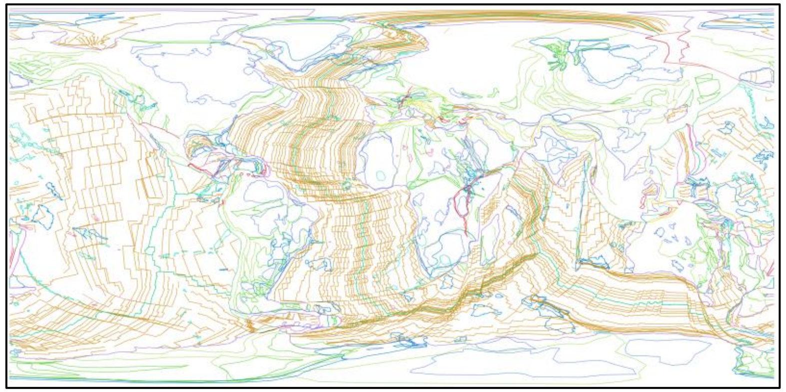
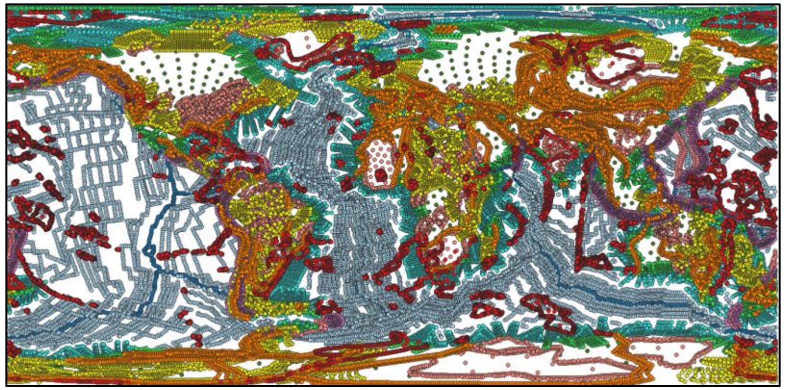
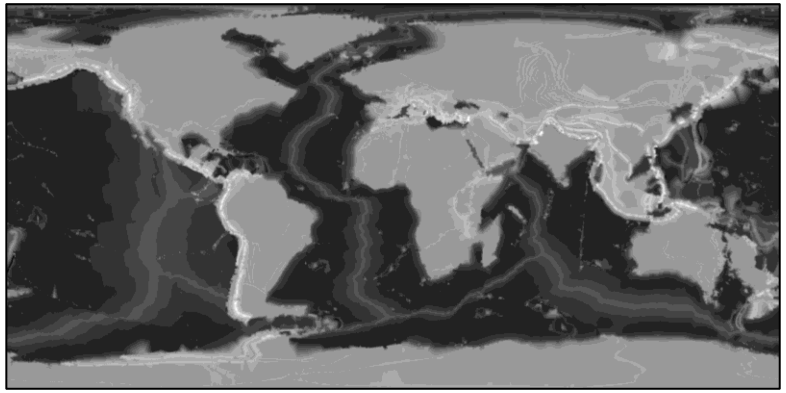
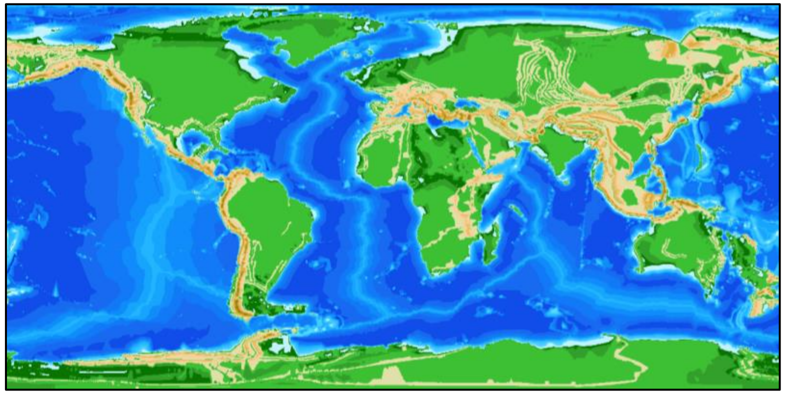
Quantified Palaeotopographic & Palaeogeographic Maps for the Phanerozoic with the PANALESIS Plate Tectonic Model

22nd Swiss Geoscience Meeting
Basel, 9th November 2024









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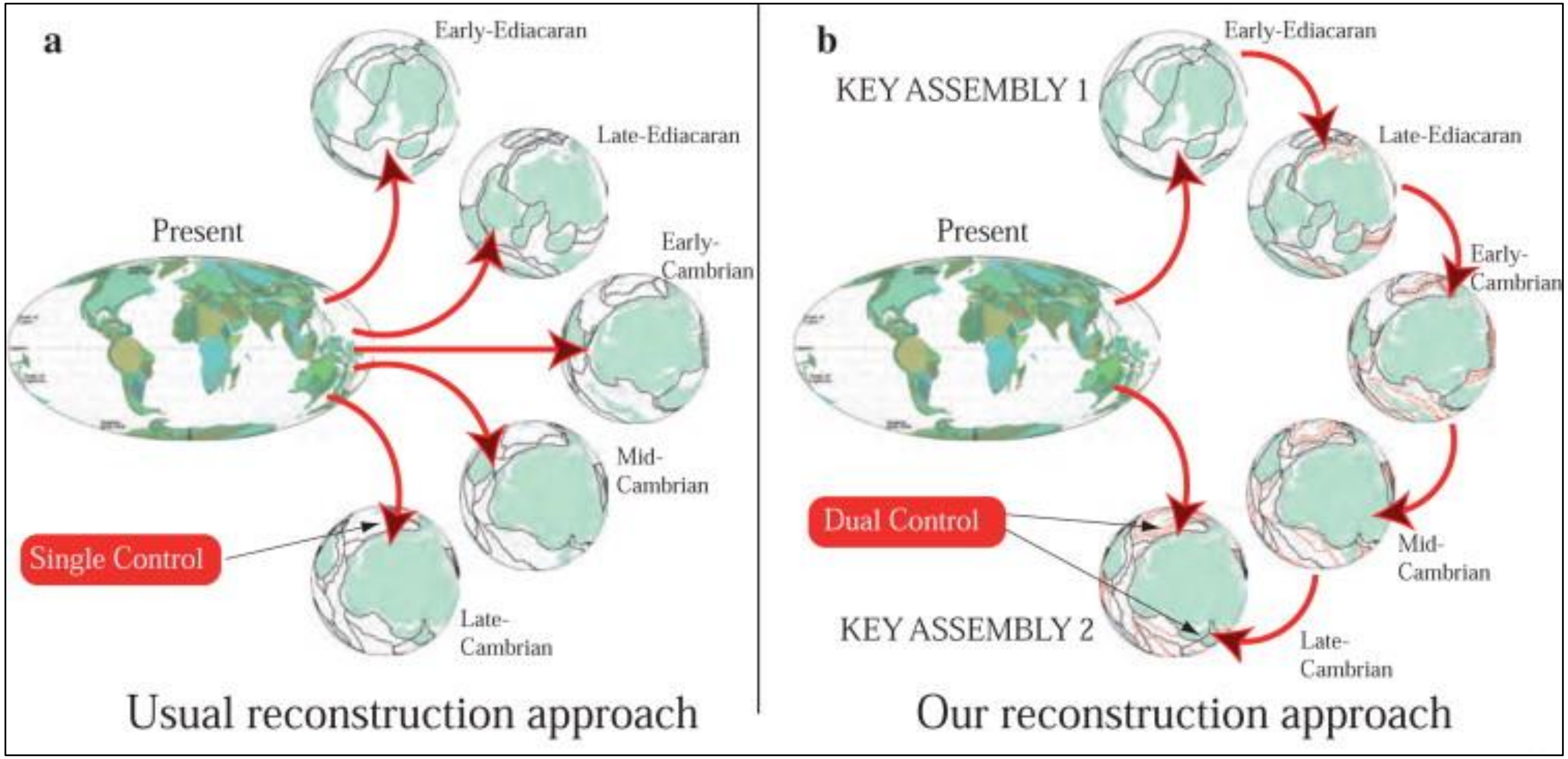
The PANALESIS model



