THREE LECTURES

CONCERNING

THE GEOLOGY OF EGYPT

BY

Professor E. SICKENBERGER, Medical School. — Cairo.

READ BEFORE THE STUDENTS OF THE SCHOOL OF THE ULEMA

June 1891.

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By permission of H. Exc. the Minister of Public Instruction, and in consequence of an invitation from the Rector of your College, I have the honour to explain to you in a short summary the actual state of our acquaintance with the geological formation of our country. To have some knowledge of the soil where we live, and from which we obtain harvests, and the materials for our habitations and for our industry, may be very useful.

I begin with those generalities that are absolutely wanted, and I shall present to you afterwards the particularities of Egypt.

A mineral is the name of everything that is not of artificial origin and which has no life in the sense of the life of animals or plants. Minerals do not increase from the interior to the exterior like animals or plants. Minerals do not take any food that can be digested in the body to increase their substance; they increase only by the external addition to themselves of matters which are not digested.

The Science of Minerals is called Mineralogy, and its divisions are: —
Mineralogy Proper, the knowledge of the simple minerals.

Geognosy, the knowledge of the compound stones and rocks forming the globe.

Paleontology, the knowledge of the fossils or remains of former beings now petrified in the earth.

Geology Proper, the science of the origin and transformation of rocks.

The Auxiliary Sciences to Mineralogy and Geology are:

1) Geometry, for Crystallography, or the knowledge of the forms of Crystals.
2) Physics and Chemistry.
3) Botany and Zoology, for the knowledge of fossils.

All minerals are either crystallized or amorphous. Crystallized minerals are those of which every specimen is bounded by regular straight mathematic lines and planes.

The origin of all rocks is due to Fire, or to Water, or to Air.

**Fire.**

If a hole is made in the earth, the temperature increases by 1° Centigrade to each 110 ft. Therefore in the interior of the earth a point will be found as hot as boiling water, and there is still deeper another point where everything will be in igneous fusion. This opinion is confirmed by the circumstance that certain springs reach the surface, as a heat much more considerable than that of the surrounding soil. There are springs whose temperature
surpasses that of boiling water. These springs are forced up in consequence of pressure, and a few of them have in solution a quantity of silica; they are generally called Geysers.

There are mountains with an aperture from whence they throw from time to time matter in igneous fusion, hardening by refrigeration, called lava. This matter is so hot that if a piece of iron, or of stone like granite, is put into the liquid, it will be melted immediately. If this matter refrigerates slowly the different minerals which compose the mass have time to crystallize one beside the other, as may be seen in granite. If the refrigeration is more rapid, you see, as in porphyry, only one part of the mass crystallized, and the other in a non-crystallized, amorphous state. Here only felspar is separated in crystals; the quartz and mica have not had sufficient time to separate.

If the whole mass is refrigerated very quickly, it all appears as a stone without any crystallization like obsidian and lava.

There is no clearly defined limit between these three states but transition from one to the other in proportion as the refrigeration has taken place slowly or quickly. There are stones which are in appearance without crystallization, but which, under the microscope are seen to be composed of very small crystals: they are called microcrystallized.

In all rocks of igneous formation no remains of organic matter or fossils have been found.
Water.

If a rock of igneous origin is under the influence of differences of temperature, the single minerals which compose it are neither expanded nor contracted in the same degree. Their cohesion is also diminished and ultimately is completely destroyed. The stone is split, and falls in small pieces. If water as rain or dew enters into the clefts, dissolving some parts of the stone, or only acting by the difference of temperature or both combined, the result is the same.

The water takes away small pieces, as is evident when the water of the increasing Nile becomes red by the mud resulting only from the above mentioned decomposition of the rocks of mountains in the interior of Africa. The stream deposits in its course first the heavier and afterwards the lighter matter in suspension, always carrying some of it into the lakes or into the sea. Here the mud is deposited in regular strata according to its specific gravity, and at the same time are deposited with it the remains of animals and plants living in the same country, brought down by the stream or fallen by accident into the water. These remains now bedded in the mud are petrified and preserved for all time in rocks that are formed in this way. It is possible by means of the fossils found in rocks to determine the relative age of each formation that contains them.

