Using Space Imagery in the Exploration of Useful Raw Materials

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Abstract: The new technology of remote sensing and space imagery has contributed to a great extent in exploring subsurface resources and useful materials, through preparing structural, mineral and geospatial maps, and determining the structural factors which help in raw materials formation.

We would like to refer here especially to the lineaments and annular structures that became clearly distinguished after using these techniques by determining their properties which contribute largely in the resent metallogeny studies. These techniques have contributed also in solving several matters such as:

A- Determination of unclear structures which have great importance in preparing mineral maps.

B- Speeding up the study of geological phenomena (which determine mineralization distribution), and discriminating magmatic volcanic structures and the unclear eruption parts that are not seen on the surface.

C- Showing and determining faulting and fracturing zones of deep origin which distribute and concentrate the raw materials.

D- Studying the centers of high tectonic activity associated with mineral activity this research concentrates on the study of structural phenomena (lineament and annular structures) and their classification through the important characteristics of space imagery, such as synoptic coverage, high resolution, and the possibility of digital processing. This paper refers to case studies from Syria and the Arab region.

1-Introduction:

Space imagery, through their distinguished properties and various kinds, play important role in studying and exploring underground resources and useful materials; through preparing geospatial geological, mineral and structural tectonic maps. Also, through using direct or indirect methods in the exploration processes.

Using such techniques in underground resources exploration can play a role in solving many problems such as:

E- Determination of disappeared structures which have great importance in preparing mineral maps.

F- Speeding up the study of geological phenomena (which determine mineralization distribution), and discriminating magmatic volcanic structures and the disappeared eruption parts that are not seen on the surface.

G- Showing and determining faulting and fracturing zones of deep origin which distribute and concentrate the deposit materials.

D - Studying the centers of high tectonic activity associated with mineral activity.

The basic amount of remote sensing data, used in the metallogeny research, depends on showing and determining the structural factors which help in deposit formation. We can specify here lineaments, annular structures and the other geological phenomena**.**

Characteristics of Space Images:

2-1- Synoptic Coverage:

Space images are characterized by their board synoptic coverage, so one Meteor image could cover an area of /10 000 000/Km^2, and one land sat MSS image (1/1000 000) scale covers an area of (34000)Km^2.

The coverage of the same area would need (1600) aerial photographs (1/20000) Scale. (Rukieh 2009)

Thus by satellite imagery, We can view large areas of land, not archived by conventional methods.

2-2- Repetitive coverage:

Satellite imagery provides a repetitive coverage at regular intervals E.G " Every half an hour by weather satellite" or many days, tow weeks, or more. According to the aim and kind of sensor.

Satellite imagery is mainly useful for Study natural Resources, natural hazard including, earthquakes, agricultural seasons, pollution, weather, , and others.

2-3- Different Scales of Space Images:

We can get different scales for space images 1/15 M. till 1/50000 ,1/25000 , 1/5000 , 1/1000 . We use the scale which we want according to the aim of the study and its scale. (Rukieh 2011)

2-4- Spatial Resolution:

the spatial resolution of the space images ranges from many Km like meteor image and NIMBUS till 79× 79 m as in MSS images or 30×30 m as in TM or 15m in ETM, 10m in

spot till 1-5 m as in Russian image by cosmos. 1 meter by Ikonos and others , 61cm by Quick bird, 50 cm ,in World view-1, 41cm in GEO-EYE01 and others.(Rukieh 2011)

2-5- The wide Spectral Characteristics of Space Images:

the space images has been token by different bands in visible range, Infrared, thermal infrared and Radar, With rang from 0,4. μm till several meters.

2-6- The High Informatics Of Space Images

According to the distinguished characteristics of the space images, the Information which be offered by these images is abandoned and synoptic, that have benefit in studying different kinds of deep and surface earth sources environment, natural hazards and urban planning in different dates and inaccessible regions like big forests glaciers regions and others therefore these techniques save time effort and money.

2-7-we can process these images by different methods of processing and new

Software's and using them within geographic information systems.

