Geologic interpretation of palmyrides Chains, Syria, Using different Remote Sensing Techniques

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ISPRS/COMMISSION VII/WG4

KEY WORDS: Geology, Analysis, Interpretation, Landsat, SPOT, Remote Sensing,Knowledge-Base,

ABSTRACT

A preliminary Photo-geologic investigation of the Basement rocks and structures were performed using different Remote Sensing techniques (Aerial photograghs, Landsat-TM , Spot "xs" and Spot "panchromatic" for the Palmyrides Chains which located in the central part of Syria. Structurally , the investigated area belongs to the so-called palmyrides block, which was post-jurassically Subjected to a highly differentiated strain evolution. Synchronous records of TM and Spot data of Palmyrides area are compared with each other and with geological field data ; the structural faetures known from field investigation are also presented in both satellite data direction roses. Digital image processing of TM andSpot data gives more information than with B/W photographs, especially in areas with extensive soil cover. The image processing utilised consists of linear stretching of individual TM channels and generation of color composits . TM and Spot imagery have proved useful for detailed interpretation of geological Structures .

Background :

Palmyrides Range is a folded anomalous zone developed with a rigid cratonic: the Arabian platform .Structurally positive , with a moderate mountanous relief,(Fig.1) . As it is evident from the tectonic scheme given by (Fig.2),the surveyed territory embraces two major structural elements of the Northern slope of the Arabian part of the African Platform. The Southern half of the territory includes the stable part of the slpoe of the platform with the shallow-seated pre-Cambrian basement and low-dipping Mezo-Cenozoic platform cover. The Northern half of the territory belongs to the different depths of the basement and linear and block folding in the platform cover. It occupies the zone of the interaplatform trough with a strongly dislocated Mezo-Cenozoic cover of the palmyrian folds(thier central and Southern part) and the Eastern part of the Ad-Daww basin .

To the boundary between these two major structural features of the Northern slope of the Arabian part of the African platform there is confined the big superimposed Sabkhat Mouh basin of the Neogene.

Two structural stages are clearly distinguished on the surveyed territory owing to the nature of dislocations,the recorded angular unconformities,and the mutuality of the geological history. The lower structural stage embraces Jurassic, Cretaceous and Paleogene deposits. The upper one icludes Neogene-Quaternary deposits. The characteristic of the lower structural stage are marine sedimentation conditions and epeirogenic oscillating movements. In contrast to that, the upper structural stage is characterized by continental sedimentation conditions and orogenic movements. The magnetic map(Fig.3) distinctly shows two well-defined zones,distinguished by different nature of the magnetic field intensity. In the Northern part of the territory,the anomalies of the magnetic field are confined to the folded zone of the Palmyrian ridges. This field is characterized by a sharp increase and intense variation of its vertical component (ΔT) over short distances, as well as by isometric patterns of the anomallies whose trend coincides with the general strike of the structures of the Palmyrian ridges. Well-defined positive anomalies of the vertical component of the magnetic field are confined to the zones of the big synclinal folds. Thus, in the case of the synclinal structure of Ad-Daww this component gradually increases on the surveyed territory from the side of the structure towards its central part from 3,000 to 3,200 gammas. A similar rise of 150 and even 200 gammas

