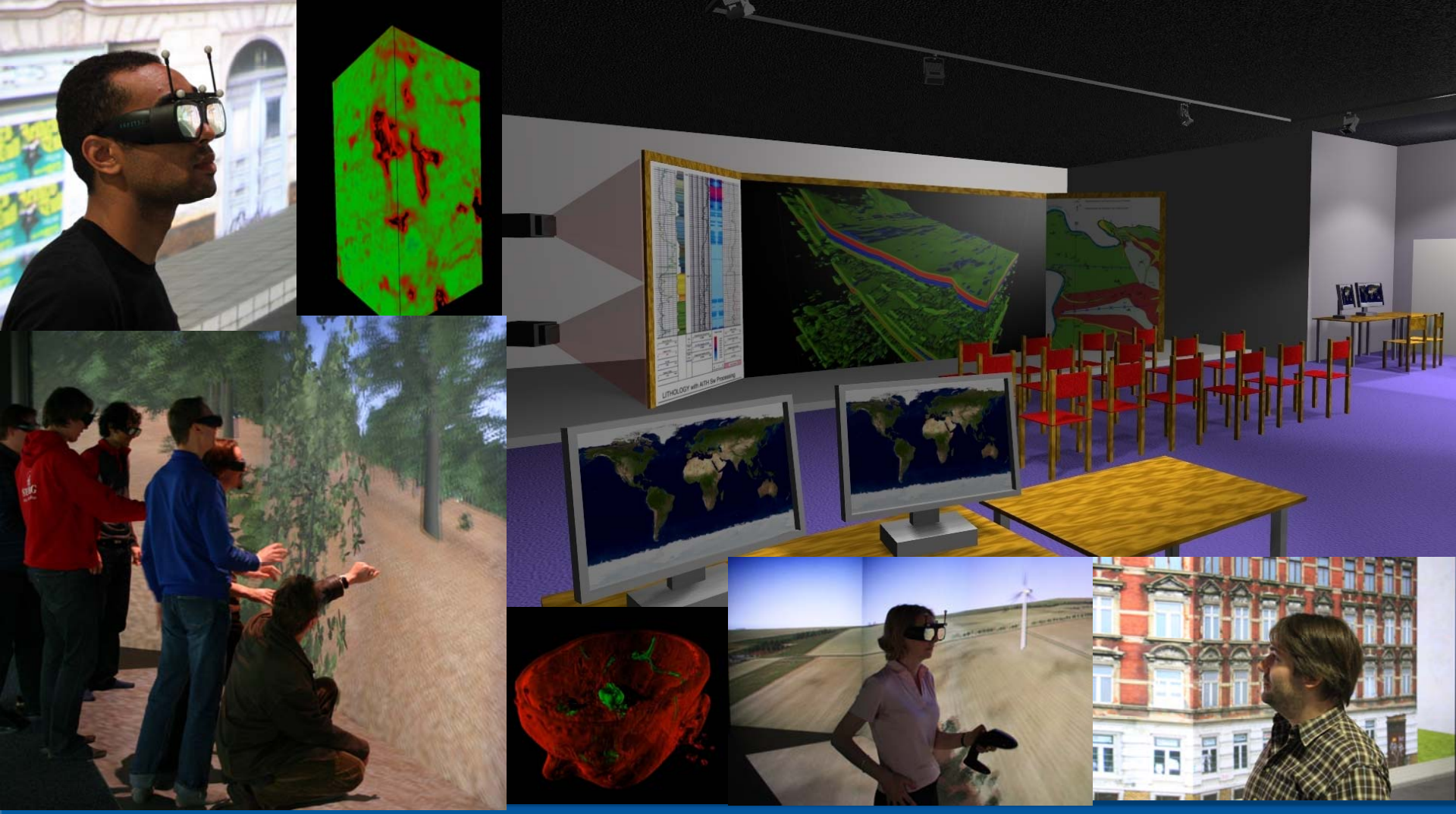

Constructing Geometric Models of the Subsurface for Finite Element Simulation

Dr. Björn Zehner, Department of Environmental Informatics
bjoern.zehner@ufz.de, bzehner@gmx.de

Given at the Annual Conference of the International Association for Mathematical Geosciences (IAMG2011)
Salzburg, Austria, 5th to 9th September, 2011

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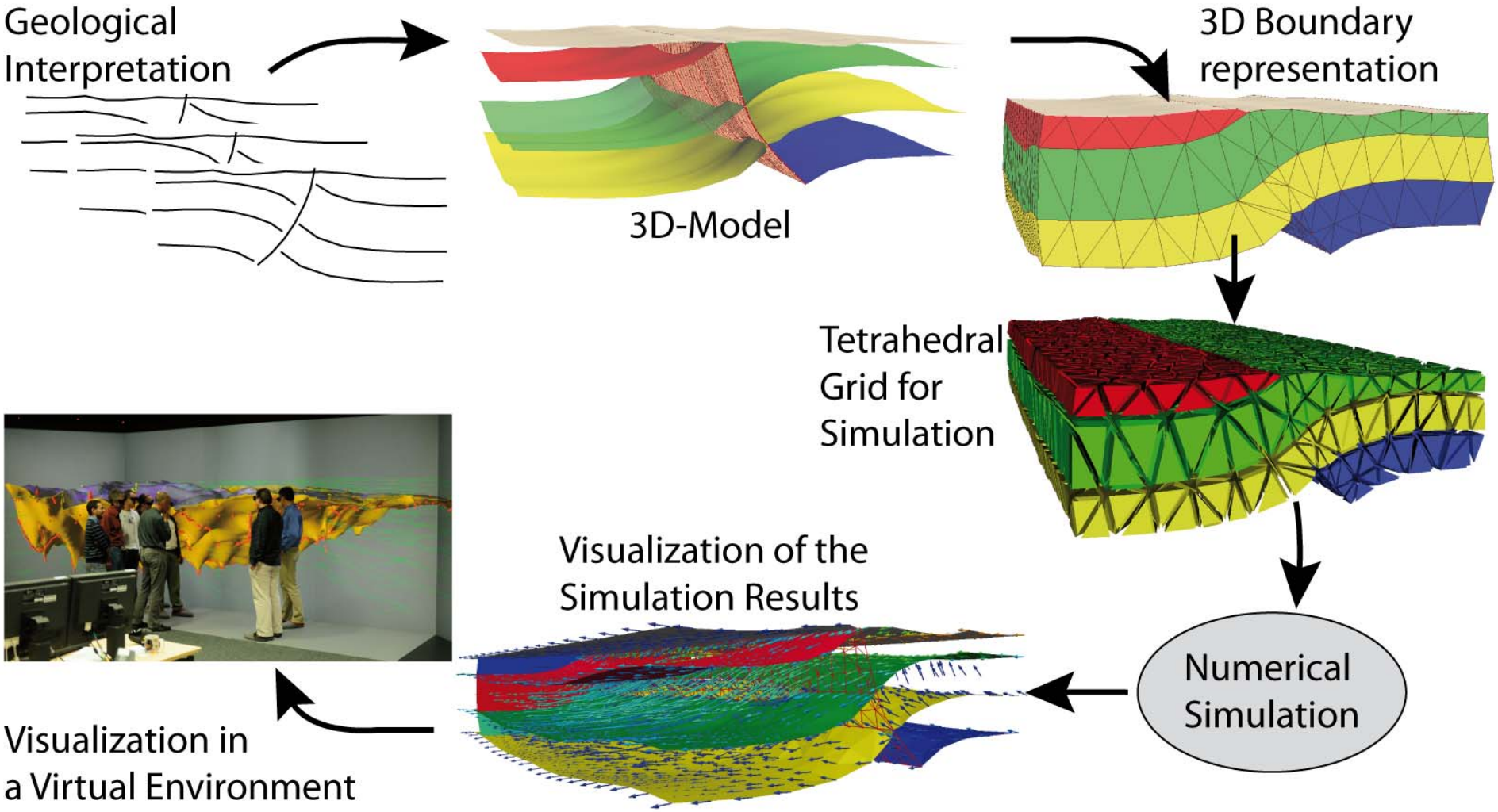
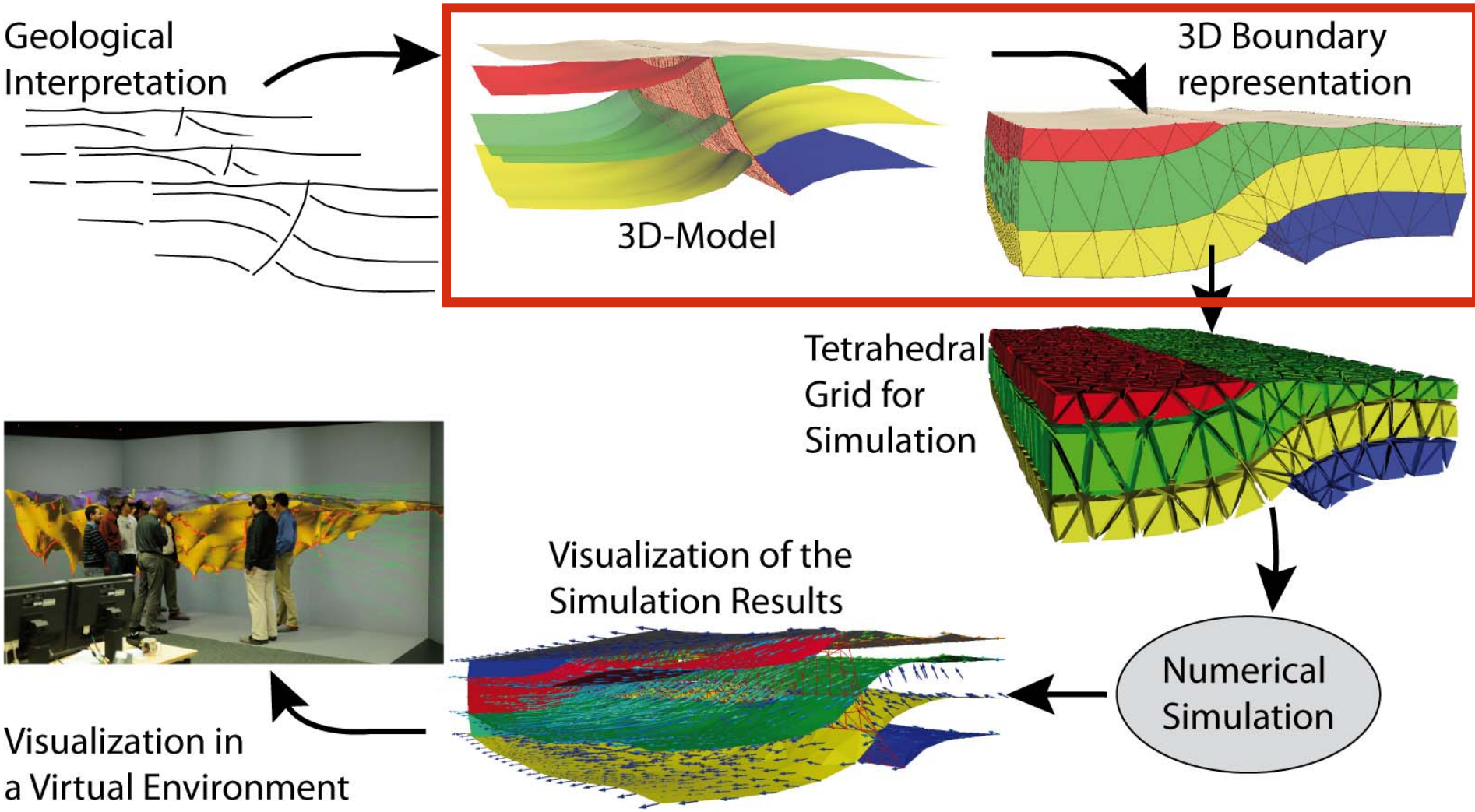
General Overview



General Overview



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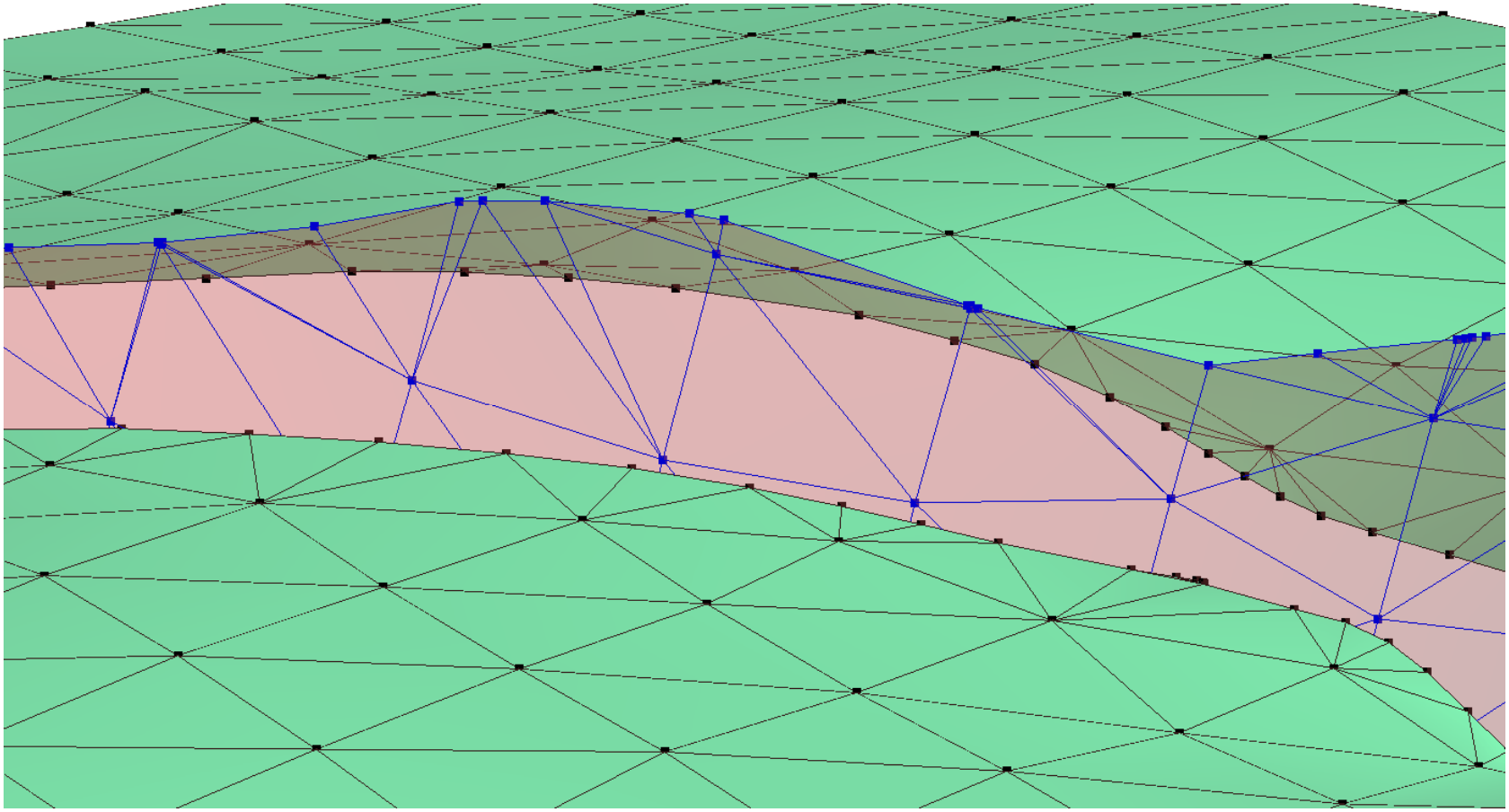

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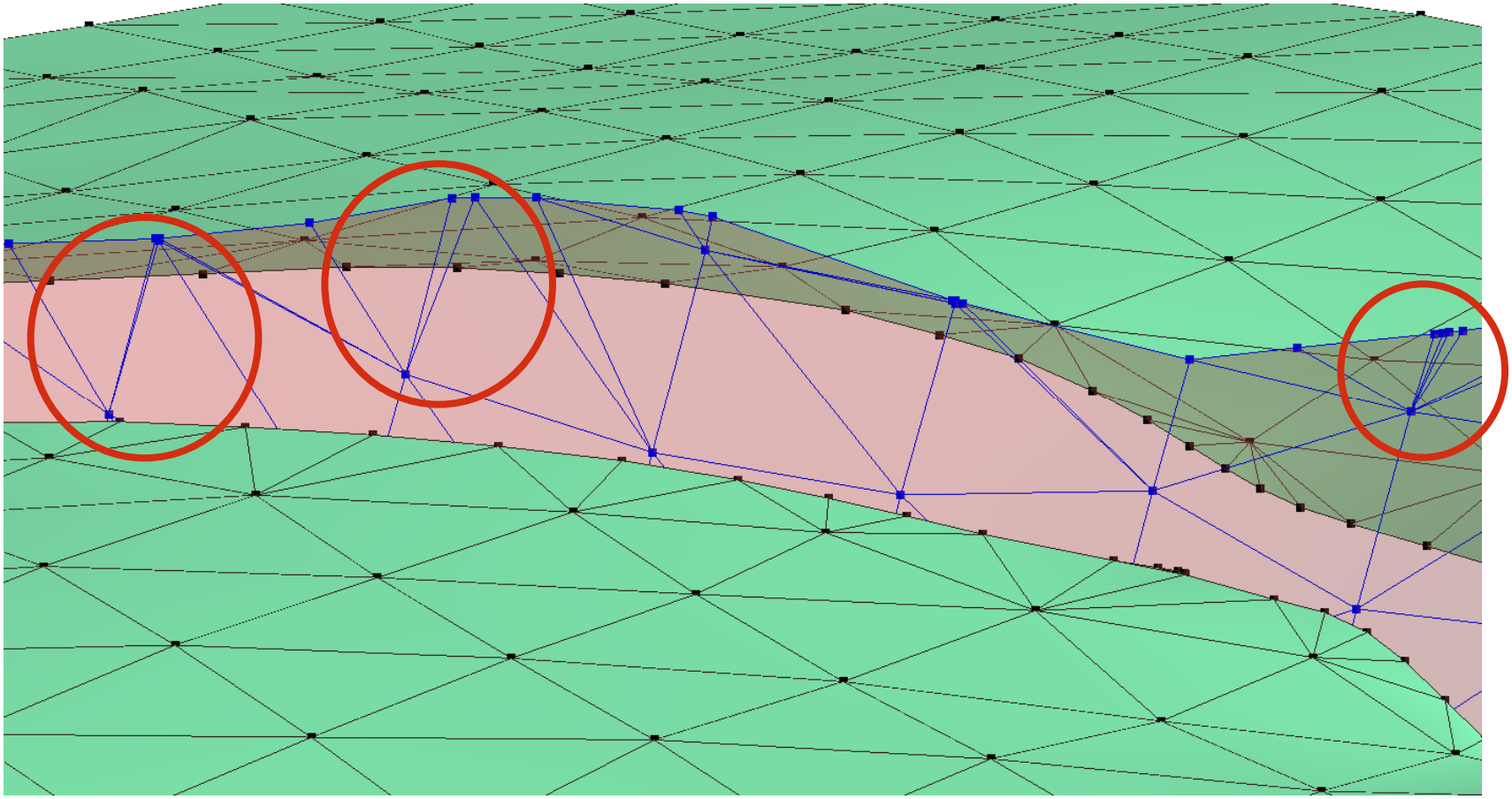
Mesh Quality Needed



