

for time = 0 to simulation duration

L: matrix form of discretized Stokes + mass conservation = $f(\text{effective viscosity})$

R: right-hand side of discretized Stokes + mass conservation

S: solution vector, contains v_x , v_y , and P

initially inaccurate, has large residual (res)

while res > tolerance



Set time step Δt to limit the increase of damage at ΔD_{\max}

$$\Delta t < \Delta D_{\max} / (\partial D / \partial t)$$

Construct **L** and **R**, using the current solution **S**

Assemble an array of effective viscosity, averaging:

- Viscosity from ductile flow law
- Plastic viscosity (yield stress / strain rate)
- Damage viscosity (from previous stresses and damage)
- Account for elastic terms

Update solution with direct solver: **Snew** = **S** - **L**\b**R**

Calculate residual **res** = $\| \mathbf{L} \mathbf{S}_{\text{new}} - \mathbf{R} \| / \| \mathbf{R} \|$

decrease ΔD_{\max} by 20% every 20 iterations if tolerance is not met

tolerance steadily increases from $1e-7$ to $1e-2$ as iterations progress

limit at 150 iterations

Update damage, elastic stresses

Advect material properties and stresses on markers

end