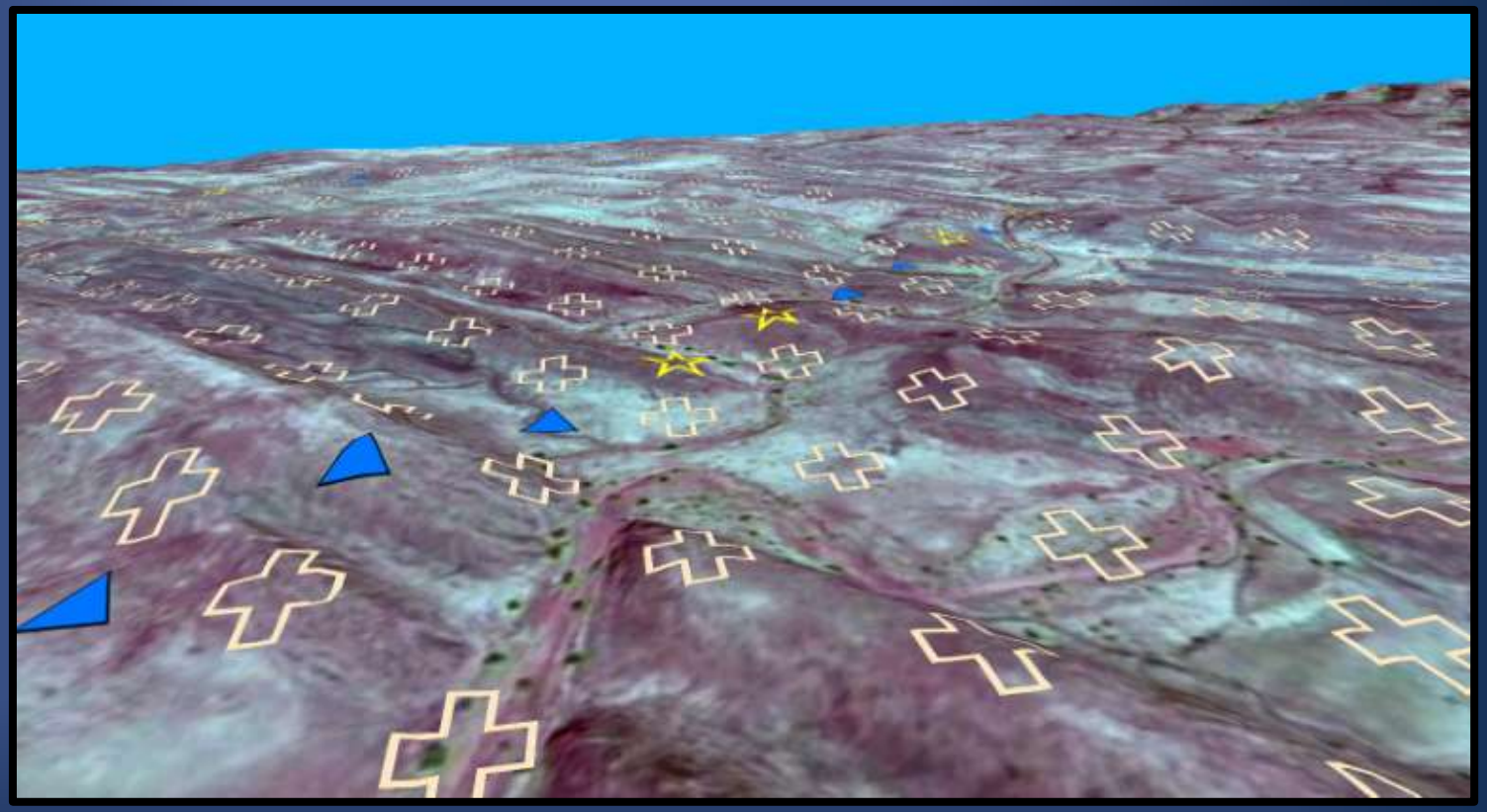
Improving land seismic field crew safety on field operations in hazardous areas of the world through the use of highly accurate stereo satellite topographic mapping

Gerry Mitchell, P.Geo, President PhotoSat

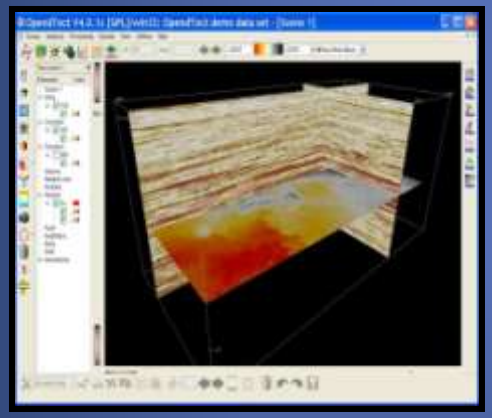


Gerry Mitchell
PhotoSat President

Three key technical components enabling geophysical elevation mapping from space

High resolution stereo satellite photos

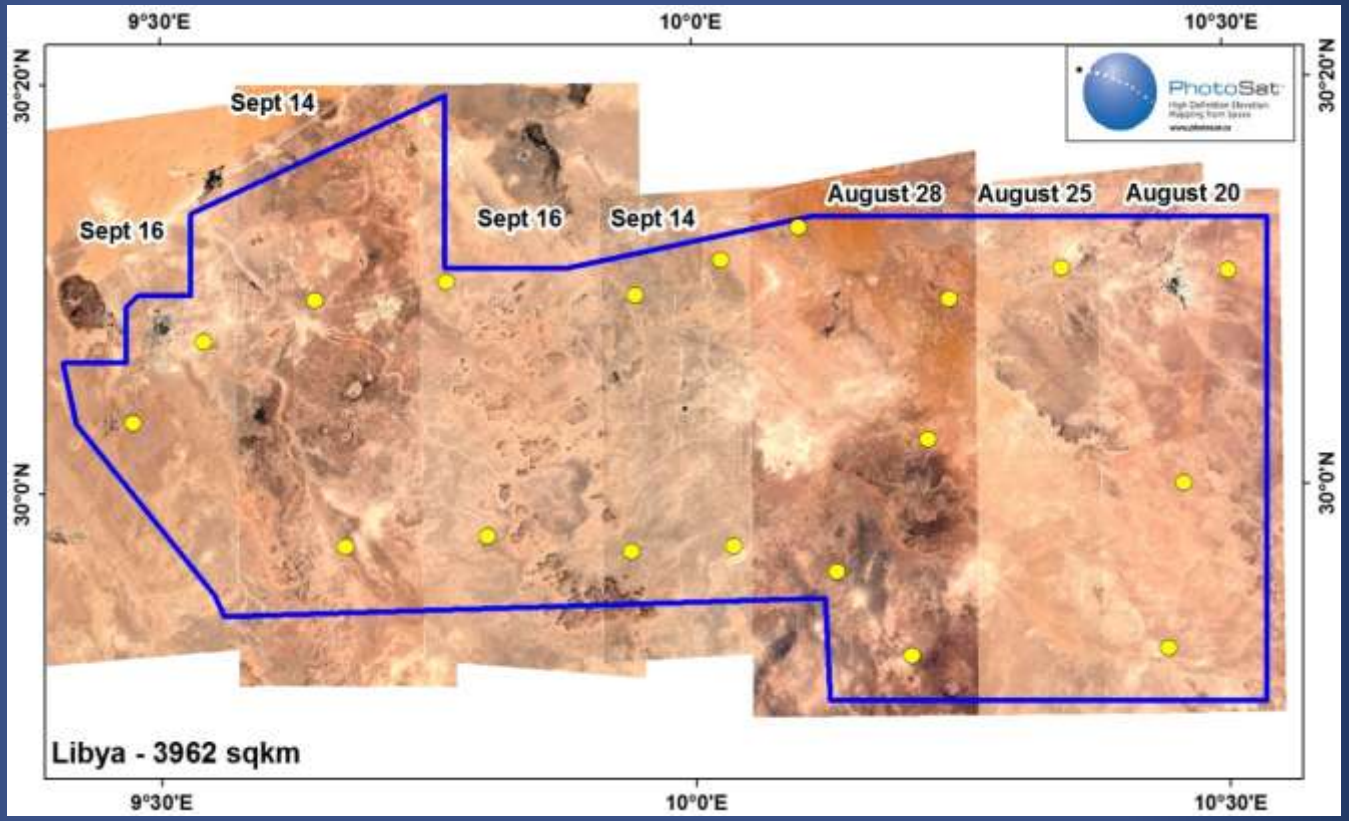
Adaptation of seismic processing systems



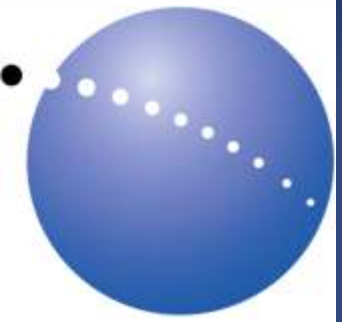
Graphics Processing Units (GPUs)

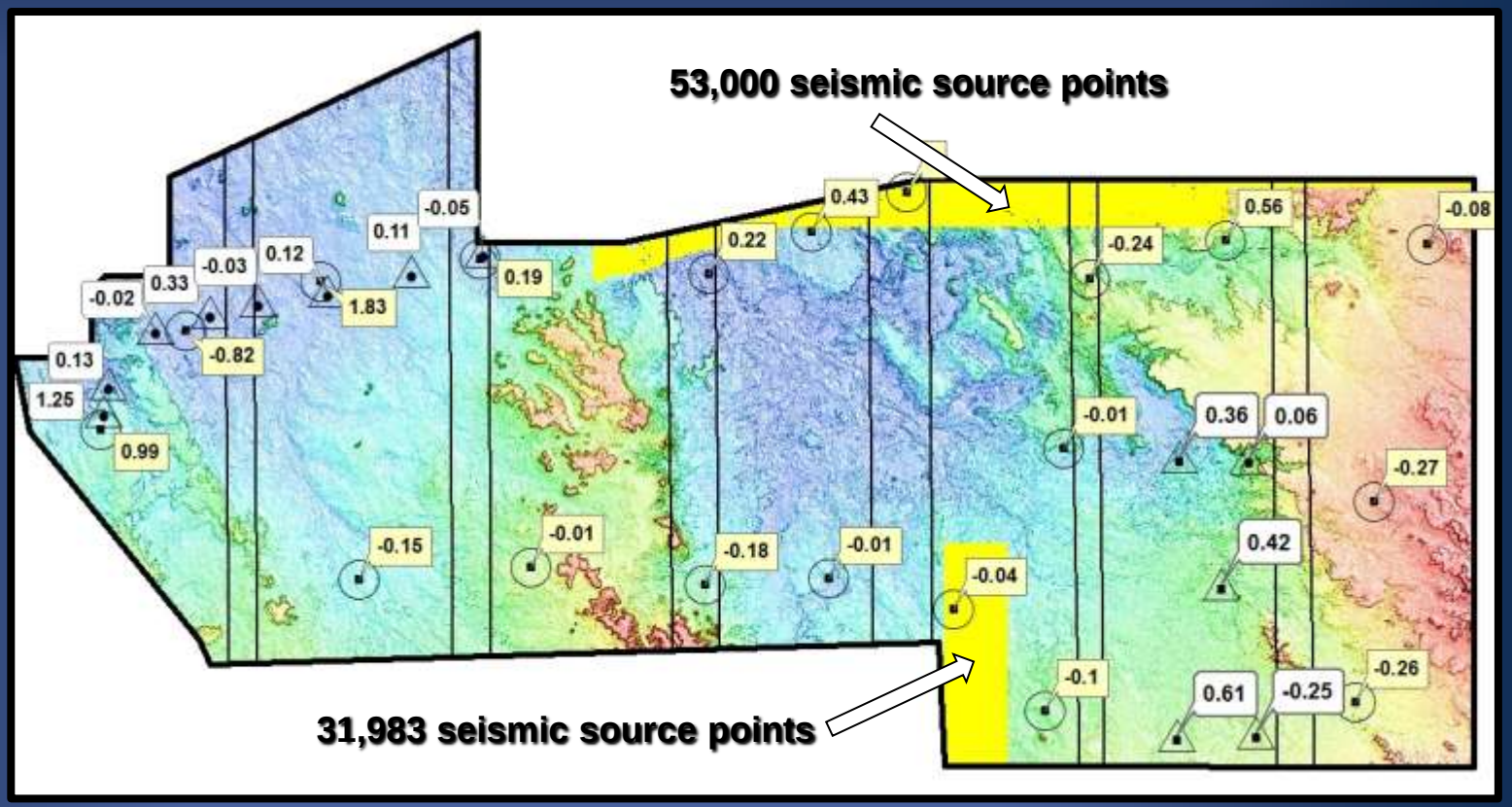
Western Libya satellite topographic mapping

Stereo WorldView-2 and survey control for the stereo satellite elevation mapping project, Ghadames Libya



