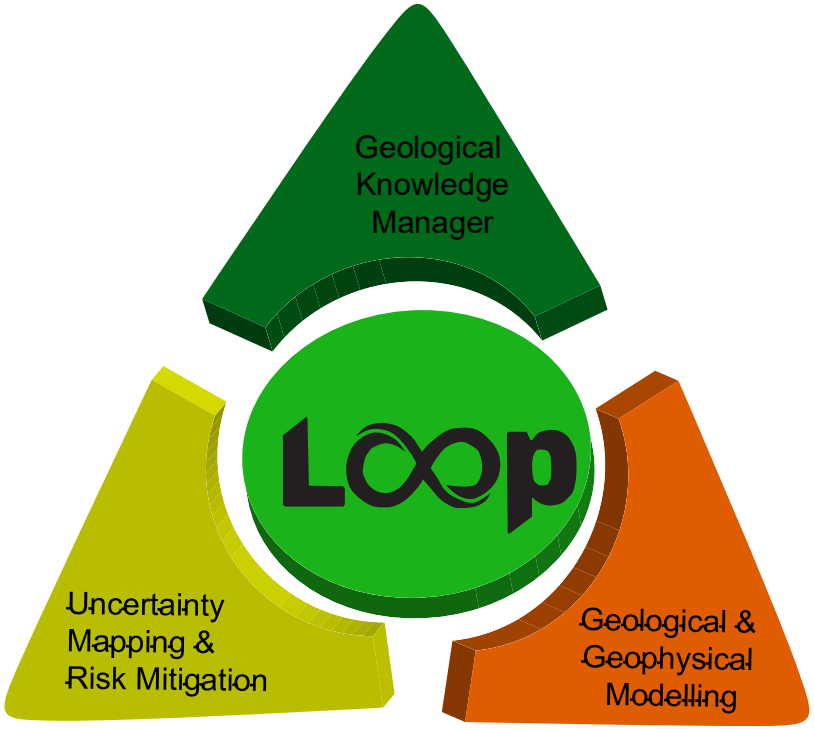
An integrated and interoperable platform enabling 3D stochastic geological modelling

The Loop Project - Overview

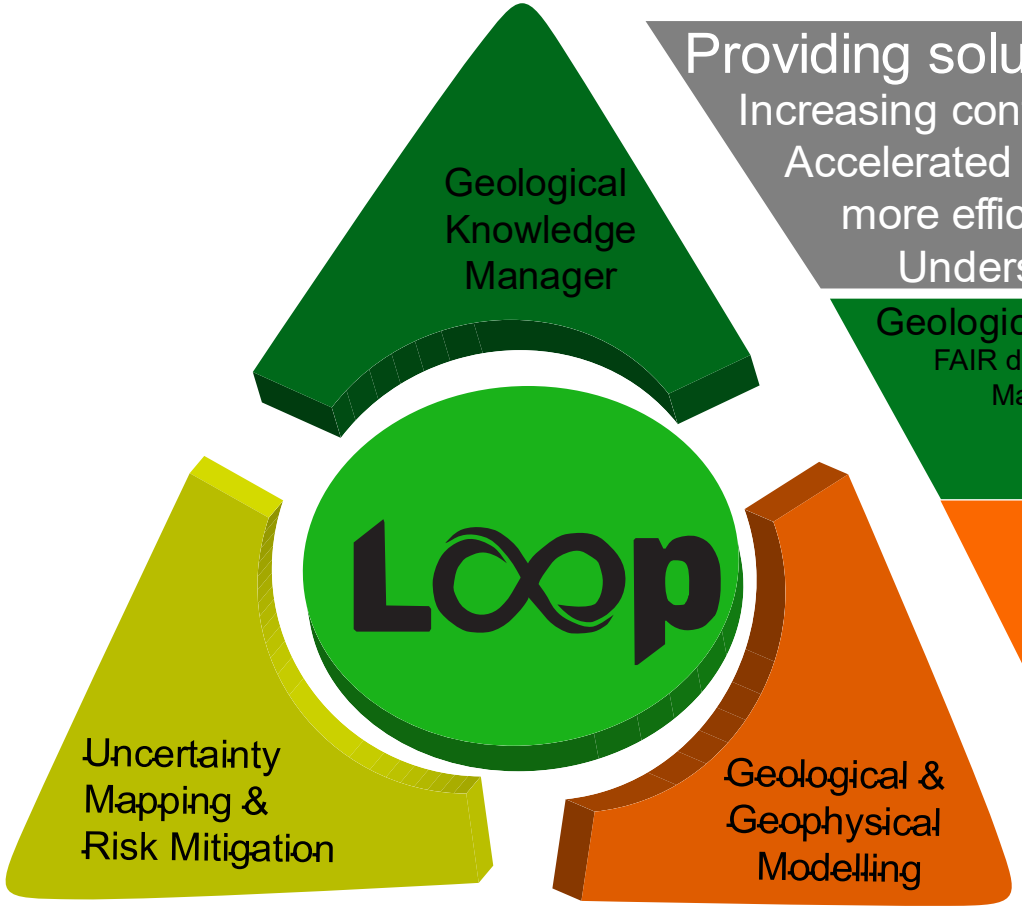
Presented by: Laurent Aillères, Lachlan Grose, Mark Jessell, Noelle Cheng, Guillaume Pirot, Angela Rodrigues, Rabii Chaarani, Vitaly Ogarko, Jeremie Giraud, Michel Nzikou

for and on behalf of the entire Loop development team



Providing geoscience data globally

An integrated and interoperable platform enabling 3D stochastic geological modelling



Providing solutions for subsurface resources management:

Increasing confidence in subsurface resources & materials management

Accelerated decision making and testing (the ability to make quicker, more efficient decisions and to test them early)

Understanding and reducing risk in resources management

Geological Knowledge Manager

FAIR data / FAIR software*

Map2loop: automated knowledge/data extraction from digital maps

Use more knowledge / use knowledge more

Encoding geological rules

3D Geological and Geophysical Modelling

Encoding structural geological rules

Developing new geologically and petrophysically constrained inversion methods

Developing joint geology/geophysics inversions

Uncertainty Mapping & Risk Mitigation

Geological simulations

Bayesian modelling

Value of information

Decision making enabler

* Findable, Accessible, Interoperable, Reusable

Open-source is the future

github.com/Loop3D/

Lead-CI

Dr Laurent Ailleres

Monash University

Loopers? Who are we?

