EXPLORING THE RELATIONSHIPS BETWEEN LOW-TEMPERATURE THERMOCHRONOMETERS, TEMPERATURE-TIME HISTORIES, AND GEOLOGICAL PROCESSES USING Tc1D

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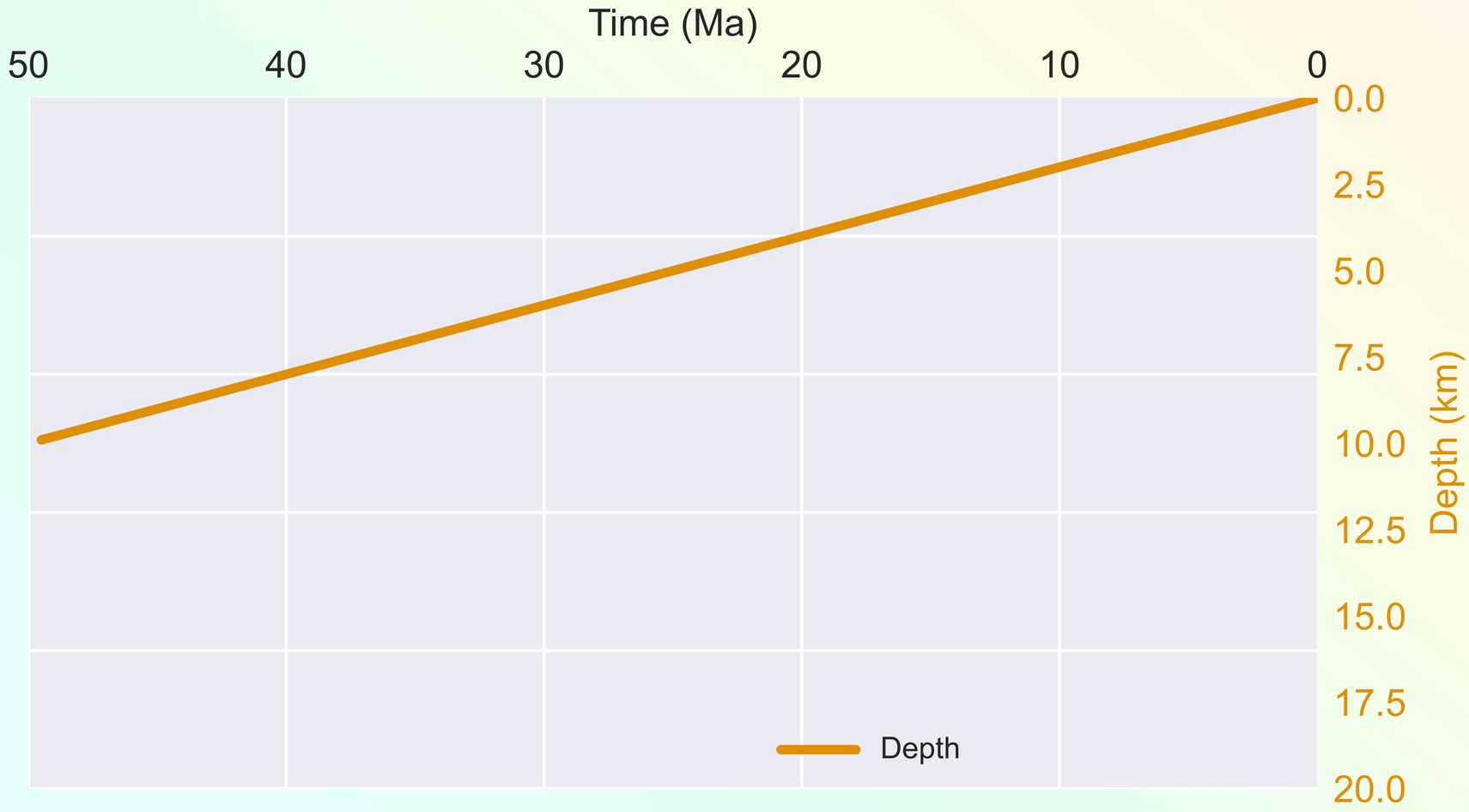
COOLING FROM THE SAME DEPTH

AN ILLUSTRATIVE EXAMPLE

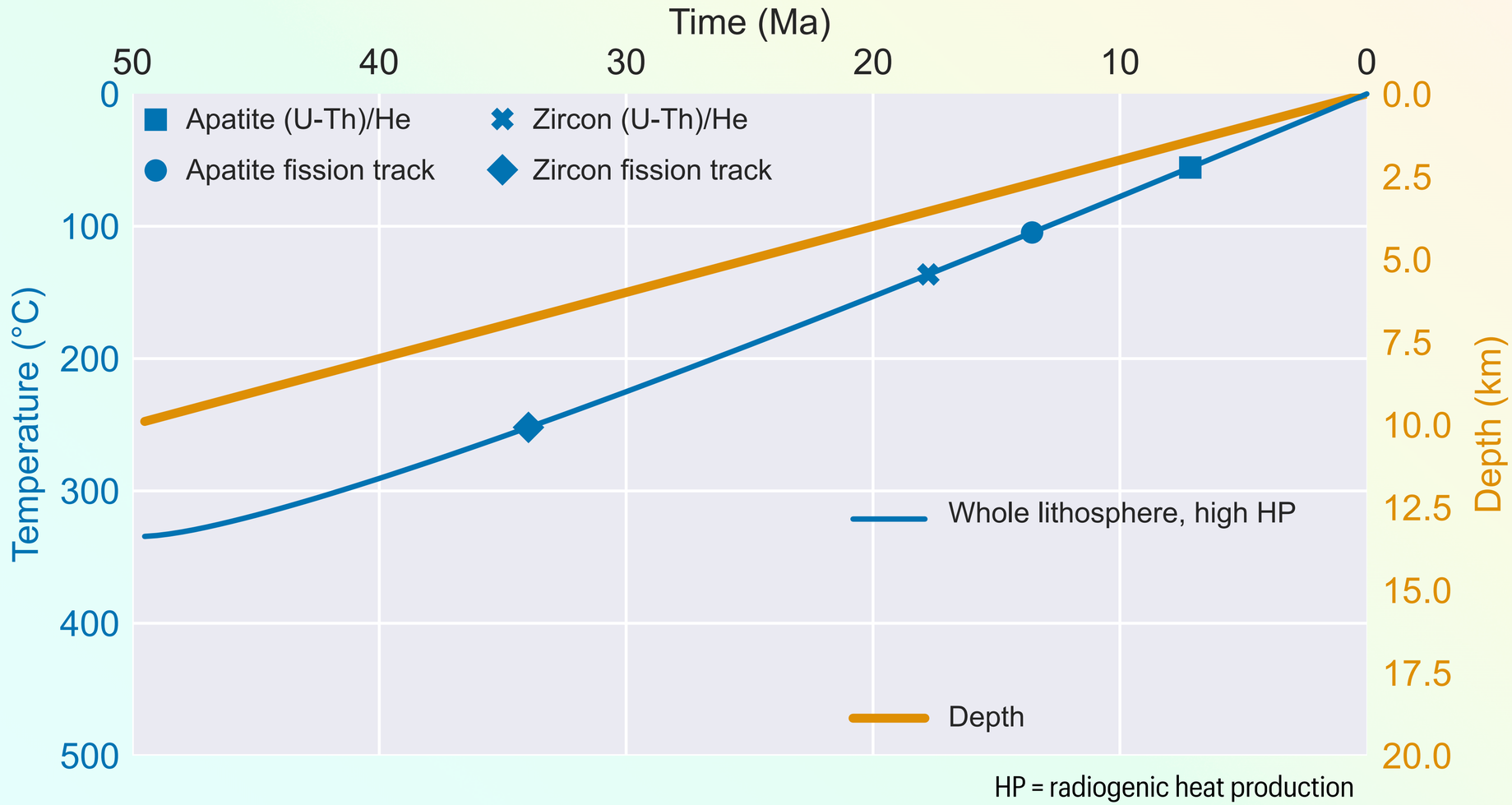
- Exhumation rate:
  0.2 mm/yr
  (constant)



