3D modelling of fractured geological systems technique and numerical results

Cacace M., Blöcher G., Lewerenz B.,
Scheck-Wenderoth M., Huenges E

EGU General Assembly
7th April 2011

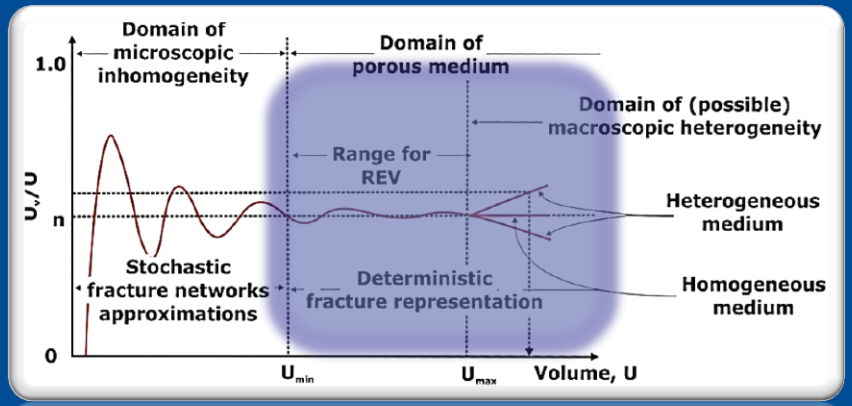
GFZ Helmholtz Centre Potsdam

Universität Potsdam

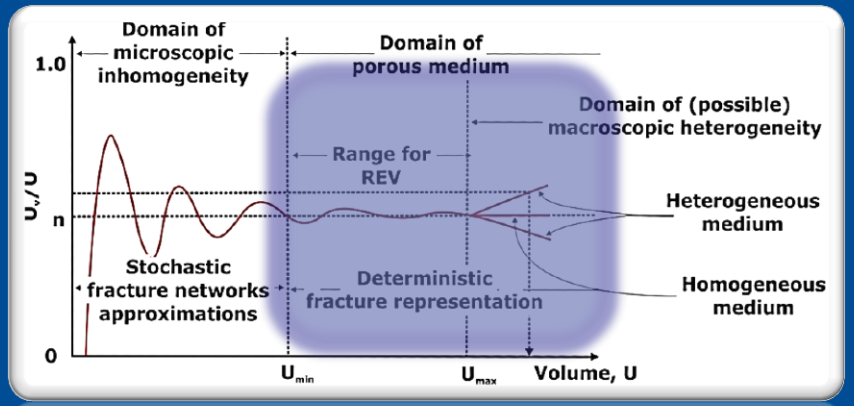
GeoEn

Bundesministerium für Bildung und Forschung

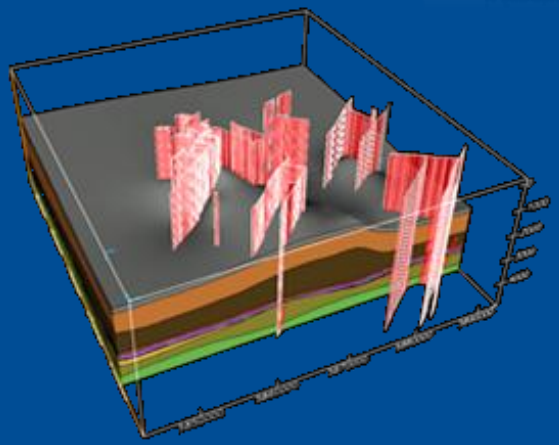
HELMHOLTZ ASSOCIATION



Introduction: Prerequisites



Geology

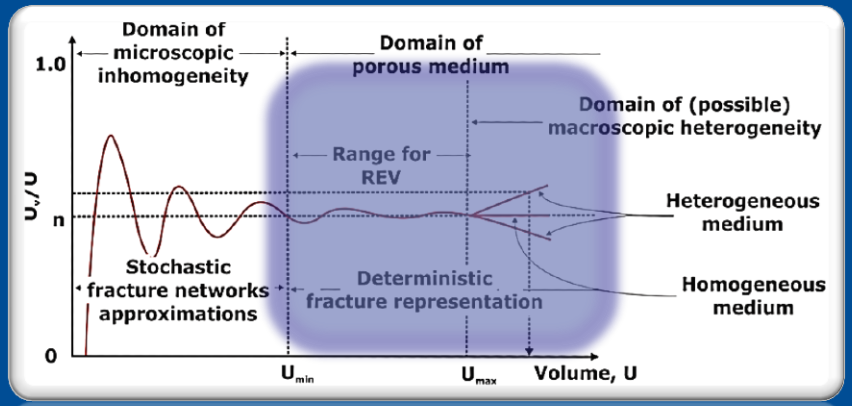


Earth Vision
Petrel
GoCad
...

Introduction: Prerequisites

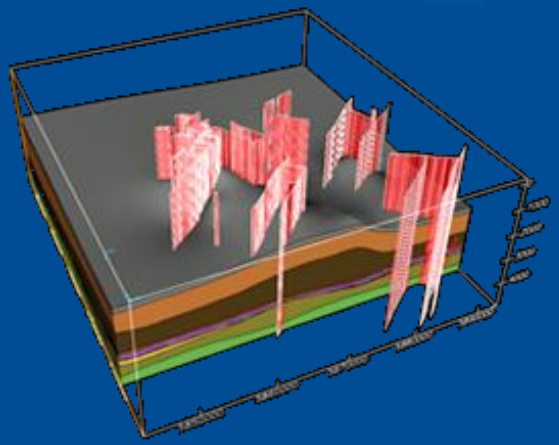
GFZ Helmholtz Centre Potsdam

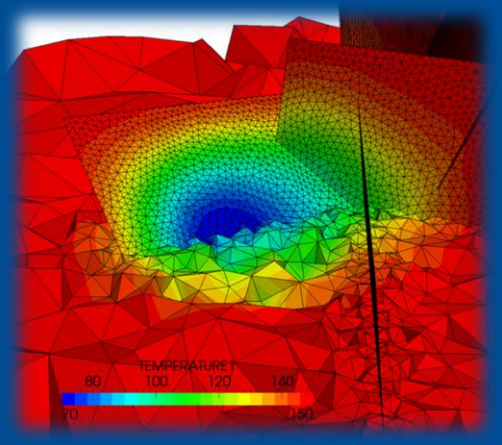
HELMHOLTZ ASSOCIATION



Geology

Processes





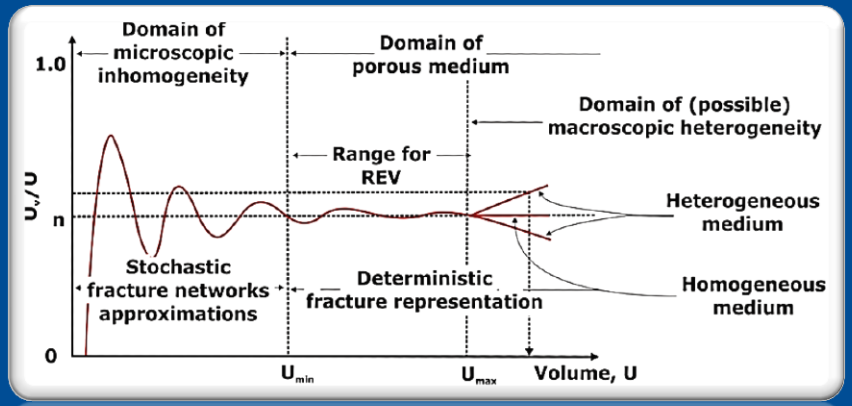
Earth Vision
Petrel
GoCad
...

OpenGeosys
Tough
Eclipse
...

Introduction: Prerequisites

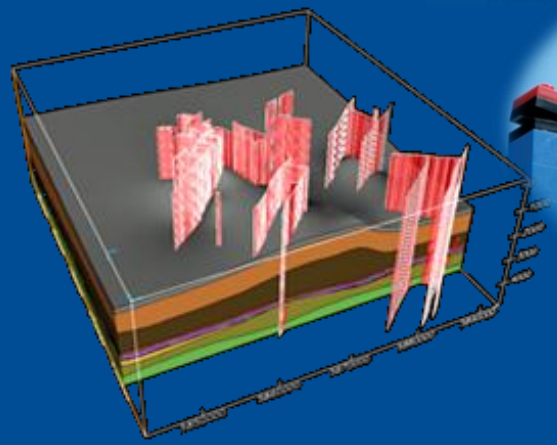
GFZ Helmholtz Centre Potsdam

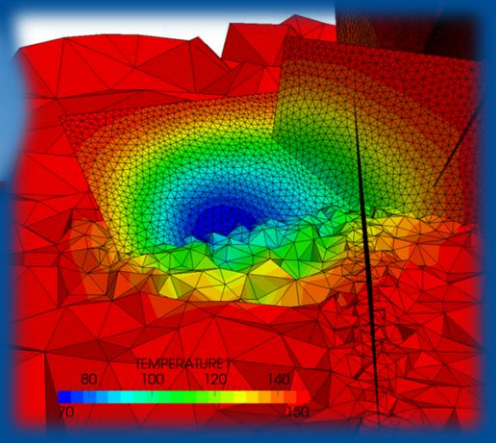
HELMHOLTZ ASSOCIATION



Geology

Processes





Earth Vision
Petrel
GoCad
...

