

Towards Real Earth Models – Computational Geophysics on Unstructured Tetrahedral Meshes?

Colin Farquharson, Peter Lelièvre, Seyedmasoud Ansari, Hormoz Jahandari

Memorial University of Newfoundland,
St. John's, Newfoundland & Labrador,
Canada.



Outline:

Geological models!

Advantages of unstructured tetrahedral meshes.

EM geophysics on unstructured tetrahedral meshes.

Disadvantages, difficulties, challenges.

Conclusions.

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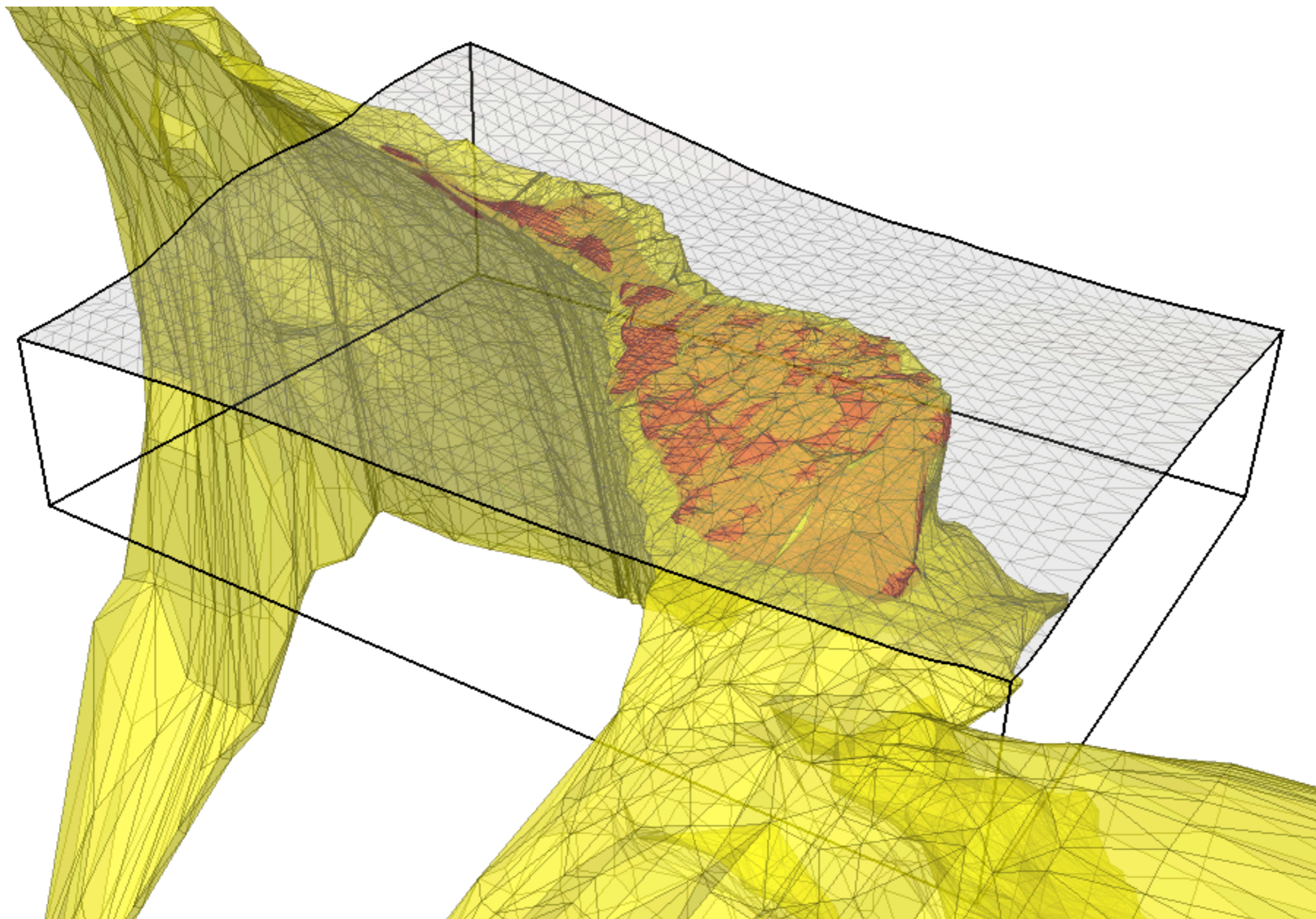
Geological models!

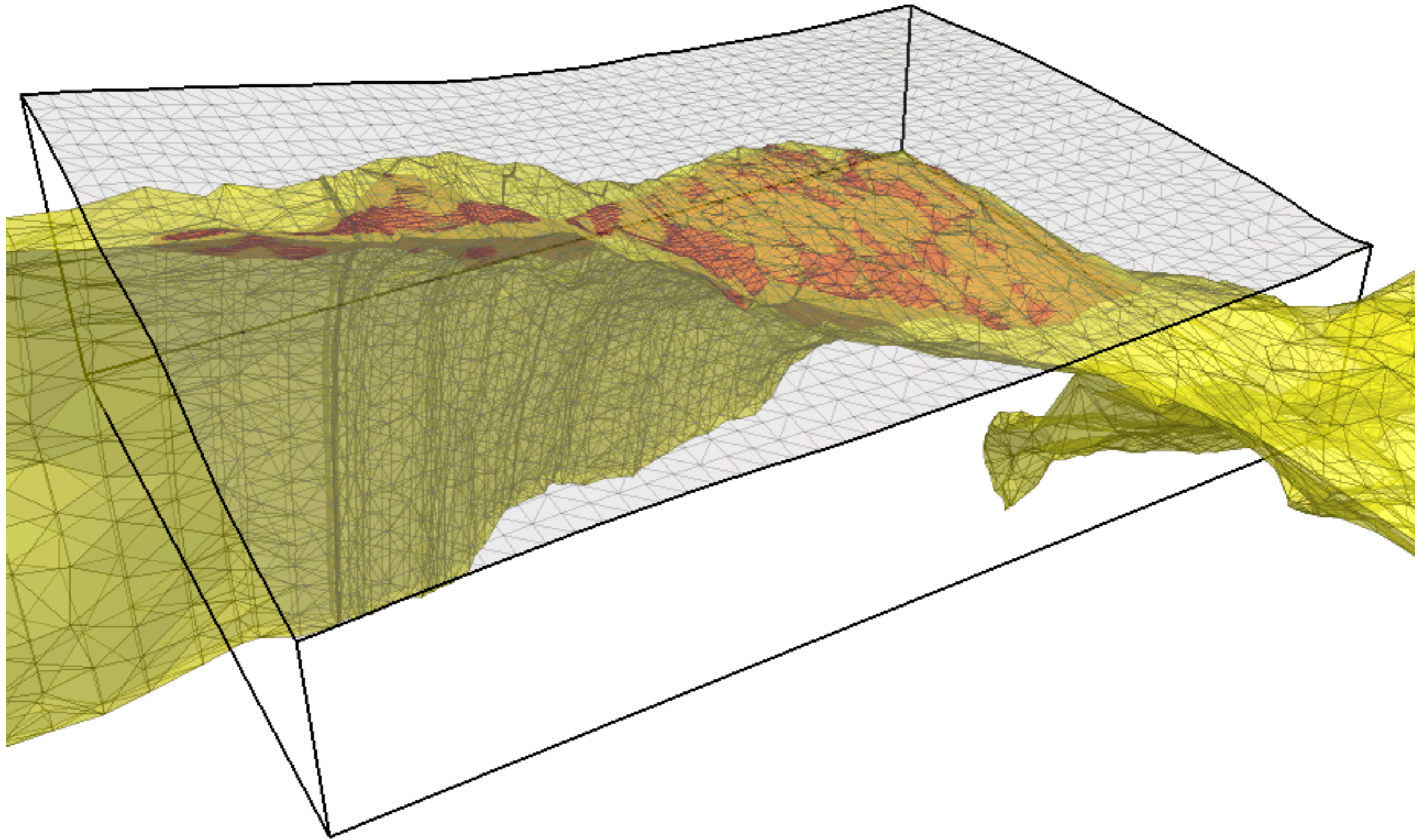
Advantages of unstructured tetrahedral meshes.

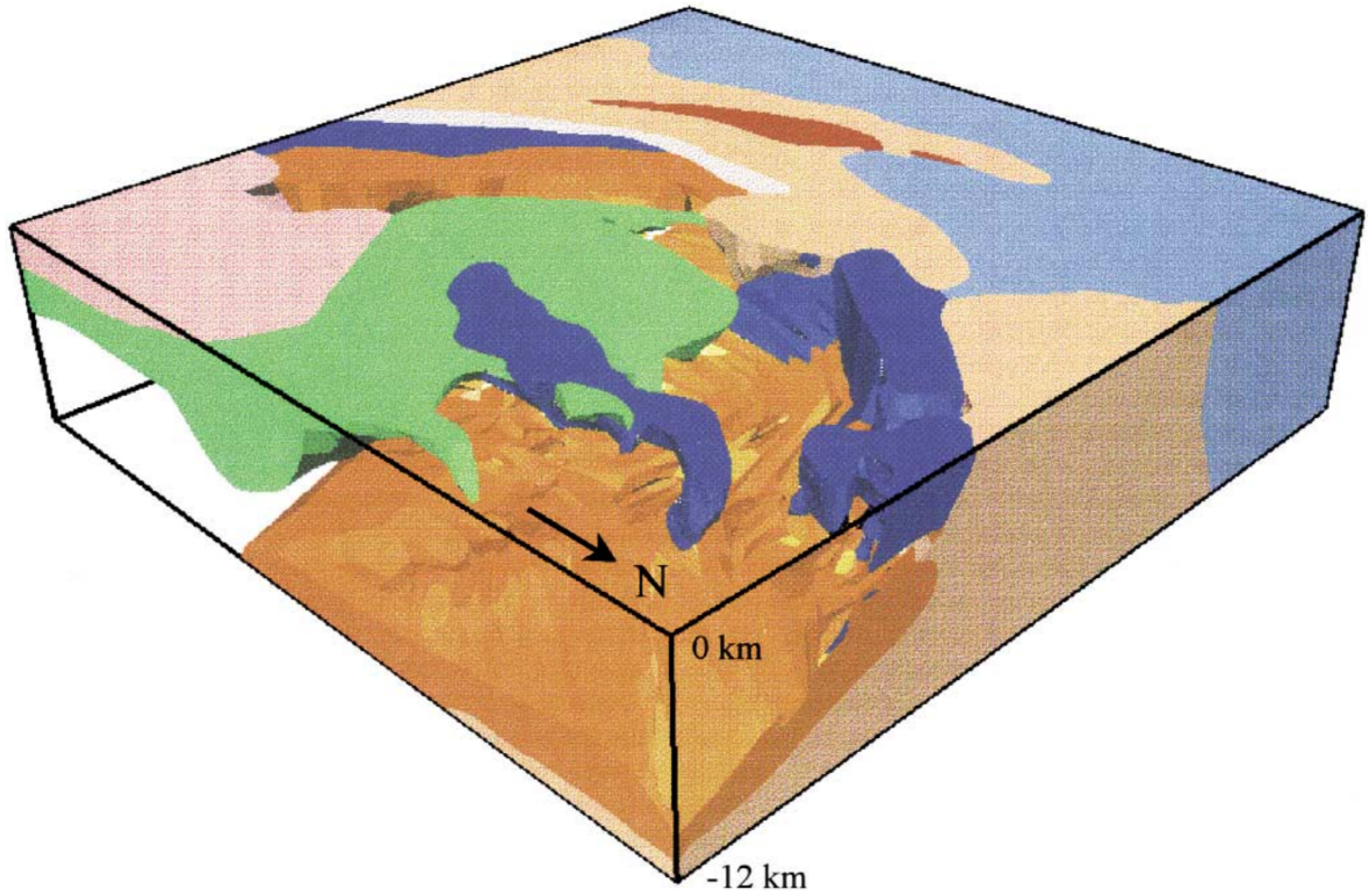
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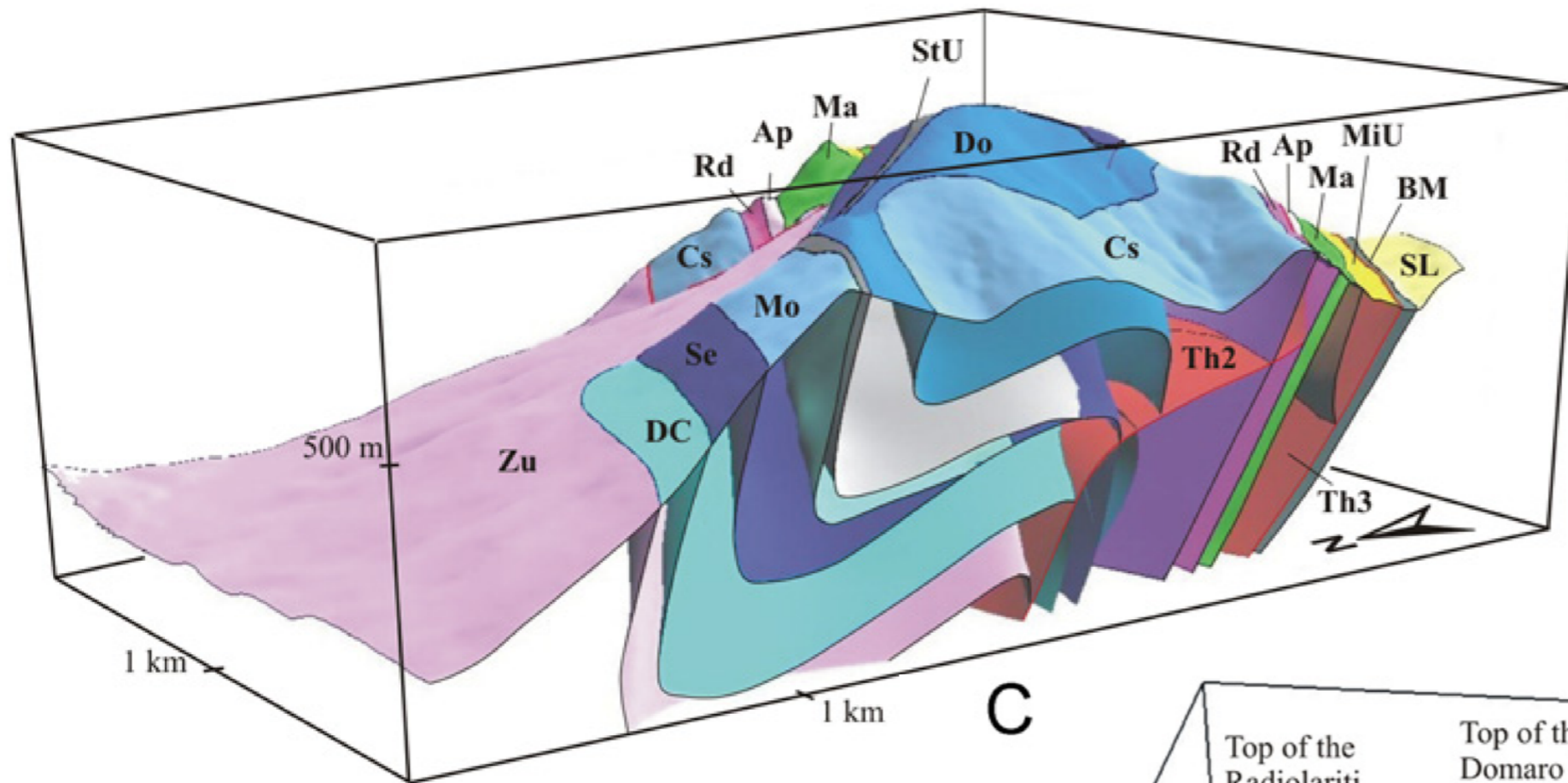
Conclusions.





