LaMEM short course

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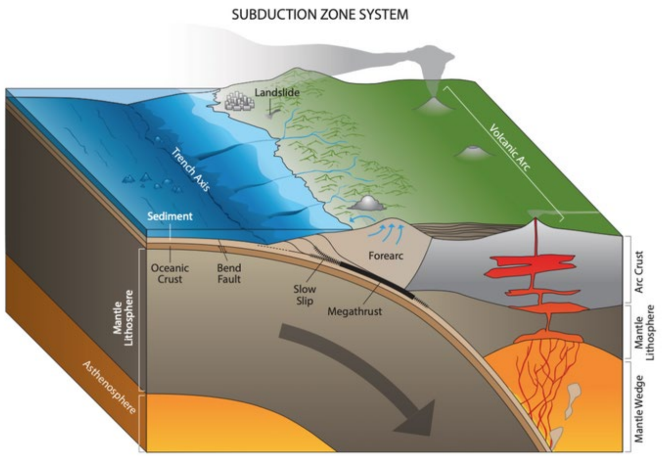
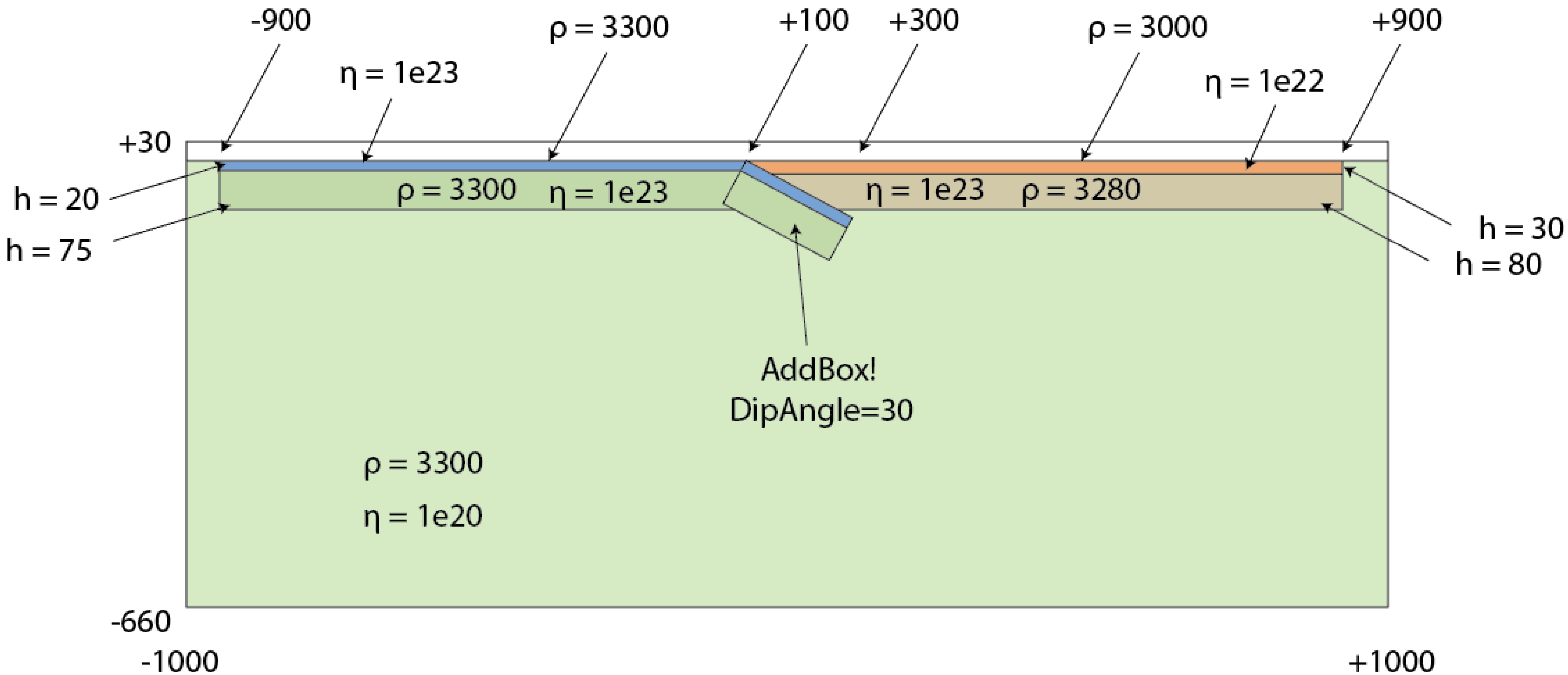