Covering 100% of the Earth surface

600 – 000 Ma (v0)
888 – 000 Ma (v1)

Dual control approach

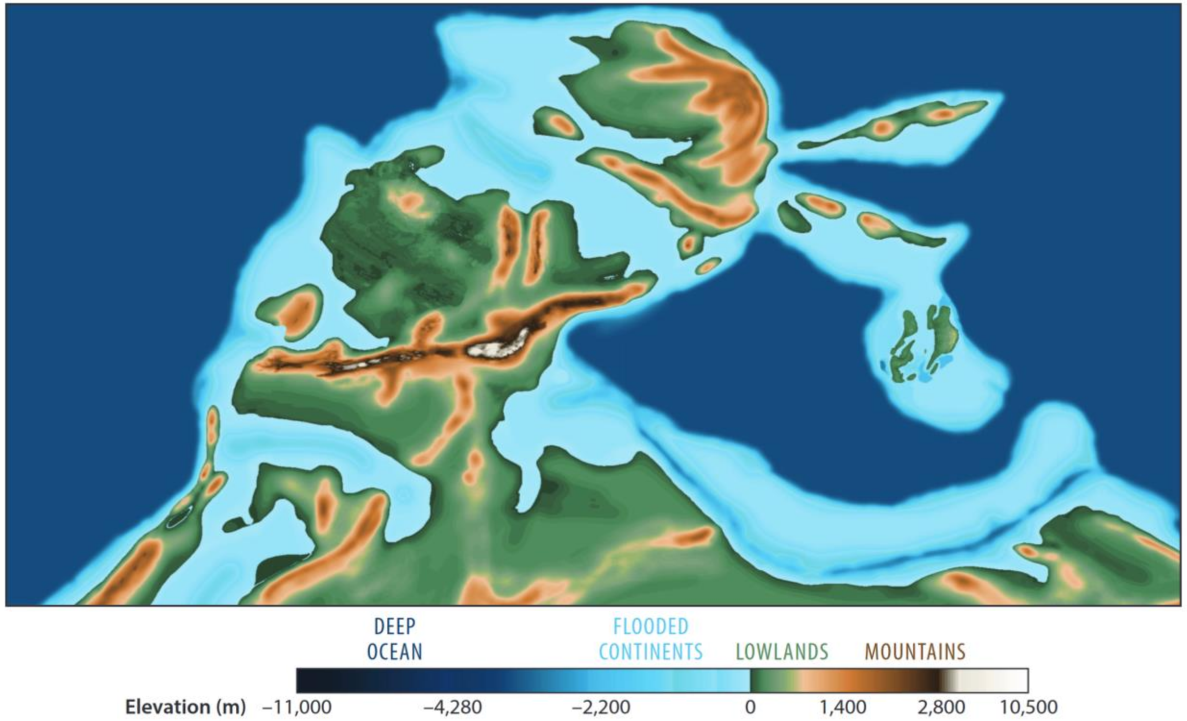
Not openly accessible...**yet!**

Modified after Vérard *et al.*, 2015

Approaches to palaeogeography #1

Reconstruction at 280 Ma

Elevation (m)	Environment(s)	Geological evidence
10,000 to 4,000	Collisional mountains	High-temperature, high-pressure metamorphics
4,000 to 2,000	Andean-type mountains	Andesites/granodiorites in a continental setting
2,000 to 1,000	Island arc volcanoes	Andesites/granodiorites in a marine setting
	Intracontinental rift shoulders	Adjacent fanglomerates
1,000 to 200	Rift valley	Basalts, lake deposits in grabens
	Some forearc ridges	Tectonic mélanges
200 to sea level	Coastal plains	Alluvial complexes
	Lower river systems	Major floodplain complexes
	Delta tops	Swamps and channel sands
Sea level to −50	Inner shelves	Heterogeneous marine sediments
	Reef-dammed shelves	Bahamian-type carbonates
	Delta fronts	Topset silts and sands
−50 to −200	Outer shelves	Fine sediments, most bioproductites
	Some epeiric basins	Fine clastics or carbonates
	Pro-deltas	Foreset silts and proximal turbidites
−200 to −4,000	Continental slope/rise	Slump/contourite facies
	Mid-ocean ridges	Oceanic crust less than 60 million years old
	Pro-delta fans	Bottomset clays and distal turbidites
−4,000 to −6,000	Ocean floors	Pelagic sequences on oceanic crust
−6,000 to −12,000	Ocean trenches	Turbidites on pelagic sequences

