EUROPLANET SCIENCE CONGRESS OSPA

This poster participates in the

OSPA

Outstanding Student Poster Award Contest

TIDAL WALKING

ON EUROPA'S STRIKE-SLIP FAULTS

INSIGHT FROM NUMERICAL MODELING

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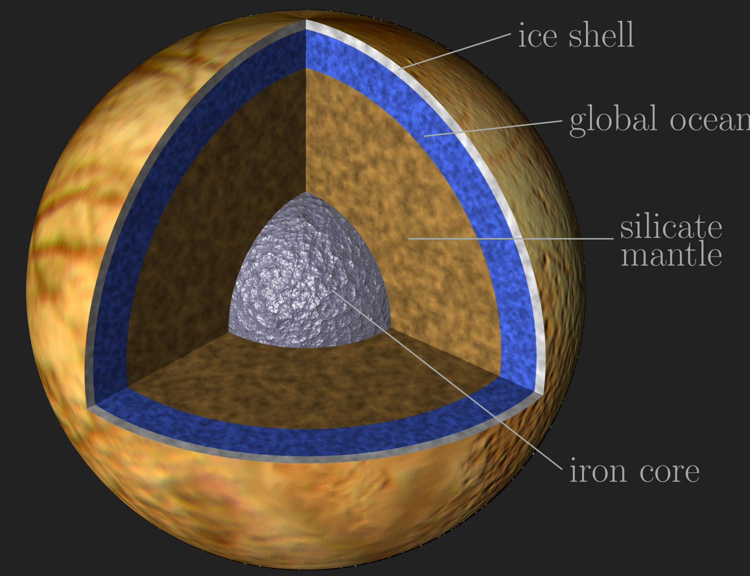
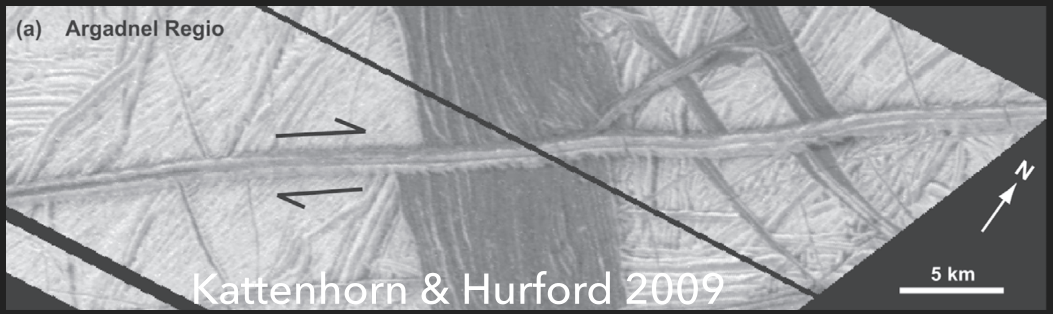
EUROPA:

- is divided into iron core, silicate mantle, global ocean and ice shell
- has a young surface (tens of kyr) with multitude of superposed crosscutting lineaments
  - on some of the faults, strike-slip offset of a few kilometers was observed



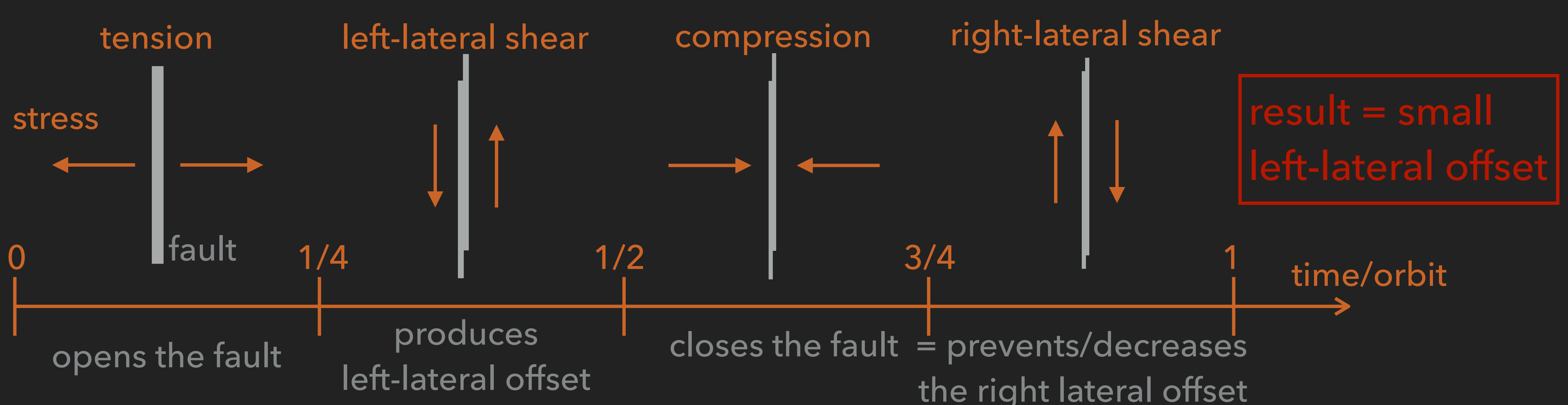
Background image: courtesy of JPL NASA.



