

# Crustal Deformation Modeling Tutorial

## Debugging PyLith Simulations

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# What parameters are available?

Parameters are specified as a hierarchy of components and properties

- Components (Facilities) are the object building blocks  
Appendix B of the PyLith manual lists all of the components
  - Problem `TimeDependent`
  - Boundary conditions `DirichletBC`
  - Faults `FaultCohesiveKin`
  - Materials `MaxwellViscoelastic3D`
  - Output managers `OutputSolnSubset`
  - Readers `MeshIOCubit`
- Properties are the basic types
  - String `mat.viscoelastic.spatialdb`
  - Integer `4`
  - Float `2.3`
  - Dimensioned quantity `2.5*year`
  - Array of Strings, Integers, or Floats `[0, 0, 1]`

# How do I show the values of the current parameters?

Case study: `examples/3d/hex8/step01`

- All current parameters and their values

```
pylithinfo [--verbose] [-o pylith.parameters.txt] [-h] [PyLith args]
```

```
pylithinfo --verbose step01.cfg
```

- Components and properties for given component `--help`

```
step01.cfg [pylithapp.timedependent.bc.z_neg]
```

```
shell pylith step01.cfg --timedependent.bc.z_neg.help
```

- Current components of a given component `--help-components`

```
step01.cfg [pylithapp.timedependent.bc.z_neg]
```

```
shell pylith step01.cfg --timedependent.bc.z_neg.help-components
```

- Current properties of a given component `--help-properties`

```
step01.cfg [pylithapp.timedependent.bc.z_neg]
```

```
shell pylith step01.cfg --timedependent.bc.z_neg.help-properties
```

# What about a GUI?

Browser-based GUI under development

- Use web browser as GUI to parameters
  - See all parameters with descriptions
  - See possible choices for components and properties
- Basic validation of parameters
- Export parameters to single file  
Facilitate archiving parameters used in given simulation

Started in Oct 2013 but v2.0 and v3.0 releases have higher priority

# Debugging Examples

See `examples/debugging`

**Step01** Simple shear using Dirichlet BC in static simulation

**Step02** Prescribed fault slip with Dirichlet BC

- Static simulation
- Fault is embedded within the domain

**Step03** Spontaneous rupture with Dirichlet BC

- Static simulation
- Static friction ( $\mu_f = 0.6$ )
- Slip driven by simple shear

Correct files are provided for reference

# Step01: Error 1

Error found while doing very basic validation of parameters

```
$ pylith step01.cfg
```

## Python stacktrace

Traceback (most recent call last):

```
File "/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/bin/pylith", line 27, in <module>
```

```
    start(applicationClass=PyLithApp)
```

```
File "/Volumes/Tools/unix/cig/gcc-4.7.3/lib/python2.7/site-packages/pythia-0.8.1.15-py2.7.egg/shell.run(**kwds)
```

```
File "/Volumes/Tools/unix/cig/gcc-4.7.3/lib/python2.7/site-packages/pythia-0.8.1.15-py2.7.egg/app.applyConfiguration(context)
```

```
File "/Volumes/Tools/unix/cig/gcc-4.7.3/lib/python2.7/site-packages/pythia-0.8.1.15-py2.7.egg/raise ValueError("%s\nBacktrace - Component %s" % (err.message, aliases))
```

## Error message

ValueError: Error while configuring Dirichlet boundary condition (dirichletbc , x\_pos):

Error while configuring boundary condition (dirichletbc , x\_pos):

Label for group/nodeset/pset in mesh not specified.

## Component hierarchy

Backtrace - Component dirichletbc , x\_pos

Backtrace - Component bc

Backtrace - Component timedependent , problem

Backtrace - Component pylithapp

# Step01: Error 1 Resolution

Error found while doing very basic validation of parameters

## Error message

```
ValueError: Error while configuring Dirichlet boundary condition (dirichletbc , x_pos):  
Error while configuring boundary condition (dirichletbc , x_pos):  
Label for group/nodeset/pset in mesh not specified.
```

## Component hierarchy

```
Backtrace – Component dirichletbc , x_pos  
Backtrace – Component bc  
Backtrace – Component timedependent , problem  
Backtrace – Component pylithapp
```

# Step01: Error 1 Resolution

Error found while doing very basic validation of parameters

## Error message

```
ValueError: Error while configuring Dirichlet boundary condition (dirichletbc , x_pos):  
Error while configuring boundary condition (dirichletbc , x_pos):  
Label for group/nodeset/pset in mesh not specified.
```

## Component hierarchy

```
Backtrace – Component dirichletbc , x_pos  
Backtrace – Component bc  
Backtrace – Component timedependent , problem  
Backtrace – Component pylithapp
```

**Debug:** Examine parameters for `pylithapp.problem.bc.x_pos`



# Step01: Error 1 Resolution

Error found while doing very basic validation of parameters

## Error message

```
ValueError: Error while configuring Dirichlet boundary condition (dirichletbc , x_pos):  
Error while configuring boundary condition (dirichletbc , x_pos):  
Label for group/nodeset/pset in mesh not specified.
```

## Component hierarchy

```
Backtrace – Component dirichletbc , x_pos  
Backtrace – Component bc  
Backtrace – Component timedependent , problem  
Backtrace – Component pylithapp
```

## Debug: Examine parameters for `pylithapp.problem.bc.x_pos` Resolution

```
[pylithapp.timedependent.bc.x_pos]
```

# Step01: Error 2

Error found in parsing .cfg file

```
$ pylith step01.cfg
```

.cfg file with line number

```
>> step01.cfg:100:
```

## Error message

```
— pyre.inventory (error)
— pylithapp.timedependent.implicit.output.outputsoln.write.filename <- 'output/step01.vtk'
— unknown component
'pylithapp.timedependent.implicit.output.outputsoln.write'
```

