

PyLith 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/clang-3.6.0/bin/pylith", line 27, in <module>
    start(applicationClass=PyLithApp)
File "/Volumes/Tools/unix/cig/clang-3.6.0/lib/python2.7/site-packages/pythia-0.8.1.15-py2.7.egg/shell.run(**kwds)
File "/Volumes/Tools/unix/cig/clang-3.6.0/lib/python2.7/site-packages/pythia-0.8.1.15-py2.7.egg/app.applyConfiguration(context)
File "/Volumes/Tools/unix/cig/clang-3.6.0/lib/python2.7/site-packages/pythia-0.8.1.15-py2.7.egg/raise ValueError("%s\n\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:99:
```

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
```

Python stacktrace

Fatal error. Calling MPI_Abort() to abort PyLith application.

Traceback (most recent call last):

```
File "/Volumes/Tools/unix/pylith-dev/clang-3.6.0/lib/python2.7/site-packages/pylith/apps/Petsc.py", line 10, in self.main(*args, **kwargs)
File "/Volumes/Tools/unix/pylith-dev/clang-3.6.0/lib/python2.7/site-packages/pylith/apps/PyLith.py", line 10, in self.problem.initialize()
File "/Volumes/Tools/unix/pylith-dev/clang-3.6.0/lib/python2.7/site-packages/pylith/problems/Problem.py", line 10, in self.formulation.initialize(self.dimension, self.normalizer)
File "/Volumes/Tools/unix/pylith-dev/clang-3.6.0/lib/python2.7/site-packages/pylith/problems/Problem.py", line 10, in self._initialize(dimension, normalizer)
File "/Volumes/Tools/unix/pylith-dev/clang-3.6.0/lib/python2.7/site-packages/pylith/problems/Problem.py", line 10, in integrator.initialize(totalTime, numTimeSteps, normalizer)
File "/Volumes/Tools/unix/pylith-dev/clang-3.6.0/lib/python2.7/site-packages/pylith/feassemble.py", line 10, in ModuleElasticityImplicit.initialize(self, self.mesh())
File "/Volumes/Tools/unix/pylith-dev/clang-3.6.0/lib/python2.7/site-packages/pylith/feassemble.py", line 10, in def initialize(self, *args): return _feassemble.IntegratorElasticity_initialize(self, *args)
```

Error message

```
RuntimeError: Error occurred while reading spatial database file 'mat_elastic.spatialdb'.
Spatial distribution with data dimensions of 0 cannot have more than one point.
Found 3 points in distribution.
```

Abort message

```
application called MPI_Abort(MPI_COMM_WORLD, -1) - process 0
```

Error Messages

Step01

```
sis: mpirun: exit 255
```

```
n/pylith: /Volumes/Tools/unix/pylith-dev/clang-3.6.0/lib/python2.7/site-packages/pylith/apps/Petsc.py", line 10, in self.main(*args, **kwargs)
```

Step01: Error 3 Resolution

Error found when initializing integrators

Error message

RuntimeError: Error occurred while reading spatial database file 'mat_elastic.spatialdb'.
Spatial distribution with data dimensions of 0 cannot have more than one point.
Found 3 points in distribution.

Step01: Error 3 Resolution

Error found when initializing integrators

Error message

RuntimeError: Error occurred while reading spatial database file 'mat_elastic.spatialdb'.
Spatial distribution with data dimensions of 0 cannot have more than one point.
Found 3 points in distribution.

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

Step01: Error 3 Resolution

Error found when initializing integrators

Error message

RuntimeError: Error occurred while reading spatial database file 'mat_elastic.spatialdb'.
Spatial distribution with data dimensions of 0 cannot have more than one point.
Found 3 points in distribution.

