

## **New Data about the Tectonic Structure of the Arabian Plate by Interpretation of Space images**

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#### ***Introduction:***

This research aims to study the tectonics of the Arabian plate using space images data of distinguished characteristics, especially the multispectral TM of resolution 30m, where we can take benefit from the important specifications of these images such as:

#### 1- Synoptic Coverage:

These images enable us to see, in the same time, the Arabian Plate completely, and study its general tectonic characteristics.

2- The multi-spectral characteristics of these digital images give more information about the specifications of the plate.

3- The possibility of processing these images by the different digital processing methods through modern software as IRDAS and merging of different channels.

Through this research we prepared several tectonic schemes (13/1 million) and less, and we get important data about the structure of the Arabian Plate, the most important of them are:

- Identifying three annular structures of different dimensions (big and very big).

- Identifying five tectonic systems which extend for hundreds of kilometers towards western north, starting from Alaqaba gulf in the western south till the Arabian gulf in the eastern north. As well as identifying another fault systems.
- Identifying the general characteristics of the Arabic Rift System, which forms the western borders of the Arabian Plate
- Identifying the erupted volcanic rocks inside the plate, especially in the area of Harrat Asham, Jordan, Wadi Sarhan, Jadah and Almedina in Saudi Arabia and the wind phenomena in it.

### ***The Location of the Arabian Plate:***

The Arabian Plate forms the northern part of the African plate where it was separated from it during the Miocene by the Red Sea rift. The southern part named Arabian Peninsula where three seas surround it from three directions: the Red sea from the western south, Addan gulf and Arab sea from the south and the eastern south, and the Arabian Gulf from the eastern north. It is bordered by a bend belt and the faults of AlAnadoul, Zagharous and Tebles (fig.1). In its western south parts the Precambrian Arabian shield rocks are revealed, and covered by recent sedimentary rocks to north and eastern north from Paleozoic till Quaternary. The rocks thickness exceeds 10kms in the north of Iraq and Syria.

### ***The General Tectonic Characteristics of the Arabian Plate:***

The following main annular and linear structures have been identified through the interpretation of the space images (13/1 million – 1/5 million scales) (fig.2)

## **1- Annular structures:**

The annular structures represent the geological shapes and phenomena which have central symmetry, and of ring, circular or oval shapes and they are different, in their structures, from other surrounding phenomena. Also, these structures differ in their dimensions, origin and the characteristics of their identification on earth or space images. They form one of the most important structural elements in the earth crust. Their dimensions range from many meters till hundred or thousands kms.

Our study has shown the following main annular structures:

### **The first one:** (no.1 in fig.2)

It covers the most important part of the western plate on the eastern south side of the Red Sea, its northern borders reach Alaqaba gulf. It is composed of many concentric rings which take an oval-oblate shape; its radius reaches more than 900km. It seems that the rift of the Red sea has divided it into two parts (right and left); the right one appears in the Arabian plate, it is very big and forms one of the most known regional structures on the glob.

We can notice inside this structure many smaller structures such as the one which exists to the east of Alaqaba gulf (no.1-B), where its diameter reaches about 150km. The rocks of the Arabian shield form the central core of this structure, these rocks reveal in the east of the Red sea and appear in the space images as a bow, its depression reaches about 700km in its middle part, then it gradually confined towards north for less than 100km in Jordan, and less than 200km in the south of Yemen, after that it disappears under the recent sediments (Abed 2000). The rocks of the Arabian shield are composed of two main groups (Ashanti 1993): the first group is composed of igneous rocks, which can found as intrusive batholith and dyks, they are composed of basic and ultrabasic rocks as Gabbro, Pyredotite, Dunite, or middle as Diorite or acidic as Granite which exposed to metaphorphism and deformation. The second group is composed of metamorphic rocks as schist, Gneiss, slate, and others which were resulted from the transformation of sedimentary pyroclastics layered rocks.

The researchers agree that the age of the Arabian Nubian shield rocks range between 1000-450 million years (Bentror 1985, Mc Court 1990, Ashanti 1993) in spite of the fact that there are some signs refer that their age may reach 1600 million year.

## **The second structure (no.2, fig.2):**

It is located on the northern borders of the first structure; it is concentric and composed of core and outer ring and covers the areas of west of Iraq, south of Syria, east of Jordan and north of Saudi Arabia. It conforms , geologically, part of Arrotbah uplift, its radius reaches 350km, and the radius of its core is about 70km. The volcanic eruptions have deformed its western south side in the south of Syria, north of Jordan.