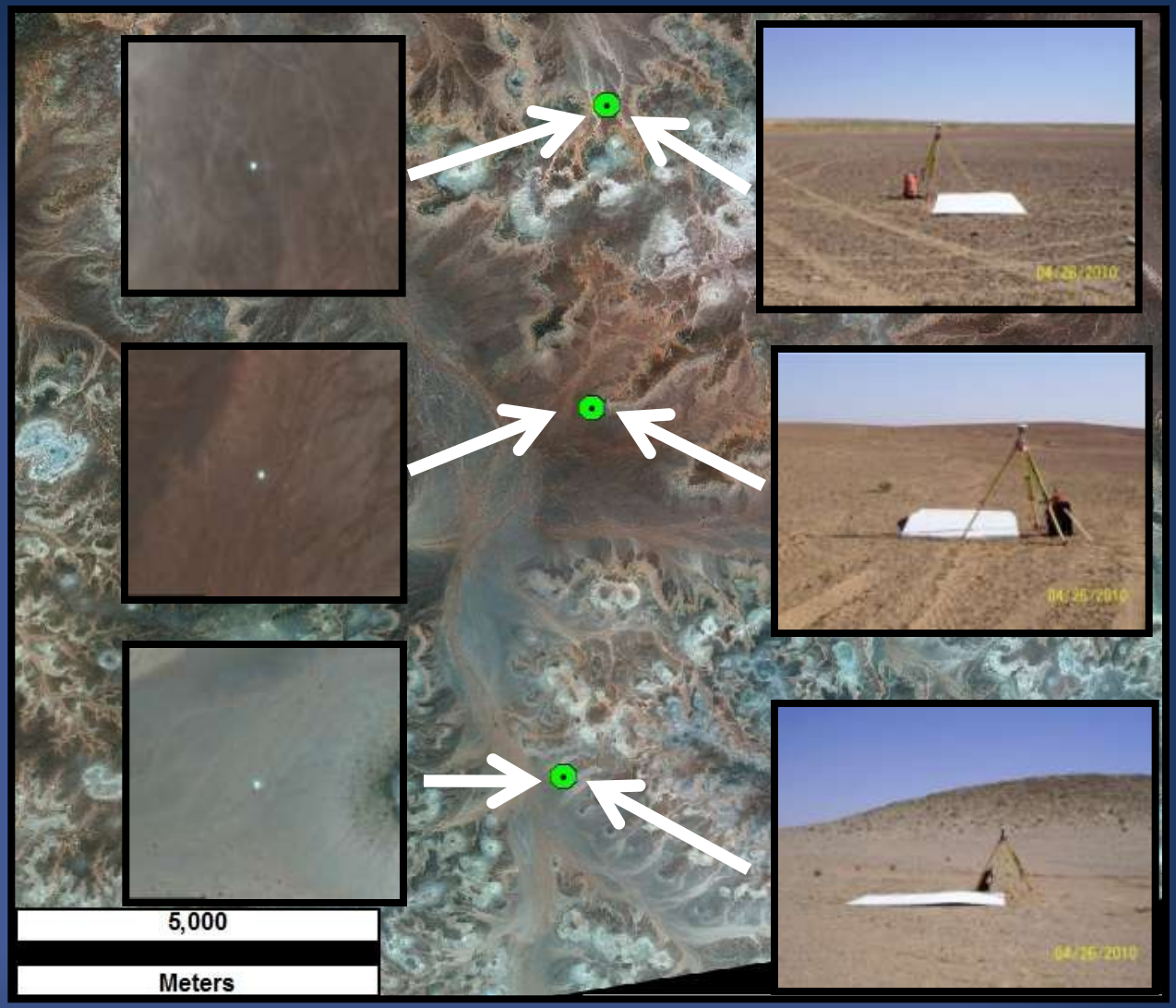
The Stereo WV2 satellite photos that were processed to a 1m DEM. The yellow dots show the initial survey control points. These points were not consistent with the stereo WV2 elevations and were consequently <u>not</u> used to control the elevation processing.





Seismic source points with accurate GPS elevations shown in yellow. The entire 3,962 km2 WV2 elevation mapping project was referenced to the seismic source points. The differences between the survey point elevations and the stereo WV2 elevations are shown in the figure.

1.2m x 2.4m white painted steel sheets were used as ground survey targets.



Three ground survey points were used to reference the stereo satellite elevation mapping.

Seismic sources were vibroseis trucks

Seismic source locations were determined by GPS antennas mounted on the vibroseis trucks. These locations are usually accurate to better than 10cm in X, Y and Z.

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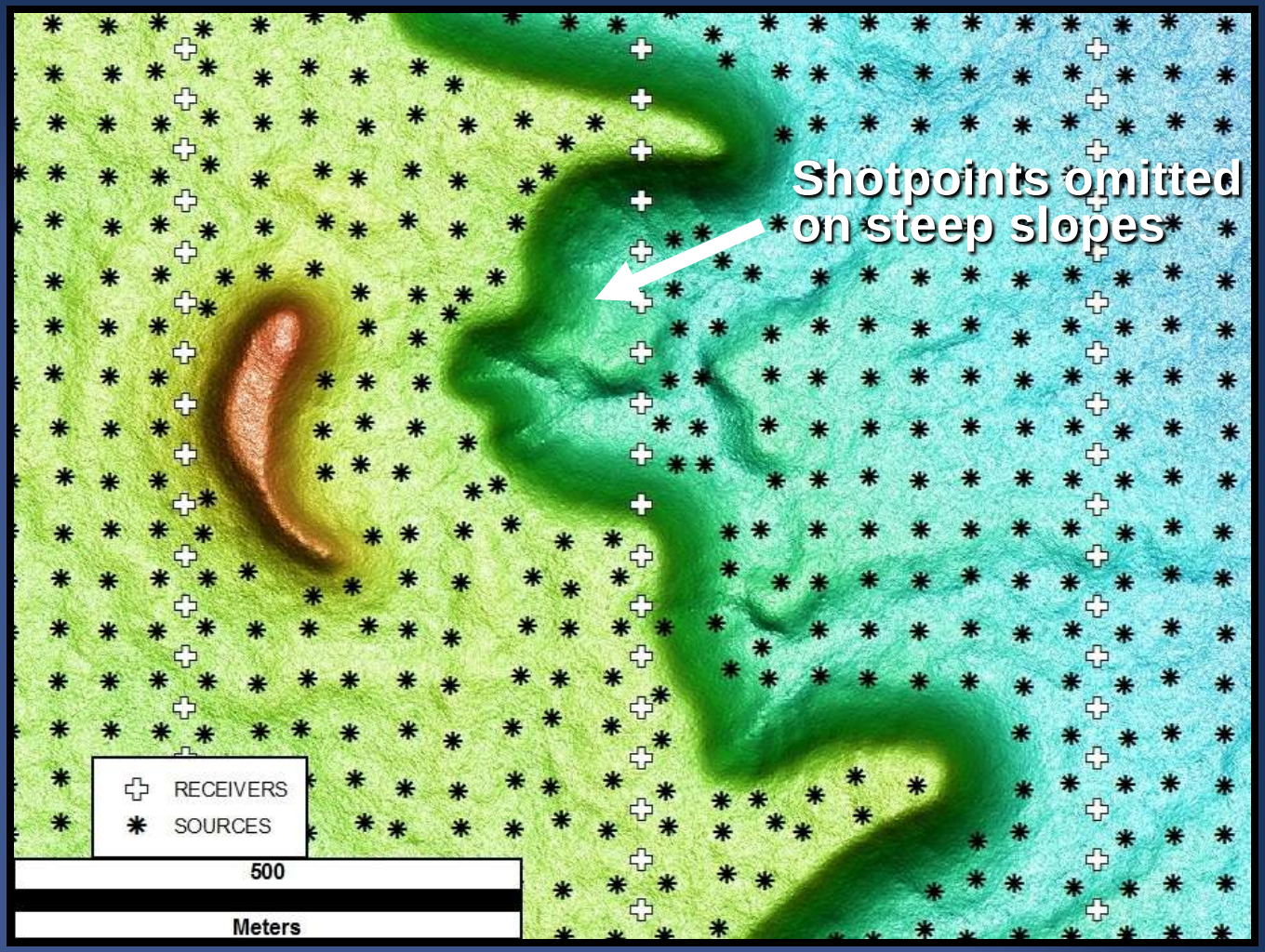
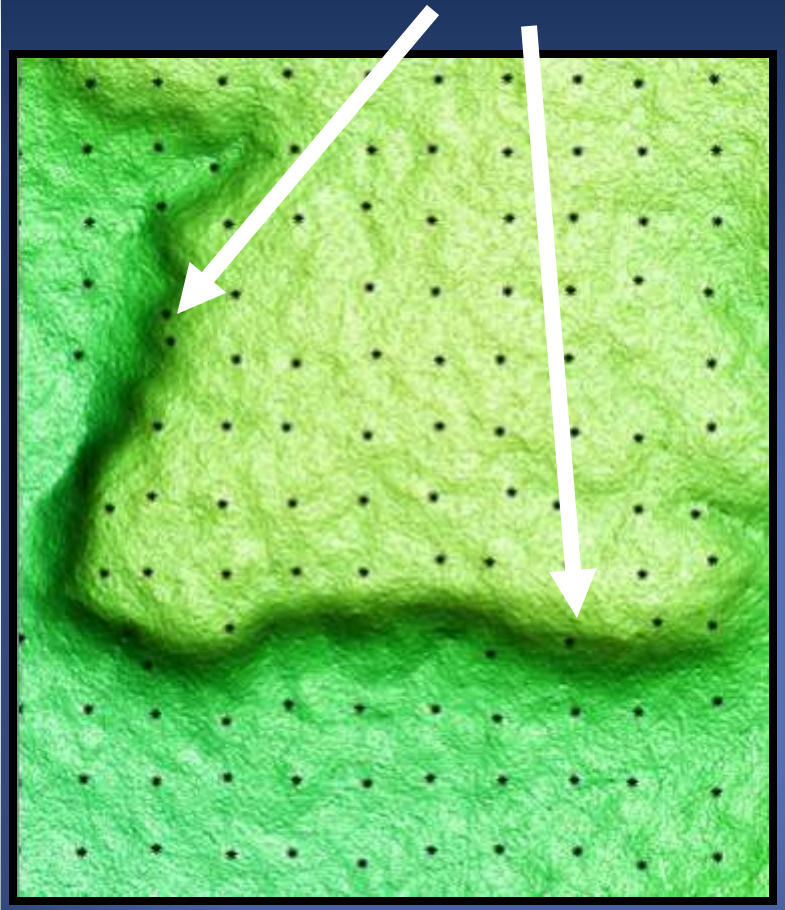
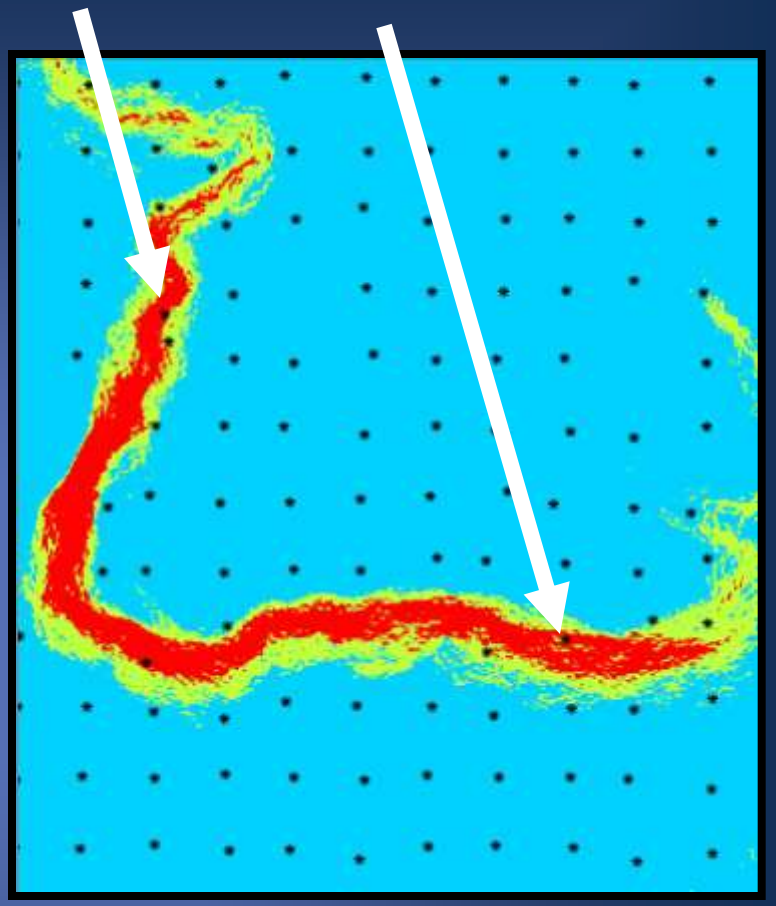


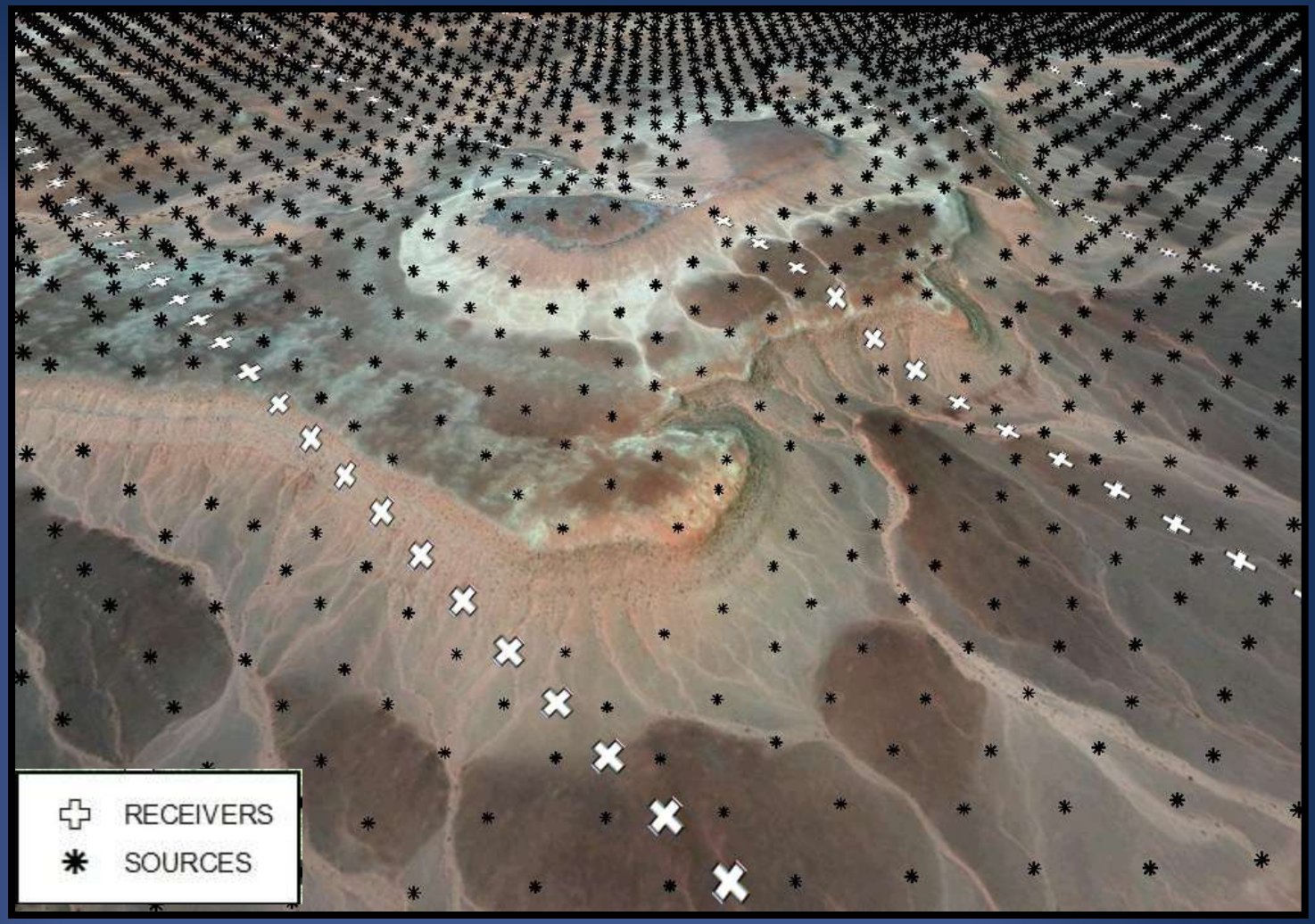
Shotpoints on 50m grid, except on steep slopes
Receiver points on 50m by 450m grid

Shotpoints on steep slopes





Not all shotpoints on steep slopes were omitted. Red = slope > 15% grade. The DEM data was not available for the planning of this seismic survey.

