between Africa and Asia, as is shown in the fossil record.

An often forgotten factor is that the geology of these fossil sites forms a natural barrier to coastal erosion in the Baynunah area. From Tarif to Jebel Barakah the fossil-bearing rock forms a plateau about 40 metres above sea level and hard rocks form the base of the sea cliffs such as at Shuwaihat. If through development, this natural barrier is weakened or removed, then there is the possibility that coastal erosion will increase at a greater rate than at present.

The pace of progress in the UAE is remarkable. An area of desert that is untouched one year can, the following year, be the site of a major development and the landscape in which Abu Dhabi’s Late Miocene fossils are found has been subjected to major changes. Many of the fossiliferous areas easily visited in the 1990s during the initial research are now inaccessible due to fencing. Within these compounds, the desert has often now been planted with thousands of shrubs and trees, while the tops of many jebels have been leveled to make way for water towers or for other purposes.

It is now almost impossible to visit many of the fossil sites originally discovered in the 1990’s. Those fossiliferous deposits which still survive require urgent protection, many being under threat from coastal development. Initial proposals, a decade ago, for the protection and conservation of key sites have not thus far been implemented, and losses continue. Together with the Environmental Research and Wildlife Development, Agency (ERWDA), and in line with Abu Dhabi’s existing environmental protection legislation, ADIAS continues to work for proper designation of and protection of the most important sites. They should be preserved for the long term cultural, educational and scientific benefit of the people of the UAE.
The early phases of work on the fossils, led by the teams from the British Natural History Museum and Yale University, laid important groundwork for what was to follow. It proved that the Late Miocene fossil vertebrate fauna of the Western Region of Abu Dhabi was of international importance.

The more recent involvement of ADIAS in this fieldwork would not have been possible without the important legacy inherited from this former work. Our understanding of the Ruwais fossil site, as well as other new discoveries made by our team in the field during the past few years, is only made coherent by the detailed and painstaking scientific research carried out by a multitude of specialists who appear in the “Fossil Vertebrates of Arabia” publication (ed. P.J. Whybrow and A. Hill). The ADIAS team was working closely with the late Peter Whybrow up until less than a year before his sadly premature death in February 2004. We would like to conclude with some words written by Peter in one of his final publications...

“The Western Region of Abu Dhabi will, for me, always be a special place, for its desert and for the opportunity to look into Arabia’s past and discover the remains of animals that once lived around its ancient rivers”

APPENDIX 1

Catalogue of the Fossils in the Exhibition “Abu Dhabi 8 Million Years Ago – Fossils from the Western Region”

Mark Beech

Main Showcase (the Shuwaihat and Ruwais elephant fossils)

The large elephant fossils displayed in the main showcase originate from two localities in the western region of Abu Dhabi, Shuwaihat Island (site S6) and Ruwais (site RUW0044).

Shuwaihat elephant fossils

The Shuwaihat site was first discovered by Andrew Hill (Yale University) and Peter Whybrow (Natural History Museum, London) in late 1990. During their survey of the area they observed fragmented bones lying on the surface which belonged to the back part of an elephant (proboscidean) mandible. In January 1992 excavation began on the jaw carried out by Gillian Cromerford (Natural History Museum) and Andrew Hill. It was during this excavation that the cranium was first discovered.

The excavators realised that there might be more of the remainder of the skeleton. Further excavation was therefore postponed until April 1992 when a team of eight specialists from the Natural History Museum arrived to carry out further work. They excavated the proboscidean cranium, and attempted to recover more of the skeleton. A second season of excavations took place in April 1994. A total area of 153 sq. metres was excavated in total. Bones which were retrieved from the proboscidean skeleton included a cranium, mandible, atlas, 7 thoracic vertebrae, 1 lumbar vertebra, 11 nearly entirely preserved ribs, right scapula, partial right radius, right femur, and right and left tibiae. Size and growth stage of these different elements are in agreement, so it is very likely that they belong to the same individual (a young adult, with its third molar not yet erupted and epiphyses of long bones not fused).

