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A mineralogical and geological examination of the salinity of soils, Nile Valley. Upper Egypt.

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Abstract

Salinty of soils is the factor leading to the limitation of agriculture. Due to the reduction of suitable fields farming is also reduced. As a consequence farmers have to leave farms. This problem is specially important in Egypt where cultivated land is limited to the Nile Valley.

A mineralogical and geological investigation of this phenomenon is conducted at Heracompolis and surrounding areas showed the presence of the following minerals as white salty coatings covering the surface of local soils:

The absence of natural floods of Nile stopped due to the construction of the Aswan Dam is the reason for the continuous elevation of the degree of the salinity of soils. Evapotarion of water used for agriculture cannot be prevented but the process of mineralization has to be stopped if Egypt wants to avoid reduced food production.

Key words: Nile Valley, mineralogy, soil, salinity, agriculture

Geology

The Heraconpolis archeological site, as well as near by areas, is located on quaternary mixed sediments (Fig. 1, 2) showing various genesis (Liwingstone 1980, Williams, Williams 1980.

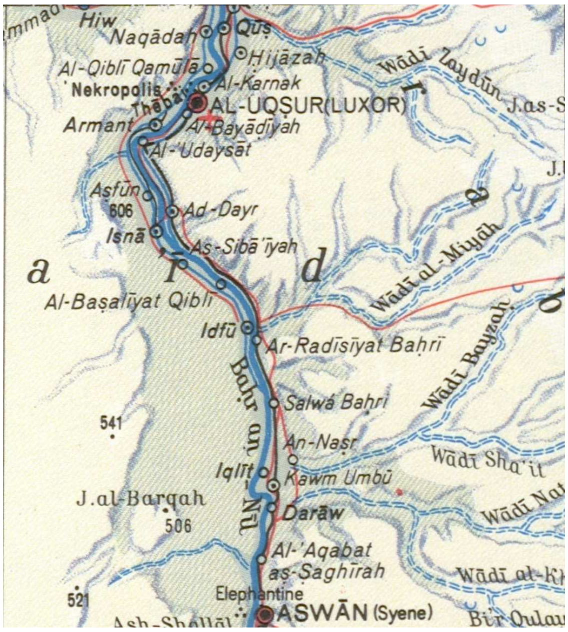


Fig. 1 - Map of the location of site Heraconpolis

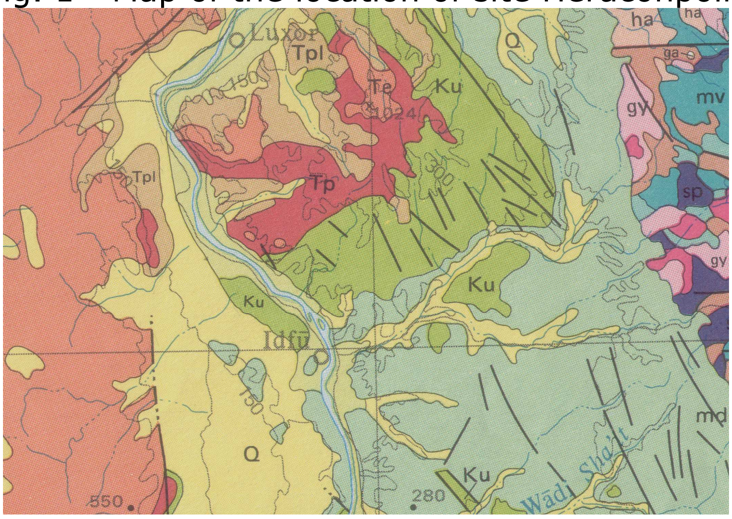


Fig. 2 - Geological map of the region of the site Heraconpolis (by: Egyptian Geological Survey and Mining Authority). Q - undivided Quaternary, Tpl - Eocene, Te - Eocene, Tp - Paleocene, Ku - Undivided Cretaceous, J (blue) - Jurassic, gv - Younger Granitoides, ha - Hammamat Group, sp - Serpentinite, mv - Geosinclinal Metavolcanics.

