AUTOMATING FAULT CHARACTERIZATION AND FEATURES EXTRACTION FROM 3D SEISMIC DATA FOR UNDERGROUND MINE PLANNING

Stano Hroncek[1], Gary Fallon[2], Peter Chern[3], Jim Dirstein[4], Alistair Stanley[4]

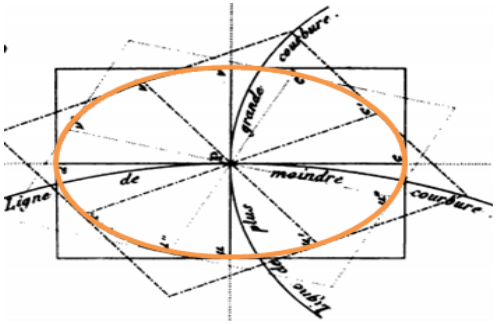
1. Geoproxima Pty Ltd (www.geoproxima.com.au)
2. Geophysical Resources and Services Pty Ltd (www.consultgrs.com.au)
3. Idemitsu Australia Resources Pty Ltd (www.idemitsu.com.au)
4. Total Depth Pty Ltd (www.totaldepth.com.au)

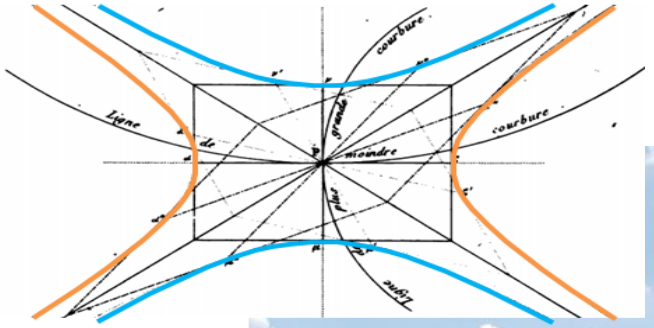
MORPHOMETRY

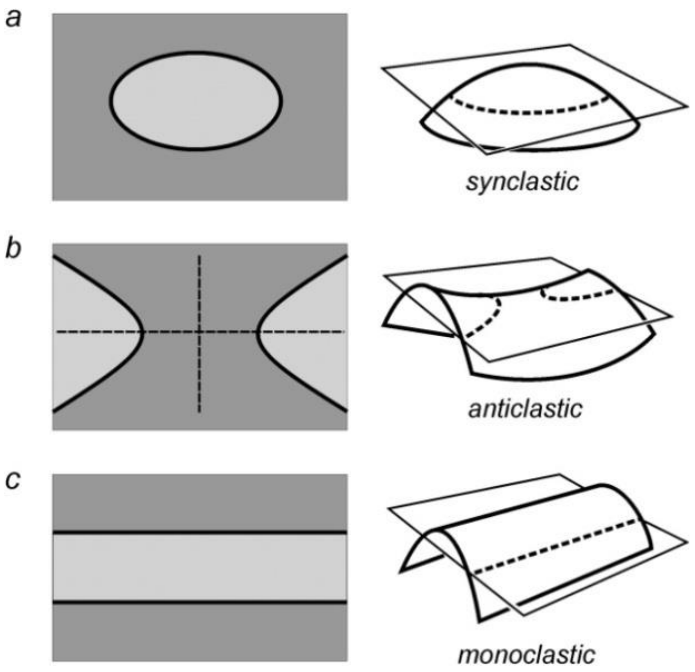
Morphometry of a surface is defined by differential geometry.

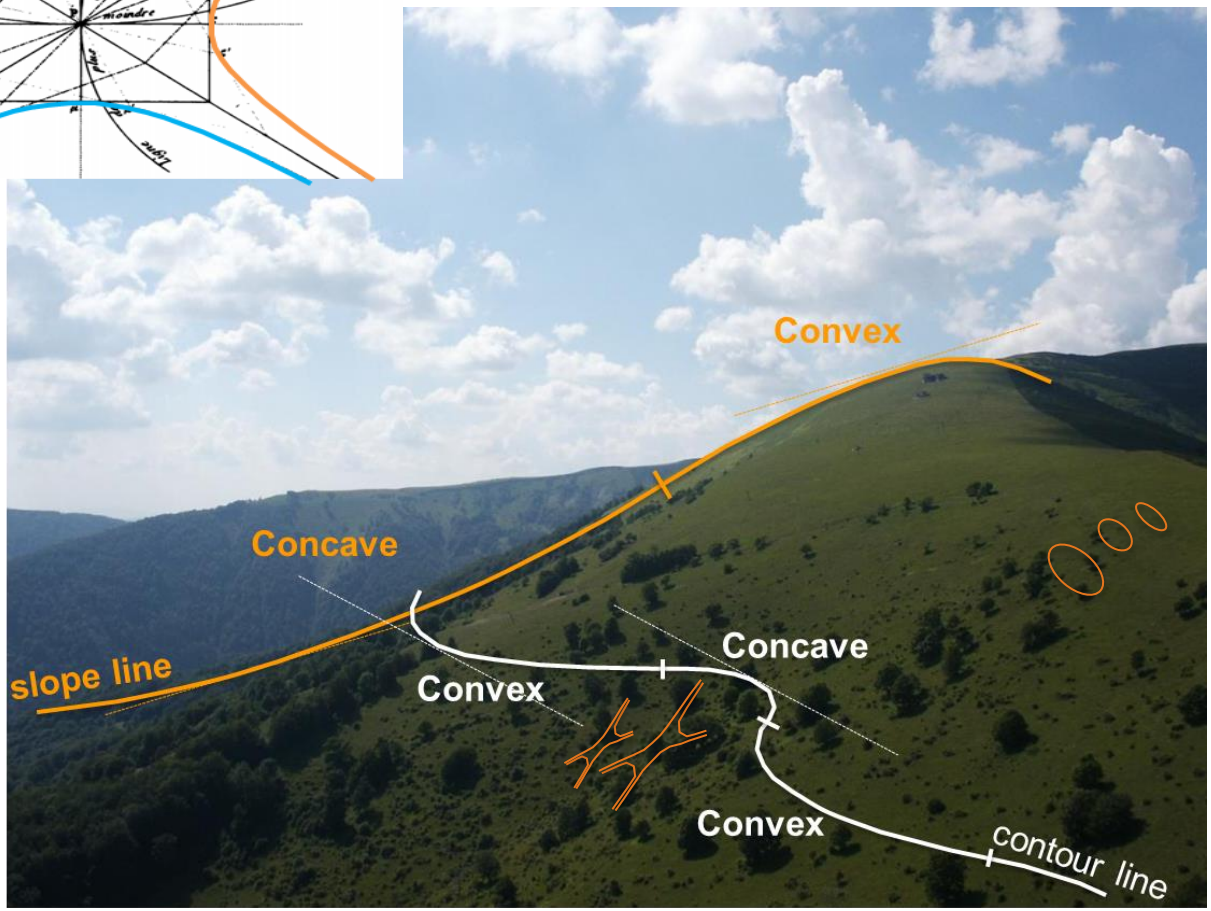
Dupin's indicatrix is geometrical descriptor of surface shape at it's every single point.

Not so straightforward with digital surface…







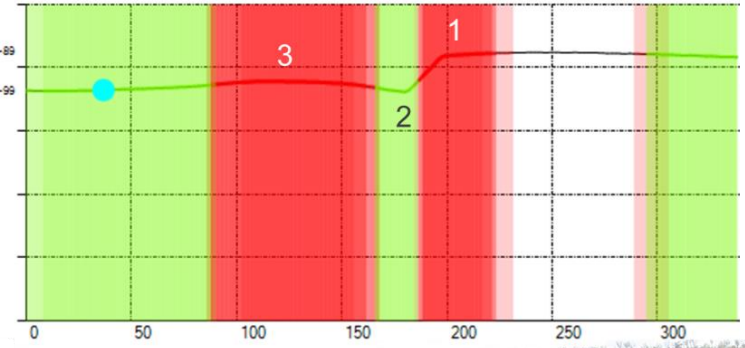


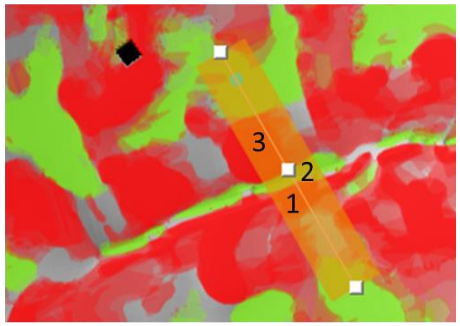
MORPHOMETRY RELATED TO COAL

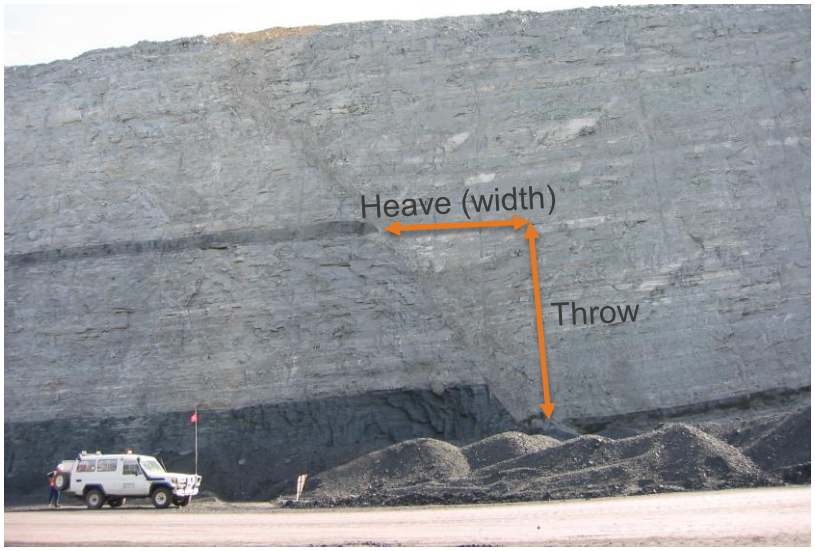
Coal mining is affected by “shape” of a coal seam.

Morphometric properties of seismic surface are describing the “shape” of a coal seam.

Morphometric features can be used to track faults and calculate heave and throw.

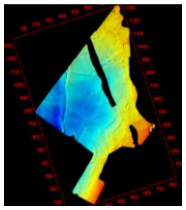




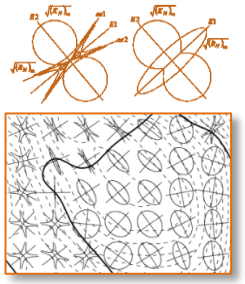


METHODOLOGY

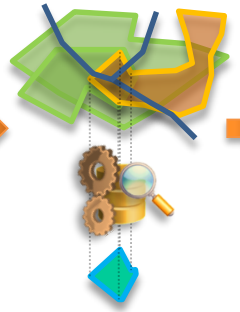
3D seismic volume as input data.



Seismic surfaces were extracted from 3D seismic volume and key surfaces related to coal seam were used for further processing.

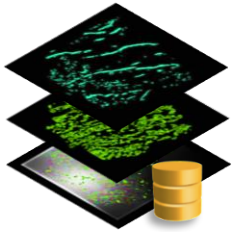


Applied technology uses differential geometry techniques to automatically map surfaces geometric properties as defined by Dupin's Indicatrix.

