

# **INTEGRATION OF REMOTE SENSING DATA AND FIELD STUDIES IN STUDYING OF VOLCANIC ROCKS IN SOUTHERN PART OF SYRIA**

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## **ABSTRACT**

Volcanic Basaltic Rocks covered more than 6000 km<sup>2</sup> in southern Syria which belong to Neogene and Quaternary. And continues to Jordan up to Saudi Arabia, where it is known as Harrat Ash Shaam. It is the largest Late Cenozoic basaltic field in the region. Methodology of the work in this study adopts, on the integration of the space and the Ground data and linked with geographical information systems, and integration between the office and field works. We had studied these rocks by interpretation of many space images with different types and scales (TM, spot, Russian) and different resolution from 30m to 5m in Russian Images

We prepared with field truth number of Tectonic and tectonic schemes in different scales (1\ 6000000, 1\ 500000, 1\ 200000, 1\ 50000).(we present part of them in this article). These schemes have showed the tectonic settings and different volcanic lavas in the studied area. It has shown about 400 Volcano, most of them associated with regional faults extended from south of Arabic platform to the North West direction. The type of eruptions is intercontinental. There are important eruption centers, which have annular forms, the first one is located in Alsweida area, and the second located in Telol Alsafa area. Also it have many annular structures, the diameters of which are ranging from several 10 m to tens km. The detailed schemes show new information about the Quaternary lava, which provisions in its shape and time of its accruing. The number of it reaches to 11 lavas by our interpretation, while it not more than 6 lavas in geological maps.

One important Phenomena has shown in Telol Alsafa area, its are wind erosion extended to the east direction for more than 100km.in a straight lines. Our field work shows the phenomena have tectonic base. The field work and absolute age basalt samples K-Ar dating, shows the age of Volcanic flows beginning from 18, 5 Ma until the Early Holocene generations with the Neolithic artifacts on the surface, and younger flows, which erupted from small volcanoes within the lava field and covered constructions and signs of inhabitation dated archaeologically as of Neolithic, Chalcolithic and even Early Bronze Age. The most recent flows can be dated back to the beginning of the second half of the III millennium BC. With Bones of animals in it in Khirbet El-Umbashi, and Hebariye places.

## **1-INTRODUCTION**

The Syrian Volcanism is a part of the larger region of the Neogene–Quaternary basaltic volcanism in the northern and central parts of the Arabian plate. Volcanic basaltic Rocks spread in many sites of Syrian land, the main part of them concentrated in the Jebel Arab Plateau, in southern part of Syria, where they covered more than 6000 km<sup>2</sup>. (Ponikarov et al., 1967) The volcanic activity, accompanied the evolution of the Arabic Rift during the Neogene and quaternary, it is mostly found in the eastern regions of the Rift (Rukieh, 2004, Trifanov et.al.2007), including sites distributed in the extreme south-west of the Arabian plate in the area of Aden and Taz in Yemen along about 400 km,. East and north of Mecca and Medina along about 800 km (Fig.1), but The Harrat Asham volcanoes are form large volcanic area in the regions, where that extends to the northwest from Wadi Sirhan in Saudi Arabia across the Alazraq area in Jordan and even southern Syria in the Jabal Arab and Tlul Safa areas at a distance of more than 500 km, and spread over an area of 45,000 km<sup>2</sup>,( Rukieh M. 2000) it have

continental volcanoes (Jubilee and others 1998) .Fig.1, 4. The Harrat Ash Shaam basalt eruptions occurred in three episodes: at 26–22 Ma, 18–13 Ma and 7 to, 0.5 Ma (Mor 1993; Ilani et al. 2001). The most complete section of the Neogene–Quaternary basalts is observed in the Jebel Arab Plateau, with thickness up to 1000 m (Rukieh, 2004).

Our study concentrated on Tlool al Safa area and northern part of Jebel Arab Plateau.