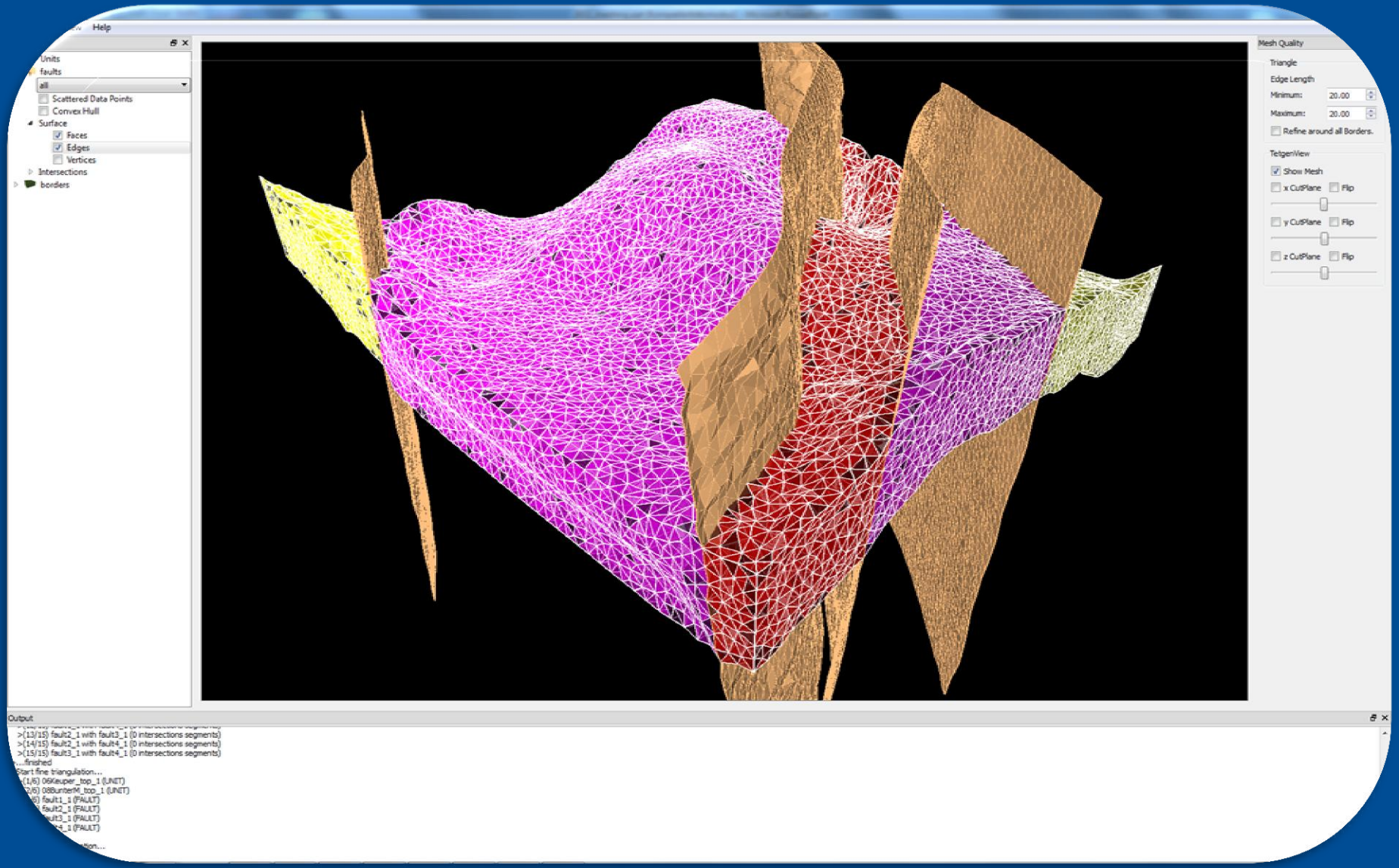
?

OpenGeosys
Tough
Eclipse
...

Introduction: Prerequisites

GFZ Helmholtz Centre Potsdam

HELMHOLTZ ASSOCIATION



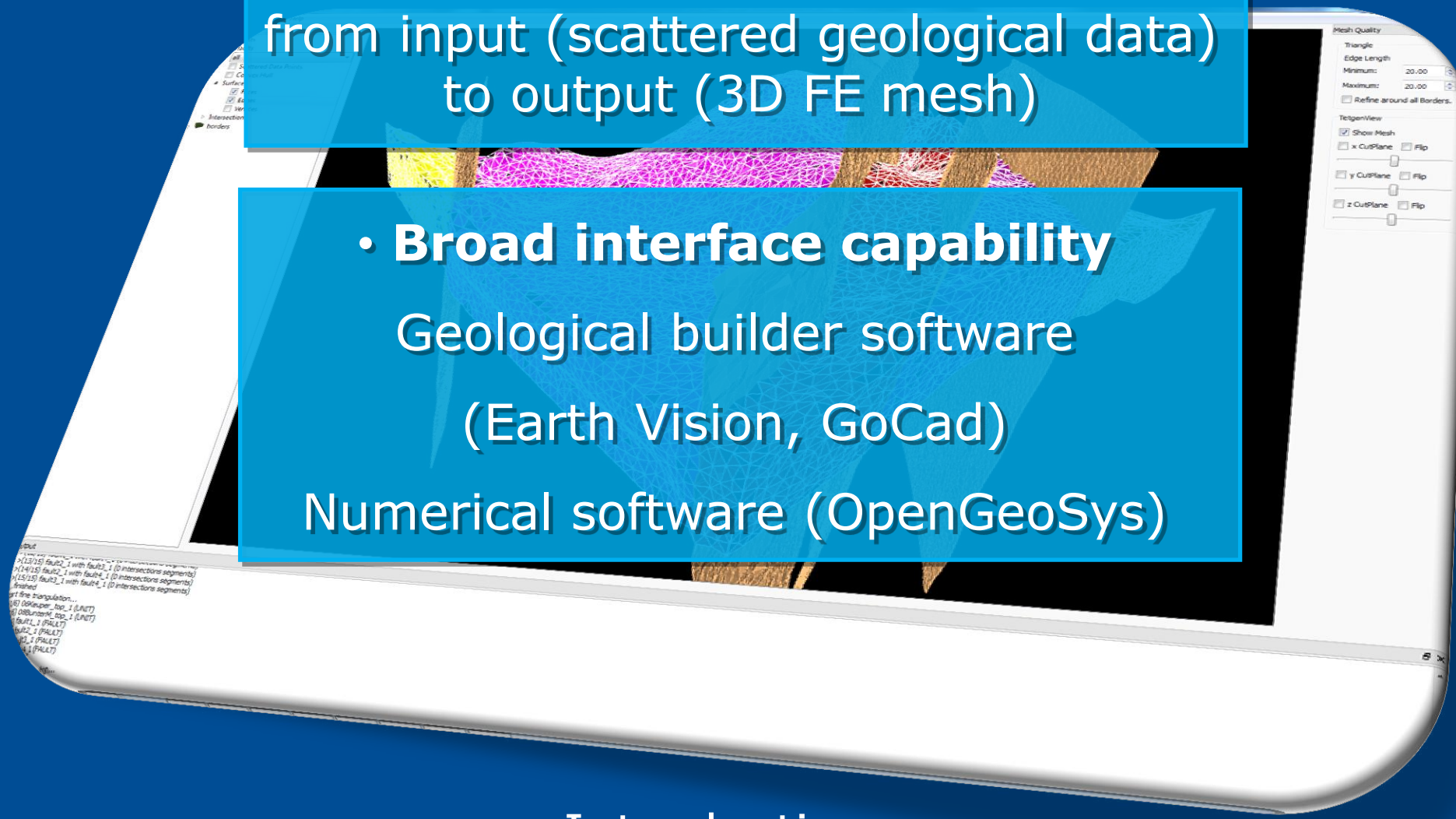
Introduction: Prerequisites

GFZ Helmholtz Centre Potsdam

HELMHOLTZ ASSOCIATION

- **Fully Automatised**

from input (scattered geological data) to output (3D FE mesh)



