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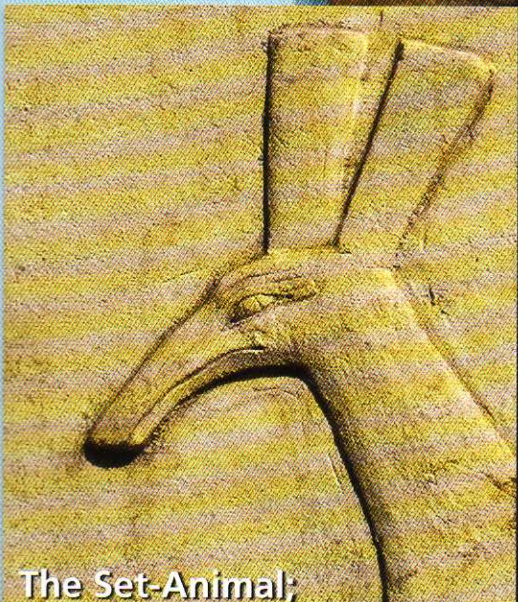
The History, People and Culture of the Nile Valley

Lord Carnarvon, Egypt and Tutankhamun



The Set-Animal; a real or imagined beast?

The Geology of Egypt and ancient Climate Change

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The Geology of Egypt

*The geological history of Egypt is complicated. Geologist **Colin Reader** gives an overview of the way the Egyptian landmass evolved and how the very nature of the country affected the ancient civilisation.*

The story of the evolution of the Egyptian landmass is not an easy one to tell. There are many gaps in the geological record and many of the processes that took place are little understood. This means that to give a 'comprehensive' account of Egyptian geology, a considerable amount of imagination (and space) is required. To keep this article to a reasonable length I have, therefore, had to generalise.

One other point to bear in mind is that the surface of the world has been anything but static throughout our planet's long history. As the position and shape of the world's land masses have altered through geological time, both climate and the associated ecosystems have also changed drastically. For example, during the Early Palaeozoic (some 500 million years ago[Mya]), Africa was part of a single huge southern continent, with Cairo located at about 70 degrees south and buried deeply beneath glacial ice. By contrast, palaeontologists working in the Bahariya Oasis have established that, at the time of the dinosaurs (some 240 to 65 Mya), this area of Egypt was swamp-land, similar to the Florida Everglades. Egypt, then, has not always been arid; in fact the current arid conditions may only have developed in the last four or five thousand years.

If nothing else, this will be a story of change, but not change at a galloping pace. The processes that shaped the Egyptian landmass will largely have occurred at the same rate as geological processes do today – that is, generally rather slowly. It is only because we have compressed huge swathes of time into a small number of pages that the pace of our story appears far more dramatic.

Figure 1: Geological Timescale

Eon	Era	Period	Epoch	Years ago	Time of day
Phanerozoic	Cenozoic	Quaternary	Holocene	10,000	
			Pleistocene	2 Million	11 59 PM
		Tertiary	Pliocene	5 Million	11 58 PM
			Miocene	24 Million	11 52 PM
			Oligocene	36 Million	11 49 PM
			Eocene	57 Million	11 42 PM
			Paleocene	65 Million	11 40 PM
	Mesozoic	Cretaceous		150 Million	11 13 PM
		Jurassic		200 Million	10 57 PM
		Triassic		240 Million	10 45 PM
	Palaeozoic	Permian		290 Million	10 29 PM
		Carboniferous		365 Million	10 06 PM
		Devonian		405 Million	9 53 PM
		Silurian		440 Million	9 42 PM
		Ordovician		520 Million	9 17 PM
		Cambrian		560 Million	9 06 PM
Pre-Cambrian				4600 Million	

Geological Timescales

In archaeology, as in most walks of life, the word 'ancient' is generally used to describe events within, perhaps, the last ten thousand years: hence the term 'ancient Egypt' nicely encompasses the period from the death of Cleopatra VII, through the Pharaonic Period and as far back as the earliest identifiable settled communities of the Predynastic Period.

To a geologist, such timescales are of little relevance. To discuss geological time adequately, it is necessary to consider tens, hundreds and even thousands of millions of years, with the words 'recent' and 'ancient' taking on meanings that, to the non-geologist, can be difficult to comprehend.

To help with this, a useful approach is to reduce the history of the earth to a single twenty-four hour day, with the various geological periods represented by the appropriate time of the day. This approach will be demonstrated shortly.

