Validating 3-D structural models with geological knowledge for improved uncertainty evaluations


Presenter: Che Chak Meng
Advisor: Prof. Jia-Jyun Dong

2019.12.05
Introduction

Methodology
- Uncertainty simulation in geological models
- Application to the geological model of a graben structure
- Integrating geological knowledge

Discussion

Conclusion
Introduction

- Factors for uncertainty of models

Bowden (2003) illustrated modelling constraints resulting uncertainty
Actual position of formation surface

Possible ambiguous interpretations

a) Type 1: Ambiguity of structure based on uncertainties in raw data

Contact location uncertainty

b) Type 2: Uncertainty of interpolation and extrapolation away from known points

Accurate position

Uncertainty away from points

c) Type 3: Problem of uncomplete knowledge of structures in subsurface

Fault

Without fault

With fault

(Wellmann et al., 2010)
Initial model and input points and their uncertainties

Normal Fault —
Formation Surface —
Methodology
Uncertainty simulation in geological models

- Geological modeling using potential-field based stochastic simulation.

- It can automatically reconstruct the model from the changed the spatial location of a surface contact point or the dip angle of a fault.

- Uncertainties in input parameters are then considered through appropriate probability distributions, assigned to the parameters. Considered parameter correlations, if known.

- A range of probable input data sets is generated through random draws from the parameter distributions and for each of these data sets, a model is generated.

(Wellmann et al., 2010)
Application to the geological model of a graben structure

Standard deviation of $F = 100$ m, EW-direction
Standard deviation of $z = 75$ m, z-direction
Integrating geological knowledge

- (1) can directly be evaluated for a sampled value.
- (2) can be checked for pairs of values defining lower and upper surface of a layer.
- (3) can be determined from the comparison of surface contact points on both sides of a fault.
- (4) are evaluated from the comparison of vertical thickness in separate compartment.
Discussion

- All of these model realizations preserve the expected overall geological setting and relevant geological features of normal faults through sedimentary layers forming a graben structure.

- Not only obtain a set of valid models as an ensemble, but information on the rules that resulted in rejection.

- The sampled geological parameter sets could be analyzed to determine posterior distributions and evaluate parameter correlations.

- Every model change or extension with new data could be checked against these filters to detect potential violations with specific expected geological aspects of the domain.
Conclusion

➢ The results show that successfully implemented validation filters into an uncertainty simulation workflow for structural geological models.

➢ Detailed analysis may provide interesting insights into the validity of model assumptions and provide meaningful parameter correlation matrix, providing more effective sampling for subsequent inverse studies.

➢ It is suggested that these types of filters can be useful for the construction phase of geological models, even if only a single model is created.

➢ A mismatch could highlight possible problems with either the recent change or the applied filter and motivate a careful revision of the latest steps.
Thanks for Listening!