The influence of convergence rate on the formation of the Himalayan-Tibet region

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Velocity in the region

- **Decreases in convergence velocity (Fig 1):**
  - **~50 Ma** – India Asia collision/indentation[3,4,5,7].
  - **~40 Ma** – Himalayan Orogeny, Tibet formation (?)
  - **~20 Ma** –Himalayan Fold and Thrust (FAT) belt[2].

Can these decreases in velocity be linked to structures observed in the Himalayan-Tibet region

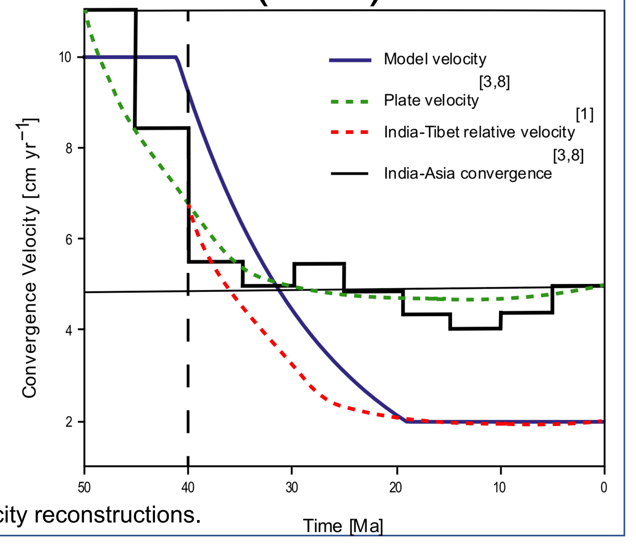


Fig 1: Velocity reconstructions.

Model Setup

- **Underworld** used to solve conservation of mass, momentum & energy[6].
- **Crust** - 25 km thick, 2 types (Fig 2), in agreement with pre-collisional rifting thickness[9].
- **Geotherm** - 25 °C km^{-1} for 10 km, then 12 °C km^{-1} →1300 °C reached at LAB (97.5 km)
- **Rheology** – Viscoplastic (Fig 2). Non-linear dislocation creep encompasses strain-rate, which varies as a function of convergence rate and localization. Plastic strain weakening is also included.
- Wet olivine fossilized subduction zone to initially localize deformation, diabase backstop to stop migration of crust towards right side wall.
- Decreasing velocity non-linearly from 10-2 cm yr^{-1} over 50 Myr on left boundary (Fig. 1).
- 2 cm yr^{-1} for last ~20 Ma as the relative velocity between India & Tibet is ~1.7-2.1 cm yr^{-1} [1].
- Total of ~2700 km of convergence, which is estimated to have occurred since collision[4].
- Insulating top and side walls (no heat flux), open temperature bottom boundary.