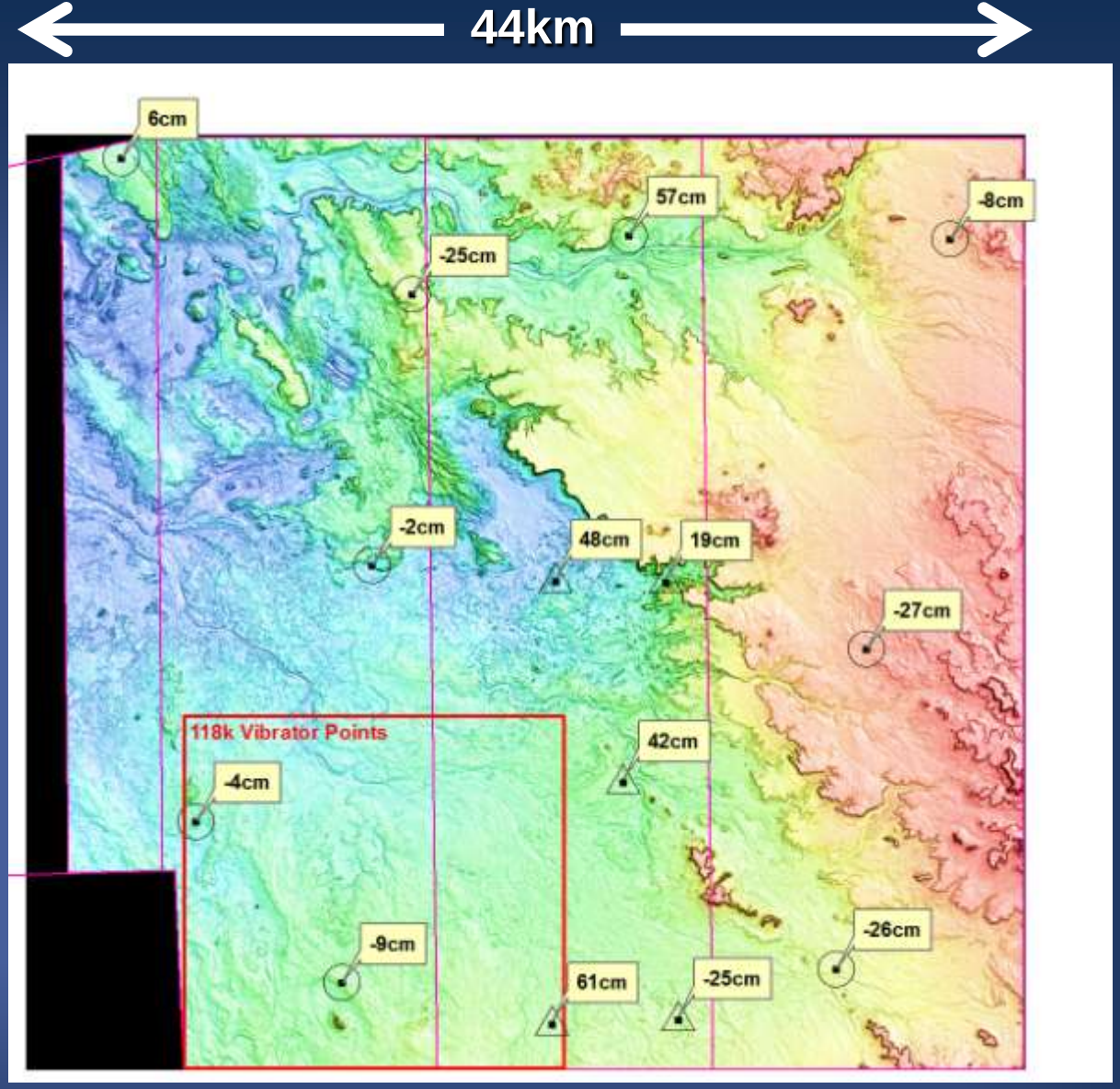


Shotpoints on 50m grid, except on steep slopes
Receiver points on 50m by 450m grid

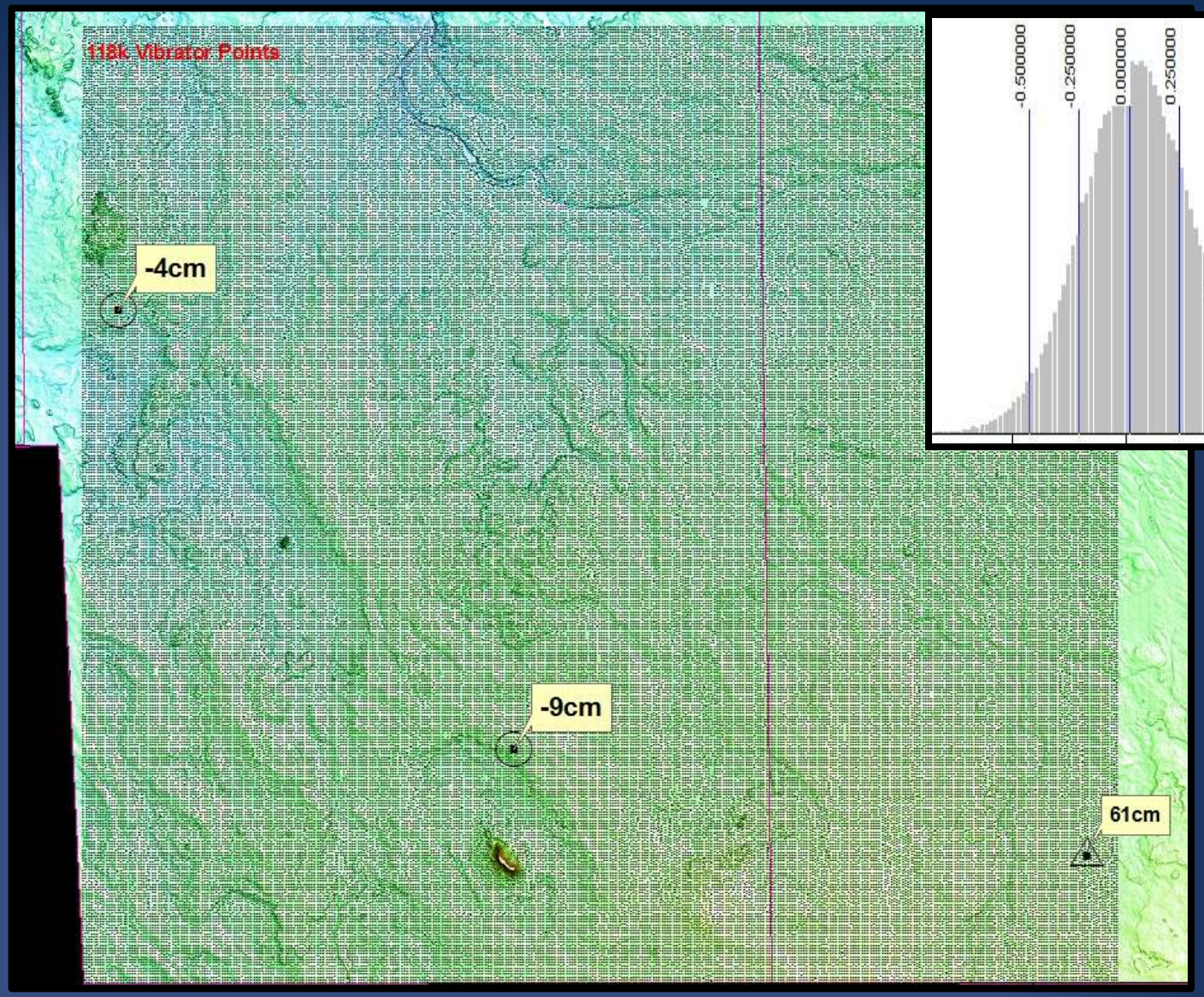
Seismic receivers were Geospace Seismic Recorders. These seismic receivers include GPS antennas. They record their locations to within about 2m in X and Y and 3m in elevation.

Receiver points surveyed with a backpack GPS

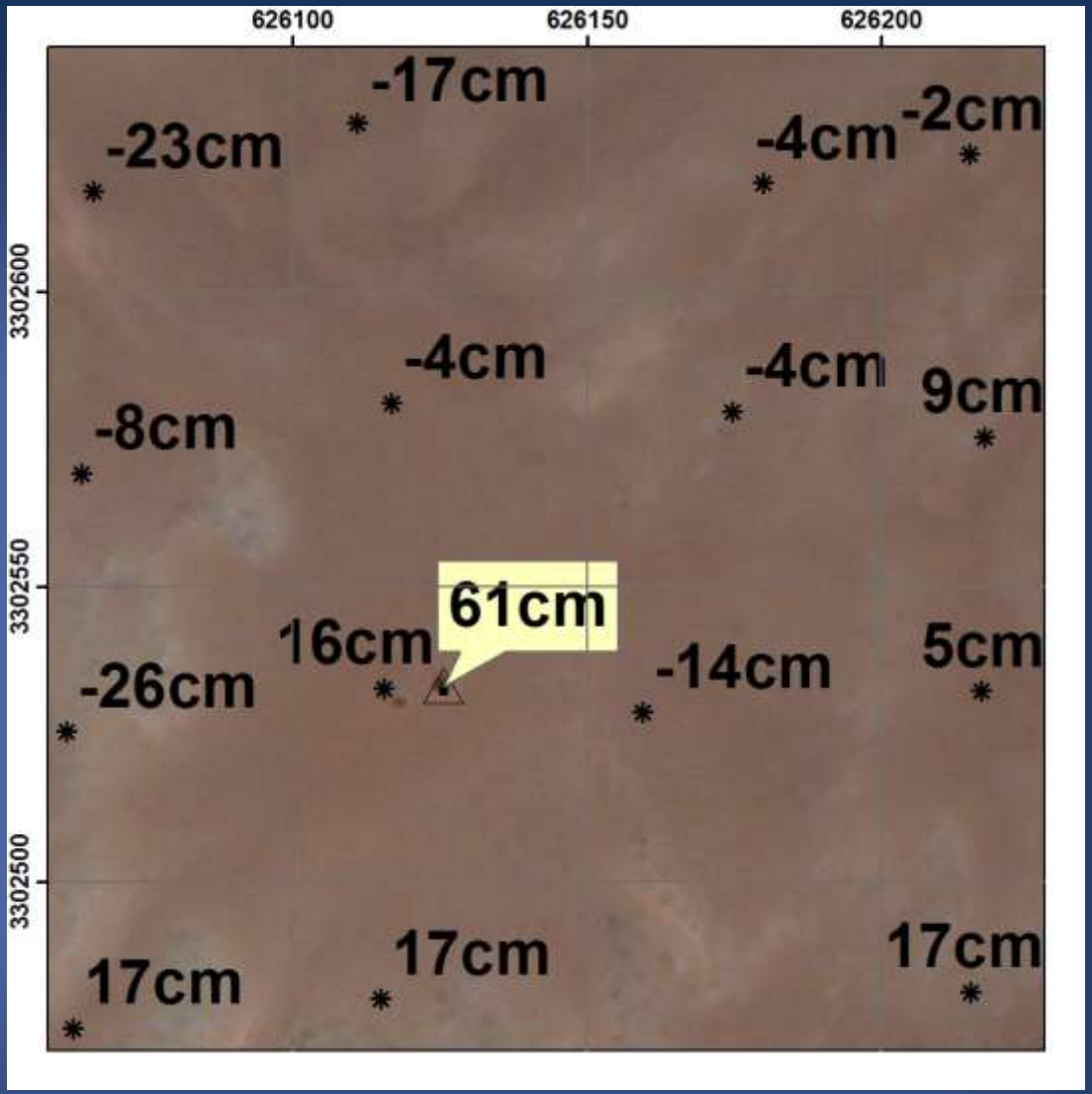
Receiver points surveyed with a backpack GPS



Elevation differences between the eastern stereo satellite DEM and the survey points showing the location of 118,000 seismic source points provided after the DEM was generated.



