Loop - Enabling 3D stochastic geological modelling

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SUMMARY

Loop is a new open source 3D geological and geophysical modelling platform in full development.

The new platform consists of 4 main work packages:

1. Knowledge Management: use of AI techniques for knowledge extraction from literature, maps and reports using geological ontology. Geological rules will be encoded to ensure proper knowledge extraction.

2. Geological Event Management: Loop is a time-aware geological modelling platform and the event manager is capturing topological and time relationship between geological objects and structural events

3. Forward and inverse structural modelling: we will encode structural geological rules in a time-aware context to account for folds (including overprinting), faults, shear zones, unconformities and intrusions. The modelling is based on probabilistic modelling and allows for the definition of an objective function for geology and quantification of uncertainty via posterior probabilities.

4. Uncertainty characterisation and modelling: using stochastic simulations or the result of Bayesian modelling, Loop allows for characterisation and quantification of 3D uncertainty.

Key words: structural modelling, Bayesian modelling, uncertainty, 3D geological modelling.

INTRODUCTION

With the assumption that all our resources are structurally controlled, one of the great challenges in both resources exploration and management, and geological research is to predict and represent geology in 3D. There is currently a critical technology gap in our 3D geological modelling workflow:

- Current platforms only use a subset of the geological information available which makes building 3D geological models of hard-rock terranes very difficult;
- The integration with geophysical imaging is limited to the use of interpretative cross- sections or the use of 3D models as reference model for a-posteriori inversions that ignore geological data and information;
- Models' uncertainty is extremely high and usually neither quantified nor utilised.

These three shortcomings in the modelling process conspire to promote the production of geological models with limited economic or scientific value and render compliant, published resource estimation models a rarity. The step change is to allow for proper, geophysically constrained AND structural geology-rule based geological modelling and domaining.

LOOP - PRESENTATION

The Loop project is a OneGeology initiative, initiated by Geoscience Australia and funded by territory, state and federal geological surveys (Australia and in-kind from Canada, UK and France), the Australian Research Council and the MinEx CRC.

We will develop a new open source "3D implicit geo-structural simulator and modelling platform" that will address the entire 3D geological modelling workflow from guiding

efficient observations sampling in the field to the production of a series of consistent 3D geological models with uncertainty assessment and characterisation.

Building 3D models, even with the advent of implicit techniques, is still a highly specialised and costly task (both in time and computing resources) and often only adapted to "simpler" basin geometries. The Loop project aims to develop technologies to mitigate 3D geological risk in resources management. The project is expected to create new knowledge and methods in the field of 3D geological modelling through the innovative application of mathematical methods, structural geology concepts and cutting-edge probabilistic programming. The expected outcomes are an enhanced capability to model the subsurface, characterise model uncertainty and test multiple geological scenarios. This enhanced capability is extremely important for the future of subsurface management; including urban geology and our continuously growing sustainable resources industry (including water).

Loop is a new platform (Figure 1) that will enable field geologists, researchers from academia and government organisations, explorers, resources modellers, and managers to better define their 3D geological environment as well as assessing the requirement for optimised additional data/knowledge acquisition. The platform will be open source, scalable and applicable to problems from the mine scale to the plate scale, in data rich and poor environments. It will serve to solve problems related to urban geology, basin resources exploration and exploitation as well as minerals and scientific exploration in poly-deformed metamorphosed terranes.

CONCLUSIONS

We present the overall philosophy behind the project and current advancement in the field of forward and reverse structural modelling (Figure 2a,b) and inverse geophysical modelling (Figure 2c) as well as the proposed modelling workflow for the next generation 3D geological and geophysical modelling platform.