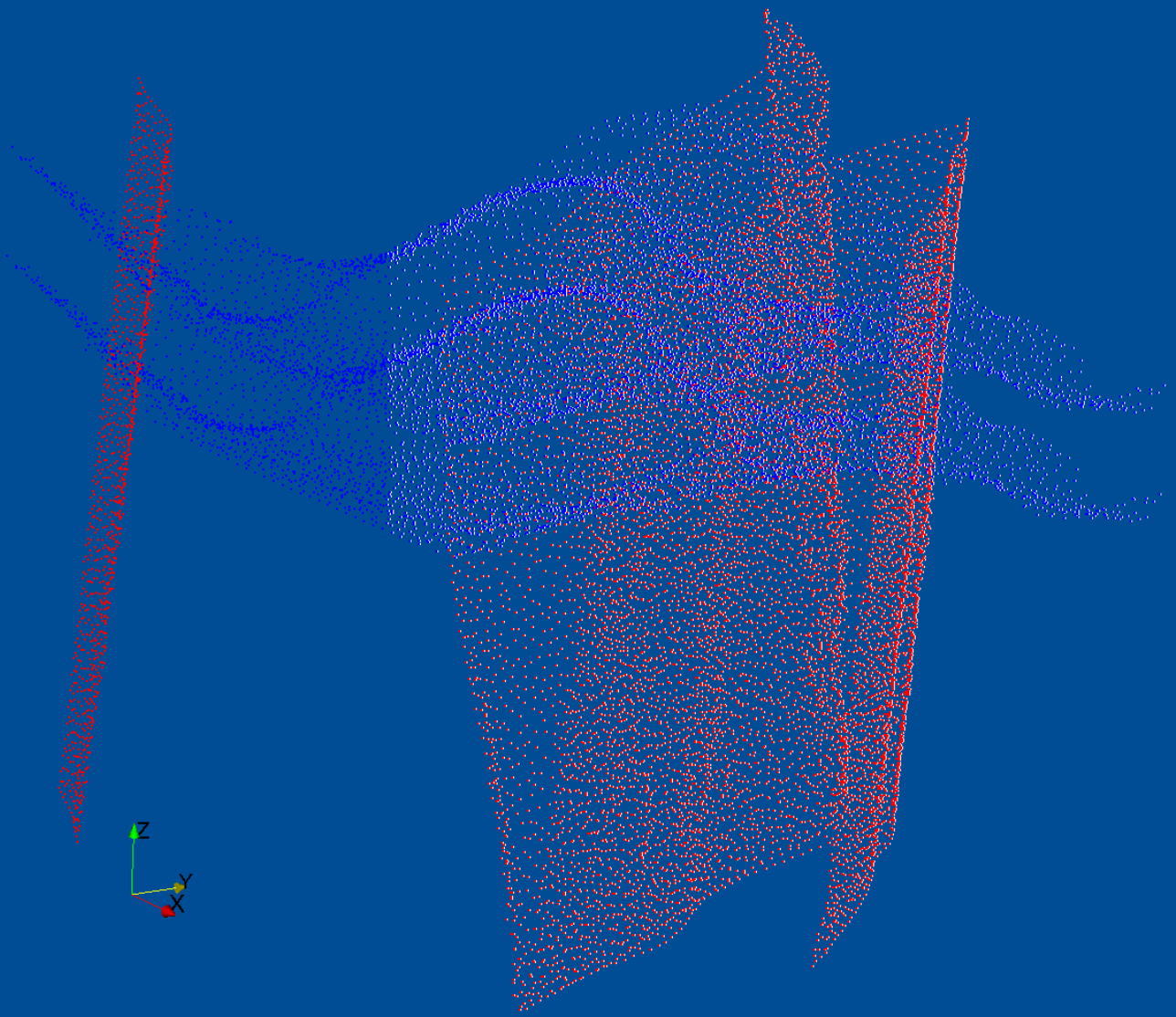
- **Broad interface capability**

Geological builder software

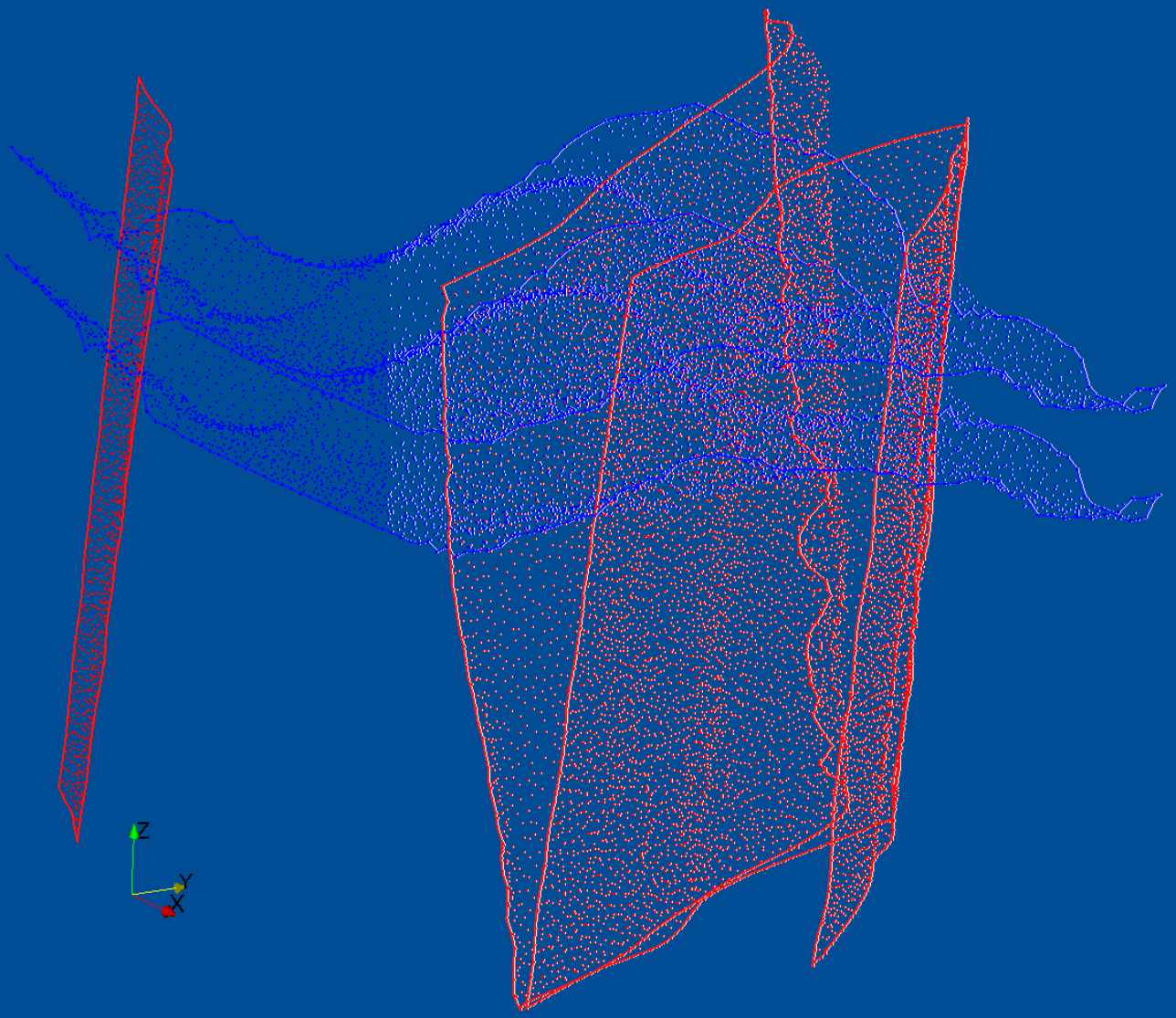
(Earth Vision, GoCad)

Numerical software (OpenGeoSys)

