A new way to recover pressure in Finite Element geodynamics codes based on the penalised pressure formulation

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Alongside temperature, strain-rate, material properties and accumulated strain, pressure is one of the key variables which comes into play in the complex rheological equations implemented in today's geodynamics codes. In particular, a subset of these codes relies on the Q1-P0 finite element with a penalised formulation. This means that the pressure is no longer an unknown in the algebraic system to be solved, but is instead recovered from the divergence of the velocity field. Unfortunately it has been abundantly documented that this pressure field needs to be smoothed as it displays a so-called checkerboard pattern. I present a new way of computing the pressure field from the velocity field, which involves an additional finite element solution for the nodal pressures using the same finite element basis and numerical quadrature as used for the velocity. I compare the results obtained with this method with those obtained with traditional smoothing methods for a variety of benchmarks.