R & D providers

MONASH University

THE UNIVERSITY OF WESTERN AUSTRALIA — Centre for EXPLORATION TARGETING

Australian Government
Geoscience Australia

CANADA 1842 — Geological Survey - Commission Géologique

British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

Partners

Université d'Orléans — Earth Sciences Institute of Orléans — ISTO

RING — Université de Lorraine

USGS — science for a changing world

RWTH AACHEN UNIVERSITY

VICTORIA — State Government

Funding

Australian Government
Australian Research Council

Australian Government
Geoscience Australia

NSW Government — Regional NSW

Tasmanian Government

NORTHERN TERRITORY GOVERNMENT

Government of Western Australia
Department of Mines and Petroleum

Queensland Government
Business Queensland

Government of South Australia
Department of State Development

SOUTH AUSTRALIA

MinEx CRC

AngloAmerican

100 YEARS

BHP

Government of Western Australia
Department of Mines and Petroleum

AuScope

NORTHERN TERRITORY GOVERNMENT

CSIRO

Australian Government
Geoscience Australia

Government of Western Australia
Department of Mines and Petroleum

Data / case studies

Government of Western Australia
Department of Mines and Petroleum

CSIRO

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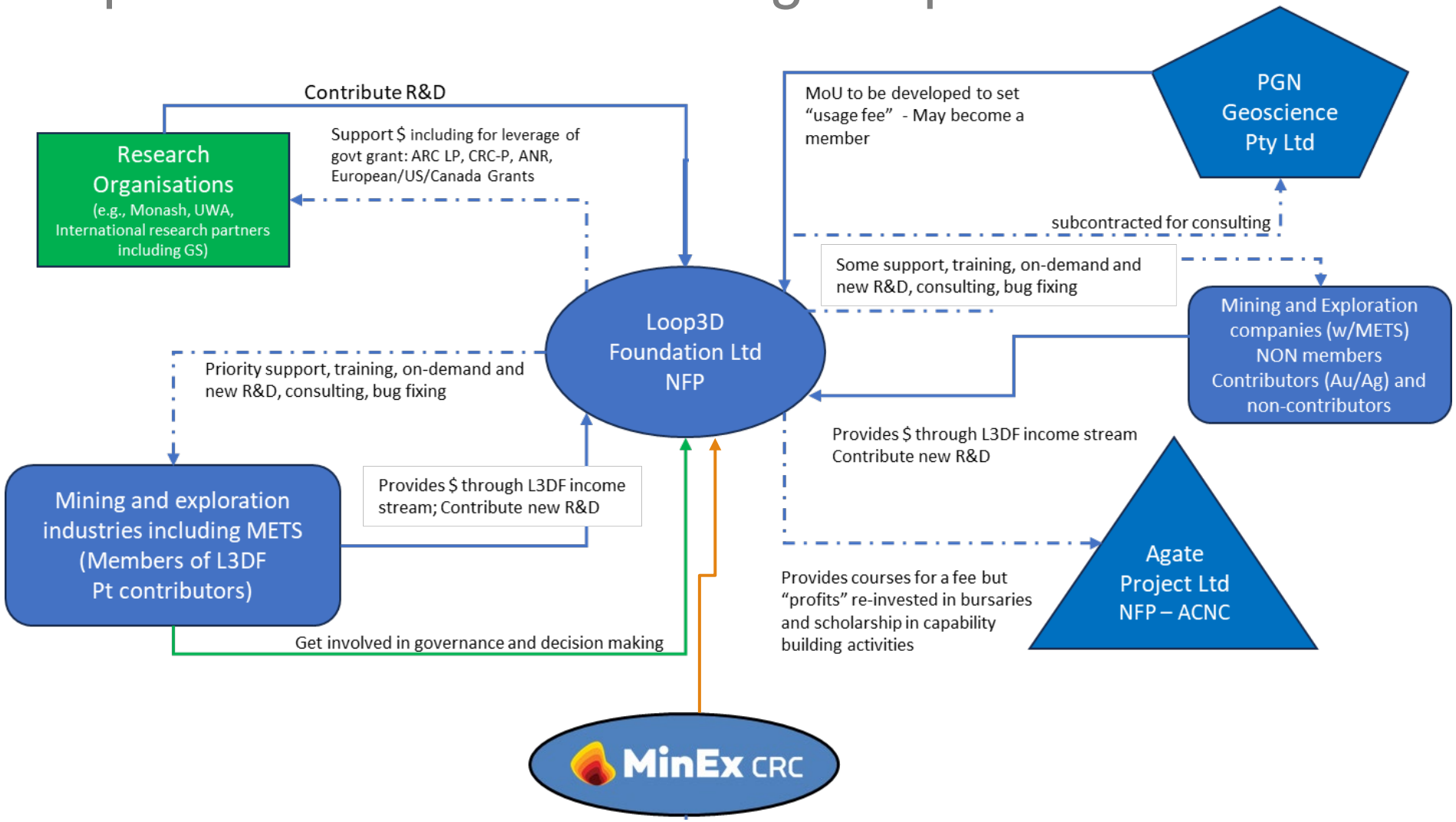
Loop

Loop3D Foundation – Making Loop R&D sustainable

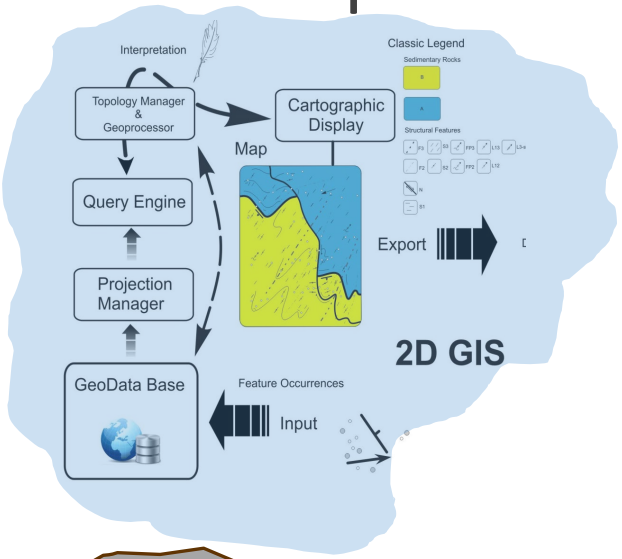


a NFP public company

Loop3D Foundation – purpose (constitution extract)

- The company's object is to pursue the following purpose(s) which may be charitable in nature:
- (a) to research, develop, maintain, and administer software that concerns 3D geological (sub-surface) modelling (software);
- (b) to make the software freely and widely available via a general use license or other appropriate means;
- (c) to support and administer the software and/or its use as part of a 3D probabilistic geological and geophysical modelling platform;
- (d) to provide solutions for subsurface resources management including via use of the software and/or associated platform;
- (e) to advance the natural environment through educating and/or promoting the education of the community about geological resources and related issues;
- (f) to research, maintain, develop, review, collaborate and contribute knowledge concerning any or all of these purposes;
- (g) to provide formal or informal training and supervision concerning the software and/or the platform or the research and application thereof, and grant or facilitate prizes, scholarships and/or funding in respect of such training;
- (h) to provide services (commercial or otherwise) concerning the software and/or the platform, including training, consulting, and tailored application requirements; and
- (i) to support members in connection with any of the above purposes

Loop modelling workflow

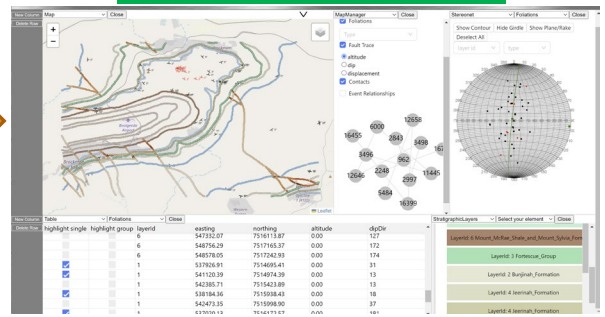


Tomofast-x

Map Analytics

map2loop

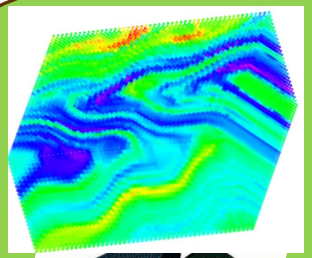
Augmented Data



LoopStructural

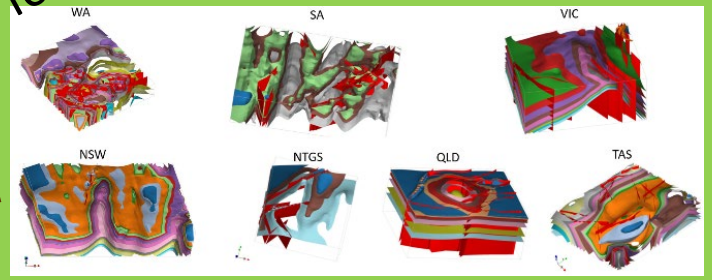
Structurally ruled 3D modelling

Tomofast-x



LoopResources

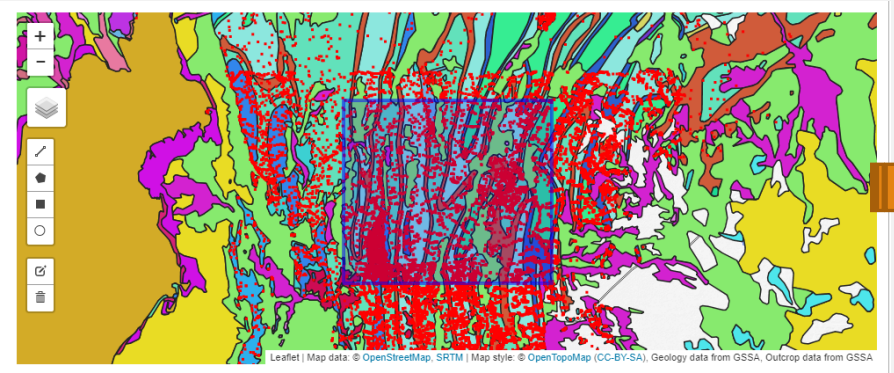
LoopMeshing



Export to numerical simulations packages: Underworld; Modflow; Stress modelling; …

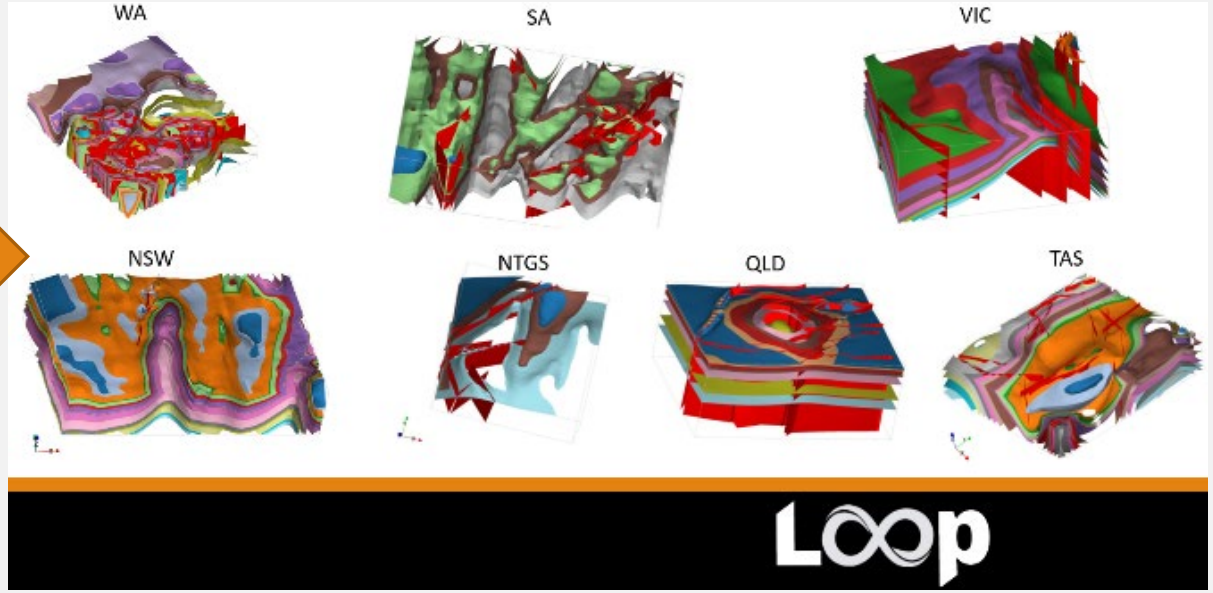
Automation of Geological Digital Twin(s)

Automated 3D model creation with the link: map2loop -> LoopStructural



Data served by Geological Surveys in Australia

m2l analysis and data augmentation



EGU European Geosciences Union **Geoscientific Model Development**

Special issue

The Loop 3D stochastic geological modelling platform – development and applications

Editor(s): GMD topical editors | Coordinator: Laurent Ailleres

LoopStructural models calculated in a few minutes (inc. map2loop and loopstructural time) on a "normal" laptop

E.g. Flinders ranges: 10K+ orientation data points; overall time ~11 minutes (Dell Inspiron 15).

