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STUDY OF MINERAL AND OIL EXPLORATION USING REMOTE SENSING APPLICATION

A Project Submitted as Partial Fulfillment for the Requirements of the Degree of Bachelor of Science in Mining Engineering

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ABSTRACT

The research, consisting of four chapters, was written, the main purpose of which is to make the reader understand the importance of remote sensing for mineral exploration and to know whether it is possible to extract this mineral and benefit from it. We first talked about remote sensing, its types and applications used in it, and we talked about GIS and its importance in determining Maps and its applications in the fields of engineering, then we took previous studies of mineral and rock exploration for areas in northern Iraq, which are lineaments. The geological structural features such as lineaments have been taking much interest in the geological studies lately, because it is considering as a very important structural and geological indicator to determine general and local tectonic trends and fractures zones in the rocks, especially in the areas which are characterized that are covered extremely by the soils. The principle objective of this study is to design a suitable method for automatically and digital lineament analysis and use the results in the tectonic induction. The second study is a hydrocarbon Seepage. The present study focused on the structural elements which controlled the hydrocarbon seepages in some areas of northern Iraq. remote sensing techniques were used to identify anomalous areas or alteration zones caused by hydrocarbon seepages. The last chapter is the practical chapter exploring gypsum in western areas of Mosul city using data and processing it using a ENVI program.

ACKNOWLEDGEMENT

To whom do I prefer it over myself, she sacrificed for me and never hesitated to make me happy.

(my beloved mother)

I have reached this great milestone thanks to your uninterrupted support.

(dear father)

To my Dear sisters that are depend on in every big and small thing.

(Dear sisters)

To the woman who was the reason for my success and who was my first supporter and cheerleader. Without her, my name would not have become an engineer.

(**My love)**

To My engineering friends, without whom this project would not have been completed.

(My strong team)

I dedicate my graduate thesis to you and I thank God Almighty for what He has bestowed upon me. He has provided me with the conditions and facilitated the accomplishment of this work with His great grace and general generosity. I want to thank the professors who helped me complete this research, in the forefront of them is Professor Dr. supervising this, Head of the Department of Mining Engineering, Dr. Azealdeen S. Al-Jawadi, who provided assistance for me, as is his habit with all students, and I would sit with him for long hours, reading and learning from him, and he would not be bothered by that, rather he would be happy to help every student, and he would always urge me to search and success. He has all my all appreciation, thanks and gratitude, may God protect him and grant him health and wellness and benefit everyone with his knowledge and giving, and i thank Mr. Mauj Ali who helped us complete our research and gave us a lot of advice, and also extend our thanks to the management of the Remote Sensing Center at the University of Mosul, led by Dr. Ryan Ghazi who helped us complete this research.

LIST OF CONTENTS

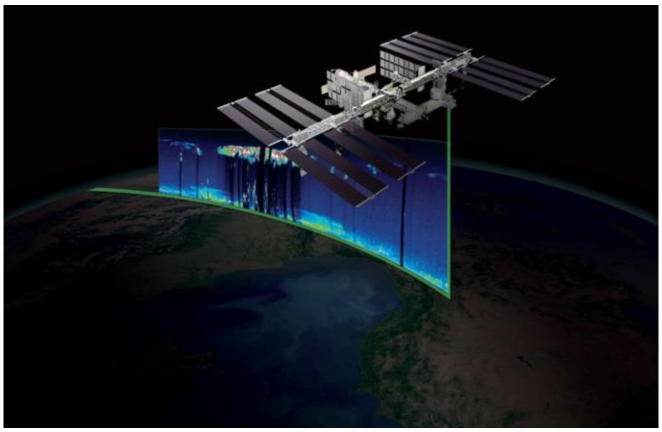
CONTENTS	Page
ABSTRACT…………………………………………………………	I
ACKNOWLEDGEMENT……………………………………………	II
CONTENTS…………………………………………………………	III
LIST OF FIGURES……………………………………………………	IV
LIST OF TABLS………………………………………………………	V
CHAPTER 1- Introduction…………………………………………	1
1-1. GIS function and GIS application…………………………………	2
1-2. Principles and Process of Remote Sensing…………………………	5
1-3. Remote sensing to mineral exploration……………………………	7
1-4. GIS application in Petroleum Geology……………………………	10
1-5. Previous studies.	12
CHAPTER 2- Methodology………………………………………………	
FIRST STUDY: Automatic Extraction and Geospatial Analysis of Lineaments .	16
Methodology………………………………………………………………	16
SECOND STUDY: study Structural Control Evaluation of Hydrocarbon Seepage.	21
Methodology………………………………………………………………	21
CHAPTER 3- Results and Discussion…………………………………	
FIRST STUDY: Automatic Extraction and Geospatial Analysis of Lineaments.	23
Discuss the map & results………………………………………………	23
SECOND STUDY: study Structural Control Evaluation of Hydrocarbon Seepage.	28
Discuss the map & results………………………………………………	28
CHAPETR 4- practical part (The exploration of Gypsum Rocks in Nineveh)	
Preface………………………………………………………………………	34
study area…………………………………………………………………	34
Results………………………………………………………………………	36
References…………………………………………………………………	39

LIST OF FIGURES

Figures	subjects	page
1.1	Simplified map of Iraq showing study area	13
2.1	Geographic location of the study area	15
1.2	Flowchart shows steps of the study	17
2.2	Filtered images in N-S, E-W, NW-SE, NE-SW, directions	19
3.2	Flowchart shows steps of the study	22
1.3	Lineaments maps with four principal trends	24
2.3	Frequency distribution and basic statics of the lineaments	25
3.3	Lineaments Density map of the overall lineaments by grids and contours	26
4.3	Rose diagram illustrating all lineament trend over the FCC Landsat image of some selected zones of the studied area	27
5.3	Applying three digital processing	30
6.3	Applying three digital processing	31
7.3	Alteration zones	32
8.3	X-Ray analysis of selected sample	32
9.3	A: FCC Landsat image. B: classification of DEM. C: Topographic sections of concluded subsurface structure. D: Tonal anomaly.	33
10.3	A virtual model of hydrocarbon seepage along listric fault plane	33

LIST OF TABLS

Table	Subject	Page
1-2	Sobel - kernels in four principle directions	18
1-3	Suggested parameters values	23



CHAPTER 1

Introduction to REMOTE SENSING & GIS in mineral and oil exploration.

CHAPTER PARAGRAPHS

- GIS function and GIS application.
- Principles and Process of Remote Sensing.
- remote sensing to mineral exploration.
- GIS application in Petroleum Geology.
- Previous studies.

Introduction:

Remote sensing and remote sensing techniques in the search for minerals, given that Iraq is a rich country, but rather oil and minerals, and given the extreme importance that results from the search for minerals that increase the country’s economies and works to open laboratories and factories to employ people and provide job opportunities. This research was adopted to discuss the whereabouts of rocks carbon and minerals and the possibility of creating mines or quarries to extract these minerals and send them to manufacturing units or export them abroad. A geographic information system (GIS) a computer-based system capable of assembling, storing, manipulating, and displaying Georeferenced data. (GIS) is a powerful technological tool that can be used in the problem-solving process facing any exploration and exploitation team. A GIS can provide the team with a whole new way of analyzing, visualizing, and integrating data. And is It is very important in petroleum and mineral exploration. GIS is a very dynamic technology, and it enables the user to display a map of any location in the world and to rescale that map instantly. Interpreters can zoom into a specific area of interest by simply defining the four geographic coordinate boundaries of the map. Remote sensing is the process of acquiring data/information about objects/substances not in direct contact with the sensor, by gathering its inputs using electromagnetic radiation or acoustical waves that emanate from the targets of interest. An aerial photograph is a common example of a remotely sensed (by camera and film, or now digital) product. The sun is a source of energy or radiation, which provides a very convenient source of energy for remote sensing. The sun's energy is either reflected, as it is for visible wavelengths, or absorbed and then reemitted, as it is for thermal infrared wavelengths. The reason for the continuous increase in the use of remote sensing techniques in various geological applications is due to the emergence of modern techniques proposed by researchers, which in turn lead to the ease of obtaining information from satellite visualizations, and the development of software and the improvement of the spatial and spectral specifications of satellite visualizations contributed to supporting studies on geological applications. The aim of the study was to explore and evaluate the minerals and oil found in specific areas in Iraq using the applications of remote sensing and geographic information systems. It starts first by explaining the applications of remote sensing and geographic information system, then a detailed study of mineral and oil exploration for some areas in Iraq using remote sensing and geographic information systems. The term remote sensing is often wrongly applied to satellite-borne imaging of the earth’s surface only. Remote sensing is the common name for all methods used to collect data at a distance from the object under study by some kind of recording device. The use of remote sensing techniques is increasing rapidly, finding new fields of application as technology advances in developing the remote sensing systems. The aim with this paper is not to fully review existing remote sensing methods but rather to introduce the concept of remote sensing to the reader. It will provide a foundation to the understanding of the principles of remote sensing needed when working with applications of this technique. The emphasis will be on satellite sensor remote sensing but some aspects of traditional photographic remote sensing and aerial photography using digital aerial cameras will also be treated.

(1-1). GIS function and GIS application.

Preface:

The acronym “GIS” can stand for Geographical Information Science or Systems. The science deals with the study of spatial and earth referenced data, and how they relate in terms of proximity to surrounding data or objects. A system is designed to capture, query, analyze, manipulate, store and present all types of geographically referenced data. Any variable that can be located spatially, and increasingly temporally, can be referenced using a geographical information system. In the simplest of terms, GIS is the merging of cartography, statistical analysis, and database technology. (Julie P. E, 2015)

Geographical information systems (GIS) is a powerful mechanical device that can be used in the critical thinking process facing any investigation and a double-dealing group. A GIS can give the group a completely different approach to investigating, imagining and integrating information. Innovating GIS Currently available across all computer stages, including the web. Lately, its expenses have basically diminished, while the benefit has definitely been an upgrade. Recently, the exponential expansion of implementation. Also, the falling costs of computers (the personal computer) phase has accelerated the development of the use of GIS. GIS innovation has become completely logical and simple Uses. The real strength of a GIS is that it offers another way to dissect datasets. GIS enables the expert to visualize information as it is spatially addressed. An investigation of the spatial connections of advanced datasets can offer new pictures of information that could not otherwise be collected by deconstructing simple visualizations of informational indexes. GIS is an exceptionally powerful innovation, and it enables a customer to show evidence of any area on the planet and to instantly re-scale that evidence. Moderators can zoom in on a particular area of interest by characterizing essentially the four geographic directions of the guide. (Barrell K. A, 2000)

Function of GIS:

- Capturing Information - The capacity to catch geographic (coordinate) and plain (property) information utilizing different means makes the Framework flexible.
- Storing Data- There are two essential configurations for addressing and putting away information: vector and raster. Vector records address cartographic elements similarly as guides or scaled drawings do - with focuses, lines, and regions. Each kind of calculation addresses a different element class. Vector documents furnish discrete portrayals of reality with known facilitates attached to their elements. Raster documents address a lattice of lines and segments, with every framework cell having some worth. These frameworks might give discrete or persistent portrayals of the real world, and could conceivably be referred to known arranges at the hour of creation. Numerous raster designs exist. Symbolism in a GIS is just accessible in raster design. Cell values contain variety band information. As advanced photos contain more detail with an expanded pixel count for every 4-inch x 6-inch picture, raster pictures can contain more detail with an expanded cell count for each unit region. The degree of detail is all the more precisely named the spatial goal of the raster, and relies on the gadget used to catch the picture. Raster's will be examined further inside the text. Both vector and raster designed records are introduced as layers in a GIS. These layers contain both the geographic and quality information. Trait information is put away in even structure inside a data set. Information layers are put away in a few unique configurations, which will be examined later inside the text. Layers can be overlaid and spatially adjusted for performing inquiries, examining to create new information, and essentially showing connections that may somehow be disregarded with discrete paper guides, tables, or other more customary wellsprings of data.
- Questioning Data - A GIS should have orders or utilities for tracking down highlights with explicit traits. Normal orders incorporate choosing highlights by ascribes or by area. Choices can likewise be founded on conditions. For example, choices can be founded on a past determination, or upon the convergence or association of at least two elements, either inside a similar layer or from various layers. Raster cells can be chosen by normal or one of a kind credits. They as well, can be chosen in view of restrictive proclamations determined by the client. A Frameworks can draw designs, whereupon they likewise, can be utilized to choose specific highlights or cells inside a layer. One more method for questioning in a GIS is by estimating highlights.
- Examining Information - A GIS should have the option to recognize spatial connections between various datasets. Geoprocessing is characterized as an

activity performed on geographic, or spatial information. It includes an info dataset and a device or order to break down and create new data coming about, in a result dataset. Instances of geoprocessing would incorporate putting a 50-foot cradle around streams to keep away from improvement here, or inserting a raster height surface from estimated rise focuses. Spatial inquiries, as made sense of above, are likewise viewed as a geoprocessing activity.

- Showing Information - A GIS should have a point of interaction and illustrations fit for showing results at various scales and with numerous Symbology. It can frequently mimic three dimensional pictures from 2-D pictures utilizing concealing methods. A GIS is fit for three dimensional displaying when a third, and frequently final aspect, is given.
- Yielding Information - Most Frameworks give choices to results to be shown in different arrangements, like guides, tables, reports and diagrams. (Julie P. E, 2015)

So how is information gathered for use in a Geographical information system?

Advanced information can be made by examining paper guides or airborne photographs, imported from accounting sheets or different data sets, somewhat detected from satellites or different sensors, as well as caught in the field from conventional electro-optical overview instruments, or all the more straightforwardly, from worldwide situating framework collectors. We will momentarily examine the subtler techniques for information assortment. Simple information should constantly be digitized prior to being added to a geographic data set. Checked paper guides or photos can be utilized as raster information, as examined prior, or digitized to deliver a vector portrayal. Contingent on the configuration and qualities of the information, the simple to-computerized change might require reformatting or rebuilding. Similarly, as with any such change, the first information might be modified accordingly, presenting vulnerability. This is where information norms become useful. A huge part of GIS information is caught through remote detecting. Remote detecting is the estimation of physical, synthetic and natural properties of articles without direct contact. A training includes sensors mounted on satellites, airplane, inflatables and different stages to recognize (fundamentally) noticeable, infrared, and warm radiation reflected or transmitted from sources on or beneath earth. (Julie P. E, 2015)

GIS application:

Geographical information systems are on a very basic level about critical thinking - as is designing. While the application began basically for the military and mainstream researchers, regular citizen engineers have figured out how to coordinate spatial investigations and geoprocessing into their work processes to expand exactness's, perception, and efficiency. The utilities area depends vigorously upon GIS to plan formats and give inventories of oil and gas pipelines, water/storm water/storm sewer pipe organizations, and electric lines and transformers. Oil, water driven, clean sewer, and electrical architects use GIS to oversee data sets of their organizations, and to inquiry and pinpoint expected issues inside frameworks. Utilizing territory and land use information, electrical or atomic designers can process the most un-expensive way for development of another power transmission line. Transportation engineers use GIS to guide and stock streets and bike ways, as well as to design new courses. Traffic engineers use GIS to examine mishap areas along courses and frequencies at convergences. They may likewise foster clearing weakness maps for tropical storms or flames, in light of populace densities and road entrance and departure. Synthetic specialists use GIS to anticipate harmful substance spills. They might show situations for the area and degree of fluid or potentially vaporous spills from truck mishaps or train crashes utilizing populace conveyances and support regions (individuals living inside a specific distance of the accident). A GIS can aid hydrologic examinations through mechanized watershed depictions, in estimating steady distances used to process stream season of fixations, and in assessing storm spillover disseminations across a heterogeneous watershed(s). Pressure driven or water asset designs likewise use GIS to assist with robotizing the monotonous course of territory handling for use in extension and floodplain demonstrating. Ecological specialists and land use organizers use GIS to display poison loads across a heterogeneous. (Julie P. E, 2015)

(1-2). Principles and Process of Remote Sensing.