Introduction:
Prerequisites

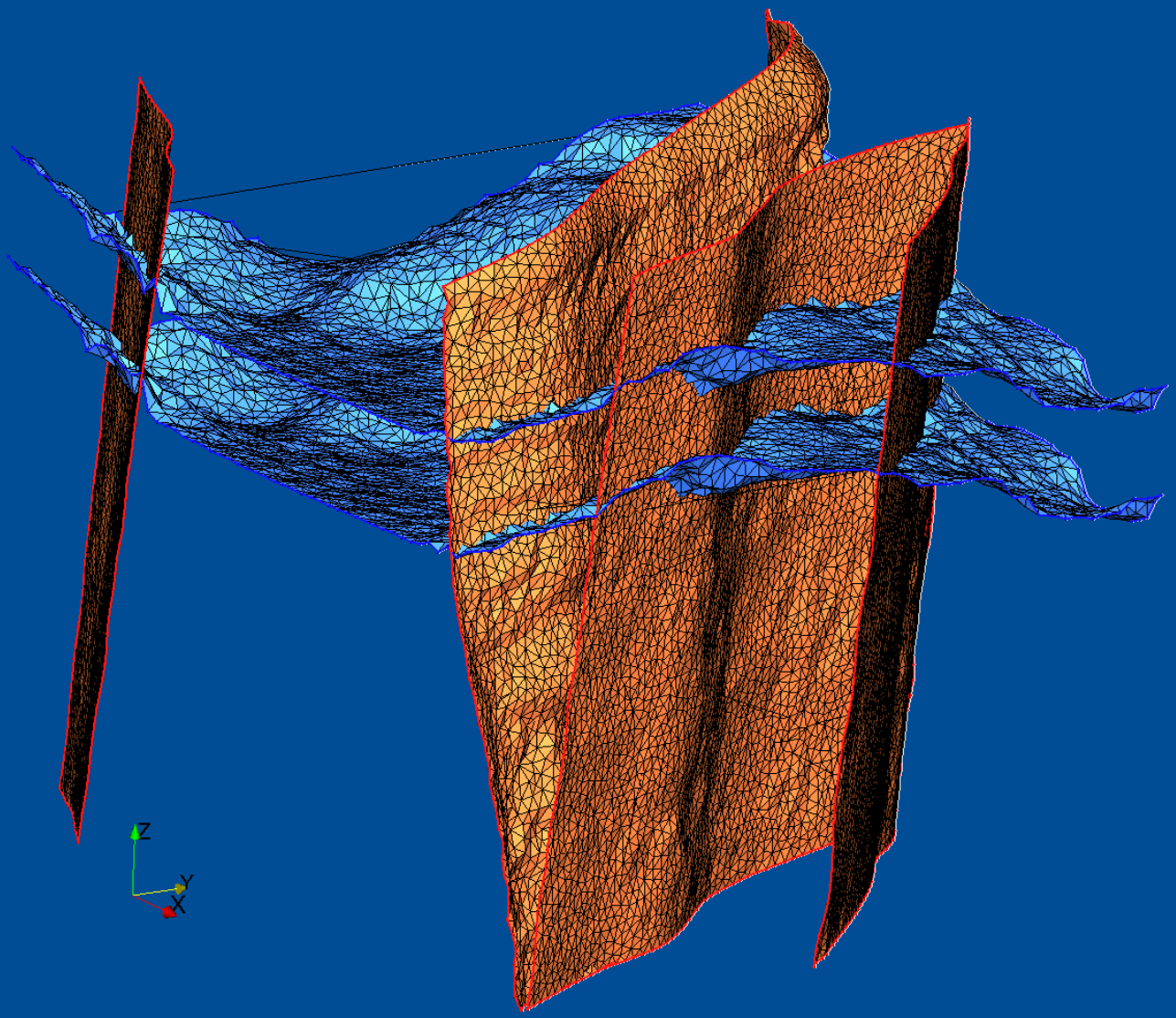


Step 1:
Scattered Data Points



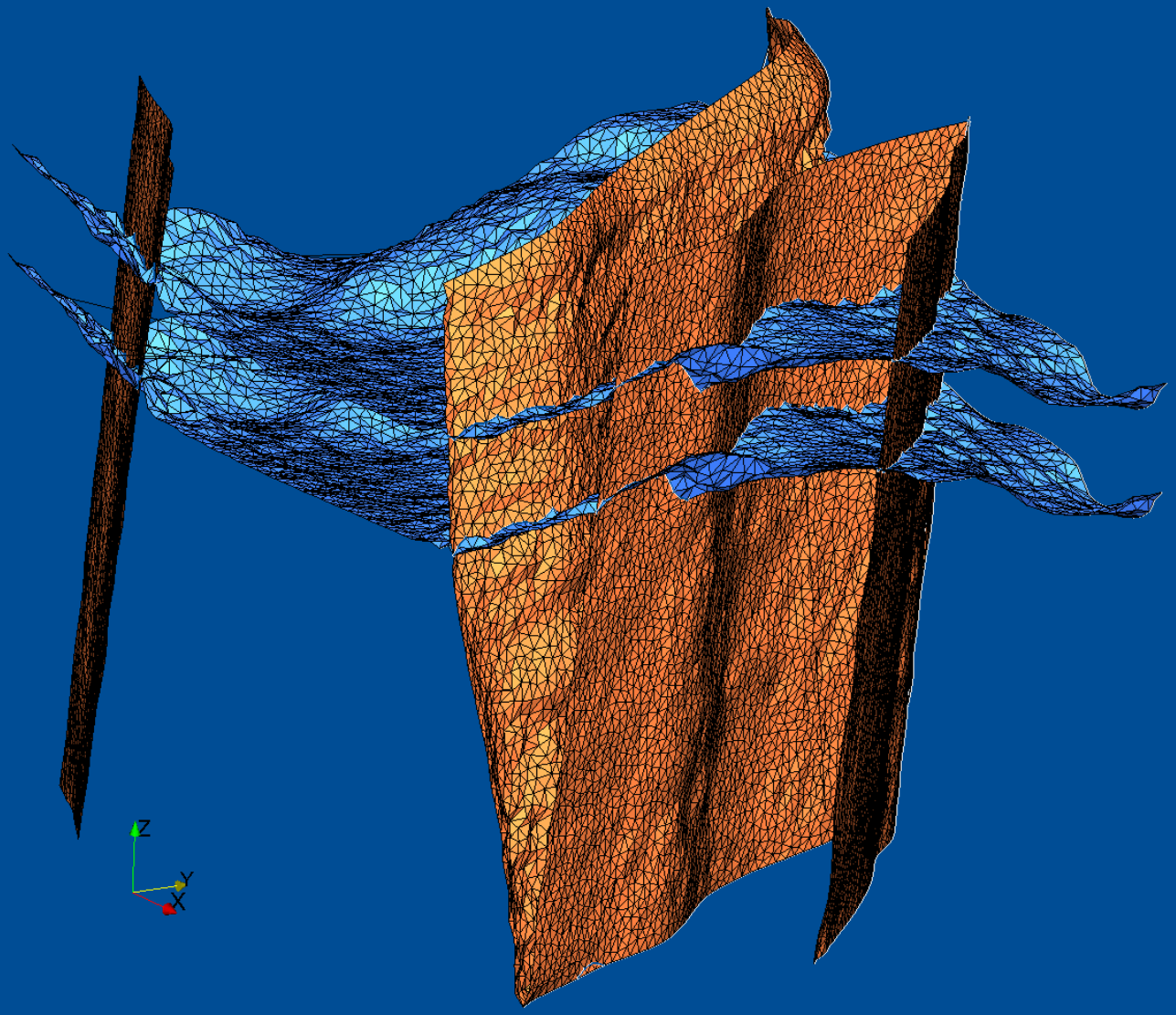
Graham, R. L., 1972. An efficient algorithm for determining the convex hull of a finite planar set. Information Processing Letters 1 (4), 132-133.

Step 2: Convex Hull



Shewchuk, J.R., 2002. Delaunay refinement algorithms for triangular mesh generation. Computational Geometry: Theory and Applications 22 (1–3), 21–74.

