3D Geophysical Inversion for Surface-Based Model Geometry

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Mesh-based inversion

- Physical property distributions
- Many parameters
- General
Mesh-based inversion

- Smooth distributions
- Inconsistent?
What is surface-geometry inversion?

- Fundamentally different
- Use geological models directly
What is surface-geometry inversion?

- Fundamentally different
- Use *archaeological, etc.*, models directly

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Ercoli et al., 2016, "Inside the polygonal walls of Amelia (Central Italy) ...", JAG

Panisova et al., 2016, "Geophysical fingerprints ... in the Church of St. George ...", JAG
Historical attempts

Historical attempts

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Richardson & Maclnnes, 1989, The inversion of gravity data into three-dimensional polyhedral models, JGR
Challenges

1. Parameterize effectively and efficiently

2. Difficult numerical problem

3. Topological rules
Parameterization

- Node coordinates
- Control nodes + splines
Numerical solution

- Only misfit measure required
  \[ \Phi_d = \sum_i \left( \frac{F(m)_i - d_i}{\sigma_i} \right)^2 \]

- Regularization optional
Numerical solution

\[ \Phi_d = \sum_i \left( \frac{F(m)_i - d_i}{\sigma_i} \right)^2 \]

- Global optimization
  (PSO, GA, MCMC)
Our previous attempts

- Ellipsoid, gravity data

Lelievre et al., 2015, 3D potential field inversion for wireframe surface geometry, SEG Expanded Abstracts
Our previous attempts

- IOCG deposit

Lelievre et al., 2015, 3D potential field inversion for wireframe surface geometry, SEG Expanded Abstracts
Our previous attempts

Cocagne Subbasin

Lelievre et al., 2016, Inversion for wireframe surface geometry applied to the Cocagne Subbasin ..., SEG Expanded Abstracts
Topological rules

- Ignore? Avoid?
Topological rules
Topological rules

- Collision detection
Triangle-triangle intersection tests

- Moller, 1997
- Guigue & Devillers, 2003
- Tropp et al., 2006
- Wei, 2014
- Sabharwal & Leopold, 2015
- … and more
Topological rules

Triangle-triangle intersection tests

- Moller, 1997
- Guigue & Devillers, 2003
Our current examples: SMS synthetic

MS lens / MS lens

Stockwork
Our current examples: SMS synthetic
Our current examples: SMS synthetic
Our current examples: SMS synthetic - bimodal system

MS, stock (younger)
MS, stock (older)
Hydrothermal alteration zone
Our current examples: SMS real data

Galley et al., EMRP2.3 (Monday), EGU2019-10598
Invert for surface position

Single, unified models for geophysics & geology

Provide statistical information