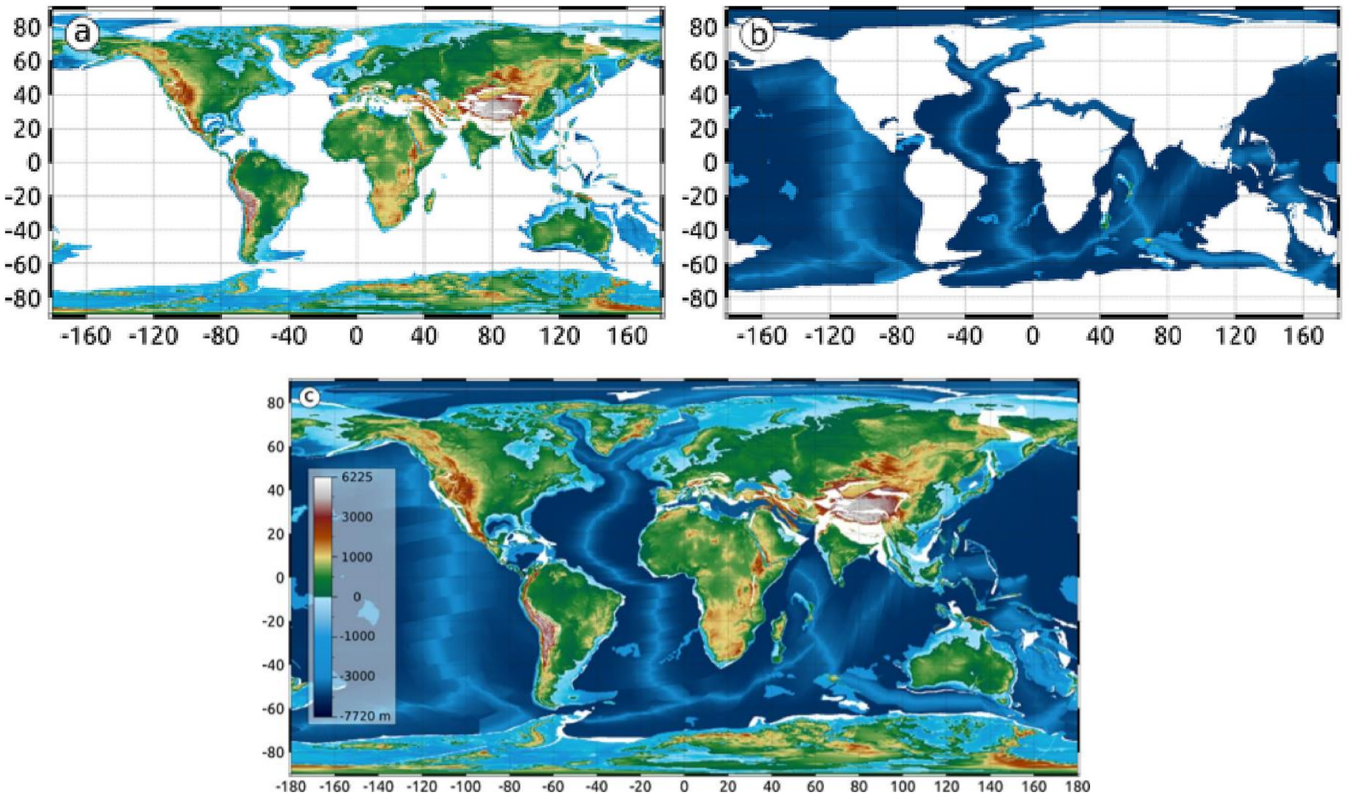


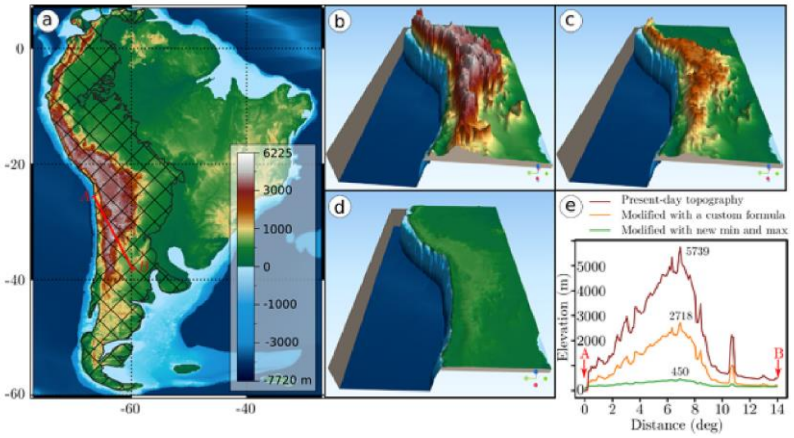
Semi-quantitative,
flat seafloor

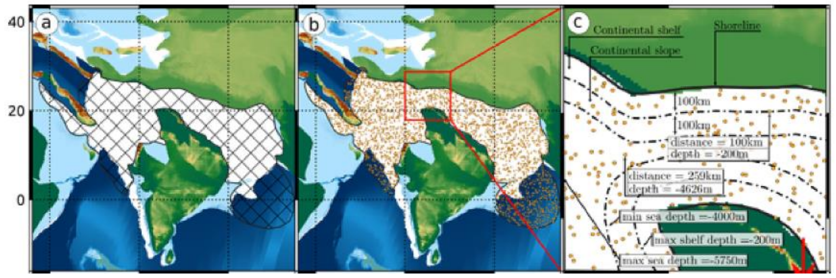
Modified after Scotese et al. (2021)

Approaches to palaeogeography #2

Reconstructions at 30 & 50 Ma







Manual process, user-knowledge driven

Modified after Aminov et al. (2023)

