A Regional Multi-scale 3D Geological Model of the Eastern Sub-Athabasca Basement, Canada: Implications for Vectoring towards Unconformity-type Uranium Deposits

ANNESLEY, Irvine R.[1, 2], REILKOFF, Brian[2], TAKACS, Erno[2], HAJNAL, Zoltan[2], and PANDIT, Bhaskar[2]

[1] formerly of JNR Resources Inc., 204 – 315 22nd St. East, Saskatoon, SK, S7K 0G6

[2] Department of Geological Sciences, University of Saskatchewan, 114 Science Place, Saskatoon, SK, S7N 5E2

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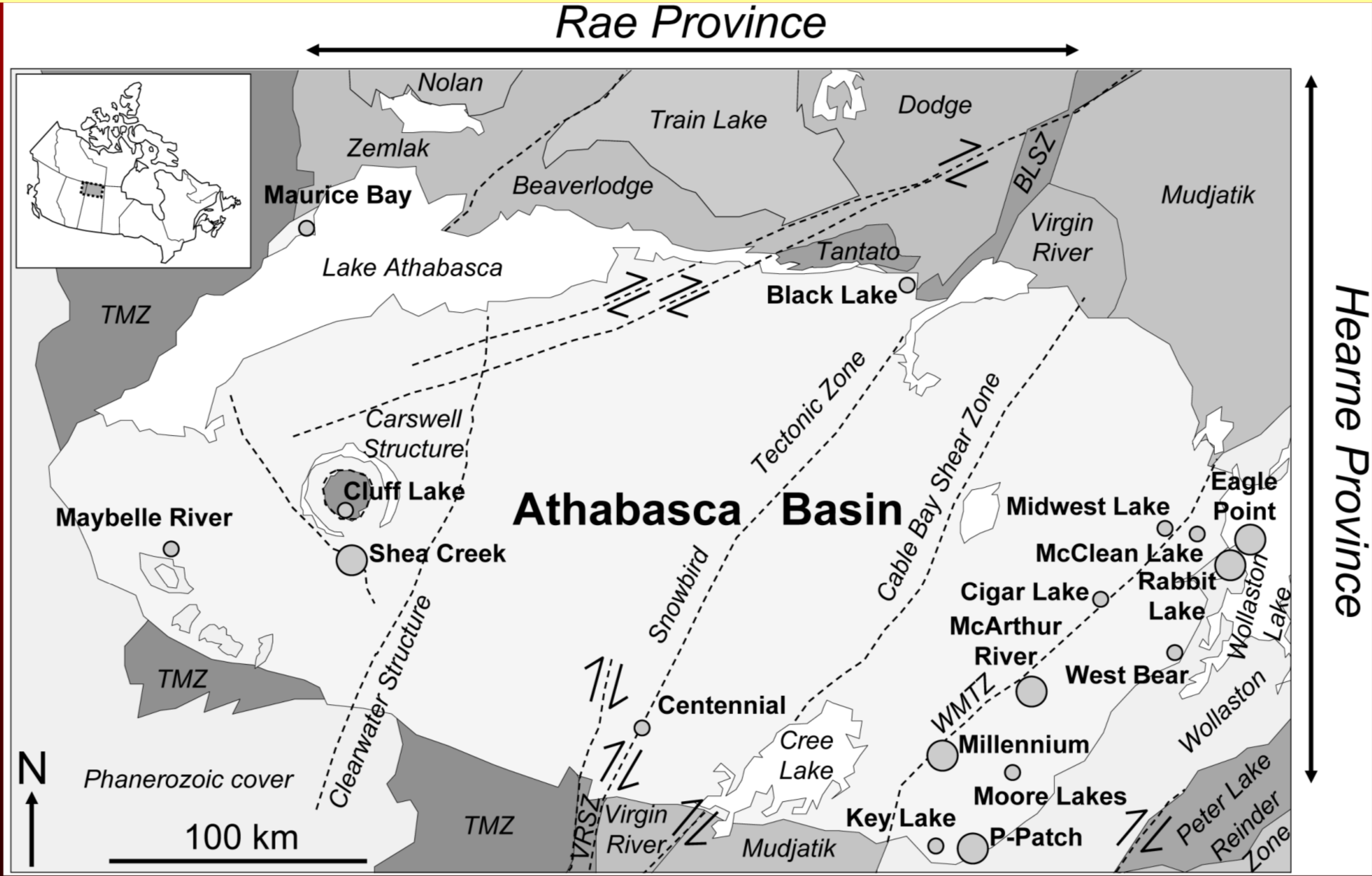
Presentation Outline

- Introduction
- Regional geological setting
- Building a regional 3D model
- Snapshots of the regional 3D model
- Applications to other types of modeling
- Moore Lakes GOCAD model (district scale)
- Fraser Lakes GOCAD model (deposit scale)
- Summary and Conclusions

Purpose of our Research

- To characterize the basement geology in the vicinity of unconformity-type uranium deposits,
- To define the role of basement lithologies and structure in the genesis of unconformity-type uranium deposits,
- To provide the lithological and structural architecture necessary for fully coupled modeling of the eastern Athabasca unconformity-type uranium deposits
- To identify key exploration vectoring criteria using a combination of tools, including GOCAD

Location of uranium deposits in the Athabasca Basin



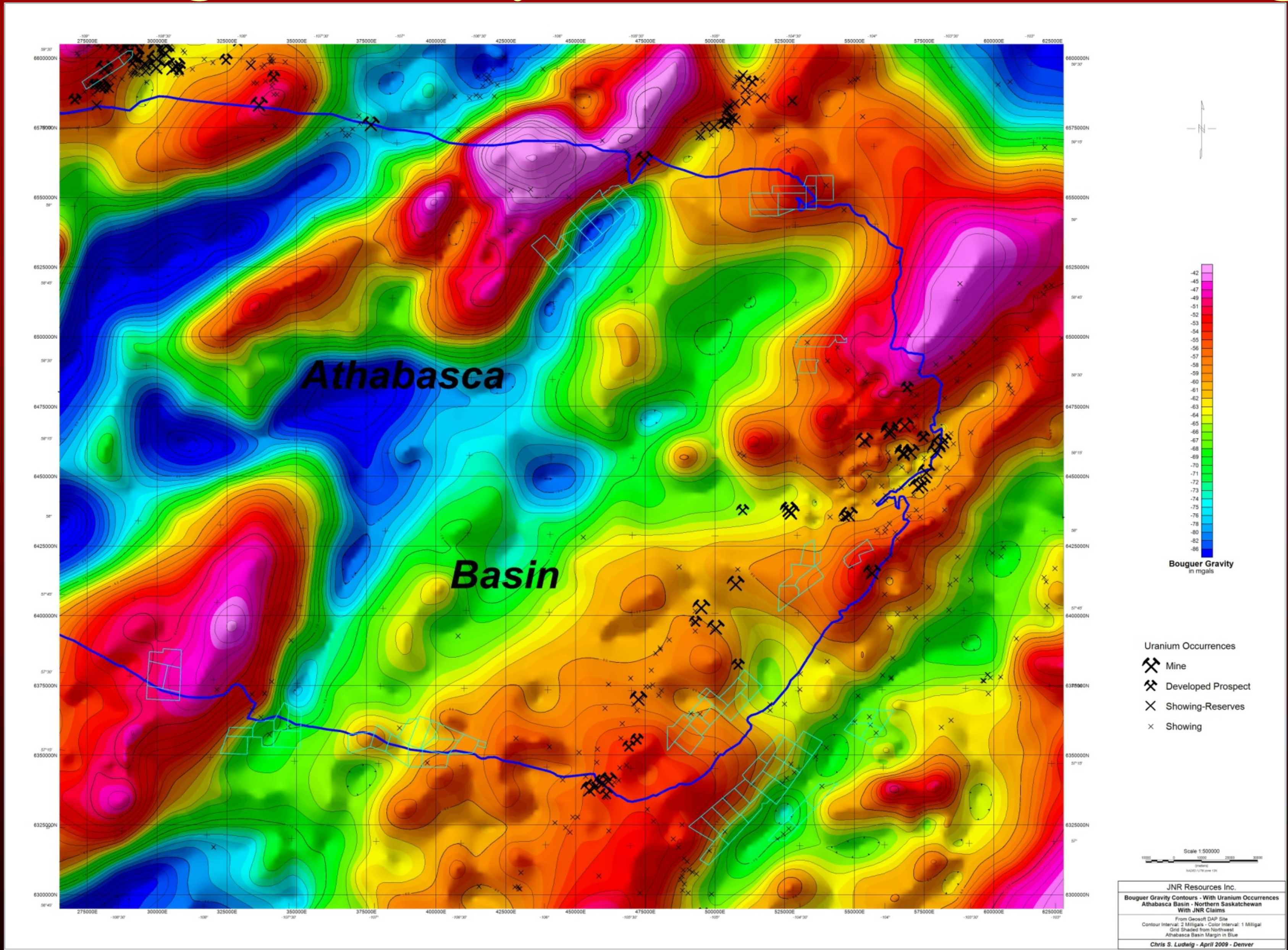
Modified after *Jefferson et al., (2007)*

Numerous deposits

Principal location is on the eastern side (WMTZ)

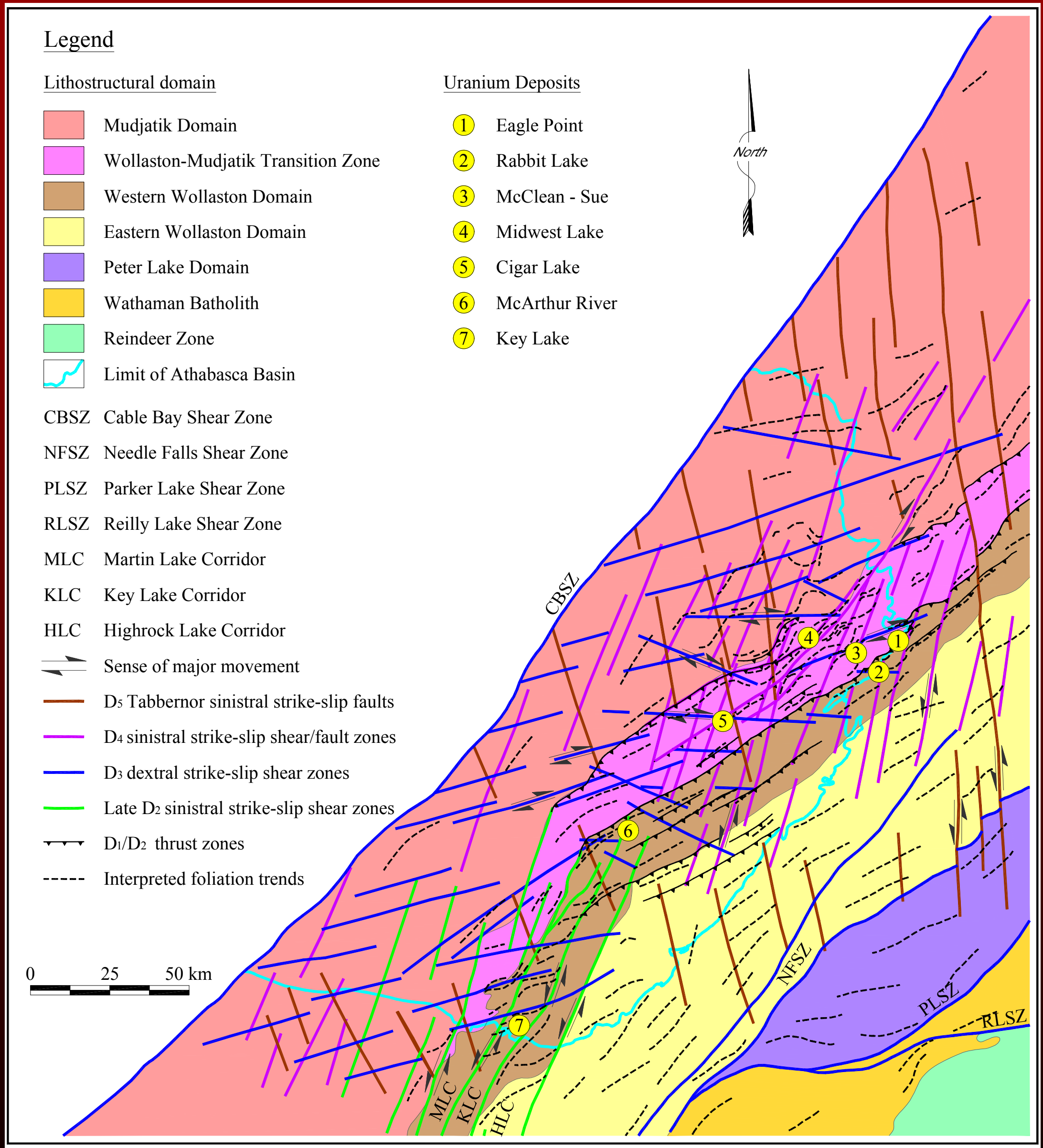
Relation of deposits – large scale regional transcrustal structures

GSC Bouguer Gravity of the Athabasca Basin region



(after Annesley et al., 2009a, 2009b)

GEOLOGICAL BACKGROUND

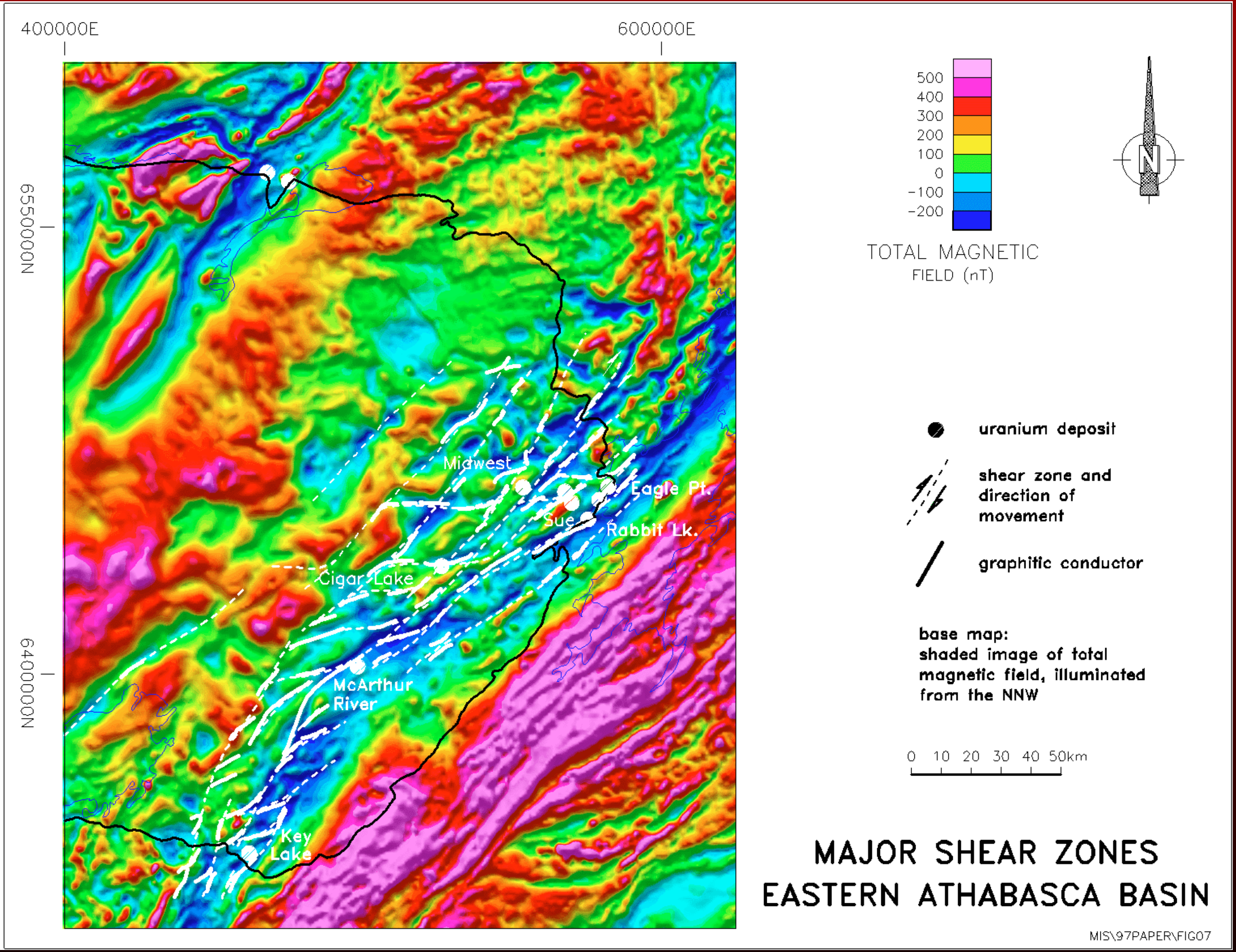


Eastern Sub-Athabasca Basement Subdivision

- Eastern Wollaston Domain
- Western Wollaston Domain
- Wollaston-Mudjatik Transition Zone
- Mudjatik Domain

