Mapping Active Faults from a 3D Model Based on Drone's Photos: An Example from Ye'elim Creek, Dead Sea Escarpment

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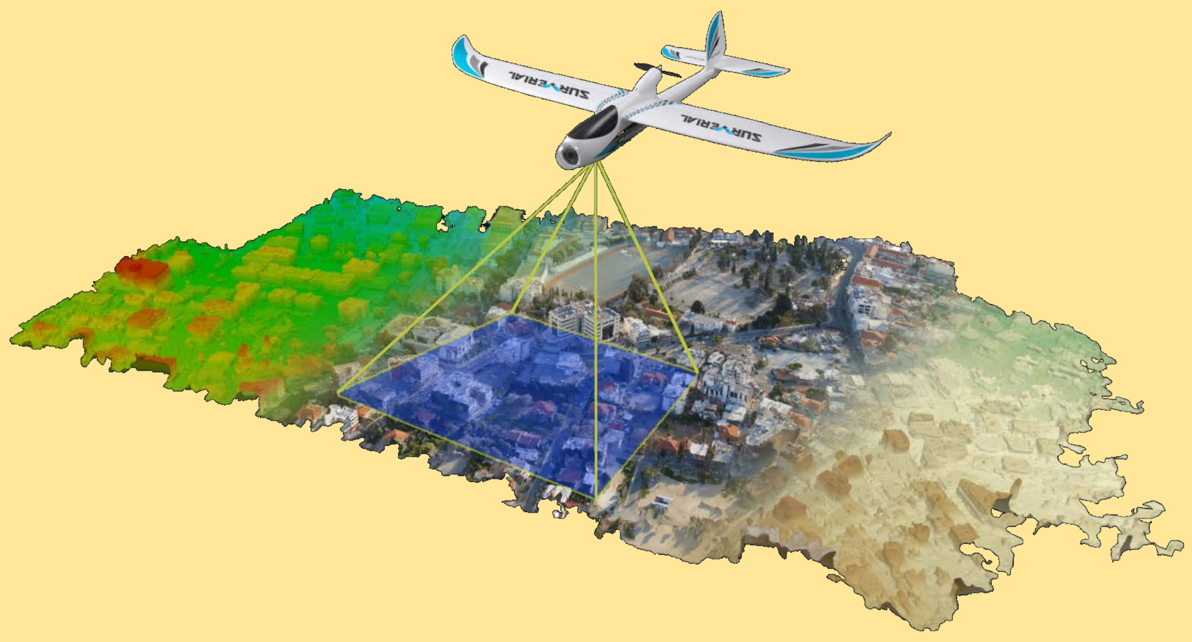
1. Introduction

Drones - gadgets leading the new technologies - are becoming an efficient tool in the industry and also for environmental sciences, including tectonics and geomorphology. With the rise of drones, the prohibitive costs of aerial geological surveys have dramatically diminished. We use this indispensable instrument for high-resolution mapping of unique antithetic active faults near Ye'elim Creek at the Dead Sea fault escarpment, Israel.

What is photogrammetry?

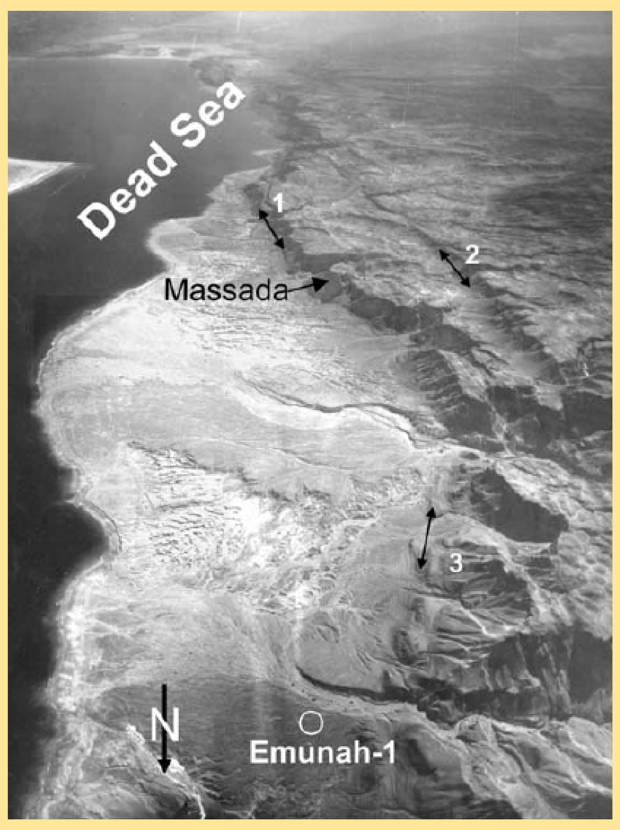
Photogrammetry takes 3D geometric measurements from photographs for recovering the precise positions of surface points. The output of photogrammetry is typically a map, drawing, measurement, or a 3D model of some real-world object or scene.



