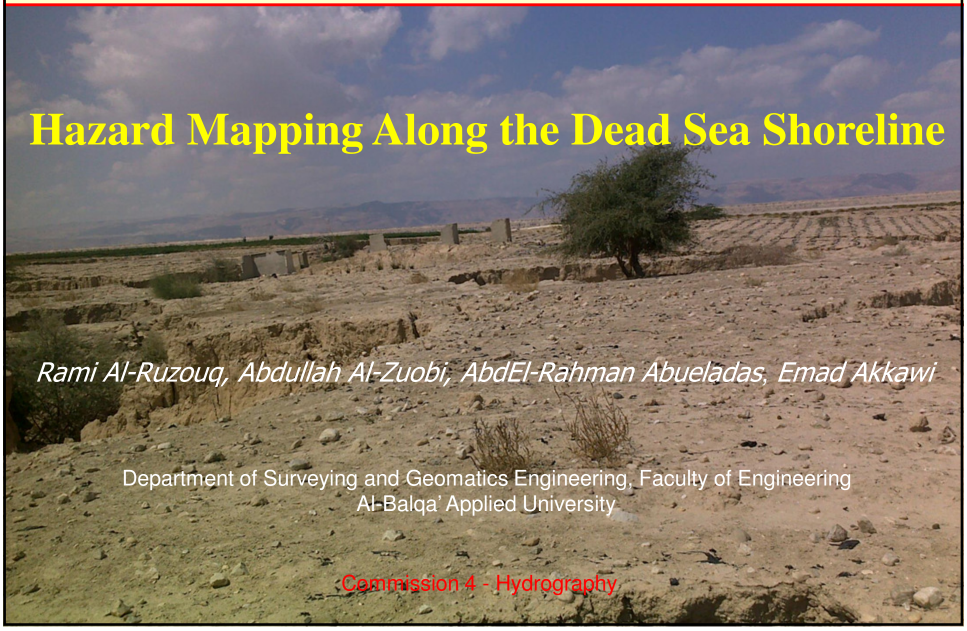
FIG Working Week in Marrakech, Morocco 18-22 May 2011



Hazard Mapping Along the Dead Sea Shoreline

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Commission 4 - Hydrography

1-Introduction

❑Hazard mapping is a process of creating a geographic trace for these particular phenomena extents which are likely to pose a threat to people, property, infrastructure, and economics activities.

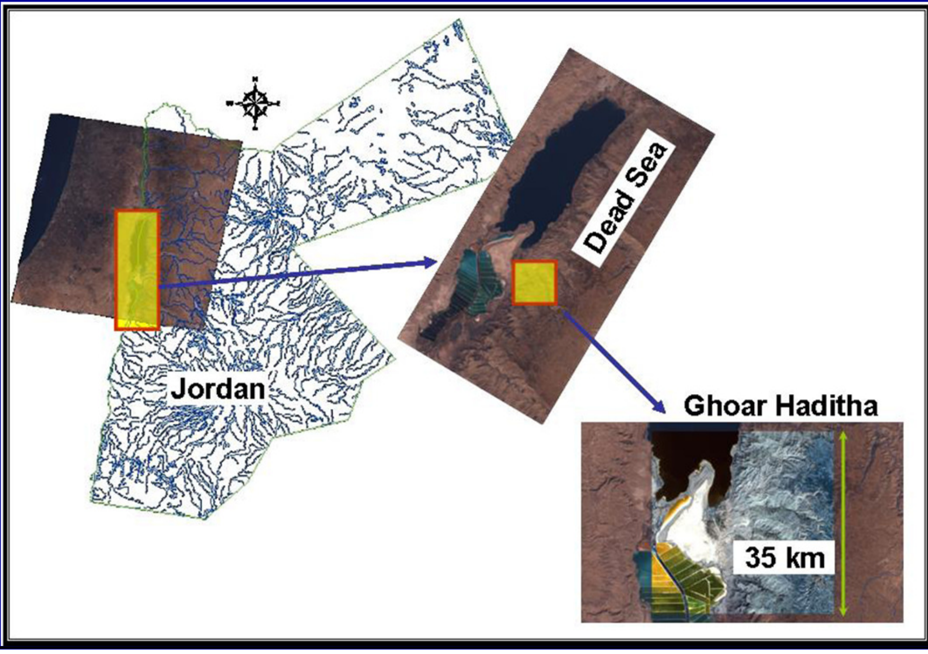
❑ Hazard mapping represents the output of hazard analysis on a map.