## Usage information

```
usage: pylith [--<property><value>] [--<facility ><property><value>] [FILE.cfg] ...
component 'pylithapp'
  properties: help, help-components, help-persistence, help-properties, initialize-only, job,
  facilities: job, launcher, mesh_generator, perf_logger, petsc, problem, scheduler, weaver
```

For more information:

```
—help-properties: prints details about user settable properties
—help-components: prints details about user settable facilities and components
pylithapp: configuration error(s)
```

# Step01: Error 2 Resolution

Error found in parsing .cfg file

## Error message

```
— pyre.inventory (error)  
— pylithapp.time-dependent.implicit.output.outputsoln.write.filename ← 'output/step01.vtk'  
— unknown component  
'pylithapp.time-dependent.implicit.output.outputsoln.write'
```

# Step01: Error 2 Resolution

Error found in parsing .cfg file

## Error message

```
— pyre.inventory(error)
— pylithapp.timedependent.implicit.output.outputsoln.write.filename <- 'output/step01.vtk'
— unknown component
'pylithapp.timedependent.implicit.output.outputsoln.write'
```

**Debug:** Look up the properties of the OutputSoln object

# Step01: Error 2 Resolution

Error found in parsing .cfg file

## Error message

```
— pyre.inventory (error)  
— pylithapp.time-dependent.implicit.output.outputsoln.write.filename <- 'output/step01.vtk'  
— unknown component  
'pylithapp.time-dependent.implicit.output.outputsoln.write'
```

**Debug:** Look up the properties of the OutputSoln object

## Resolution

```
[pylithapp.problem.formulation.output.domain]  
writer.filename = output/step01.vtk
```

# Step01: Error 3

Error found when initializing integrators

```
$ pylith step01.cfg
```

## Error message

```
terminate called after throwing an instance of 'std::runtime_error'  
  what(): Error occurred while reading spatial database file 'mat_elastic.spatialdb'.  
I/O error while reading SimpleDB data.
```

## Abort message

```
[0]0:Return code = 0, signaled with Abort trap: 6
```

# Step01: Error 3 Resolution

Error found when initializing integrators

## Error message

```
terminate called after throwing an instance of 'std::runtime_error'  
  what(): Error occurred while reading spatial database file 'mat_elastic.spatialdb'.  
I/O error while reading SimpleDB data.
```

# Step01: Error 3 Resolution

Error found when initializing integrators

## Error message

```
terminate called after throwing an instance of 'std::runtime_error'  
  what(): Error occurred while reading spatial database file 'mat_elastic.spatialdb'.  
I/O error while reading SimpleDB data.
```

**Debug:** Look at `mat_elastic.spatialdb` for errors in data



# Step01: Error 3 Resolution

Error found when initializing integrators

## Error message

```
terminate called after throwing an instance of 'std::runtime_error'  
  what(): Error occurred while reading spatial database file 'mat_elastic.spatialdb'.  
I/O error while reading SimpleDB data.
```

**Debug:** Look at `mat_elastic.spatialdb` for errors in data

## Resolution

```
num-locs = 1 // number of locations
```

# Step01: Error 4

Error found when initializing integrators

```
$ pylith step01.cfg
```

## Error message

```
terminate called after throwing an instance of 'std::runtime_error'  
  what(): Error occurred while reading spatial database file 'mat_elastic.spatialdb'.  
Number of dimensions in coordinates of spatial distribution (2) does not match number of dimensions
```

## Abort message

```
[0]0:Return code = 0, signaled with Abort trap: 6
```

# Step01: Error 4 Resolution

Error found when initializing integrators

## Error message

```
terminate called after throwing an instance of 'std::runtime_error'
```

```
  what(): Error occurred while reading spatial database file 'mat_elastic.spatialdb'.
```

```
Number of dimensions in coordinates of spatial distribution (2) does not match number of dimens
```

# Step01: Error 4 Resolution

Error found when initializing integrators

## Error message

```
terminate called after throwing an instance of 'std::runtime_error'  
  what(): Error occurred while reading spatial database file 'mat_elastic.spatialdb'.  
Number of dimensions in coordinates of spatial distribution (2) does not match number of dimensions
```

**Debug:** Look at coordinate system in `mat_elastic.spatialdb` header

# Step01: Error 4 Resolution

Error found when initializing integrators

## Error message

```
terminate called after throwing an instance of 'std::runtime_error'  
  what(): Error occurred while reading spatial database file 'mat_elastic.spatialdb'.  
Number of dimensions in coordinates of spatial distribution (2) does not match number of dimens
```

**Debug:** Look at coordinate system in `mat_elastic.spatialdb` header  
Resolution

```
space-dim = 3
```

# Step01: Error 5

Error found when setting up solution field

```
$ pylith step01.cfg
```

## Python stacktrace

Fatal error. Calling MPI\_Abort() to abort PyLith application.