COOLING FROM THE SAME DEPTH

AN ILLUSTRATIVE EXAMPLE

- Exhumation rate: **0.2 mm/yr** (constant)
- Can predict cooling ages for this exhumation history with a **thermal model**

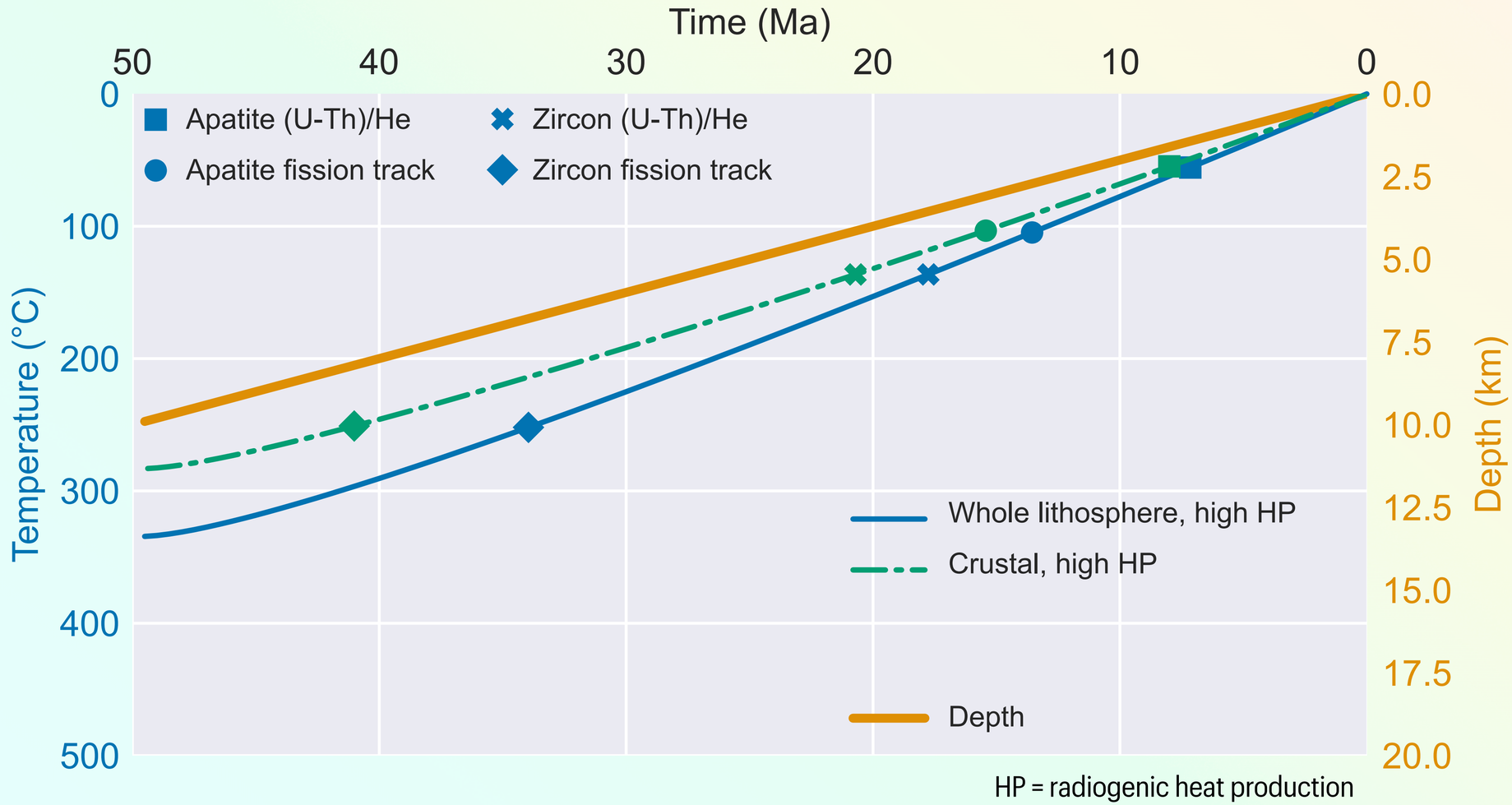


HP = radiogenic heat production

COOLING FROM THE SAME DEPTH

AN ILLUSTRATIVE EXAMPLE

