Compressional Evolution of the PNG Margin; A Tale of Two Collisions*

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Abstract

New and existing thermochronology data across the Muller Range and north to the Sepik Terrane have been analysed to determine the time temperature history, particularly burial and erosion events. This was to investigate the large regional angular unconformity between mid-Late Cretaceous beds and the Miocene Darai Limestone. QTqt modelling of four profiles reveals that the Muller area was buried by >1.5 km of sediment during the Late Cretaceous to Eocene, presumably by the Chim, Moogli and Mendi beds as preserved near the Porgera Mine. The area was then uplifted and eroded during the Oligocene due to docking of the Sepik Terrane such that an Eocene accretionary prism over-rode the margin. During the Early Miocene there was regional extension and subsidence as exemplified by metamorphic core complexes in northern PNG and grabens in the Darai on the Fly Platform. This led to deposition of the Darai Limestone and distal marls that cover the suture between the Sepik Terrane and mainland PNG. A crustal-scale, fully restored section across the PNG orogenic belt reveals the Oligocene to Recent compressional deformation of the margin. The northern end of the section comprises the Landslip Metamorphics, the accreted continental terrane, separated from the main part of the Fold Belt by the Eocene accretionary prism. Neogene compression commenced around 12 Ma with ~70km shortening in the Om terrane and ~38km shortening in the Fold Belt. Existing thermochronology data indicate shortening of ~12mm/year from 12-4 Ma, but only 2.5mm/year from 4-0 Ma, consistent with a change in structural style in the Fold Belt from thrust to more ductile, fold-dominated deformation. The model also requires substantial thickening of the continental crust beneath the Muller Ranges, here represented by 'basement' underthrusting. Gravity modelling indicates the presence of sedimentary graben up to 10 km deep beneath the Fold Belt, which were strongly inverted, such as beneath the Lavani Valley. A key issue is when this inversion occurred, in the Oligocene or Pliocene, as this has a significant influence on the timing of hydrocarbon generation and migration.

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Mahoney L., McLaren S., Hill K., Kohn B., Gallagher K and Norvick M. 2019. Late Cretaceous to Oligocene burial and collision in western Papua New Guinea: Indications from low-temperature thermochronology and thermal modelling. Tectonophysics 752, p. 81-112.

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Compressional evolution of the PNG margin; A tale of two collisions

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Margins@Melbourne

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- Some of this work was carried out in 2016 whilst Kevin Hill was working at Oil Search and we deeply thank them and their JV partners for allowing us to show the regional sections.
- Thanks also to the Basin Genesis Hub, Sandra McLaren, Barry Kohn, & Martin Norvick and to Move™ for software

- However, the views presented here are entirely our own, and do not necessarily reflect the opinions of any company or other person.

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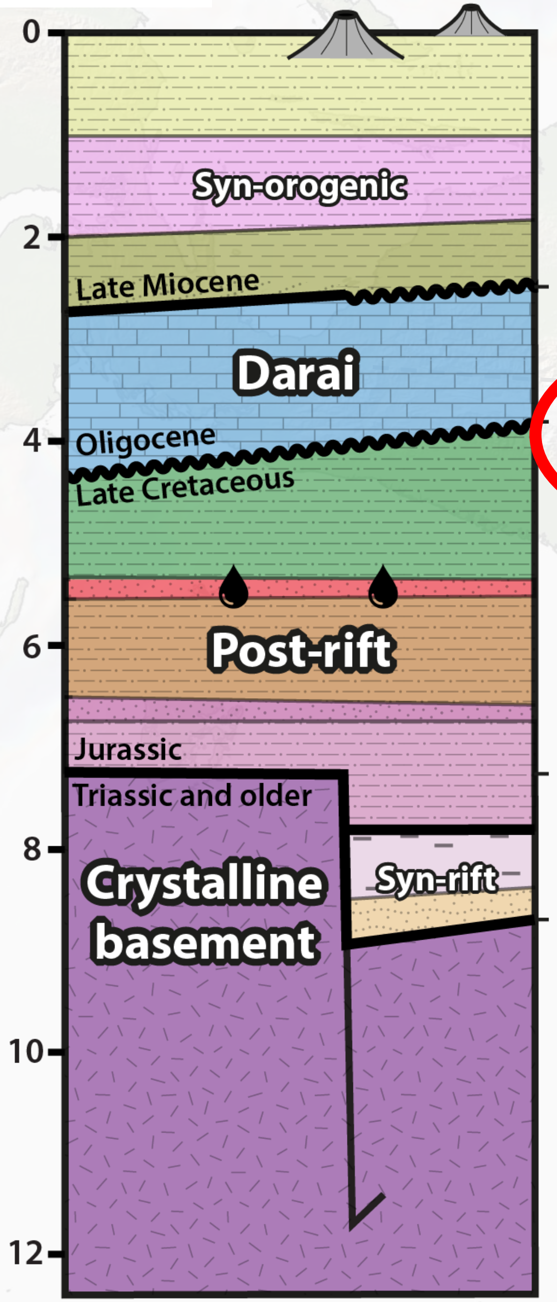
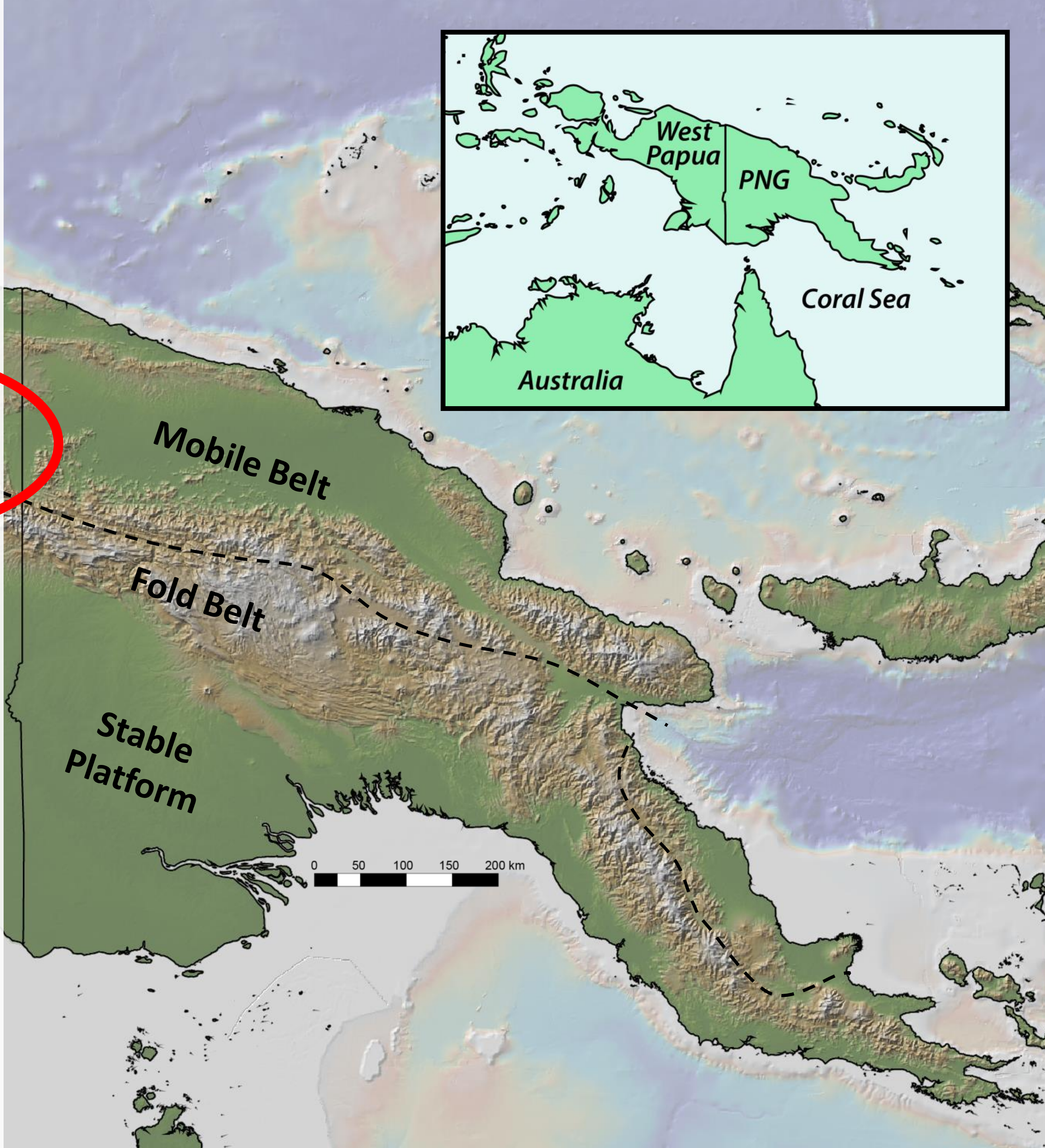
- **Background and Location**
- Thermochronology
- Regional section
- Conclusions

