

WADI HITAN

EARLY WHALE EVOLUTION

John Parkins

'In bony, ribby, regions of the earth, where at the base of high broken cliffs masses of rock lie strewn in fantastical groupings upon the plain, you will often find images as of the petrified remains of the leviathan....'

Moby Dick
Herman Melville

On the west bank of the River Nile, just over one hundred kilometres south of Cairo, lies a green and fertile area, the Fayum, (Al-Fayoum, al Fayyum, etc.). See fig.1.

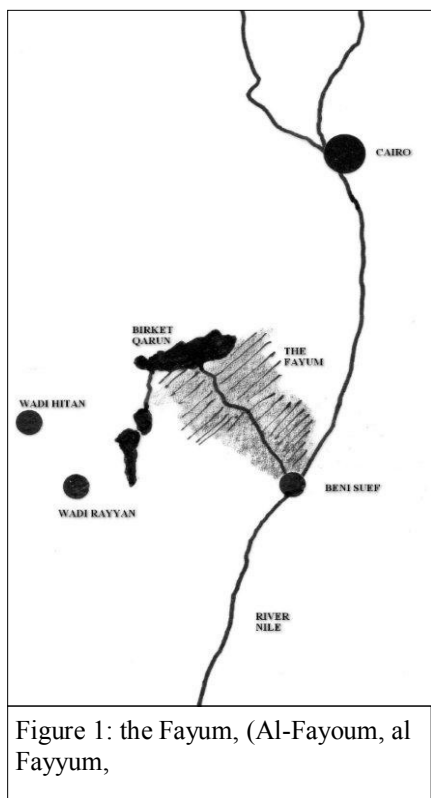


Figure 1: the Fayum, (Al-Fayoum, al Fayyum,

The name comes from the Coptic 'peiom', meaning lake. Often called an oasis, it is situated in a depression as are the oases deeper in the Western Desert but, unlike them, it does not rely for water on the aquifer held in the Nubian Sandstone. During the Pharonic era a canal, the Bahr Yusif, was dug along the line of a flood channel to connect the Fayum to

the River Nile. After feeding rich agricultural land, the water drains into Birket Qarun, a saltwater lake. There are two overflow lakes in nearby Wadi Rayyan that have a unique waterfall between them. The Fayum is noted for the production of cotton, cereals, figs, grapes, olives and attar of roses.

The Western Desert of Egypt is rich in varied and often spectacular geology, (see Journal 28, autumn 2009). This is certainly true of the Fayum and if the geology of the area is complex then the palaeontology is exceptional. When standing in the midst of the Sahara today, with no sign of life for hundreds of miles in any direction, it can be hard to realise how rich and fertile the whole area has been for much of the past. Just how recently it was so is recorded by the people who lived here, as shown in fig.2, rock art from Libya.



Figure 2: evidence of life in an earlier age

The area retains much fossil evidence of life during the early Cainozoic. Of particular importance are the Eocene and Oligocene periods which record the evolution of early Tertiary plants and animals and, in particular, the evolution of whales from land to fully aquatic animals. During the early Eocene, c.55Ma, Africa was much further south than at present with the Tethys Ocean between it and Europe. The ocean's southern shore was aligned with present day Aswan. By the late Eocene, c.35Ma, the shoreline had moved north to the Fayum and by the late Oligocene, c24Ma, it was aligned with present day Cairo.

Thus the deposits of the Fayum area reflect the very different conditions prevailing there across that period. The key beds in the story of whale evolution are the Gehannam Fm., dated ca 40-41Ma., and the Birket Qarun Fm.; both yield early whales. The main fossil bearing stratum of the Upper Eocene is the Qasr al-Sagha Fm. Consisting of layers of limestone and shale it is of marine origin but also contains the remains of many animals washed in from nearby land. Above this is the Fluvio-Marine Fm. containing marine reptiles and early mammals. The latter includes *moeritherium*, 'Dawn Elephant', and *arsinoitherium*, a 3.4 metre, 11 foot long, two-horned rhinoceros-like animal. Since the fossils lie at different levels they give evidence of response to climatic and ecological changes over millions of years thus providing valuable evolutionary indicators.

