IMPORTANCE OF SPACE DATA TO STUDY EARTHQUAKES RISK IN ARABIAN RIFT ZONE

Prof. .Mohamad Rukieh
General Director of AAFAQ Establishment, Syria
Former General Director of General Organization of remote Sensing in Syria (GORS)
Damascus , Mazzeh, P.O.Box 9916, rukiehm@gmail.com

KEY WORDS: space Images, Faults, Tectonic Maps

ABSTRACT: The continued research seismic dangerous regions and active tectonic zones, pointed out, the large benefit and wide use of space images, after its processing with help other data in solving many problems related to the studies and predicting of earthquakes.
For that we used space data to study the tectonic position of Arabic Rift zone, linking between lineaments and Epicenters of Earthquakes , and establish Active Faults map of Syria
1-By interpretation of multi scales and bands space images, we prepared multi tectonic schemes, scale at 1/4000000, 1/500000 till 1/50000 for Arabian rift zone which extend from the red sea rift in the South to the North, through the gulf Aqaba, the dead sea, Tiberia lake and Lebanese Boukaa, consequently though the AlBokeaa and of Alghab rift in Syria, as for as Turkish Boundary along 1100 km with branch of the Palmerids fold belt in Syria. The rift faults are considered left lateral displacement about 0,5 -1cm by year.
2-Our research focused Also on the relationship between Space data and epicenters of Earthquakes. As it had become evident that most epicenters are found along the lineaments identified on space images, or along their Zones or blocks which they bordered , or in the intersection points of different tectonic displacements.
The tectonic scheme for the Arabic rift system from space images and the epicenters of Earthquakes which had happened between 1910- 1993, 1995-2005 pointed out to the thirteen relationship between faults and lineaments determined by interpretation of space images and Earthquakes.
3-We prepared tectonic active faults Map, formed or continued to develop during the Neogene and quaternary in Syria and adjacent territory .
The active faults (like Sirghaya Hasbaya, Rashaya, Yammoneh, Damascus fault , alolab, al Ghab fault, Palmerids faults ..etc.)are the main sources of seismic, volcanic and other geological hazards.
IN RESULTS: The active Faults concentrated with three main tectonic units :A;- Syrian Lebanese rift zone or associated with it Territory ,B- Palmerids fold belt, C- and the collegian zone among the Arabian plate in the North Syrian boundary with the Turkish and Anatolian belt in the South of Turkey, which forms important zones of frequent Earthquakes.
IN CONCLUSION: By using the multi scale, multi spectral and kinds of space images and its interpretations and analysis with data of GNESS enable in long and short time investigation monitoring, assessment, and predicting of earthquakes. That lead to put and developed integrated space monitoring system for seismic dangerous regions.

1-INTRUDUTION

The Arabic rift start from red sea in the south, it moves to the north through the Gulf of Agaba, the Dead sea, Tabaraya lake and Lebanese Bekaa, consequently through the rift of Alghab in Syria, as far as Turkish bonders and Iskenderun regions (fig. 1) along about 1100 km with branch of the Palmerids fold belt in Syria, the rift faults are considered left lateral displacement with vertical movement in different sites.
This Rift formed northern part of the Arab-African Great Rift, who is considered one of the largest Rifts on the globe, which extends from the Zambezi River in the south through eastern Africa, Arabic machreq along the 6,500 km (Belassof 1976).

2- STRUCTURAL CHARACTERISTICS OF THE RIFT

The tectonics of this region in different Countries (Egypt - Saudi Arabia - Jordan - Lebanon - Palestine - Syria - Turkey), Has studied a very large number of researchers from different nationalities from different countries of the

world since the beginning of the twentieth century's, it reaches more than two hundred researcher. It has been shown through these studies and researches that I've made in the areas of Rift Valley and the Arabian plate using remote sensing techniques ,and prepared many schemes of different scales(at 1/13000000 till 1/50000) (Rukieh 1991, 1994, 1997, 1998, 2000, 2001, -2004, 2005, 2006, 2009, 2016, 2020) fig.1, that Rift is characterized by a set of structural characteristics including:

-A -The Rift characterized by side left lateral movement compatible with the movement of the Arabian plate towards the north up in the Dead Sea area to 105 km (Quennel 1959, freund et ale 1968 - 1970, Garfunkel 1981, Walley 1988) of which about 65 km in the Miocene and about 35 to 40 km has During the Pliocene – quaternary ,and thus the rift movement here began to develop since about 25 million years (Garfunkel 2001, Hurwitz 2002, But the basic problem here is the presence of a significant difference in the amount of lateral displacement between the Rift in the Dead Sea area and in northwest Syria in the Alghab area where a total of the lateral side of the displacement in western Syria (12 to 20 km) (Rukieh, Habib 1993, 2004 Trifanov 1985, Gorovich and others, 2005).fig.2, Appear here following question: Where is the continuity of the Rift Miocene? Some of Researches linked it with the movement of ophiolitic rocks in the north of Syria (Frand 1970) and depending on this Garfunkel and others in(2001) estimated that most of the kinetic power continuing along faults north of the Yamuna and even Alghab and southern Turkey. Chaimov indicates ((Chaimov at all 1990-1992) through the analysis of the geological map of Syria to the implications of seismic reflectance and indicates that the southern Palmyride Folding belt takes about 20 km of this movement and this sucked part of the driving force , the amount remaining 35-40 km by Rukieh, Trifanov and others 2005 focused on the length of the Rums Fault during the began and Late Miocene, and adds Rukieh (1991 – 1994) the impact of the collision between the northern end of the Arabian plate and Eurasian plate at ease and impede the movement as we head north, and I think (Rukieh 2008) that all these factors have contributed in blur of this difference of movement between the southern part of the Rift Valley and the northern part of it. The annual amount of the movement in the area of the Gulf of Aqaba and the Red Sea reach to about 1-2 cm, while not exceeding 5- 6 mm in northwest of Syria.

