

The following was presented at DMT'12  
(May 20-23, 2012).

The contents are provisional and will be  
superseded by a paper in the  
DMT'12 Proceedings.

See also earlier Proceedings (1997-2011)

<http://ngmdb.usgs.gov/info/dmt/>

A photograph of a geyser erupting in a landscape with a lake and mountains in the background. The geyser is a tall, narrow column of water and steam rising from a rocky mound. The surrounding area is a flat, grassy plain with a large body of water in the distance. The sky is blue with scattered white clouds.

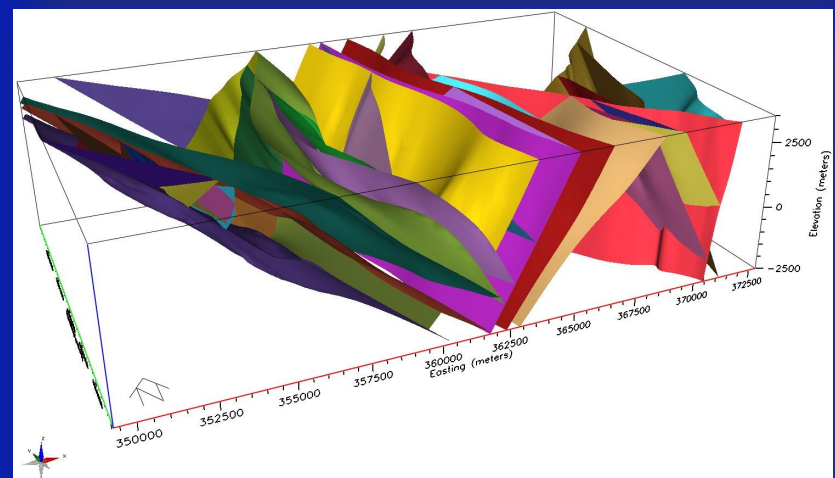
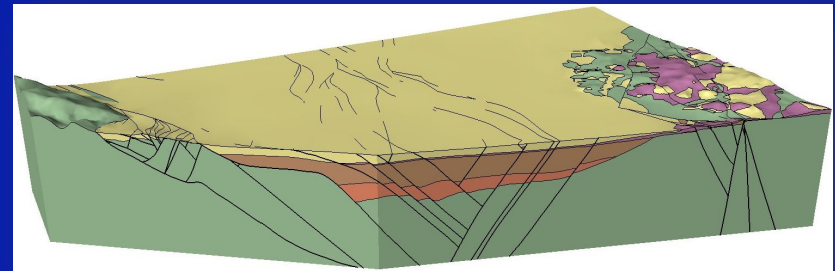
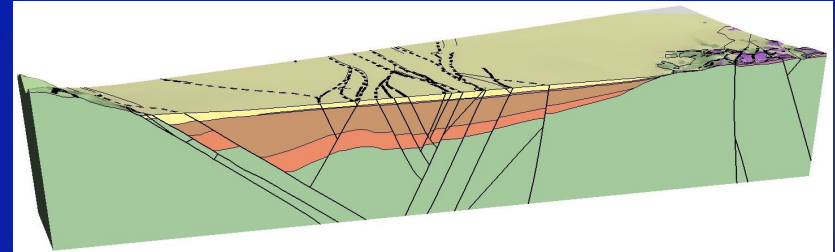
# **3D GEOLOGIC MAPPING – STRUCTURAL STUDIES OF GEOTHERMAL SYSTEMS IN THE BASIN AND RANGE**

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Drew Siler  
Jim Faulds

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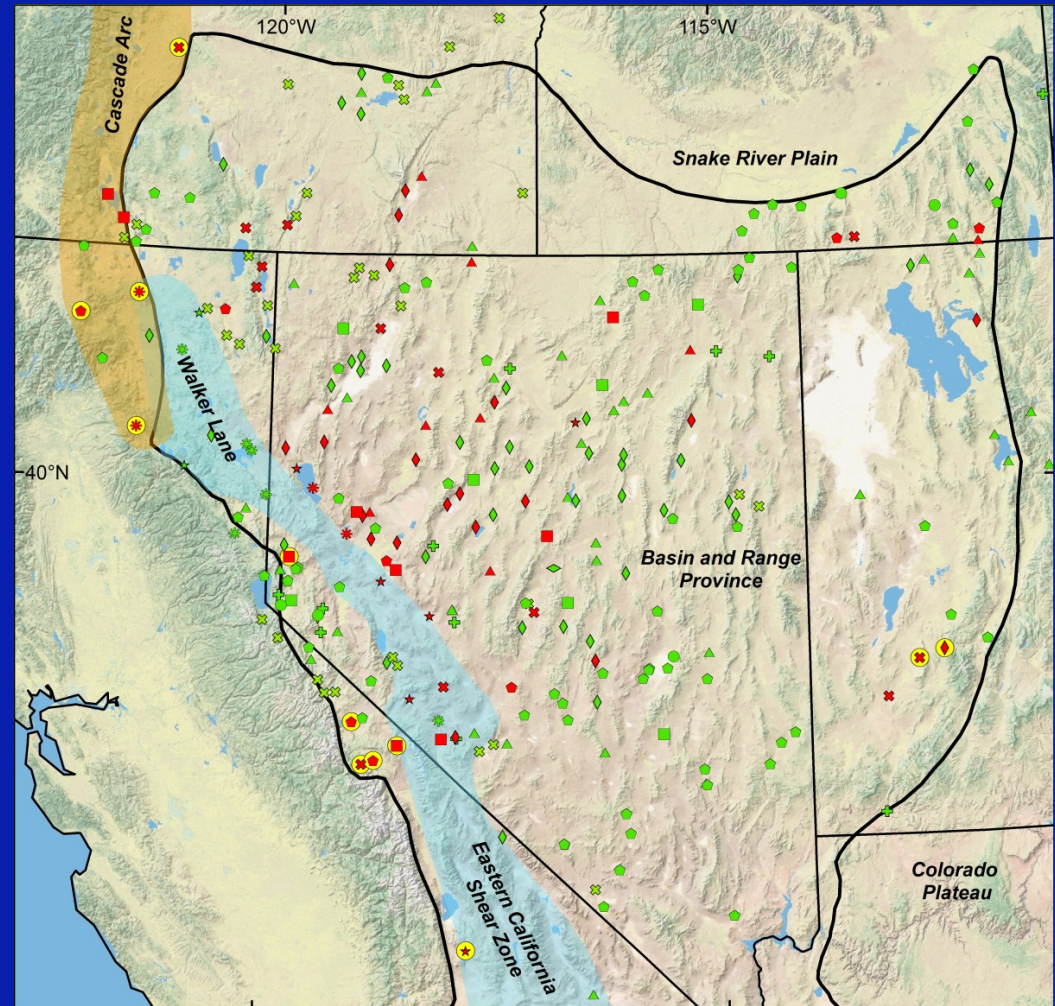
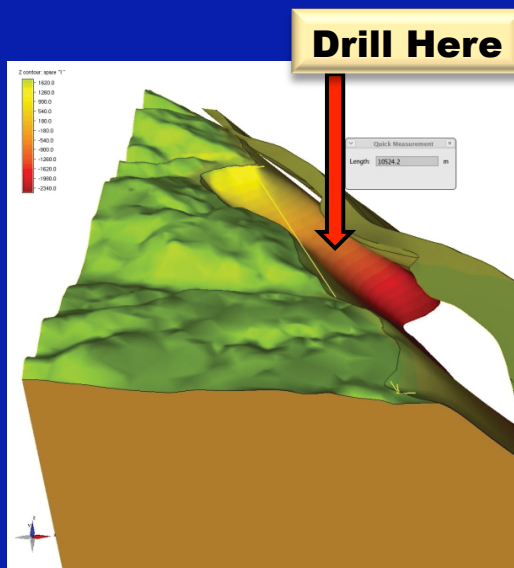
# 3D Geologic Mapping

- 3D geological mapping used by
  - Oil and Gas industry
  - Minerals industry
  - Groundwater resources/contamination
  - Seismic hazard
- Only recently employed by the geothermal industry (5 yrs)
- “Mapping” vs “Modeling”



# Geothermal Systems in the Great Basin region

- Most systems are amagmatic
- Most systems are blind
- Fluid flow and producing reservoirs are largely controlled by faults

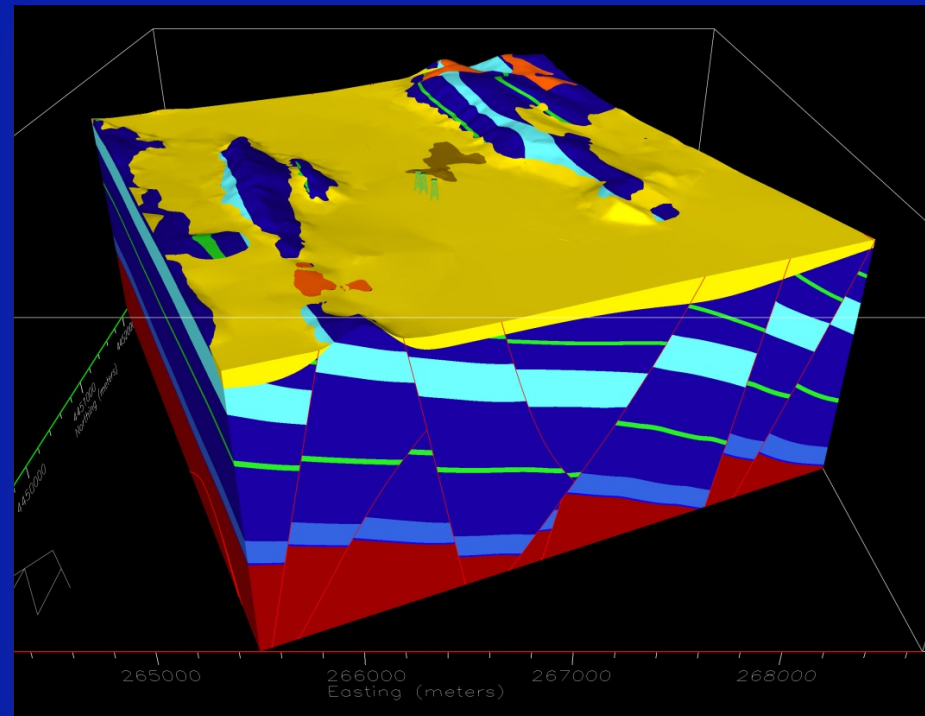


Structural Settings of Geothermal Systems: Red symbols  $\geq 150^{\circ}\text{C}$ , Green symbols  $< 150^{\circ}\text{C}$