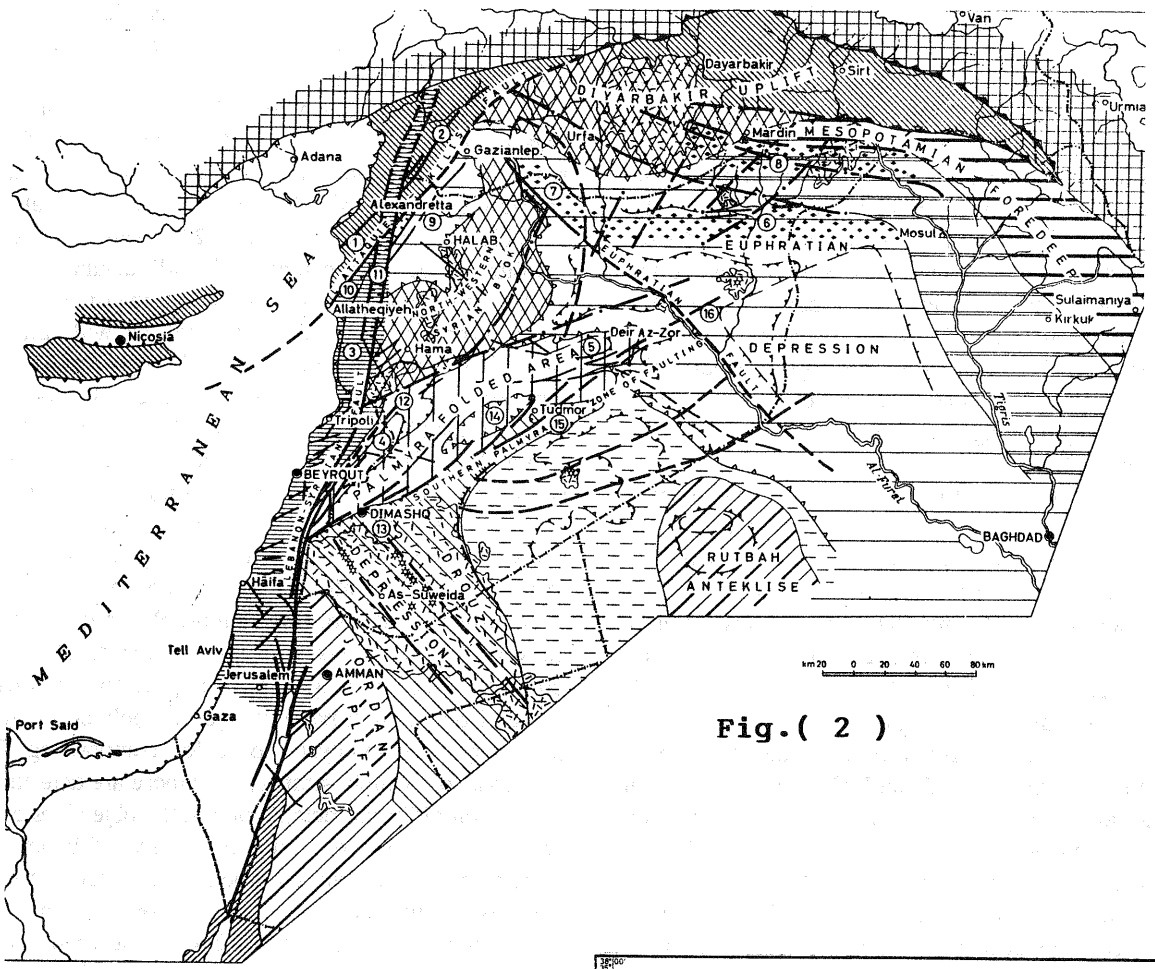


Fig.(2)

Fig. (6)

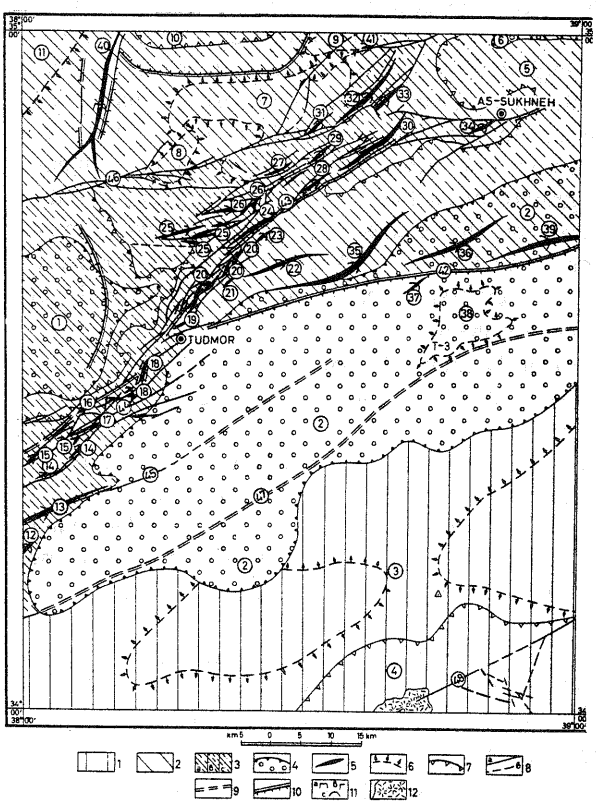
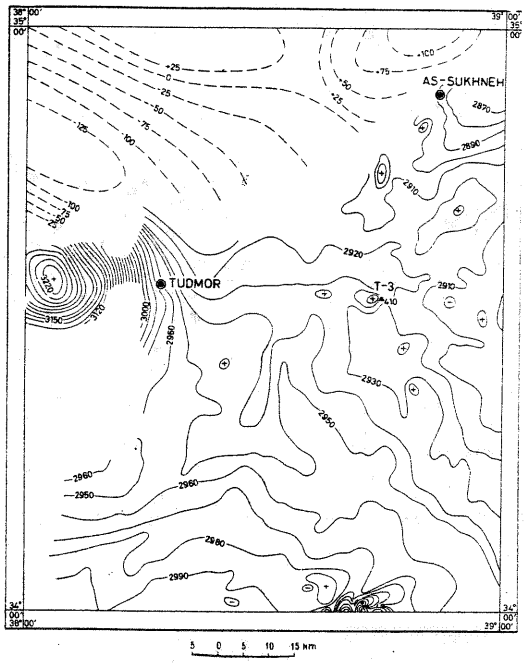