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
```

Python stacktrace

Fatal error. Calling MPI_Abort() to abort PyLith application.

Traceback (most recent call last):

```
File "/Volumes/Tools/unix/pylith-dev/clang-3.6.0/lib/python2.7/site-packages/pylith/apps/Petsc.py", line 10, in self.main(*args, **kwargs)
File "/Volumes/Tools/unix/pylith-dev/clang-3.6.0/lib/python2.7/site-packages/pylith/apps/PyLith.py", line 10, in self.problem.initialize()
File "/Volumes/Tools/unix/pylith-dev/clang-3.6.0/lib/python2.7/site-packages/pylith/problems/Problem.py", line 10, in self.formulation.initialize(self.dimension, self.normalizer)
File "/Volumes/Tools/unix/pylith-dev/clang-3.6.0/lib/python2.7/site-packages/pylith/problems/Problem.py", line 10, in self._initialize(dimension, normalizer)
File "/Volumes/Tools/unix/pylith-dev/clang-3.6.0/lib/python2.7/site-packages/pylith/problems/Problem.py", line 10, in integrator.initialize(totalTime, numTimeSteps, normalizer)
File "/Volumes/Tools/unix/pylith-dev/clang-3.6.0/lib/python2.7/site-packages/pylith/feassemble.py", line 10, in ModuleElasticityImplicit.initialize(self, self.mesh())
File "/Volumes/Tools/unix/pylith-dev/clang-3.6.0/lib/python2.7/site-packages/pylith/feassemble.py", line 10, in def initialize(self, *args): return _feassemble.IntegratorElasticity_initialize(self, *args)
```

Error message

```
RuntimeError: 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 in coordinate system (3)
```

Abort message

```
application called MPI_Abort(MPI_COMM_WORLD, -1) - process 0
```

Error Messages

Step01

```
sis: mpirun: exit 255
```

```
n/pylith: /Volumes/Tools/unix/pylith-dev/clang-3.6.0/lib/python2.7/site-packages/pylith/feassemble.py:10: ModuleElasticityImplicit.initialize: def initialize(self, *args): return _feassemble.IntegratorElasticity_initialize(self, *args)
```

Step01: Error 4 Resolution

Error found when initializing integrators

Error message

```
RuntimeError: 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 in coordinate system (3)
```

Step01: Error 4 Resolution

Error found when initializing integrators

Error message

```
RuntimeError: 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 in coordinate system (3)
```

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

Step01: Error 4 Resolution

Error found when initializing integrators

Error message

```
RuntimeError: 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 in coordinate system (3)
```

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/clang-3.6.0/lib/python2.7/site-packages/pylith/apps/Petsc.py", line 10, in self.main(*args, **kwargs)
File "/Volumes/Tools/unix/pylith-dev/clang-3.6.0/lib/python2.7/site-packages/pylith/apps/PyLith.py", line 10, in self.problem.initialize()
File "/Volumes/Tools/unix/pylith-dev/clang-3.6.0/lib/python2.7/site-packages/pylith/problems/Problem.py", line 10, in self.formulation.initialize(self.dimension, self.normalizer)
File "/Volumes/Tools/unix/pylith-dev/clang-3.6.0/lib/python2.7/site-packages/pylith/problems/Problem.py", line 10, in self._initialize(dimension, normalizer)
File "/Volumes/Tools/unix/pylith-dev/clang-3.6.0/lib/python2.7/site-packages/pylith/problems/Problem.py", line 10, in constraint.setConstraintSizes(solution)
File "/Volumes/Tools/unix/pylith-dev/clang-3.6.0/lib/python2.7/site-packages/pylith/bc/bc.py", line 10, in def setConstraintSizes(self, *args): return
bc.DirichletBC.setConstraintSizes(self, *args)
```

Error message

RuntimeError: Found overly constrained point while setting up constraints for DirichletBC bound

Abort information

application called MPI_Abort(MPLCOMM_WORLD, -1) - process 0

/Volumes/Tools/unix/cig/clang-3.6.0/bin/nemesis: mpirun: exit 255

/Volumes/Tools/unix/pylith-dev/clang-3.6.0/bin/pylith: /Volumes/Tools/unix/cig/clang-3.6.0/bin/

