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WORKSHOP ON REMOTE SENSING TECHNIQUES WITH APPLICATIONS TO AGRICULTURE, WATER AND WEATHER RESOURCES

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INTEGRATED REMOTE SENSING AND AEROMAGNETIC MAPS FOR LOCALIZING GROUNDWATER MEGA-AQUIFERS IN ARID REGIONS: A CASE STUDY IN SINAI PENINSULA

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ABSTRACT

Remote sensing techniques are quite dependable tools in investigating geologic problems specially those related to resources assessment. The LANDSAT-imagery provides discrimination between land uses and forms, detection of land cover and delineation of large scale structures. In order to fulfil the aim of geologic application of remote sensing, essential statistical treatment through digital image processing procedures might be done prior to the target verification.

The recent progress in integration of remote sensing data with other geophysical and geochemical data allows the resources assessment to be carried out in a better way than that achieved with either of the individual data sets. Afterwards, the field verification should lead to the interpretation of a comprehensive geoloic model of the study area to apply for the target problem.

One case history applied successfully for groundwater exploration in Sinai Peninsula, using integrated data of remote sensing, aeromagnetic survey and field geologic investigations is presented.

INTRODUCTION

Remote sensing is the practical tool of measuring properties of materials expressed by electromagnetic waves, reflected or emitted, from large areas without having the measuring device in contact with the object. The application of remote sensing in the field of earth sciences can then be explained simply as the study of the earth's nature utilizing electomagnetic radiation which is either reflected or emitted from land surfaces in waves ranging from ultraviolet to microwave.

Many applications of earth studies are identification of mineral and rock raw materials, detection of groundwater aquifers, discovery of energy resources, classification of soil and land cover and contributing solutions for problems related to the national development programs. To realize these objectives, it is necessary to go through a series of phases with overall objective of greatly increasing the chances of discovering an economic resource or solution of a problem at a minimum cost. For searching a specific resource target, the task of earlier phases is not to discover them but to locate areas where the potentinal for finding them is greatly increased' and to screen these areas for any indications of its presence they may contain.

The tools of remote sensing, available up till now, include many techniques such as conventional visible light, black and white or colored photography, infrared multispectral and RADAR imagery and microwave sensing.

The space imagery is similar to aerial photography in geologic mapping but at different scall. Accordingly the features and sings needed to be studied on the images are tone, color, texture, pattern, shape, size, effect of shadow and seasonal variation. Also there is much overlap between remote sensing and geophysical techniques. The only apparent difference is that the remote sensing tools sense the reflected or emmitted electromagnetic radiation from the exposed surface while geophysical tools receive waves transmitted and reflected through deeper surfaces in the crust either they are electromagnetic or non, such as magnetic, seismic, gravitational and electric.

in case of small differences of spectral reflectance between rock types, some form of image enhancement is needed to distinguish between them. Some of the enhancement techniques are the density slicing, pattern recognition, contrast enhancement and ratio methods. During the past fifteen years, the remote sensing research has concerned mainly with the following areas :-

1- Development of imagery techniques that improves resolution and geometric corrections. Also, the advent and deployment of scanners with more spectral channels upgrade the methods of interpretation.

2- Improvement of enhncement techniques concerns mainly with digitization and ratioing techniques. The ratioing method depends on the fact that the electromagnetic spectral bands can be sensed separately by multispectral channels scanners. Each material has its reflectance property for every electromagnetic spectral band. This property is based upon abundance or deficience of a specific mineral or a chemical radical in the imaged surface material. In other words, it signifies the proportional chemical or mineralogical content of such material. In case of overlying two spectral band images of the same material, the product reflects the proportional content of two specific minerals or radicals in this material presented in a composite retio relationship form.

The progress in the ratio techniques facilitates visual interpretation of lithologic units and structural elements of specific surface features as seen on digitized ratio images. Addition or subtraction of the ratios are often tried to bring out the main required feature or conditions. The inversion of one ratio and its addition to another one may show most of the features being studied.

GEO - IMAGERY INTERPRETATION

The earth's land surface is composed of many terrain elements a[illegible] governed by many factors. Each one depends or affects the oth[illegible]rs. For example a land-form may be bounded or cut by a fault and the fault may or may not be responsible wholly or in part for

the presence of a land form. The erosional processes controlled by the structural features, composition and attitude are responsible for the shape of the land form. The drainage maps of an area are essential elements to interprete lithology and structures. The collection of such data on the ground is relatively slow tedious and expensive while the remote sensing for regional surveys provide appreciable savings in cost, effort and time, although they do not replace completely the field observation. The analysis and interpretation of remote sensing images for purposes of resources assessment are divided into the following phases and steps :

(I) VISUAL IMAGE READING :

To start analysis of data from satellite images land use boundaries have to be defined at first because the cultural development always obscure soil, geology and drainage boundaries. Then, trace out all areas that have internal homogeniety with reference to shape e.g. plains, terraces, valleys, areas of similar type hills, and areas of similar slopes. These features are termed land form mapping. The tracing of drainage is necessary to define erosion patterns and to recognize the factors, materials in terms of density, fineness, angularity, tributary intersection ... etc, a change in material and conditions can be inferred. The previous maps facilitate, the possibility to discriminate between the lithologic units of land cover and to detect large scale structural elements.