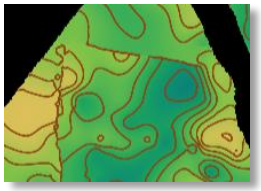


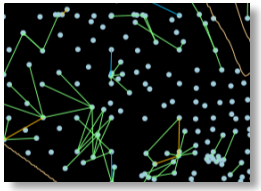
Features and objects are generated using pre-defined combinations and patterns of geometric and spatial attributes.

The features extracted are compiled into a queryable database which is ready for interpretation and further processing.



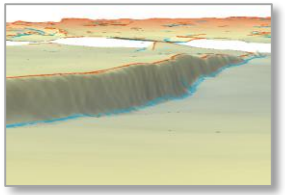
Velocity field was calculated considering fault features as interpolation constraints.



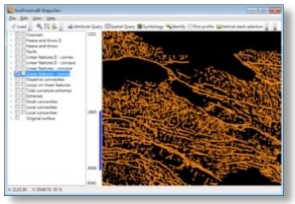


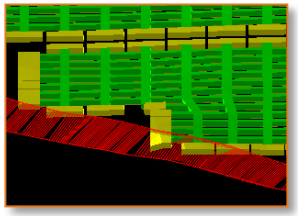
Borehole data were used for velocity field calculation. Special procedures were used to QC the borehole data, picked TWT surface, calculated velocity field, and depth model.

Depth model was calculated and used to bring morphometric features into depth domain.



The final project database containing the processed results and accompanying data are delivered through the delivered software allowing for a fast review of results.

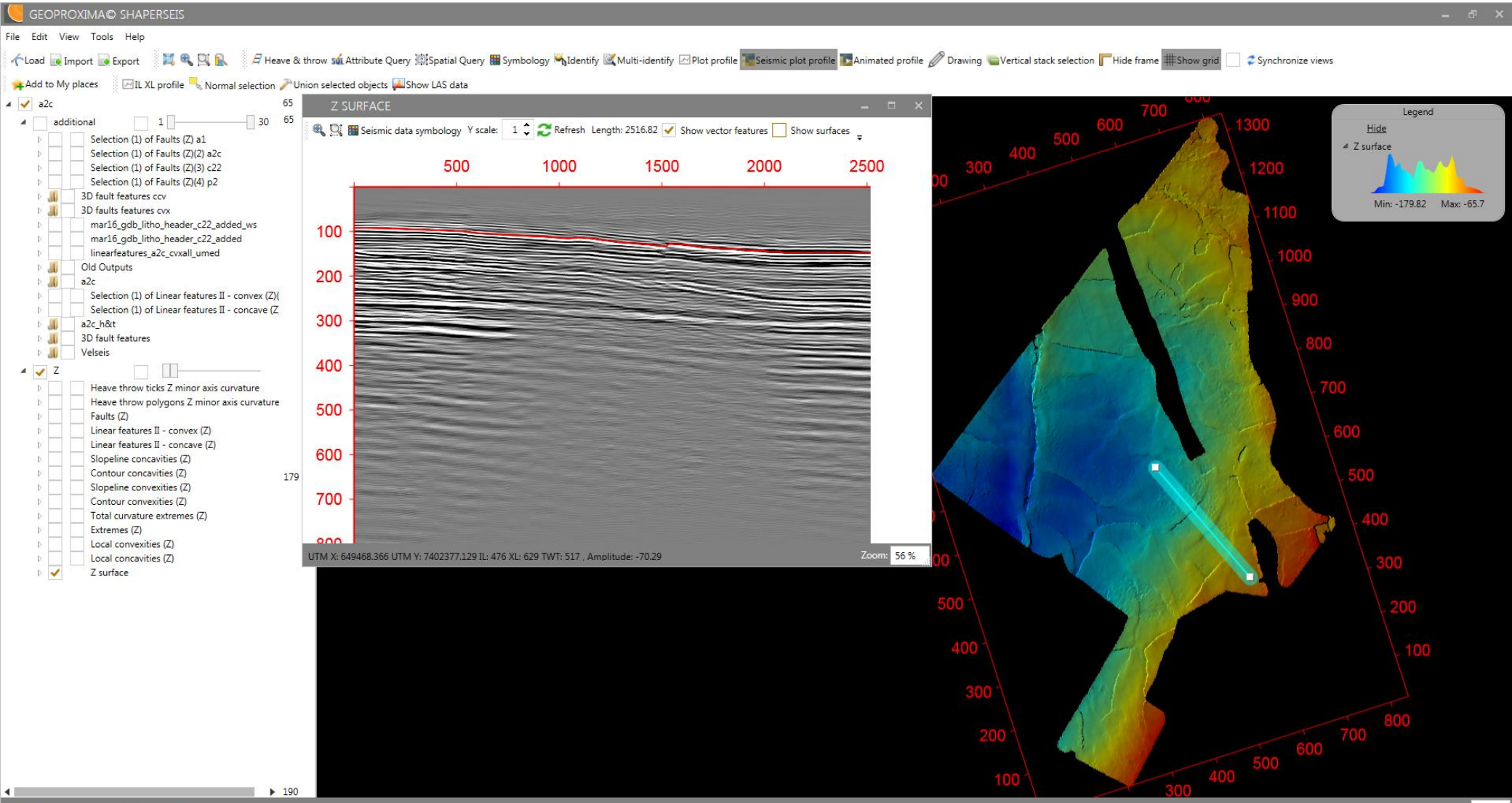




Heave and Throw, Linear convex and concave, and other features were imported into mine planning packages.

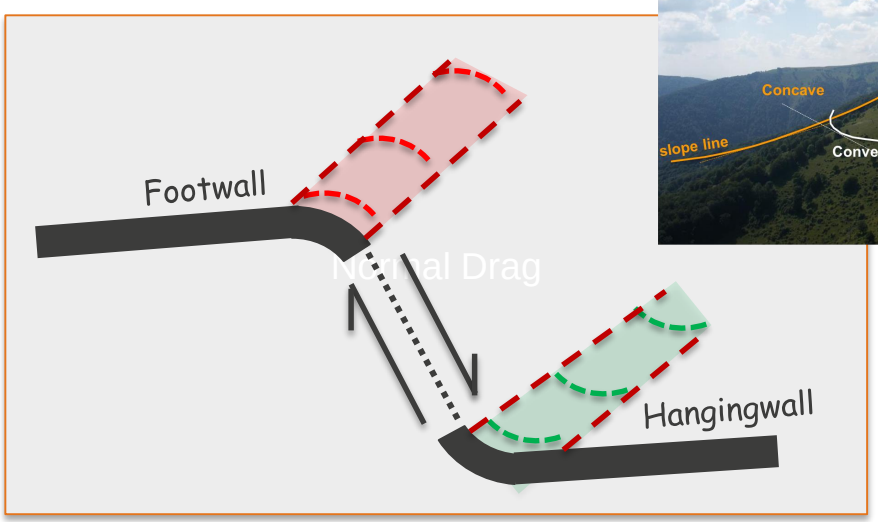
SEISMIC DATA

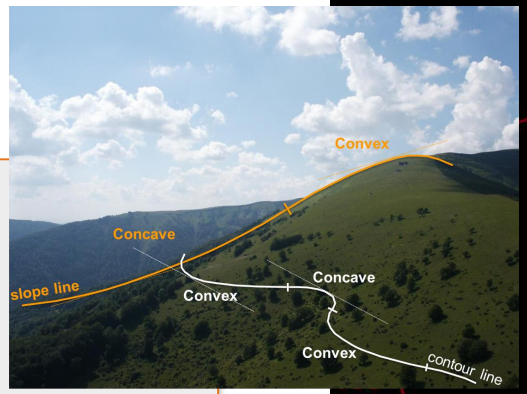
3D seismic data covering the entire underground mine plan was acquired and processed by Velseis. TWT surfaces were automatically extracted by Total Depth using Seisnetics.