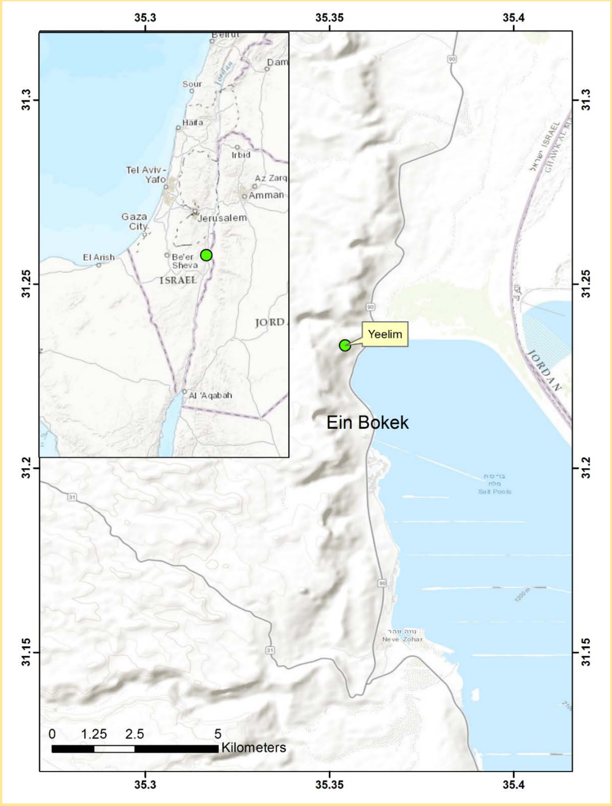
2. Work Area

This area, on the western fault escarpment of the Dead Sea Valley, exhibits antithetic faulting expressed as narrow and elongated horsts and grabens. The elevation spans 270 to 380 meters below mean sea level, and the surface is lined by beach sediments from the receding Lake Lisan, deposited between 14 and 15 ka. Hence, except in east-west running rills, the topography is a proxy for the geological structure that was formed by active faults. Exposure of the underlying Judea Group bedrock supports the structural interpretation.

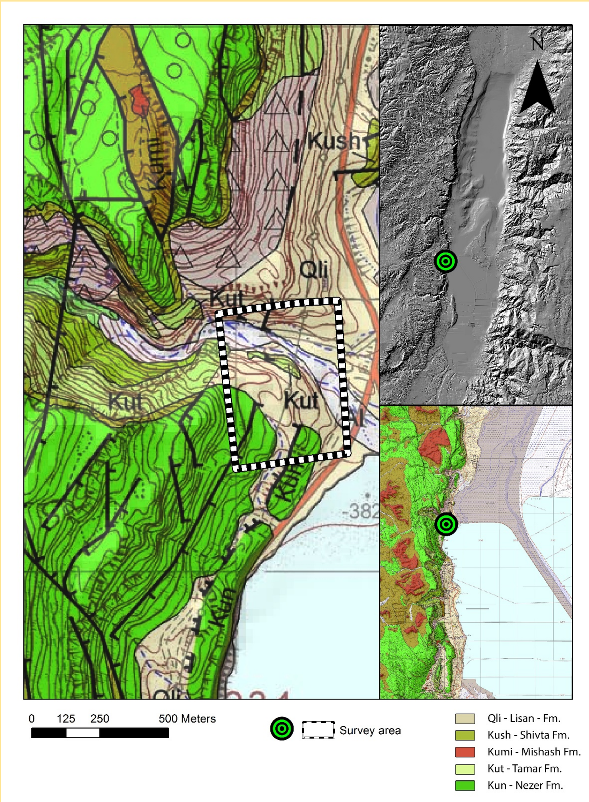
Based on Gilat and Agnon (1981) and Agnon and Sagy (2011) the exposures in the area consist of Nezer and Tamar dolostone Formations of Judea Group, and chalk, sands and pebbles of the Lisan Formation.