The above sequence was terminated during the Late Oligocene when western runoff following the initial uplift of the Red Sea Mountains created a delta on the Tethys coast in the area of the Fayum. These gravels became the Gebel Qatrani Fm. Further tension later spread a thick sheet of basalt over this and is visible capping the Gebel Qatrani Escarpment on the northwest of the Fayum. During the Miocene the whole area was subjected to uplift and a high energy river cut the Nile canyon. It was in the Pliocene infill of this that the present Nile cut its bed. As noted in Journal 28, there is much debate, involving water and wind erosion, as to how the depressions of the Western Desert were formed. In the case of the Fayum there is a view that solution weathering of younger Pliocene limestone above the weaker Gebel Qatrani conglomerates caused cavern roof collapse. Wind erosion would have acted on this to enlarge the depression. Stress fractures from initial Africa/Europe contacts would have hastened this process.

Fossils from the Fayum area cover a full spectrum from trace to primates and make it one of the most important sites in the world. Of particular interest is what is revealed about early whales for, along the southern shore of the Tethys during the Eocene, mammals in the same clade can be traced from Early Eocene land species to Late Eocene fully aquatic animals. Much of the evidence for this is to be found in Wadi Hitan, an area 12km, 7.5 miles,

to the southwest of the depression. It is also known as 'The Valley Of The Whales'. Over an area of 10km more than four hundred fossil skeletons of early whales, sea cows, crocodiles and turtles have been found. Other fossil finds, animals and plants, have enabled a clear picture of the land and seascape during the Upper Eocene to be understood. This shallow coastal area consisted of mangrove-fringed estuaries and lagoons containing a rich flora and fauna. The top marine predator around 35/40Ma was *Basilosaurus*, an eighteen metre, sixty foot, fully aquatic whale, fig.3.

One of the two species present, *Basilosaurus*

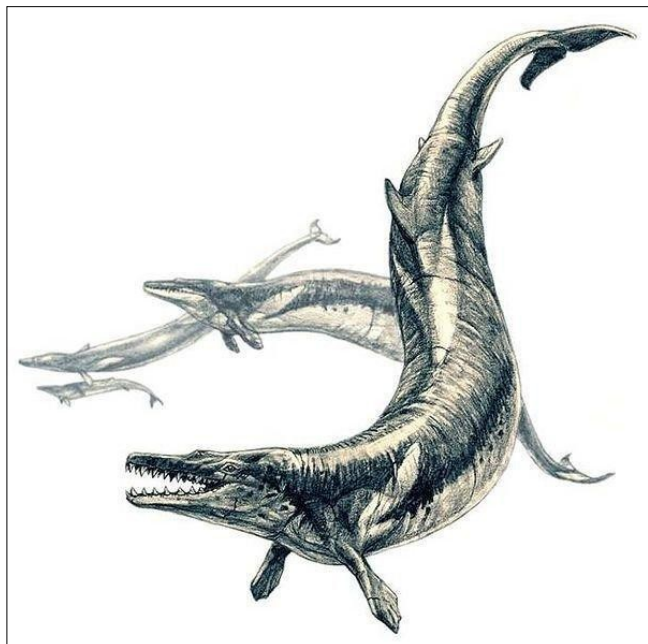


Figure 3: *Basilosaurus*, an eighteen metre, sixty foot, fully aquatic whale found around 35/40Ma.

isis, reached twenty one metres, fig.4. It had an elongated form and carnivorous dentition. *Basilosaurus* was equipped with five-fingered flippers on the forelimbs but had vestigial hind legs, feet and toes.

Fig.5 compares the structure of these legs with that of modern baleen whales. In toothed whales the structure is even more reduced. Having no locomotive value, it has been suggested that the rear limbs acted as a mating aid.