## **2- MATERIALS AND METHODS**

We used space images of different scales, of various spectral channels /500-980/, 400-1100 nanometer, of different resolution /5 to 45m/, some of the images were taken by Russian satellites. The digital processing of space Images had been done by using ERDAS programme. In this study we focused to the following data had been processed (Rukieh M. 1991, 1993, 2004)

-Photographic space image taken by MK6 camera loaded on Resource Russian satellite in spectral bands /500-980/ nanometres, 1 / 200000 scales, with resolution 5m.

-Colour space Land sat TM image Synthesis for three spectral channels with (red, green, and blue) with resolution 30m and 1/200000 scales (Fig.2).and 1/6000,000 scale.

Methodology of the work in this study adopts, on the integration of the space and traditional data and linked with geographical information systems, and integration between the office and field works

In this study we used five stages of the work for maps with scale 1/200000 which consist of:

1-Preliminary stage: in which different data are collected about the study area including space images.

2-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.

3-Field check stage in which the following are done:

o Checking the data of space interpretation and preliminary schemes.

o Taking notes points for the indicative sites ,anomalies phenomena and Other importance features

o Taking volcanic rocks samples from important sites for analyzing and absolute data.

o Taking field photos.

4-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.

5-The final layout of schemes and maps are prepared for the study area.

## **3-DISCUSSION**

### **3-1 –PREPARING LETO-TECTONIC SCHEMES**

By our Methodology we prepared two main leto-tectonic schemes for studying area 1/200000 scales, and one with general view 1/6000000 scale .The first one covered south and west of Damascus, with part of Lebanese and Palestinian territories (fig. 3 ), Prepared by interpretation of land sat TM color image. In this scheme we could recognize the following:

-The boundary between Volcanic and Sedimentary Rocks

-Rift Arabic Fault North and North East direction , with associated Rashayya, Hasbaya, Serghaya, and Damascus faults ,North East Direction, and Rum ( Beirut ) fault, to the North- north west Direction, continuing to the Med.sea

-Neogene and Quaternary Basalt in Golan Plateau.

-Neogene Basalt and Neogene basaltic Mountains in the south of Damascus

-Five types of Quaternary Basalt lava flow in the north part of plateau of Gebel Al Arab (Allajat area)

-High and low reflection Quaternary sediments, with Q3 sediments. That is related with moisture of the land, and type of materials.

-Ring structures in many sites

- The scheme of general view 1/6000, 000 scale for the northern part of the Arabian Plate, that prepared by interpretation of Landsat TM Image, shows throughout the Arabic Rift zone from the Gulf of Aqaba in the south to the Turkish territory in the north, and the important Harrat al-Sham volcanic area, which continuing from south Syria to the northern part of Saudi territory, through the Jordanian land along of 500 km. In the scheme, for the first time,It has been interpreted tree interesting wind erosion Phenomena, One of them in the Tlool al Safa area in Syrian Territory, and 2 others in Jordanian territory, (Fig. 4) its extend to the east direction for more than 100km.in a straight lines. Our field work shows that the phenomena has tectonic base.

-The third scheme for Tlool Al Safa Volcanic area, to the south East of Damascus, it was more detailed, that we used 5 m resolution space image. We recognized 14 different Neogene and Quaternary basaltic lava flow (fig.5), 11 of them belong to the Pleistocene and Holocene volcanic eruptions, while it presented only 6 lava flow in geological Maps scale 1/ 200000. As we see in this scheme, here tens of volcanoes are located in the NNW-trending extension faults, and most of faults take NNW-SSE direction. One important Phenomenon has shown in the North West end of the scheme, its wind erosion. Our field work shows the phenomena has tectonic base, which we talked about in the previous paragraph.