(i) LAND USE MAPPING

Regional land use classification depends on the statement saying; each land cover unit has a uniquie feature on every spectral band and on the false color composite images". The differential characteristics on various bands are because of each band records different proportions of the electromagnetic spectrum. It is therfore, the study of the various bands and the composite images help better indentification of elements of land use classes. Numerous land use classifications have been made suitable to particular needs of many countries. Attempets have been made to include sufficient detail in the definition to provide a general understanding of what is included in each category, (Anderson & others 1976, Tiwari: 1976). Here a provisional classification of the Arab world land uses, is presnted.

1- BARREN LAND : land without significant cover other than thin vineer of soil.
2- DESERT LAND : Land covered by non-consolidated eolian sand and sand dunes of variable scales.
3- AGRICULTURAL LAND : Land covered by crops, and confined feeding operations.
4- FOREST LAND : Land covered by trees either deciduous or evergreen.
5- RANGE LAND : At which the natural vegetation is predominant. The land is covered by grasses, shrups and brushes.
6- URBAN LAND : Land covered by built up area and human settlements either residential, commercial, industrial, transportation, or utilities.
7- WET LAND : Areas inundated either vegetated or not. Swamps and sabkhas are included in this category.
8- WATER : Land covered by water either streams, lakes, ponds, pools, reservoirs, bays, gulfs or seas.
9- SNOW AND ICE : Land covered by snow or ice.

(ii) DRAINAGE PATTERN RECOGNITION

A drainage system that develops on a regional surface is controlled by the slope of the surface and the types and attitudes of the underlying rocks. Drainage patterns which are easily visible on photographs and images reflect to varying degrees the lithology and structure of the study area. Drainage patterns in an area of stratiform rocks depend mainly on the type, distribution and attitude of the surface rocks.

The drainage pattern is ordinarly dendritic. Radial, concentric and annular patterns develop over domes in stratiform rocks, owing to the slope and the variable resistance of concentric rock exposures in such structures. Compressional stress

usually yields a series of nearly parallel folds, the spacing and form of which depend on the types and thicknesses of the folded strata and the intensity of stress. A general parallelism of trunk stream denotes parallel folds. High angle junctions of tributaries are common, the resultant pattern is called trellis.

Understanding of the controls exerted by lithology and structures on a stream cource is valuable in the interpretation of remote sensing data. Change in rock type along a stream can be informed from segmental changes in valley width, degree of channel incision, valley or channel trend and habit and deposits in the valley floor. Local bending or segmental gradient changes in a stream valley may be caused by local warping or by faulting transverse to the stream course. These geologic-drainage relations must be taken into consideration during the interpretation because they help better understanding of geologic setting of the region under investigation.

(iii) LANDFORMS MAPPING

This map type is dealing with the homogeniety and instability of the material with reference to the old and present conditions. The indications of instability are mostly slides, tears, angularity or gentleness of slopes and hills, while the homogeneties are categorized as plains, terraces, valleys, plateaux, hills, mountains and so on. The dip and strike of bedding planes, foliation and other structural elements make clues for the landform unit, even it is not stereoscopic. The land has a highly complex and varied surface. The relief, pattern and form of land may point to the rock materials which underlie each part of the surface and the factors of change which have acted upon them. Each type of rock, fracture, and erosional and depositional feature bears the imprint of the conditions which controlled it.

The element most useful in terrain studies is topography. Because most landforms are erosional- depositional and are produced by atmospheric agents (water, wind and ice), topography is modified by one or more of these agents. Some special landforms are created by the solvent action of water in near surface rocks or by the movement of magma through the crust and to the surface by volcanism. Some landforms are directly produced by tectonic forces while most landforms are affected by tectonism. The interpreter must be aware of lithologic and structural influences, the activity of subaerial agents, the effects of past and present climates and the influences exerted by organisms. Therefore the landforms can be categorized into (1) Landforms produced by internal or endogenic processes such as tectonism, metamorphism and magmatism and (2) Landforms produced by external or exogenic processes such as erosion, deposition and solution.

(iv) DELINEATION OF STRUCTURAL ELEMENTS :

Experience with space imagery had demonstrated the exceptional value of synoptic view for displaying extended structural elements such as closed anticline, dome, fault zone, regional joint pattern, folded belt and intrusive body, (Short and Lowman, 1973). Where the rock is exposed, the surface experession of tectonized parts of the crust was often better revealed on images. Also new lineaments of considerable magnitude and extent can be picked out in the images because of their breadth and continuity.

In the report presented in the COSPAR-Symposium held at Brazil (El Ghawaby and others, 1974) the authors have pointed out that on the global scale, the space imagery may provide the data not only for continental geologic mapping but also for basic studies in continental drift and plate tectonics. After four years, Press (1978) said most important aspect of LANDSAT imagery for exploration is the way in which it allows us to see the entire geological setting and structure of an area with a degree of perspective not afforded by other methods. He said that above all the careful analysis of lineament patterns, it gives us unique information on geological stress and global structure.