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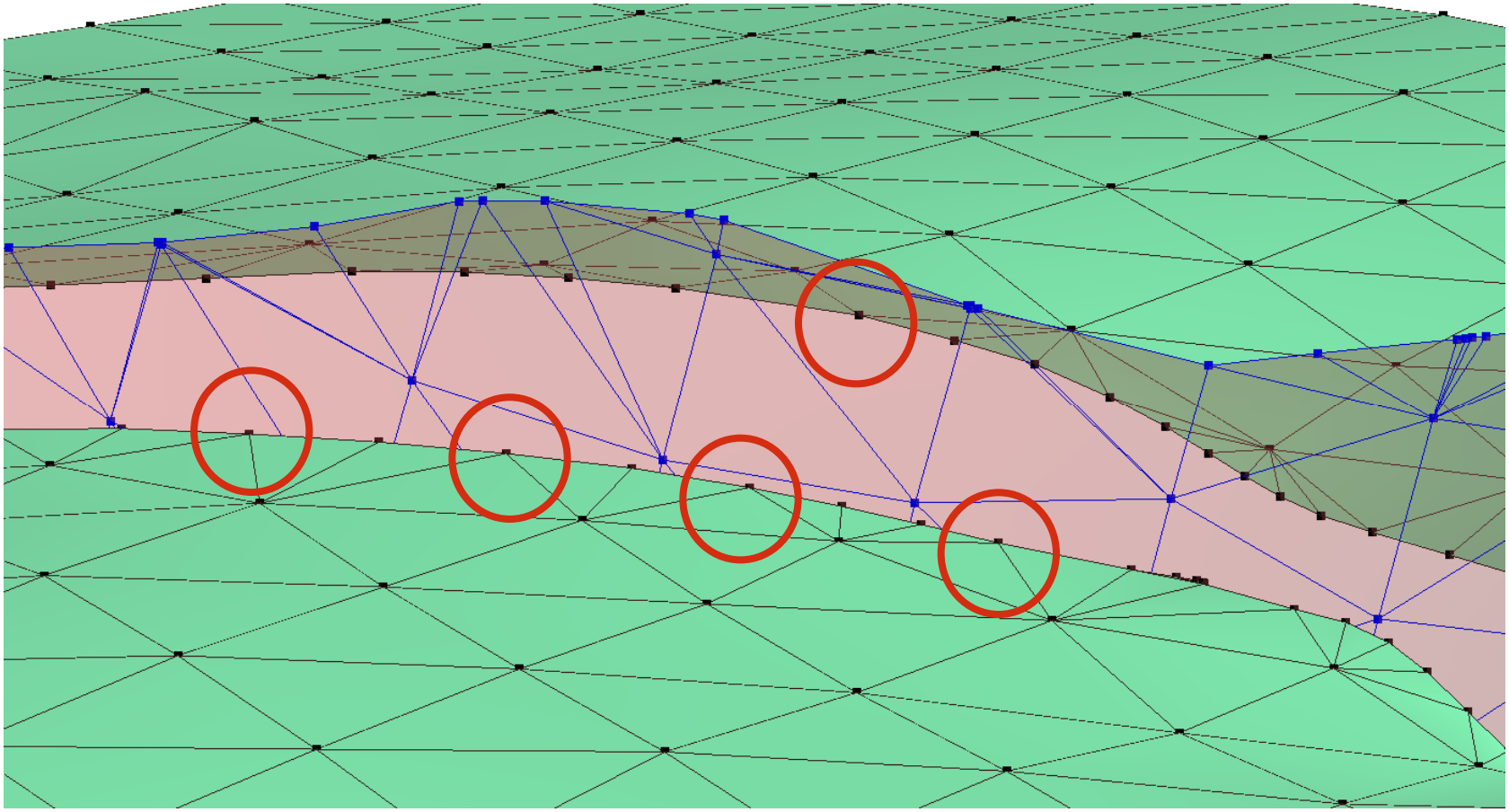
Mesh Quality Needed



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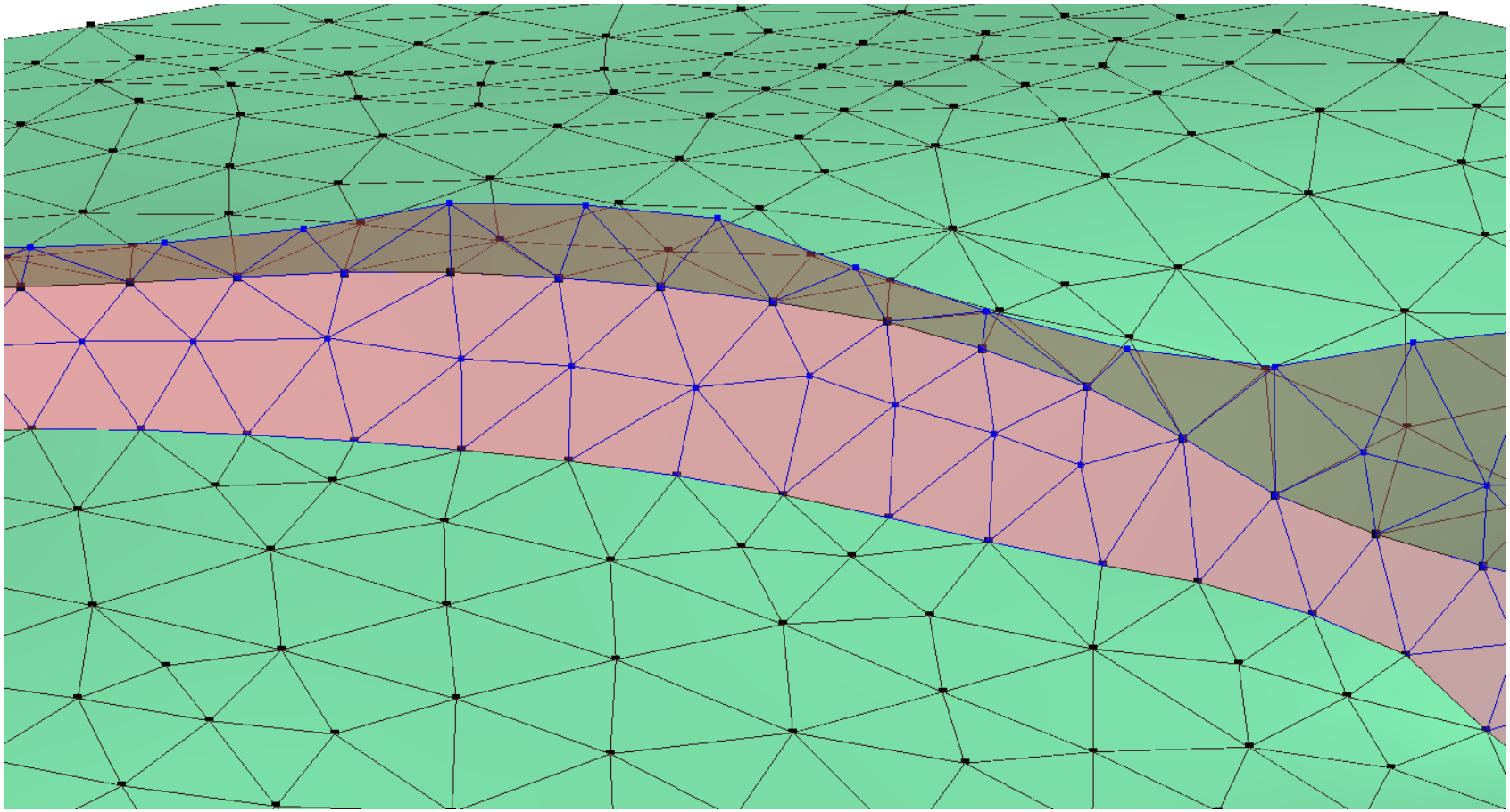
Mesh Quality Needed



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I will not present an automatic algorithm !

Which workflow should a geologist follow and which additional tools does he need to construct a model that fits our needs?

Advantage: In difficult situations that can hardly be meshed it is possible to simplify / generalize the model including the knowledge from geology.

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Two different examples/approaches for construction

Simple large-scale regional models

- Works projective on the XY plane (layer cake models)
- Structurally relative simple
- Incorporation of faults is limited to vertical faults and cases where the contact line of the horizons on the fault is known

Fault systems / complicated structures

- Small scale
- Requires more individual work

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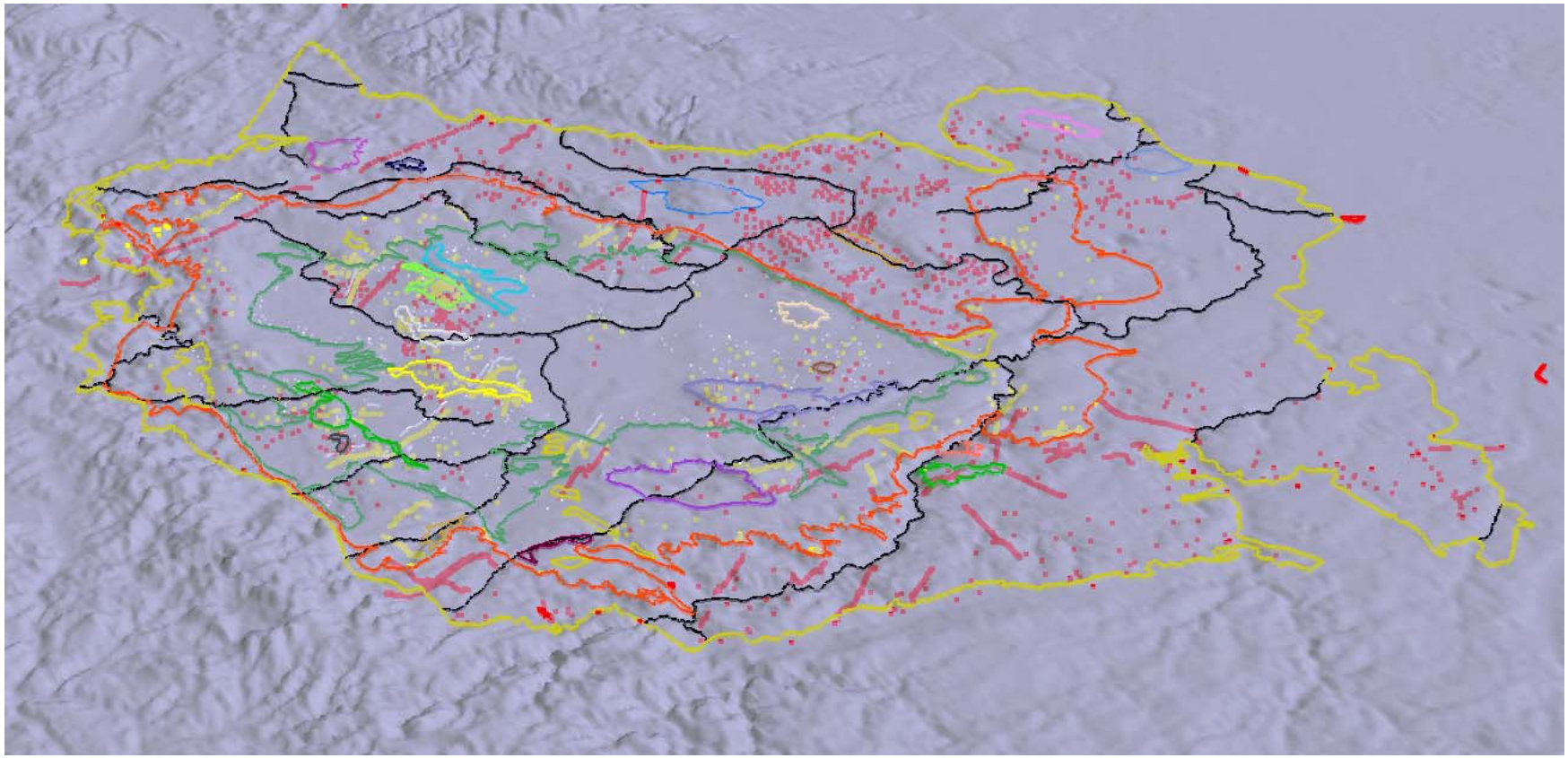
Example Data: The Thuringian Basin



Data: Martin Kober, 2009

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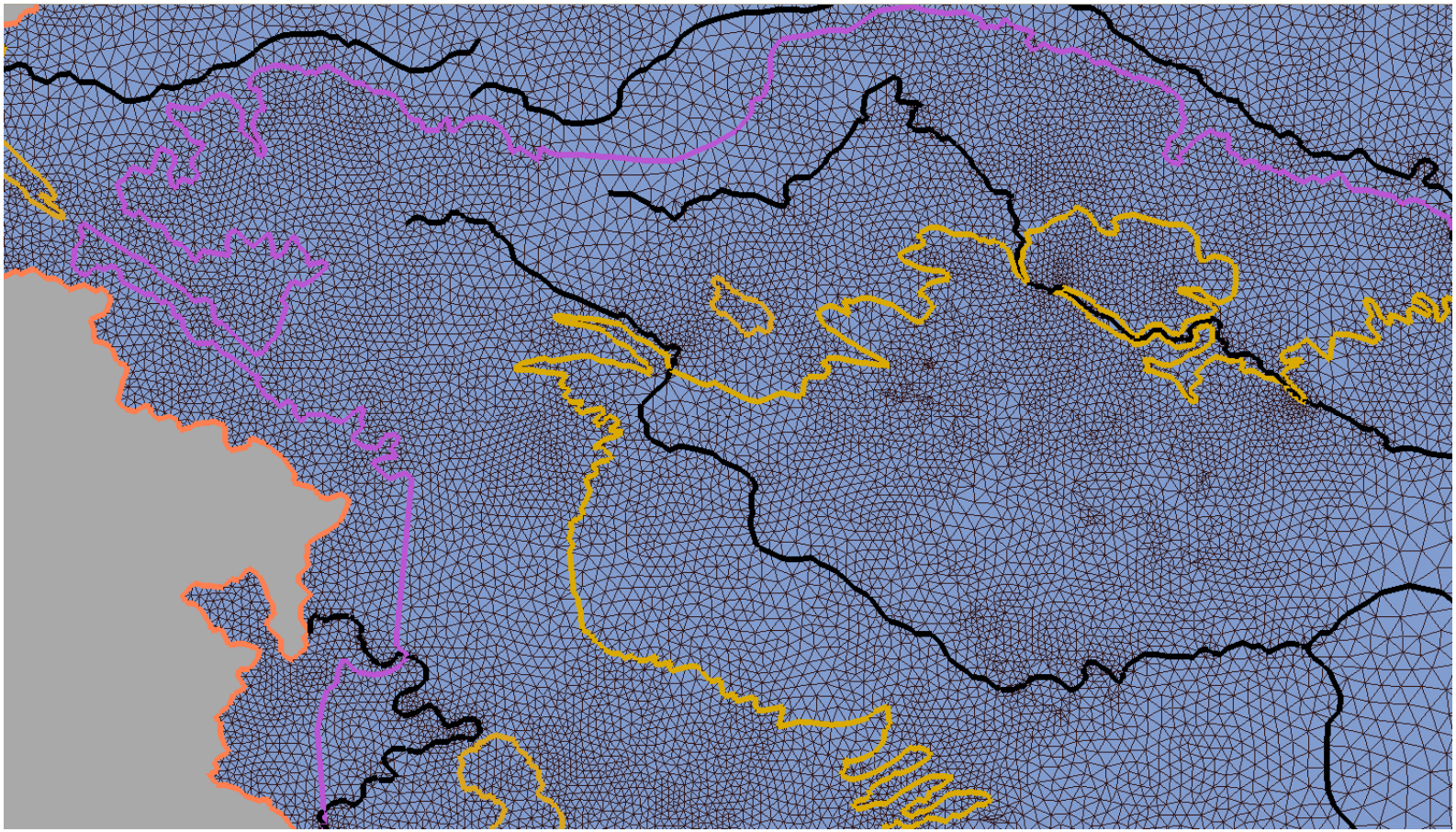
Large scale models