Subduction setup

- Study buoyancy driven subduction
- Retrieve P-T-t paths
- Include phase diagrams
- Include creep laws

Buoyancy driven subduction setup



Thermal ages:

- Oceanic lithosphere = 70 Myr
- Oceanic pre-subducted slab = 60 Myr
- Overriding plate = 70 Myr

Model parameters:

Resolution	= (256,1,96)
T air	= 20.0
T bottom	= 1300.0
nstep_max	= 400

Buoyancy driven subduction setup

- Note that, although we prescribe a temperature profile the setup uses iso-viscous rheologies

- Apply the following plastic parameters for the lithosphere and continental crust:

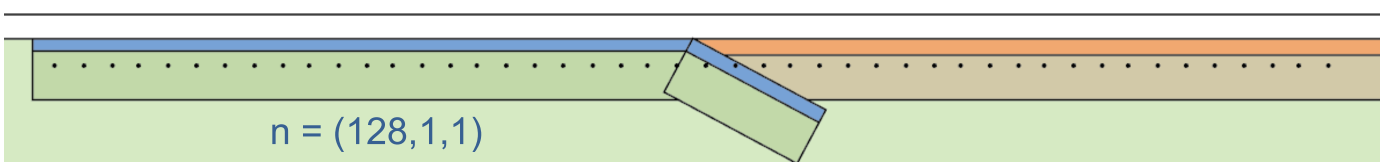
```
ch                = 20e6,
fr                = 10,
```

- For the oceanic crust use:

```
ch                = 5e6,
fr                = 0,
```

