USING GEOSTATISTICAL ANALYSIS AND SPECTRAL SIGNATURE FOR IDENTIFYING SHALE DISTRIBUTION AND TYPE IN EL-SALHIA PROJECT, ISMAILLIA, EGYPT.

EL NAHRY A.H.
Soil Science Dept.
National Authority for Remote Sensing and Space Sciences
23 Joseph Brows Tito St.ElNozha ElGedida ,P.O Box 1564,Cairo,
Egypt.

ABSTRACT:- The current work aimed at recognizing shale distribution and its type in El Salhia project where it represents a serious limiting factor that preclude the agricultural development in that project. Shale is a fine-grained sedimentary rock whose original constituents were clays or muds. It is characterized by thin laminae breaking with an irregular curving fracture, often splintery and usually parallel to the often-indistinguishable bedding plane. Shale formation are typically as a result of deposition in very slow moving water and are often found in lake and lagoonal deposits, in river deltas, on floodplains and offshore of beach sands.Two main landforms affecting shale distribution were recognized in the project i.e. 1-The Nile river terraces. 2-The deltaic stage of the river terraces. Geostatistical analysis was performed to identify shale spatial distribution. Spectral analyses and consequently clay minerals identification representing shale type was realized by matching the unknown spectra that extracted from the field radiometer to predefined (library) spectra providing score with respect to the library spectra . Two weighting methods i.e. Spectral Feature Fitting (SFF) and Binary Encoding (BE) have been used to identify mineral type producing score between 0 and 1. Montmorillonite and Kaolinite were identified scoring high values of 1.0 and 0.944 respectively while illite scored values of 0.833 using SFF weighting method. Same clay minerals recorded scores of 0.883, 0.833 and 0.667 respectively using BE weighting method.
Key words: spectral signature, geostatistical analysis and clay minerals

1 Introduction

Shales have a wide distribution on the Egyptian territories. One of these territories is El-Salhia project area which is located to the south west of Ismaillia Governorate. It is bounded by 30^{O} 24^{-} 02^{--} and 30^{O} 32^{-} 16^{--} latitudes and 31^{O} 57^{-} 36^{--} and 32^{O} 03^{-} 06^{--}longitudes as shown in Figure (1).

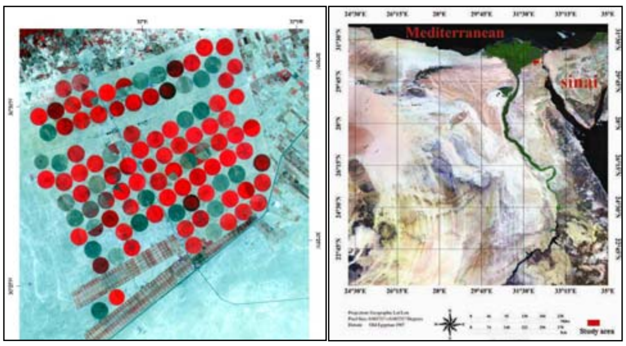

Fig.(1): Location of the study area

The current work is resulted from executed works in the abovementioned project that funded by 500000 LE .The project soils are suffering from the abundance of shale sediments on the form of isolated shallow and/or deep spots. .From Late Precambrian to Mid-Cretaceous sediments were deposited all over Egypt in largely shallow and near shore marine environments, inter-bedded with continental (fluvial) and deltaic sediments [1].Shale especially in the agricultural area represents a serious limiting factor as it act as impermeable layer affecting root zoon aeration and water movement throughout and/or downward the soil .The main objectives of the current work are to identify shale distribution and to recognize its type using advanced techniques instead of traditional methods.

2 Materials and methods

2.1 Field work and soil sampling

A reconnaissance survey was made throughout the investigated area in order to gain an appreciation of the broad soil patterns. 188 soil profiles and 177 auger were dug to identify shale locations and for the purpose of geostatistical analysis as well as spectral analysis for some collected samples -GPS Garminl2XL was used in the field to recognize the accurate locations of the soil sampling.-Fourteen subsurface shale samples were collected for spectral signatures extraction.