Inside this structure, we have noticed several smaller oval annular structures, it is complex tectonically and affected by a big number of faults, of north, western north or eastern north direction, for example Akfan and Alolab faults, they are of right lateral displacement (Rukieh and others 2002) which extend on areas of more than 150km. in addition to several faults and fissures which take the mentioned directions and they form small depressions.. Arrotba uplift is considered as one of the most important tectonic phenomena in the north of Arabian Plate, it was originated during the Paleozoic and continues till the following ones, where it formed positive high starting from the Carboniferous, the most occurrences of the early Paleozoic are concentrated in this uplift (Sawaf etal.1993).

## **The third Structure: (no.3-fig.2):**

It is located on the western north side of the Arabian gulf inside Saudi Arabia and Kuwait lands, it is distinguished by reflective tone differ of what surround it, its radius reaches about 150km, it is crossed by Euphrates regional fault, from the east, which extends towards north and western north, its length reaches more than 1500km.

This structure is crossed with the first annular structure by a lineament of eastern north direction of length more than 800km where it reaches Kuwait lands.

## ***2- Fault Structures:***

The Arabian plate is distinguished by the existence of the Arabian rift zone on its western borders, in addition to several fault systems of western north direction, where they extend for several hundred kilometers. There are also some regional faults which take north direction, or they take the eastern north direction.

## ***The Arabian Rift System:***

The Arabian depression forms the western borders of the Arabian plate, it extends from the Red sea in the south, and then direct towards north passing through Alaqaba gulf then Wadi Araba, Dead sea, Jordan hollow, Teberia lake, and Lebanese Boukaa where it takes east north direction, then it continues in the Syrian lands towards north through Alboukea, Mosyaf and alghab depression till the south of Turkey on an extension more than 1100km.

The Arabian Rift zone forms the northern part of the African –Arabian Rift which is considered as one of the largest rifts on the globe, where it extends towards north for 6500km (Belassov 1976) from Zambezi river in the west, passing through the east of Africa then to the Arabic rift in north.

Our study (Rukieh 1991, 1993, 1994, 1997, 2001) and some other studies (Trifanov 1983, 1986, Ponikarov 1966, 1969, Barazangi. M, Seper.D, Chaimov.T, Sawaf, Lirak.R, Best.T. 1993, 1997) have shown the following:

- The rift shows left lateral displacement movement, it reaches more than 105km in the area of the Dead sea, and (12-15km) in the west north of Syria, this movement conforms with the Arabian plate one towards north, after its separation from the African plate starting from Neogene till now of average 0.5-1 cm yearly. This is in addition to the vertical movement which reaches several thousands meters in Jordan valley, Teberia and Aghab.
- The rift is distinguished by its turn towards eastern north starting from the north of Teberia passing through Lebanese lands till Syrian Alboukea depression where it conforms to the fold and the faults of Palmyrides. Group of faults branch from it and take eastern north direction where they form inclined letter V, their continuity in this direction forms the Palmyrides faults.

- The rift forms- starting from AlBoukeaaa in Syria- two main faults, not one fault as it was believed before (Rukieh 1991-1994). These two faults continue towards north where they form Alghab depression, then they continue towards north in the Turkish lands.
- The rift is distinguished by the formation of several plunges along its course as the Dead sea, Jordan hollow, Teberias lake, Alhawla depression, AlBoukeaa, Alghab, Al'Omek and others, resulting from depression the central part of the uplift and the articulation of these faults according to the pull-apart phenomena.
- The space interpretation showed (Rukieh 1991, 1998, 2001, 2004) that there are several annular structures and arch shapes along the rift course directed to the south. Some of them are crossed by the rift faults, and the most of them are located on the eastern side of the rift it has been thought that the arch shapes are formed as a result of the rift movement toward north (fig3)
- The rift is characterized by the basalt volcanic activity which accompanied its development, especially during Meocen, Beleocene and Quaternary, whether in Jordan, Syria, and Saudi Arabia, most of them are located on the eastern side of the rift.

There are some other faults parallel and near the rift as that in the east of Alaqaba gulf, in addition to two other faults parallel to the

rift inside the second annular structure, they extend for more than 200km (fig. 2-3 ) in the far west south side of the Arabian Plate there are Khalifat Hamad fault of north direction on an extension of several hundred kilometers. The studies refer that this fault is related to Precambrian where mass of serpentine ultra basic or basic or acid rocks related to Precambrian also, and they are mostly cracked, broken and mylonite with the formation of melang, (Garmanov A. X 1987).