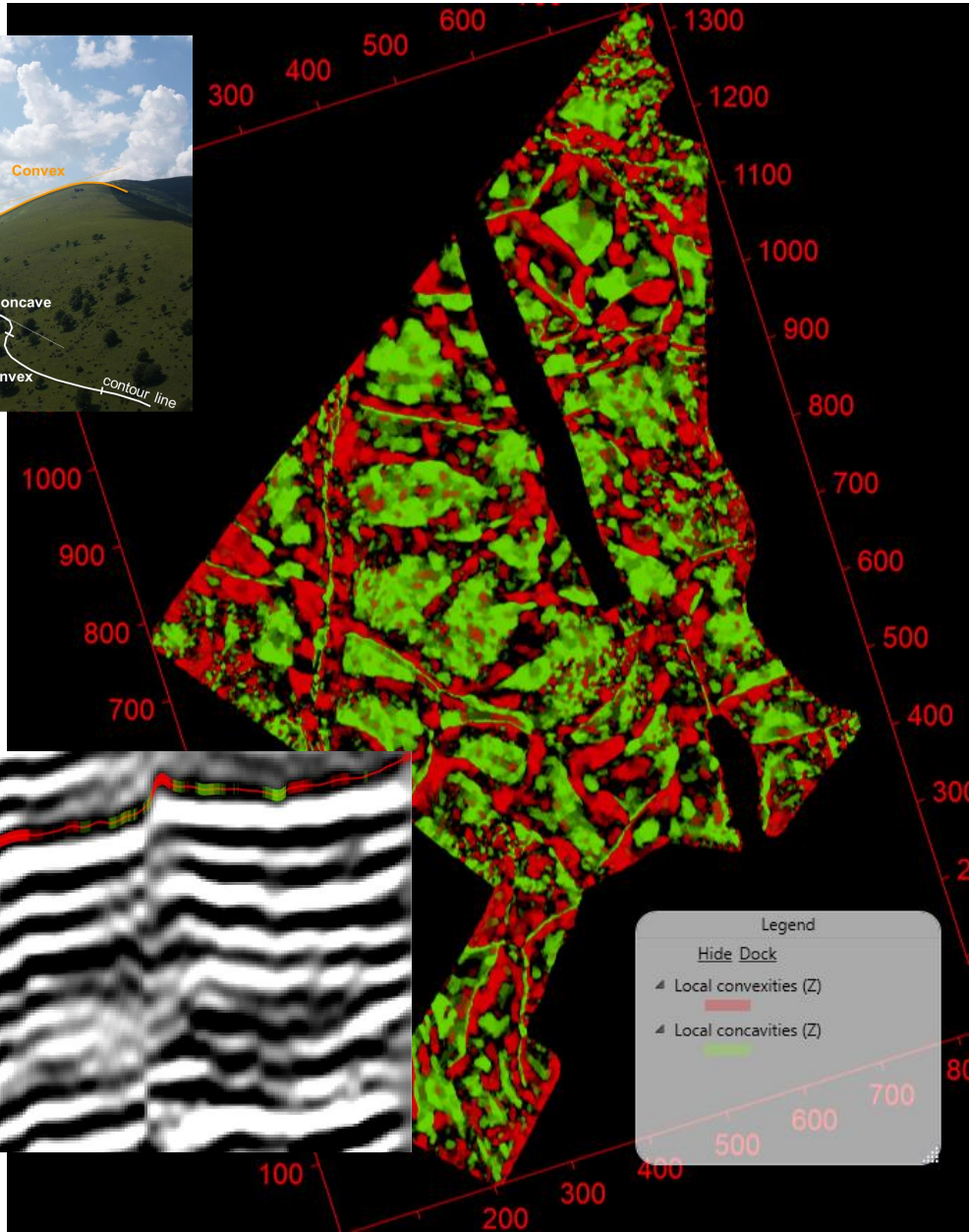


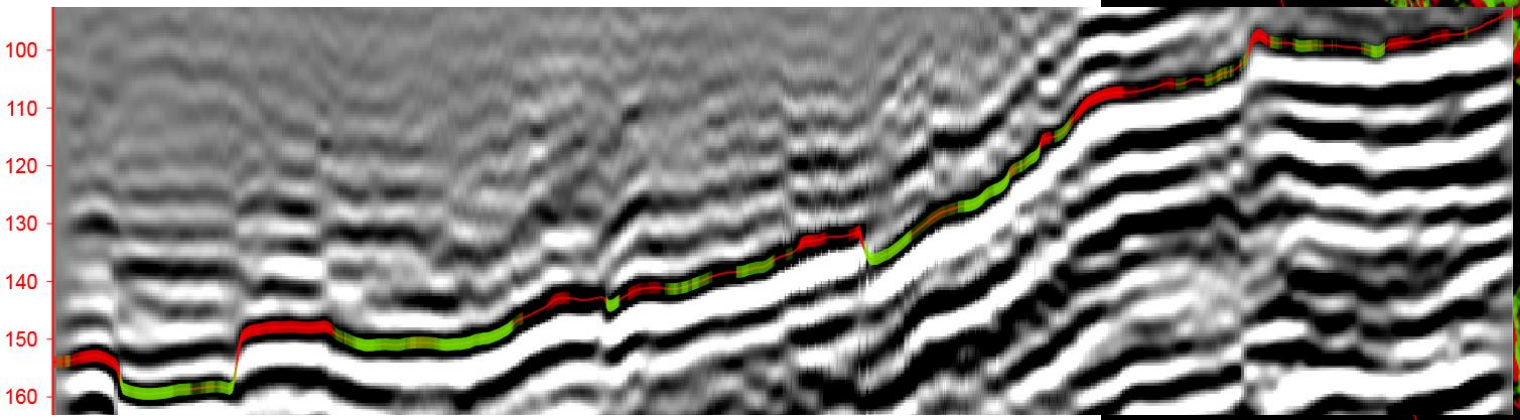
MORPHOMETRIC FEATURES

Locally convex (red) and locally concave (green) features automatically extracted on several levels of detail







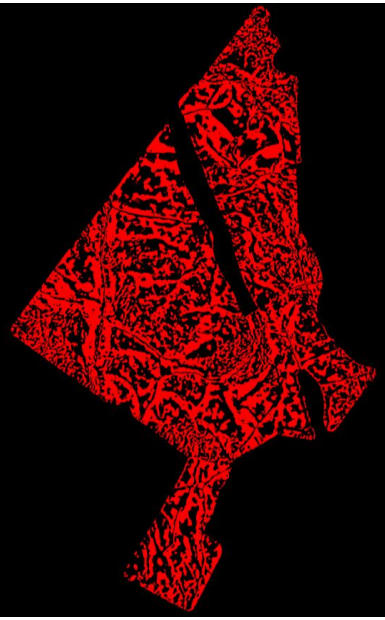


LEVELS OF DETAIL

GEOPROXIMA

Level of detail 1

high detail features



Level of detail 3

mid-level detail features

Level of detail 5

increasing influence of larger scale structures

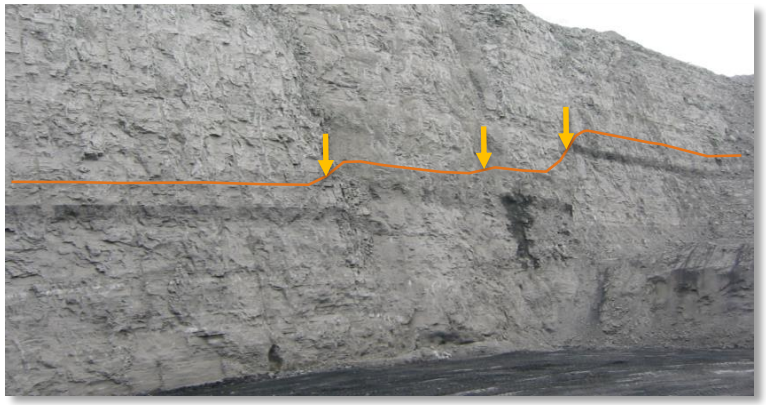
Level of detail 10

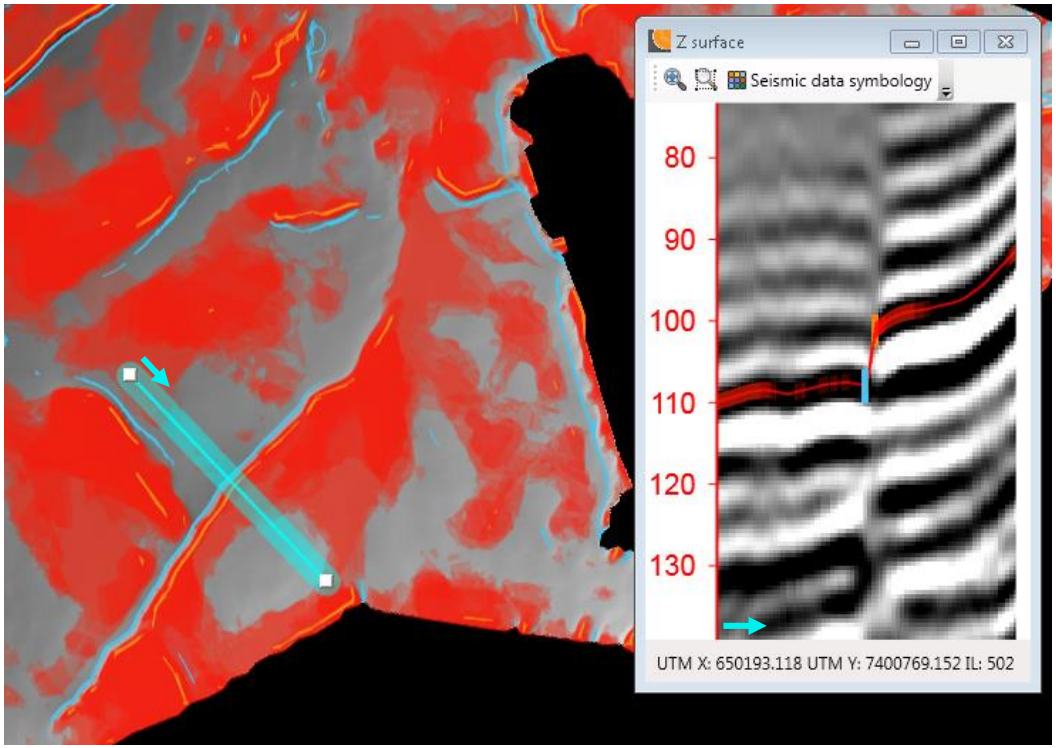
shows the major regional trends

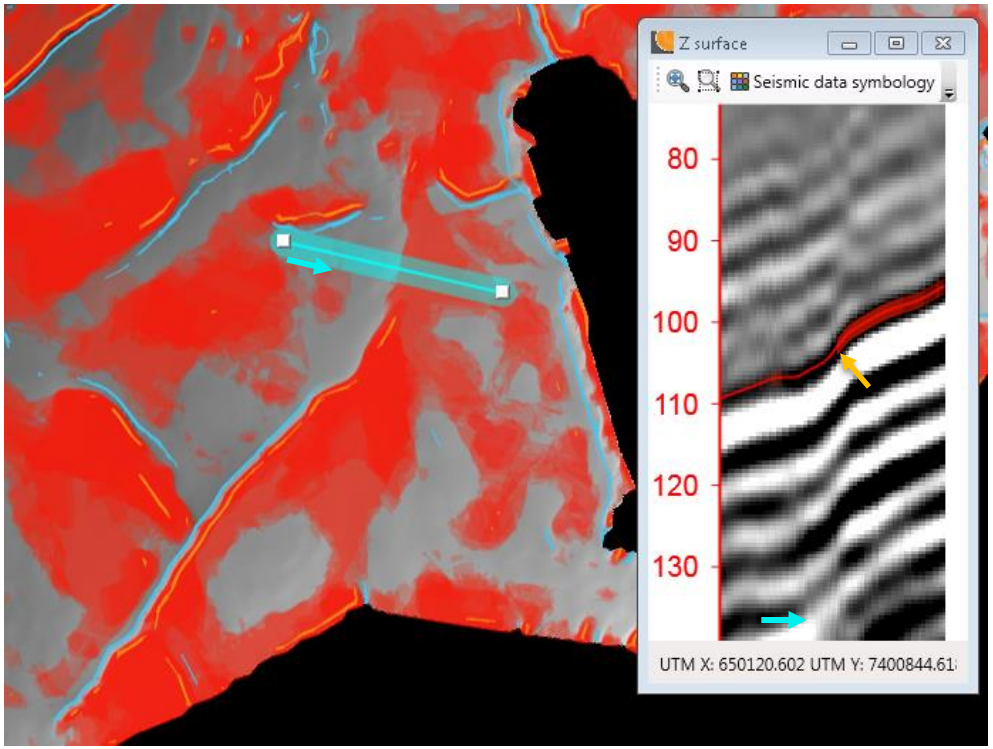
SPATIAL CORRELATION

Spatial correlation of convexity boundaries on several levels of detail is detecting possible continuation of a major fault.

Depending on seismic data resolution and quality as well as processing quality, inflexion lines can delineate subtle features.