### 3-2-GEOLOGICAL SETTINGS AND K-Ar DATES

Late Cenozoic (Late Oligocene to Quaternary) basalts cover large areas in the northern and central parts of the Arabian plate [Camp, Roobol, 1989] and occupy Syria and adjacent territories of Turkey up to the Taurus suture (Çapan et al., 1987; Yilmaz et al., 1998) and Jordan up to Saudi Arabia. Similar, but less extensive volcanism occurs in the Arabic Rift zone (Garfunkel, 1989; Sharkov et al., 1994; Yürür, Chorowicz, 1998; Abdel-Rahman, Nassar, 2004; Chorowicz et al., 2005). (Rukieh M. 1991, 1995, 1998, 2000, 2004, 2006, 2007)

The volcanic eruptions have been associated with regional faults systems, where is the Magma stepped through channels, which was formed in the areas of intersection of major tectonic trends, in addition to the intersection points of the main faults with Rift faults. The Magma has flowed, through many cracks or craters which took place in the region. A general trend northwest South East. Appear in many areas well-preserved of volcanic cones and craters, where there are only in the south of Syria, more than 400 volcano, (overcome them alkaline basaltic rocks) The age differentiation of the Neogene–Quaternary Syrian basalts is grounded in their geological relationships with surrounding sediment and the K-Ar dating. (Rukieh M. 2004, Trifanov et al. 2007, 2011)

According to the data on Saudi Arabia, volcanism started in the belt 32–30 Ma and continued till ~20 Ma with maximum 21–24 Ma ([Camp, Roobol, 1992). The Arabic rift was originated in the Early Miocene (20–17 Ma). The Early Miocene basalts with dates from  $21.1 \pm 0.9$  Ma to  $17.3 \pm 0.8$  Ma was obtained in the larger territory. In the north, Turkey, the K-Ar dates  $18.6 \pm 0.8$ ,  $17.1 \pm 0.8$  and  $16.5 \pm 0.6$  Ma (Arger et al., 2000); were obtained in the large lava field to the SE of the town of Kahmaran-Maraş as mentioned Trifanov 2011,. In the south, Jordan, the oldest basalts with the K-Ar ages of 26–22 Ma were found in the eastern margin of the Harrat Ash Shaam and its central part, where the basalts compose ruins of oldest volcanoes [Ilani et al., 2001]. The Middle Miocene basalts (17–13 Ma) were found only in the north of the Jebel Arab Highland and near the city of Homs, (Trifanov et al. 2011). In the Late Miocene the lava flows, dated as 12–7 Ma are situated in the same N-trending band, whose northern part spread to the east up to the Euphrates valley and to the north-eastern part of the Shin Plateau. In the Middle Pliocene–Quaternary, stage, the Arabian plate moved to the north and produced shortening in its northern boundary. The N–S-trending compression and the W–E-trending extension favored eruptions on the NNW-trending and N-trending extensional faults in Central and Northern Arabia. After the brief wane of volcanism ~4–3.5 Ma, corresponding to the moment of rebuilding of the Arabic rift system, volcanism resumed, became more intensive in the Middle Pliocene and continued to the Late Pliocene, Pleistocene, and locally Holocene. This volcanism occupied the Jebel Arab Highland and its Jordanian continuation and spread to the east, into the northern part of the Syrian Desert, the Euphrates valley and the northern margin of the Mesopotamian Fore deep near the Turkish-Syrian boundary. (Trifanov et al. 2011)

The correlation between main stages of evolution of the basaltic volcanism and neotectonic demonstrates genetic links between these processes in the Arabian plate and its boundary zones and has to be taken into account for understanding volcanism origin. (Trifanov V.G et.al 2011)

Results of interpretation of space images and field work carried out the K-Ar dating and paleomagnetic studies of some lava flows, studied relationships of the flows with bedrock and capping layers, we corrected distribution of Holocene basalts in the Jebel Arab Highland. The new ages of the basalts together with earlier K-Ar samples and  $^{40}\text{Ar}$ - $^{39}\text{Ar}$  age determinations (Giannérini et al., 1988; Sharkov et al., 1994, 1998; Sharkov, 2000; Demir et al., 2007) give a possibility to correct the map of basalts to outline a history of the Late Cenozoic Syrian volcanism and correlate it with tectonic structure and evolution.