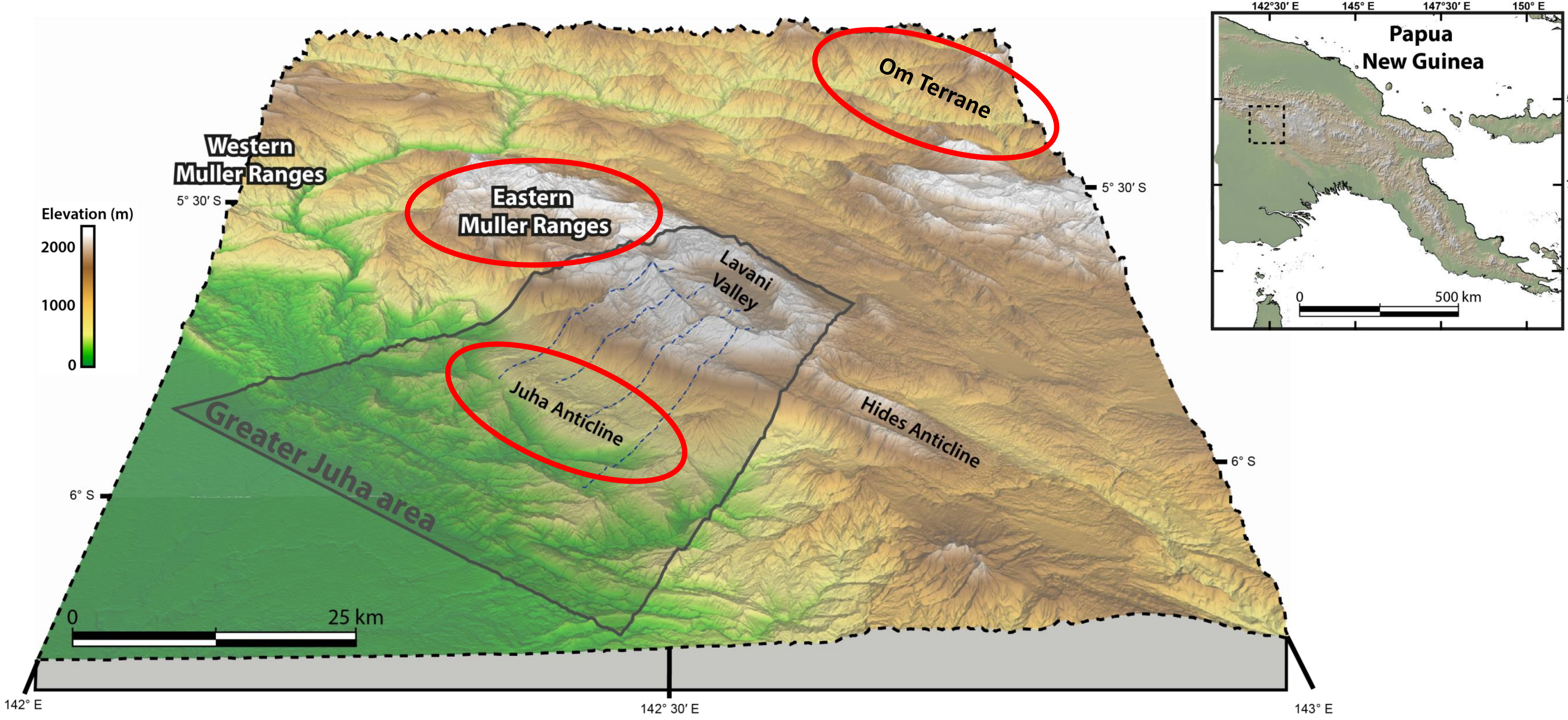
Background



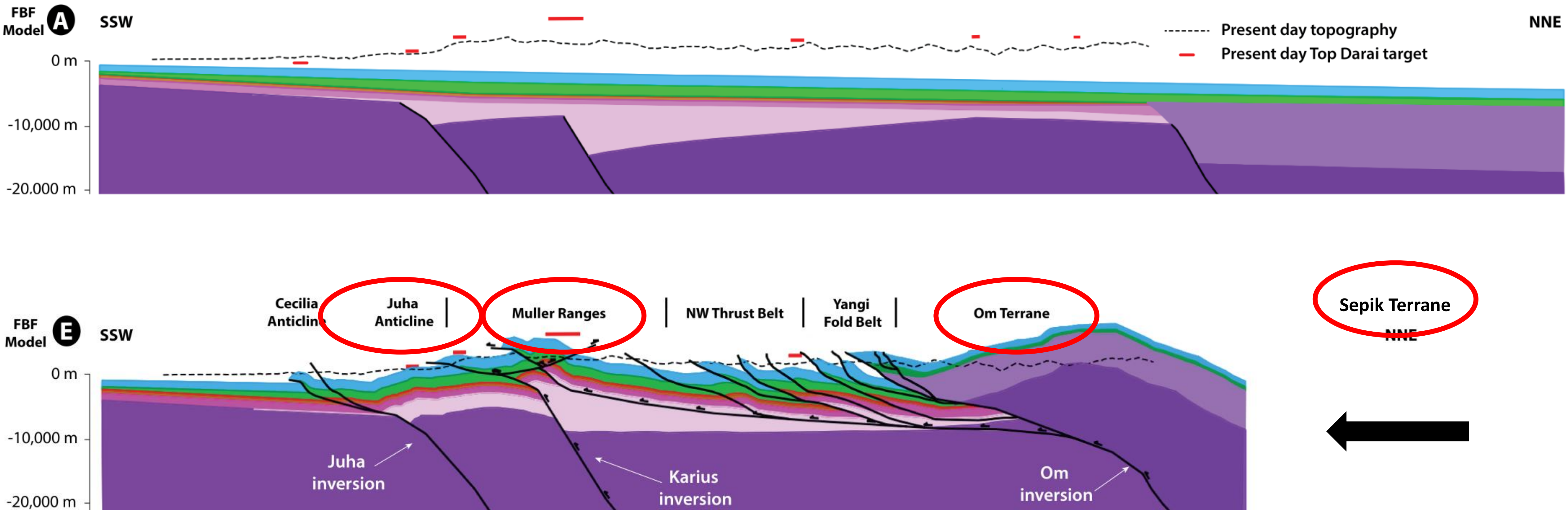
Big Unconformity – what happened?



Study area. - Mahoney et al. Journal of Structural Geology, 2017.