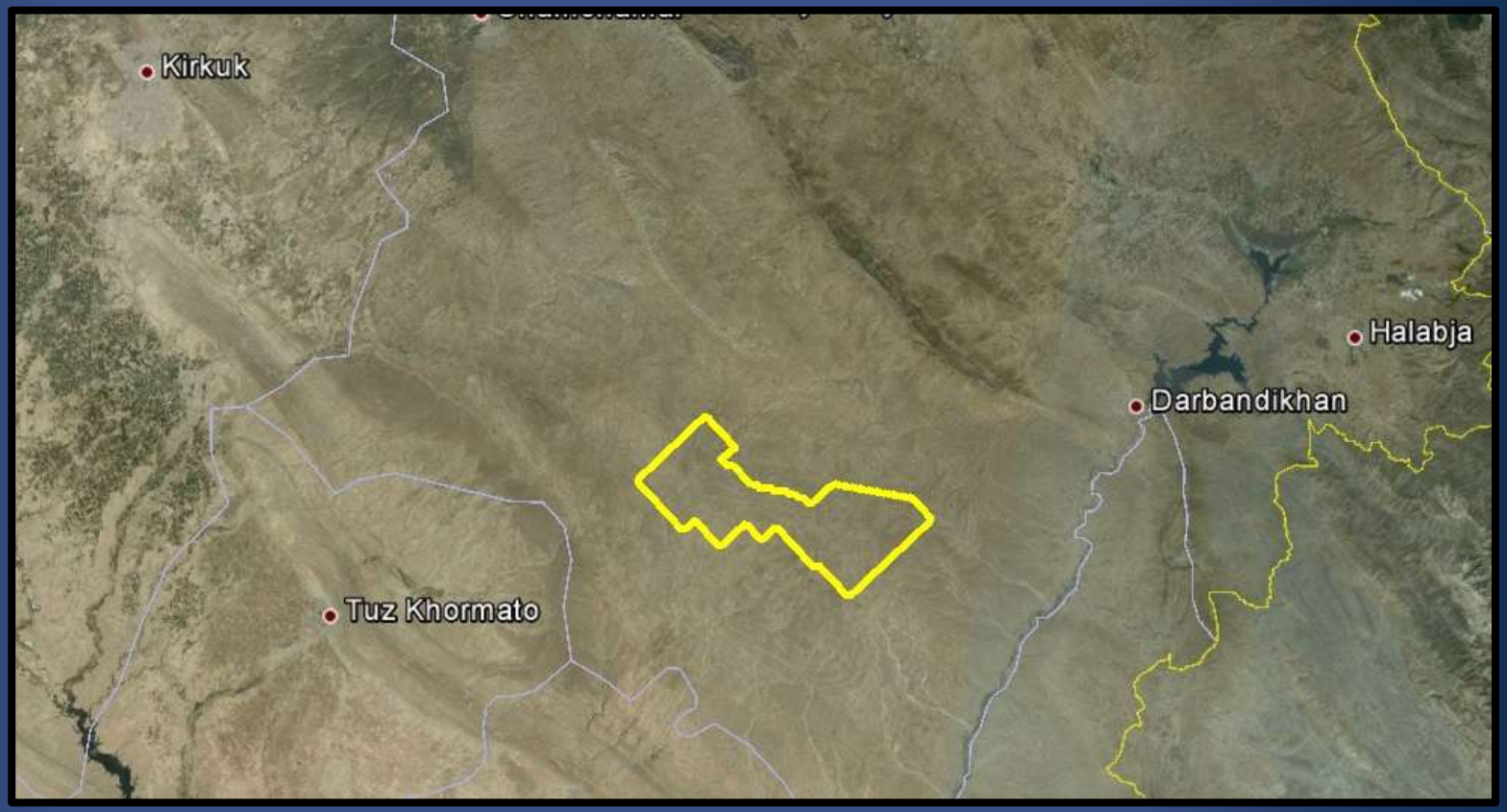
Elevation differences between the 118,000 seismic source points and the stereo satellite elevations; Standard Deviation 28cm. The elevation differences between three of the survey points and the stereo satellite elevations are shown.



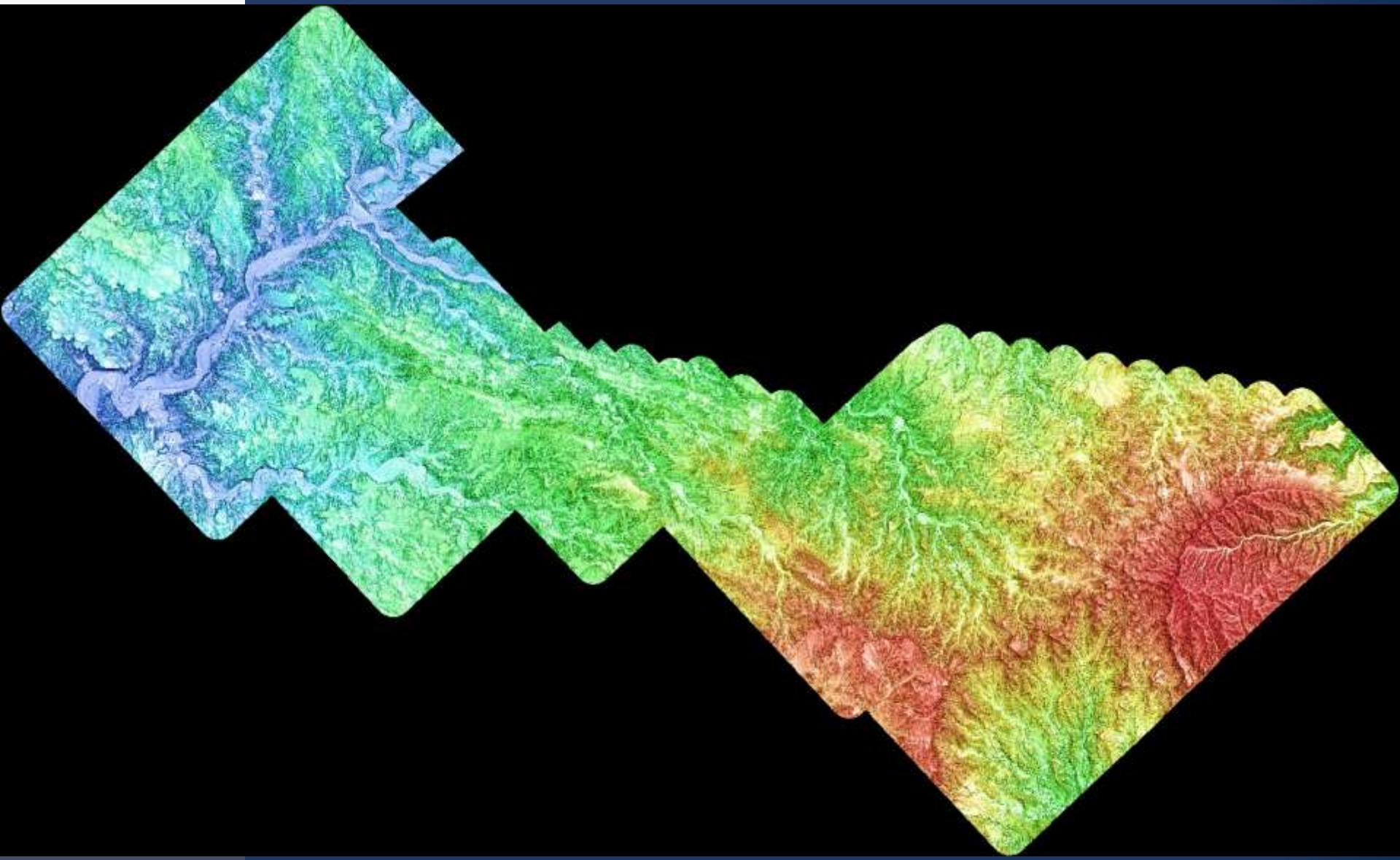
Differences between the source point GPS elevations and the stereo satellite elevations. The 61cm elevation difference for one of the survey points is also shown. The source point GPS elevations match the stereo satellite elevations about 40cm better than does this survey point elevation.

Kurdistan

PhotoSat satellite topographic mapping
North Garmian Project
Kurdistan

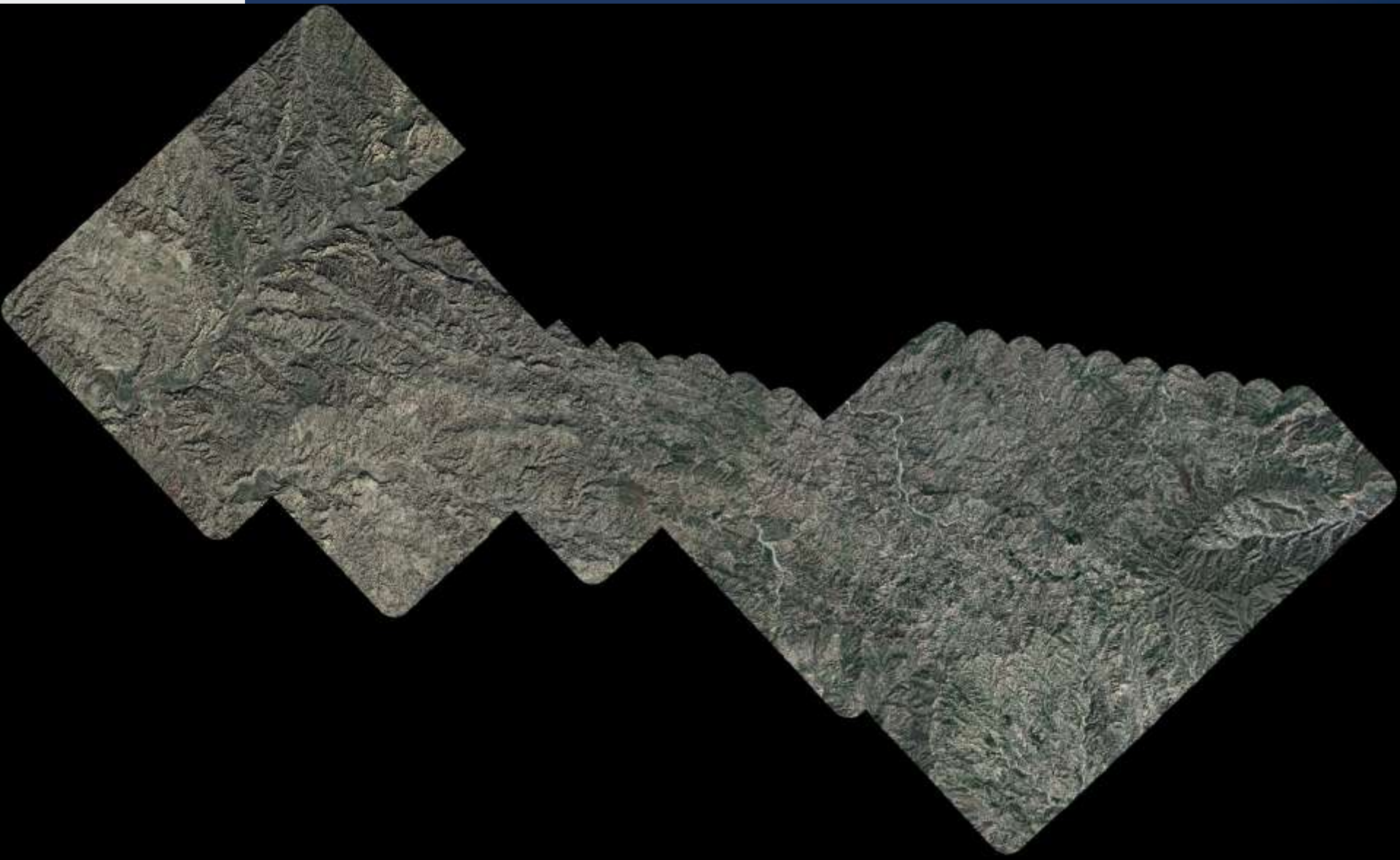


Stereo Satellite Topographic Mapping



North Garmian Project topographic image

Stereo Satellite Topographic Mapping



North Garmian Project stereo Pleiades satellite photos

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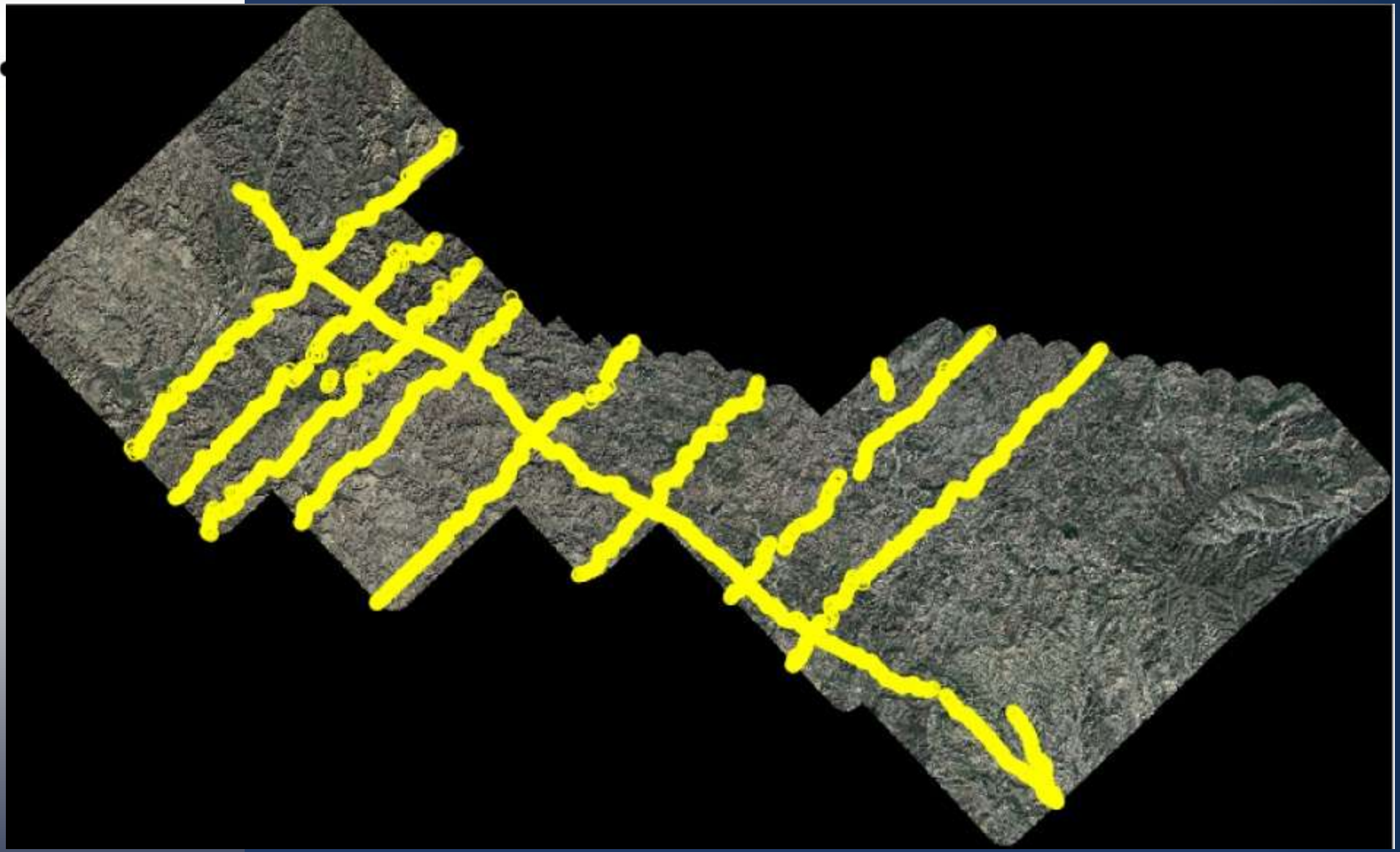
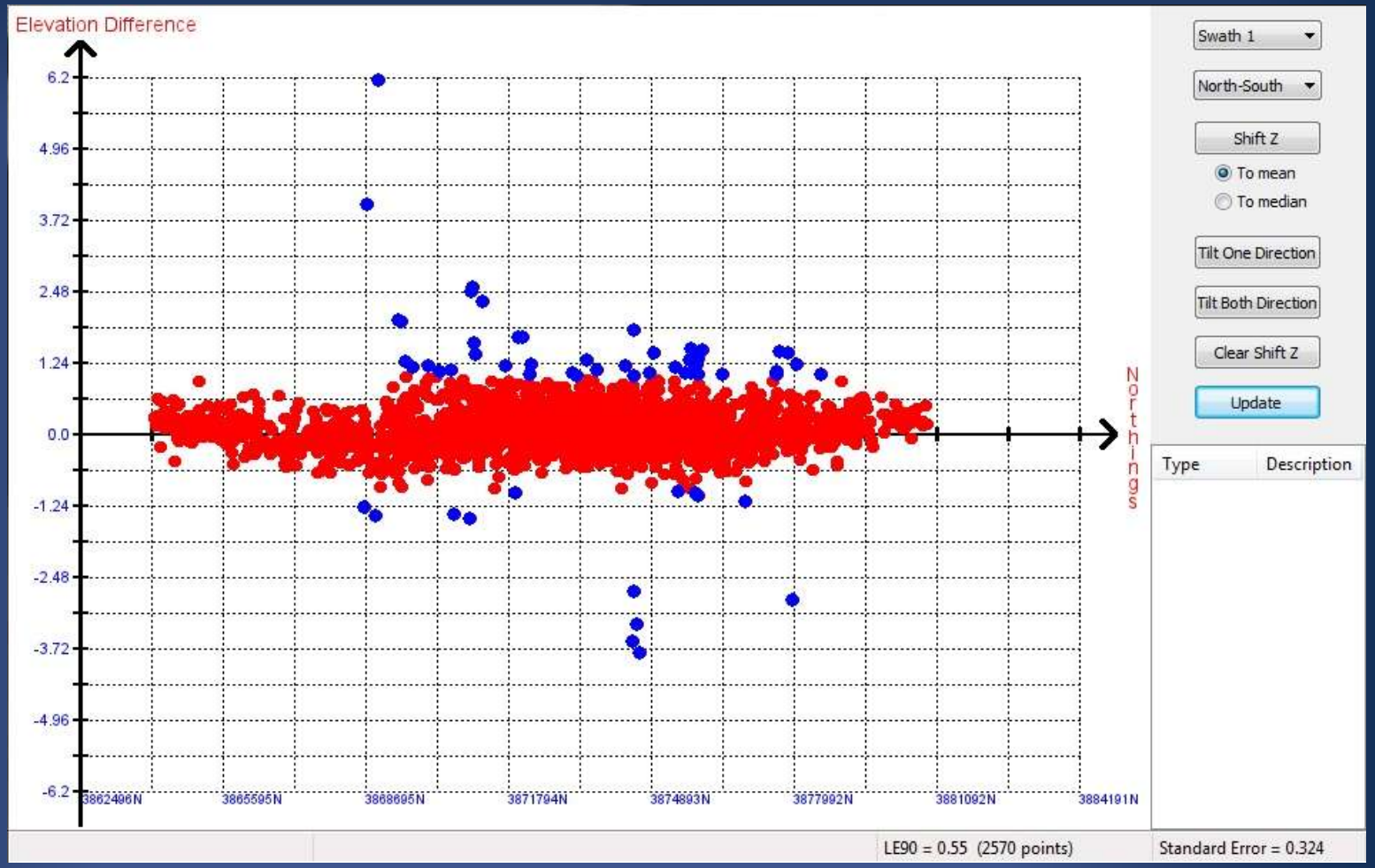
Stereo Satellite Topographic Mapping