(v) LITHOLOGIC UNITS MAPPING

The solid crust of the earth is composed of various kinds of rocks. Sometimes these rocks are exposed but over large area of

the land surface, they are concealed by soil and unconsolidated material. Detailed geologic interpretation is possible only upon close inspection of rock exposures in the field. On the other hand, the patterns visible on remote sensing imagery or during aerial flights usually provide adequate data for lithologic reconnaissance, particularily in areas where bedrock is exposed. Even where the obscuring influences of vegetation or soil cover are strong, it is usually possible to identify such lithologic units as shale, sandstone, granite and lava by observation of the criteria recorded on the images.

It is known that the earth has a complicated surface and its relief, pattern and form are indicative prints for (a) the rock materials that underlie each part of the surface, and (b) the chronological history of changing factors such as sedimentation and erosion. The previously mentioned criteria including land uses topographic expression, drainage pattern, and structures are important to delineate lithologic and soil units and landforms, in a provisional map form for the area under investigation. This mostly help starting the second phase.

By interpretation of structural pattern and lithologic units distribution, an integration of information can be realized which mostly help development of a provisional model for the area under investigation, using the available procedures of digital image processing and statistical analysis for more discriminant land cover units mapping.

(II) DIGITAL IMAGE PROCESSING AND ANALYSIS :

The image processing phase consists of three steps :-

(1) Selection of the most informative channels that provide the maximal information for establishment of the target map. This can be confirmed by scattergrams of various channel.

(2) Determination of thresholds of digital data classification by detailed analysis of representative pilot zones. This can be calculated by :

(a) the frequency histograms

(b) reflect once proprety tranects in the pilot zones and (c) statistical characterization of test zones.

This analysis enables :

(a) the determination of the limits for an autamatic classification of imagery-data.

(b) the selection of test-zones

(c) the statistical characterization of test zones

(d) the establishment of sample field maps.

(iii) Multispectral classification of remote sensing digital data by the random clustering method which groups pixels with similar spectral classes. This grouping resulted in a computer-assisted multi-colored thematic map composed of multi-themes. This map was used as a basis for compiling a map of surface conditions.

INTEGRATION OF DATA

The remote sensing techniques till now are not penetrative tool or going deep into earth's surface except some specific methods as RADAR that penetrates to few meters of terrain cover. Generally, they are giving information only on the surface or near surface material and relief. Integration of remote sensing data with geophysical and geochemical data on a digitized composite maps is the prospective methodology for abtaining better understanding of the deep-level and surface geologic structures.

The geophysical and geochemical data are commonly prepared for presentation by computer and therefore like the satellite imagery become amenable to image processing techniques. Regional geophysical surveys such as aeromagnetic maps reflect the interaction of the earth's magnetic field with susceptible materials in the upper 15 km or 50 of the crust. Its integration with the surface remote sensing geologic mapping provide information not only about the nature of these materials but also about their structure and form in depth as well as on surface.

Integration of the geophysical and remote sensing data using image processing techniques proivde great advantages to the

interpreter over more conventional approaches. Sometimes the structural lineaments can not be identified as such on LANDSAT imagery having no specific reflectance property. However, on the geophysical data map, it may form a very strong feature by its particular geophysical gradient. Also the measure of texture derived form the LANDSAT imagery would differentiate high and low relief areas of the same lithology that the other techniques may not discriminate.

A classification map of integrated geochemical data and remote sensing product in the from of a composite image could provide an input relating to the chemical composition of the different lithologies. Applying the discriminant function analysis of such data might provide greater insight into the geological relationship of the area with its resources content.

These integrated composite maps (ICM) might show a more significant results with the lithologic units and structural elements governing mineral, water or energy resources.

MODELLING AND VERIFICATION

Remote sensing imagery allows the earth scientist to review a studied area in a synoptic format and if the surface characteristics are well defined on imagery and patterns of geological significance is identified, a provisional model can often be developed. The construction of such model is mostly guided by the characterization of an area of known or proved wealth of resources. By field verification through transects or profils in the same region and correlating their data with each other, they may confirm the proposed model. Then a regional picture has to be thought on.

The development of a proper model, needs several trials of image analysis with data derived from field investigation and other data sources. Often, the interpreter has a preconceived model in mind prior to analysing the imagery but the correct way is to start with the available smallest scale imagery for some key areas to be analyzed objectively using a systematic recognition proceoure and without influence of any ancillary information. This systematic analysis should define a regional model. Then, one proceeds to larger scales using scale imagery including the previously identified key areas.Sometimes the interpretation of small scale imagery can be revised though analysis of larger scale imagery eventully a point is reached where groud data or additional remote sensing data are required to resolve conflicts in or confirm the validity of the interpretation. The analyst should compare these new developed model with the available ancillary information and finally correlate these key areas with the other similar areas.

INTEGRATED REMOTE SENSING AND AEROMAGNETIC MAPS

FOR

LOCALIZING GROUNDWATER MEGA-AQUIFERS IN ARID REGIONS

A CASE STUDY IN SINAI PENINSULA

AIM OF STUDY

TO ASSESS THE POSSIBILITY OF USING INTEGRATED REMOTE SENSING, FIELD AND GEOPHYSICAL DATA FOR LOCALIZING GROUNDWATER MEGA-AQUIFERS IN AN ARID REGION, (CENTERAL SINAI, EGYPT).