Combination of inversion and thin-skin



Mahoney 2015 AAPG ICE

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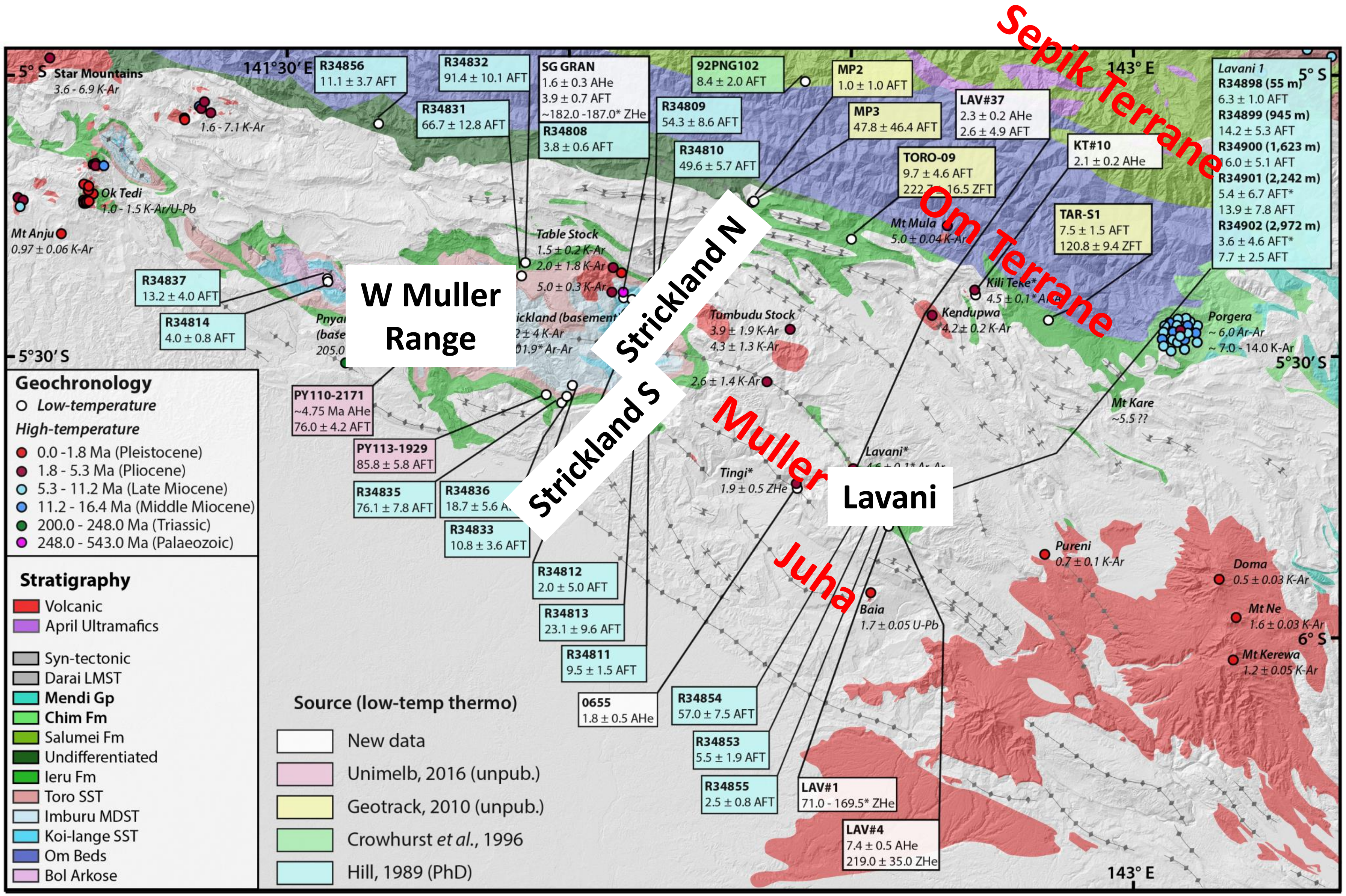
Low T thermochronology Mahoney et al 2019 Tectonophysics