It is also not difficult to know if any stratum has been deposited by fresh or by salt water, by seeing whether the fossils belong to species living in fresh water or in the sea.
Organized beings begin with animals and plants of simple construction: the more the organization of the fossils is complicated, and similar or identical with those that are living now, the more recent is the date of the formation. The sea, the mother of organized beings, has retained in solution all matters soluble in water since the separation of the land from the water. These substances act chemically on the mud and on all substances brought by the streams; and they change or vary the quality of the deposits which are formed. Pure sea-water if it is brought to spontaneous evaporation precipitates, first, the marl and the hydrate of the oxide of iron; then carbonate of lime, then gypsum, afterwards chloride of sodium, then sulphate of magnesium, chloride of magnesium, and finally bromides and iodides. Deposits of chloride of potassium commence during the deposition of chloride of sodium, and accompany all the following deposits.

Rivers bring to the sea, besides mud, different salts in solution, which augment the contents of the sea, and which constantly become more concentrated by its evaporation, where the salt does not evaporate and which will also be deposited by the sea in the degree in which the content is not more soluble in sea-water in proportion to the temperature.

If afterwards these deposits become dry land, either by the elevation of the bottom or by the retreat of the water, it is possible to examine them, and to determine their quality and their relative age.

The Mokattam, whose layers contain so many fossils may serve as an example.
The rocks formed by deposition under water are called Sedimentary Rocks.

They are classified according to their relative age, as Primary, Secondary, Tertiary, and Quarternary formations.

The rocks of these different formations do not present any differences; breccias, sandstones, limestones and marls, occurring in all of them, and distinction is only possible by a comparison of their fossils.

The primary formation is characterised by fossils of species which are now extinct, of corals shells and crabs of a very simple organisation. Of vertebrated animals there are to be found only fishes with a cartilaginous skeleton, of marine vegetables only some algas, and of terrestrial plants only cryptogams, ferns, some of them arboreous indicating a hot and moist climate, and furnishing the material for pit-coal.

In the layers of the secondary formation are found mollusks and fishes of a more developed organisation; many kinds of sharks, some echinites and insects, gigantic lizards and some flying lizards; the first birds, and of mammals only a few carnivorous marsupials. There appear also cycadeous and coniferous trees, generally forming an intermediate stage between those of the primary formation and those of the present time.

In the tertiary formation occur species of animals and plants which are of the same kind as those living to day associated with others now extinct.

This formation is divided into three parts: —

The Eocene, containing only a few of the species occurring to day;
The Miocene, containing about half of them;
The Pliocene, containing many more of the species
which are now found.

The Quarternary formation comprises all rocks and
layers which are of recent or modern formation. The
marine sandstone near Alexandria and the layers of Nile
mud may serve as examples. Some remains of mankind,
and objects bearing signs of human labour, are found.

Air.

The air has a similar action on rocks and stones to
water. The wind, often bearing sand, carries away
from the stones scraps which have been formed by dif­
ferences of temperature, and the action of humidity.
They are accumulated or dispersed, and by the aid of
rain or, dampness, chemically decomposed. All contents
are taken away, the silica only resists, and remains in
the form of grains of sand, rounded by the friction
operated by rolling in the wind, like the hills of quick­
sand near Khankah.

The wind also carries dust of marl and chalk, and in
this way, if there is any little humectation by rain or
dew, is formed natural ashlar, which soon hardens into
breccias or sandstone in layers of considerable extent, as
in the desert near Cairo.

The silicious sand, under the action of the air and
under the influence of differences of temperature and
humidity in contact with a small quantity of fine alu­
minous dust, brought by the wind, is solidified, and
changed into a very hard and often much resistant
sandstone.
It is always possible to ascertain the origin of stones formed in this manner by examining remains of the original rock which has furnished the sand. These primary stones are in general not far from the sandstones of the derived formation. In the Nubian sandstone occurring in so large an extent in Upper Egypt, are found fragments of hornblende, which proves that it is derived from the Syenitic granite; in another sandstone is found white mica, if it is the result of the decomposition of pegmatite rocks. If the wind carries lime the action is complicated, and the formation of calcareous sandstone takes place, as in Upper Egypt in the neighbourhood of lime stone. This latter circumstance greatly facilitates the formation of sandstone.

The sand, moved by the wind, gnaws and polishes the rocks, and has the same effect of erosion as water, the Wadies in the desert are a good example of this.

These formations, submitted to the same action of the air, are again decomposed and reconstituted so that the desert is always undergoing change, like the rest of Nature.

Rocks formed by the action of the air are called eolic formations.

Let us now enquire into the properties of rocks of different origins.

\textit{a) Of old igneous formation.}

The chief stone of this formation is granite and its varieties. This is the primary material of all other rocks. Its origin is due to slow refrigeration under a
very high pressure, this pressure having been caused by the weight of the atmosphere, which was as much greater as the temperature of the earth was higher than to day. Granite is composed of quartz, felspar, and mica. The quartz is pure silica and the others are multiple silicates of alkali, earths, iron and manganese, and they furnish by decomposition material for other rocks. The crystals of the component matters are well developed, one beside the other. The stone is called "granite" because the component crystals resemble grains.