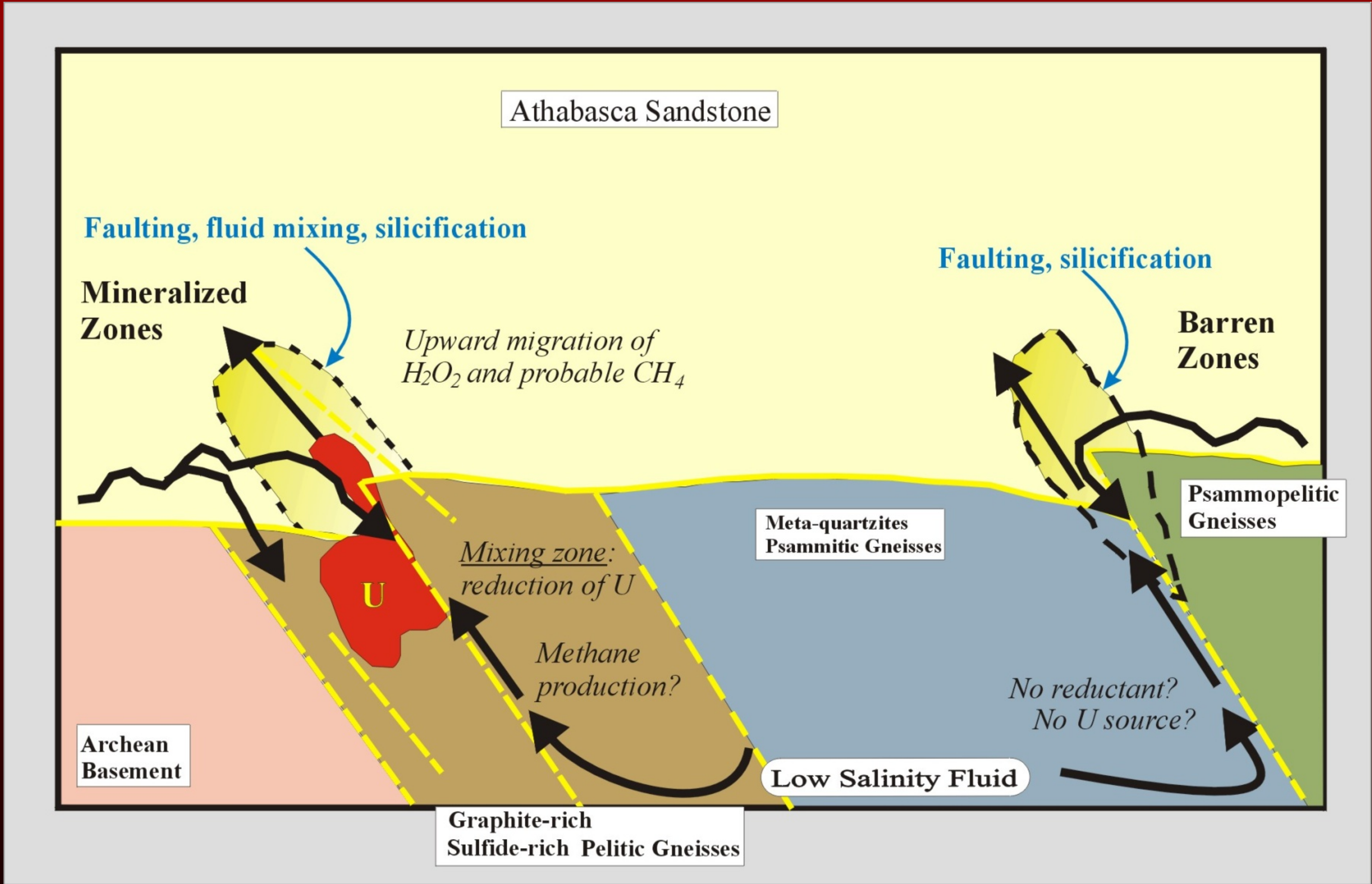
(after Portella and Annesley, 2000; Annesley et al., 2005, 2006)

GEOLOGICAL BACKGROUND 2



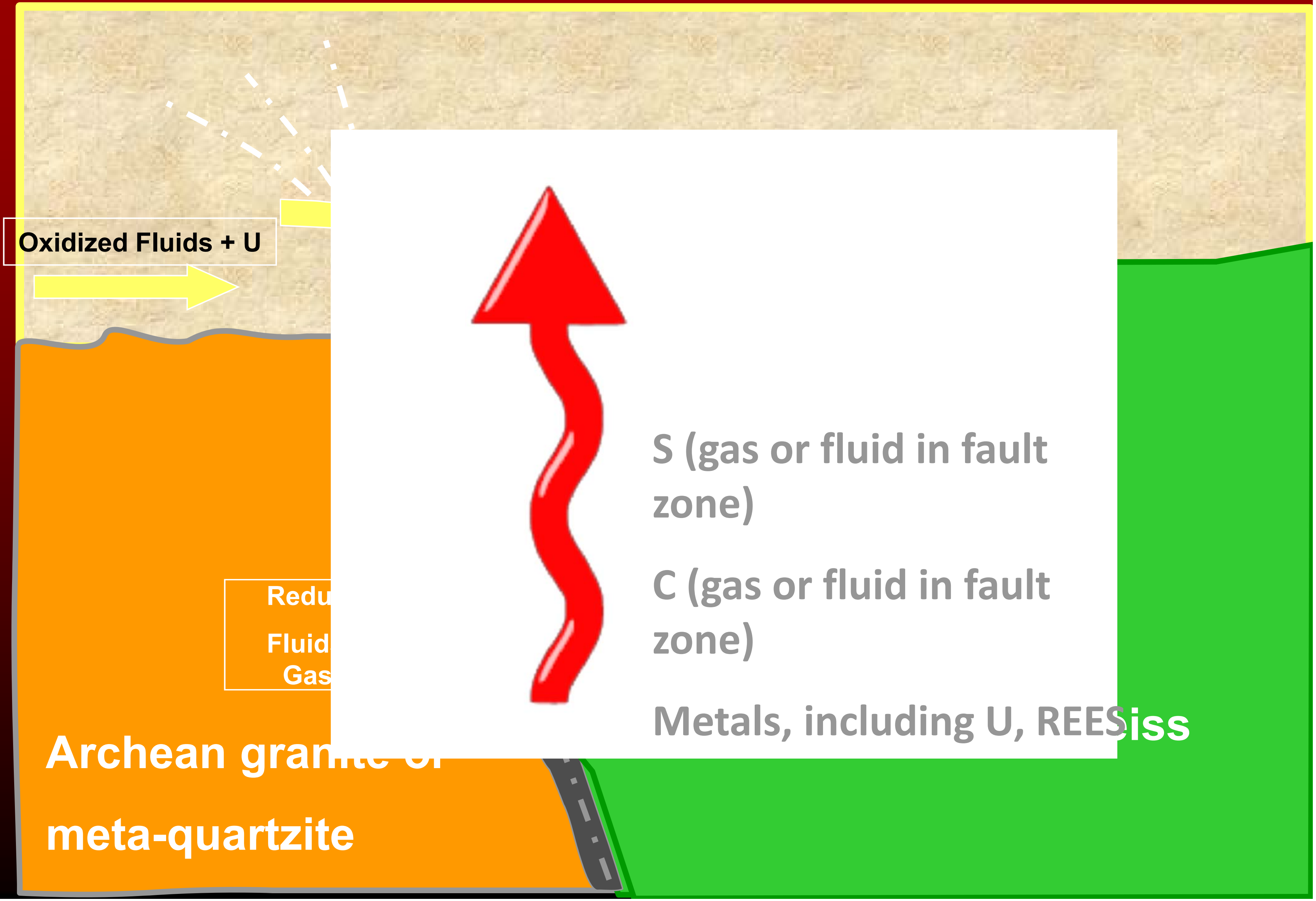
Major reactivated shear/fault zones (white dashed lines); defined by EM conductors within the crystalline basement rocks underlying the eastern Athabasca Basin (after Matthews et al., 1997).

Schematic sketch of fluid circulation and possible implications for the genesis of unconformity-type uranium deposits (ca. 1550 Ma)



(Note: modified after Derome et al., 2003)

Fluid Movement in the Basin (~1550 Ma)

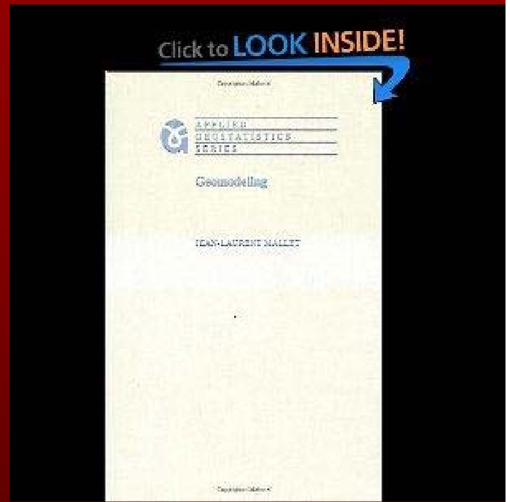


Integration of Geological Data / Interpretation Sets (1989 - 2006)

- Field Mapping (1:50,000 scale)
- Drill Core Logging (~1,600 DDH relogged)
- Basement Petrography (~9,000 thin sections)
- Whole-rock Geochemistry (~2,000 samples)
- U-Pb Geochronology (58 samples – zircon, monazite, titanite)
- Vertical Gradient & Total Field Aeromagnetics
- 2D & 3D Seismic Profiles/Models
- GOCAD Modelling

What is GOCAD and its software?

GOCAD (Geological Object Computer Aided Design) is the name of a project started in 1989 by Professor Jean-Laurent Mallet at Nancy Université.



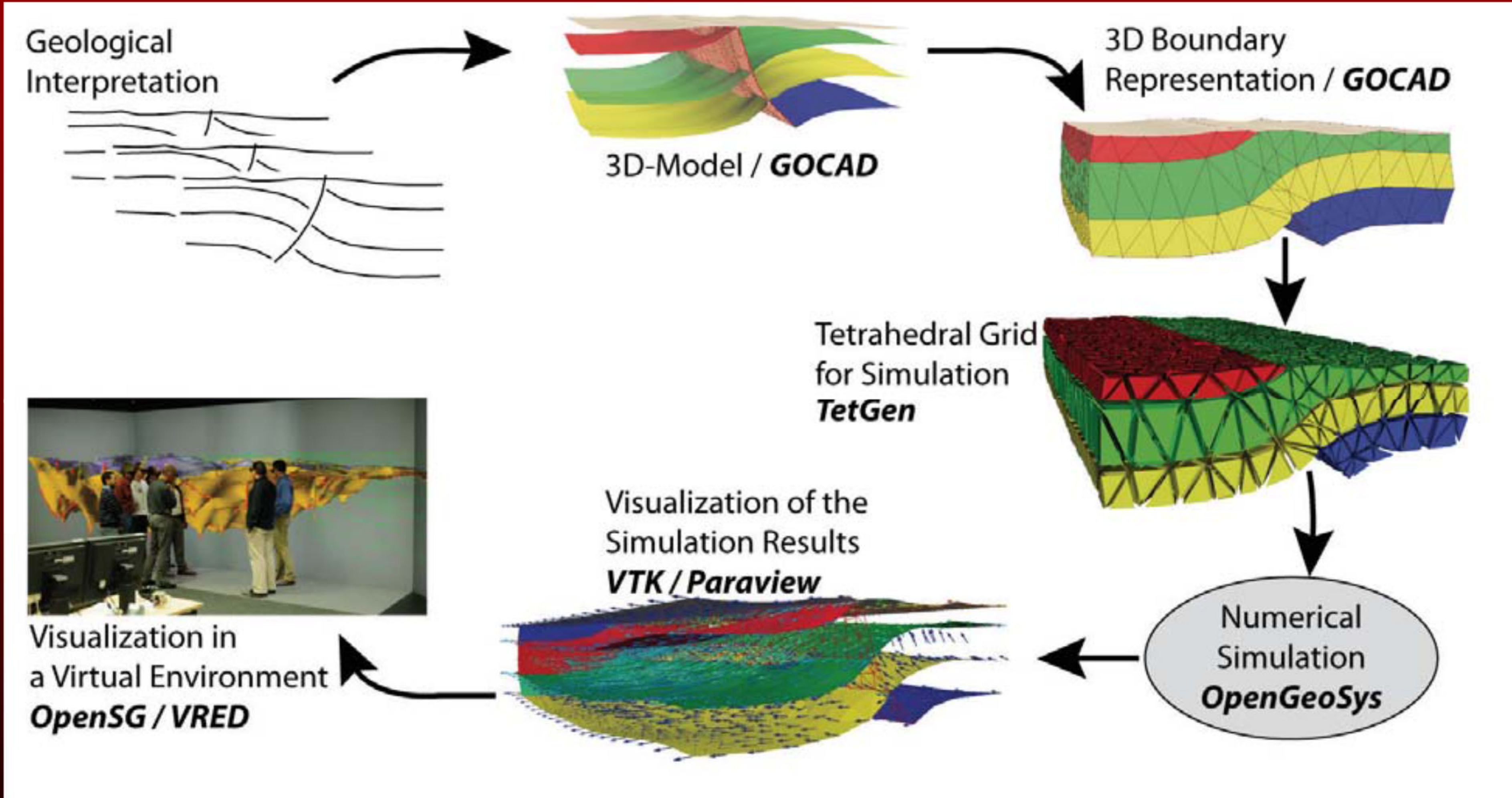
So the GOCAD project is actually three entities:

- The GOCAD Research Group
- The Mathematical Geosciences journal
- The GOCAD Consortium

- The GOCAD software was developed by the GOCAD Research Group during the 1990's. This software and application programming interface is now commercial and fully owned by and can be obtained from Paradigm Geophysical. Mira Geosciences has the commercial selling rights for the mining and exploration industry worldwide, in cooperation with Paradigm.
- The geologic modeling bible is written by Professor Mallet:

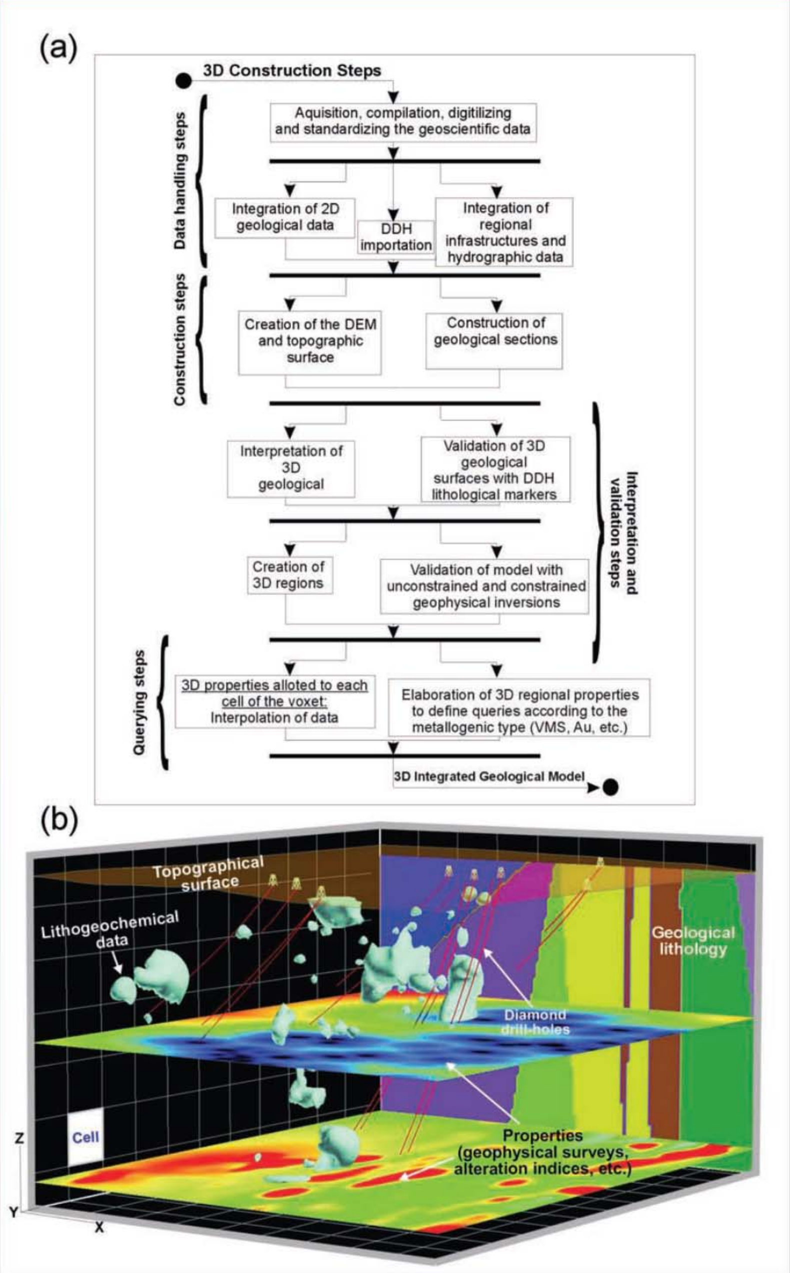
Geomodelling (2002)