➡ STRIKE-SLIP FAULTS

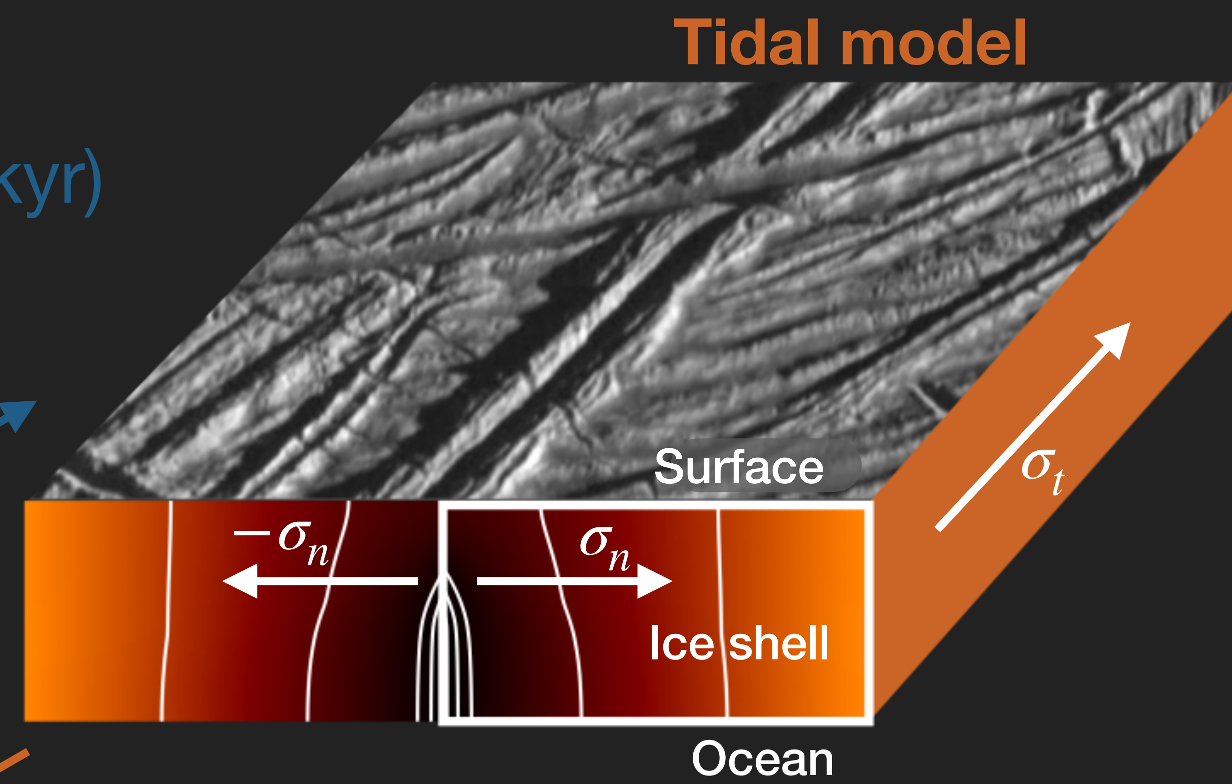
- formation of strike-slip offset?
  - reactivation of pre-existing faults
  - by diurnal tides => **tidal walking model** (Hoppa et al. 1999)