Step 3: Coarse Triangulation

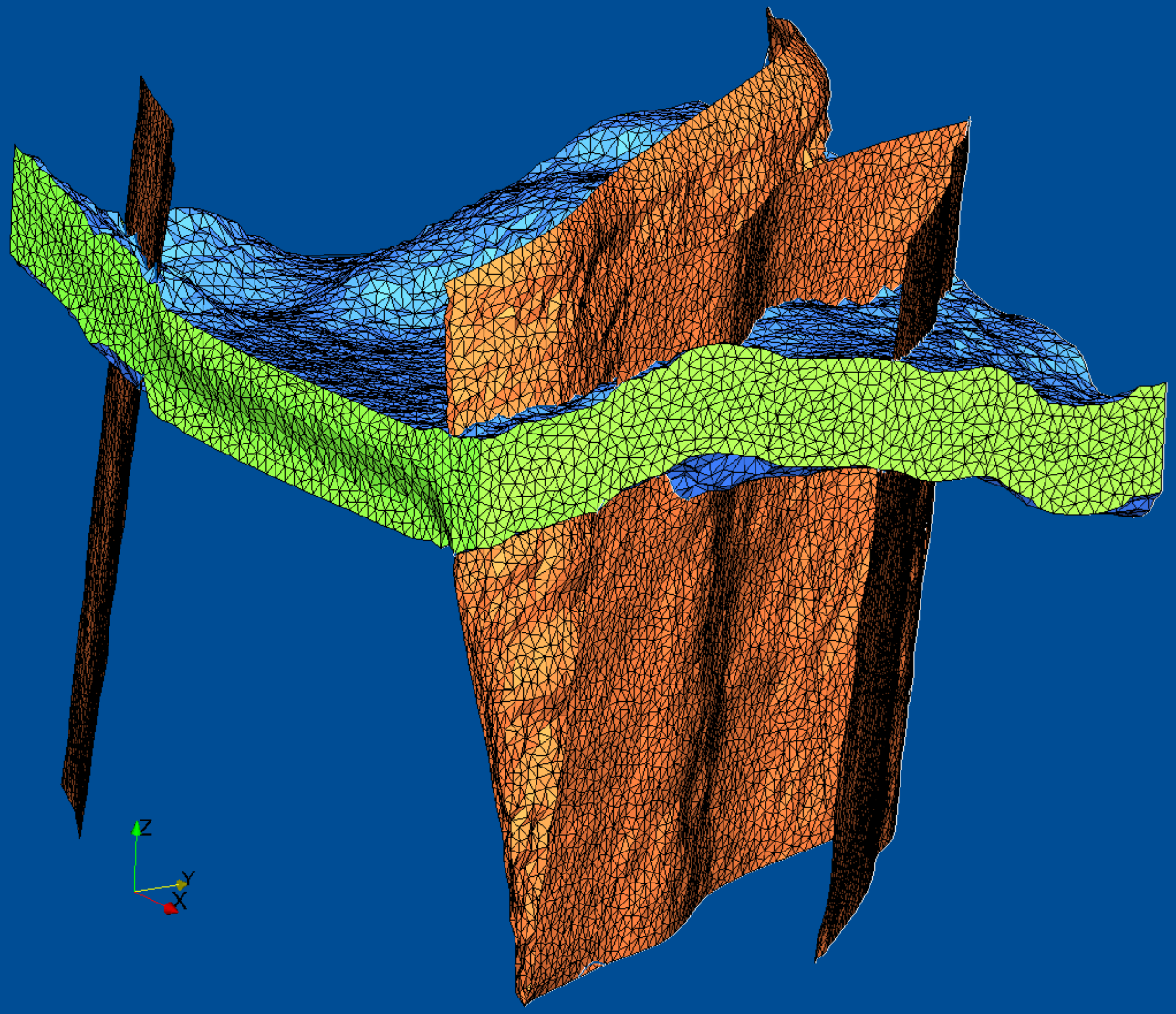


Shewchuk, J.R., 2002. Delaunay refinement algorithms for triangular mesh generation. Computational Geometry: Theory and Applications 22 (1–3), 21–74.

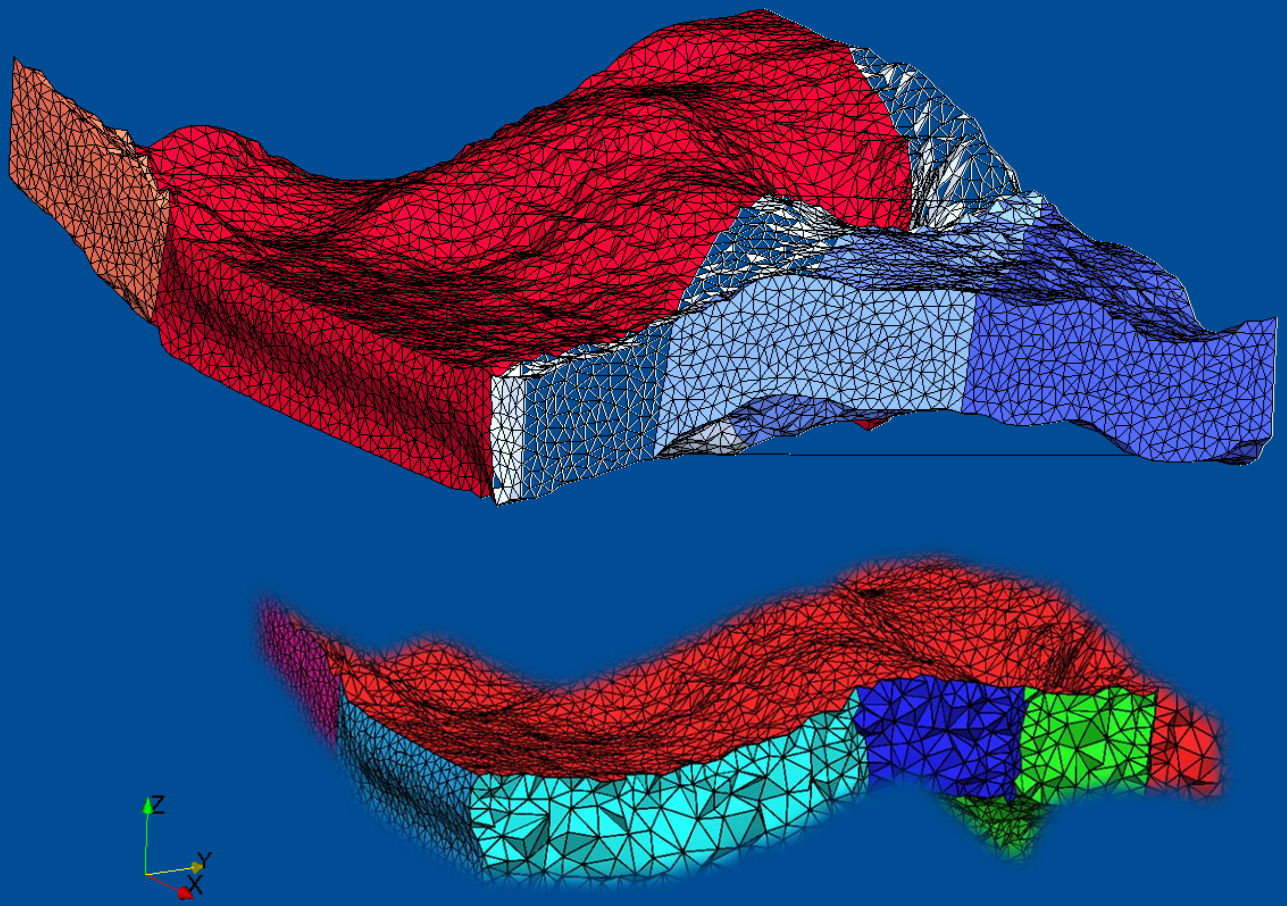
Step 4: Intersection Splines and Refined Triangulation

GFZ Helmholtz Centre Potsdam

HELMHOLTZ ASSOCIATION



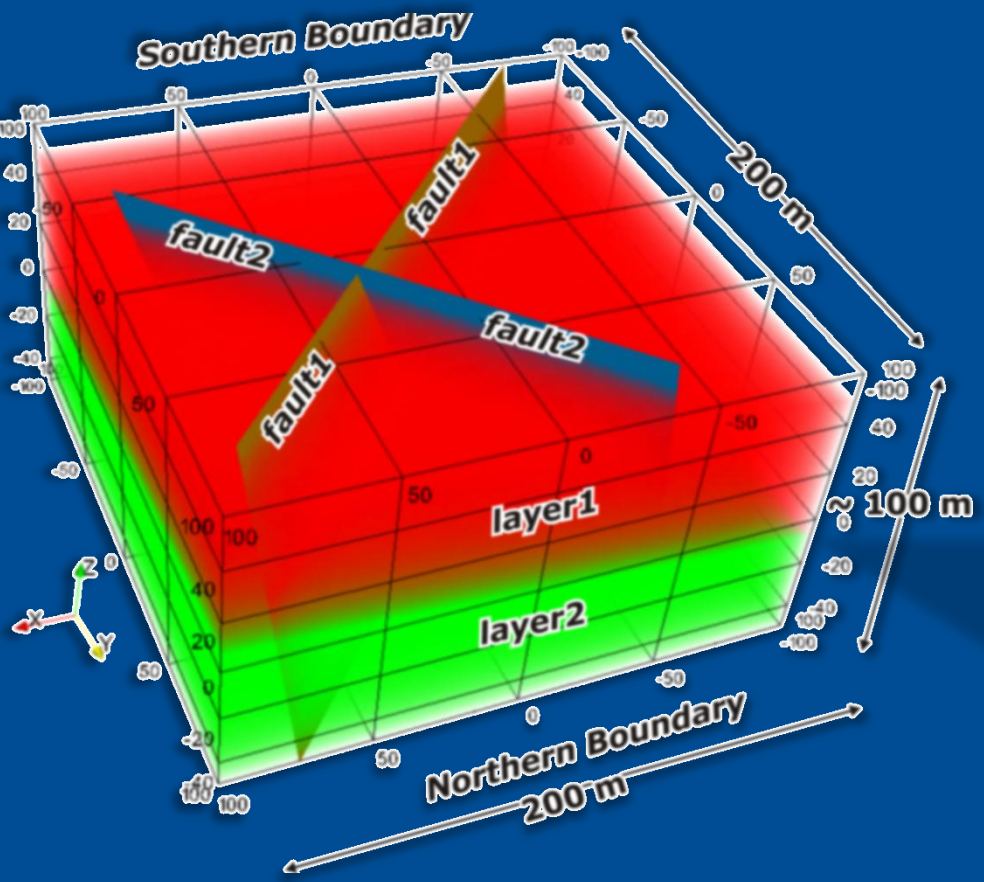
Step 5:
Closing Model Domain



Si, H., 2008. Three dimensional boundary conforming Delaunay mesh generation.
PhD. Thesis, Technical University Berlin, Institute of Mathematics.
[URL: http://tetgen.berlios .de]

Step 6:
Final 3D Mesh

Test Case Study
(T-H simulation with OpenGeosys[1])



Property	Layer 1	Layer 2	Fault 1	Fault 2
Porosity [-]	0.15	0.08	1	1
Storage [Pa^{-1}]	7E-10	7E-10	4.6E-10	4.6E-10
Permeability [m^2]	2E-14	1E-14	1E-8	5E-10
Aperture [m]	-	-	0.05	0.05