Loop

Loop user interface

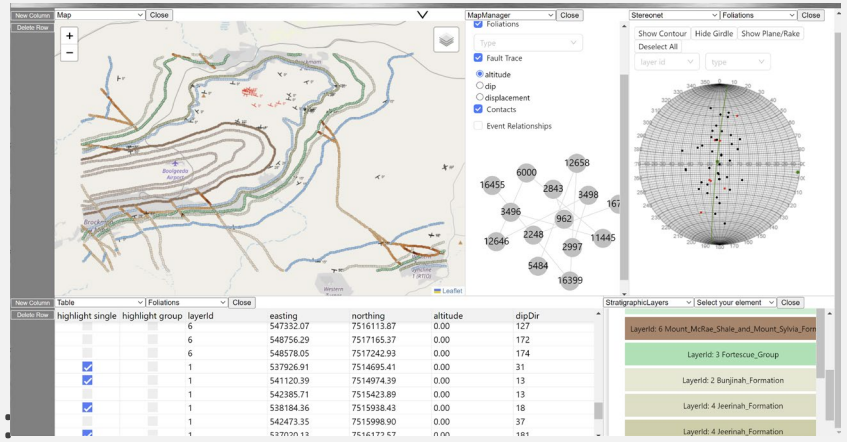
Notebook and raw python coding

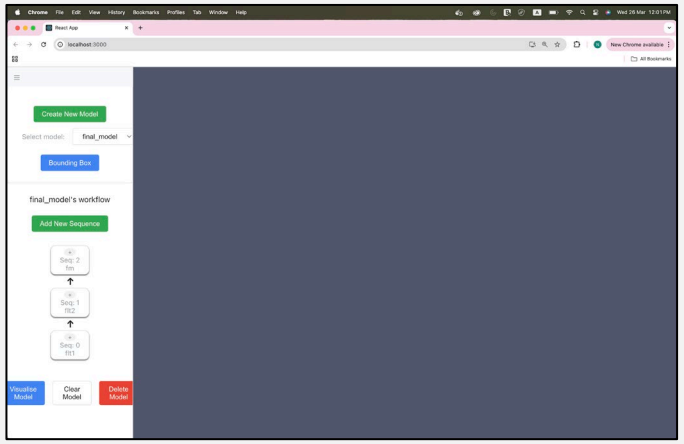
WebApps:

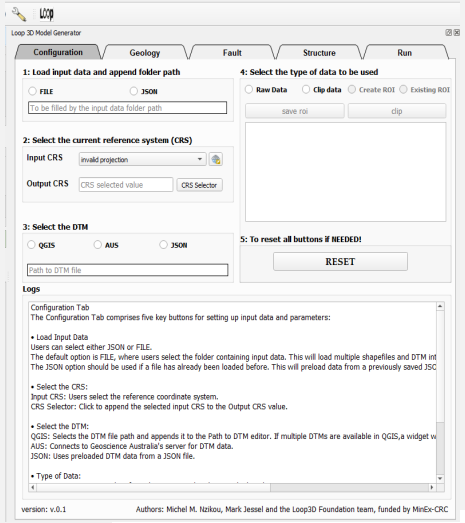
- Visualisation of map2loop outputs
- LoopStructural modelling

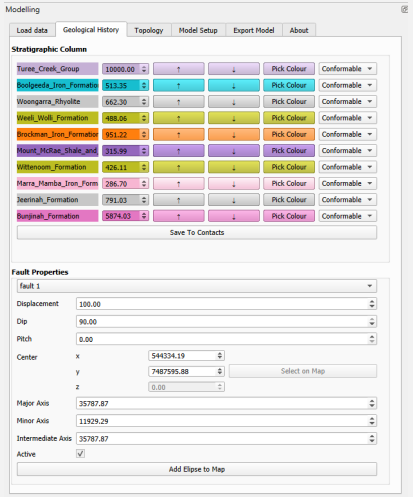
QGIS plug-ins:For example, at the mine scale:

- Map2loop plugin
- LoopStructural plugin

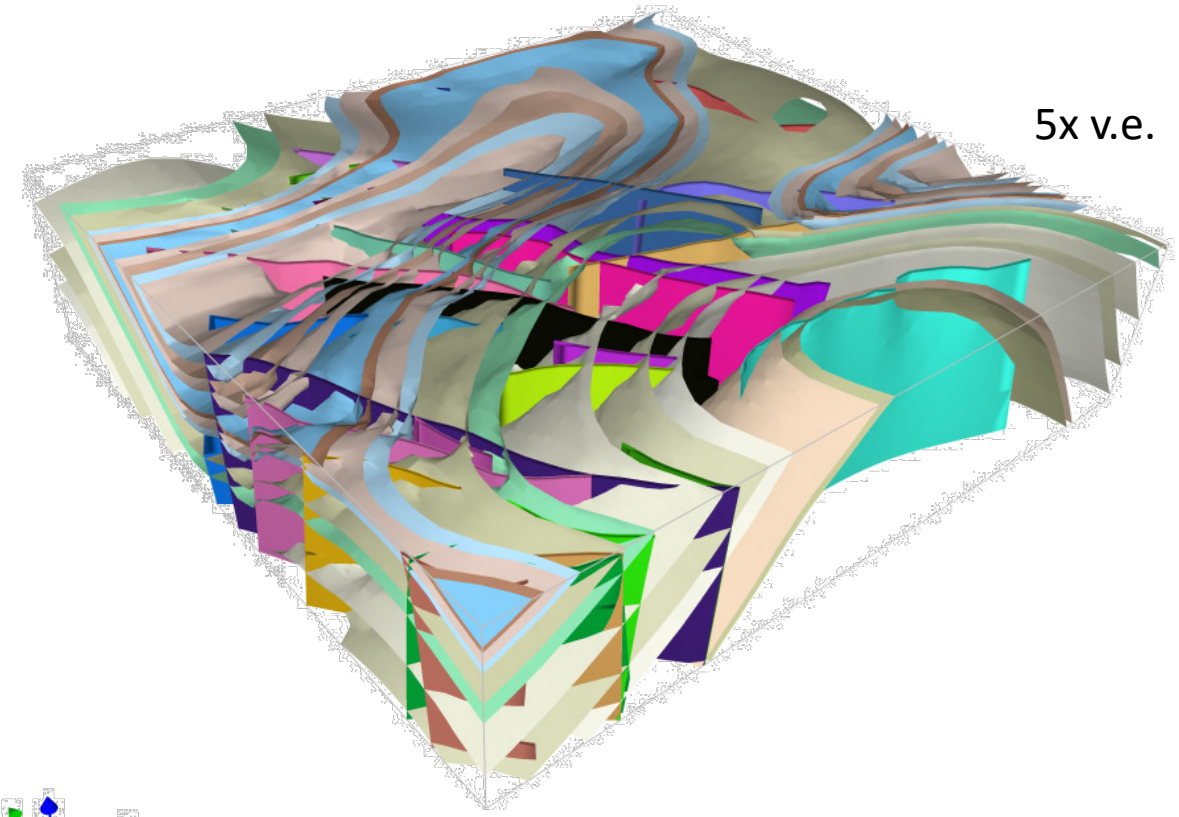




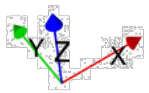




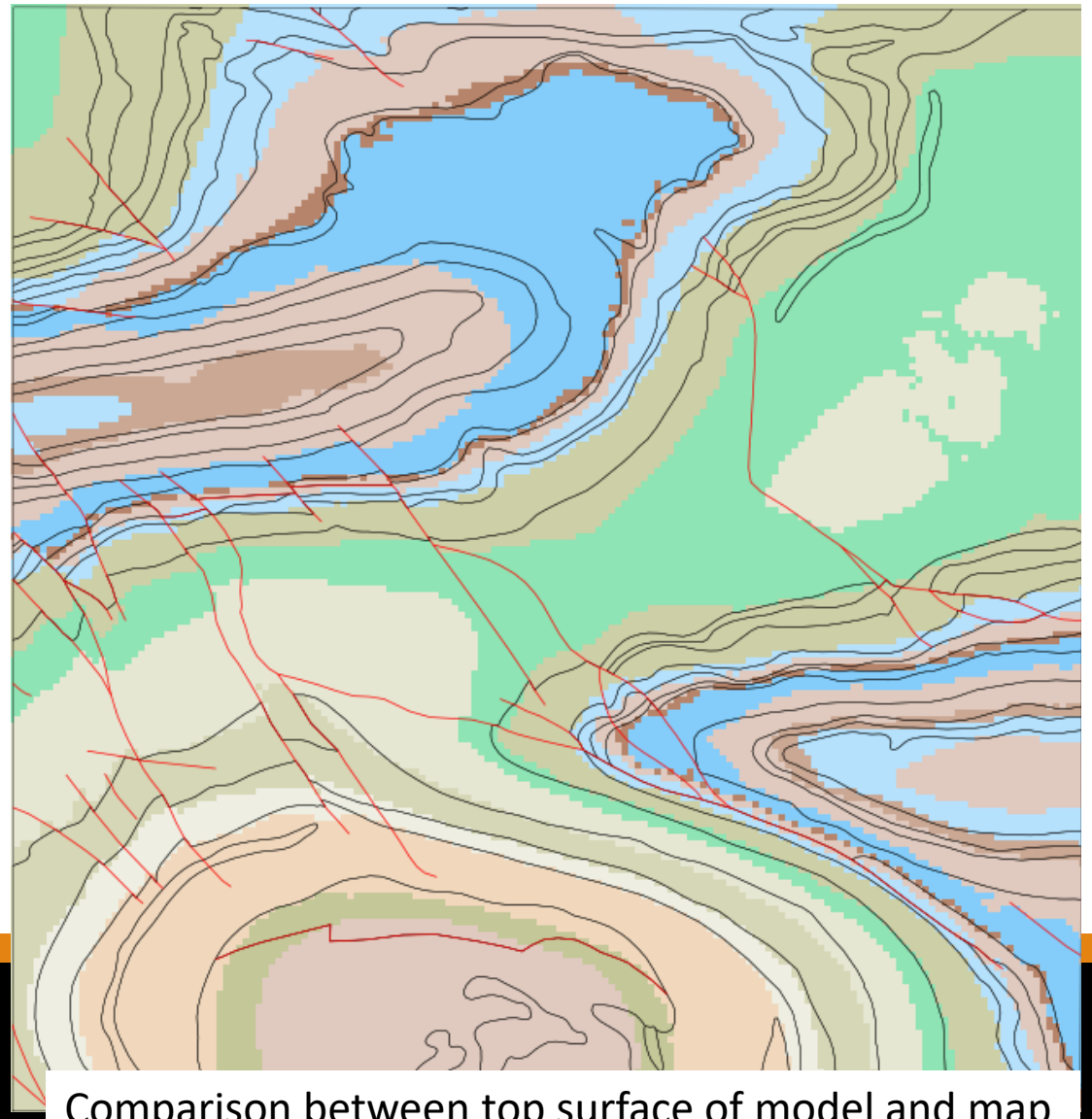
3D modelling LoopStructural



5x v.e.

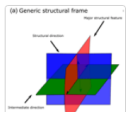


~15 minutes from raw data
(6 mins *map2loop*, 9 mins *LoopStructural*)



Comparison between top surface of model and map

LoopStructural 1.0: time-aware geological modelling



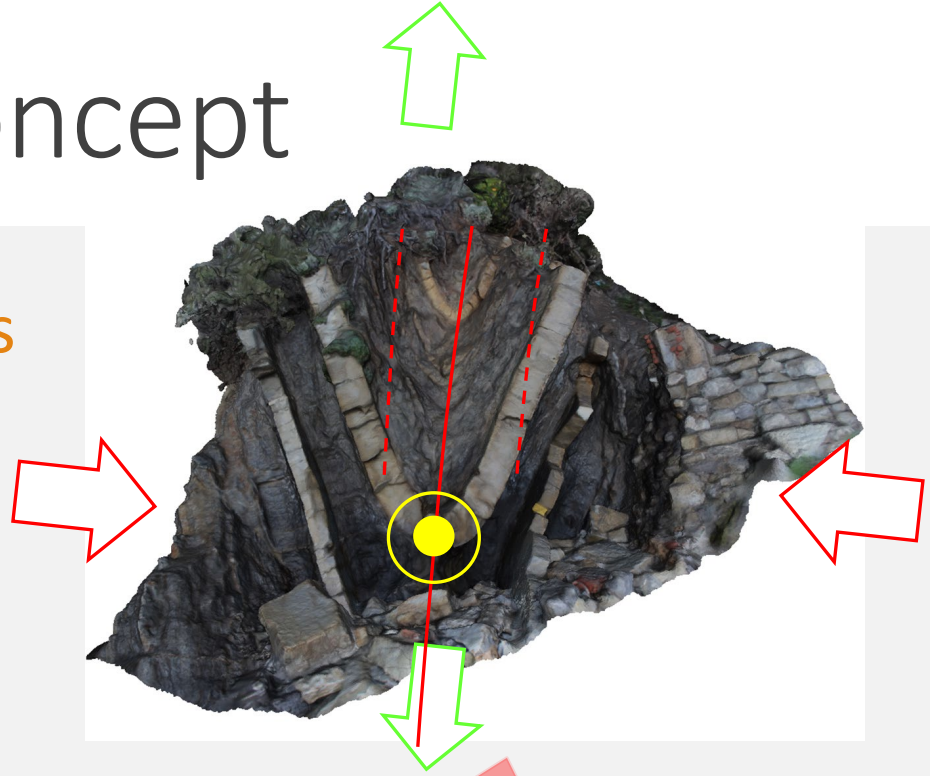
Lachlan Grose[1], Laurent Ailleres[1], Gautier Laurent[2], and Mark Jessell[3]

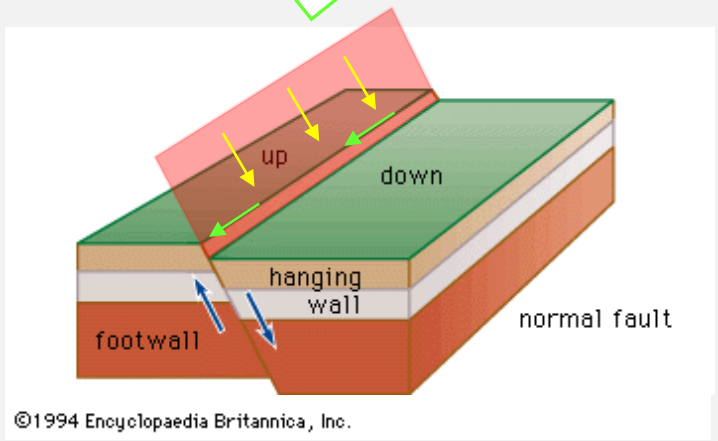
Geosci. Model Dev., 14, 3915–3937, 2021
https://doi.org/10.5194/gmd-14-3915-2021

The Structural Frame concept

Three coordinates – three scalar fields

1. **Major structural feature**
   - fault surface
   - fold axial surface
   - intrusion major axis
2. **Structural direction**
   - fault slip direction
   - fold axis
   - intrusion flow direction
3. **Additional direction (if required)**
   - Fault , e.g. fault extent