Strikes directions: 024º±015º and 340º±016º (Sagy et al., 2003)



Ye'elim Creek area



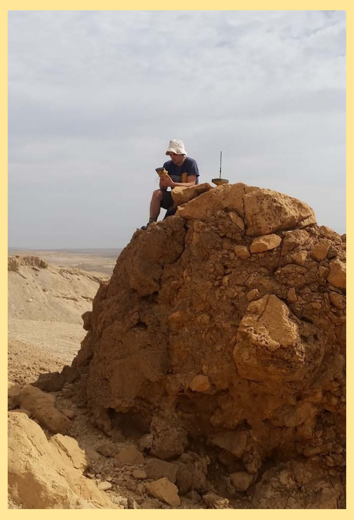
Geological map of the area

3. Methods

- Photos taken by DJI's Phantom 3 Pro.
- Ground landmarks marked and taken by Differential Global Positioning System (DGPS) - Topocon GR-3.
- 3D model generated by Agisoft PhotoScan by photogrammetric processing of digital images.
- ArcMap used for fault detection.

Final landmarks used to build the model

Example for a ground landmark at the field

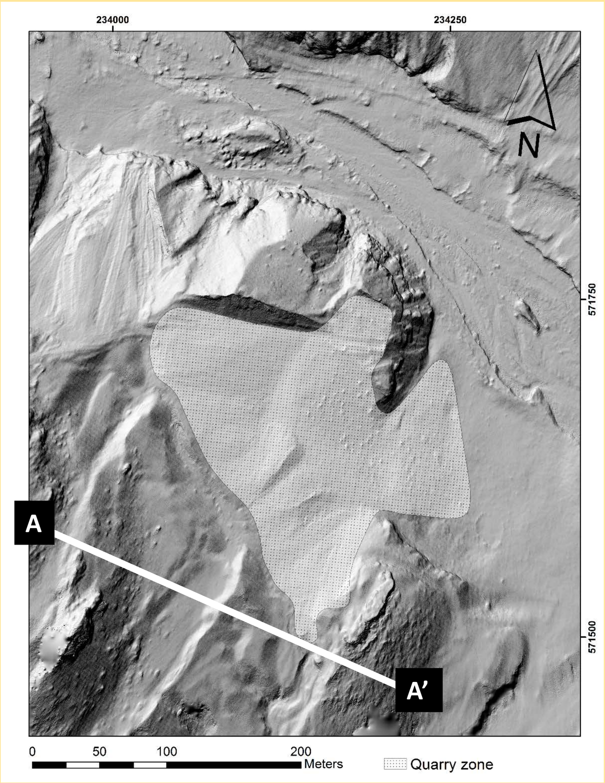


Taking a landmark point (Ran Shemesh)