The general sequence of sediments observed there is shown in Fig.3. At the base at depths below 3-5 m (various depth at various places), present top of silts representing Sahaba formation (data 12 000-10 000 B.P. - Said 1966, Ginter et al. 1983, 1987, 1988, Pawlikowski 1993, 1994 a, b, c, d, 2004). They are represented by brownish compact clayey slits containing various admixtures of fine sand. The color of these silts is different at various places and depends on the admixture of red soils washed out from local hills - gebel (Pawlikowski 1994 b, c). If the admixture is higher, silts are reddish, if lower-brown but the stratgraphic position is always the same.

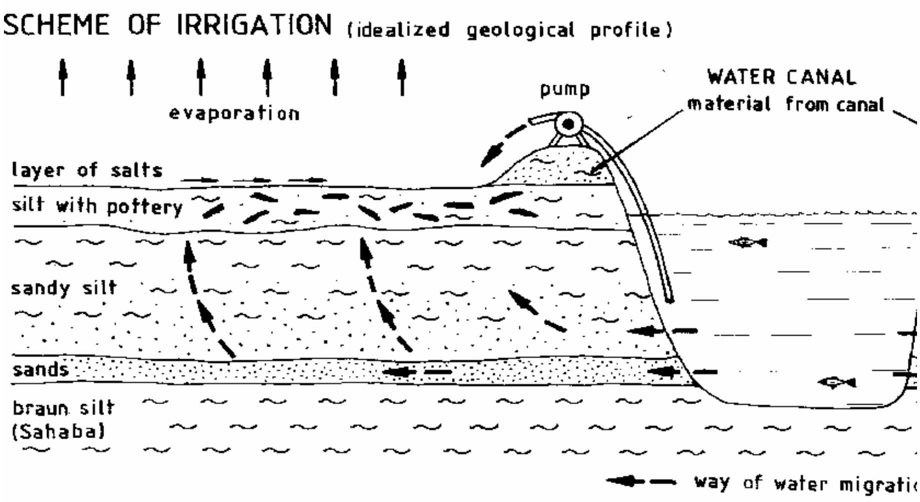


Fig. 3 – A scheme of the geological profile and functioning of the irrigation system in the area of Heraconpolis

Above the Sahaba formation, one can see sandy silts and sometime sands of various thickness but not thicker, generally, than 0.5 m. These sandy silts, or even sands, represent the so called older and younger pediment (water sediments) present between gebel and the zone of agriculture (flood zones - M. Pawlikowski 1994 c, d). At Heraconpolis, these sands are composed of material transported there from a big Valley (wadi) present just about 1-2 km west of the site. The sands are yellowish, sometime brownish (an admixture of brown silt) or white if iron oxides are dissolved and removed by organic substances (organic acids) present at the overlaying layers. These sands at the top contain pre- and protodynastic pottery as well as flint artefacts. The temple of the Old Kingdom was build exactly on the top of these sands which are locally deposited at secondary position by the wind.

All these sediments mentioned together with the destroyed relicts of the temple of Old Kingdom are covered with younger undivided brownish Nile silts of various thickness. These silts represent end of the Old Kingdom and the Middle Kingdom (Pawlikowski 2002 a, b, Pawlikowski, 2004). At the bottom, they contain pottery of the Old Kingdom sometime mixed with older fragments (Nagada). The temple of the New Kingdom was constructed just on the top part of these silts.

The silts mentioned contain a lot of New Kingdom pottery, but all these layers i.e. sands and young silts of the Nile, are strongly mixed because of human activity at this site. Because of this relatively thin layer (up to 1.m), one can see pottery representing all the archaeological periods.

The fields in the Nile Valley in the area of Heraconpolis are supplied with water by the use of two methods.

First is the surface supply where water came to the fields as artificial streams coming from canals. This water penetrated the soil and supplied plants.

The second way of supply came by underground waters coming from artificial canals. This water supplied plants via their roots.

Regardless of the way farmed plants were supplied with water, very strong evaporation of waters used took place. This phenomenon occurred because of the solar heating of soil surfaces as well as due to the consumption of part of the water by plants. Both phenomenon led to high concentrations of dissolved salts in waters and in consequence, intensive crystallization of evaporites.

The determination of methods reducing the growth of soil salinity is one of the most important scientific problems of Egyptian agriculture deciding about production of food in this country.