Study of the skeletal structure has led to the conclusion they swam with an anguilliform, or eel-like, motion and that they were not capable of sustained swimming or deep diving. They

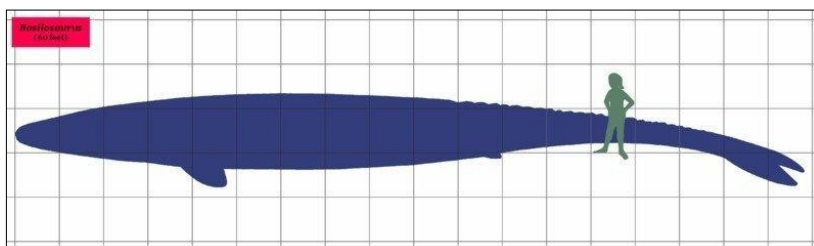


Figure 4: *Basilosaurus isis* reached 21 metres

are not considered to have been social animals. The high number of infant skeletons suggests that this shallow nutrient-rich area was used for calving. The suffix 'saurus' appears totally inappropriate for a mammal. When the first specimen was named it was thought to be a marine reptile and called 'King Reptile'. When later correctly indentified as a mammal, the name *Zeuglodon*, 'yoked tooth'

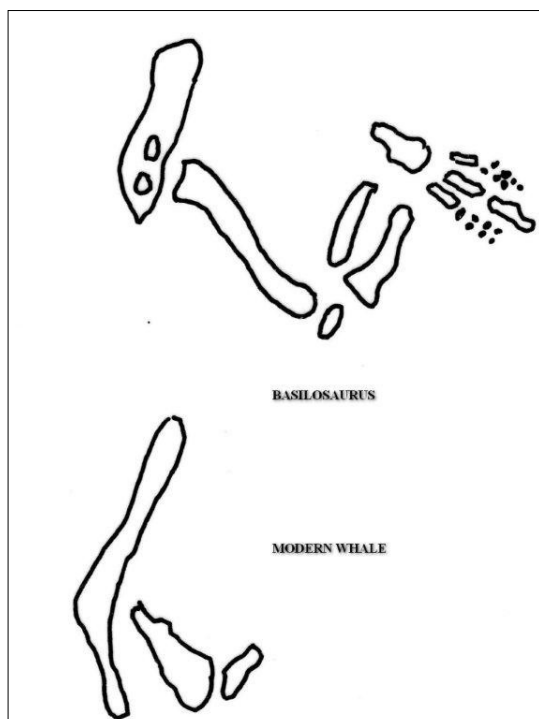


Figure 5: comparison of legs from *Basilosaurus* with modern baleen whale.

was proposed. Taxonomic priority prevailed and *Zeuglodon* went the same way as the much lamented *Brontosaurus*, it became a synonym. This synonym, however, did better than most, for some maps and books still name the whale site 'Wadi Zeuglodon'. There are nine species of Basilosauridae,

two of which are present at Wadi Hitan. Finds range from the United States to Pakistan, indicating that the family was present along the length of the southern Tethys seaboard.

Sharing the sea with *Basilosaurus* were three other whale species. One of these, *Durodon atrox*, 'Spear tooth', was a sub family of the Basilosauridae, fig.6. This archeocete whale measured five metres, 16ft, in length and was once thought to be the juvenile form of *Basilosaurus*. Body mass is estimated as 2,240kg. This whale is only known from North Africa. It also had the vestigial hind legs. Finds of associated fish bones indicate part of its diet. *D. atrox* had a hearing system that had some elements in common with modern whales but different to primitive terrestrial mammals; these elements aided the reception of underwater sound. One other species of *Durodon* is known. The large percentage of juvenile remains suggests that this whale also calved here. Some of the skulls show unhealed bite marks of *Basilosaurus*. Was this opportunistic snacking during shared birthing space or something more organised and periodic? Today predators gather at predation 'choke points'; bears at Canadian salmon runs, crocodiles at African river crossings, *Orca* at seal nurseries. Was this the case here? This is, of course, pure conjecture, but such conjecture changes these animals from dry bones in the desert to living