- Ages vary depending on **how much of the lithosphere is being exhumed**

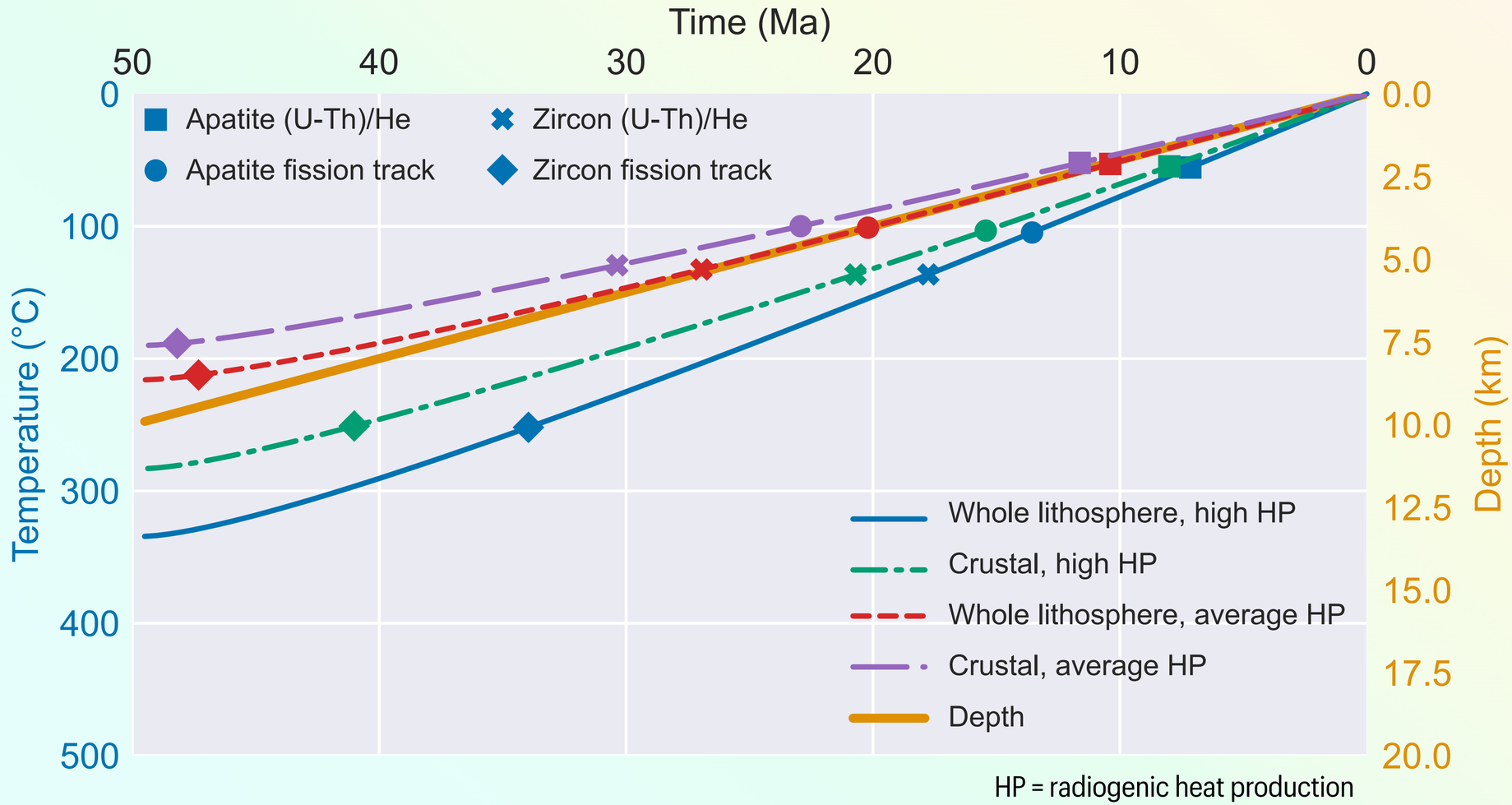


HP = radiogenic heat production

COOLING FROM THE SAME DEPTH

AN ILLUSTRATIVE EXAMPLE

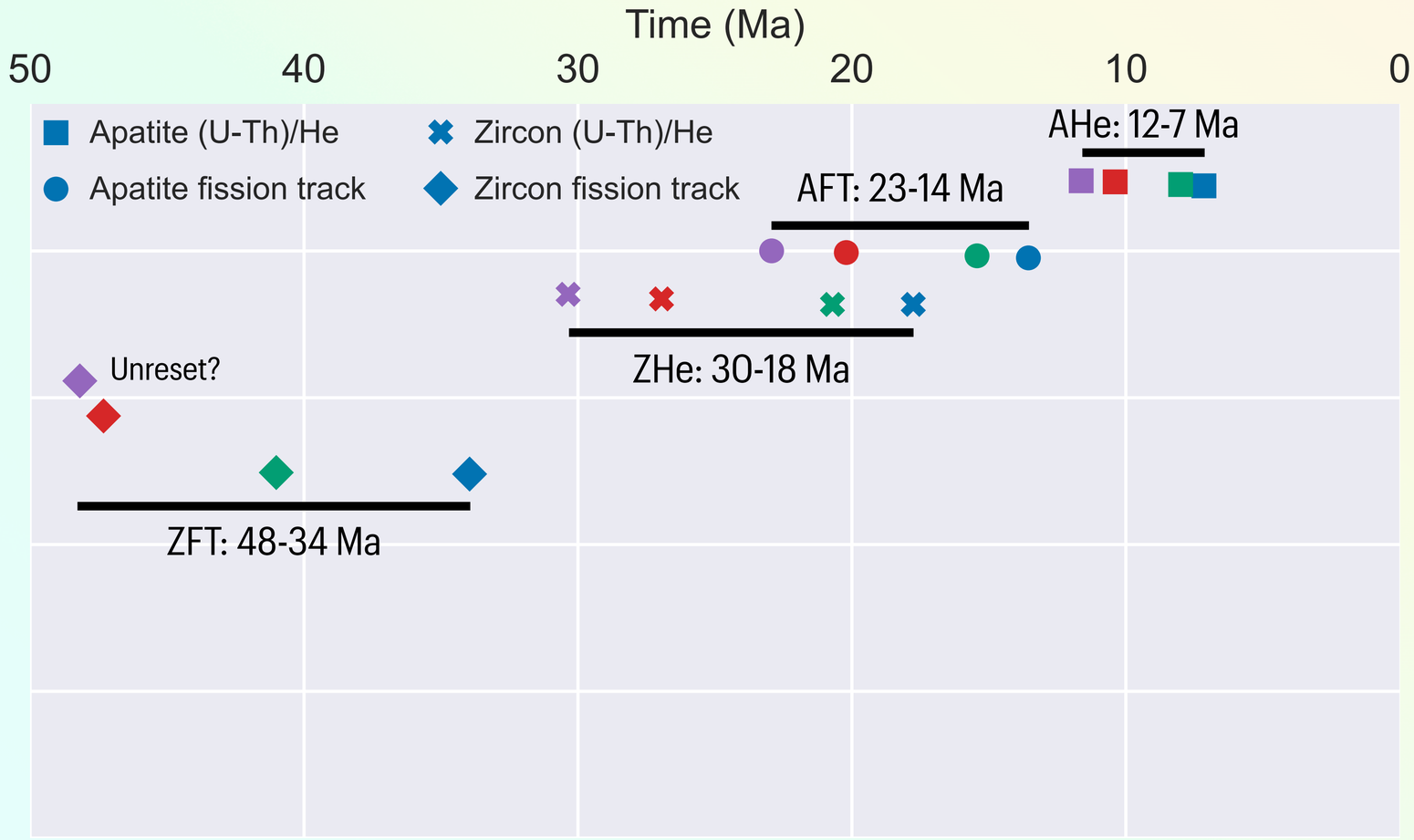
- Ages vary depending on **how much of the lithosphere is being exhumed**
- **Crustal heat production** affects the ages as well