- |   |  |   |
|---|--|---|
| ▲ Termination of a major normal fault           | ● Apex or salient of normal fault                    | ★ Pull apart in strike-slip fault zone                |
| ◆ Stepmover or relay ramp in normal fault zones | ◊ Antithetic normal fault to major range-front fault | ⬤ Analyzed system, structural setting not yet defined |
| ■ Accommodation zone                            | ✕ Fault intersection                                 | ● Known or inferred magmatic system                   |
| ⊕ Major normal fault                            | * Displacement transfer zone                         |   |

# Data Available for 3D Geologic Mapping

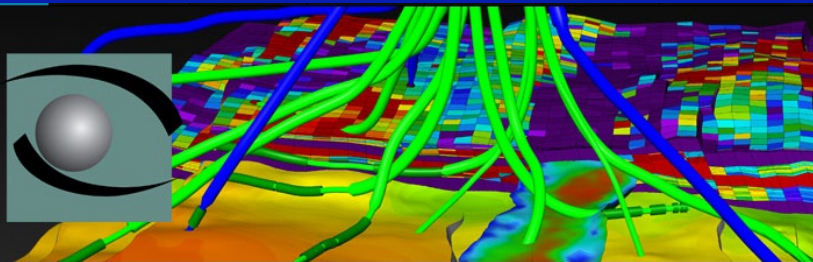
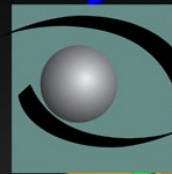
- 2D geologic map data
- Drill hole data
- 2D/3D seismic reflection data
- Gravity data
- Aeromagnetic data
- MT, CSAMT, ZTEM, etc.
- *Geologist's interpretations*



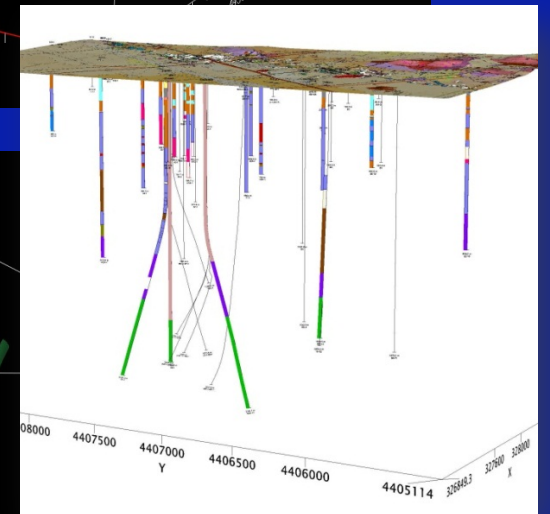
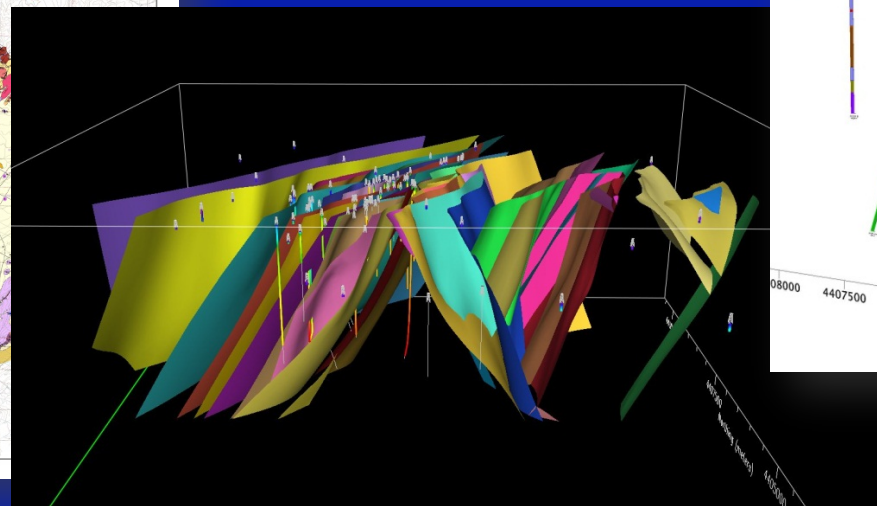
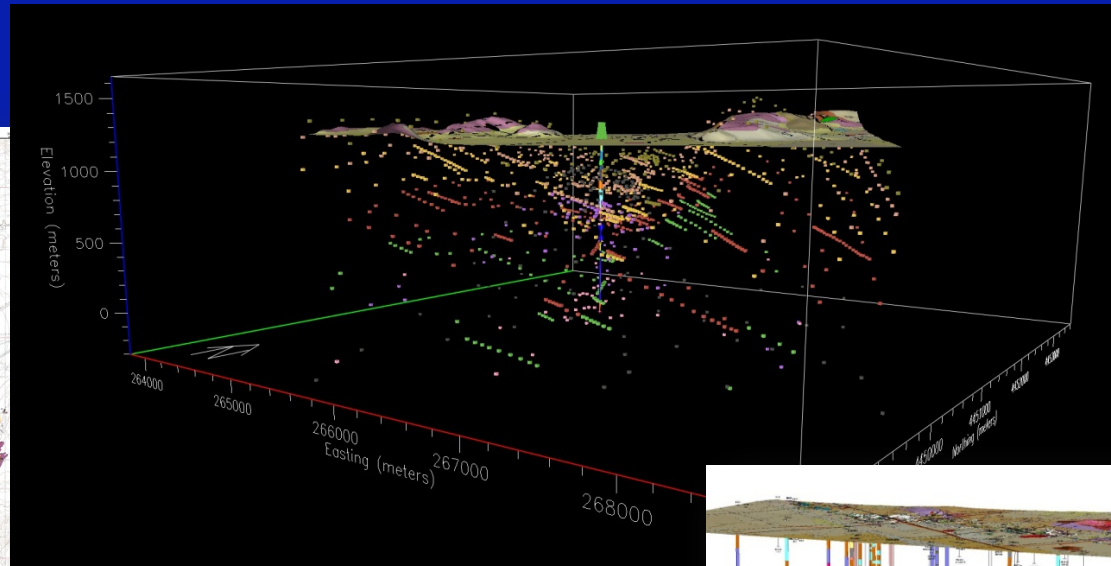
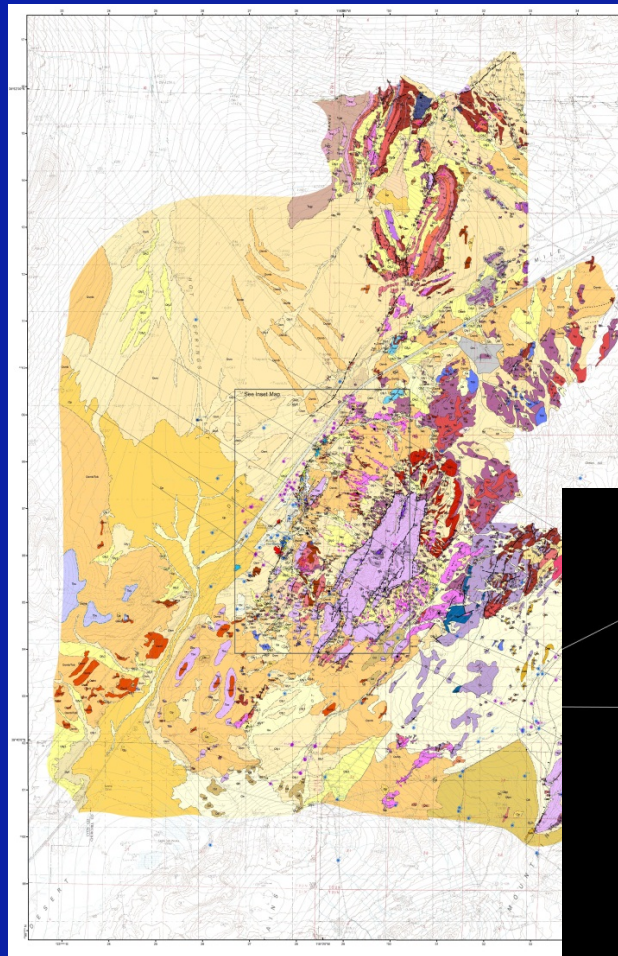
# Workflow

1. 2D Surface Map Data
2. 2D Geologic Cross Sections
  - Map data + Drill hole data + Geophysics
3. Build 3D model, *faults first, then contacts*
  - Include data intermediate to cross-sections
  - Rebuild 3D model
  - Add intermediate control points as necessary
  - Rebuild 3D model
  - Add/modify control points as necessary
  - Rebuild 3D model...

earthVision  
by DYNAMIC GRAPHICS, INC.