The fossils lay on a pebbly gravel layer suggesting that the bones had accumulated in an old river channel away from the main course of the river. The elephant probably died nearby. After decomposition the skeleton was partly disarticulated, then parts of the skeleton were transported by flooding of the river channel. A larger scale flood then buried the skeleton under a thick layer of sandy silt together with additional thin layers of gravel. Besides the 35 bones recovered from the proboscidean skeleton, other fauna represented included mainly crocodile, fish, two suid specimens, a bovid horn core and a piece of ostrich egg shell.
Figure 36

**Catalogue details:**
Common name: Elephant
Scientific name: *Stegotetrabelodon syrticus* Petrocchi, 1941
Element: Mandible
Locality: Site S6, Shuwaihat
Catalogue: ADIAS 503 (same individual as ADIAS 502)

**Description:**
The mandible you can see at the left end of the display was excavated by a team from the Natural History Museum in 1992. The mandible was almost entirely preserved with the right lower tusk *in situ*.

Figure 37

**Catalogue details:**
Common name: Elephant
Scientific name: *Stegotetrabelodon syrticus* Petrocchi, 1941
Element: Skull
Locality: Site S6, Shuwaihat
Catalogue: ADIAS 502 (same individual as ADIAS 503)

**Description:**
The upside down skull you can see in the centre left of the display is of a young adult *Stegotetrabelodon*. It was excavated by a team from the Natural History Museum in April 1992. The skull belongs to the same individual as the mandible (see above). The teeth you can see are the upper first and second molars.
Catalogue details:
Common name: Elephant
Scientific name: *Stegotetrabelodon syrticus* Petrocchi, 1941
Element: Femur
Locality: Site S6, Shuwaihat
Catalogue: ADIAS 506

Description:
The femur you can see to the right side of the display is from the same young adult *Stegotetrabelodon* as the skull and mandible. It is from the back right leg of the animal. The ends of the bone (epiphyses) are not joined to the main shaft which demonstrates that it is immature.

Ruwais elephant tusk

The Ruwais site was first discovered in April 2002 by a team from the Abu Dhabi Islands Archaeological Survey (ADIAS). ADIAS had been commissioned by TAKREER, the Abu Dhabi Oil Refining Company, to undertake an Environmental Impact Assessment of an area close to Ruwais where the BeAAT Central Environment Protection Facilities are to be built. The area to be surveyed lay just immediately south of the Tarif to Sila’a highway and east of the Ghiyathi junction. The initial survey demonstrated that this was an area of very considerable palaeontological significance. A brief visit was made to Ruwais in June 2002, more extensive work then taking place between October to December of 2002, and March of 2003.

It was during the third phase of survey of the core zone of the TAKREER development site in November 2002 that an astonishing discovery was made. Amongst the 60 locations discovered with clusters of fossils on the modern-day ground surface was one particular special one, at locality RUW0044. All that was visible on the surface was a light scatter of white bone fragments stretching in a linear fashion down some gently sloping terrain. Closer examination by Dr Mark Beech suggested that these might in actual fact belong to a tusk from a primitive form of elephant. Together with the help of volunteers from the Emirates Natural History Group, the area around the tusk was carefully cleaned and excavated. To our astonishment a large tusk was revealed lying just below the modern day ground surface. This proved to be an almost complete upper tusk of the primitive elephant, *Stegotetrabelodon syrticus*. Dr Geoffrey King and Peter...
Hellyer (Academic and Executive Directors of ADIAS) had wandered off into the distance in search of more fossil sites. Peter excitedly called Mark on his mobile saying “Come over here, we have found a good fossil site!” (which subsequently proved to be “Elephant Hill”, site RUW0048) .... Mark said to him “Forget that... you really need to see what we have just discovered over here, its mega !!”.