As shown in the table in Figure 1 *(see opposite)*, the geological history of the Earth is divided into two major periods, the Pre-Cambrian and Phanerozoic Eons, with the Phanerozoic having three principle subdivisions: the Palaeozoic (meaning ancient animal life), Mesozoic and Cenozoic Eras.

You will see from Figure 1 that the Pre-Cambrian Eon accounts for most of the earth's history, from the planet's formation, some 4,600 Mya, to a point about 550 Mya, when significant life can first be identified in the fossil record. On our 24-hour clock *(see the right-hand column in Figure 1)*, the end of the Pre-Cambrian, that is the dawn of most animal life on earth, occurred as late as 9 o'clock at night!

The Pre-Cambrian of Egypt

Most, if not all, of the Egyptian landmass is underlain at depth by Pre-Cambrian rocks, referred to as the Pre-Cambrian Basement. This name is particularly useful, as it correctly conveys the idea that these ancient rocks form a foundation or basement on which all younger strata sit.

Across most of Egypt, the presence of the Pre-Cambrian Basement has only been demonstrated by deep boreholes, usually associated with oil and gas exploration. As shown by the pink areas on the simplified geological map shown overleaf in Figure 2, however, at a number of locations, such as Aswan or the Red Sea Hills, the Pre-Cambrian rocks are exposed at the surface.

The oldest Pre-Cambrian rocks in Egypt have been tentatively dated to about 2,000 Mya (about 10:30 am on our 24-hour clock) and are thought to be the remains of an ancient continental landmass. Given their great age, these rocks have undergone tremendous earth-movements over immense periods of time. As a result of this long and complex history, the rocks of the Pre-Cambrian Basement of Egypt, which include such unique stones as the Imperial Porphyry quarried at Mons Porphyrites, are of great interest both academically and economically and contain a wide variety of metals and minerals, together with precious and semi-precious stones.

What Happened to the Palaeozoic?

Comparison of Figure 1 with Figure 2 shows that there is a huge gap in the geological record, with very few, if any, exposures of Palaeozoic strata found within Egypt. (The Palaeozoic strata are shown in grey on Figure 2 – you may need to look quite closely to find them!) Why would this be so?

Marine conditions are generally regarded as providing a depositional environment – over time, sediments accumulating on the sea-floor become lithified, that is, they become rock. Most, if not all, sedimentary rocks are laid down under marine conditions. By contrast, when land is elevated above sea level, deposition gives way to largely erosive conditions in which the action of rivers etc, modifies the landscape. Consequently, the worldwide geological record largely reflects marine conditions and, with some exceptions such as volcanic rocks or wind-blown deposits, there is little to record events on land.

Except for a small number of isolated examples, such as in the Gilf Kebir region of south western Egypt *(see Figure 2)*, there are very little Palaeozoic strata in Egypt, either exposed at the surface or found at depth. On our 24-hour clock, the Palaeozoic Era extends from just after 9 pm (555 Mya) to about 10:45 pm (240 Mya). This huge gap in the geological record can probably be attributed to the landmass that we now know as Egypt having been raised above sea level throughout this immense period of time.

The Nubian Sandstones

During the long reign of the dinosaurs, throughout the Mesozoic Era (from 240 to 65 Mya or 10:45 to 11:40 pm, Egypt was progressively inundated by the sea from the north. During the early Triassic, the sea appears to have covered only the extreme north east of Egypt, resulting in limited deposits of Triassic strata, only in the Sinai. By the Cretaceous (150 Mya – 11:15 pm) most of the country was, however, under fully marine conditions. The rocks formed from the sediments laid down in this, the Tethys Sea, are generally known as the Nubian Sandstones.

As can be seen from Figure 2, the Nubian Sandstones (coloured green on the map) are exposed across large parts of Egypt, generally south of the latitude of Asyut. In the north of the country, a number of more limited Nubian Sandstone exposures occur. These include a thin north-south strip to the west of the Pre-Cambrian strata of the Red Sea Hills and the rocks of the Bahariya Oasis, to the south west of the Fayum. The Bahariya Oasis has proven to be an area of immense interest for dinosaur hunters – the home to previously unknown species, including some of the largest dinosaurs yet identified.

Towards the end of the Cretaceous, the northern part of Egypt (north of Asyut) was subject to earth movements on a large scale, which folded the strata of the sea floor into a series of northeast-southwest ridges and troughs. This northern folded area of Egypt has been dubbed the Unstable Shelf and the areas to the south, which appear to have largely escaped the effects of the folding, are referred to as the Stable Shelf. The undulations of the northern Unstable Shelf area played an important part in the geological evolution of sites such as the Giza Plateau.