# Why 2D Cross-Sections?

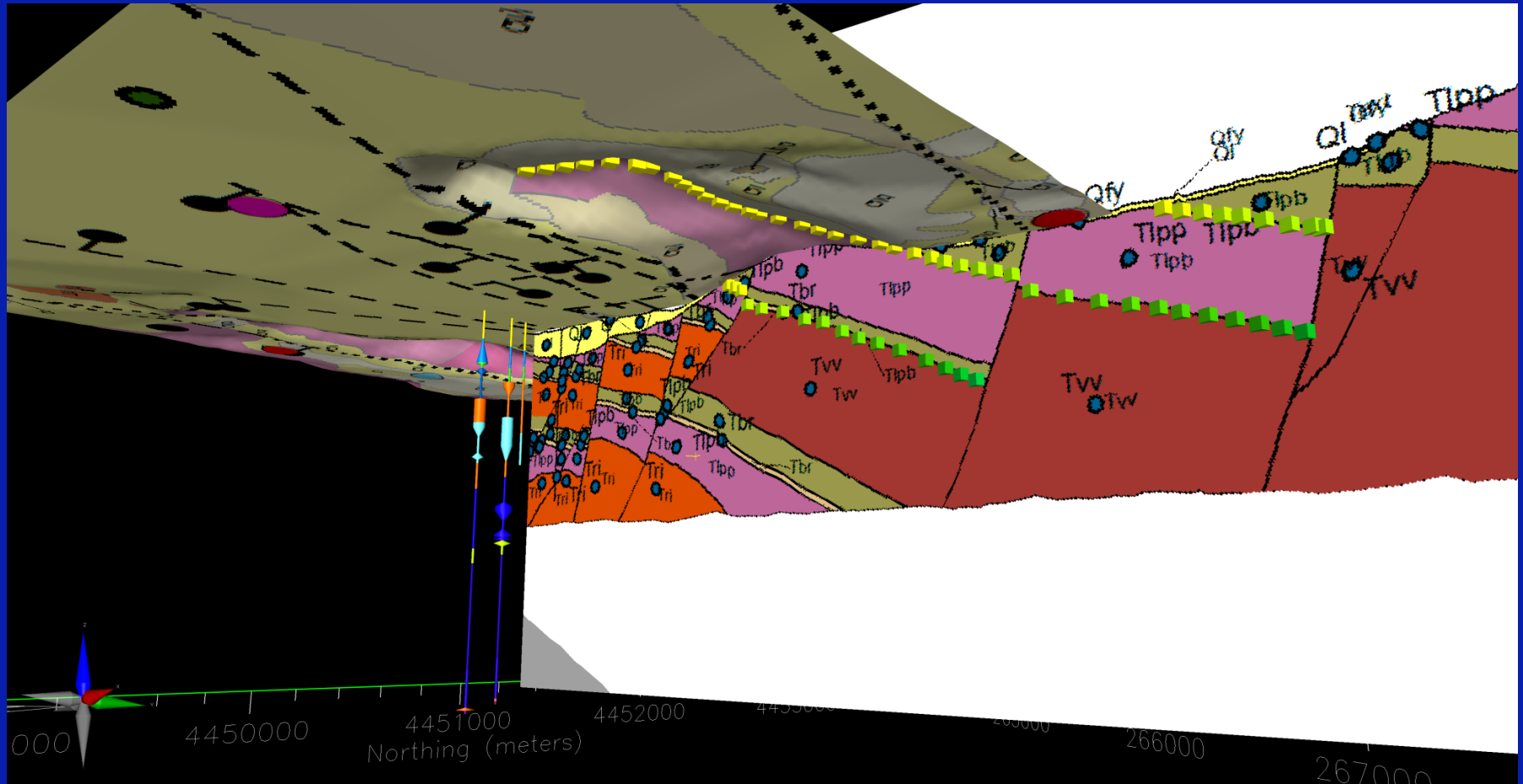




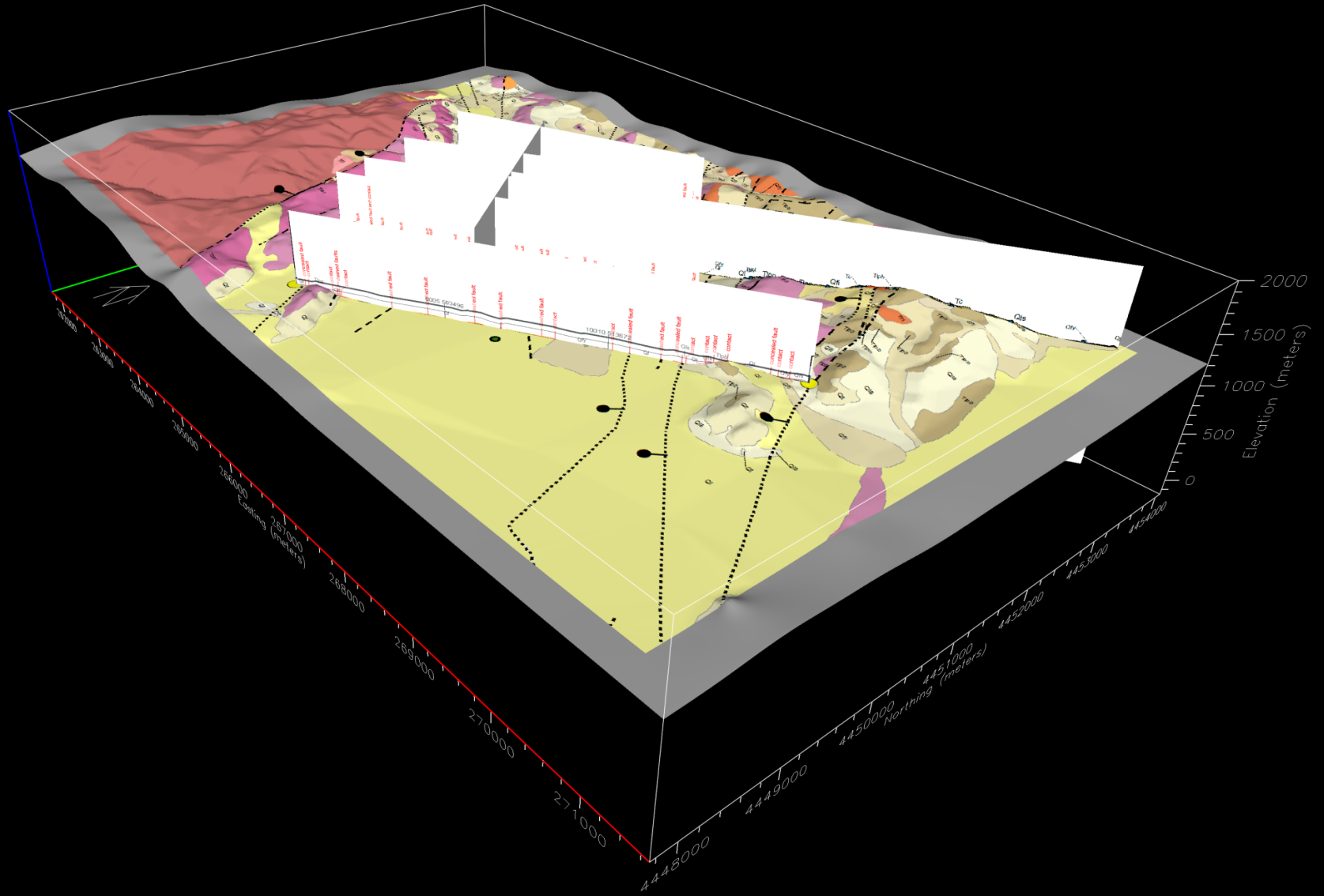




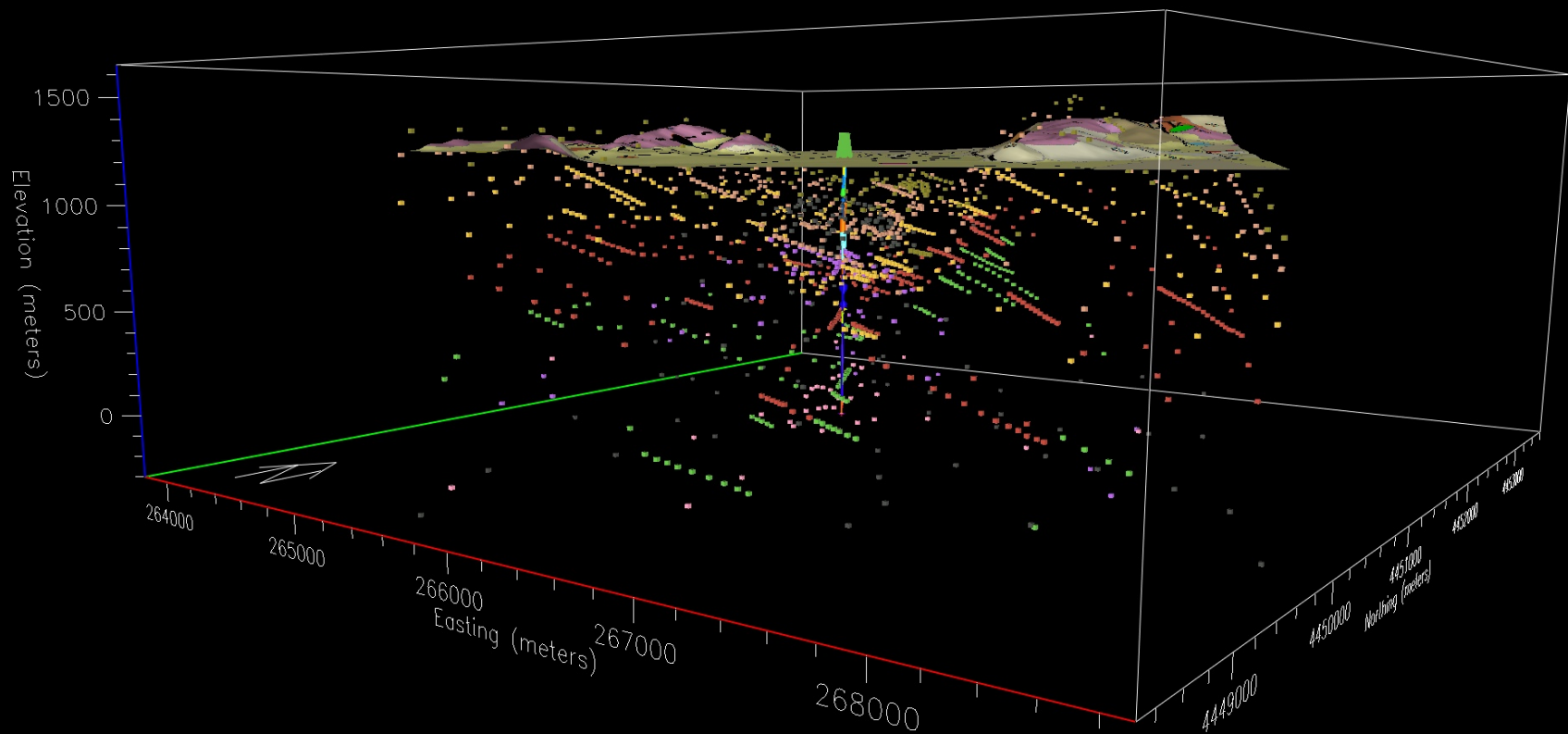