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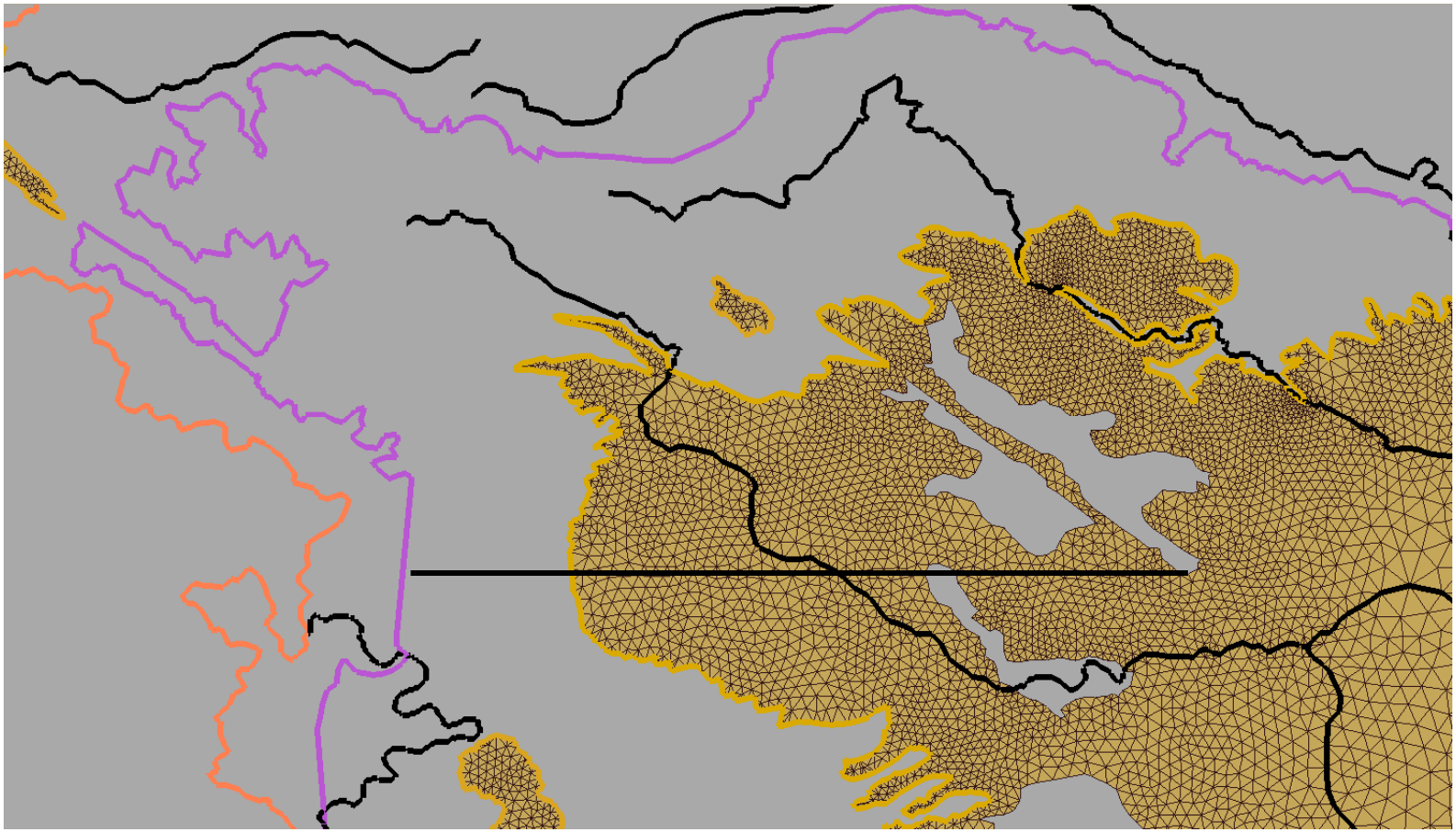
Large scale models



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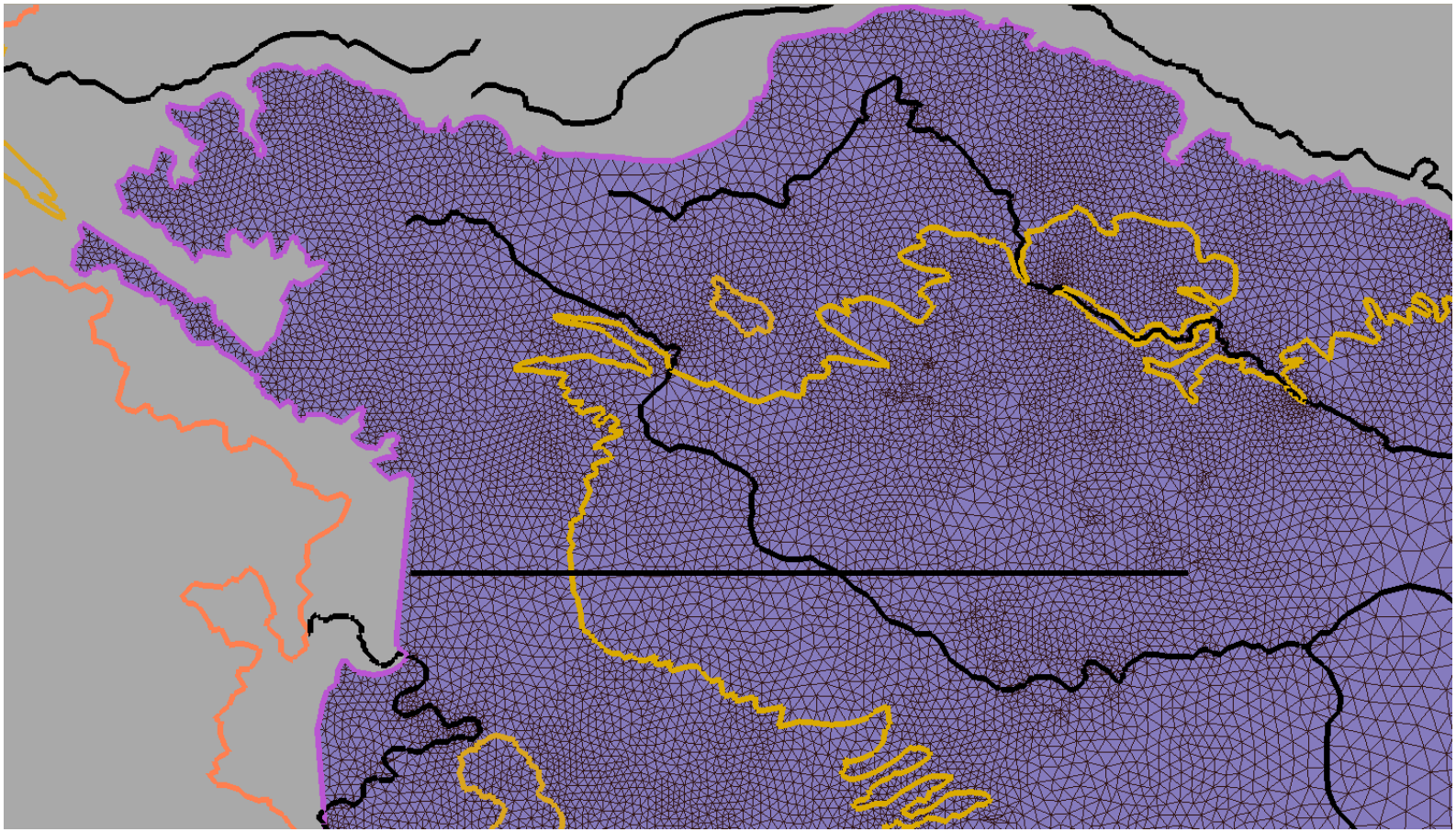
Large scale models



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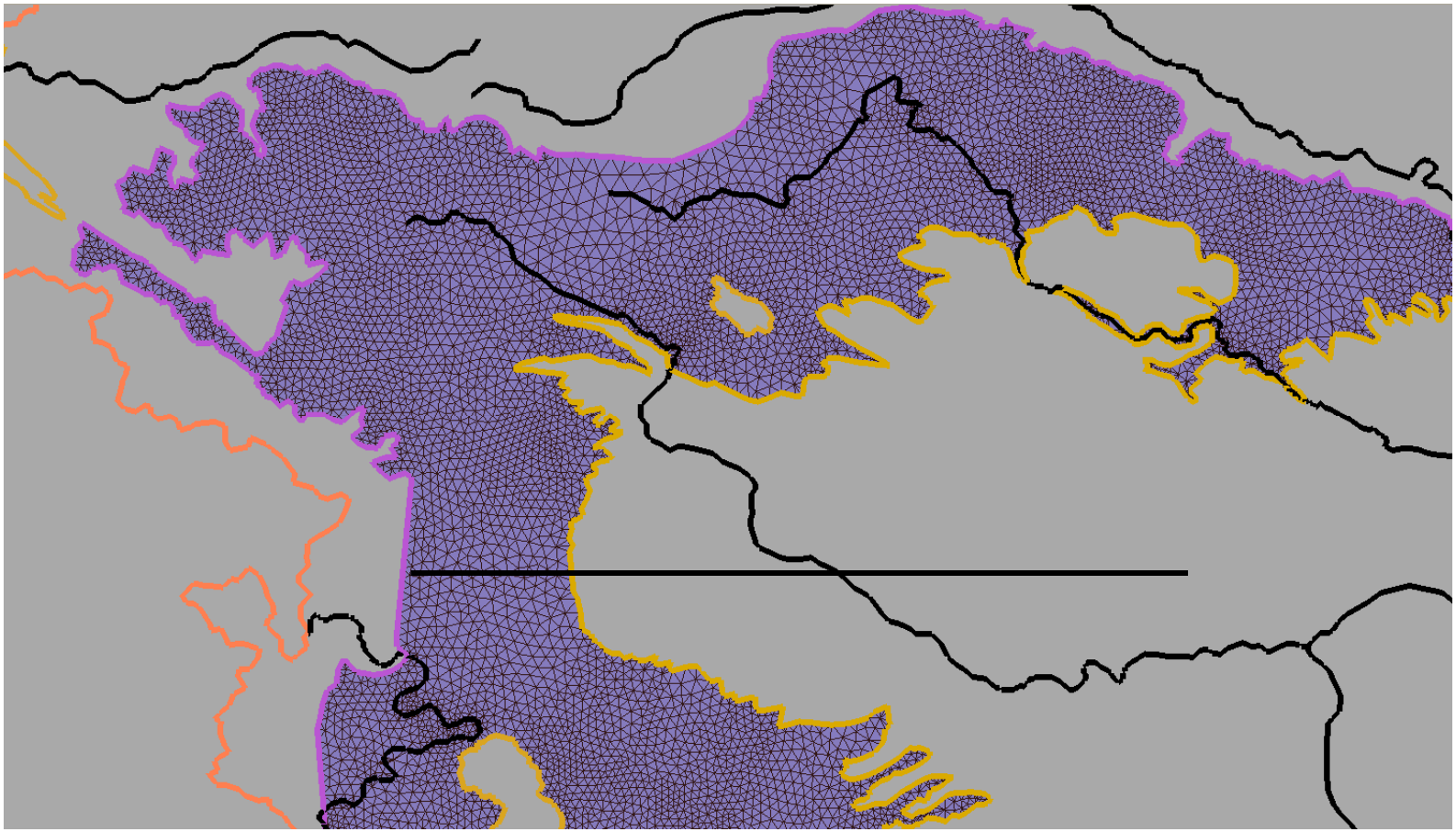
Large scale models



Outcrop Muschelkalk

Basis Keuper

Basis Muschelkalk

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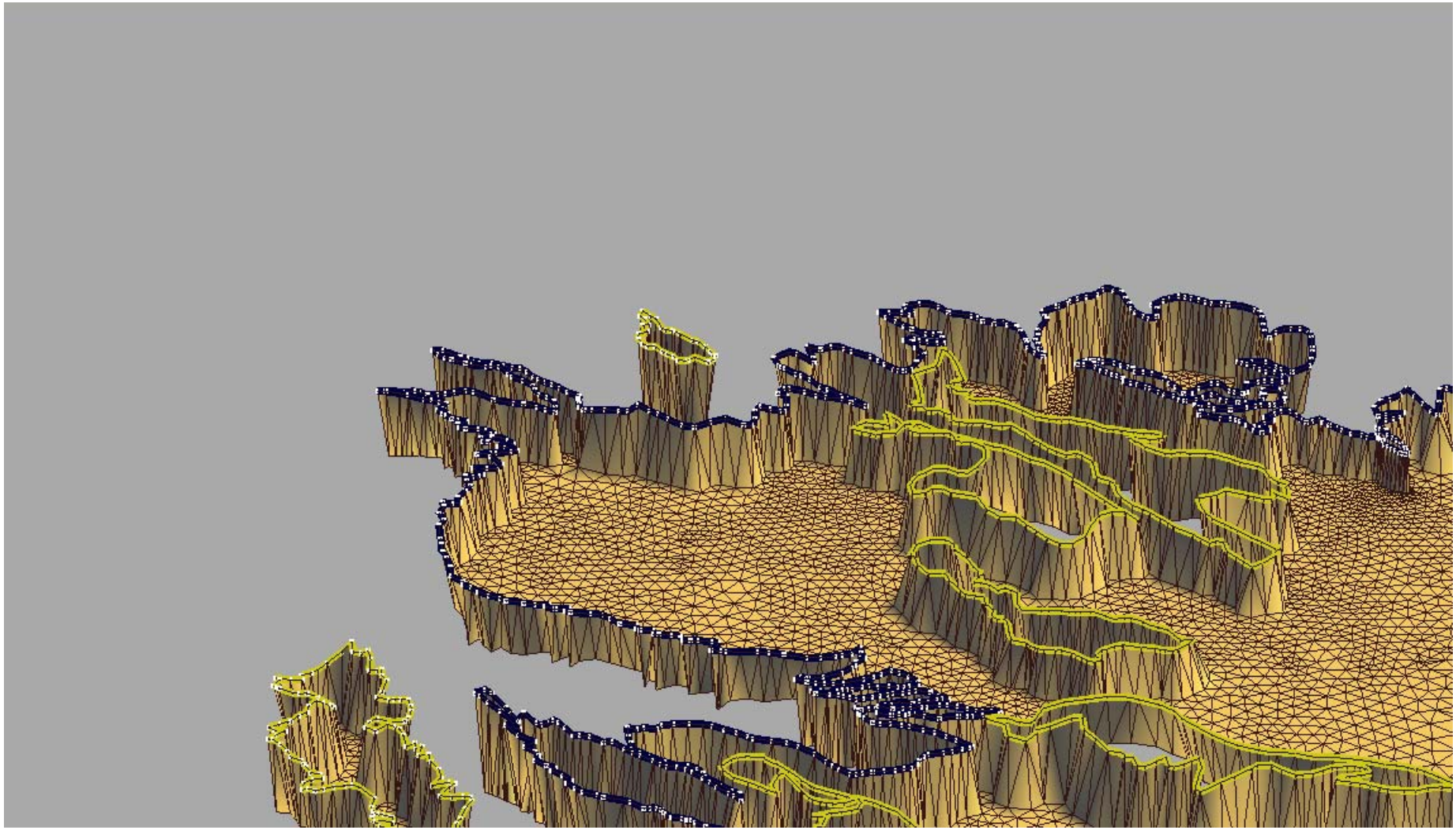
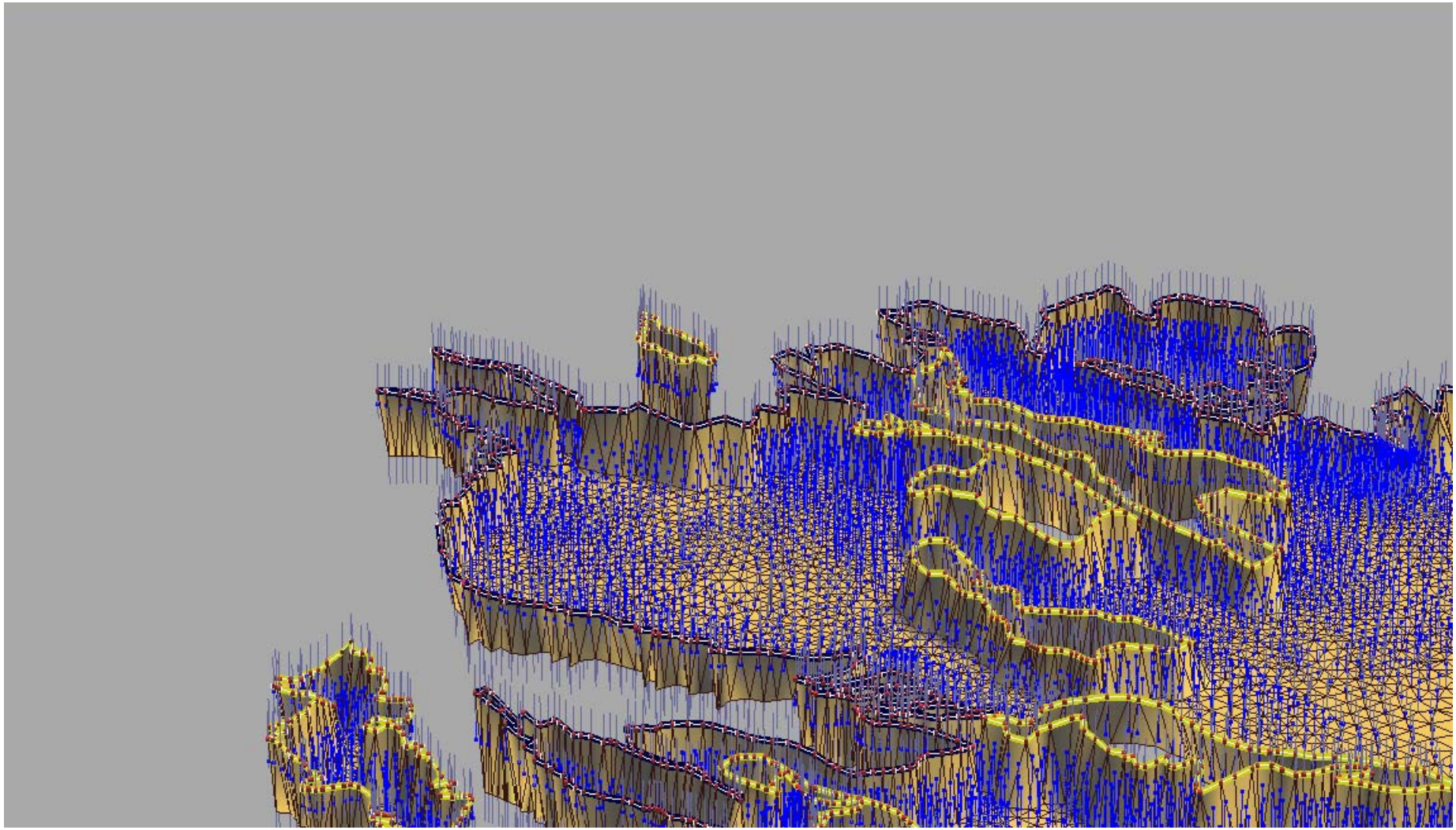
Large scale models