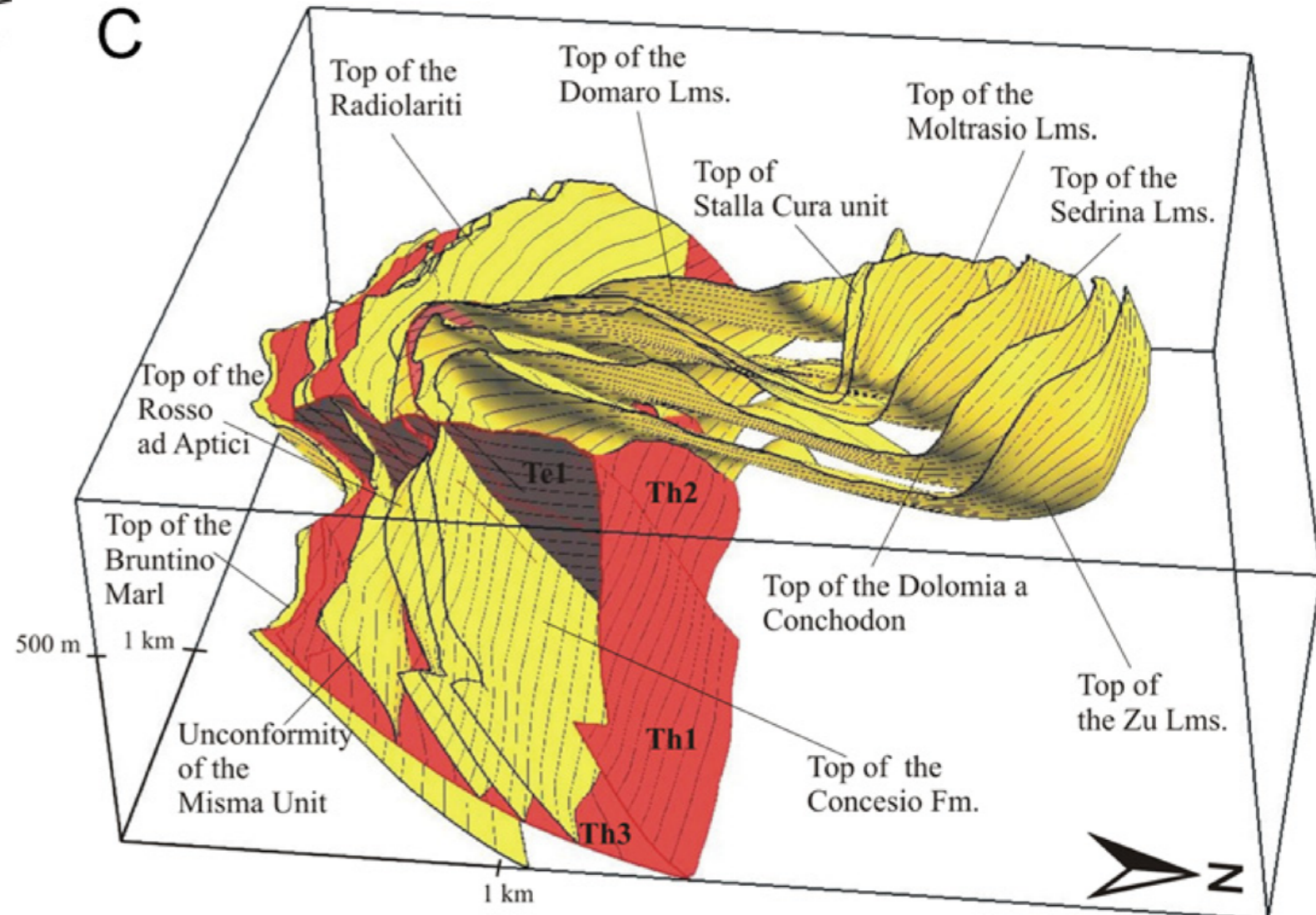


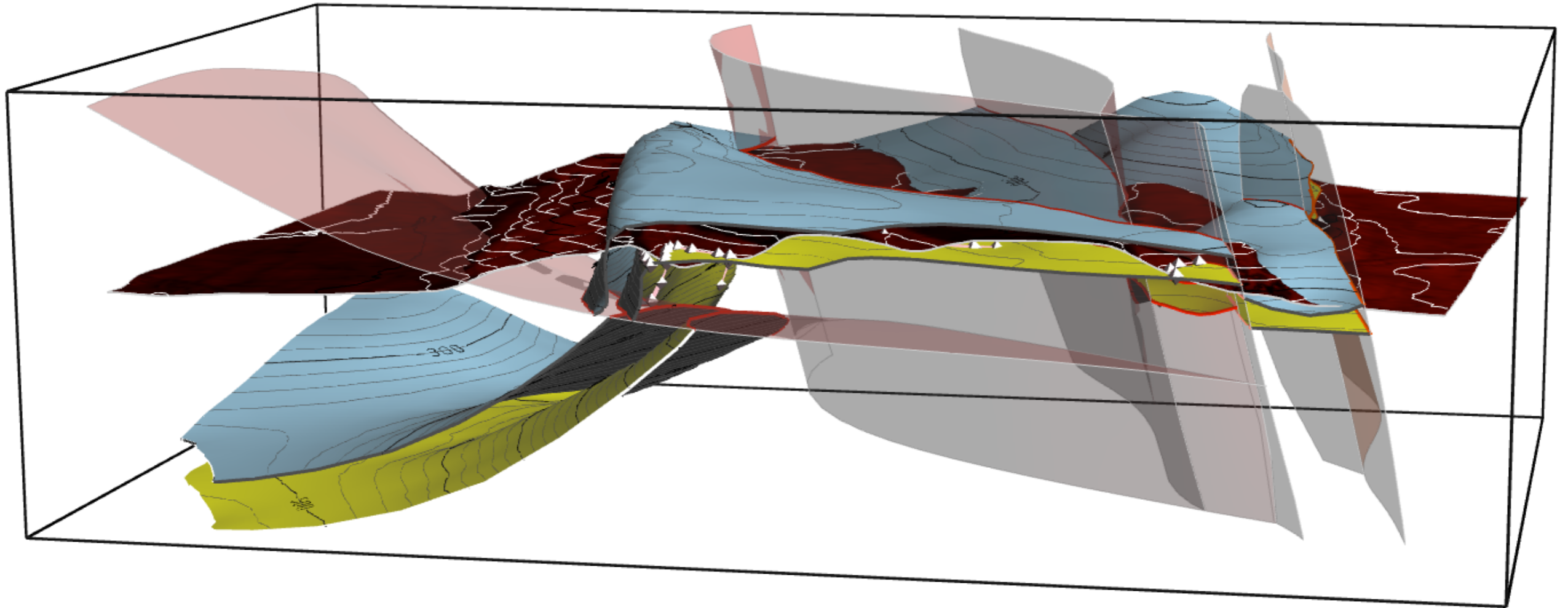
Courrioux et al. (Tectonophysics, 2001)



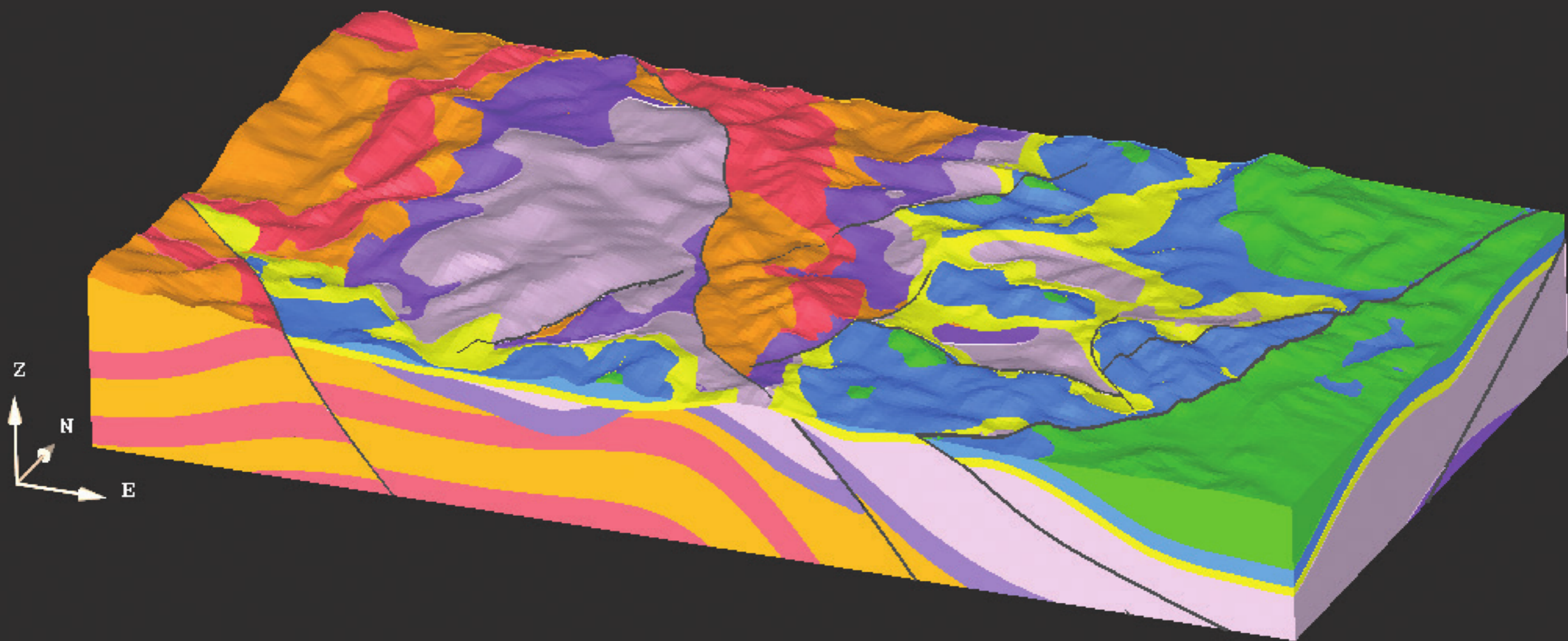
C

Zanchi et al.
 (Comps. & Geosci., 2009)

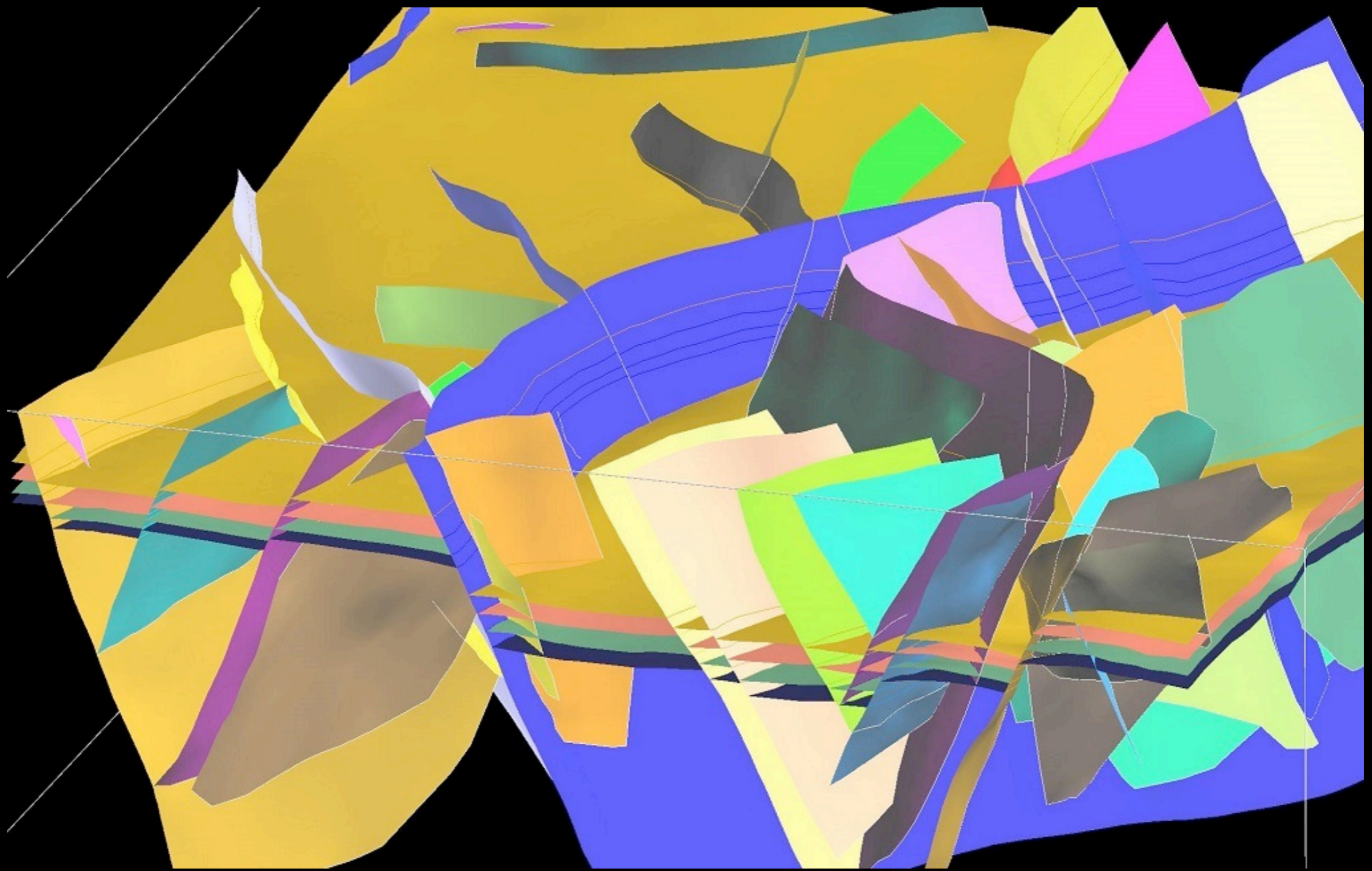




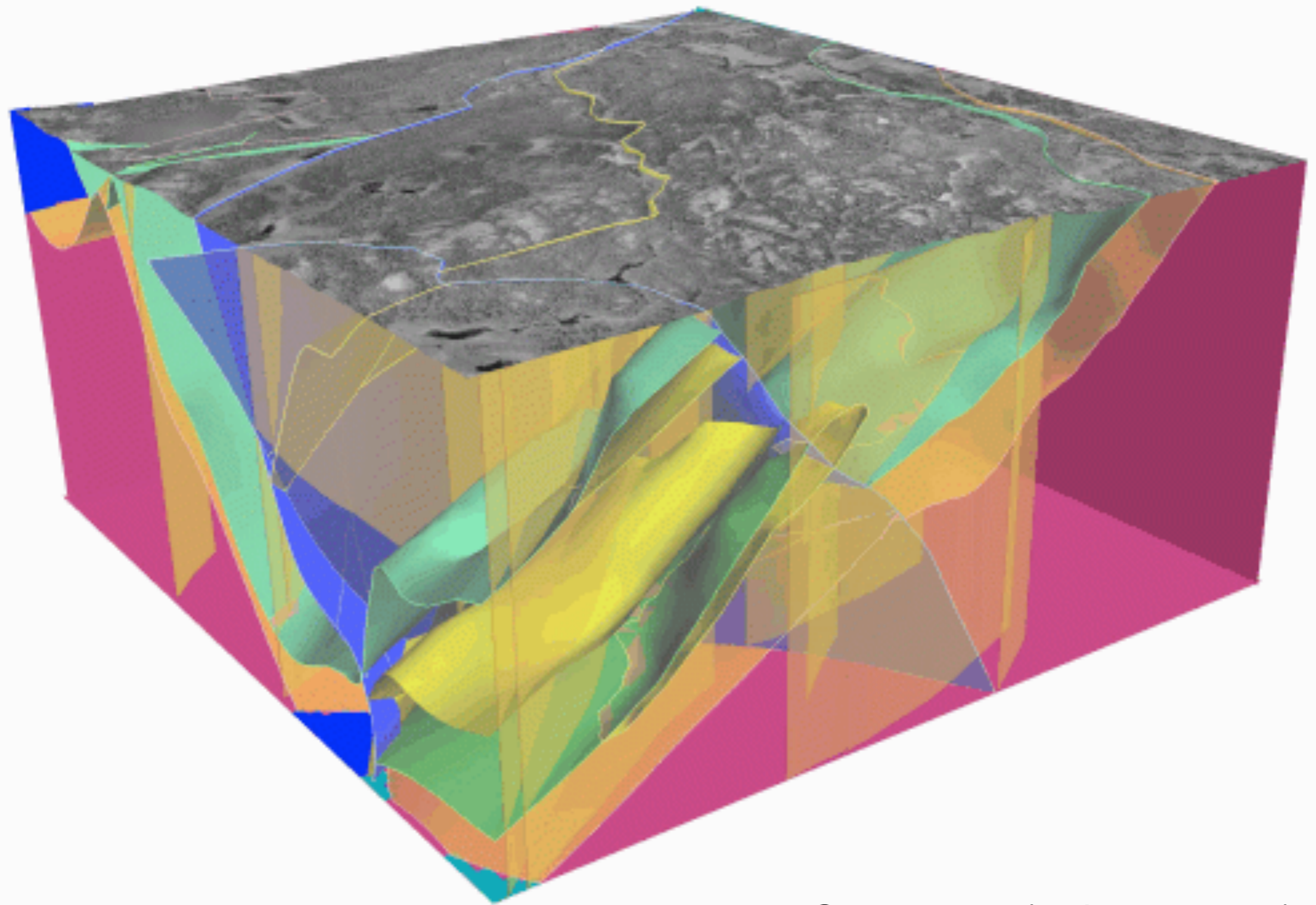
Caumon et al. (Math. Geosci., 2009)



BRGM/GeoModeller (Research Report, 2012-13)



Paradigm/GOCAD (web-site, 2014)



Mira Geoscience (web-site, 2014)