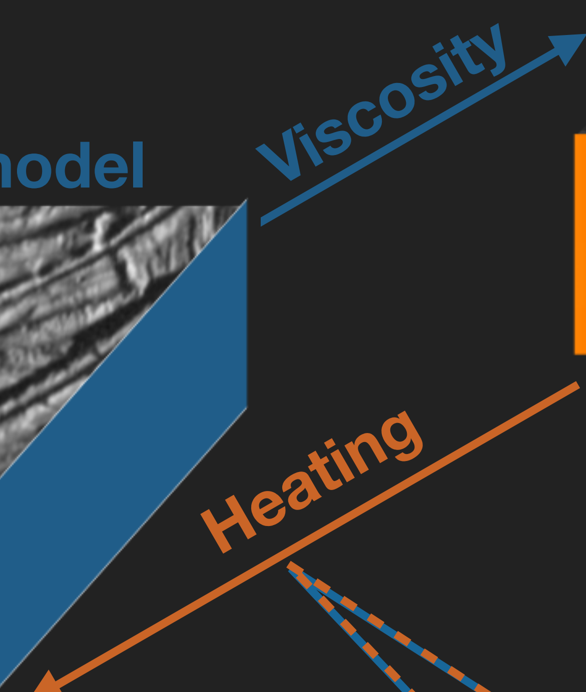
in the simplest setting

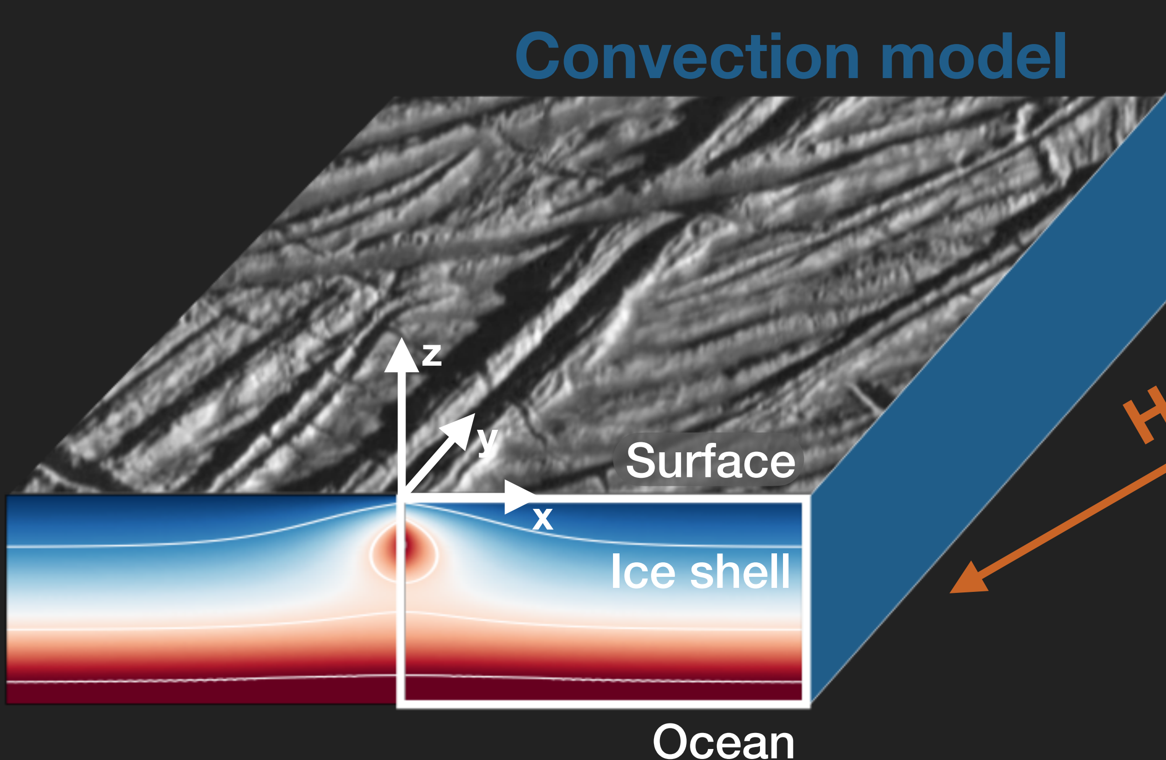


MOTIVATION —> MODEL

- aim: to test the tidal walking hypothesis with numerical model, quantify the offset and thermal signatures on surface
- the problem has 2 timescales:
  - offset formation timescale (100s of kyr)
  - diurnal tides timescale (~3.5 days)
  - ➡ 2 coupled models







- viscoelastic continuum with an embedded fault plane subjected to tidal stresses

- thermal convection with viscosity described by composite creep (equations)

exchange of information (viscosity & heating) takes place every convection step (detailed flow chart)

TIDAL MODEL

- solves mass and momentum balances of incompressible Maxwell medium
- with preexisting fault subjected to diurnal stresses