INTRODUCTION

IN SEARCH FOR GROUNDWATER AQUIFERS, LARGE QUANTITIES OF DATA ARE OFTEN COLLECTED; DATA FROM THE LANDSAT-IMAGERY INTERPRETATION, THE AERBORNE GEOPHYSICAL SURVEY, FIELD MEASUREMENTS AND LABORATORY ANALYSES OF ROCK SPECIMENS.

HOW CAN THIS WEALTH OF DATA BE USED TO FULL ADVANTAGE ?

FACTOR ANALYSIS IS OFTEN PLAYING THE IMPORTANT ROLE TO EXPOSE RELATIONSHIPS AMONG THESE DATA.

THE REMOTE SENSING IS NOT A PENETRATIVE TOOL, AND THE GROUNDWATER IS MOSTLY ISSUING FROM DEEP STRATA.

ON THE OTHER HAND, THE AEROMAGNETIC SURVEY REFLECTS THE FORM AND STRUCTURES IN THE UPPER 15 Km OR SO OF THE CRUST.

INTEGRATION OF SURFACE DATA OBTAINED FROM SATELLITE IMAGERY AND SUBSURFACE DATA INTERPRETED FROM THE DRILLED WELLS AND THE AEROMAGNETIC SURVEY PROVIDE MORE OBVIOUS COMPOSITE DATA RELATIONSHIPS BETWEEN THE GOVERNING FACTORS OF GROUNDWATER OCCURRENCE.

THESE FACTORES MIGHT REFER TO THE CAUSES THAT CONTROL GROUNDWATER ACCUMULATION.

SINAI PENINSULA

SINAI PENINSULA COVERS SLIGHTLY MORE THAN 60,000 KM^2 (6% OF THE TOTAL EGYPTIAN TERRITORIES).

IN ITS HEART, WADI EL ARISH HYDROGRAPHIC MEGA-BASIN OCCUPIES ABOUT 17,000 KM^2 , WHERE POSSIBLE FERTILE LANDS CAN BE RECLAIMED AND CULTIVATED IN CASE OF WATER ACCESSIBILITY.

THE GROUNDWATER IN SINAI IS MOSTLY HOSTED IN DEEP STRATA AND COMES TO THE SURFACE EITHER ALONG NATURAL FRACTURES AND FAULTS OR THROUGH DRILLED WELLS.

THE AREA IS COVERED BY SANDSTONE, CARBONATE AND SHALE SEQUENCE. THE DRY VALLEYS ARE COVERED WITH GRAVELS AND STONY ALLUVIUL DEPOSITS.

GROUNDWATER IS STORED IN MEGA-AQUIFERS IN PALEOZOIC-EARLY MESOZOIC, LATE CRETACEOUS, PALEOGENE AND/OR THICK QUATERNARY COVER UNDER CONDITIONS FAVOURABLE FOR EXPLOITATION.

THE DEEP AQUIFERS ARE MOSTLY CONTROLLED BY MAJOR STRUCTURES SUCH AS SYNCLINES AND DOWN FAULTED BLOCKS, AS WELL AS CERTAIN LITHOLOGIES OR CONSTITUTIONAL STRATIGRAPHIC HORIZONS.

Problem Definition

THE SITUATION IS A 17000 KM^2 AREA IN A VERY ARID ZONE, WHERE THE NEED FOR WATER IS ESSENTIAL FOR LIFE. IN THIS AREA, A NUMBER OF DEEP WELLS WERE DIGGED. ONLY FOUR PROVED TO BE PRODUCTIVE WHILE MORE THAN 10 WELLS WERE NEGATIVE.

REGIONAL GEOLOGIC STUDY IS UNDERTAKEN TO DETERMINE IF AND WHERE, SIMILAR PROMISING LOCATIONS FOR GROUNDWATER RESOURCES MIGHT BE EXPECTED TO EXIST.

IT IS CONFIRMED THAT THE SEDIMENTARY COVER THAT MAY HOST WATER AQUIFERS REACHES AT MORE THAN 5 KM THICKNESS RESTING UPON A MASSIVE CRYSTALLINE BASEMENT ROCKS.

PRESUMABLY, WE SHOULD GATHER INFORMATION THAT WILL TELL US SOMETHING ABOUT :

WHY THE GROUNDWATER OCCURS ? AND WHERE IT DOES ?

THAT IS OUR PRIME CONCERN SHOULD BE WITH CAUSALITY.

THE CAUSES OF GROUNDWATER ACCUMULATION ARE UNDOUBTEDLY MANY AND VARIED.

FACTOR ANALYSIS IS A TECHNIQUE BY WHICH VARIABLES MEASURED ON A SET OF SAMPLES ARE LINEARLY COMBINED GIVING RISE TO A NEW FUNDAMENTAL QUANTITIES (FACTOR) WHICH CAN BE NAMED AND SIMPLY INTERPRETED IN THE LIGHT OF SOUND GEOLOGIC REASONING.

ONE MAY SAY THAT DATA IS MEASURED ALONG ARBITRARY AXES AND THEY ARE ROTATED TO OCCUPY SYMMETRIC POSITION WHICH DO HAVE MEANING.