Preface:

Remote Sensing: is the collection of information relating to objects without being in physical contact with them. Thus our eyes and ears are remote sensors, and the same is true for cameras and microphones and for many instruments used for all kinds of applications or, said another way: Remote sensing is the process of acquiring data/information about objects/substances not in direct contact with the sensor, by gathering its inputs using electromagnetic radiation or acoustical waves that emanate from the targets of interest. An aerial photograph is a common example of a remotely sensed (by camera and film, or now digital) product. The sun is a source of energy or radiation, which provides a very convenient source of energy for remote sensing. The sun's energy is either reflected, as it is for visible wavelengths, or absorbed and then reemitted, as it is for thermal infrared wavelengths. there are two main types of remote sensing passive remote sensing and active remote sensing. (Ali A.K,2010) Remote sensing actually done from satellites as moon or airplane or on the ground. to repeat the essence of the definition above, remote sensing uses instrument that house sensors to view the spectral, spatial and radiometric. Relation of observable object and materials at a distance. most sensing modes are based on sampling of photon. Corresponding frequency in the electromagnetic (EM) spectrum.in much of remote sensing, the process involves an Interaction between incident radiation and the targets of interest. This is exemplified by the use of imaging system Where the following seven elements are involving. Note however that remove sensing also involve the sensing of emitted. Energy and the use of non-emitted sensors:

1- energy source or illumination: the first requirement for remote sensing is to have an energy source which illuminates or provides electromagnetic energy to the target of interest.
2- Radiation and the atmosphere: as the energy travels from its source to the target, it will come in contact with and interact with the atmosphere it passes through.
3- Interaction with the target: once the energy makes its way to the target the atmosphere; it interacts with the target. Depending on the properties of both the target and the radiation.
4- Recording of energy by the sensor: after the energy has been scattered by, or emitted from the target, we require a sensor (remote-not in contact with the target) to collect and record the electromagnetic radiation.
5- Transmission, reception, and processing: the energy recorded by the sensor has to be transmitted, often in electronic form, to a receiving and processing station where the data are processed.
6- Interpretation and analysis: the processed image is interpreted, visually and/or digitally or electronically, to extract information about the target, which was illuminated.
7- Vii. Application and analysis: the final element of the remote sensing process is achieved when we apply the information we have been able to extract from the imagery about the target in order to better understand it, revel some. New information, or assist in solving a particular problem. (Ali A.K,2010)

Type of remote sensing:

- passive remote sensing: detect radiation that is emitted or reflected by the object or surrounding area being observed. Reflected sunlight is the most common source of radiation measured by passive sensors. Examples of passive remote Sensors include film photography, infrared, and radiometers.
- active remote sensing: on the other hand, emits energy in order to scan object and areas whereupon a sensor then. Detect and measures the radiation that is reflected or backscattered from the target. RADAR is an example of active Remote sensing where the time delay between emission and return is measured, establishing the location, height, Speeds and direction of an object. (Ali A.K,2010)

Application of remote sensing:

There are probably hundreds of applications that we will take part of:

- meteorology: study of atmospheric temperature, pressure, and wind velocity.
- ocean: measuring sea surface temperature, mapping ocean current, and wave energy spectra.
- Glaciology: measuring ice cap volumes, ice stream velocity, and sea ice distribution.
- Oil and mineral exploration: locating natural oil seeps and slicks, mapping geological structures, monitoring oil field.
- Military: developing precise maps for planning, monitoring military infrastructure, troop movement and ship.
- Climate: the effects of climate change on glaciers and arctic and Antarctic regions. (Ali A.K,2010)

(1-3). Remote sensing to mineral exploration.

Preface:

The utilization of remote sensing for discrimination of the different topographical materials on the outer layer of the earth depends on the manner in which the electromagnetic radiation collaborates with the various highlights on the earth. Rocks comprising of gatherings of minerals contain various proportions of different elements, held together as molecules by different types of bonds. When EMR interacts with these materials, three kinds of changes can happen, viz., electronic, vibrational and rotational. The transitions are conditioned by such features as the types of bonds, the co-ordination state of atoms within the molecules of the minerals of which the rock is made of, the valency of the atoms, etc. The energy detected by the remote sensing systems over the spectrum of EMR is therefore a function of how energy is partitioned between its source and the materials with which it interacts on its way to the detector. The energy of any particular wavelength of radiation may be transmitted through the material, absorbed within it, reflected by its surface, scattered by its constituent particles or re-radiated at another wavelength after absorption. Any material therefore has a characteristic spectrum, depending on its chemical and molecular composition. Be that as it may, since the World's surface includes a large group of different organic and inorganic compounds, the actual spectrum observed may have extensive variety of parts. The features from the satellite imagery are identified and mapped based on the characteristic spectrum and the reflectance recorded by the sensor from each feature by using the interpretation keys viz., tone/colour, texture, shape, pattern and association. The choice of the satellite information for geological/mineral exploration studies depends on the sort and scale on which the mapping/exploration is to be done. The current day satellites have the capacities to give information of low to exceptionally high spatial goals, appropriate for land planning and mineral investigation on provincial along with neighborhood levels. The high-resolution remote sensing data is being widely used for mineral exploration mainly in updating the existing geological maps, mapping of major as well as minor structural elements and local fracture patterns that control the occurrence of ore deposits. Hyperspectral remote sensing data is a useful geological tool for mineral exploration and forms an important dataset for identifying and mapping set of minerals related with mineral deposits using spectral matching algorithms. Availability of satellite remote sensing data in digital form makes it amenable for applying of various digital enhancements through the digital image processing techniques, which further help in bringing out valuable information on litho contacts, structural features and various anomalies associated with the occurrence of mineral deposits. (Krishnamurthy & Sreenivasan 2005)

The most important things to consider when mineral exploration:

Type of Remote Sensing data required for mineral exploration will depend on various factors like the scale of mapping, the type of terrain under investigation, the target minerals and the stage of mineral exploration. During reconnaissance survey phase low spatial resolution satellite data (50 -100 m resolution, i.e. IRS LISS-II and LISS-III data) can be used. For semi-detailed survey medium resolution data (~25 m resolution, IRS LISS-III data) is useful. During the phase of detailed survey high-resolution data (~ 5 m resolution; IRS-1C/1D PAN, IRS-P6 LISS-IV data) is most useful. Mineral exploration strategy will depend on, firstly, what kind of geological/

lithological terrain we are exploring, which necessitates the need for geological mapping as an initial step. Secondly, the strategy will also depend on what kind of minerals are likely to be found in the terrain, which necessitates the need for knowledge of rock and mineral association. (Krishnamurthy & Sreenivasan 2005)

It is equally important to know mineral genesis, i.e., the nature of mineralization or its origin. Whether the mineral deposit is:

- Primary (In Igneous rocks)
- Secondary (in sedimentary and metamorphic rocks)
- Tertiary (transported - Placer deposits)

And also, it is required to know the processes responsible for mineral formation, i.e., whether the deposit has formed due to:

- Sedimentary
- Metamorphic
- Igneous
- Hydrothermal
- Syngenetic/epigenetic processes.

Another important aspect to look for during mineral exploration is the 'controls on mineralization'. Most of the mineral deposits have structural control, e.g. gold, copper, etc., whereas some minerals like bauxite have geomorphological control. There are other mineral deposits, for example, diamond, which are controlled by litho stratigraphy apart from the structures. The mineralization related anomalies are the most important parameter, which has to be looked for while extracting information from satellite imageries for mineral exploration. Some of the important mineralization related anomalies that can be interpreted from satellite data are:

- Gossan zones
- Alteration zones (gold, copper, etc. mineralization)
- Highly fractured zones, shear zones and carbonate rocks in metamorphic regime (hydrothermal mineralization)
- Shear zones and lineament intersection zones in highly deformed rocks specially in mineralized areas
- Pegmatite bodies (micas & base metals)
- Quartz veins (hydrothermal mineralization such as gold)
- Basic dykes, silicified rocks and ultrabasic bodies (base metals)
- Old mine workings (metallic deposits)
- Circular anomalies (indicating Kimberlite pipes for diamonds)
- Drainage and vegetation anomalies etc.

- Rock out crops, intrusive bodies and reactive rocks.
- Carbonatite bodies (hydrothermal mineralization)

Remote sensing techniques in mineral exploration studies can be used for extracting the following information:

- Mapping of rock types, exposures, geomorphology and structural features.
- Source rock for mineralization.
- Contacts between different rock types
- Shear zones and the important faults/fractures, lineament intersections.
- Extension of existing mineralized belts/ formations.
- Anomalies and structures associated with mineral deposits
- Mapping of alteration zones as indicator of mineralization
- Base feature information such as road/rail network, drainage & water bodies. (Krishnamurthy & Sreenivasan 2005)

(1-4). GIS application in Petroleum Geology.

Preface:

The oil is the most significant and central energy on the planet as of now. It is likewise the most capital concentrated. Incomes are huge, similar to the costs. It also makes headlines for unforeseen accidents and environmental hazards. The truly changing elements of this industry drives supported endeavors for expanded efficiencies and hazard mitigation. The petrol business requires the taking care of and examination of various sorts of information, which can be partitioned:

a) into unstructured data like reports inside a record the executive's framework.
b) structured data in data sets, and spatial information accessible from GIS. (Abdalla, 2018)

The Oil and Gas industry is driven by an expected 80% information that has a spatial part. This is the only industry that harnesses spatial information at every stage of the life-cycle, beginning with opportunity analysis and exploration, through appraisal and production, right up to the abandonment phase. So organizations are starting to comprehend the significance of geospatial to expand return for money invested as well as limit risks. (Abdalla, 2018) Finding new wellsprings of oil in front of the opposition is one of the critical ways of remaining fruitful in the petrol business. A GIS framework can assist you with assessing the potential for oil in promising areas. Investigation frequently requires examination of satellite symbolism, computerized elevated photomosaic, seismic reviews, surface geography studies, subsurface and cross segment translations and pictures, well areas, and existing framework data. (Dr.

Rifaat Abdalla) A GIS can relate these information components to the area being referred to in map structure and permit you to overlay, view, and control the information to examine and grasp its true capacity. GIS innovation today permits you to deal with the spatial parts of these ordinary oil business objects, like leases, wells, pipelines, ecological worries, offices, and retail outlets, in the corporate data set and apply proper geographic examination proficiently across the venture. (Abdalla,2018)

Application of GIS in Petroleum Exploration:

- The oil and gas exploration gathers a huge amount of information; a large portion of them depend on spatial geographic position.

- GIS is utilized to make due, request, break down, and envisioned information, the information, figures and data are all overseen incorporated.
- Spatial components can be framed by this spatial information with GIS, the information will be all coordinated in a foundation of a uniform data set.
- By the solid capacity of the spatial examination, a compelling investigation will be finished.
- It is a new applied character of consolidating the GIS with the innovation of oil and gas investigation in the field of oil investigation.
- The management in petroleum exploration by GIS includes:

a) build a database to manage the data of oil and gas exploitation, such as logging data, drilling data, and experimental analysis etc.

b) integrate all of the data mentioned above to detailed describe the stratum layer, litho logic characters, and tectonic structure of the oil reservoir. (Abdalla,2018)

(1-5). Previous studies.

FIRST STUDY:
Automatic Extraction and Geospatial Analysis of Lineaments in some areas of Northern Iraq using Remote Sensing Techniques and GIS.

Preface:
Earth surface linear features have been concentrate on subject for geologists through numerous years. The old term lineament, presented toward the start of the twentieth 100 years. Hobbs (1911) is one of the primary geologists utilized lineaments and understood that this highlights are the consequence of zones of shortcoming or underlying uprooting in the outside layer of the earth, likewise, Hills (1953) is one of first geologist considers lineaments. A lineament is a mappable linear or curvilinear feature a surface whose parts adjust in a straight or marginally bending relationship (Hung, 2005). They might be a statement of a flaws, joints or other line shortcoming. The lineament might be having a geomorphological ramification, for example major underlying edges, precipices, porches and adjusted portions of a valley are ordinary geomorphological articulations of lineaments. Contrasts in vegetation, dampness content, and soil or rock sythesis represent most apparent differentiation which are utilized to remove the linear feature (O'Leary et al. 1976). Satellite pictures and flying photos are broadly used to portray lineaments for various purposes, like characterizing geographical designs and structural textures (Neawsuparp and Charusiri, 2004). In this unique circumstance, attributes of lineaments, for example, pattern, length and thickness are show to the zones and patterns of high porousness rocks (Masoud and Koike, 2011). Since satellite pictures are viewed as a superior device to separate the lineaments and to create preferable data over regular elevated photos (Casas et. al., 2000). Lineaments can be displayed in both elevated photos and in satellite pictures as a discontinuity that is hazier or lighter in variety in separation with the encompassing region. The guideline objective of this study is to plan a reasonable strategy for auto-extraction and computerized lineament examination and afterward utilize the outcomes in the structural enlistment. The upside of the proposed strategy is its ability for applying in the region which their outcrops portrayed that are covered very by the dirt's (like the region under study). Thus, the dirt's concealing the fundamental primary components like joints and this lead to entangle concentrate on the structural setting of this area. Be that as it may, the examination of the extricated lineaments map with the geospatial examination performing by (Geographic information systems GIS), for example,

density, length and orientation will add to the figuring out the structural connection between the lineaments and the primary components in the review region. (Thannoun, 2013)

Study area:

The region being scrutinized covers around (1100 km2) and situated at the north west of Mosul city between (Lat. 36°44'49.818"N and 36°34'36.783"N) and (Long. 42°23'14.534"E and 42°52'46.283"E) (Fig.1-2). A few primary components with their lithological units are uncovered at the surface along this area. Ain-Zala, Ravan, Butmah and Qusair anticlines address these primary components which anticlines represent these structural elements which characterized that are asymmetrical, cylindrical anticlines, and their fold axis trend towards East-west (Ain -Zala and Butmah), West, North West- East, South East (Ravan and Qusair). The lithological units are uncovered in these designs incorporate Fatha and Injana developments and furthermore Quaternary deposits (Geosurv-Iraq, 1995) (Fig.1-1).