# Importing and/or digitizing in EV



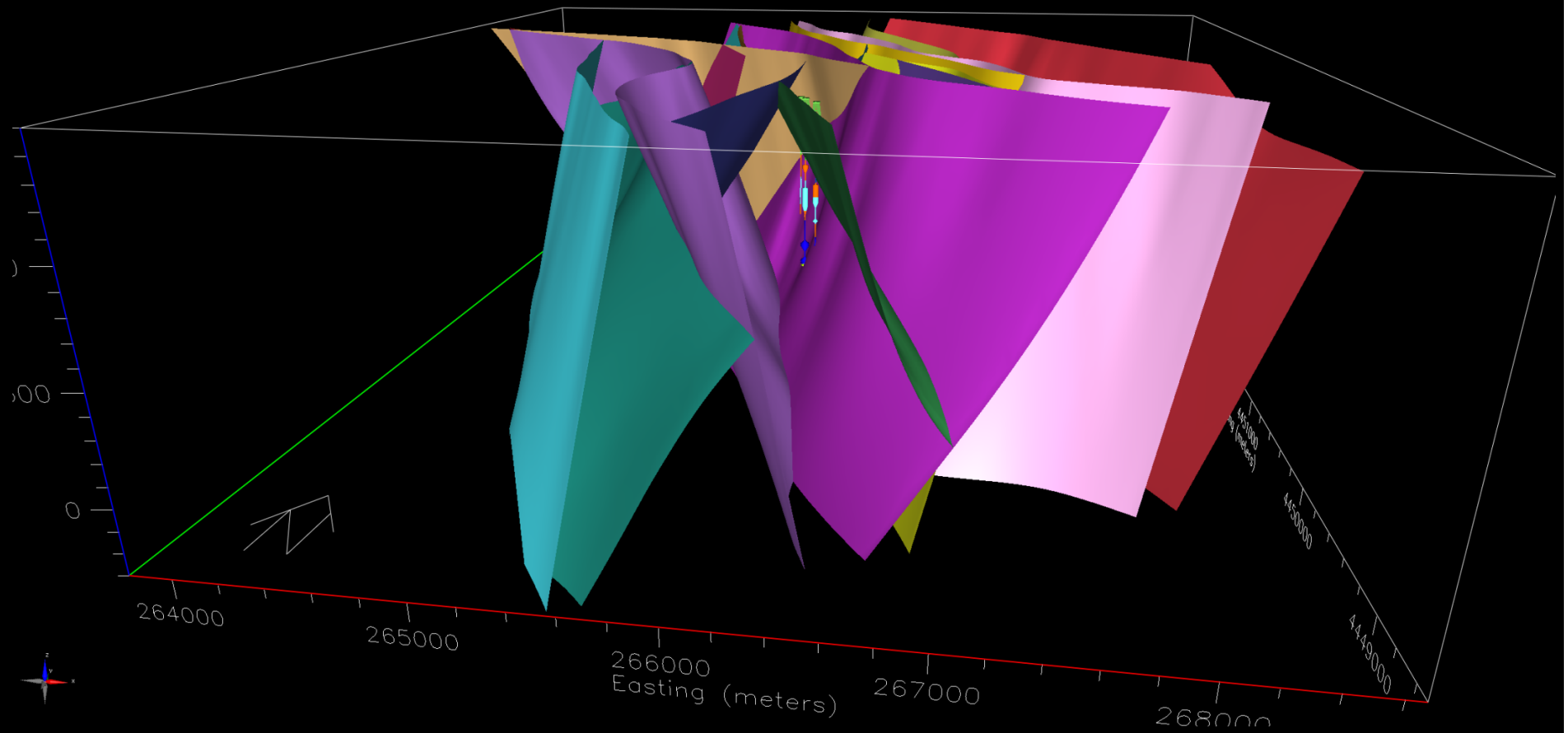
# Multiple cross-sections



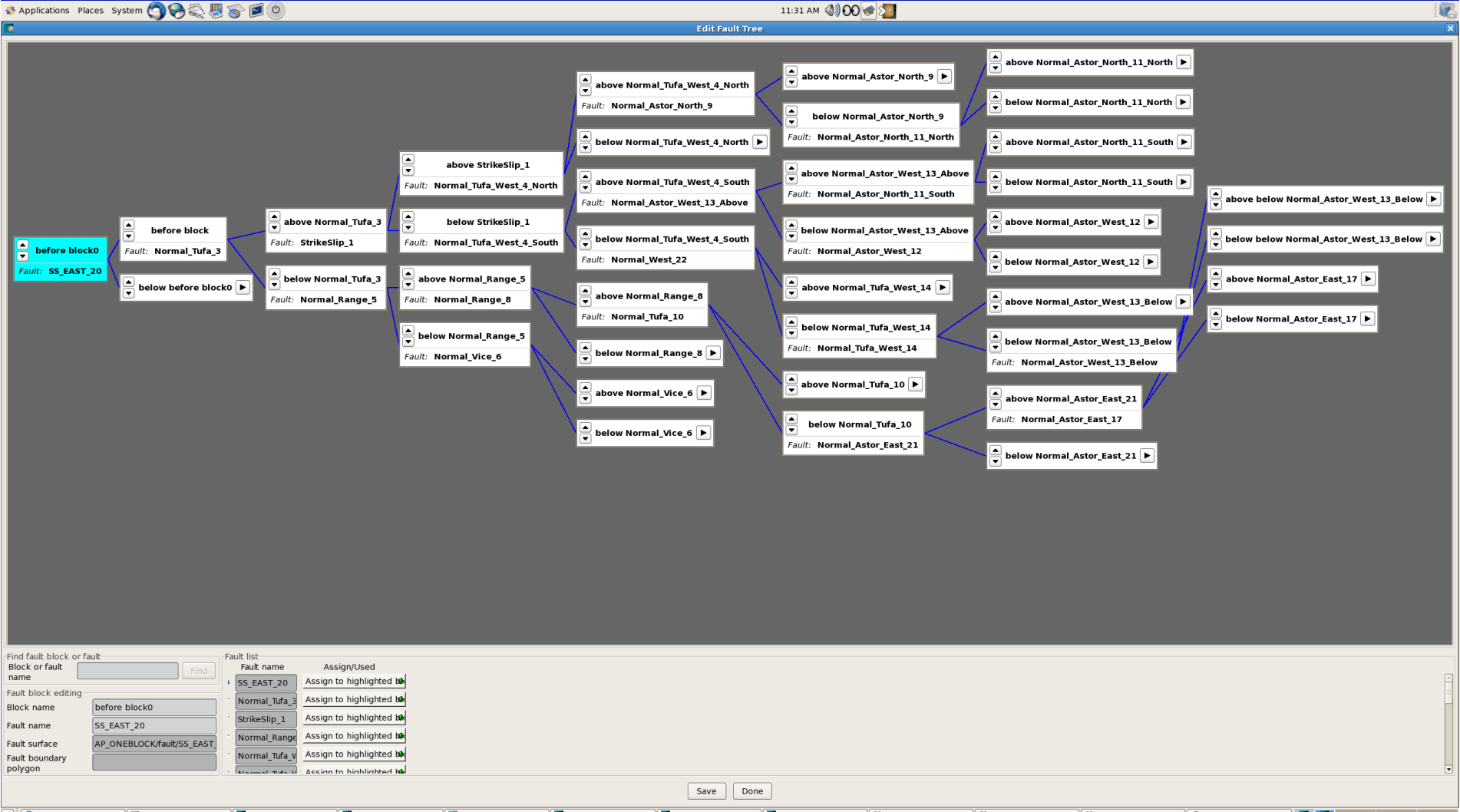
# Input data completely imported/digitized and attributed