HP = radiogenic heat production

COOLING FROM THE SAME DEPTH?

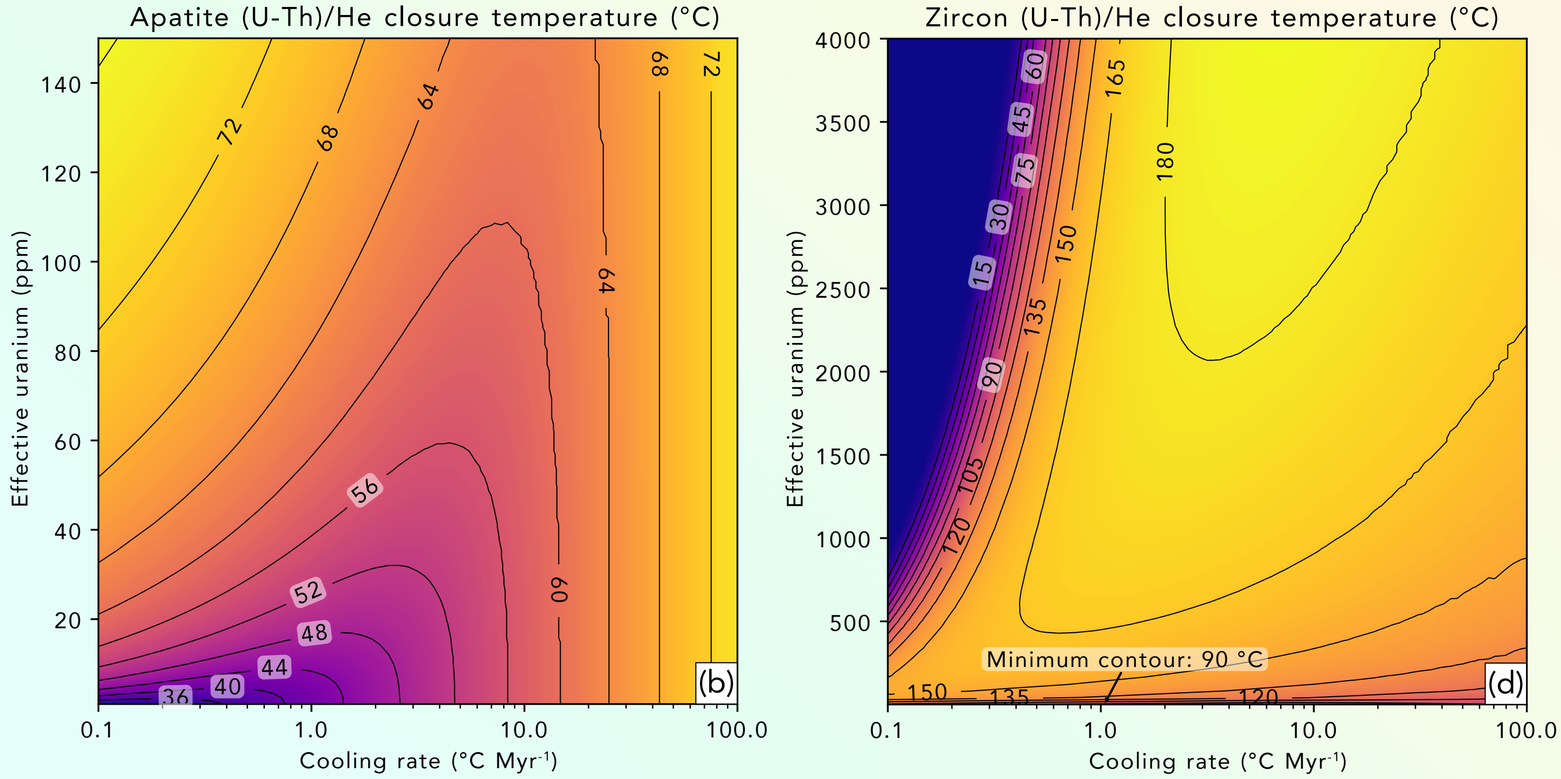
- Ages for the models **vary considerably**
- In the absence of a model or clear geological constraints, one might infer **quite different exhumation histories for these ages**



AND IT GETS WORSE...