Material and methods

The material for a mineralogical investigation was collected in the area of Heraconpolis near Edfu where one of most important archeological sites is located (Fig, 1, 2). The area under consideration contains Nile silts intercalated with sandy material and layers containing archaeological artefacts (Fig. 3).

Evaporites crystallizing are present on the surface of the soils there (Photo 1) where they form coatings up to 5-8 cm thick. Secondary mineralization is also seen on the surface of soil cracked because of drying; i.e. changing the volume of clay minerals (Photo 2), as well as on various tissues of local plants (Photo 3). Crystallization of various evaporites can be seen at natural and artificial depressions where small basins filled with underground waters exist (Photo 4).

Photo 1

Photo 2

Photo 3

Photo 4

Photo 1 Thick cover (up to 5 cm) of evaporated salts crystallizing on the surface of primary soil
Photo 2 Dry, cracked soils covered with a layer of secondary salts
Photo 3 Stalks of plants mineralized by secondary crystallized evaporates
Photo 4 Small basin with evaporated salts crystallizing on the shore

Collected samples were examined using SEM and XRD methods.

SEM Jeol 540 coupled with an EDS counter was used for the determination of morphology and chemistry of the tested evaporites.

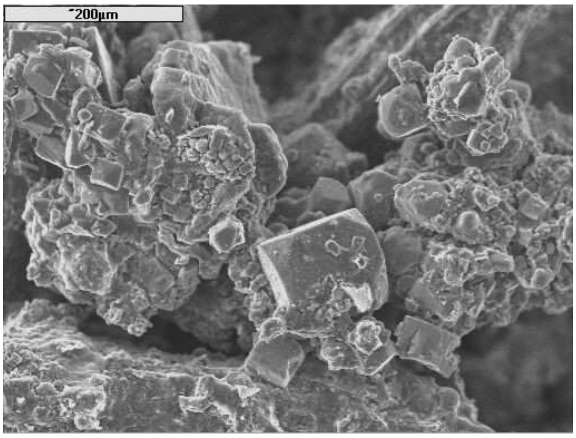
XRD analyses were focused on natural Nile silt and evaporites. Both materials were examined for minerals (salts) secondary crystallizing on soil and plants. A Philips diffractometer with Cu Kα radiation was used. Interpretation of results was done using X-rayan computer program.

Results of investigation

SEM

Microscopic observations document the various morphology of tested evaporites. They are mostly represented by geometric crystals of various shape such as cubes, plates and others (Photo 5, 6). Crystals are present together with salts in the form of irregular grains and coatings (Photo 7, 8).

Semi quantitative EDS chemical identification of observed salts showed they are composed of chlorites (Fig. 4 A, B, C, D), sulfates, carbonates and dangerous chlorides of Na, K, Ca, Mg. The relation between these substances is not constant and, generally, all tested samples contained the mixture of the minerals mentioned.



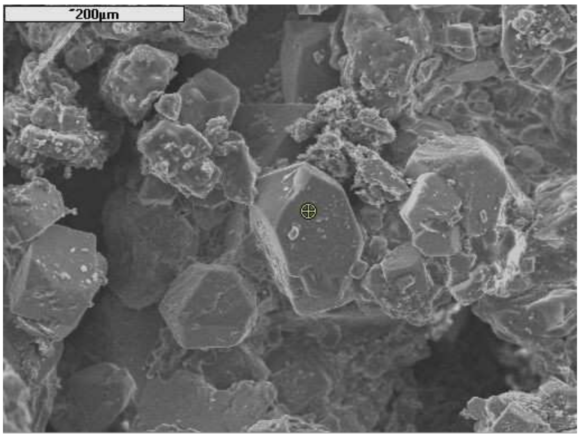
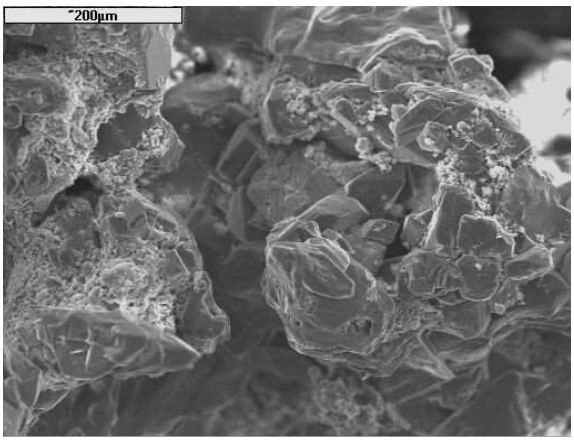


Photo 5

Photo 6

Photo 5-6 SEM pictures of various salts crystallizing on the surface of soil due to the evaporation of water used for the irrigation of plants.