-B– The Rift featuring have also the vertical movement to several thousands of meters and notes are evident in the Jordan Valley, Tabaraya lake and in the Alghab in Syria, the total movements vertical up to several thousands of meters in the Jordan Valley, and the eastern side of the Rift is higher than the west. The vertical displacement in the Alghab area rising west Wing (1400 m) more than the east (600 m) (Ponikarov and others, 1969).

-C - The Rift featuring that from the Hula Valley and over Lebanese territory even Syrian Bokayaah Depression, turns towards the north-east is compatible with folds and faults of Anti Lebanon and Palmyride,(fig.1)

-D- The Rift form from the Syrian Bokayaah Depression two main faults as showed our studies (Rukieh 1991) (see Figure 1) is not only one fault as previously thought, .these faults continue to north and were taking the spacious ranging from North Masyaf forming Alghab Depression where the east fault of the eastern boundary of Depression ,path to the east of the Afrin city and continues north towards the Turkish land, but the west fault limit the western boundary of depression heading north towards depth Lake and continues in Turkish territory and is associated with Anatolia faults. Each of two mentioned faults Ramifications to a group of faults that branch turn to other small faults and take different directions, giving it a fan form and this distinguishes usually ends of Rift faults. The small faults form sometimes small local Depression as Harem and Idlib and others as show tectonic scheme scale 1/500000 prepared by interpretation of satellite images (Figure 21). In addition was determined many of the faults associated with Rift, were not previously know. Long some of them reach tens of kilometers, and showed the complex tectonic situation of the northern part of the Rift starting from the Tabaraya Lake.

-E - The Rift formed along his track many Depressions in the form of Grabn like Dead sea, the Jordan Valley, Tabaraya Lake, Hula dried Lake, low Bokayaa and depressions of the Alghab , Roge and Al Amok,(Fig.1,2) as well as some small Wahdat, which we have identified by interpretation of space images and field truth such as Yamuna Wahda with length 1.8 km. Alwahdat between Bokayaa and Masyaf ,Wahdat Harem and Idlib and other (Rukieh, 1991, Chorowicz and others 2005), a result of falling for the advancement of the central section and the articulation of faults in the Depressions according to pull apart phenomenon. These Depressions (Wahdat) filled with Neogene - Quaternary sedimentary rocks and some of them are filled with volcanic rocks as near of Ashek Omar South of Masyaf. , Estimated the annual movement of these Alwahdat to 3.3 mm (Chorowicz and others 2005). Our study

(Chorowicz, Rukieh and others 2005) show that the dimensions and length of these Depressions depends mainly on the time and motion, the smaller one is 1.1 km old 0.33 million years ago, and Yamuna ones along the 1.8 km- the old 0.55 million years, while Bokayaa its old 4.25-million-year with length of 14 km. And it can be said that the northern part of the Rift from Hula low began from six million years ago.

F - interpretation of space data showed (Rukieh ,1991.1994, 1997, 2001.2004, 2006) that there is a path of the Rift many ring structures and arc shapes towards to the south and harvested by Rift faults,(fig.1) including Idlib and Jabil Alhelo, diameters ranging from several hundred Meters and up to 100 km, as in the structure of the advancement of Coastal ridge on the western edge of the Rift of northwest Syria,(fig.3) and structure of southeast of Tabaraya Lake and on the edge of the Dead Sea, and structures of Safita in west of the Rift , Tripoli and Qaraoun and many others. (fig.1)

G –The Rift characterized efficiency volcanic basalt, which was accompanied by intense development, especially during the Neogene and Quaternary, the Basalt is continental, and resides mostly on the eastern edge of the Rift. (fig.2)

H - The impulsive, metamorphic and volcanic rocks known as the Arabian Shield belonging to the pre-Cambrian unfold in the southern side of the Rift on the East and West of Gulf Aqaba and on the eastern side of the Wadi Araba along the 170 km. these rocks to the north covered by more recent sediments ranging from Paleozoic including the brown and white sandy Cambrian rocks even Quaternary rocks

3-ACTIVE FAULTS IN SYRIA AND RIFT ZONE,

Active faults in Rift zone , Syria and adjacent territories are the main sources of seismic, volcanic and other geological hazards .Fig. 4, demonstrates major active and weakly active faults in Syria and adjacent territories. They are:

A -The Levant fault zone (Arabic Rift), The Levant fault zone corresponds completely to the DST in its southern part and forms the main Yammoneh and El Ghab segments of the DST in the northern part (Fig. 2). The segments were renewed during the historical and recent (post-1900) earthquakes (Ambraseys & Jackson, 1998). The El Ghab segment is 240 km long from the Bokayaah basin and strikes generally to the N–S. Like the southern (Dead Sea–Jordan) segments of the Levant zone.