Here we want a weak crust to act as a weak subduction interface

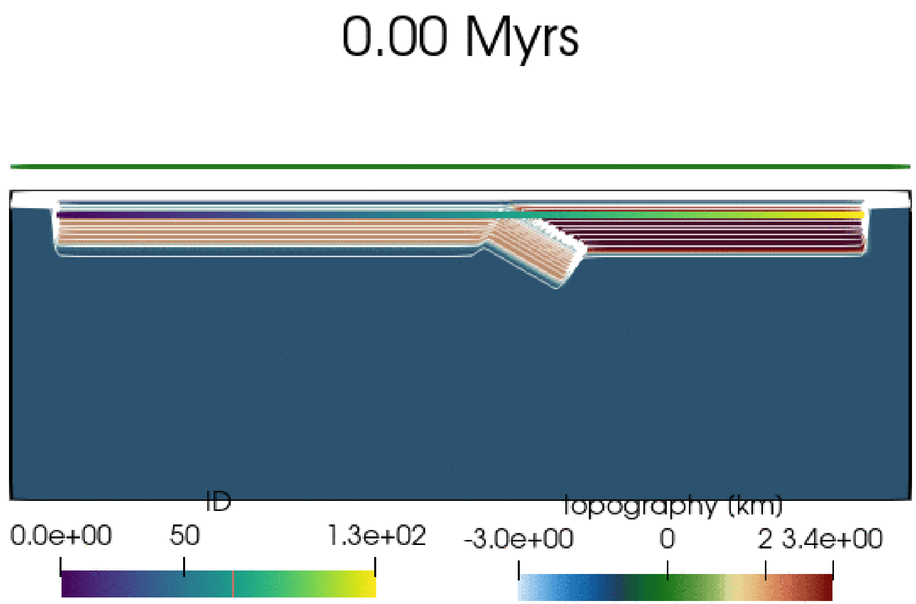
- Add passive at 35 km depth



- Perform the simulation

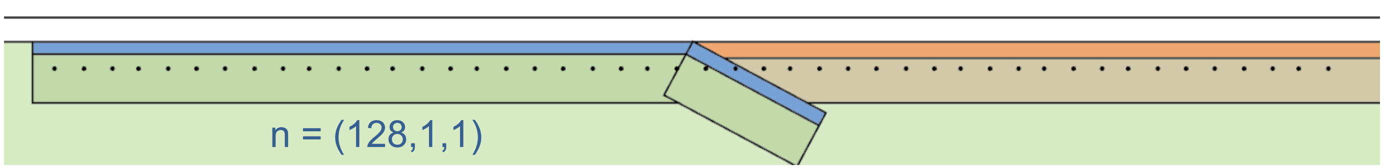
Buoyancy driven subduction setup

- Example of subduction modelling results



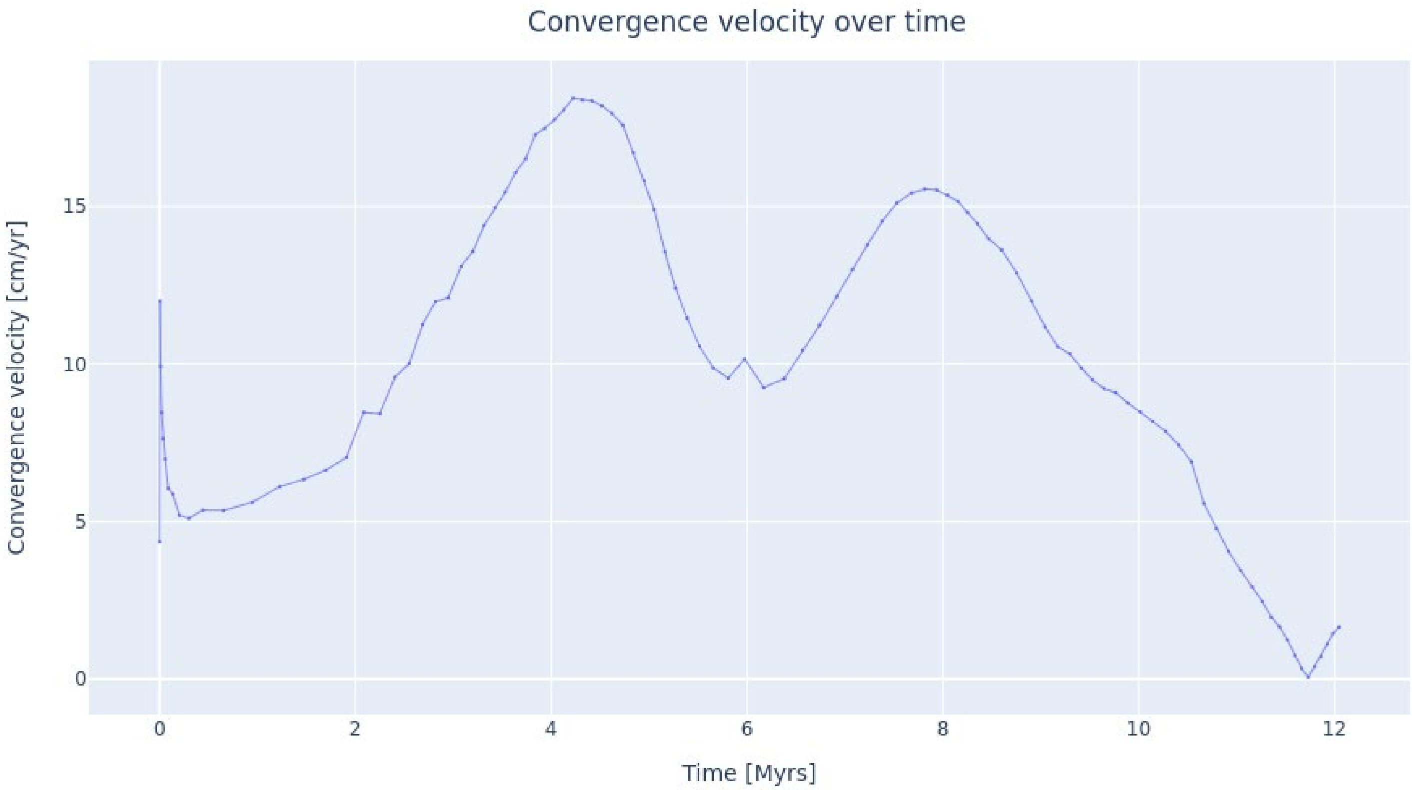
- Compute and display the evolution of the convergence velocity in cm/yr