- Kinds of Space Images:

The space images are divided to many kinds related to cameras and scanners onboard of the satellites or planes and their height spectral bands and processing methods for those images

3-1- The multi spectral images

These images have been taken by cameras and scanners with multi spectral bands, these images are digital like TM, MSS, SPOT, Meteor and some Russian images or normal taken by special films like Kate 140 and MKF-6 cameras, these images are covered by bands ranges from 0,4m - 1,1m and others in thermal band like TM.

3-2-Thermal Infrared Images :

All wave length of thermal IR radiation are not uniformly transmitted through the atmosphere, IR radiation at wave length from 0,74 - 2,50 , 3,40 4,20 , 8 - 14 , 30 - 80μm is readily transmitted through the atmosphere and these regions are referred to as atmospheric windows.

The reflected IR region ranges from wave length of 0,7 - 2,50 μm and Includes the photographic IR band (0,7 - 0,9 μ m) that may be detected by IR sensitive film, but the thermal region(3 - 14 μ m) detected by thermal. The thermal images manifest, the thermal anomalies on the earth surfaces which related many factors like earth movements earthquakes, hot water volcano and minerals deposits. etc. (Rukieh2009)

3-3-Radar Images

Radar imaging systems provide a source of electromagnetic energy to illuminate the terrain Energy returned from the terrain is detected by the System and recorded as imagery, Radar

is called an active form of remote sensing in contrast to passive forms such as photographic and thermal IR Systems which detected the available energy reflected or radiated from the terrain .

Radar systems can be operated in dependently of lighting condition and largely independently of weather radar is the acronym for indicating that it operates in the Radio and Microwave bands of the electromagnetic spectrum ranging from several meters to few millimeters in wavelength .There are also television laser and other images.

4 - methodology of the work and its stages:

I Recommended the next methodology for exploration raw materials of seven steps for maps with scale 1/200000 -1/50000 which consist of:

- **Preliminary stage:** in which different data are collected about the study area including space images.
- **Office interpretation for the space images and preparing preliminary maps:** in which preliminary schemes are prepared out of the space data interpretation, in addition to other different data.
- **Field check stage in which the following are done:**
  - Checking the data of space interpretation and preliminary schemes.
  - Taking GPS measurements for the indicative sites ,anomalies phenomena and Other importance features
  - Taking samples from rocks and soils in addition to water samples, from important sites.
  - Taking field photos**.**
- The **semi-final lab or office stage**, in which Analyzing the samples in labs , the input, output and processing of the semi-final schemes are taken place according to GIS system.
- **Final field rounds to check the accurate data .**
- **The final layout of schemes and maps are prepared for the study area.**
- **Preparing the final report with the results and recommendations.**

In case the scale more small the steps of methodology decrees to five ,or three steps
The following chart symbolizes our work method with its different stages starting from collecting data till preparing the final report.

The work scheme

Field work

Office - Laboratory work

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1- Preliminary stage

Collection of different data about the study area- preparing the necessary maps and images

⇩

2- Office interpretation stage and producing the preliminary maps including the following schemes (contours, settlements, roads, geological , geomorphologic, tectonic, and mineralization schemes, ,

⇩

3- Field check stage

Checking the office interpretation data

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GPS measurements for the indicative sites and importance features

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collecting samples of soils, rocks and water

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- Field photography

⇩

5- Final special tours stage

⇩

4- Laboratory analyses of the data ,The semi-final office work stage

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- input the schemes according to GIS

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Linking the analyses results with the schemes

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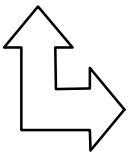
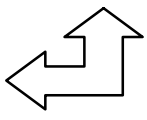
Output the schemes with appropriate scales

⇩

6- The final output of maps



7- Preparing the final report with the results and recommendations



5 - Discussion

Remote Sensing data play great role in exploration of metallic , non metallic, oil and gas deposits .by direct through analyze surface phenomena which reflect in space images, or indirect through structure and geodynamic analyzing and complex interpretation from other data .