The Khirbet El-Umbashi, Hebariye sites in Jebel Arab Plateau, South of Syria lava flow (fig. 6) is really a combination of products of several eruptions with bones belongs to the domestic cattle animals, which happened during the time interval between the Neolithic and the Middle Bronze.(Fig.6, 7) The last eruption took place ~2200-1600 BC. This shows that the same volcano could generate several

eruptions and can be considered as potentially still active now. (Trifanov et al 2011) The area, covered by bones reaches several hectares. As minimum, the bones represent several ten thousand animals. According to the published data (Dubertret & Dunand, 1954–1955) and data of our collection analyzed by Dr. E.M. Vangengeim, bones of domestic animals and gazelles are prevailing.

The most recent flows can be dated back to the beginning of the second half of the III millennium BC (Trifanov, Karakhanian, 2008). Simkin and Siebert (1994) mention that the Safa volcano erupted in XVII century AD,. The last volcanic eruption in Saudi Arabia it was in 654 AH (1256) year, near the Medina (Abed, 1978, Mukhtar 2008) followed by a rash of volcanic in 692 AH year (Mukhtar 2008).

The Syrian basalts are mostly high  $TiO_2$  (1.8–3.7 %) alkaline mafic rocks (basanites, hawaiiites and alkali basalts) and rarer transition/tholeiitic basalts of  $SiO_2$  with 44.3 to 52.5 % and basaltic andesites. The  $Na_2O/K_2O$  ratios vary from ~1.5 to 5.6 and show positive correlation with the  $SiO_2$  content (Sharkov et al., 1994; Sharkov, 2000; Lustrino, Sharkov, 2006). Some authors assumed that the basalts in the central-northern Arabia were caused by the mantle plume situated in the astenoshere or lower (Garfunkel, 1989; and others) or they were linked with the Afar deep mantle plume (Sobolev et al., 2005), But Lustrino and Sharkov (2006) consider that the basalts were generated in the shallow mantle sources (<90 km), situated in the lower lithosphere or the upper astenoshere.

The Late Cenozoic pyroclasts and some basalt contain mantle xenoliths of mainly the spinel lherzolitic, spinel and garnet-spinel websterites, and rare xenoliths of the pyroxene granulites, probably representing the old oceanic crust (Sharkov, 2000).

### 3-3- RESALTS

1-We identified through the use of space images and remote sensing data a new volcanic lava flow in the study area does not exist in the previous geological maps

2-For the first time identified tree interesting wind erosion, with tectonic base Phenomena, One of them in the Tlool al Safa area in Syrian Territory, and 2 others in Jordanian territory, its extend to the east direction for more than 100km.in a straight lines.

3-Our field work and K-Ar dating gave us new information about geological settings of the Volcanic Rocks and main stages of its forming, which begging from 30 Ma in Saudi Arabia, through early, middle, late Miocene and Pliocene –Pleistocene, Holocene, until the last thousand to several hundred years, with bones belongs to the domestic cattle animals in The Khirbet El-Umbashi, Hebariye sites in Jebel Arab Plateau, South of Syria.

### 4. CONCLUSION

The Research shows the importance and effectiveness of remote sensing data Integrated with field work in volcanic researches and preparing the Geological and leto- tectonic schemes. These methods will quickly develop in future and will give more correct and certain information.