Fig.(1)

occurs at a certain distance from the central, most uplifted part
of the Palmyrian ridges(from the El-Mrah,Abou Rajmein and other anticlinal folds) towards the Khasara and El-Mitlaa synclinal folds.
A study of the gravity field of the territory (Fig.4) shows that its gravity anomalies have in general the negative values. Two zones, distinguished by different characteristics of gravity fields are well defined on the gravity map. These two fields are separated from each other by a gravity interval of a North-Eastern strike the intensity of which equals to 10 mgl. Spatially the gravity interval coincides with a series of regional folds, passing along the Southern face of the Palmyrides.
A whole number of linear gravity anomalies of a North-Eastern strike which practically coincides with the strike of separate local structures of this area is distinguished in the Northern half of the territory(which unfortunatly has not been completely covered by the gravity survey of the 1:500,000 scale).Towards the center of the El-Qayed and El-Mazar anticlinal folds,the gravity anomalies change from -35 mgl to -27.5 mgl and in the Tantour anticlinal fold from -35mgl to -17.5 mgl. On the other hand,in the Ad-Daww synclinat structure the values of gravity anomalies change from -35 mgl in the sides to -50 mgl in the center. The Southern and South-Eastern parts of the surveyed territory are characterized by a relatively undisturbed isometrical gravity field with a small amplitude of variation of gravity anomalies - from - 27.5 mgl to - 42.5 mgl. Noteworthy is the fact that spatially the chains of local gravity anomalies are confined to the Al-Abtar and Sawwanet faults. In conclusion, one should say with regard to the magnetic and gravity maps that they confirm rather well the division of the studied territory into two tectonic regions which are marked not only by superficial structural difference, but also differ substantially in their deep structures.

Geologic Interpretation :

By using of Remote Sensing techniques, TM, Spot imagery
shows three tectonical subzones, which can be distinguished morphologically from south to north (Fig.5). The first tectonical subzone includes major anticlinal linear foldes, the second is characterized by the series of linear box-shaped anticlinal foldes, the third includes major structures situated north of the Matnet System of faults. Remote Sensing techniques helped to mapping the tectonical subzones, and gave new information mainly in the plattform areas surrounding the palmyrides.
A synoptic view of large areas is the major advantage of using Satellite Remote-Sensing techniques. A Landsat TM scene (Fig.6) gave the same view as a Landsat MSS-scene (Fig.7), but TM's improved geometric resolution makes it possible to detect objects about one fifth the size of those detectable by MSS. As most image-processing systems can display 512 x 512 pixels on a color monitor, this means that with MSS-data with a pixel size of 80 x 80 m one can display an area of 40 x 40 km, and with TM an area of 15 x 15 km. The conclusion from this is that an image-processing system suitable for TM data should at least be able to display 1024 x 1024 pixels on a color monitor. Thus, one can also take full advantage of the TM's high resolution and at the same time have the same synoptic view of large areas as with Landsat MSS. The linear features derived from SPOT scene took roughly the same higher content of information of the TM data(Fig.8). On the other hand, the resolution offered by SPOT HRV imagery, plus the fact that SPOT steriopairs are recorded directly in digital form, appears to offer a more satisfactory approach to this type of study. Reference to the the processing concepts, it is a fact , that all information derived from TM-seven-band sensor and Spot-three band-HRV sensor ,can not conveniently be presented within one single image product. Hence it is generally a problem to select a subset from a multiband image for enhancement by rationing , PC-analysis or color compositing. The decisions on which strategy to choose are determined by several different facts,involving the objectives of the particular application, and the choice of bands and algorithms. The enhancement of solely spectral variations within two (or more) bands by simultaneously suppressed albedo differences is the major advantage of ratio trasformations. However,in our data, non-linearities and non-periodic loss of rows affects band to band registration throughout different bands. Although haze-corrections were applied it was not possible to remove the remaining patterns completely. The principal component transformation is a widely used method for calculating "n" new, statistically independent components of "n" input bands, based on the covariance matrix. It can be applied to any number of bands. Three of the resulting components may be displayed as a color composite, or the components are used for decorrelation stretching before retransformation. Based on correlation techniques and known spectral characteristics, three significant bands for additive color coding are selected. The combination of bands 1,4,7(TM) facilitates excellent overall rock discrimination. The digital classification, though rendering more detailed discrimination of the Palmyrides region than visual interpretation alone, nevertheless represents only an intermediary stage in the information extraction process. The results of the digital classification have to be reinterpreted and modified for the production of a thematic map. The mapped lineaments from three test areas were digitised and analysed, which have been produced a variety of discrimination diagrams including histograms, rose diagrams, sector maps and gridded maps.