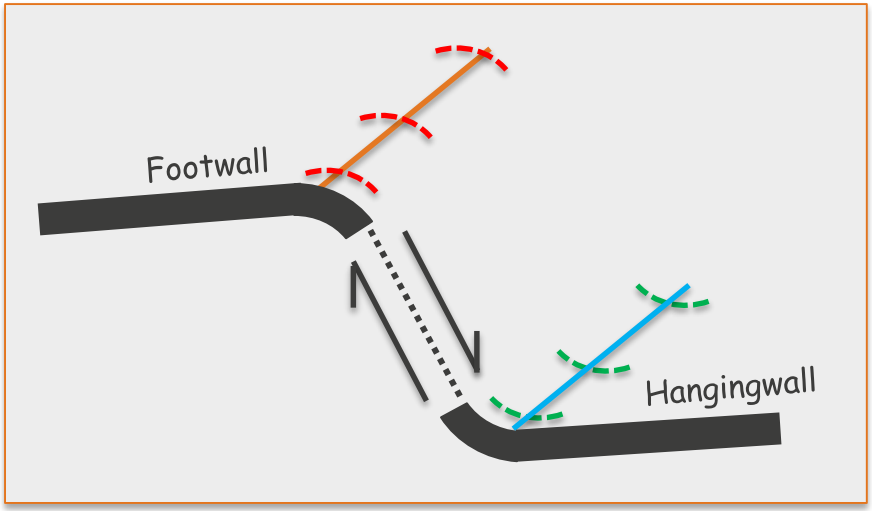


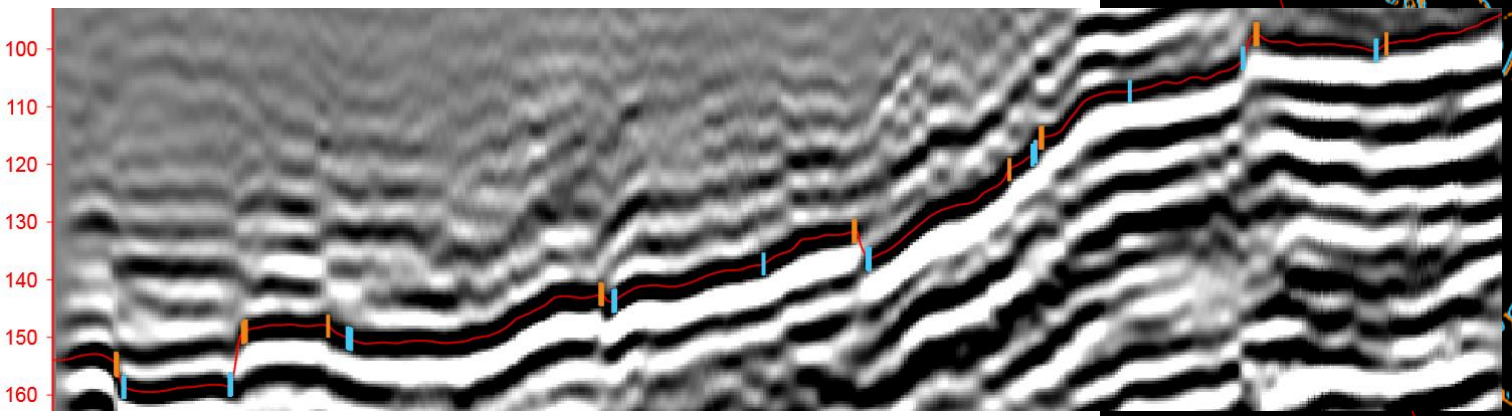


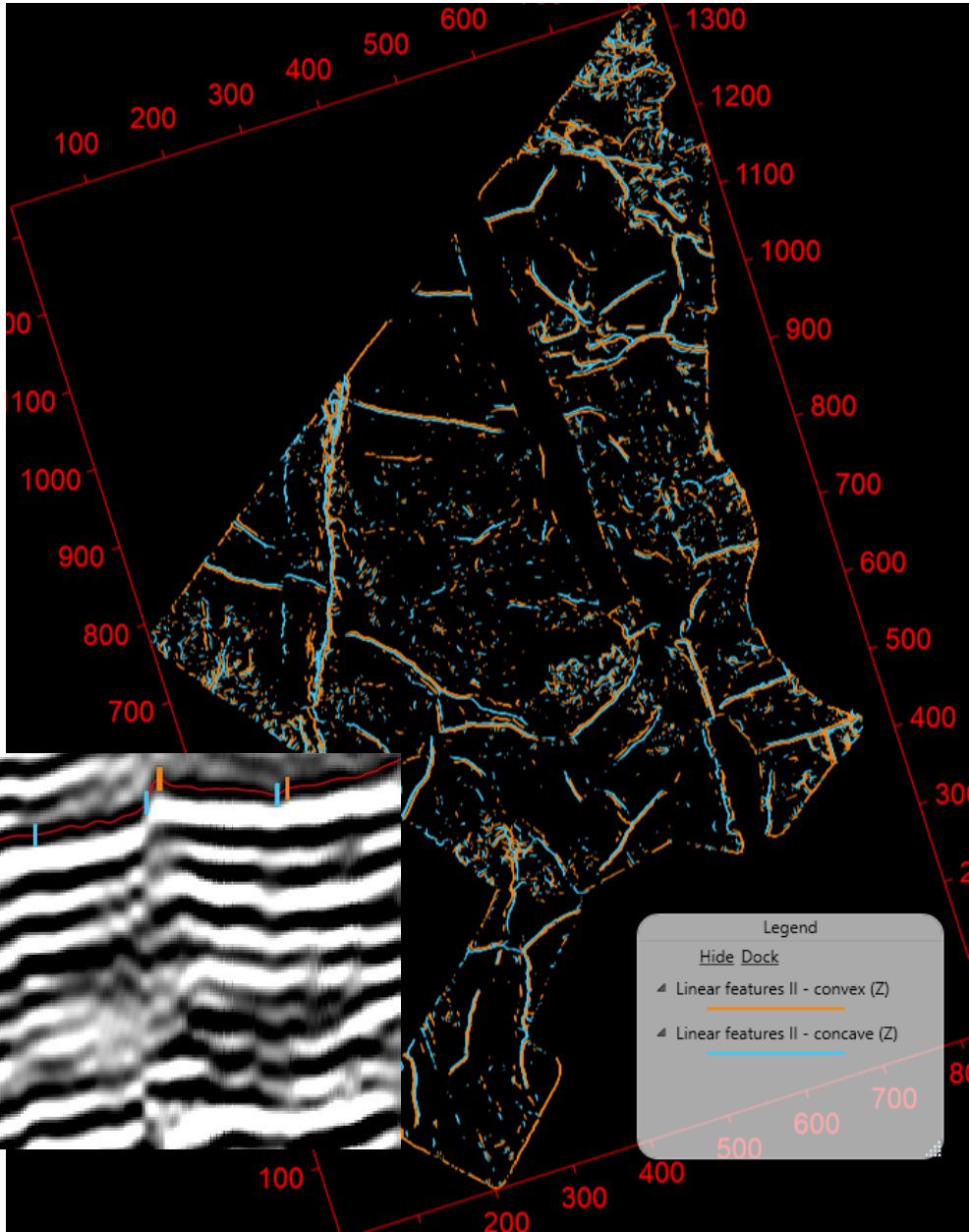
FAULT FEATURES

Linear features are tracking most curved convex and concave parts of a surface.

Automatically extracted features are used to track footwall and hangingwall parts of the surface faults.



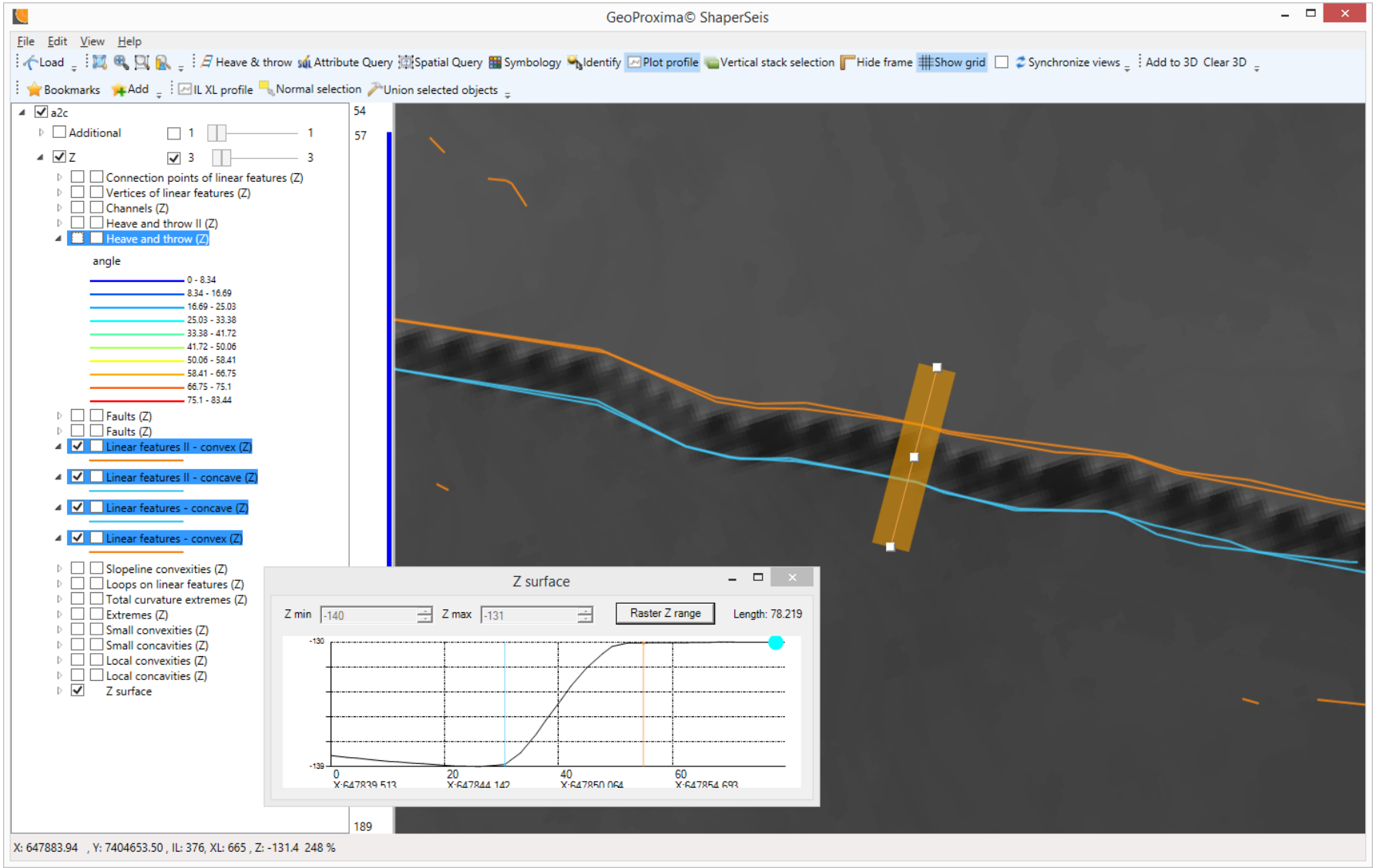




FAULT FEATURES

Footwall and hangingwall are tracked by linear convex (orange) and concave (blue) features respectively