❑Sinkholes and subsidence are natural phenomena that may occur in shallow geology sediments at different regions in the world.

❑Sinkholes hazard assessment is one of the most difficult nearby subsurface investigation process.

❑Geophysical methods (Microgravity, seismic, geoelectric, ground penetrating radar) are a powerful tools for detecting subsurface cracks, cavities, faults which assists to determine the sinkholes anomalies.

❑Dead Sea is located at the mid west part of Jordan and represents the lowest region of the world. The study area is located along the eastern side of the Dead Sea shoreline.



The sinkholes and subsidence hazard that is developing in this region are affecting :

Objectives

➢ This study focus on investigating the hazard detection and mapping based on the development of the Sinkholes and subsidence over the study areas.

➢Data from different sources and research areas that includes Photogrammetric art, Global Positioning System (GPS), Three Dimensional (3D) Geographic Information System (GIS) and Ground Penetrating Radar (GPR) has been integrated for hazard mapping.

2-PHOTOGRAMMETRIC PROCESSING

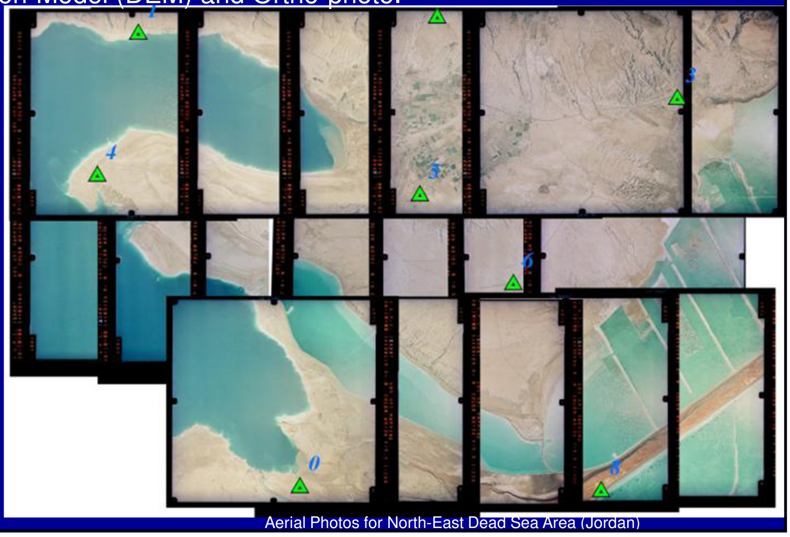
❖Photogrammetry and aerial photo is one of the main sources for spatial data.

❖Processing of aerial photos, includes the standard procedures of inner, relative and absolute orientation.

❖The generated stereo model was checked using a set of well distributed check points.

❖The RMS based on the differences between ground and model coordinates of those points was found to be 0.305m.

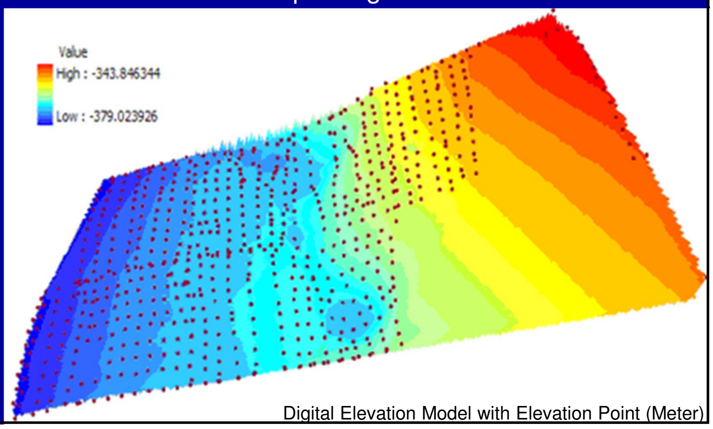
The aerial photos have the following properties:
1-Overlap between two adjacent photos equal 60 %.
2-Photos Scale is (1:25000) with film format ($23cm^2$).
3-Spatial resolution is about 50cm where area per photo is about ($5.7km^2$).
4-In this study, two main photogrammetric products were generated; Digital Elevation Model (DEM) and Ortho-photo.