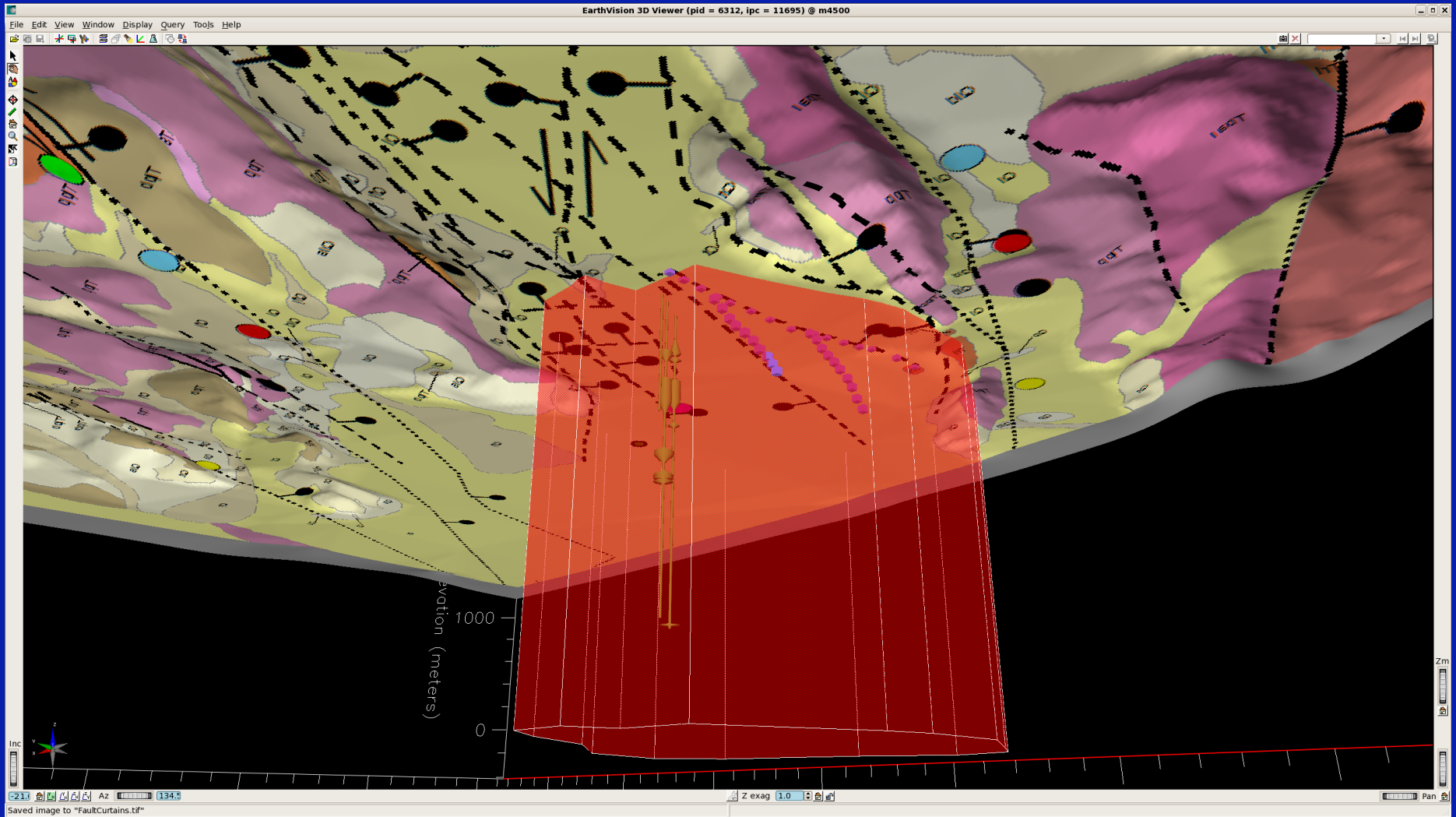
# Part 1 - Building Fault Surfaces



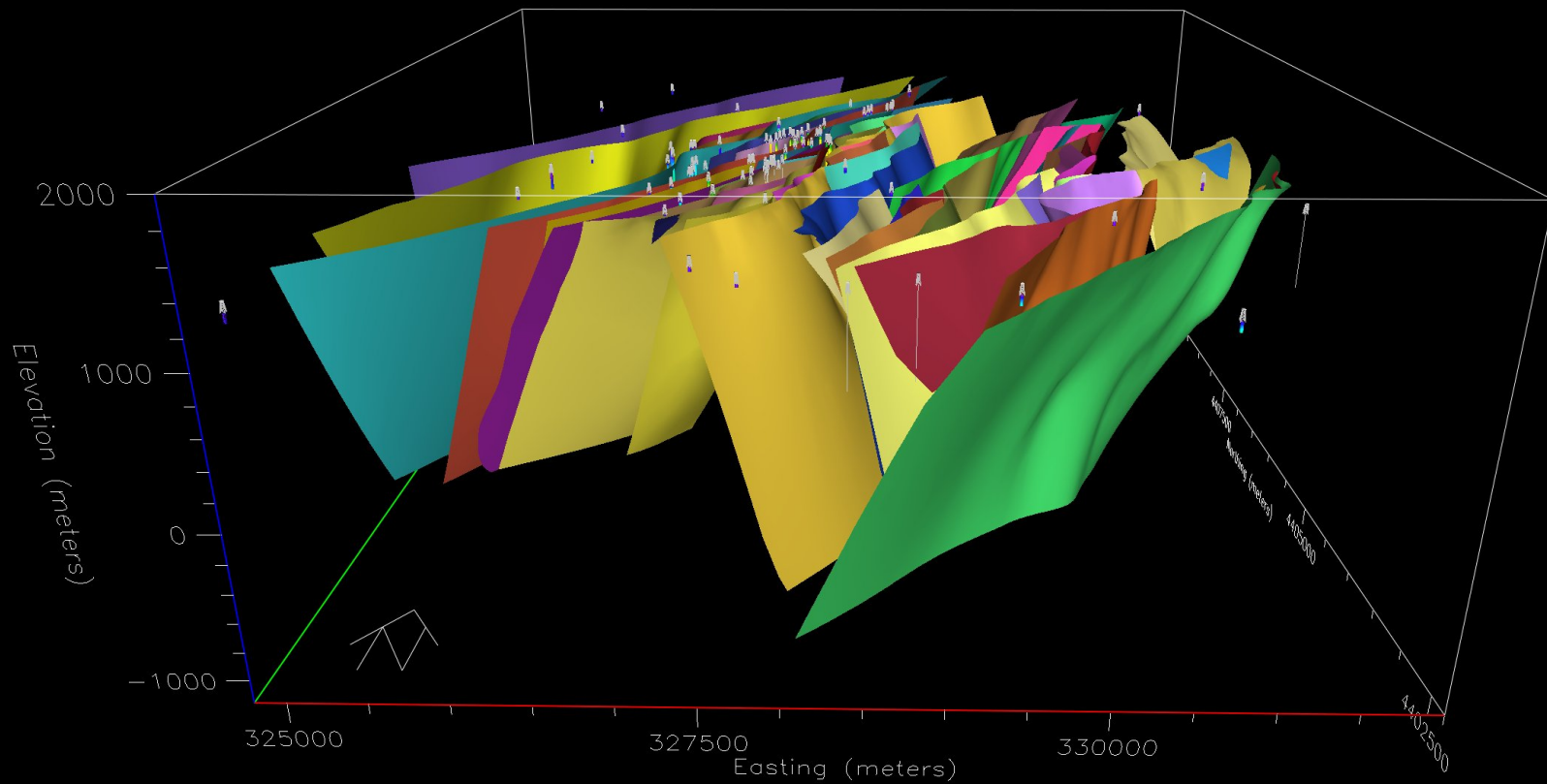
# Fault Hierarchy



# Fault Curtains

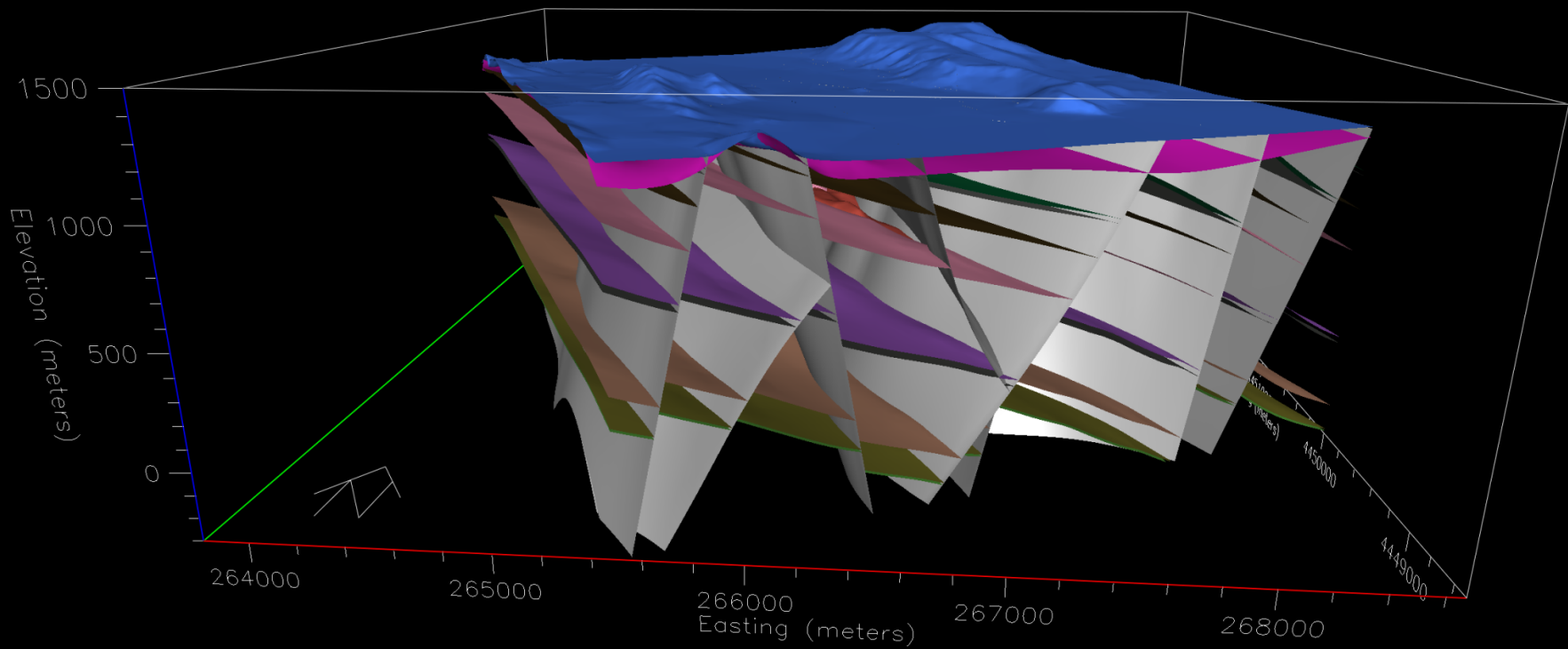


# Completed Fault Surfaces





# Stratigraphic Contacts



# Stratigraphic Sequence and Horizon Modeling

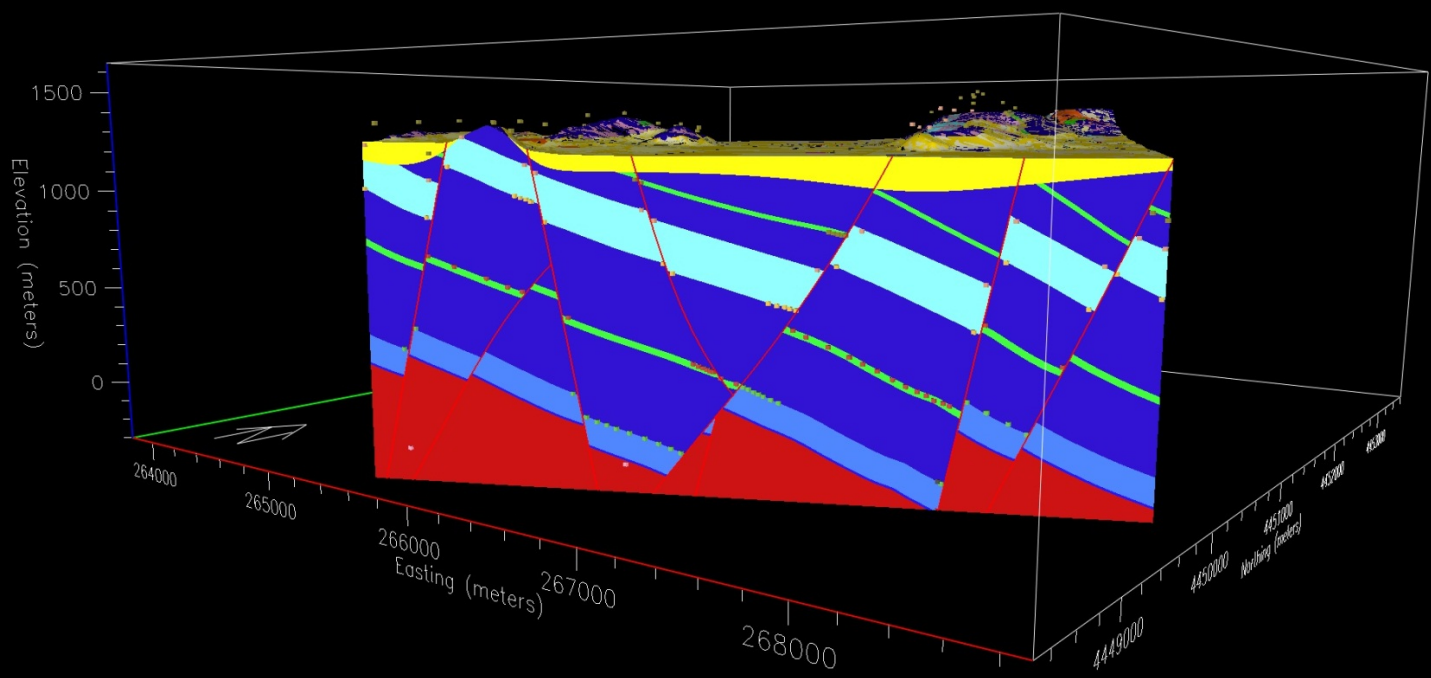
The screenshot displays the EarthVision 8.1 software interface. The main window, titled "Stratigraphic Sequence and Horizon Modeling", features a table for defining zones and horizons. The table includes columns for Zone/Horizon name, Horizon type, Operation, Horizon data/grid/const., Z field, Number of points, and Compute Use. Below the table are sections for "Zone/Horizon modeling and parameters" and "Zone files and references".