HELMHOLTZ CENTRE FOR ENVIRONMENTAL RESEARCH – UFZ

Large scale models



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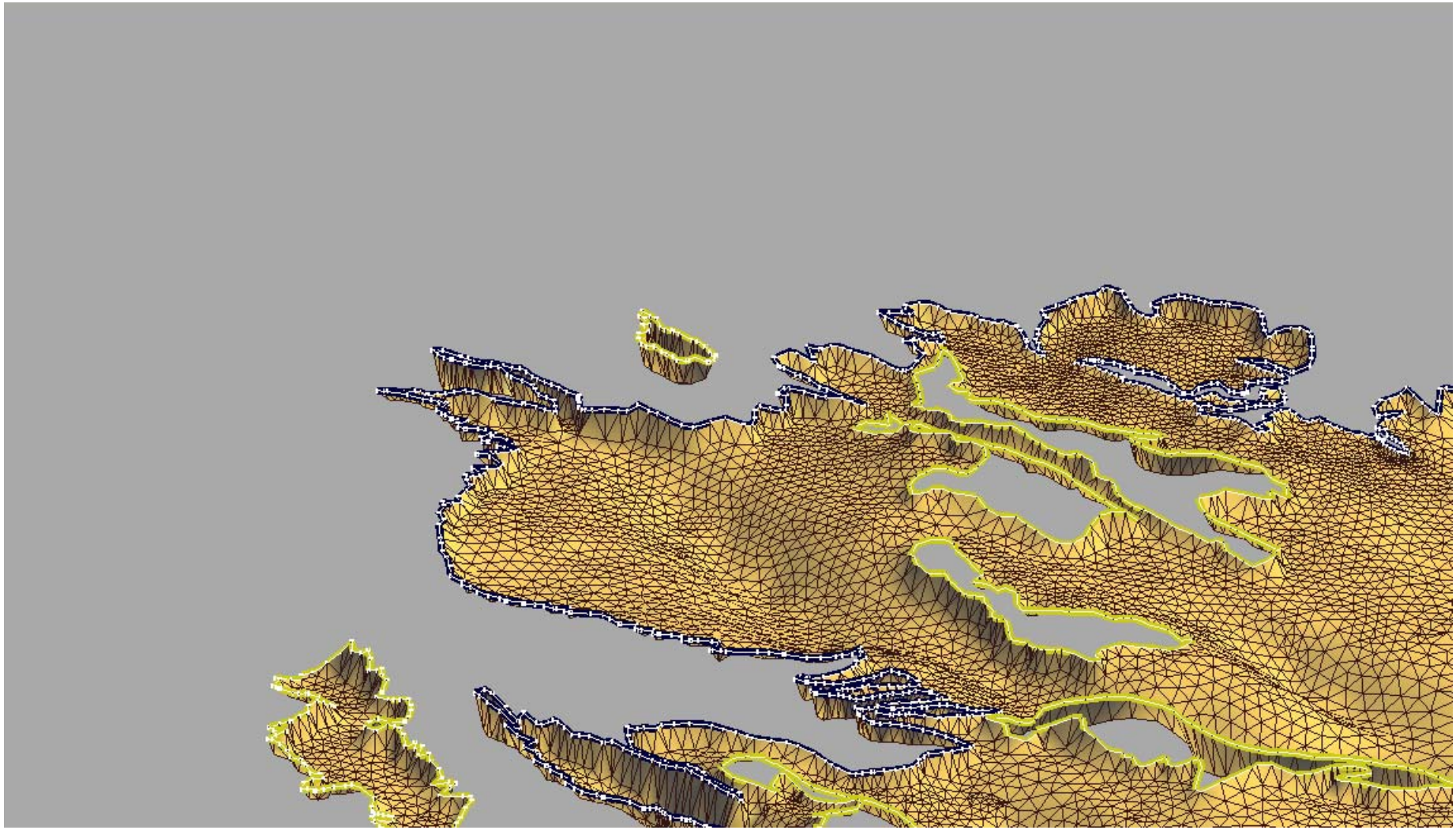
Large scale models



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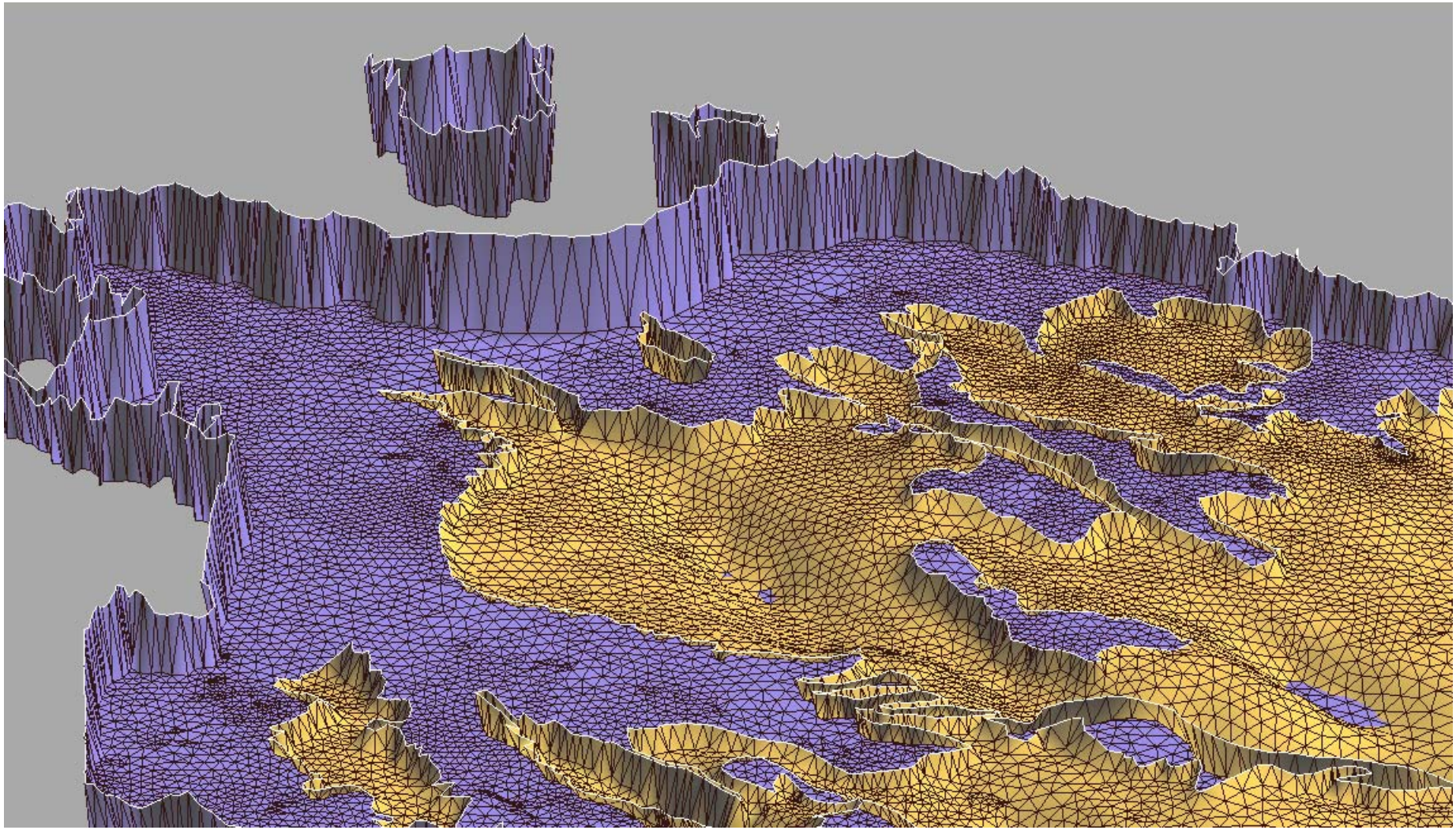
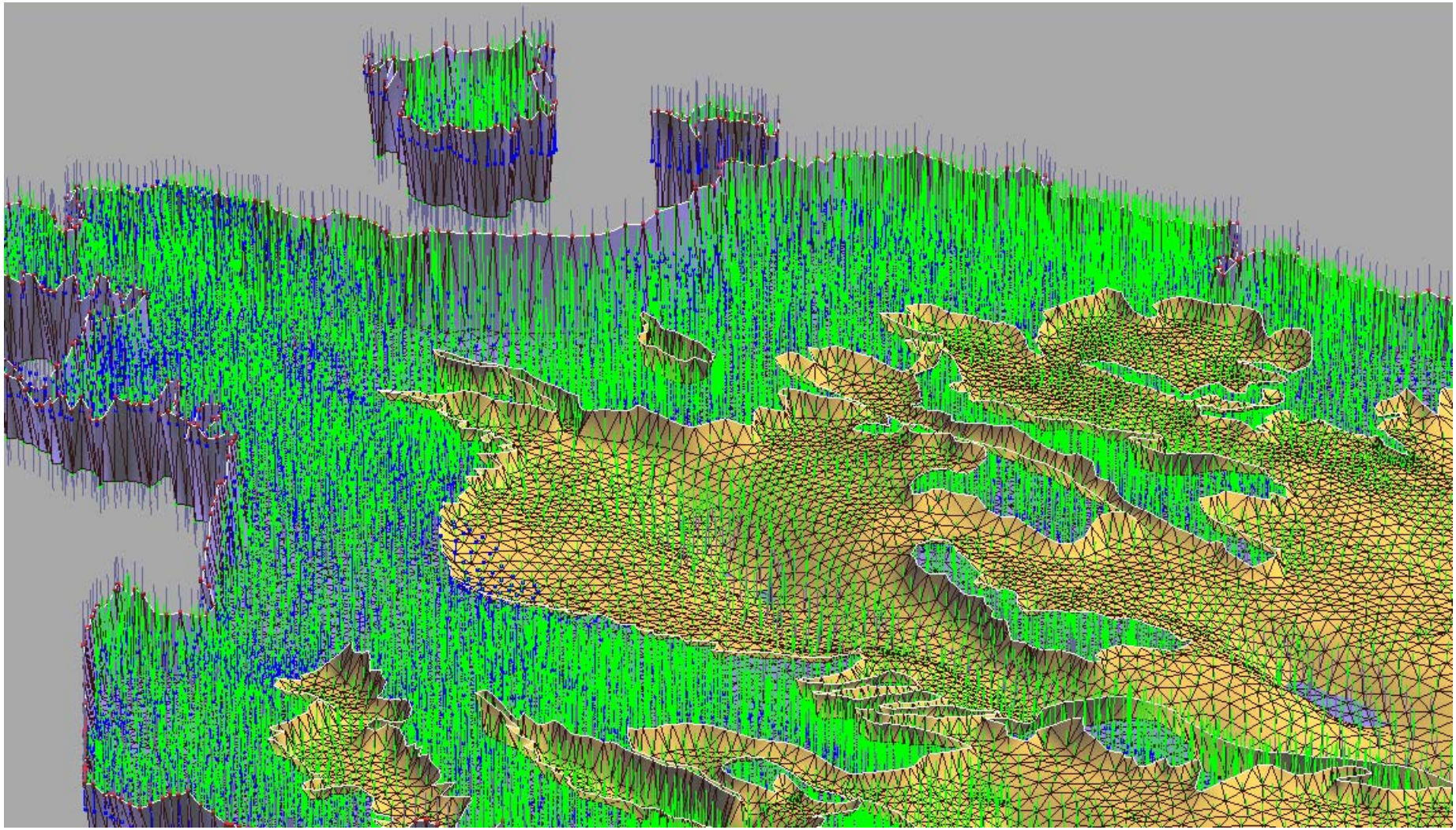
Large scale models



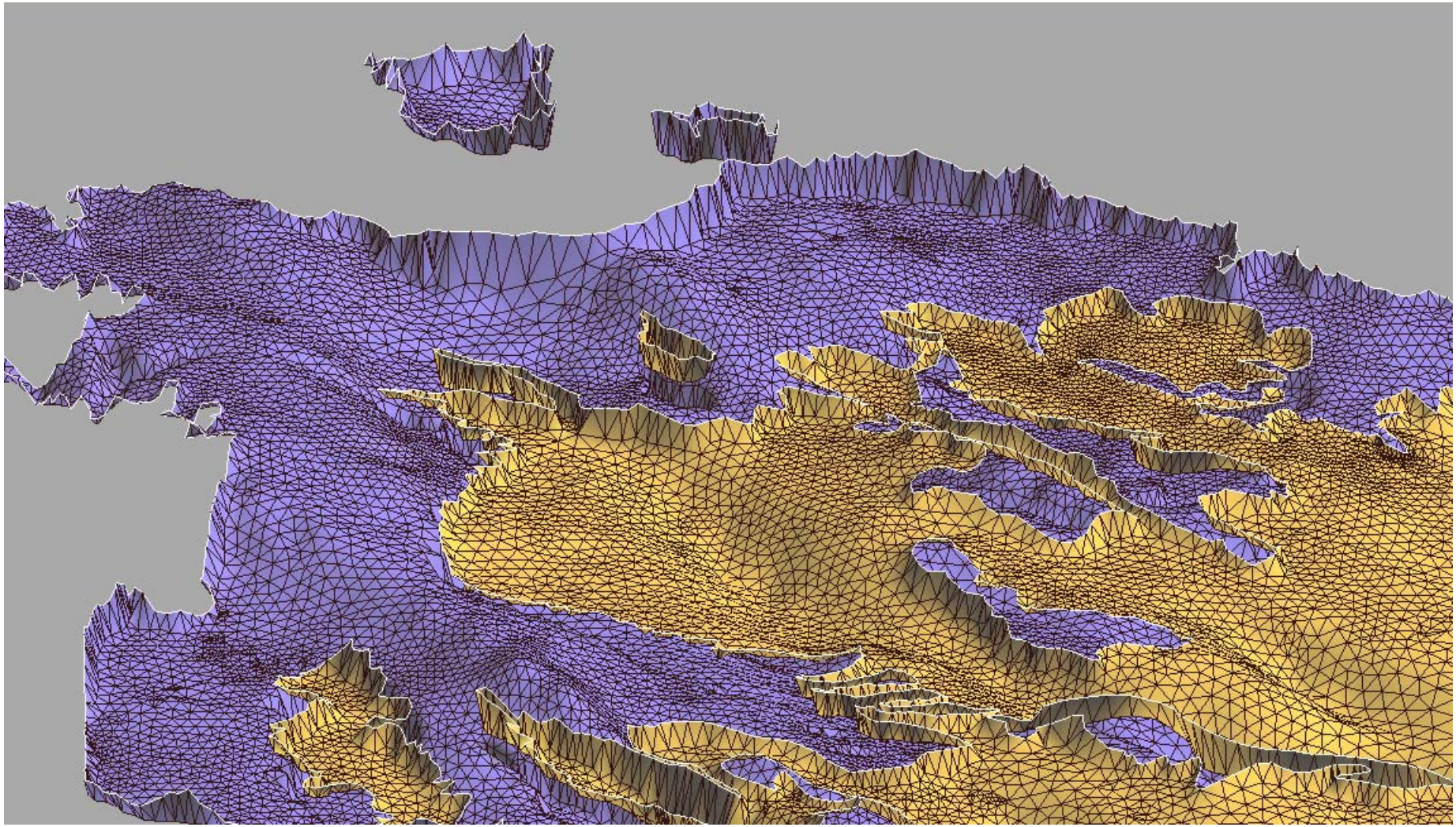
HELMHOLTZ CENTRE FOR ENVIRONMENTAL RESEARCH – UFZ

Large scale models



HELMHOLTZ CENTRE FOR ENVIRONMENTAL RESEARCH – UFZ

Large scale models



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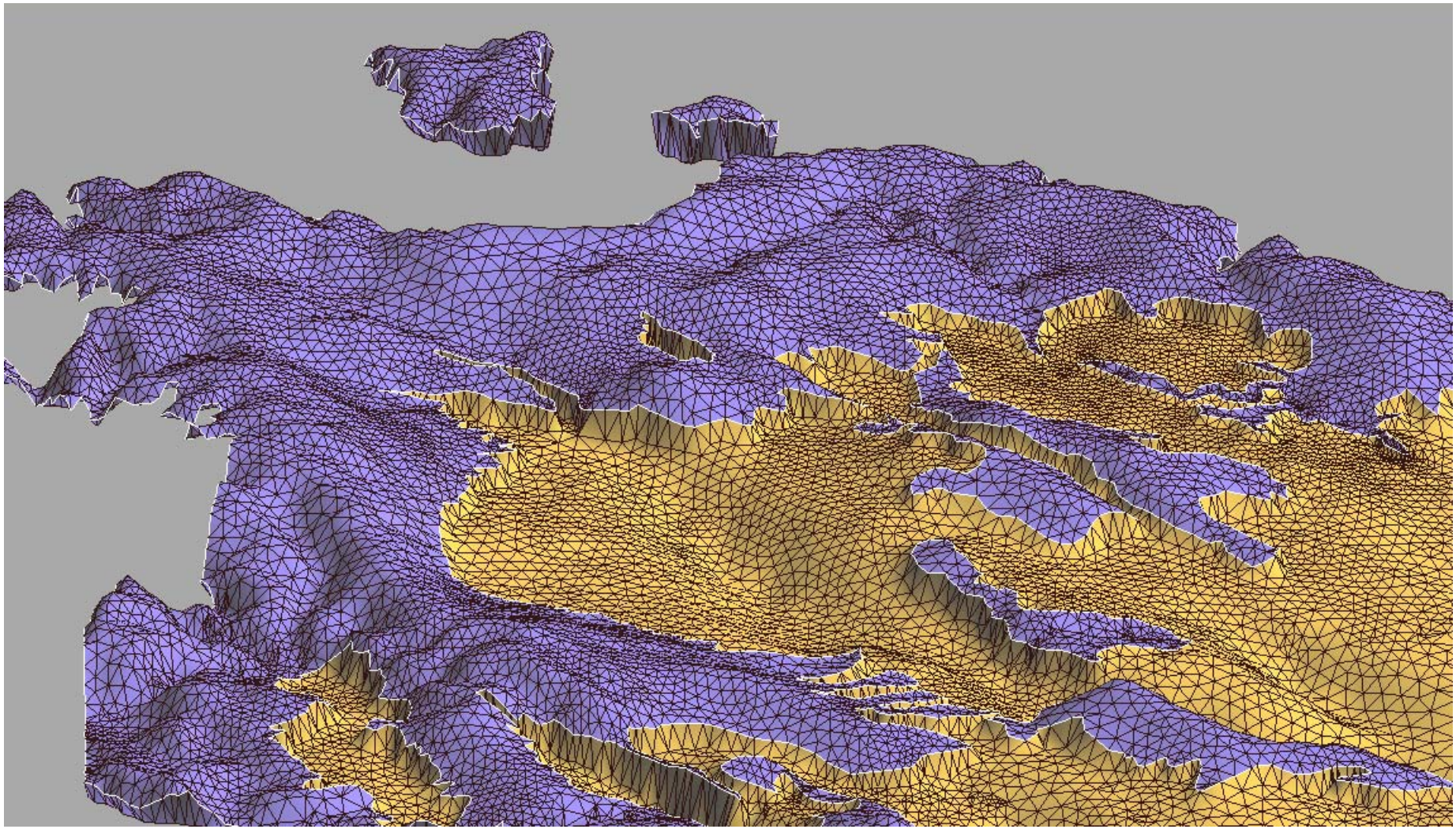
Large scale models