Magnetic map. Magnetic isoanomals are drawn every 10 γ

Fig.(3)

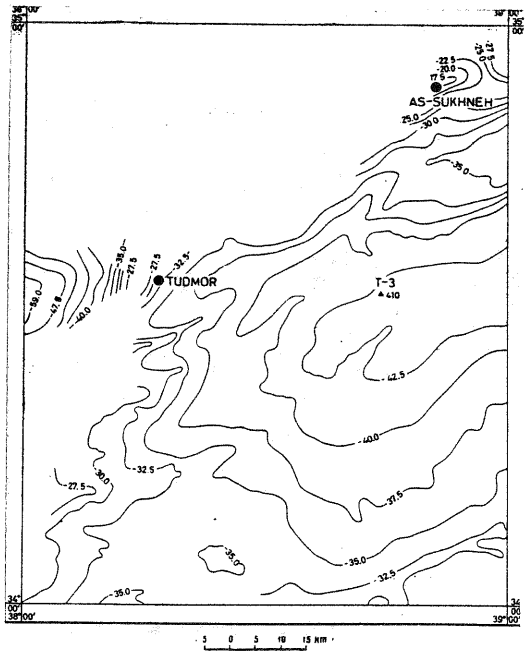


Fig.(4)

Gravity map. Gravity contour lines are drawn every 2.5 mgl

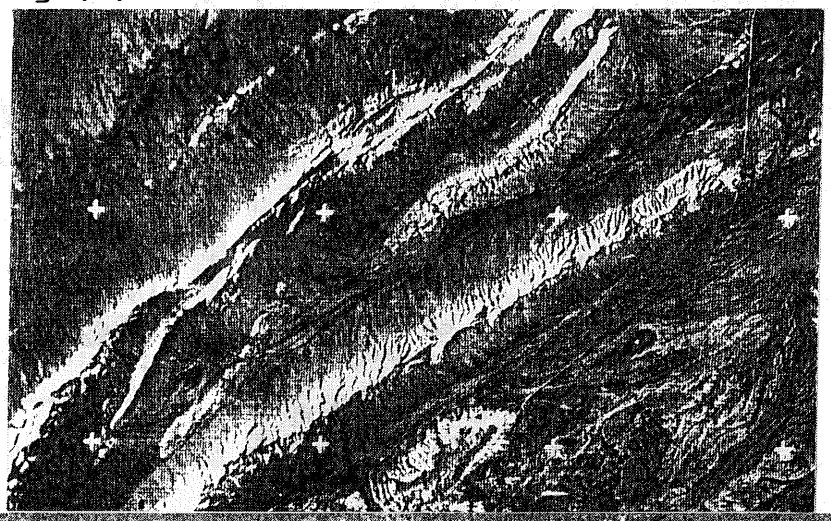


Fig.(5)

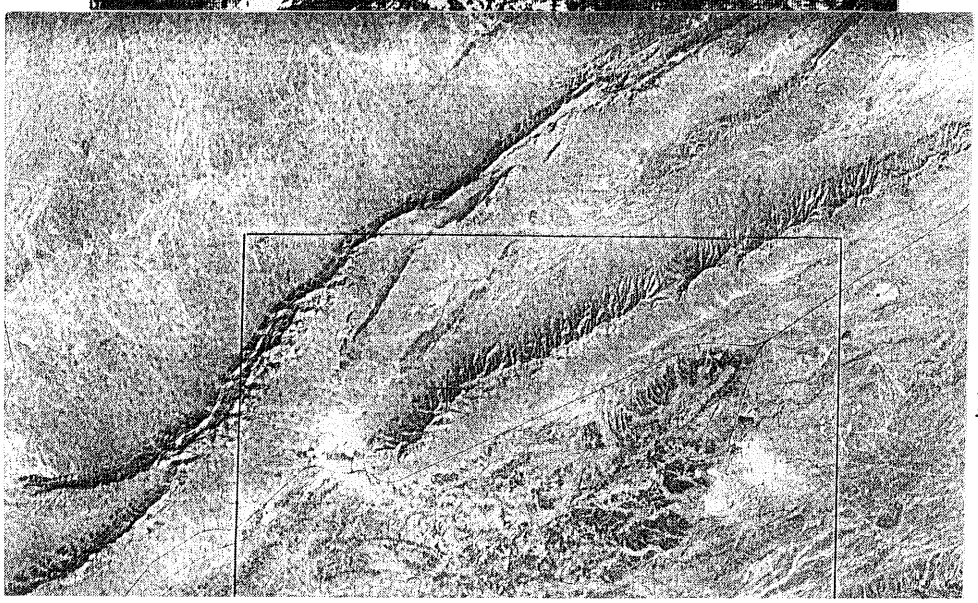


Fig.(8)