2.2 Morphological description

A detailed morphological description of soil profiles was noted based on the basis outlined by [2]

2.3 Laboratory analyses

Mechanical analysis was determined to identify texture class due to [3].

2.4 Geostatistical analysis

Interpolation between sampling locations was made as ordinary kriging interpolation method performed using the Geostatistical Analyst extension available in ESRI© ArcMap™ v9.2 [4].

2.5 Spectral analysis

2.5.1 Using field radiometer

The field radiometer CE 313-2 version was used. It is equipped with two detectors: one silicon detector for measurements in the 350-1100 nm band and one InGaAs detector for measurement in the infrared range from 1100 to 2500 nm.

2.5.2 Using USGS Spectral Library (Minerals):

Used spectra (spectral library) were measured on a custom-modified, computer - controlled Beckman spectrometer at the USGS Denver Spectroscopy Lab. U.S.A. Wavelength accuracy is on the order of 0.0005 micron (0.5 nm) in the near-IR and 0.0002 micron (0.2 nm) in the visible light [5]. Matching spectral signatures derived from radiometer measurements with those of the spectral library was performed to identify the clay minerals consequently shale type.

3 Results and discussions

3.1 Landforms of El Salhia project

Landforms identification of El Salhia project is very important issue so that they explain the shale sedimentation conditions. Landforms of El Salhia project are represented by the river terraces, both of fluvial and deltaic origin. Spot heights and contour lines were used to differentiate between those two landforms using geostatistical analysis as shown in Figure 2.

3.1.1 The Nile river terraces

The river terraces deposits are of purely fluvial origin and have a rather high elevation (up to 30 and locally even 50 m above present Nile level) and consist of nearly flat or undulating gravelly, loamy and partly fine sandy to silty material. They are presumably of Pleistocene age and show the development of the reddish desert soils in the sandy profile. This means that, they have a distinct desert top soil and more or less reddish subsoil.

3.1.2The deltaic stage of the river terraces

The deltaic stage of the river terraces was influenced by both sea and river during its formation. These terraces are partly coarse sand with some gravels, partly loamy-clay which have a lower elevation than the gravelly Nile terraces. The soils are younger than the gravelly Nile deposits. Only a weak reddish coloring sometimes being found in the subsoil of the sandy profiles, as well as desert topsoil. The deltaic deposits are strongly affected by wind and the relief is not, therefore, entirely flat.

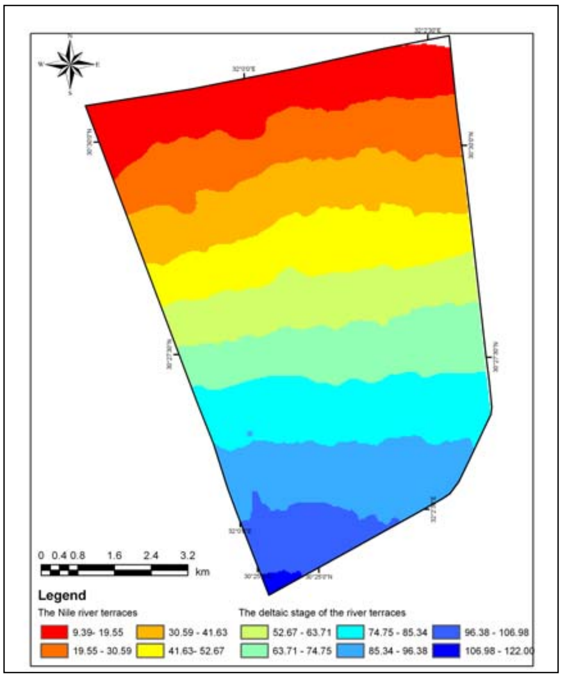

Fig.(2) Landforms of El Salhia project

3.2 Shale identification

Shale is a fine-grained sedimentary rock whose original constituents were clays or muds. It is characterized by thin laminae breaking with an irregular curving fracture, often splintery and usually parallel to the often-indistinguishable bedding plane. This property is called fissility. Non-fissile rocks of similar composition but made of particles smaller than 1/16 mm are described as mudstones. Rocks with similar particle sizes but with less clay and therefore grittier are siltstones,[6]

