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FANTOM: a new 2D/3D creeping flow model for the solution of geological problems

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We present a new finite element code for the solution of the Stokes and energy equations that has been purposely designed to address crustal-scale to mantle-scale flow problems in two and three dimensions. The code is based on an Arbitrary Lagrangian-Eulerian description of the flow field and allows for large deformations of the free surface. The finite element discretization is based on a regular quadrilateral/hexahedral division of space. A variety of rheologies has been implemented including linear, non-linear and thermally activated creep and brittle (or plastic) frictional deformation. The large system of algebraic equations that results from the finite element discretization and linearization of the basic partial differential equations is solved using a (sequential or massively parallel) direct solver that can efficiently factorize poorly conditioned systems resulting from the highly non-linear rheology. The code can be run both in sequential and parallel modes. We illustrate the code performance and algorithms by presenting 1) very high resolution two-dimensional model results ; 2) large deformation (at moderate resolution) three-dimensional model results.