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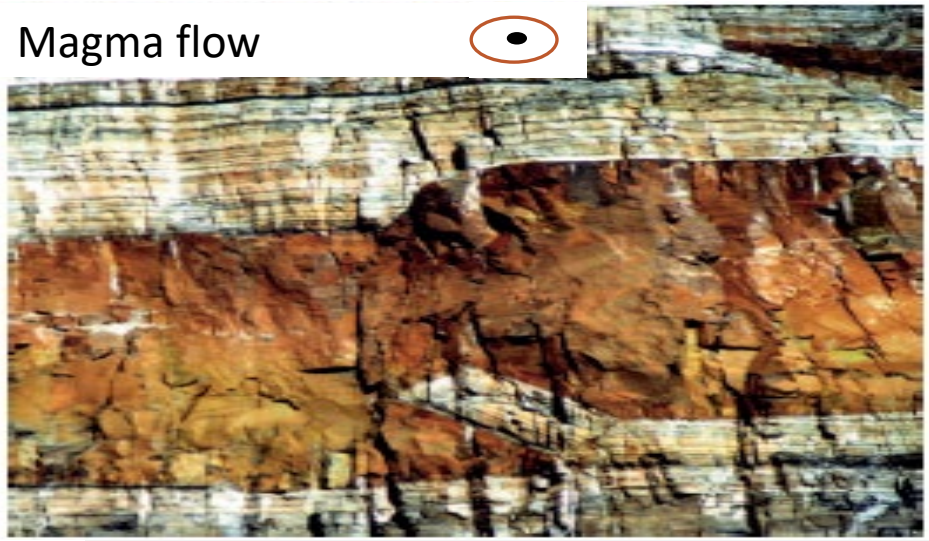
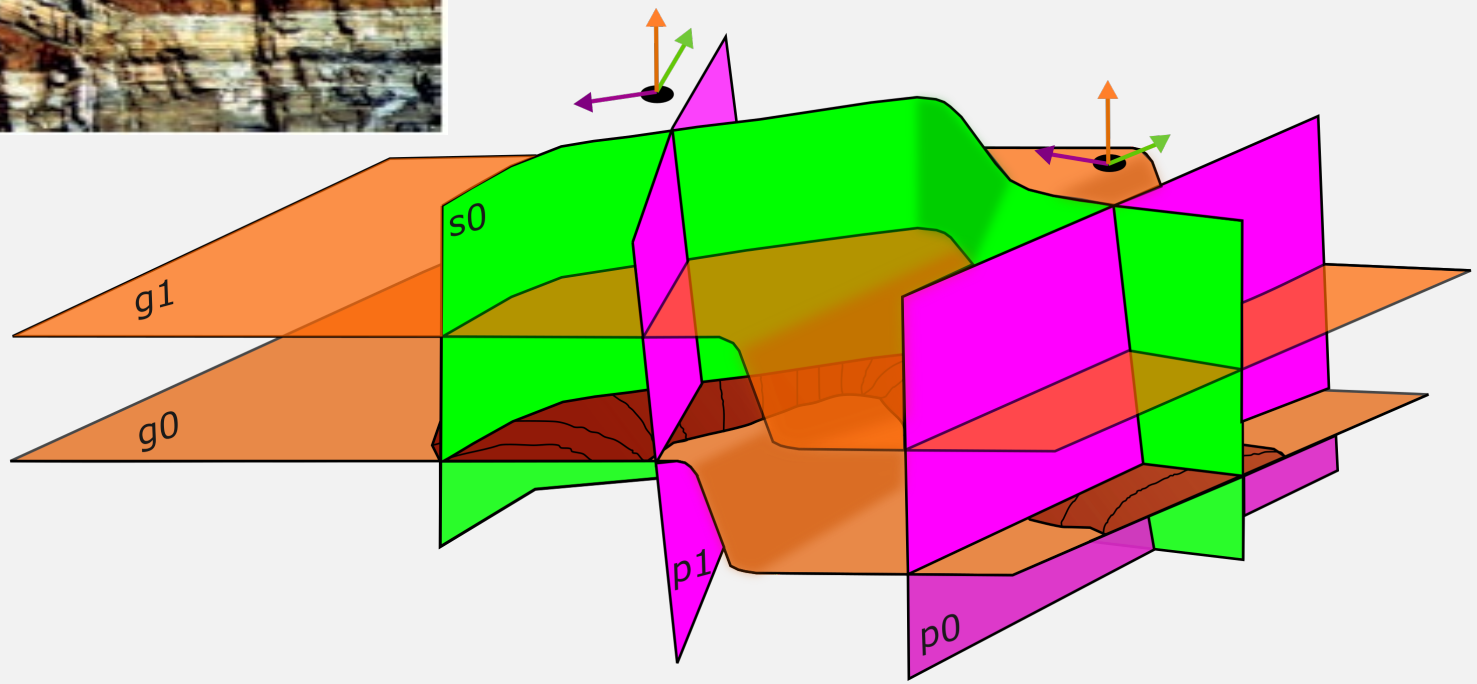
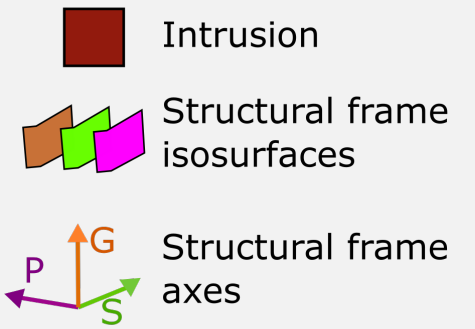
Intrusion Structural Frame



Step geometry, sill (Hutton, 2009)



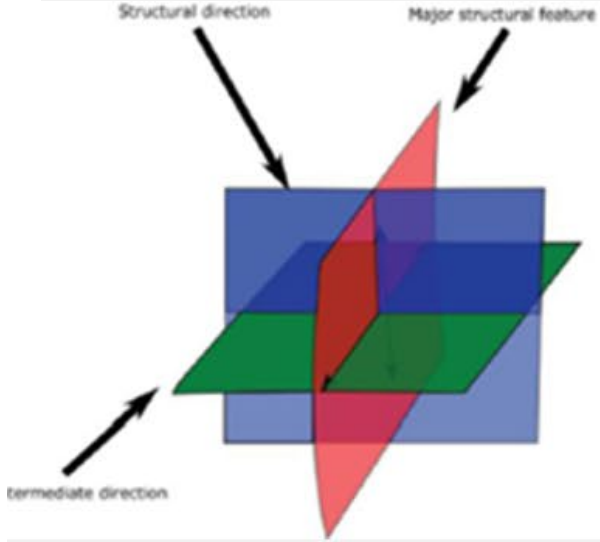


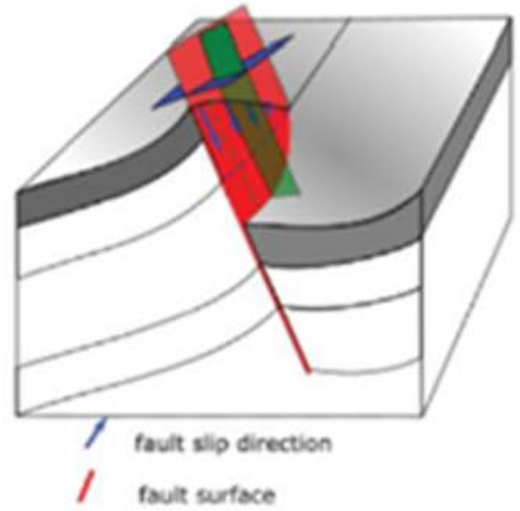
Fernanda Alvarado-Neves (PhD candidate, Monash University

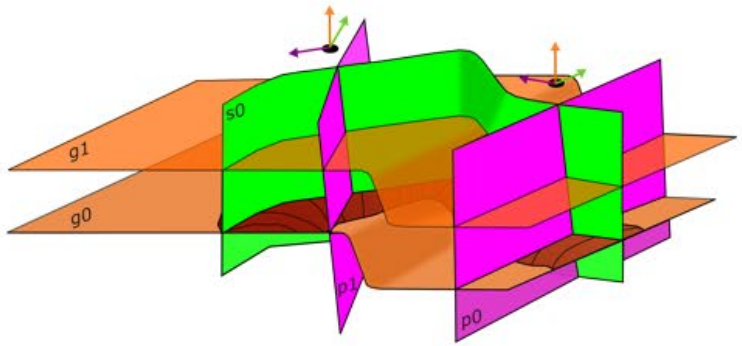
LoopResources Reducing the Mining Footprint

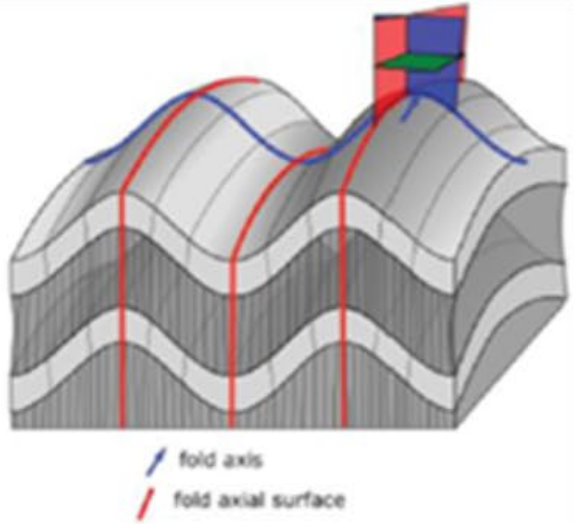
- an automated, reproducible, update-able, workflow to model geology based on structural geological rules
- integration with geophysical modelling (early piecewise inversions or late level-set inversions)
- a characterisation of uncertainty that will guide further data acquisition (where and what)

AND a framework using structural frames to model ore body properties including: lithology, alteration, mineralogy, metallurgy, geotechnical parameters and grades