The tusk proved to be 2.54 metres in length from base to tip making it probably the largest mammalian fossil ever to be found in the Arabian peninsula. The next problem was how were we going to get it back to Abu Dhabi in once piece! To read more about how we managed this feat, see Chapter 3.

Figure 39

Catalogue details:
Common name: Elephant
Scientific name: Stegotetrabelodon syrticus Petrocchi, 1941
Element: Upper tusk
Locality: Site RUW0044, Ruwais
Catalogue: ADIAS 1923

Description:
The elephant tusk you can see in the centre of the display is an upper tusk from a large adult Stegotetrabelodon. This was discovered by a team from the Abu Dhabi Islands Archaeological Survey (ADIAS) in November 2002 during their survey of an area near Ruwais. The tusk measured 2.54 metres from base to tip, making it the largest Miocene fossil ever to be found in the Arabian peninsula.
Side Showcase (Various fossils from the Western Region)

The cabinet at the left hand end of the display has various fossils from different sites located in the Western Region of Abu Dhabi. These are some of the best specimens available in the collection from a representative range of animals found in the Late Miocene deposits.

Fixed on the wall at the top of the display:

![Image of Tragoportax cyrenaicus](image)

**Figure 40**

**Catalogue details:**
- Common name: Antelope
- Scientific name: *Tragoportax cyrenaicus* (Thomas, 1979)
- Element: Cranium
- Locality: Site T2, Tarif
- Catalogue: ADIAS 442

**Description:**
The horncores and partial skull of *Tragoportax cyrenaicus*, a primitive type of antelope, was discovered by staff from the United States Geological Survey. It was found in a small cave-like excavation at the foot of a small hill cut by the Tarif-Habshan road.
Figure 41

Catalogue details:
Common name: Hippopotamus
Scientific name: *Hexaprotodon aff. sahabiensis*
Element: Mandible
Locality: Site S4, Shuwaihat
Catalogue: ADIAS 481

Description:
The lower mandible of a hippopotamus was found at site S4 at Shuwaihat. This is from an immature animal, judging from the status of its teeth.
Top shelf:

All the fossil specimens on the top shelf represent jaws or teeth from terrestrial animals.

Figure 42

Display no. 1

Catalogue details:
Common name: Horse
Scientific name: *Hipparion* sp.
Element: Tooth
Locality: Site JD5, Jebel Dhanna
Catalogue: ADIAS 144 and 676

Description:
These teeth are from the small three-toed ancestors of the modern horse called "hipparion". One of the equid teeth is embedded in a resin block. This was done to prepare the tooth for thin-sectioning during analysis.

Figure 43

Display no. 2

Catalogue details:
Common name: Hyaena
Scientific name: *Hyena* sp.
Element: Mandible
Locality: Site JD3, Jebel Dhanna
Catalogue: ADIAS 294

Description:
This jaw fragment is from a very large indeterminate species of hyaena.
**Figure 44**

**Display no. 3**

**Catalogue details:**
Common name: Wolverine  
Scientific name: *Plesiogulo praecocidens* Kurtén, 1970  
Element: Mandible  
Locality: Site H4, Hamra  
Catalogue: ADIAS 45

**Description:**
This left mandible is from *Plesiogulo*, a type of wolverine. Wolverines are the largest terrestrial member of the family Mustelidae. Their appearance is somewhat bear-like, although movement and associated behaviour are distinctly characteristic of the weasel.

---

**Figure 45**

**Display no. 4**

**Catalogue details:**
Common name: Antelope  
Scientific name: *Pachyportax latidens* (Lydekker, 1876a)  
Element: Mandible  
Locality: Site H6, Hamra  
Catalogue: ADIAS 266

**Description:**
This right mandible is from an adult antelope. Its second and third molars are in middle wear.
**Second shelf (from top):**

All the fossil specimens on this shelf represent terrestrial animals.