A- Indirect remote sensing methods for exploration useful raw materials

Begin to use these methods through the development of air space structural, metallurgical maps, depending mainly on the show and determine the structural factors help to form the raw materials, especially lineaments, annual structures and other geological phenomena as folds, Blocks, lithostratigrafical formation and hydrothermal alteration zones and others Can be resolved by these techniques the most important set of issues (Rukieh M.1996)

1 - identify hidden or obvious structures , which are of great importance in the preparing of mineral maps

2 - speed up the study of geological phenomena that determine the distribution and identification of Mineralization, volcanic structures – magmatic and intrusive hidden bodies as catalysts to search for raw materials

3 – appear and determine the cracking and the deep origin fractures zones distributed and collected for mineral and oil deposits

4 - Studying severe tectonic activity places and the accompanying mineralization .

A-1- Studying lineaments which determine and concentrate deposits:

Lineaments may form faults and fractures of different degrees, or structural and lithological borders of rocks, and they have extension on earth crust level Lineaments appear clearly on aero and space images, the degree of their clearness changes by the change of scale, kinds and resolution of the used images; the more the scale is small the more the regional lineaments and the very deep faults (as the rift faults) (Fig.1). which shows the Arabian rift zone from the Red Sea in the south until Turkey in the north, with large annul structures and some faults in the fold belt of Iran's north-west direction, (Rukieh M. 2004) We usually distinguish between boundary and crossed lineaments; the boundary lineaments are usually separate between tow areas, of different reflectance intensities on space images, and they usually appear, in nature, blocks' borders of different degrees and Neotectonic development (Fig.2). The crossed lineaments appear on space images of different scales, as lines or bands cut the fields of one or similar incident light. They can be crossed or displaced according to each other.

Out of the important characteristics of these lineaments is that they reflect deep faults and tectonic cracking systems, which usually don't appear on surface, in recent relief or in sedimentary occurrences structure (Fig. 2). Rukieh M.2006 .

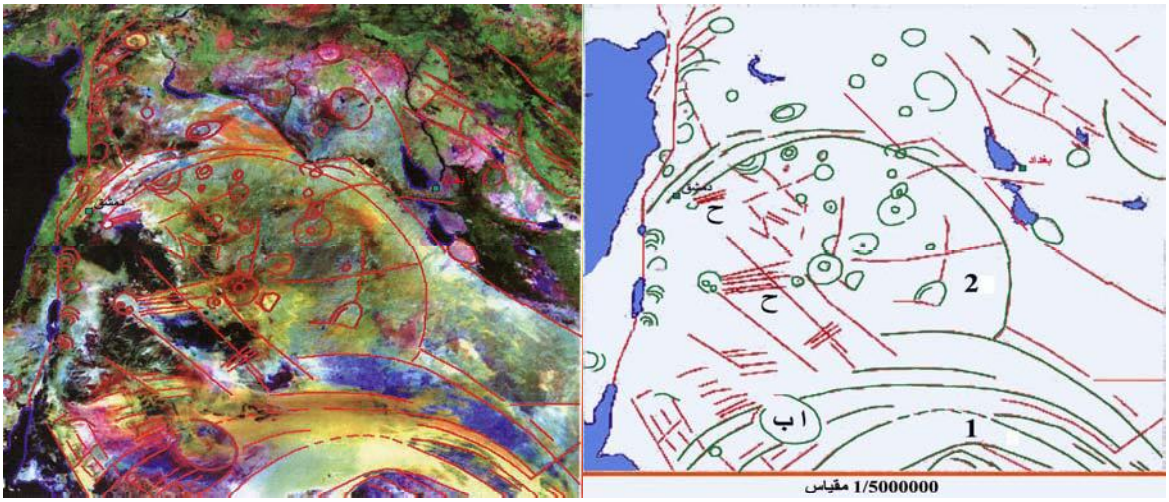


Fig. 1- Space image ™ and the tectonic scheme of the Arabian rift and North Arabian plate scale 1/5 million.(Rukieh 2004)