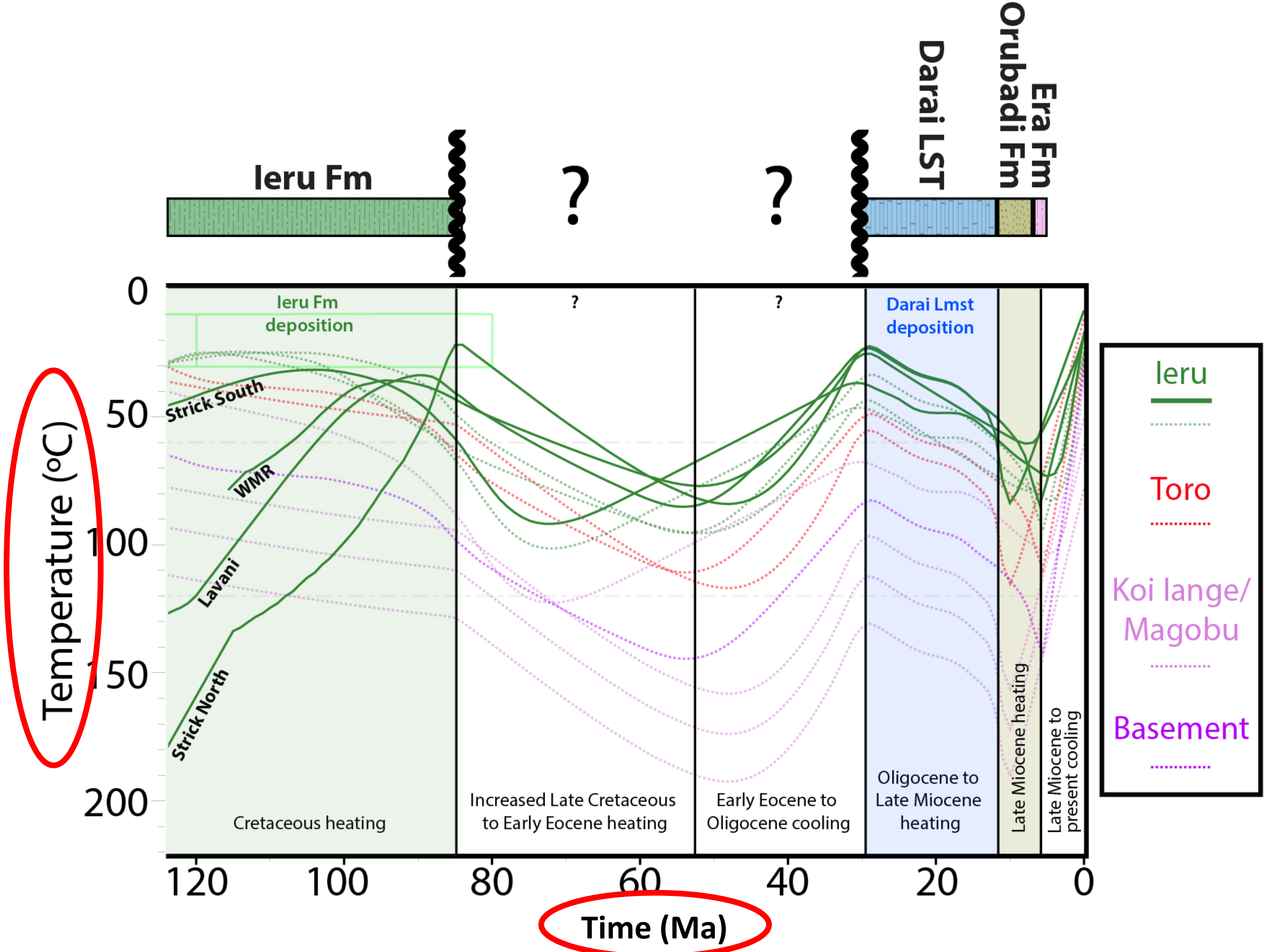
New Data

AHe 8 samples 53 grains
- **40-80°C**

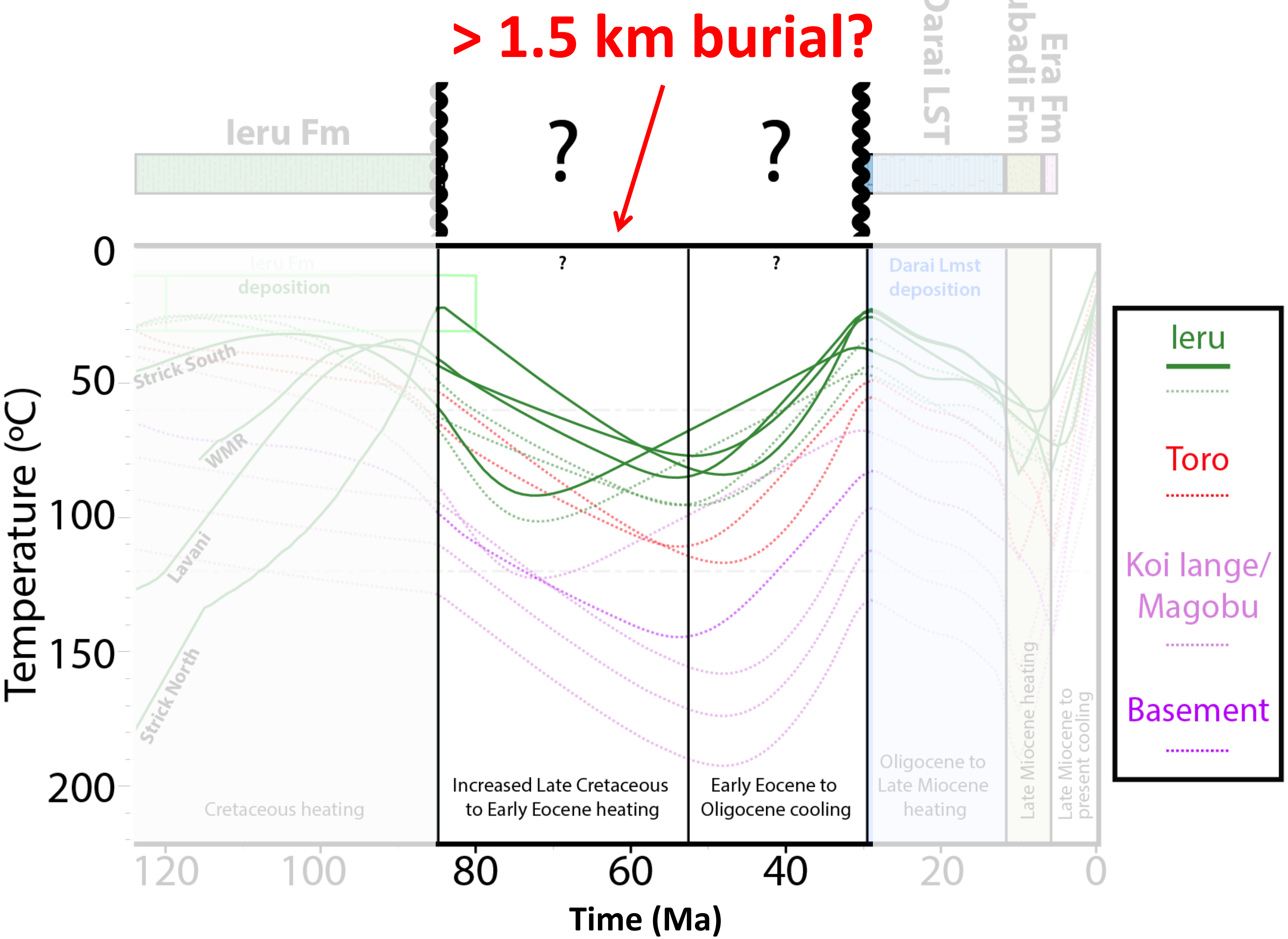
AFT 2 samples
- **60-110°C**

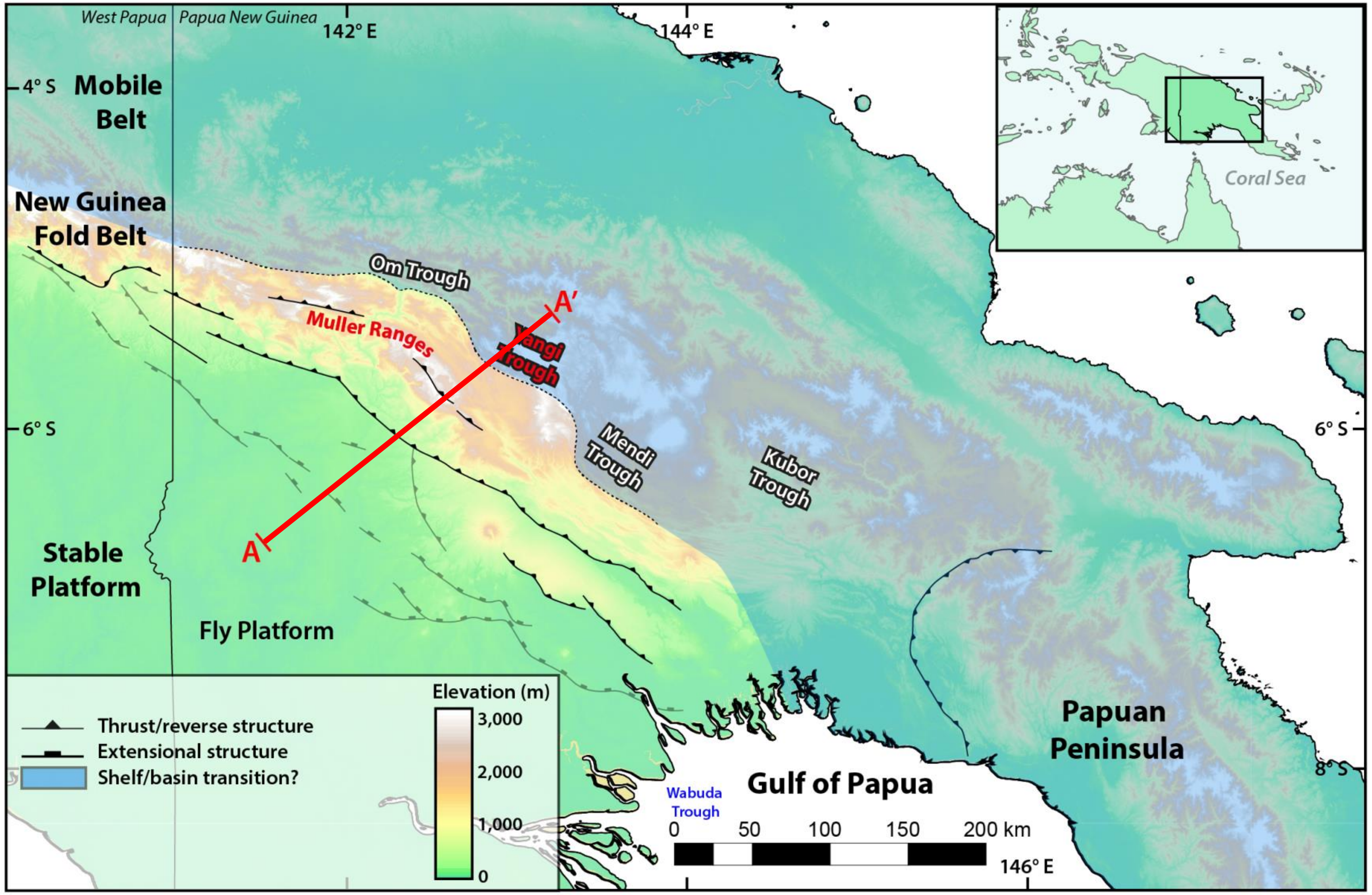
ZHe 12 samples 67 grains
- **130-200°C**