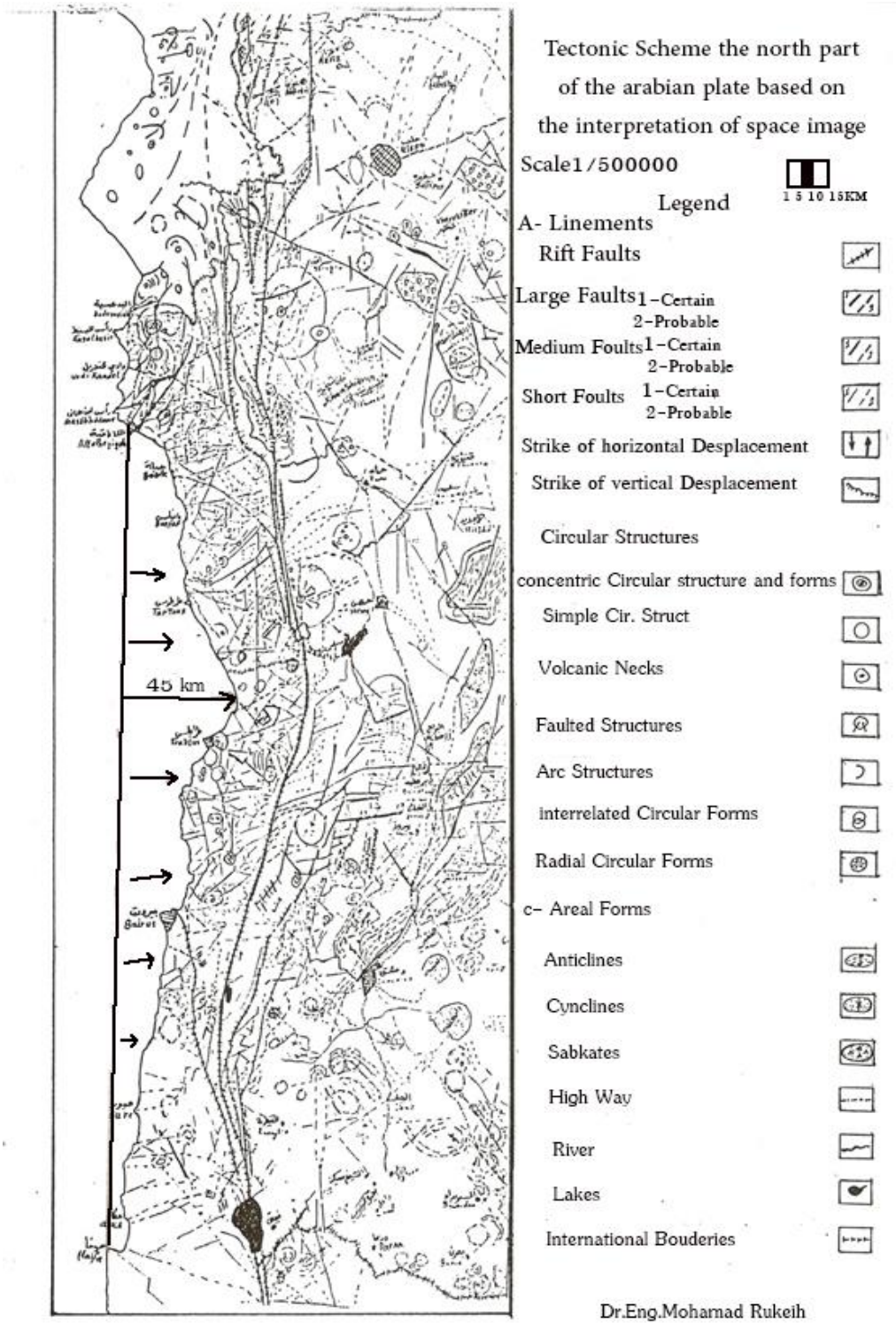
B- Rashaya and Serghaya faults, The, Rashaya and Serghaya faults branch out the northern side of the Hula basin of the Levant zone to the NE.. They are certainly active. The Rashaya fault extend 40 km. To the NE, The Serghaya fault is marked as the 120 km long linear topographic feature between village of Bqaassem and town of Baalbek in the southeastern side of the Bekkaa valley. According to space imagery interpretation, the fault line can continue 20 km more, the left-lateral slip rate on the fault during last 6,000 years as 1.4 mm/y, Gomez et al. (2001, 2003)

-C ST. SIMEON FAULT, The 80-km long St. Simeon Fault branches out the eastern side of the El Ghab basin to the NE**.** it is subdivided into two segments. The southern segment is 33 km long and runs from the El Ghab Basin (the village of Armanaz) to the young depression of Ad Dana. The northern segment is 47 km long and stretches from the Ad Dana depression to the village of Qatma;.. The Ad Dana depression separates the segments one from another and has geometry similar to a pull-apart basin. The greatest dimensions of the depression are 14 km along the longer axis, and 4 km along the shorter one.