EFFECTS OF ALPHA-DECAY DAMAGE IN (U-TH)/HE CHRONOMETERS

- Beyond thermal history effects, ages can be affected by factors such as **radiation damage in dated crystals** (e.g., Flowers et al., 2009; Guenthner et al., 2013)
- And the effects **vary with the cooling rate**



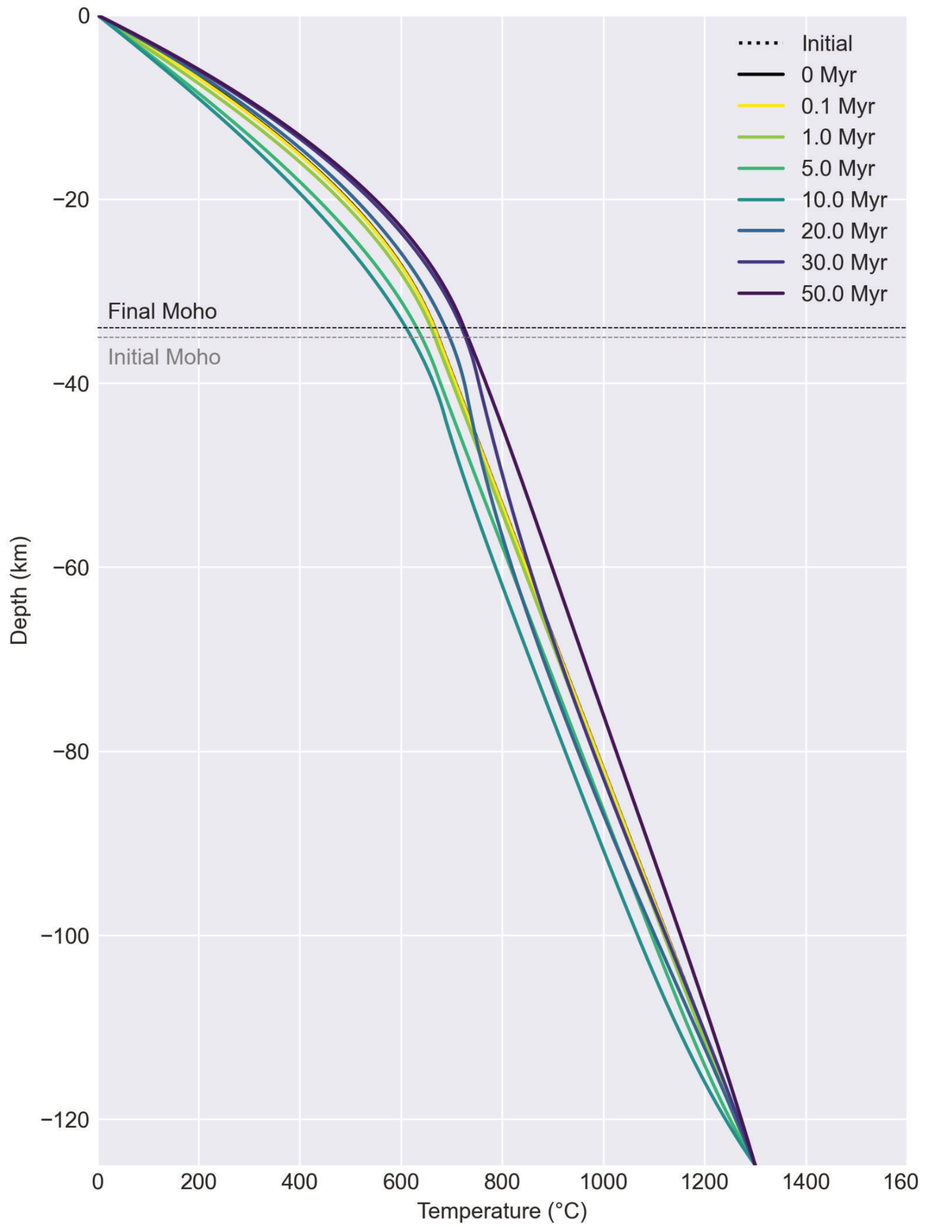
Whipp/Kellett et al., 2022

T_c1D

WHAT DOES IT DO?

T_c1D is a new, open-source thermal and thermochronometer age prediction model for **simulating the effects of tectonic and surface processes** on thermochronometer ages

- Written (mostly) in Python
- Supports AHe, AFT, ZHe, and ZFT chronometers
- **Key features**: Several erosion models, variable crust/mantle material properties, can compare to observed ages, batch mode, etc.



Example geotherms calculated using T_c1D

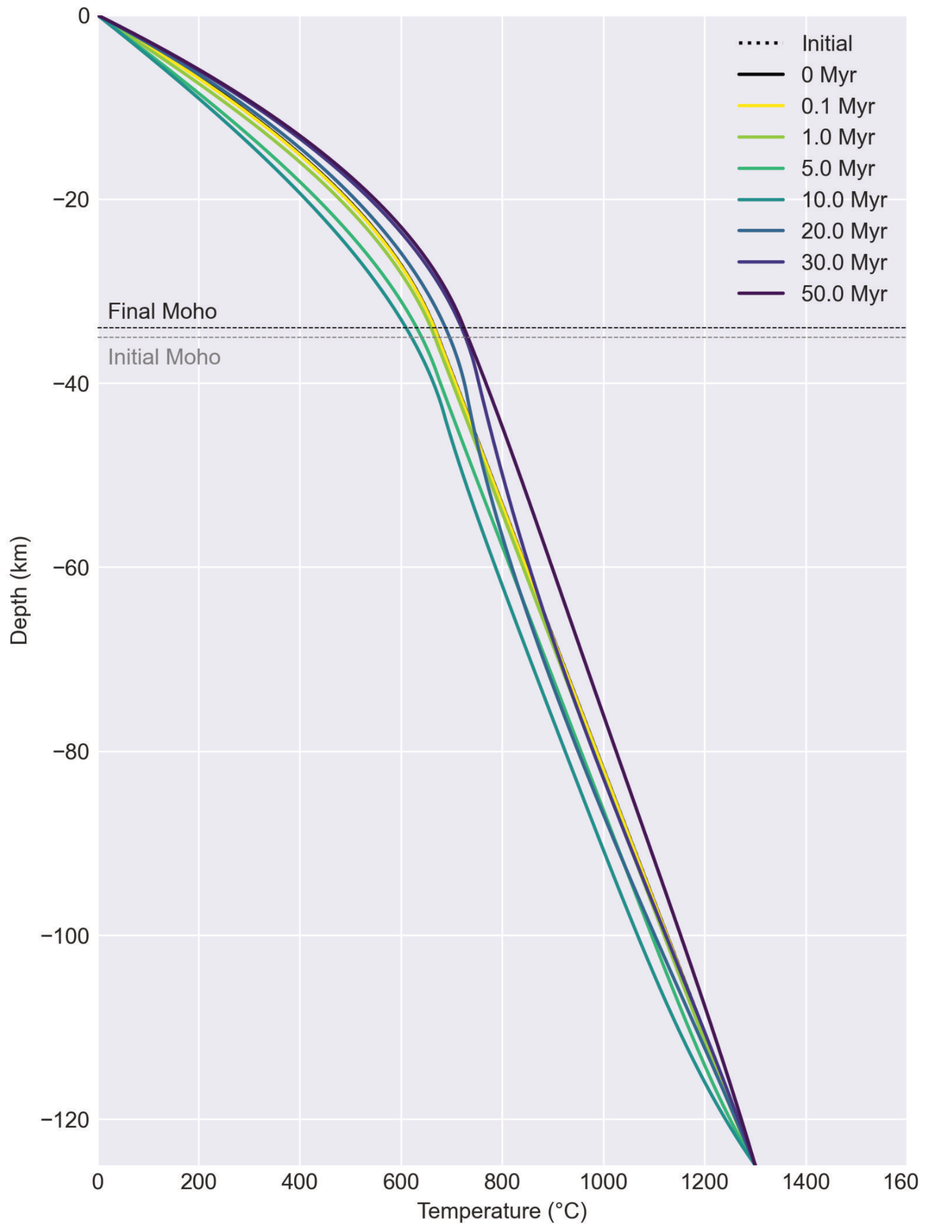
WHY T_c1D?