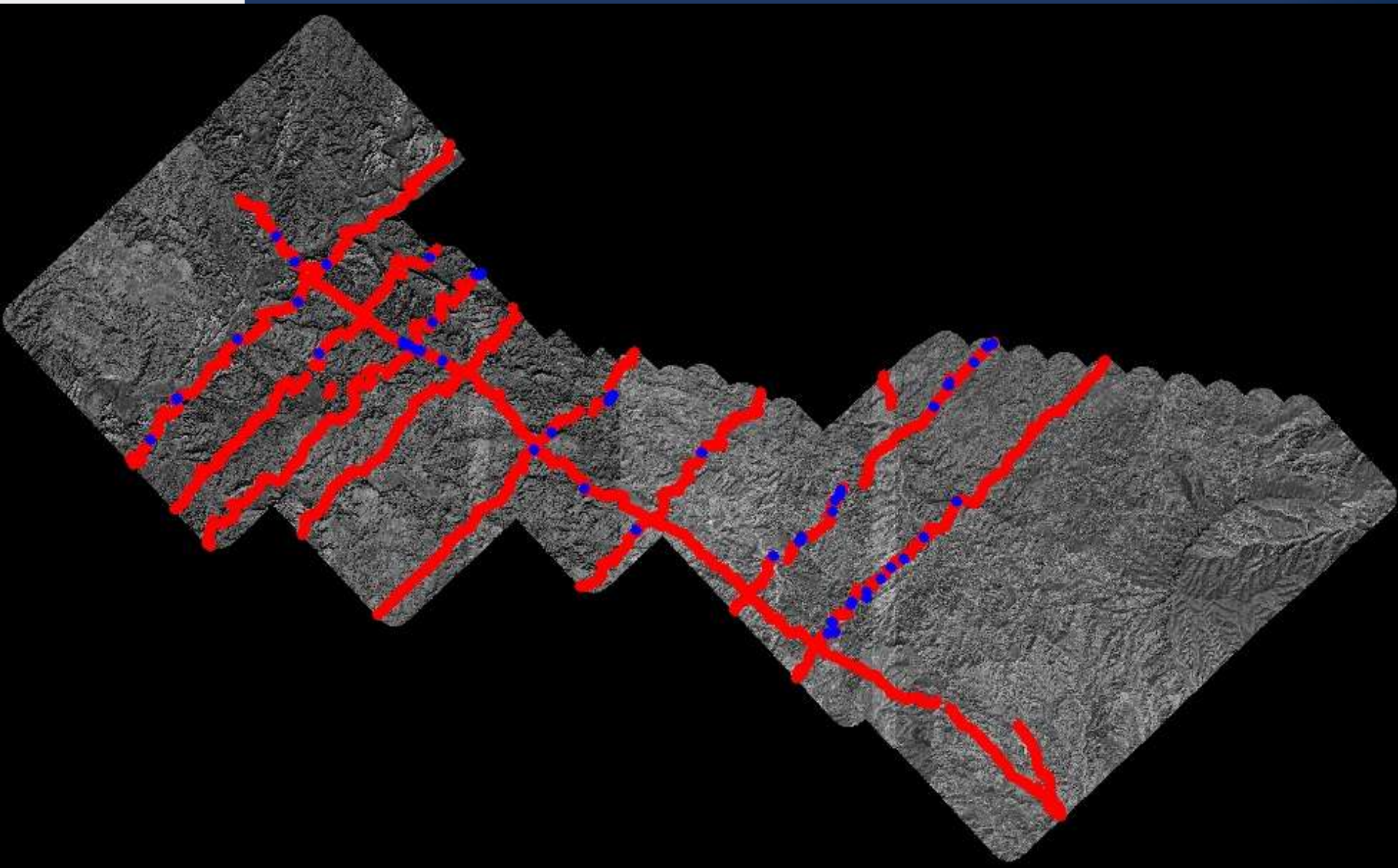
2D seismic source points

Stereo Satellite Topographic Mapping



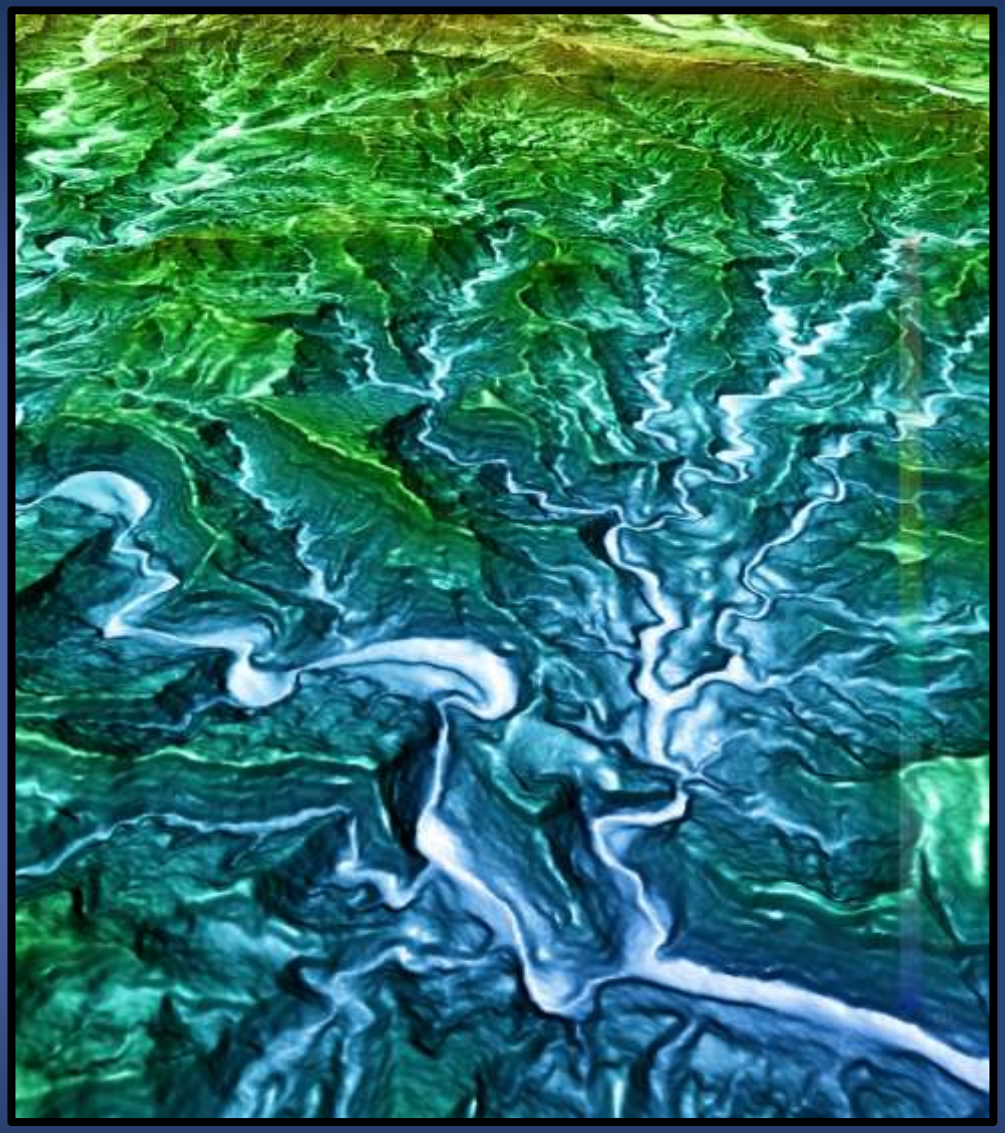
North Garmian Project scatter plot of elevation differences between seismic source points elevations and satellite topography. Standard deviation 34cm.

Stereo Satellite Topographic Mapping



Seismic source points > 1m elevation difference

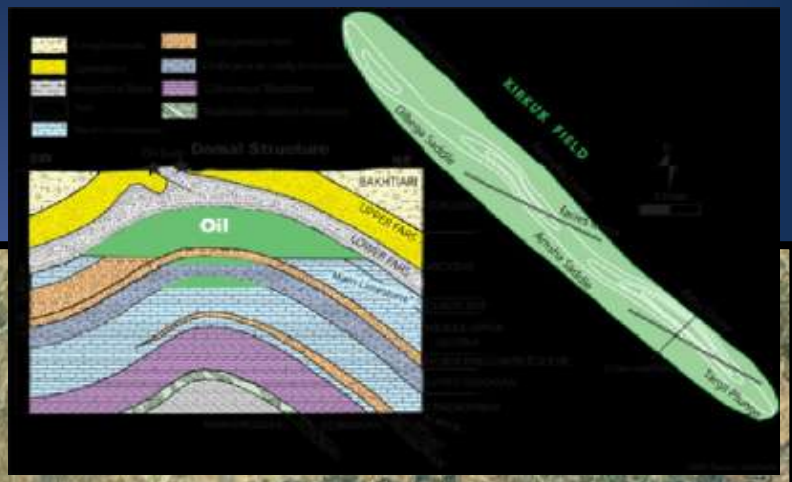
Stereo Satellite Topographic Mapping



3D view of satellite topography.