3.3 Shale formation and genesis in Egypt

The process in the rock cycle which forms shale is compaction. The fine particles that compose shale can remain suspended in air after the larger and denser particles of sand have deposited out. Shales are typically deposited in very slow moving water and are often found in lake and lagoonal deposits, in river deltas, on floodplains and offshore of beach sands. They can also be deposited on the continental shelf, in relatively deep, quiet water, [6] Most of the studies which have been carried out on the shale sediments of Egypt, either virgin or cultivated were concentrated on the identification of clay minerals and their genesis.In her studies on the shale deposits in Egypt [7], found that, the dominant clay minerals in the studied samples from Shaloufa, Qasr El Sagha, Kasr El Basel, Kom Oshim (Fayoum), Maadi and Hellwan area, were montmorillonite followed by kaolinite and illite. [8] indicated the presence of the attapulgite mineral in the non-calcareous purple-red shale of Kharga oasis soils in the Western Desert. [9] discussed the mineralogical characteristics of some shale deposits of El Minia Governorate. They reported that montmorillonite was the dominant clay mineral followed by kaolinite and hydrous mica. Quartz and feldspars were present in less amounts. [10] studied three shale deposits in Aswan area; namely, South and North Abu El Reesh shale as well as Kalabsha kaolin. Their results revealed that the Aswan shale were kaolinitic clays containing variable amounts of quartz, illite and iron materials. They also showed that the kaolinite/quartz ratio was increased in the order of Abu El Reesh South< Abu El Reesh North < Kalabsha kaolin with the decrease of Fe_2O_3 in the same order. [11] studied kaolinite shale deposits (Carboniferous & Cretaceous) in different localities in Egypt at Abu Zenima area , Wadi Qiseid, Wadi Abu Sanduk, Wadi Abu Had , Aswan and Wadi Kalabsha (western desert). They found that the studied kaolinite deposits contain wide varieties of accessory minerals, the coarser of which are generally quartz, feldspars, moscovite and heavy minerals as well as micro-size minerals.

[12] examined shale deposits sampled from Abu Zenima (Sinai), Qasr El Sagha (Fayoum), El Saff, El Gedida (El Baharia Oasis) and Abu El Rish Quibly and Bahary (Aswan). They found that the dominant clay minerals were kaolinite in Sinai and Aswan, montmorillonite in Fayoum and illite in Baharia Oasis meanwhile, interstratified minerals dominate El Saff deposit samples. Moreover, interstratified minerals or quartz were common in Fayoum and Sinai, respectively. On the other hand montmorillonite was moderate in El Saff samples.

3.4 Shale in El Salhia project

Shale = quiet water deposition. A side from this, it is hard to say anything definitive about the environment of shale since most environments had periods and places of quite water deposition. For example, shale in El Salhia project is common because of soils of the project represent old Nile river terraces as well as the deltaic stage of the Nile terraces, so that sediments were deposited slowly and in different eras constituting platy layer or lamella. The dark gray of this specimen indicates a low oxygen environment. From its geologic context, it was relatively, deep water carrying very fine materials .These sediments were deposited through the soil profile.

