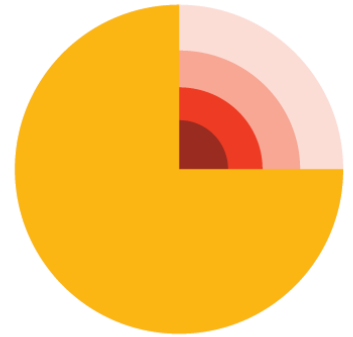


pTatin3D
WP2 - Status



ChEESE-2P

pTatin3D

3D Long-term geodynamic modelling

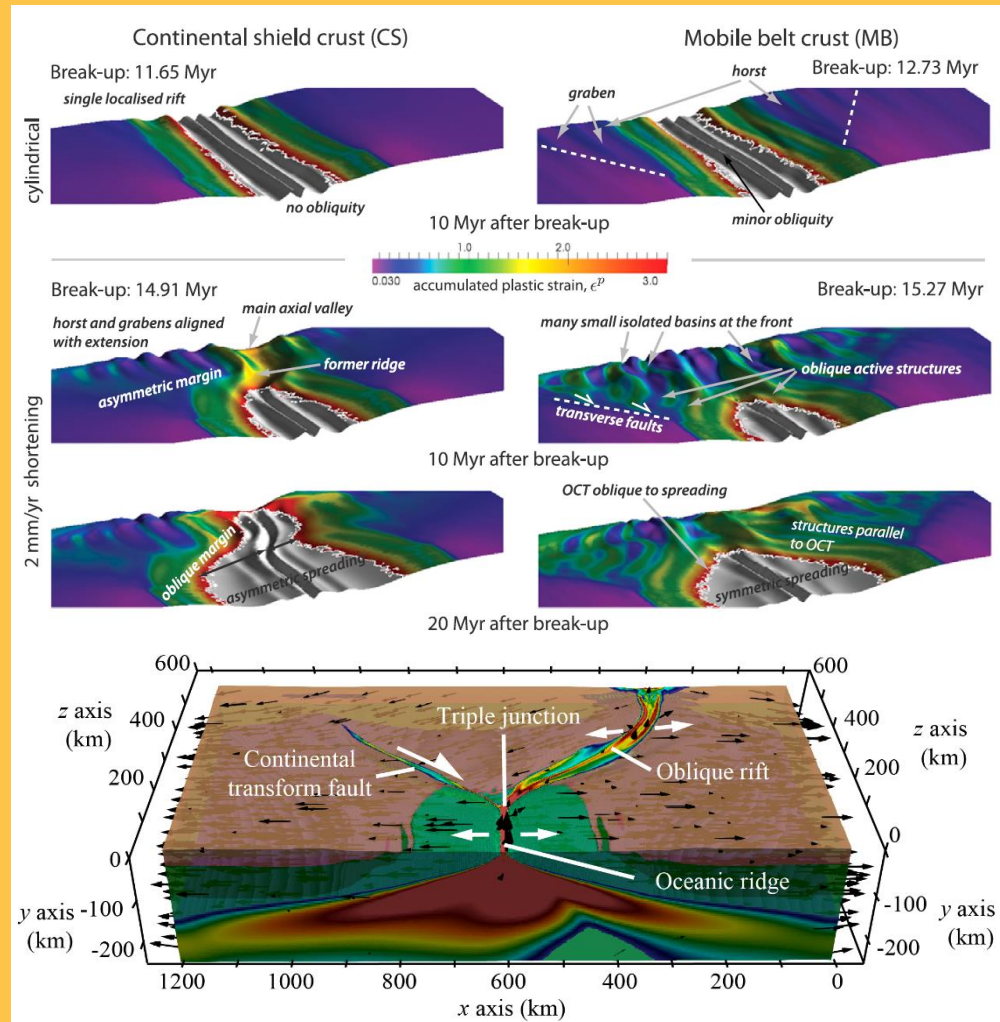
- Incompressible
- Non-linear
- FEM – Q2-P1disc
- Deformable free-surface
- ALE with marker-in-cell method
- Massively parallel
- CPU & GPU
- Relies on PETSc (currently used version: 3.15)

Repository:

<https://bitbucket.org/dmay/ptatin-total-dev>

pTatin3D's team:

Laetitia Le Pourhiet (SU, contact)
Anthony Jourdon (LMU, contact)
Dave May (UCSD)



Conservation of momentum, incompressible, steady-state:

Deviatoric stress tensor

Pressure gradient

Volume forces

$$\nabla \cdot \underline{\underline{\tau}}(\mathbf{u}, p) - \nabla p + \rho \mathbf{g} = \mathbf{0}$$

No inertia

$$\nabla \cdot \mathbf{u} = 0$$

No volume change

Mechanical model: visco-plastic Stokes

Non-linear velocity and pressure dep. viscosity

$$\underline{\underline{\tau}}(\mathbf{u}, p) = 2\eta(\mathbf{u}, p)\underline{\underline{\epsilon}}(\mathbf{u})$$

Strain rate tensor

Energy conservation:

Thermal inertia

$$\rho C_p \left(\frac{\partial T}{\partial t} + \mathbf{u} \cdot \nabla T \right) = \nabla \cdot (k \nabla T) + H$$