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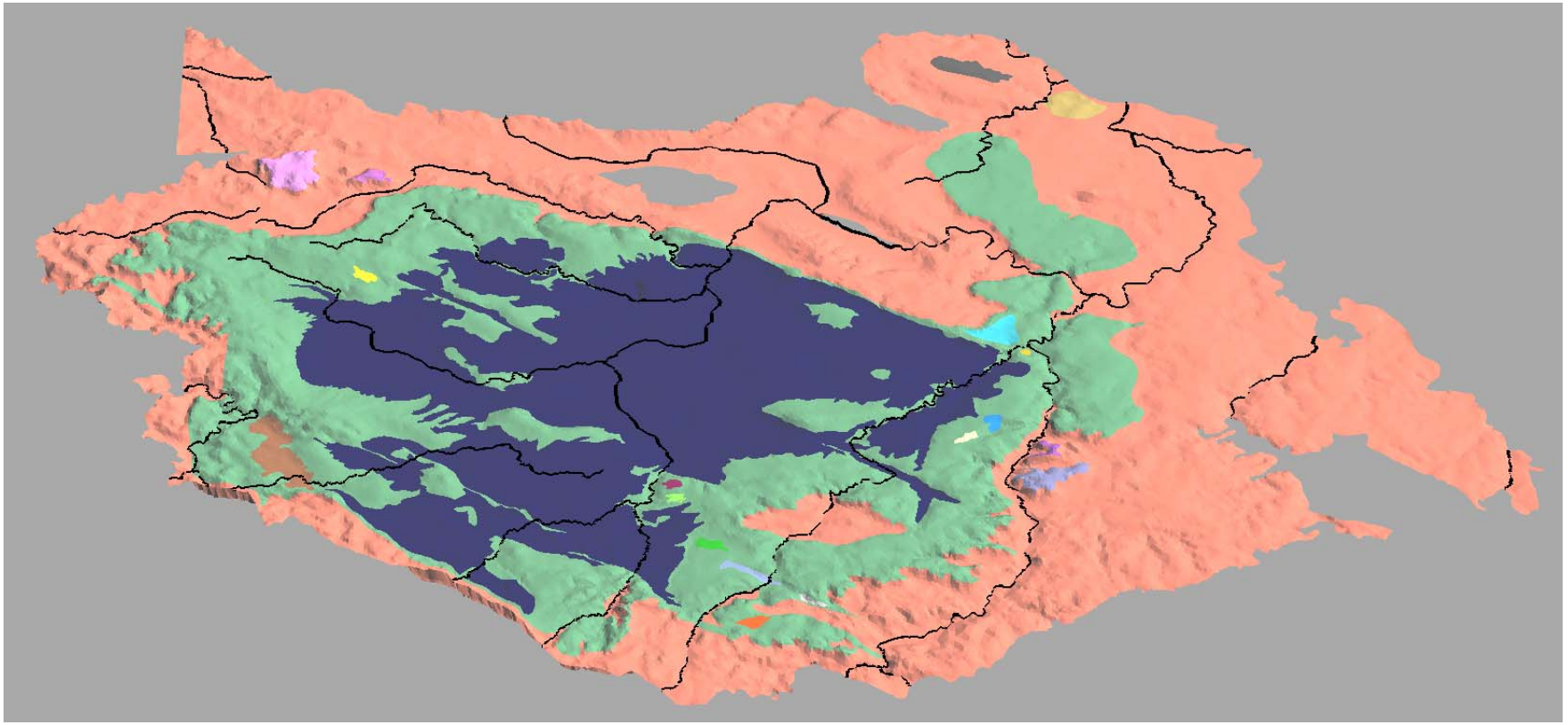
Large scale models



Tetrahedral Grid of the Thuringian Basin as TSolid,
Gridding was done using TetGen,
Colours indicate different parts

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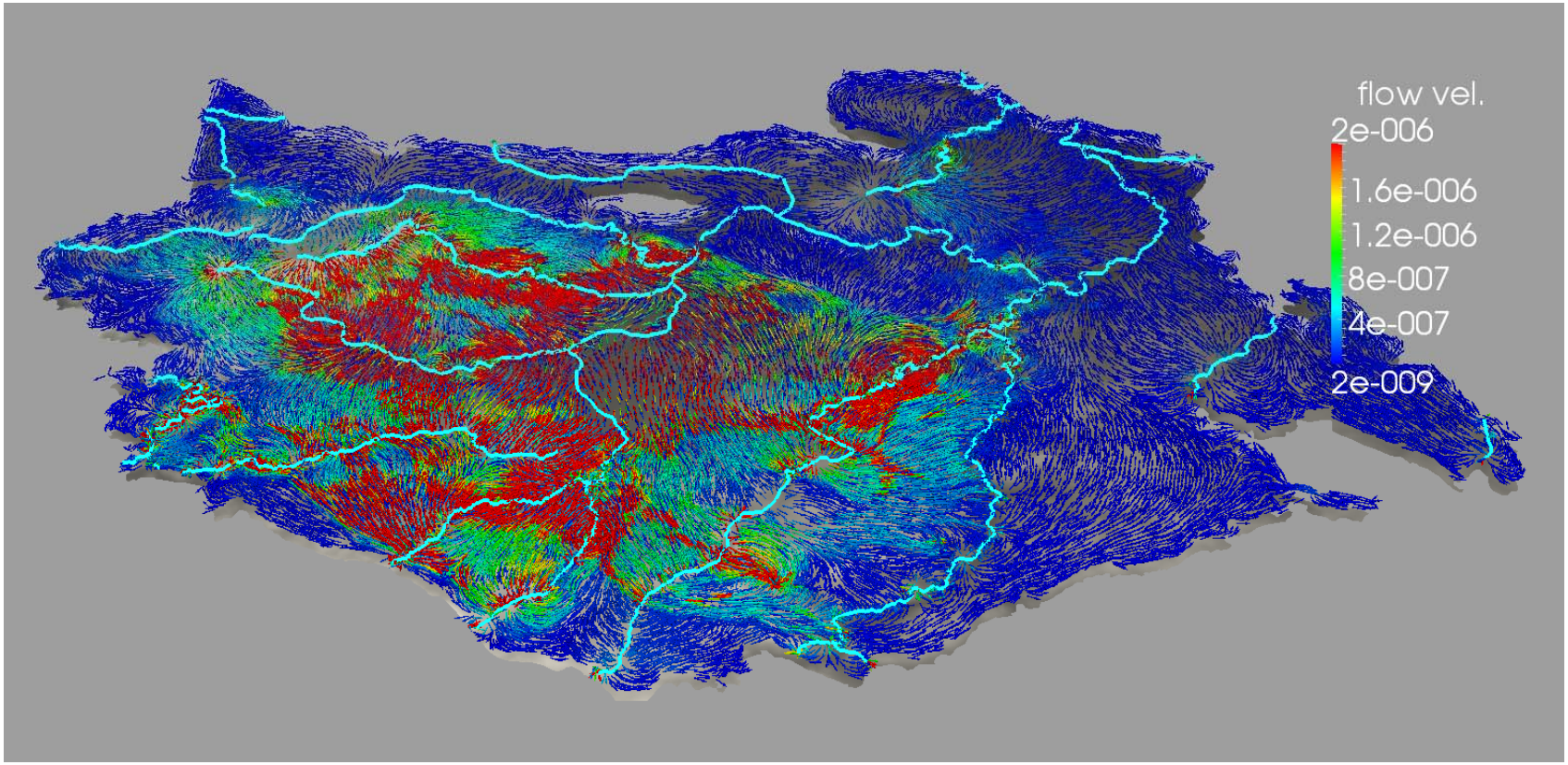
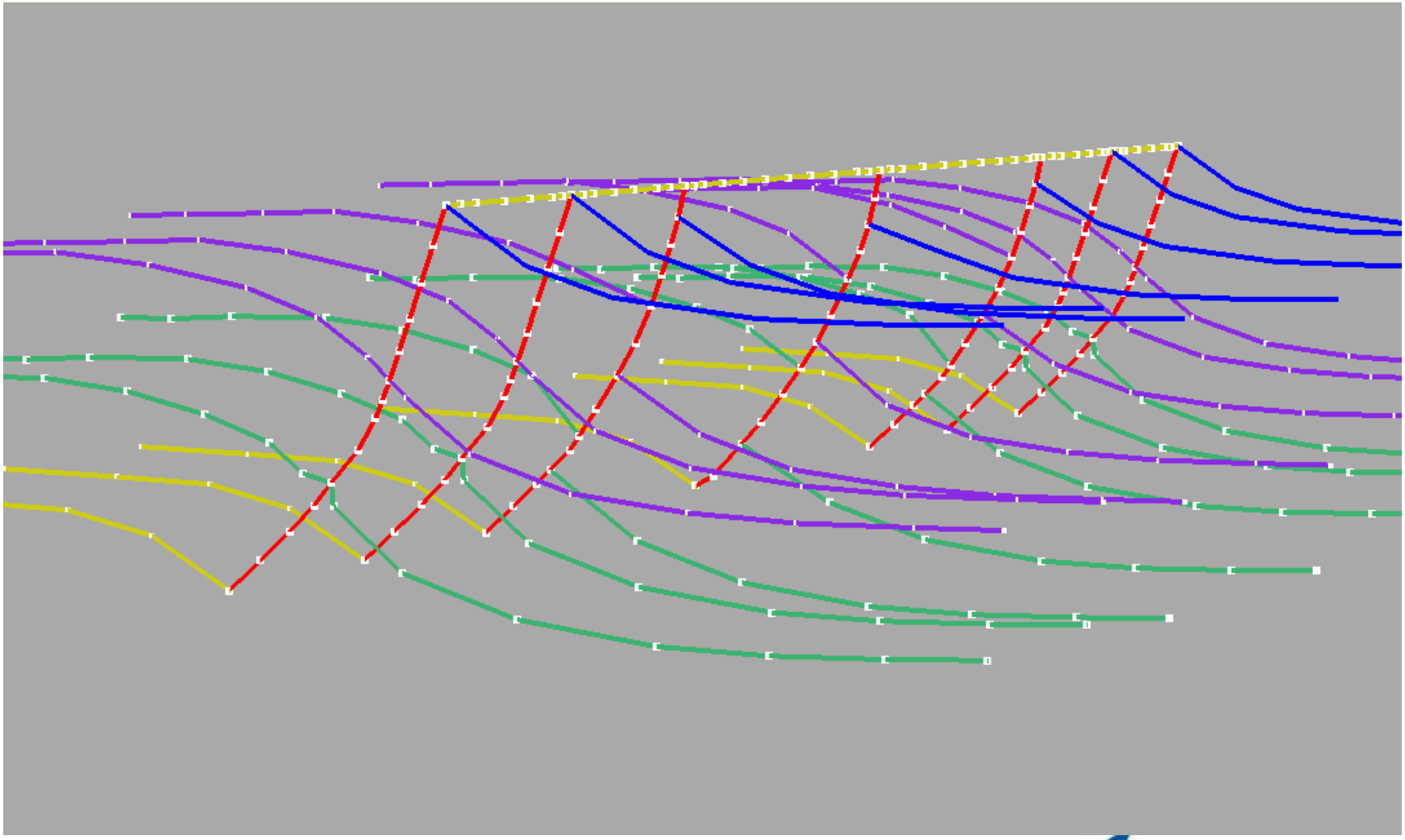
Large scale models



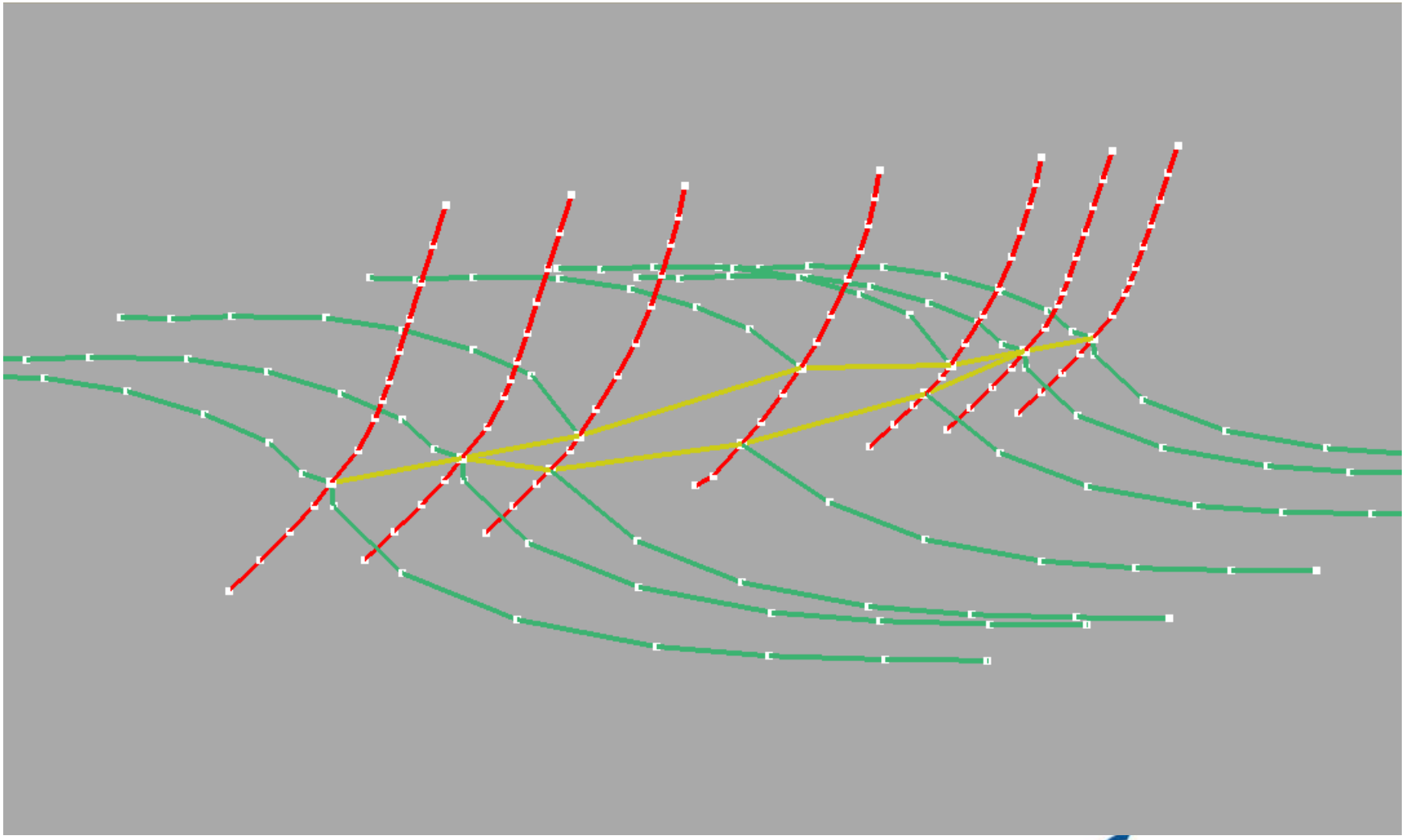
HELMHOLTZ CENTRE FOR ENVIRONMENTAL RESEARCH – UFZ

Model of a fault



HELMHOLTZ CENTRE FOR ENVIRONMENTAL RESEARCH – UFZ

Model of a fault



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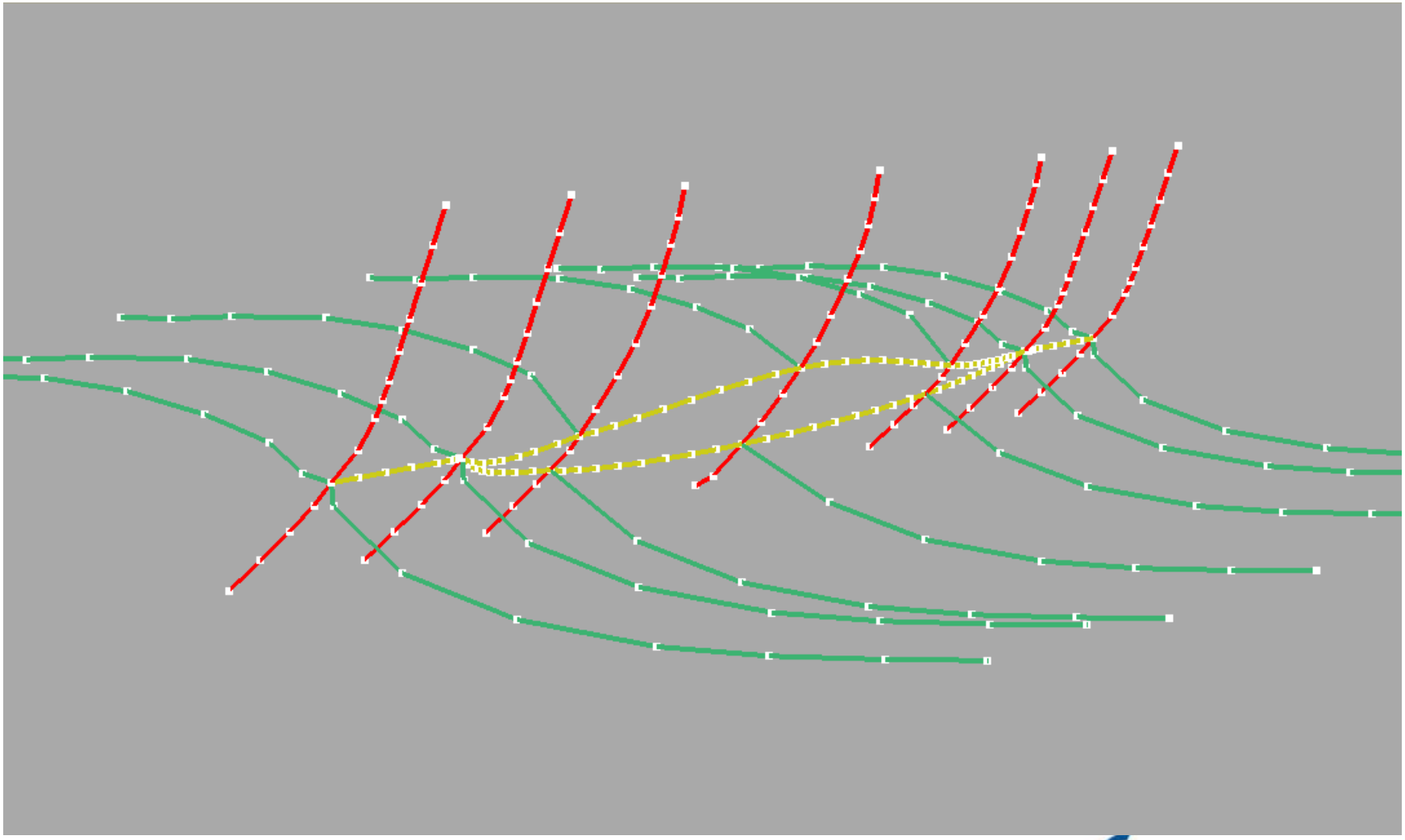
Model of a fault



