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Human Habitat in Deltas: Geological Investigations on Tell El Roba Archaeological Site, Nile Delta, Egypt

Tell el Roba once situated on the western bank of the vanished Mendes Branch in the Nile Delta, was occupied by successive human settlements. Recent excavations down to the water table level exposed well demarcated contaminated and uncontaminated sediments. The composite stratigraphy of the five m thick alluvial succession includes pre-pharoanic sediments, the pharoanic, the Greek-Roman and post-Greek-Roman sediments. Contaminated sediments represented period(s) of human activity while uncontaminated sediments represent period(s) of flooding.

The mount was investigated by surface inspection of artifacts and their provenance. Surface sediments and pit samples were subjected to mechanical analysis and microscopic investigations. Mound-surface reconstruction to datum helped much in understanding the nature of human activities.

Sequential sampling in test pits led to the detection of burial levels. Phosphorus content of the sediments pinpointed potential sites for future excavations. Incidentally, human activities prior to the construction of the pharoanic Naos Shrine in Tell el Roba was recognized as a result of the conducted geological investigations.

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Climate Variability, Solar Cycle, Stratospheric and Atmospheric Circulation

During the Holocene, the modifications of the continental environment show a wide range of climatic variations at tropical or subtropical latitudes. These variations are readable in lake oscillations, glacier fluctuations, vegetation density, biomass or run-off regime changes, etc. Their succession and amplitude can be different from one point of the world to the other, with regard to regional context (atmospheric circulation, altitude, latitude, etc.). These variations have frequencies at several time scales of the order a few of hundreds and thousands of years. These oscillations can show rhythms or pseudocycles during several intervals of time.

Climatic variations at a decadal time scale have a good chronology for the last hundreds of years; they have been correlated with solar activity in different manners in various areas of the world. For instance, in the southwest of the United States, drought reappears about every 22 years and the aridity maximum nearly coincides with minimum sunspot. Tree rings show a 10.4 year periodicity in California. In the near east of Asia, Lake Van oscillations follow closely solar sunspots since 1944 and high lake level coincides with strong solar activity. In India, the correlation of atmospheric perturbations or rainfalls with the solar cycle is different in high-altitude sectors and coastal areas. In Ethiopia, the 72 year rainfall record seems to present a good correlation coefficient with the 11 year solar cycle, the rainfall peaks leading the sunspot peaks by an average of 1.3 years. In South Africa, since 1910, in the summer rainfall area there is a quasi 20 year oscillation of rainfall while the coast of South Cape has a weak 10 year oscillation. In the Sahel of West Africa, extreme water run off of the main rivers closely coincides with a minimum solar activity and show a quasi-biennial oscillation.

These examples demonstrate that there is no simple and systematic correlation, but complex relations, different and sometimes in opposition in different regions.

The mechanism of these discontinuous possible solar activity effects on global climate may be in the interaction between the low ionosphere and the high troposphere through the gravity waves of the quasi biennial oscillation (QBO). Because electric currents in the earth's magnetic field have opposed latitudinal displacement with their zonal direction, they tend to compress or expand the polar vortex. And because the electrojets change their west to east direction with solar activity, they are the probable link through the following simplified process.

When and where the ionospheric electroject gravity waves come to add their momentum to high tropospheric jets they speed the general circulation. This could give a "cold global situation" (Leroux) with a strong polar vortex and a feeble monsoon with more frequent droughts in Sahel.

When the situation is reversed and the electrojet direction is opposite, they tend to slow down the high trospospheric wind, and a "warm global situation" is more frequent: The northern hemisphere summer monsoon can expand more and droughts are less frequent.

In this proposed mechanism, one momentum is of gravity origin in the general, neutral, atmospheric circulation (Coriolis) and the other one takes its dynamics in the electromagnetic forces (ampere) of the ionized stratosphere and ionosphere.

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Effect of Salts and Pore Size Distributions on Durability of Limestone at the Sphinx

The original limestone strata forming the Great Sphinx of Giza belong to the upper part of the Middle Eocene Mokkatam Formation. Geologic mapping (Figure 1) reveals that these strata may be distinguished as three distinct units according to their petrographic constitution.

The weathering profile of the Sphinx is a composite of alternating protruding and recessed layers revealing the differential soundness of these strata. The protruding, less weathered layers have smaller quantities of water soluble salts—halite and gypsum—and large, large-pore volumes than the indented, more weathered strata, suggesting that the durability of these rocks has been controlled by salt content and pore size distributions.

The less weathered rock is a biomicritic grainstone, and the more weathered layers are made of micritic mud. The variations of lithology has occurred due to rhythmic sedimentation while the variable pore size distributions are due to diagenetic processes.

The depositional porosity in carbonate rocks depends upon the relative quantities of the matrix (1-3 μm carbonate particles) and the grains (0.1 to + 2 mm particles). Grainstones with up to 10 percent matrix consisting of lime-mud are generally macroporous, whereas packstones with 20-50 percent lime-mud are dominated by micropores. The diagenetic changes altered the depositional microporosity such that the development of the microspar from the micritic mud produced a new microporosity. Further, continuing circulation of the meteoric water through the sediment preferentially produced large cavities. The end result was the formation of variable ink-bottle pores. These are large cavities connected by narrow throats of different sizes.

The salt crystallization in the pores damages stone. The damage is maximum when favorable conditions of porosity exist because the pore size distributions control the rate and the degree of water saturation of rocks. Those rocks which become fully saturated with water easily succumb to hydraulic pressures when salt crystals begin to grow from saturated solution. On the other hand, in those rocks which do not become critically saturated, such pressures may be dissipated due to the empty space present in the pores. The first situation is presented by highly microporous rocks where strong capillary suction fills all the pores: voids and throats alike. The second situation occurs in rocks which have an abundant volume of larger throats and a large volume of voids. On this basis, the following equation was developed which provides a quantitative description of durability of the Sphinx limestones.

$$DF = 1.234 \times V_1 + 2.662 \times V_2 - 0.984 \times V_3$$

where DF is the durability factor, and V_1, V_2 and V_3 are the volumes of pores in the ranges of >5, 0.5-5, and $>0.5\mu$m, respectively. The value of the constants for this equation were derived from the solution of 3 simultaneous equations in which the highly durable stones of the Sphinx, as seen from the degree of weathering, were assigned the values of 100, 98, and 95. The calculated durability factors closely matched the rest of the Sphinx strata as well as certain excellently preserved limestones that had been used in a phaeronic restoration some 5000 year ago.

For this study, the pore size distributions were measured by mercury intrusion porosimetry. Pv-data was obtained for the first intrusion for up to 30,000 psi, extrusion and reintrusion of mercury. The entrapment of mercury after extrusion gave the volume of large pores while the reintrusion gave the volume and size distribution of the throats.

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