### ***The faults system of western north direction:***

It has been shown through the interpretation (especially on schemes 1/13 million, 1/10million till 1/5million) that there are fault systems take the direction of north west/ south east composed of five main zones along the Arabian plate and they are parallel to the regional fold belt in the Iranian-Iraqi lands to the eastern north of the Arabian gulf and their direction is from east to west.

#### ***1- Euphrates fault zone:***

It expands from AlRobee Alkhali area in the south, on the western side of the Arabian gulf, and it continues towards western north till reaching Syria through Euphrates depression, on an extension of more than 2000km. Euphrates faults in Syria which expand for 640km from the eastern Euphrates side which form rift basin inside the continent, and it was formed through upper Cretaceous and its landmarks disappeared by the Cenozoic occurrences Ponkapov etal.1969, Barazangi 1993, Sawaf 1993, Litak 1997.

#### ***2- AlDahnaa fault zone:***

it passes near the western side of the second annular structure on the outer sides of the first annular structure and it continues on an extension about 1000km.

**3-The faults zone in volcanic rocks:** in Harrat Asham, Jordan, and Wadi Sarhan in Saudi Arabia and disappear under the sediment rocks in the middle. Then they appear partially in the eastern side of the Arabian Shield. They are old faults reactivate through Miocene, Paleocene and Quaternary, they contribute in the formation of big volcanic rocks in the north of the Arabian Plate, and these faults expand for more than 1000km.

**4- The displacement Najd faults:**

They appear clearly inside the Nubian Arabian Shield rocks which are related to Precambrian and expand for more than 1000km. Several secondary faults are accompanied to them.

**5- Group of faults passing to the east of Alaqaba gulf** they reach the eastern south sides of the Dead Sea in Jordan and they expand for more than 500km.

In addition to the mentioned faults zones, there are two faults zones in the eastern south side of the Arabian Plate within Oman and Emirates lands and they take arch shape. There are also some faults with left lateral displacement.

**The faults of eastern north direction:**

The Arabian plate is distinguished by the existence of big fault inside the Saudi Arabia lands (Waddi Arram and Wadi Albaten fault) it takes the direction of eastern north and expand for more than 800km,

400km from it is inside the Arabian shield of 45° angle then it turns towards north of 60° angle and reach Shat AlArab area. Its trace appears clearly inside the sediment rocks of different ages, this refers to its late activity zone and perhaps it is active till now. Also there are faults surround the Palmyra fold belt from south and north, they are big of deep occurrence. The southern faults seem clearer than the northern ones which covered by recent sediments and they expand towards eastern north for several hundred kilometers. They deviated from the rift to the north of Teberias lake. The Palmyra fold belt form Aolacogin depression which has been formed in the beginning of the Mesozoic, then it was exposed to folding and faulting at the end of the Mesozoic and the beginning of the Cenozoic till its end.

There are several faults of the eastern north direction or near to the transverse ones on the eastern south sides of the big annular structure inside Saudi Arabia lands and they expand from ten to hundred kilometers which lead to complicate the plate structure.

### ***The Volcanic Rocks:***

The Arabian plate is characterized by the spread of volcanic rocks in several sites as the areas expand to the east and south of Maka and Medina on an extension about 600km, and in the far western south of the plate in Adan and Taz in Yemen. The important volcanic rocks spread in the western north side –in several areas- in the Syrian areas, especially in the south of Syria and Jordan, and north of Saudi Arabia where this area is considered as one of the big volcanic areas

in the world, it expands towards western north and eastern south on 500km distance which covered more than 45000 km (Volcanic Harrat Asham area) it starts from the south of Damascus and it covers Horan , Jabal AlArab and Telol Alsafa in Syria, then it passes Jordan between Arrowshed, AlAzrak and Erbed of length 180km and then it continues in Saudi Arabia on an extension of 210km on the eastern side of Wadi Sarhan these rocks related to the mentioned faults in the volcanic area.

The ages of these rocks are related to Neogene (Miocene, Pliocene) and Quaternary (with its different stages), the eruptions continue for the past several southands years in the south of Syria. Several cones and craters appear inside this volcanic area, some of them are in the south of Syria (more than 400 volcanoes), alkaline basalt rocks prevail on it; its thickness reaches 1000m in Syria.

### ***Tectonic- wind erosion phenomena in the Arabian Plate:***

Our study (Rukieh 1993, 1998, 2002) has shown that the Arabian plate in the volcanic Harrat Asham area is characterized by two similar and important phenomena in Syria and Jordan; they are wind erosion phenomena of tectonic base: the first one is in Syria, it is located to the eastern south of Damascus in Tal Dakwa area, the second is located inside the Jordanian lands in Kae AlAzrak area in the east south of Oman where we can notice wind occurrence aspects of straight lines shape inside the volcanic rocks which expand from west towards east for tens of kilometers.