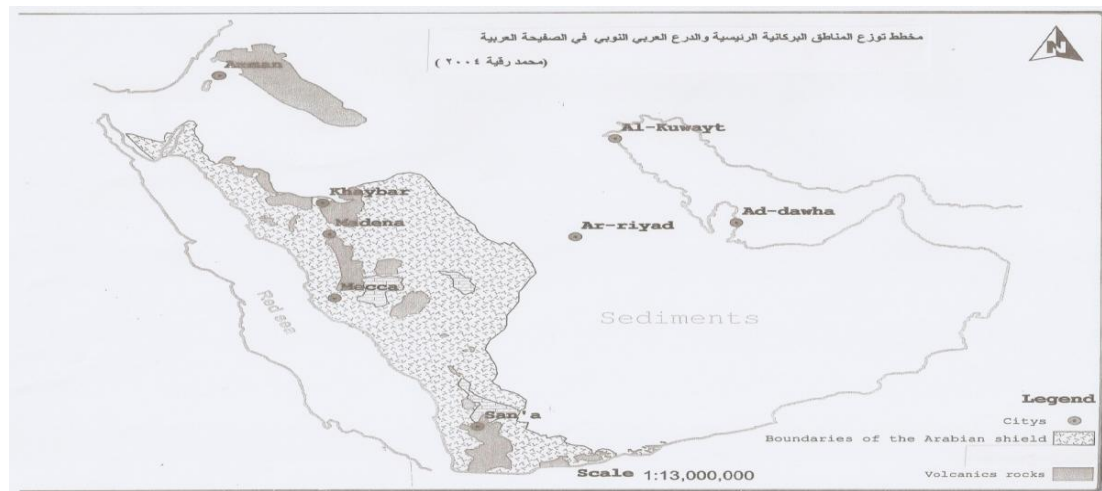


Figure 1, shows the distribution of the Arabian shield and volcanic rocks in the western and southern part of the Arabian plate (Rukieh, 2004)



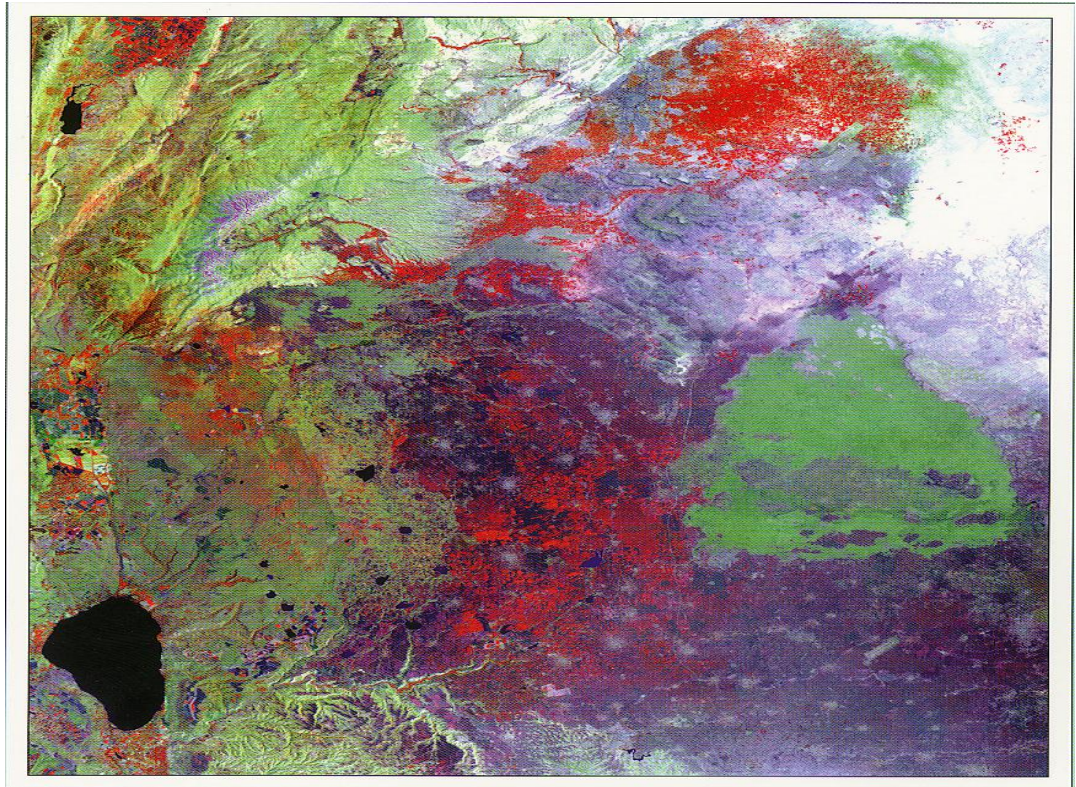


Figure. 2 false Color composed Land sat TM Image for area of south of Damascus and part of Lebanese and Palestinian territories. It seems Tabaraya Lake in black color and Damascus city (Sours GORS)