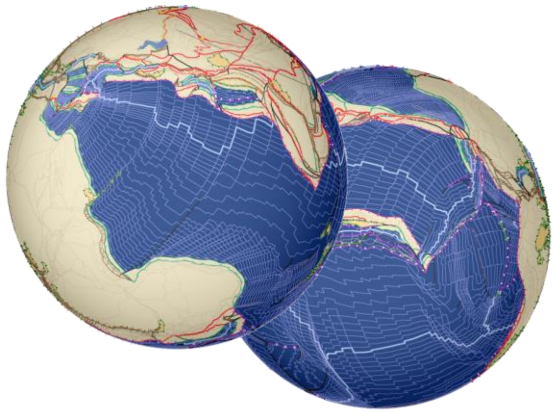
Palaeogeography: Approach #3

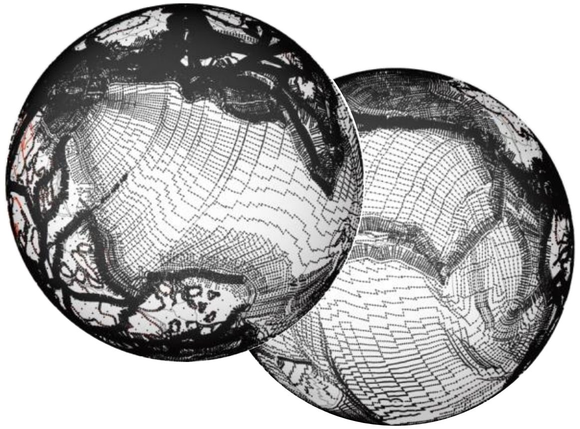
(1)
Geological Features

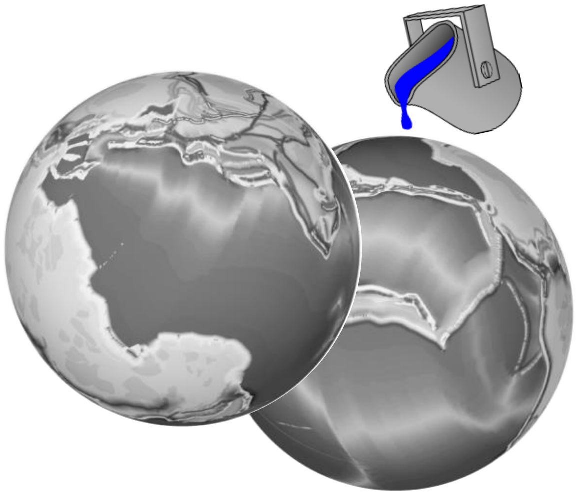
(2)
Profiles/Nodes

(3)
Palaeo-DEM

(4)
Palaeogeography



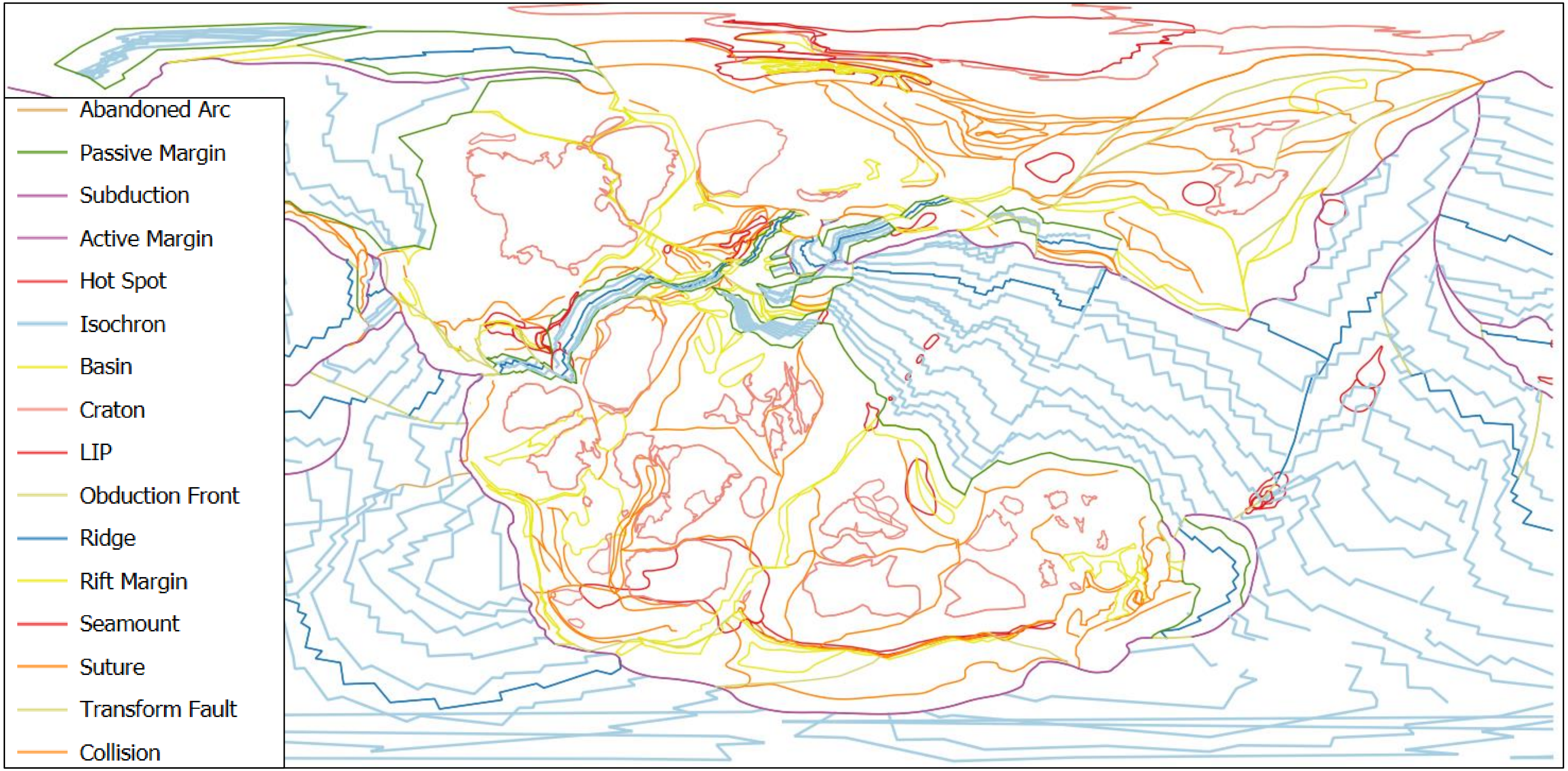




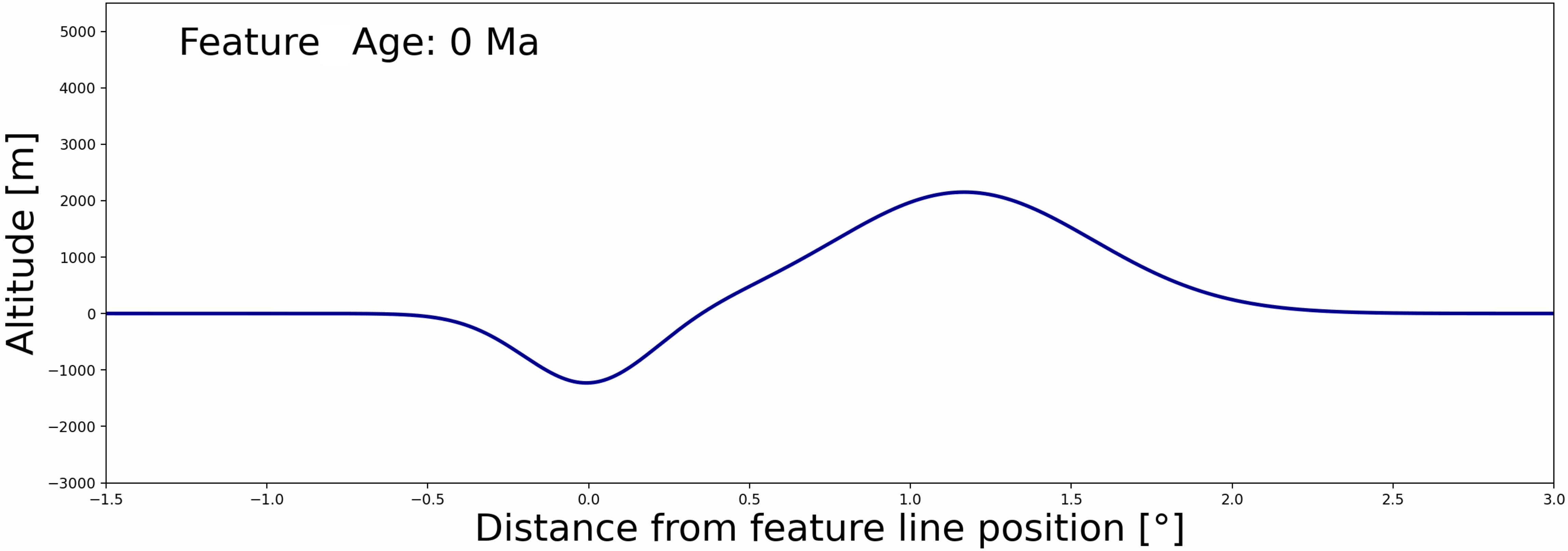
Automated, quantitative &
synthetic palaeogeography