DO WE REALLY NEED ANOTHER MODEL?

T_c1D was developed to be a **"Goldilocks" model** for thermochronology – not too simple, not too complex

Main aims:

- Model exhumation scenarios and their effects on ages
- Include effects of radiation damage
- Keep it simple (1D) and accessible (open source, Python)
- Easy to use



Example geotherms calculated using T_c1D

WHAT CAN IT DO?

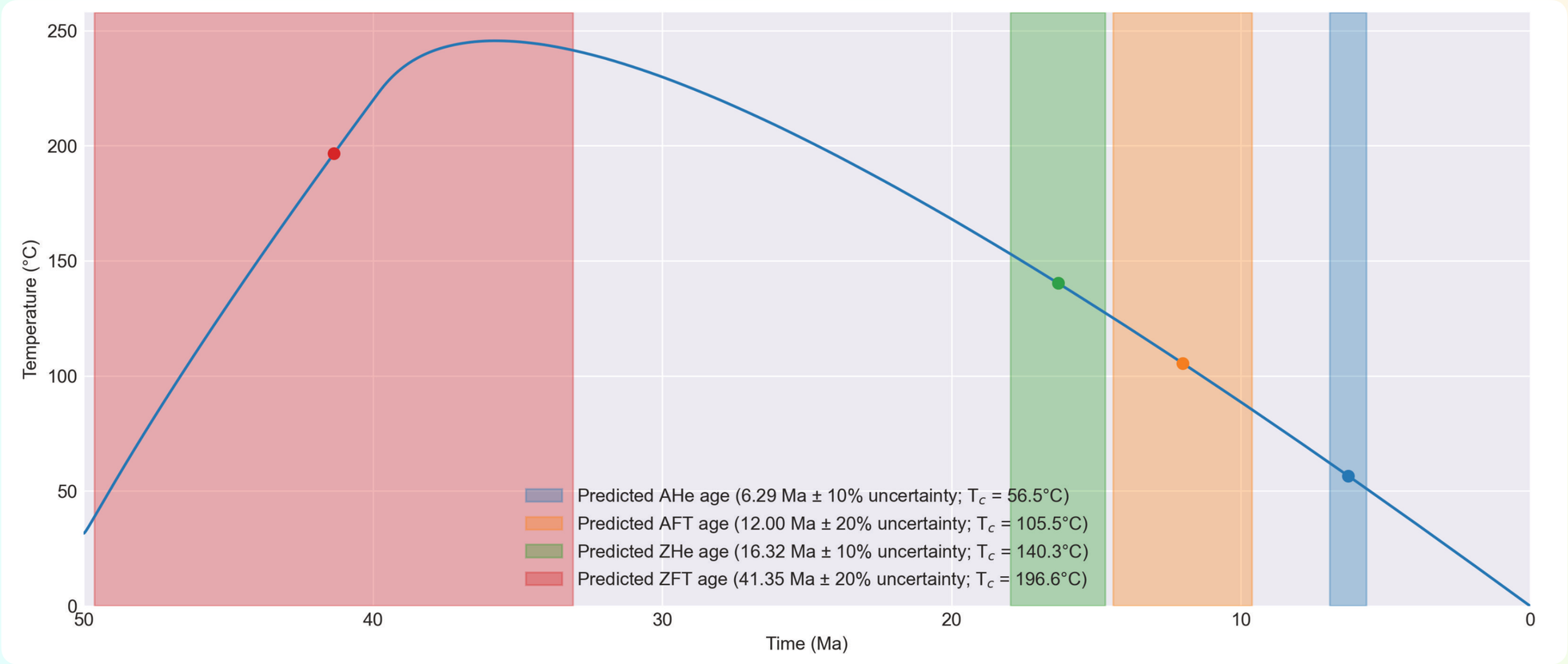
SEDIMENTARY BURIAL AND EXHUMATION

Scenario

- 10 km of burial in 10 Myr
- 9 km of exhumation in 40 Myr

Observations

- Peak T reached at ~35 Ma
- ZFT unreset



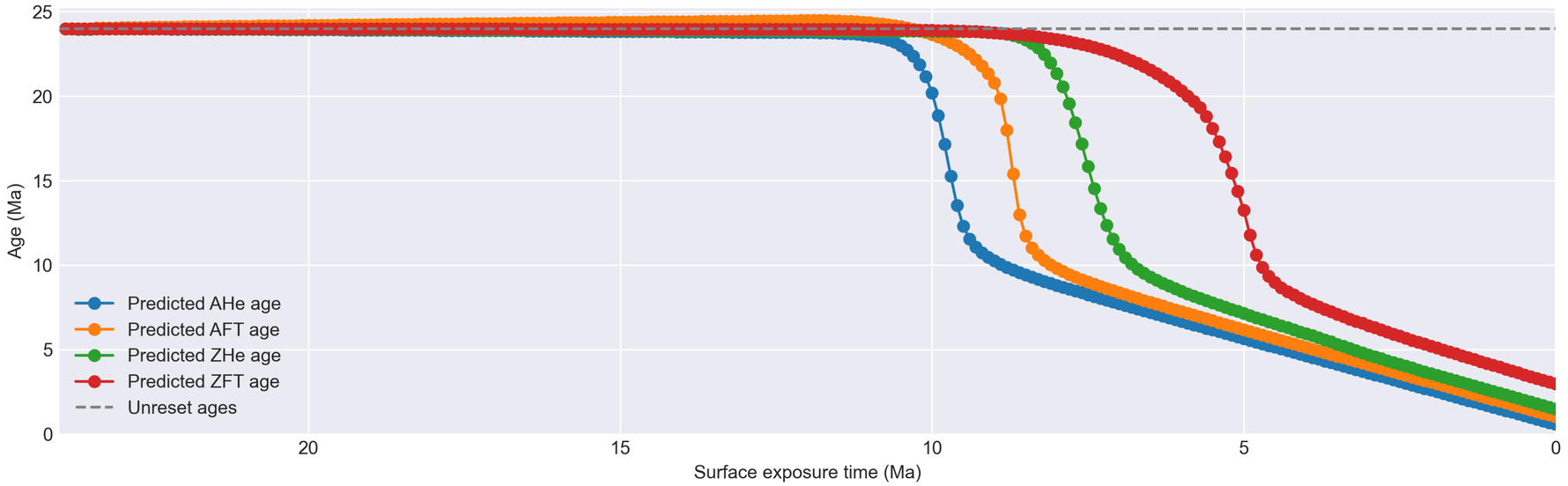
Example time-temperature history and predicted ages