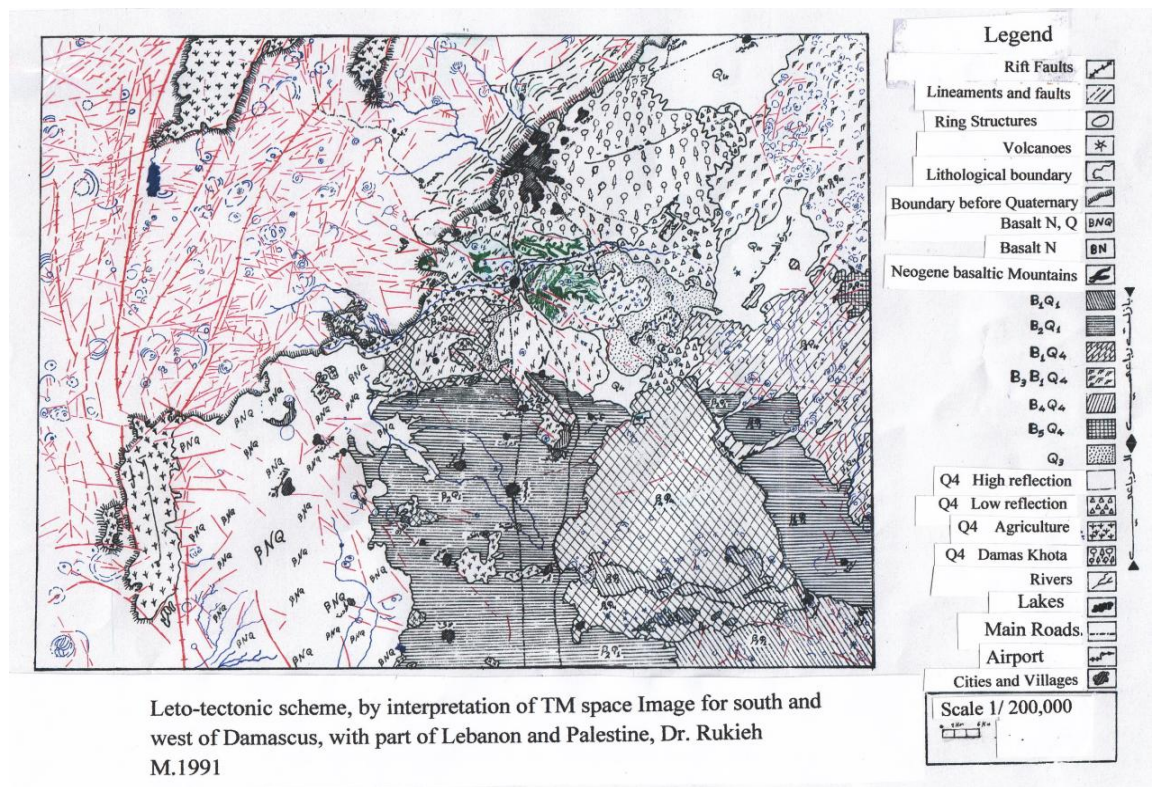


Figure.3 Leto- Tectonic scheme for south and west of Damascus, with part of Lebanese and Palestinian territories, by interpretation of land sat TM image (Rukieh M.1991)