Modified after Vérard (2019)

(1) Geological Features: 165Ma example

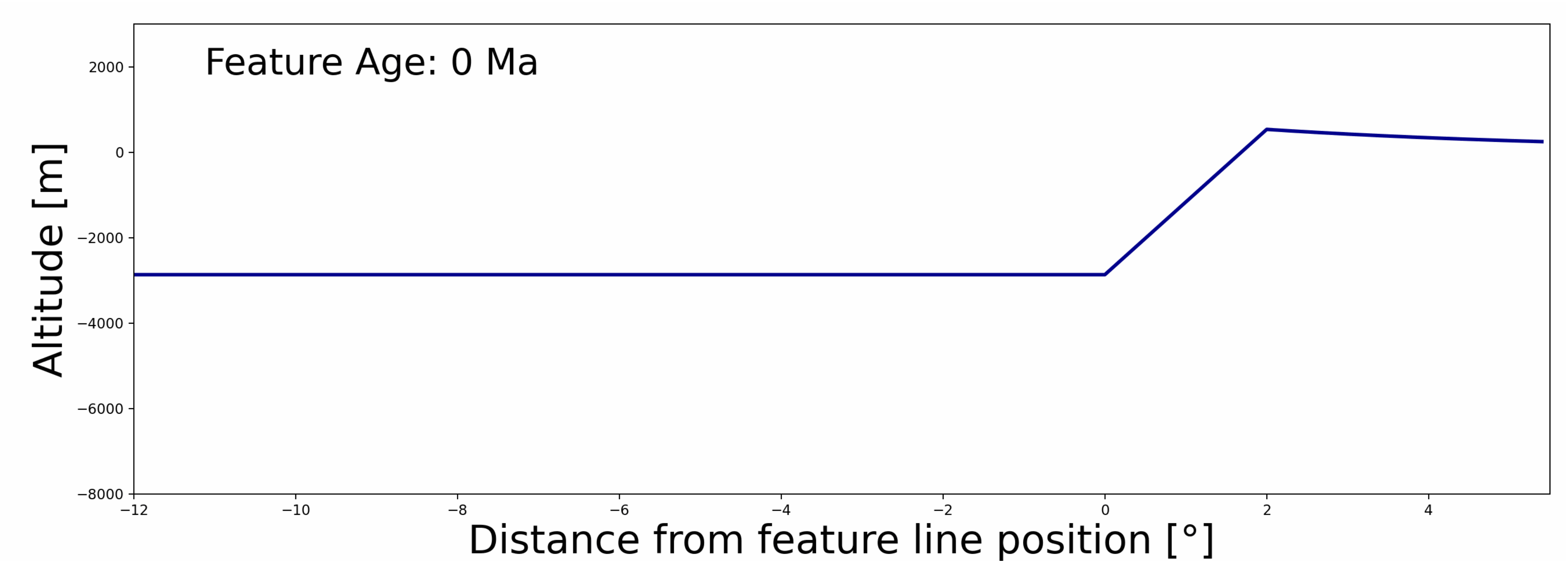


(2) Profile/Nodes: Collision Profile



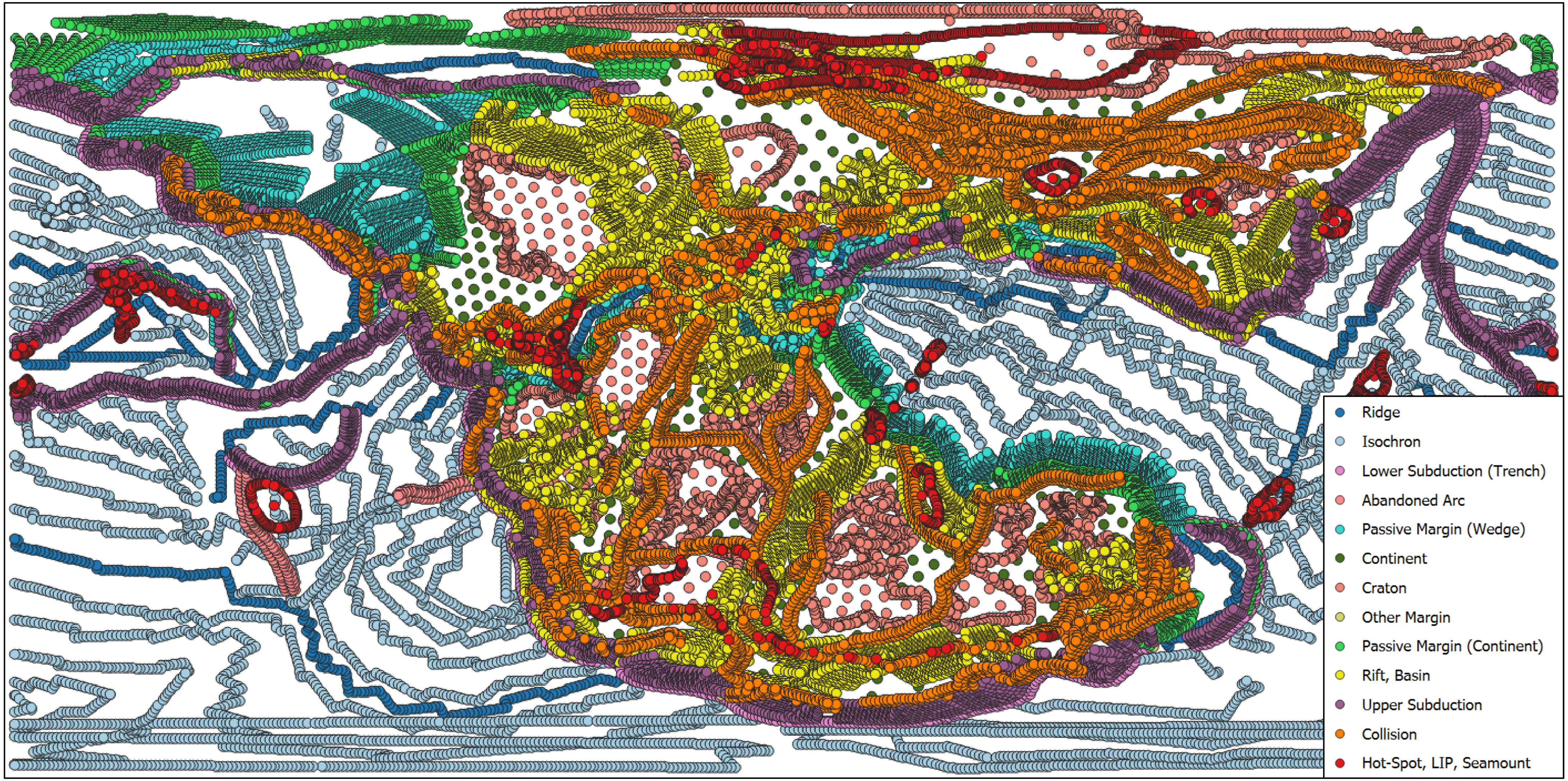
Synthetic profiles based on current day topography (Vérard 2017).
Lateral movement & elevation variation.
function of age of feature line from the model.