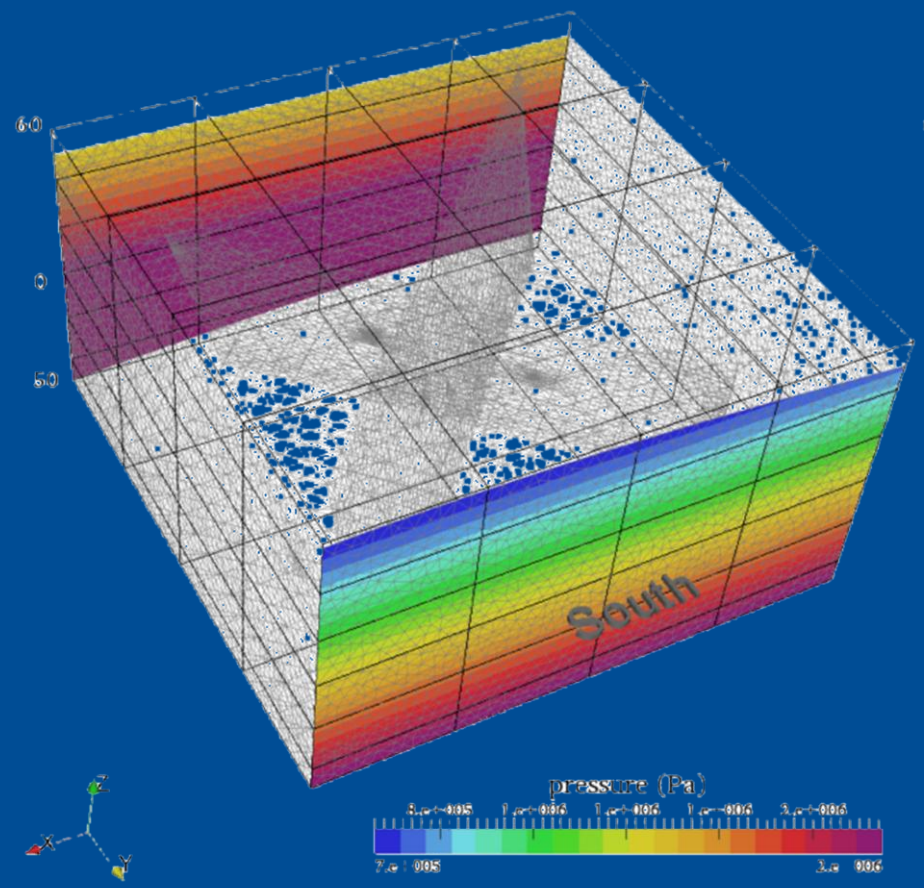
[1] Wang W., Kosakowski G. & Kolditz O. (2009):
A parallel finite element scheme for thermo-hydro-mechanical (THM) coupled problems in porous media.
Computers & Geosciences 35(8), 1631-1641.

GFZ Helmholtz Centre Potsdam

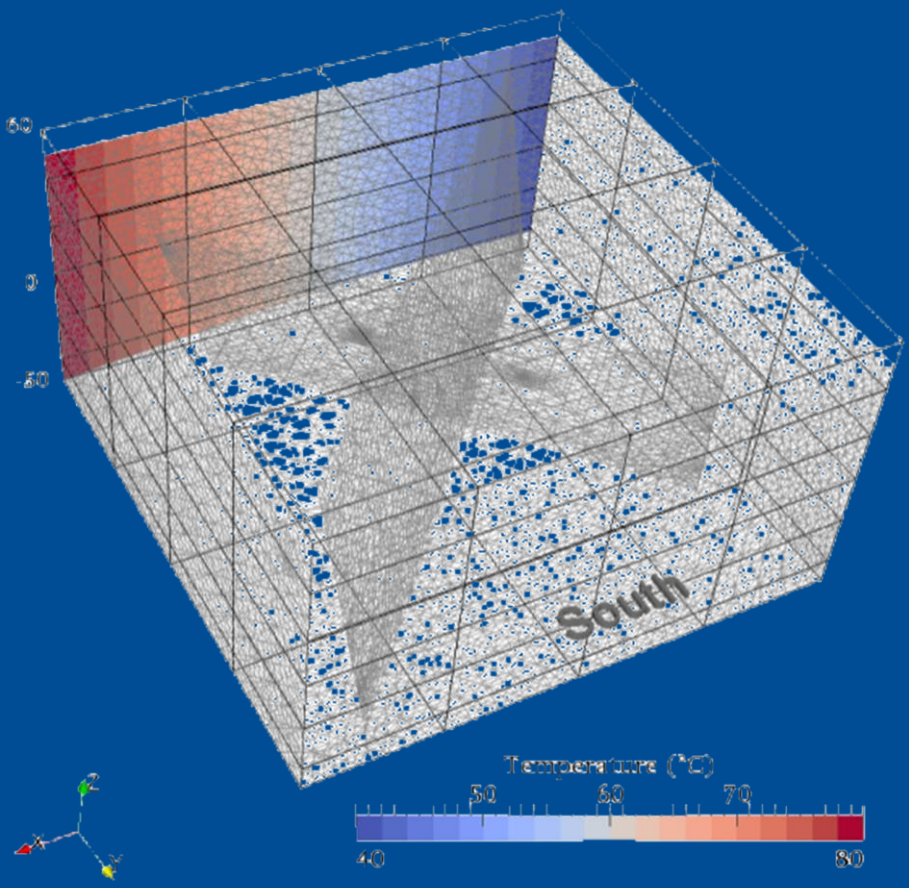
Model domain and parametrisation

HELMHOLTZ ASSOCIATION

Test Case Study
(T-H simulation with OpenGeosys)