MEANWHILE THE DATA STRUCTURE WHEN ROTATED TO REFER TO THE NEW AXES DECOMPOSES INTO SIMPLER AND INTERPRETABLE STRUCTURES.

THE GEOLOGIST WORKING IN THIS AREA MIGHT FEEL THAT PALEO-ENVIRONMENT OVER 400 MY MIGHT BE A MAJOR CONTROL, SIMILARLY THE TYPE AND THICKNESS OF SEDIMENTS, THE DEFORMATION PATTERN AS WELL AS THE PHYSICAL PROPERTIES OF THE COUNTRY ROCKS.

IT IS, OF COURSE, IMPOSSIBLE TO MEASURE THE AMOUNT OF THESE CAUSES. RATHER WE CAN MEASURE THE SPATIAL, COMPOSITIONAL, DEFORMATIONAL AND GEOLOGIC PROPERTIES WHICH REFLECT THESE CAUSES TO SOME DEGREE.

DATA PROCESSING AND COMPUTATION

STANDARD STATISTICS IS APPLIED TO THE RAW DATA TO COMPUTE MEANS AND MEASURES OF DISPERSIONS AND NORMALITY CHECK FOR EACH VARIABLE ARE COMPUTED AS WELL.

A DETAILED DISCUSSION OF FACTOR ANALYSIS IS REFERED TO HARMAN (1960) AND COMREY (1973).

THE REMOTE SENSING, THE GEOPHYSICAL AND FIELD DATA ARE COLLECTED AND STORED IN SEPERATE FILES. THESE DATA ARE IN THE FORM OF GRID PATTERN MAPS.

THE PRESENT COMPUTATION IS CARRIED ON AN AT/IBM COMPUTER.

THE PROGRAM EXTRACTS THE EIGEN VALUES AND EIGEN VECTORS FROM THE CORRELATION MATRIX USING THE HOUSEHOLDER TECHNIQUE BY SUBPROGRAM (TRED 2) AND MATRIX INVERSION BY THE TWO SUBPROGRAMS LUDCMP AND LUBKSP (PRESS ET AL, 1986). THROUGH MATRIX MANIPULATION (COMREY, 1973), THE PRINCIPAL FACTORS ARE EXTRACTED AND ROTATED.

SINCE THE AREA IS VAST AND WELL EXPOSED, A SAMPLING GRID IS DESIGNED SUCH THAT 58 STATIONS ARE CHOSEN TO BE EVALUATED.

THE REMOTE SENSING, AEROMAGNETIC AND FIELD DATA ARE CALCULATED AND TREATED STATISTICALLY.

SCORES OF THE ORIGINAL DATA ARE RELATED TO THE PRINCIPAL FACTORS.

FROM THE ABOVE PRESENTATION AND FACTOR ANALYSIS, FOUR COLUMNS OF SCORE FACTORS ARE OBTAINED NAMELY F1, F2, F3, AND F4.

WHEN FACED WITH A LARGE ARRAY OF DATA SUCH AS THIS MANUFACTURED DATA MATRIX, THE TECHNIQUE OF FACTOR ANALYSIS IS OFTEN ABLE TO EXPOSE OF THEIR RELATIONSHIPS.

SINCE I AM NOT MATHEMATICIAN, YOU WILL BE ASKED TO FORGET HOW THE DATA MATRIX IS OBTAINED, BUT, RATHER, ASKED TO PRETEND THAT IT IS THE NORMAL RESULT OF COMMON GEOLOGIC MAPPING PROCEDURES.

IN THIS HYPOTHETICAL MODEL, WE WILL, IN FACT, SPECIFY THAT THESE CONTROLS ARE ALL IMPORTANT.

FURTHERMORE, LET US ASSUME THEIR ROLE AND SPECIFY THE DISTRIBUTION OF THEIR CAUSES AT EACH ONE IN A GRID PATTERN.

TABLES AND FIGS ILLUSTRATE THE DISTRIBUTION OF CAUSES IMPOSED AT THE SAMPLE LOCATIONS.

FACTOR 1 (F1) CAN BE THOUGHT OF AS AN EQUATION GOVERNING THE GENERAL TREND AND GRADE OF TERRAIN SLOPE.

FACTOR 2 (F2) SHOWS THE AREAL DISTRIBUTION OF THE FACTOR SCORES OF LINEATION AND DRAINAGE INTENSITY.

FACTOR 3 (F3) IS MADE UP OF PHYSICAL PROPERTIES , WHILE

FACTOR 4 (F4) IS CONCERNED WITH THE SEDIMENTARY COVER THICKNESS AND DEFORMATION PATTERN.

FIGURES 1, 2, 3 & 4 SHOW THE RELATIVE DISTRIBUTION OF EACH FACTOR.

FROM IT, WE HOPE TO DEDUCE SOMETHING ABOUT THE PRESENCE OF GROUNDWATER IN THE AREA UNDER STUDY.

WE DO NOT KNOW HOW MANY CAUSES THERE ARE GOVERNING THE OCCURRENCE OF THESE AQUIFERS ?

WE DO NOT KNOW THE RELATIONSHIPS OF THE GEOLOGIC PROPERTIES TO GROUNDWATER AQUIFERS ?