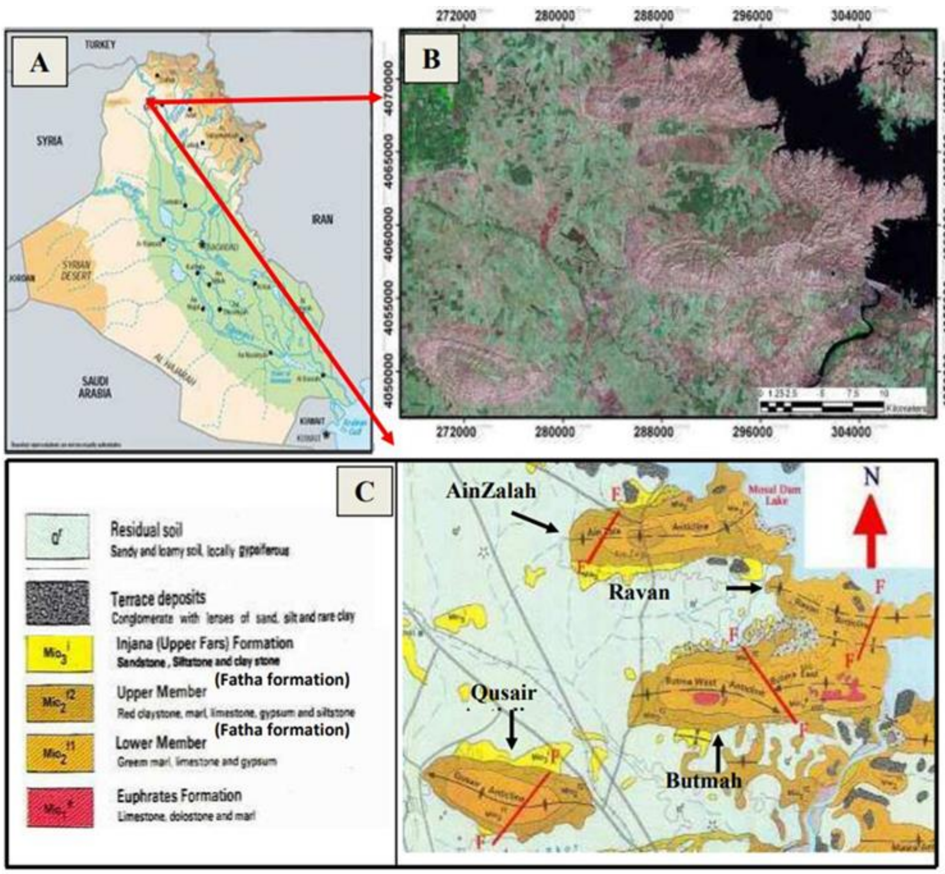


Fig.1-1: A. Simplified map of Iraq showing study area. B. Landsat ETM+ false color composite image. C. Geological map modified from (Geosurv-Iraq, 1995), (Thannoun, 2013)

The stratigraphic units of Fatha development (Center Miocene) at the concentrated on region contain of green marl, limestone and gypsum at the lower individual from the arrangement and red claystone, marl, limestone, gypsum and siltstone at the upper part. Injana arrangement (upper Miocene) in a similar region contains outcrops of sandstone, siltstone and claystone. The Quaternary deposits incorporates leftover soil, incline and valley filling stores. (Thannoun,2013).

SECOND STUDY

study Structural Control Evaluation of Hydrocarbon Seepage in Northern Iraq Using Remote Sensing Techniques.

Preface:

The current review zeroed in on the underlying components which controlled the hydrocarbon seepages in certain areas of northern Iraq. remote detecting strategies were utilized to distinguish atypical regions or modification zones brought about by hydrocarbon seepages. Three image processing methods were used to detect this type of seepage including band ratioing, principal component analysis (PCA), and false-color composition (FCC). Tonal anomalies and subtle changes in spectral content are consider as surface indicators for microseepage. Because of recent forming structures and plausible being financial oil repository, the current review zeroed in on them by performing morph tectonic examination with new methodology utilizing computerized height model to recognize the obscure and new development folds. The outcomes demonstrated present of new subsurface designs which may likely to be promising supply in light of the fact that the surface soil uncovered tonal anomaly in the satellite images. The review uncovered that the central point controlling the leakages is district flaws. That is the seepage was focused on one side of the openness structures. The present study represents an endeavor of applying remote sensing and digital image processing in primary geological explorations. Since the inception of the Landsat program in the early 1970s, remote sensing in particular has become an increasingly important tool for improving conventional methods of data collection and map production in geosciences. The area under investigation located in the foreland belt. (Thannoun & Al-Azawi,2020)

Study area:

Iraq, explicitly on the low and high folded zone as indicated by the structural division of Iraq. It is determined between (Long. 45° 43' 46.3145" and 42° 03' 31.8447" N) and (Lat. 36° 52' 21.5298" and 35° 11' 48.2829" E) (Fig.4-2). A few primary components with their lithological units are uncovered at the surface along this area.

The geological time of these units ranging from Mesozoic to recent. The present study focused on the structural elements which controlled the hydrocarbon seepages in some areas of northern Iraq. The seepages of hydrocarbons fall in two types. Firstly, Microseepage which are invisible and contain mixture of hydrocarbon gasses. Secondly, Macroseepage that are visible such as bitumen. Microseepage can only be detected by chemical alteration and gas seep at the surface. Schumacher (1996) suggested that long-term seeps of hydrocarbons can establish locally anomalous redox zones that favor the development of a diverse array of chemical and mineralogical changes in rocks and soil. (Thannoun & Al-Azawi,2020)

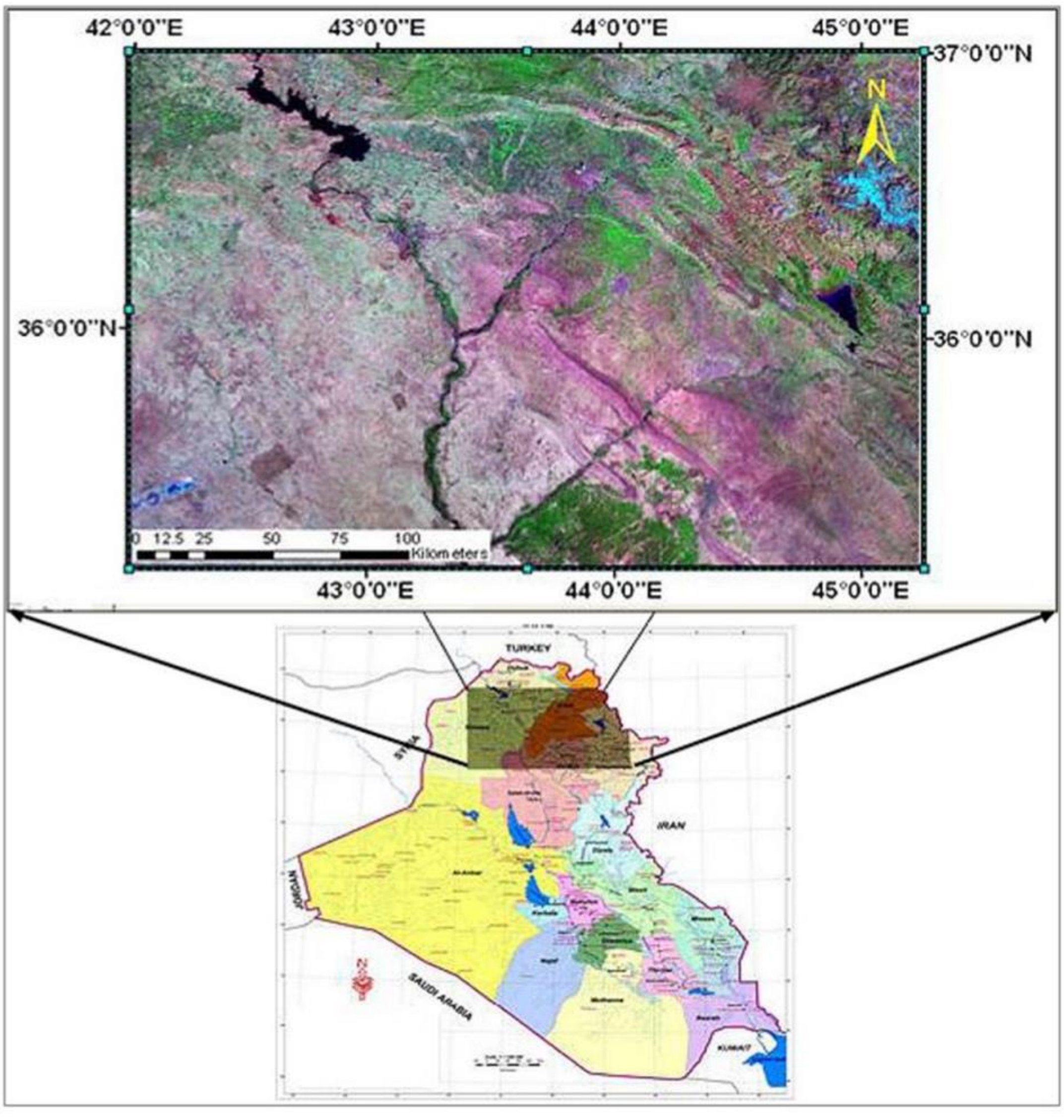
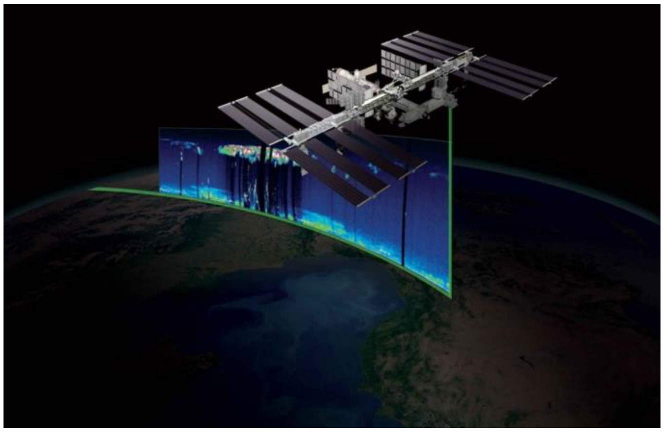


Fig.2-1: Geographic location of the study area according to Iraq. (Thannoun & Al-Azawi,2020)



CHAPTER 2

Methodology of exploration using remote sensing methods

CHAPTER PARAGRAPHS

- FIRST STUDY

Automatic Extraction and Geospatial Analysis of Lineaments in some areas of Northern Iraq using Remote Sensing Techniques and GIS.

- SECOND STUDY

study Structural Control Evaluation of Hydrocarbon Seepage in Northern Iraq Using Remote Sensing Techniques.

FIRST STUDY:

Automatic Extraction and Geospatial Analysis of Lineaments in some areas of Northern Iraq using Remote Sensing Techniques and GIS.

Methodology:

The significant flowchart which are applied for the lineament Extraction and analysis is yielded (Fig.1-2). The strategy of this examination made out of five progressive advances:

1) The initial step is the determination of the appropriate band of Landsat ETM+ for lineament auto extraction and geospatial investigation.
2) The subsequent step is the applying some of picture handling techniques to improve the edge and course of lineaments
3) The third step rely upon the strategies for extricating the lineaments by utilizing an adequate upsides of PCI geomatica LINE module parameters software.
4) The fourth step is the assessment of lineament map with their headings by computation geospatial investigation like density and the lengths of these feature.
5) The fifth step incorporates assess the structural setting of the area relying upon the aftereffects on the results of the suggested method in this paper.

The data used in this research is a subset of panchromatic spectral band (Band 8) of Landsat-7 ETM+ informational index (Line 35/Way 170), dated 13 Jun 2001. Panchromatic band has favored in lineament analysis as a consequence of its improved spatial resolution (15 meter). False color composite image (7Red, 4Blue and 1Green) of landsat-7 ETM+ data set (Row35/path 170) additionally utilized for addressing the auto extraction and geospatial lineaments investigation results. In this review, there are two methods have been utilized. First is connected with the software's, second includes the picture handling to perform edge upgrades. The most broadly involved programming for the programmed lineament extraction is the LINE module of the PCI geomatica. Likewise, utilizing (ENVI 4.6) programming various cycles (like digital filtering) have been finished to the panchromatic band to get the high proficiency of separated lineaments. Geographical Information Systems (GIS) programming (ArcGIS 9.3) is used to perform Geospatial examination and plan last guides of lineaments. (Thannoun,2013)

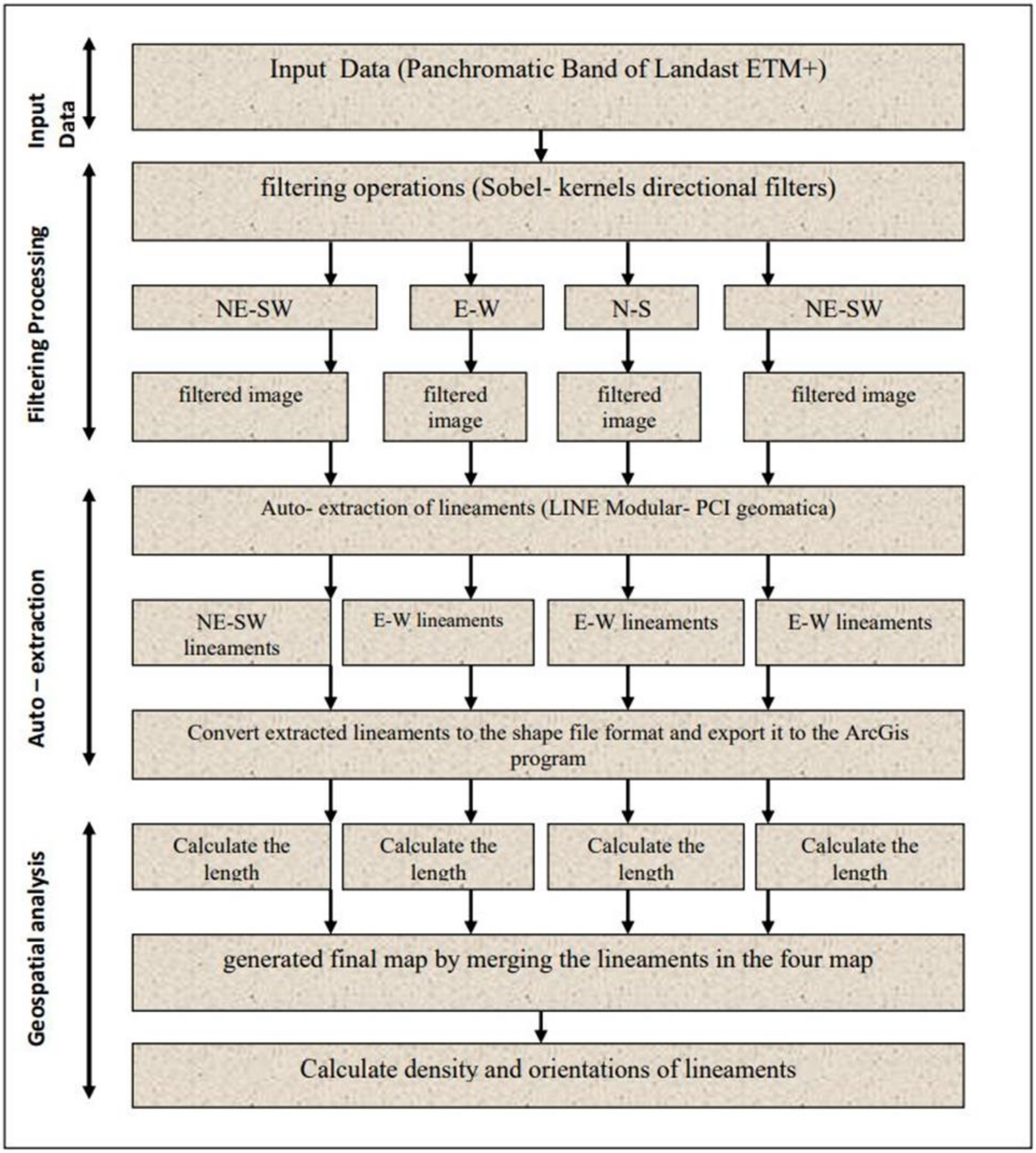


Fig.1-2: Flowchart shows steps of the study, (Thannoun,2013)