Fig (2) colored Space image (TM) shows boundaries and crossed lineaments (north east of Sudan)

In Volcanic Areas Remote sensing allows abetter mapping of the different lava flows projected materials and sediments between them .R.S. observation of the geomorphology associated to field observation may then indicate which Rocks porous enough to be considered minerals. Our study (Rukieh M.1993, 1997) to the volcanic area southeast of Damascus, show importance of space images to mapping different lava and tectonic situation in it , with may be useful materials . (fig 3)

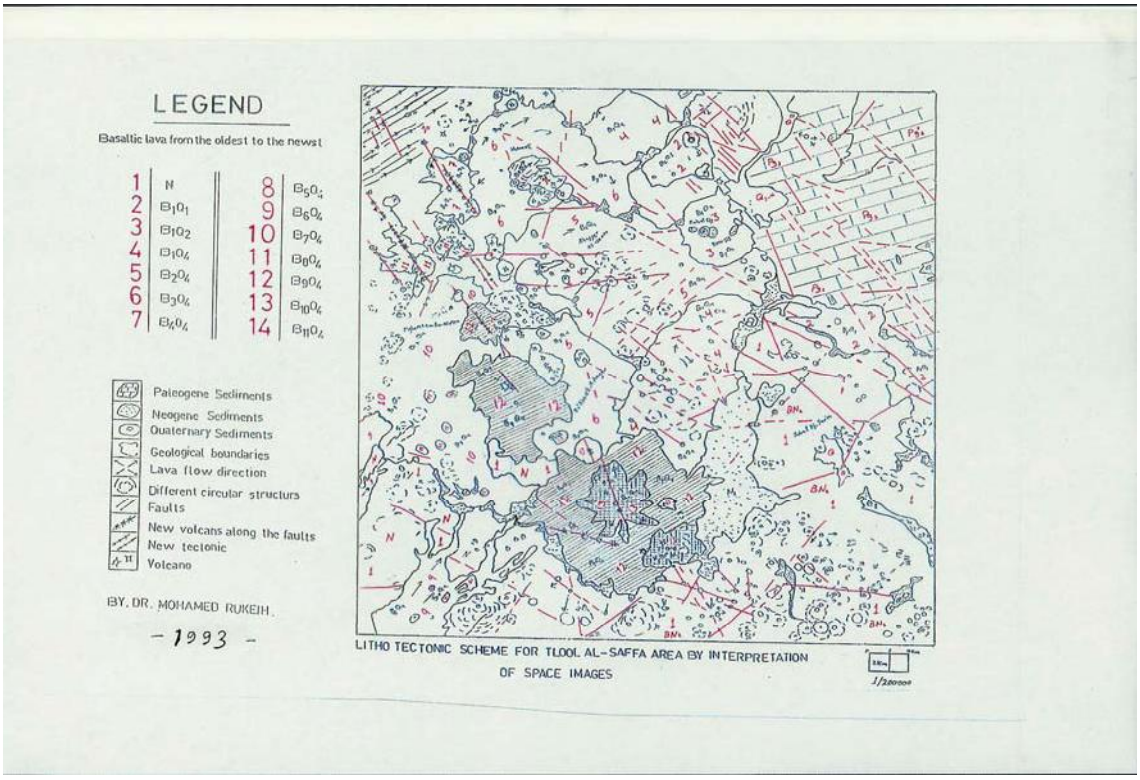


Fig. 3- show litho- tectonic scheme for Tlool Al-safa area (south east of Damascus),by interpretation of MKF6 colored space images with resolution 5 m.

Another approach is to study the tectonic context of the volcanic structures . It is necessary know if the Volcanism has been associated to extension , normal faulting ,subsidence and formation of sedimentary basins beneath the volcanites as is often the case .this can be done by Remote Sensing study of the shape and map distribution Volcanic edifices . Elongate Volcanoes , linear clusters of adjacent Volcanoes, Volcanic ridges , dykes are rooted on tension fractures .The tension fractures used by the magma to reach the surface , and other tension fractures that have been filled only with sediments, may form en-echelon systems that mark potential or real normal faults .Subsidence and sedimentary filling of basins hidden by the Volcanic Rocks may be associated to the minerals .The best images to be used for the study are radar ,Landsat and spot data . and if possible DEMs,for the morphology.