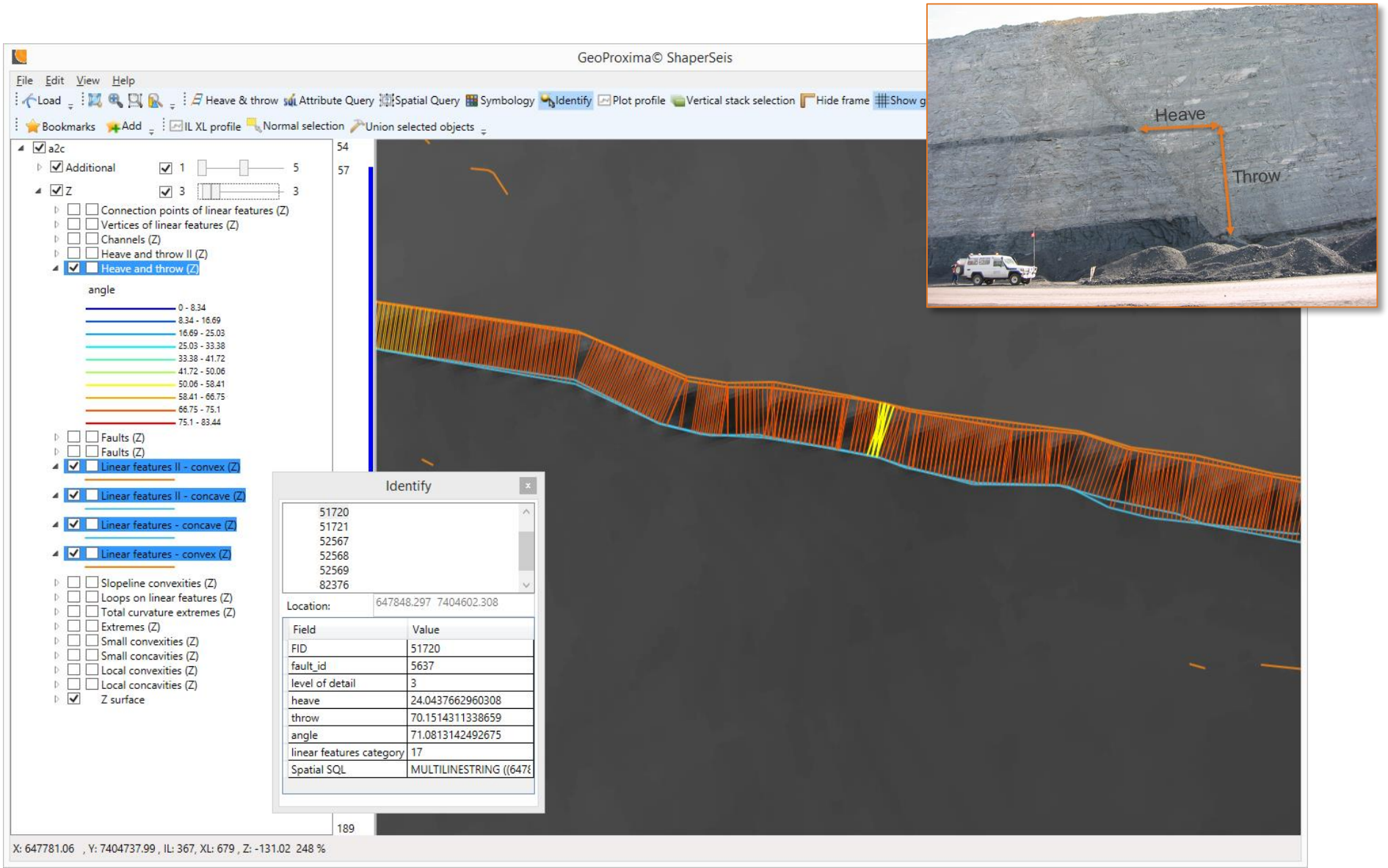
Profile is showing twt section with marked features intersections



FAULT FEATURES

Automatically constructed locations of measurement of heave and throw.

Calculated values are stored within the attribute table along with other attributes.

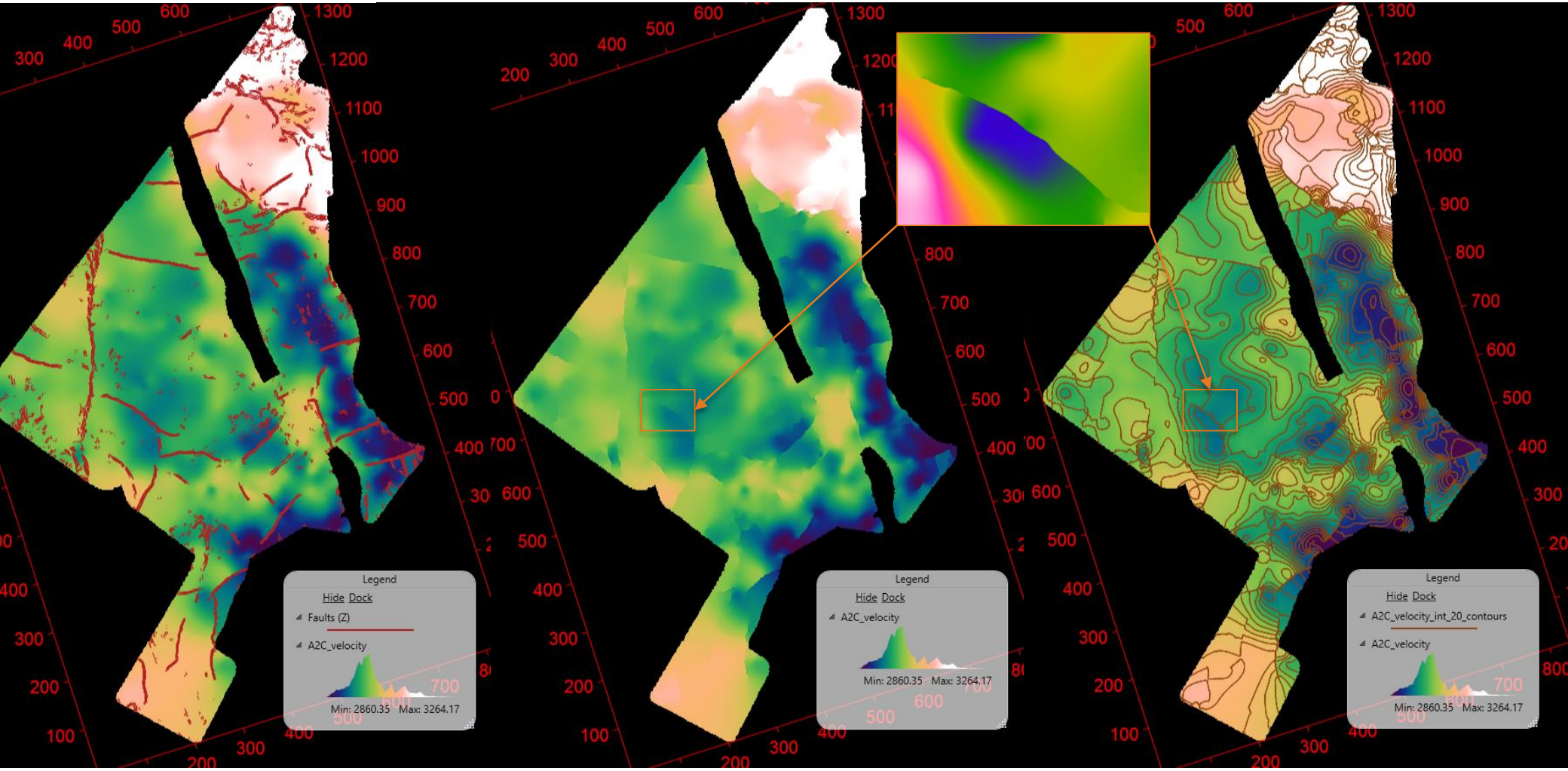


VELOCITY MODELING

Extracted fault features were used as a spatial constraint for velocity field modeling.

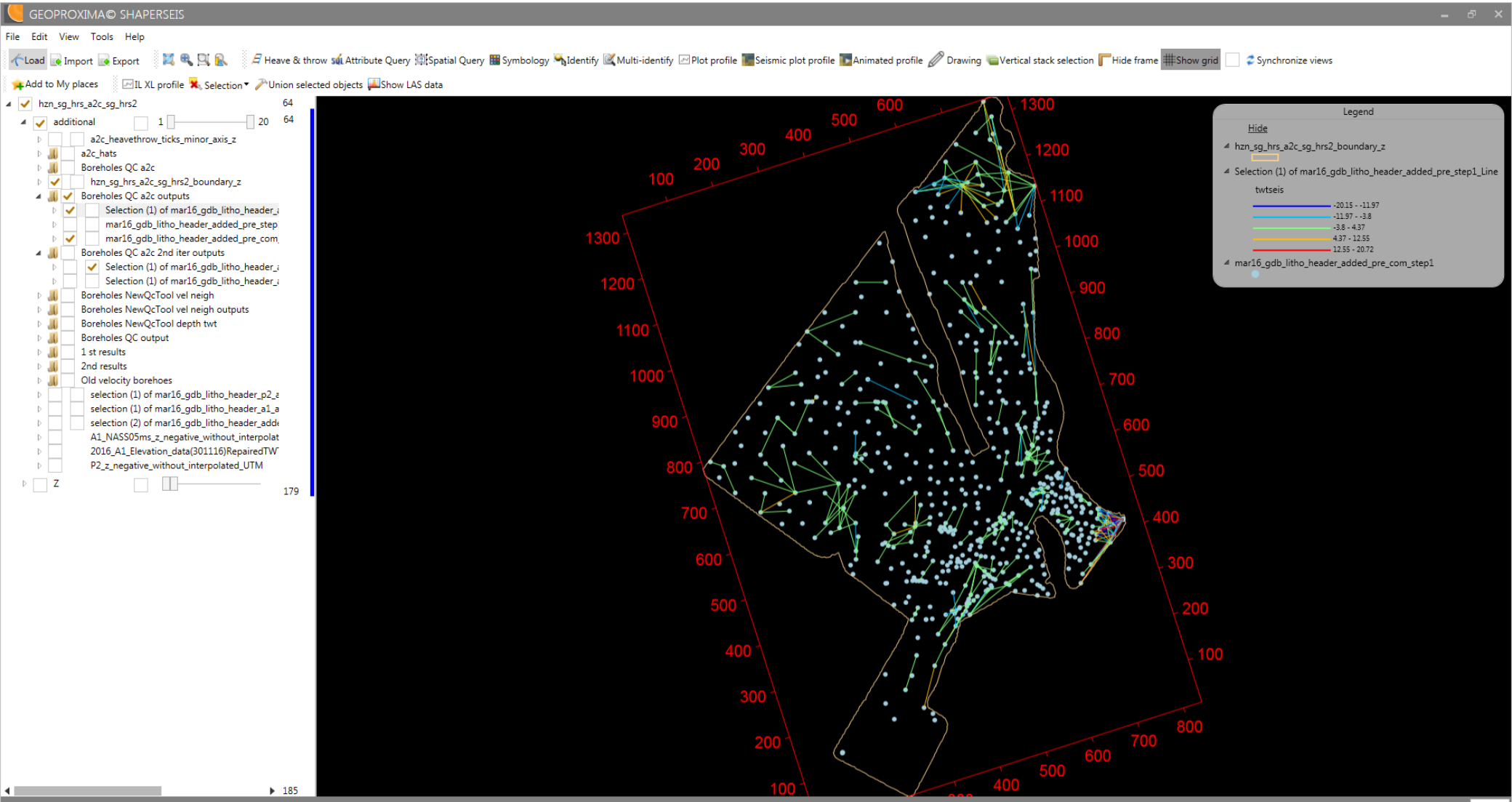
Velocity values at borehole locations were interpolated in such way that interpolation is not allowed to smoothly spread across the fault.

Therefore different velocity values are calculated along hangingwall side of a fault from those on footwall side.