(2) Profile/Nodes: Passive Margin Profile

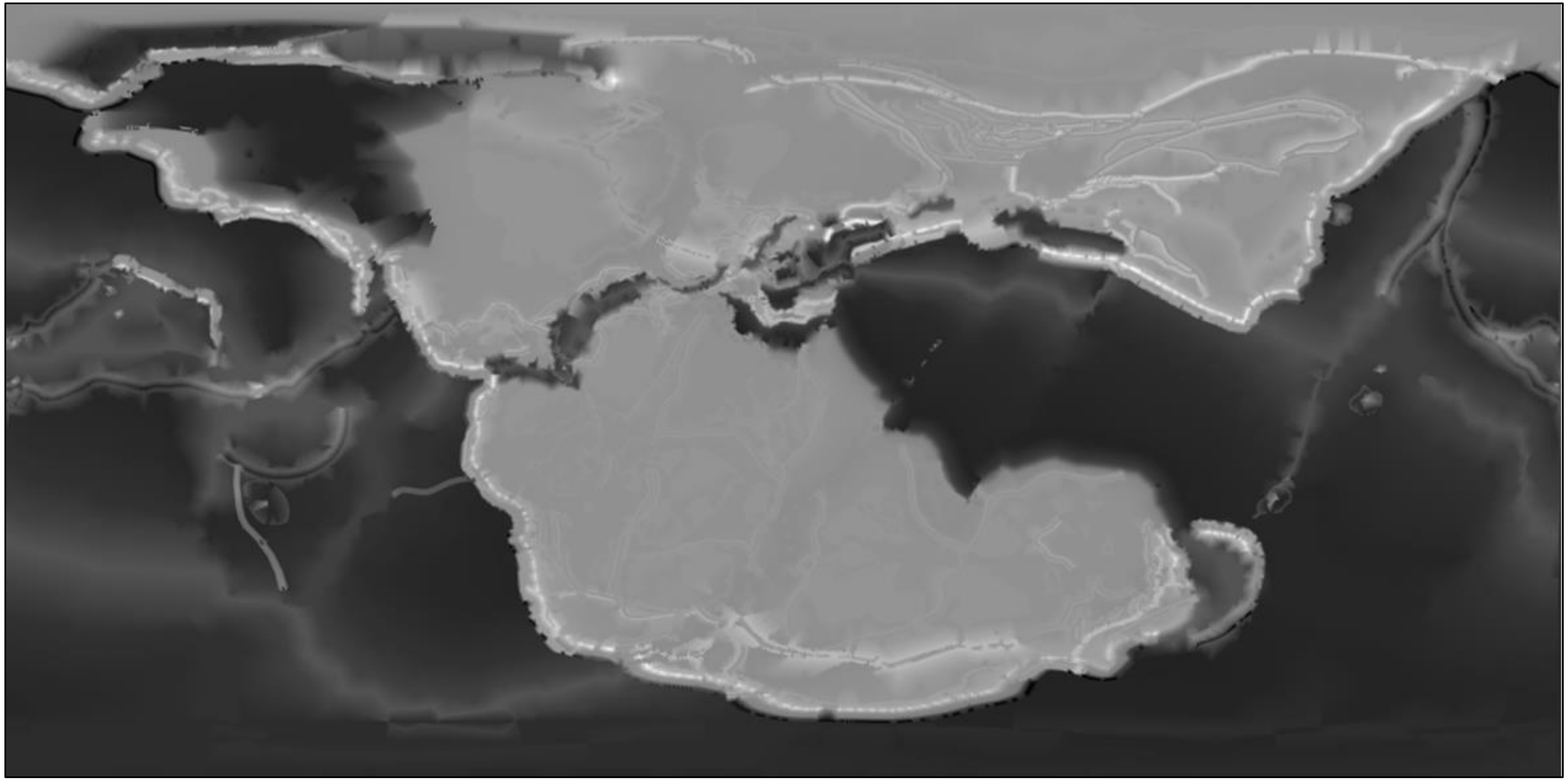


Synthetic profiles based on current day topography (Vérard 2017).
Lateral movement & elevation variation.
function of age of feature line from the model.

(2) Profile/Nodes: 165 Ma example



(3) Palaeo-DEM interpolation: 165 Ma example



0.1°x0.1° map

Z=0m is relative to what a present-day topography would yield.

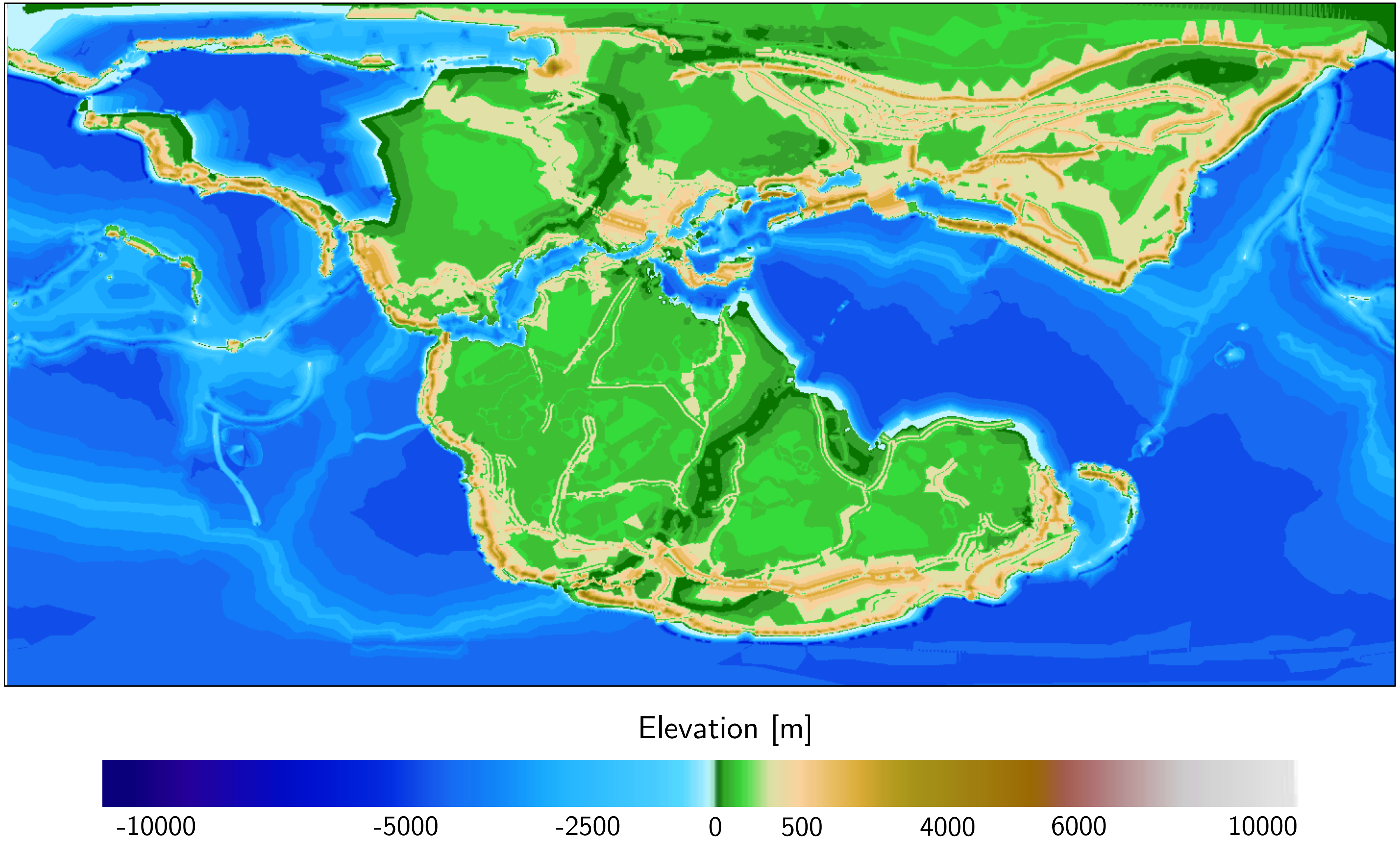
Accuracy strongly dependant on interpolation method