Zone/Horizon name	Horizon type	Operation	Horizon data/grid/const.	Z field	Number of points	Compute Use
Quaternary_Tufa	Reference	Unconformity	USER_MADE_FILES/		23	✓
Erosion_Tufa	Reference	Channel eros	USER_MADE_FILES/		22	✓
Quaternary	Reference	Deposition	USER_MADE_FILES/		23	✓
Pre_Q_Unconformity	Reference	Channel eros	USER_MADE_FILES/		22	✓
TRIs	Reference	Unconformity	USER_MADE_FILES/		18	✓
Erosion_TRIs1	Reference	Channel eros	<byfaultblock>		23	✓
Erosion_TRIs2	Reference	Channel eros	<byfaultblock>		23	✓
Erosion_TRIs3	Reference	Channel eros	<byfaultblock>		23	✓
Erosion_TRIs4	Reference	Channel eros	<byfaultblock>		23	✓
Erosion_TRIs5	Reference	Channel eros	<byfaultblock>		23	✓
TLP1	Intermediate	Deposition	400		8	✓
TS	Intermediate	Deposition	20		11	✓
TLP2	Reference	Deposition	USER_MADE_FILES/	z	203	24 ✓
TRI1	Intermediate	Deposition	145		18	✓
TLP4	Intermediate	Deposition	125		19	✓
TRI2	Intermediate	Deposition	350		19	✓
TLP3	Intermediate	Deposition	135		18	✓
TVS	Intermediate	Deposition	560		15	✓
TLP4	Intermediate	Deposition	30		14	✓
TB	Intermediate	Deposition	320		13	✓
TRI3	Intermediate	Deposition	135		12	✓
TMV	Intermediate	Deposition	120		11	✓
Basement	Intermediate	Deposition	10		10	✓

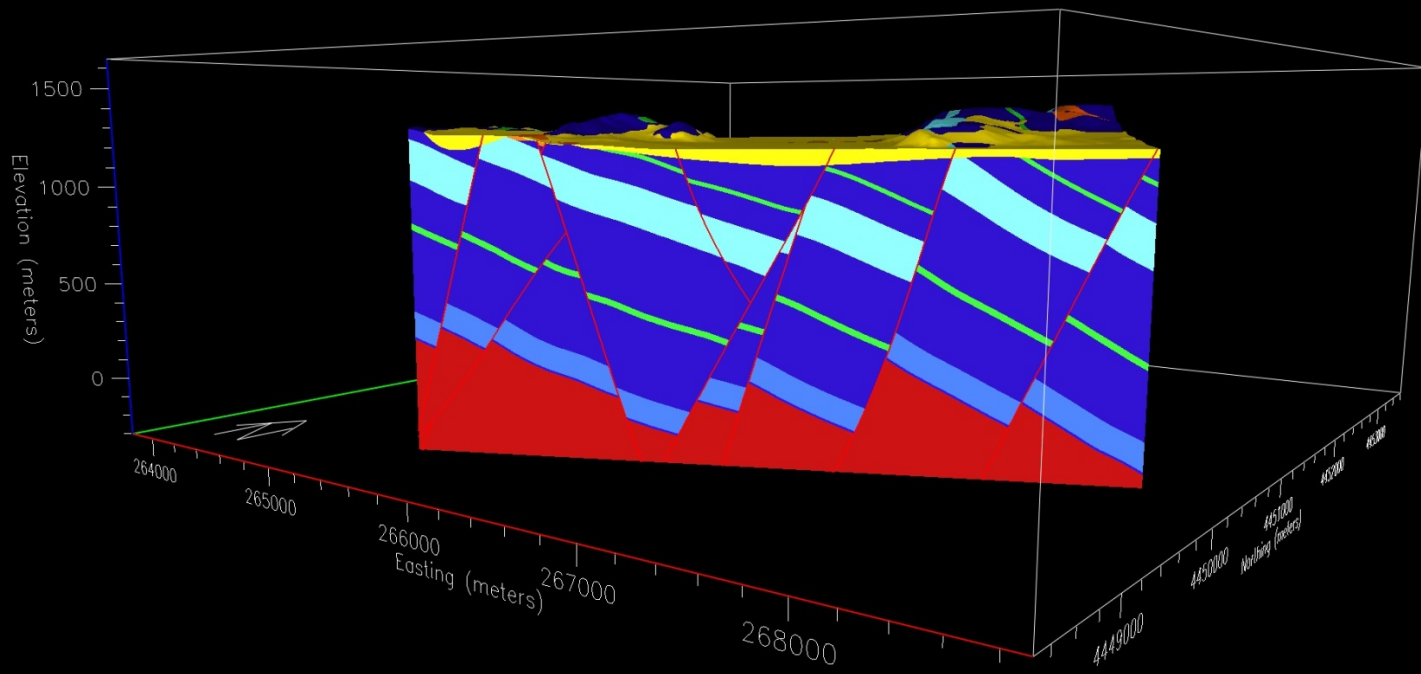
The "Zone/Horizon modeling and parameters" section includes tabs for "Zone files and references", "General gridding parameters", "Per zone gridding parameters", and "Report". The "Per zone gridding parameters" section contains fields for "Reference horizon(s)", "Reference horizon location is", "Above reference horizon", "Below reference horizon", and "Local faults".

The "WFM main window" in the background shows project information for "AstorPass" and a "Computation" table with columns for Operation, Settings, Validate after ready, Progress, and Status. The "Computation" table lists operations like "Fault modeling", "Fault tree building", "Horizon modeling", and "3D structural model".

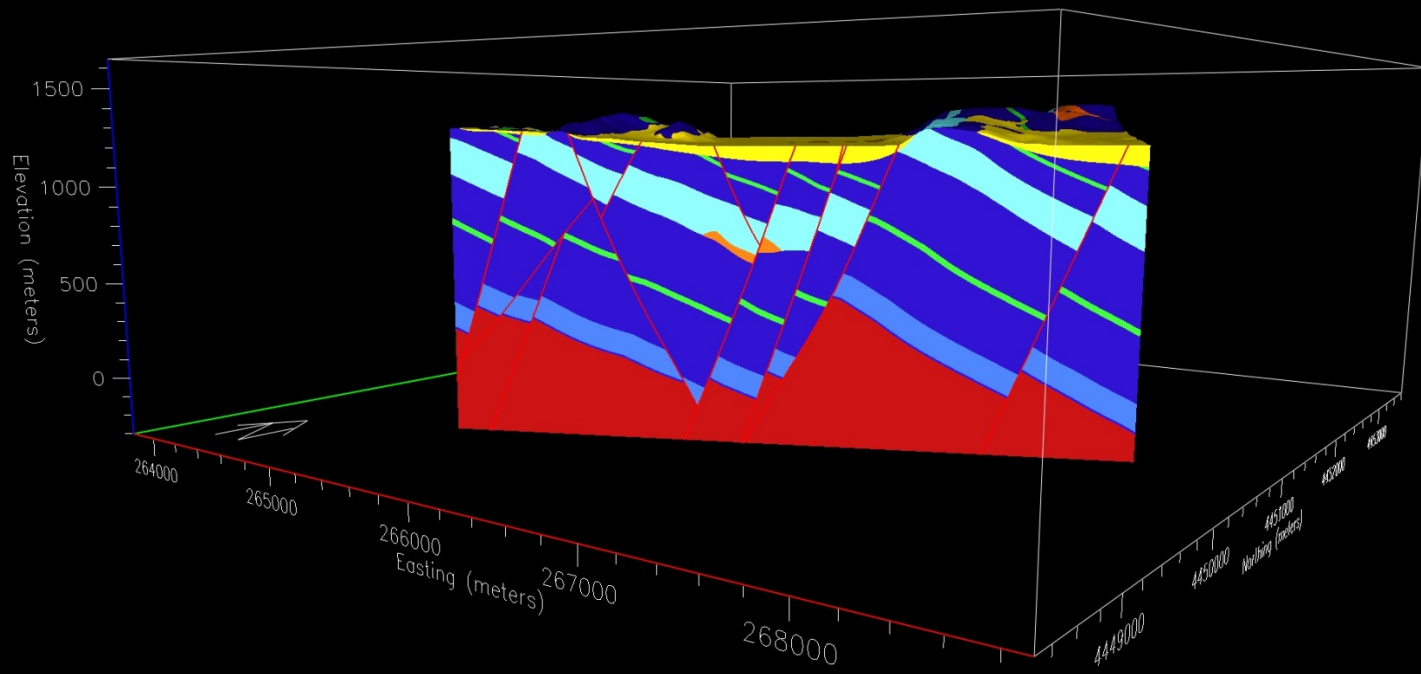
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- 9 Quaternary\_Tufa
  - 8 Quaternary
  - 7 TR1s
  - 6 TLP1
  - 5 TS
  - 4 TLP2
  - 3 TRI1
  - 2 TLPA
  - 1 TRI2
  - 0 TLP3
  - 1 TVS
  - 2 TLP4
  - 3 TB
  - 4 TRI3
  - 5 TMV
  - 6 Basement