Traceback (most recent call last):

```
File "/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/lib/python2.7/site-packages/pylith/apps/PetscA
  self.main(*args, **kwargs)
File "/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/lib/python2.7/site-packages/pylith/apps/PyLithA
  self.problem.initialize()
File "/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/lib/python2.7/site-packages/pylith/problems/Tir
  self.formulation.initialize(self.dimension, self.normalizer)
File "/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/lib/python2.7/site-packages/pylith/problems/Im
  self._initialize(dimension, normalizer)
File "/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/lib/python2.7/site-packages/pylith/problems/Fo
  constraint.setConstraintSizes(solution)
File "/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/lib/python2.7/site-packages/pylith/bc/bc.py",
  def setConstraintSizes(self, *args): return _bc.DirichletBC.setConstraintSizes(self, *args)
```

## Error message

```
RuntimeError: Found overly constrained point while setting up constraints for
DirichletBC boundary condition 'face_zneg'. Number of DOF at point 503 is 3
and number of attempted constraints is 4.
```

## Abort information

```
application called MPI_Abort(MPI_COMM_WORLD, -1) - process 0
/Volumes/Tools/unix/cig/gcc-4.7.3/bin/nemesis: mpirun: exit 255
/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/bin/pylith: /Volumes/Tools/unix/cig/gcc-4.7.3/bin/neme
```

# Step01: Error 5 Resolution

Error found when setting up solution field

## Error message

```
RuntimeError: Found overly constrained point while setting up constraints for  
DirichletBC boundary condition 'face-zneg'. Number of DOF at point 503 is 3  
and number of attempted constraints is 4.
```

# Step01: Error 5 Resolution

Error found when setting up solution field

## Error message

```
RuntimeError: Found overly constrained point while setting up constraints for  
DirichletBC boundary condition 'face-zneg'. Number of DOF at point 503 is 3  
and number of attempted constraints is 4.
```

**Debug:** Look at overlap of constraints in Dirichlet BC



# Step01: Error 5 Resolution

Error found when setting up solution field

## Error message

RuntimeError: Found overly constrained point while setting up constraints for DirichletBC boundary condition 'face-zneg'. Number of DOF at point 503 is 3 and number of attempted constraints is 4.

## Debug: Look at overlap of constraints in Dirichlet BC Resolution

```
[pylithapp.timedependent.bc.y_pos]
bc_dof = [0]
...
[pylithapp.timedependent.bc.y_neg]
bc_dof = [0]
```

# Step02: Error 1

Error found in parsing .cfg file

```
$ pylith step02.cfg
```

## Configuration error

```
>> step02.cfg:30:  
— pyre.inventory (error)  
— timedependent.nondimelasticquasistatic.relaxation_time ← '2.0*years'  
— name 'years' is not defined  
pylithapp: configuration error(s)
```

# Step02: Error 1 Resolution

Error found in parsing .cfg file

## Error message

```
>> step02.cfg:30:  
— pyre.inventory (error)  
— timedependent.nondimelasticquasistatic.relaxation_time ← '2.0*years'  
— name 'years' is not defined  
pylithapp: configuration error(s)
```

# Step02: Error 1 Resolution

Error found in parsing .cfg file

## Error message

```
>> step02.cfg:30:  
— pyre.inventory (error)  
— timedependent.nondimelasticquasistatic.relaxation_time ← '2.0*years'  
— name 'years' is not defined  
pylithapp: configuration error(s)
```

**Debug:** Pyre is poorly documented. Look for example. :(

# Step02: Error 1 Resolution

Error found in parsing .cfg file

## Error message

```
>>> step02.cfg:30:  
— pyre.inventory(error)  
— timedependent.nondimelasticquasistatic.relaxation_time ← '2.0*years'  
— name 'years' is not defined  
pylithapp: configuration error(s)
```

**Debug: Pyre is poorly documented. Look for example. :(**

```
$ python
```

```
>>> from pyre.units.time import *  
>>> dir()  
['__builtins__', '__doc__', '__name__', '__package__', 'day', 'hour', 'micro', 'microsecond',  
'milli', 'millisecond', 'minute', 'ms', 'nano', 'nanosecond', 'ns', 'pico',  
'picosecond', 'ps', 's', 'second', 'us', 'year']
```

## Resolution

```
relaxation_time = 2.0*year
```

# Step02: Error 2

Error doing some basic validation of input

```
$ pylith step02.cfg
```

## Python stacktrace

Fatal error. Calling MPI\_Abort() to abort PyLith application.

Traceback (most recent call last):

```
File "/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/lib/python2.7/site-packages/pylith/apps/PetscA
  self.main(*args, **kwargs)
File "/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/lib/python2.7/site-packages/pylith/apps/PyLithA
  self.problem.verifyConfiguration()
File "/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/lib/python2.7/site-packages/pylith/problems/Tir
  self.formulation.verifyConfiguration()
File "/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/lib/python2.7/site-packages/pylith/problems/Fo
  integrator.verifyConfiguration()
File "/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/lib/python2.7/site-packages/pylith/faults/Fault
  ModuleFaultCohesiveKin.verifyConfiguration(self, self.mesh())
File "/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/lib/python2.7/site-packages/pylith/faults/fault
  def verifyConfiguration(self, *args): return
_faults.FaultCohesiveLagrange.verifyConfiguration(self, *args)
```

## Error message

```
RuntimeError: Number of dofs in reference cell (3) is not compatible
with number of edges (4) in cohesive cell 256 for fault 'fault_ext'.
```

## Abort info

```
application called MPI_Abort(MPI_COMM_WORLD, -1) - process 0
/Volumes/Tools/unix/cig/gcc-4.7.3/bin/nemesis: mpirun: exit 255
/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/bin/pylith: /Volumes/Tools/unix/cig/gcc-4.7.3/bin/neme
```

# Step02: Error 2 Resolution

Error doing some basic validation of input

## Error message

```
RuntimeError: Number of dofs in reference cell (3) is not compatible  
with number of edges (4) in cohesive cell 256 for fault 'fault_ext'.
```

# Step02: Error 2 Resolution

Error doing some basic validation of input

## Error message

```
RuntimeError: Number of dofs in reference cell (3) is not compatible  
with number of edges (4) in cohesive cell 256 for fault 'fault_ext'.
```