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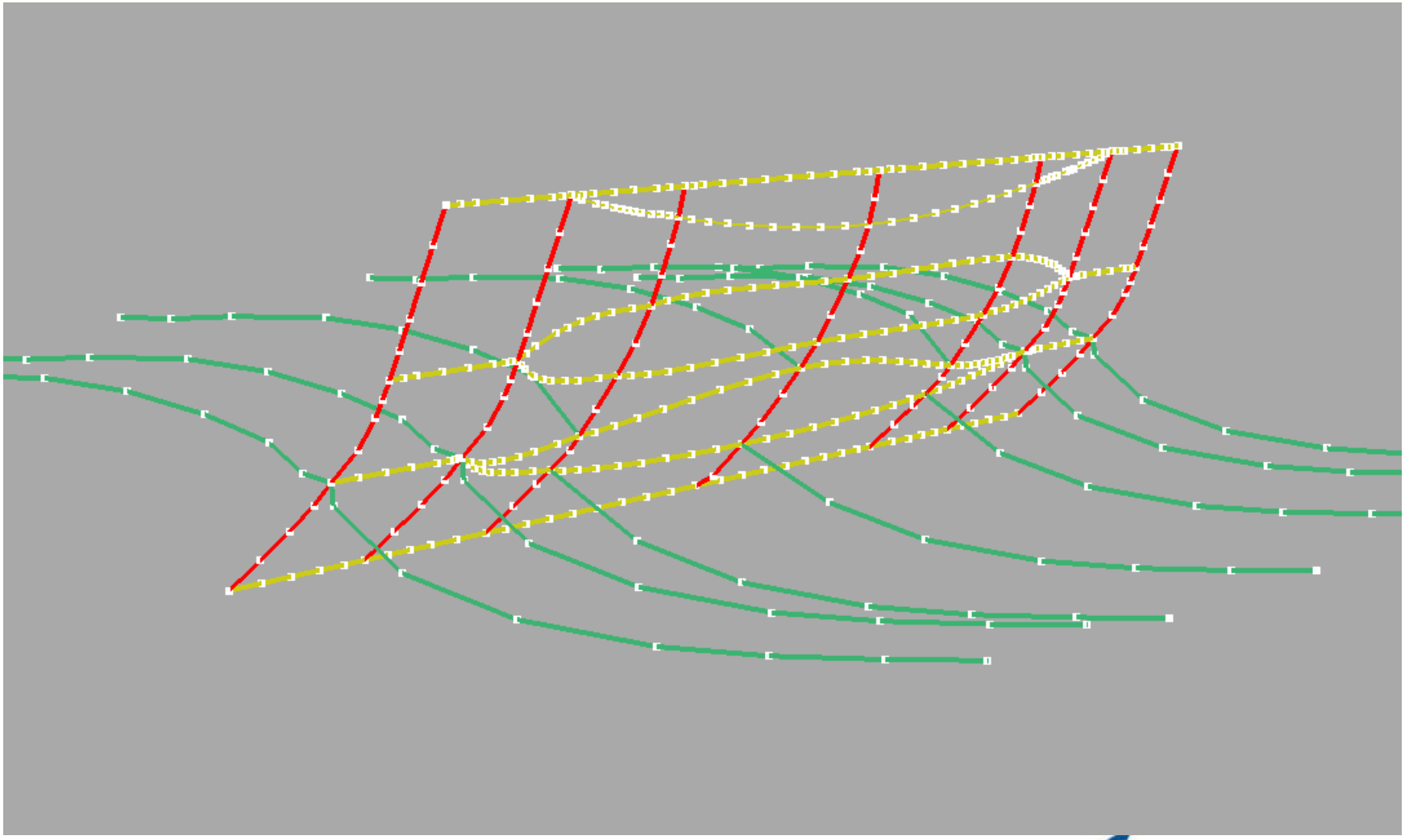
Model of a fault



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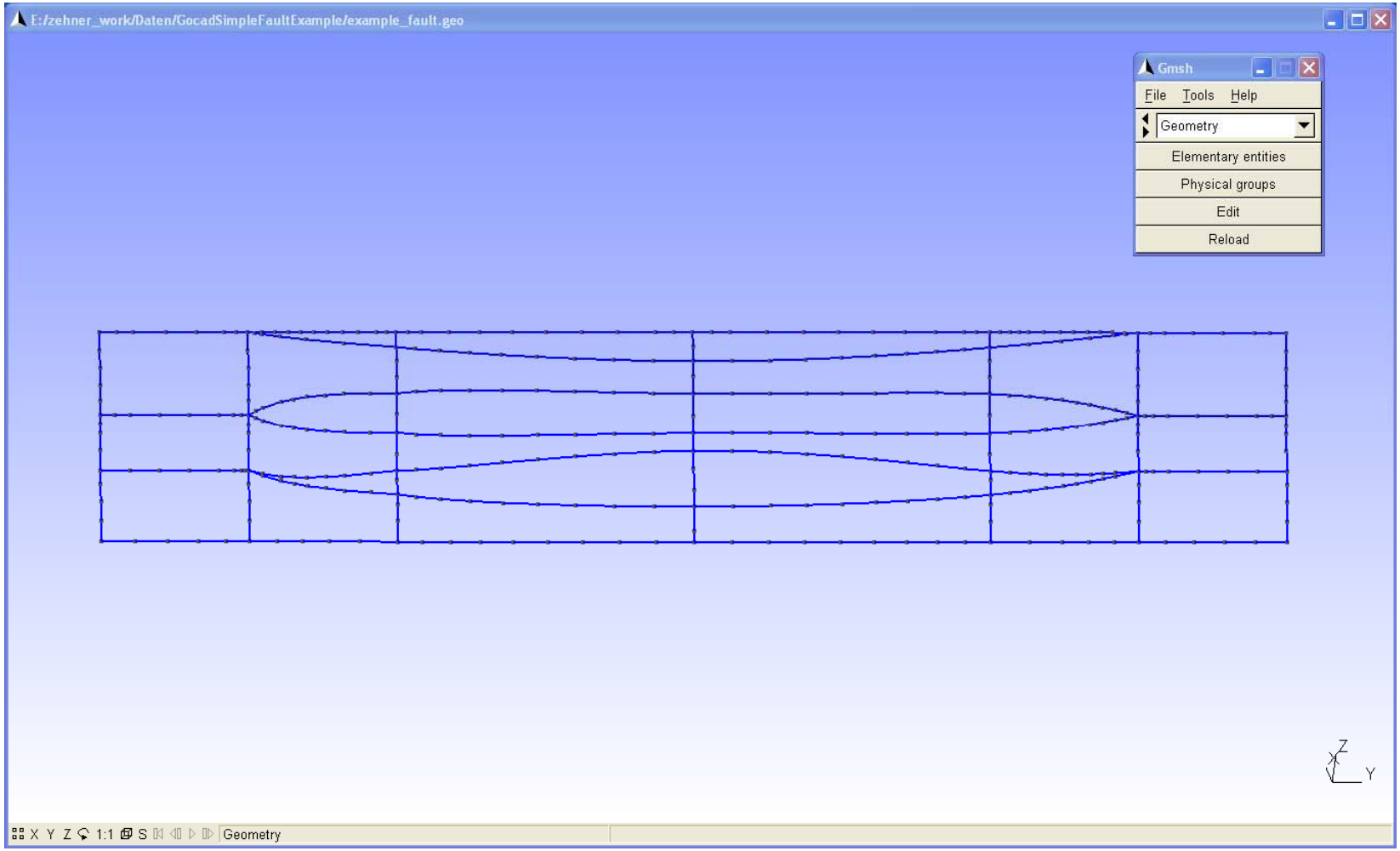
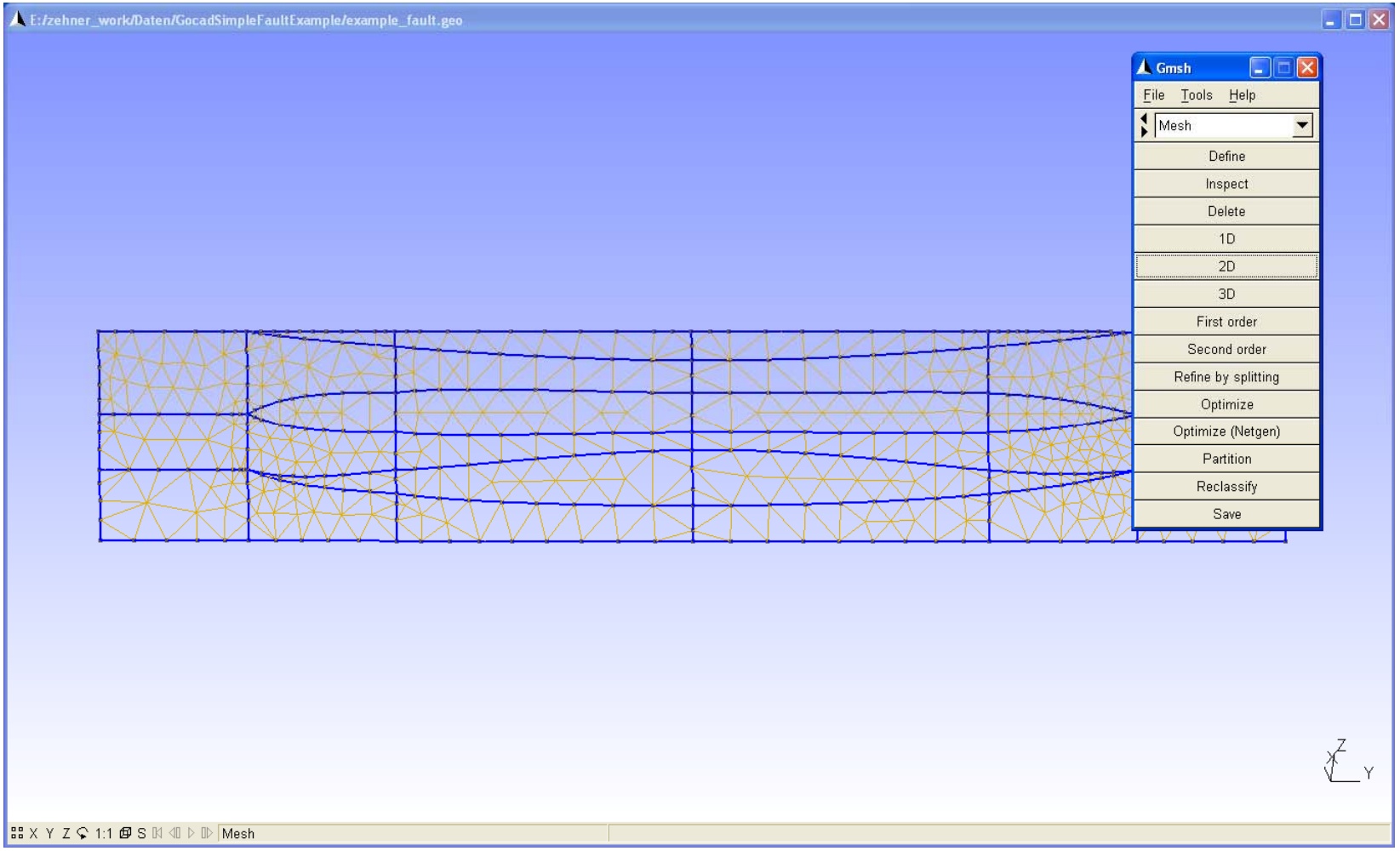
Model of a fault



Gmsh, Geuzaine, C. & Remacle, J.-F.

HELMHOLTZ CENTRE FOR ENVIRONMENTAL RESEARCH – UFZ

Model of a fault



Gmsh, Geuzaine, C. & Remacle, J.-F.

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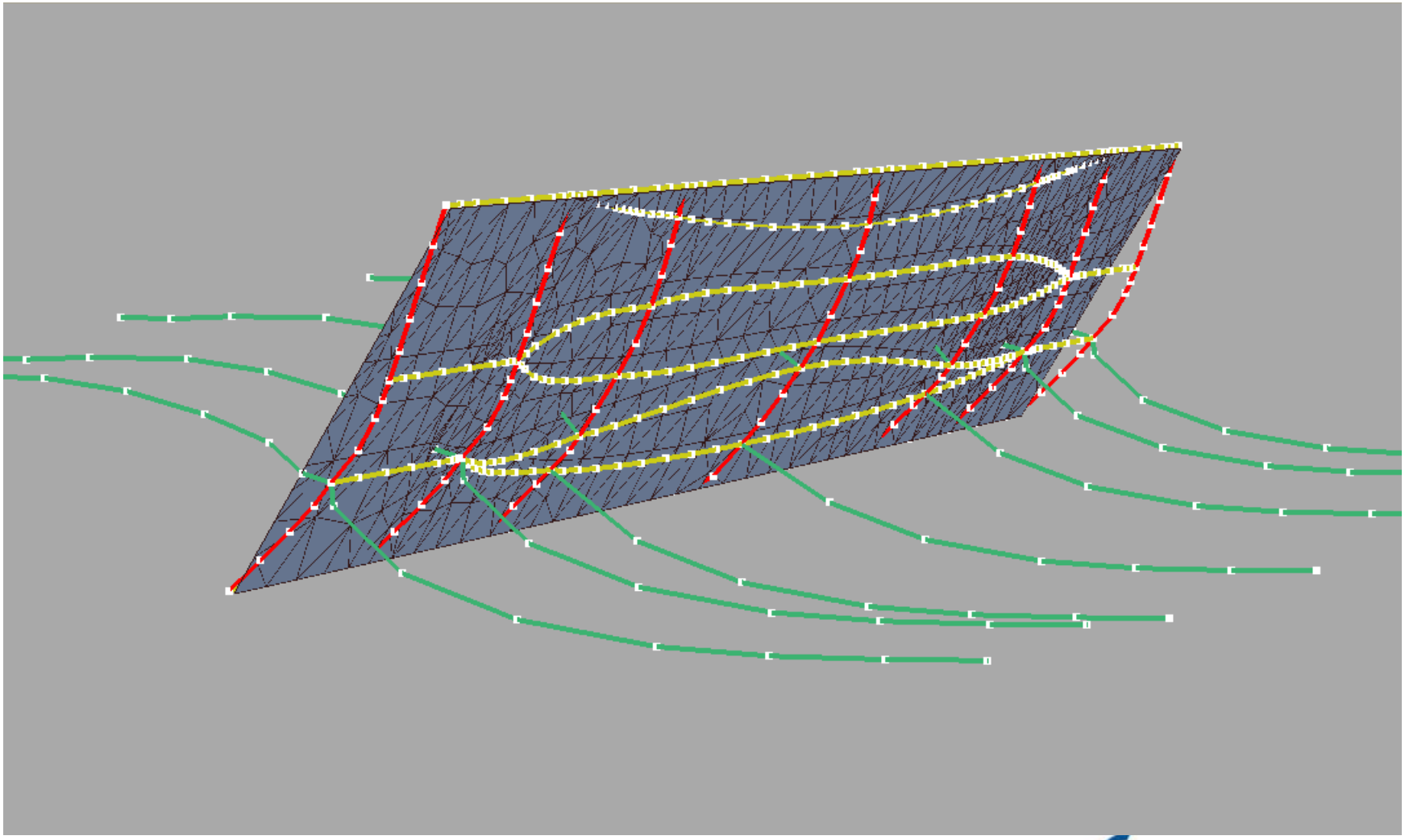
Model of a fault



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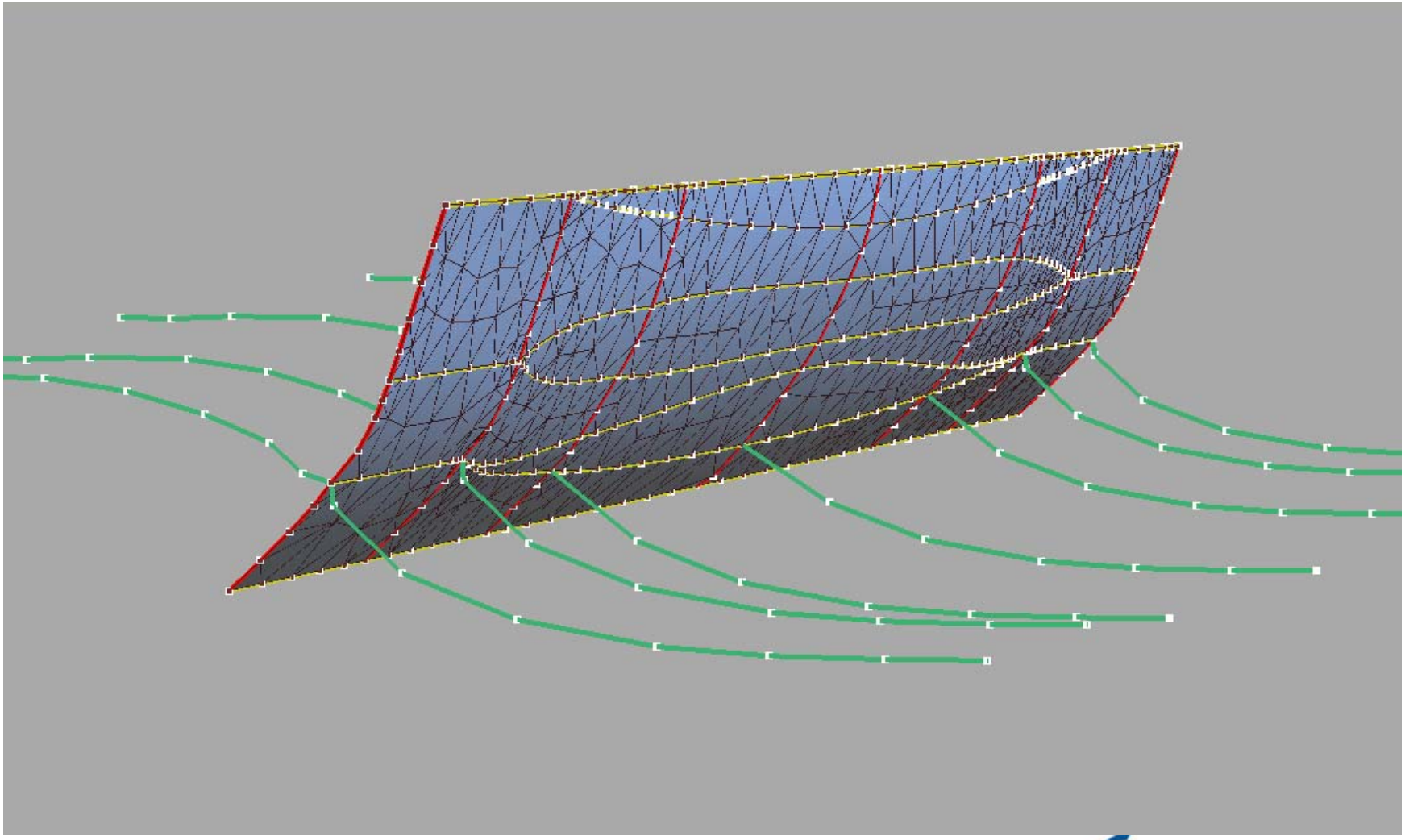