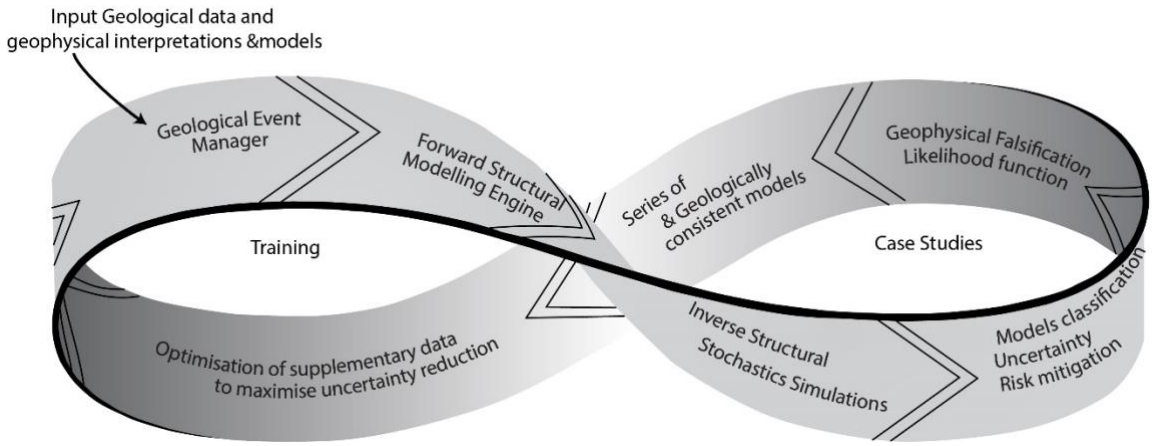

Figure 1. Newly proposed open source platform (called Loop) to solve 3D structural geological modelling problems from the mine scale to the plate scale and including geological problems, related resources exploration and management in urban geology settings, basins geology environment and poly-deformed terranes.

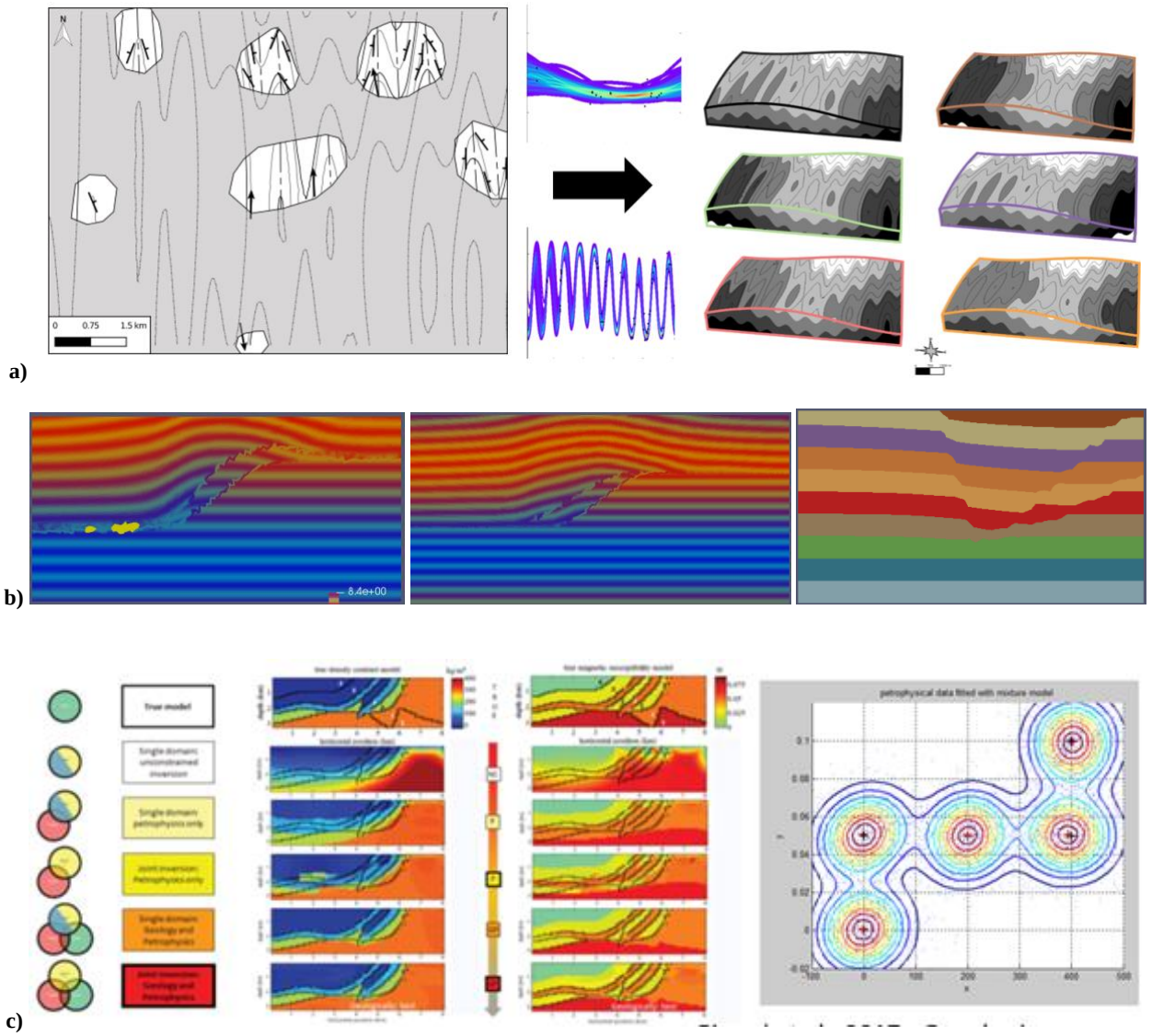

Figure 2. a) Bayesian modelling of poly-folded stratigraphy; b) Bayesian modelling of faults and shear zones; c) geophysical inversion scheme utilising lithological probabilities.