## Debug: Turn on journal for quadrature

```
$ pylith step02.cfg --problem.interfaces.fault.quadrature.help-components
```

```
facilities of 'quadrature':
```

```
  cell=<component name>: Reference cell with basis fns and quadrature rules.  
    current value: 'fiatsimplex', from {default}  
    configurable as: fiatsimplex, cell
```



# Step02: Error 2 Resolution

Error doing some basic validation of input

## Error message

```
RuntimeError: Number of dofs in reference cell (3) is not compatible  
with number of edges (4) in cohesive cell 256 for fault 'fault_ext'.
```

## Debug: Turn on journal for quadrature

```
$ pylith step02.cfg --problem.interfaces.fault.quadrature.help-components
```

```
facilities of 'quadrature':  
  cell=<component name>: Reference cell with basis fns and quadrature rules.  
    current value: 'fiatsimplex', from {default}  
    configurable as: fiatsimplex, cell
```

```
[pylithapp.journal.info]  
fiatlagrange = 1  
fiatsimplex = 1
```

## Resolution

```
[pylithapp.timedependent.interfaces.fault]  
quadrature.cell = pylith.feassemble.FIATLagrange
```

# Step02: Error 3

## Error found when initializing integrators

```
$ pylith step02.cfg
```

### Python stacktrace

Fatal error. Calling MPI\_Abort() to abort PyLith application.

Traceback (most recent call last):

```
File "/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/lib/python2.7/site-packages/pylith/apps/PetscA
  self.main(*args, **kwargs)
File "/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/lib/python2.7/site-packages/pylith/apps/PyLithA
  self.problem.initialize()
File "/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/lib/python2.7/site-packages/pylith/problems/Tir
  self.formulation.initialize(self.dimension, self.normalizer)
File "/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/lib/python2.7/site-packages/pylith/problems/Im
  self._initialize(dimension, normalizer)
File "/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/lib/python2.7/site-packages/pylith/problems/Fo
  integrator.initialize(totalTime, numTimeSteps, normalizer)
File "/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/lib/python2.7/site-packages/pylith/feassemble/
  ModuleElasticityImplicit.initialize(self, self.mesh())
File "/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/lib/python2.7/site-packages/pylith/feassemble/
  def initialize(self, *args): return _feassemble.IntegratorElasticity_initialize(self, *args)
```

### Error message

RuntimeError: Determinant of Jacobian (1.25e-07) for cell 0 is smaller than minimum permissible value (1e-06)! The two most likely causes of this are highly distorted cells and nondimensionalization with a length scale that is much larger than the dimensions of the cells.

### Abort info

# Step02: Error 3 Resolution

Error found when initializing integrators

## Error message

RuntimeError: Determinant of Jacobian ( $1.25e-07$ ) for cell 0 is smaller than minimum permissible value ( $1e-06$ )! The two most likely causes of this are highly distorted cells and nondimensionalization with a length scale that is much larger than the dimensions of the cells.

# Step02: Error 3 Resolution

## Error found when initializing integrators

### Error message

RuntimeError: Determinant of Jacobian ( $1.25e-07$ ) for cell 0 is smaller than minimum permissible value ( $1e-06$ )! The two most likely causes of this are highly distorted cells and nondimensionalization with a length scale that is much larger than the dimensions of the cells.

### Debug: Look at nondimensional scales relative to the parameters

```
$ pylith step02.cfg --problem.normalizer.help-properties
```

```
properties of 'nondimelasticquasistatic':
```

```
  length_scale=<dimensional>: Value to nondimensionalize length scale.
```

```
    default value: 1000*m
```

```
    current value: 1e+06*m, from {file='step02.cfg', line=28, column=-1}
```

```
    validator: (greater than 0*m)
```

```
  relaxation_time=<dimensional>: Relaxation time to nondimensionalize time.
```

```
    default value: 3.15576e+07*s
```

```
    current value: 6.31152e+07*s, from {file='step02.cfg', line=30, column=-1}
```

```
    validator: (greater than 0*s)
```

```
  shear_modulus=<dimensional>: Shear modulus to nondimensionalize pressure.
```

```
    default value: 3e+10*m**-1*kg*s**-2
```

```
    current value: 3e+10*m**-1*kg*s**-2, from {file='step02.cfg', line=29, column=-1}
```

```
    validator: (greater than 0*m**-1*kg*s**-2)
```

# Step02: Error 3 Resolution

## Error found when initializing integrators

### Error message

RuntimeError: Determinant of Jacobian ( $1.25e-07$ ) for cell 0 is smaller than minimum permissible value ( $1e-06$ )! The two most likely causes of this are highly distorted cells and nondimensionalization with a length scale that is much larger than the dimensions of the cells.

### Debug: Look at nondimensional scales relative to the parameters

```
$ pylith step02.cfg --problem.normalizer.help-properties
```

```
properties of 'nondimelasticquasistatic':
```

```
  length_scale=<dimensional>: Value to nondimensionalize length scale.
```

```
    default value: 1000*m
```

```
    current value: 1e+06*m, from {file='step02.cfg', line=28, column=-1}
```

```
    validator: (greater than 0*m)
```

```
  relaxation_time=<dimensional>: Relaxation time to nondimensionalize time.
```

```
    default value: 3.15576e+07*s
```

```
    current value: 6.31152e+07*s, from {file='step02.cfg', line=30, column=-1}
```

```
    validator: (greater than 0*s)
```

```
  shear_modulus=<dimensional>: Shear modulus to nondimensionalize pressure.
```

```
    default value: 3e+10*m**-1*kg*s**-2
```

```
    current value: 3e+10*m**-1*kg*s**-2, from {file='step02.cfg', line=29, column=-1}
```

```
    validator: (greater than 0*m**-1*kg*s**-2)
```