The following are the most important rocks which occur in Egypt: —

1) Granite proper, — quartz, potassic felspar, and coloured mica.

2) Pegmatite, — quartz, potassic felspar, and white mica.

3) Syenitic granite or syenite proper in the old sense, the mica substituted partially or entirely by hornblende.

4) Diorite, — the potassic felspar is substituted partially or entirely by sodic felspar, and the mica by hornblende.

5) Amphibolic rock, — quartz and hornblende.

Numbers 4 and 5 are generally in practice called Diorite, because there is often no difference or only a very slight one in their appearance, and transition or intermediary rocks occur.

Gneiss is stratified granite.

Mica schists and amphibolic schists are called granites when the mica or the hornblende are in regular layers so that the stone splints like slate.
b) Of recent igneous or volcanic formation.

1) Trachite — a grey felspathic friable mass, with crystals of felspar or mica.

2) Basalt and its varieties — black rocks not friable of amorphous felspathic mass with magnetic iron.

3) Lava — the liquid ejections of actual volcanoes, indurating to a scoriaceous and vesiculous, or vitreous structure.

The age of these rocks is to be determined by the circumstance that the sedimentary rocks in contact with those igneous rocks are altered in their stratification or composition if volcanic rocks have passed through them in a liquid state; that occurs only when the sedimentary rocks are older than the igneous. The transformation of the sedimentary rocks by heat is called metamorphism. If the sedimentary rocks touching the igneous rocks are not changed the former are more recent.

c) Of sedimentary and eolic formation.

These are classified: —

(I) According to their structure, in heterogeneous and homogeneous rocks.

The heterogeneous are: —

1) Pudding stones and Breccias — big fragments of different stones, cemented together.

2) Sandstones — small cemented fragments of different stones.

3) Heterogeneous sand without cement.
The homogeneous are: —
1) Homogeneous rocks.
3) Homogeneous sand.

(II) According to their chemical composition: —
1. Silicious Rocks.
2. Argillous Rocks, or marls.
3. Calcareous Rocks, or limestones.

All rocks which are easily divided in leaves are called slates, or schists.

II.

The rocks of different origin are distributed in the country as follows: —

From the high mountains of igneous origin in Abyssinia comes a branch in a northern direction between the Nile and the Red Sea. Some of its summits attain the height of 6,500 ft. This branch ends near Gebel Zed, but reappears in the Sinai Peninsula forming the mass of Sinai, 8000 ft. high. This chain sends out in a western direction other branches which occasion the cataracts of the Nile. Two of these belong to Egypt proper, the cataract of Wady Halfa, and the cataract of Assouan. These mountain branches are composed of granite, porphyry, gneiss, and amphibolic rocks, and particularly at Wady Halfa and at Assouan, of Syenitic granite, diorite, and of transitions from one to the other. Granite without hornblende and pegmatite is not much developed; neither is porphyry.

In the range between the Nile and the Red Sea there is more porphyry; the granite and the amphibolic rocks occupying only the second rank.
The diorite at the cataracts is often microcrystallized, black, and formed like trap rock. On account of that some ancient authors have called it, and taken it for basalt.

In the Gebel Doohan are quarries of the imperial red and white porphyry — porfido rosso antico — which was employed to decorate palaces belonging to the Roman and Byzantine emperors. Near these quarries are to be seen ruins of ancient Roman buildings, and under Emperor Hadrian a large penal settlement was there. This red porphyry is even now much desired in Europe, and of great value. There is also some very good black porphyry, spotted with white.

Volcanic rocks proper only occur near Aboo Zabel. Here are some small eruptions of a kind of basaltic rock termed Dolerite, because it has an almond-like structure. It contains a few minerals and small crystals, especially olivine.

SEDIMENTARY FORMATIONS.

The granitic formations of Wady Halfa and of Assouan are accompanied by a sandstone without fossils. The sandstone continues downwards, and has been considered to be of sedimentary origin; but it becomes now more and more evident that these rocks belong to the Eolic formation, and on account of that I shall treat them in that chapter.

The primary sedimentary formation occurs in small development in the Wady Arabah between the Nile and the Red Sea. Here there are limestones with fossils of
the Devonian formation, and in the Wady Redisieh are some carboniferous slates. But all researches for fossil coal have been fruitless.