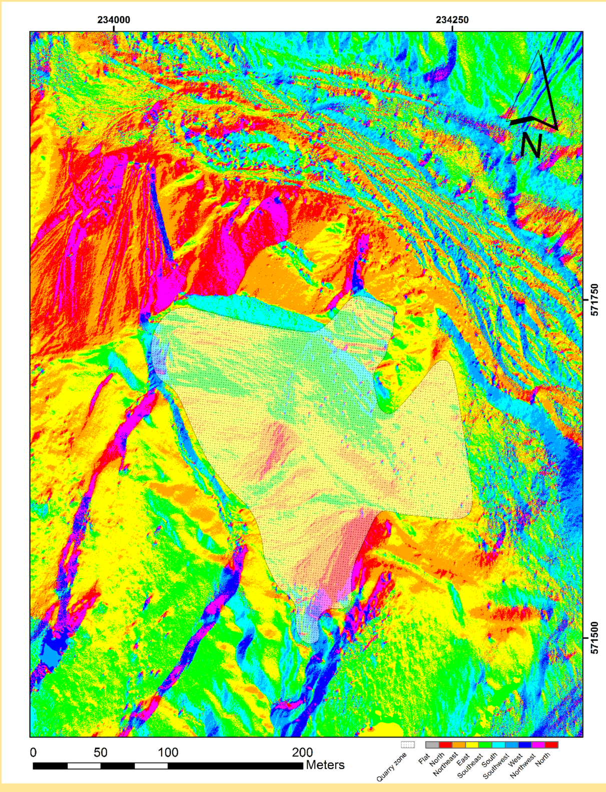
4. Results

We took 411 photos and georeferenced them to Israel TM Grid according to seven landmarks measured by DGPS. Based on that we created a dense point cloud which led to the final high-resolution 3D model. The model covers about 300,000 square meters with a negligible error of 12 centimeters. From this 3D model we extract a Digital Elevation Model (DEM) file with resolution of 13 cm per pixel.

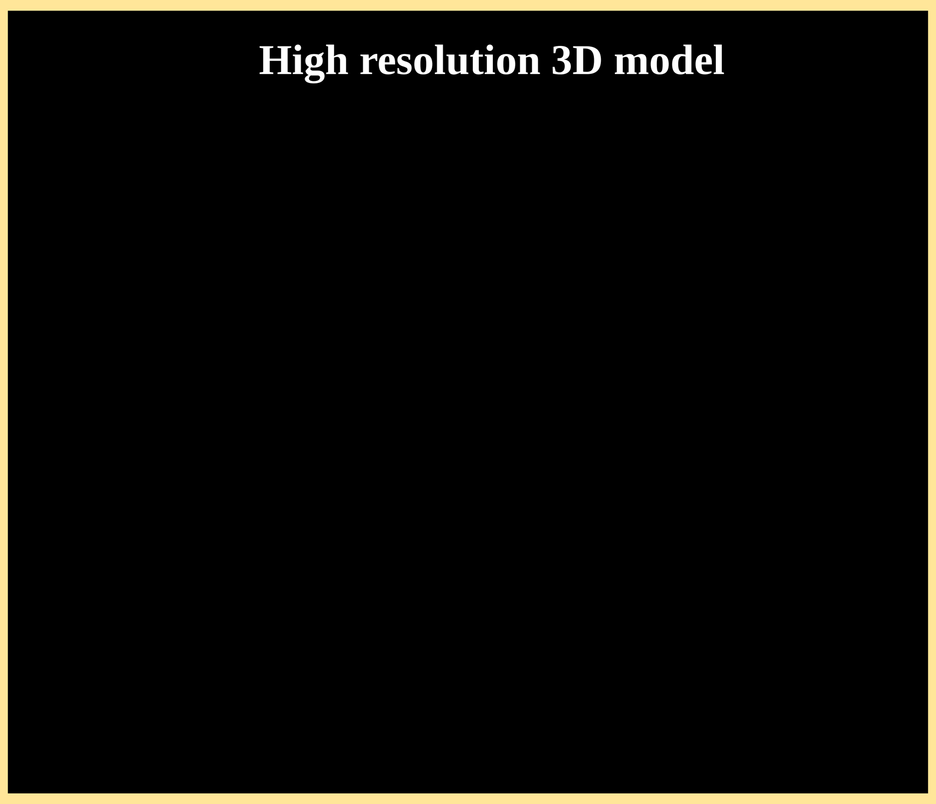
We used ArcMap's Aspects algorithm to inspect any patterns of maximum slopes. We filtered the data and kept only straight lineaments and finally used the Aggregate Function to join the overlapping elements and clarify the segments.

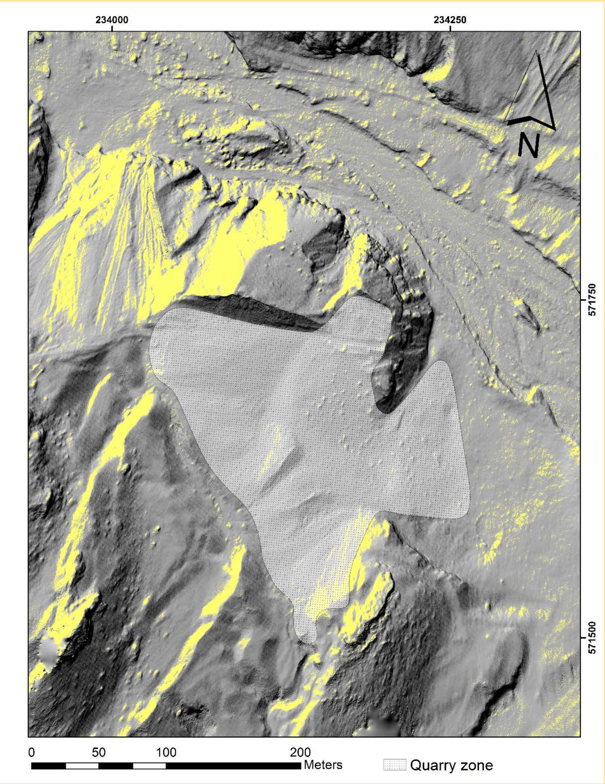


Digital Elevation Model (DEM)