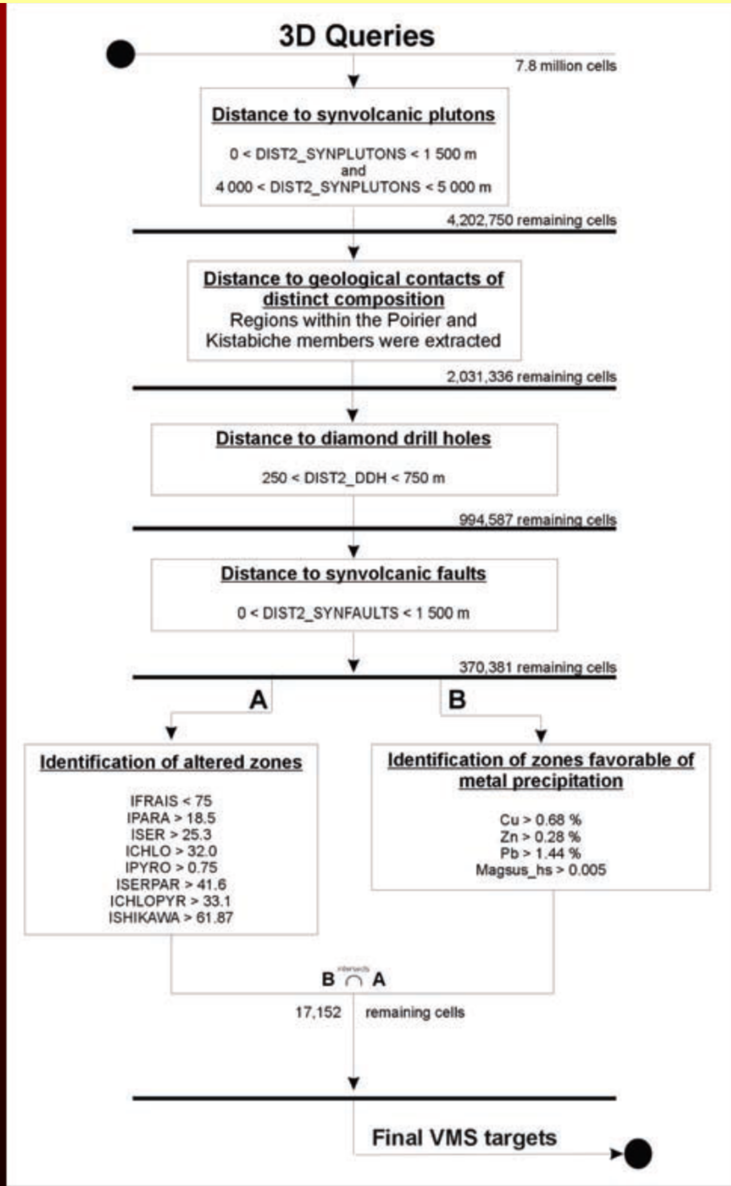
What is the GOCAD software?



From Fallara et al., 2006

What is the GOCAD software?





From Fallara et al., 2006

Data Import into GOCAD

- **Original data in MapInfo or Excel format**

Topography

Geographic data (vegetation, water, roads, ...)

Geological maps (1:50,000)

Airborne magnetics, VTEM, radiometrics, and Bouguer gravity data (1:50,000 to 1:250,000 scales)

Geochemical data (bedrock, DDHs, soil, lake and stream sediments); High-resolution seismic data

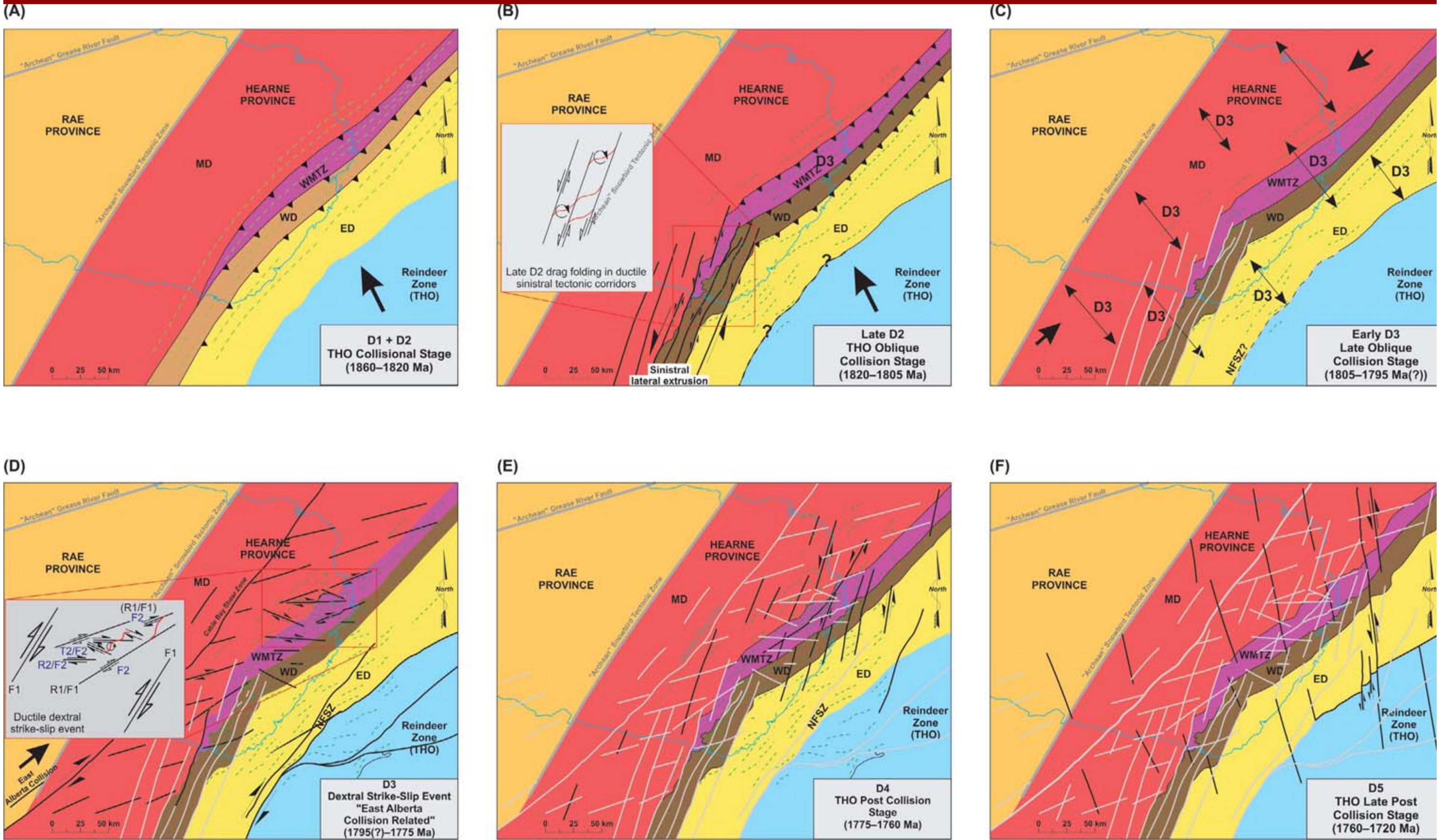
Translating with Universal Translator or by creating an Access file

Universal Translator	***.TAB***	***.shp***
Access Processing	***.xls***	***.csv***

- ***Importing into Gocad***

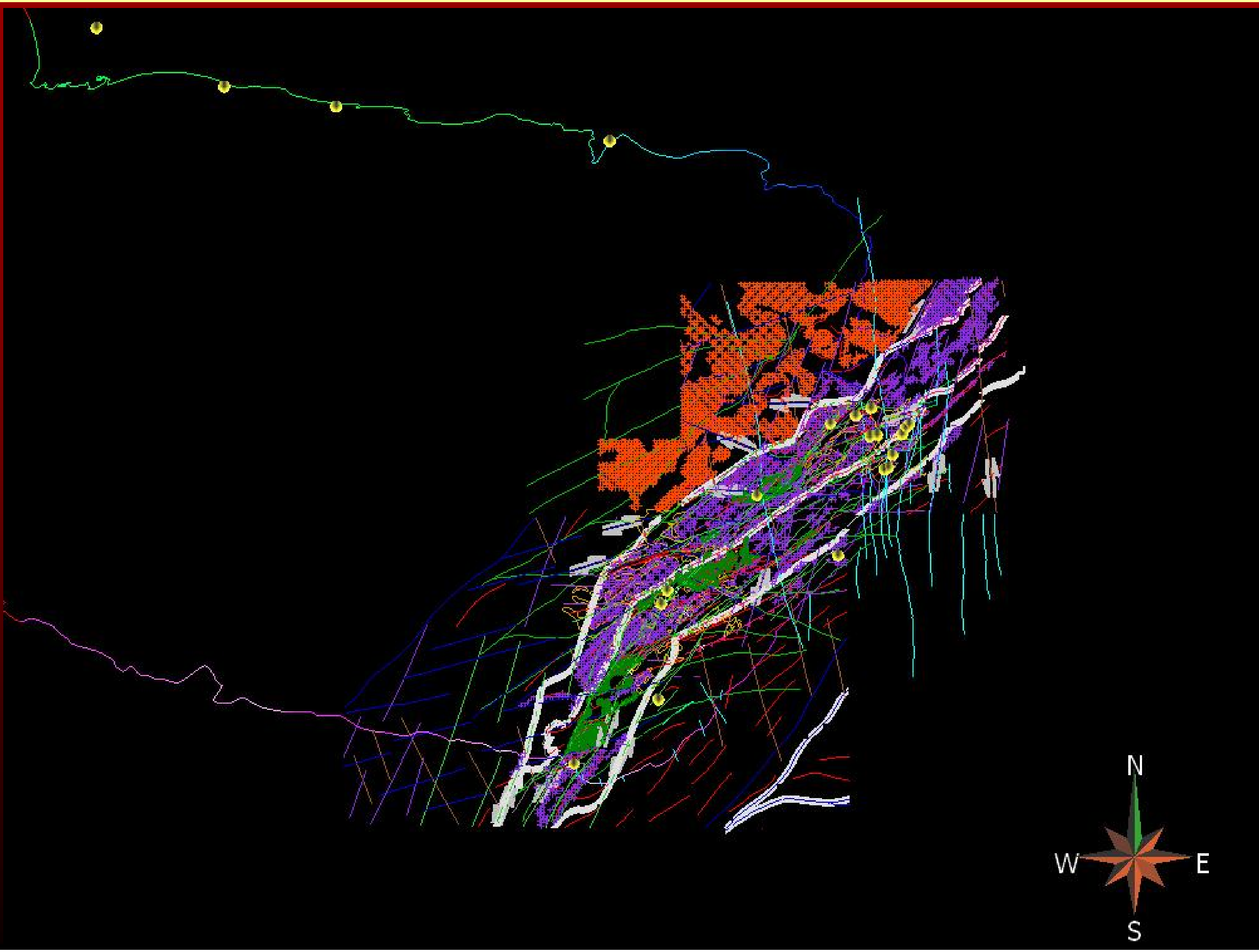
After Annesley et al., 2006a, 2006b

Structural Development during the THO (1860 – 1720 Ma)



(from Annesley et al., 2005)

Data Compilation



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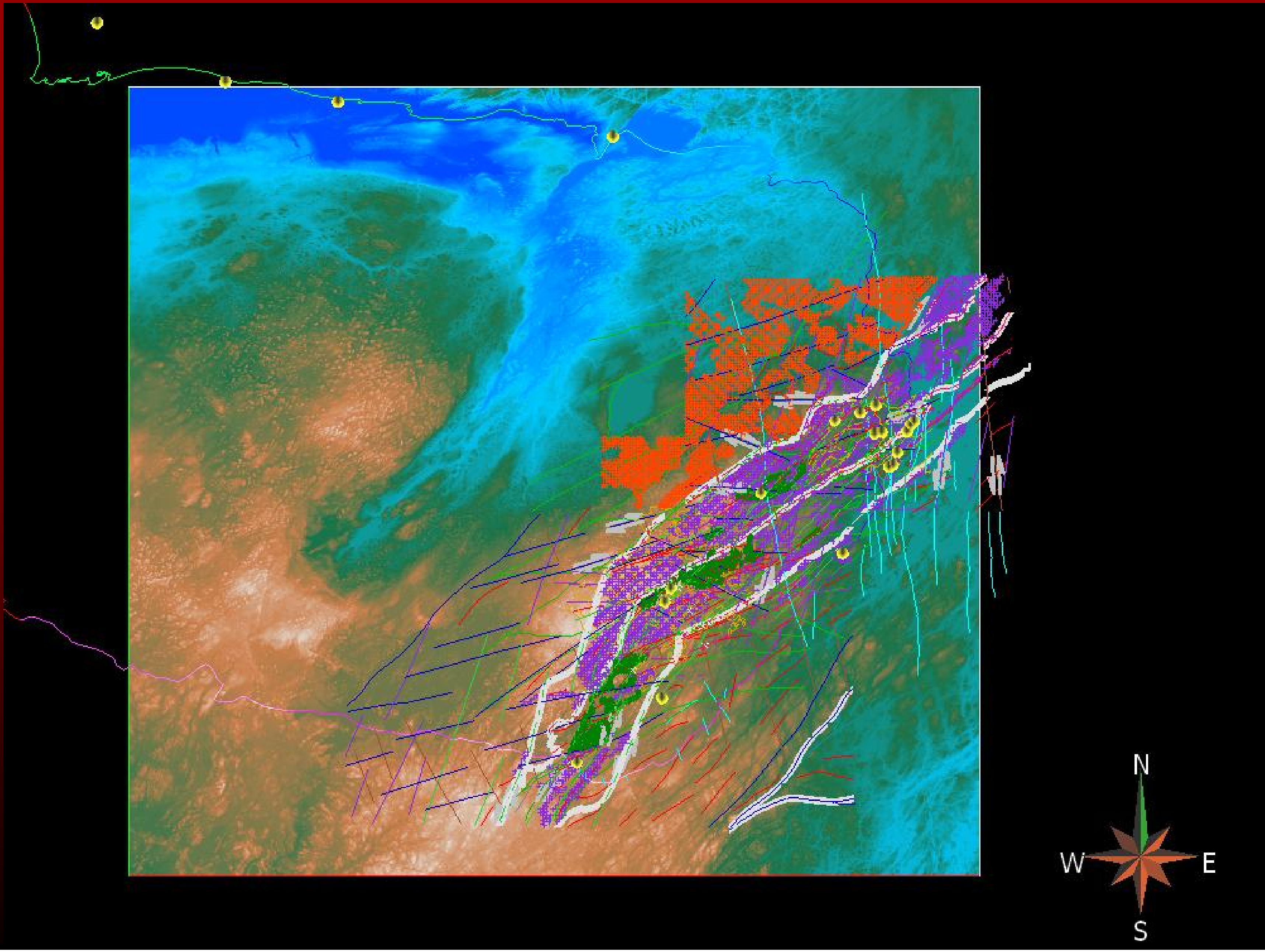

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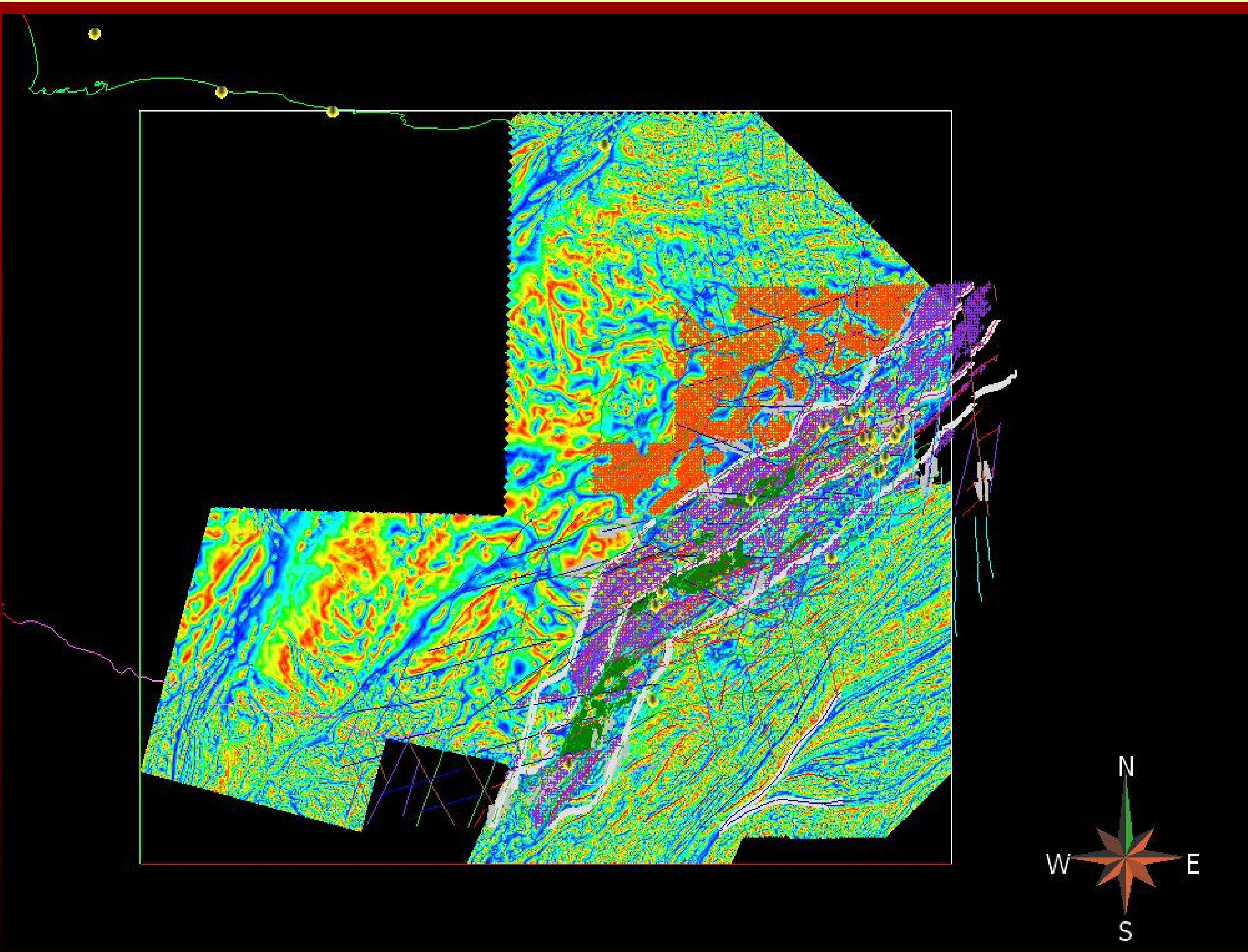