The secondary formation, comprising in Egypt the cretaceous formation supports in the Upper country the tertiary formation, and reaches the soil to the West of the Gizeh pyramids, near Aboo Roash, at the foot of the Gebel Attaka near Suez, and at some places between the Nile and the Red Sea. The secondary formation is characterised by a quantity of flints, and fossils called ammonites and hippurites.

The tertiary formation, characterised by nummulites and echinites, begins at 25° 10’ near Edfoo with the layers called Suessionian, including the oyster Ostrea janigena and Ostrea pterygota. These strata belong to the lower part of the tertiary which is called Eocene.

This Suessionian forms only a border to the Londinian strata, which begin immediately and which extend without interruption from Edfoo to Minyeeh, where the Parisian strata set in and close the nummulite part with the Mokattam near Cairo.

The splendid limestone of the Gebel Haridi belongs also to the Londinian layers. The nummulites in the Eocene vary in size from a lentil to a florin. Formerly people believed that these were the petrified remains of lentils which served as food to the builders of the Pyramids. These nummulites are the remains of foraminiferous animals, containing in life a quantity of phosphoric acid; and as this acid is not a volatile one, and as the basic phosphate of lime is almost insoluble in water, the
phosphoric acid of the living nummulites has been preserved in the fossils and now enters into the soil through the successive decomposition of the stones, and greatly ameliorates its quality: it forms the best manure for the cultivation of cereals and beans. From this circumstance it may well be understood why for many thousand years Egypt has had abundant crops, while Tunis and Sicily, where the soil has been exhausted through the excessive exportation of wheat, and which countries have not this stock of phosphoric acid, furnish no more redundant harvests.

In Egypt not only does the Nile bring down much organic refuse but in the mountains in the nummulite part on both sides of the stream is stored an inexhaustible treasure of phosphoric acid. To the cooperation of the Nile with the decomposition of these rocks is to be attributed the fact that the greater part of the country is so fertile. It is likewise the lower part of the tertiary formation which furnishes building-stone for a large part of the country. Near Cairo are quarries of this stone, in the layers of rough limestone in the Mokattam.

The middle part of the tertiary is called the Miocene. It begins with the northern front of the Mokattam and includes the Gebel Ahmar and other hills like it. To this system belongs also the petrified wood on both sides of the Nile. Sometimes this wood occurs enclosed in rocks of silicious sandstone, like the Gebel Ahmar. It is believed that the petrification of the wood and the formation of the sandstone and of the quartzite of the Gebel Ahmar have taken place through the effect of hot springs.
containing silicious acid in solution, like the Geysers of Iceland and of the Yellowstone Park in N. America. This theory is supported by the fact that in the silicious sandstone of the Gebel Ahmar the pebbles of crystallized quartz are cemented by amorphous silica, which it is possible to dissolve and separate from the crystallized quartz by chemical treatment, proving that this silica has been deposited from solution in water.

The hard stones of these layers furnish mill-stones of superior quality. More to the North, near the Suez Canal (Gebel Geneffe) the formation belonging to the middle tertiary becomes calcareous, and very good fossil echinates are found.

The upper part of the tertiary formation is called Pliocene, and to this belongs the formation which is called Saharian. It extends to the neighbourhood of Alexandria where the quarternary formation begins. This Saharian system covers a large part of the desert, and the desert sand belongs almost entirely to it. The fossils, occurring here are nearly all of species living in the sea at present but a few are extinct like the big echinite clypeastre gyzechensis, which appears to the South of the Pyramids of Gizeh, and is sold under the name of "shell" by the Bedouins to visitors of the Pyramids.

The small echinite which exactly resembles a biscuit, occurring towards the Red Sea, is to day living in the sea between South Africa and Mauritius.

We reach at last the quarternary formation, consisting of the alluvium of the Nile, the marine sandstone at Mex, near Alexandria, the hills called Koms, and all
that is now in process of formation. As fossils we find traces of mankind, remains of animals of species now living, and objects evidently worked by human hands. I shall only instance the instruments of flint, knives, needles and hammers, belonging presumably to the time when iron was unknown.

We now have reached the province of archæology which I do not enter.

III.

Having considered the rocks of igneous and of sedimentary formation, I shall now speak about the Eolic formation, as it is in Egypt of an extraordinary importance.