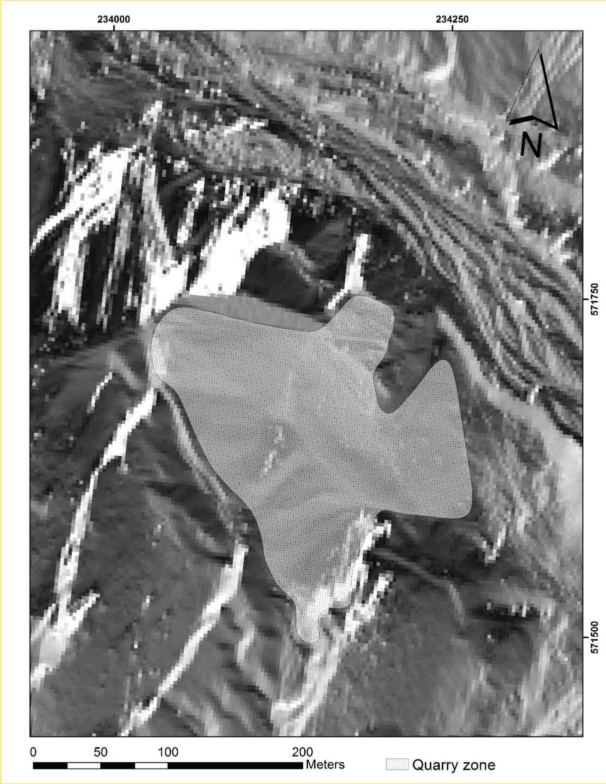


Maximum slope in each direction - Aspects



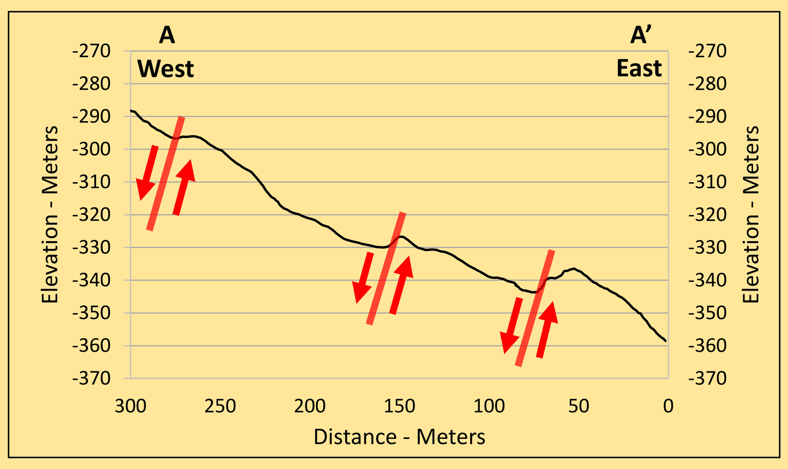


Maximum slope facing west and north west



The Aggregate layer of overlapping elements

Normal faults exposed in dolomite bedrock in the Ye'elim Creek. Photo taken from Ye'elim's thalweg toward south.



A topographic section measured from the model (shown on the DEM).

5. Conclusions

Based on photogrammetry and some ArcMap algorithms we use a 3D model that includes three straight lineaments that suggest active antithetic fault structure with a strike of 030º and intervals of about 100 meters. The slip displacements are measured from the model and they are up to approximately 10 meters.

This suggests an average slip rate of about two thirds of a millimeter per year. These slip rates are likely reflecting slope instability on a large scale, in line with open crevices reported north of the Ye'elim Canyon (Arkin, 1989) and a fault plane solution for a 4.1M earthquake (Van Eck & Hofstetter, 1989).

References

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