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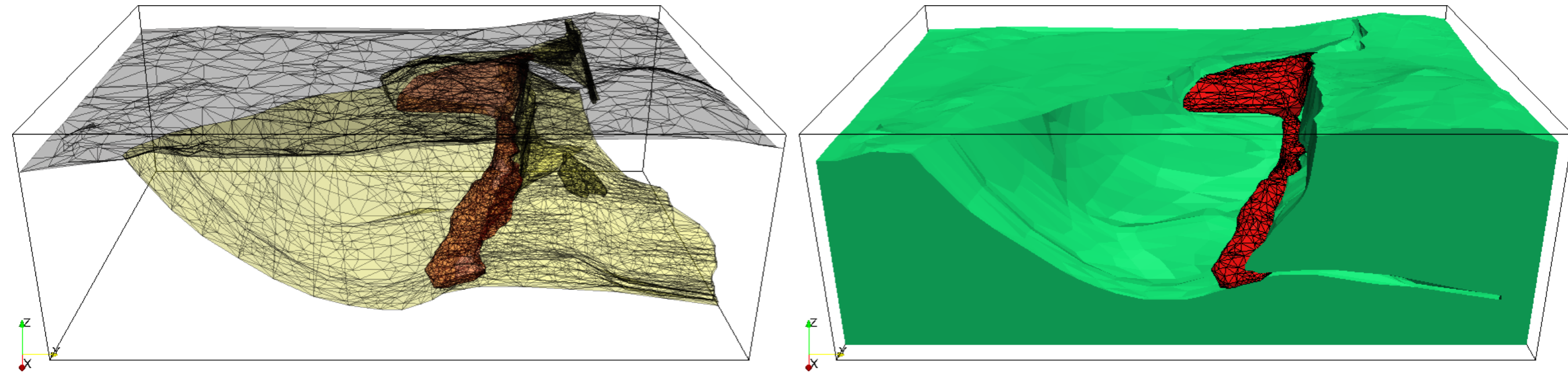
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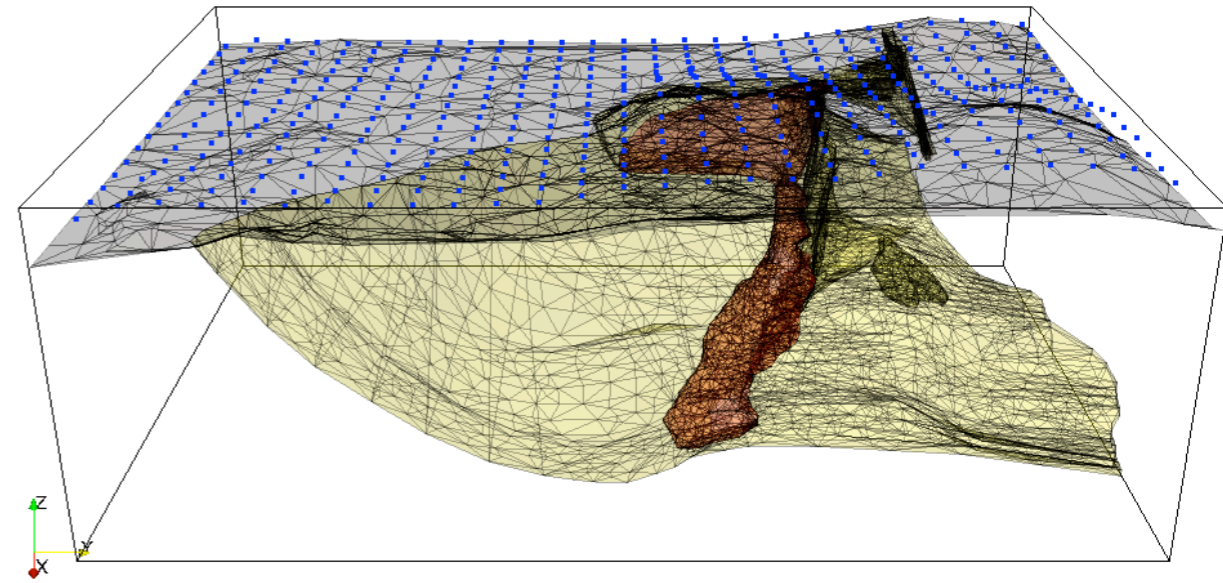
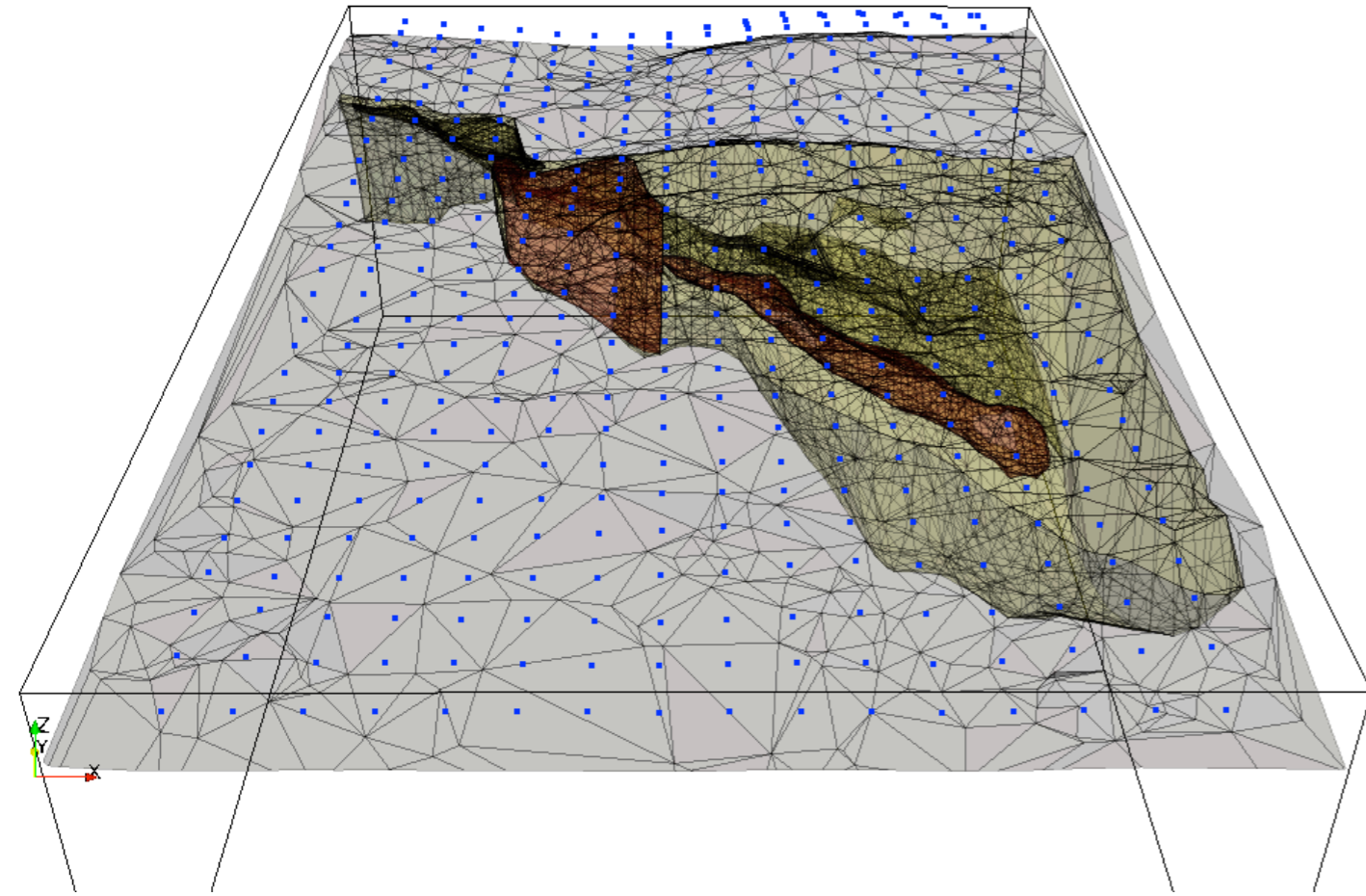
Conclusions.

Unstructured meshes:

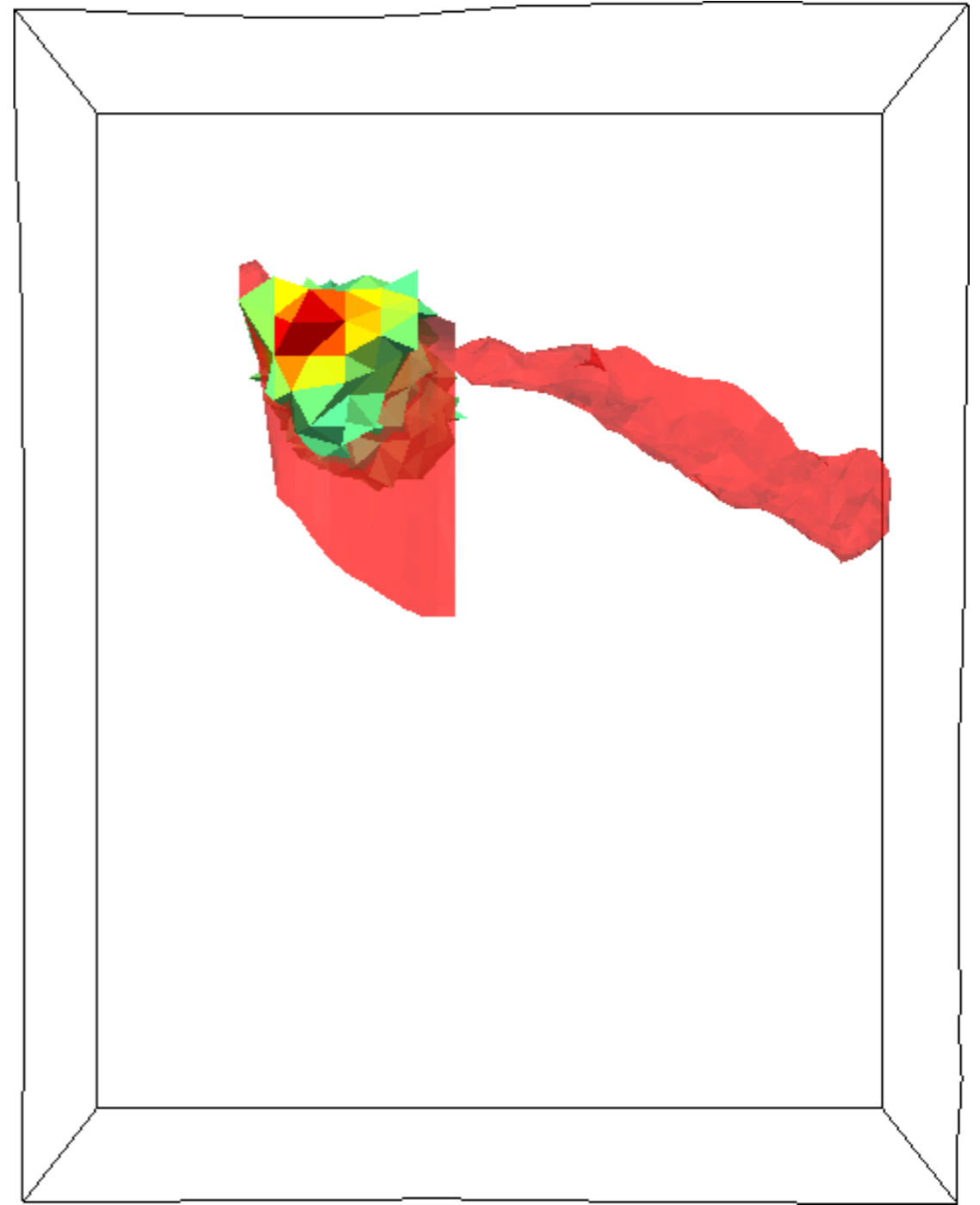
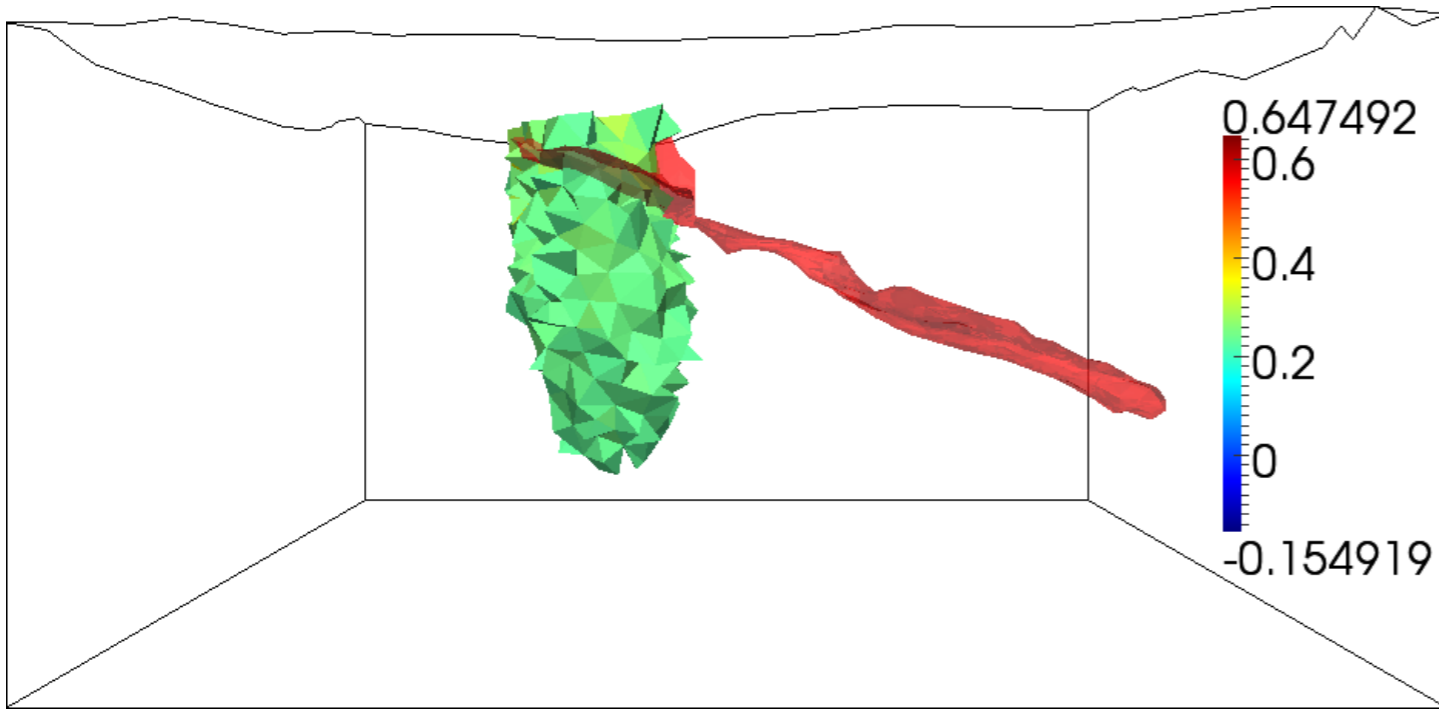
- geological and geophysical models can share the same mesh;
- they can, in essence, be the same model;
- a single, unified **Earth model**.



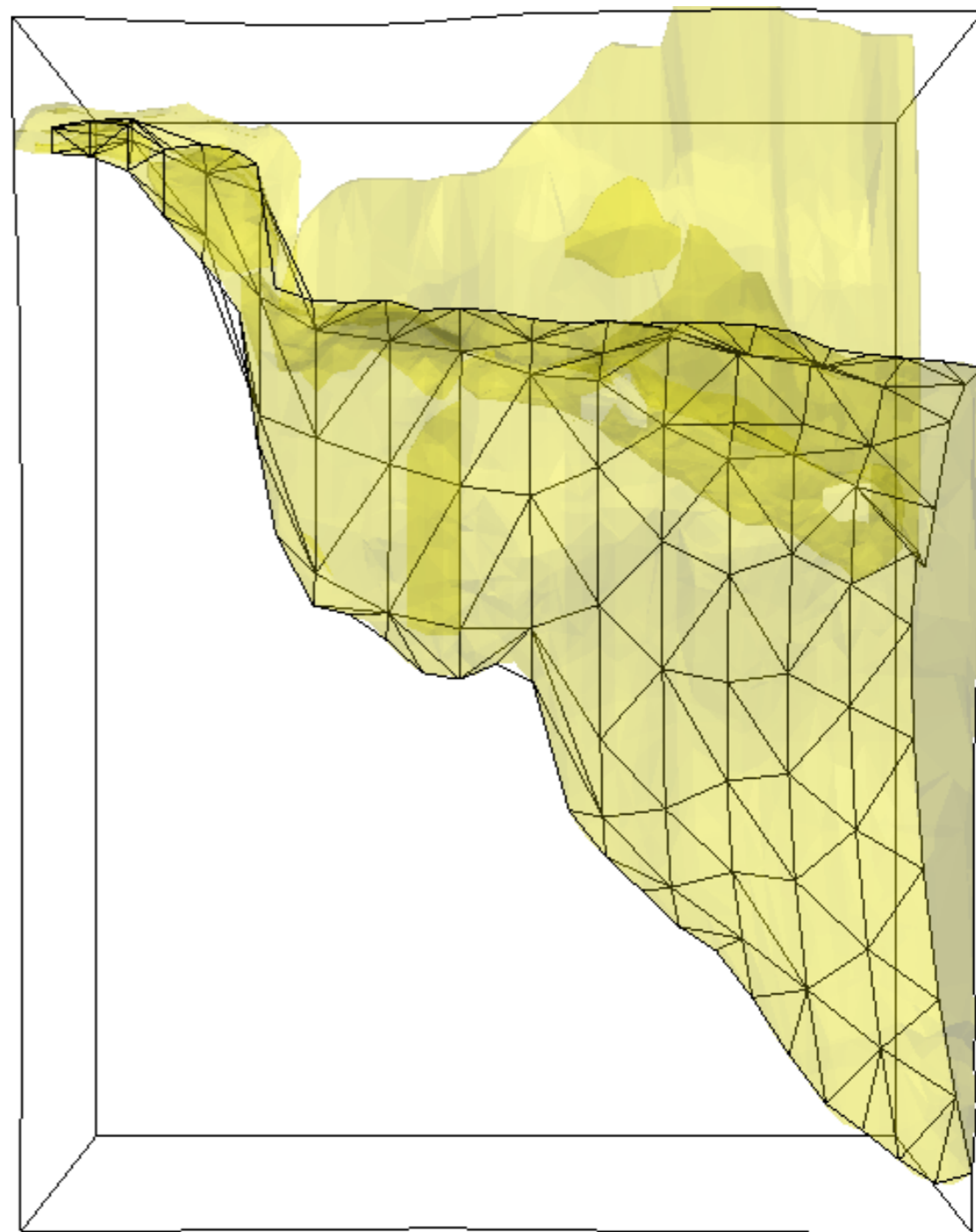
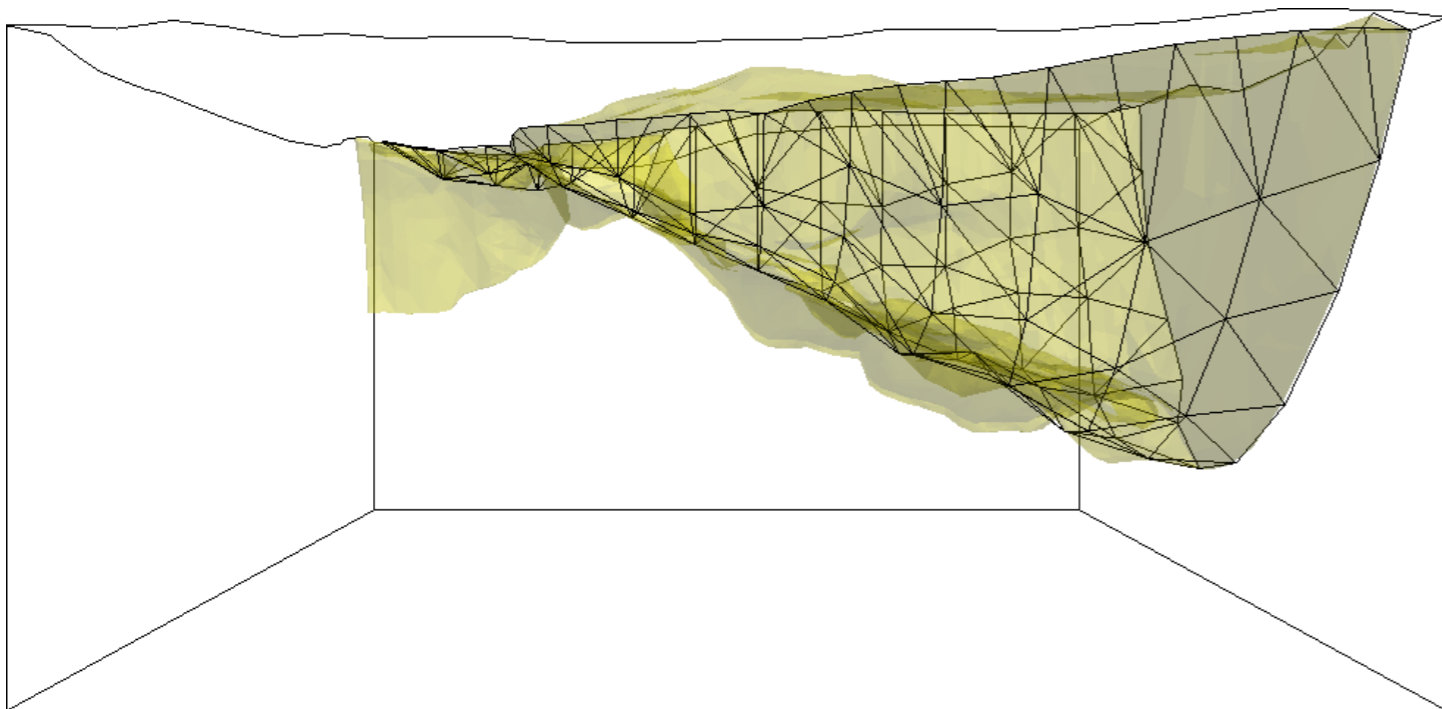
Constrained inversion ...