The studies by using space images showed that regional and large lineaments have a importance mineralization, especially in the system of permeable zones which renew and activate in the magma -tectonic activity ages. These zones appear on earth surface as systems, of continuous small fractures, with same direction or as lithological borders, or as continuous series of basins and craters. Some of these lineaments can be determined on

space images, through structural geomorphologic analysis Drainage analysis, and the minute fissures analysis.

Several studies around the world showed that mineralization can be associated with many lineaments; . Konaleek, Kold and Kron from Pennsylvania University, showed that there is a strong relation between lineaments determined on space images and the different mineralization. Also, they showed that there are eight sites for copper and lead deposits in many kind of rocks along Taeron Maonteneon fault, which extend for more than 160 km in Pennsylvania State.(Kats, est.… 1988) These mineralization are noticed also in the crossing zones of lineaments of different directions in Mongolia as shown in (Fig. 4).(Kravestov V.C., Kats R. 1988)

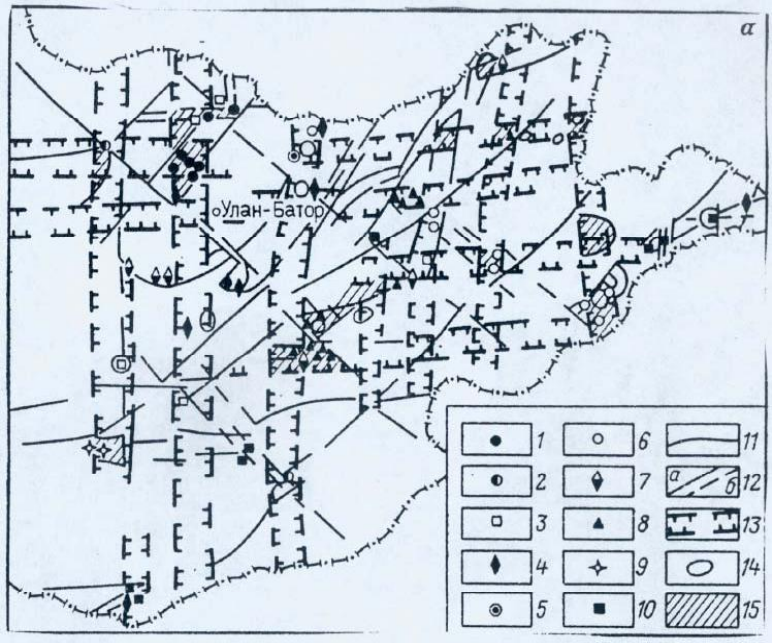


Fig (4) shows lineaments and fractures in south of Mongolia by interpretation of space images and their role in concentrating the mineral deposits (Au (1), Cu and Mo(2), Fe(3), Sn, (4), w and Mo (5) ,w (6), SN and w (7),Plagioclase(8),F,ST(9),Pb,Zn,Cu,(10)). Big lineaments(11),small lineaments with mineralization(12) ,geomorphologic structures systems(13),Annual structures(14),intersecting structures with mineralization(15) by Kravetsov V.C. and Kats R.(1988)

Geologists concluded that small space images, which cover large areas, are characterized by the importance of appear regional structures in formation and occurrences deposits. These indicators are used in next studies in the other areas or in more detailed sites.