(4) Palaeogeography: 165 Ma example

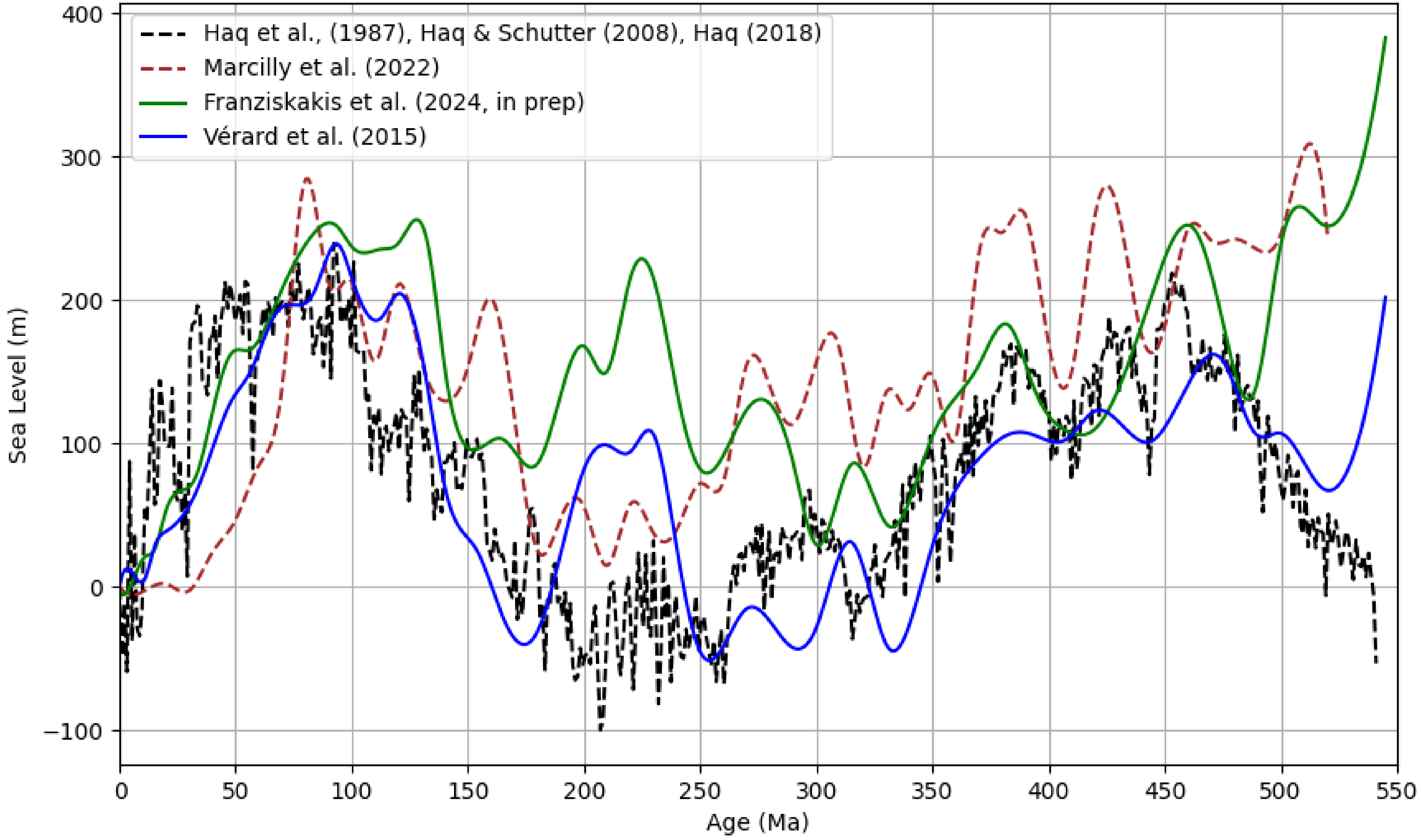
Oceanic volume calculated (below z=0m)

Sea-level corrected to reach full oceanic volume (reference = present-day)

Correction of elevation with Airy model of isostasy



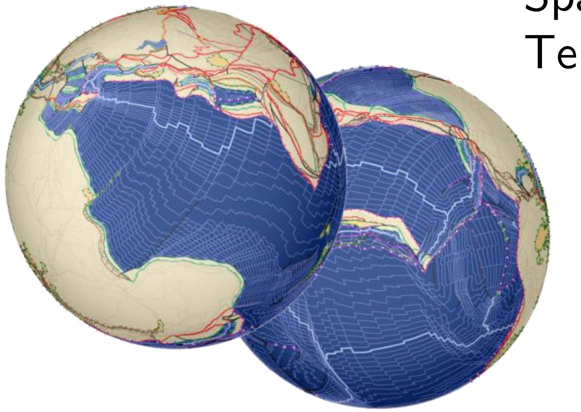
Phanerozoic Sea Level Reconstructions



Estimating Uncertainties

Spatial resolution (1 – 1.5°)
Temporal resolution (± 5Ma)