  - select tracers ID=0 and ID=127 (first and last tracers)



Buoyancy driven subduction setup

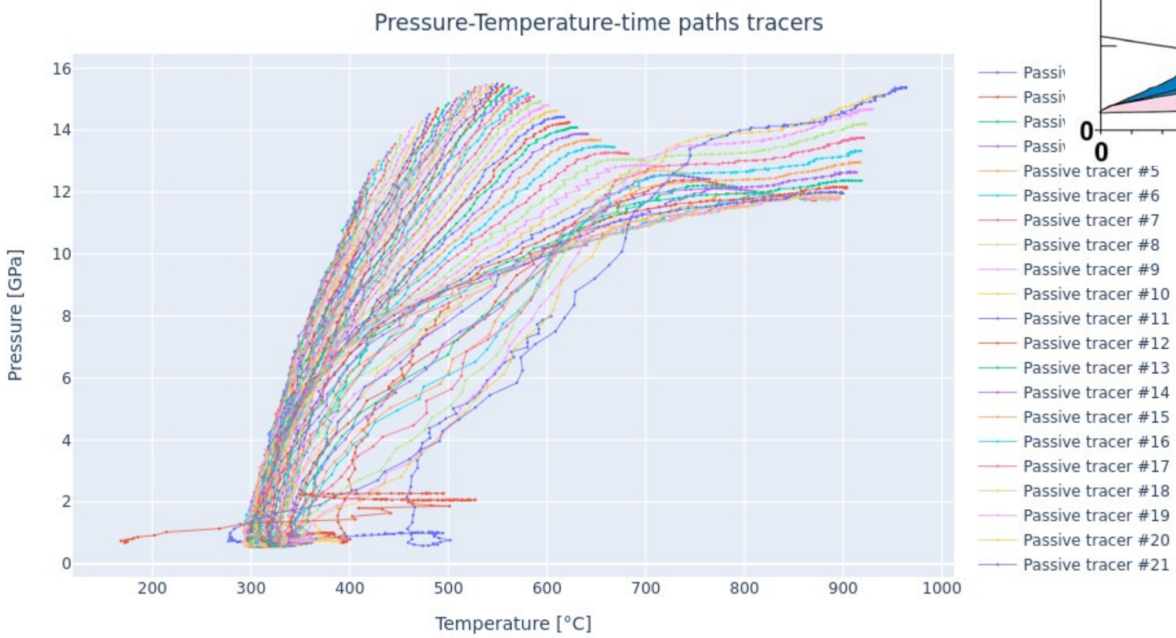
- Evolution of the convergence velocity:

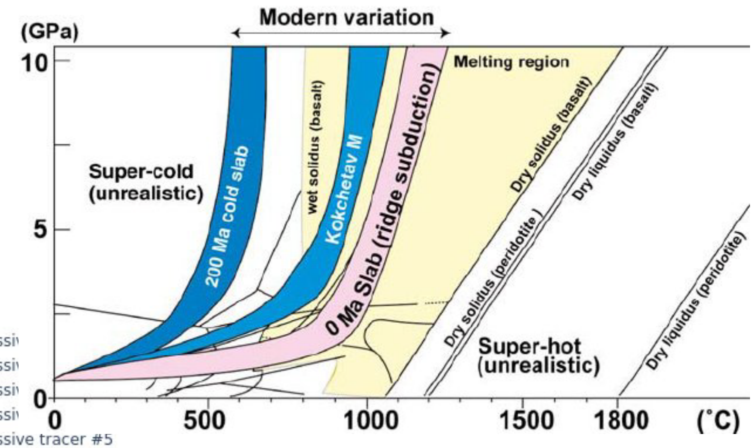


- Next, select the tracers belonging to the oceanic lithosphere (phase .== 3) and plot the Pressure-Temperature-time paths of the path

Buoyancy driven subduction setup

- Pressure temperature path of the slab





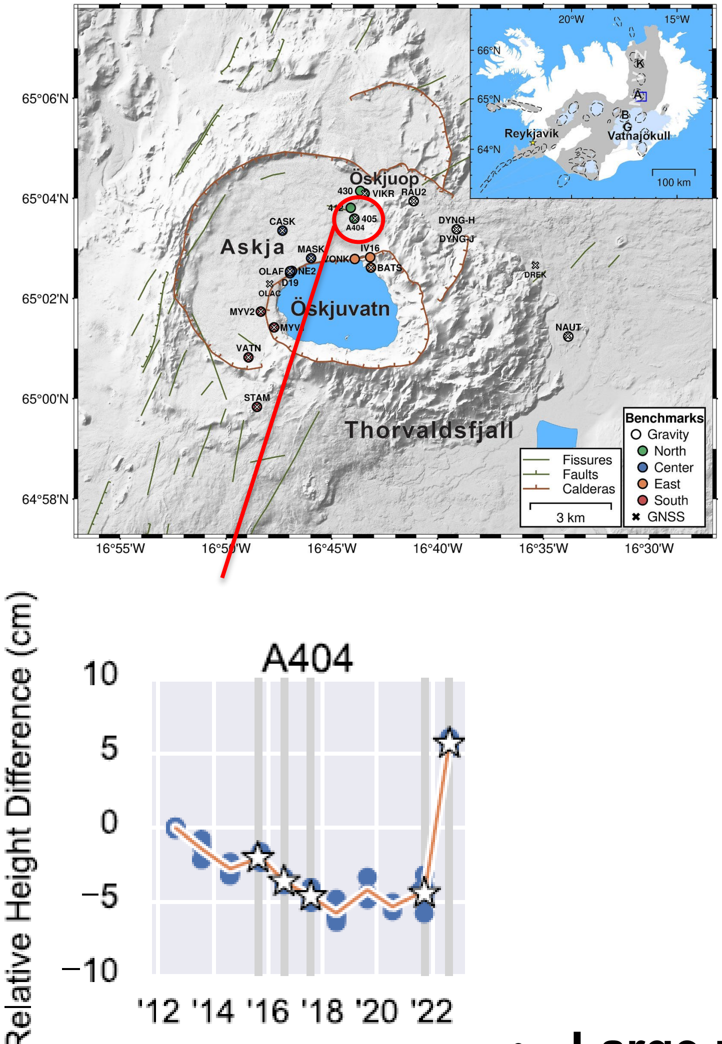
Santosh et al., 2010

- Temperature of the slab is too low compared to cold slab, why is that?