3.5 Spatial variability of shale

To study the spatial variability for subsurface shale, an interpolation method was used. 188 soil profiles and 177 augers were dug to represent texture classes which are considered helpful guide for identifying the distribution patterns of the shale, Figure (3). Ordinary kriging method was used to estimate the value of a continuous characteristic at an unsampled location using only data on this characteristic as a linear combination of neighboring observations. As for other linear regression procedures, ordinary kriging weights are chosen to minimize the estimation or error variance under the constraint of unbiased. Semivariogram values for different lags, are derived from the semivariogram model fitted to experimental values. Under stringent hypotheses of normality and homoscedasticity, the kriging variance combined with the estimated value to derive a confidence interval of 95%.

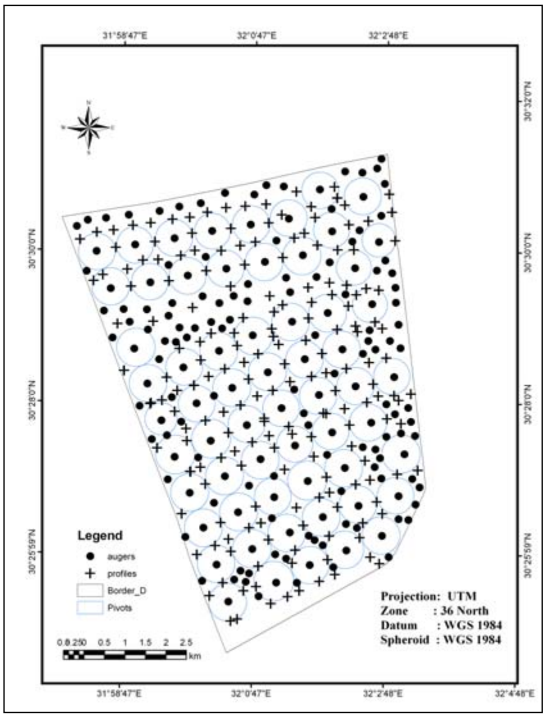

Fig. (3) Soil profiles and augers

3.6 Using field radiometer to extract spectral signatures

Spectroscopy has been used to identify specific rocks and minerals. The technique hinges on the interaction of light with geologic materials that absorb specific wavelengths creating a fingerprint signature. The resulting spectrum contains information on both the primary elemental composition as well as crystallographic coordination. At shorter wavelengths, the optical and infrared (0.4 to ~ 2.5 µm), the resulting spectrum is most sensitive to iron (oxides, oxyhydroxides) and alteration cations (water, hydroxyl, carbonate), [13];[14]. In the infrared (5 to 50 µm) absorption features from various classes of silicates are apparent [15];[16]. Field radiometer was used to identify the spectral signature of the collected shale from different sites in the project, Figure (4). The obtained data were prepared in ASCII files and imported in the spectral library of ENVI 3.4 software for comparison purposes.

Fig.(4) :Collected shale

3.7 Matching unknown spectra to library spectra.

Spectral analyses and consequently clay minerals identification representing shale type could be obtained by matching the unknown spectra that extracted from the field radiometer to predefined (library) spectra providing score with respect to the library spectra, [17]. Two weighting methods i.e. Spectral Feature Fitting (SFF) and Binary Encoding (BE) have been used to identify mineral type producing score between 0 and 1, where the value of 1 equaling a perfect match. As it is known, some minerals are similar in one wavelength range, yet very different in another range. For best results, wavelength range that contains the diagnostic absorption features was used to distinguish among minerals. The output of the spectral analyst is a ranked score or weighted score for each of the materials in the input spectral library,(Table 1).

Table (1) Weighting and mineral identification

Weighting Method (Score 0-1.0)			
SFF		BE	
Mineral type	Score	Mineral type	Score
Montmorillinite	1.000	Montmorillinite	0.883
Kaolinite	0.944	Kaolinite	0.833
Illite	0.833	Illite	0.667

The highest score indicates the closest match and indicates higher confidence in the spectral similarity where Montmorillonite and Kaolinite, scored high values of 1.0 and 0.944 respectively while illite scored values of 0.833 using SFF weighting method. Same clay minerals recorded scores of 0.883, 0.833 and 0.667 respectively using BE weighting method. These obtained results indicate the dominancy and identification (ID) of these minerals in the selected classes as shown in Figures (5,6 and 7).