Overlying the Nubian Sandstones, and representing the uppermost Cretaceous strata, are beds of fine white limestones (or chalk). These chalk deposits have been exposed in limited areas only, such as the White Desert, in the area of the Farafra Depression *(see Figure 2)*.

Cenozoic Strata

The Cenozoic Period represents the last twenty minutes or so of our 24-hour day. This period, however, is the time during which the limestones that cover much of Egypt (in blue on Figure 2) were laid down, under extensive tropical seas.

In terms of the evolution of the Egyptian landscape, the Cenozoic is the most significant period and, in order to understand this evolution, we need to break the Cenozoic into a series of smaller sub-divisions, or Epochs, as shown on Figure 1.

The earliest of the Cenozoic Epochs, the Palaeozoic, was a fairly quiet period and the few Palaeozoic deposits that have been mapped are of not great significance for our story. It is the subsequent Epochs, the Eocene, through the Oligocene and beyond to the Quaternary that will be explored in the rest of this article.

In the Eocene (from about 20 minutes to midnight or 57 Mya), the landscape was very different from that at present. Neither the Red Sea nor the Nile existed and what will become the Mediterranean was a much greater expanse of water – the Tethys sea – which extended a considerable distance south of Asyut, covering the Unstable Shelf in the north and parts of the Stable Shelf further south.

Relatively thin Eocene sediments were laid down on the flat-lying Nubian Sandstones of the Stable Shelf area. As the Eocene progressed, however, and the shores of the Tethys retreated to the north, more substantial Eocene deposits were laid down over the undulating surface of the Unstable Shelf. Although huge thicknesses of limestones had been laid down by the end of the Eocene (36 Mya or 11:49 pm), much of this has subsequently been eroded away. In many areas in the south of Egypt, as well as areas such as the Bahariya Oasis (as discussed above), this erosion has once more exposed the underlying Nubian Sandstones.

Although the Nile river system had not developed at this stage, there is evidence for the development of other huge river systems in North Africa. To the west of the Fayum, the rocks of the Eocene include fossilised wood, the remains of trees carried downstream and deposited in a huge river delta. Eroded fragments of these trees can be seen today, scattered across many of the pyramid sites.

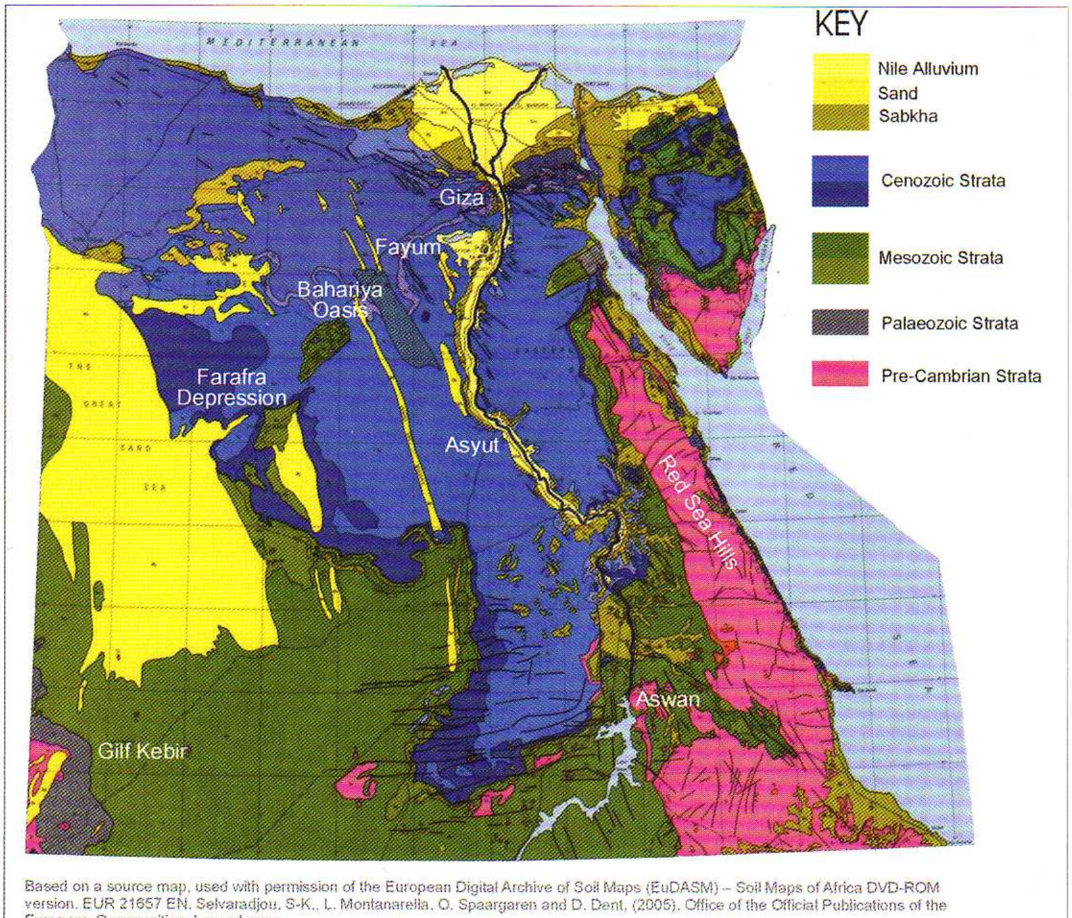
As we enter the Oligocene (36 Mya or 11:49 pm), things start to get more interesting. The Red Sea has not yet opened up and, as a result of the northward retreat of the Tethys Sea, the northern Egyptian coast now lies at the approximate latitude of Cairo. This northward retreat of the Tethys had been underway since the Eocene and is thought to have been the result of earth movements, which were lifting the North African landmass. As this uplift continued through the Oligocene, run-off from the most elevated areas in the east of the landmass led to the formation of rivers which drained to the north into the Tethys.