Auto-extraction Procedures:

This parts involves the procedures which have been used to extract lineaments from Landsat panchromatic band and geospatial analysis:

1) Edge enhancement:

One of the characteristic features of the satellite pictures is a boundary called spatial frequency which is known as the number of changes in brightness value per unit distance for any particular part of an image. In the event that there are not many changes in that frame of mind over a given region in a picture, this is alluded to as a low-frequency region. Alternately, assuming that the brightness values change decisively over brief distances, this is an area of high frequency detail. Consequently, filtering operations are utilized to underscore or deemphasize spatial recurrence in the picture. This recurrence can be credited to the presence of the lineaments in the area. In other words, the filtering operation will sharpen the boundary that exists between adjacent units. In this review, Directional filtering has been utilized to upgrade, concentrate and ordered the situated lineaments. The direction was chosen depending on the structural and tectonic features of the area, however, directional filters are applied to image using a convolution process by mean of constructing a window normally with a (3×3) pixel box of Sobel - kernels filters (Table.1-2).This type of filter was used in order to get a high accuracy in auto extraction of oriented lineaments because the directional nature of Sobel kernels generate an effective and faster way to evaluate lineaments in four principal directions (Suzen et al.,1998).

Table.1-2: Sobel - kernels in four principle directions (Thannoun,2013)

N-S			NE-SW			E-W			NW-SE		
-1	0	1	-2	-1	0	-1	-2	-	0	1	2
-2	0	2	-1	0	1	1			-1	0	1
-1	0	1	0	1	2	0	0	0	-2	-1	0
						1	2	1			

As displayed in (Fig.2-2), four filtered images have been created by ENVI programming connected with the directions N-S, E-W, NE-SW and NW-SE, which are utilized as an info pictures for auto extraction techniques (Thannoun, 2013).

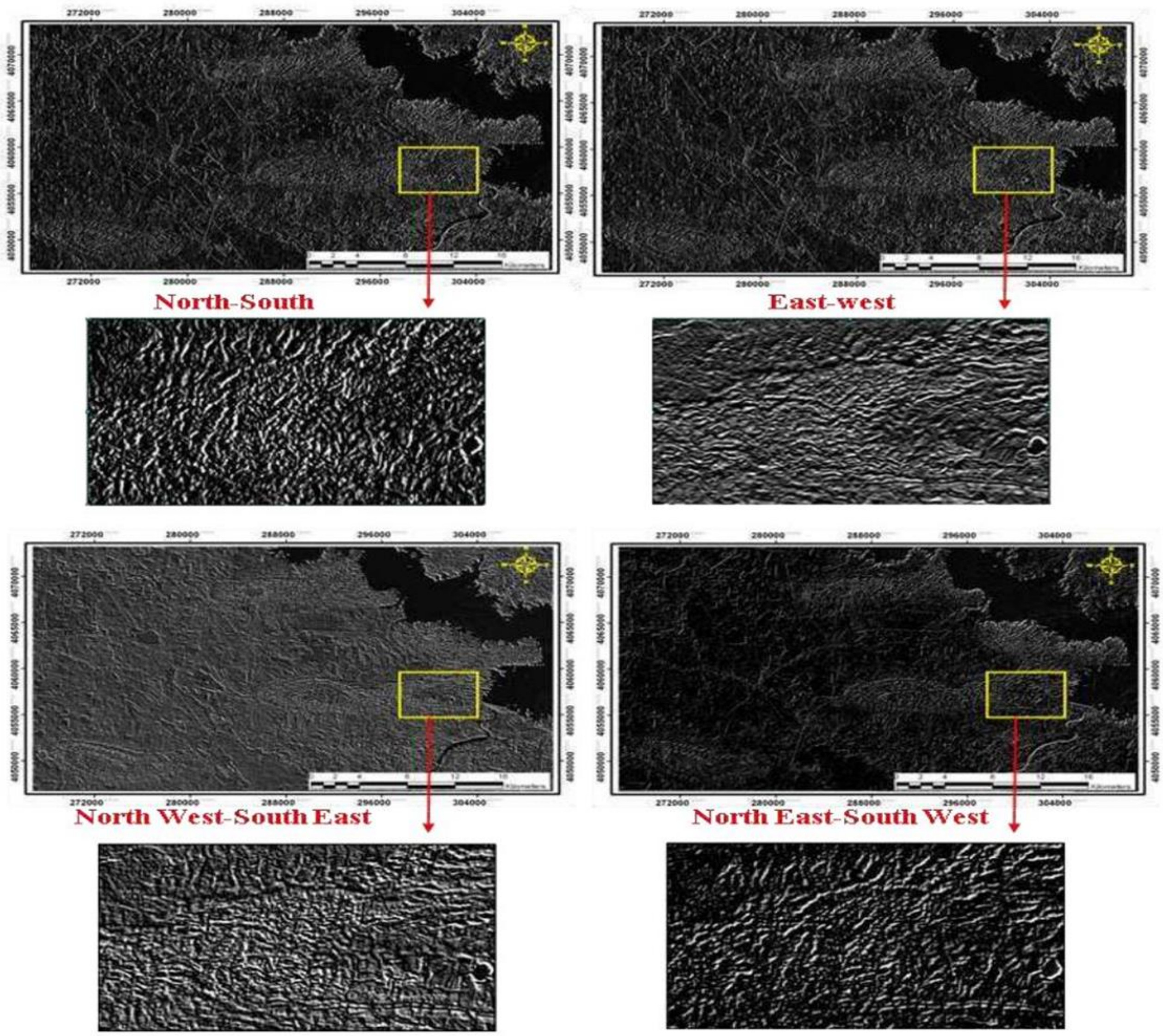


Fig.2-2: Filtered images in N-S, E-W, NW-SE, NE-SW, directions (Thannoun,2013)

2) Auto extraction parameters:

Numbers and lengths of separated lineaments relies upon the information boundaries values and input parameters values which are represent optional digits of the LINE modular in PCI geomatica programming. The algorithm of this modular comprises of three phases: edge detection, thresholding, and curve extraction. however, LINE module extracts lineaments from an image and convert these linear feature in vector form by using six optional parameters (RADI, GTHR, LTHR, FTHR, ATHR and DTHR). (Thannoun,2013)

- RADI (Filter radius):

This parameter determines the range of radius of the edge detection filter (in pixels). It generally decides the smallest detail level in the info picture to be identified. The information range for this boundary is somewhere in the range of 0 and 8192.

- GTHR (Gradient threshold):

This boundary determines the limit gradient level for an edge pixel to obtain a binary image. The information range for this boundary is somewhere in the range of 0 and 255.

- LTHR (Length threshold):

This boundary determines the base length of bend (in pixels) to be considered as lineament or for further consideration (e.g., connecting with different bends). The information range for this boundary is somewhere in the range of 0 and 8192.

- FTHR (Line fitting error threshold):

This parameter determines the maximum mistake (in pixels) permitted in fitting a polyline to a pixel bend. Low FTHR values give better fitting yet additionally more limited portions in polyline. The information range for this boundary is somewhere in the range of 0 and 8192.

- ATHR (Angular difference threshold):

This parameter determines the maximum angle (in degrees) between segments of a polyline. In any case, it is portioned into at least two vectors. It is additionally the maximum angle between two vectors for them to be connected. The information range for this boundary is somewhere in the range of 0 and 90.

- DTHR (Linking distance threshold):

This parameter determines the base distance (in pixels) between the end points of two vectors for them to be connected. The information range for this boundary is somewhere in the range of 0 and 8192.

3) Lineaments digitizing saving:

Extracted lineaments converted over completely to the shape document to trade it to the ArcGIS program which is contains expert devices for the geospatial examination and information handling. (Thannoun,2013)

SECOND STUDY

study Structural Control Evaluation of Hydrocarbon Seepage in Northern Iraq Using Remote Sensing Techniques.

Methodology:

The data used in this exploration is as a subset of single spectral bands of Landsat-7 ETM+ data set (Row 35/Path 170- dated 13 Jun 2001 and Row) and (Row 35/Path 169 - dated 16 April 2000). These pictures likewise are geo-referred to the UTM coordinate framework, Zone 38 North in light of a few accessible geological maps with acceptable root mean square error. Utilizing (ENVI 4.6) software several processes have been done to the used bands to get the high efficiency of extracted spectral anomaly. Geographical Information Systems (GIS) software (ArcGIS 9.3) is utilized to prepare final maps. (Thannoun & Al-Azawi,2020)

Various strategies for image handling are applied to fulfill the good extraction of the spectral anomaly as well as to define the main characteristic features of alteration zones in the rocks. technique could be summed up as follows:

1. Pre-processing operation includes FLAASH corrections (to remove atmospheric noise) and image rectification to correct the image geometrically.
2. Apply image transformation using principal components analysis (PCA) and ratio method of Landsat ETM+ data, and then use the Eigen value and Eigen vector in principal component analysis, as well as, use the best rationing combination images for detecting minerals associated with microseepage.
3. Image enhancement using false color composite image to extract anomaly zone.
4. Classified the digital elevation models (DEM) to extract distinct topographical features that may reflect subsurface structures, especially if these topographical features coincide with the trends of the geological structures in the studied area and then also some tonal anomaly can find an explanation for their presence
5. Integrated all previous extracted data to conclude the role of tectonic setting in the control of hydrocarbon seepage.

Remote sensing techniques were utilized to recognize irregular regions or change zones brought about by hydrocarbon seepages. Three image processing methods were used to detect this type of seepage including band ratioing, principal component analysis (PCA), and false-color composition (FCC). Tonal anomalies and subtle changes in spectral content are consider as surface indicators for Microseepage. The past strategies were applied on seven regions in the Foreland Belt and the outcomes were affirmed by ground truth in the field. (Thannoun & Al-Azawi,2020)

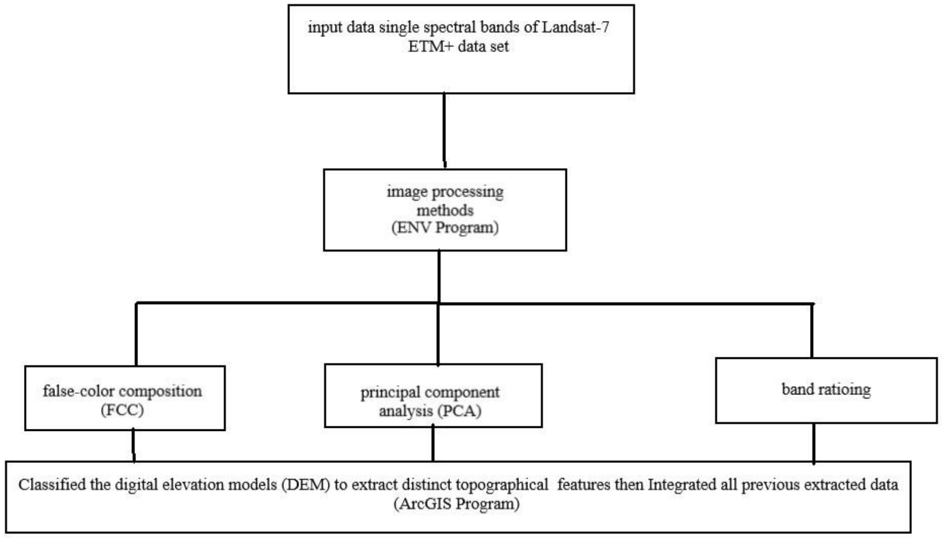
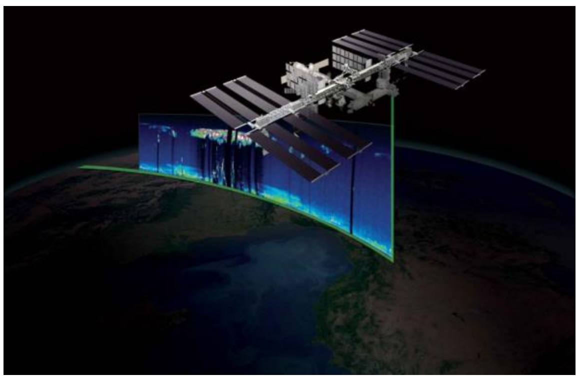


Fig.3-2: Flowchart shows steps of the study



CHAPTER 3

Results and Discussion

CHAPTER PARAGRAPHS

- FIRST STUDY

Automatic Extraction and Geospatial Analysis of Lineaments in some areas of Northern Iraq using Remote Sensing Techniques and GIS.

- SECOND STUDY

study Structural Control Evaluation of Hydrocarbon Seepage in Northern Iraq Using Remote Sensing Techniques.

FIRST STUDY

Automatic Extraction and Geospatial Analysis of Lineaments in some areas of Northern Iraq using Remote Sensing Techniques and GIS.