Northern Iraq

Kirkuk oil field, Kurdistan



Kirkuk oil field

Mapping area

Kirkuk oil field, Kurdistan

Stereo Pleiades Band 143 image

August 2012

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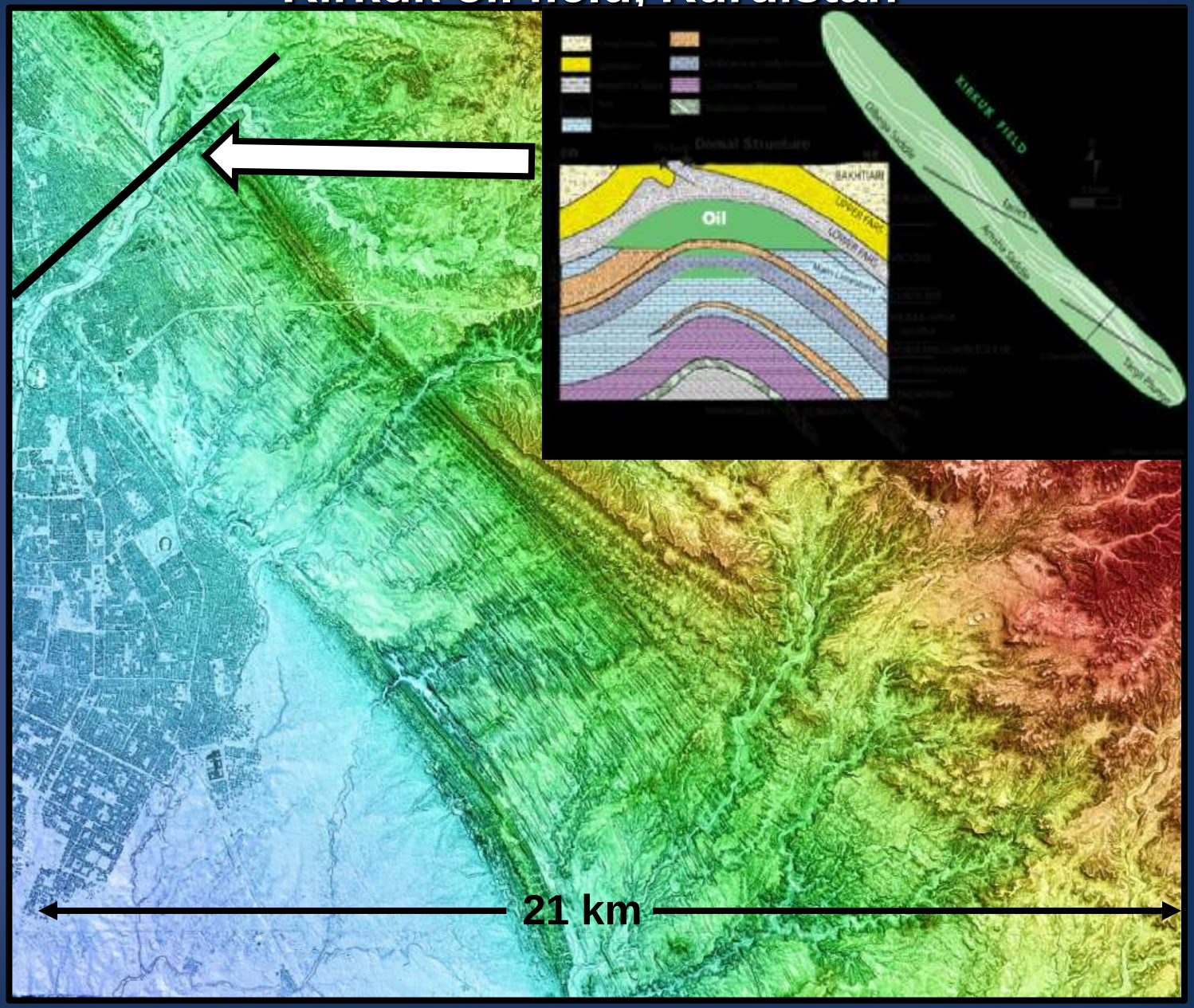
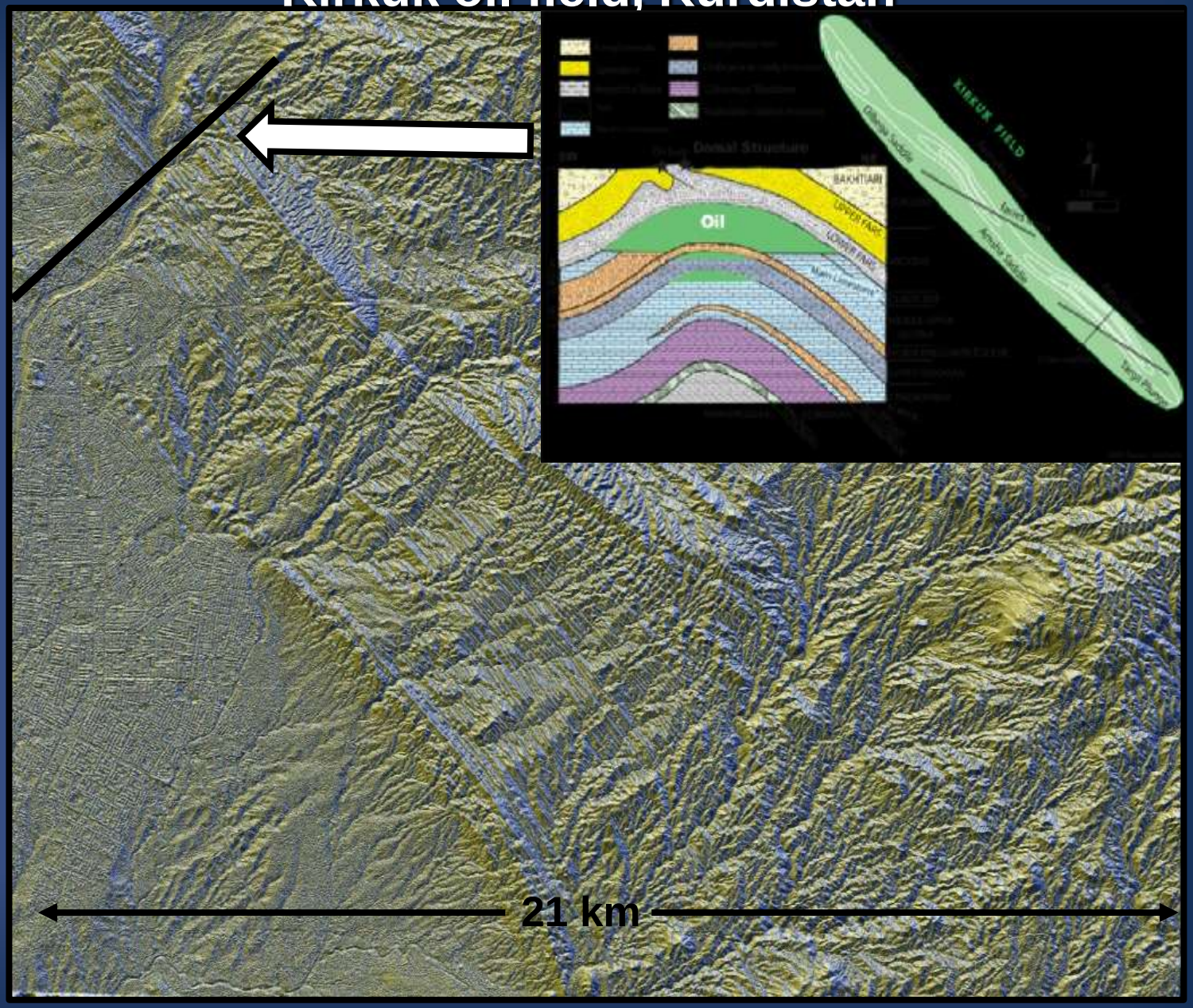
Kirkuk oil field, Kurdistan