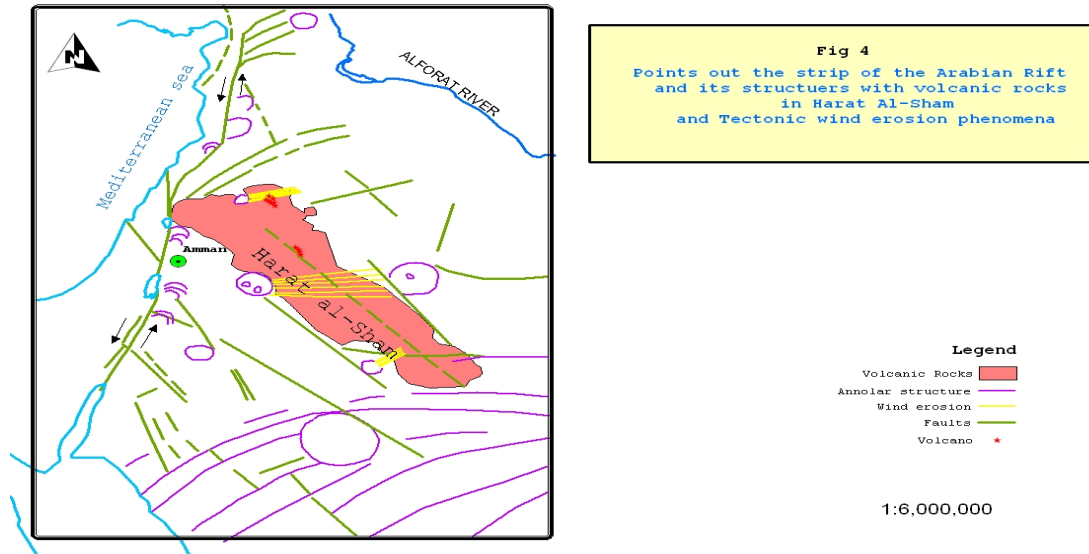


Figure. 4 shows throughout the Arabic Rift zone from the Gulf of Aqaba in the south to the Turkish territory in the north, and Harrat al-Sham volcanic area, with tectonic wind erosion Phenomena, by interpretation of TM space Image (Rukieh M. 2004)