Discuss the map & results:

To get the most fitting lineaments connected with the structural setting of the concentrated on region, ideal qualities for LINE particular boundaries are recommended (Table.1-3). Past four separated pictures (Fig.2-2) are utilized as input data to the line modular in order to calculate and estimate the length, orientation, numbers, and density of the lineament to each one of these input data (i.e. four filtered images). (Thannoun,2013)

Table.1-3: Suggested parameters values, (Thannoun,2013)

Parameters	Suggested Parameters values
Filter Radius	5
Edge Gradient Threshold	75
Curve Length Threshold	10
Line Fitting Error Threshold	2
Angular Difference Threshold	20
Linking Distance Threshold	1

(Fig.1-3) shows the lineaments map over the four info information with various patterns. In this specific circumstance, lineaments are breaking down by three course of geospatial examination to extract further information related to distribute and nature of these structures. Geospatial analysis process is including: length, density and orientation analysis. (Thannoun,2013)

1. Length analysis

The connection between the lineaments in every one of the four maps in number (frequency) and lengths is displayed in (Fig.2-3). A sum of (3463) geologic lineaments (for all directions) were distinguished carefully. Length per unit region for each line is totally determined carefully and afterward represented the value of length (in meter) by attributes table in the data base as a new field. As displayed in (Fig.2-3), It has been seen that the (NE-SW) lineament map have larger number and higher number and length compared with the other. As per the boundaries values which are utilized in this review, the greatest length of the lineaments is (2916m) kept in the (NE SW) bearing. What's more, the most extreme recurrence of lineaments is (810) kept in a similar course which will be which is around (50 %) of the last guide. (Thannoun,2013)

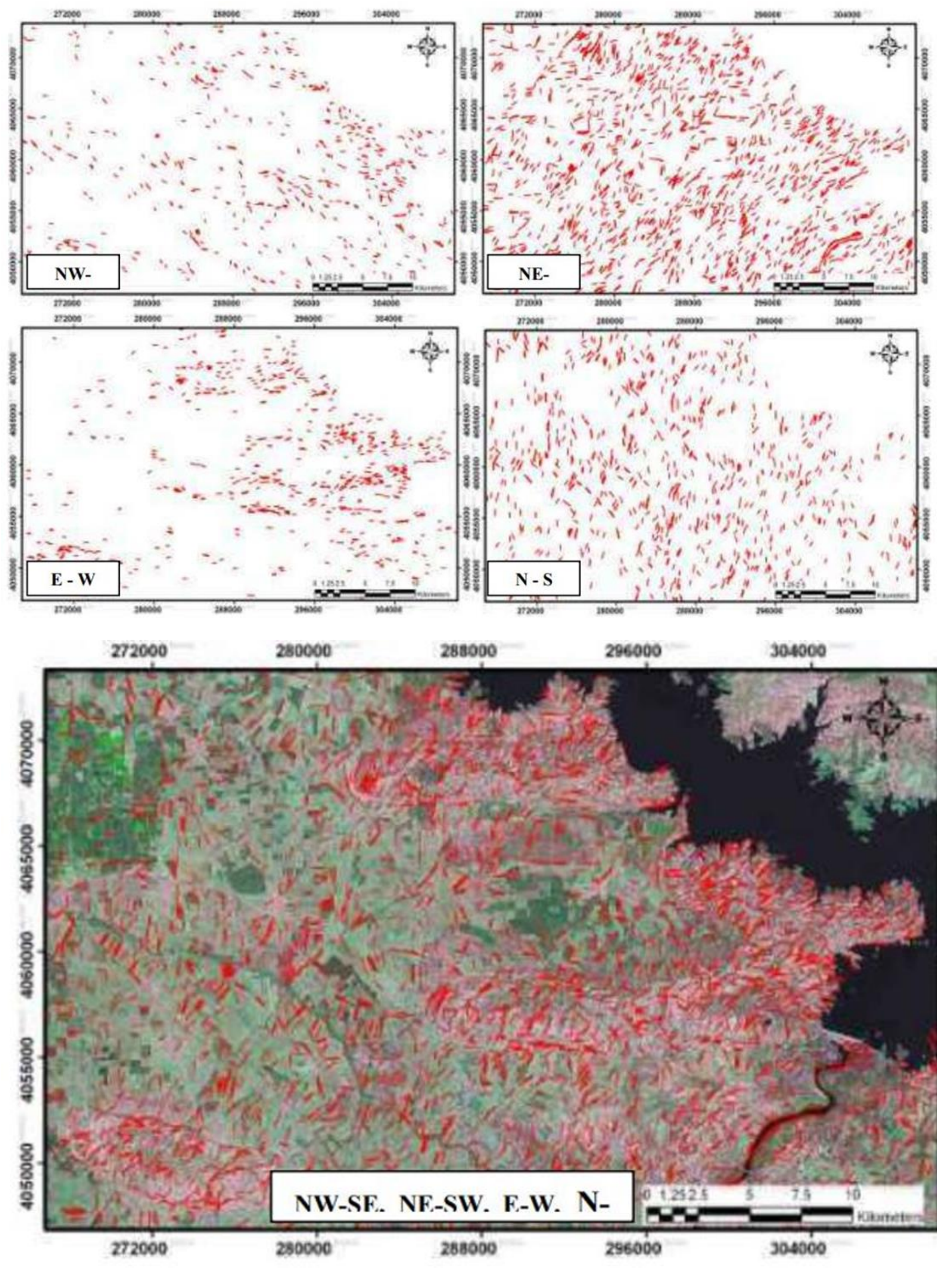


Fig.1-3: Lineaments maps with four principal trends (Thannoun,2013)

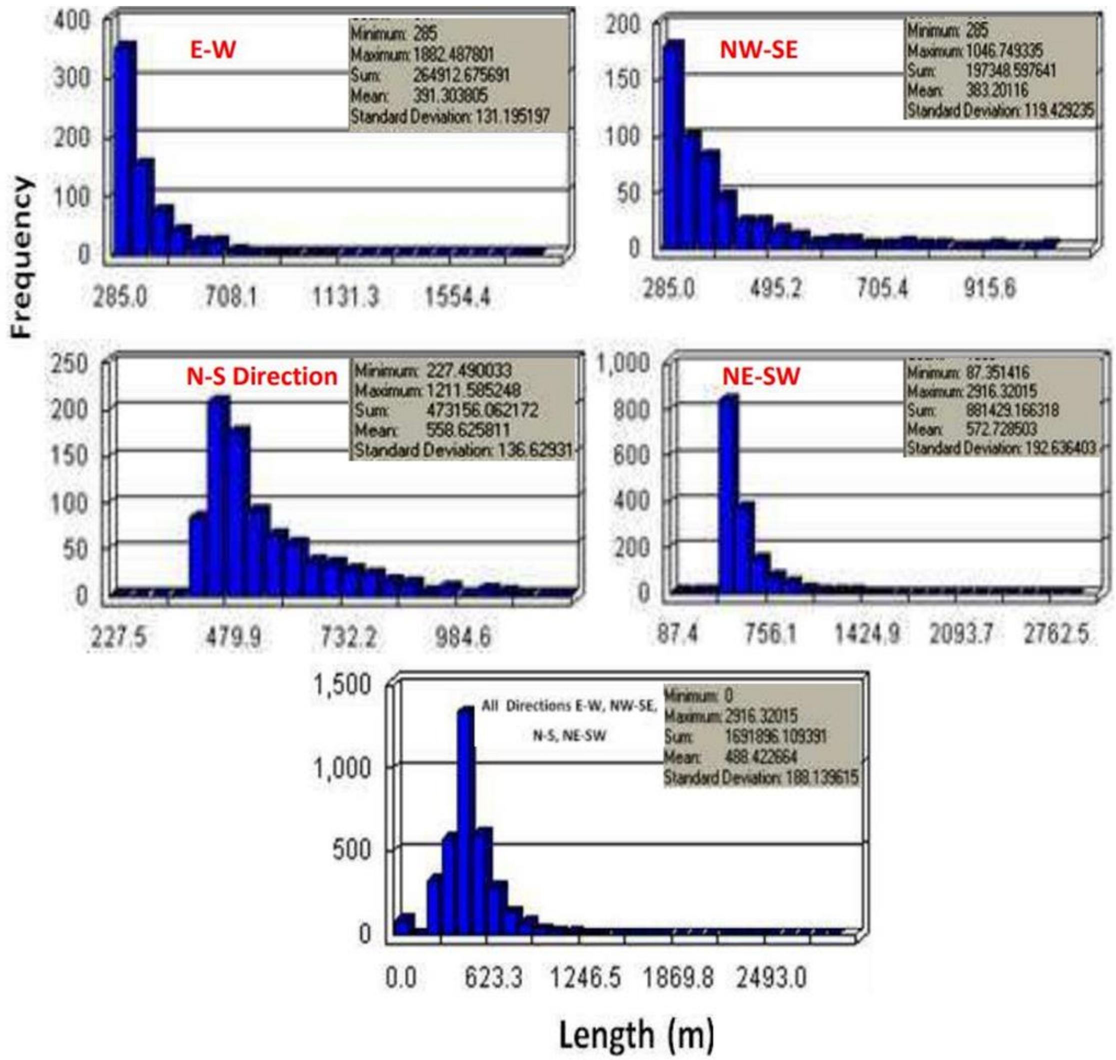


Fig.2-3: Frequency distribution and basic statics of the lineaments (Thannoun,2013)

2. Density analysis:

This analysis computes the frequency of the lineaments per unit region (Hung et al., 2005), and afterward produce a guide showing centralizations of the lineaments over unit region. In this review, the lineament density is made spatial analyst tool in (ArcGIS 9.3) program by counting lines carefully per unit area (number/km2) and afterward plotted respective grid centers and contoured using the same tool. Lineaments density map of the overall lineaments (the four directions) is created and shows in (Fig.3-3) by grids and contours. The high density of lineaments is located in the areas within inside the main structures (I. e. anticlines). Meanwhile, it is clear that most areas adjacent to the main faults has also a high density of lineaments

Notwithstanding, the scopes of lineament numbers are differed between (2 to 7 for every/km2). (Thannoun,2013)

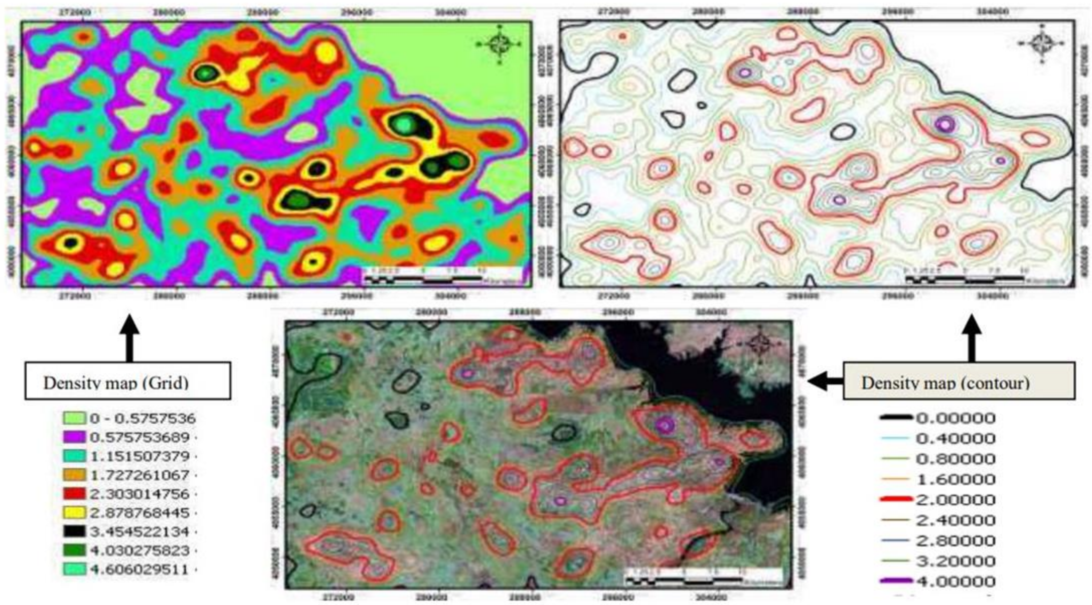


Fig.3-3: Lineaments Density map of the overall lineaments by grids and contours (Thannoun,2013)

3. Orientation analysis:

Lineaments directions are typically breaking down by rose graph in all explores which are managing these designs. In auto extraction, this graph shows the directional recurrence of the separated lineaments over the particular region. A rose graph device from the (ArcView3.2) was utilized to determine lineament headings in the chose part in the concentrated on region. As displayed in (Fig.4-3), The rose outline shows four headings (for example NE-SW, N-S, E-W and NW-SE) are seen yet in various reaches, in any case, the predominance patterns in the headings are include: NE-SW, N-S. The rose outline on lineament showed additionally that the over 80% of the lineaments falling in NE SW. (Thannoun,2013)

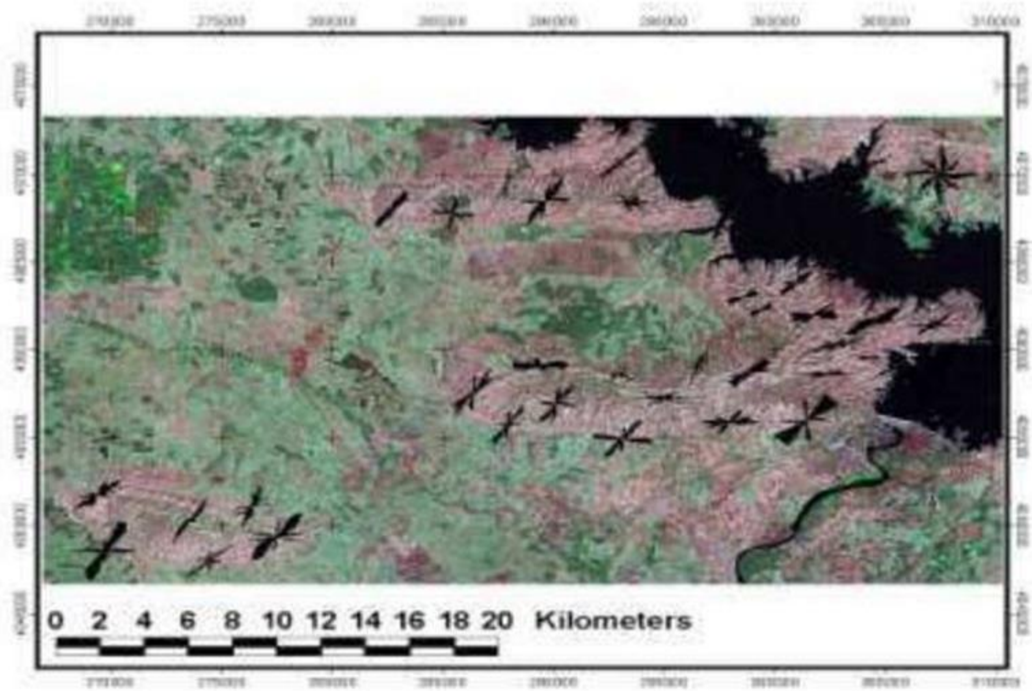


Fig.4-3: Rose diagram illustrating all lineament trend over the FCC Landsat image of some selected zones of the studied area (Thannoun,2013).

The flowchart of this study is a proficient way for removing and examining the land lineaments over enormous districts with little outcrops (covered region). Blend of auto extricated lineaments with the geospatial information (length, density and trend) can refresh the structural setting and decide the fracture zones. The geological structural features such as lineaments have been taking much interest in the geological studies lately, because it is considering as a very important structural and geological indicator to determine general and local tectonic trends and fractures zones in the rocks, especially in the areas which are characterized that are covered extremely by the soils. The principle objective of this study is to design a suitable method for automatically and digital lineament analysis and use the results in the tectonic induction. Consequently, an adaptive approach for tectonic lineaments extraction were used and it is including (five steps). Throughout this study, panchromatic Landsat band-8 was used for auto extraction under user- suggested parameters values within PCI geomatica software. Three geospatial analyses are applied in order to evaluate the lineaments, these are: length, density and orientation analysis. The results have indicated that, The Lineaments in the area have two main trends in the NE-SW and N-S directions and a subordinate E-W and NW-SE trend. The total number and length of the lineaments is more in the dominant trend (NE-SW). Most of the faults and major lineaments are located very close to the locations with high values of lineaments density. Geospatial analysis of lineaments is given a good correspondence with the arrangement of the main tectonic forces of the studied area. This report and accompanying GIS datasets describe the results of both automated and manual mapping of lineaments throughout some areas of Northern Iraq we define lineaments as "map able linear or curvilinear features of a surface whose parts align in a straight or slightly curving relationship that may be the expression of a fault or other linear zones of weakness" as derived from remote sensing sources such as optical imagery, radar imagery or digital elevation models. Lineament identification and analysis have long been used as a reconnaissance tool to identify minerals of all kinds. (Thannoun,2013)

SECOND STUDY
Study Structural Control Evaluation of Hydrocarbon Seepage in Northern Iraq Using Remote Sensing Techniques.