WE HAVE MEASURED THESE PROPERTIES BECAUSE WE THINK THEY MAY HAVE SOME IMPORTANCE BUT WE ARE NOT ENTIRELY SURE !!

AFTER KNOWING THE AMOUNT OF EACH CAUSE AT EACH SAMPLE LOCATION AND THE DEGREE OF RELATIONSHIP BETWEEN EACH PROPERTY AND EACH CAUSE, WE ARE IN A POSITION TO PREDICT EXACTLY THE MEASURABLE AMOUNT OF EACH PROPERTY AT EACH LOCALITY.

NOW, WE KNOW THAT THERE ARE A NUMBER OF OPERATING CAUSES OF GROUNDWATER LOCATIZATION.

TABLE (3) OF DATA MATRIX IS GENERALLY ALL WE HAVE TO WORK WITH. IT MIGHT BE THE END RESULT OF INTENSE EFFORT.

BY COMPARING THE RESULTS OF THE FACTOR SCORE MAPS WITH THOSE CREATED BEFORE AS VARIABLE MAPS, AND BY COMBINING THE FOUR FACTOR MAPS INTO ONE AND LOCATING THE KNOWN PRODUCTIVE WELLS ON IT, A SPECIAL SET OF CONDITIONS IS APPARENTLY REQUIRED FOR GROUNDWATER OCCURRENCE.

ON THE MAP , IT IS NOT DIFFECULT TO SEE THAT AT LEAST ONE OTHER SIMILAR AREA TO THE CONDITIONS OF EVERY PRODUCTIVE WELL LOCATION. COULD BE TRACED.

THE SHADED AREAS THUS BECOME THE PRIMARY TARGET FOR FURTHER EXPLORATION.

ADMITTEDLY, ONE MIGHT ASSURE; THESE FACTORS, IN A WAY OR ANOTHER, ARE DEPENDING ON THE EXPERIENCE, KNOWLEDGE AND SHREWDNESS OF THE INTERPRETER.

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A CASE STUDY

DESERT LAND & SOIL CLASSIFICATION

IN SW-SINAI

INTRODUCTION

DESERT LAND SOIL CLASSIFICATION IS ONE OF THE MAIN JOALS FOR DEVELOPMENT PLANNING IN THE ARID ZONES. THE STUDY AREA IS CHOSEN ACCORDING TO THE NATIONAL STRATEGIC PRIORITIES AND AVAILABILITY OF THE OTHER AGRICULTURAL RESOURCES SUCH AS PROPER CLIMATE, NECESSARY ENERGY RESOURCES, WATER SUITABILITY, (QUALITATIVELY AND QUANTITATIVELY), AND ITS ACCESSIBILITY FROM AND TO THE CONSUMING AREAS.

THE TERRITORIES OF EGYPT COVER ONE MILLION KM^2, ABOUT 97% OF THE LAND OF EGYPT IS COVERED BY DESERT LYING IN ONE OF THE MAJOR ARID ZONES OF THE WORLD. THESE DESERTS INCLUDE THE WESTERN DESERT, THE EASTERN DESERT AND THE PENINSULA OF SINAI.

Here, an example illustrates the significance of satellite image interpretation for desert land and soil classification in SW Sinai Peninisula. The prevailing arid conditions over Sinai Peninsula necessitate the dominance of desert conditions in general with a limited exception of the relatively deep courses and fan-deltas of the main old dry valleys that draine towards the Gulf of Suez, where possible fertile lands can be reclaimed and provided by the accessible needed water.

Landsat-image.ry is available as magnetic tapes and printed images which are made on positive transparencies and hard prints for each of the various bands. Statistical analysis, choice of sampling procedures and test zones, characterization of each image-unit and field verification was done by Abdel Hady (1987).

PROCEDURE AND RESULTS

I. Visual Analysis :

It revealed the principal geomorphic units. Also, it provided us with some indications related to the spectral behaviour of different surfaces. It determined the locations of the subimages based on the criterion of containing the maximal variation of colors & contrast values.

II. Digital-image processing :

(a) Selection of the most informative channels, due to their scatterograms which revealed that :

The pixels of channels 4 & 7 form spread points which indicate that these 2 channels are the least correlated for each other. This weak inter-correlation refers to their role for being used in a multivariable classification & for studying the relationships between satellite-digital data and parameters of soil surface conditions, (S.S.C.).

The scatterograms of 6 & 7 is presented in a narrow area. This analysis permitted to select channels 4, 5 & 7 for data classification.

(b) Determination of thresholds by detailed analysis of subimages :

* Carrying on frequency histograms of every subimage.

* Graphic presentations to achieve spectral class segmentation more easier. They allow to estimate the maximum & minimum values of each theme.

* Radiometic characterization of test-zones. Test zones were selected and radiometically characterized. The standard deviations, their averages, maximal and minimal values of these zones were extracted.

(c) MULTISPECTRAL CLASSIFICATION :

THE PREVIOUSLY CONCLUDED THRESHOLDS WERE USED TO ELABORATE A SEMI-SUPERVISED MULTISPECTRAL CLASSIFICATION, IN WHICH SPECTRALLY SIMILAR POINTS WERE PACKED INTO "CUBES" THEN GROUPED INTO "THEMES" WHICH WERE RECONSTITUTED AS "ASSISTED-COMPUTER MAP". IT IS USED AS A BASIC MAP FOR SOIL SURFACE CONDITIONS.