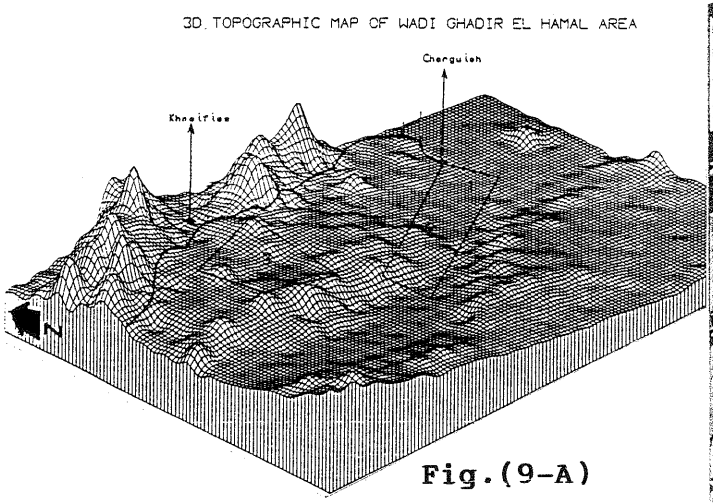


Fig.(9-A)

Fig.(7)

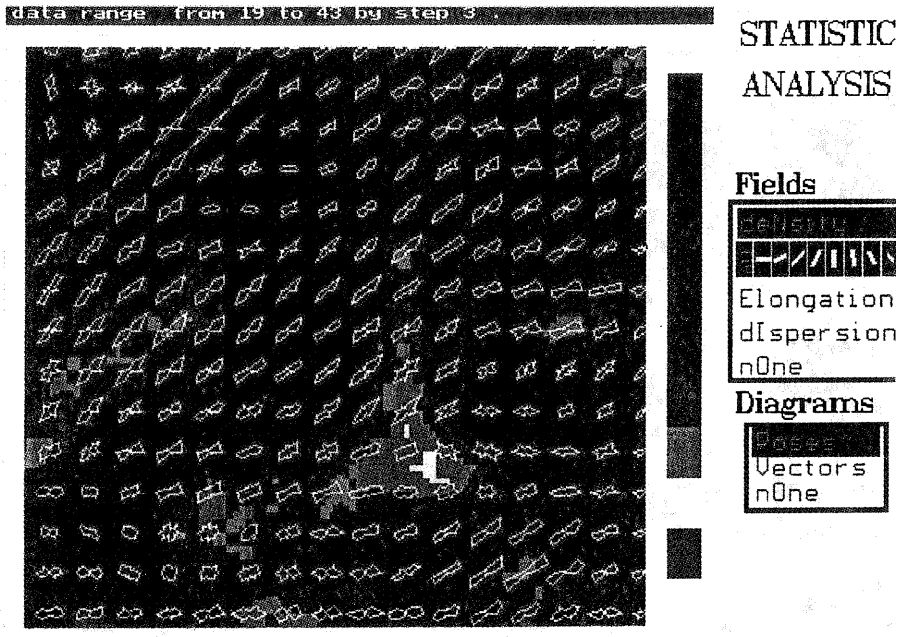


Fig.(9-B)

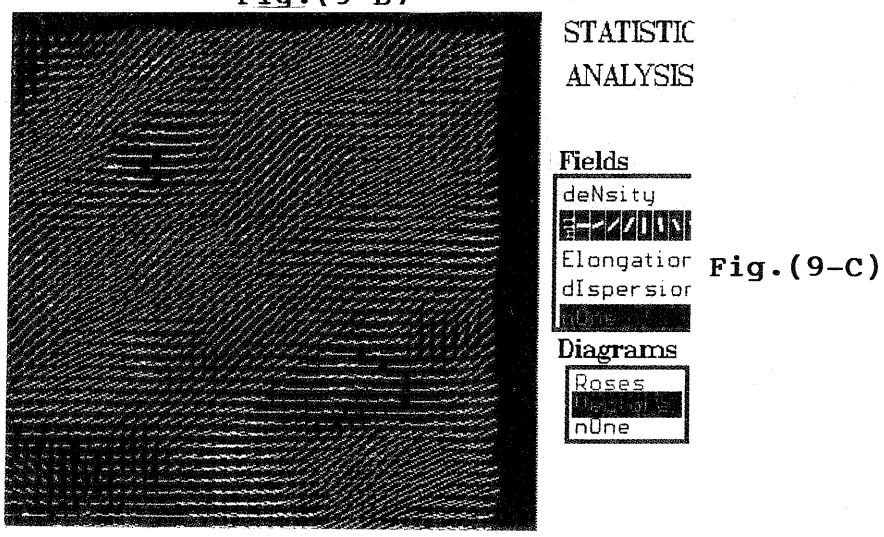


Fig.(9-C)