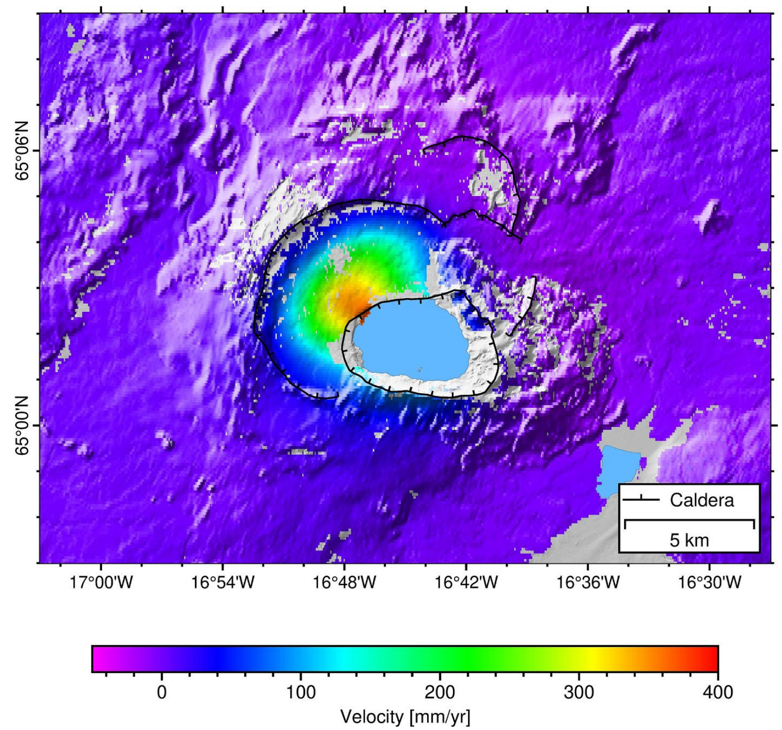
Volcano setup

- Study the impact of magmatic recharge/vesiculation on surface uplift

Askja Volcano - Iceland

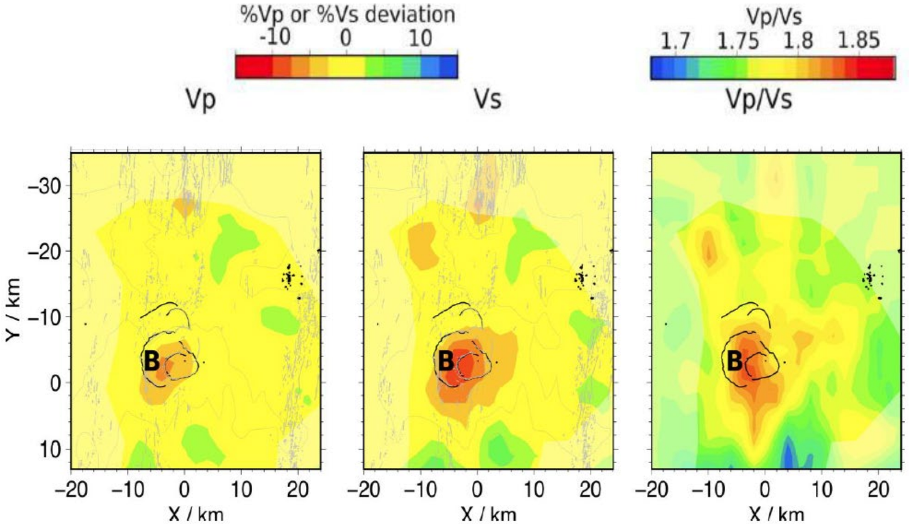