The granitic mountains of Upper Egypt are always submitted like all others to the influence of the atmospheric agents. The differences of temperature and humidity cause the stones to split, and the wind carries sand, which acts like water in the mechanical destruction of the rocks. The first to be decomposed is felspar; its aluminium forms clay, and the sodium and potassium are taken away by solution in water; the remainder constitutes a sand of mica, hornblende and quartz. Both the former of these, though having so long resisted decomposition, are now destroyed, and furnish the iron and magnesia found in the soil. Only the crystals of quartz are persistant in their resistance, and assume by rolling and friction a roundish shape, known as sand-corns, of the sand of the desert.
In this part of Upper Egypt lime is absent, and only a very minute quantity of argile in powder is necessary, when brought by the wind and mixed by it with the sand, to cement it and form it into a sandstone without fossils — a sandstone of eolic formation, which is known as Nubian Sandstone.

In most of the samples of Nubian Sandstone it is cognizable whether they result from the decomposition of Syenitic granite or of other primitive rocks; and the nearer one layer Nubian Sandstone is placed to the primitive rock, so it is easier to acknowledge its origin after examination of the undecomposed remains of the primitive rocks which it contains. There are Nubian sandstones which contain small fragments of the mica and the hornblende of the Syenitic granite, or only of the hornblende of the amphibolic rocks, and others contain only the white mica of pegmatite. As the distance increases, these remains become rarer, and at last we find another sandstone that contains only oxide of iron resulting from the decomposition of the mica and the hornblende, or only pure quartz, where all other contents are removed.

With the appearance of limestone, the calcium enters into association, and multiplies the results of the formation of the sandstone. In the true silicious Nubian sandstone there are no fossils, because the snails, the only mollusks found in the desertic sand, are quickly destroyed, and as no sedimentary formations exist in the neighbourhood, their fossils cannot occasionally enter.
As soon as limestone detritus enters into the formation of sandstone, the fossils of the respective layers can enter with it. But that does not prove anything about the age of the sandstone itself as it would be possible to find all fossils occurring in the primary formations, older than the sandstone itself. There also occur frequently in the compound calcareous sandstone remains as hornblende or white mica, which conduce to settle the original mother-stones. This eolic formation extends largely over the desert, and occasions immense layers of breccias and of sandstones of different ages. In this way we may see that geological formation is yet unfinished, and that we are living in the midst of actual present geological development.

I shall now show you samples of stones and minerals which occur in Egypt, and are of any technical use. They are: —

Syenitic granite with red felspar.
Diorite, spotted black and white.
Microcrystallized black Diorite.
Red imperial Porphyry.
Green Porphyry.
Porphyries of different other colours.
(All these have been employed for making valuable monuments and precious vases).
Limestone, for building.
Limestone, for paving floors.
Limestone, for making quicklime.
Silicious Limestone, for durable works of art.
Hydraulic Limestone, for cement.
Marble of Upper Egypt (wrongly called alabaster). Its constitution is carbonate of lime, while alabaster is sulphate of lime. This marble has been used to a great extent in the Citadel Mosque of Cairo.
Iceland spar, from the Londinian Strata of the Gebel Harida.
Gypsum, both in crystals and amorphous.
Quartzite, of the Gebel Ahmar and the upper layers of the Mokattam, furnishing millstones of the first quality.
"Tafl" a kind of fullers' earth.
Fireproof Clay, of the Mokattam.
Flint, from Abou Roash, employed in making gun-flints, exported in great quantity to Darfur and Wady.
Rock crystals, from Sinai.
Onyx, from Upper Egypt.
Jasper.
Agate.
Chalcedony.
Emerald, from Zabara.
Beryl, or Aqua marina, from Geziret Sbergeh.
Zircon.
Granate.
Turquoise, from Wady Nasb.
Gold, from Fashoda, and in the Nile Sand.
Galena, from Koseir.
Copper Ore, from Gebel Dib and Gebel Bara.
Iron, as silicate everywhere in the desert.
Sulphur, from Wady Hof.
Anthracite, from Bir el Fachme.
Asphalt and petroleum, from Gebel Zed.
Coal Slate, from Wady Redisieh.
Salt.
Natron.
Alum, from the Oasis el Khargheh.
Nitre.
Sulphate of Barium.
Sulphate of Strontium, used in the preparation of Strontium salt for red fire.

I take the opportunity afforded by this publication warmly to thank W. Willcocks Esq. who, assisted by Mr. F. Roux, and Moh. Effendi Saber of the Public Works, has very kindly collected specimens of all stones of interest from Wady Halfa to Minyeh. He has also noted and measured the strata to which these stones belong.

This circumstance has rendered possible the settlement of the question of the Nubian sandstone, which has been under discussion for nearly a century.

Mr. Willcocks has confided his collection to the museum of the School of Medicine, at Cairo, where it is now preserved, and I hope to come back to it on another occasion.

Cairo, June 30th, 1891.

E. SICKENBERGER.
Three lectures concerning the geolog