D- THE ROUM FAULT AND ITS NORTHERN OFFSHORE CONTINUATION, this fault was probably the most active in the Miocene. But their weaker activity has continued up to now.

E- **THE SOUTHWESTERN TERMINATION OF THE EAST ANATOLIAN FAULT ZONE**, Several active faults are known in the southwestern termination of the EAFZ. They are (from the W to the E): the Yakapinar-Görsun fault onshore of Iskenderun Gulf, the Amanos fault in the northwestern sides of the Amok and Karasu basins and the East Hatay fault eastward. All they are sinistral faults with essential reverse component (Lyberis et al., 1992; Adiyaman & Chorowicz, 2002). The Pliocene–Quaternary or Quaternary left-lateral slip rates on these faults are ~2

mm/a, 1–1.7 mm/a, and 2.5–4.3 mm/a, correspondingly (Westaway, 2004; Yürür & Chorowicz, 1998; Yurtmen et al., 2002).



(Figure 1) tectonic scheme of the northern part of the Arab Rift by interpretation of satellite images (Rukieh, 1991)

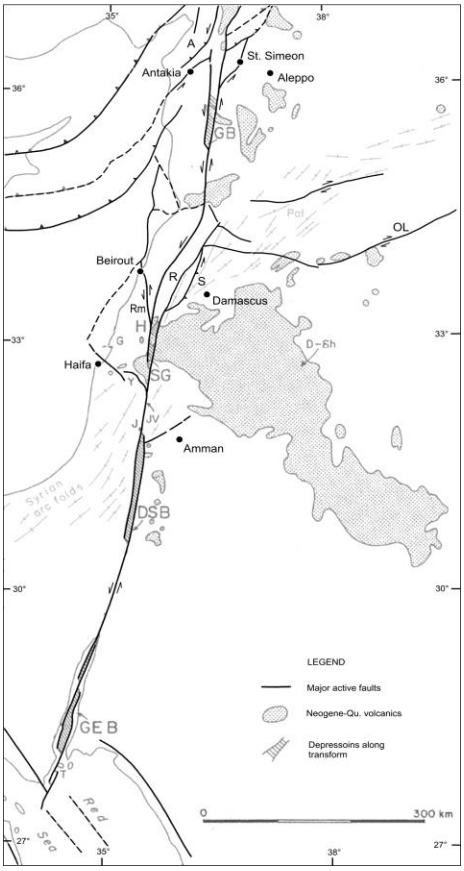


Fig.2, The Arabic Rift, with depression and volcanic rocks (Garfunkel, Ben-Abraham, 2001; Rukieh et al., 2005; Trifanov et.al.2007

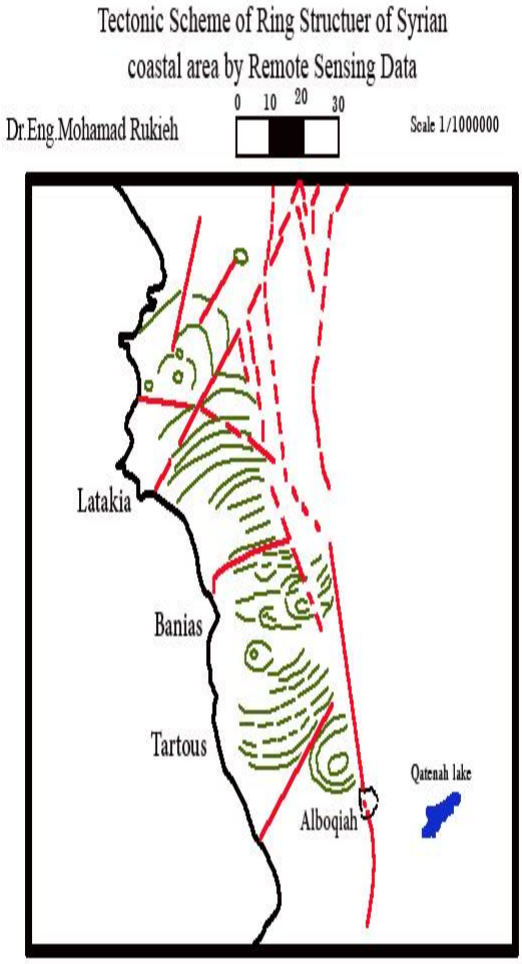


fig. 3, Ring structure for Syrian Coastal ridge by interpretation of Space TM images (Rukieh M.2001,2006)

F- DAMASCUS FAULT It belongs to the Palmyride thrust-folded belt. The fault strikes to SW–NE and bounds a chain of the northwestern Palmyride folds from the SE. All the anticlines are asymmetric: their southeastern limb is steeper than the northwestern one and is often overturned up to 70–90°. So, the thrust or reverse component of motion on the Damascus fault is evident.