Step01: Error 5 Resolution

Error found when setting up solution field

Error message

```
RuntimeError: Found overly constrained point while setting up constraints for DirichletBC bound
```

Step01: Error 5 Resolution

Error found when setting up solution field

Error message

RuntimeError: Found overly constrained point while setting up constraints for DirichletBC bound

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 bound

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/clang-3.6.0/lib/python2.7/site-packages/pylith/apps/Petsc/self.main(*args, **kwargs)
```

```
File "/Volumes/Tools/unix/pylith-dev/clang-3.6.0/lib/python2.7/site-packages/pylith/apps/PyLith/self.problem.verifyConfiguration()
```

```
File "/Volumes/Tools/unix/pylith-dev/clang-3.6.0/lib/python2.7/site-packages/pylith/problems/self.formulation.verifyConfiguration()
```

```
File "/Volumes/Tools/unix/pylith-dev/clang-3.6.0/lib/python2.7/site-packages/pylith/problems/integrator.verifyConfiguration()
```

```
File "/Volumes/Tools/unix/pylith-dev/clang-3.6.0/lib/python2.7/site-packages/pylith/faults/FaultModuleFaultCohesiveKin.verifyConfiguration(self, self.mesh())
```

```
File "/Volumes/Tools/unix/pylith-dev/clang-3.6.0/lib/python2.7/site-packages/pylith/faults/faultdef.verifyConfiguration(self, *args): return _faults.FaultCohesiveLagrange.verifyConfigurat
```

Error message

RuntimeError: Quadrature is incompatible with cell for fault 'fault_ext'. Cell 256 has 4 edges

Abort info

```
application called MPI_Abort(MPLCOMM_WORLD, -1) - process 0
```

```
/Volumes/Tools/unix/cig/clang-3.6.0/bin/nemesis: mpirun: exit 255
```

```
/Volumes/Tools/unix/pylith-dev/clang-3.6.0/bin/pylith: /Volumes/Tools/unix/cig/clang-3.6.0/bin/
```

Step02: Error 2 Resolution

Error doing some basic validation of input

Error message

```
RuntimeError: Quadrature is incompatible with cell for fault 'fault_ext'. Cell 256 has 4 edges
```

Step02: Error 2 Resolution

Error doing some basic validation of input

Error message

RuntimeError: Quadrature is incompatible with cell for fault 'fault_ext'. Cell 256 has 4 edges

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: Quadrature is incompatible with cell for fault 'fault_ext'. Cell 256 has 4 edges

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/clang-3.6.0/lib/python2.7/site-packages/pylith/apps/Petsc.py", line 10, in self.main(*args, **kwargs)
File "/Volumes/Tools/unix/pylith-dev/clang-3.6.0/lib/python2.7/site-packages/pylith/apps/PyLith.py", line 10, in self.problem.initialize()
File "/Volumes/Tools/unix/pylith-dev/clang-3.6.0/lib/python2.7/site-packages/pylith/problems/Problem.py", line 10, in self.formulation.initialize(self.dimension, self.normalizer)
File "/Volumes/Tools/unix/pylith-dev/clang-3.6.0/lib/python2.7/site-packages/pylith/problems/Problem.py", line 10, in self._initialize(dimension, normalizer)
File "/Volumes/Tools/unix/pylith-dev/clang-3.6.0/lib/python2.7/site-packages/pylith/problems/Integrator.py", line 10, in integrator.initialize(totalTime, numTimeSteps, normalizer)
File "/Volumes/Tools/unix/pylith-dev/clang-3.6.0/lib/python2.7/site-packages/pylith/feassemble/ModuleElasticityImplicit.py", line 10, in ModuleElasticityImplicit.initialize(self, self.mesh())
File "/Volumes/Tools/unix/pylith-dev/clang-3.6.0/lib/python2.7/site-packages/pylith/feassemble/IntegratorElasticity.py", line 10, in 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
The two most likely causes of this are highly distorted cells and nondimensionalization with a

Abort info