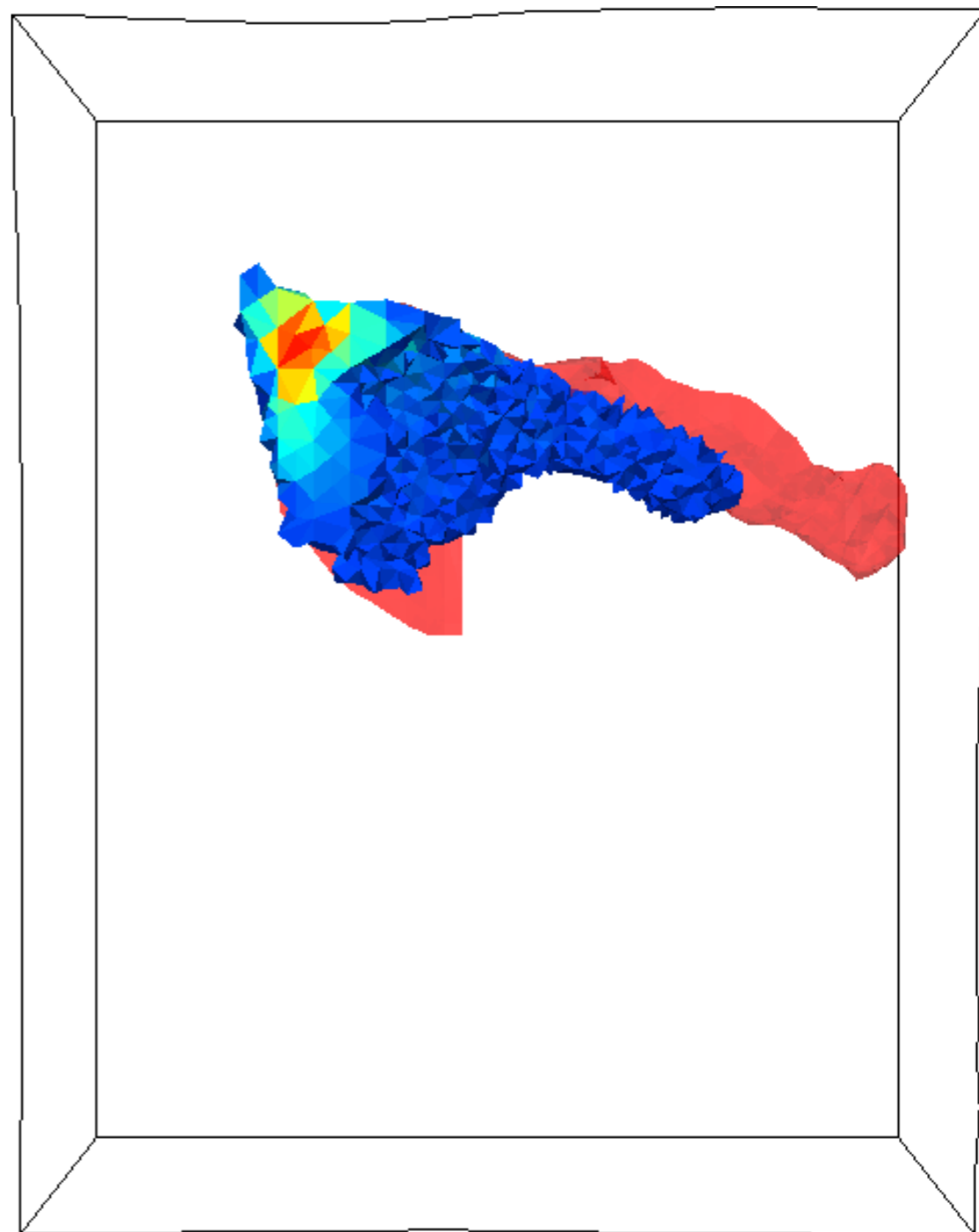
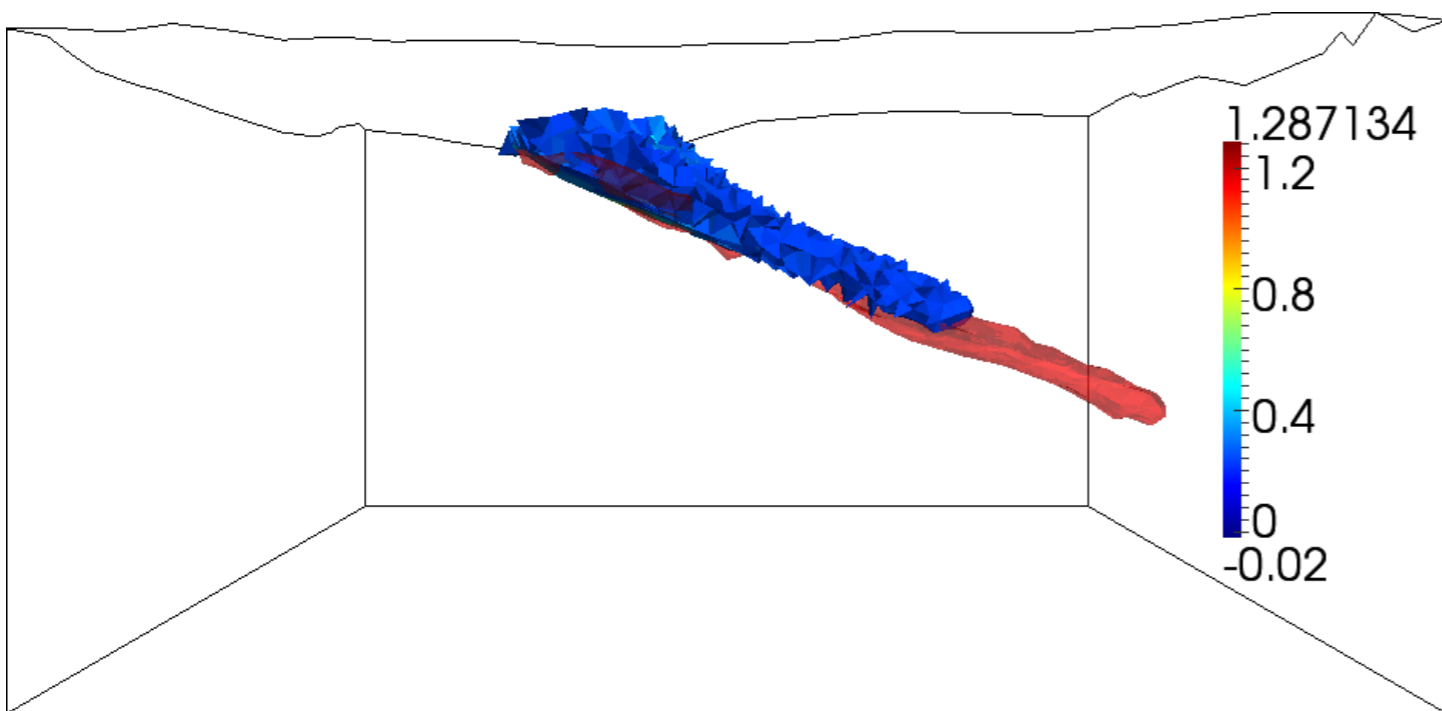
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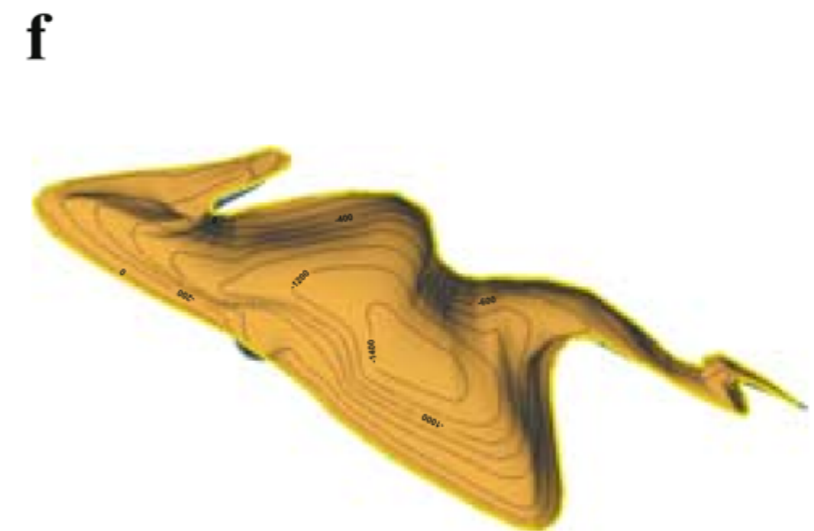
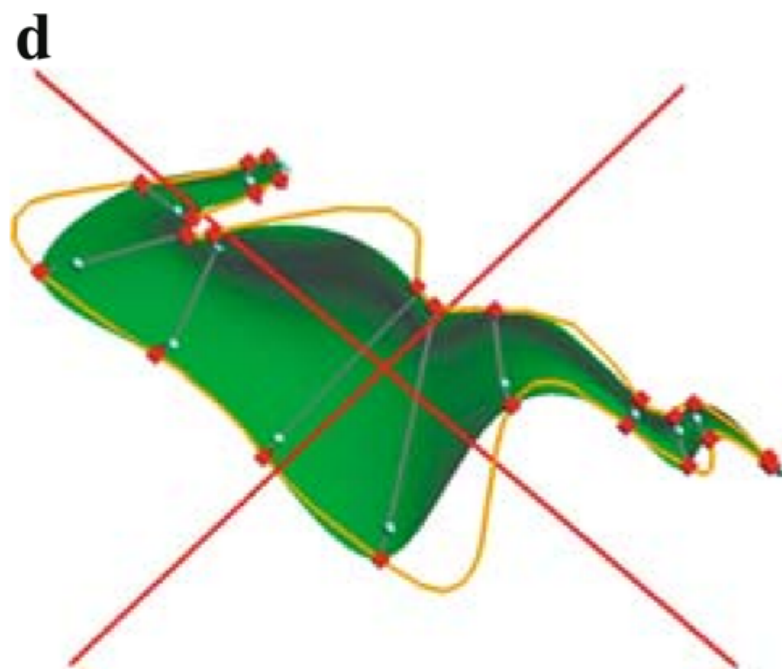
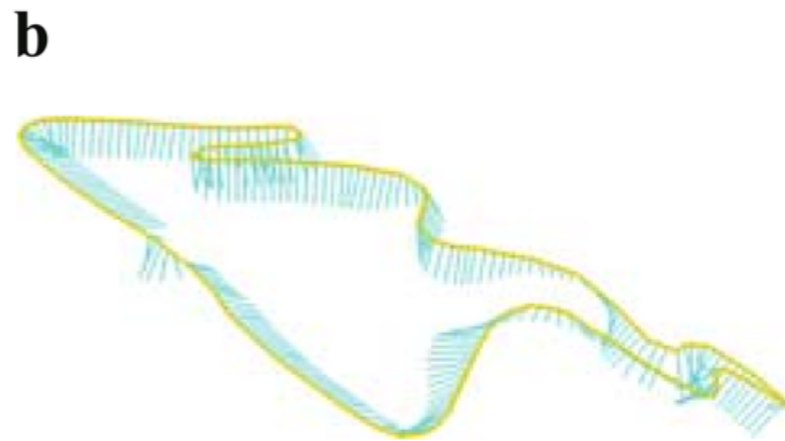
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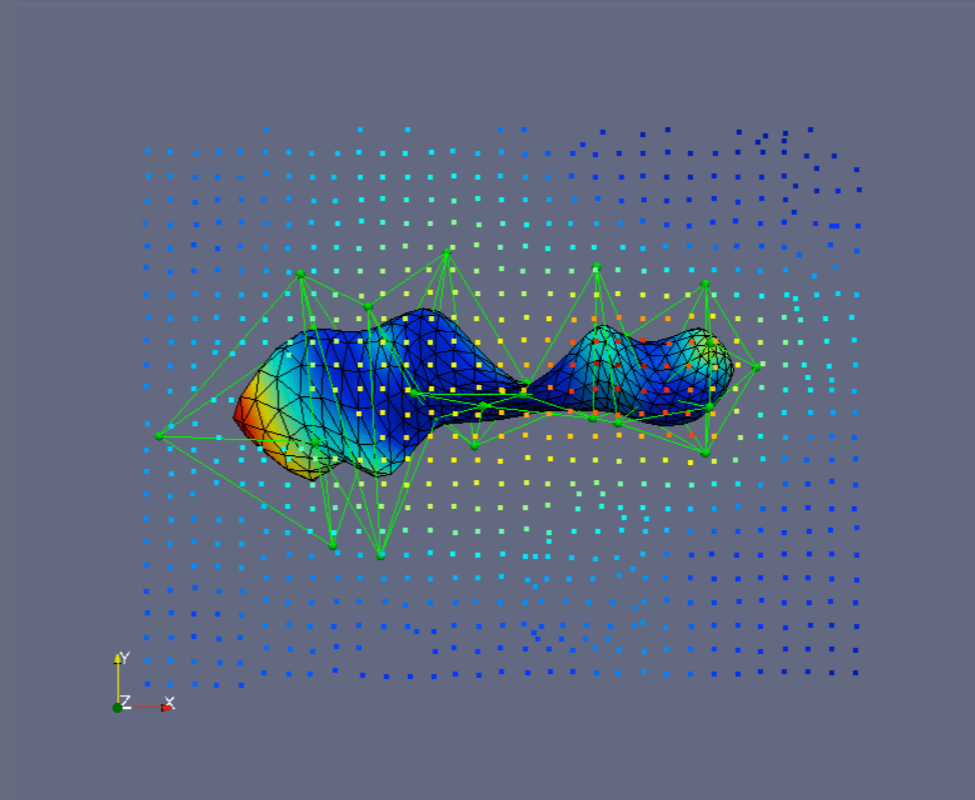
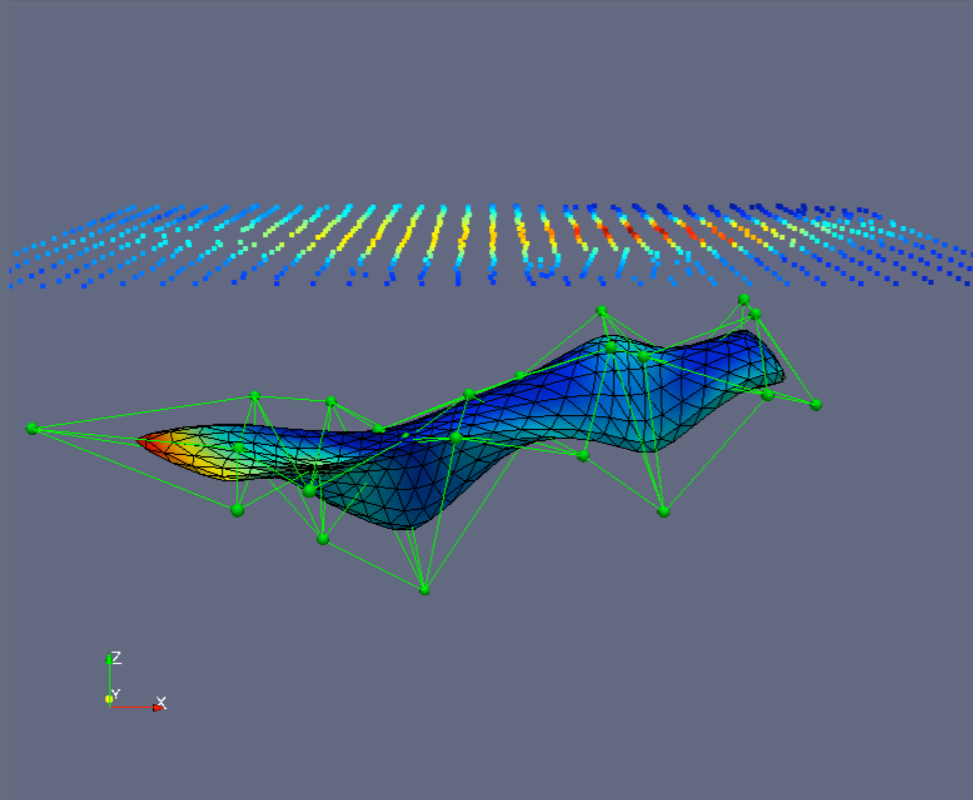
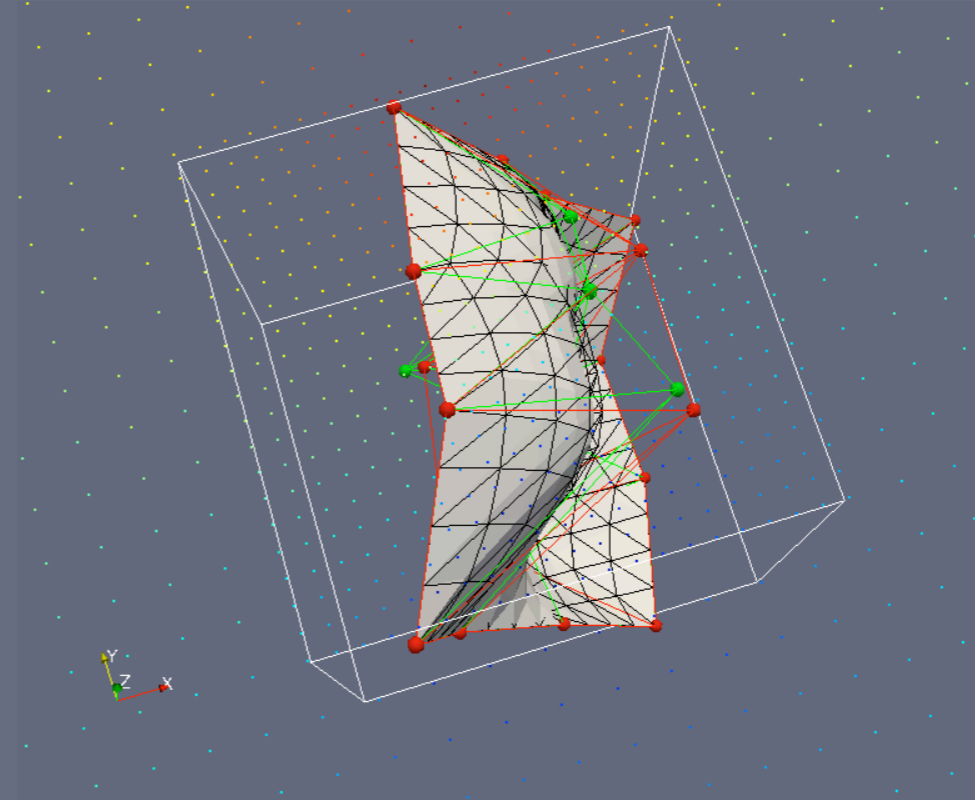
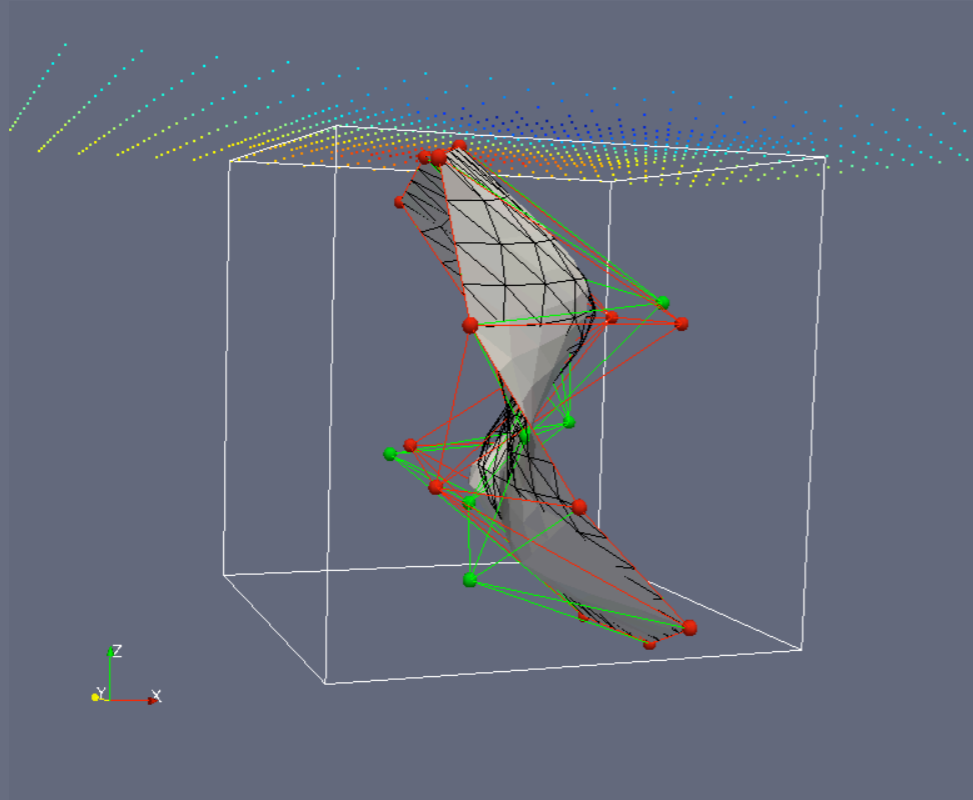