Lineament interpretation :

A lineament can be defined as a linear feature visible on the Earth's surface or seen on a satellite image. The lineaments may be surface expressions of geological structures such as faults,bedrock boundaries, bedrock foliation,cruch zones,etc. which are of great importance for the geologist. The mapped lineaments from the three test areas were analysed using LESA sofware (Fig.9-A,B,C) TM, Spot-based lineament interpretation led to the definition of the Palmyrides chains trending fault-zone,which includes the prominent faults (Fig.10-lineament interpretation resulting from the integrading of Spot and TM data). The TM image and aireal photos do show a prominent valley running parallel to the bedrock foliation. There are no structures indicative of strike-slip motion .

RESULTS :

Using of different Remote Sensing techniques led to the folowing results : within the zone of the intraplatform trough of the folded region of the palmyrian ridges, three tectonic subzones can be distinguished morphologically from South to North.The first tectonic subzone includes in the South of the following major anticlinal linear folds : the Ad-Dawwara coffer-shaped anticline, the Arak coffer-shaped anticline and the Ad-Dbayyat arch-like anticline. The anticlinal folds of this subzone are, as a rule, 20 to 25 km long and have an asymmetric box-,coffer-,or arch-like structure (Fig.11) .Along the Southern rim of the subzone there passes a big flexure which from now on we shall call the Arak flexure. The beds in this flexure have a Southward dip reaching 70 degrees. Continuing in the Western direction, in the area of the town of Tudmor, the flexure passes into a fault. In the North the subzone is limited by the As-Satih system of faults. Within the subzone there is only one synclinal fold-the J.Quleilat, which is bigger than the anticlinal folds of the same subzone. Its long axis extends for 27-28 km. The second tectonic subzone is characterized by the series of linear box-shaped anticlinal folds of the first order, striking in a North-Eastern direction . It includes (from South-WestMazar box anticline, The compound As-Safra coffer anticline, As-Satih box anticline and Thaniyyet As-Satih system of faults which, continuing in the South-Western direction, passes into the Hayyan system of faults. Its Northern border is the Matnet system of faults. The Ad-Daww basin is situated in the central part of this subzone. Its description is given under "Basins of the Neogen-Quaternary ". The anticlines have linear forms (generally they are 5 to 10 km long and not more than 1.5 to 2 km wide, more rarely they are 3.5 to 4 km wide), an asymmetrical box-,coffer-,or arch-like structure, and are characterized by considerable development of faults of a normal or thrust nature, and the existence of numerous small fractures feathering out from the major faults. All anticlines are located in echelon, being separated from each other by large longitudinal faults with a displacement amplitude of 600 to 800 m. The displacement planes of the faults are inclined at an angle of 75 to 85 degrees to the South-East in the Southern limbs of the anticlinal folds and to the North-West in the Northern ones. The flat arches of the folds of this subzone are generally inclined at an angle of 5 to 10 degrees to the North-West and their Sothern limbs are cut off by faults. Within the big anticlinal folds of the first order it is possible to define smaller anticlines and synclines of the second and third order, which complicate the main folds. The characteristic morphological features of the folds of the second and third order are their asymmetricity, box structure and the existence of numerous small longitudinal faults. The third tectonic subzone : it includes major structures situated North of the Matnet system of faults. A limited number of faults is observed in this subzone. They are associated with anticlinal folds. The amplitudes of the fault are considerably smaller than in the first tectonic subzone and do not exceed 100 m. Faults are not observed in the synclines, as a rule. The subzone under consideration has numerous flexure-like bends of the beds of 40 to 50 degrees, confined to the limbs of the anticlinal folds. Some of these flexures pass into fault dislocations .