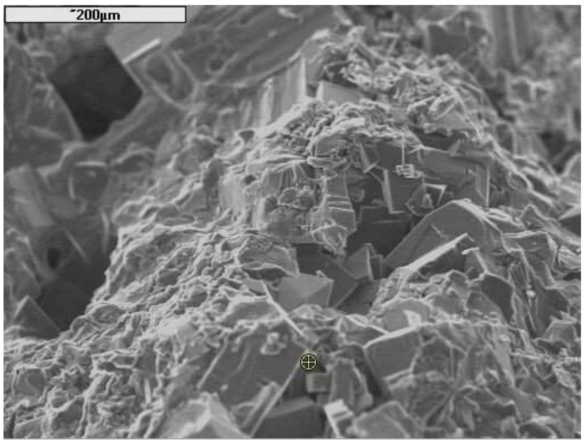


Photo 7

Photo 8

Photo 6-8 SEM pictures of various salts crystallizing on the surface of soil due to the evaporation of water used for the irrigation of plants.

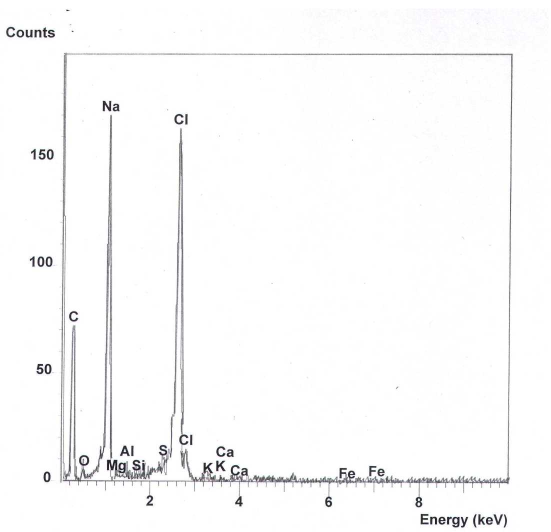


Fig. 4A

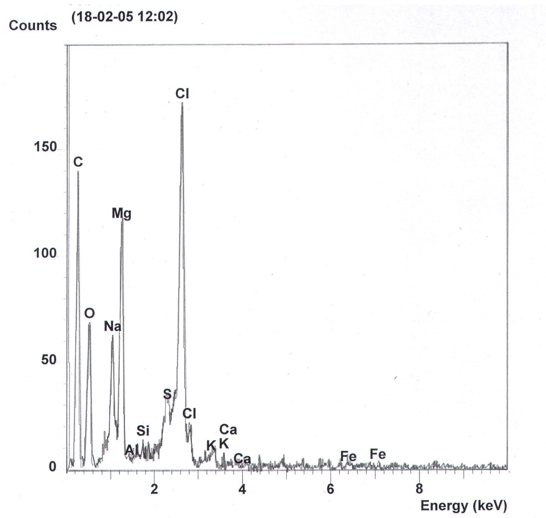


Fig. 4 B

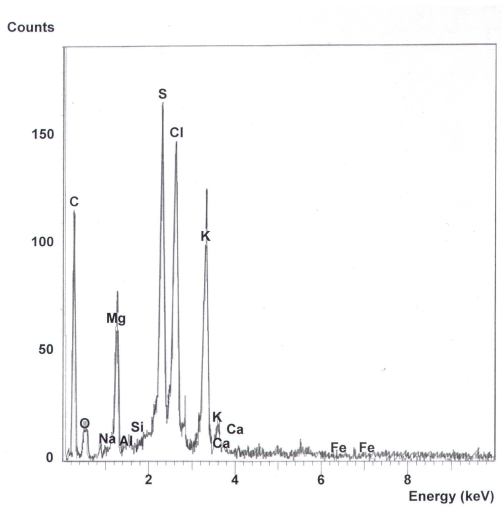


Fig. 4 C

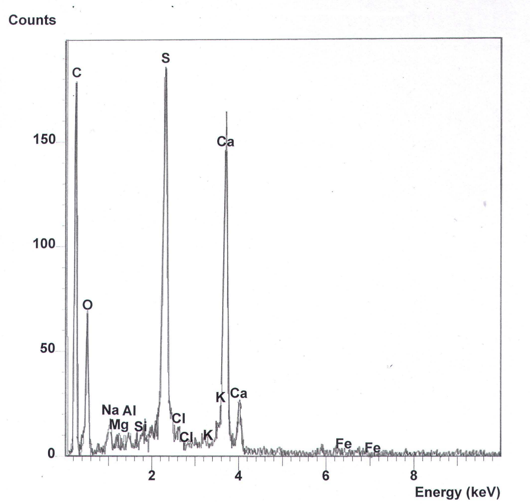


Fig. 4 D

XRD analyses showed that local silt constituting the base of local soil is composed of quartz, clay minerals represented by illite, kaolinite and smectite. Quartz, calcite, traces of albite and cordierite were determined together with clay minerals (Fig. 5). X-ray examination confirmed that local silts and primary soils do not contain chlorides or sulphates.

XRD examination showed that white salts crystallizing on the surface of soils are composed of chlorites (halite, silvine), sulphates (hexahydrite) hydrated carbonates of Fe and Mn (sjogrenite) as well as amonium phophates i.e. mundrabillaite (Fig. 6). The results obtained confirm that chlorides, sulphates and phosphates crystallizing as salts coating the soil are originally dissolved in the water supplying fields.

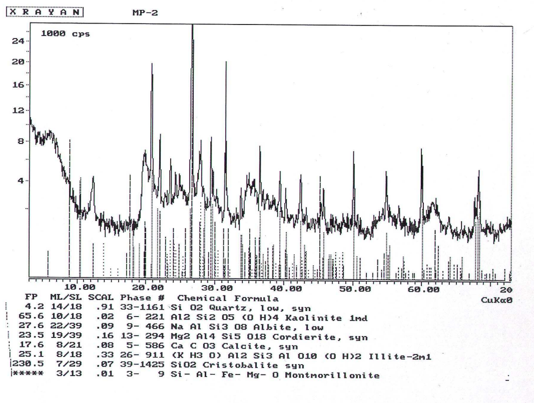