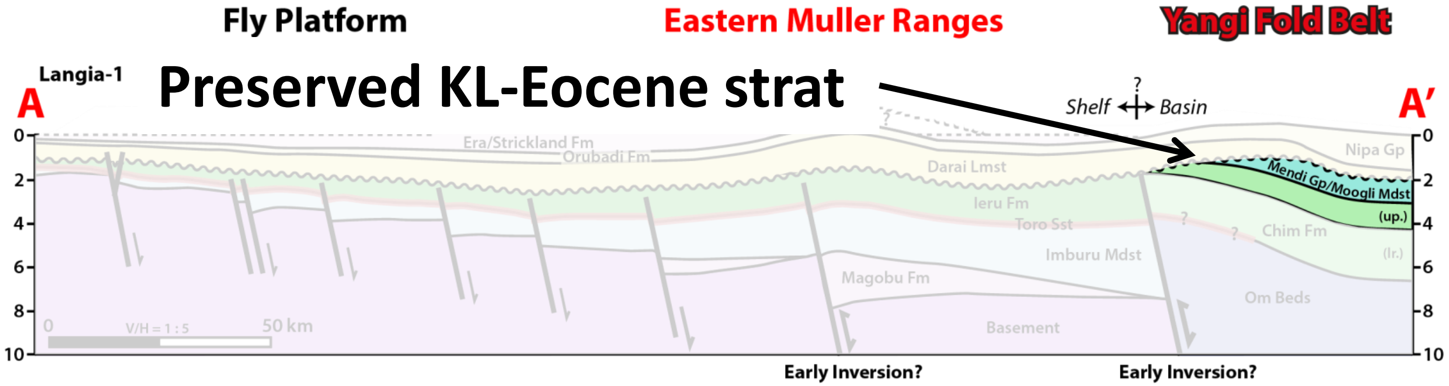
Thermal history modelling - QTQt



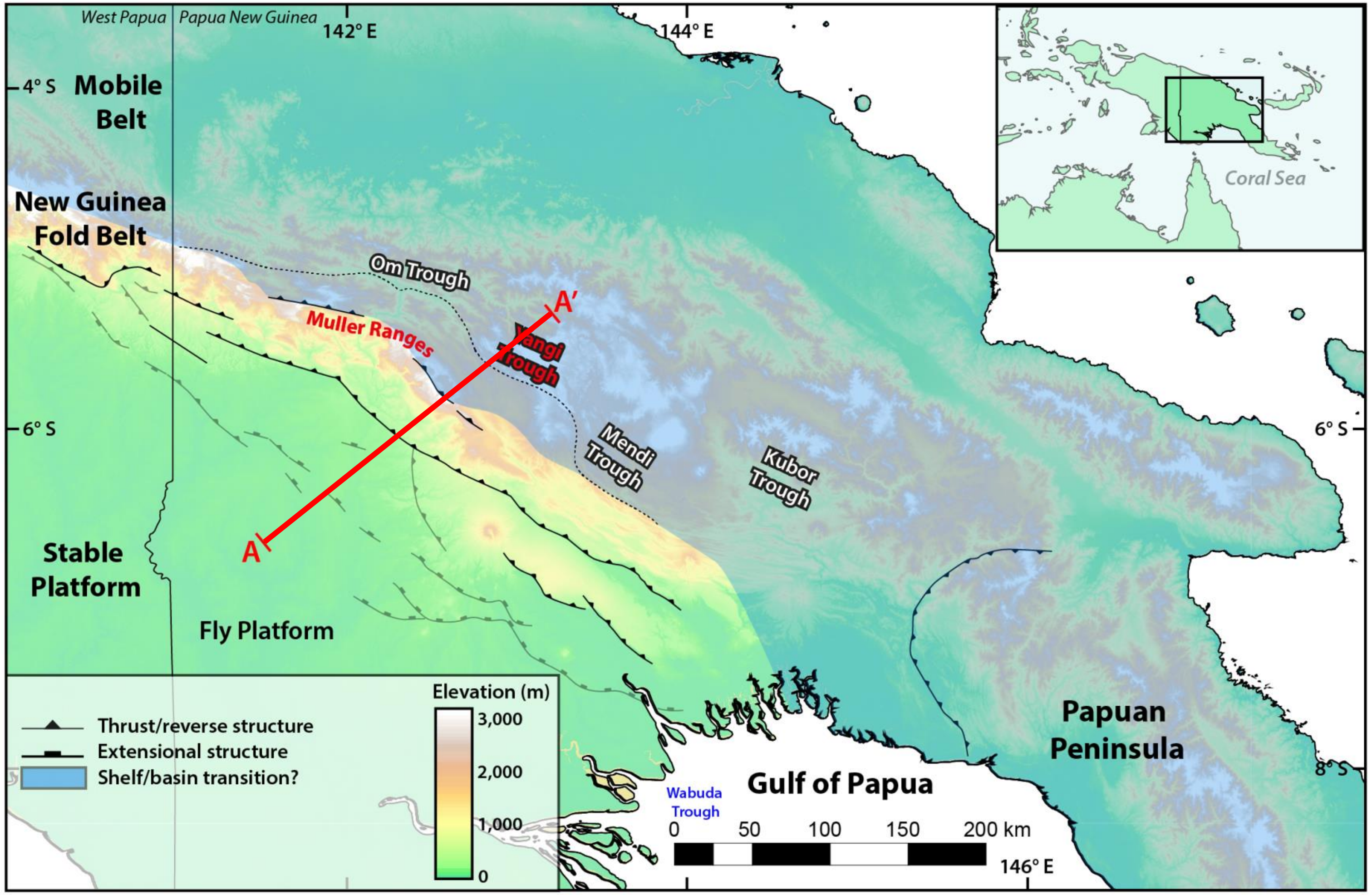
Late Cretaceous to Eocene heating (55-80°C)