Contact surface inversion ...

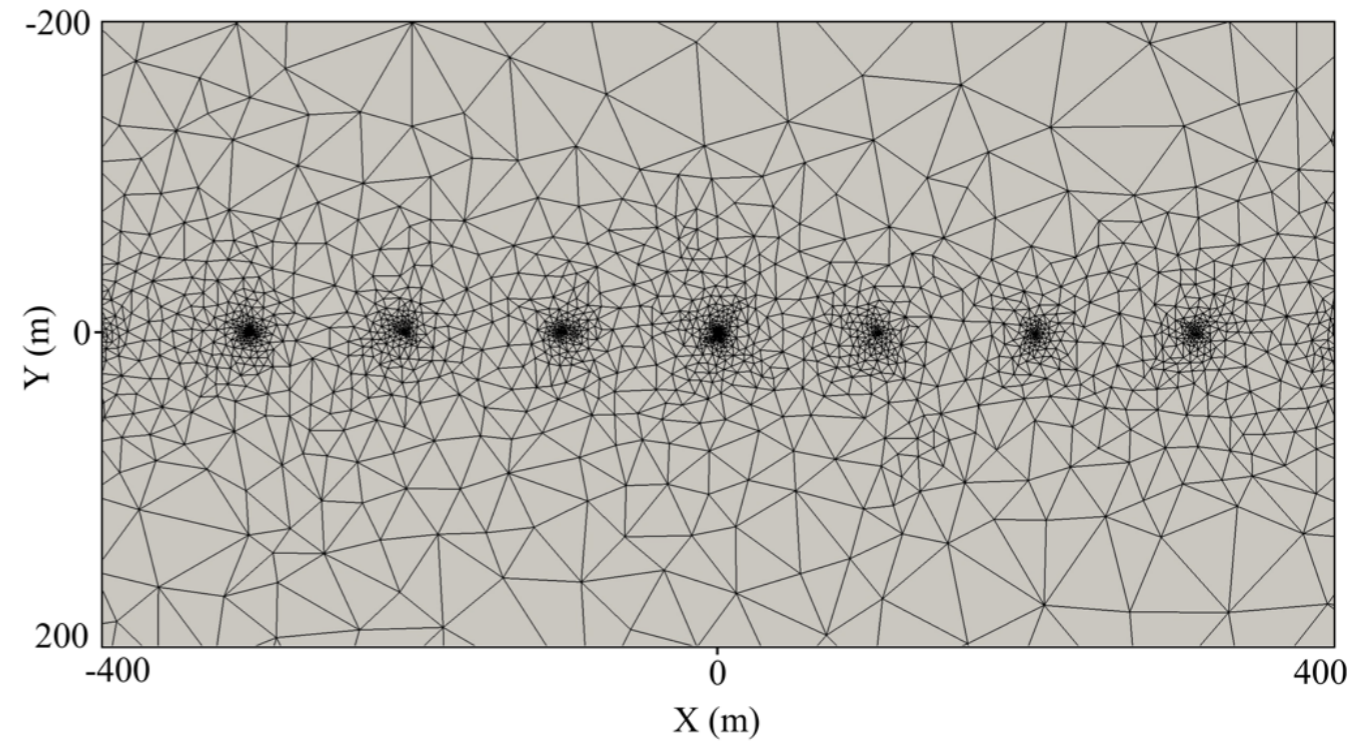
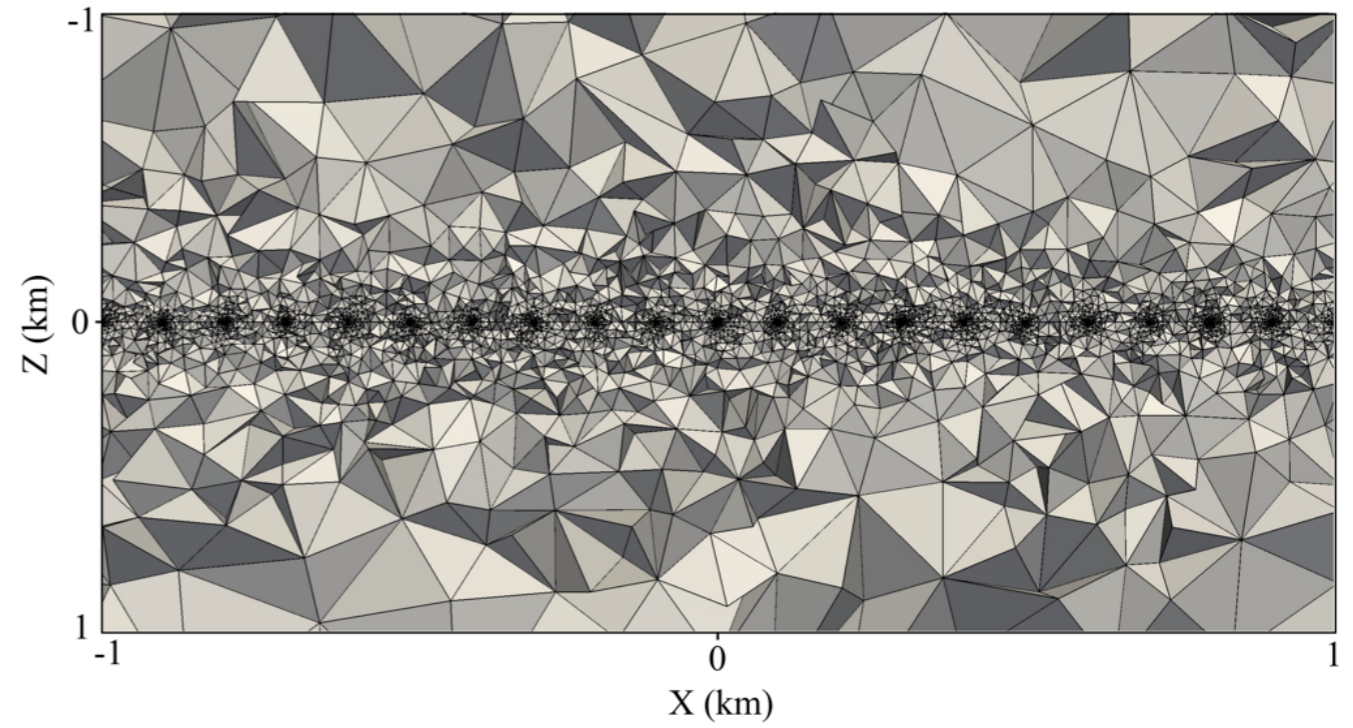
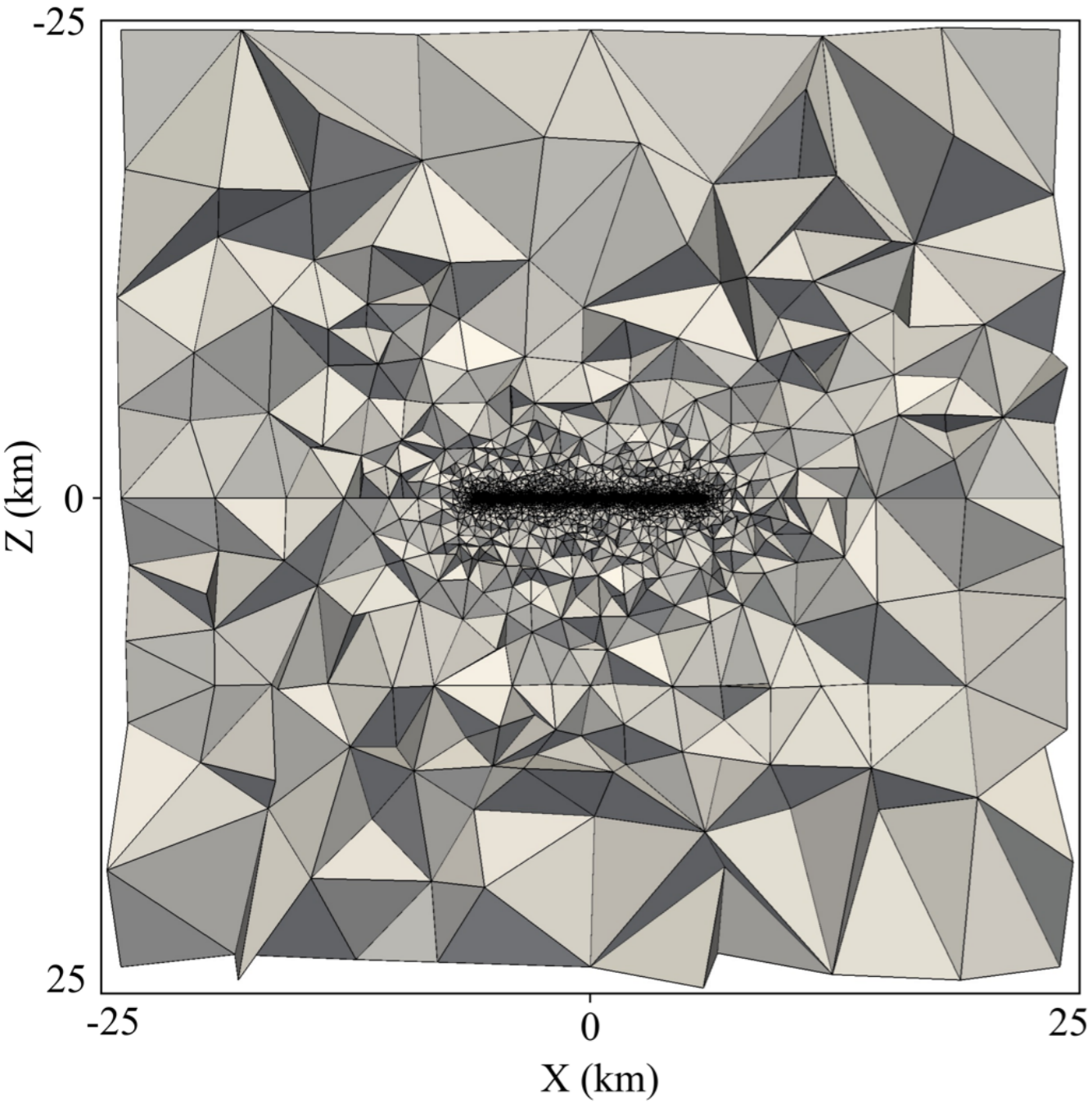


Sprague & de Kemp (GeoInfo., 2005)

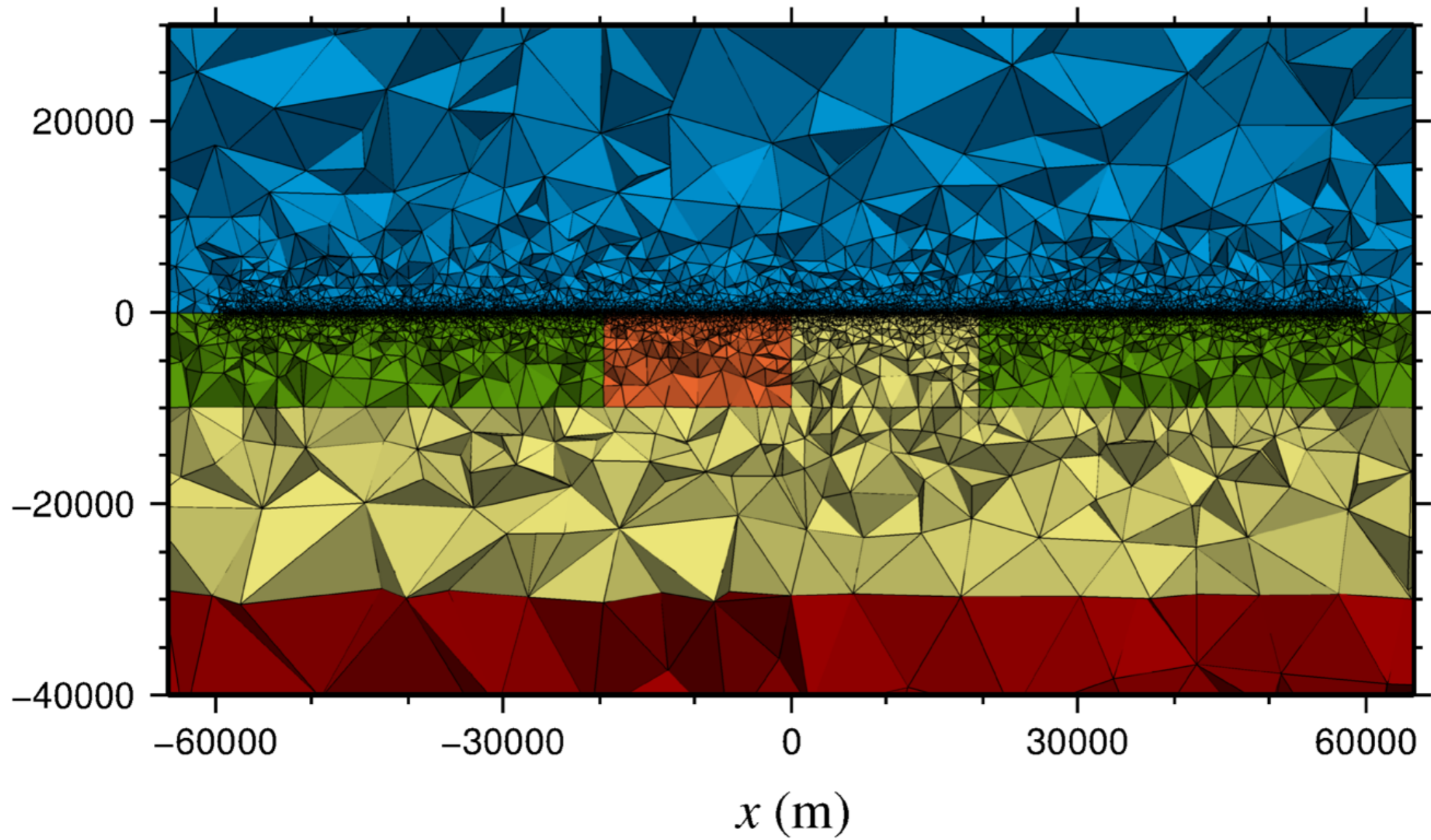
Contact surface inversion ...