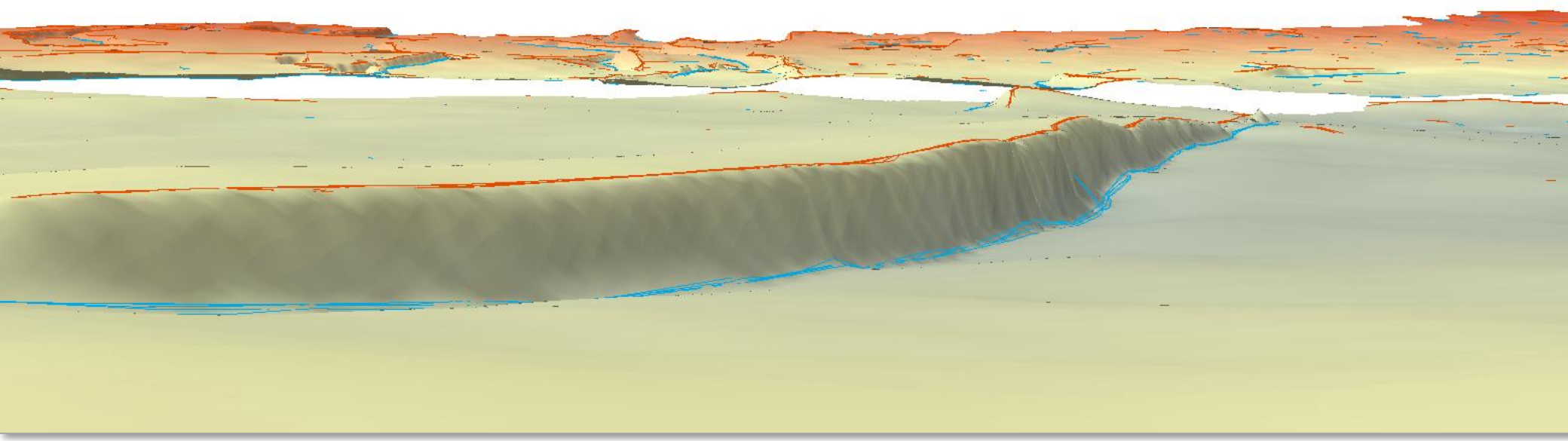
BOREHOLES DATA QC

Using specialized tools, borehole data (Velocity, TWT, depth and distance values) were examined to identify significant deviations and inconsistencies. This process helps to ensure that spurious points do not create errors in the velocity field.



DEPTH MODEL

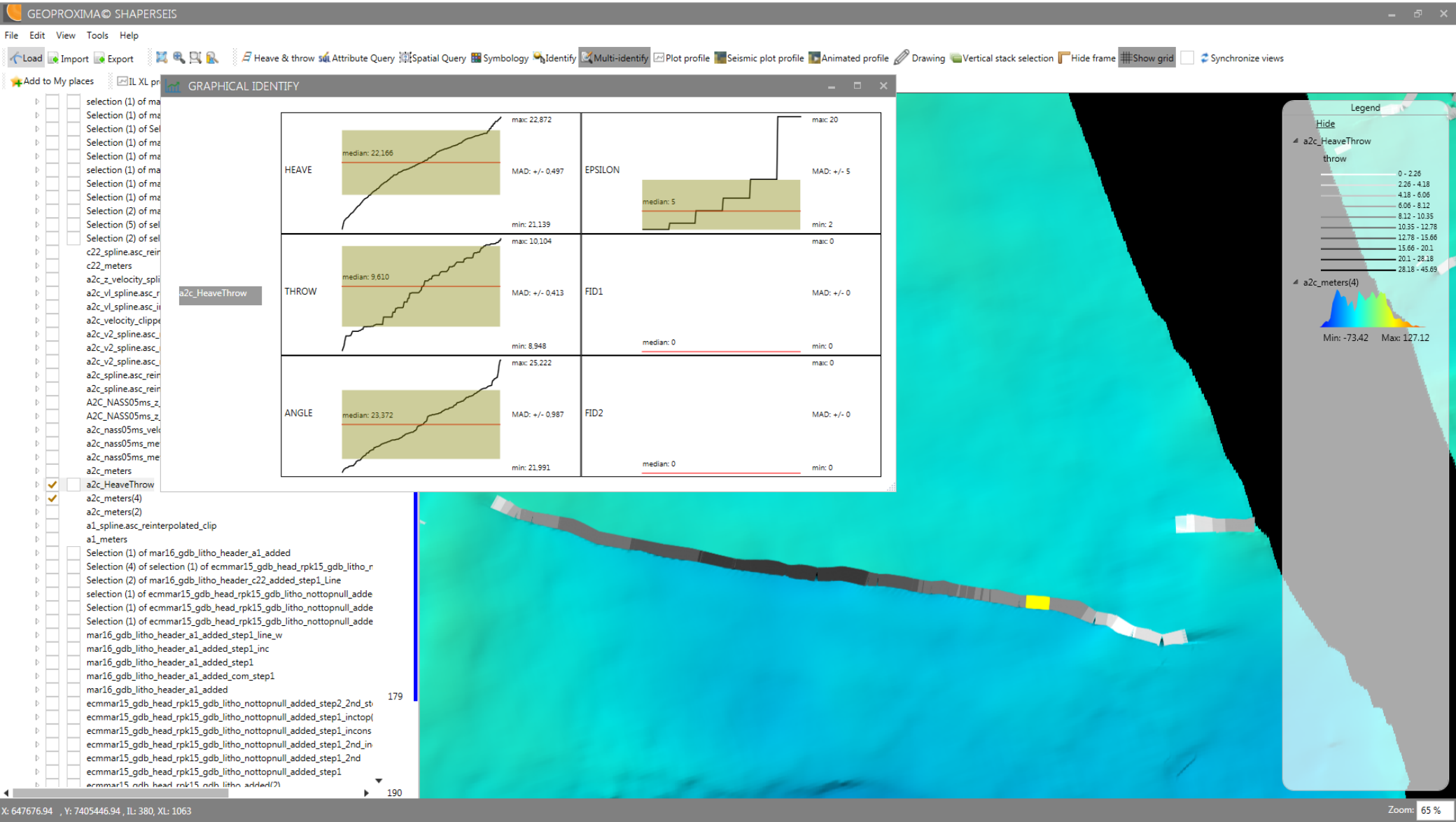
Major result is the depth model and depth converted morphometric features



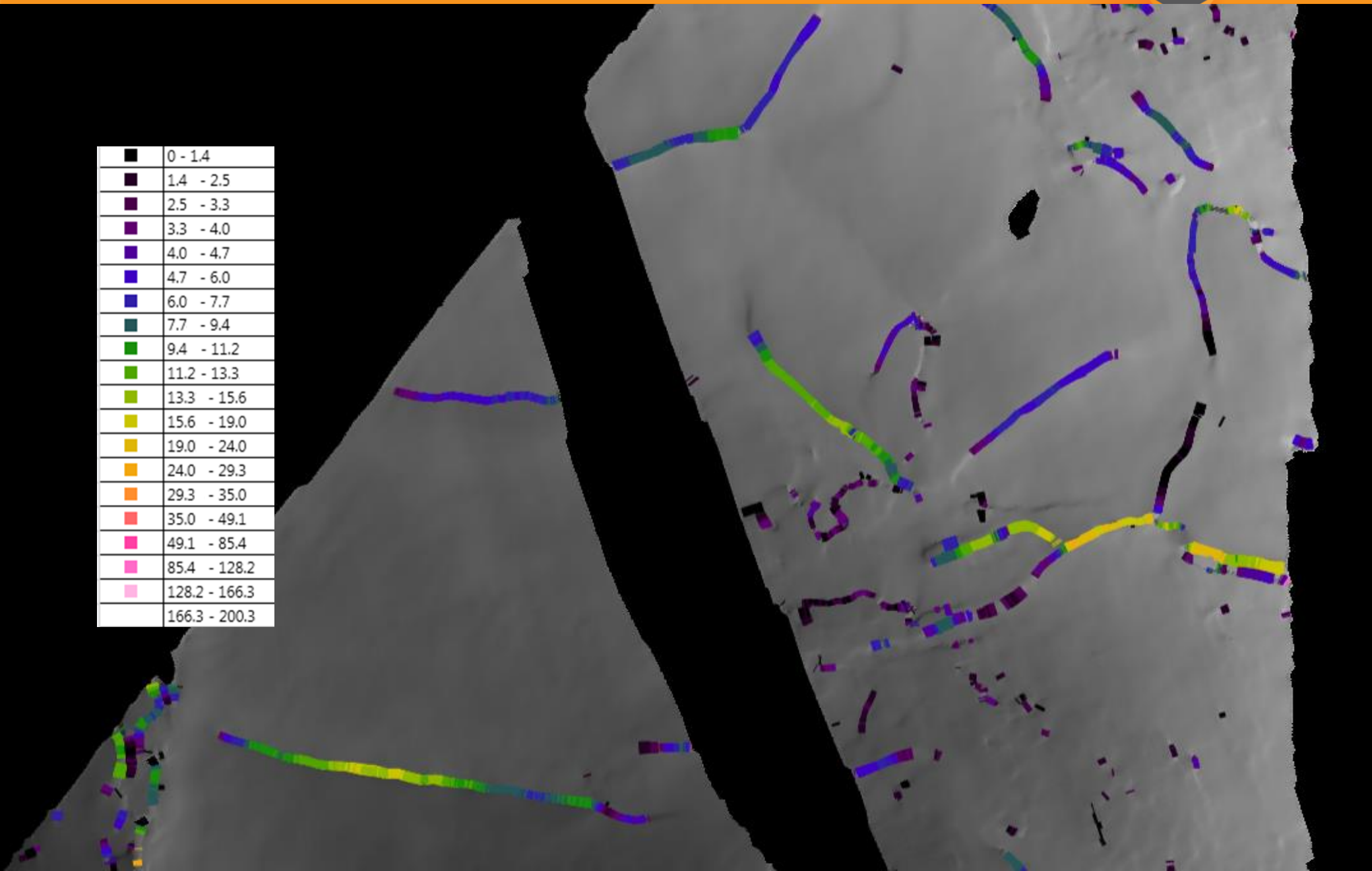
FEATURES IN DEPTH DOMAIN

Specialized tool was developed in order to provide assessment of statistical error based on large number of automatically calculated measurement locations

