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Relationships between electrical properties and petrography of El-Maghara sandstone formations, Egypt

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Abstract Realization of electrical and petrography of rocks is absolutely necessary for geophysical investigations. The petrographical, petrophysical and electrical properties of sandstone rocks (El-Maghara Formation, North Sinai, Egypt) will be discussed in the present work. The goal of this paper was to highlight interrelations between electrical properties in terms of frequency (conductivity, permittivity and impedance) and petrography, as well as mineral composition. Electrical properties including (conductivity and dielectric constant) were measured at room temperature and humidity of (~35%). The frequency range used will be from 10 Hz to 100 kHz. Slight changes between samples in electrical properties were found to result from changes in composition and texture. Electrical properties generally change with grain size, shape, sorting, mineralogy and mineral composition. The dielectric constant decreases with frequency and increases with increasing clay content. The conductivity increases with the increase in conductor channels among electrodes. Many parameters can combine together to lead to the same electrical properties. The samples are mainly composed of sand with clay and carbonate.

1. Introduction and geologic setting

The elements of the samples will be separated electrically into semiconductor or nonconductor elements. Fig. 1 shows the location map of the samples.

El-Maghara section has a thickness of nearly 1900 m. It was subdivided into six marine and continental formations (Fig. 2, El Far, 1966; Kassab, 2004; Gomaa et al., 2015; Kassab et al., 2016). Samples are collected from Safa, Shusha and Mashaba

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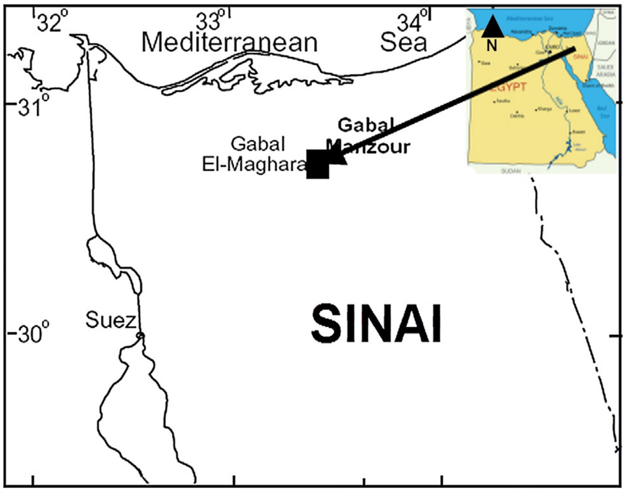

Fig. 1 Location map of the study area.

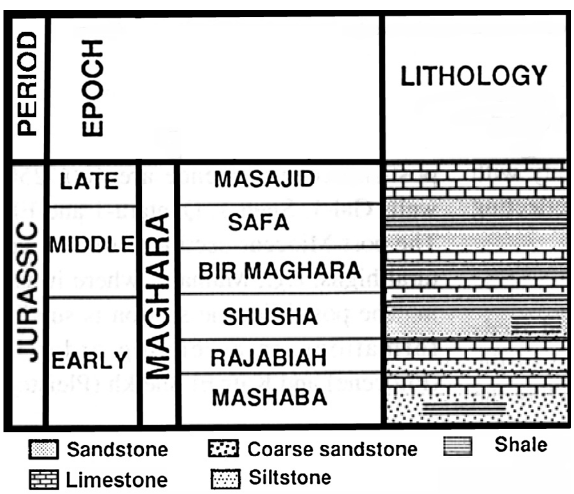

Fig. 2 A generalized stratigraphic column of Gebel El-Maghara in the northern Sinai area.

Formations. These three formations (from base to top) mostly consist of clastic rock samples (9 samples).

Geologic description of sampled formations is summarized as follows:

1- *Mashaba formation (bottom)*

It is the oldest Jurassic outcrop (thickness 100 m). It is composed of clay and sand, interbedded with shales and thin bed of sandy limestone, fine to coarse grained, overlain by thick sand bodies. The top part consists of clayey limestone and thin beds of sandstone.

2- *Shusha formation (middle)*

Some outcrops are detected at Shushat El-Maghara area (272 m thickness). The Shusha is formed from a clastic sequence interbedded with carbonate. The sediments consist of sand with some interbeds of shale and claystone which is the dominate part in the Formation. The top part is represented by argillaceous limestone.

3- *Safa formation (top)*

It is composed of sand and clayey sand with interbeds of limestone and clay in addition to some coal bearing facies (thickness of approximately 215 m).

The following is the description of the clastic rock samples collected from of the three formations (Mashaba, Shusha and Safa) according to the field observation.

2. Sample description

The following is the description of the clastic rock samples which are collected from the three formations (Mashaba, Shusha and Safa) according to field observation:

Sample M1 is ferruginous calcareous sandstone: Varicolored (dark brown and pale yellow), fine grained and hard, Mashaba Fm. Sample M15 is ferruginous clayey calcareous sandstone: Brownish white, fine to medium grained and hard, Mashaba Fm. Sample M32 is Sandstone: Light yellow with brown points, fine to medium grained and semi-hard, Shusha Fm. Sample M35 is ferruginous clayey calcareous sandstone: Light brown, very fine grained and hard, Shusha Fm. Sample M40 is ferruginous sandstone: Varicolor (pale white to yellow and brown), fine grained and semi-hard, Shusha Fm. Sample M47 is ferruginous sandstone: Brown, fine grained and hard, Shusha Fm. Sample M54 is sandstone: Pale yellow to light browns, fine grained and hard, Shusha Fm. Sample M71 is sandstone: Brown, fine grained and semi-hard, Safa Fm. Sample M87, Ferruginous Clayey Calcareous Sandstone: Pale red, fine grained and hard, Safa Fm.

3. Methodology

3.1. Petrography

Polarizing microscope was used to study thin sections for petrographical and mineralogical investigations. Impregnated blue dye was used to describe the sample pore spaces (Dickson, 1965). Fig. 3 represents the petrography photomicrographs and Fig. 4 represents the photomicrographs taken from Scanning Electron Microscope (SEM Model Philips XL 30 was used).

The samples were cleaned in the warm solvent extracted in extractor apparatus (soxhlets). Methanol and toluene were used as organic solvents for sample cleaning. The toluene removes any residual hydrocarbons (in pores) and the methanol removes water and salts from pores. At the end of this series, samples were dried at 90 °C until their weights were stable.

3.2. Petrophysics and electrical measurements

Porosity was measured using both matrix-cup helium porosimeter (gas-expansion method) and DEB-200 instrument (Archimedes' principle). Porosity ϕ is the proportion of the measured volume of pore space or void V_p (cm^3) to the total sample volume V_b (cm^3)

$$\phi = \frac{V_p}{V_b} \quad (1)$$