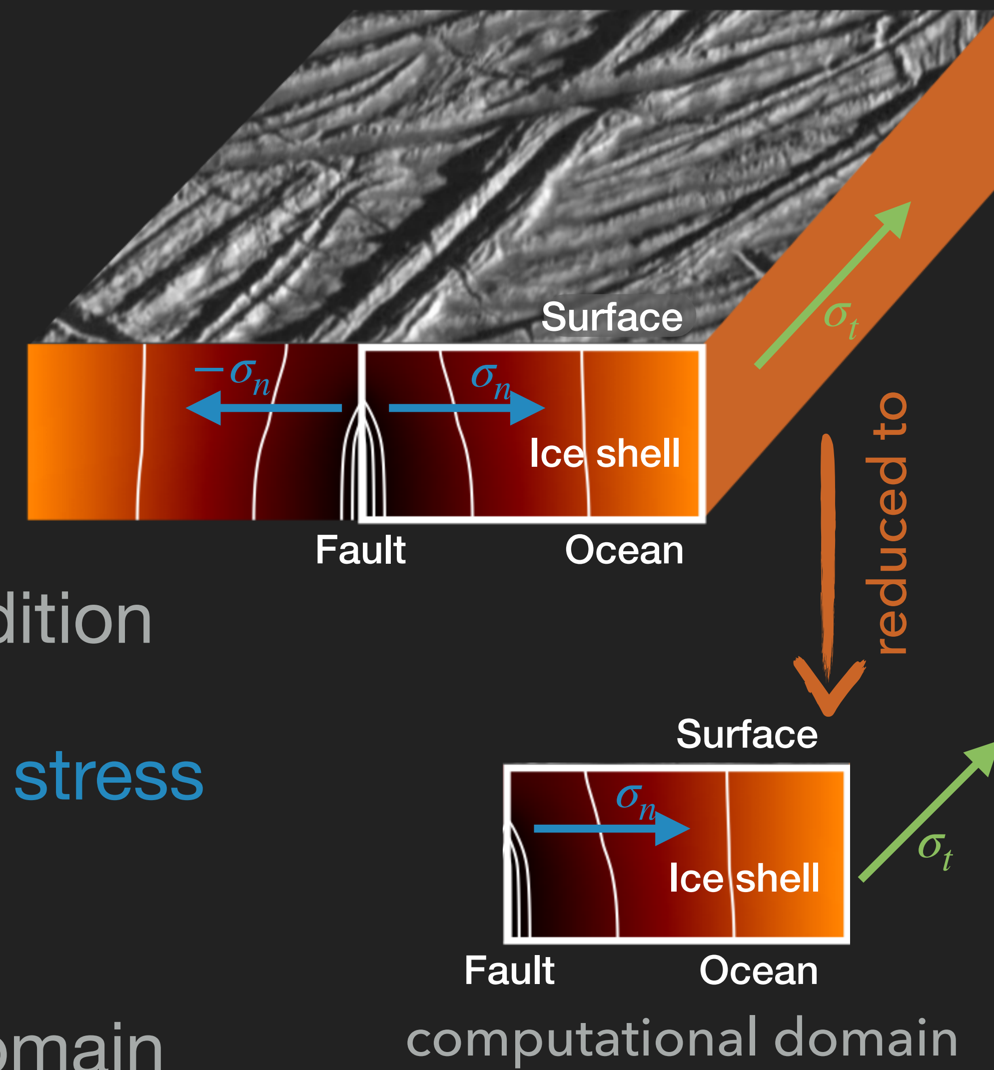
amplitude of loading stress

  - tangential: $\sigma_t = \sigma_0 \sin(\omega t)$ - boundary condition

orbital frequency   phase shift

  - normal: $\sigma_n = \sigma_0[\sin(\omega t - \varphi)]$ - in the yield stress

- uniformity of the fault => 2D cut
- anti-symmetry of the problem => 1/2 of the domain



FAULT

slip velocity   shear stress on the fault   yield stress

- Mohr-Coulomb criterion - 2 states:
  - stick $v_{slip} = 0 \Leftrightarrow |s_x| < \sigma_Y$
  - slip $v_{slip} \neq 0 \Leftrightarrow |s_x| = \sigma_Y$
- approximated with Navier-slip boundary condition and effective coefficient of friction (pseudoplasticity)

ice density   magnitude of gravity acceleration   depth

- yield stress $\sigma_Y = \max\left(0, \mu_f(\sigma_n + \varrho g h)\right)$

coefficient of friction

  - varies in time due to normal diurnal tides => opening/closing of the fault

More details in Sládková et al., 2020

RESULTS

- model run for 100kyr
- heat flux anomaly = difference in heat flux above the fault at the end and at the start of the computation