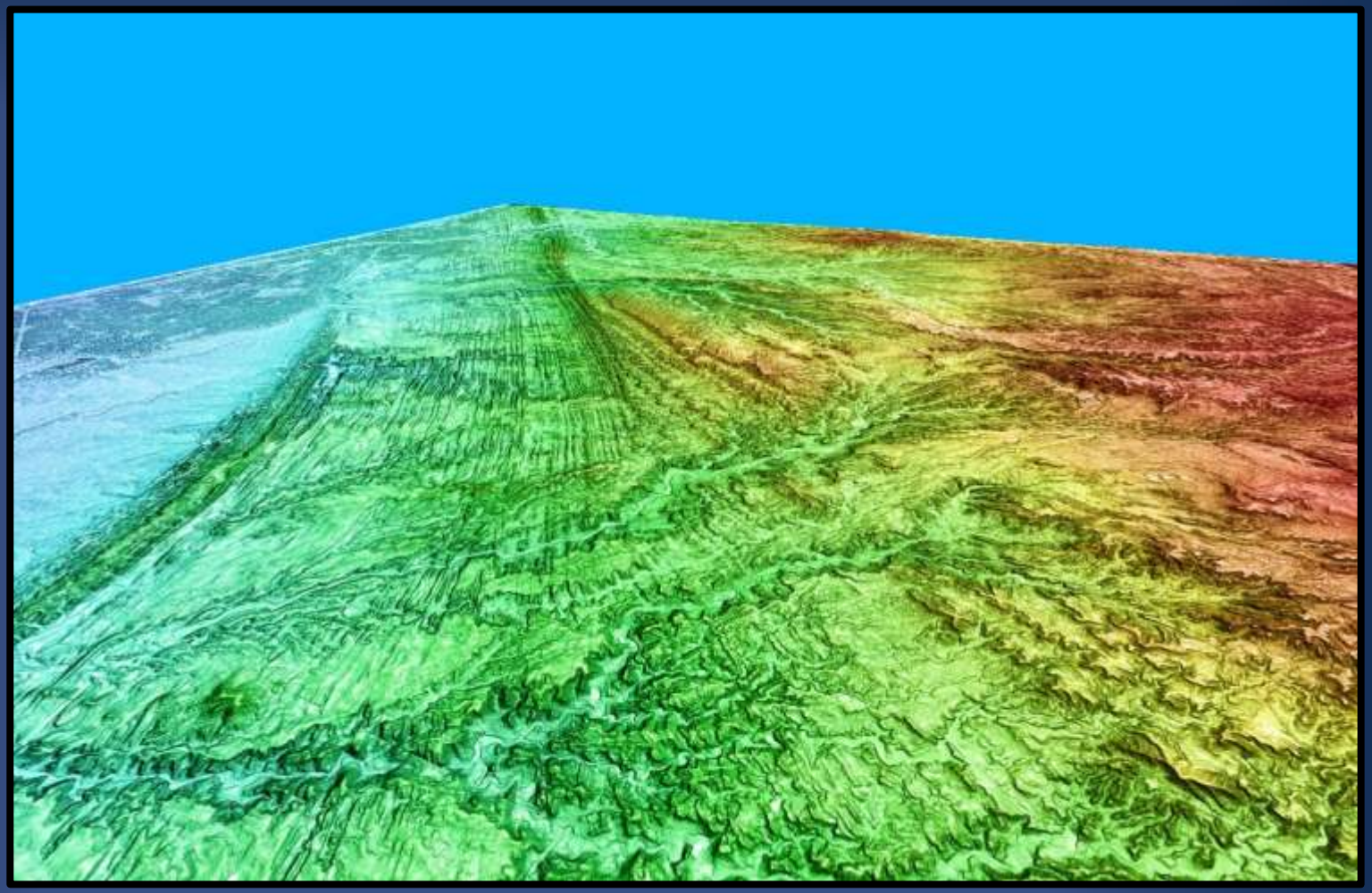
Stereo Pleiades topographic image

Kirkuk oil field, Kurdistan



Stereo Pleiades slope direction image

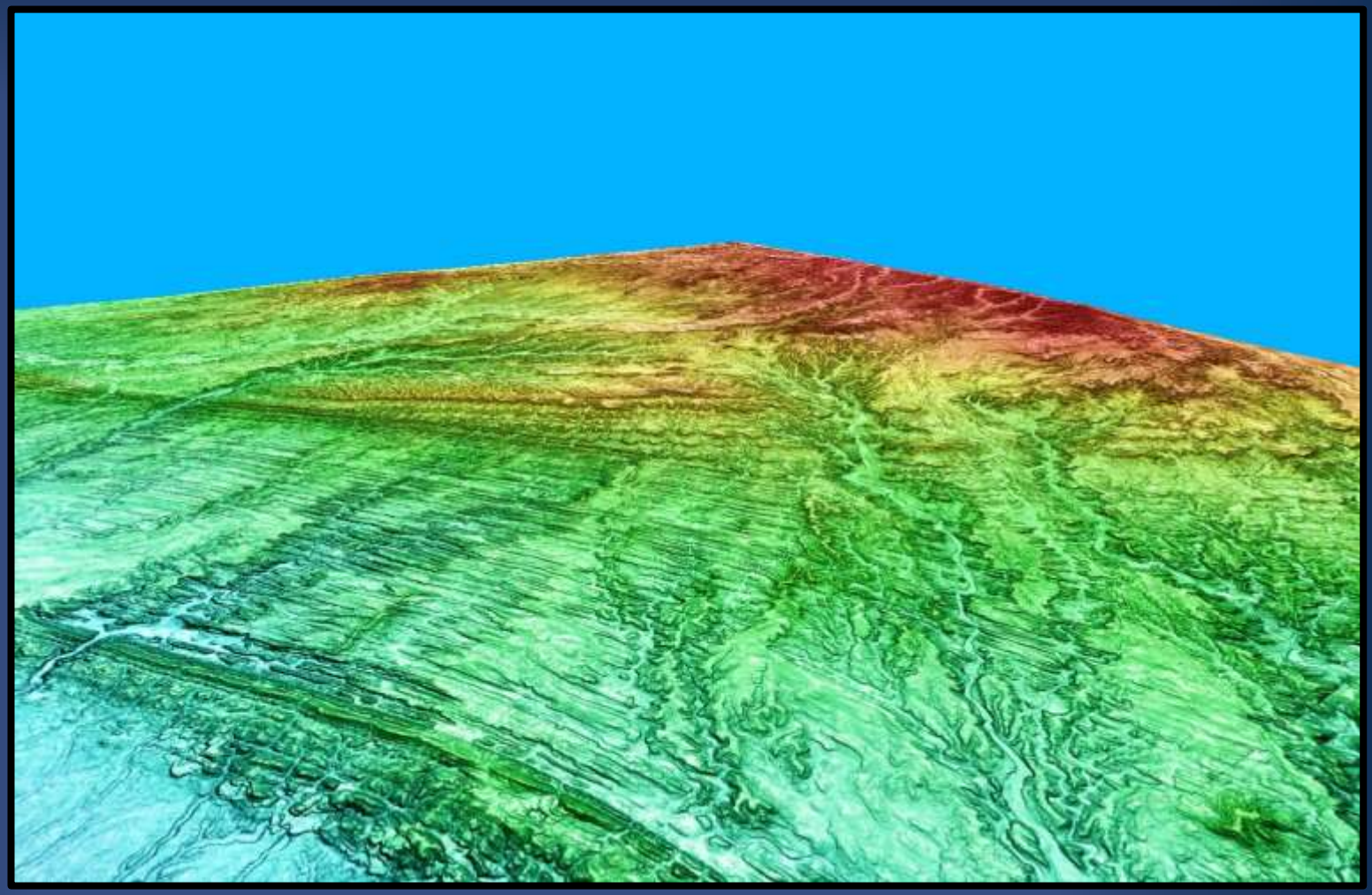
Kirkuk oil field, Kurdistan



Pleiades 3D topographic image

Looking NW

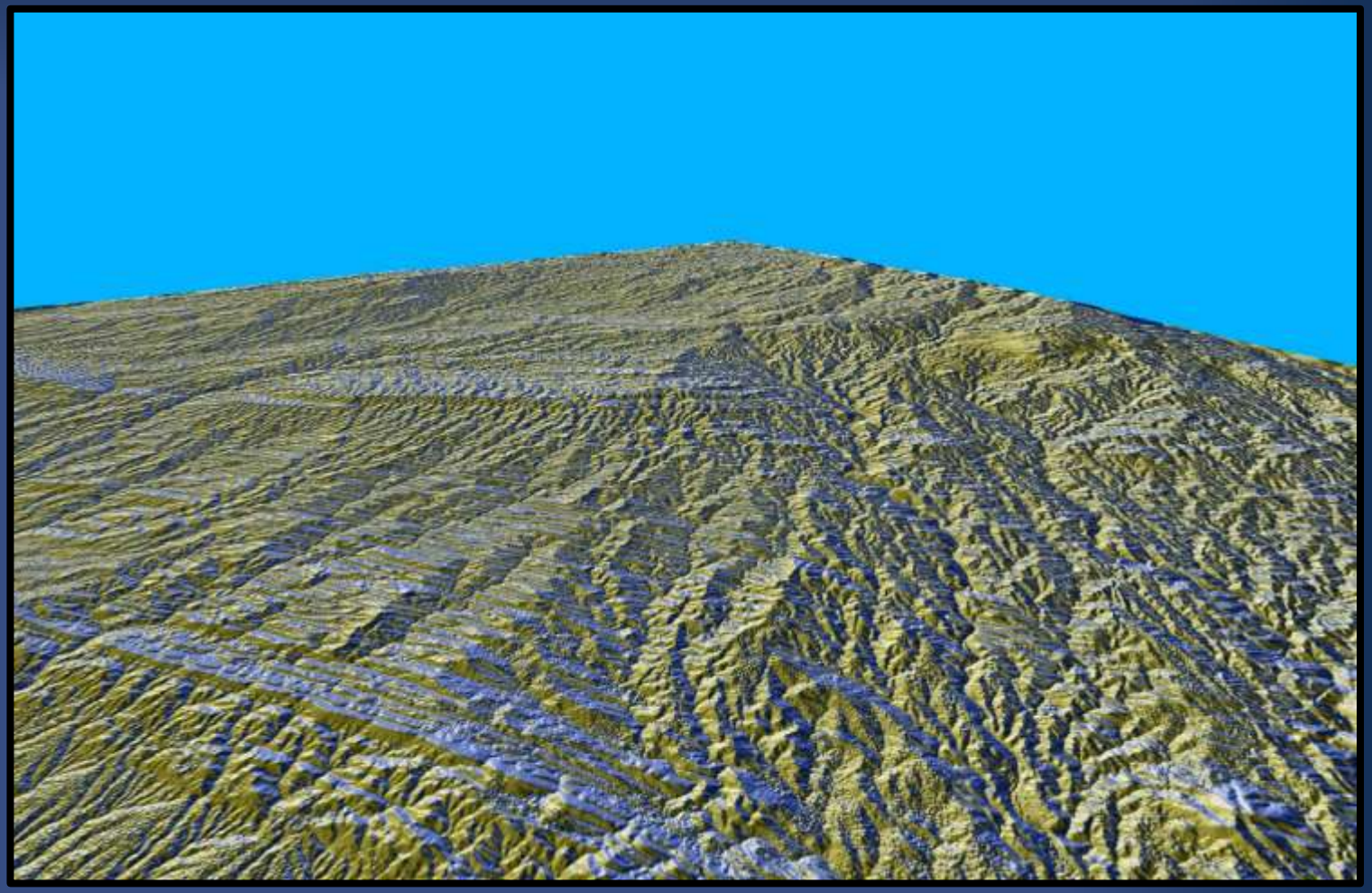
Kirkuk oil field, Kurdistan



Pleiades 3D topographic image

Looking NE

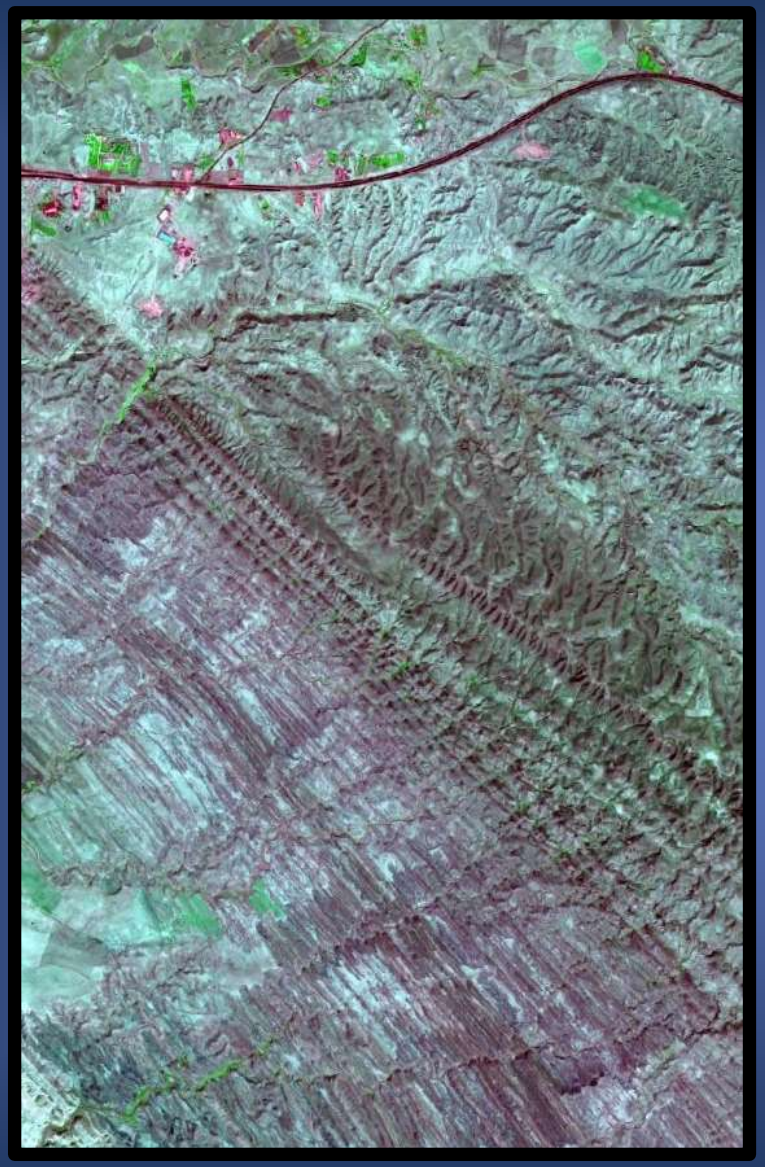
Kirkuk oil field, Kurdistan

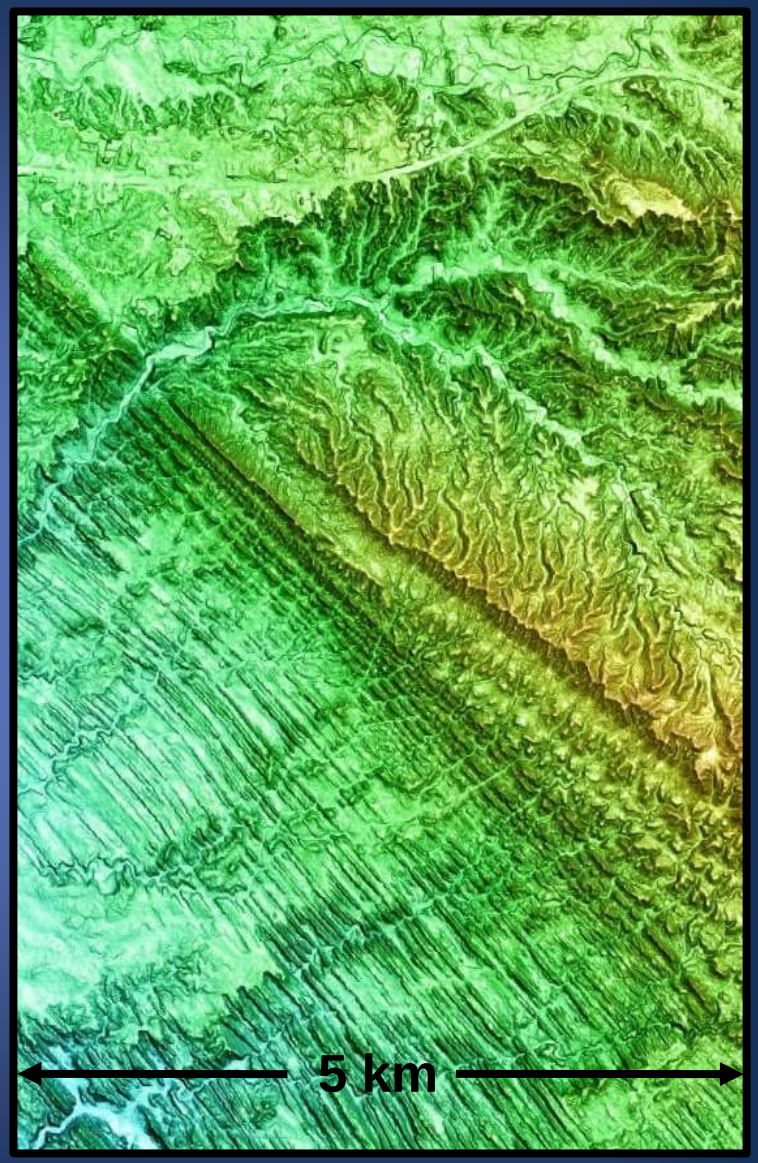


Pleiades 3D direction of slope image

Looking NE

Kirkuk oil field, Kurdistan





Pleiades ortho photo

Pleiades topographic image

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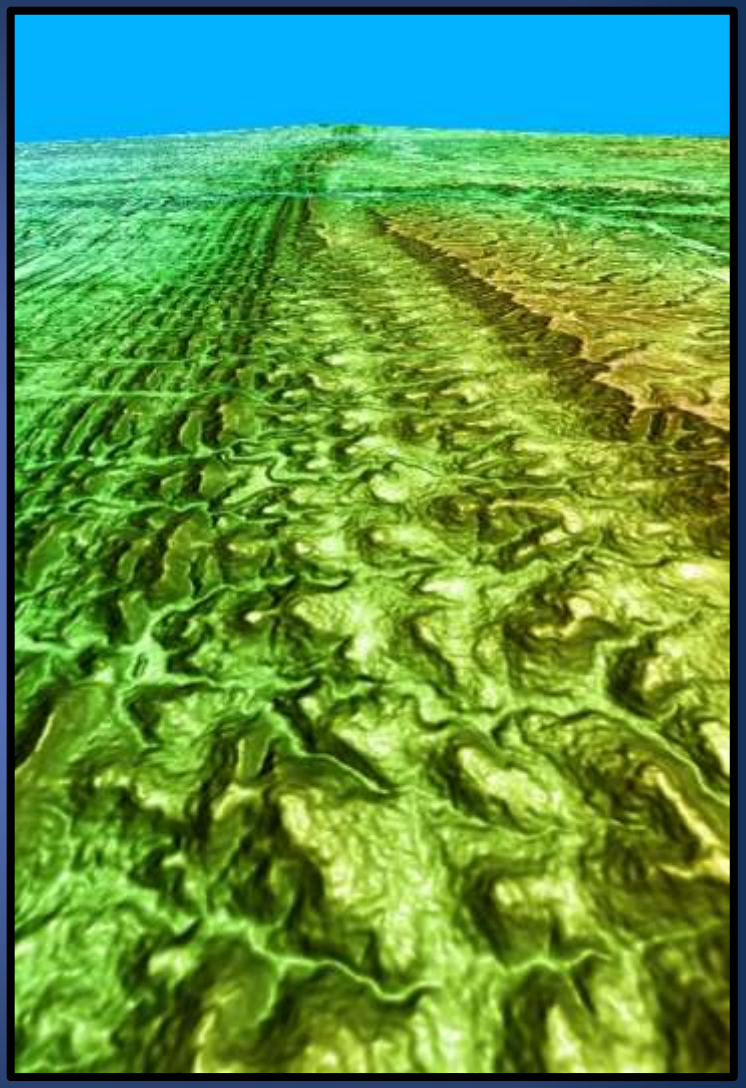
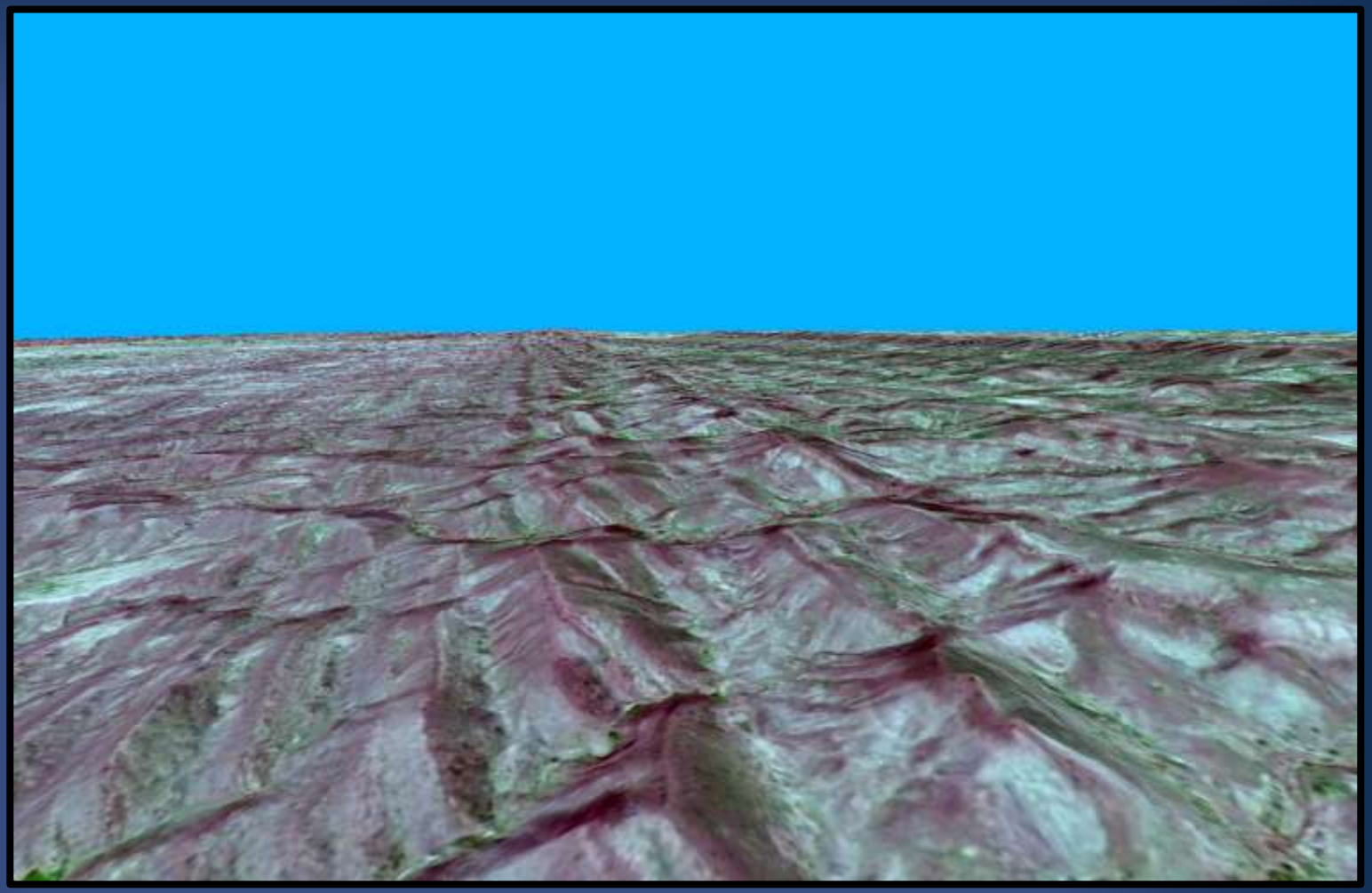
Kirkuk oil field, Kurdistan