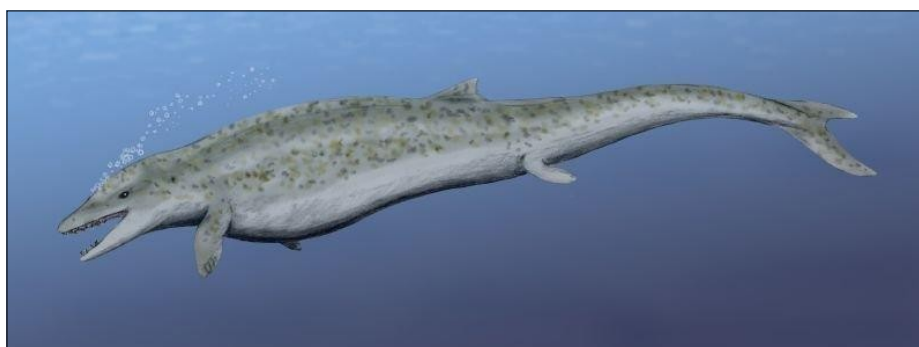


Figure 6: *Durodon atrox*, 'Spear tooth'

hunters in a rich biosphere. The BBC series 'Walking with Beasts' episode 2 reconstructs the Upper Eocene environment and follows the life cycle of an individual *Basilosaurus* which includes hunting *Moeritherium* and *Durodon*.

The Eocene of Pakistan provides two earlier markers in the story of whale evolution that reflect key stages in the process. From the Early Eocene comes *Pakicetus*, fig7. The skull of this small quadruped has some features in common with creodonts, wolf size carnivores, but others that relate to the earliest whales. With limited swimming ability its lifestyle has been

suggested as that of a carnivore which, due to resource famine, took to shore line scavenging and shallow water ambush hunting. *Ambulocetus*, 'the walking, swimming whale', comes from the Mid Eocene, 40/41Ma, fig.8. It was about the size of a sea lion and was far more adapted to the aquatic life with hind limbs further back along the body.

Powerful rear feet provided the main form of propulsion. Various degrees of amphibious mobility have been postulated. A strong case has been made for *Ambulocetus* being otter like, although seal like has also been suggested. With the *Basilosauridae* the transition to a fully aquatic mode of life can be

remembering at this point that none of these were species, these were 'stages towards' something else. They were animals fully adapted to their environment. The Eocene laid the foundations that would lead to many of our modern species and in doing so demonstrated the adaptability of the evolutionary process; a process that can move life from out of the sea onto land, from the land into the air and from the land back into the sea again. In his award winning update of Darwin's 'Origin', Steve Jones, the evolutionary biologist, notes that modern whales have their history embedded in their DNA and that today individuals are sometimes