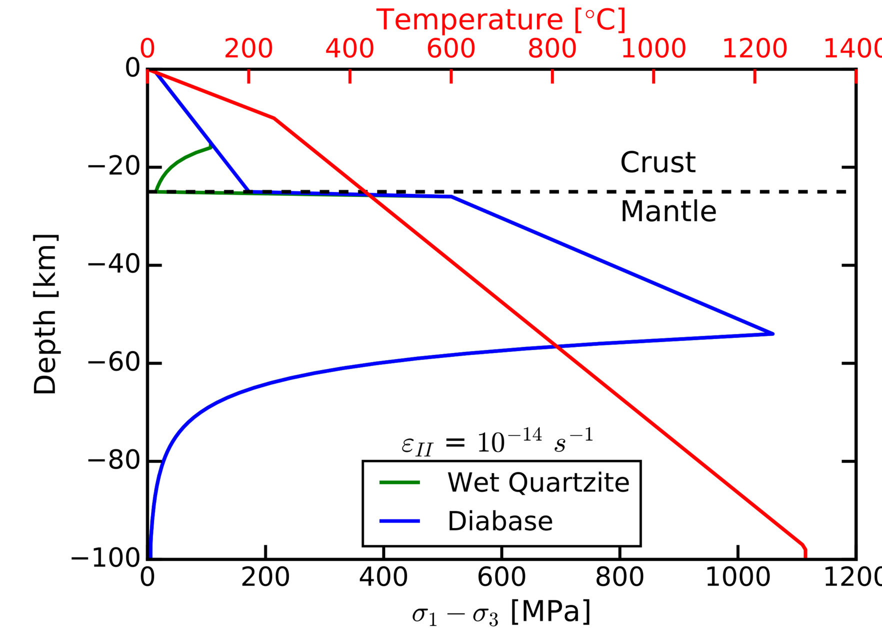


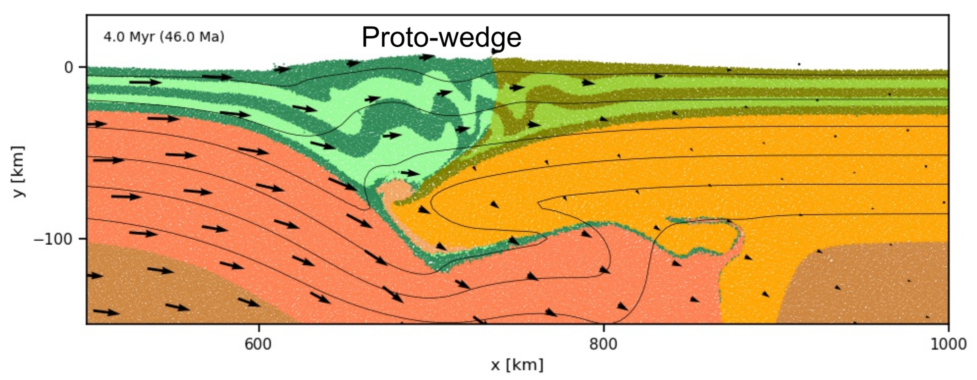
Fig 2: Strength profile of the crust & mantle.

Wet Quartzite | Diabase | Dry Olivine | Wet Olivine

Fig 3: Model setup and evolution, with 0.5 Myr intervals between timestep. Black contours represent temperature (200 °C)

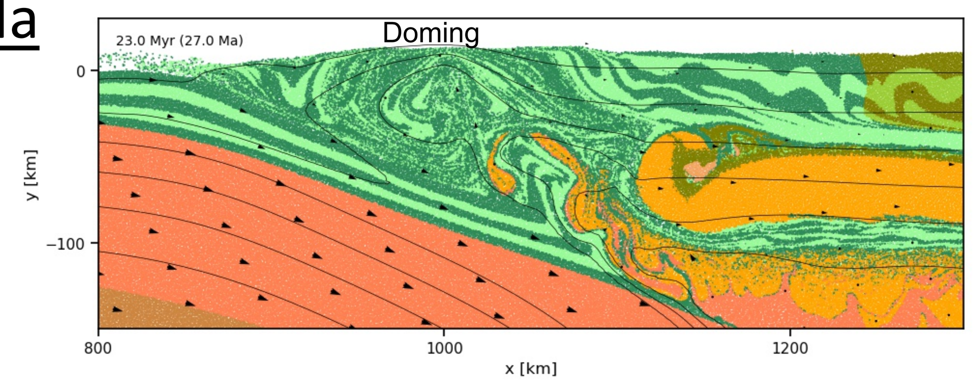
Model timeline

Fig 4: Model evolution at selected timesteps showing the main features of each stage.



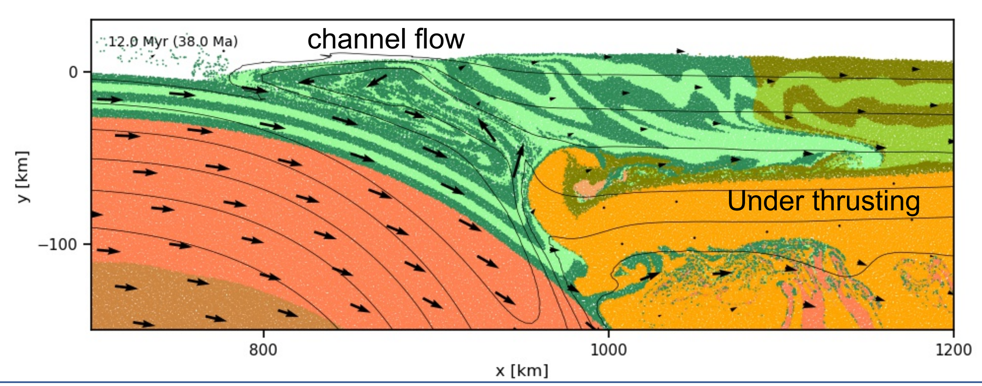
Stage 1: 50 - 44 Ma

- Proto-wedge formation and stacking above fossil subduction zone.