G- **LATAKIA FAULT ZONE**, It is the neotectonic feature separating the Bassit ophiolitic block and the Nahr El Kabir sedimentary basin .Thrusting and deformation of the ophiolites had taken place in the Maastrichtian, before the Latakia fault zone was originated. The complex structure of the zone was formed in the Neogene–Quaternary.

H-**AAFRIN FAULT** ,This Fault continued the Latakia fault zone into the eastern side of the El Ghab basin in the Pliocene,. The southeastern side of the Aafrin fault is subsided and has been filled by the Quaternary sediments. offset of the Late Quaternary colluviums to 0.4 m .The Quaternary offset ranges from 0.3 m.to 0,4 m

I- **OLAB FAULT** , The W–E-trending Olab fault is linked in the W with the northeastern termination of the Serghaya fault zone (Fig. 4). It is represented by several en echelon segments that continue about 400 km. to the E up to the Euphrates River valley.fig.4.The fault offsets the Palmyride folds and major tributaries of the Euphrates dextrally to 2.5–3 km. The Middle Pleistocene basalts are offset much less. It shows that the fault was active up to the Middle Pleistocene and gives a possibility to estimate the slip rate as ~1.2–1.5 mm/a

J -**EIN QITA FAULT ,** The Ein Qita fault, also qualified as weakly active, strikes to the WSW from the southern margin of the El Ghab pull apart basin, intersects the Jebel Alaweia ridge and reaches the Mediterranean coast northward town of Banias, Total length of the fault together with its offshore continuation reaches 80 km. The southern side is relatively uplifted everywhere.

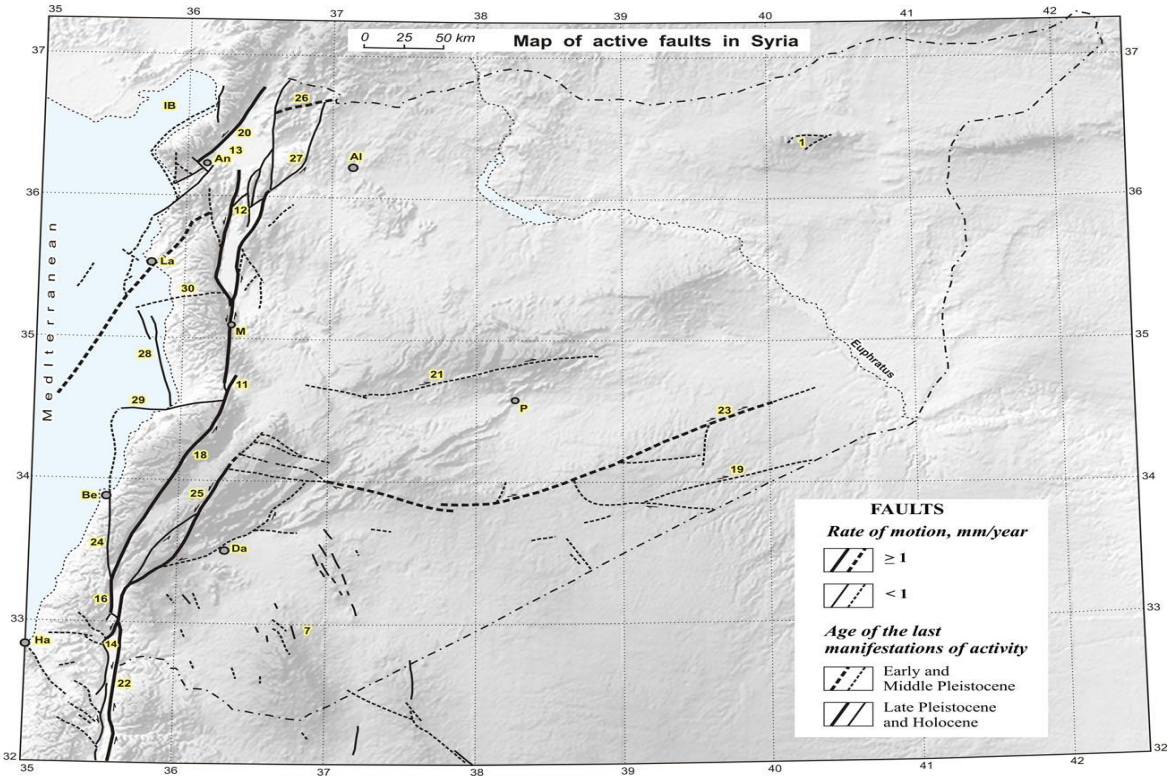


Fig. 4. Active faults in Rift Zone- Syria and adjacent territories. Basins: (9) Ad Daw, (10) Bekkaa Valley, (11) Bokayaah, (12) El Ghab, (13) Amok, (14) Galilean Lake, (15) Homs, (16) Hula, (17) Nahr El-Kabir, (18) Yammuneh. Faults: (19) Akfan, (20) Amanos, (21) Jhar, (22) Jordan River, (23) Olab, (24) Roum, (25) Serghaya, (26) Aafrin, (27) St. Simeon, (28) Tartus, (29) Tripoli, (30) Ein Qita. Al, Aleppo; An, Antakia; Be, Beirut; Da, Damascus; Ha, Haifa; IB, Iskenderun Bay; La, city of Latakia; M, town of Masyaf; P, town of Palmyra

4- WHY THE RIFT ZONE VEERS TOWARDS THE NORTHEAST IN THE LEBANESE TERRITORY?