Koymans et al., 2023



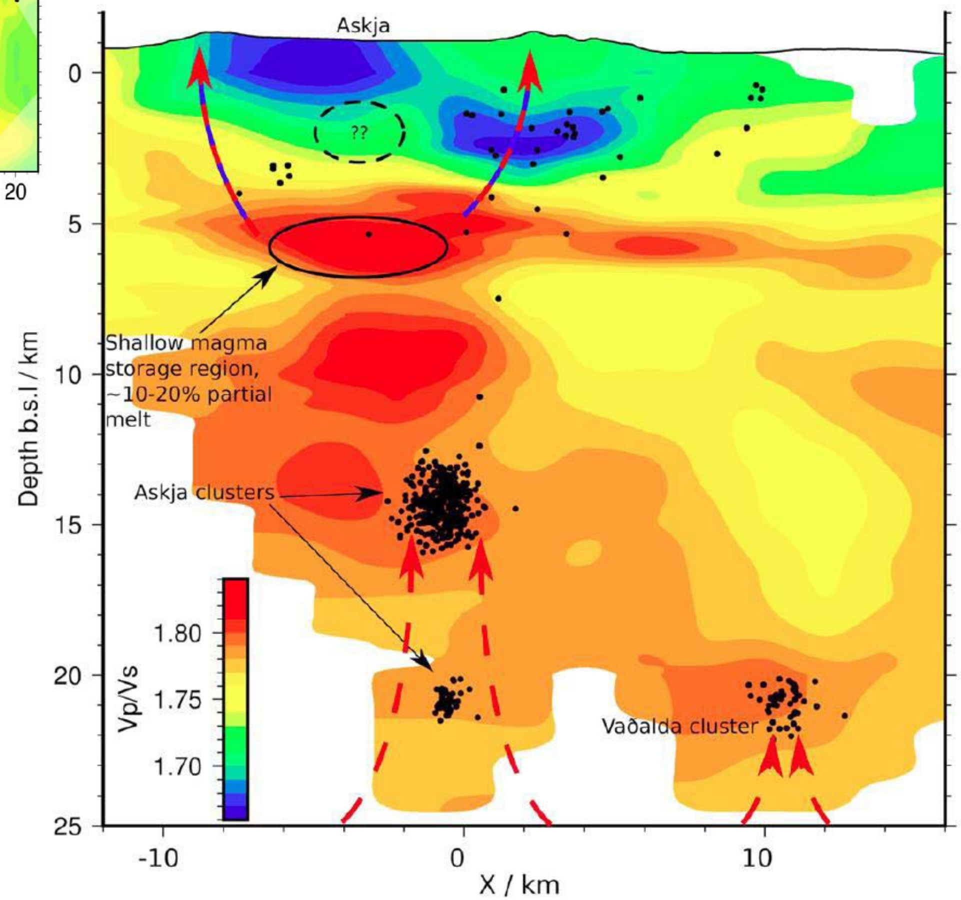
- **Large uplift between 2021-2022, up to 10 cm!**
- Magma vesiculation or change in the hydrothermal system??