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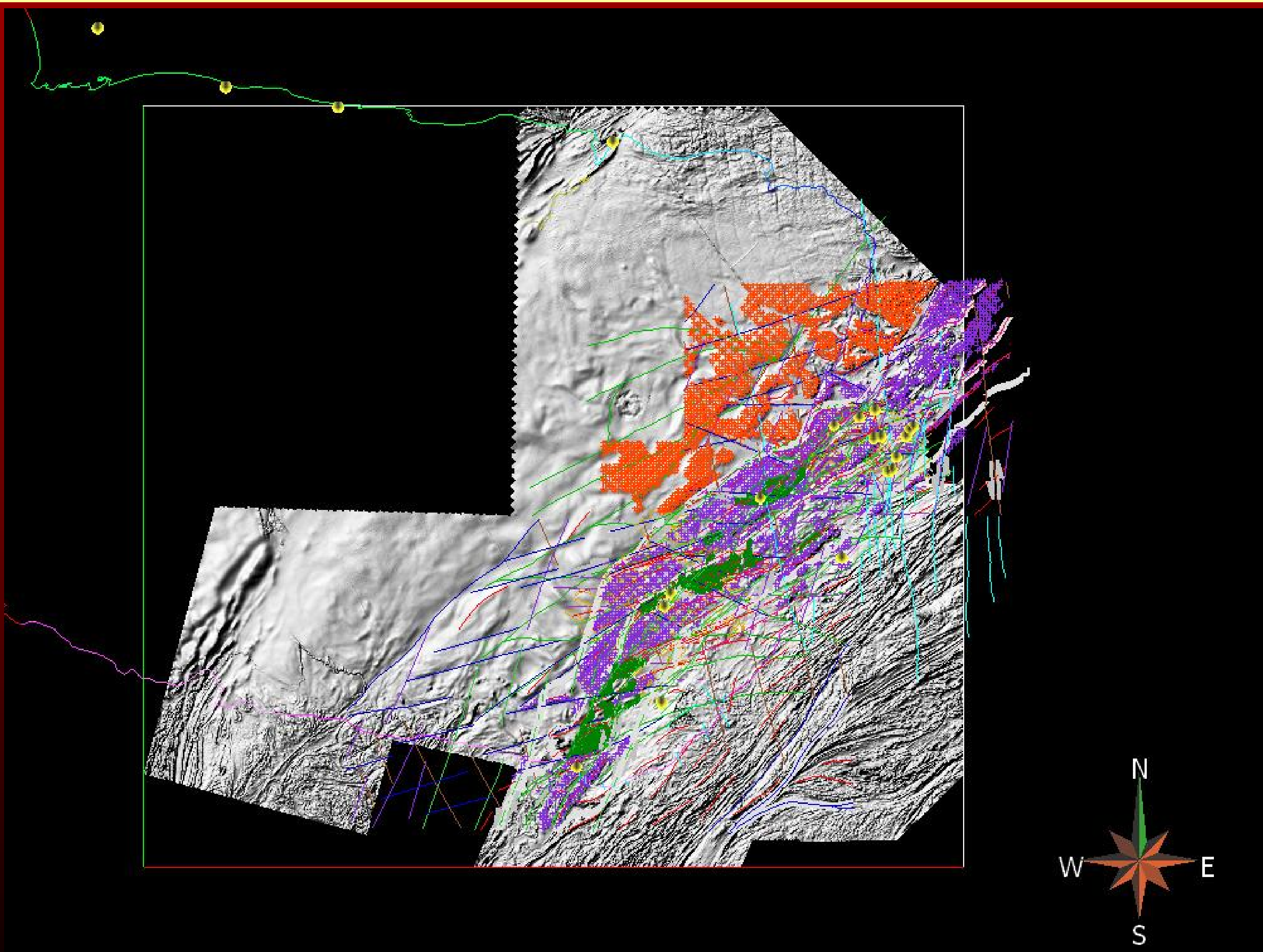

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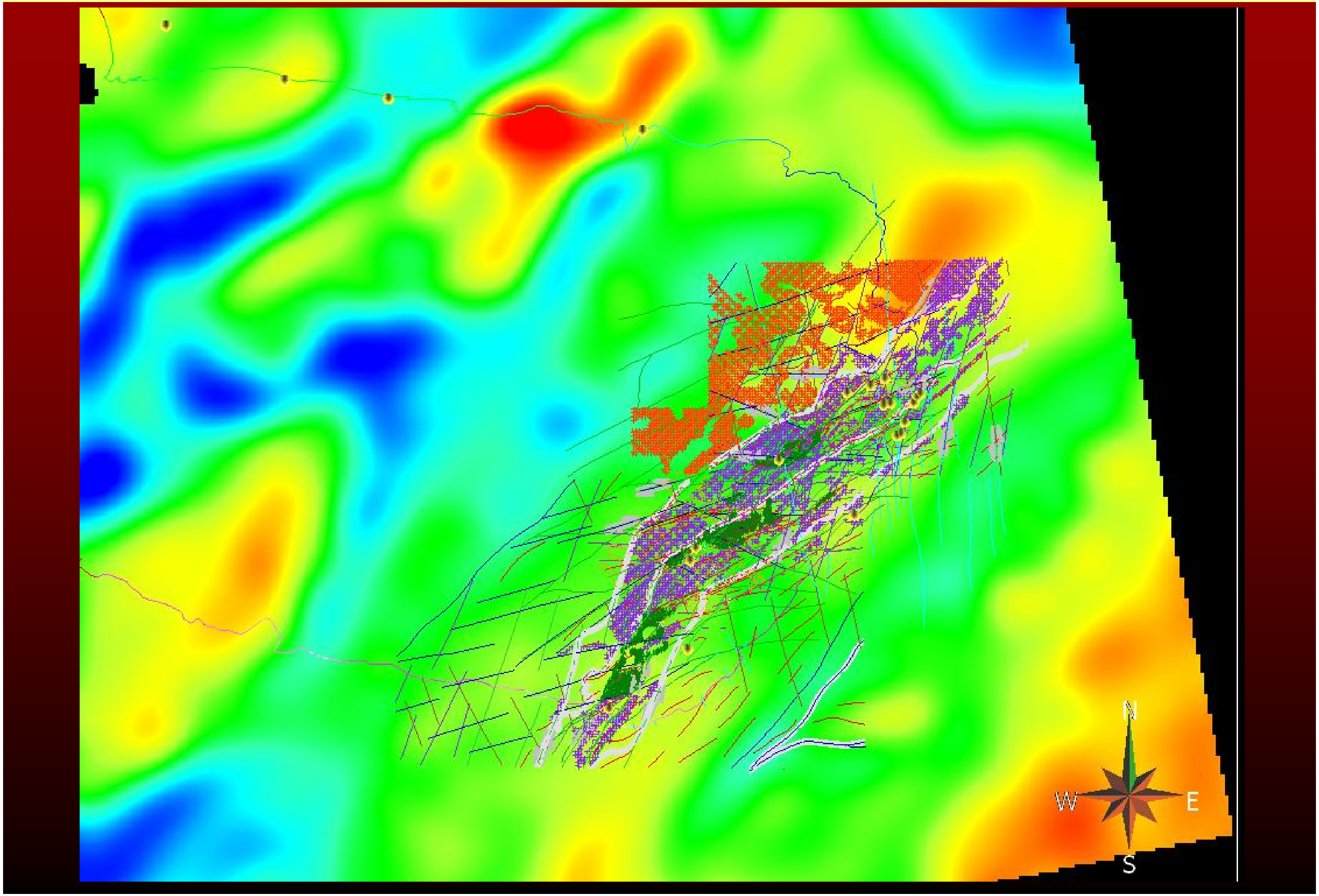

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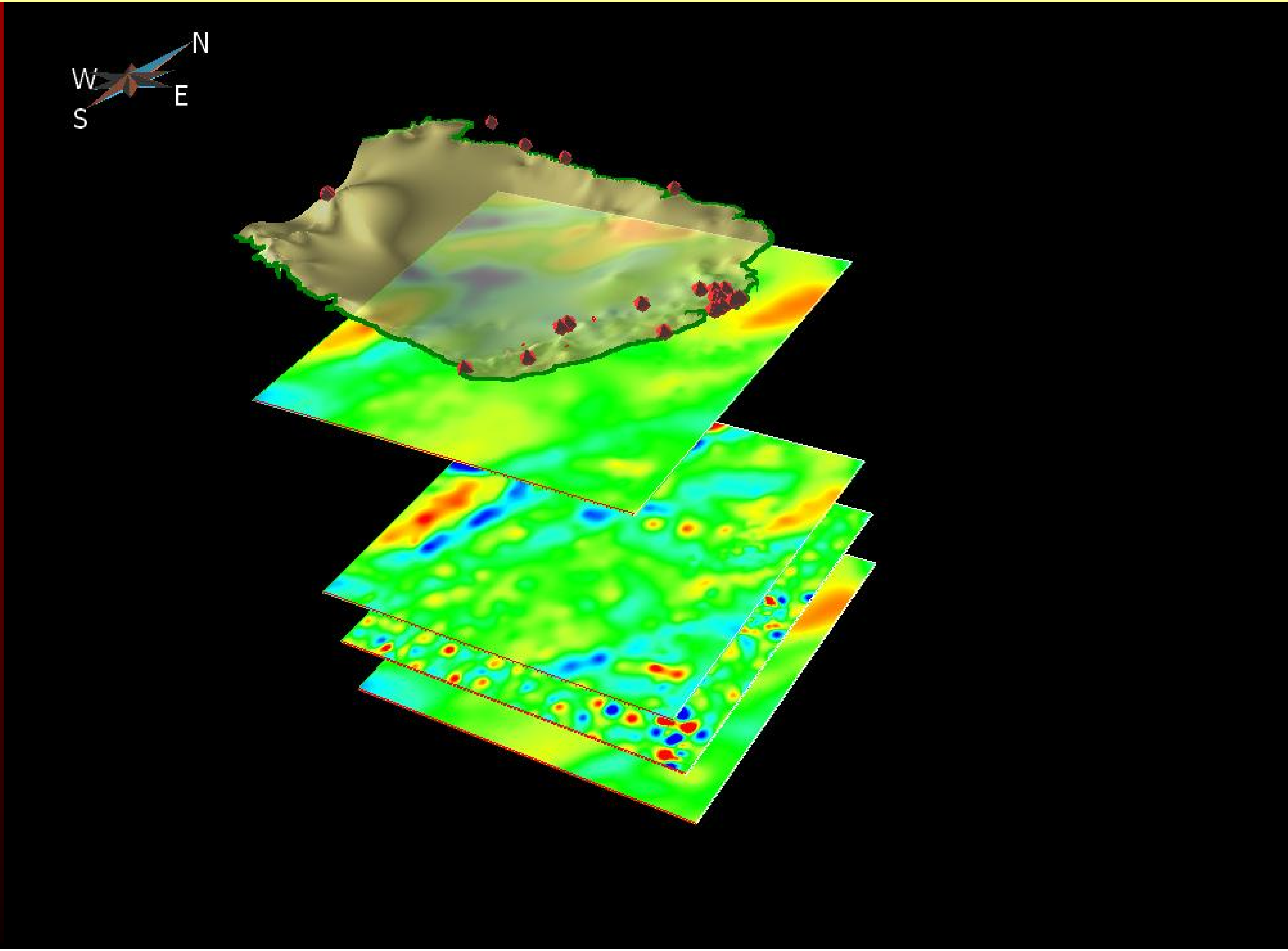

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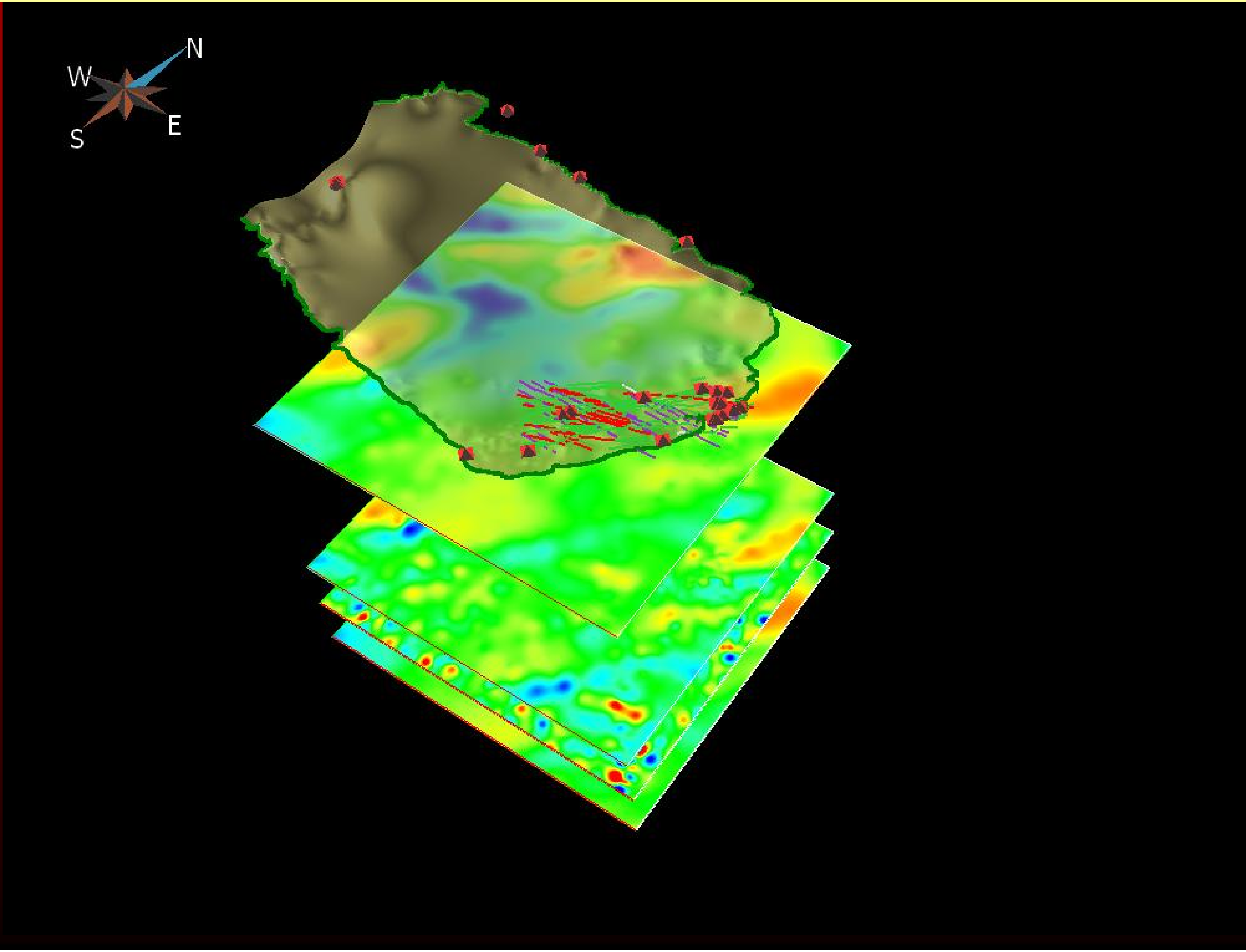