All the studies pointed to a deviation of the Rift in Lebanese territory towards the north-east. Chorowicz and others 2005, pointed out, that the direction of unconformity Rift in Aqaba and the Jordan Valley while N5E but at Yamuna fault in Lebanese territory N35E, while in the Alghab area in northern Syria, takes northern direction from Bokayaah, This refers to the deviation of the Rift in Lebanese territory from the Hula Valley about 30 degrees to the north-east. What are the reasons of this deviation or shift, who researchers did not pay enough attention? The perception of the overall shore line from the Haifa in the south until Latakia in the north indicate that whenever we head north the shore line deviates towards the east, and note in each deviation find gross fault (Figure 1) and so on until we get to the Akkar plain and low Bokayaah on the Syrian-Lebanese border, while from this site and even Latakia in the north, we find that the extension of shore line takes the reverse direction ,it means whenever towards to the north, the shore line deviates to the west until Latakia. And by measuring the amount of maximum deviation in Akkar from a straight line between Haifa and Latakia show that up to about 45 km, as shown in Figure 1. .Also the perception view to the rare satellite image taken during Syrian-Soviet joint space flight in 1987 , which covering

the region clearly indicate the amount of distortion and deviation, which affects to the Rift Valley in this region and forms Western and Eastern Lebanese mountains and Palmyride. As it is in the same direction extends huge fault Aljhar in the Palmyride region, and some other faults. , this indicates that the area exposed to the forces and movements pressing from the west and north-west formed with left side kinetic powers of the Arabian plate towards the north. Its formed forces outcome towards N35E-, which led to a deviation in the Rift Valley region in this direction. And these forces reached its zenith at the head of the triangle in the Syrian Bokayah (Rukieh, 1991.1994) as these forces have led to the formation of a Western and Eastern Lebanese series and the series of Palmyride result of these pressures. Also led to the formation of a set of faults that takes a north east direction like Rashaya and Hasbaya faults in Lebanon and Serghaya fault in Syria.These forces has reached maximum pressure in during of the Miocene, while in the Pliocene and quaternary formed the Rift in Syria and Lebanon and continued to North toward compatible with the movement of the Arabian plate.

5-THE LINK BETWEEN THE FAULTS DETERMINED FROM SPACE IMAGES AND EPICENTERS OF EARTHQUAKES IN THE ARABIC RIFT:

The link between Tectonic scheme for Arabic Rift scale 1/ 4 million prepared by interpretation of Landsat space images (Rukieh ,1991) and Epicenters of earthquakes ,which happened in the region, between 1910 and 2001, magnitude ranging between 3.5 and 6.5 degrees exceeded the number Hundreds, showing certain relationship between the centers of earthquakes and faults, as shown in Figure (5) and through this figure we can observe that the earthquakes that have occurred in the southern part of the Rift until the Hula Valley is an average and weak except one earthquake and mostly associated with Rift and its nearby branches, while in the northern part of the Rift we note that some of these earthquakes associated with faults branching from the Rift towards the north-east and compatible with chains Palmyride ,.while the third part is interlinked with the Latakia- Kalles Fault and its continuity in the sea, and it has happened four basic, earthquakes which reaches about 5.5 degrees . The work that we have done the signing of earthquakes that were magnitude ranged between 3 and 4 degrees during the period between 2003 - 2006 on the space image covered Arab Rift areas and collected from seismic monitoring station in Syria and from the scientific research center in Lebanon (Figure 6) shows that the Part of them happened on the Palmyride Folding. The second part focuses on the scope of the Rift, especially from the northern Hula Valley within Lebanese territory. Part III focuses on the marine waters between Haifa and Cyprus and Lattakia.

6- CONNECTIVITY BETWEEN THE CENTERS OF EARTHQUAKES AND TECTONIC UNITS IN SYRIA AND NEIGHBORING COUNTRIES

The qualitative and quantitative analysis of the neotectonic data to Syria and neighboring countries , centers of historical and mechanical earthquakes and its density in the region, shows that earthquakes are concentrated in three major moving tectonic units as shown in Figures 7,.

A **– RIFT ZONE**, which starts from the Gulf of Aqaba in the south even to Turkey in the north, going through the land of Jordan and the Palestinian, Lebanese and Syrian, lands s. Estimated the annual movement's in Lebanon and western Syria from 0.5 to 0.6 cm, The Earthquakes will be often. Medium to strong and not more than seven on the Richter scale.

B **– ZONE OF THE COLLISION BETWEEN THE ARABIAN PLATE TO THE SOUTH AND THE EURASIAN PLATE** (under the Anatolian plate- Tourous, Zagarous orogenic belt) from the north, where the Arabian plate subdict under the Eurasian plate as a result of its movement towards the north forming the Taurus - Zagros Mountains range and many active faults. the annual movement of the faults arc exceed (1 cm). (Gorovich and others 2005). So this Zone is a large seismic region, which can occur strong earthquakes, which can be up to 9 on the Richter scale. So it poses a great danger to the population who lives in areas of this region and cause casualties and significant material such as an Izmit, earthquake in Turkey in 1999 and the Bam earthquake in Iran in 2005.

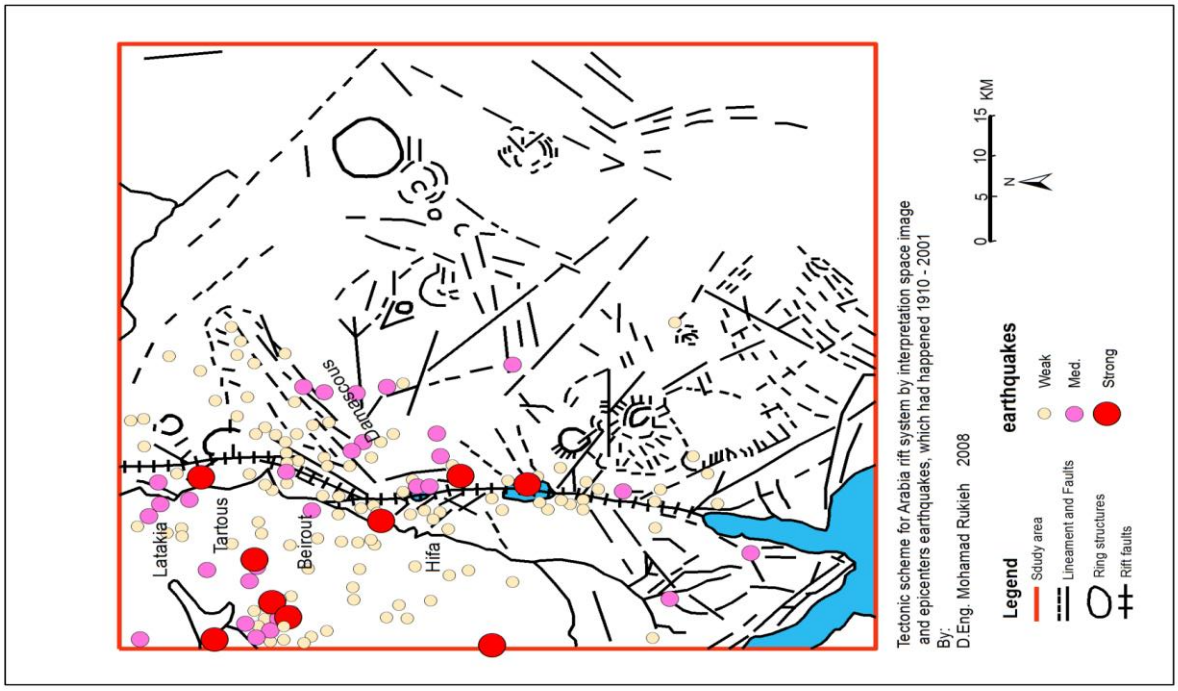
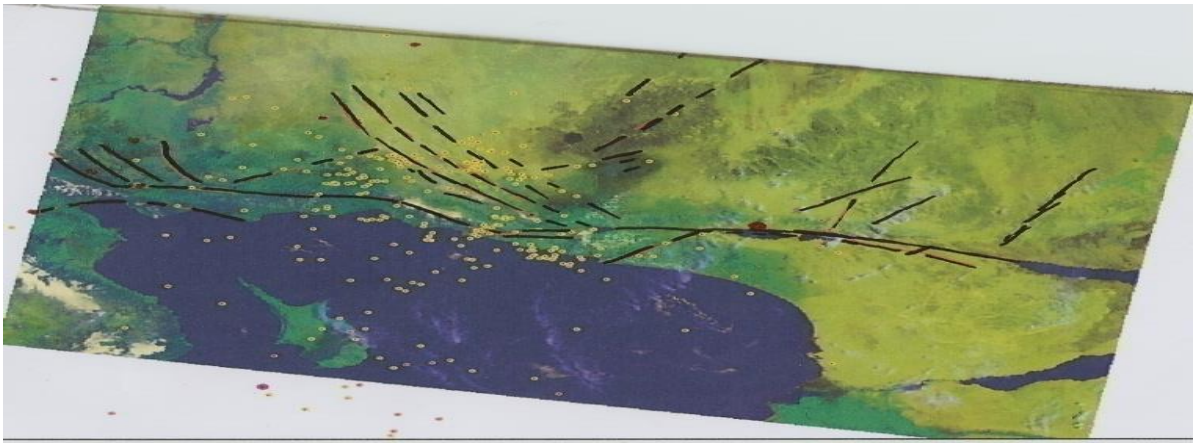


Fig.5, Tectonic scheme for Arabic Rift system by interpretation of space Images and Epicenters Earthquakes, had happened 1910-2001(Rukieh 2008)



(Figure 6) earthquakes of intensity (3-5) degree that occurred between,(2003 to 2006)) in Syria and neighboring areas (RUKIEH 2008).