<table>
<thead>
<tr>
<th><strong>Figure 46</strong></th>
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<tr>
<td><strong>Catalogue details:</strong></td>
<td><strong>Common name:</strong> Sabre-tooth cat</td>
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<tr>
<td></td>
<td><strong>Scientific name:</strong> <em>Machairodontinae</em> gen. et sp. indet.</td>
</tr>
<tr>
<td></td>
<td><strong>Element:</strong> right calcaneum</td>
</tr>
<tr>
<td></td>
<td><strong>Locality:</strong> Site K1, Kihal</td>
</tr>
<tr>
<td></td>
<td><strong>Catalogue:</strong> ADIAS 241</td>
</tr>
<tr>
<td><strong>Description:</strong></td>
<td>This is the ankle bone from a large sabre-tooth cat. It is complete and in excellent condition. The bone is from a large species about the size of a lion or tiger.</td>
</tr>
</tbody>
</table>

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<td><strong>Catalogue details:</strong></td>
<td><strong>Common name:</strong> Giraffe</td>
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<td></td>
<td><strong>Scientific name:</strong> <em>Palaeotragus</em> sp.</td>
</tr>
<tr>
<td></td>
<td><strong>Element:</strong> Metatarsal</td>
</tr>
<tr>
<td></td>
<td><strong>Locality:</strong> Site S4, Shuwaihat</td>
</tr>
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<td></td>
<td><strong>Catalogue:</strong> ADIAS 249</td>
</tr>
<tr>
<td><strong>Description:</strong></td>
<td>This distal metatarsal, or lower leg bone, comes from a giraffe-type animal. The presence of giraffids suggests that the environment in Abu Dhabi could have been quite like modern day east Africa, i.e. a southern or hot-country climate but not with any substantial development of aridity.</td>
</tr>
</tbody>
</table>
Figure 48

Display no. 7

Catalogue details:
Common name: Monkey
Scientific name: Cercopithecidae gen. et sp. indet.
Element: Canine
Locality: Site JD3, Jebel Dhanna
Catalogue: ADIAS 35

Description:
Lower left canine of a ?male cercopithecid. This is the only fossil primate specimen so far found in Abu Dhabi, and the only fossil monkey so far known from the Arabian peninsula. This specimen was discovered by Peter Whybrow on 10 January 1989 in sediments from the Baynunah formation at site JD3, Jebel Dhanna.

Figure 49

Display no. 8

Catalogue details:
Common name: Giraffe
Scientific name: Bramatherium sp.
Element: Thoracic vertebra
Locality: Site JD3, Jebel Dhanna
Catalogue: ADIAS 223

Description:
This specimen is a neck vertebra from a large giraffe. This had a shorter neck than modern giraffes.
<table>
<thead>
<tr>
<th>Display no. 9</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Catalogue details:</strong></td>
</tr>
<tr>
<td>Common name: Ostrich</td>
</tr>
<tr>
<td>Scientific name: <em>Struthio</em> sp.</td>
</tr>
<tr>
<td>Element: Egg shell</td>
</tr>
<tr>
<td>Locality: Site B2, Jebel Barakah</td>
</tr>
<tr>
<td>Catalogue: ADIAS 472</td>
</tr>
<tr>
<td><strong>Description:</strong></td>
</tr>
<tr>
<td>Here are some typical fragments of Late Miocene ostrich egg shell. These are commonly found on many fossil sites throughout the Western Region of Abu Dhabi.</td>
</tr>
</tbody>
</table>
Third shelf (from top):

All the fossil specimens on this shelf represent aquatic animals.

Figure 51
Display no. 10
Catalogue details:
Common name: freshwater clam shells
Scientific name: *Mutela* and *Leguminaia* sp.
Element: bivalve
Locality: Site H6, Hamra
Catalogue: ADIAS 675a

Description:
These two types of bivalves are the commonest types of shells found at Late Miocene fossil sites in the Western Region of Abu Dhabi. They indicate that freshwater rivers once ran through this area with fast flowing, clean water.
Figure 52

Display no. 11

Catalogue details:
Common name: Catfish
Scientific name: *Bagrus shuwaiensis* sp. nov. and *Clarias* sp.
Element: Pectoral spine, Post-temporal and Vertebra (centrum).
Locality: Various sites at Jebel Dhanna and Shuwaihat.
Catalogue: ADIAS 117, 751 and 744.