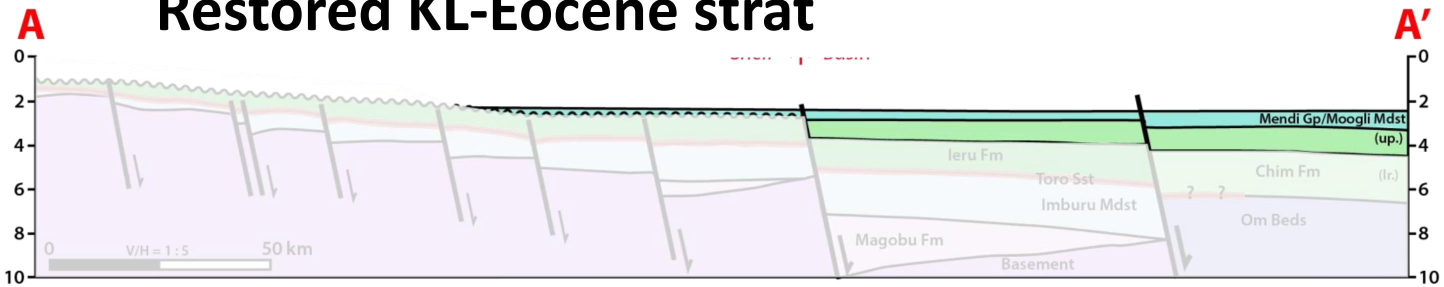


Distal sediments preserved at Porgera Mine



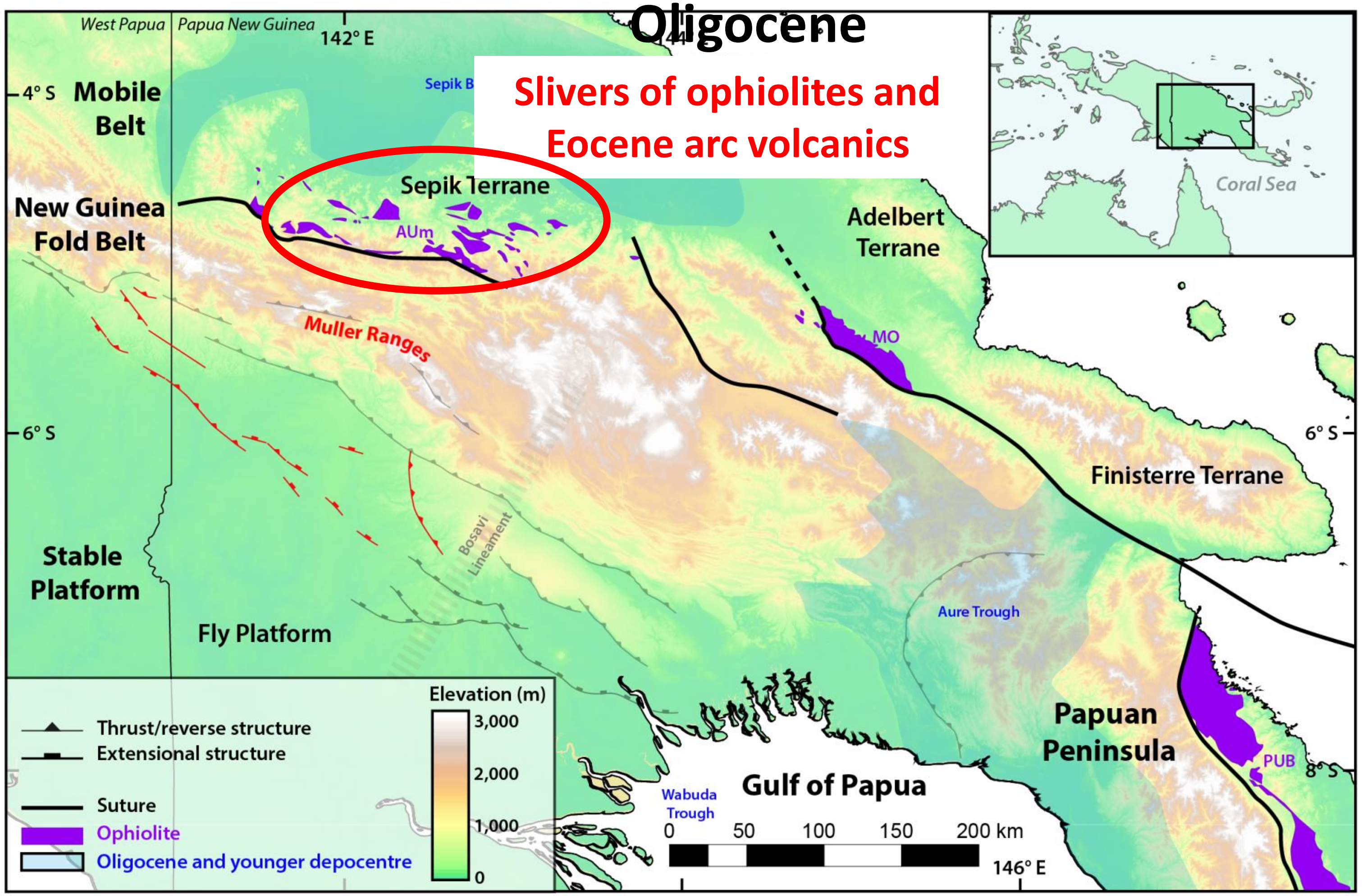
Fly Platform | Eastern Muller Ranges | Yangi Fold Belt