THE MEASURED VARIABLES TAKEN INTO CONSIDERATION
IN EL QA'A PLAIN

SOIL SURFACE VARIABLES :
- STONY COVER
- CRUST
- BARE SURFACE (FREE FROM CRUST & STONY COVER)

SOIL TEXTURAL VARIABLES :
- COARSE SAND
- MEDIUM SAND
- FINE SAND
- CLAY & SILT

COMPSITION VARIABLES :
- A. CARBONATES
  - TOTAL CARBONATES
  - CALCIUM CARBONATES
  - CALC & MAGN. CARBONATES
- B. GYPSUM

PHYSICAL PROPERTIES VARIABLES :
- ELECTRIC CONDUCTIVITY OF SOIL PASTE

REFLECTANCE VARIABLES :
- SIGNATURE OF CHANNELS 4, 5, 6 & 7
- CHANNEL COMBINATIONS

(D) THE CORRELATION MATRIX REVEALED THE FOLLOWING :

(1) MSS-IMAGERY CORRELATION :

- CHANNELS 4,5,&7 ARE STRONGLY INTERCORRELATED.
- THE HIGHEST CORRELATION IS LIED BETWEEN 6&7 CHANNELS WHILE THE WEAKEST CORRELATION CHANNELS IS BETWEEN 4&7.
- THE RATIOS ARE SO WEAKLY CORRELATED. THE 7/6 IS THE WEAKEST CORRELATION.

(2) S.S. CONDITION- MSS DATA CORRELATION :

- 9 S.S.C HAVE SIGNIFICANT CORRELATION TO MSS DATA.
- CHANNELS 4 &7 & 7/6 ARE THE MOST STRONGLY CORRELATED DATA TO S.S.C.

- THE S.S.C COULD BE CLASSIFIED ACCORDING TO THEIR RELATION WITH MSS- DATA INTO 4 GROUPS :-

(I) GROUP WITH S.S.C. HAVING NON- SIGNIFICANT CORRELATION WITH MSS- DATA; H (COLOR HUE), C (COLOR CHROMA) & V (COLOR VALUE) C (SUMMATION OF SAND TYPES).

(II) GROUP WITH S.S.C. HAVING NO- CORRELATION WITH CHANNEL AVERAGES AND CHANNEL RATIOS ; CR (CURSTED SURFACE) & CAR (TOTAL CARBONATES).

(III) GROUP WITH S.S.C HAVING NO CORRELATION WITH CHANNELS RATIOS; CE (COARSE ELEMENT), CEN (WEIGHTED COARSE ELEMENT), C+S (CLAY+SILT), CALC (CALCIUM CARBONATES) AND DOLO (DOLOMITES) THEY ARE CORRELATED TO THE CHANNELS AND THEIR SUMMATION. THE STRONG CORRELATION ARE :-

C+S & CEN TO MSS 7

CALC AND EC TO MSS 4

CEN AND CE TO MSS 6.

(IV) GROUP WITH S.S.C. HAVING CORRELATED WITH 7/4 RATIO (R=0.310). THIS PARAMETER IS COMPOSED ONLY OF G (GYPSUM).

THE CORRELATION MATRIX OF (S.S.C.-MSS) ALLOWS TO DIVIDE THE S.S.C. INTO TWO CLASSES :-

(1) CLASS WITH +VE CORRELATION WITH MSS. THEY ARE CR, SF, (C+S), V AND THE CARBONATES.

(2) CLASS WITH -VE CORRELATION; CEN, CE & EC.

THE S.S.C. THAT HAVE CAPITAL INFLUENCE ON MSS DATA CAN BE EXPRESSED BY THIER DETERMINATION COEFFECIENT (R). THIS COEFFECIENT ALLOWS TO CONSTITUTE THE SERIES OF S.S.C. THAT HAVE THE STRONGEST INFLUENCE IN SINAI PENINSULA ON THE MSS DATA. THIS SERIES WHICH IS COMPOSED OF CALC, DOLO AND (C+S) CAUSES 45% OF THE VARIABILITY OF MSS DATA.

THE OBJECTIVE OF THE STUDY OF THE CONCERNED RELATIONSHIPS IS TO PROVIDE NEW INFORMATION PRECISING THE MAPPING OF THE SOILS AND THEIR SURFACES. THIS STUDY ENABLES US TO DETERMINE THE MSS- MOST DISCRIMINANT PARAMETERS OF S.S.C.

(A) CONCERNING THE MSS CHANNELS :

1. CHANNEL 7 IS USED TO DIFFERENTIATE THE CRUSTED SURFACES FROM NON-CRUSTED.

2. CHANNEL 6 IS USED TO MAP ACCURATELY THE COARSE ELEMENTS.

3. CHANNEL 4 TRACES THE DIFFERENT CATEGORIES OF THE TOTAL CARBONATES.

(B) CHANNEL RATIOS :

1. 6/4 IS ABLE TO DIFFERENTIATE THE DIFFERENT COLORED ZONES.