### Resolution

```
[pylithapp.problem.normalizer]
```

```
length_scale = 1.0*m
```

# Step02: Error 4

Error found when initializing fault

```
$ pylith step02.cfg
```

## Error message

```
terminate called after throwing an instance of 'std::runtime_error'  
  what(): Could not find value left-lateral-slip in spatial database  
Final slip. Available values are:  
  lateral-slip  
  reverse-slip  
  fault-opening
```

## Abort message

```
[0]0:Return code = 0, signaled with Abort trap: 6
```

# Step02: Error 4 Resolution

Error found when initializing fault

## Error message

```
terminate called after throwing an instance of 'std::runtime_error'  
  what(): Could not find value left-lateral-slip in spatial database  
Final slip. Available values are:  
  lateral-slip  
  reverse-slip  
  fault-opening
```

# Step02: Error 4 Resolution

Error found when initializing fault

## Error message

```
terminate called after throwing an instance of 'std::runtime_error'  
  what(): Could not find value left-lateral-slip in spatial database  
Final slip. Available values are:  
  lateral-slip  
  reverse-slip  
  fault-opening
```

## Resolution

```
slip.values = [left-lateral-slip , reverse-slip , fault-opening]
```



# Step02: Error 5

Error found when setting up solution field

```
$ pylith step02.cfg
```

## Python stacktrace

Fatal error. Calling MPI\_Abort() to abort PyLith application.

Traceback (most recent call last):

```
File "/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/lib/python2.7/site-packages/pylith/apps/PetscA
  self.main(*args, **kwds)
File "/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/lib/python2.7/site-packages/pylith/apps/PyLithA
  self.problem.initialize()
File "/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/lib/python2.7/site-packages/pylith/problems/Tir
  self.formulation.initialize(self.dimension, self.normalizer)
File "/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/lib/python2.7/site-packages/pylith/problems/Im
  self._initialize(dimension, normalizer)
File "/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/lib/python2.7/site-packages/pylith/problems/Fo
  integrator.checkConstraints(solution)
File "/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/lib/python2.7/site-packages/pylith/faults/fault
  def checkConstraints(self, *args): return _faults.FaultCohesiveLagrange.checkConstraints(se
```

## Error message

RuntimeError: Vertex with label '396' on negative side of fault 'fault\_ext' is constrained.  
Fault vertices cannot be constrained.

## Abort info

```
application called MPI_Abort(MPLCOMM_WORLD, -1) - process 0
/Volumes/Tools/unix/cig/gcc-4.7.3/bin/nemesis: mpirun: exit 255
/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/bin/pylith: /Volumes/Tools/unix/cig/gcc-4.7.3/bin/neme
```

# Step02: Error 5 Resolution

Error found when setting up solution field

## Error message

`RuntimeError: Vertex with label '396' on negative side of fault 'fault_ext' is constrained.  
Fault vertices cannot be constrained.`

# Step02: Error 5 Resolution

Error found when setting up solution field

## Error message

RuntimeError: Vertex with label '396' on negative side of fault 'fault\_ext' is constrained.  
Fault vertices cannot be constrained.

Debug: Oops. Didn't mean to use through-going fault!

# Step02: Error 5 Resolution

Error found when setting up solution field

## Error message

RuntimeError: Vertex with label '396' on negative side of fault 'fault\_ext' is constrained.  
Fault vertices cannot be constrained.

**Debug: Oops. Didn't mean to use through-going fault!**

## Resolution

```
[pylithapp.timedependent.interfaces.fault]  
label = fault
```

# Step02: Error 6

## Error when initializing fault

```
$ pylith step02.cfg
```

### Python stacktrace

Fatal error. Calling MPI\_Abort() to abort PyLith application.

Traceback (most recent call last):

```
File "/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/lib/python2.7/site-packages/pylith/apps/PetscA
  self.main(*args, **kwargs)
File "/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/lib/python2.7/site-packages/pylith/apps/PyLithA
  self.problem.initialize()
File "/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/lib/python2.7/site-packages/pylith/problems/Tir
  self.formulation.initialize(self.dimension, self.normalizer)
File "/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/lib/python2.7/site-packages/pylith/problems/Im
  self._initialize(dimension, normalizer)
File "/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/lib/python2.7/site-packages/pylith/problems/Fo
  integrator.initialize(totalTime, numTimeSteps, normalizer)
File "/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/lib/python2.7/site-packages/pylith/faults/Faul
  FaultCohesive.initialize(self, totalTime, numTimeSteps, normalizer)
File "/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/lib/python2.7/site-packages/pylith/faults/Faul
  ModuleFault.initialize(self, self.mesh(), self.upDir)
File "/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/lib/python2.7/site-packages/pylith/faults/faul
  def initialize(self, *args): return _faults.Fault.initialize(self, *args)
```

### Error message

RuntimeError: Error computing orientation of cell face.

Up direction (0, 0, 1) cannot be parallel to the face normal (0, 0, 1).

If the face is horizontal, adjust the up\_dir parameter.

### Abort info

# Step02: Error 6 Resolution

Error found when initializing fault

## Error message

RuntimeError: Error computing orientation of cell face.  
Up direction (0, 0, 1) cannot be parallel to the face normal (0, 0, 1).  
If the face is horizontal, adjust the up\_dir parameter.