Numerical/computational benefits:



Inversion, sensitivity computations (MT):



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EM geophysics on unstructured tetrahedral meshes:

Börner et al. (GJI, 2008);

Um et al. (GEOPHYSICS, 2010);

Mukherjee & Everett (GEOPHYSICS, 2011);

Schwarzbach et al. (GJI, 2011);

Puzyrev et al. (GJI, 2013);

Ren et al. (GJI, 2013);

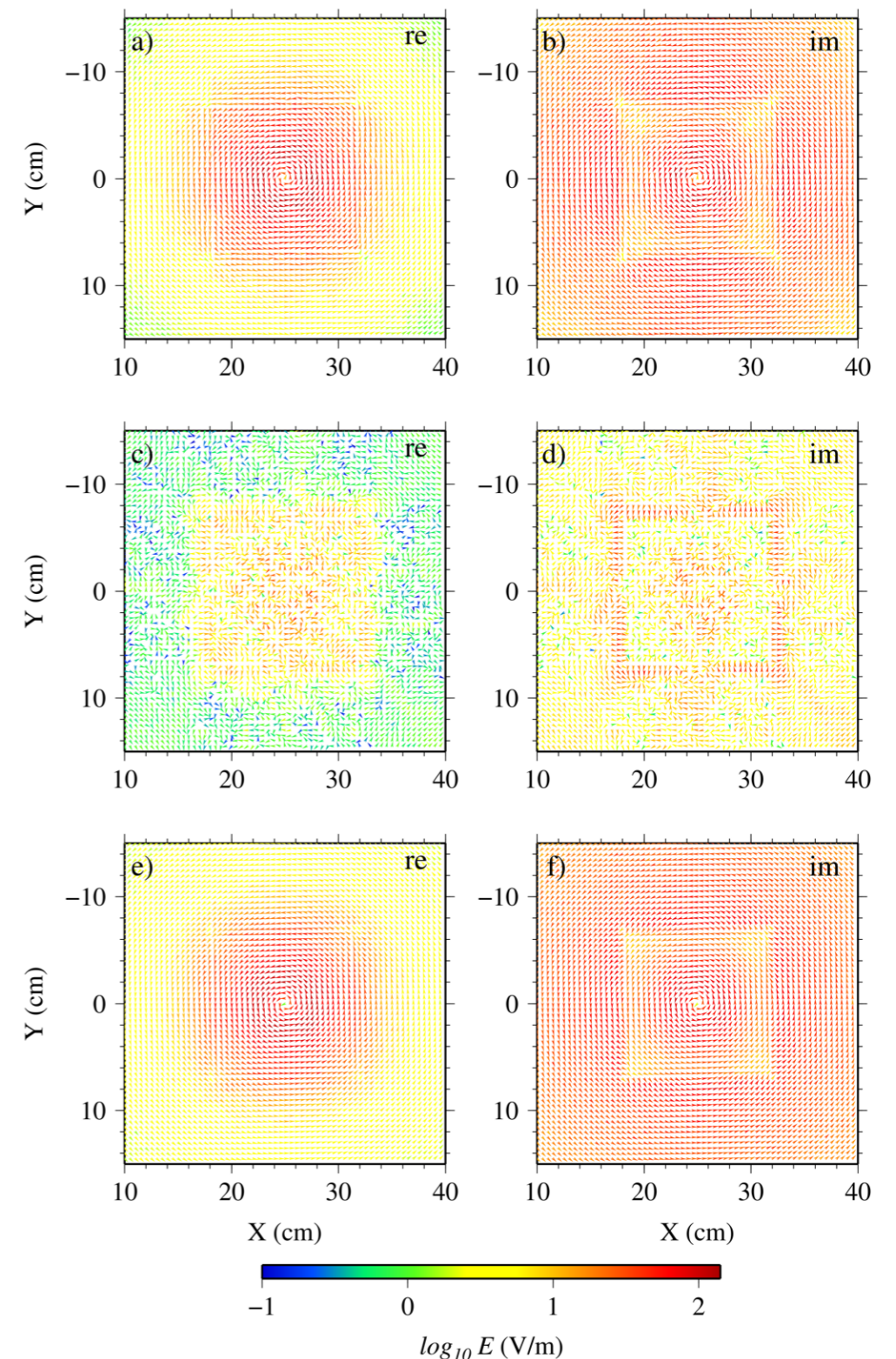
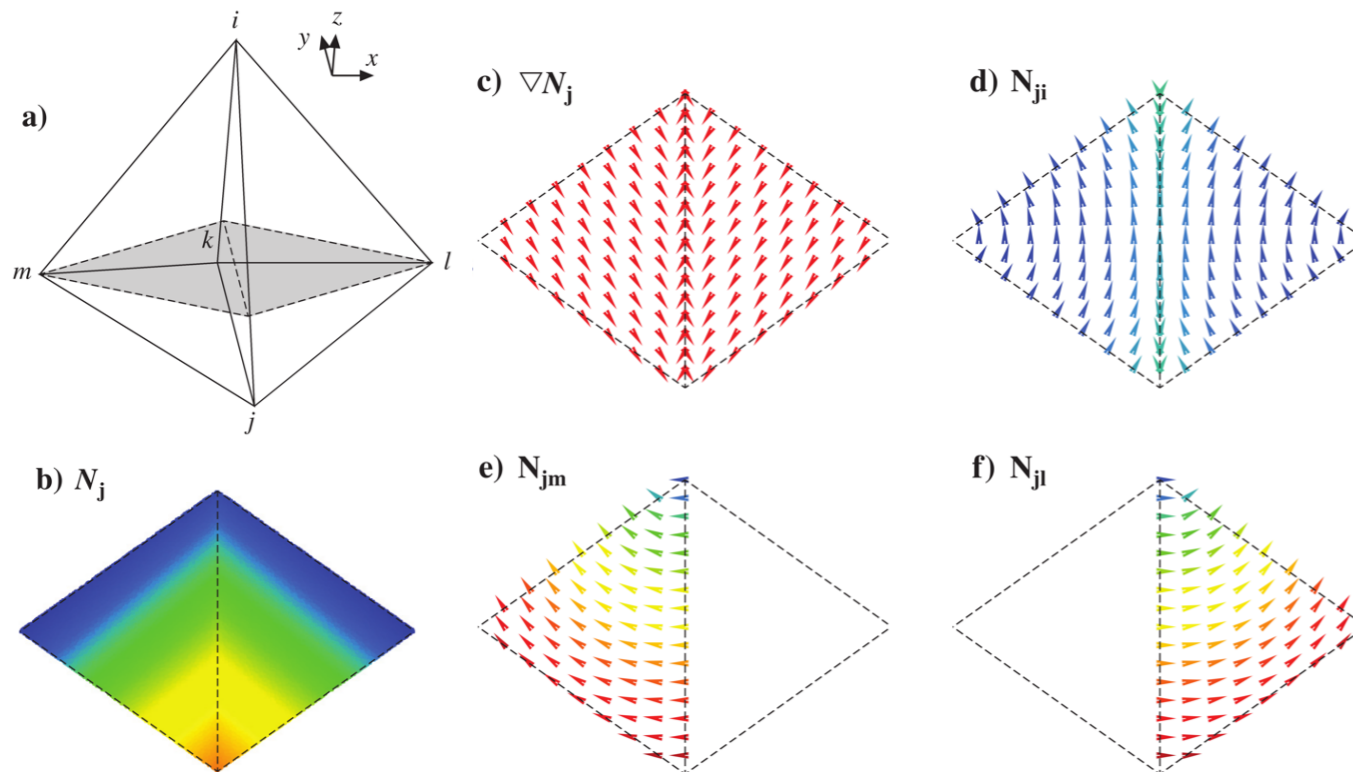
Schwarzbach & Haber (GJI, 2013);

Um et al. (GJI, 2013).

Also ...

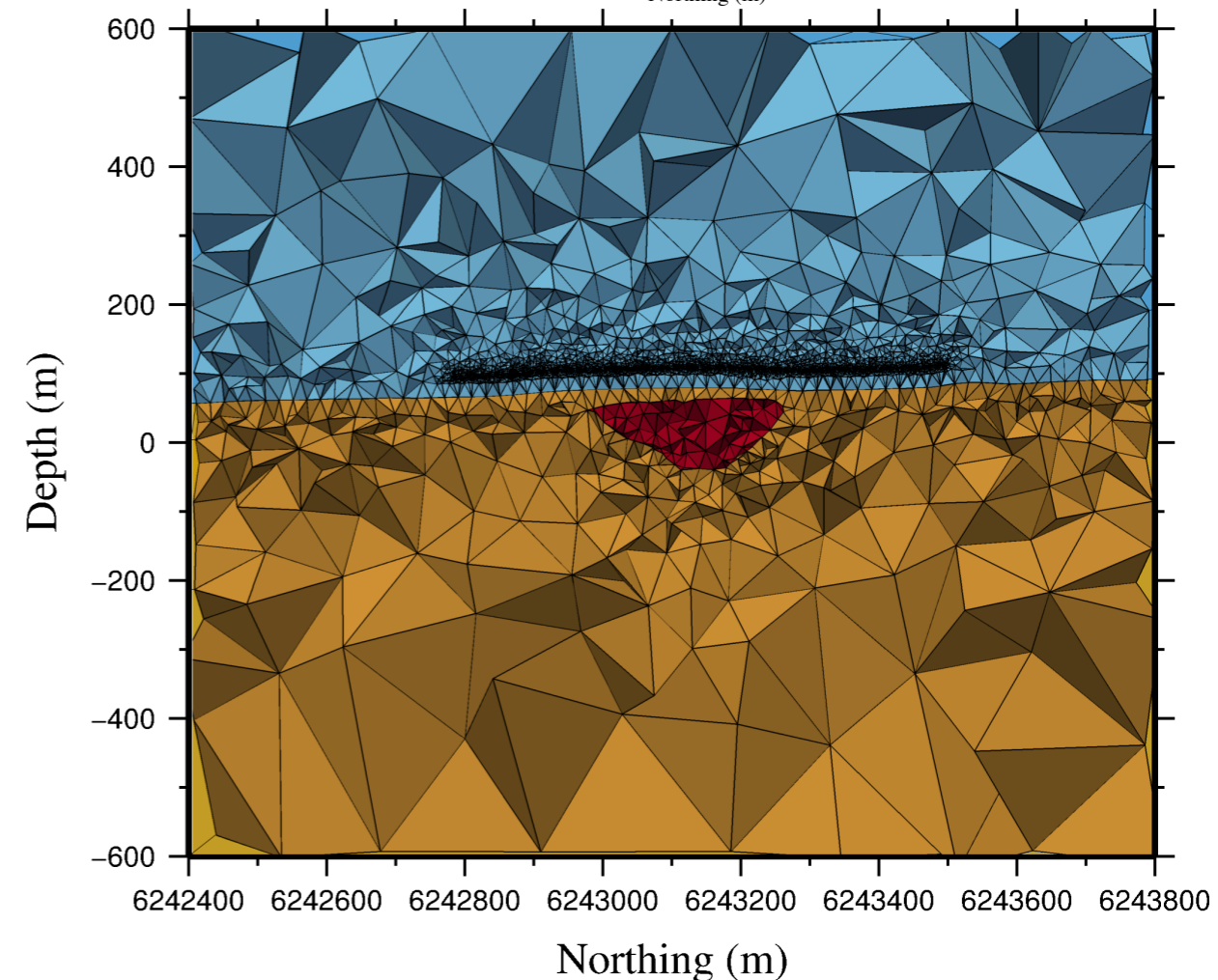
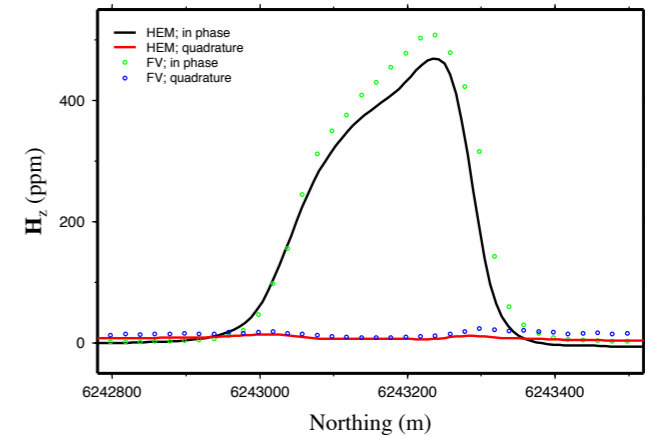
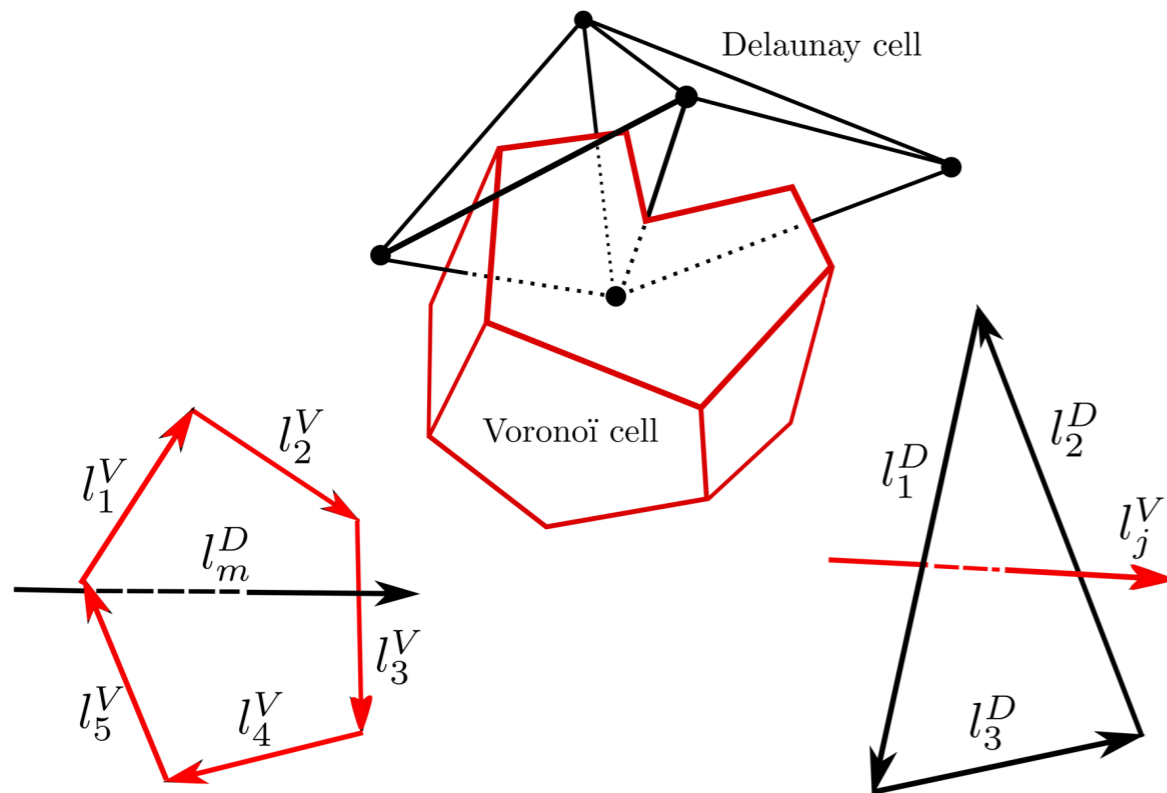
We E108 03 - A Potential Method for Three-dimensional Numerical Modeling of Geophysical Electromagnetic Problems - *Ansari & Farquharson.*

- $\mathbf{A} - \phi$ decomposition;
- linear edge elements & nodal elements;
- total field;
- magnetic & electric sources.



We E108 02 - Forward Modelling of Geophysical Electromagnetic Data on Unstructured Grids Using a Finite-volume Approach - *Jahandari & Farquharson.*

- staggered grid finite difference;
- total field;
- magnetic & electric sources;
- \mathbf{E} field; $\mathbf{A} - \phi$ decomposition.