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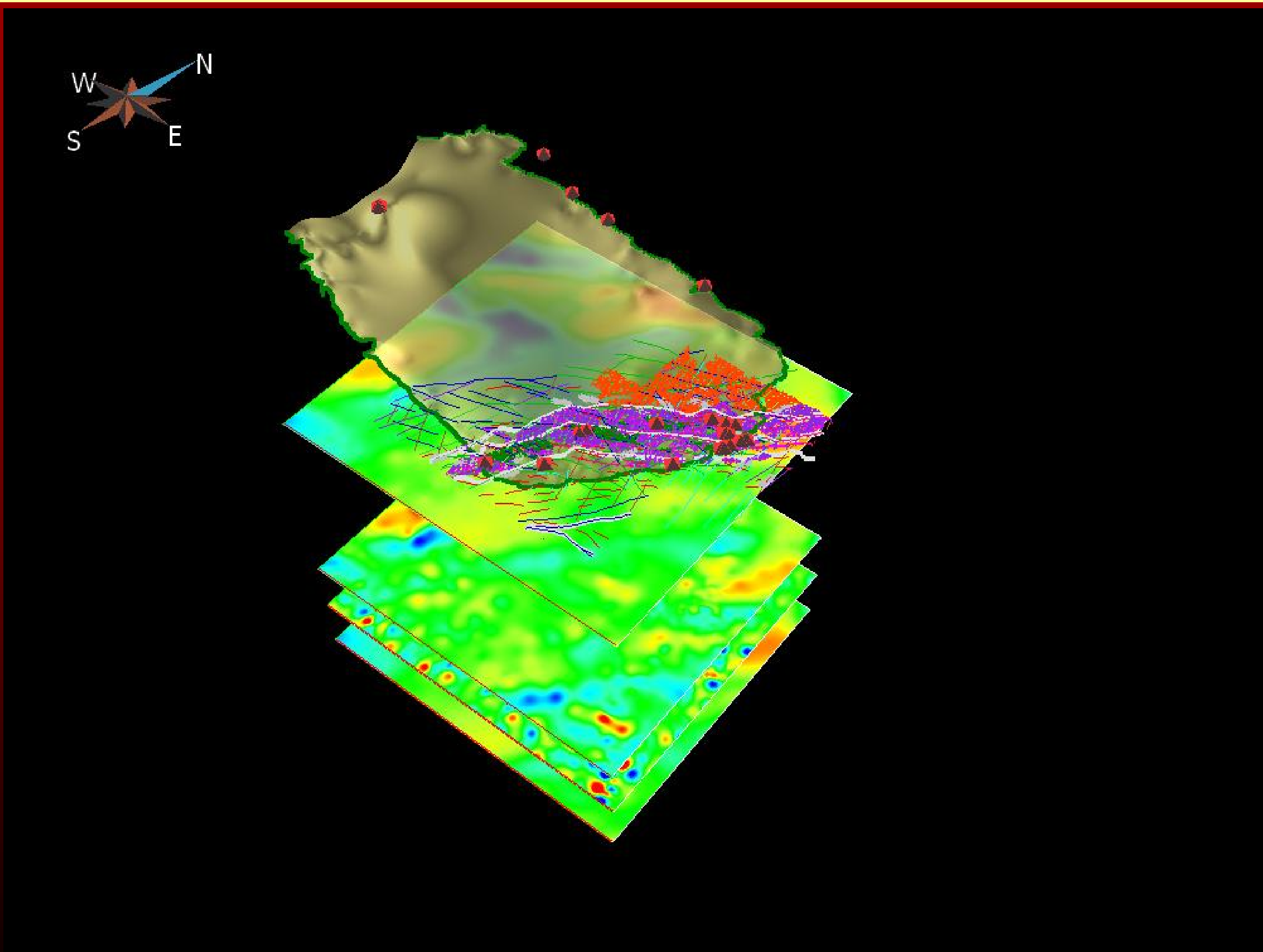

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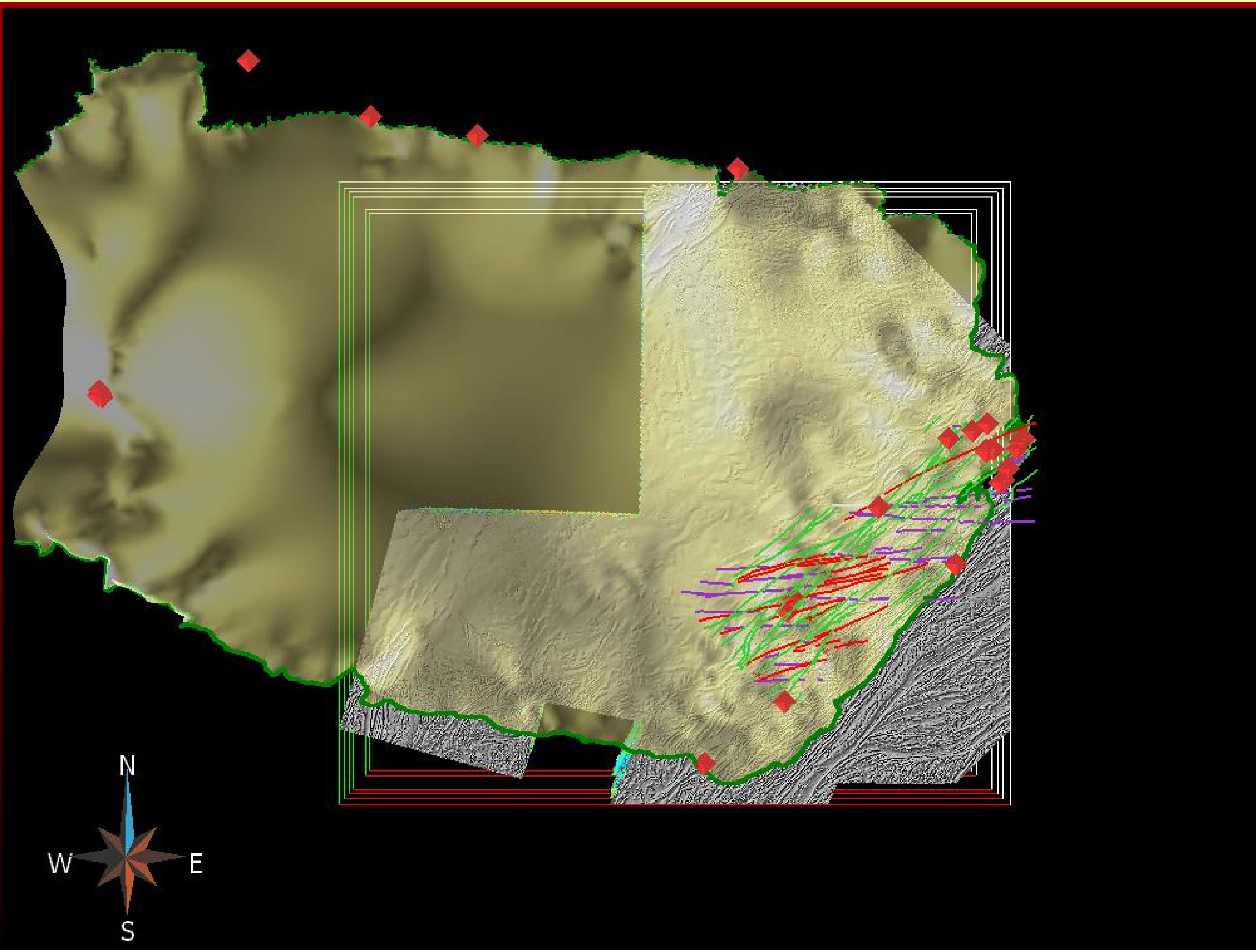

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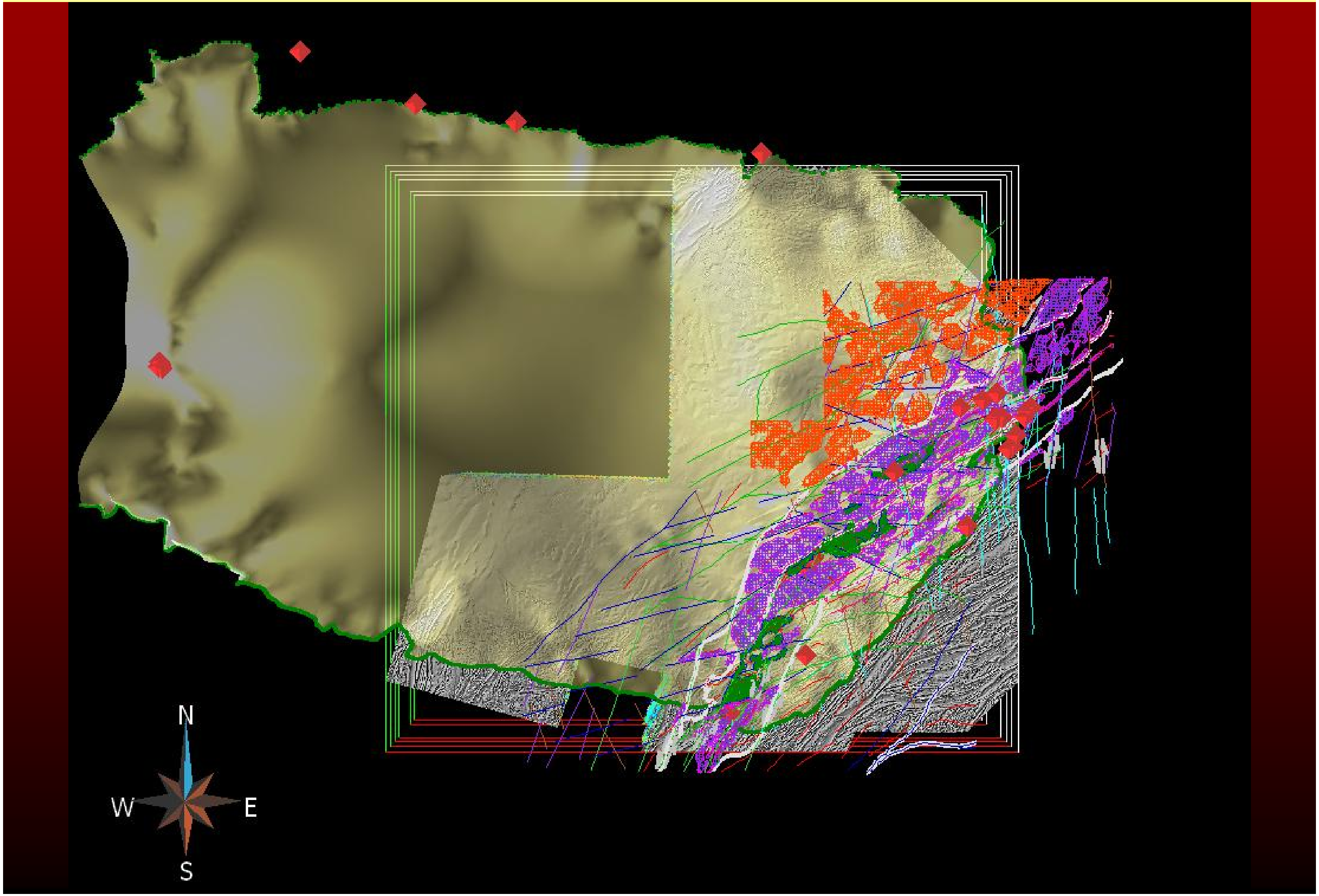

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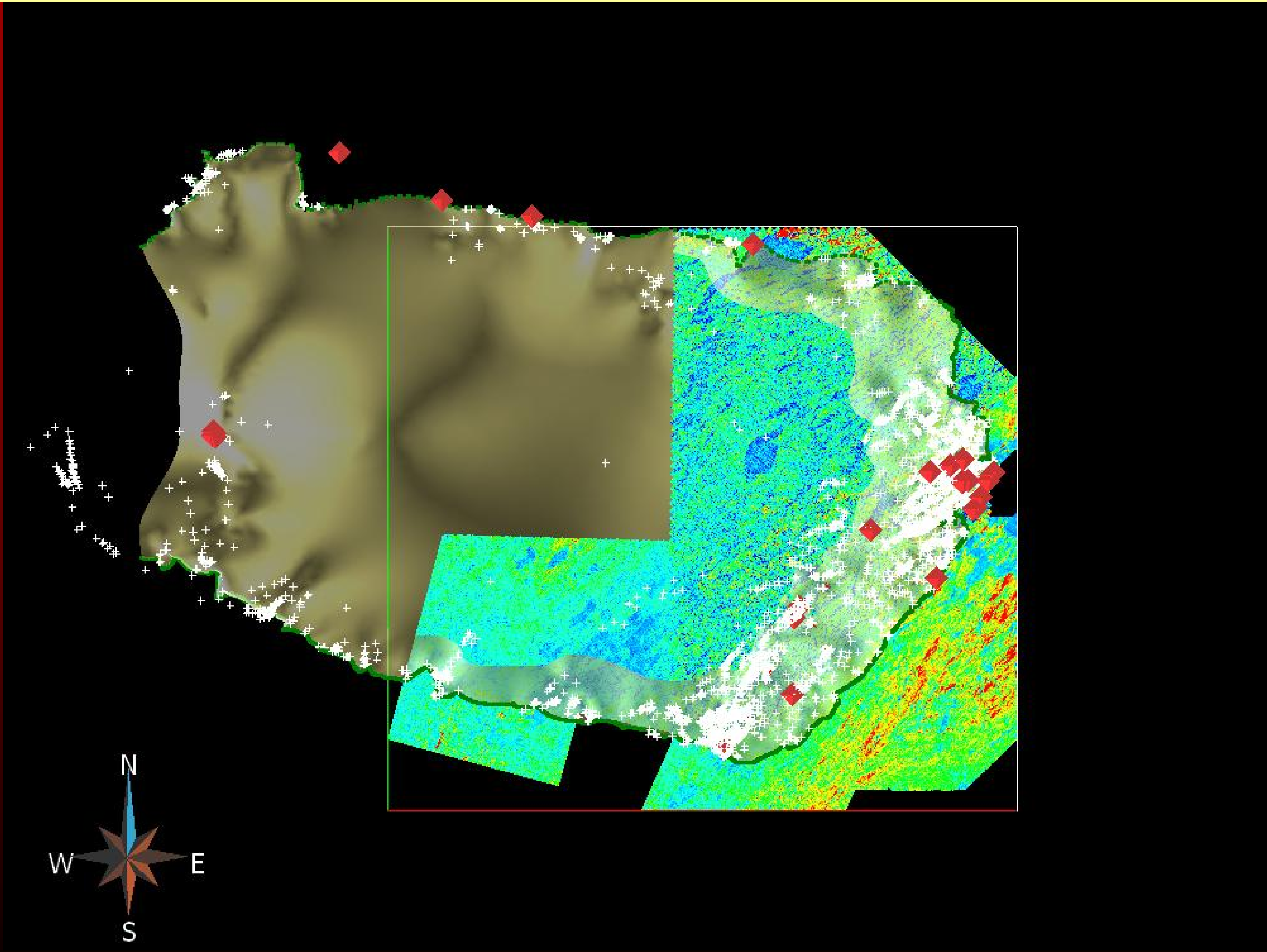

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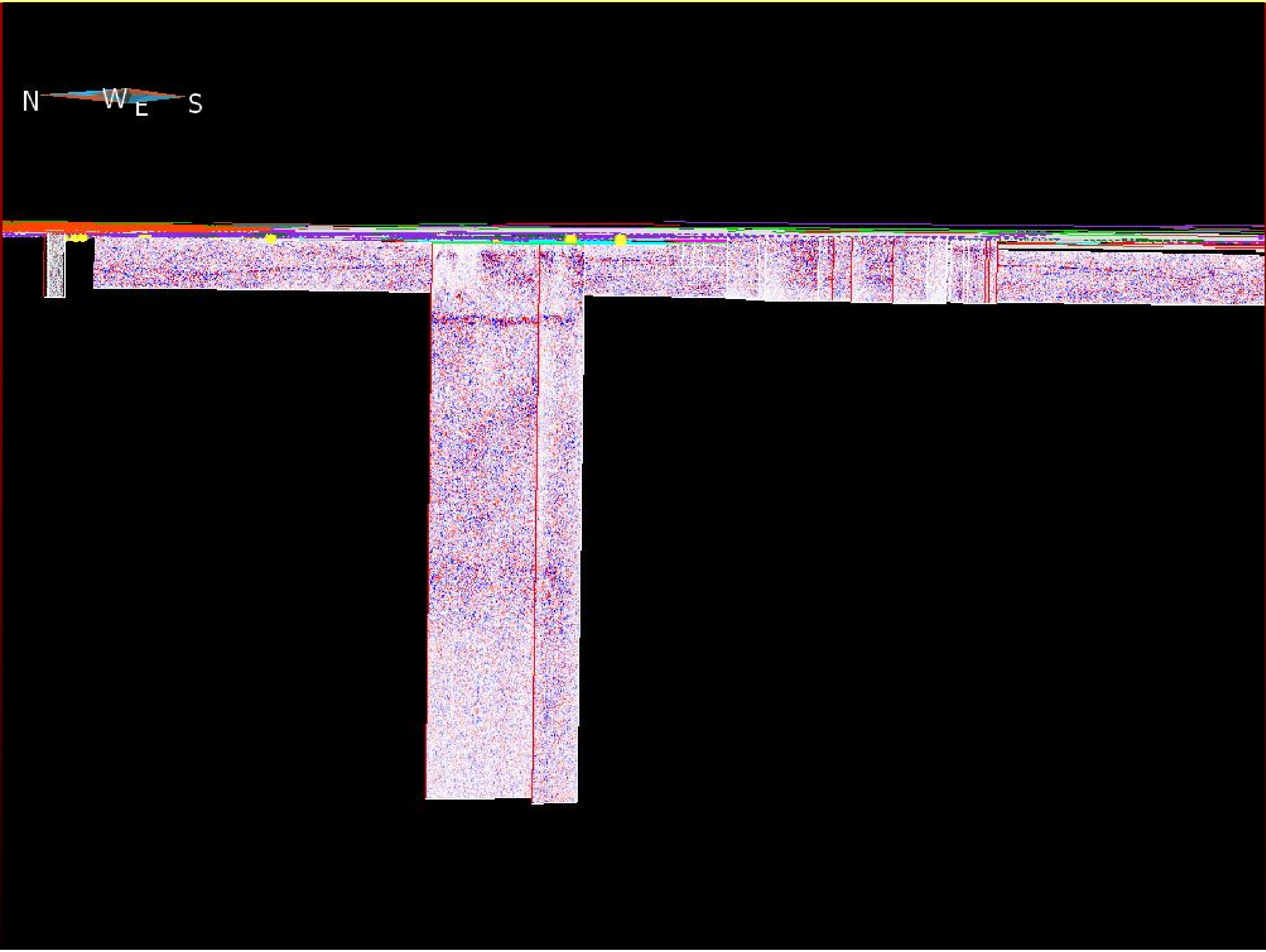