Aerial Photos for North-East Dead Sea Area (Jordan)

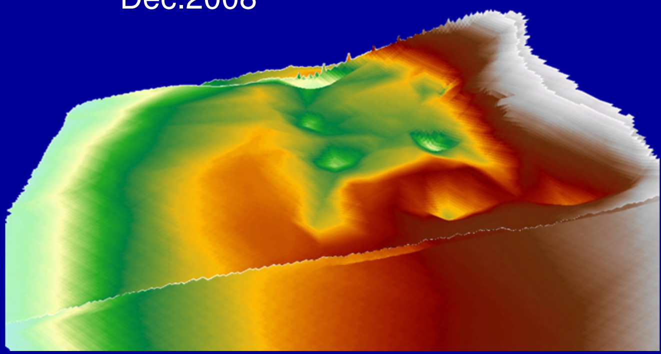
2.1 Digital Terrain Model (DTM) Extraction

○ DTM is simply a statistical representation of the continuous surface of the ground by a large number of selected points with known X, Y, Z coordinated in an arbitrary coordinate field.
○ At present, most DTM data are derived from three alternative sources: Ground surveys, Photogrammetric data capture and global positioning system (Baldi, 2008; Hanley and Fraser, 2001; Paul, 2000).
○ The figure illustrates the final DTM after editing and processing with (5m x 5m) cell size, which will be used in the Ortho-photo generation.



Digital Elevation Model with Elevation Point (Meter)

Rapid subsidence in DTM 2008



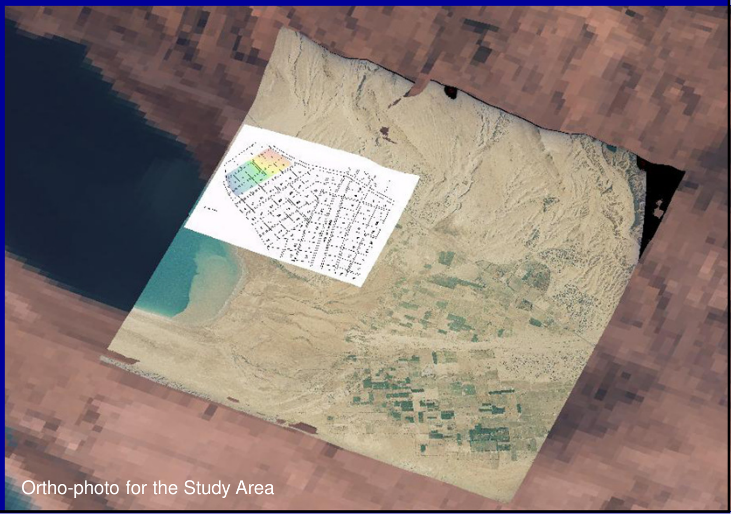
Subsidence in Ghoar Al-Haditha Area

Suddenly changes

Study Area in Feb-2008

2.2 Ortho-Photo Generation

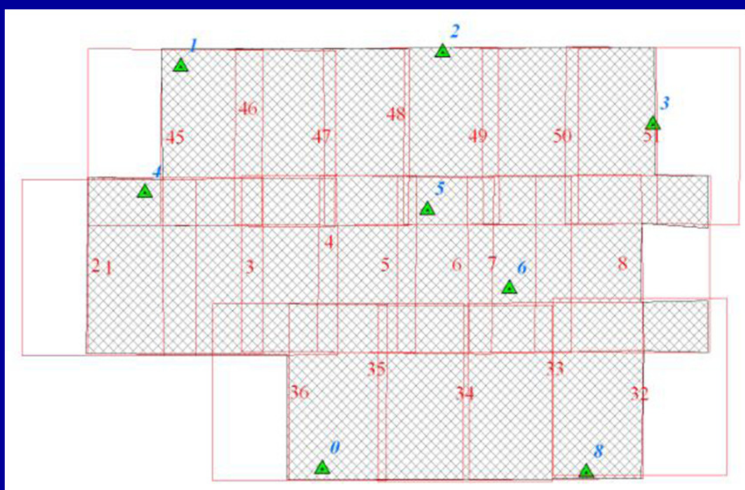
- An Ortho-photo is a photo with the same characteristics of a map.
- The Ortho-photo can be used as a map to define measurements and accurate geographic locations of the features.
- Ortho-photos are generated from aerial photographs and satellite images via a process known as an Ortho-rectification process (Hanley and Fraser, 2001; Paul, 2000).
- In this study, an Ortho-photo was generated for the study area using information obtained from the photogrammetric processing and the DTM .