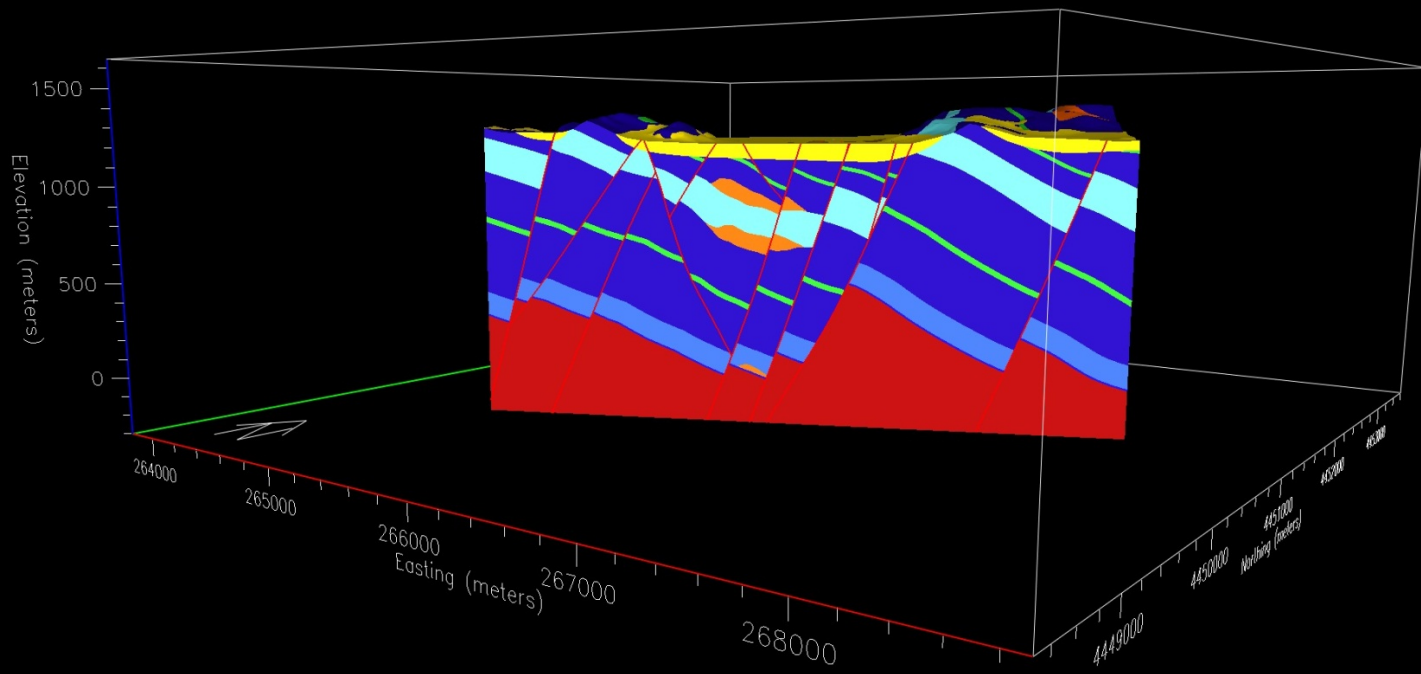
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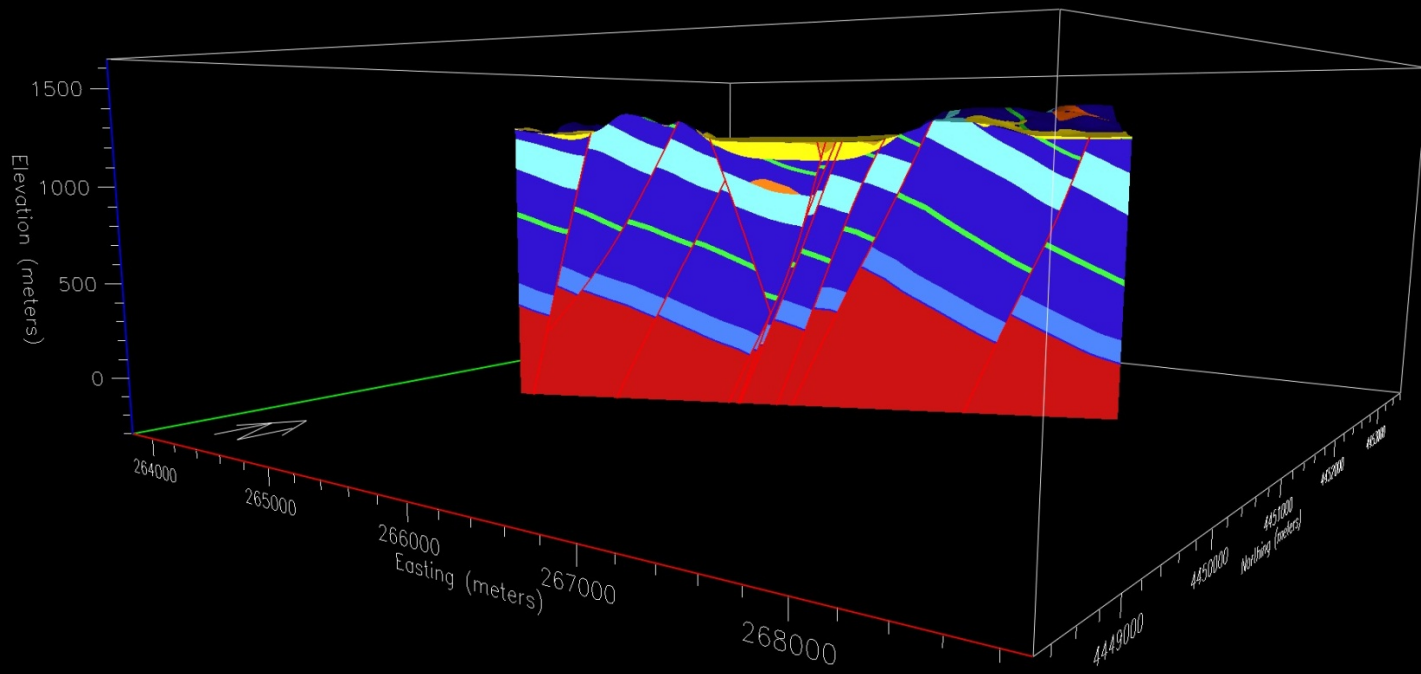
- Attribute = Zone
- 9 Quaternary\_Tufa
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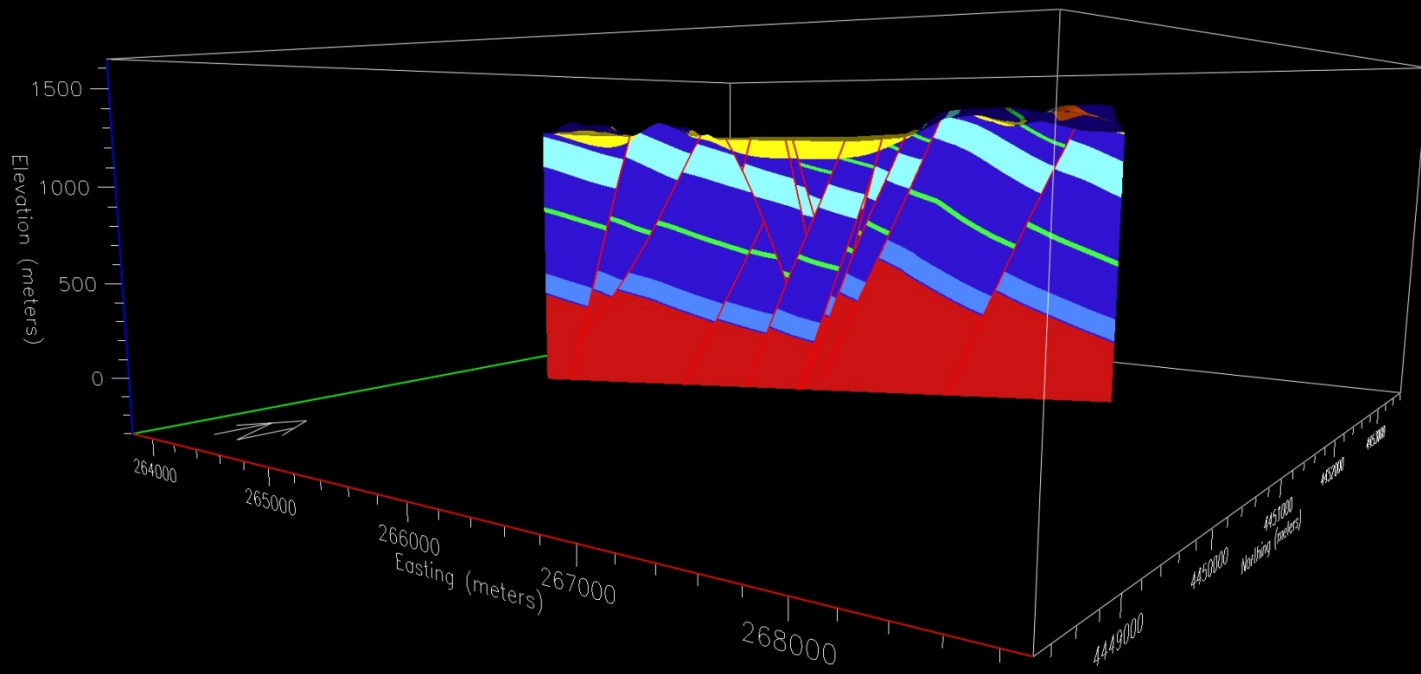
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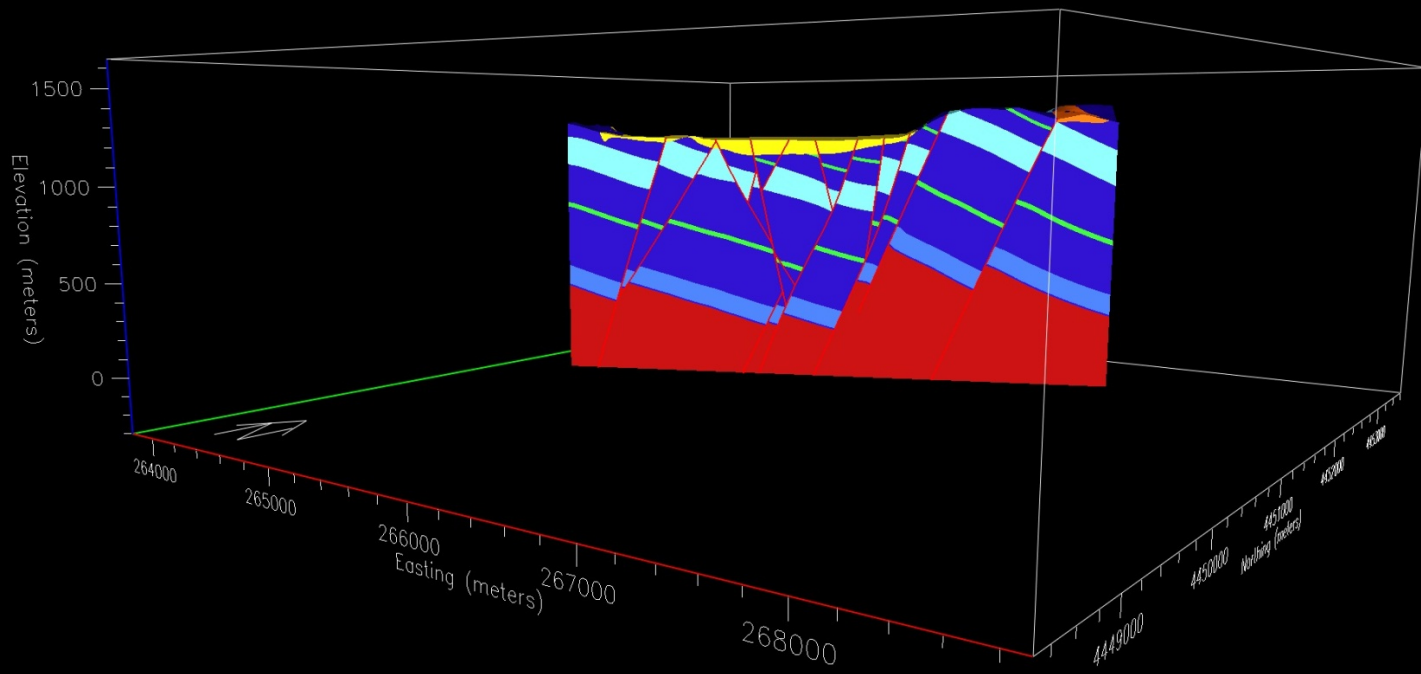


