Crustal Deformation Modeling Tutorial

Using Gravity and Initial Stresses

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Concepts Covered in this Session

- When are gravitational stresses necessary?
- Usage of gravitational body forces in 2D
- Usage of reference stresses to balance body forces
- Usage of incompressible elasticity to achieve a reference state
- Usage of traction boundary conditions to represent a surface load

When Do We Need to Use Gravitational Stresses?

- Pressure/stress-dependent rheology
  - Pressure-dependent bulk rheology (e.g., plasticity)
  - Stress-dependent fault rheology (e.g., friction)
- Viscoelastic simulations where we care about vertical deformation
- Other simulations where we care about the absolute stress state

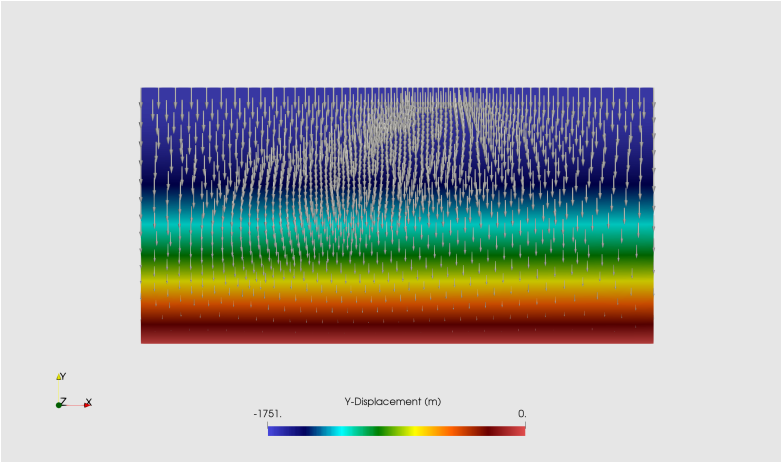
Two-dimensional Gravity Simulations

Files are in `examples/2d/reverse`. None of these problems involve faulting.

1. `step01` Use gravitational body forces with no reference stresses.
   - Entire domain deforms vertically since material is compressible.
2. `step02` Use gravitational body forces and balance them with analytically-determined reference stresses.
   - Stresses are reasonably-well balanced and there is much less deformation.
3. `step03` Use gravitational body forces for an incompressible elastic material.
   - Stresses are nearly isotropic and there is virtually no deformation.
4. `step04` Use traction boundary conditions to represent a surface load.
   - Primarily vertical deformation centered beneath the applied load.

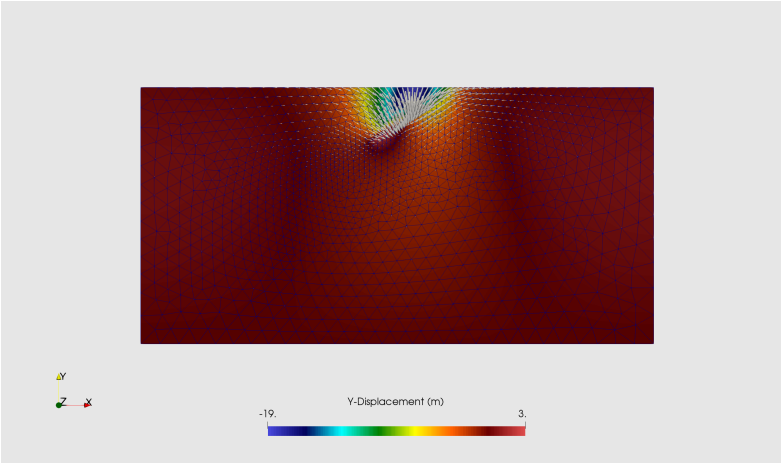
Step 1

Gravitational body forces applied to elastic material



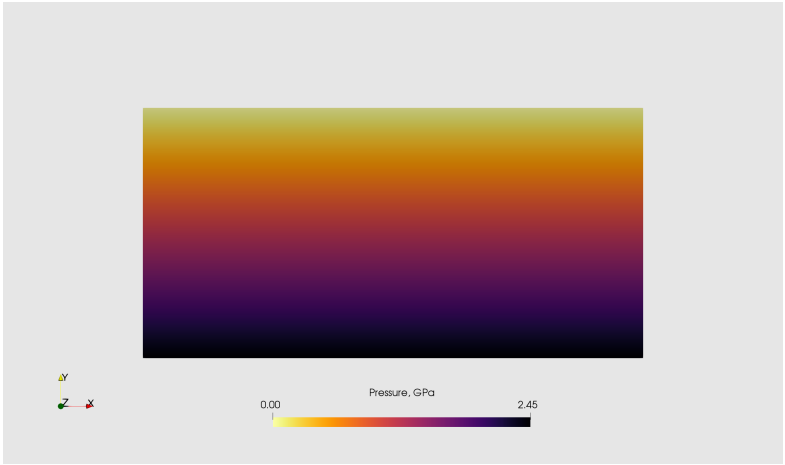
Step 2

Gravitational body forces with reference stress



Step 3

Gravitational body forces applied to incompressible elastic material



Step 4

Normal tractions applied to simulate a surface load