Restored KL-Eocene strat



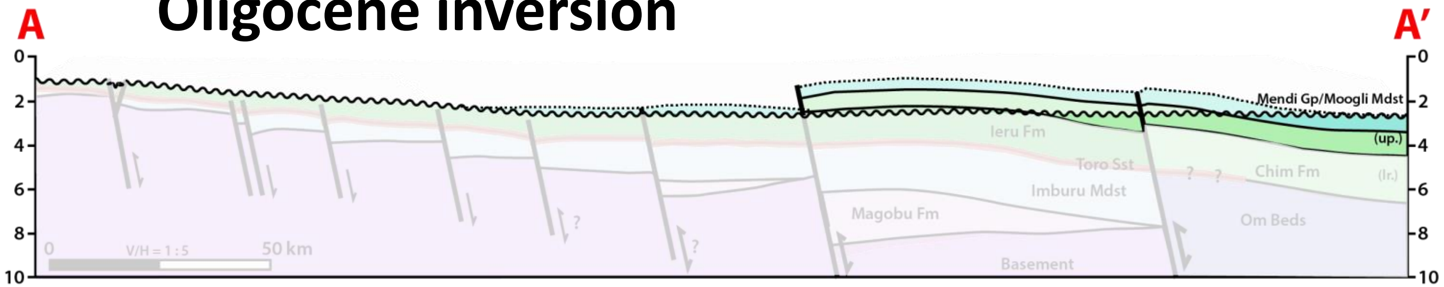
Oligocene

Slivers of ophiolites and Eocene arc volcanics

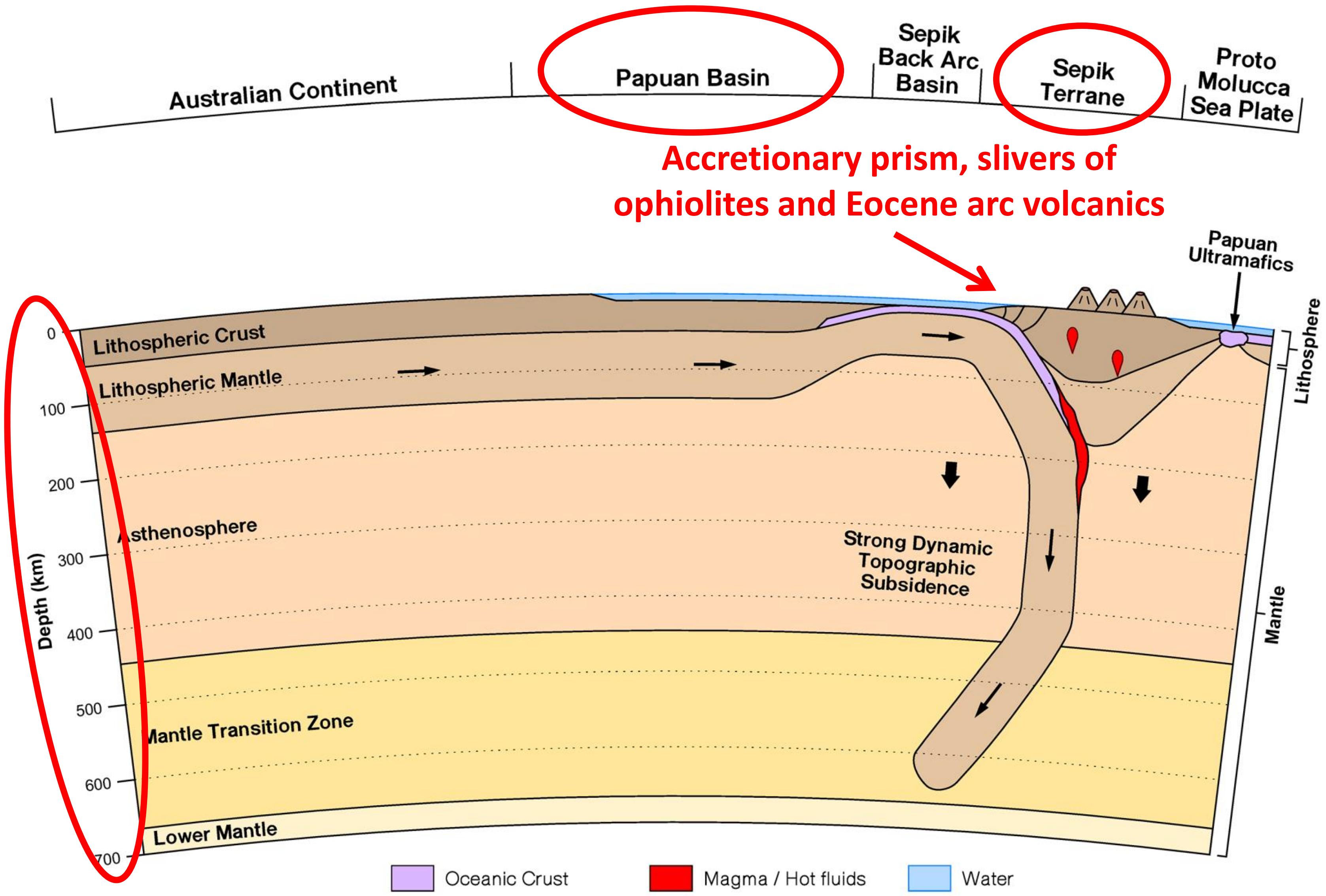


Fly Platform **Eastern Muller Ranges** **Yangi Fold Belt**

Oligocene inversion



Eocene Tectonic Setting, after Sabin Zahirovic (BGH) and Jeremy Iwanec (OSL)



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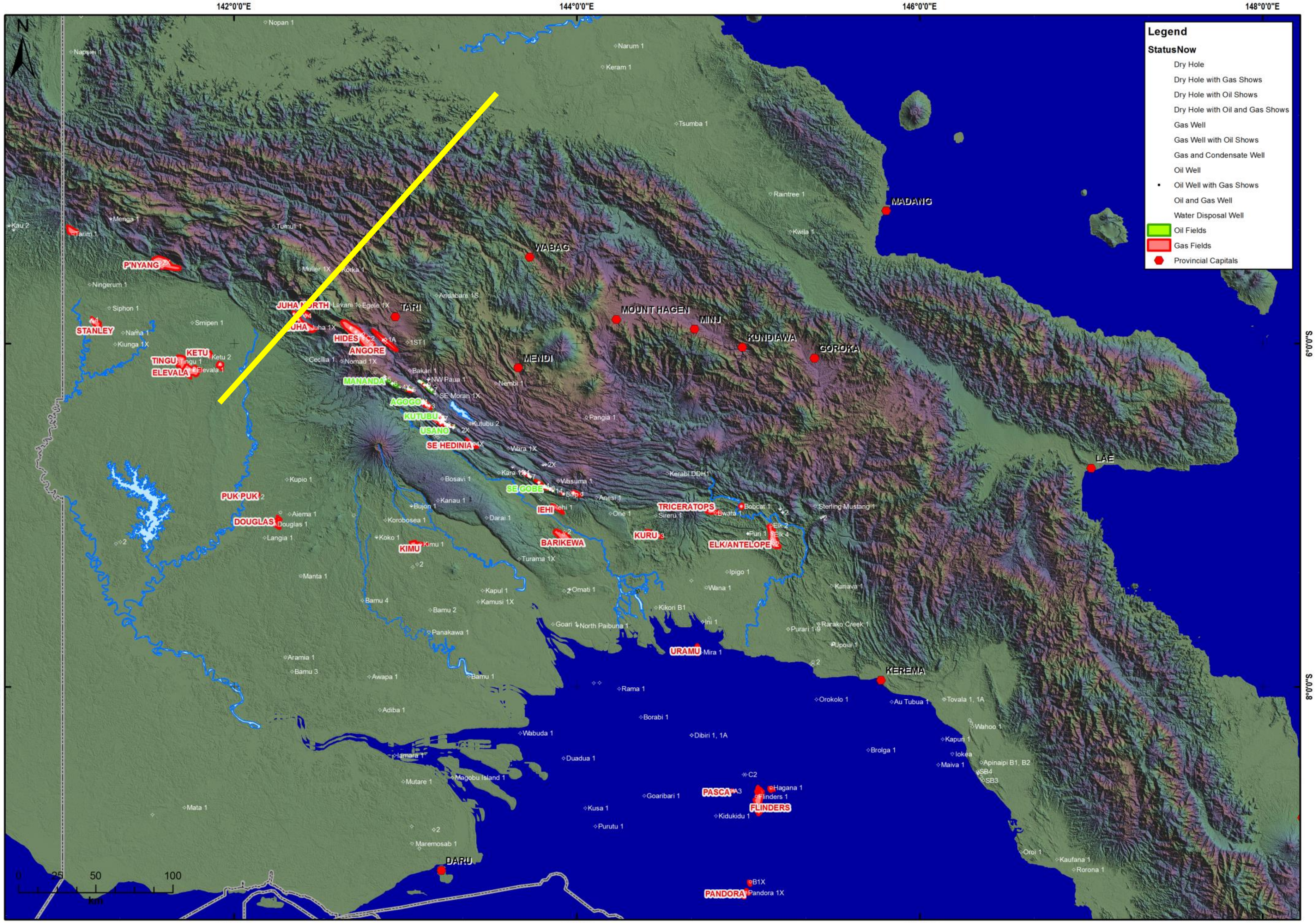
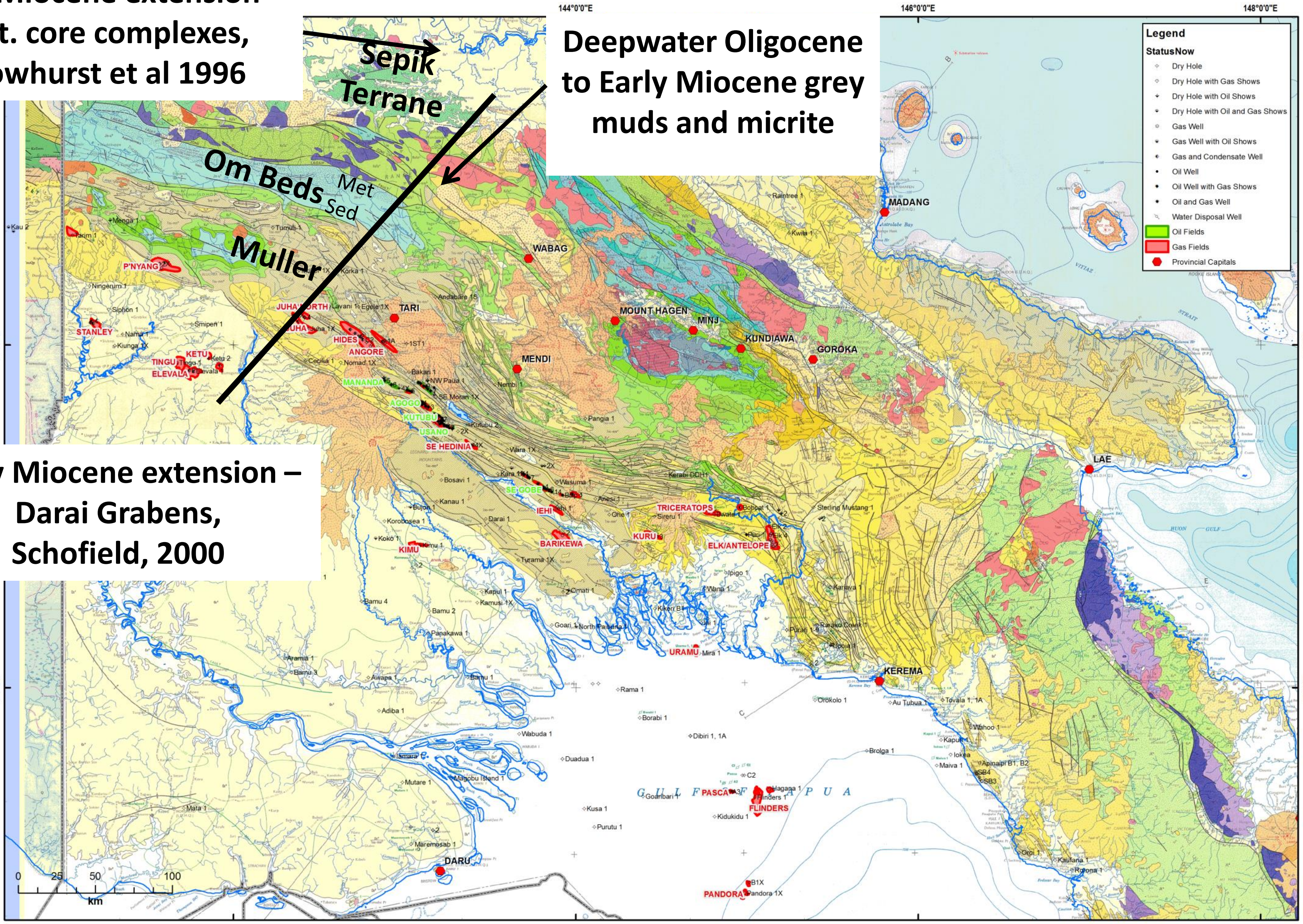
Regional section