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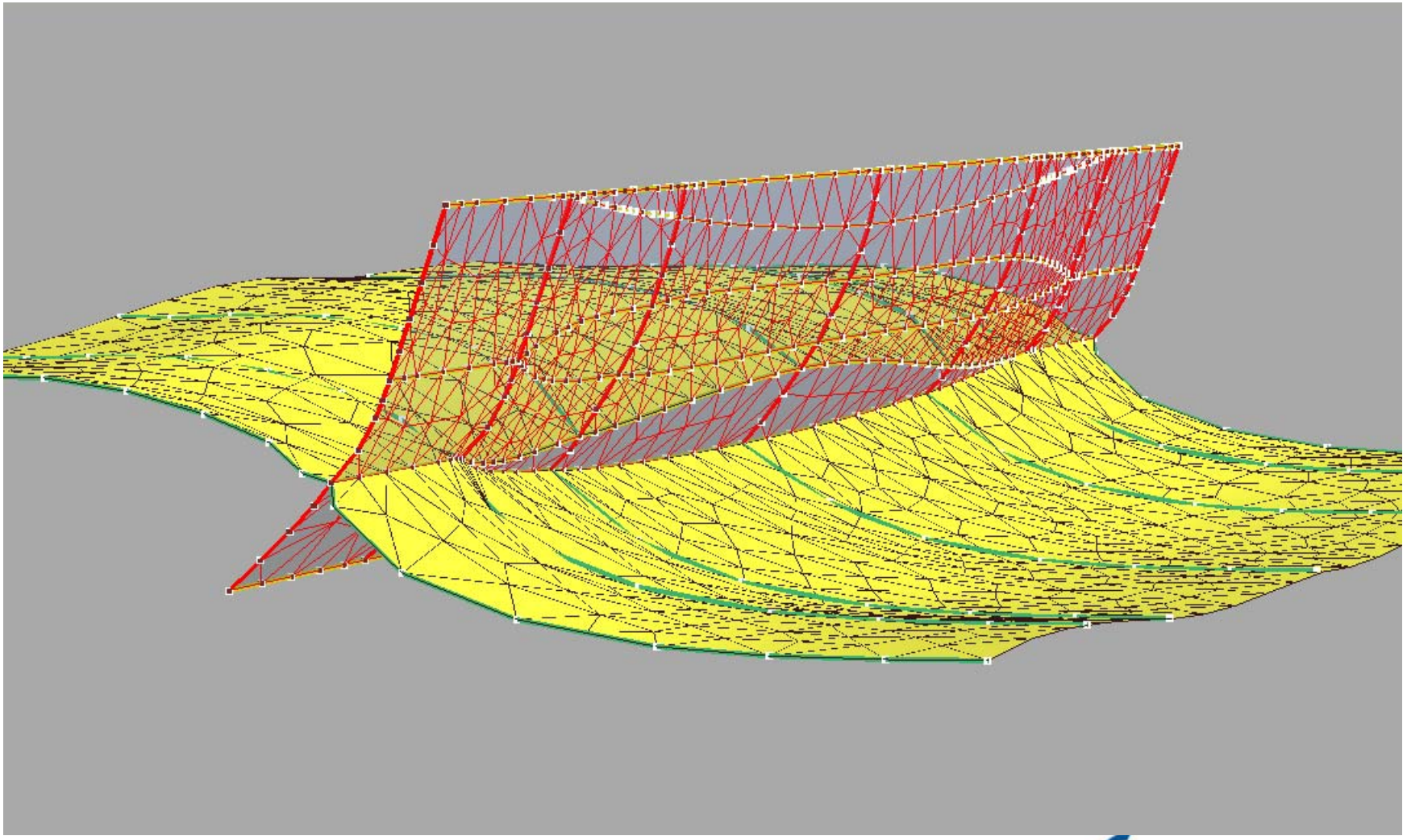
Model of a fault



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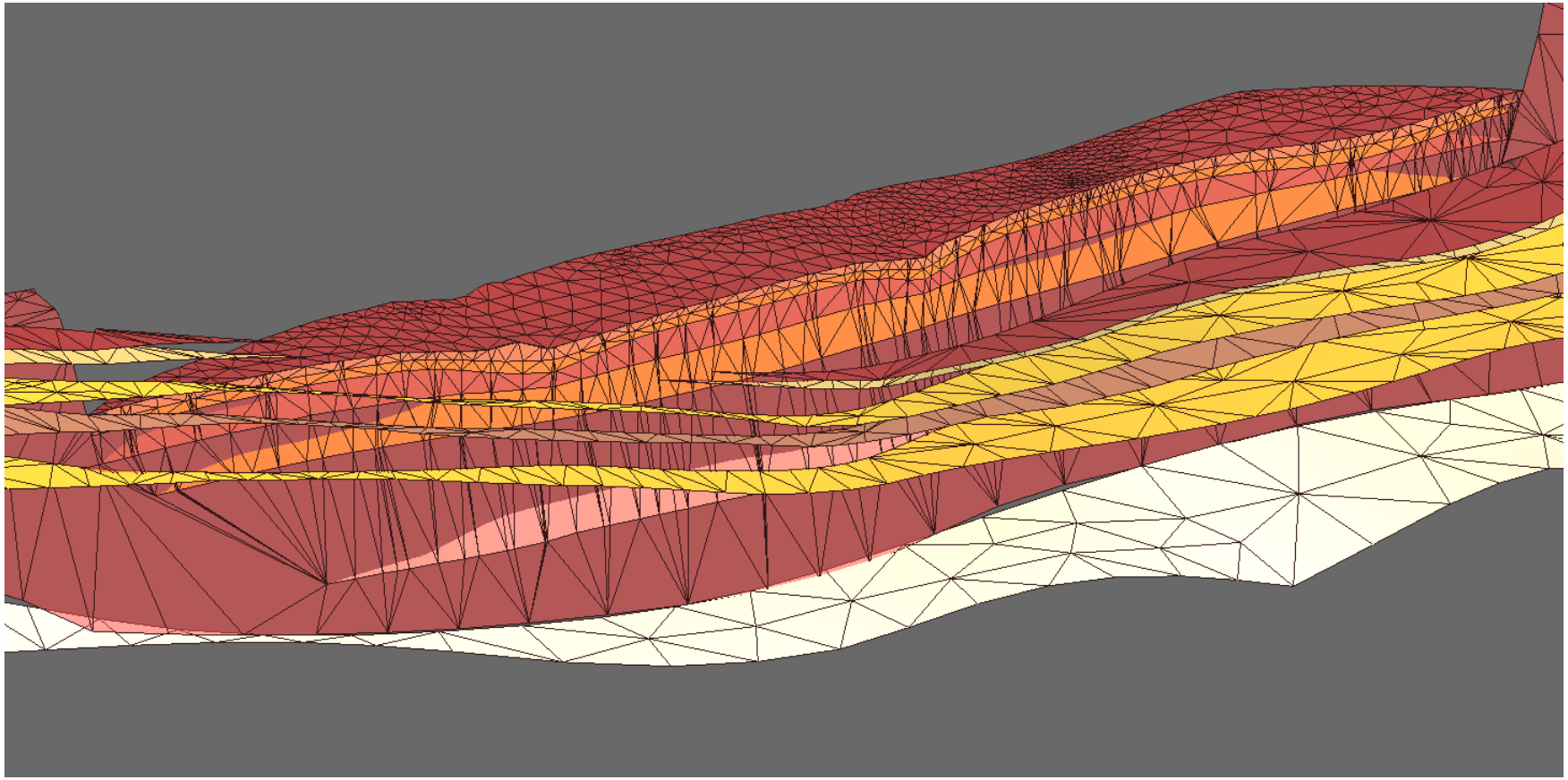
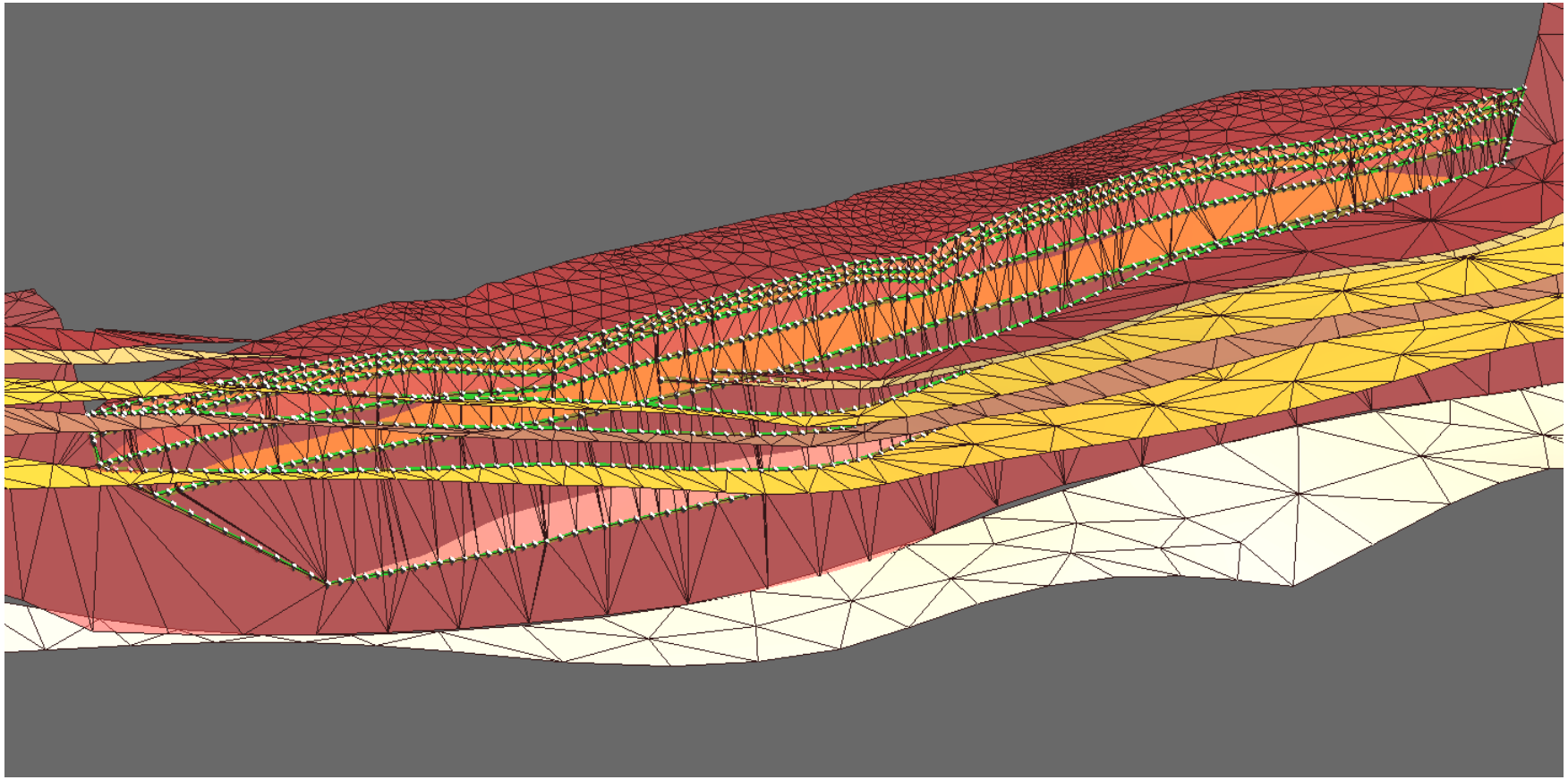
Model of a fault – Finne fault example