GEOPROXIMA



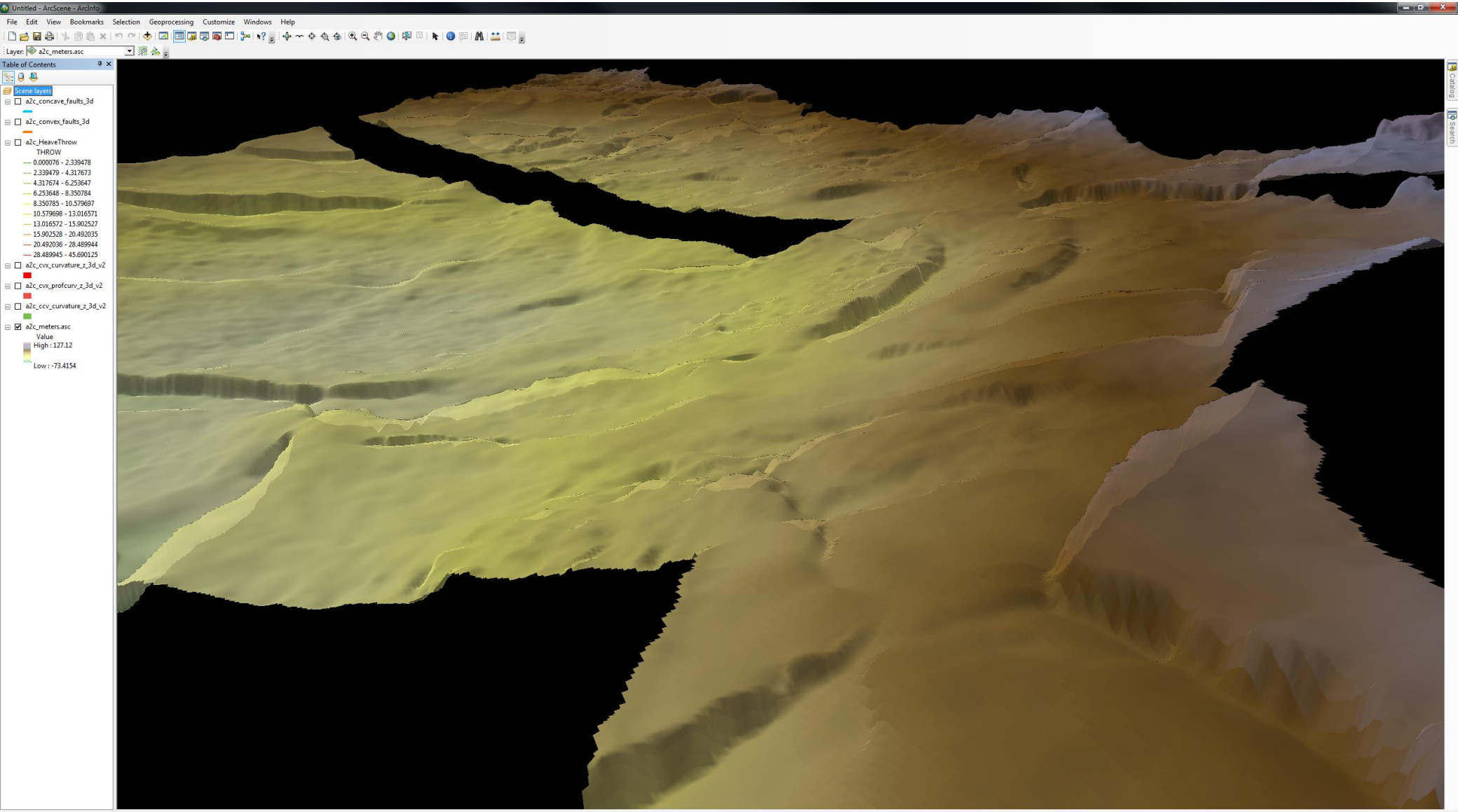
FEATURES IN DEPTH DOMAIN



DEPTH MODEL

Resulting depth surface rendered in 3D

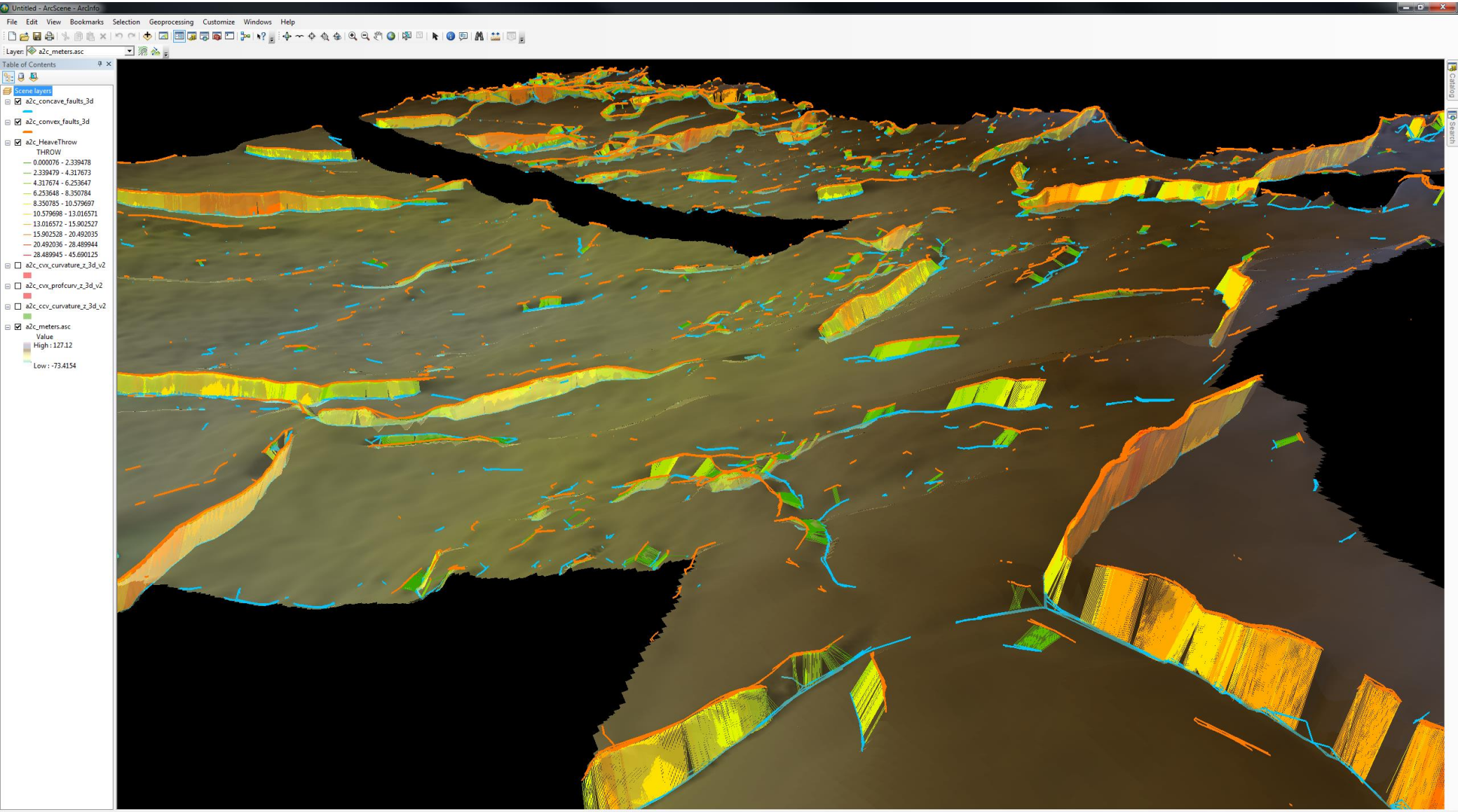
GEOPROXIMA



DEPTH MODEL & FAULT FEATURES

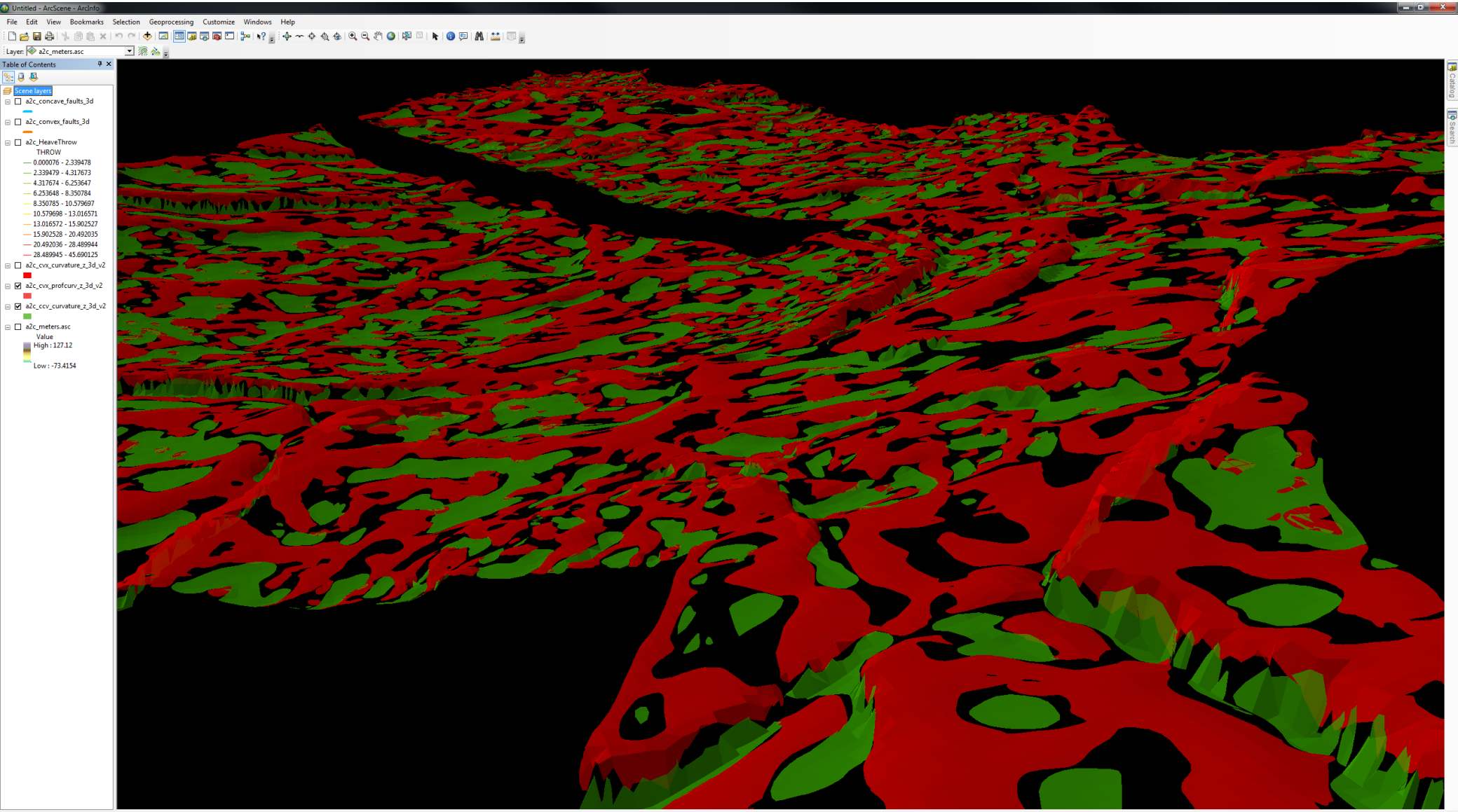
Linear convex and concave features are shown on the depth surface.

Heave and throw measurement lines are coloured according to Throw values.