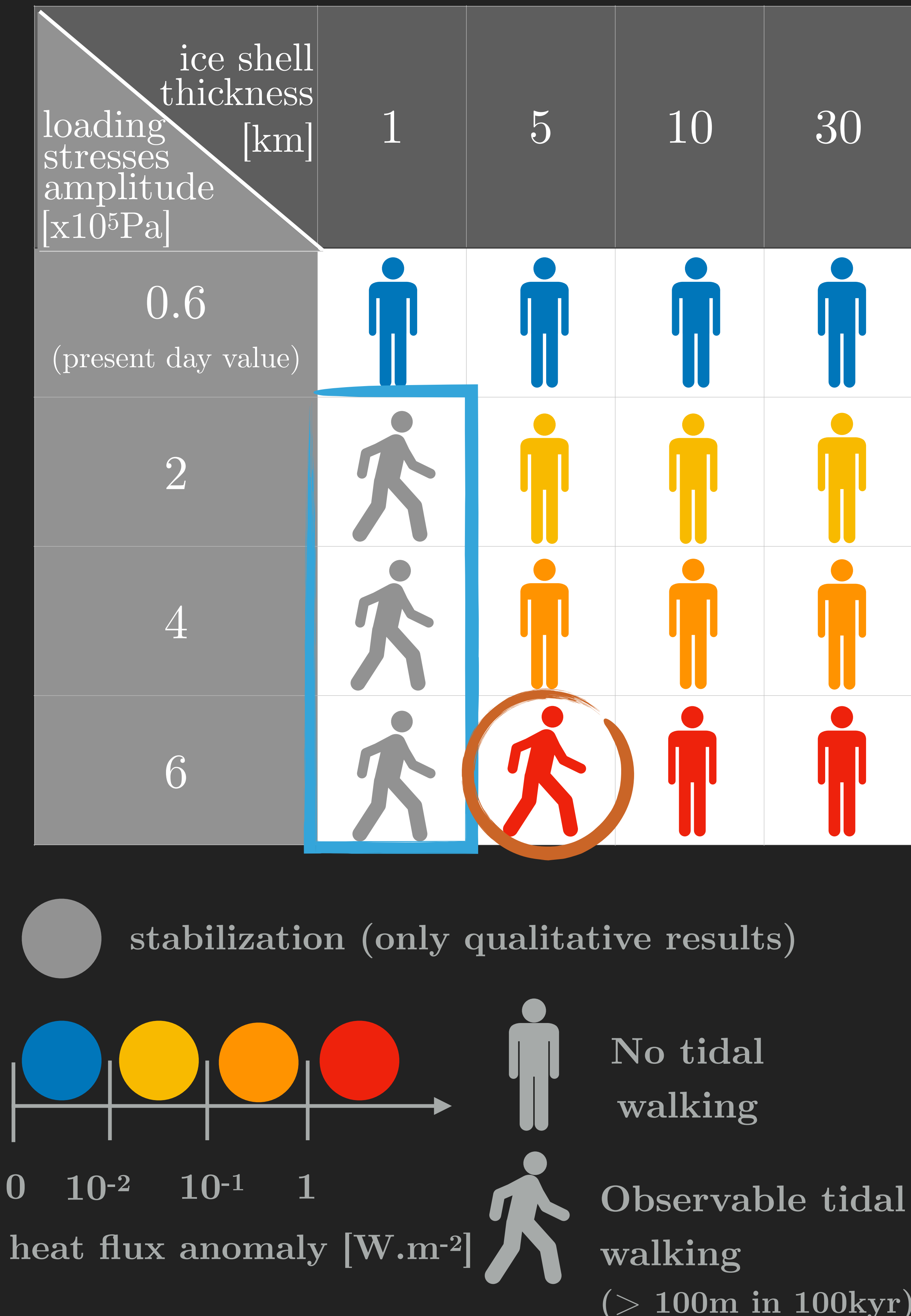
➡ challenging to produce observable offset (few walking figures)

➡ unrealistically thin shell and high stresses needed except for:

- thermally activated run =
  - the fault and its surroundings are heated by frictional and shear heating, viscosity drops enabling the accumulation of the offset

➡ measurable heat flux anomalies can be produced without observable offset

Figure from Sládková et al., 2020



CONCLUSIONS

- an observable offset can be produced if the active part of the fault reaches either the bottom of the shell or penetrates to a very low viscosity zone (e.g. produced by extensive heating => thermally activated run)

➡ thermo-mechanical coupling is important

- whole shell penetration:
  - improbable in present days
  - possible if the cracks are filled with water compensating the overburden pressure and enabling a significant offset even for the present-day estimates of the tidal forcing amplitudes and ice-shell thickness ≦ 10 km
- moderate surface heat flux anomaly between 10 and 100 mW m^{-2} is observed (even when the accumulated offset is negligible) = a possible tool for identifying active strike-slip faults on Europa

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