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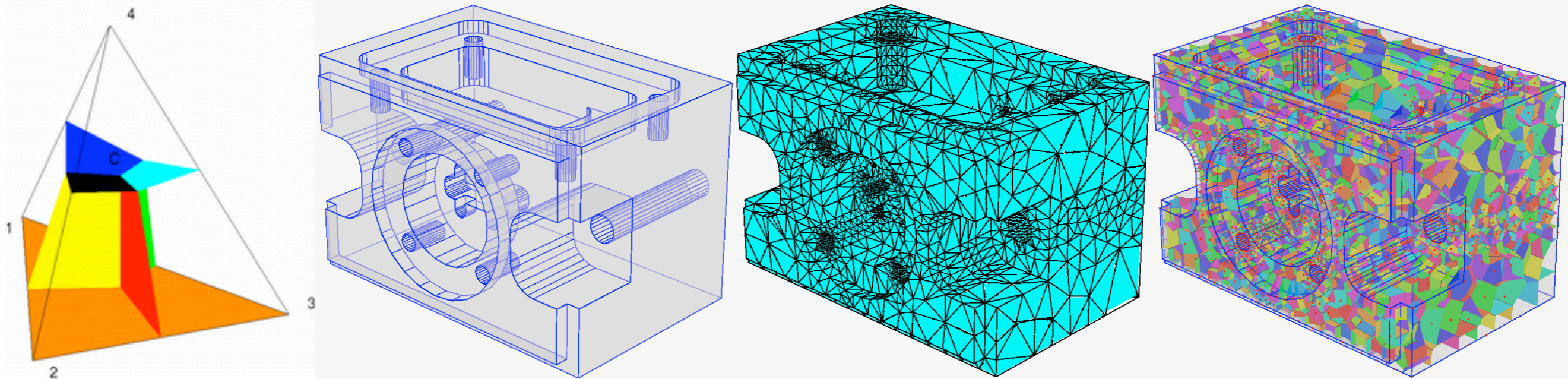
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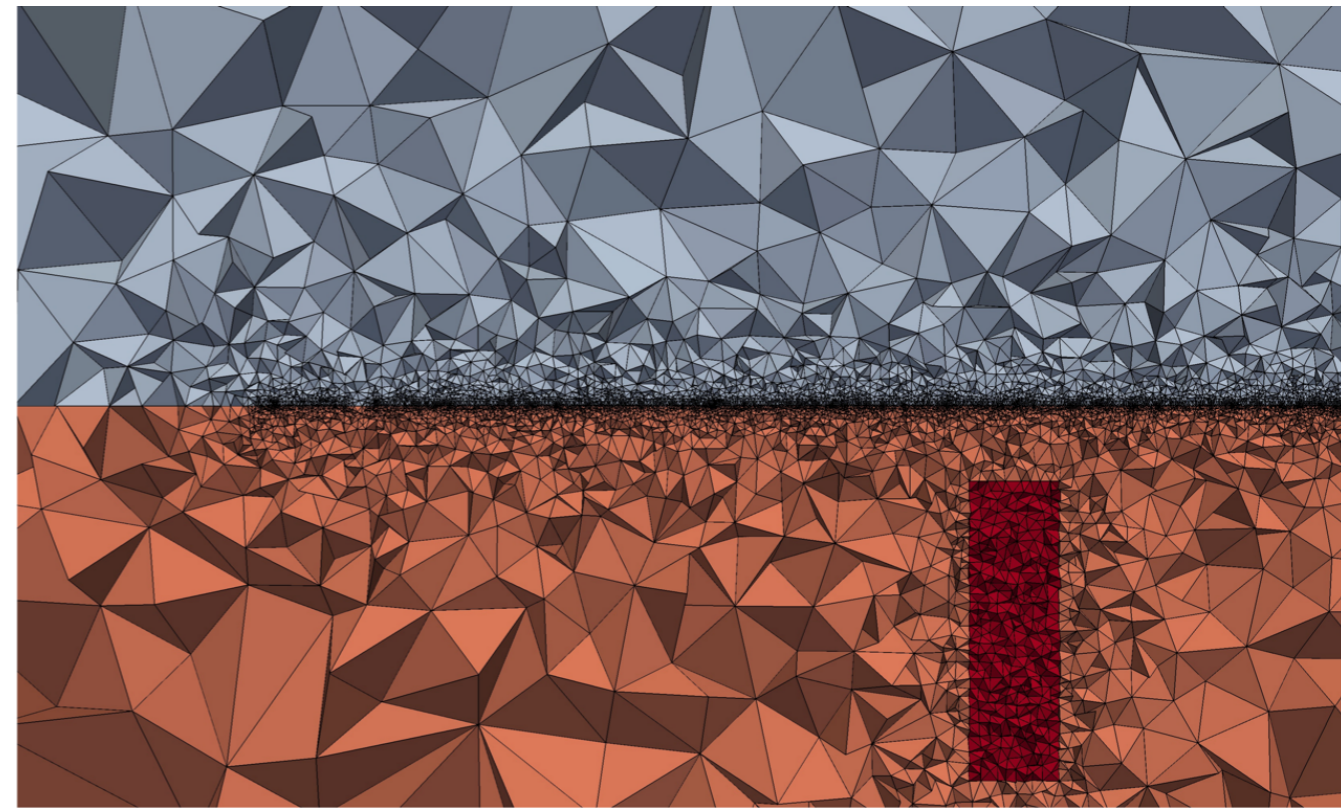
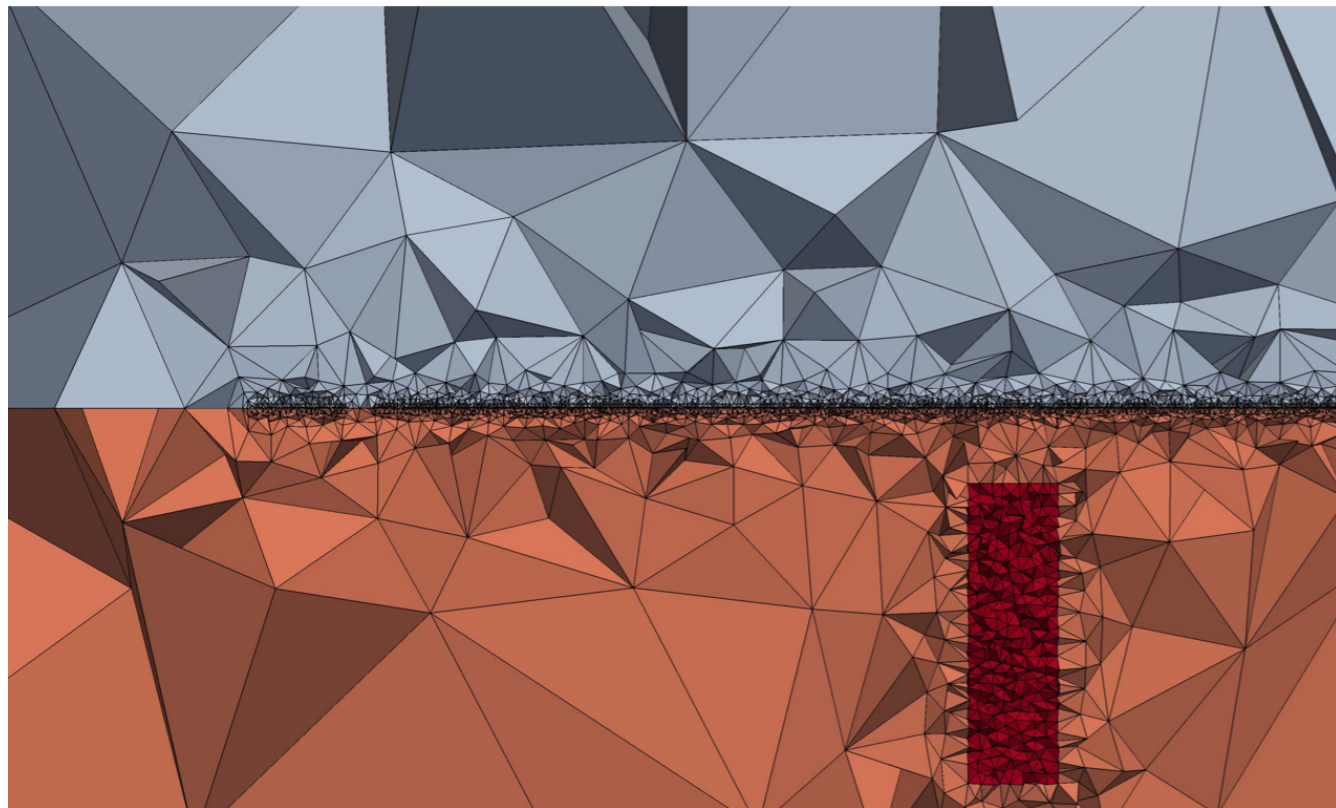
→ **specialized** mesh generation;

e.g., TetGen (Hang Si, <http://wias-berlin.de/software/tetgen/>)



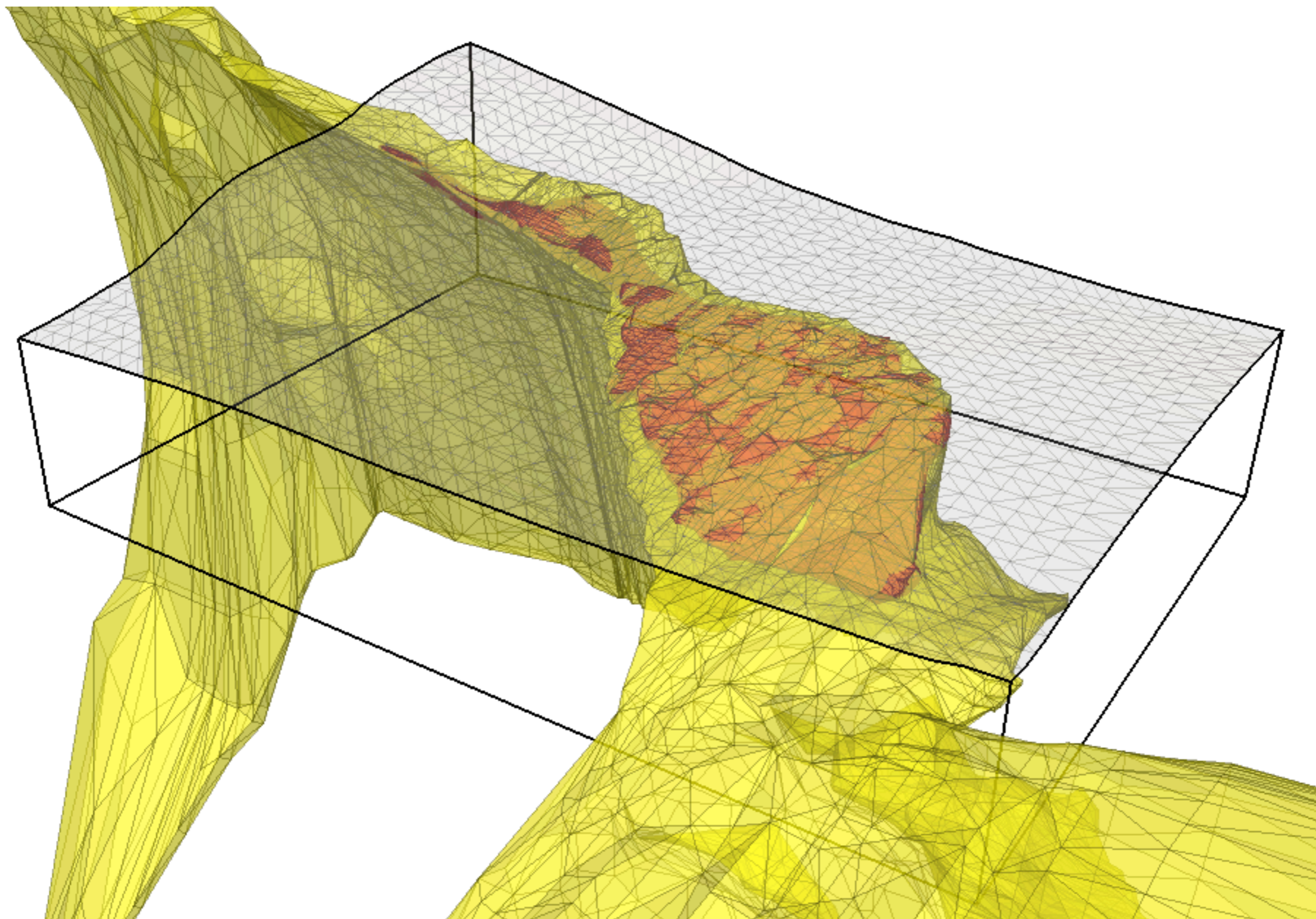
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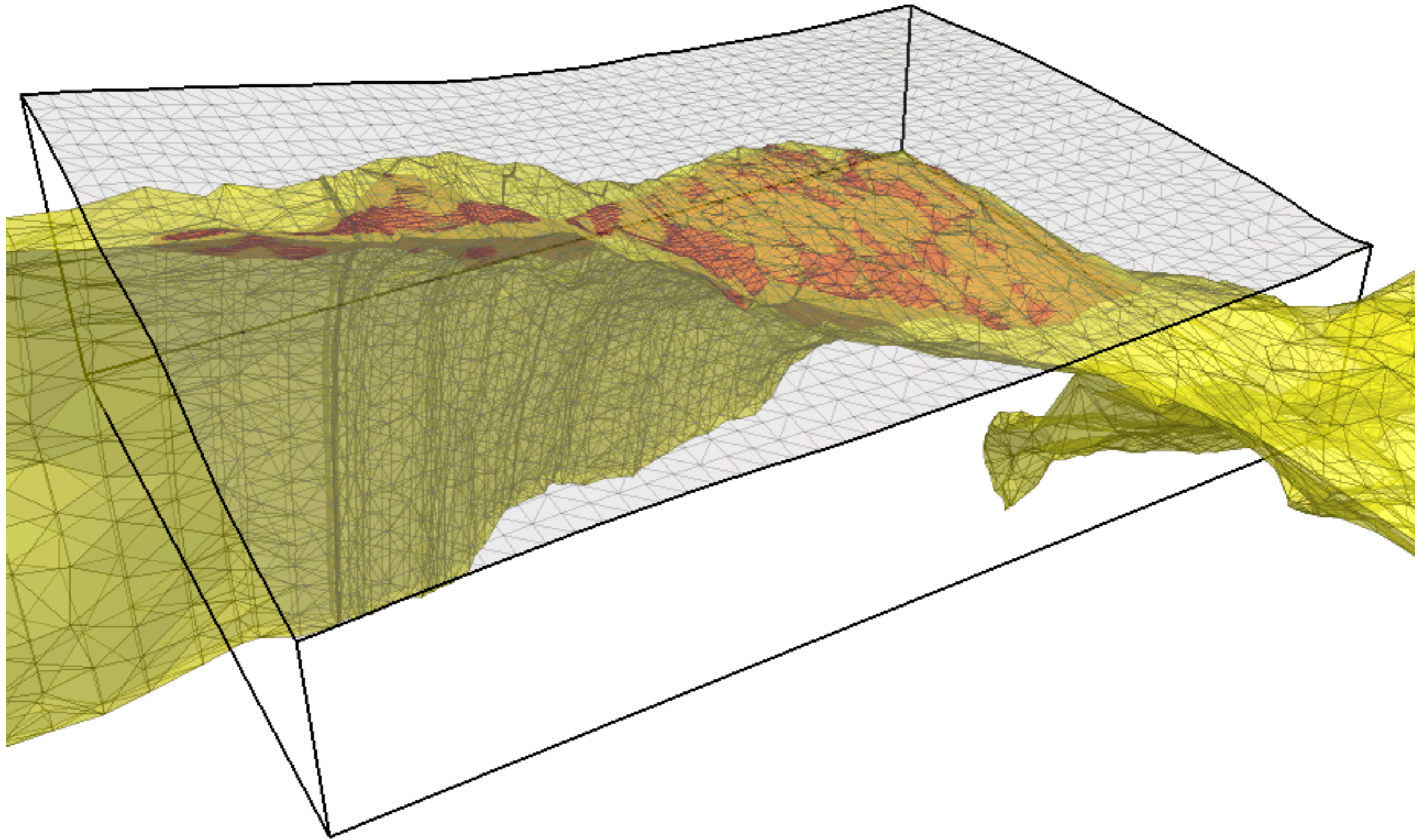
- **specialized** mesh generation;
- **quality** mesh generation;