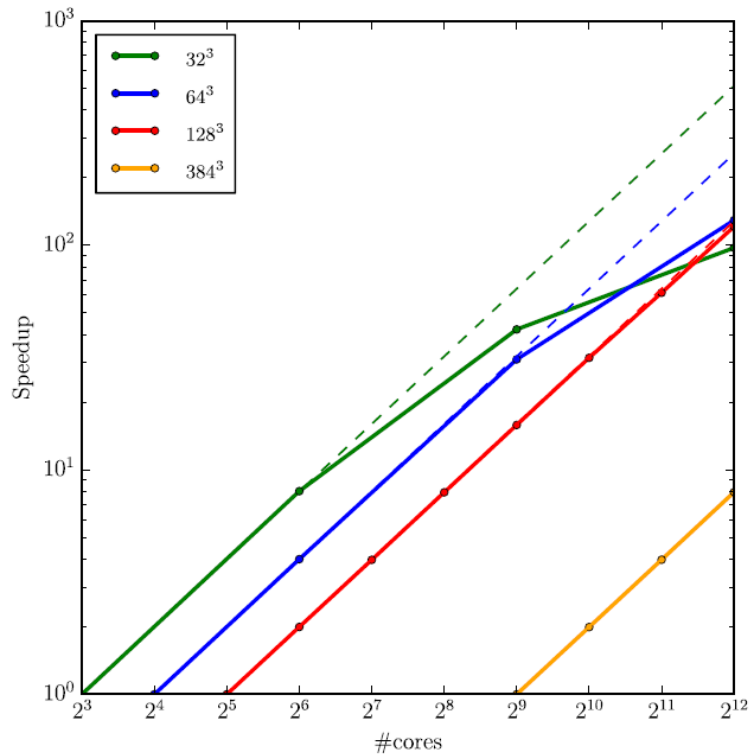
Advection (incompressible)

Diffusion

Heat sources (radiogenic, shear heating)

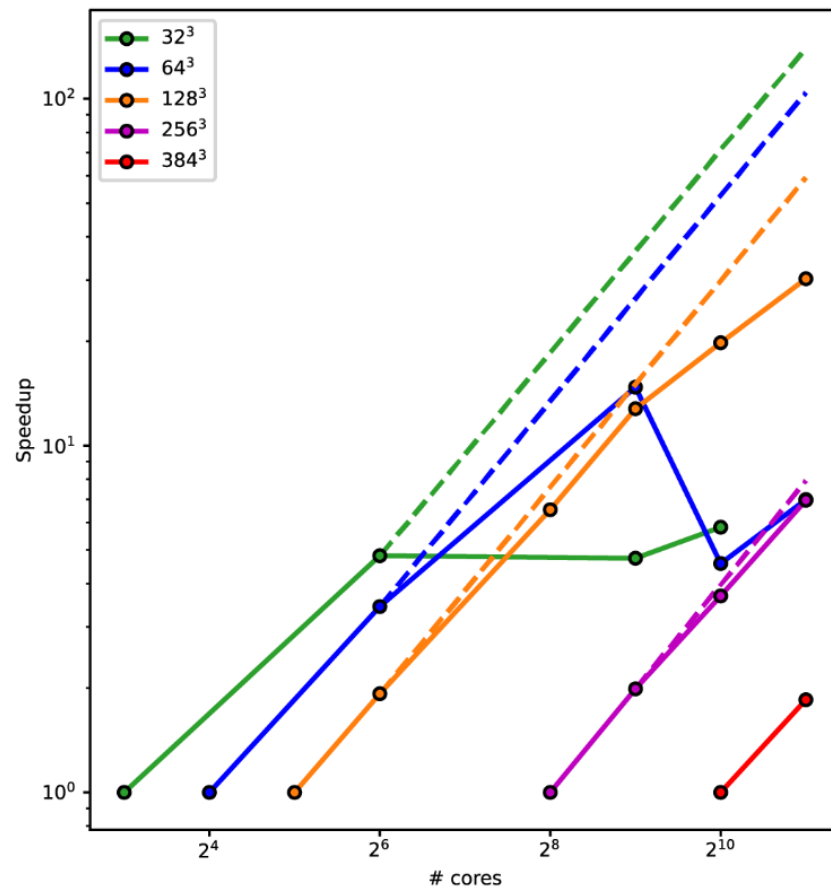
Speedup matrix-free SpMV

Cray XE6 Hexagon, 2015



Speedup matrix-free SpMV

SuperMUC-NG, 2022



Total's Pangea supercomputer:

No actual numbers to report however:

- Code ran for long periods of time (> 2 months for a single job) without interrupting on 2048 MPI ranks
 - Runs have been done on > 4096 MPI ranks without any trouble
- ➔ pTatin3D is stable, scalable and reliable, theoretically scalable beyond petascale





Dependencies:

Petsc, which requires BLAS-LAPACK

CPU: MPI

GPU: MPI+CUDA & MPI+OpenCL

CPU & GPU repository:

<https://bitbucket.org/dmay/ptatin-total-dev>

Mini-app:

CPU available

GPU to do

Physical test: sinking body in a linear and/or non-linear viscous medium

Planned developments (WP5):

- Add support for Navier-slip type boundary conditions for spherical cap regional model domains using a symmetric Nitsche formulation.
- Accurate projection of material properties (stress and density) into a field defined on a mesh.
- Integration of pTatin3D output data formats with ASAGI to enable efficient import of 3D volume data into SeisSol.