A determination for many mineral resources deposits as (mercury, gold antimony and silver in Kazakhstan, deposits of copper, magnetite and bauxite using remote sensing methods depending on studying lineaments in different areas around the world has been done. Our Remote sensing and field studies discovered some Hydrothermal minerals (Fe,zn,cu, As,)

in Zebdani- Sirghaya area, north west of Damascus (Syria.) fig.5 (Rukieh M. 1989, 1991,2003)

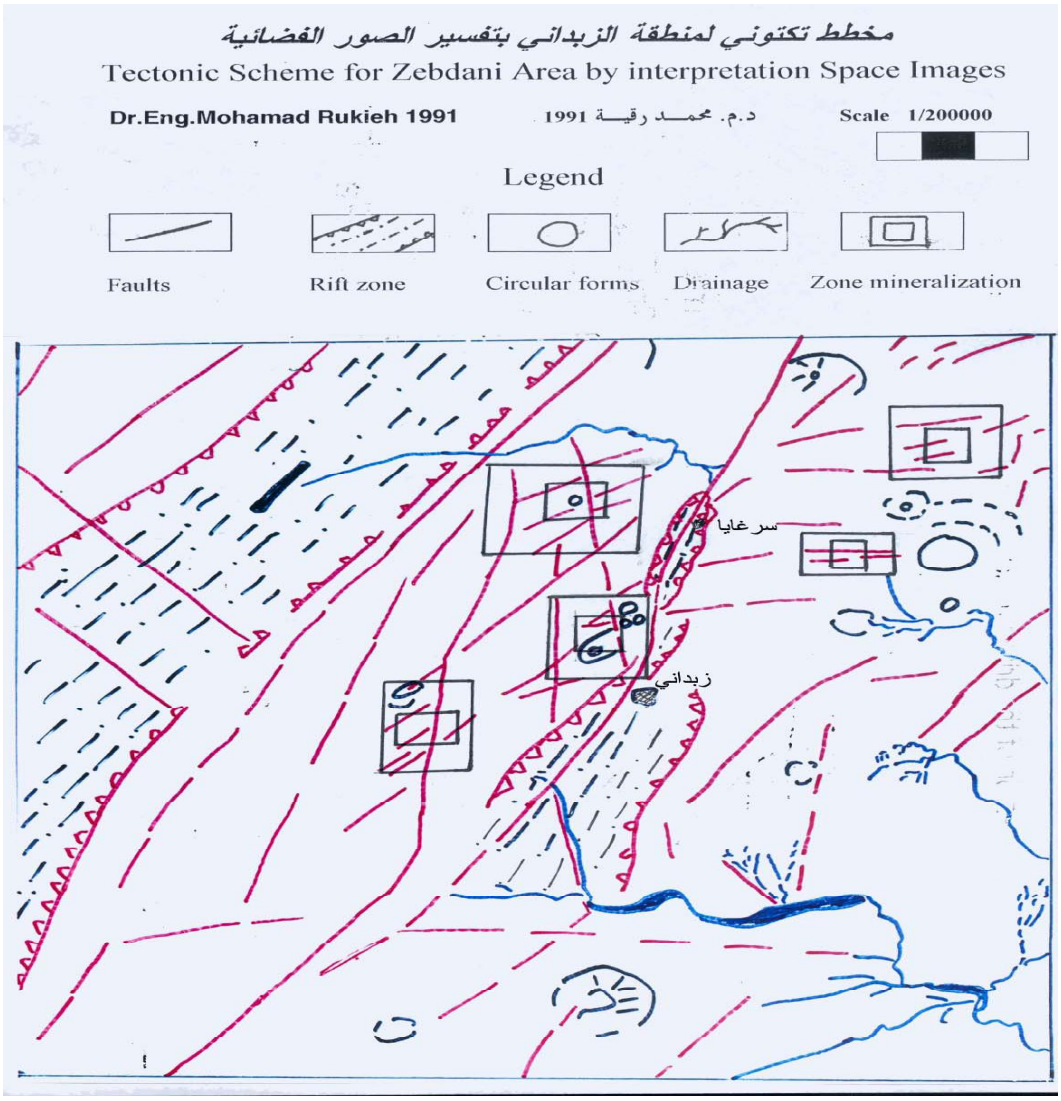


Fig.5- tectonic scheme with zone (hydrothermal Fe- Zn-Cu mineralization) in Zebdani-sergaya area-Syria by interpretation space images(Rukieh 1991-2003)

A-2- Studying annular structures determined to deposits:

Annular structures are geological phenomena of central symmetric, which take circular or oral shapes. They differ, in their structures from the surrounding phenomena, origin, dimensions, and their clearness properties on earth surface and space images.(Rukieh 2006) Annular structures form one of the most important structural elements to the continental earth crust and the transition areas. Their dimension range from several meters till hundreds or thousands kilometers . They can be simple, composed one circle, or complex, composed of several ones (Fig.6).