# Step02: Error 6 Resolution

Error found when initializing fault

## Error message

RuntimeError: Error computing orientation of cell face.  
Up direction (0, 0, 1) cannot be parallel to the face normal (0, 0, 1).  
If the face is horizontal, adjust the up\_dir parameter.

## Debug: Change up-dir

```
up_dir = [1,0,1]
```

# Step02: Error 6 Resolution

Error found when initializing fault

## Error message

RuntimeError: Error computing orientation of cell face.  
Up direction (0, 0, 1) cannot be parallel to the face normal (0, 0, 1).  
If the face is horizontal, adjust the up\_dir parameter.

## Debug: Change up-dir

```
up_dir = [1,0,1]
```

## Debug: Look at fault surface



# Step02: Error 6 Resolution

Error found when initializing fault

## Error message

RuntimeError: Error computing orientation of cell face.  
Up direction (0, 0, 1) cannot be parallel to the face normal (0, 0, 1).  
If the face is horizontal, adjust the up\_dir parameter.

## Debug: Change up-dir

```
up_dir = [1,0,1]
```

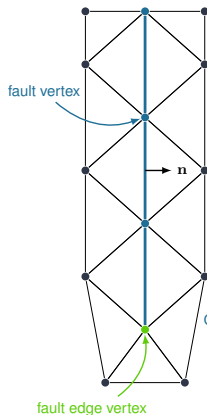
## Debug: Look at fault surface

## Resolution: Mark buried edges

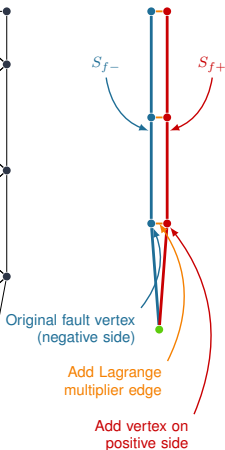
```
[pylithapp.timedependent.interfaces.fault]  
label = fault  
edge = fault_edge  
up_dir = [0,0,1]
```

# Insertion of Cohesive Cells

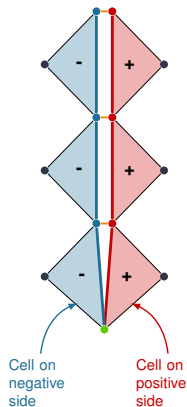
(a) Original mesh



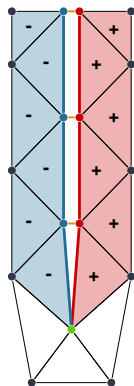
(b) Add collocated vertices



(c) Update cells with fault faces



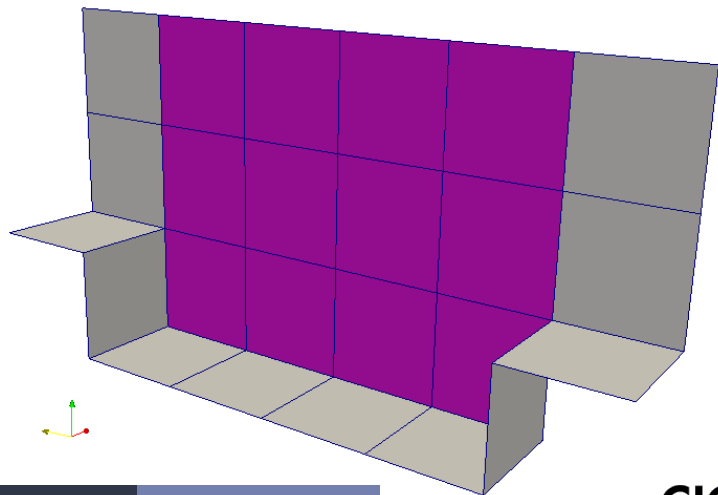
(d) Classify cells and update remaining cells



# Forgetting to Mark Buried Edges

PyLith will extend the fault one cell in an arbitrary fashion

Purple region shows intended fault surface.



# Step03: Error 1

## Error doing basic validation on parameters

```
$ pylith step02.cfg
```

### Python stacktrace

Fatal error. Calling MPI\_Abort() to abort PyLith application.

Traceback (most recent call last):

```
File "/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/lib/python2.7/site-packages/pylith/apps/PetscA
self.main(*args, **kwds)
```

```
...
```

```
File "/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/lib/python2.7/site-packages/pylith/faults/Fault
FaultCohesive.verifyConfiguration(self)
```

```
File "/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/lib/python2.7/site-packages/pylith/faults/Fault
self.output.verifyConfiguration(self.mesh())
```

```
File "/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/lib/python2.7/site-packages/pylith/meshio/Output
self._verifyFields(self.dataProvider().availableFields)
```

```
File "/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/lib/python2.7/site-packages/pylith/meshio/Output
raise ValueError(msg)
```

### Error message

ValueError: Requested fields not available for output.

Data provider: 'faultcohesivedyn'

Field type: 'vertex'

Data type: 'data'

Available fields: 'slip' 'slip\_rate' 'traction'

Fields not available: 'initial\_traction'

### Abort info

application called MPI\_Abort(MPLCOMM\_WORLD, -1) - process 0

: mpirun: exit 255

# Step03: Error 1 Resolution

Error doing basic validation on parameters

## Error message

```
ValueError: Requested fields not available for output.  
Data provider: 'faultcohesivedyn'  
Field type: 'vertex'  
Data type: 'data'  
Available fields: 'slip' 'slip_rate' 'traction'  
Fields not available: 'initial_traction'
```

# Step03: Error 1 Resolution

Error doing basic validation on parameters

## Error message

```
ValueError: Requested fields not available for output.  
Data provider: 'faultcohesivedyn'  
Field type: 'vertex'  
Data type: 'data'  
Available fields: 'slip' 'slip_rate' 'traction'  
Fields not available: 'initial_traction'
```

## Resolution

```
vertex_data_fields = [slip, slip_rate, traction]
```

# Step03: Error 2

## Error creating solution field

```
$ pylith step03.cfg
```

### Python stacktrace

Fatal error. Calling MPI\_Abort() to abort PyLith application.