Description:
Top: Left pectoral spine of *Clarias* (ADIAS 117) from Site S1, Shuwaihat.
Bottom left: Post-temporal of *Clarias* (ADIAS 751) from Site JD3, Jebel Dhanna.
Bottom right: Centrum of *Bagrus shuwaiensis* sp. nov. (ADIAS 744) from Site JD3, Jebel Dhanna.

Both *Clarias* and *Bagrus* are types of fish which generally prefer slow-moving waters.

Figure 53

Display no. 12

Catalogue details:
Common name: Crocodile
Scientific name: *Crocodylus* sp. indet.
Element: Posterior part of Skull.
Locality: Site S1, Shuwaihat
Catalogue: ADIAS 32

Description:
The almost complete posterior part of a crocodile skull was found lying on the western face of the island of Shuwaihat's easternmost jebel.
**Figure 54**

**Display no. 13**

**Catalogue details:**
- **Common name:** Turtle
- **Scientific name:** *Trionyx* sp.
- **Element:** Carapace fragment
- **Locality:** Site M2, Mirfa
- **Catalogue:** ADIAS 301

**Description:**
This is a fragment of the bony shell of a freshwater turtle. These turtles were good swimmers with paddled limbs. *Trionyx* generally preferred flowing wide systems, lakes or rivers.

---

**Bottom shelf:**

**Figure 55**

**Display no. 14**

**Catalogue details:**
- **Common name:** ?Carnivore species
- **Element:** Coprolite
- **Locality:** Site Q1, Ras Al Qa’la.
- **Catalogue:** ADIAS 428

**Description:**
These remarkable specimens are pieces of fossil excrement. Their general shape and characteristics suggest that they come from some sort of carnivore. The form of the larger specimen, depicted here on the left, is reminiscent of the stools of large cats.
**Figure 56**

**Display no. 15**

**Catalogue details:**
- Common name: Elephant
- Scientific name: *Stegotetrabelodon syrticus* Petrocchi, 1941
- Element: Right third molar
- Locality: Site R2, Ras Dubay’ah
- Catalogue: ADIAS 456

**Description:**
This well preserved tooth was discovered by Dr Walid Yasin Al-Tikriti at Ras Dubay’ah in December 1989.
### Display no. 16

**Catalogue details:**
- **Common name:** Acacia
- **Scientific name:** *Acacia* sp. indet.
- **Element:** branch
- **Locality:** Site H1, Hamra
- **Catalogue:** ADIAS 6

**Description:**
Here are some typical examples of fossil acacia wood. These are commonly found at many of the Late Miocene fossil sites in the Western Region of Abu Dhabi, e.g. at Hamra, Ra's Al Qa'la, Ruwais and Shuwaihat.
APPENDIX 2

Constructing the scale model of *Stegotetrabelodon syrticus*

Abdul Hafeez, Izhar Hafeez and Mark Beech

Although there have been other attempted depictions of similar animals in the form of sketches and paintings, such as that by Dr Henry Woodward of *Tetralophodon angustidens* in E. Ray Lancaster’s book “Extinct Animals” published in 1905 (Figs. 57-58), Mauricio Anton in the publication on the Logatham fossil site in Tanzania (Fig. 59), and even an example on postage stamps in Libya (Fig. 60), this model is the first lifelike reconstruction ever attempted of a *Stegotetrabelodon*. Hopefully in the future there will be an opportunity to reconstruct a full-size version! This would provide an attractive feature of a Miocene section of the Early History of Abu Dhabi gallery in a future National Museum in Abu Dhabi.

The model you can see in the display is a ca. 20% size scale model of the primitive elephant species, *Stegotetrabelodon syrticus*. Work on the design and production of this model took over one year to complete. The master model was made by Abdul and Izhar Hafeez and their staff from the Private Department of the late President, Sheikh Zayed bin Sultan Al Nahyan.