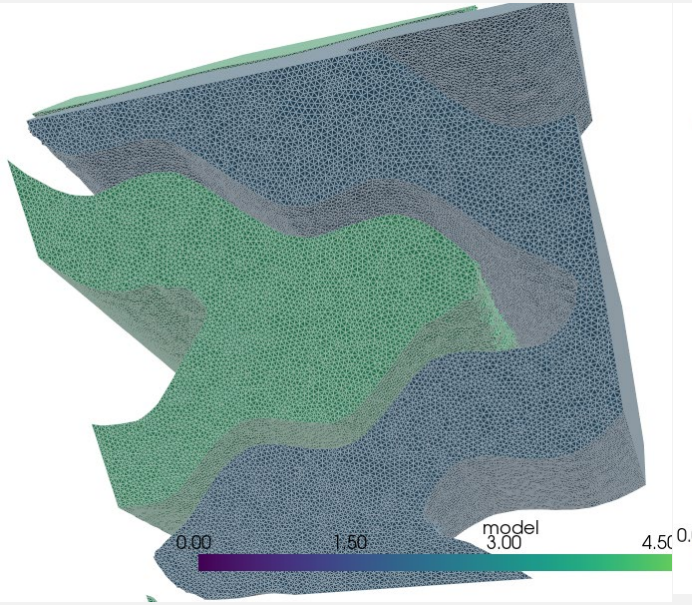


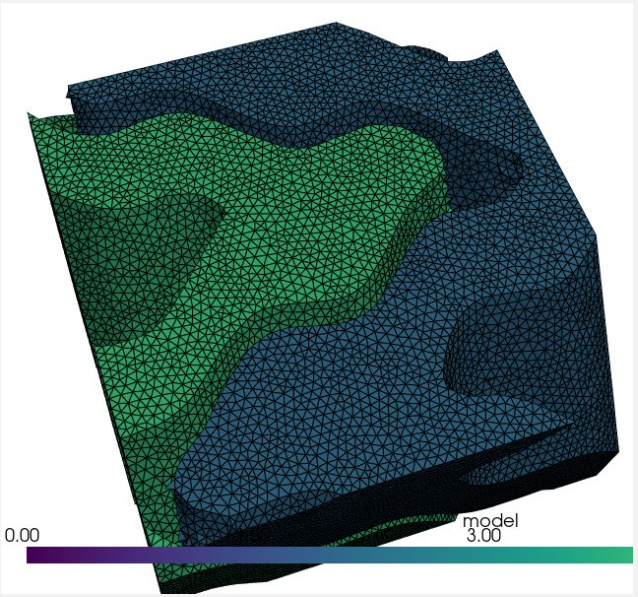




LoopResources Reducing the Mining Footprint

- The Loop Vision:
  - Create more realistic digital-twin of the geology at all scales
  - Help and optimise decision making related to managing our resources
  - For example, at the mine scale:
    - Optimise drilling from 1st intersection
    - Propagate and consider uncertainty throughout the modelling process, including property modelling
    - Increase recovery rate
    - Decrease the amount of resources needed to extract (less energy for less drilling, optimised crushing and processing chain, less water…) with enhanced 3D ore body modelling



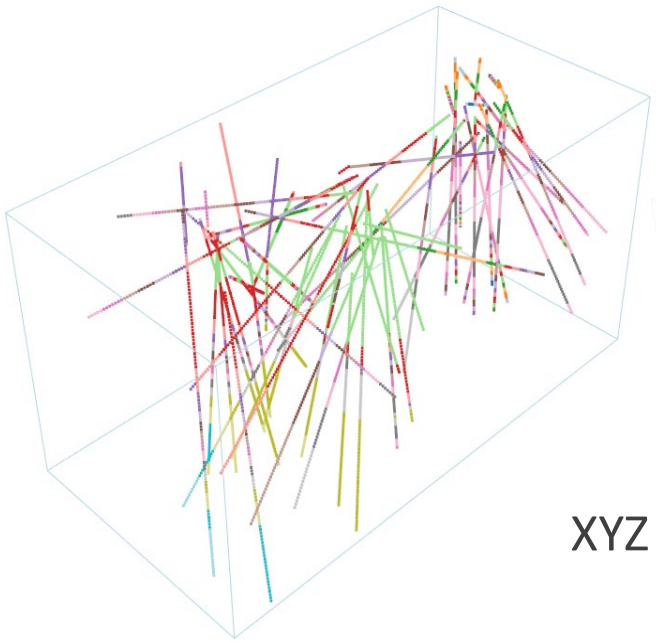


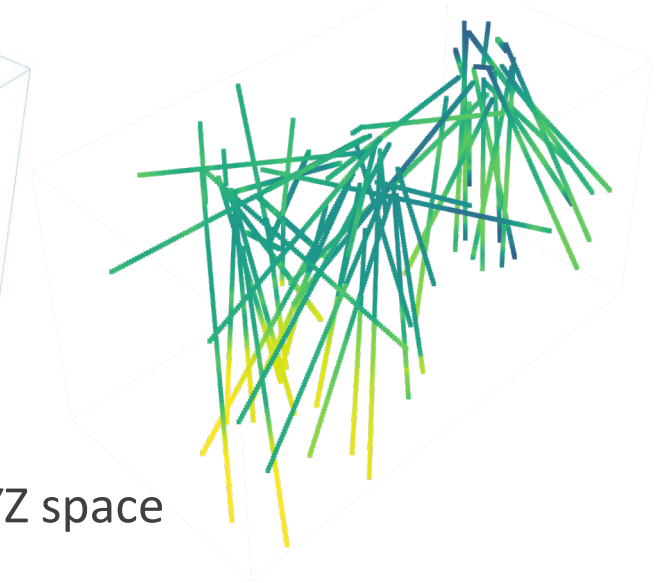
Optimising the extraction of resources for a greener tomorrow