The analysis of the tectonic situation and the field checks which we had been carried out for the phenomena in Syria refer to the possibility that these phenomena are of tectonic base, and this is reflected in form the phenomena of erosion and wind occurrence, especially after noticing transverse faults expand from the rift in both Syria and Jordan , in the areas of these phenomena.

## **Results:**

- 1- identifying three big and very big regional annular structures in the Arabian plate zone, their dimensions range between (300-1800km), one of them is in the center of the plate, its core forms the Nubian Arabian Shield rocks, and the second is in the western north of it, the third is in the eastern side to the west of the Arabain gulf.
- 2- The Arabian rift zone forms the western borders of the plate which expands from Alaqaba gulf in the south till Turkey in the north for 1100km, the plate moves towards north of an average 0.5-1cm yearly in conform with it.
- 3- The Arabian Plate is characterized by the existence of five main fault systems expand towards north west/ south east for hundreds and thousands kilometers starting from the Arabian gulf in the east till Alaqaba gulf in the west. As well as the plate is distinguished by the spread of group of regional faults which take the direction of east north east / south west as the Palmyra series faults in Syria and Wadi Arram - Wadi Albaten faults in

Saudi Arabia, also there are some fault systems of north or transverse directions.

- 4- Alkaline basalt volcanic rocks spread in some areas of the Arabian plate especially in Adan and Taz in Yemen, the areas of Arabian shield in Saudi Arabia, the volcanic areas in Harrat Asham in north of Saudi, Jordan and south of Syria.
- 5- Our study has shown the existence of two similar important phenomena represented by erosion and wind occurrence of tectonic base in Syria and Jordan inside the spread volcanic rocks as straight lines on an extension of tens kilometers towards west east.

## **References:**

- 1- Abed Alkader Abed, the Geology, Environment and water of Jordan, Amman , Jordan, PP. 571, 2000.
- 2- A.X Kagarmenov, Geology of Africa and Arabia, Nedra-Lenengrad, pp.150, 1987.
- 3- Barazangi M., Seber D. , Chaimov T., Best J., Litak R., Alsaad D., Sawaf T. 1993, Tectonic Evolution of the Northern Arabian Plate in Western Syria, Kluwer Academic Publishers in Netherlands, pp. 117-140.
- 4- Litak R. k., Barazangi M., Beauchamp W., Seber D., Brew G., Sawaf T., Al Youssef W. 1997, Mesozoic – Cenozoic Evolution of the Interplate Euphrates Fault System, Syria

- Implications for Regional Tectonics Journal of the Geological Society, London, Vol. 154, pp. 653-666.
- 5- Ponikapov, V.P. et al. 1969, Geology of Syria and its Mineral Resources (in Russian) , Leningrad USSR, pp.215.
  - 6- Rukieh M. 1991, Report on the Tectonic of the Western and Southern Part of Syria and Lebanon by Interpretation of Space Images, GORS- Damascus, pp. 33.
  - 7- Rukieh M. , New Data about Volcanic Rocks in the Southern Area of Syria by Space Images Interpretation, GORS- Damascus, 1993, paper of the 31 International Conference of Geology/ Brazil- Rio de Janeiro 2000.
  - 8- Rukieh M., Study about the rift Structure in the Northern Part of the Arabian Plate by Using Space Imagery Interpretation, published in the proceedings of the 5<sup>th</sup> Jordanian Geological Conference on the Geology of Arab Homeland, Amman- Jordan, pp. 436-456.
  - 9- Rukieh M., Volcanic Rocks in the Southern Part of Syria and their Role in the Formation of Soils, presented in the Geological Science Week organized by the Syrian Geographical Society, Damascus, 1998.
  - 10- Rukieh M., New Data about Volcanic Rocks in the South of Syria and North of Jordan by Space Images Interpretation, presented in the 6<sup>th</sup> Jordanian Conference on Geology, Amman.

- 11- Rukieh M., Akafri A.A., Khalaf A.A., New Data about the Tectonic Activity in Wadi Almyah in Syria by Space Images Interpretations, presente in the 6<sup>th</sup> International Cinferece on the Geology of Arab World, Cairo University, 2002.
- 12- Rukieh M., Annular Sturctures of the Arabian Plate by Interpretation of Multispectral Space Images and Its Economic Importance, presented in the 8<sup>th</sup> Jordanian Conference in Geology, Amman, 2004.