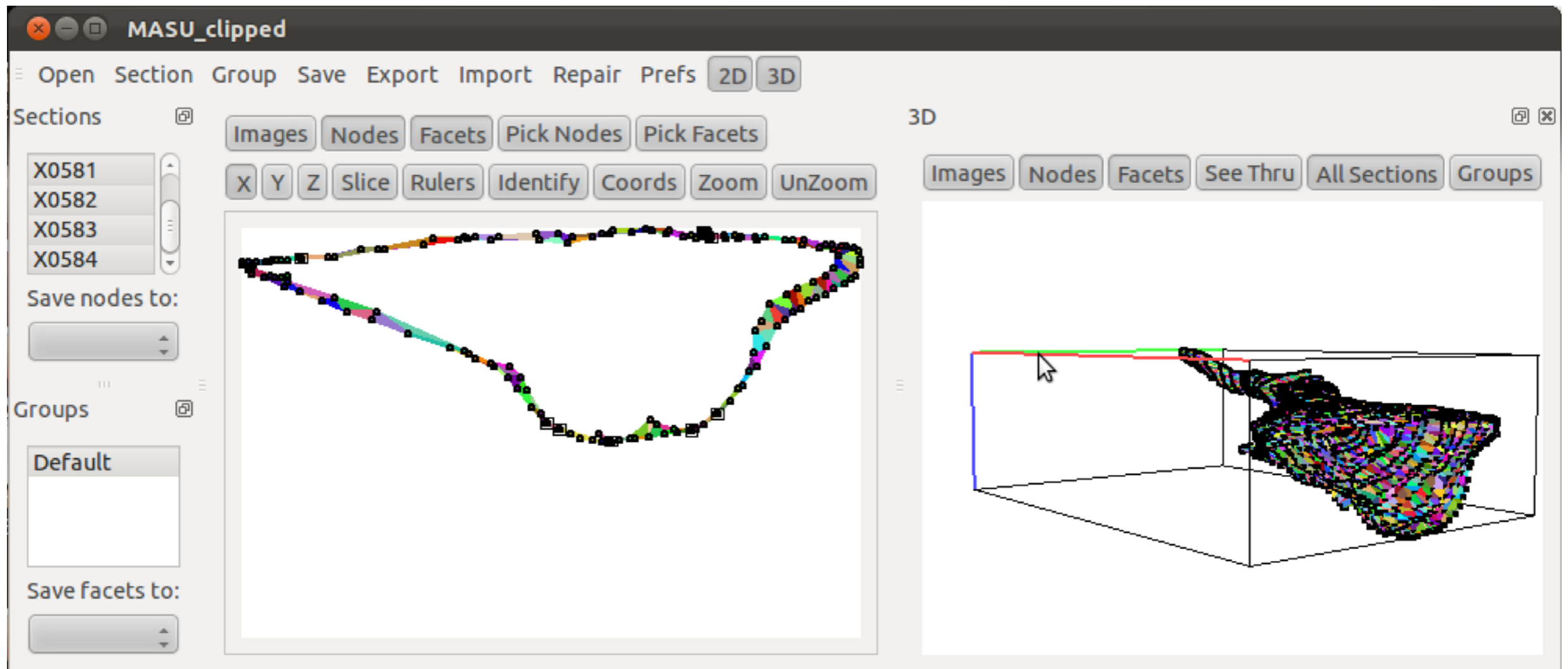


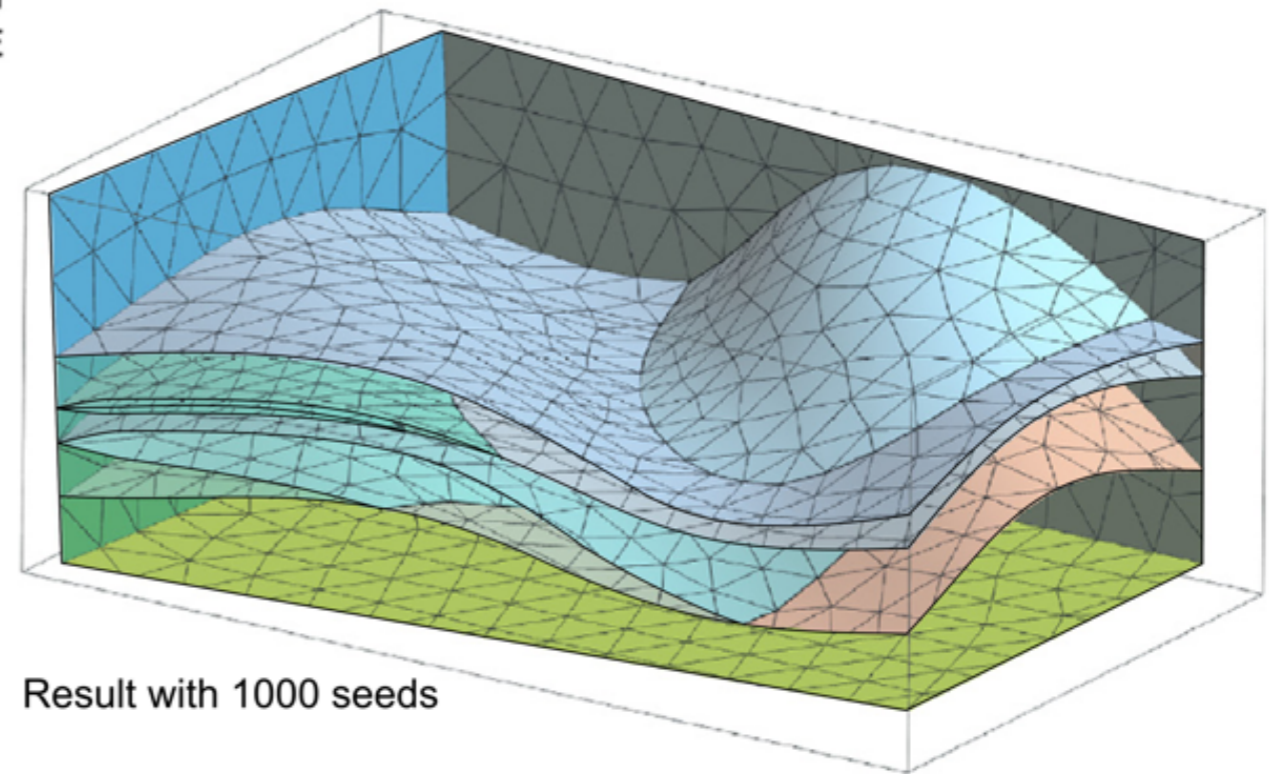
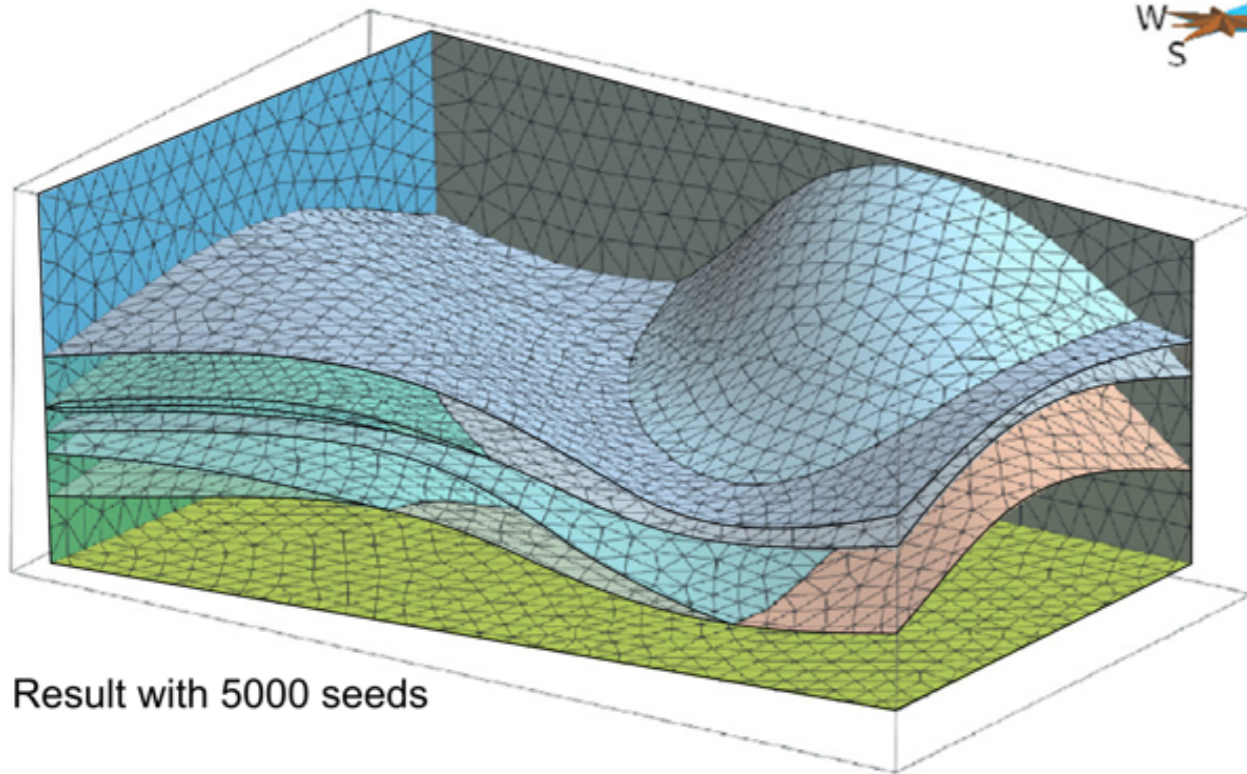
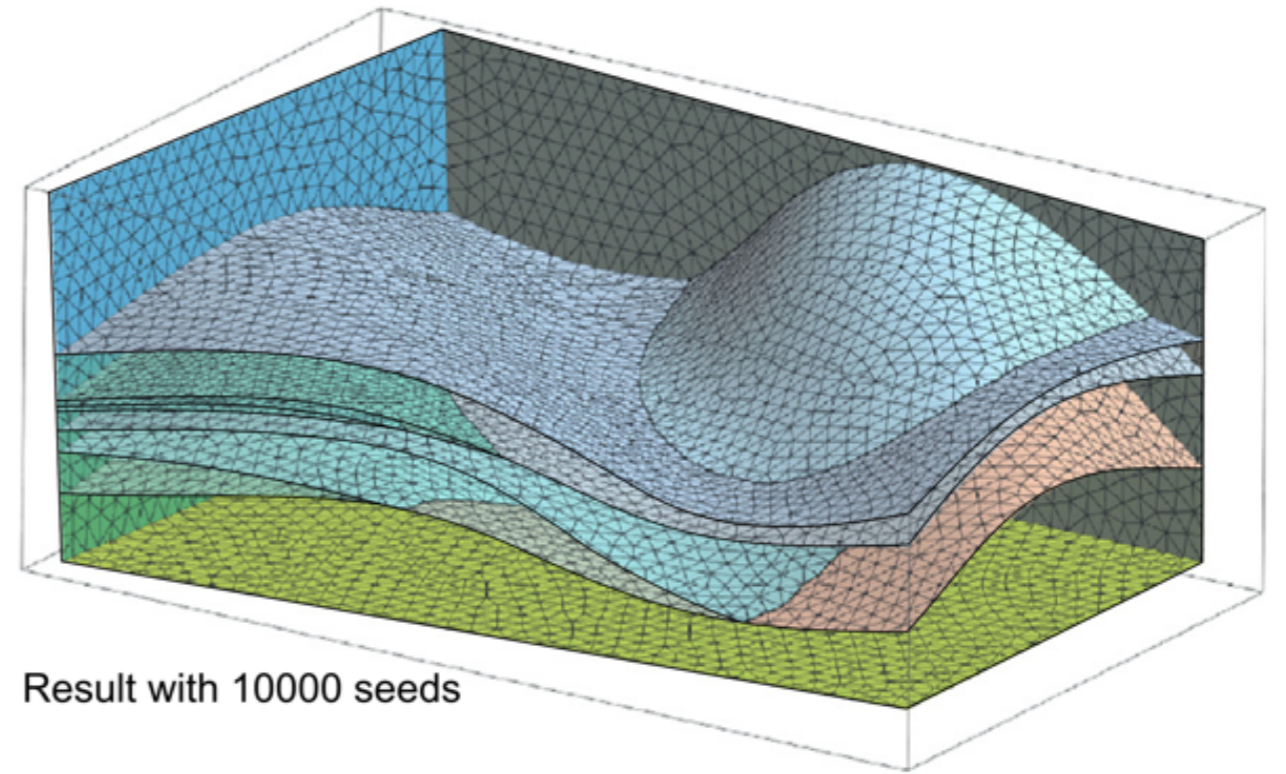
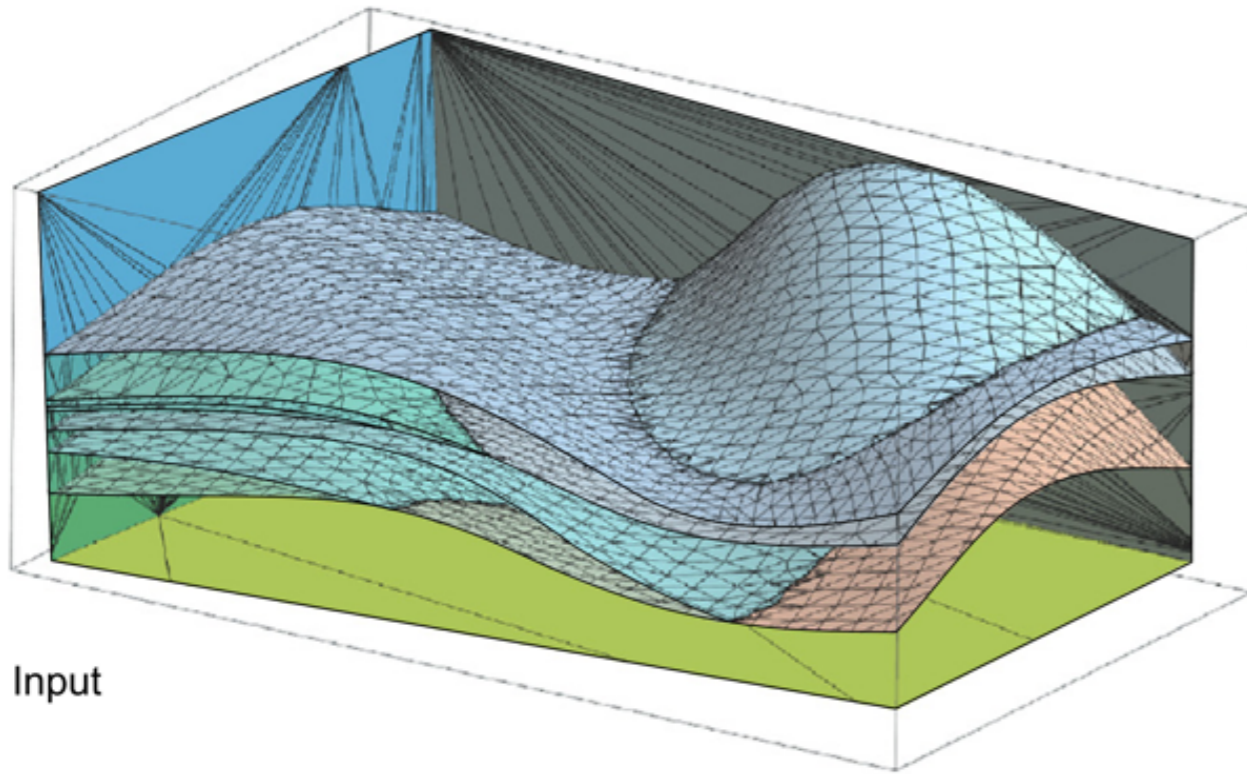
Unstructured meshes:

- **specialized** mesh generation;
- **quality** mesh generation;
- **quality** mesh generation **between tessellated surfaces ...**









Pellerin et al. (Comps. & Geosci., 2014)

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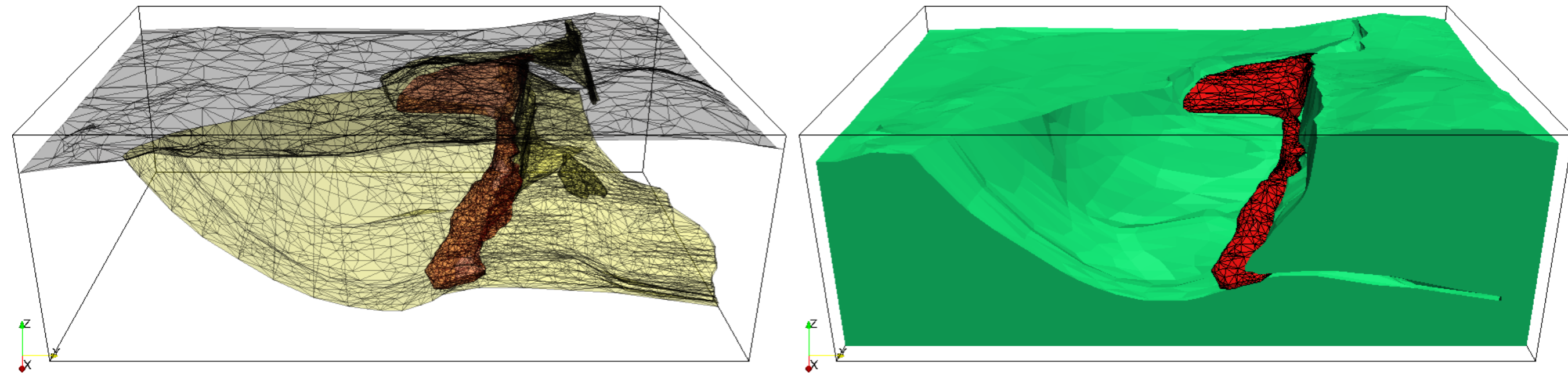
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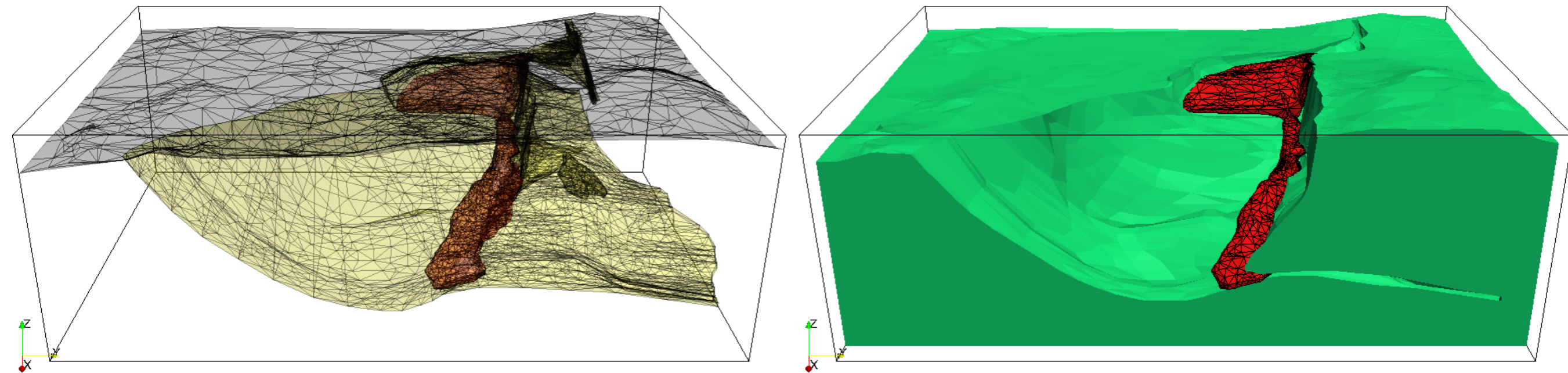
A single, unified Earth model.



Surface and volumetric meshing of Earth models is an active area of research.

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