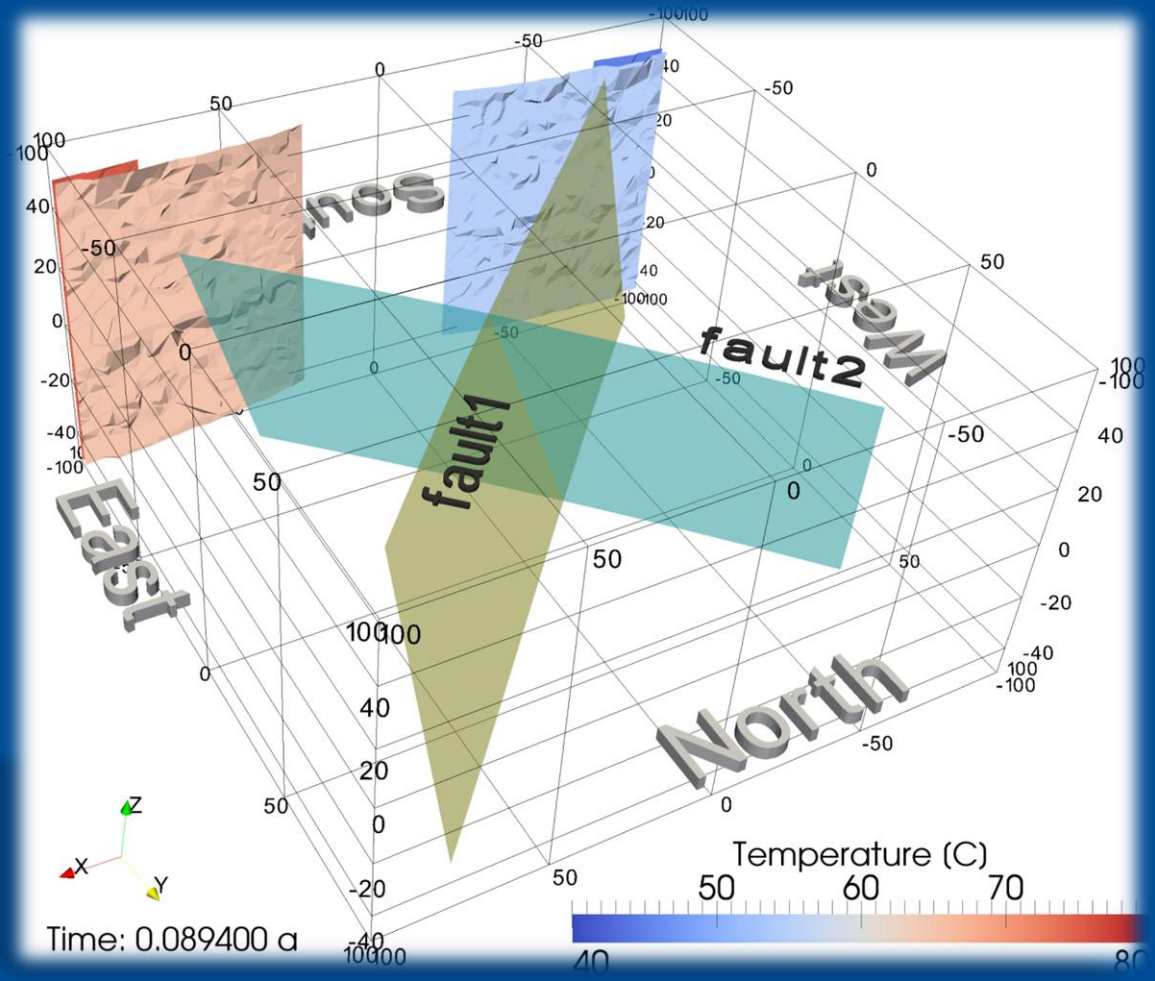
Pressure Boundary Conditions



Temperature Boundary Conditions

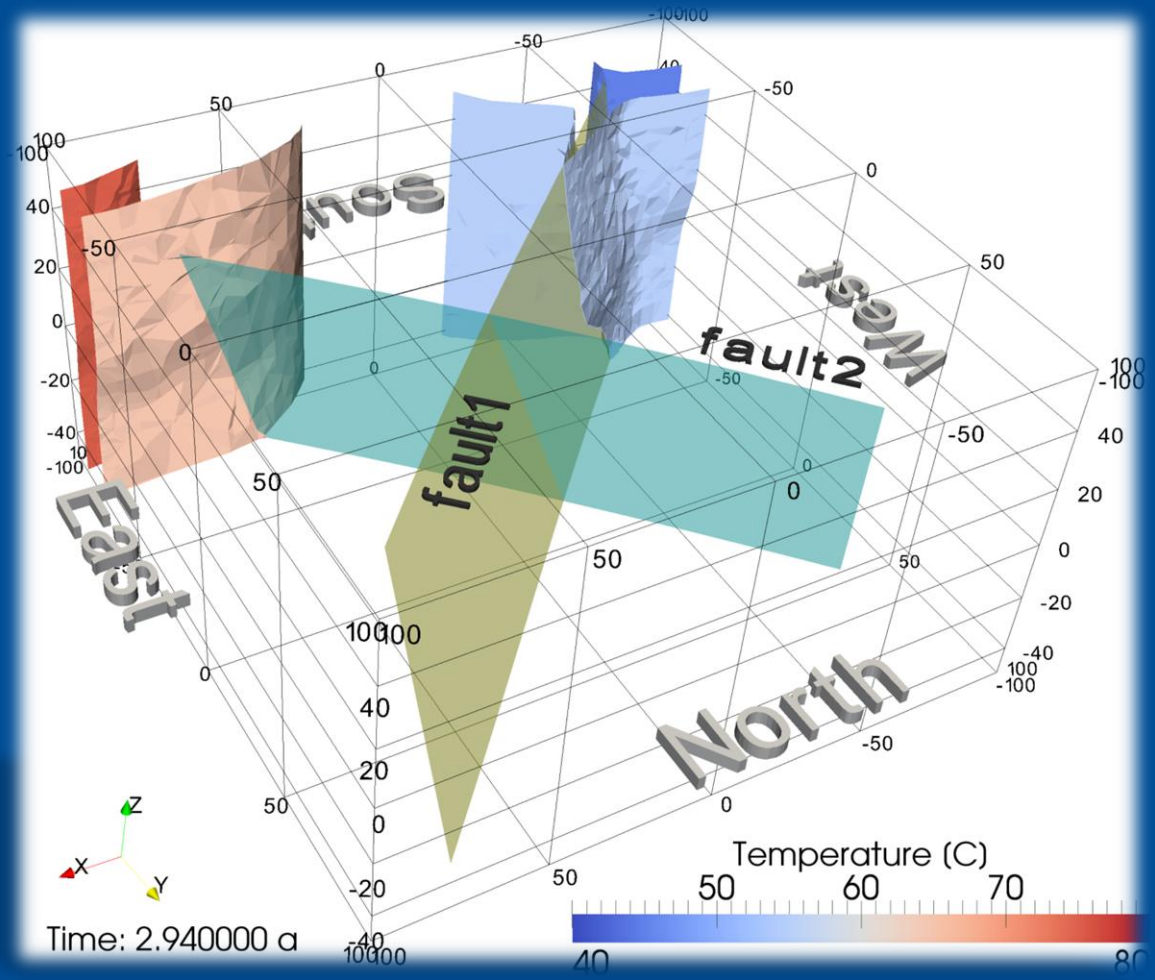
P-T boundary conditions

Diffusion → no fluid motion



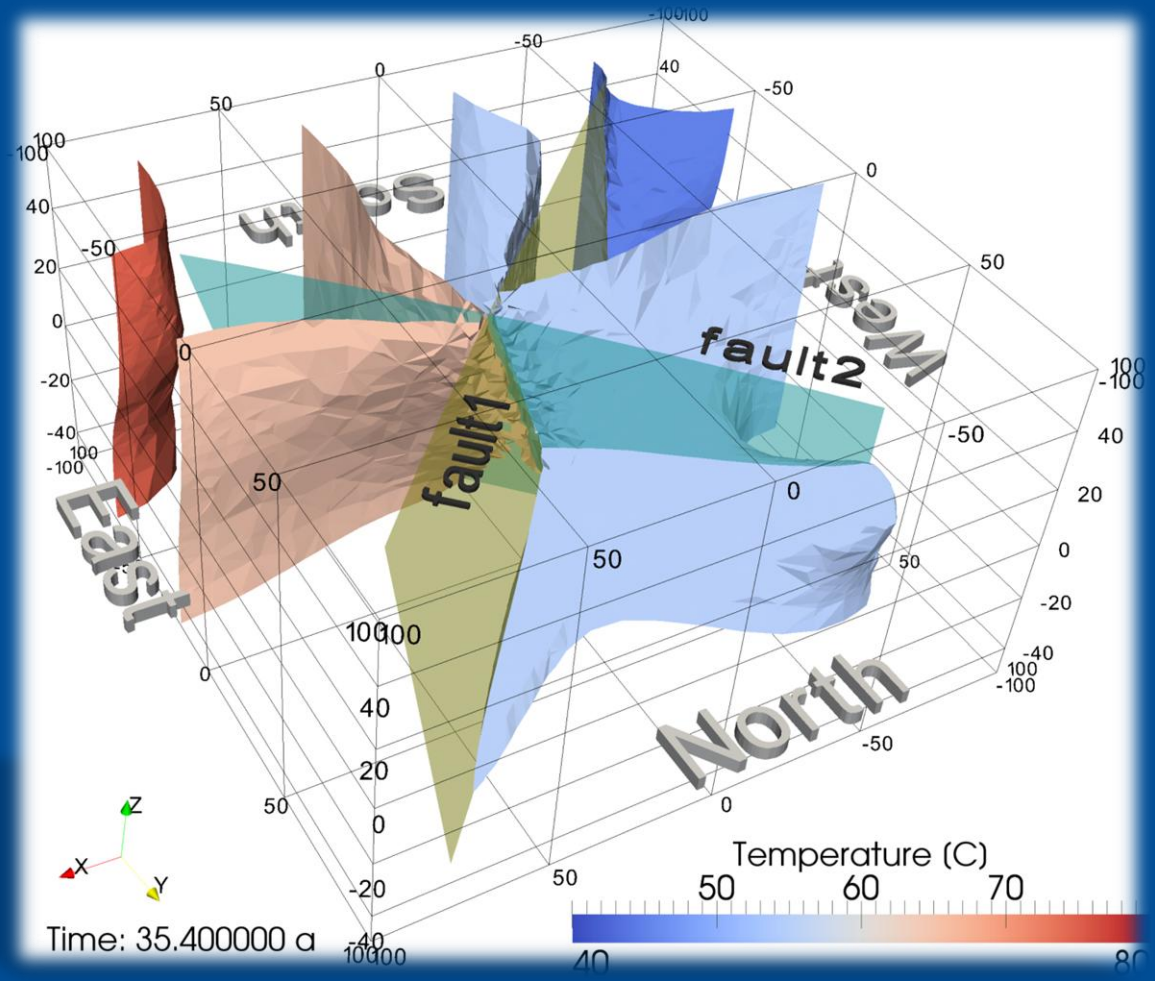
Results: T-t evolution

Advection → cold water propagating along the fault plane



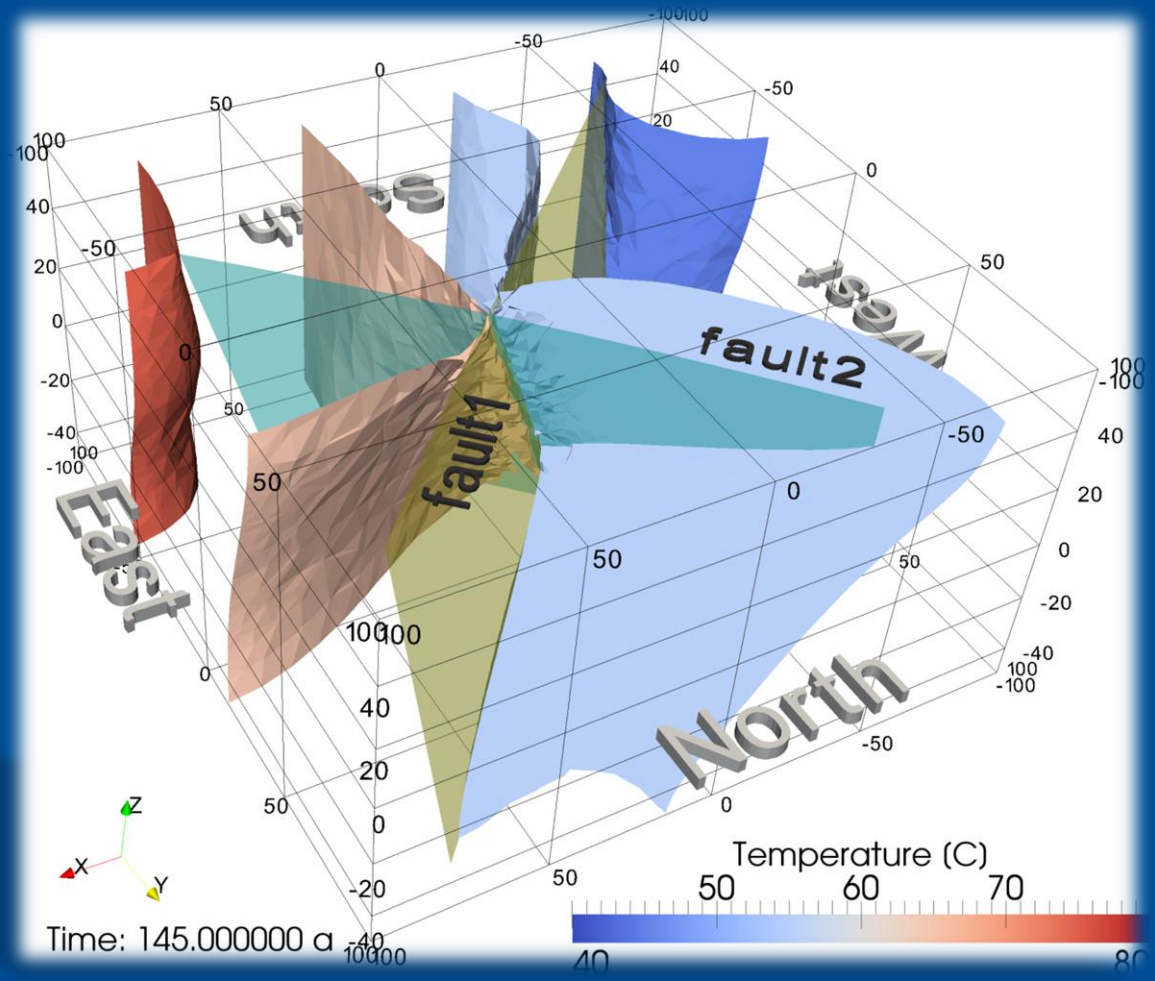
Results: T-t evolution