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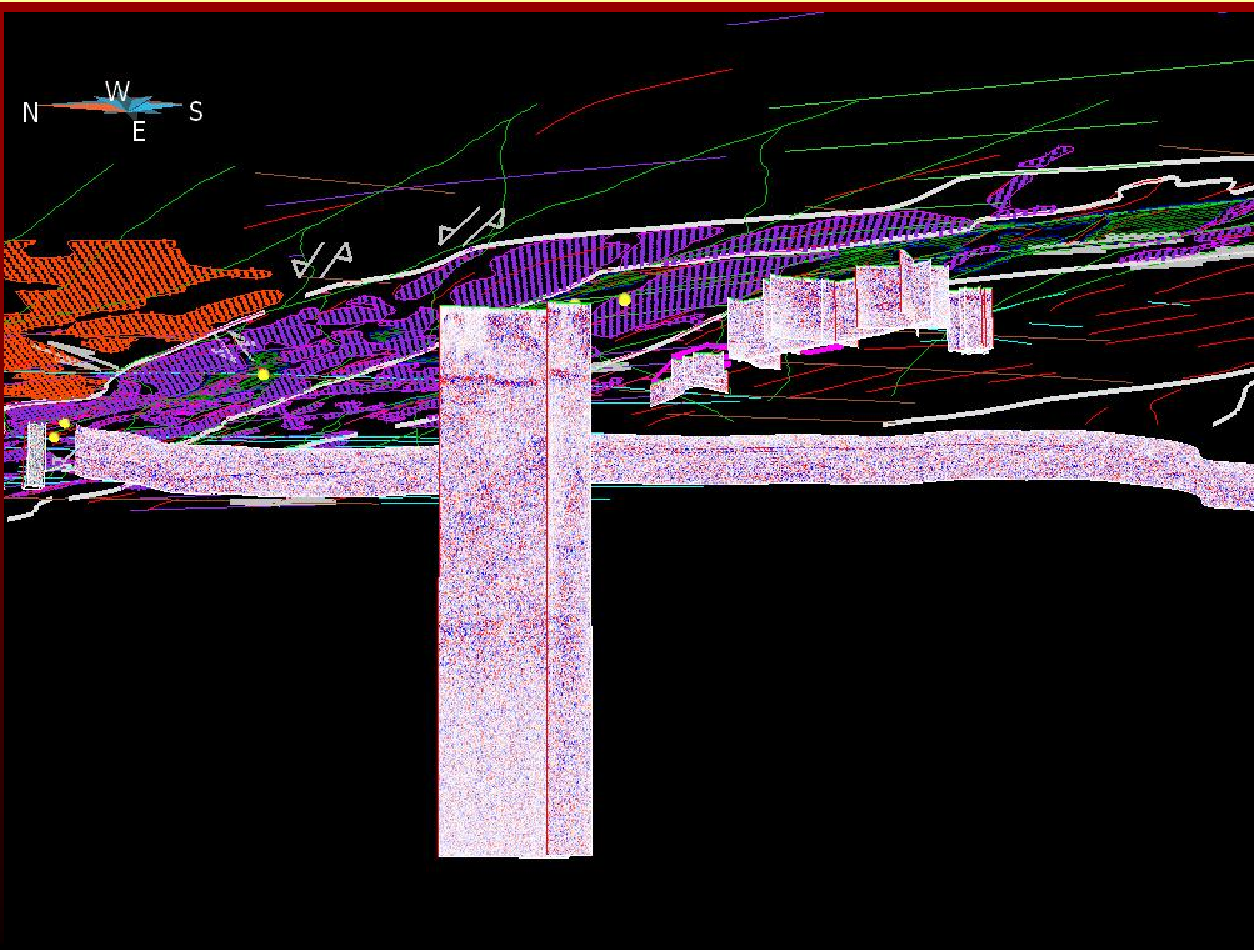
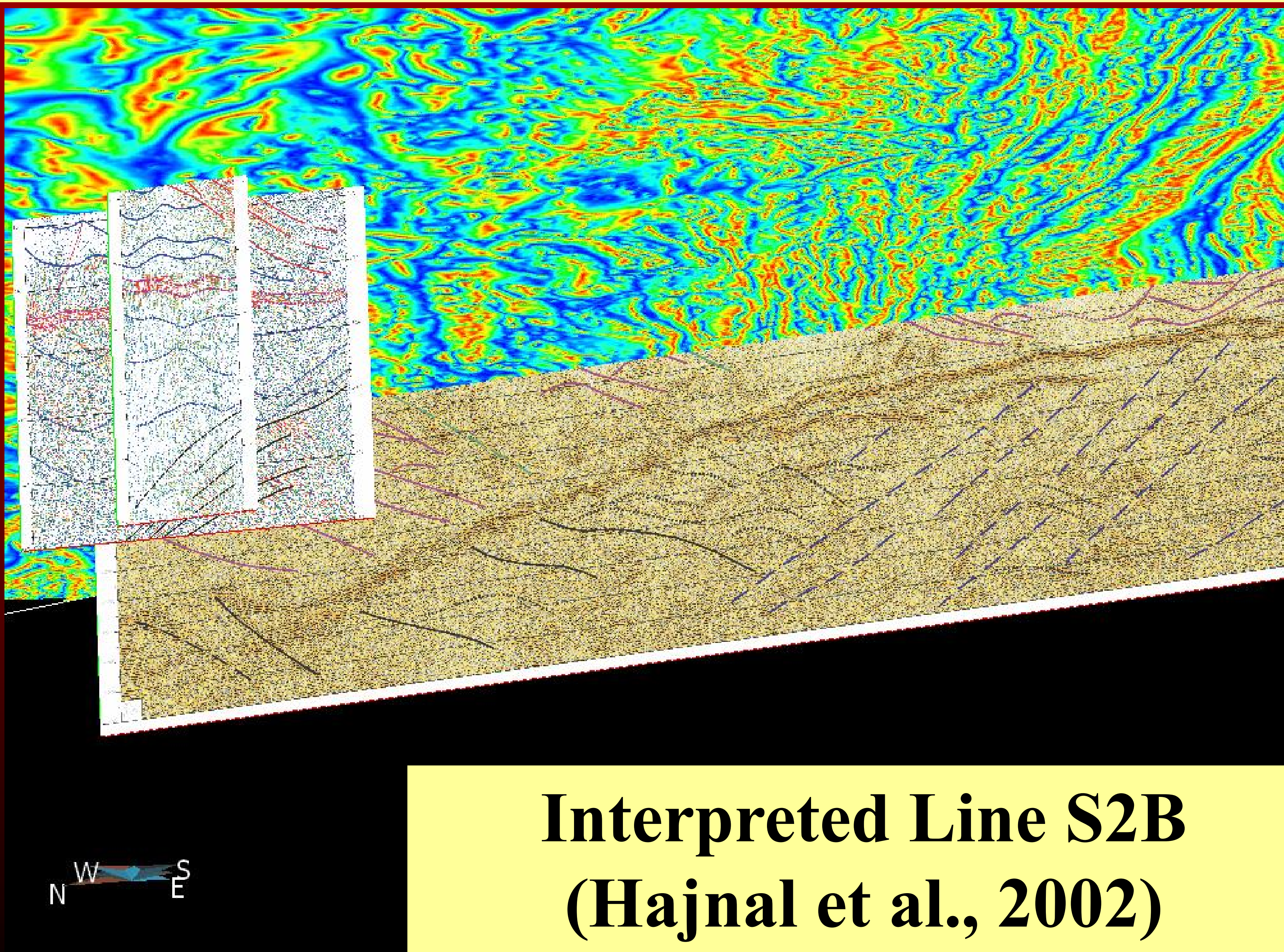
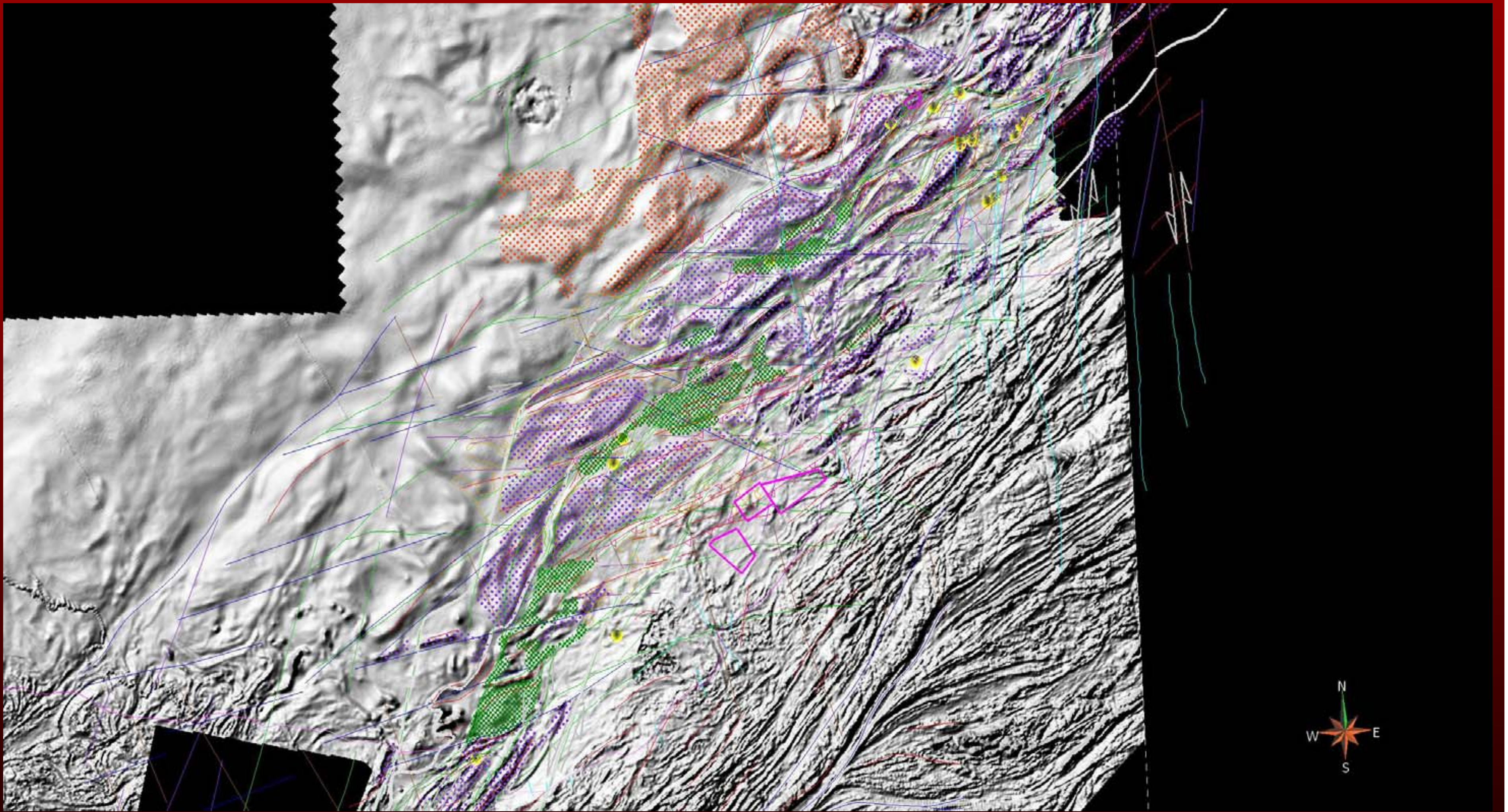