Original model provided by Alexander Malz,
University of Jena

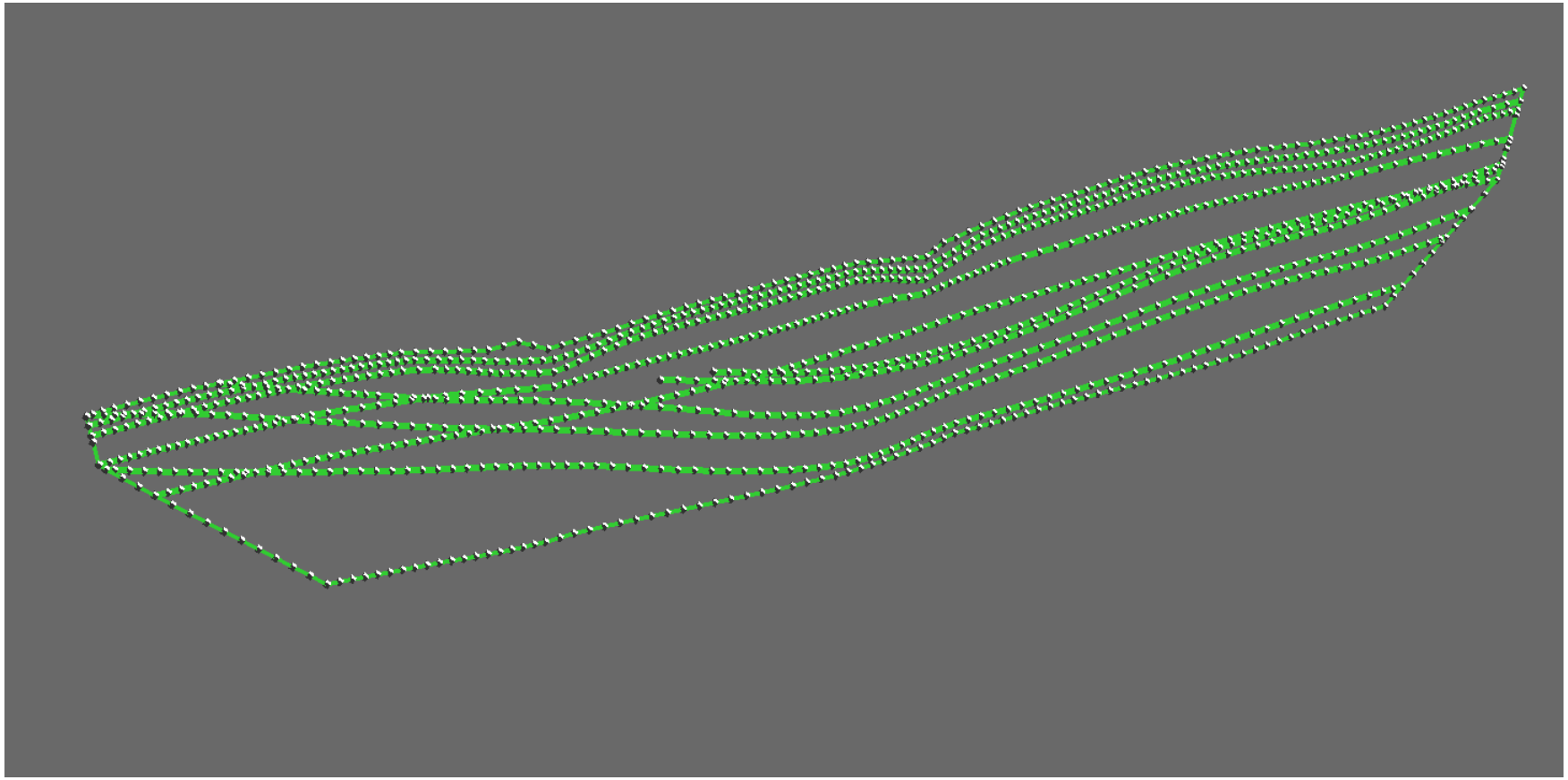
HELMHOLTZ CENTRE FOR ENVIRONMENTAL RESEARCH – UFZ

Model of a fault – Finne fault example



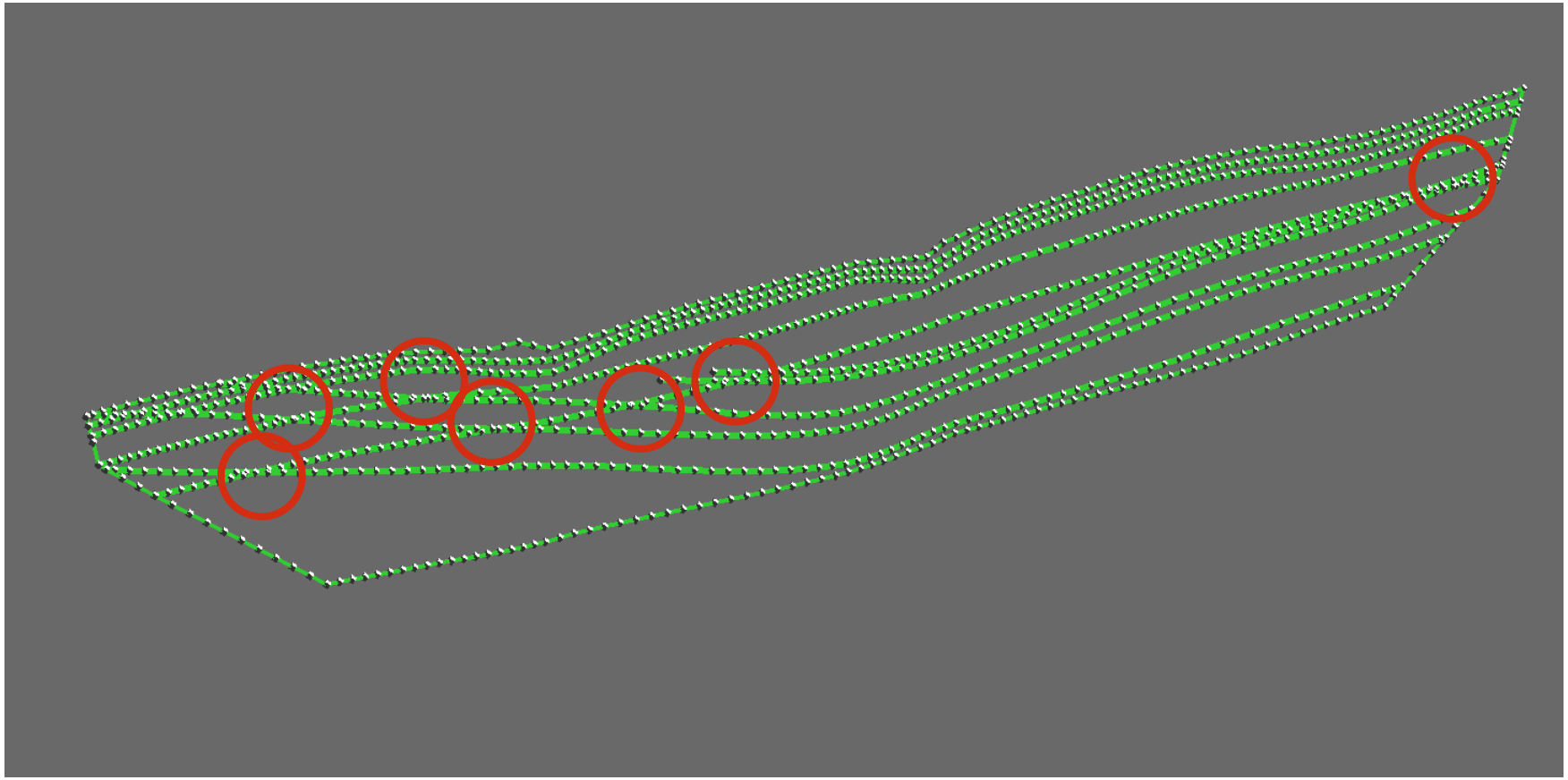
HELMHOLTZ CENTRE FOR ENVIRONMENTAL RESEARCH – UFZ

Model of a fault – Finne fault example



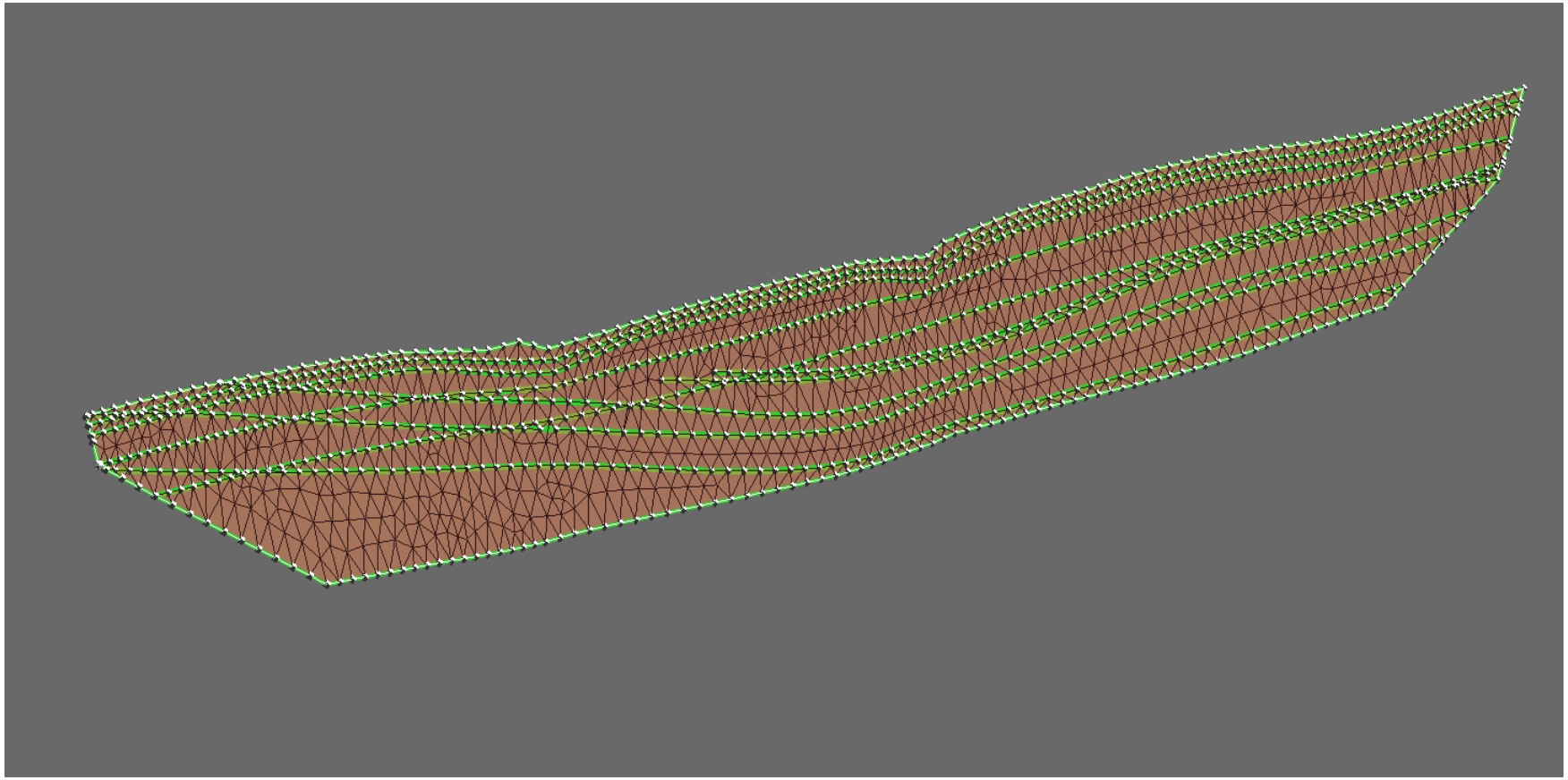
HELMHOLTZ CENTRE FOR ENVIRONMENTAL RESEARCH – UFZ

Model of a fault – Finne fault example



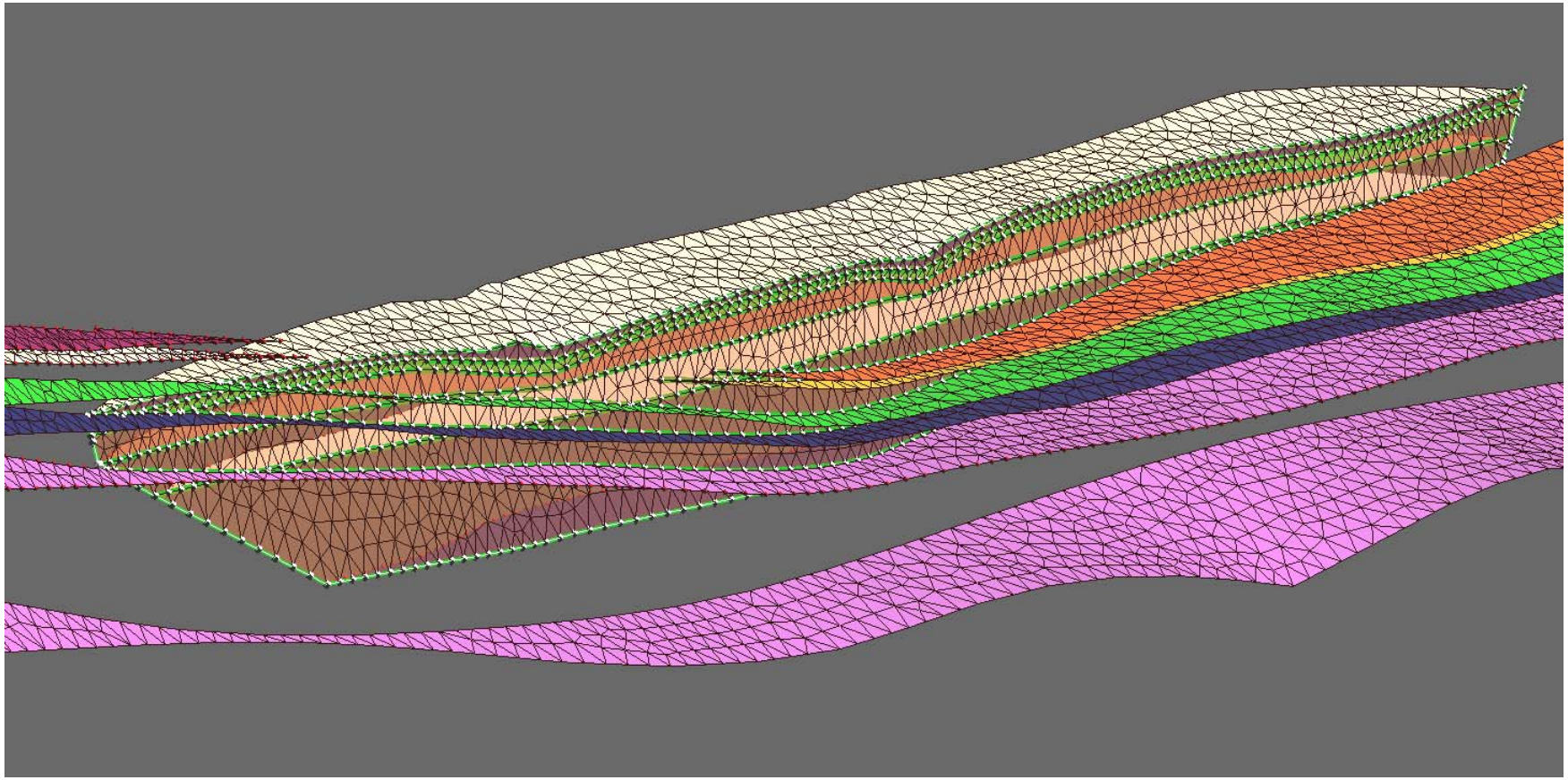
HELMHOLTZ CENTRE FOR ENVIRONMENTAL RESEARCH – UFZ

Model of a fault – Finne fault example



HELMHOLTZ CENTRE FOR ENVIRONMENTAL RESEARCH – UFZ

Model of a fault – Finne fault example



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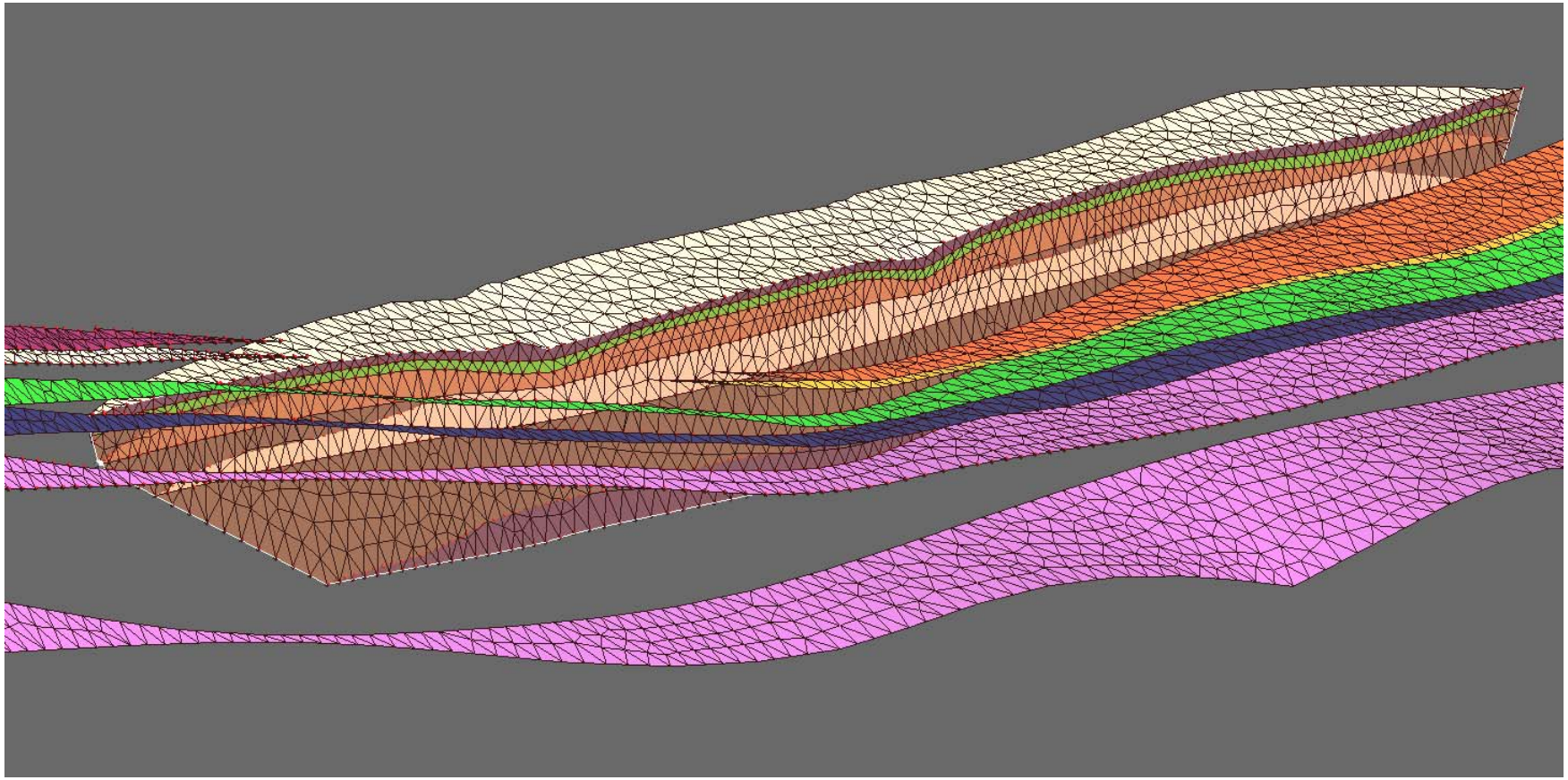
Model of a fault – Finne fault example



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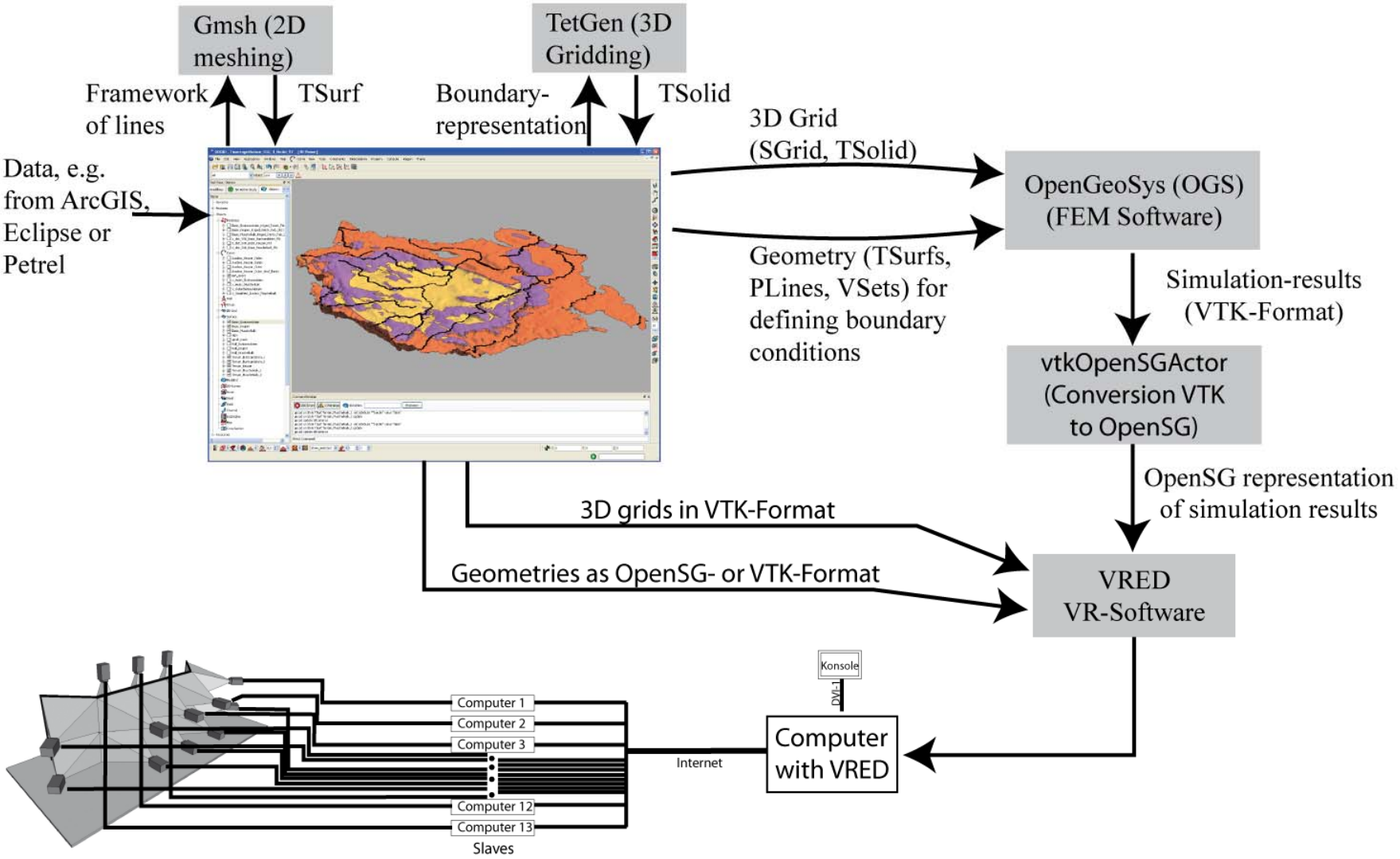
Data-flow


Gmsh (2D meshing)
TetGen (3D Gridding)
Framework of lines
TSurf
Boundary-representation
TSolid
Data, e.g. from ArcGIS, Eclipse or Petrel
3D Grid (SGrid, TSolid)
Geometry (TSurfs, PLines, VSets) for defining boundary conditions
OpenGeoSys (OGS) (FEM Software)
Simulation-results (VTK-Format)
vtkOpenSGActor (Conversion VTK to OpenSG)
OpenSG representation of simulation results
3D grids in VTK-Format
Geometries as OpenSG- or VTK-Format
VRED VR-Software
Konsole
DVI
Computer with VRED
Internet
Computer 1
Computer 2
Computer 3
Computer 12
Computer 13
Slaves