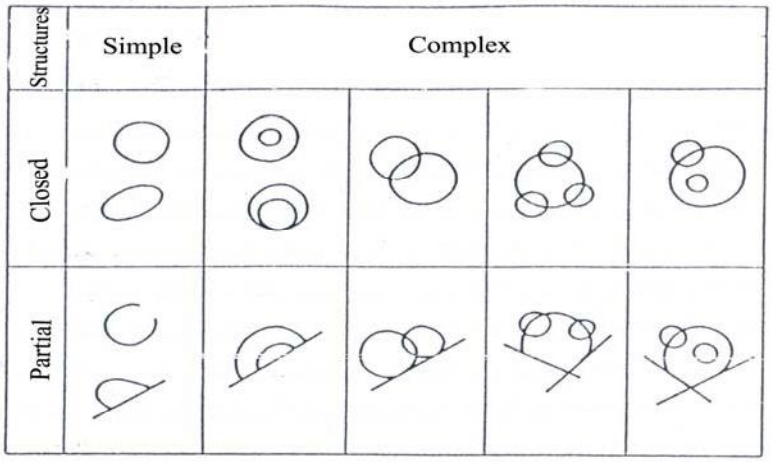


Fig (6) Shapes of annular structures according to Krotkof(Rukieh 2006)

We can distinguish magmatic, volcanic, metamorphic, tectonic, seismic, nuclear, Annular Structures and structures which were formed from meteorite.

We can determine the annular shapes on space images on the basis of reflectance intensity and geomorphologic structural analysis to the relief and drainage system. We can use these bases separate or comprehensive way and by any space image scale.

Annular structures in various continents (5000 annular structures are shown in the former Soviet Union), shows between 70-75% out of the known deposits on earth are connected, in place, with the annular structures, this is not occur by occasion, but there is a strong relation in origin between them.

Fig. 1 Shows in space Image and scheme the Arab Rift and the northern outskirts of the regional ring structure (1), and some details of structure No. (2), which contains several structures including a smaller rings with a central nucleus, which constitute an important structure for oil and mineral ores. In Iraq , Saudi Arabia and Syria .in addition to some ring structures in Iraqi and Turkish, and many of the arc and ring structures, often on the eastern edge of Arab Rift .(Rukieh 2004)

Scientists assured the annular structures' possibility of concentrating mineral and oil deposits. It has been shown that these structures are connected with the formation of many black, colored, precious and rare mineral deposits.

Remote sensing studies and the field checks clarified that there is a clear relation among the kinds of specific origin of annular structures and the different mineral resources. This can be done according to the following:

1- In the outside borders of the annular structures, especially if their borders are surrounded by annular faults.

2- Out and near annular borders, especially when they are surrounded by folding belts.

3- In the crossing points of the annular structures with faults and lineaments of different degrees, scales and origin.
4- In the places of interference sites of annular structures of different scales, degrees and origin.
5- In the sides of eruption bodies which appear on space images as annular structures.(Rukieh M.2000)

In all mentioned cases, the friable degree and intensive rocks' permeability of earth crust which depend on the degree of their faulting, fracturing and cracking play the basic role. Upon studying mineralization properties for different annular structures, it is necessary to use space images of different scales and comprehensive degree from smaller to bigger. Also, using images of one scale taken in different times is useful.