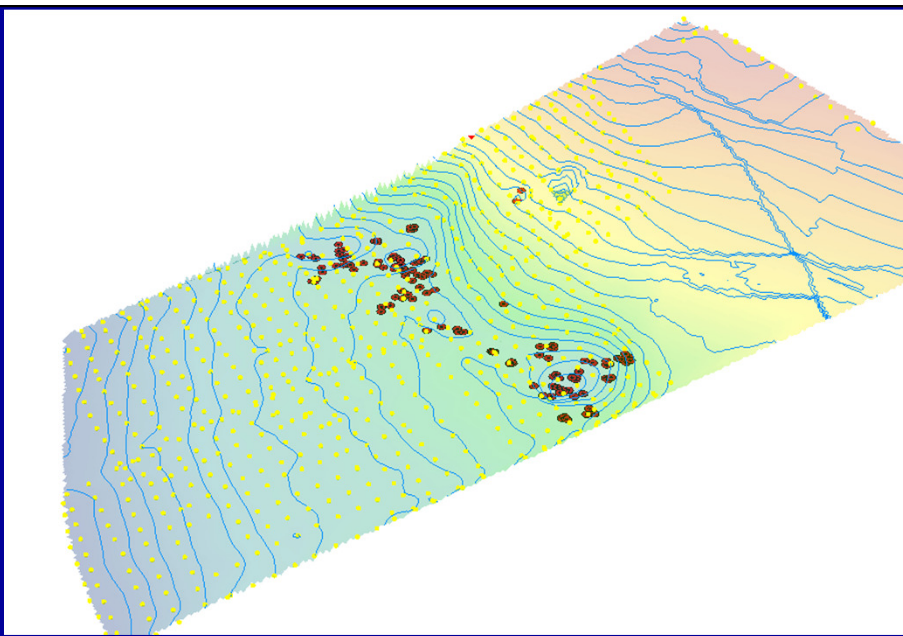
Ortho-photo for the Study Area

3. GLOBAL POSITIONING SYSTEM (GPS)

After collecting the project aerial-photos, ground control points (GCPs) is needed.
Planning and distributing of the GCPs on the photos is essential for an appropriate selection of the GCP over the study area.



Ground Control Point Distribution in aerial photos

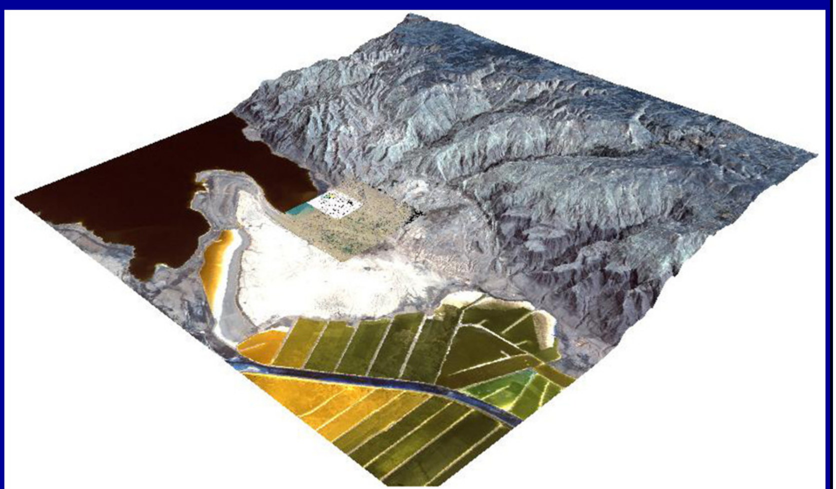


The location of ground control points (GCPs) (red) overlaid on the DTM of the study area.