Discuss the map & results:

The past strategies were applied on seven regions in the Foreland Belt and the outcomes were affirmed by ground truth in the field. In this paper, two regions will be shown. (Thannoun & Al-Azawi,2020)

The first: Kirkuk anticline is an asymmetrical and cylindrical fold, with fold axis towards northwest – southeast. It is an oil trap as well as it contains gas spring. The intriguing of hydrocarbon leaks at Kirkuk anticline has drawn in the considerations of numerous specialists. In the current review three strategies for computerized picture handling were applied to a piece of Kirkuk anticline (Fig.5-3). This large number of strategies demonstrated presence of miniature leakage by identifying some of marker minerals like Jarosite and iron oxide, and so on.

The second: Shaikh-Ibrahim anticline is the major anticline in the review region. Topographically, this anticline lies primarily in the low folded zone in Iraq and is unbalanced, tube shaped and double plunging anticline. The fold axis of this structure trends towards NW – SE. Past strategies for multispectral advanced multispectral digital Image processing were applied on this anticline and then some of tonal anomaly has been detected which is reflected alteration zone in the exposed rocks (Fig.6-3), as well as the field work proved presence of these alterations by observing altered limestone, replacement gypsum by limestone and bitumen bearing gypsum (Fig.7-3). In addition, some of collected samples are subjected to x-ray analysis and it confirmed the previous results (Fig.8-3). (Thannoun & Al-Azawi,2020)

Detect Subsurface Structures by Digital Elevation Model (DEM) Because of significance of recent forming structures and probable being economic oil reservoir, the current review zeroed in on them by performing morphotectonic examination with new method to recognize the obscure and new development folds. Arranged by that, DEM symbolism grouped into height zones and afterward a few recognized geographical zones have been seen Which corresponded in pattern with the local folds nearby (Fig.8-3), as well as, the soil above these concluded subsurface structures shows spectral anomaly on the FCC Landsat images. this affirms the effect of soils (over these designs) by the discharged gases from it (Fig.9-3). (Thannoun & Al-Azawi,2020)

Tectonic interpretation of hydrocarbon seepage is The study revealed that the major factor controlling the seepages is listric faults (Fig.10-3). That is the seepage was concentrated on one side of the anticline and the side was controlled whether the fault is foreland or suture types. The prevalence of Macroseepage in the High Folded Zone and microseepage within the Low Folded Zone indicated that the seepage as an operation was controlled regionally by the field tectonism. That is high uplifted in High Folded Zone made the oil traps lost their light hydrocarbons and most of heavy oil which formed bitumen bearing rocks, while low tectonism in the Low Folded Zone caused traps not actively affected by tectonic uplift. The altitudes 872-979m above sea level are considered as the boundary between micro and Macroseepage, above this boundary the Cretaceous reservoirs were exposed to the surface and this boundary also is in coincidence with the north and northeastern margin of the Arabian Plate. The existence of some anticlines between two sets of strike slip fault lead to active Macroseepage as a result continuous movement of these faults. (Thannoun & Al-Azawi,2020)

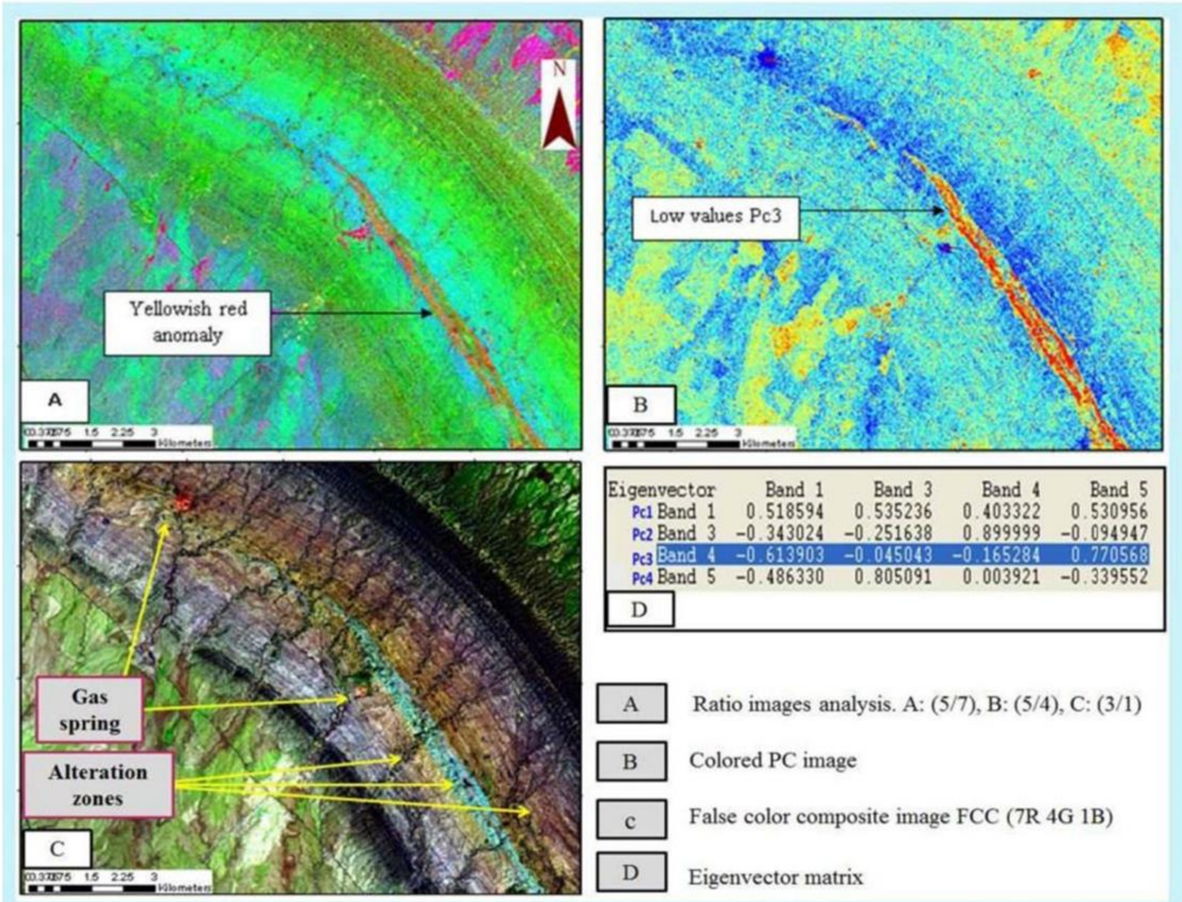


Fig.5-3: Applying three digital processing (part of Kirkuk anticline).

(Thannoun & Al-Azawi,2020)

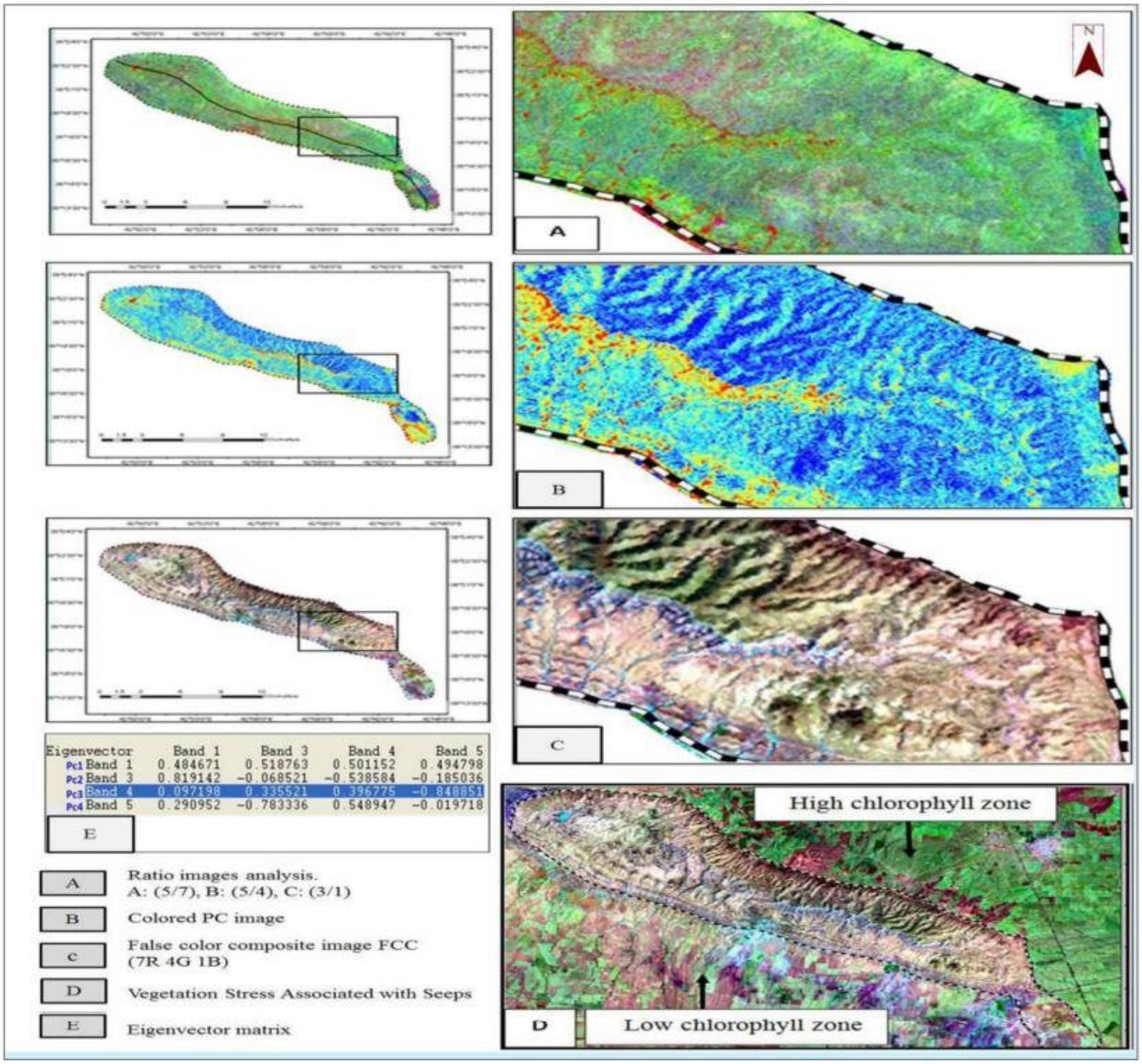


Fig.6-3: Applying three digital processing (Shaikh-Ibrahim anticline).

(Thannoun & Al-Azawi,2020)

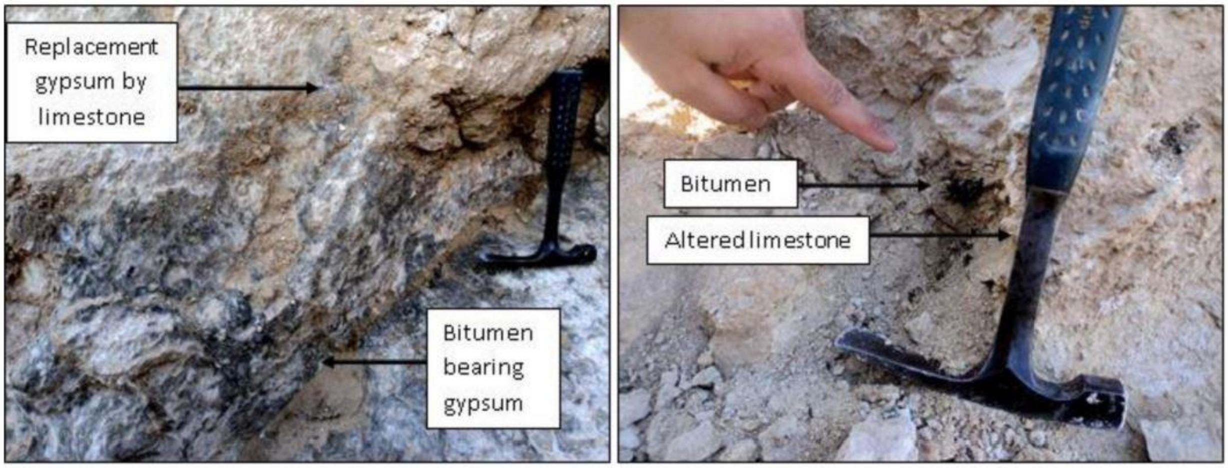


Fig.7-3: Alteration zones (Fatha Formation, middle Miocene) at southern limb of Shaikh-Ibrahim. (Thannoun & Al-Azawi,2020)