A wooden and metal frame was first constructed, around which steel netting was shaped (Fig. 61). This provided a surface onto which modeling clay could then be applied. The body of the animal was then patiently sculpted in clay by Abdul Hafeez (Fig. 62a, b). This was carried out under the scientific guidance of Dr Mark Beech. All efforts were made to use the fossil specimens obtained from Shuwaihat and Ruwais to help determine the correct proportions, size and morphology of the animal. It was estimated that the shoulder height of a *Stegotetrabelodon* would have been at least 3m.

Once the master model was completed a fiberglass mould was then made (Fig. 63). The actual model was then cast from the mould using resin (Fig. 64). Final touches included painting the model surface with textured paint and the addition of body hair.
Figure 58. Various reconstructions of *Stegotetrabelodon* and similar animals.
Top: *Tetrabelodon angustidens* by Dr Henry Woodward in: Lankester 1905 (Fig.82).
Middle: *Tetrabelodon angustidens* by Dr Henry Woodward in: Lankester 1905 (Fig.83).
Bottom: Reconstruction of *Stegotetrabelodon orbus* by Mauricio Anton in: Leakey and Harris 2003 (Fig.8.1).
Figure 59. Postage stamps from Libya issued in 1995 depicting *Stegotetrabelodon syrticus*.

Figure 60. Abdul Hafeez and his team from the Private Department of His Highness the President working on the construction of the model of *Stegotetrabelodon syrticus*. 
Figure 61. Applying modelling clay onto the frame.

Figure 62. Abdul Hafeez patiently sculpting the model of *Stegotetrabelodon syrticus*. 
Figure 63. Izhar Hafeez prepares a fibreglass and latex mould of the model.

Figure 64. Scale model (1:5) of *Stegotetrabelodon syrticus*. 
APPENDIX 3

The reconstruction painting “Abu Dhabi - 8 million years ago”

Gemma Goodall and Nigel Larkin

The backdrop of the fossil display was produced by a UK-based artist, Gemma Goodall, together with the assistance of her partner, Nigel Larkin. A series of initial sketches were prepared under the guidance of Dr Mark Beech (Fig.65). These took into account the new information collected from the Ruwais fossil site.

Additional inspiration came from various earlier attempts by other artists to depict Miocene animals and landscapes. These included four pictures produced by an artist from the Natural History Museum in London for the "Hot Fossils from Abu Dhabi" exhibition held in the museum in 1991 (Fig.66a-d).

The most recent attempt at reconstructing Late Miocene environments are the beautiful sketches of Mauricio Anton (Fig.67) which graced the recent publication of fossils from Logatham in northern Kenya (Leakey and Harris 2003). Other pictures which provided inspiration were: the Miocene megafauna picture which was created by the American Museum of Natural History for their Timelines Exhibit (Fig.68), Zdenek Burian’s pictures of the Miocene proboscideans, *Gomphotherium* and *Tetralophodon* (Fig.69a,b), and Charles R. Knight’s illustration of a four tusked mastodon (*Trilophodon*) from the Early Image public domain images website (Fig.70). Further inspiration was also derived from modern photographs of animal scenes in the vicinity of rivers in East Africa. Design and layout of the picture was decided upon by Gemma Goodall and Nigel Larkin in collaboration with Dr Mark Beech.

The picture was initially sketched and after lots of deliberations, discussions, rubbings out and amendment, it was then painted with watercolour paints. The painting was made on standard watercolour paper 200g/m2 in three separate panels. These were dampened, stretched and taped onto a wooden background. The three panels of completed watercolour paintings were digitally photographed by Gulf Colour Film, Abu Dhabi. These three panels were then digitally stitched together using Photoshop to form a single continuous image ca. 7 metres wide x 2 metres tall. This picture formed the diorama background for the fossil exhibition (Fig.71). Printing, production and installation of the diorama picture was undertaken by Riaz Neon, Abu Dhabi. The picture was printed onto special sticker paper which allowed the flexibility to create the necessary curved effect in the display.
Figure 65. Working sketches for the painting “Abu Dhabi – 8 million years ago” by Gemma Goodall.