LoopResources – structural frames clean geostatistics

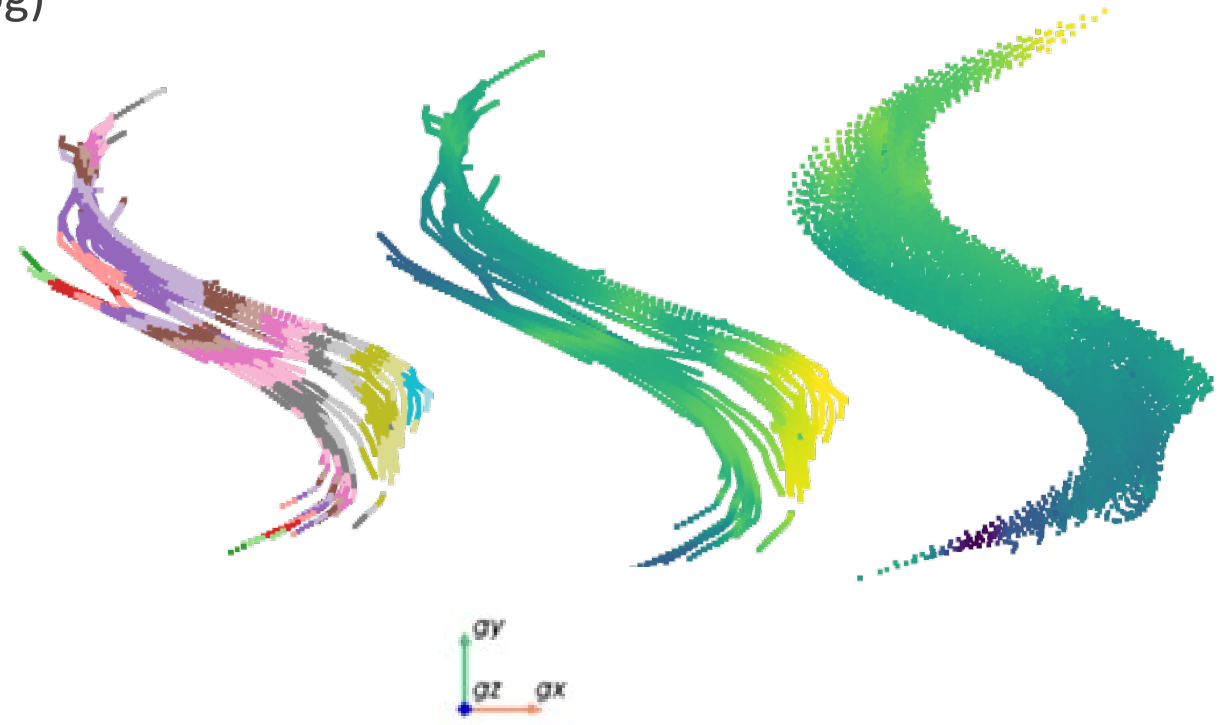
A. Lithology

B. Property observations (log)



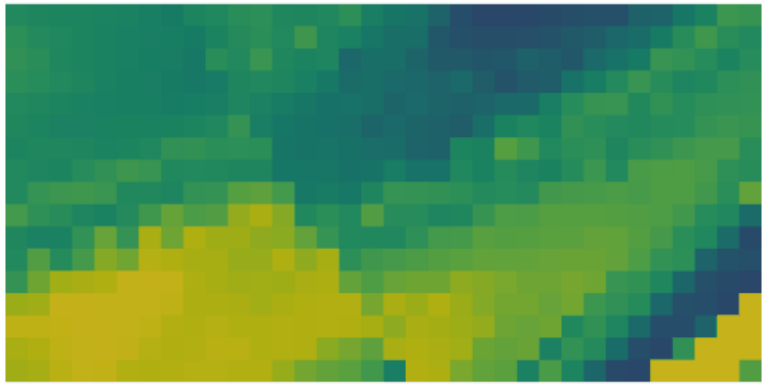


XYZ space

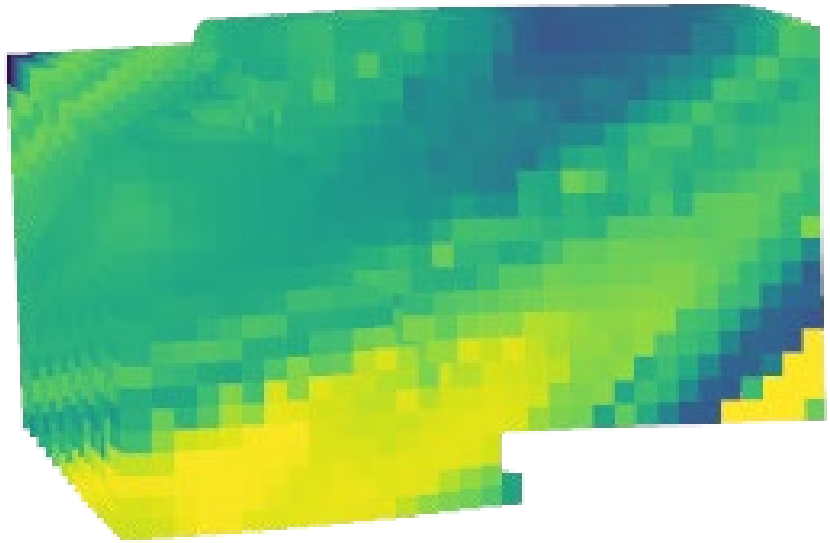


Resulting property field

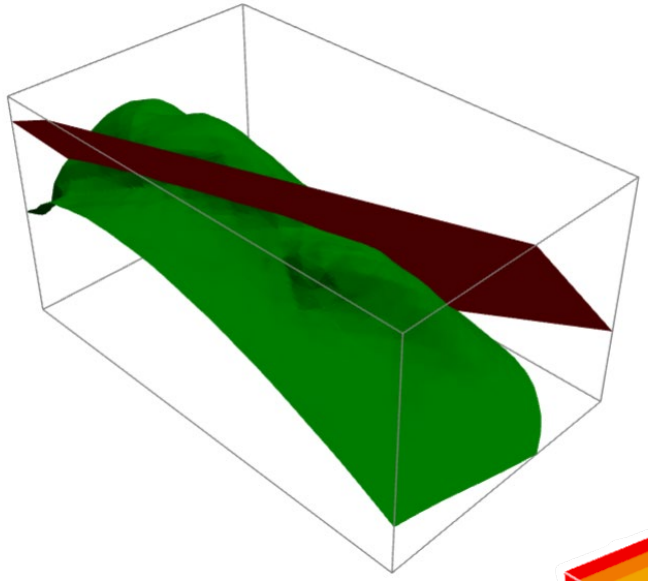
Property (logscale)