```
application called MPI_Abort(MPI_COMM_WORLD, -1) - process 0
/Volumes/Tools/unix/cig/clang-3.6.0/bin/nemesis: mpirun: exit 255
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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
The two most likely causes of this are highly distorted cells and nondimensionalization with a

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
The two most likely causes of this are highly distorted cells and nondimensionalization with a

Debug: Look at nondimensional scales relative to the parameters

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

```
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
The two most likely causes of this are highly distorted cells and nondimensionalization with a

Debug: Look at nondimensional scales relative to the parameters

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

```
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*km
```

Step02: Error 4

Error found 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/clang-3.6.0/lib/python2.7/site-packages/pylith/apps/Petsc.py", line 10, in self.main(*args, **kwargs)
File "/Volumes/Tools/unix/pylith-dev/clang-3.6.0/lib/python2.7/site-packages/pylith/apps/PyLith.py", line 10, in self.problem.initialize()
File "/Volumes/Tools/unix/pylith-dev/clang-3.6.0/lib/python2.7/site-packages/pylith/problems/Problem.py", line 10, in self.formulation.initialize(self.dimension, self.normalizer)
File "/Volumes/Tools/unix/pylith-dev/clang-3.6.0/lib/python2.7/site-packages/pylith/problems/Problem.py", line 10, in self._initialize(dimension, normalizer)
File "/Volumes/Tools/unix/pylith-dev/clang-3.6.0/lib/python2.7/site-packages/pylith/problems/Problem.py", line 10, in integrator.initialize(totalTime, numTimeSteps, normalizer)
File "/Volumes/Tools/unix/pylith-dev/clang-3.6.0/lib/python2.7/site-packages/pylith/faults/Fault.py", line 10, in FaultCohesive.initialize(self, totalTime, numTimeSteps, normalizer)
File "/Volumes/Tools/unix/pylith-dev/clang-3.6.0/lib/python2.7/site-packages/pylith/faults/Fault.py", line 10, in ModuleFault.initialize(self, self.mesh(), self.upDir)
File "/Volumes/Tools/unix/pylith-dev/clang-3.6.0/lib/python2.7/site-packages/pylith/faults/Fault.py", line 10, in def initialize(self, *args): return _faults.Fault.initialize(self, *args)
```

Error message

RuntimeError: 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

```
RuntimeError: 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

```
RuntimeError: 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/clang-3.6.0/lib/python2.7/site-packages/pylith/apps/Petsc.py", line 10, in self.main(*args, **kwargs)
File "/Volumes/Tools/unix/pylith-dev/clang-3.6.0/lib/python2.7/site-packages/pylith/apps/PyLith.py", line 10, in self.problem.initialize()
File "/Volumes/Tools/unix/pylith-dev/clang-3.6.0/lib/python2.7/site-packages/pylith/problems/Problem.py", line 10, in self.formulation.initialize(self.dimension, self.normalizer)
File "/Volumes/Tools/unix/pylith-dev/clang-3.6.0/lib/python2.7/site-packages/pylith/problems/Problem.py", line 10, in self._initialize(dimension, normalizer)
File "/Volumes/Tools/unix/pylith-dev/clang-3.6.0/lib/python2.7/site-packages/pylith/problems/Problem.py", line 10, in integrator.initialize(totalTime, numTimeSteps, normalizer)
File "/Volumes/Tools/unix/pylith-dev/clang-3.6.0/lib/python2.7/site-packages/pylith/faults/Fault.py", line 10, in FaultCohesive.initialize(self, totalTime, numTimeSteps, normalizer)
File "/Volumes/Tools/unix/pylith-dev/clang-3.6.0/lib/python2.7/site-packages/pylith/faults/Fault.py", line 10, in ModuleFault.initialize(self, self.mesh(), self.upDir)
File "/Volumes/Tools/unix/pylith-dev/clang-3.6.0/lib/python2.7/site-packages/pylith/faults/Fault.py", line 10, in def initialize(self, *args): return _faults.Fault.initialize(self, *args)
```

Error message

RuntimeError: Error computing orientation of cell face. Cannot resolve tangential components in 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. Cannot resolve tangential components in
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. Cannot resolve tangential components in 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. Cannot resolve tangential components in 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. Cannot resolve tangential components in 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]
```

