



Valley of Whales, Fayum oasis, Egypt: an Eocene window in the evolution of Cetaceans

The present-day Mediterranean Sea is the remnant of the Tethys Ocean a former tropical body of saltwater that separated the continental blocks of Laurasia from Gondwana during much of the Mesozoic and early Cenozoic Era. The Tethys Sea extended far south into Gondwana (i.e., northern Africa) and gradually retreated north depositing thick layers of fossiliferous marine sediments (sandstone, limestone and shale) of early Palaeogene age in the area of northern Egypt. This slow regression through millions of years created a northward moving shoreline separating between terrestrial and marine environments. Palaeomagnetic studies (Lotfy and Van der Voo 2007) suggest that this retreating shoreline crossed equatorial palaeo-latitudes in a tropical setting. A plethora of marine invertebrate and vertebrate faunal remains (including numerous skeletons of early whales, Fig. 1) as well as mangrove roots, were deposited in the shallow marine near-shore sediments at the Valley of Whales (Wadi Al-Hitan) area in the Western Desert of Egypt.

The Valley of Whales area is located 150 km to the southwest of Cairo in the Fayum oasis in the Western Desert of Egypt. It is covered by Eocene siliciclastic and calcareous rocks, which are divided into three sedimentary formations (Said 1962; Gingerich 1992) of Late Eocene age, that were deposited in a shallow marine environment: (1) Gahannam Formation, of Bartonian age (ca. 41.2–37.7 Ma), consists of white marly limestone and gypseous shale, overlain by (2) Birket Qarun Formation, of Priabonian age, made of sandstone, clay and limestone, and (3) the youngest (37.7–33.9 Ma) Qasr El-Sagha Formation (Gameil et al. 2016). The marine mudstones form the flatter ground areas today and the yellowish open marine sandstones forming most of the cliffs and buttes that were shaped by later wind

and water erosion under dry desert conditions, which gives rise to a fascinating and picturesque landscape (Fig. 2). The three Eocene sediment formations forming the Wadi Al-Hitan area are of high palaeontological interest; the Gahannam and Birket Qarun Formations host many vertebrate skeletons of four species of extinct archaic whales (archaeocetes), sirenians (sea cows) as well as shark teeth, remains of turtles and crocodylians, while the Qasr El-Sagha Formation contains a rich shallow marine invertebrate fauna (Gingerich 1992). More than 400 skeletons of whales are well-exposed and well-preserved in the area (Gingerich 1992). The largest whale skeleton found is up to 18 m in length and belongs to *Basilosaurus isis*, an early archaeocete first described from this site, that was a top predator in this fossil ecosystem (Voss et al. 2019). Rhizoliths of mangrove origin in a bay-margin or lagoon setting are common in the area (Abdel-Fattah and Gingras 2020).

The Wadi Al-Hitan site, thus, provides a rich fossil record of millions of years of coastal marine life about 41–37 million years ago. It is one of very few sites in the world that yield such a number, concentration and quality of such fossils in an attractive and protected landscape, because of that, it was included in 2005 by the UNESCO to the list of protected World Heritage Sites within the wider landscape of the attractive Wadi El-Rayan area (Badman 2005). These unique fossil-rich sediments enable to reconstruct the Eocene palaeoenvironmental conditions of a tropical marine shelf sea and its life forms. The palaeontological importance of the Wadi Al-Hitan site especially derives from its fossil evidence for the emergence and evolution of early whales as secondary aquatic, ocean-going mammals that developed from previous land-based ungulates. These archaeocete

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Fig. 1 A fossil whale spine and ribs of *Basilosaurus* in the desert of the Wadi Al-Hitan site



Fig. 2 View of the valley of Whales landscape with eroded buttes of marine sandstone of Birket Qarun Formation forming the bedrock of the Wadi Al-Hitan

whales (basilosaurids) represent an archaic and extinct group of whales, which are the forebears of all modern toothed and baleen whales. Fully articulated fossil whale skeletons with reduced hind limbs display the evolutionary transition from land to sea and are found today in a desert setting. This is not only an exceptional example for the evolution of life on planet Earth but also illustrates how environmental and climatic conditions can change over geological time scales: exposing marine whale fossils in a desert. The diversity of fossils in the Valley of Whales provides a unique window into Eocene marine life and environment, including the evolution of early whales. The Wadi Al-Hitan geoheritage is accessible through an asphaltic road from Cairo (Cairo-Fayum road) and then a desert track road (to Wadi Al-Ryan) to the protected site.

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Declarations

Conflict of interest We declare that there is no any financial or personal relationship or conflicts of interest with other people or organizations that could inappropriately influence this work.

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