Figure 66a. Hippos (*Hexaprotodon*) on the riverbank and swimming in the river together with a freshwater turtle. Crocodiles slip down into the river gliding towards their prey. In the distance some antelopes graze on the plain.

Figure 66b. Group of old world monkeys. Three ostriches in the distance.
Figure 66c. Group of Deinothere with giraffids (Sivatheres) in the distance.

Figure 66d. A sabre-tooth cat pounces and attempts to sink its teeth into the neck of a hipparion, with egrets on the riverbank in the distance.

Figure 67. Reconstruction by Mauricio Anton of the Late Miocene period Nawata Formation Habitat, Logatham, northern Kenya (after Leakey and Harris 2003, Fig.13.1).
Figure 68. Miocene megafauna. Picture created by the American Museum of Natural History for their Timelines Exhibit.

Figure 69. Zdenek Burian’s pictures of the Miocene proboscideans, *Gomphotherium* (left) and *Tetralophodon* (right).

Figure 70. Charles R. Knight’s depiction of the four-tusked mastodon, *Trilophodon* (Early Images public domain images website).
Figure 71. “Abu Dhabi 8 million years ago” by Gemma Goodall (Antares Design, U.K.).
APPENDIX 4

The audio-visual presentations in the Exhibition “Abu Dhabi 8 Million Years Ago – Fossils from the Western Region”

The overall design of the DVD for the fossil exhibition was by Dr Mark Beech (ADIAS). Editing of the DVD films was by Arshad H. Khan from Cloud 7 Art Production (Abu Dhabi). Copies of the DVD may be purchased from the Abu Dhabi Islands Archaeological Survey (ADIAS), P.O. Box 45553, Abu Dhabi, U.A.E. fax: +971 (0)2 6810008. Email: adias@erwda.gov.ae – Price 80 UAE dirhams (equivalent to approx 21 US dollars).

Details of the films are as follows:

Figure 72. DVD film - Fossils from Western Abu Dhabi - The Animals of 8 million years ago.

Duration: 4 mins, 12 secs.
Produced and Directed: Will Higgs and Dr Mark Beech (ADIAS).
Music: Jonathan Higgs (U.K.).
Music title: Elephantiasis.
Mixing: Arshad H. Khan (Cloud 7 Art Production, Abu Dhabi) and Dr Mark Beech (ADIAS).
Film editing: Arshad H. Khan (Cloud 7 Art Production, Abu Dhabi).
Arabic translation: Tariq Faham (Senior Translator, Emirates News Agency WAM, Ministry of Information and Culture).
Revision of Arabic text: Ahmad Alshemari and Hamid Almutairi (Kuwait National Museum) and Wafa Al-Morda’a (ADCO, Abu Dhabi).
Year: 2005.
Figure 73. DVD film - Hot Fossils from Abu Dhabi.

Duration: 5 mins, 27 secs.
Presenter: David Attenborough.
Sponsor: United Arab Emirates University.
Photography: John Rathbone, Phil Crabb and Ray Blewitt.
Sound: George Lang.
Editor: Neil Roberts.
Produced and Directed by: Dave Holmes RKD Productions Ltd. for the Natural History Museum, London.

Arabic version produced by: Dr Mark Beech (ADIAS).
Film editing: Arshad H. Khan (Cloud 7 Art Production, Abu Dhabi).
Arabic commentary: Salam Nemer (Zayed University, Abu Dhabi).
Arabic soundtrack recording: Bradley Young (Zayed University, Abu Dhabi).
Year: 2005.
Figure 74. DVD film - Abu Dhabi - the Missing Link.