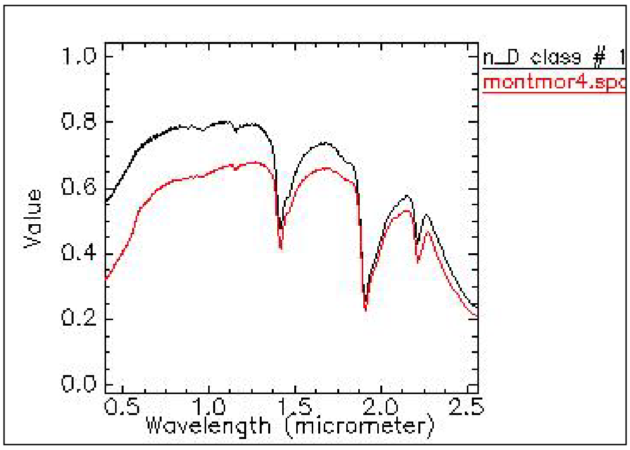

Fig (5) identification of montmorillinite

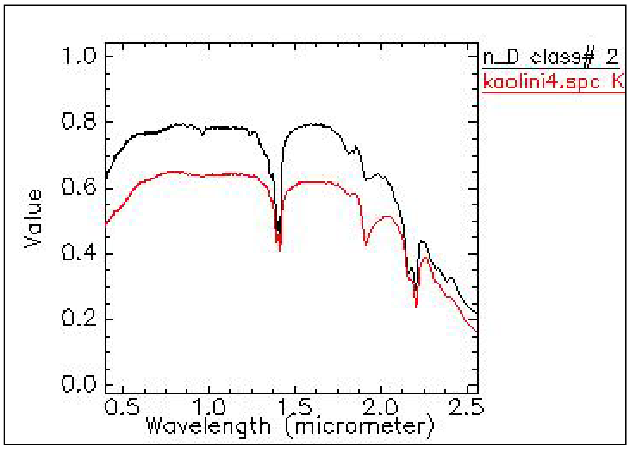

Fig (6) identification of kaolinite

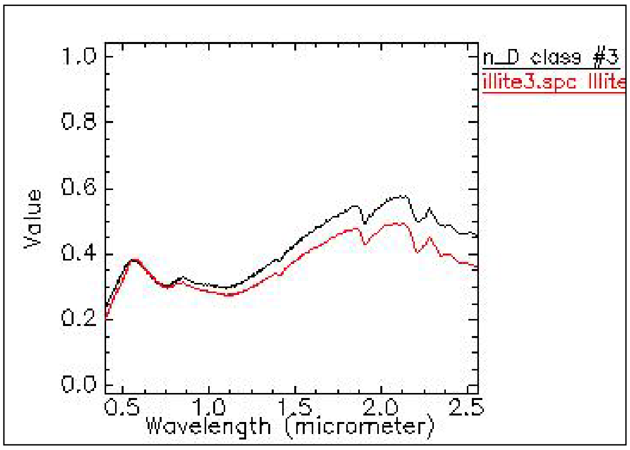

Fig (5) identification of illite

4 Conclusion and recommendation

Shale represents a big and serious problem in the investigated area. From management point of view, dealing with this problem could be summarized as follows:

1-Soils which have shale layer close to the surface have to be excavated and replaced with light soil to improve their texture.

2- Soils which have deep shale layer should be ploughed with sup soil plough in longitudinal lines with spacing up to 15-20 feet to pour the drainage water in ditches.

3- Using the treated shale as amendments. This could be done by leaching excessive soluble salts, heating and drying, disaggregating, mixing with compost and adding to sandy soils for improving water holding capacity and physical properties .

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