Both water front mixing at the faults intersection point



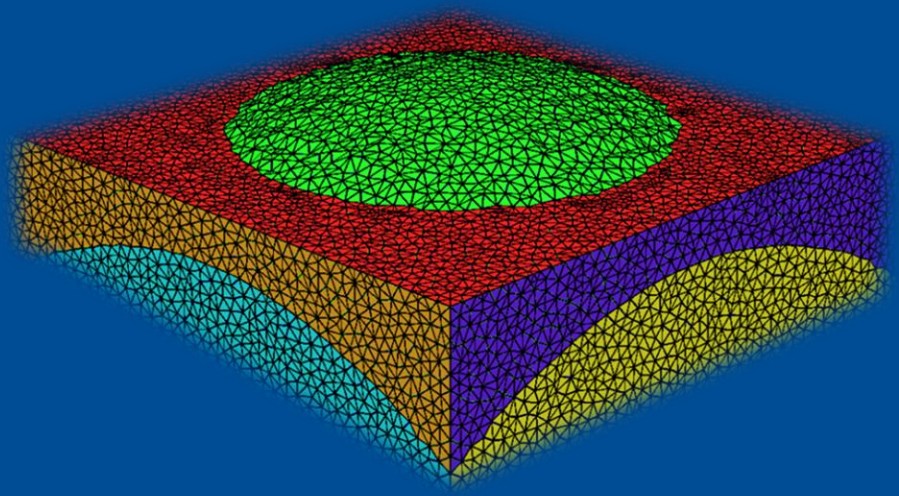
Results: T-t evolution

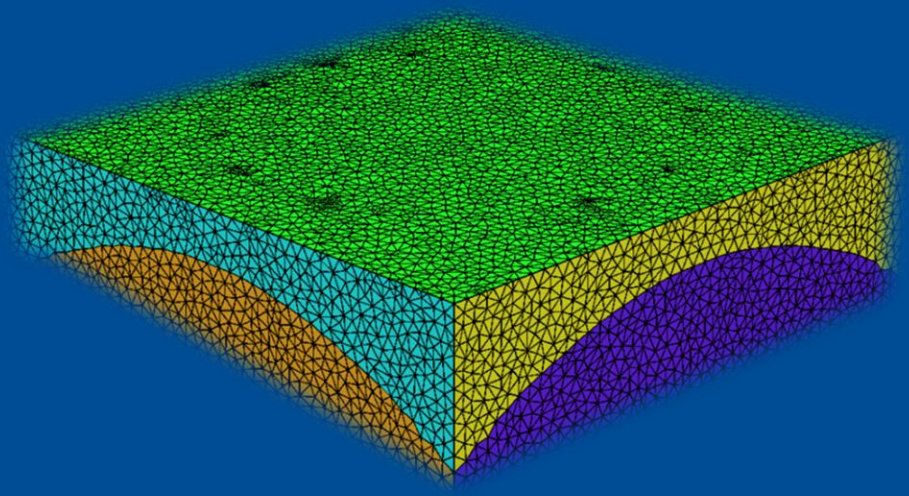
Regional cooling due to fault permeability contrasts



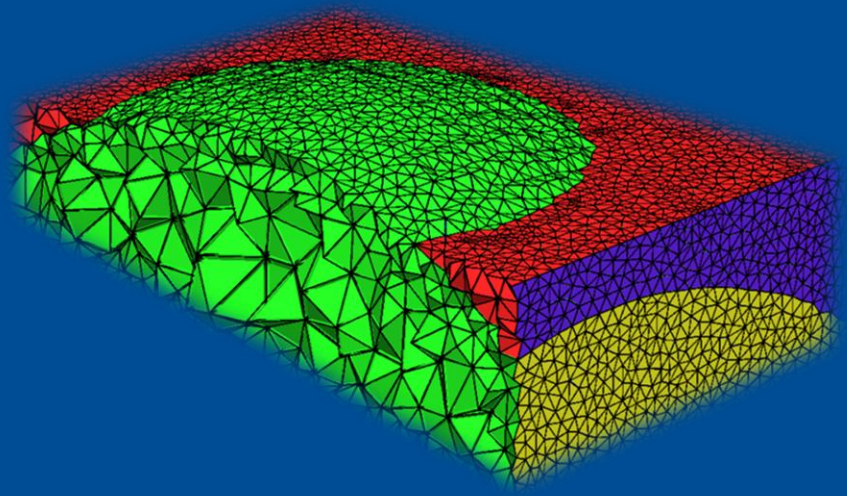
Results: T-t evolution

Geological unconformities

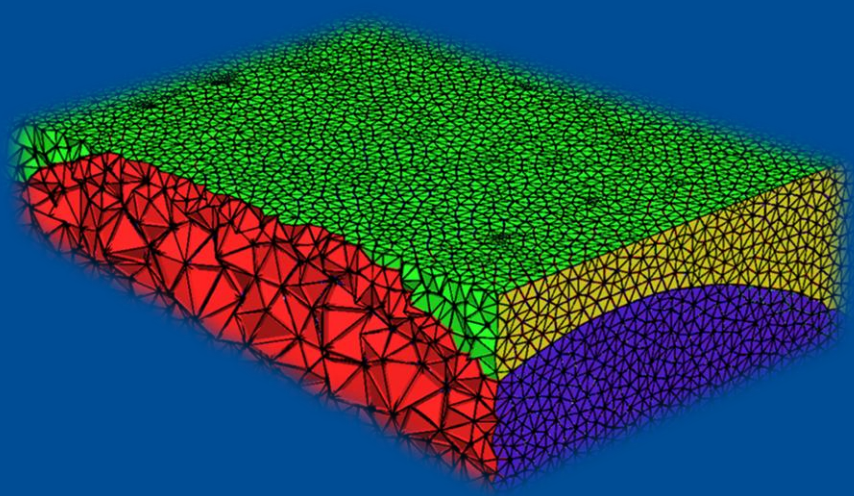




Salt tectonics



Erosional



Other applications