Traceback (most recent call last):

```
File "/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/lib/python2.7/site-packages/pylith/apps/PetscA
self.main(*args, **kwargs)
File "/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/lib/python2.7/site-packages/pylith/apps/PyLithA
self.problem.initialize()
File "/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/lib/python2.7/site-packages/pylith/problems/Tir
self.formulation.initialize(self.dimension, self.normalizer)
File "/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/lib/python2.7/site-packages/pylith/problems/Im
self._initialize(dimension, normalizer)
File "/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/lib/python2.7/site-packages/pylith/problems/Fo
constraint.setConstraintSizes(solution)
File "/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/lib/python2.7/site-packages/pylith/bc/bc.py",
def setConstraintSizes(self, *args): return _bc.DirichletBC.setConstraintSizes(self, *args)
```

### Error message

RuntimeError: Found overly constrained point while setting up constraints for DirichletBC boundary condition 'face\_zneg'. Number of DOF at point 535 is 3 and number of attempted constraints is 4.

### Abort info

```
application called MPI_Abort(MPI_COMM_WORLD, -1) - process 0
/Volumes/Tools/unix/cig/gcc-4.7.3/bin/nemesis: mpirun: exit 255
/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/bin/pylith:
: exit 1
```

# Step03: Error 2 Resolution

Error creating solution field

## Error message

RuntimeError: Found overly constrained point while setting up constraints for DirichletBC boundary condition 'face\_zneg'. Number of DOF at point 535 is 3 and number of attempted constraints is 4.



# Step03: Error 2 Resolution

Error creating solution field

## Error message

RuntimeError: Found overly constrained point while setting up constraints for DirichletBC boundary condition 'face\_zneg'. Number of DOF at point 535 is 3 and number of attempted constraints is 4.

**Debug:** Look for overlap of constraints in Dirichlet BC

# Step03: Error 2 Resolution

## Error creating solution field

### Error message

RuntimeError: Found overly constrained point while setting up constraints for DirichletBC boundary condition 'face\_zneg'. Number of DOF at point 535 is 3 and number of attempted constraints is 4.

### Debug: Look for overlap of constraints in Dirichlet BC Resolution

```
[pylithapp.timedependent.bc.x_pos]  
bc_dof = [0, 1]  
...  
[pylithapp.timedependent.bc.x_neg]  
bc_dof = [0, 1]
```

# Step03: Error 3

## Error creating solution field

```
$ pylith step03.cfg
```

### Python stacktrace

Fatal error. Calling MPI\_Abort() to abort PyLith application.

Traceback (most recent call last):

```
File "/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/lib/python2.7/site-packages/pylith/apps/PetscA
  self.main(*args, **kwds)
File "/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/lib/python2.7/site-packages/pylith/apps/PyLithA
  self.problem.initialize()
File "/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/lib/python2.7/site-packages/pylith/problems/Tir
  self.formulation.initialize(self.dimension, self.normalizer)
File "/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/lib/python2.7/site-packages/pylith/problems/Im
  self._initialize(dimension, normalizer)
File "/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/lib/python2.7/site-packages/pylith/problems/Fo
  integrator.checkConstraints(solution)
File "/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/lib/python2.7/site-packages/pylith/faults/fault
  def checkConstraints(self, *args): return _faults.FaultCohesiveLagrange.checkConstraints(se
```

### Error message

RuntimeError: Vertex with label '605' on negative side of fault 'fault\_ext' is constrained.  
Fault vertices cannot be constrained.

### Abort info

```
application called MPI_Abort(MPLCOMM_WORLD, -1) - process 0
/Volumes/Tools/unix/cig/gcc-4.7.3/bin/nemesis: mpirun: exit 255
/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/bin/pylith :
/Volumes/Tools/unix/cig/gcc-4.7.3/bin/nemesis: exit 1
```

# Step03: Error 3 Resolution

Error creating solution field

## Error message

RuntimeError: Vertex with label '605' on negative side of fault 'fault\_ext' is constrained.  
Fault vertices cannot be constrained.

# Step03: Error 3 Resolution

Error creating solution field

## Error message

RuntimeError: Vertex with label '605' on negative side of fault 'fault\_ext' is constrained.  
Fault vertices cannot be constrained.

**Debug:** Look for overlap in fault and BC nodesets

# Step03: Error 3 Resolution

## Error creating solution field

### Error message

RuntimeError: Vertex with label '605' on negative side of fault 'fault\_ext' is constrained.  
Fault vertices cannot be constrained.

### Debug: Look for overlap in fault and BC nodesets Resolution

```
[pylithapp.timedependent.bc.z.neg]  
...  
label = face_zneg_nofault
```

# Step03: Error 4

No error but funky results

# Step03: Error 4 Resolution

No error but funky results

Debug: Did the solver converge?



# Step03: Error 4 Resolution

No error but funky results

Debug: Did the solver converge?