4. THREE DIMENSIONAL GIS

Most standard and GIS maps are in flat (two-dimensional, 2D) format, but presentation of landscapes as three-dimensional (3D) views is very useful.

A realistic 3D representation Ortho-photo dropped over DTM with 3D band combination for 4-3-2 LandSat bands.



Representation of band 4-3-2 landsat superimpose with Ortho-photo

5. GROUND PENETRATING RADAR

❑Ground Penetrating Radar (GPR) has become an important non-invasive non-destructive technique for rapid geophysical mapping of shallow subsurface.

❑A short pulse of high frequency from 10 MHz to 1 GHz electromagnetic pulses transmitted in to the ground from an antenna towed across.

❑The GPR signal is reflected, refracted and attenuated depending on the distribution of the electrical properties of the subsurface layers which it also depends on water content and the physical properties of the layers

❑The GPR profiles was situated at the main roads between agriculture units to avoid the noise from the power lines, water buried metallic pipes and water pumps distributed at the study area.

❑ The maximum depth penetration was approximately 3 m for 400 MHz antenna where the estimate depth was made using a soil velocity of 0.11 m/nanosecond.

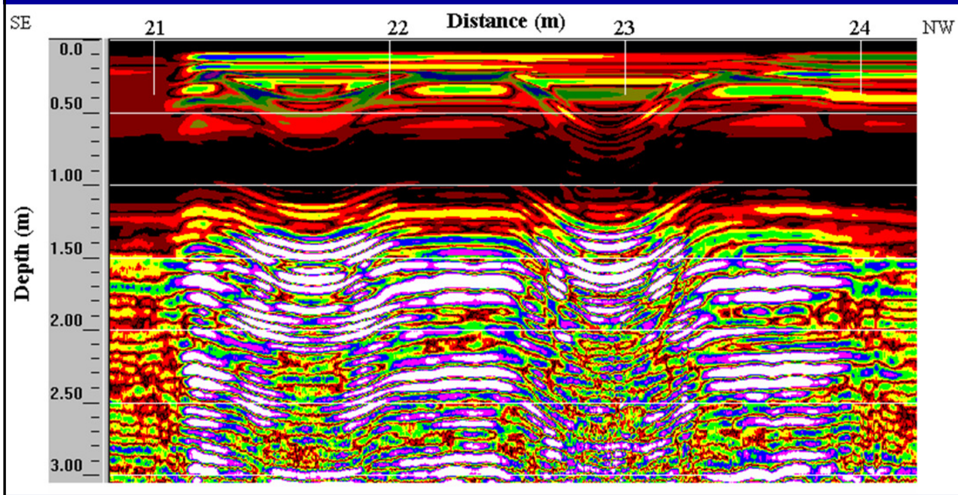
Nine continuous GPR profiles were surveyed using SIR-20 system, manufactured by Geophysical Survey System Inc. (GSSI), USA with 400 MHz bow-tie mono-static antenna.

SIR-20 GPR from GSSI. USA

400 MHz antenna

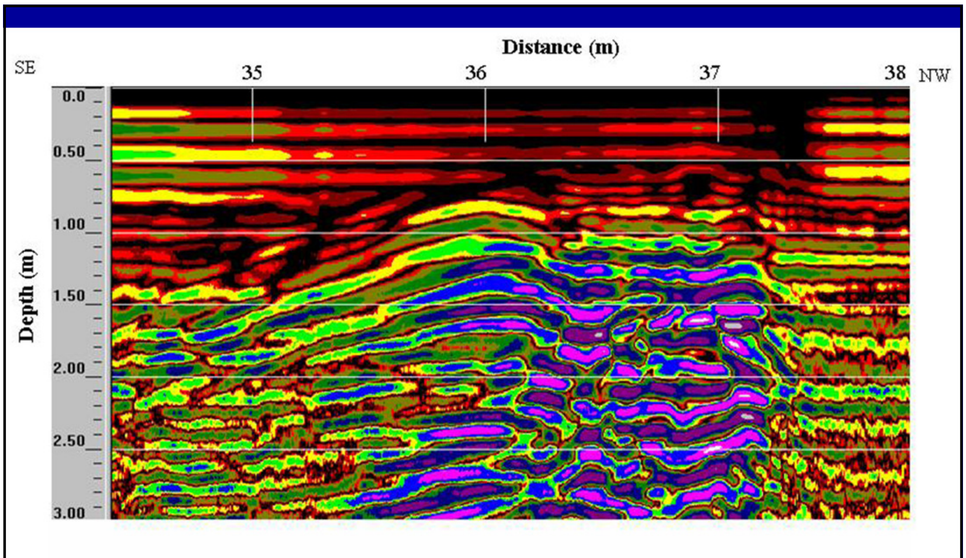
Location Map of the study area showing the GPR lines