Data Compilation

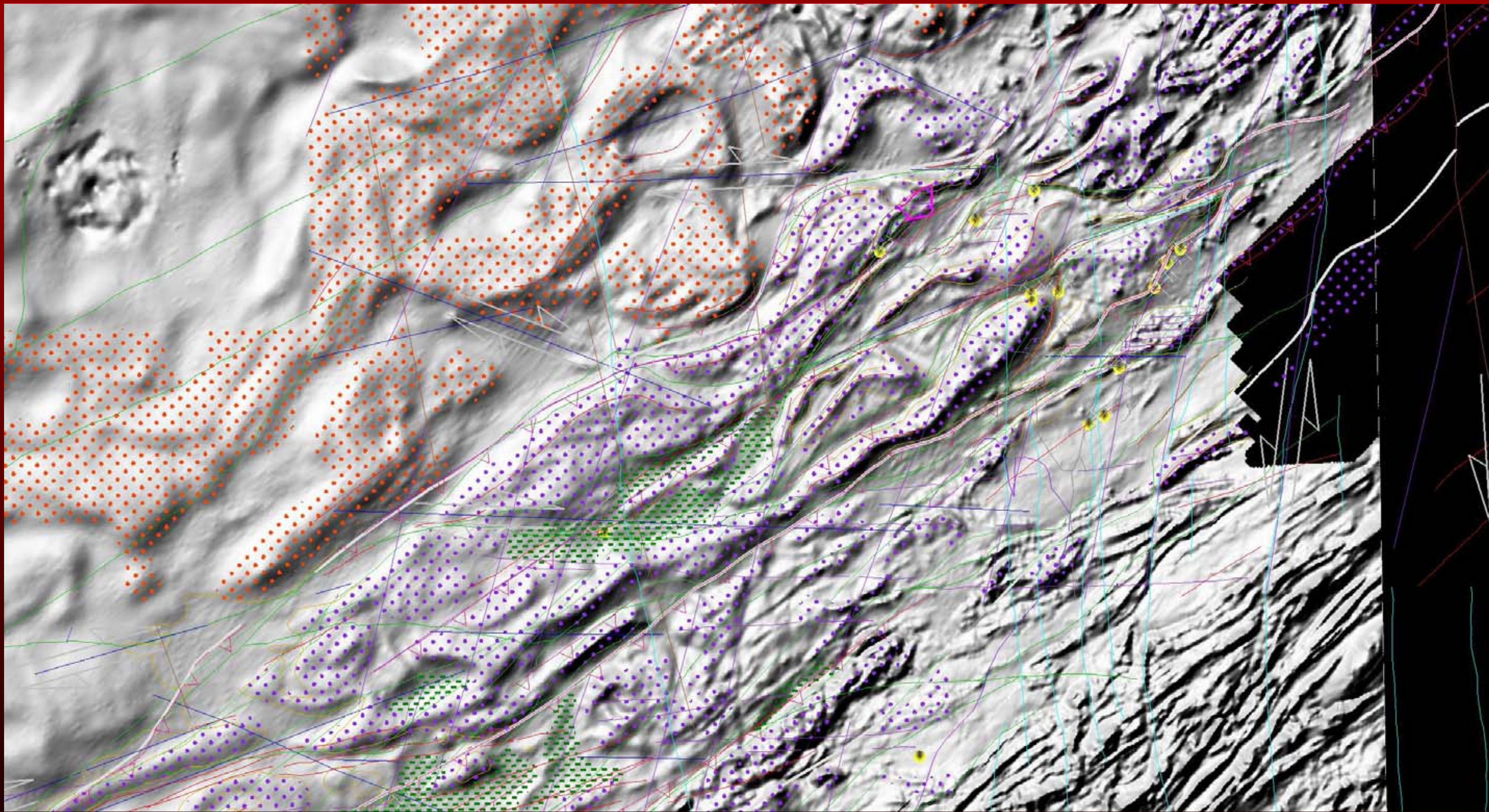


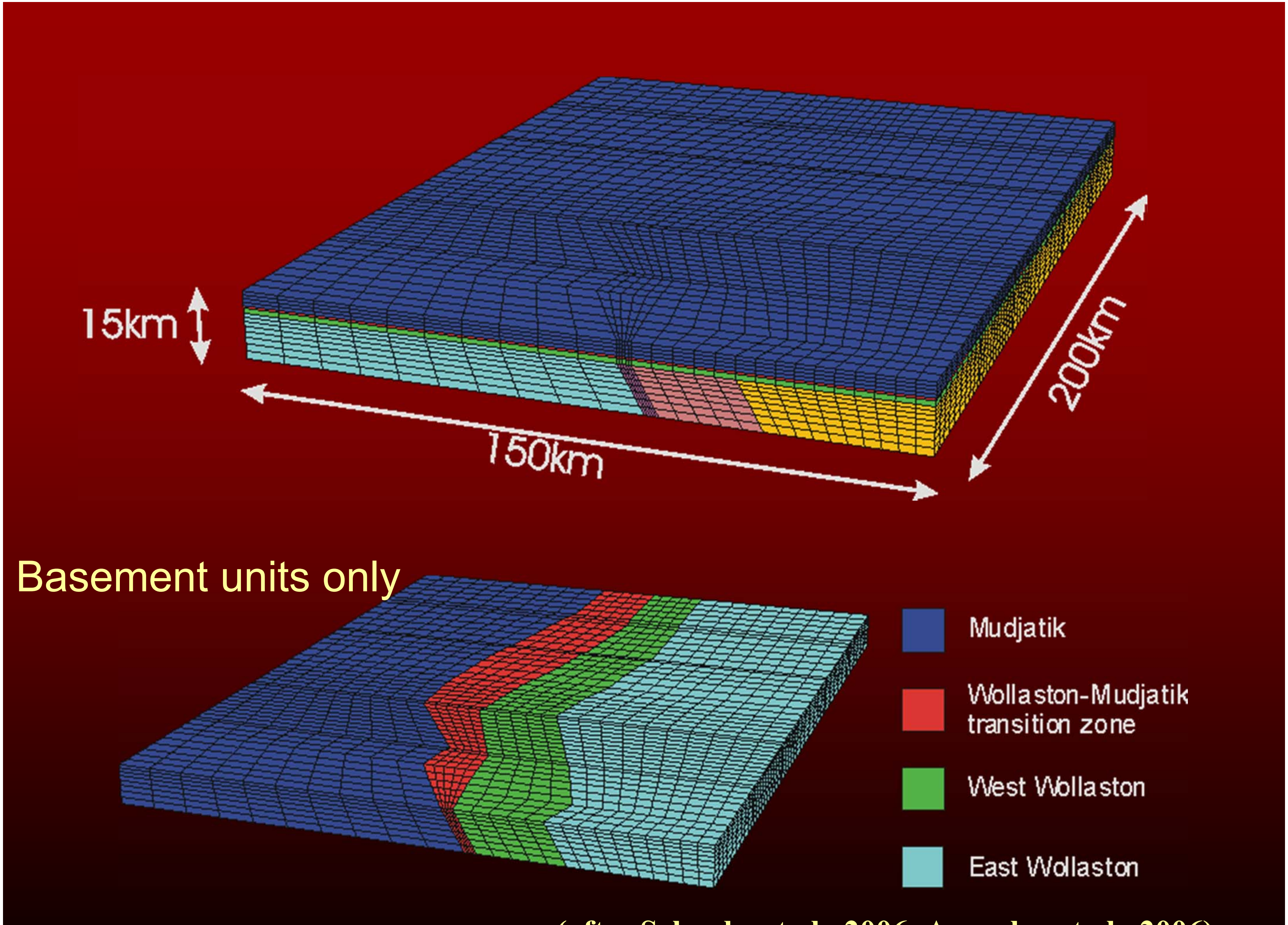
Interpreted Line S2B
(Hajnal et al., 2002)

Data Compilation and Interpretation



Data Compilation and Interpretation

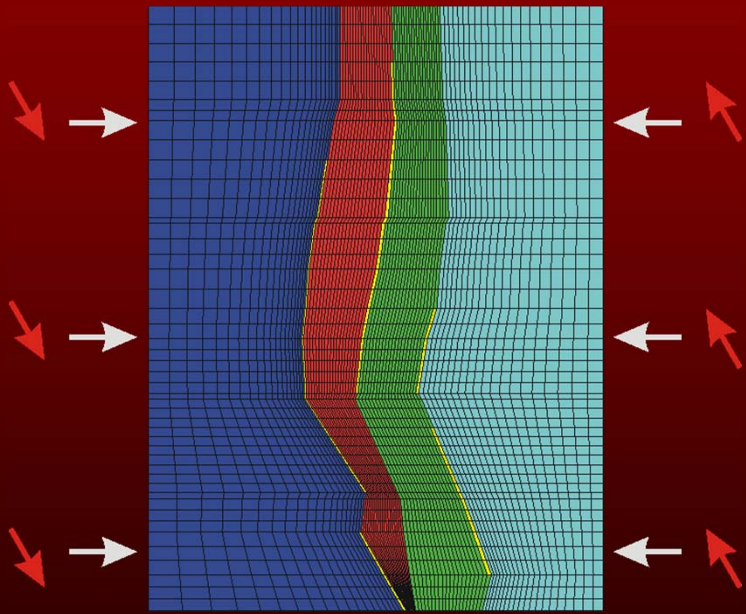




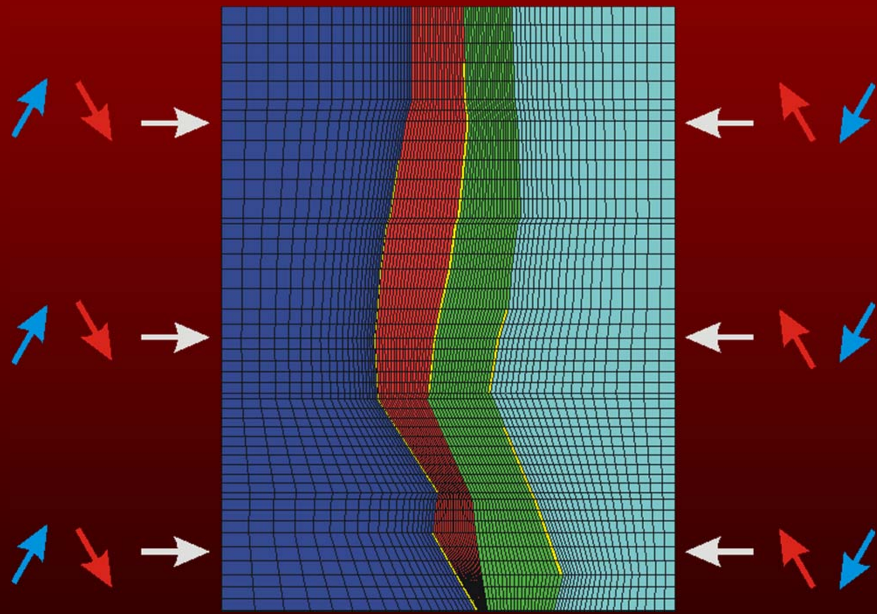
(after Schaubs et al., 2006; Annesley et al., 2006)

Different scenarios

Compression → Sinistral strike slip

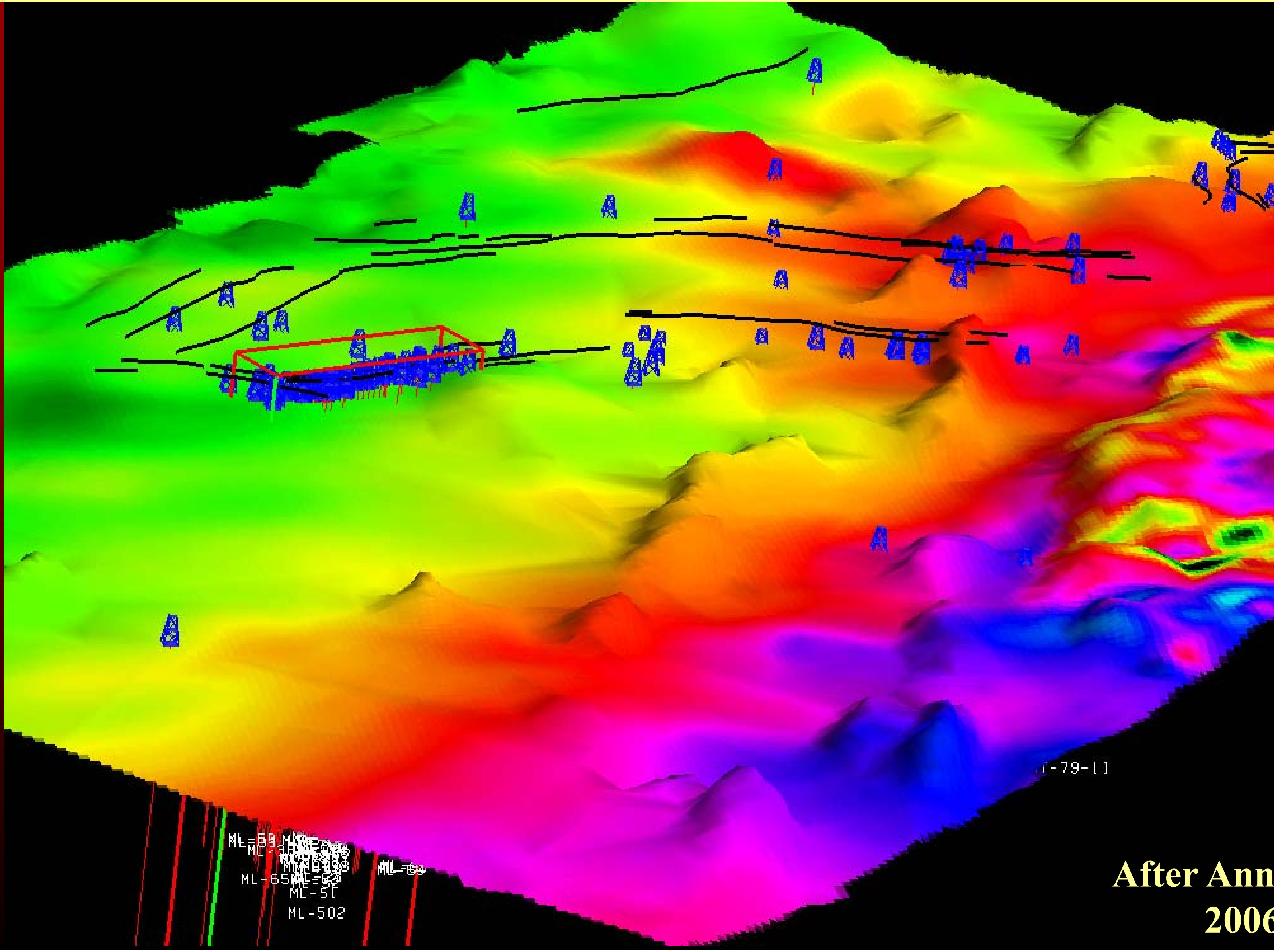


Compression → Sinistral strike-slip
→ Dextral strike-slip



(after Schaubs et al., 2006; Annesley et al., 2006)

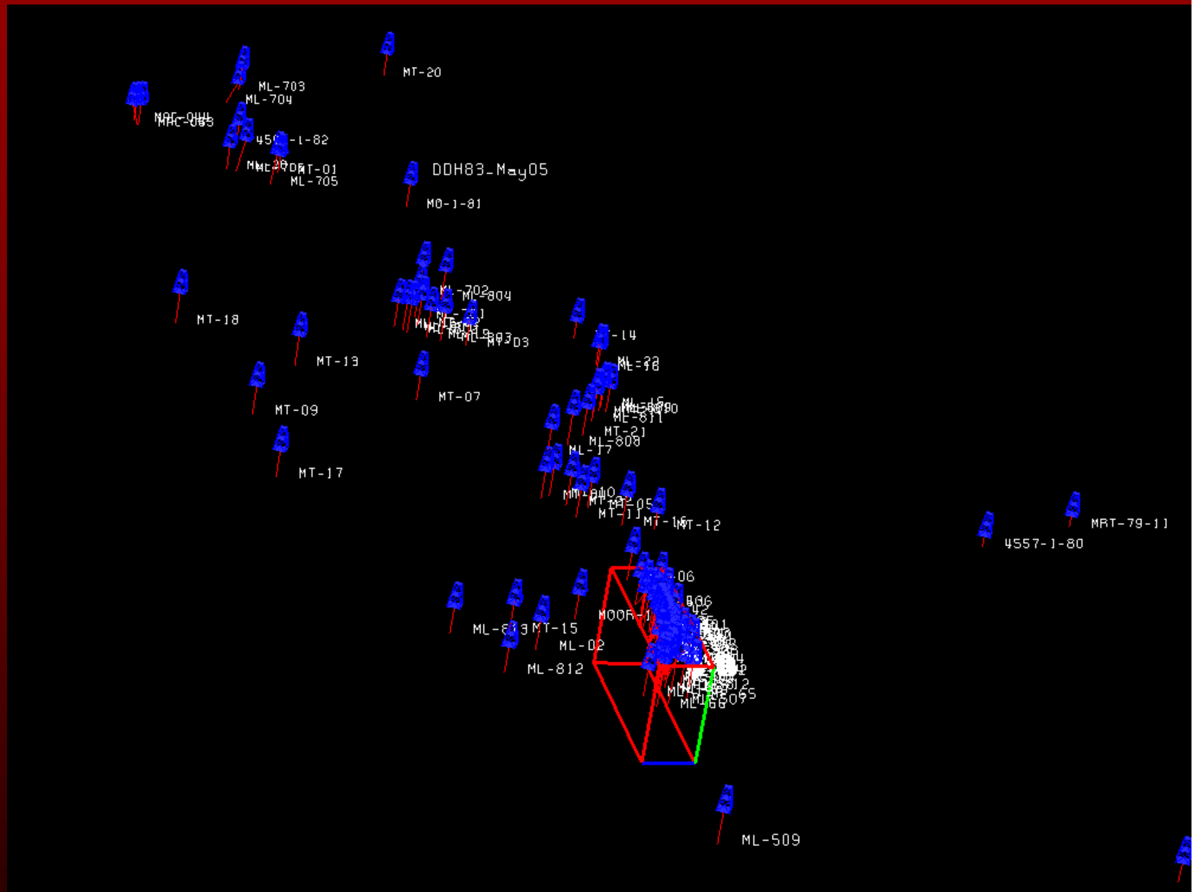
GOCAD View (to NNW) of Total Magnetic Intensity Draped on Topography



After Annesley et al., 2006a, 2006b

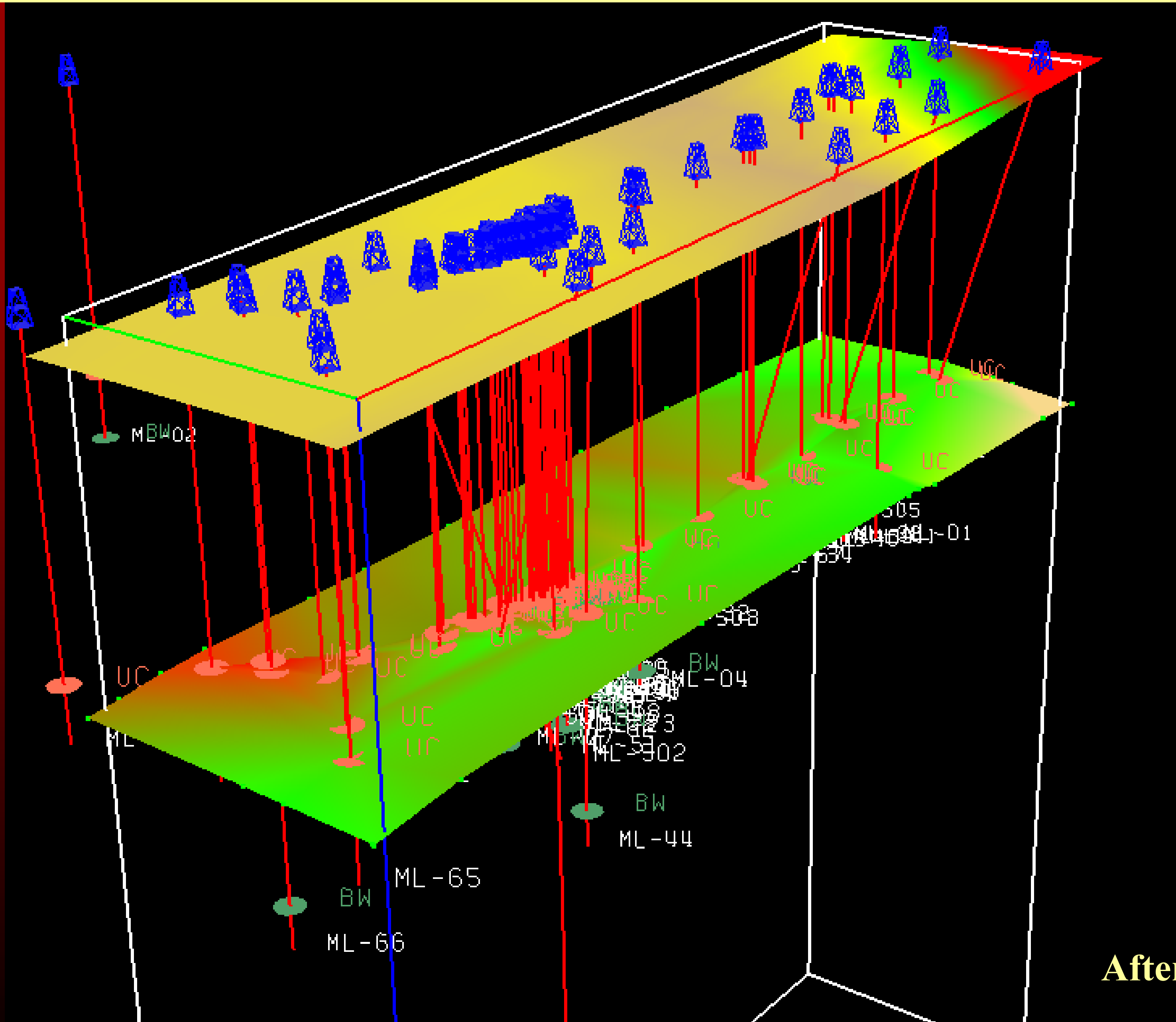
Voxet Dimensions at Moore Lakes

- Length (ENE-WSW): 1800 meters (dx = 10m)
- Width (NNW-SSE): 500 meters (dy = 2.5m)
- Depth : 1000 meters (dz = 1.0m)