## Resolution

```
[pylithapp.petsc]
ksp_monitor = true
ksp_converged_reason = true
ksp_error_if_not_converged = true
```

```
snes_converged_reason = true
snes_error_if_not_converged = true
snes_monitor = true
```

# Step03: Error 5

Nonlinear solver diverges

## PETSc error message

```
[0]PETSC ERROR: _____ Error Message _____  
[0]PETSC ERROR: SNESolve has not converged  
[0]PETSC ERROR: See http://www.mcs.anl.gov/petsc/documentation/faq.html for trouble shooting.  
[0]PETSC ERROR: Petsc Development GIT revision: v3.4.4-4559-g852d360 GIT Date: 2014-05-19 15:0  
...  
[0]PETSC ERROR: #1 SNESolve() line 3765 in /Volumes/Tools/unix/petsc-dev/src/snes/interface/sn  
[0]PETSC ERROR: #2 SNESLogConvergenceHistory() line 150 in /Users/baagaard/src/cig/pylith/librs
```

## Debugging

### Examine KSP and SNES residuals

Fatal error. Calling MPI.Abort() to abort PyLith application.

Traceback (most recent call last):

```
File "/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/lib/python2.7/site-packages/pylith/apps/PetscA  
self.main(*args, **kwds)  
File "/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/lib/python2.7/site-packages/pylith/apps/PyLithA  
self.problem.run(self)  
File "/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/lib/python2.7/site-packages/pylith/problems/Tir  
self.formulation.step(t, dt)  
File "/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/lib/python2.7/site-packages/pylith/problems/Im  
self.solver.solve(displncr, self.jacobian, residual)  
File "/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/lib/python2.7/site-packages/pylith/problems/pr  
def solve(self, *args): return _problems.SolverNonlinear.solve(self, *args)
```

## Abort info

RuntimeError: Error detected while in PETSc function.

# Step03: Error 5 Resolution

Nonlinear solver diverges

## PETSc error message

```
[0]PETSC ERROR: _____ Error Message _____  
[0]PETSC ERROR: SNESolve has not converged  
[0]PETSC ERROR: See http://www.mcs.anl.gov/petsc/documentation/faq.html for trouble shooting.  
[0]PETSC ERROR: Petsc Development GIT revision: v3.4.4-4559-g852d360 GIT Date: 2014-05-19 15:0  
...  
[0]PETSC ERROR: #1 SNESolve() line 3765 in /Volumes/Tools/unix/petsc-dev/src/snes/interface/sn  
[0]PETSC ERROR: #2 SNESLogConvergenceHistory() line 150 in /Users/baagaard/src/cig/pylith/libsrc
```

# Step03: Error 5 Resolution

Nonlinear solver diverges

## PETSc error message

```
[0]PETSC ERROR: _____ Error Message _____  
[0]PETSC ERROR: SNESSolve has not converged  
[0]PETSC ERROR: See http://www.mcs.anl.gov/petsc/documentation/faq.html for trouble shooting.  
[0]PETSC ERROR: Petsc Development GIT revision: v3.4.4-4559-g852d360 GIT Date: 2014-05-19 15:0  
...  
[0]PETSC ERROR: #1 SNESSolve() line 3765 in /Volumes/Tools/unix/petsc-dev/src/snes/interface/sn  
[0]PETSC ERROR: #2 SNESLogConvergenceHistory() line 150 in /Users/baagaard/src/cig/pylith/libsrc
```

## Debug: Examine KSP and SNES residuals using log file

```
$ pylith step03.cfg >& step03.log
```

```
$ grep " norm" step03.log
```

# Step03: Error 5 Resolution

Nonlinear solver diverges

## PETSc error message

```
[0]PETSC ERROR: _____ Error Message _____  
[0]PETSC ERROR: SNESolve has not converged  
[0]PETSC ERROR: See http://www.mcs.anl.gov/petsc/documentation/faq.html for trouble shooting.  
[0]PETSC ERROR: Petsc Development GIT revision: v3.4.4-4559-g852d360 GIT Date: 2014-05-19 15:0  
...  
[0]PETSC ERROR: #1 SNESolve() line 3765 in /Volumes/Tools/unix/petsc-dev/src/snes/interface/sn  
[0]PETSC ERROR: #2 SNESLogConvergenceHistory() line 150 in /Users/baagaard/src/cig/pylith/libsrc
```

## Debug: Examine KSP and SNES residuals using log file

```
$ pylith step03.cfg >& step03.log
```

```
$ grep " norm" step03.log
```

## Resoluton

```
[pylithapp.timedependent.interfaces.fault]  
zero_tolerance = 1.0e-10
```

```
[pylithapp.petsc]  
ksp_rtol = 1.0e-20  
ksp_atol = 1.0e-12
```

```
snes_rtol = 1.0e-20  
snes_atol = 1.0e-8
```

# Step03: Error 6

Intended shear to drive fault slip

Debug: Check fault tractions

# Step03: Error 6

Intended shear to drive fault slip

Debug: Check fault tractions

Compare  $T_{shear} / T_{normal}$  against  $\mu_f$

# Step03: Error 6

Intended shear to drive fault slip

Debug: Check fault tractions

Compare  $T_{shear} / T_{normal}$  against  $\mu_f$

Resolution

```
[pylithapp.timedependent.bc.x_pos]
...
db_initial.data = [-1.0*m, 3.0*m, 0.0*m]

[pylithapp.timedependent.bc.x_neg]
...
db_initial.data = [1.0*m, -3.0*m, 0.0*m]
```



# Asking For Help

Send email to [cig-short@geodynamics.org](mailto:cig-short@geodynamics.org)

- Try to debug on your own first
- Describe what you are trying to do
  - Overview of problem, BC
  - 2-D or 3-D
  - Cell type (tri, quad, hex, tet)
  - Prescribed slip or spontaneous rupture
- Specify which version you are using AND your operating system (**PyLith v2.1.0 binary on Linux**)
- Send the **entire** error message, not just what you think is important (**entire log of output is best**)