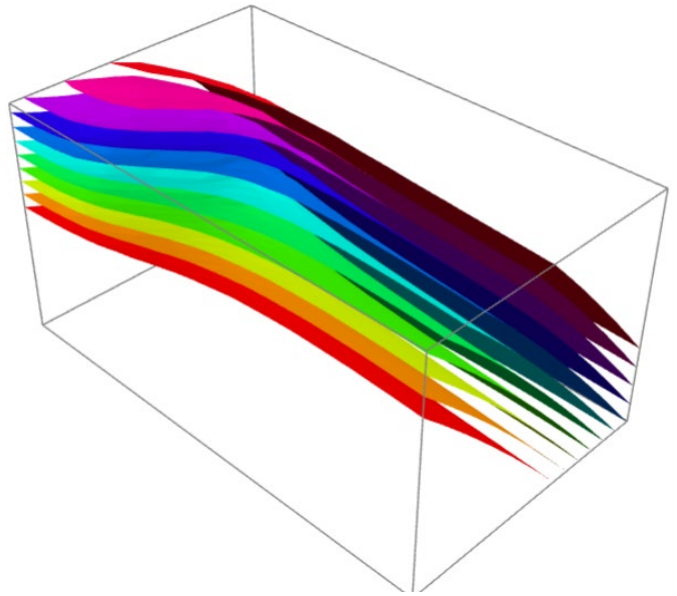


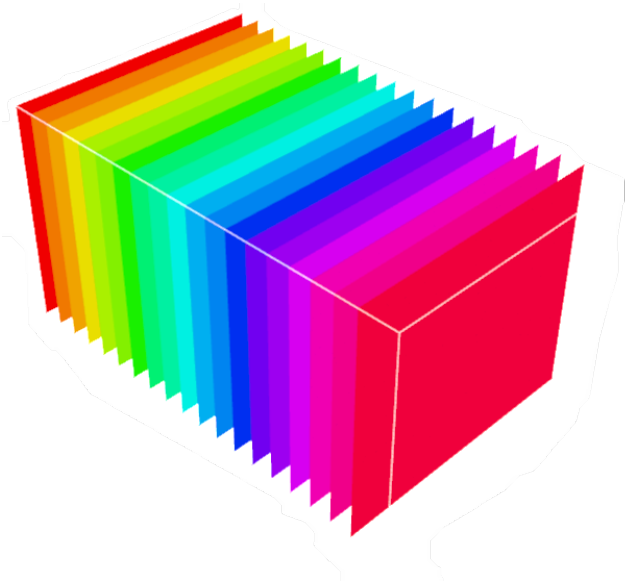
Property – restored space

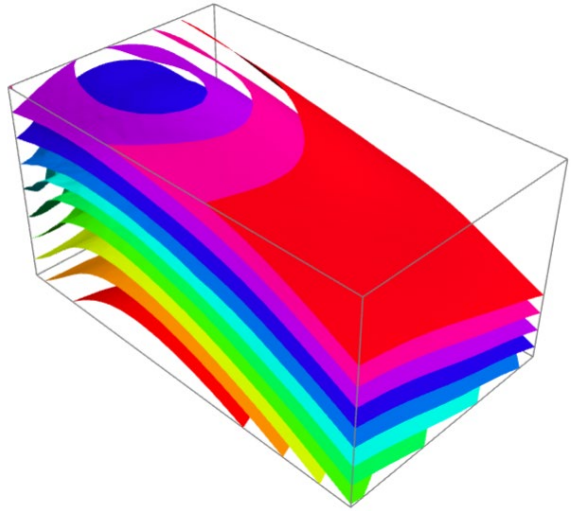


Structural frame

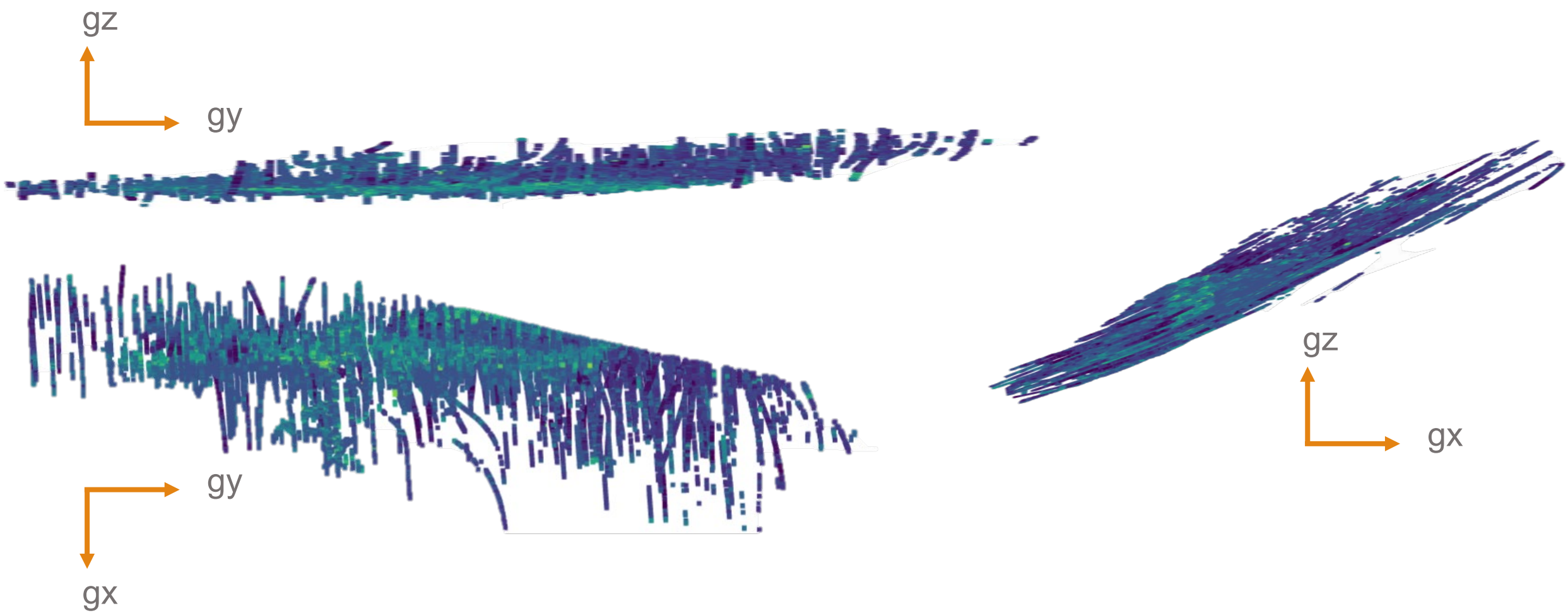


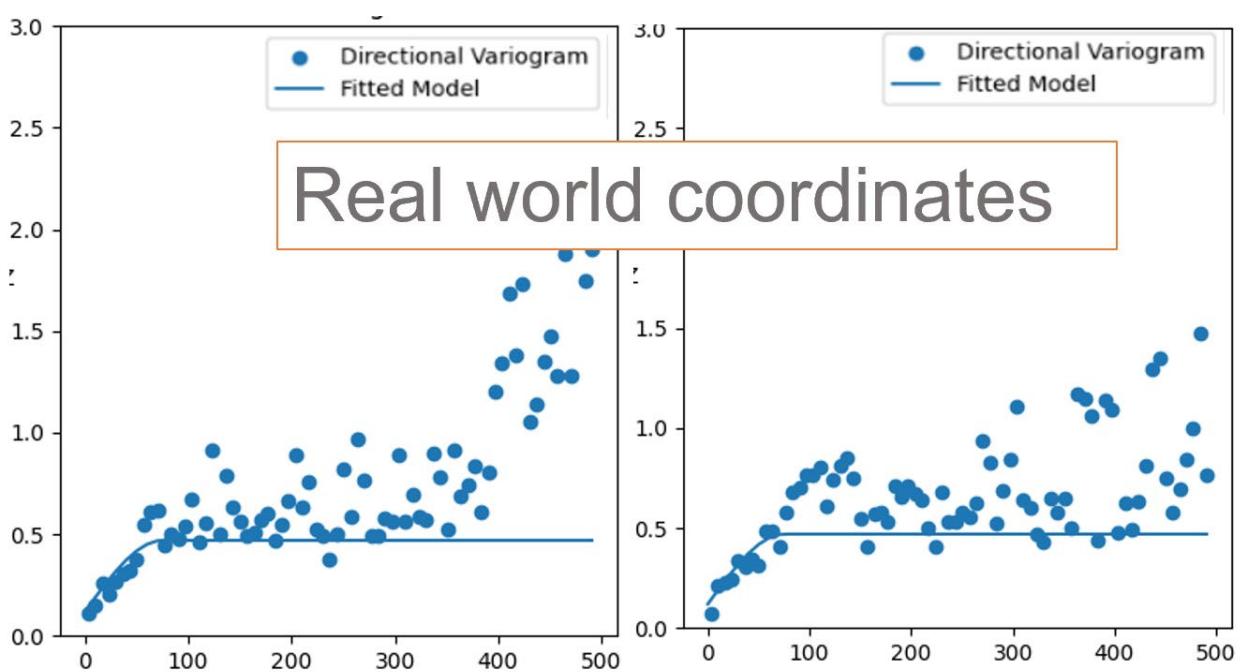




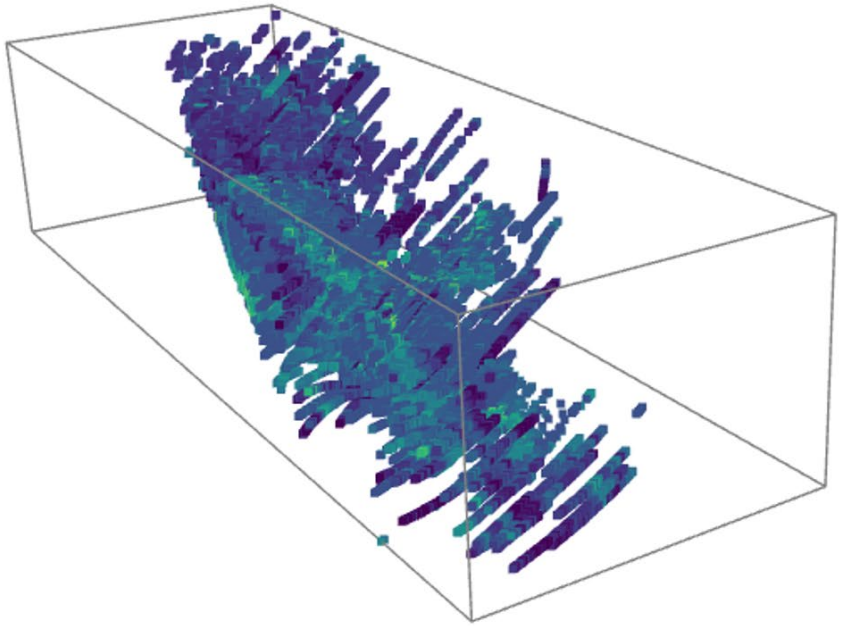


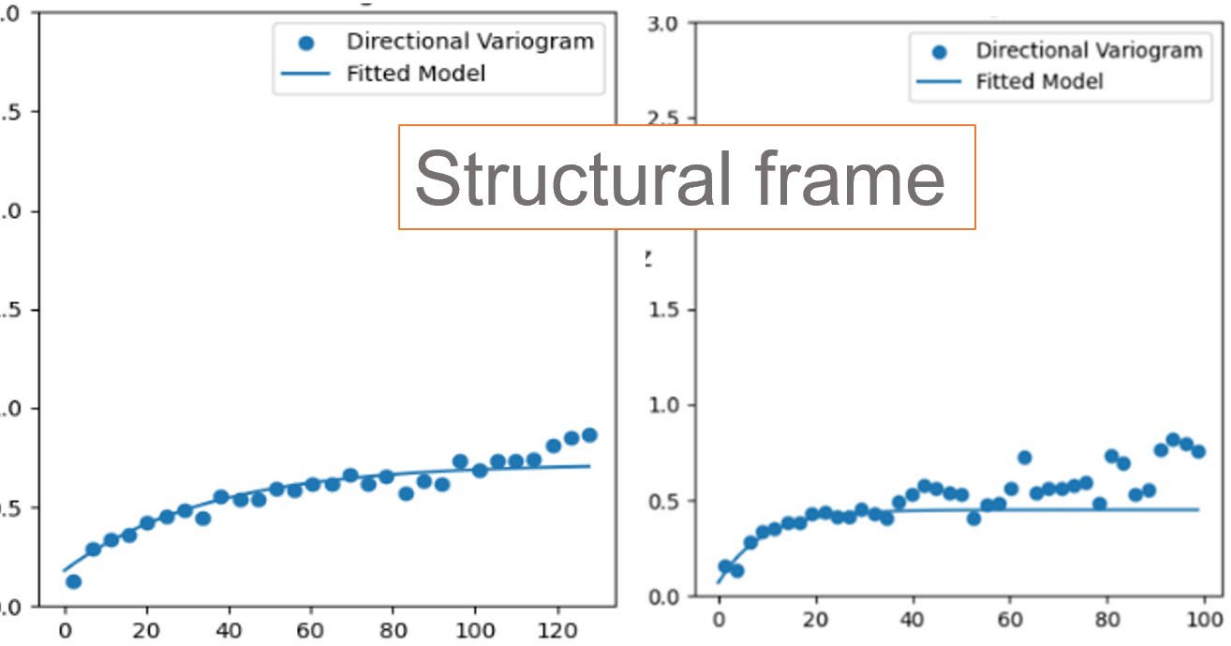
Semi-variogram in Structural frames vs XYZ space



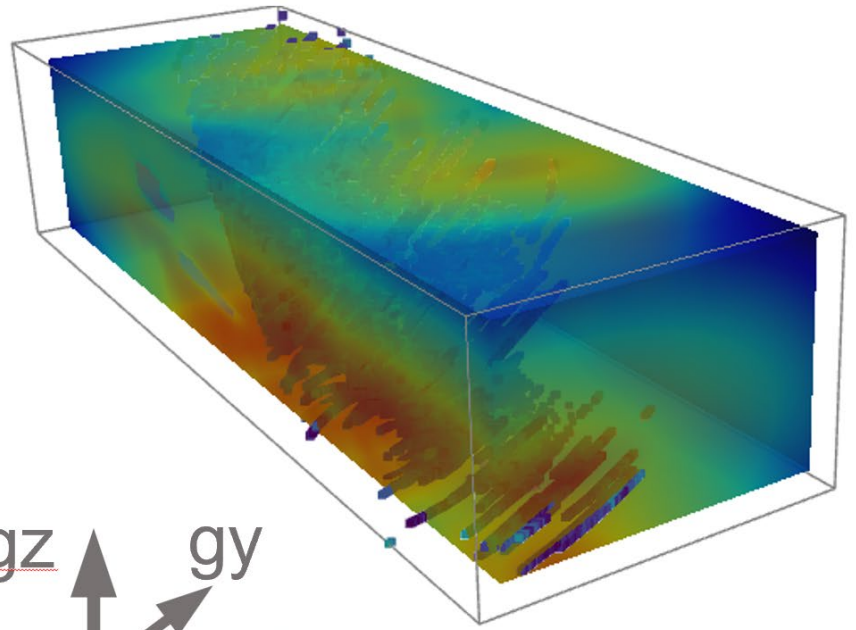


Real world coordinates





Structural frame



Panel Discussion

- Current use of 3D geological modelling? What do people actually do, why and to what end?
- Current limitations of 3D modelling, what are the potential solutions?
- How well do we integrate with geophysical modelling?
- Is the future of 3D modelling in AI? What would that look like?