WHAT CAN IT DO?

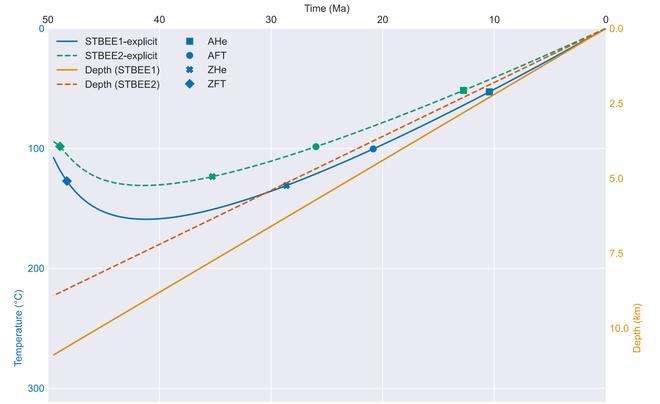
OTHER SCENARIOS

T_c1D can be used to explore **many different scenarios**, including: exhumation histories of basin sediments, erosional exhumation of thrust sheets, unusual age relationships, processes like mantle delamination, etc.

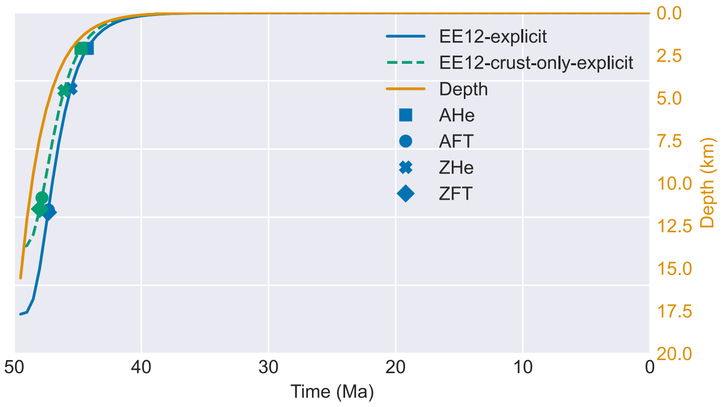
Prediction of ages through time



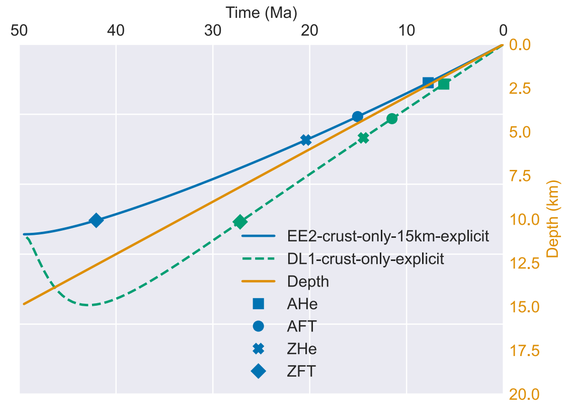
Thrust sheet emplacement and erosion



Different erosion scenarios



Mantle delimitation

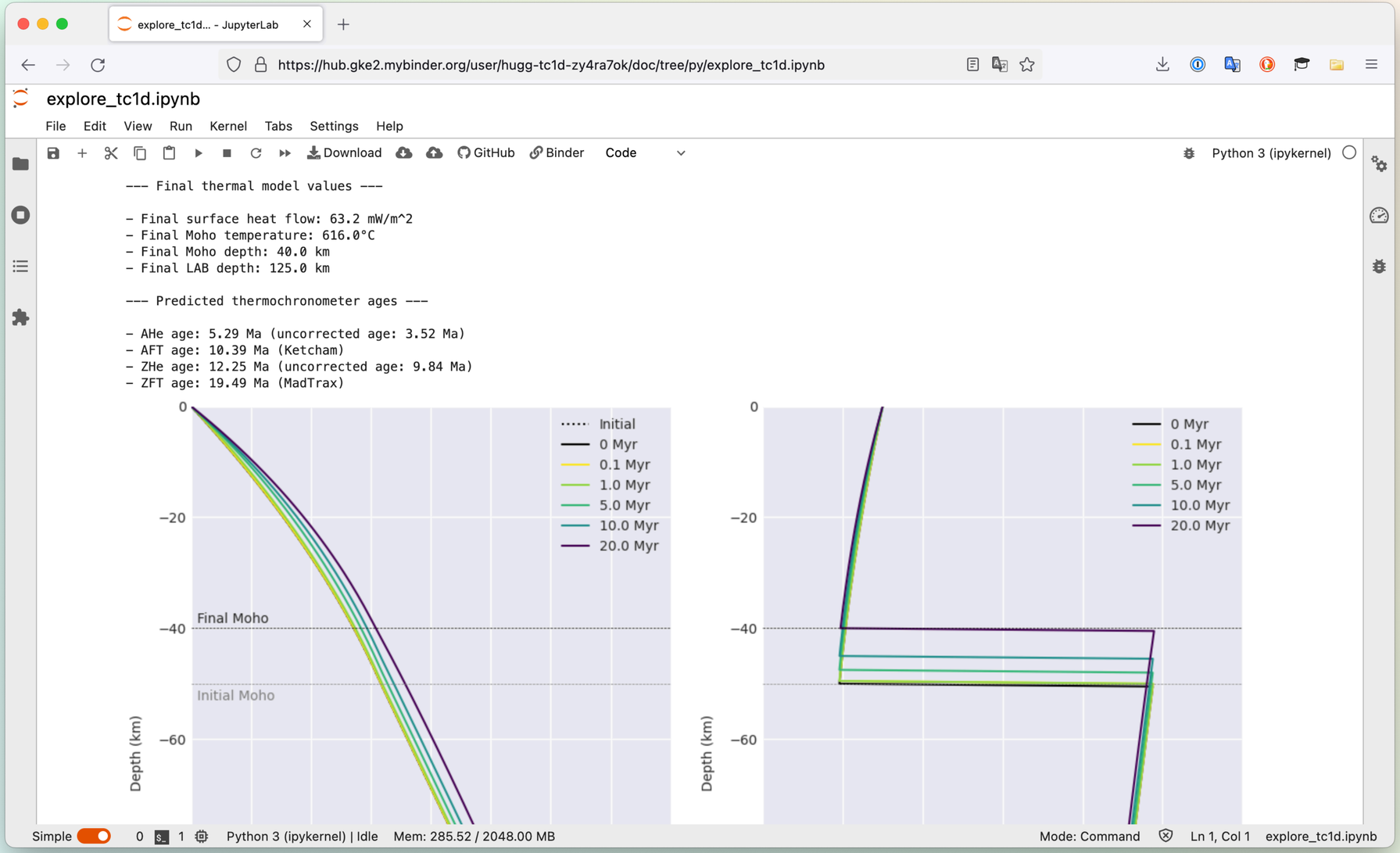


Tc1D

GETTING STARTED

You can **try out Tc1D online** with nothing more than a web browser

Try out Tc1D online

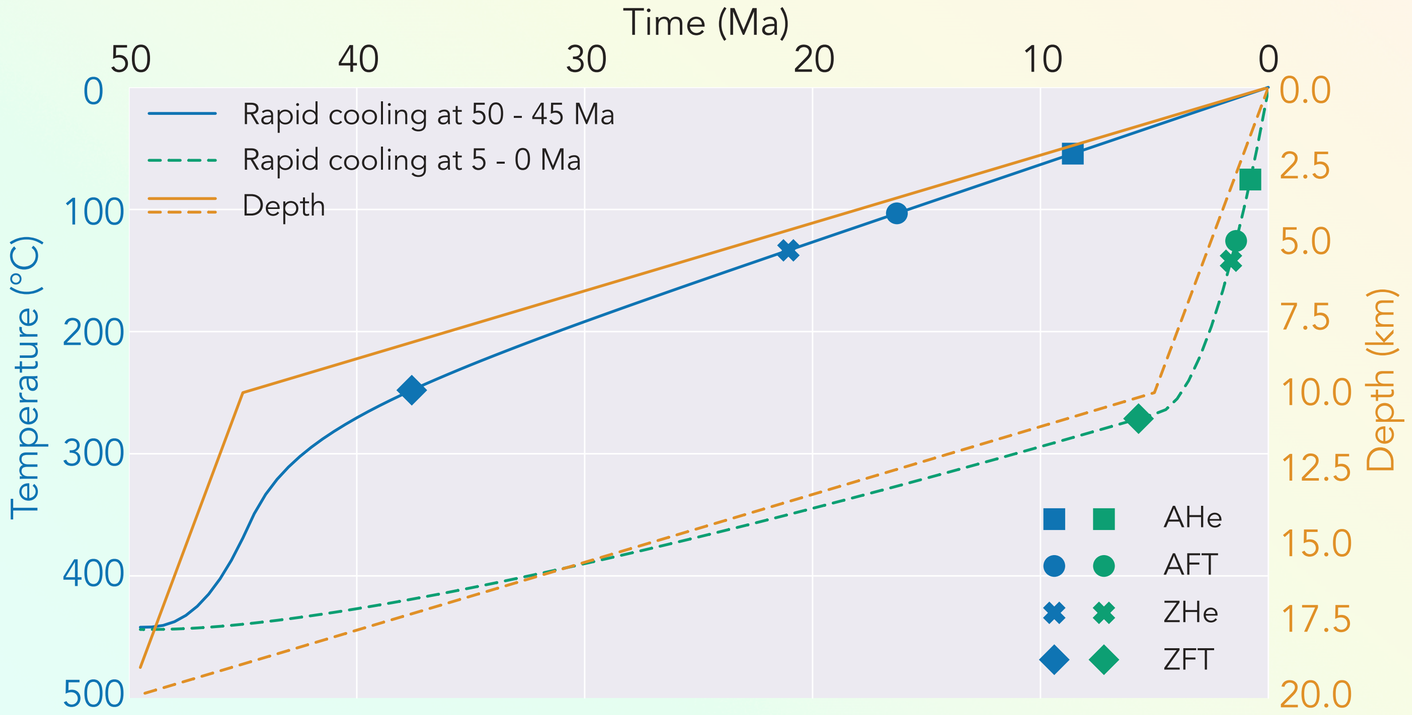


THANK YOU

Questions and comments welcome!

- Check out the code on GitHub at https://github.com/HUGG/TC1D

Try out T_c1D online



Information about how to cite T_c1D at https://doi.org/10.5281/zenodo.7124271

THE NEXT STEPS

THERAPPY AND MORE...

T_c1D: Adding support for inverse modelling, creating a graphical user interface, moving to pure Python (see TherAPPy), adding support for calling $T_c$plotter functions

...and **TherAPPy:** Thermochronometer Age Prediction codes in Python (with Dawn, Elco Luijendijk) - a Python library for thermochronometer age prediction (in progress)

TcPLOTTER + Tc1D

TOWARDS COMPATIBILITY - NEW!

Tcplotter now has the option to **read in a time-temperature history exported from Tc1D**

Example for the **slow exhumation to fast exhumation** model from earlier

```
Time (Ma), Temperature (C), Depth (m)
0.0, 0.0, 2.0503648612280045e-08
0.5, 16.135904318678996, 500.00000002050365
1.0, 31.598803517604374, 1000.0000000205036
1.5, 46.34979939490718, 1500.0000000205036
2.0, 60.33838719329246, 2000.0000000205036
2.5, 73.49623898838962, 2500.0000000205036
…
```

Example t-T file content