5.1 GPR Results:

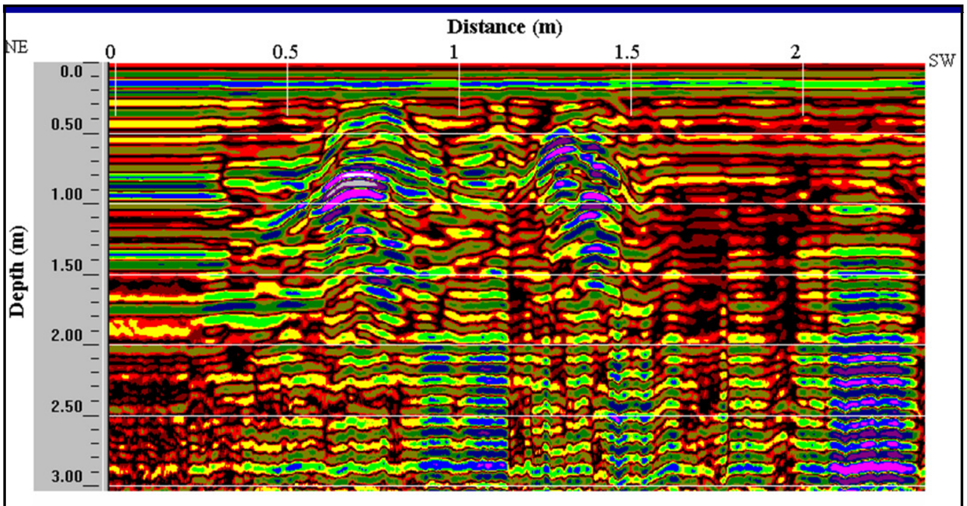


The GPR record obtained along GPR Line 1 over a known old filled sinkhole. The anomaly between a distance 21 and 24 m located at approximately 1.2 m depth represent the filled sinkhole.

The two small collapse features at distance 21.5 m and 23 m could be an indicator for new sinkholes along the line.



A part of radar cross section along GPR line 2. The main anomaly along this line at distance between 35 m and 37 m located at approximately 1 m deep may represent a buried sinkhole.



A part of radar cross section along GPR line 7. The two main subsurface targets at approximately 0.4 m depth and located at the horizontal distance 0.7 m and 1.4 m. may represent two shallow parallel dry tunnels.

6. CONCLUSION

➢ Geometics as well as geophysical science represent efficient tool to prepare accurate spatial database to assess of amount, nature and development of the existing hazard.

➢For this purpose topography (Digital Elevation Model) modeling has been build based on aerial photographs (stereo pair).Moreover, photogrammetric processing was performed in the study area to produce High resolution Ortho-photo image (Image with same characteristics of maps, where it is distortion free image, has constant scale and can be used for actual measurement in GIS systems).

➢3D GIS Model or study area was developed that includes (Boundary maps, sinkhole location, DTM, transportation layer, hydrological maps, digital elevation model, and geology of the area).

➢Ground penetrating radar is a powerful tool for delineation the old buried sinkhole and detect different subsurface target which may represent shallow tunnels and fractures which assist the leakage of the surface fresh water to the subsurface layer and washed soft material and salt in the layers that aggregate the formation of the sinkholes in the study area.

➢Continuous monitoring of the location of the GPR anomaly along the lines will provide us information about what occur beneath the surface with time and to correlate our results with the new events take place in the study area**.**