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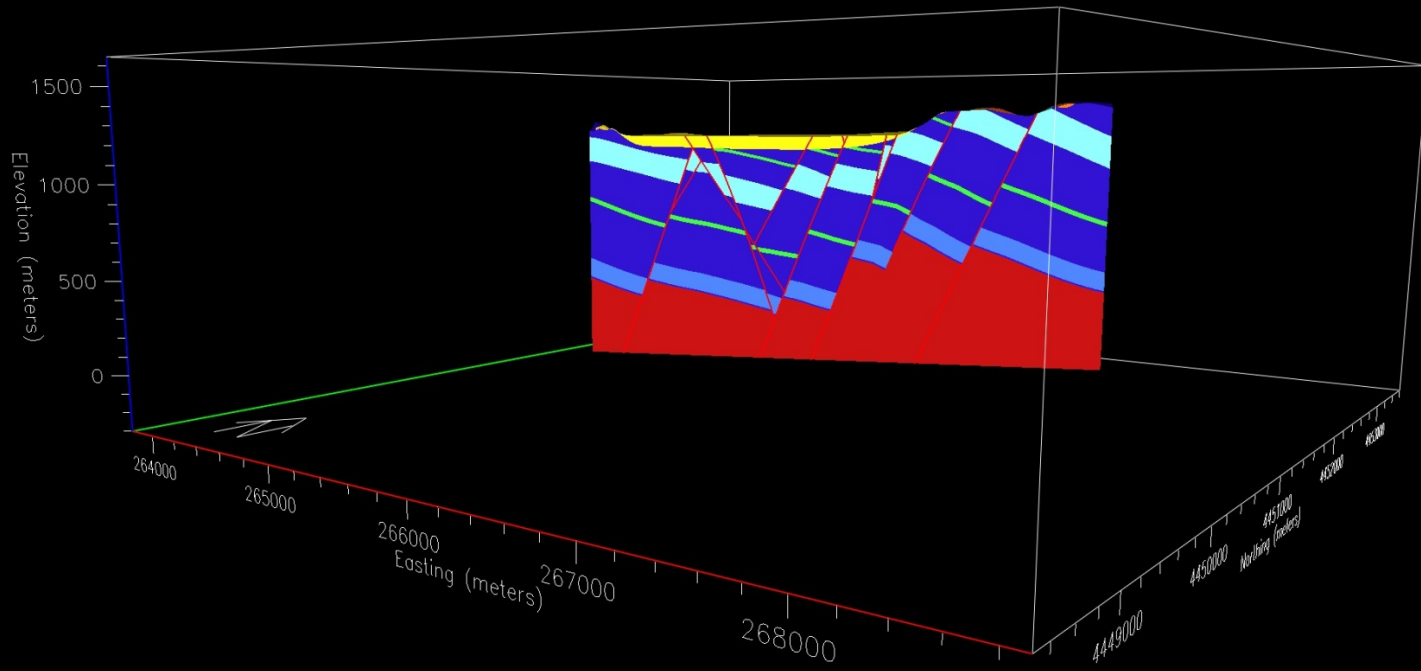




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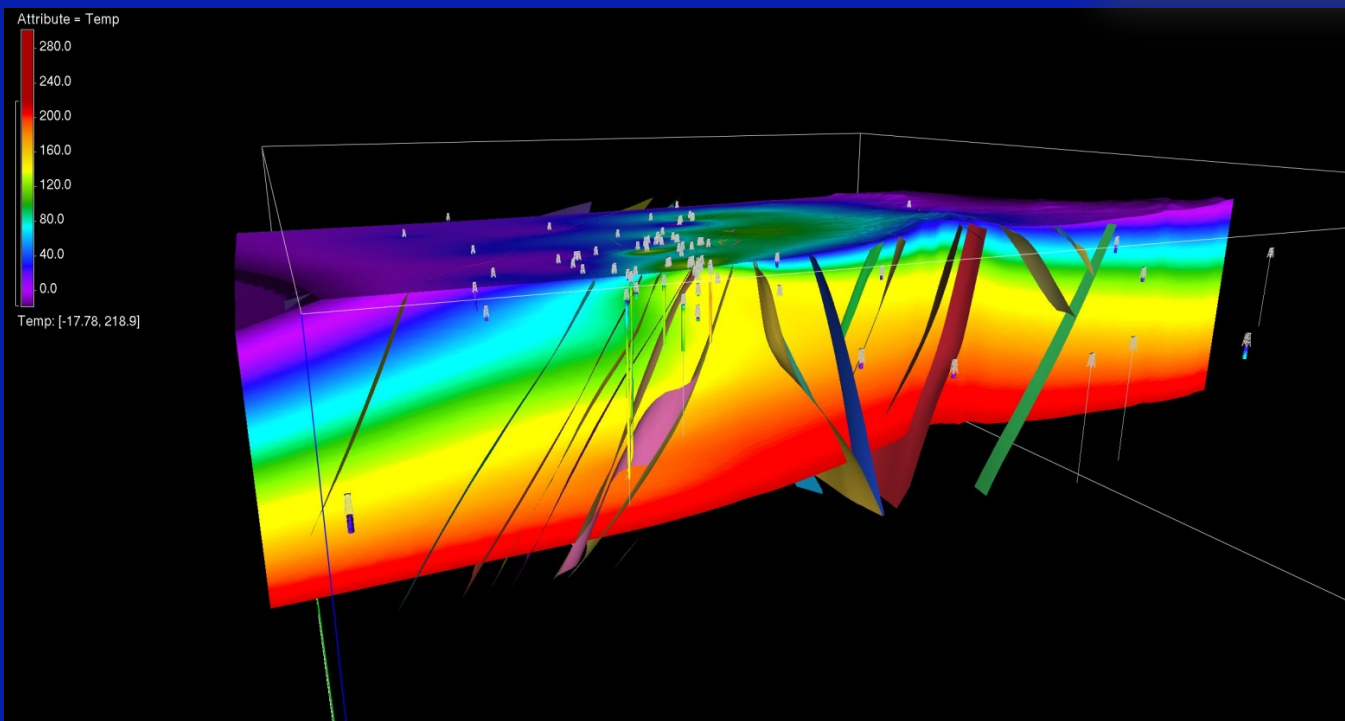
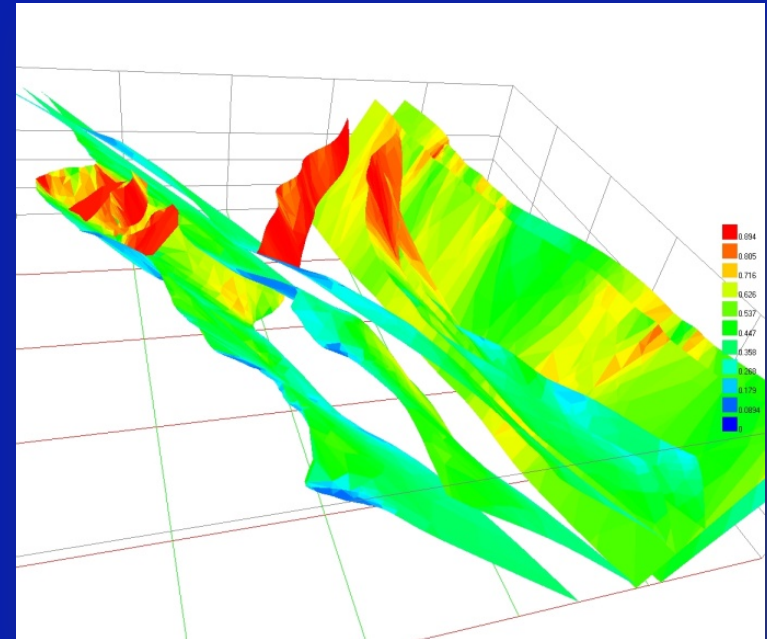


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# Model Uses

- Slip and Dilatation tendency analyses of faults
- Thermal data, alteration, etc,
- Well planning and reservoir modeling





# Publishing/Sharing

- Formats
  - Raw XYZ points
  - 3D shape files
  - 3D PDFs
  - *Software License Restrictions*
- Original point data
  - Different sources
  - Different levels of accuracy
- Rendered surfaces and volumes
  - Accuracy dependent upon source of point data
  - Also on distribution and concentration of point data