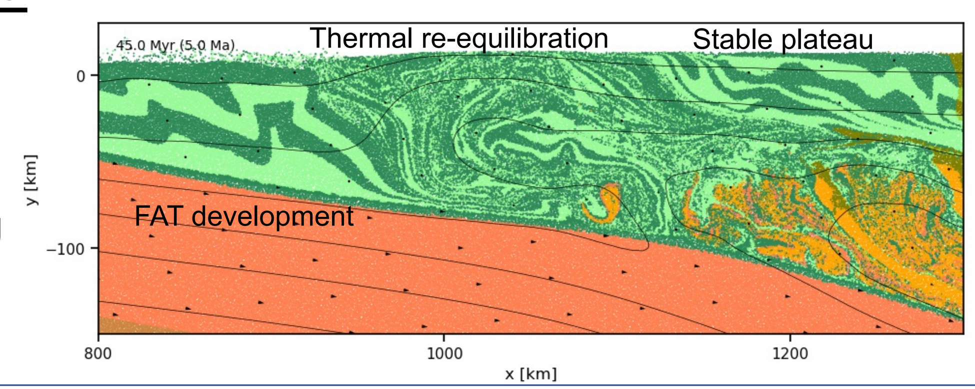
Stage 3: 32 – 22.5 Ma

- Reduction in channel flow caused by slowing of convergence. This results in doming of crust and thermal diffusion near front of plateau.



Stage 2: 44 - 32 Ma

- Under thrusting and plateau formation.
- Channel flow at front of the wedge due on-going convergence at high velocity.



Stage 4: 22.5 - 0 Ma

- Passive, stable plateau.
- FAT development at front of the wedge accommodating convergence due to temperature re-equilibration and cooling.

Insights on Himalayan-Tibet structure

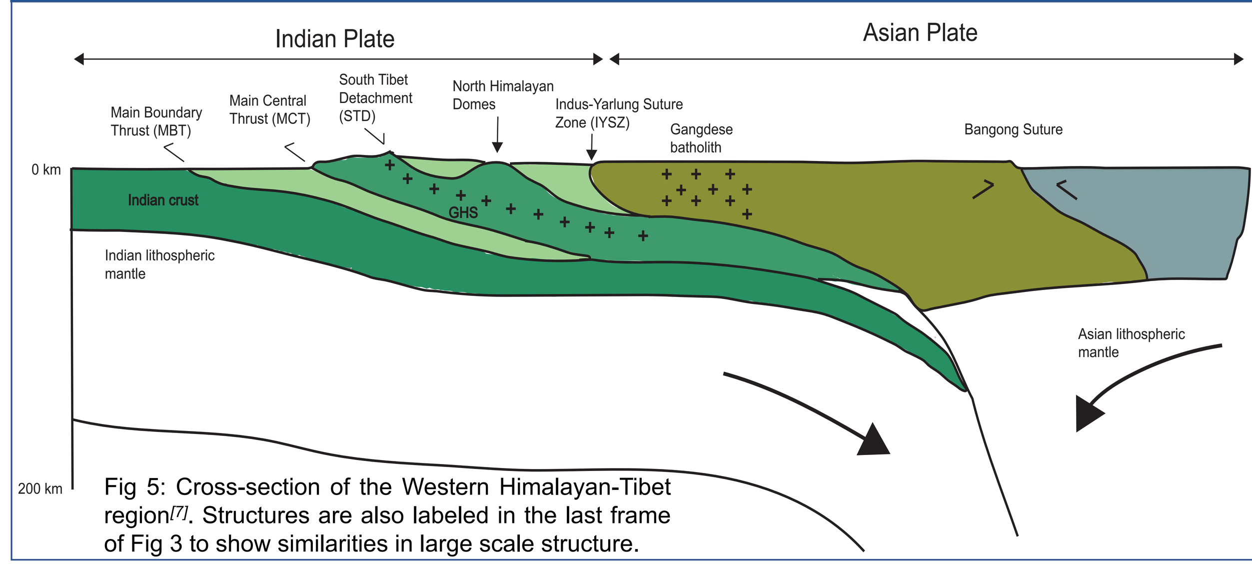


Fig 5: Cross-section of the Western Himalayan-Tibet region[7]. Structures are also labeled in the last frame of Fig 3 to show similarities in large scale structure.

- *GHS (45 - 20 Ma)* [7] - Formed due to channel flow caused by high velocities 44-32 Ma (stage 2)?
- *Domes (45 - 20 Ma)*[7] - Formed due to cessation of channel flow 32-22.5 Ma (stage 3)?
- *FAT (20-0 Ma)* [7] - Formed due to thermal re-equilibration and low velocities 22.5-0 Ma (stage 4)?

References

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Underworld

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EGU General Assembly 2020