2. 7/4 MAPS THE DIFFERENT LEVELS OF CARBONATES & GYPSUM CONTENTS.

3. REMOTELY SENSED - SOIL MAP :

LANDSAT DIGITAL DATA ALLOWED US TO ELABORATE REMOTELY SENSED SOIL MAP WHICH IS COMPOSED OF SUBJECTIVELY - SPECTRAL TEST SITES EACH TEST SITE CONTAINS 81 PIXELS.

THE FIELD STUDY DISTINGUISHED THE FOLLOWING MAIN CLASSES OF SOIL SERVICE CONDITIONS (S.S.C.) :

* CRUSTED SURFACE : GYPSUM & / OR CARBONATE CRUST COVERS MORE THAN 60%.

* MODERATELY CRUSTED SURFACE : 40 TO 60% OF THE ZONE AREA.

* SANDY SURFACE : SURFACE FREE FROM THE CRUST & COARSE ELEMENTS (NOT MORE THAN 20% OF THE AREA) .

* GRAVELLY AND ROCKY SURFACE : MORE THAN 40% OF THE ZONE AREA.

* AT THE FAN DELTAS OF BABA AND SUDR; THE CRUSTED SURFACES ARE COMPLETELY ABSENT WHILE THE GRAVELY & ROCKY ONES ARE DOMINANT.

* THE SANDY SOIL SURFACES ARE WIDELY DISTRIBUTED AT FEIRAN DELTA & THE NORTHEN PART OF EL QA'A PLAIN.

* THE SUPERFICIAL MATERIALS OF QABALIAT SLOPES AND OF THE MAIN PLAIN FORM CRUSTED SURFACES.

4. CHARACTERIZATION AND MAPPING OF S.S.C.

THIS PHASE REVEALED THE FOLLOWING SURFACIAL CHARACTERISTICS :

(1) BABA VALLEY DELTA : IS CHARACTERISED BY MODERATELY UNDULATED SURFACE, MODERATE SLOPE, COARSE TEXTURE, HIGH CARBONATES CONTENT, LOW GYPSUM CONTENT & STRONG SALINITY.

(2) SUDR DELTA : IS DISTINGUISHED BY EXTREMELY UNDULATED SURFACE, STEEP SLOPE, COARSE TO MEDIUM TEXTURE, LOW CARBONATES AND GYPSUM CONTENTS & MODERATE SALINITY.

(3) FEIRAN DELTA : IS GENERALLY CHARACHTERIZED BY SLIGHTLY UNDULATED SURFACE, GENTLE SLOPE, MEDIUM TEXTURE, LOW CONTENTS OF CARBONATES & GYPSUM & WEAK SALINITY.

(4) THE NORTHERN PART OF EL QA'A PLAIN IS SLIGHTLY TO MODERATELY UNDULATED SURFACE, MODERATE SLOPE, MEDIUM TEXTURE, HIGH CONTENTS OF CARBONATES AND GYPSUM AND RELATIVELY STRONG SALINITY.

(5) THE SOUTHERN PART OF EL QA'A PLAIN IS A PLAIN SURFACE, GENTLE SLOPE, COARSE TEXTURE, LOW CONTENTS OF CARBONATES & GYPSUM & STRONG SALINITY.

CONCLUSION

THE CAPABILITY OF LANDSAT IMAGES TO MAP THE S.S.C. OF AN ARID REGION.

THE COMPARISON BETWEEN GROUND TRUTH & COMPUTER MAP SHOWS:

1. THIS MAP COULD NOT DISTINGUISH BETWEEN THE CALCAREOUS COARSE ELEMENT SURFACE & GRANITIC ZONES.
2. THE GRAVELS AND STONES SEEM SIMILAR WHEN THE BACKGROUND IS CRUST OR SANDY SOIL.
3. IN THE INTERIOR OF SOME CARTOGRAPHIC UNITS, THE LIMITS BETWEEN THE THREE COMPONENTS "CRUST, SANDY SOIL AND COARSE ELEMENTS" DISAPPEARED.

THIS CAN BE EXPLAINED BY :

- THE SURFACE ROUGHNESS IS A DOMINANT FACTOR AFFECTING PIXELS GREY LEVEL
- THE PIXELS GREY LEVEL INTEGRATE THE INFLUENCE OF THE SOIL SURFACE CHARACTERISTICS
- THE COMPUTER MAP NEGLECTED THE SLIGHT DIFFERENCE OF PIXLES GREY LEVEL.

THE CHARACTERIZATION & MAPPING OF S.S.C. SHOWED THAT THE NORTHEN PART OF EL QA'A PLAIN AND FEIRAN VALLEY HAVE THE HIGHER AGRICULTURAL POTENTIALITY IN SW SINAI.

THE RELATIONSHIPS BETWEEN THE S.S.C. AND THEIR UNDERLYING SOILS WERE PHYSIOGRAPHICALLY ESTABLISHED; THREE GREAT GROUPS WERE DIFFERENTIATED :
GYPSIORTHIDS, PALEORTHIDS AND SALORTHIDS. THE TWO FIRST GROUPS WERE ALSO CLASSIFIED EVEN TO THE FAMILY LEVEL.