Pleiades ortho photo

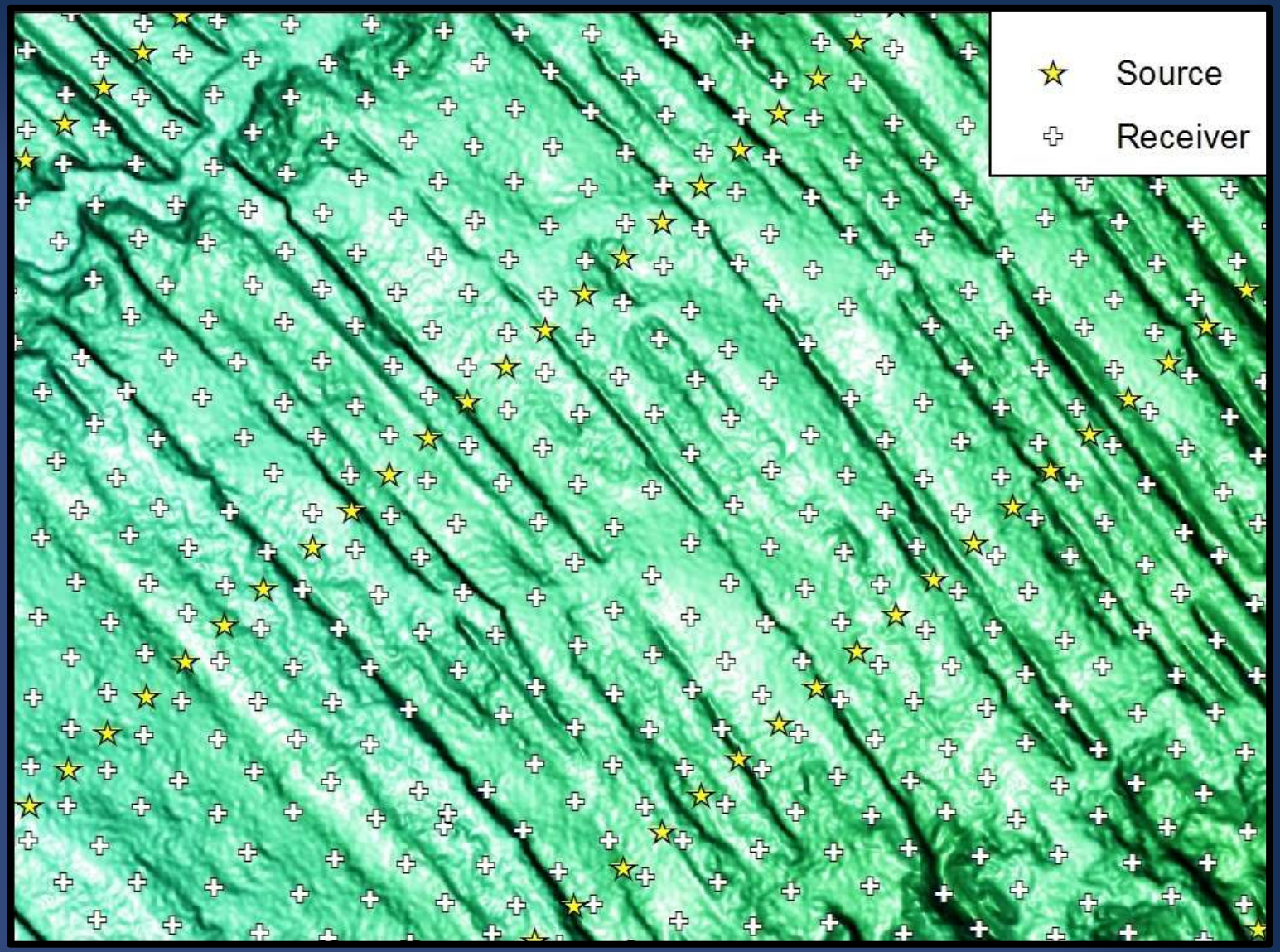


Pleiades elevation image

Kirkuk oil field, Kurdistan



Pleiades 3D ortho photo



Proposed 3D seismic survey plotted over a satellite topographic image

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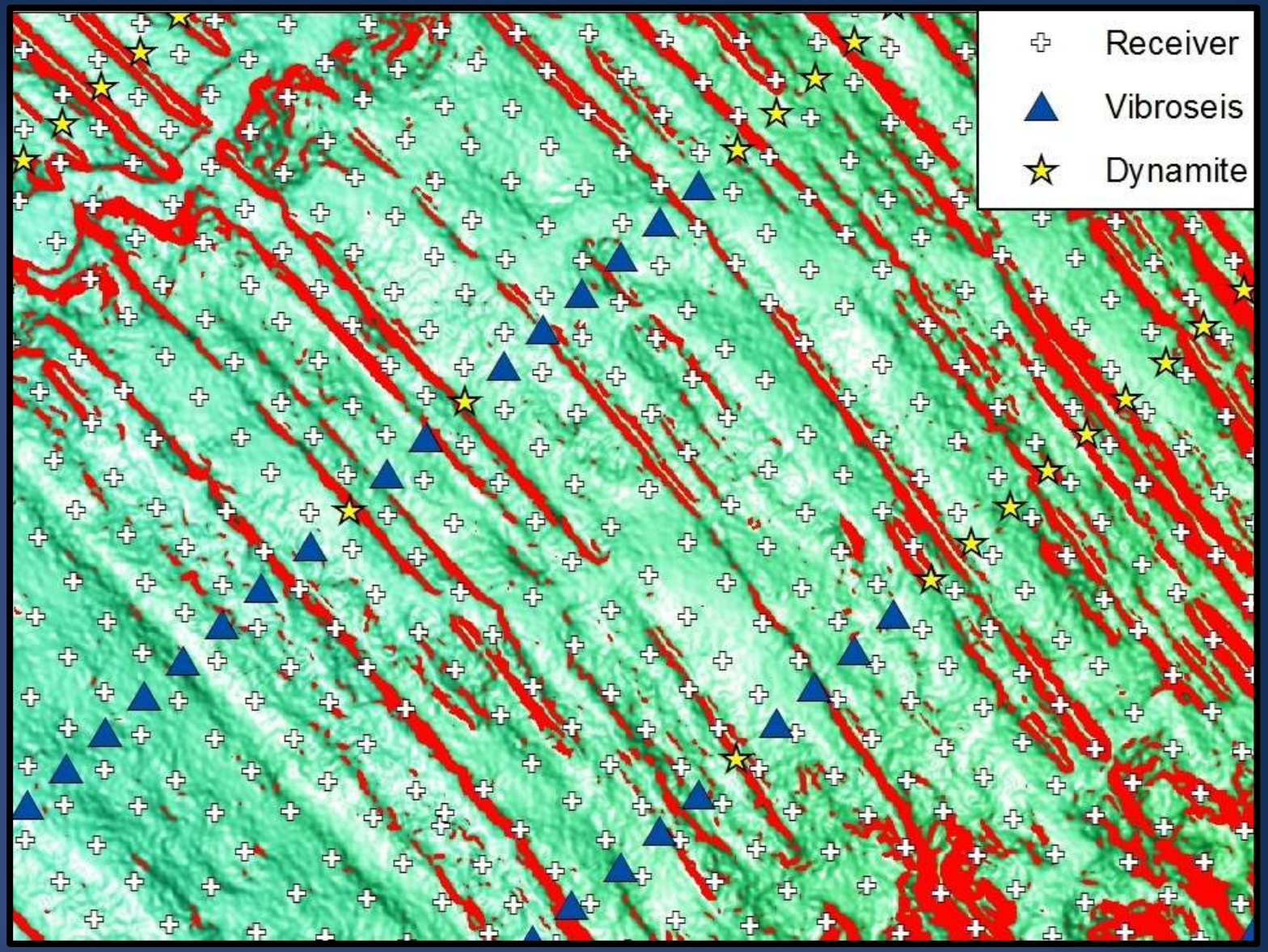
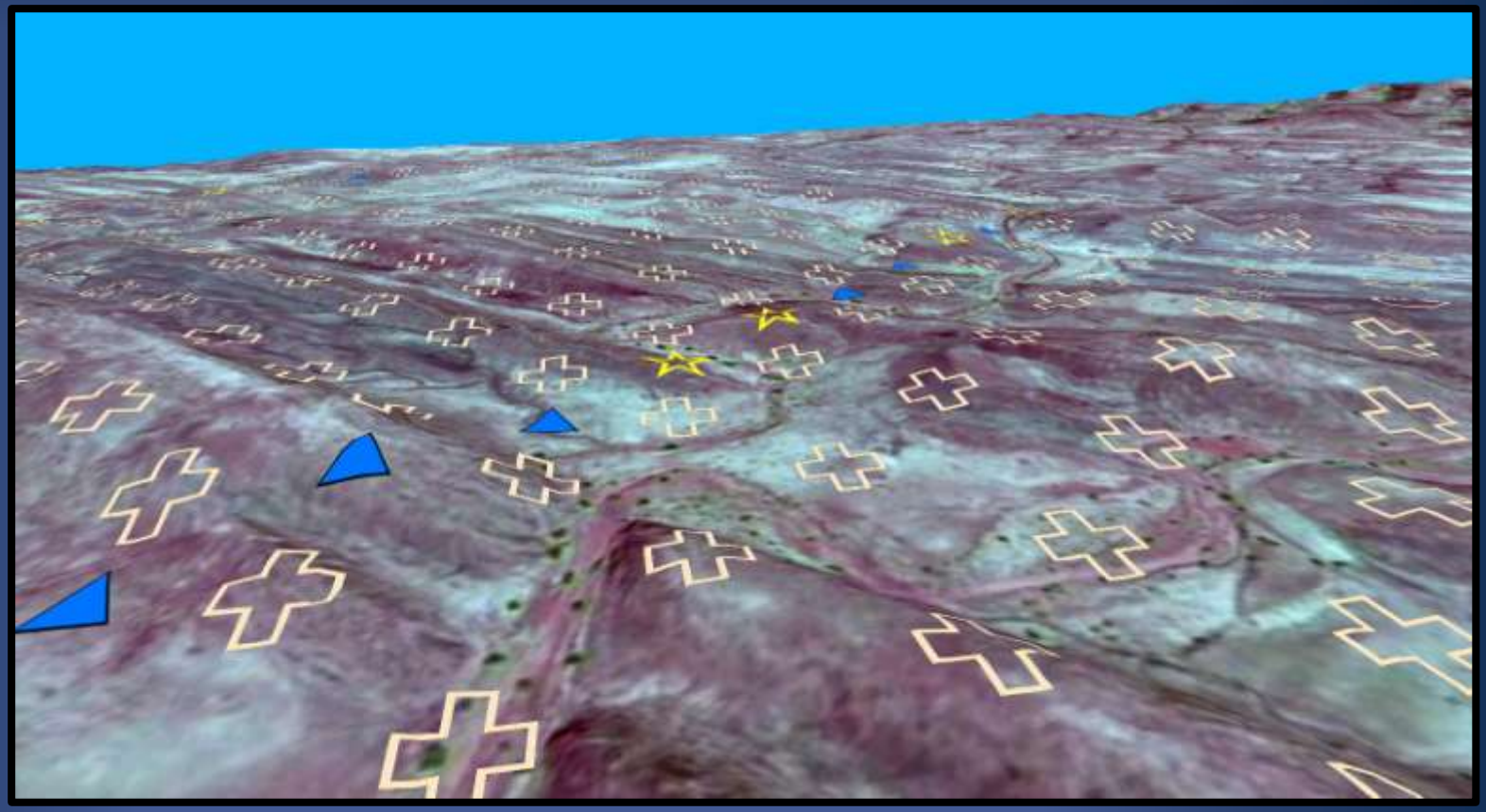


Proposed 3D survey seismic source types

Red areas: slopes > 15% grade



Proposed 3D survey seismic source types

Improved Seismic Safety

Advance scouting reduced by ~ 80%

The stereo satellite DEM and imagery gives an accurate enough picture so that only a few areas require field visits in advance, to identify inaccessible source-points and to plan for efficient disposition of the vibrator trucks, reducing the number of project personnel days.

Safer Vibroseis operations

Accurate maps of the ground slope enable mapping of no-go zones for the vibrator trucks, lessening the risk of overturning the trucks on steep inclines.

Fewer surveyor field days

Combined with Seismic Recorders with built in GPS receivers, the stereo satellite elevation mapping can eliminate surveying of the seismic receiver elevations.

Improved Seismic Quality

The stereo satellite DEM provides the necessary source and receiver location elevation accuracy for seismic processing.

The stereo satellite DEM can be used to quality control the source and receiver elevations and eliminate the need for additional surveying.

Source-points are surveyed using GPS systems mounted on the vibrator trucks. Elevation accuracy can be poor during GPS start up and during times of low GPS satellite visibility.

For seismic receivers with GPS antennas the stereo satellite DEM eliminates the need for any surveying of the receiver elevations.