Conclusion :

Data from the TM-instrument onboard the Landsat-5 satellite and HRV-instrument onboard the SPOT-3 satellite has proved very useful for detailed interpretation of geologic and tectonic structures. For structures with a length of 1 km or more, TM and SPOT imagery provides nearly as much information as high-altitude aerial photographs.Compared with MSS-data, the TM and SPOT-data gives more information about structures less than 5 km in length. Digital image processing of TM and SPOT data gives more information than the use of standard black-and-white photography, especially in areas with extensive soil cover. Image processing consists of linear stretching of individual TM-channels and generation of color composites. Four combinations of TM-channels were found to be useful, and each of them contains channel 4. These combinations are:2/3/4,1/4/7,and 4/5/7. The new shortwave infrared (SWIR)bands of the TM on Landsat 5 and the High Resolution Visible(HRV) of Spot "xs"and "Panchromatic", enable one to detect and discriminate lineaments which commonly occur in the Palmyrides region in the central part of Syria . Spectral features, evidenced by bands or changes in slope of spectral curves, appear as a result of either electronic or vibrational processes. The spectral reflectance of lineaments in visible(VIS)and near infrared(NIR)is influenced mainly by the wings of charge transfer bands in the ultraviolet, and electronic transitions at longer wavelength, which are caused by transition elements.The short-wave infrared region between 1.1 and 2,5 Mm,is a range of interest, which provides more

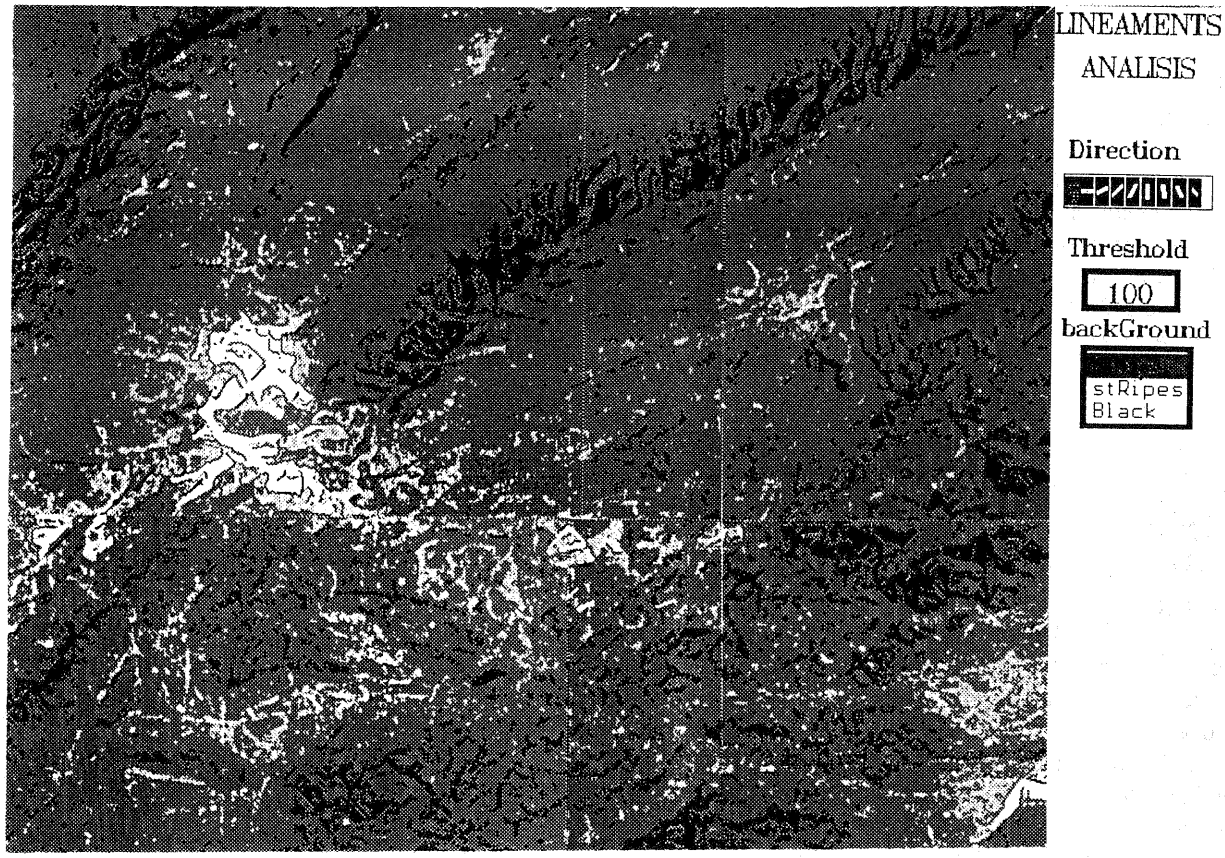

LINEAMENTS
ANALISIS
Direction
Threshold
100
backGround
stRipes
Black

Fig. (11)