B-Direct remote sensing methods for exploration useful raw materials

Adopt these methods to the study and analysis of satellite images Using Spectral properties of the deposits based on distribution of geochemical and thermal features on the surface of hosted rocks such as hydrothermal and metamorphic alteration , oxidation, gossans and other geochemical anomalies, which influence in multispectral space images, especially in the spectral range from 1.6 to 2.2 micrometers, including deposits of iron ,bauxite nickel, lettered rocks , sulfur and many hydrothermal Mineralization origin such as copper, lead, zinc, arsenic, silver, gold, tin, and others .

So using digital image processing methods such filtrating, enhancement, edges enhancement, linear enhancement and Rationing, classification or mixing an compacting colors. All these enable getting clearer information about affected rocks, and consequently determining the useful deposits sites. For example, the Occurrence of Iron ores in soil can be extrapolated through the relation between soil's contents of iron oxides and the reflected properties of soil or rocks in general. Whenever the proportion of iron metal increases, the amount of reflected ray decreases, that is because iron metal absorbs the largest proportion of the incident light on soil.(Rukieh M. ,Dalati M. 1997)

Can be in addition to use of the thermal survey in the selection of direct hydrocarbons on land or in sea areas where the gases released by giving the bottom of the sea to the surface negative thermal anomaly . commonly used here the thermal scanner with wave-length (3-6) and (8-14) micrometers and resolution 0.2 degree. by a group of Belarusian researchers headed by Qarasev O. developed a new method to detect hydrocarbons directly through the analysis and interpretation of multispectral space images such as MSS, TM , images by Know-how method fig. 7- (Karasev O.1995)

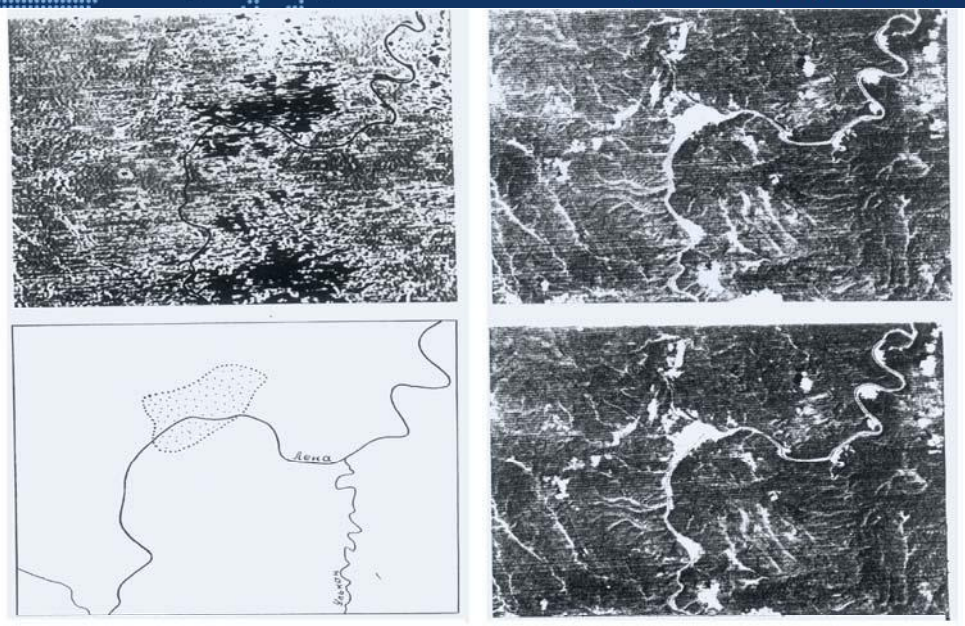


Fig (7) Shows methods of direct exploration of oil by processing of three bands MSS space images (for example. South of Siberia)

6 - Results:

1- Space images, with their different kinds and distinguished properties, form new important resource for studying earth phenomena and preparing different thematic maps.

2- These techniques, through annular structures, lineaments and the other geological phenomena, contribute in determining mineral and oil ores by indirect way.

3- Spectral properties of space images with minerals and their processing contribute to exploration of useful ore materials by direct way .

4- These techniques save Time, money, and efforts.

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