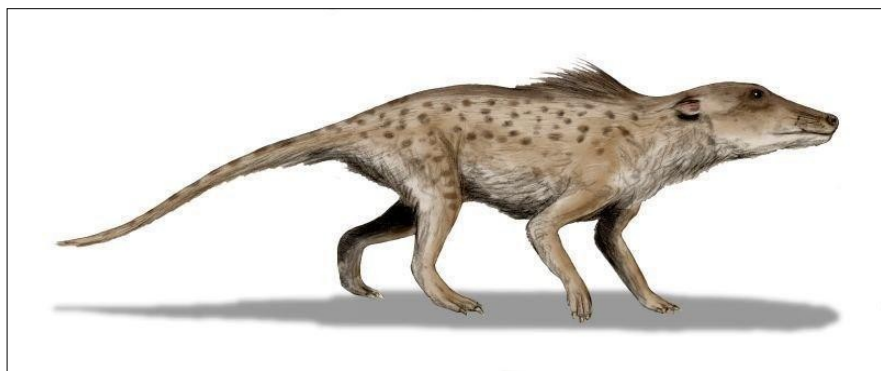


Figure 7: *Pakicetus*

born with vestigial legs. The title of his book 'Almost like a Whale' is on the front cover and above it is a photo, taken from below the surface, of a polar bear swimming. Polar bears are a present day species that due to resource famine, i.e. ice and/or seal, has individuals showing adaptive behaviour, swimming far greater distances than in the past. We may not see if this proves a successful survival technique for evolution seldom works in our timescale; the species alternative, extinction, all too often does.



Figure 8: *Ambulocetus*, 'the walking, swimming whale', from the Mid Eocene, 40/41Ma,

seen to have been made. It was in the later Oligocene and Miocene that whales diversified into the toothed and baleen types, although not directly from this line. It is worth

The first fossils were found at Wadi Hitan in 1902 and 1905 saw *Basilosaurus* finally adapted as the species name. Few people visited this comparatively remote area as the unique riches of the site were, over time, revealed. In more recent times the site suffered from the looting of specimens but now Wadi Hitan is a Special Protected Area within the Wadi Rayyan Protected Area and rangers patrol. Wadi

Hitan is, since July 2005, a World Heritage Site on par with our own Jurassic Coast. It is the one place in the world where the skeletons of these animals can be seen *in situ* and in some cases still articulated. In addition to the fossils, the desert scenery is spectacular. Day excursions from Cairo are possible and well worth a day away from the bazaars. Transport may vary but experience of deep desert travel suggests a modern 4x4 with forward facing seats is worth paying for. The Fayum is an under-visited area. The road south from Cairo passes pyramid sites off the usual tourist itinerary, including Abu Sir, Saqqara and Dashur, all three worthy of time and attention. Two important pyramids, Hawara and Maidum, as well as Lahun are in the Fayum. Other archaeological sites include the Ptolemaic Temple of Qasr Qarun and the ruins of Dionysias, a Ptolemaic-Roman town.

ACKNOWLEDGEMENTS

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Fig.3, Pavel Riha

Fig.4, Conty

Figs.6,7 & 8, Nobu Tamura

BIBLIOGRAPHY

Jones, S. Almost like a Whale. Anchor Books, (Transworld). 2000.

ISBN 1862 300025 9

Sampsell B. A Travellers Guide to the Geology of Egypt. American University in

Cairo Press. ISBN 977 424 785 X

Vivian C. The Western Desert of Egypt.

Chapter 7, The Fayum. American

University in Cairo Press. 2003.

ISBN 978 977 424 527 5

Joggins Fossils Cliffs, Nova Scotia, September 2012.

Open University Geological Society
Field Trip led by Prof. Brian Williams
and Prof. Ken Higgs.

Melissa Freeman

Joggins Fossil Cliffs at Chignecto Bay, Nova Scotia, is a UNESCO World heritage site situated on the eastern shores of the Cumberland basin and forms the northern extension of the Bay of Fundy. The highest tidal range in the world is experienced here, reaching 16.8 m twice a day. The cliffs contain a comprehensive record of Carboniferous coal-bearing strata with the most complete fossil record of Carboniferous terrestrial life in existence today; this includes the remains and tracks of very early animals and the rainforest in which they lived. On display is a 15 million year succession of sedimentary layers made up of ochreous sandstone (up to 30m high) forming the headlands. These are interbedded with thin layers of coal and there is a wide intertidal bedrock platform that runs into the sea. The low-grade coal seams, of varying thickness, exposed in the Joggins Formation, have been exploited since the late 1600s by local and British settlers. Large scale industrialisation came to the area in the late 1800s following the construction of the Joggins Railway. The mines were finally closed after a mining disaster in 1958 and the area is now a popular tourist destination.



Joggins Cliffs looking north