**Duration:** 28 mins, 47 secs.

**Sponsor:** Abu Dhabi National Oil Company (ADNOC) and Abu Dhabi Company for Onshore Oil Operations (ADCO).


**Photographer:** John Rathbone.

**Sound:** David Holmes.

**Script:** Paul Dunstan.

**Commentary:** Robert Powell.

**Co-ordinator:** Nasser Al-Shamsi, ADCO General Relations Division.

**Produced and Directed by:** Brooke Film Productions for the Abu Dhabi Company for Onshore Oil Operations (ADCO).

**Year:** 1991.
APPENDIX 5

List of Contributors

Dr Mark Beech
Senior Resident Archaeologist
Abu Dhabi Islands Archaeological Survey (ADIAS)
P.O. Box 45553
Abu Dhabi
United Arab Emirates
Email: adias@erUDA.gov.ae
Web: www.adias-uae.com

Gemma Goodall
Antares Design
3 Park Lane
Scarning
East Dereham
Norfolk NR19 2LD
United Kingdom
Email: gemma@antaresdesign.com
Web: www.antaresdesign.com

Abdul and Izhar Hafeez
Taxidermy Section
Private Department of H.H. President
Abu Dhabi
United Arab Emirates
Email: izharhafeez@hotmail.com
Web: www.taxidermynet.com

Peter Hellyer
Executive Director
Abu Dhabi Islands Archaeological Survey (ADIAS)
P.O. Box 45553
Abu Dhabi
United Arab Emirates
Email: peter@extinfo.gov.ae

Will Higgs MSc.
4 Stanley Crescent
Gilsland
Brampton
Cumbria CA8 7BH
United Kingdom
email: will@willhiggs.co.uk

Nigel Larkin BA MSc.
3 Park Lane
Scarning
East Dereham
Norfolk NR19 2LD
United Kingdom
Email: nrlarkin@easynet.co.uk
Web: www.natural-history-conservation.com

Dr John R. Stewart
Department of Biology
University College London
Gower Street
London
WC1E 6BT
United Kingdom
Email: thejohnstewart@yahoo.co.uk

Dr Walid Yasin Al Tikriti
Department of Antiquities and Tourism
Al Ain
United Arab Emirates
Email: wyasin@emirates.net.ae
Web: www.aam.gov.ae
BIBLIOGRAPHY

If you are interested to find out more information about the Late Miocene fossils of Abu Dhabi we recommend you consult the following books and websites:

Books


This latter book is the full scientific publication of all the fossils discovered during the 1990’s expeditions conducted by the Natural History Museum and Yale University. It includes detailed chapters on geology, palaeomagenetic dating, fossil mollusca, fishes, turtles, crocodiles, insectivores and rodents, monkeys, carnivores, elephants, horses, pigs, hippos and pectorans. It discusses the reconstruction of the environment of that time between 6-8 million years ago, and places it in the wider context of regional fossil fauna and flora from the Sultanate of Oman, Republic of Yemen, Africa and Asia.

Websites

Abu Dhabi 8 million years ago - An exhibition of Late Miocene Fossils from the Western Region - www.adias-uae.com/fossils.html
Information about the fossil exhibition in Abu Dhabi, including details of the films and presentations forming part of the display.

Miocene fossils from Abu Dhabi - www.adias-uae.com/fossils
Website of the Natural History Museum-Yale University Abu Dhabi Miocene Project, established by the late Peter J. Whybrow and Andrew Hill, in collaboration with the Abu Dhabi Company for Onshore Oil Operations (ADCO) and the UAE Ministry for Higher Education and Scientific Research.

Tribute to the pioneer of Miocene fossil studies in Abu Dhabi.

Pictures of the new fossils discovered by ADIAS at Ruwais, as well as press links and other related material.
Pictures of the proboscidean trackway discovered by ADIAS at Mleisa, as well as press links and other related material.

Scientific References

Many scientific articles have been published on the Late Miocene fossil material from Abu Dhabi. Here is a selection of key articles along with related publications from neighbouring areas:


