

Applications of Remote Sensing to Disaster Management

Case Study : Monitoring the Earthquakes Activities along the Syrian Rift System

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Abstract - One of the main disaster concerns in Syria is the Earthquakes, since that Northwest of Syria is part of one of the very active deformation belt on the Earth today. This area and the western part of Syria are located along the great rift System (Left-Lateral or African- Syrian rift System) . Those areas are tectonically active and cause time to time a lot of seismic events. This faulting zone system represent a unique structural feature in the Mediterranean Region. The system formed, initially, as a result of the break up of the Arabian plate from the African plate .

Key words: Earthquakes, Active Faults, DEM, Structures

INTRODUCTION

The northern continuation of the Dead Sea Fault into Lebanon and Syria is comprised primarily of the Serghaya (SF) and the Yammouneh (YF) faults that trace parallel and close lines in between the Lebanon and Anti-Lebanon mountain chains (fig. 1) . The SF is a branch of the main Dead Sea fault in south-western part of Syria , while the YF merges with the AL-Ghab fault (GF) near the Bouqeah plain in western Syria. The south-north trending GF in turn extends parallel to the Syrian coast, and merges with the major East Anatolian Fault (EAF) in southern Turkey. This complex system in Lebanon and Syria has been the location of numerous large historical earthquakes.

Although (thought to be) seismically quite at present, the area is tectonically active, geologically speaking. This young tectonic activity is the main cause for the discrete topographic relief, which allows to study in outcrop aspects of fault geometry, fault kinematics, and relations between faults and fractures. However complex, in most conditions, structural geometries tend to be relatively systematic. Therefore, models and analogues have been used and help to focus attention and interpretation according to well understood geo-mechanical concept. The analysis of space imagery, digital image processing of spectral data, and the features from digital elevation models (DEM), show that there is intensity in linear conjunctions accompanied with complex fracturing system. This complex is affected by distance stresses accompanied with intensive forces. This action indicates that these sites are active and in a continual movement. The AL-Ghab Graben complex is situated within this wide area of Cenozoic deformation. The system formed, initially, as a result of the break up of the Arabian plate from the African plate since the mid-Cenozoic. The Arabian plate is moving in a NNW direction, whereas the African plate is moving to the North. The left-lateral motion along the Dead Sea Fault Zone accommodates the difference in movement rate between both plates. Some

80 km to the North of AL-Ghab Graben both plates move into the Anatolian plate, which causes the latter to move to the West.

The analysis of TM Space Imagery and digital image processing of spectral data show that the lineaments along AL-Ghab Graben may be considered as linear Conjunctions accompanied with complex fracturing system. This complex is affected by distance stresses accompanied with intensive forces. This action indicates that these sites are active and in a continual movement. In addition to that, the statistic analysis of Thematic Mapper data and the features from a digital elevation model (DEM) produced from SAR interferometry show the existence of spectral structures at the same sites.

The area under study is located in the Northwestern part of Syria (fig.2). The AL-Ghab Graben is limited from the West by the steep slope of the Jabal An-Nusseiriyeh range and from the East by the similar steep but less high slope of the Jabal Az-Zawiyeh range (fig.2). As a whole the Graben looks like a flat-bottomed ditch about 10 km wide. The Southern part of the Graben represents a flat marshy trough up to 15 km wide. The trough is filled with Pliocene lacustrine sediments. The Pliocene sediments are covered with a thin sheet of Quaternary lacustrine sediments. This part of the Graben is called the AL-Ghab trough. The occurrence of the Pliocene deposits in the Trough is practically horizontal. The thickness of the Pliocene lacustrine sediments was fully measured only at the Eastern slope in the Southern part of the trough. There it equals 90 m.

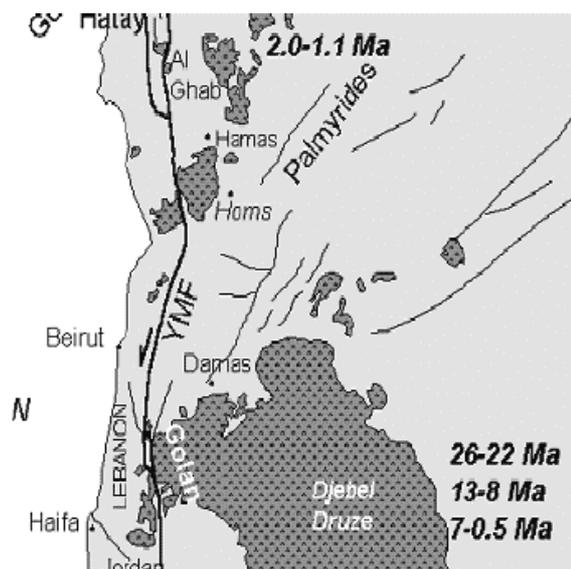


Figure 1, Showing the area under study ,the young fault-controlled relief of AL-Ghab Graben area.

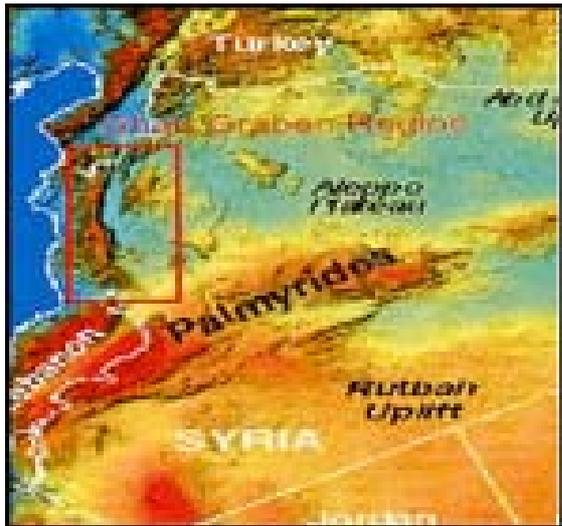


Figure 2, Showing the limitation of AL-Ghab Graben

1. REMOTE SENSING APPLICATIONS

The AL-Ghab Graben is reflected in the intensity of neo-tectonics affecting it. Neo-tectonics is active, such as active faults. TM optical and radar data are used to image, for example, fault scarps and actively growing folds. Visible and infrared imagery with moderate resolution is used to map lineaments, which are often surface expression of deep-seated fractures. The Interpretation of Space Imagery TM shows that the surface expression of AL-Ghab Basin is flat plain with almost no topographic relief. The plain is ~60 km long and ~15 km wide (Fig.3). Faults would be expected along the western margin given a typical fault step-over arrangement for AL- Ghab Basin.

To the south of AL-Ghab graben , between two strands of the Dead Sea Fault System (DSFS) is the Missyf Graben (fig. 4). The eastern fault strand can be traced northward at the surface along the eastern margin of AL- Ghab Basin before bifurcating to the north-northeast.. The basic structure of AL-Ghab Basin is a fault-controlled double depocenter. The main depocenter is positioned beneath the southern portion of the surface plain, and slight northward migration of that depocenter with time is clear from the seismic data. Also apparent are a mid-basin ridge and a second smaller depocenter to the north. Despite out interpretations that have used all available data, several issues regarding the evolution of AL- Ghab Basin remain unresolved. Furthermore, while the fault geometry controlling AL- Ghab Basin roughly fits the pattern of a 'step-over' basin), AL- Ghab Basin shows several departures from this simple transform-parallel extension case. Transverse structures, such as those found in AL- Ghab Basin, are also commonly observed in other strike-slip basins. The digital image processing of Radar imagery showing the presence of active and fresh faulting zones along the AL-Ghab Graben (Fig. 5). TM and SAR-DTM data, also showed a gradual color tone and interruptions of linear-ellipse shapes which reflecting the presence of discontinuity contours along the fault zone extension (fig.6).

This features refer to abundance of surface morphological features indicate to Fresh Faults. Recent faulting is expressed as freshly exposed soil within the colluvial apron visible by its light tone color. These indicators had



Figure 3, TM image (Colour composite) covers AL-Ghab Graben . Date : 22 /08/1998 , Landsat -5

been proved by field checks. Furthermore, the statistic digital analysis of the spectral data show that there are distribution of spectral plumes. These plumes are decreasing in intensity and color contrast from the center of the site to the direction of its edges.

This proves that there are an active tectonic reflecting the behavior of the movement and earth stresses at these fracturing zones. Results from statistic analysis of DTM image, demonstrate that the restraining bend of AL-Ghab graben involves active strike slip faulting. The AL-Ghab graben appears capable of generating large earthquakes and it should be an essential element in any regional earthquake hazards Assessment .

AL- Ghab Basin is not a textbook example of a step-over basin.

However, through comparison with other basin studies and models it was found that many of the second-order structures within AL-Ghab Basin are common to other strike-slip basins.

The basin asymmetry seen in AL-Ghab is probably related to the amount, and sense, of relative movement across the bounding lateral faults.

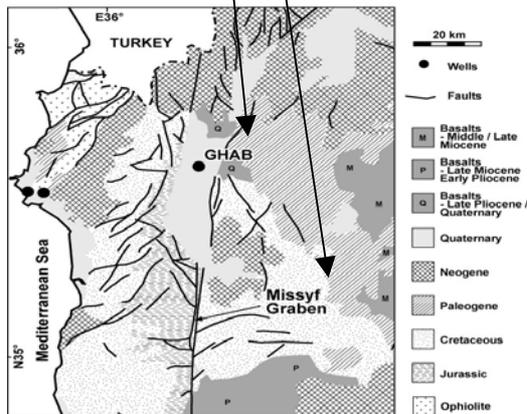
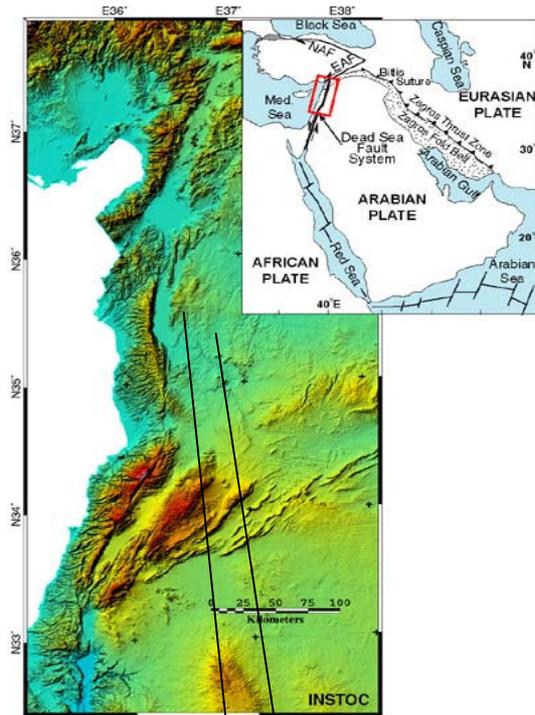


Figure 4 , Shows the AL-Ghab and Missyf Grabens And the Dead Sea Fault System (DSFS)

2. CONCLUSIONS

The results are consistent with the observed surface faults that show a greater amount of relative motion on the eastern basin-bounding strike-slip fault. Observations from AL- Ghab are echoed in theoretical models that show cross-basin oblique-slip faults accommodating initial basin opening, but most subsidence on the basin bounding faults. A northward shifting depocenter, and the subsequent development of a second depocenter in AL-Ghab Basin, are due to increasing fresh faults overlap with time and step-over of the lateral motion from the eastern to the western faults.

The system formed, initially, as a result of the break up of the Arabian plate from the African plate since the mid-Cenozoic . The tectonic evolution of Syria has been profoundly affected by movement on nearby Arabian plate boundaries,



Figure 5, Shows the Active Faults on Radar Image

which almost completely surround the country. This deformation is evidenced in large-scale geologic structures within Syria, which include the Palmyrides folds. The northern continuation of the Dead Sea Fault into Lebanon and Syria is comprised primarily of the Serghaya (SF) and the Yammounh (YF) faults that trace parallel and close lines in between the Lebanon and Anti-Lebanon mountain chains . The SF is a branch of the main Dead Sea fault in southwestern part of Syria, while the YF merges with the AL- Ghab fault (GF) near the Bouqeah plain in western Syria. The south-north trending GF in turn extends parallel to the Syrian coast, and merges with the major East Anatolian Fault (EAF) in southern Turkey . This complex system in Lebanon and Syria has been the location of numerous large historical earthquakes ($M \geq 6.5$) . Ambreasys and Barazangi (1989) reported that the fault zone may still be active and capable of generating more destructive earthquakes in the future with an estimated long return period of 200-350 years.

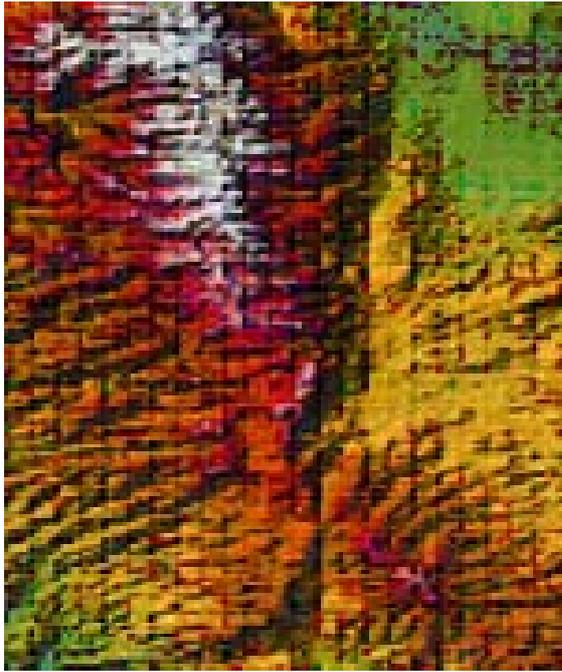


Figure 6, discontinuity contours along the fault zone extension / TM and SAR - DTM

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