Askja Volcano - Iceland

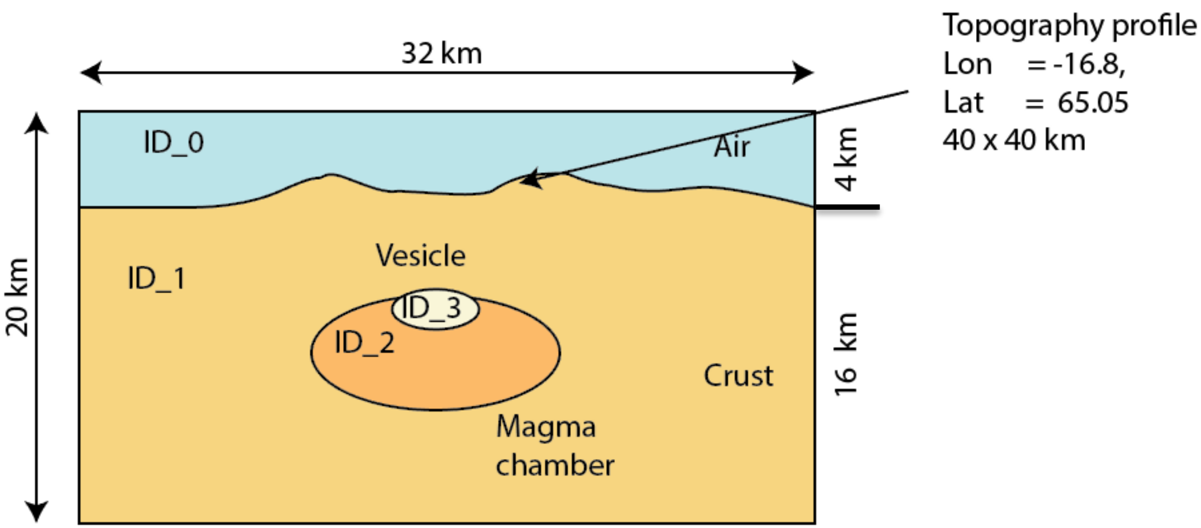


Depth slices at 6 km

White, 2017



Askja Volcano – proposed setup

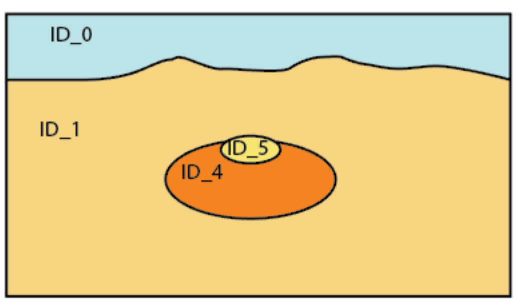


Tair = 20
Tbot = 1000
Tgradient = 25 C/km

$\dot{\varepsilon}xx$ = 5e-16 (extension)

phase transition

at t > 0.05 Myr



ID_1 = crust

ID_2 = deepcopy(crust …)

ID_3 = deepcopy(crust …)

ID_4 = deepcopy(crust … , eta = 5e16, rho = 2100)

ID_5 = deepcopy(crust … , eta = 1e16, rho = 10)

Askja Volcano – setup help

In Model(…) update the following

```
Scaling(GEO_units(  temperature     = 1000,
                    stress          = 1e9Pa,
                    length          = 1km,
                    viscosity       = 1e18Pa*s) ),

Grid(               x               = [-16.0,16.0],
                    y               = [-0.2,0.2],
                    z               = [-16.0,4.0],
                    nel             = (128,2,64) ),

Time(               time_end        = 1.0,
                    dt              = 0.00001,
                    dt_min          = 0.0000001,
                    dt_max          = 0.01,
                    nstep_max       = 80,
                    nstep_out       = 1 ),

SolutionParams(     act_temp_diff   = 1,
                    FSSA            = 1.0,
                    eta_min         = 1e16,
                    eta_ref         = 1e19,
                    eta_max         = 1e21,
                    init_guess      = 1,
                    p_lim_plast     = 1),
```

Askja Volcano – setup help

Definition of Phase Transition:

```
phaseT = PhaseTransition( ID              = 0,
                          Type            = "Constant",
                          Parameter_transition = "t",
                          ConstantValue = 0.05,
                          number_phases = 2,
                          PhaseBelow    = [2,3],
                          PhaseAbove    = [4,5],
                          PhaseDirection= "BelowToAbove" );
```

Don’t forget to add the phases, topography and phase transition to your model setup!

```
add_phase!( model, air, Crust, MagmaCrust, GasCrust, Magma, Gas)
add_topography!(model, Topo_LaMEM)
add_phasetransition!(model, phaseT)
```

Askja Volcano – setup help

- Standard modelling parameters:

```
G = 5e10                # elastic bulk modulus
rho = 2800              # Average crust density
```

<u>Thermal parameters</u>

```
alpha = 3e-5            # thermal expansivity
K = 3                   # thermal conductivity
Cp = 1000               # heat capacity
```

<u>Plastic parameters</u>

```
ch = 10e6               # cohesion
fr = 10                 # frictional angle
```

- Run simplified model first (without phase change to make sure everything is right)

Askja Volcano – setup help

- Example of modelling results for the Askja Volcano setup