C -**PALMYRIDE FOLDING BELT ZONE.** This belt branched from Rift Zone northern Hula Valley toward the northeast and a formed eastern Lebanese and Palmyride chain, with length of more than 400 km and a width of about 100 km. This is the belt of the latest mountain systems located within continents, which constitutes one of the most important structures in central Syria. It is located between the two big structures in the northern Arabian plate, the Uplift of Rutba in the south and the Uplift of Aleppo in the north and is surrounded on both sides of large deep system faults, reflected as basement faults which are considered by Aofeliand (1965),. Appears in the current

structure is more clearly south faults system than North faults system, which overspread the most recent sediments. Palmyride Folding belt represents a Olakojina Depression formed early in the second period and then subjected to folding and faulting. The South and North mountains series Palmyride forms in the Middle and Upper Miocene. (Trifonov and others, 1986). This has happened within this Zone many earthquakes, in past and present, his Earthquakes are medium type normally not exceed (6 degrees) on the Richter scale.

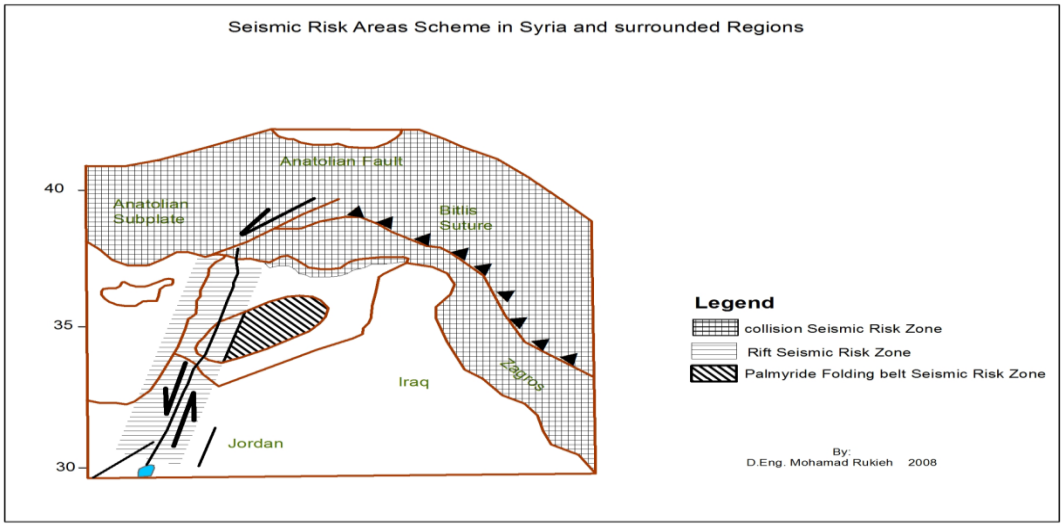


Figure 7, shows the seismic risk areas in Syria and neighboring countries (Rukieh 2008)

7- RESULTS

7-1 – The tectonic schemes for Arabian Rift prepared by interpretation of satellite images showed many, large, medium and small faults and cracks with ring structures, which were not previously known, and contributed to distinct the structural characteristics of the Rift.
7-2 - the link between the tectonic schemes established by interpretation of Space images and the Epicenters of earthquakes occurring in the region during the last hundred years, as well as historical earthquakes showed a certain relationship between faults and lineaments identified on space images and epicenters.
7-3- Our study using remote sensing techniques showed causes deflection of Arabic Rift in Lebanese territory towards the north-east and forms the Palmyride Folding belt.
7-4 –The interpretation of Space Images showed distribution of volcanic rocks in the west range of the Arabian plate. Considering that most of these volcanoes is linked with the Rift faults or other faults, The kinetics of these faults can lead to seismically and Magmatic ally dangerous volcanic eruptions, and must be given to study it.
7-5 The qualitative and quantitative analysis of the neotectonic data to Syria and neighboring countries , centers of historical and mechanical earthquakes and its density in the region, shows that earthquakes are concentrated in three major moving tectonic units:
A - Rift Zone, the Earthquakes will be often. Medium to strong and not more than seven on the Richter scale.
B - collision Zone between the Arabian plate to the south and the Eurasian plate (under the Anatolian plate) from the north, this Zone is a large seismic region, which can occur strong earthquakes, which can be up to 9 on the Richter scale.
C - Palmyride Folding belt Zone, his Earthquakes are medium type, normally not exceed (6 degrees) on the Richter scale.

8- **CONCLUSION:** By using the multi scale, multi spectral and kinds of space images and its interpretations and analysis with data of GNESS enable in long and short time investigation monitoring, assessment, and predicting of earthquakes. That lead to put and developed integrated space monitoring system for seismic dangerous regions.

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