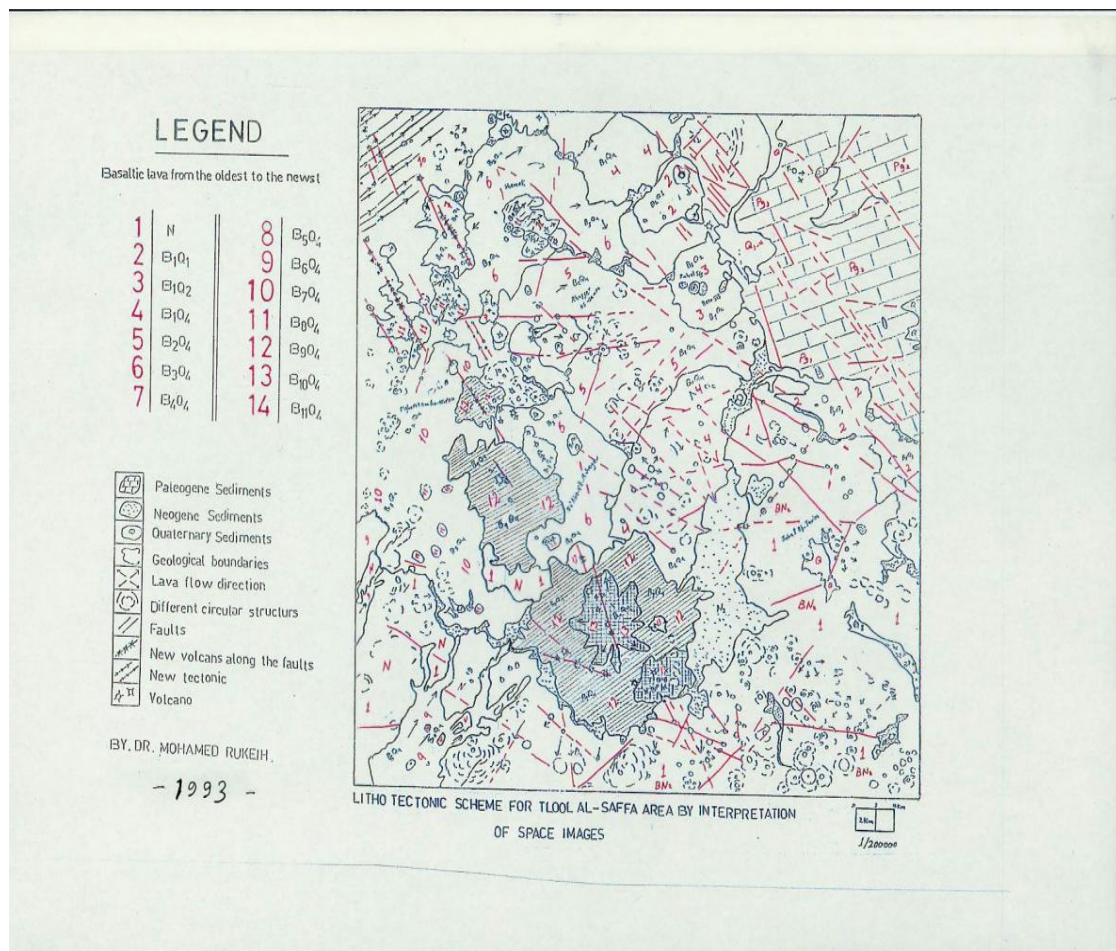


Figure. 5 Leto- tectonic scheme for Volcanic Tlool Al- Safa area, by interpretation of MKF6 space Image, 1/200000 scale (Rukieh M.1993)



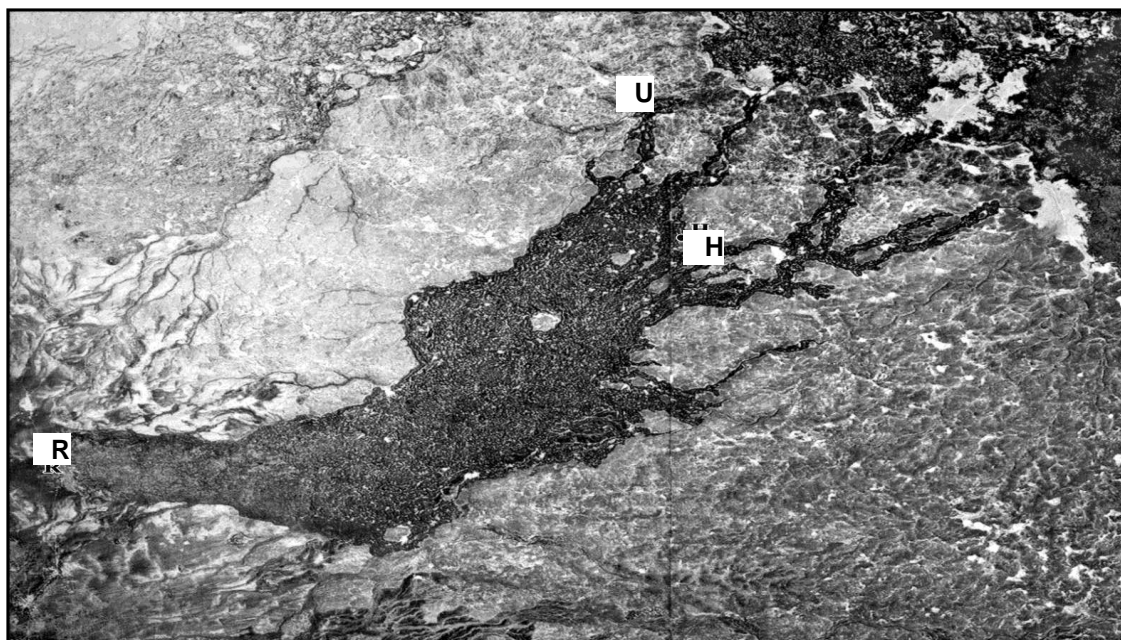


Figure. 6. Space ERTS imagery of the Kra lava flow region in the southern Syria (Space Image Atlas of Syria, 1996). U – Khirbet El-Umbashi, H – Hebariye, R – Rdetmet Ash-Shukhur.

(Trifanov et. Al., 2007)



Figure. 7 Bones soldered into the Kra basalts in Khirbet El-Umbashi. Photos by D.M. Bachmanov

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