Fig. 5 X - ray pattern of the natural soil From Heraconopolis

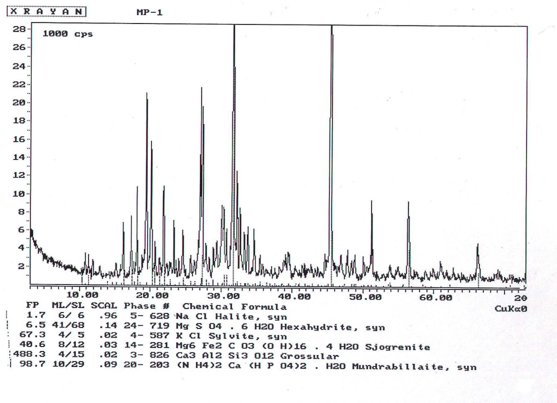


Fig. 6 X - ray pattern of the salts crystallizing on and in the soil at Heraconpolis

Conclusions

Because the tested area is located at the outcome of a big wadi (valley) coming into Nile Valley from West desert probable most of salts crystallizing on soils is first of all present in underground waters coming from west desert. These waters are mixed with the Nile water suppling the fields.

Underground waters coming from the west desert are concentrated due to eveporation under desert conditions.

The correct interpretation of the phenomenon mentioned have been confirmed by more detailed studies of the underground waters coming from the desert. Samples of waters have to be obtained from boreholes made in the wadi (valleys) coming into the Nile Valley. The data obtained will constitute a base for the next phase of work concerning the reduction of soils salinity and methods of soil desalinization.

Due to the greatest importance of the phenomenon described for Egypt, all work has to be complited as fast as possible because of the costs involved in the international program.

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