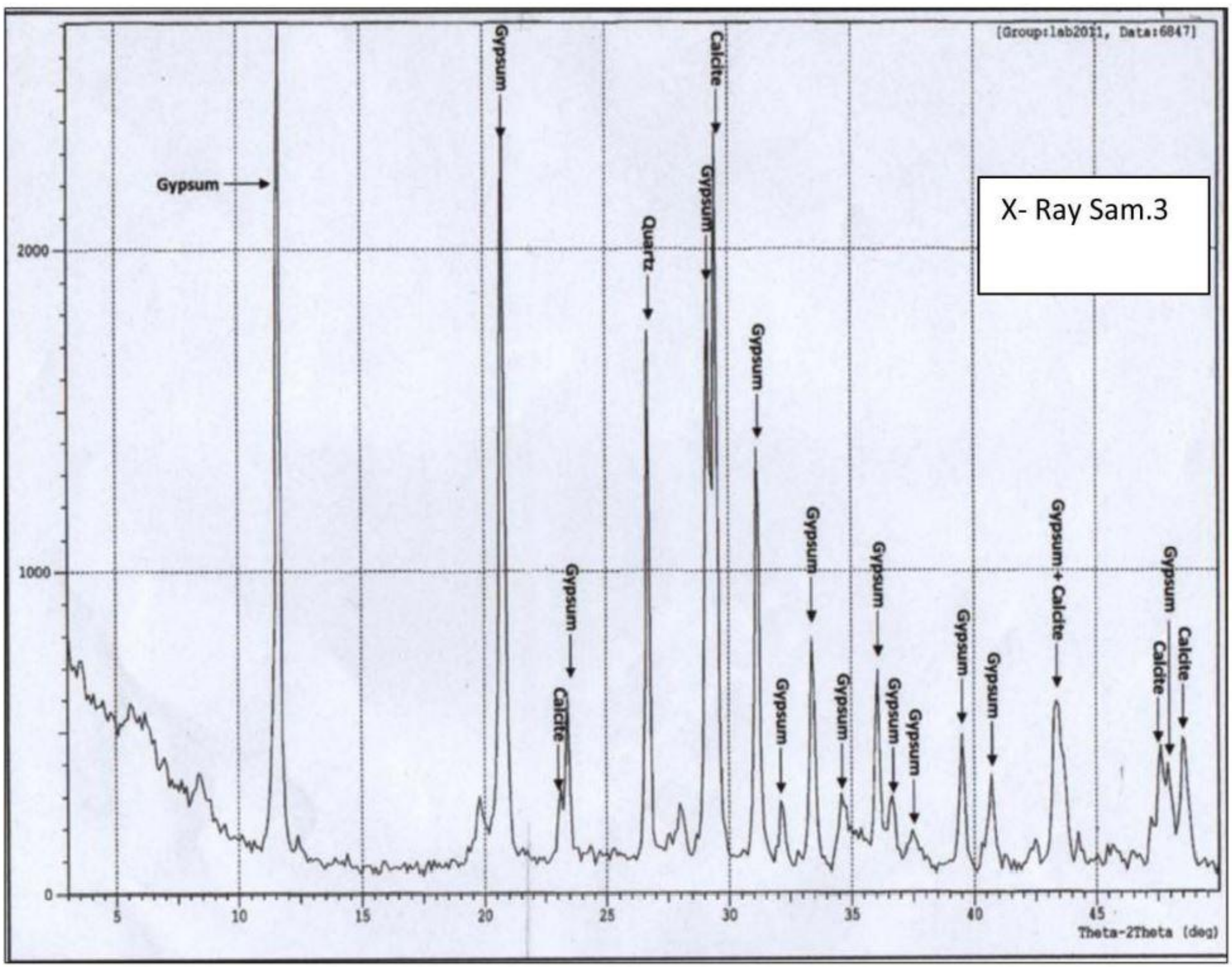


Fig.8-3: X-Ray analysis of selected sample (southern limb, Shaikh-Ibrahim anticline). (Thannoun & Al-Azawi,2020)

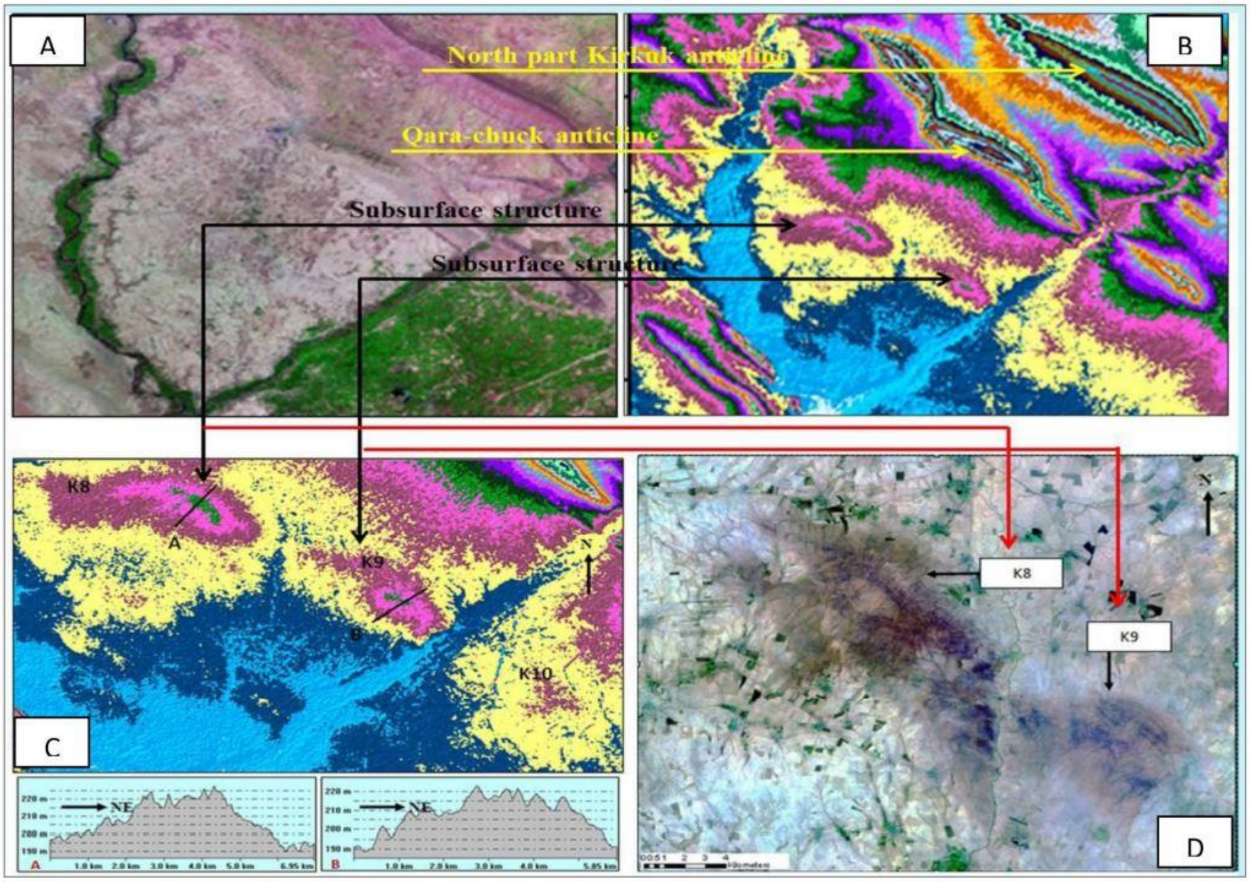


Fig.9-3: A: FCC Landsat image. B: classification of DEM. C: Topographic sections of concluded subsurface structure. D: Tonal anomaly. (Thannoun & Al-Azawi,2020)

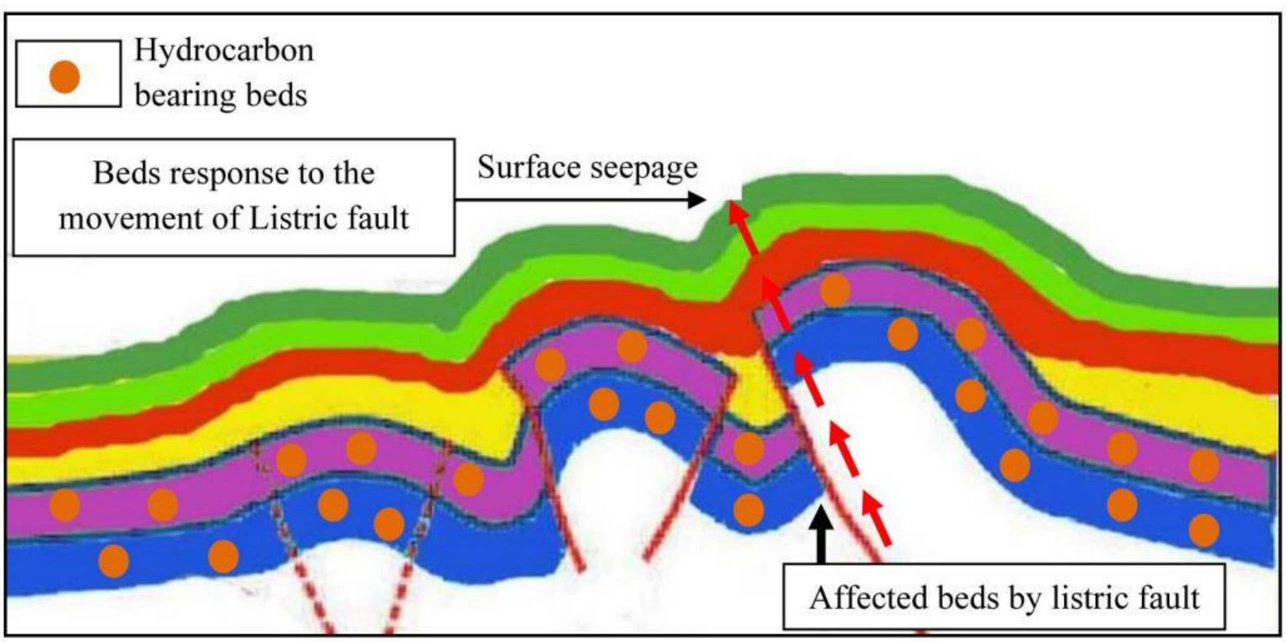
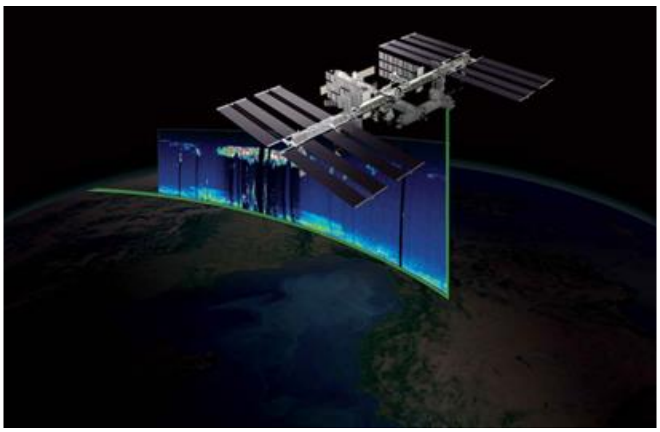


Fig.10-3: A virtual model of hydrocarbon seepage along listric fault plane. (Thannoun & Al-Azawi,2020)



CHAPETR 4

practical part

CHAPTER PARAGRAPHS

The exploration of Gypsum Rocks in Nineveh

Preface:

Gypsum rock is one of the important raw materials that are used in many industrial fields, whether in the form of raw material or the form of burnt material for the production of artistic gypsum or what is locally called plaster. Given the importance of these rocks, they have been widely used since the ancient history for various purposes, such as their use in carving statues of the winged bull for the ancient wall of Nineveh because of their low hardness according to the Mohs hardness scale, and their use as well in the floors and walls of the catacombs known as mattresses for being a good thermal insulator, as well as They were used as pillars for doors and windows in the old houses of Mosul, and they were used in wall decoration on the faces of houses and buildings.

There is no doubt that the exploration of natural resources involved in many industries is the primary goal and urgent for every country, remote sensing techniques have proven their effectiveness and importance in geological investigations, by conducting digital manipulations on the data and then analyzing and interpreting them The resulting data and the preparation of reconnaissance geological maps through which the expected exploratory evidence is identified as a preliminary stage in the exploration operations, which later paved the way for more expensive and complex methods such as geochemical or seismic surveys...etc.

Gypsum is a white powdery mineral widely found in nature. The chemical name is Calcium sulfate dehydrate. ($CaSO_4.2H_2O$)

Gypsum is calcium sulfate dehydrate ($CaSO_4$ $2H_2O$), a white or gray naturally occurring mineral. Raw gypsum ore is processed into a variety of products such as a Portland cement additive, soil conditioner, industrial and building plasters, and gypsum wallboard. To produce plasters or wallboard, gypsum must be partially dehydrated or calcined to produce calcium sulfate hemihydrate ($CaSO_4$ $½H_2O$), commonly called stucco.

In this study, data was taken previously to prepare the study area and then entered into the ENVI Software to enter map data and do image processing to show the locations of minerals.

study area:

The study area is in Nineveh Governorate to explore gypsum rocks. This study focuses on the western side of the Tigris River to ensure the presence of gypsum and the possibility of extracting it through the work of a mine or quarries to extract gypsum rocks. The study area is in Nineveh Governorate to explore gypsum rocks.

As shown in the map indicating the presence of gypsum mineral in Nineveh Governorate, Mosul, which is colored blue. In this study, we will focus on one area west of the city of Mosul to mock treatment and ensure the possibility of obtaining gypsum minerals and quarries to extract it.