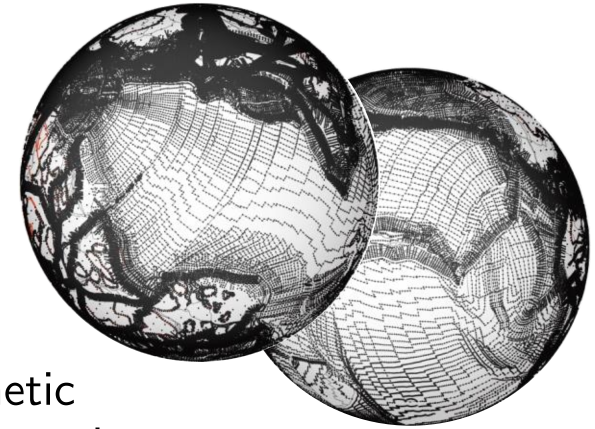
Vérard (2022)



Franziskakis et al. (in prep)

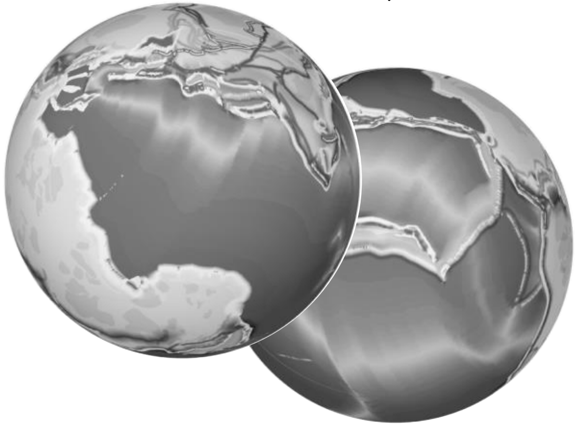
Interpolation method performance
impact on oceanic volume/sea level (>200m)

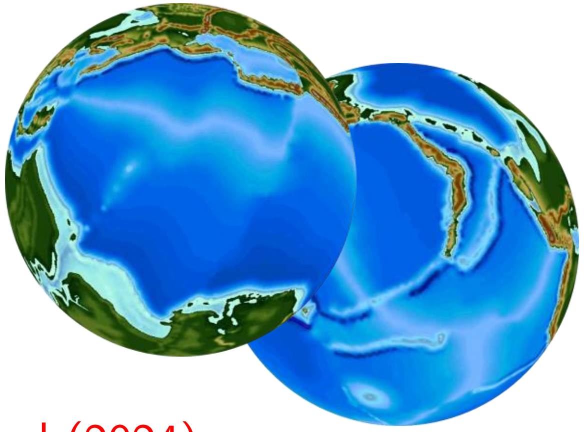
Poster just outside this room ! (P25.3)



Synthetic topographic values and profiles

Vérard (2017)





Ability to capture sea-level variations (±60m)

Vérard (2024)

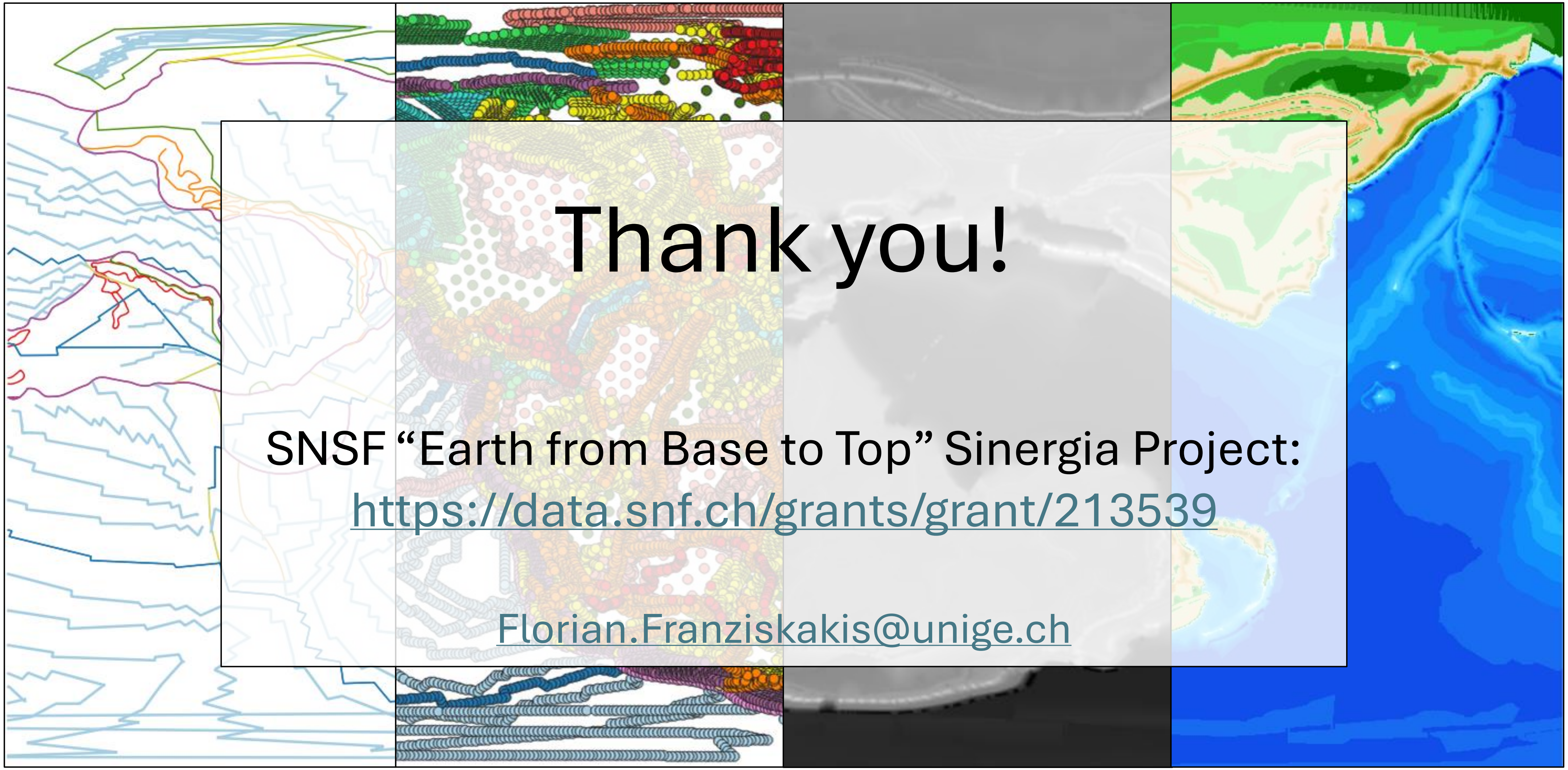
Conclusion & Outlook

Unique approach to reconstruct palaeogeography, <u>only possible with the PANALESIS model</u>.

Many uncertainties, not all of them fully quantified. <u>Propagation of error still to be looked at</u>.

Ongoing transition to open-source software & open data, <u>challenges in reproducibility of results</u>.

Future enhancements to include <u>climate & mantle feedback on topography</u>.



Thank you!

SNSF “Earth from Base to Top” Sinergia Project:

https://data.snf.ch/grants/grant/213539

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