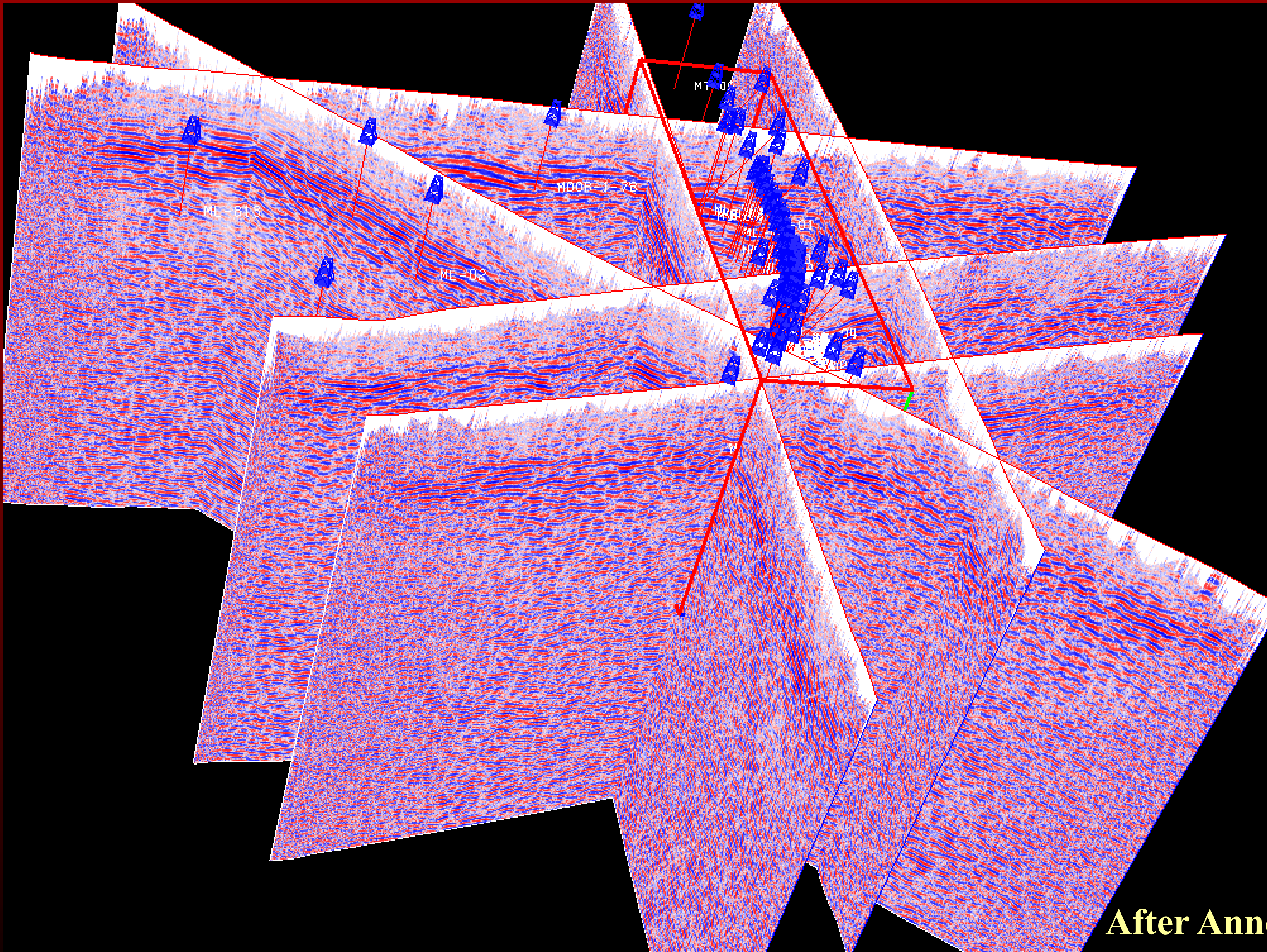
After Annesley et al., 2006a, 2006b

Moore Lakes Project Voxet



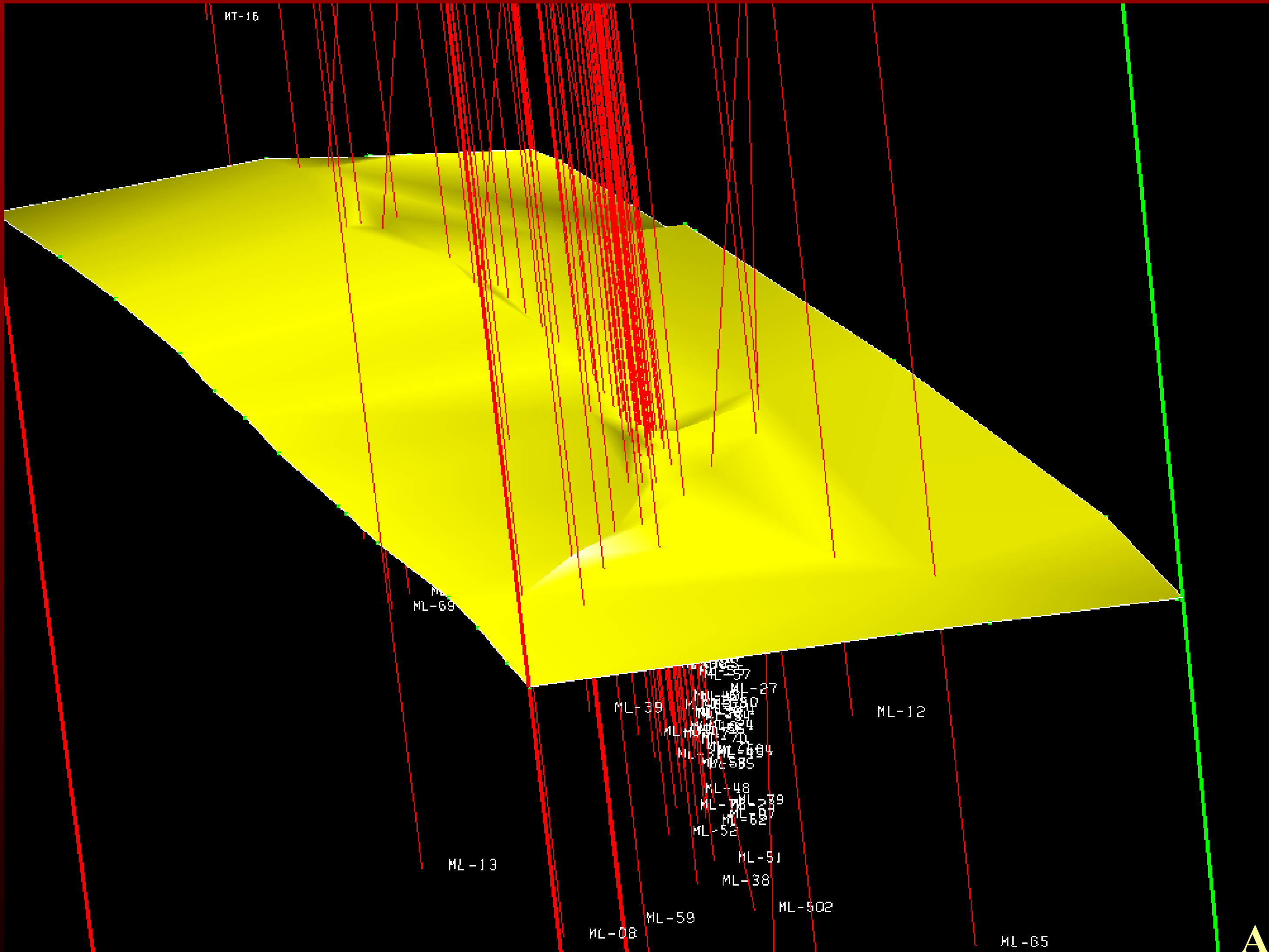
After Annesley et al., 2006a, 2006b

GOCAD View (to East) of 2D Seismic Lines



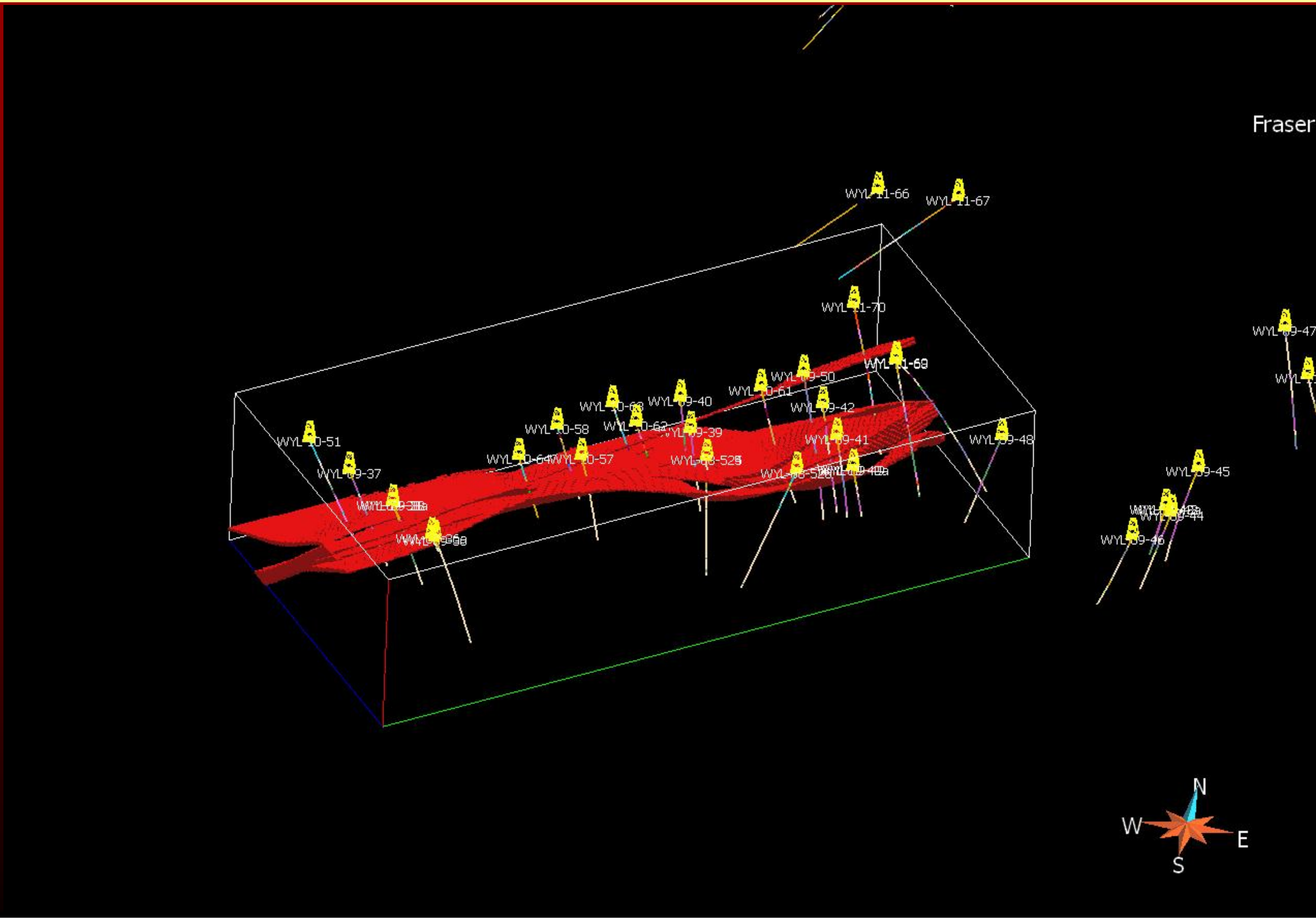
After Annesley et al., 2006a, 2006b

GOCAD View (towards East) of Maverick Zone “bump on the U/C”



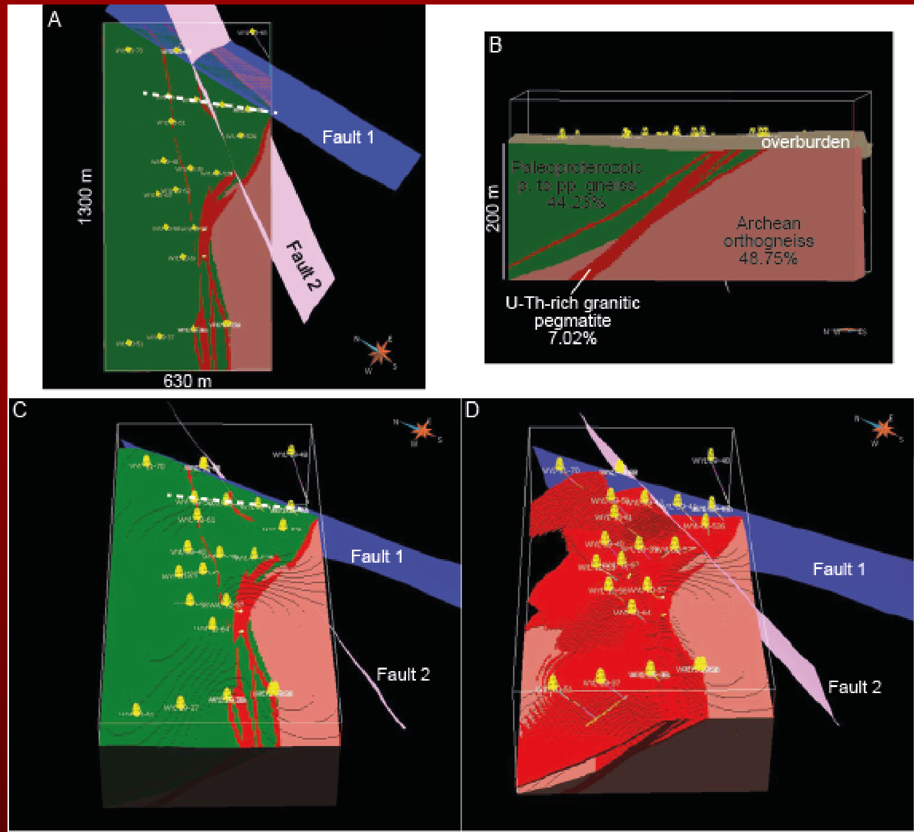
After Annesley et al., 2006a, 2006b

3D GOCAD Model for Fraser Lakes Zone B

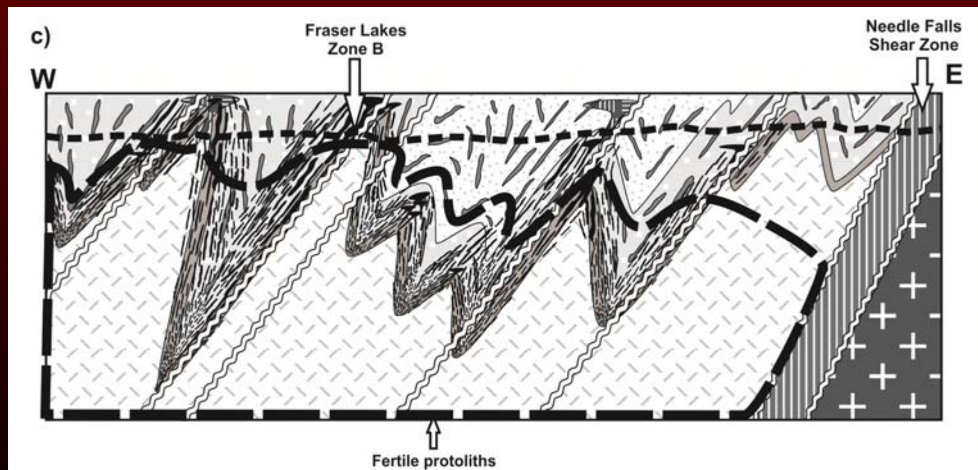


Structural controls

- Two main structural controls at Fraser Lakes Zone B
  - (1) Archean-Wollaston Group contact
    - Sheared contact
    - Rheological contrasts
  - (2) Antiformal fold noses and other dilational zones



Mercadier *et al.* (2013)



McKechnie *et al.* (2012)

Summary and Conclusions

The GOCAD common earth environment allows integration of multiple geological, geophysical, geochemical, and petrophysical data sets from surface to depth.

We are able to manipulate and visualize the regional to district scale architecture of the Wollaston fold-and-thrust belt, especially with the aid of high-resolution seismic profiles.

High-resolution seismic and diamond drilling constrain the 3rd dimension.

The GOCAD model can be used in other modelling applications.

Our research is bringing new insight(s) to the role of the basement in the genesis of unconformity-type U deposits.

Thank you

Discussion and Questions ?