The uplift of the region also led to the build-up of tension in the crust, along an approximate SE-NW axis through the African landmass and into eastern Asia. This tension was shortly to result in the formation of a series of rifts and faults – tears in the crust – which led to the formation of the African Rift Valley and the Red Sea. The elevated margins that bordered these rifts formed mountainous regions that included the Red Sea Hills.

Run-off from the mountainous regions around the Red Sea formed new rivers, which eroded the mantle of Cenozoic and Mesozoic strata and exposed the underlying ancient Pre-Cambrian strata, as a series of rugged mountain ranges. These mountains, in the Eastern Desert and Sinai, contain a rich variety of rock types and associated mineral wealth. Volcanic activity, which accompanied the continued opening of the Red Sea, also led to the intrusion of younger igneous rocks into the ancient strata of the Red Sea Hills. By the mid- to late-Miocene (about 5 Mya), run-off from the Red Sea Hills had developed into an enormous southward-flowing river system, referred to as the Qena River.

As a consequence of the continued uplift of

Figure 2: Geological Map of Egypt.



Based on a source map, used with permission of the European Digital Archive of Soil Maps (EuDASM) – Soil Maps of Africa DVD-ROM version. EUR 21657 EN. Selvaradjou, S-K., L. Montanarella, O. Spaargaren and D. Dent, (2005). Office of the Official Publications of the European Communities, Luxembourg the African landmass, but also possibly due to a global reduction in sea level, the Tethys had shrunk so much by the late Miocene (about 5 Mya or three minutes to midnight) that it appears to have dried out across large areas of what is now the Mediterranean basin. This reduction in sea level lowered the base level of many of the rivers that drained into the sea along Egypt's northern coast. Rejuvenated in this way, these northern rivers then began aggressively to erode their channels into deep canyons, which also began to cut inland towards the south. This more aggressive phase of river erosion led to possibly one of the most significant episodes in the history of the Nile region.

As erosion in one of these northern rivers continued, the river's headwaters advanced southward towards the existing Qena River system, towards the point we know today as the Qena Bend. At some point and, geologically speaking this must have happened 'overnight', the channel of this northern river broke into the channel of the Qena River in what must have been a catastrophic event. Within a very short period, the long-established southward flow of the Qena River reversed, to flow to the north along the very young, over-deepened canyon of the northern river and out towards the North African coast.

At the Qena Bend, where the two rivers met, the floor of the northern river canyon may have been much lower than that of the Qena, resulting in what was possibly a huge waterfall at the point of river capture. Continued erosion will have aggressively eroded the southern sections of the former Qena River system, ultimately forming a new composite river – the Eonile.

The Eonile channel was enormous, longer and deeper than the Grand Canyon in the USA. Although previous rivers had been largely free to meander across the landscape, given its huge size, the Eonile canyon for once fixed the course of the Nile. Although the Nile system was still to undergo a great deal of evolution before settling into the modern system, the course of the river was forever to be confined by the towering walls of the Eonile canyon. These walls can still be seen today and graphically illustrate the scale of the Eonile. The tall cliffs that border the Nile Valley many miles from today's river, at places such as Dier el Bahri *(see below)*, are the walls of the Eonile Canyon.