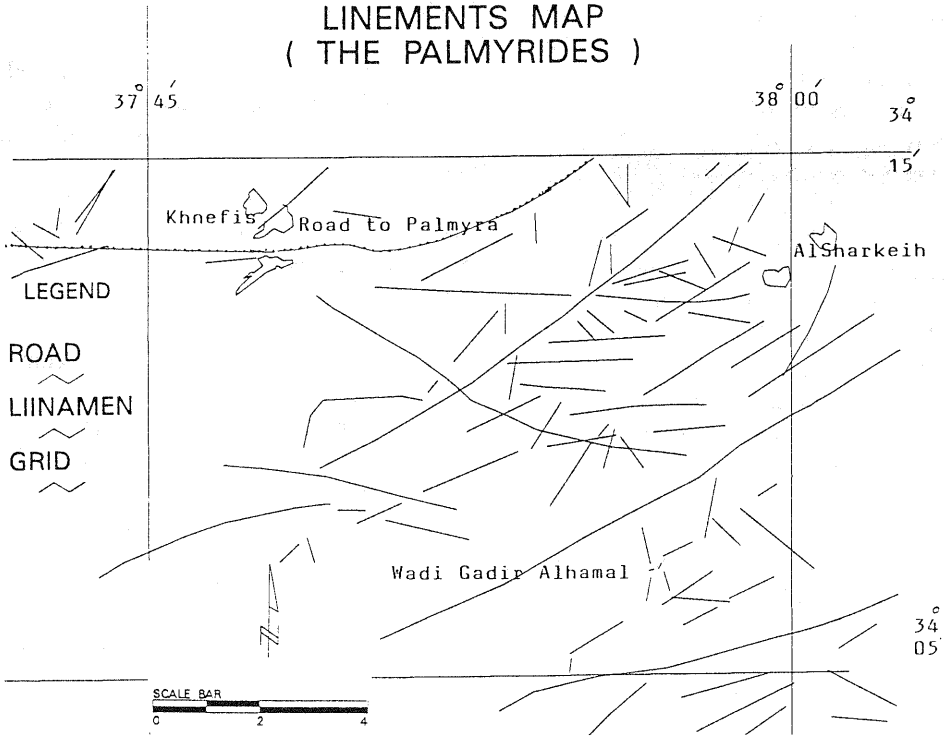

LINEMENTS MAP
(THE PALMYRIDES)
37° 45′
38° 00′
34° 15′
34° 05′
Khnefis
Road to Palmyra
AlSharkeih
Wadi Gadir Alhamal
LEGEND
ROAD
LIINAMEN
GRID
SCALE BAR
0
2
4

Fig. (10)

diagnostic spectral information about the composition of rocks than the (VIS)and (NIR)range. This region is characterised by high reflecttance values of most rock types covered by the 1.6 Mm central band(TM-5)and by strong and relatively sharp absorption features for clays, carbonates covered by the 2.2Mm centred band (TM-7)caused by lattice overtone, bending stretching vibrations of O-H bonds resp. C-O-bonds. High-resolution visible (HRV)-Spot-spectra serves as a guide for detailed examination.It is a fact, that all information derived from a seven-band sensor TM and three band sensor(Spot)can not conveniently be presented within one single image product. Hence it is generally a problem to select a subset from a multiband image for enhancement by ratioing, pc-analyses or color compositing. The decisions on which strategy to choose are determined by several different facts,involving the objectives of the particular application, and the choice of bands and algorithms.

References :

-Bjorn Rindstad & Arne Gronlie, Geological Survey of Norway, Trondheim, Norway, Landsat TM data used in the mapping of large-Scale Geological structures, 1989

-BRGM., 1977 . Photogeological survey of the Eastern Palmyrides . Ministry of Petroleum and Mineral Resources, Damascus, Syria.

-Chavez P.S. Jr,Berlin G.L.& Acosta A.V.1987 : computer processing of Landsat MSS digital data for linear enhancement. Mapping with remote sensing data. Proc.Sec.An. pecora mem. Symp., Sioux Falls,South Dakota,235-250.

-Dubertret, L., and Mouty, m., 1992. The Senonian in the Palmyridian Chain. Internal Report, SAEC, Damascus, Syria. in Arabic.

-Explanatory notes of the Geological maps of Syria .

-HAYEZ, 1985. Using of Remote Sensing to morphology Estuarine Research, vol.2: 3-22,1979.

-Magnetic and gravity maps of the Palmyrides area , TechnoExport contract 945,Syria.

-Tucker C.J.& Sellers P.I.1986. Satellite Remote Sensing of primary production. Intl. JL.of Remote Sensing ,1986, vol. 7,no 11.

-Tommervik H.T. 1986. Comparsion of SPOT-simulated and Landsat-5 TM imagery in geological mapping . In ternational Society for photogrammetry and Remote Sensing, Com. VII, "International Symposium on Remote Sensing Resources Development and Environmental Management", 25-29. August,1986,Enschede, Holland.