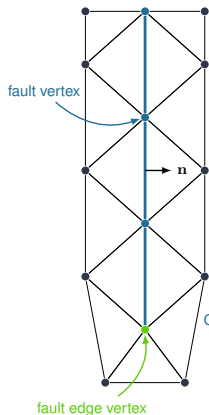
Debug: Look at fault surface

Resolution: Mark buried edges

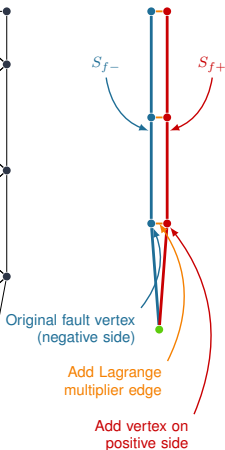
```
[pylithapp.timedependent.interfaces.fault]  
label = fault  
edge = fault_edge  
up_dir = [0,0,1]
```

Insertion of Cohesive Cells

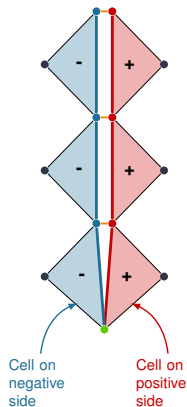
(a) Original mesh



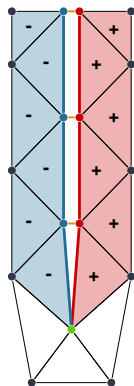
(b) Add collocated vertices



(c) Update cells with fault faces



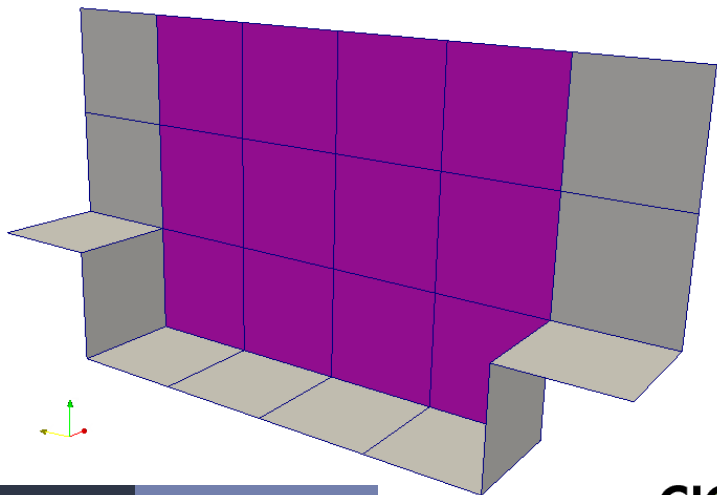
(d) Classify cells and update remaining cells



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.

```
... -1) - process 0
: mpirun: exit 255
```

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: 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
```

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 μ_f

Step03: Error 6

Intended shear to drive fault slip

Debug: Check fault tractions

Compare T_{shear} / T_{normal} against μ_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

- Try to debug on your own first
- Describe what you are trying to do
 - Overview of problem, BC (**diagrams/sketches are very helpful**)
 - 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 v2.1.2 binary on Linux x86_64**)
- Send the **entire** error message, not just what you think is important (**entire log of output is best**)