PyLith: A Finite-Element Code for Modeling Quasi-Static and Dynamic Crustal Deformation

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We have developed open-source finite-element software for 2-D and 3-D dynamic and quasi-static modeling of crustal deformation. This software, PyLith (current release is 1.5), combines the quasi-static viscoelastic modeling functionality of PyLith 0.8 and its predecessors (LithoMop and Tecton) and the wave propagation modeling functionality of EqSim. The target applications require resolution at spatial scales ranging from tens of meters to hundreds of kilometers and temporal scales for dynamic modeling ranging from milliseconds to minutes or temporal scales for quasi-static modeling ranging from minutes to thousands of years. PyLith development is part of the NSF funded Computational Infrastructure for Geodynamics (CIG) and the software runs on a wide variety of platforms (laptops, workstations, and Beowulf clusters). Binaries (Linux, Darwin, and Windows systems) and source code are available from `geodynamics.org`. PyLith uses a suite of general, parallel, graph data structures called Sieve for storing and manipulating finite-element meshes. This permits use of a variety of 2-D and 3-D cell types including triangles, quadrilaterals, hexahedra, and tetrahedra.

Current features include prescribed fault ruptures with multiple sequential earthquakes and aseismic creep, spontaneous fault ruptures with a variety of fault constitutive models, time-dependent Dirichlet and Neumann boundary conditions, absorbing boundary conditions, time-dependent point forces, and gravitational body forces. PyLith supports infinitesimal and small strain formulations for linear elastic rheologies, linear and generalized Maxwell viscoelastic rheologies, power-law viscoelastic rheologies, and Drucker-Prager elastoplastic rheologies. Current development focuses on performance improvements and adding additional bulk and fault constitutive models. We also plan to extend PyLith to allow coupling of quasi-static and dynamic simulations to resolve multi-scale deformation across the entire seismic cycle.

PyLith website: `http://www.geodynamics.org/cig/software/pylith`