At some point in the Pliocene, for reasons that are not yet fully understood, the waters of the Atlantic Ocean breached the Straits of Gibraltar and the dry Mediterranean basin was deluged. This deluge flooded the over-deepened Eonile canyon, and the Eonile valley was transformed into an arm of the sea that reached as far south as Aswan. The depth of these marine waters can be gauged today by the presence of a coarse shelly sandstone, which marked the shore of the inland sea. These beds *(see below)* can be found on top of some of the highest hills at sites such as north Saqqara, at about seventy metres above current sea level.

Since the deep erosion of the Eonile canyon in the late Miocene and the flooding of the canyon by the Pliocene sea, the evolution of the modern Nile has progressed through a series of stages, as discussed below.

Nile Evolution

It has been estimated that, by the late Pliocene (some 2 Mya), marine sediments had accumulated to fill approximately half of the Eonile canyon. By this time, however, the marine conditions in the Eonile canyon had been under increasing influence from the rivers, which flowed from the areas to the east and west of the Nile (areas which are now deserts) and from the remains of the Eonile, which discharged into the southern end of the inland sea. Gradually during the Pliocene, therefore, marine conditions gave way to brackish and then freshwater environments.

The Palaeonile was the earliest river that flowed within the Eonile Canyon and existed from the Pliocene and into the Quaternary (from about 3·5 Mya to 1·8 Mya). The sediments associated with the Palaeonile are characterised by red-brown deposits, caused by erosion in the Eastern Desert area. The end of the Palaeonile phase, as with all other phases of the Nile's evolution, was marked by an arid period during which flow along the Nile appears to have ceased. By the end of the Palaeonile phase, however, the deep Eonile canyon had become almost completely filled with marine, estuary and river sediment.

The arid event that brought an end to the Palaeonile phase of Nile evolution was superseded by a wet phase, which introduced the subsequent Protonile phase and led to the deposition of extensive coarse quartz and quartzite gravels, which can still be seen across many parts of the Nile Valley.

Deposits laid down during the next phase of Nile development, the Prenile (800,000 to 400,000 years ago), included, for the first time, material eroded from the Ethiopian highlands. Whilst this can be seen as the onset of the modern Nile system, the Prenile stage ended in yet another period of relative aridity, in which flow from Ethiopia was interrupted, to be replaced by flow once more from the Red Sea Hills and through the system of wadis that flow through the Eastern Desert. It was only in the final (and current) stage of Nile evolution (the Neonile – from approximately 12,000 years ago) that the connections with drainage from Ethiopia were re-established, though on a much smaller scale than for any of the earlier river stages.

CONCLUSIONS

The landscape of Egypt is the product of a long and often tortured geological evolution, which reaches back almost to the origins of the planet. Yet so many aspects of ancient Egyptian civilisation are linked with this geological evolution: from the gold that was mined in the Eastern Desert, to the Aswan granites and the Tura limestones used in the Pharaonic building works. This geological evolution also led to the development of the ancient cliffs of the Eonile that form both the steep edge of the Giza Plateau and the shelter beneath which the Mortuary Temple of Hatshepsut nestles and may, according to some authorities, have influenced the name of Egypt's first capital, Memphis – the White Walls.

None of this, however, is likely to have come to be if it were not for an ancient river which, under the influence of a dried-out Mediterranean, eroded south into its hinterland and, probably quite by chance, broke into the channel of the Qena River. Overnight, the southward flow of the Qena reversed, so that a new river system evolved which, in time, brought seasonal floods and fertile sediment from the Ethiopian highlands.

It is often said that Egypt is the gift of the Nile, yet civilisation is unlikely to have developed in Egypt if it were not for the geological events that led to the evolution of the Nile system.

Colin Reader

Colin is a geologist with a deep interest in ancient Egypt, in particular in the way its geology helps us to understand the history of ancient Egypt and some of its famous monuments, such as the Great Sphinx at Giza. Colin is a regular contributor to AE.

Further Reading

Bonnie M. Sampsell, *A Traveller's Guide to the Geology of Egypt.* AUC Press, Cairo, 2003.

Image Credits

Figures 1 and 2: as detailed on Figure 2.

Deir el Bahri photo: RP. Fossil photo: the author.