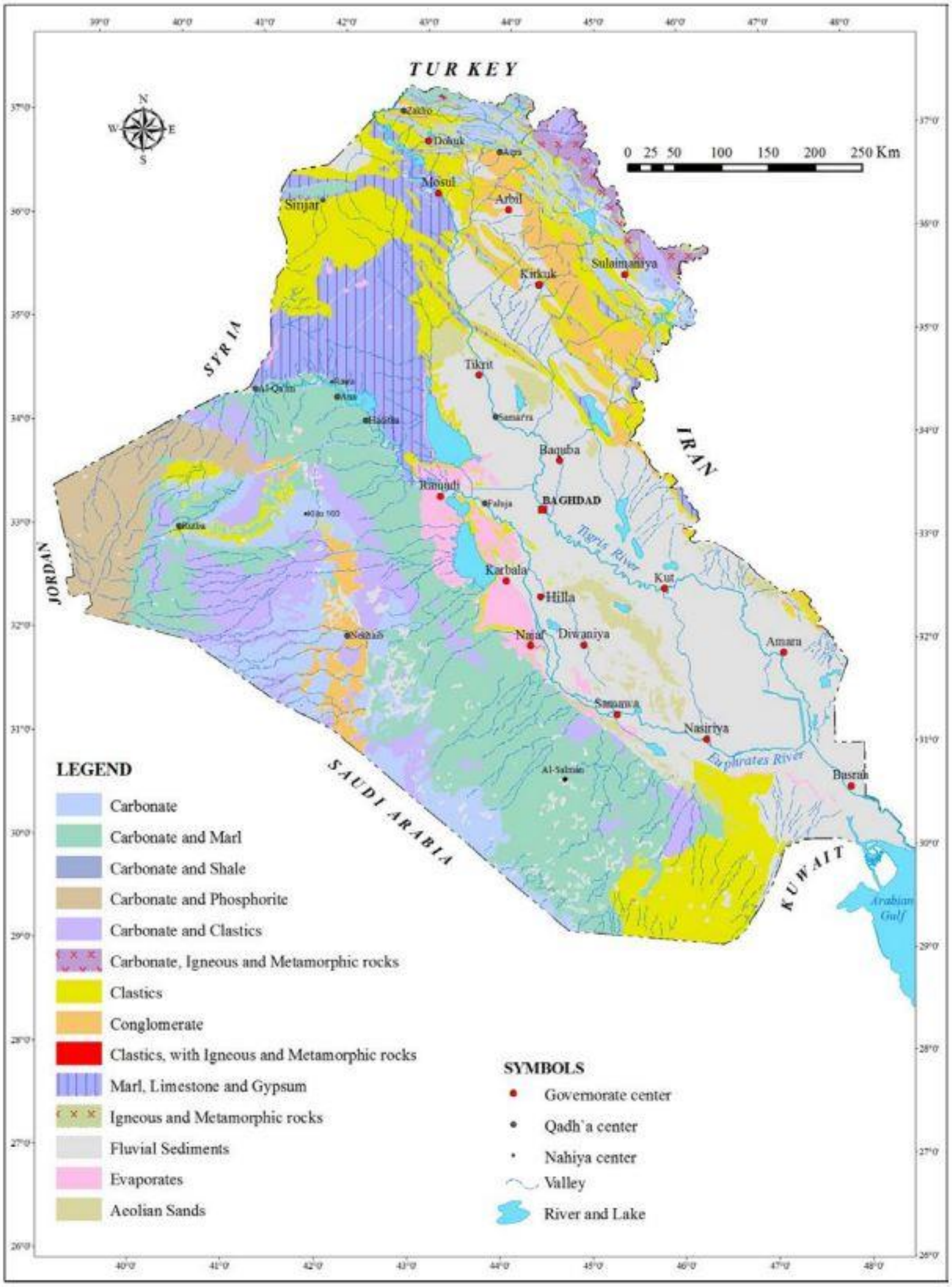
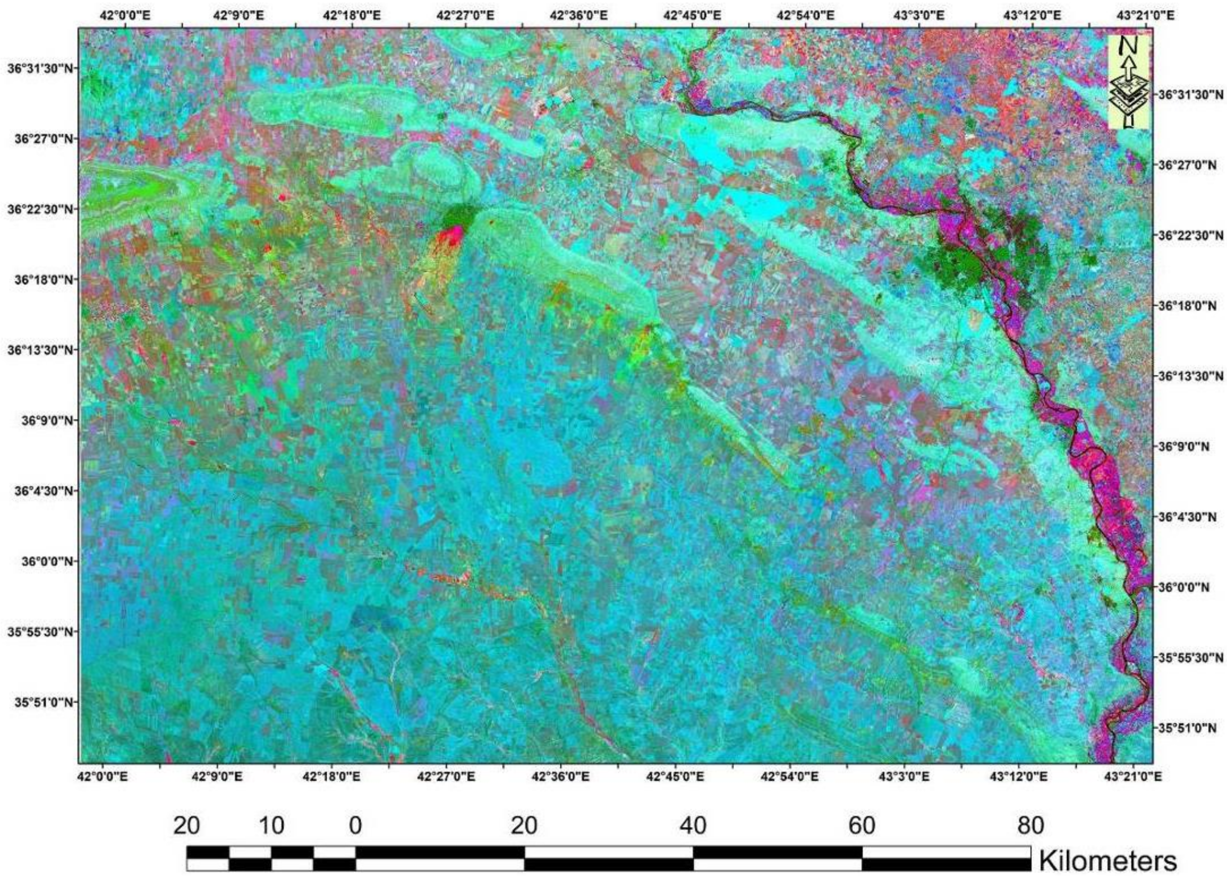


Fig.4-1: Lithological Map of the exposed formations, (Sissakian & Fouad,2014)

Results and Discussion:

It is clear through the spectral analysis of satellite image in the areas of western Mosul, which are represented in the Ashkaft, Sassan, Adaya, and Shaikh-Ibrahim anticlines discovered that gypsum rocks are spread in most of the valleys of the region. The reddish-yellow color of gypsum in Figure (4-2) represents the spread of gypsum rocks. It is noted that the largest spread of gypsum rocks was in the southwestern limbs of the anticlines and in the valleyes towards southeast. The spread of gypsum rocks disappears in the northwestern part of the study area, except in narrow areas, and this confirms that it does not spread due to the spread of the Injana Formation, and soils, which cover the Fatha Formation of the hole.



Gypsum

Fig. 4-2: A composite Land-Sat image of bands (5/7, 5/4, and 7/1) to isolate the spectral components of gypsum rocks in the study area.

In Sassan and Shaikh-Ibrahim anticlines, the spectral components of ((5/7, 5/4, and 3/1) bands are used to isolate gypsum rocks (Fig. 4-3). The gypsum rocks are highly spreading in the crest of anticlines, southwestern limbs, and valleys of Tel-Afar Region (Fig. 4-4). It is clear the extension of gypsum rocks in the deep and large valleys in the areas of axis undulation or convex. In Adaya Anticline, gypsum rocks are very clear exposed in the southeastern limb and the sinkholes around the anticline (Fig. 4-5).

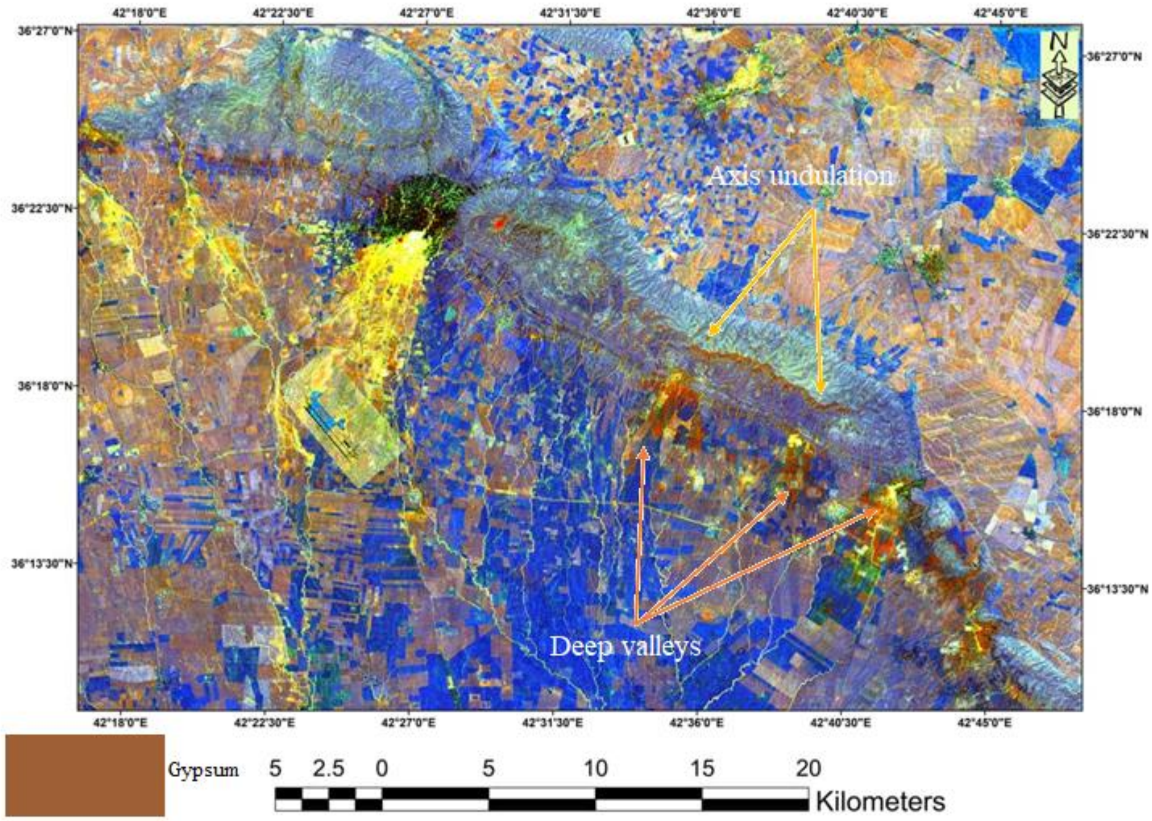


Fig. 4-3: A composite Land-Sat image of bands (5/7, 5/4, and 3/1) to isolate the spectral components of gypsum rocks in the Sassan and Shaikh-Ibrahim anticlines.

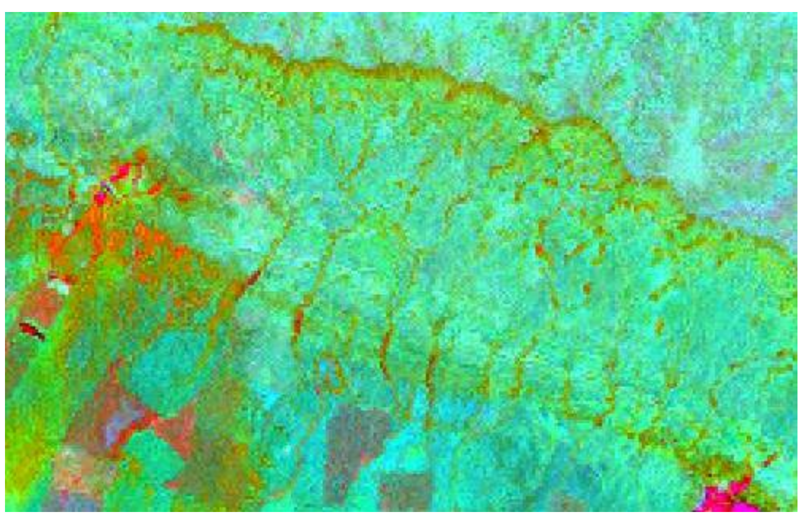


Fig. 4-4: A composite Land-Sat image of bands (5/7, 5/4, and 3/1) to isolate the spectral components of gypsum rocks in the southwestern limb of Shaikh-Ibrahim anticline.

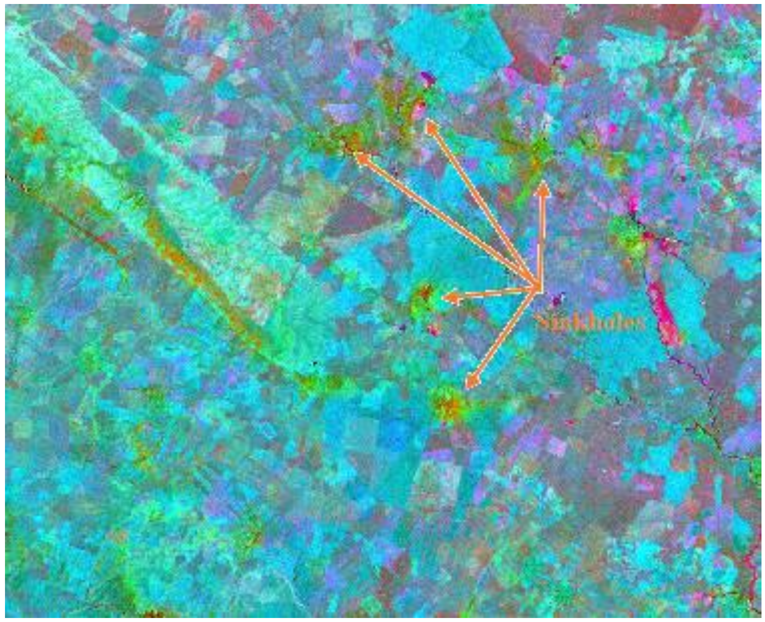


Fig. 4-5: A composite Land-Sat image of bands (5/7, 5/4, and 3/1) to isolate the spectral components of gypsum rocks in the Adaya Anticline.

The gypsum rocks are infrequent in the Atshan, Allan, and other anticlines in the study area, while some spots of exposed gypsum were appeared in the deep valleys and sinkholes as in Atshan Anticline (Fig. 4-6).

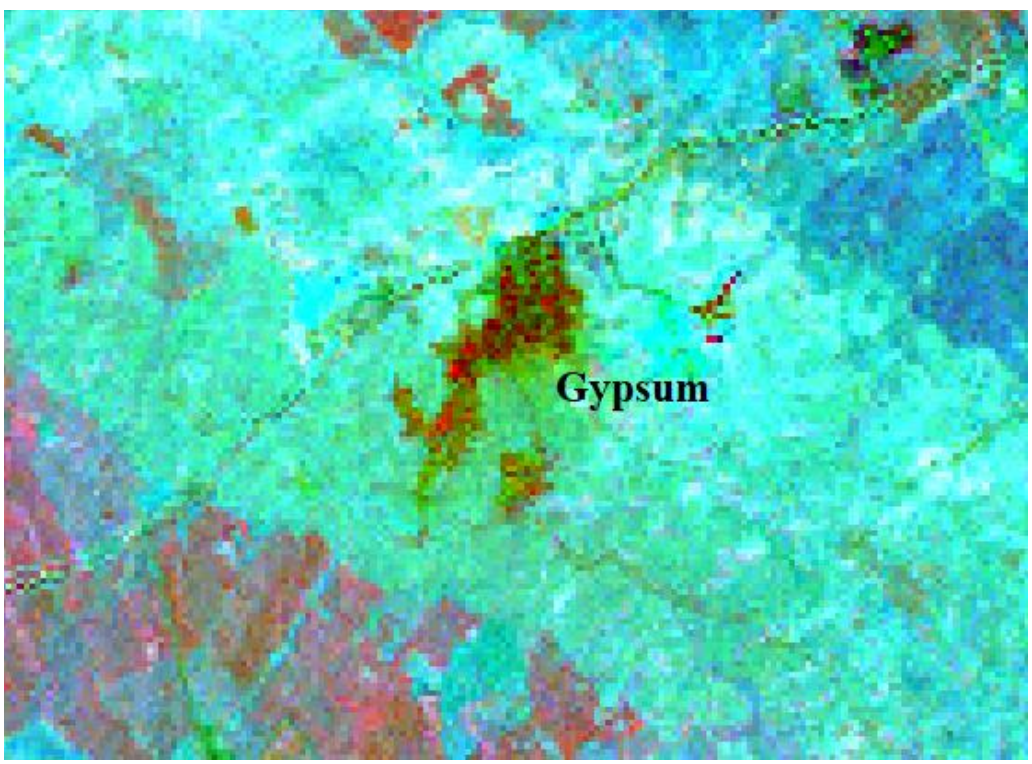


Fig. 4-6: A composite Land-Sat image of bands (5/7, 5/4, and 3/1) to isolate the spectral components of gypsum rocks in the Atshan Anticline.

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