An integrated and interoperable platform enabling 3D stochastic geological modelling

LoopStructural: 3D Geological Modeling for Structural Geologists

Lachlan Grose[1] on behalf of the Loop development team[12]
[1]School of Earth Atmosphere and Environment, Monash University
[2]Centre for exploration targeting, University of Western Australia

LoopStructural

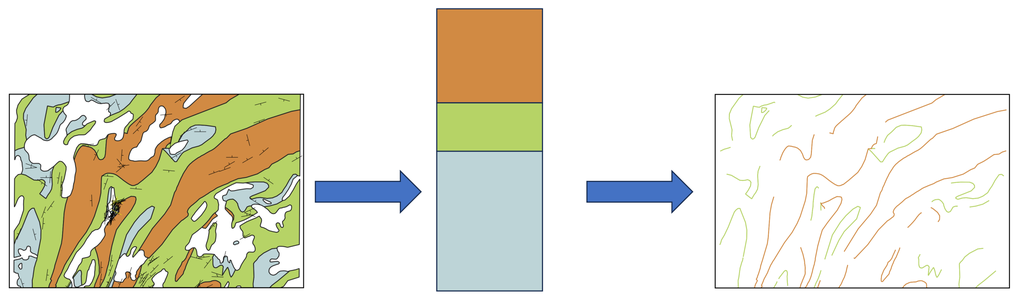
- **Multiple interpolation algorithms:** Uses discrete interpolation and data supported interpolation
- **Time aware:** Models are constructed incorporating the overprinting between different events (folding, faults, intrusion, unconformities)
- **Fault kinematics:** Kinematics are directly incorporated into model description e.g. displacement magnitude and slip direction
- **Fold overprinting:** Folds are modelled considering the tectonic foliations
- **Open-source & Extensible:** Built in Python, can be integrated into ML workflows and extended to solve boutique problems.

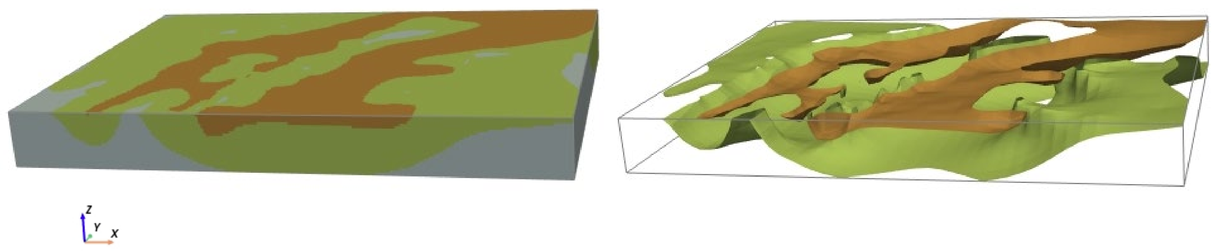
Open-source Community

Loop libraries are open source under an MIT license, meaning they are and always will be free to use. Open-source projects like rely on community contributions, whether through code development, bug fixes, documentation improvements, or financial support. Unlike proprietary software, open-source tools provide equal access to all users, ensuring that research and industry professionals can leverage advanced modeling techniques regardless of financial constraints. Sustaining development requires ongoing engagement—through volunteering time, funding initiatives, or citing the project in academic and industry work—to keep the library accessible and evolving for everyone.

Building a stratigraphic model

A LoopStructural models can be built from basal contacts, structural observations and a stratigraphic column. In the example below a subsection from the Flinders ranges is modelled using the GSSA data. Three groups (Wilpena Group, Umberatana Group and Burra Group) are modelled using only contact geometries and structural observations.





To improve this model additional constraints on the fold geometry could be added using LoopStructural by 1) additional constraints on the fold style by adding similar fold style, 2) adding fold profile constraints for constraining the shape of the fold.

LoopStructural in QGIS

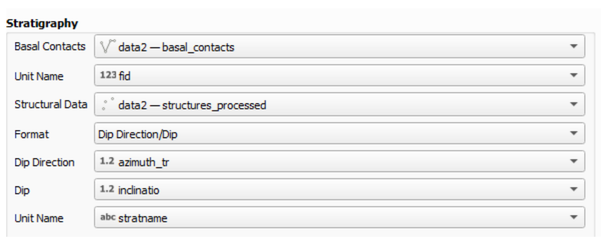
Newly developed QGIS plugin for local model building without Python code.

Model is defined by:

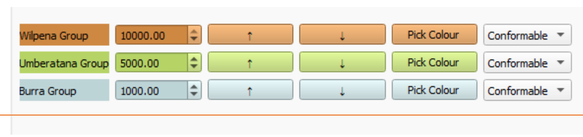
- Region of interest
- Digital terrane model
- Basal contacts
- Stratigraphic structural data
- Fault traces and kinematics
- Stratigraphic column

3D model can be viewed inside QGIS or exported into geoh5py, vtk or as a Python file.

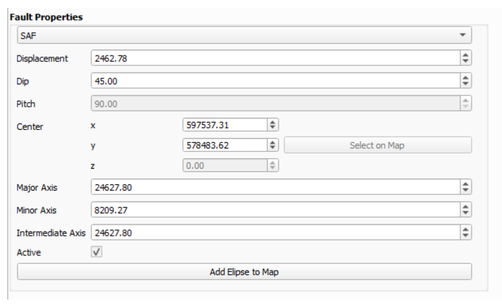
Stratigraphy is defined by the basal contacts and bedding structural data. Basal contacts must have a unit name as a unique identifier. The structural data can be recorded as strike/dip following the RH rule or dip/dip direction and must be associated with a unit name.



The stratigraphic column can be defined by changing the order, thickness, colour and contact type (conformable, erode, onlap).



Faults in LoopStructural are defined by a structural frame where the main structural feature is the fault surface, the structural direction is the slip direction and the intermediate direction is the fault extent.



To model faults the fault trace and fault dip are used to constrain the geometry of the fault surface. The fault slip direction is defined by the fault pitch. The damage ellipsoid is defined by the major, minor and intermediate axes.

Acknowledgments

The Loop platform has been supported since 2018 by the following organisations spanning research and academia, the industry and national and international government organisations