

**The Geology of Ancient Monuments:
When human hands meet stone**



Since antiquity, humans have used geological materials for constructing dwellings and various monuments for religious or spiritual purposes.

In this lecture, we will examine the geological and cultural significance of some of the more famous types of stone monuments:

- The Egyptian pyramids
- The Great Sphinx
- The Easter Island statues

Pyramids of Egypt

Of all the ancient monuments built by humans, the pyramids of Egypt are arguably the most famous.

Egypt hosts over 100 (110 currently known) pyramids in total.

To most people, the pyramids of the Giza plateau are the most familiar.



Burial Traditions

The earliest (Pre-Dynastic) Egyptians probably buried their dead in pits, along with possessions to accompany them into the afterlife.



Later on (beginning ~ 5500 years ago), rectangular mud-brick and stone structures (mastabas) were constructed to cover the graves of members of nobility. Unlike pyramids, these had flat roofs.



Djoser's Step Pyramid

The first tomb to be constructed entirely of stone was that of Pharaoh Djoser (Zoser) – built in 2800 B.C. in Saqqara.



This was an elaboration of the mastaba (a step pyramid is basically several (6) mastabas stacked atop one another)

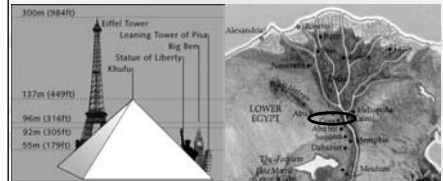
This early pyramid (called a step pyramid), made of limestone, represents a prototype of the more streamlined (and much larger) pyramid designs that came later.



Saqqara

The Great Pyramid of Khufu (Cheops)

The largest of the Egyptian pyramids (nearly 140 metres tall) is the Pyramid of Khufu (Greek translation = Cheops), located on the Giza plateau.



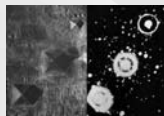
Time of construction: approximately 2589-2566 BC.

Why Build a Pyramid ?

Many scholars think the pyramid shape was an important religious statement for the Egyptians, the edges of the pyramid symbolizing the slanting rays of the sun. The utmost deity in the Egyptian religion was the sun god Ra—the creator of everything. The common interpretation of the ancient Egyptians as true "sun worshippers" is, however, questionable.



Others speculate the sloping sides were intended to help the soul of the king climb to the sky and join the gods.



Still others have argue that the orientations of the great Giza pyramids have some connection with the three stars in Orion's belt (centre of the Orion constellation).

Some Interesting Considerations

It is conventionally believed to have taken 100,000 labourers about 20-30 years to build the mammoth Khufu pyramid, using an estimated 2.3 million stone blocks (but some people argue that it could have taken as few as 20,000 labourers to finish the job in 20 years).

Each block weighs an average of about 2.5 tonnes.

Crews apparently dragged or pushed limestone blocks up mud-slicked ramps to construct the gigantic structure.

It is believed that most pyramid building occurred during periods when the Nile was in flood stage (June-November). This would have enabled farmers to contribute to the labour pool.

Nile flooding is also likely to have permitted more effective transport of building materials by water (on barges).



A limestone plaque (Dream Stele) between the paws of the Sphinx bears the name of Khafre, but the context is not known (much of the limestone surface has flaked off).



In any case, the plaque is a much later addition, having been installed by the pharaoh Thutmosis IV to commemorate the removal of sand from the Sphinx's enclosure around 1400 BC.



Some scholars believe that excavation of the sphinx and erection of the plaque were done for political reasons (Thutmosis IV was not first in the line of succession and appears to have overthrown his brother to become Pharaoh).

Also, the lower levels of the Sphinx have been covered by sand for significant periods of time (sand was cleared by the pharaoh Thutmosis IV around 1400 BC and again in the 20th century).

This shortens the time available for significant erosion (in the conventional interpretation).



The Sphinx as it was observed by Napoleon in 1798

The climate of Egypt is known to have much wetter between about 5,000 and 8,000 BC – is it possible that the Sphinx significantly predates the pyramids ?

How Old is The Sphinx ?

Geological observations suggest that the Sphinx (or at least its body) may have existed well before the time of Khafre.



The controversy concerns erosional features observed on the Sphinx's body.

It is known that Giza has been bone-dry since 2500 BC, and yet the Sphinx's body and walls of the enclosure bear a gullied surface that is typical of erosion by running water (recall the badland topography discussed a while back).



Gullied erosion patterns in walls of enclosure

The paws and head of the sphinx lack these gullies (carved from the harder limestone that was used to build the pyramids).

Another Possibility: From Eyesore to Art

Another possibility for the construction of the Sphinx is that the Sphinx's body started as quarry that ultimately proved unsuitable as a source of construction stone and was abandoned.

Although Giza was a perfect place for building pyramids, the hump of limestone left from unfinished quarrying would have spoiled the view.

Perhaps, the Sphinx was a fancy dress-up act to convert an ugly blemish into an aesthetically attractive monument ?