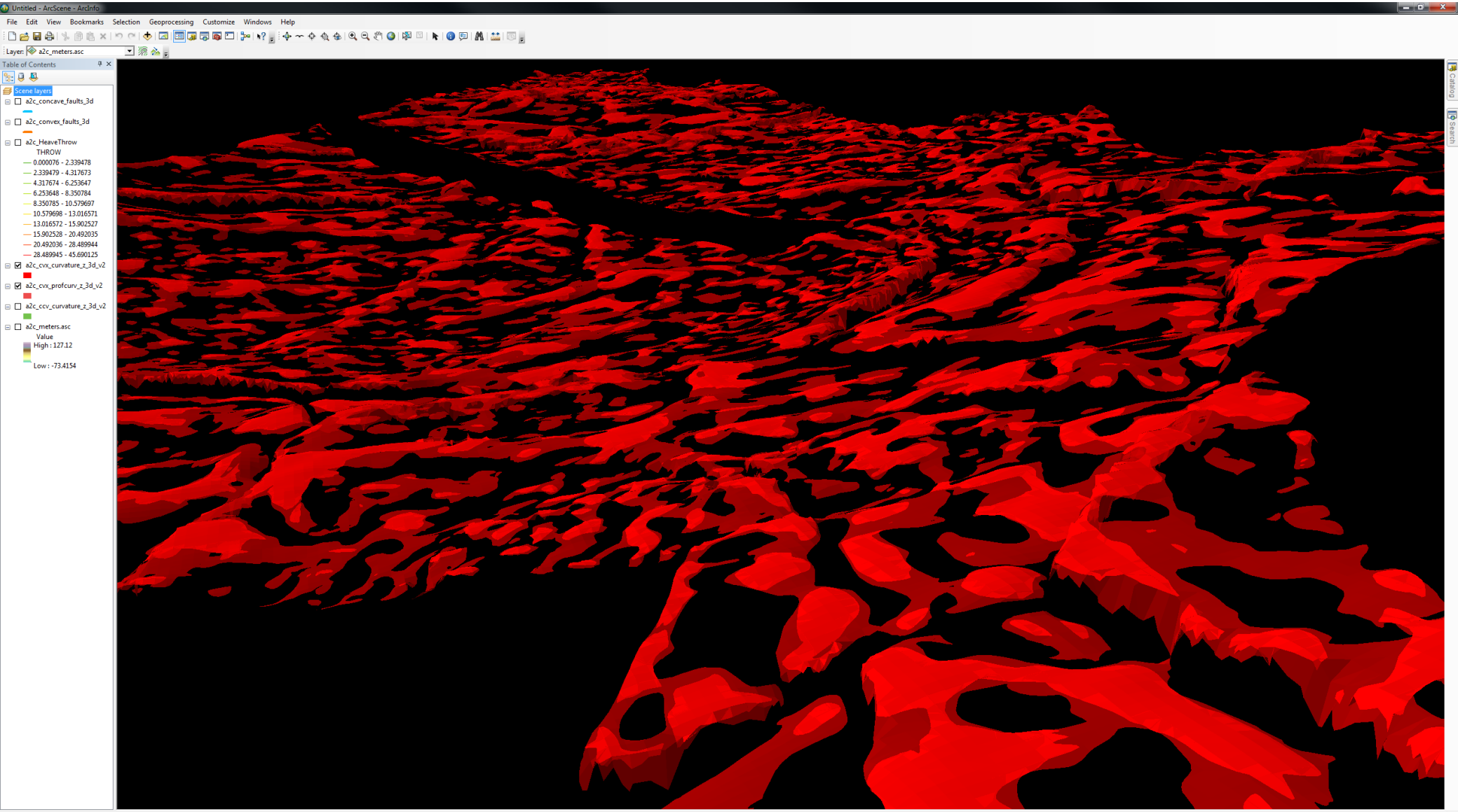
3D FEATURES

Slopeline convexities (red) and local concavities (green)



3D FEATURES

Slopeline convexities (darker red) and local convexities (light red)



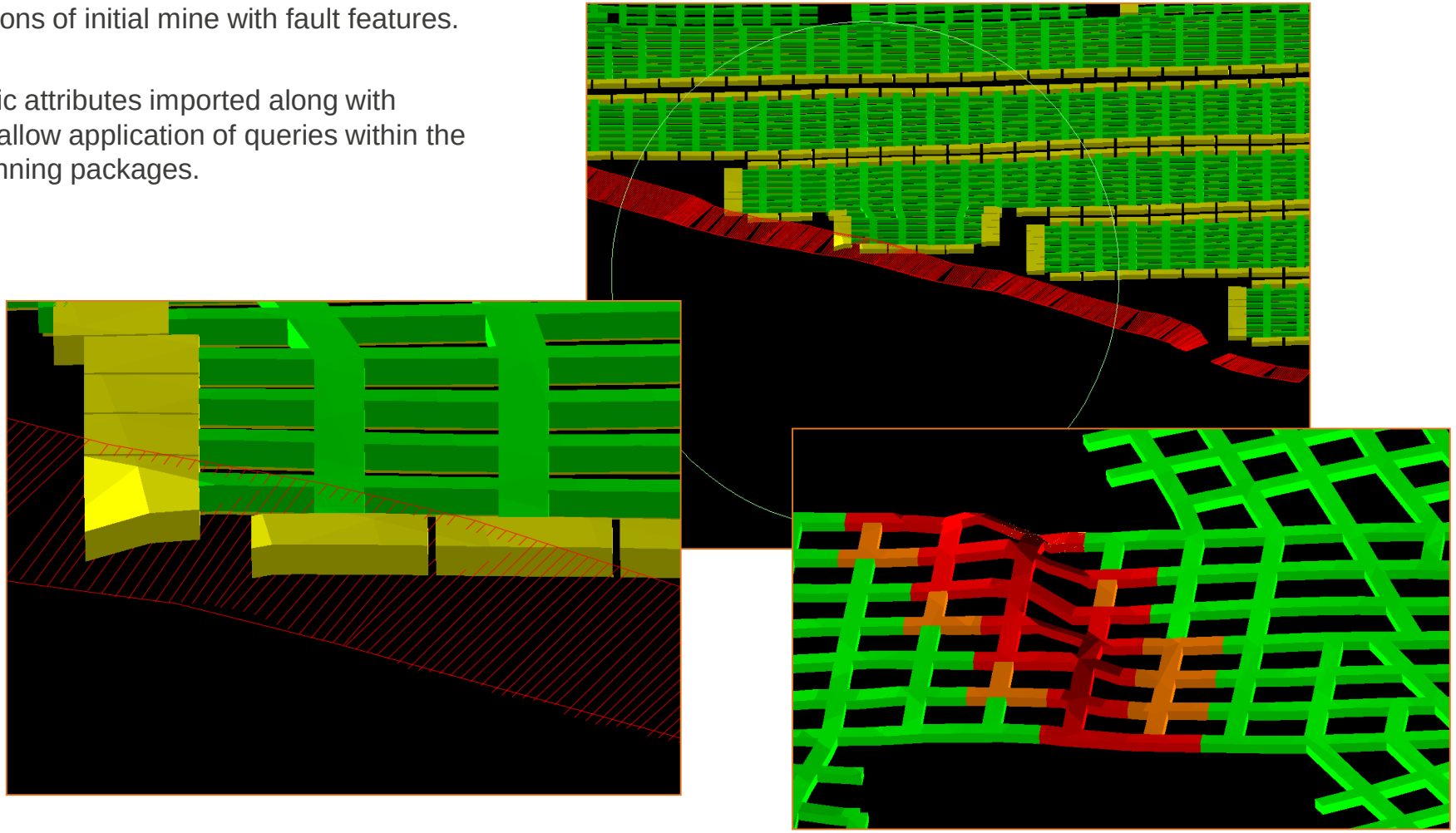
MINE PLANNING

GEOPROXIMA

Depth model, fault features and polygonal features were imported into mine planning packages.

Mine plan adjustments are made according to intersections of initial mine with fault features.

Geometric attributes imported along with features allow application of queries within the mine planning packages.



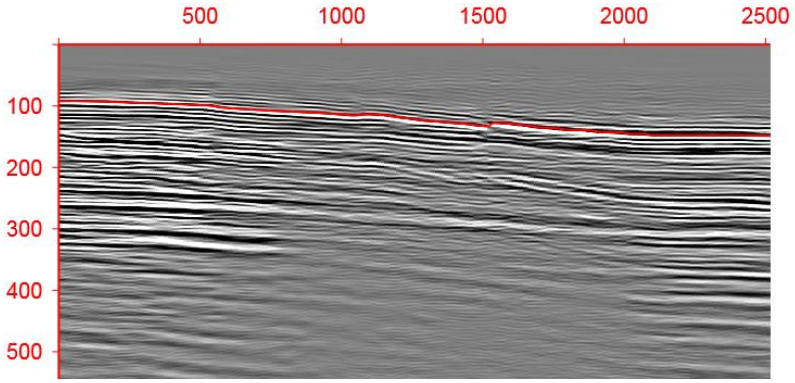
CONCLUSION

3D seismic data can be used to improve mine planning process.

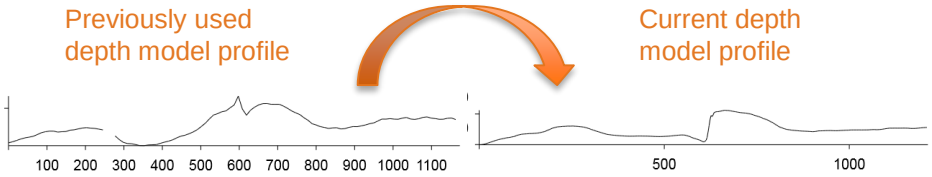
Case study from Bowen Basin illustrates application of advanced processing technology to seismic data applicable to Sydney Basin underground operations.

Automation - Recalculation of depth model and depth features on demand as new information is collected from drilling.

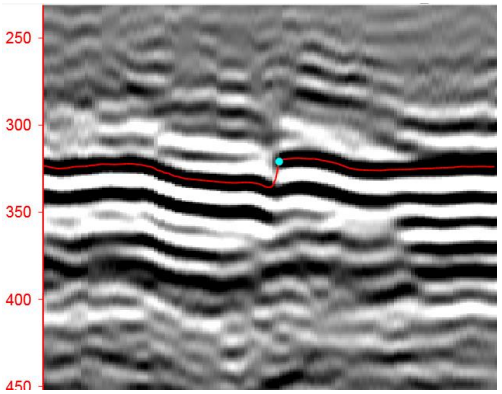
Improvement of depth model quality.



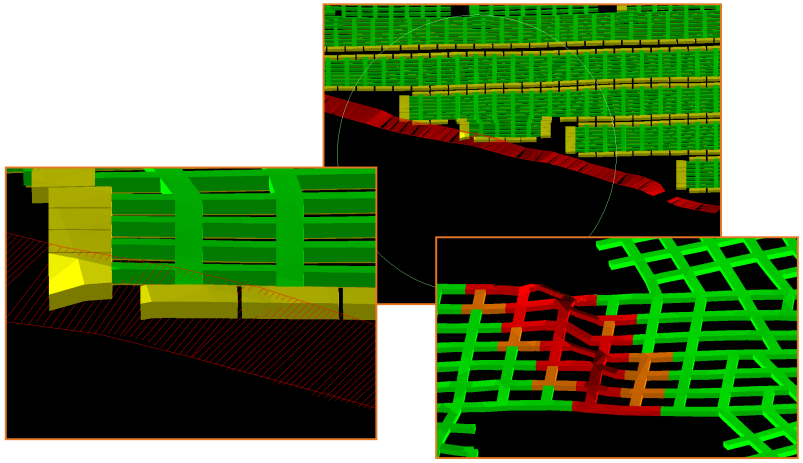
Previously used depth model profile



Current depth model profile



TWT profile on seismic section



ACKNOWLEGMENTS

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