On to the next topic...

Rapa Nui (Easter Island)

Located about 3,700 km west of Chile in South Pacific

The island first became known to the world when it was discovered by Dutch sea voyager Admiral Jacob Roggeveen on April 5, 1722 (Easter Sunday of that year).



Famous Stone Statues of Easter Island (Moai)

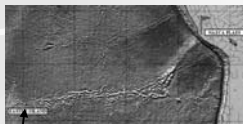
Easter Island was constructed by basaltic lava and pyroclastic debris (volcanic ash) sourced from mafic mantle material.

The most famous features found on Easter Island are the huge statues (Moai) carved from consolidated volcanic ash. Most stand about 5 metres tall and weigh about 20-40 tonnes. For the most part these were carved as one piece (monolithic).



Geologic Setting

Easter Island is located at the western end of the Sala y Gomez seamount chain, representing a chain of volcanoes produced by plate movement over a stationary mantle hotspot (similar to Hawaii).



Easter Island



Who Were the Islanders ?

Based on genetic evidence, it is believed that Easter Island was first settled in by seafaring Polynesian people from the west.

Easter Island is believed to have been first settled by about 700 AD.

For hundreds of years, Easter Island was an isolated paradise with a distinct culture.

As part of this culture, islanders created skillfully carved terraces and small statues.



Easter Island

History of Colonization of Easter Island

By about 1220 AD, the islanders were building ceremonial stone platforms called ahu, upon which the famous giant stone statues (Moai) were erected.

The largest statues weigh up to 80 tonnes!

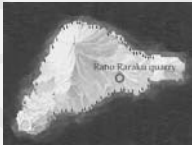


Ahu (statue platform)

Construction of Moai

Approximately 900 Moai, in various stages of construction, have been found on Easter Island.

Unfinished moai have been found in cliffs of the volcanic crater Rano Raraku, indicating that they were carved at this site.

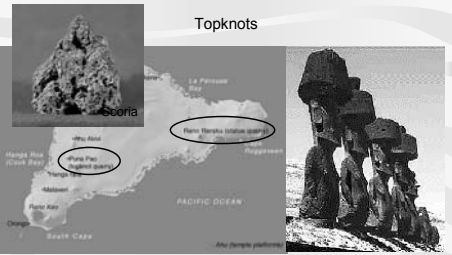


Location of Rano Raraku quarry



Partially carved moai beside a crater cliff

Topknots



Red topknots, preserved on some of the statues were quarried from iron-rich, porous (vesicular) basaltic rock (actually mostly glass) called Scoria (the red colouration is due to presence of hematite- a weathering product) at Puna Pao.

Tools Used for Moai Carving

Axes made of non-porous basalt appear to have been used to carve the statues.



Basalt axes used to carve moai

What do the Moai Represent ?

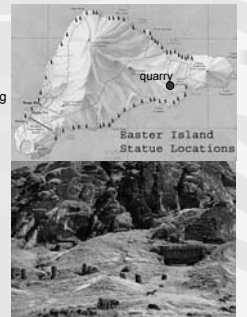
The current interpretation of the function of the Moai is that these statues were constructed as guardians of the island people.

The moai were apparently constructed by the ruling class of the island, the "long ears."



Transporting the moai to their final resting sites probably involved sliding the Moai down the side of the crater and moving them longer distances with the aid of log rollers.

By the time the Dutch explorers arrived at the island, all of the Moai had been knocked over (they have since been re-erected by various parties).



Ahu were believed to have been used, at least in part, for burials, cremations etc. of the ruling class.

The statues were thus thought to be fashioned in the likeness of the person buried beneath the ahu upon which they stand.

It is said that once the obsidian pupil was added to the coral eye of a statue, the dead king was born again inside the statue.

It is speculated that the statues were carved without legs to prevent the statues from walking around



Reconstructed Moai with eyes made of coral and obsidian.

Why War ? : The Demise of a Nonsustainable Society

The demise of the Easter Island population appears to be linked to poor resource management (we could learn from this).

Note that Easter Island is very small (22 km x 11km), so resources were quite limited to begin with.

Pollen analysis indicates that by about 1600 AD, trees (the primary source of material for fuel, the building of homes, boats, and tools for fishing) became extremely scarce.

In addition, soil erosion that resulted from the loss of trees made farming difficult.

As a result, food became scarce and the islanders turned against one another (archeological evidence suggests that even cannibalism became common practice).



The Final Blow

A desperate attempt to ration resources via contests among tribes restored peace to some extent, but this was temporary.

In 1862, Peruvian slave traders took away 1,500 islanders (1/3 of the surviving population)- within one year all but 15 died.

Survivors that returned to Easter Island brought back smallpox, which killed all but 111 people on the island.

Many details of the ancient Easter Island culture will never be solved, as the oral traditions of the culture died with the last of the native islanders (all of the present inhabitants are from Chile).

END OF LECTURE