Early Miocene extension – met. core complexes, Crowhurst et al 1996

Deepwater Oligocene to Early Miocene grey muds and micrite

Early Miocene extension – Darai Grabens, Schofield, 2000

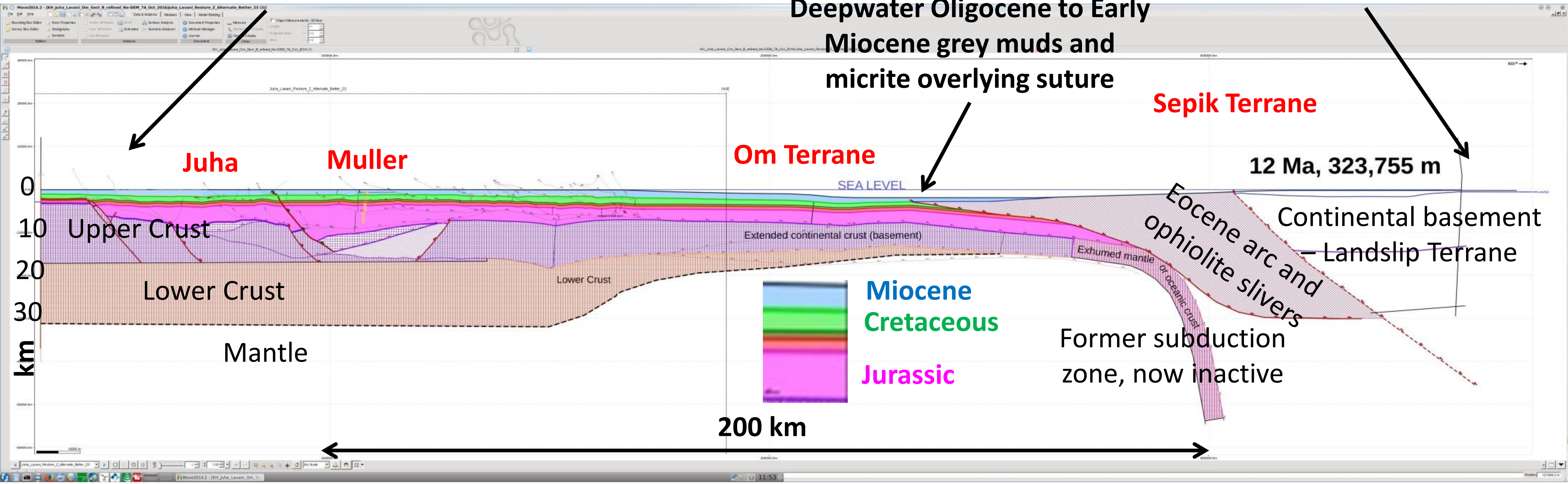


12 Ma – section constructed in MoveTM

Early Miocene extension – Darai Grabens, Schofield, 2000

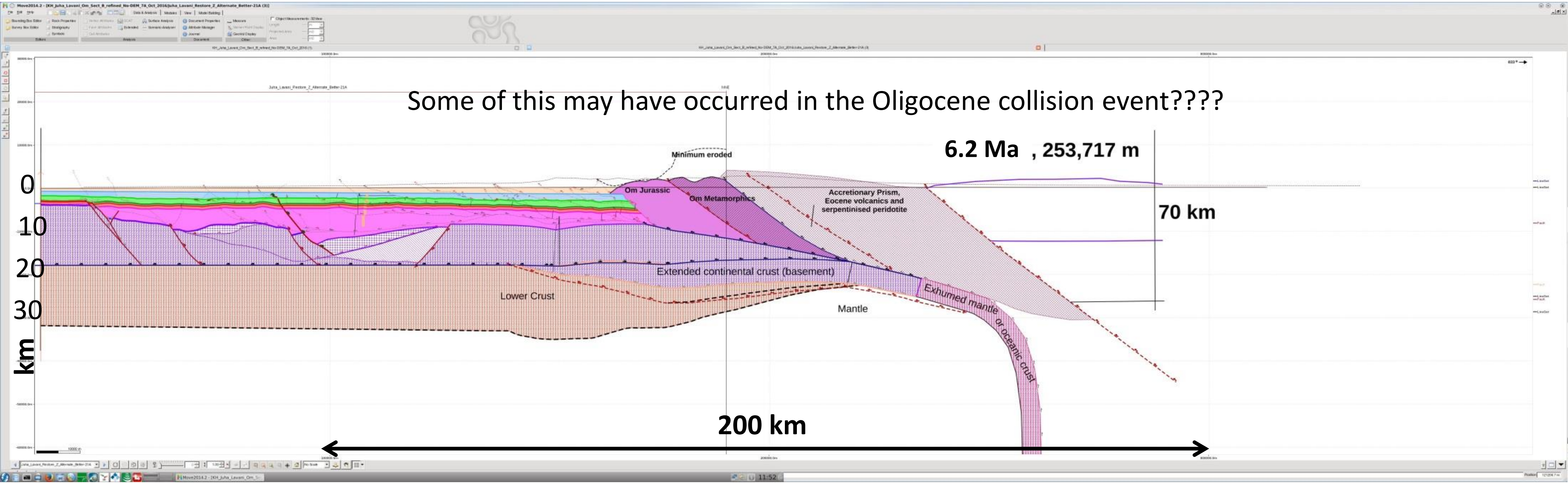
Early Miocene extension – metamorphic core complexes, Crowhurst et al 1996

Deepwater Oligocene to Early Miocene grey muds and micrite overlying suture



This work was done whilst Kevin Hill was at Oil Search Ltd, but does not necessarily reflect the views of Oil Search

6.2 Ma



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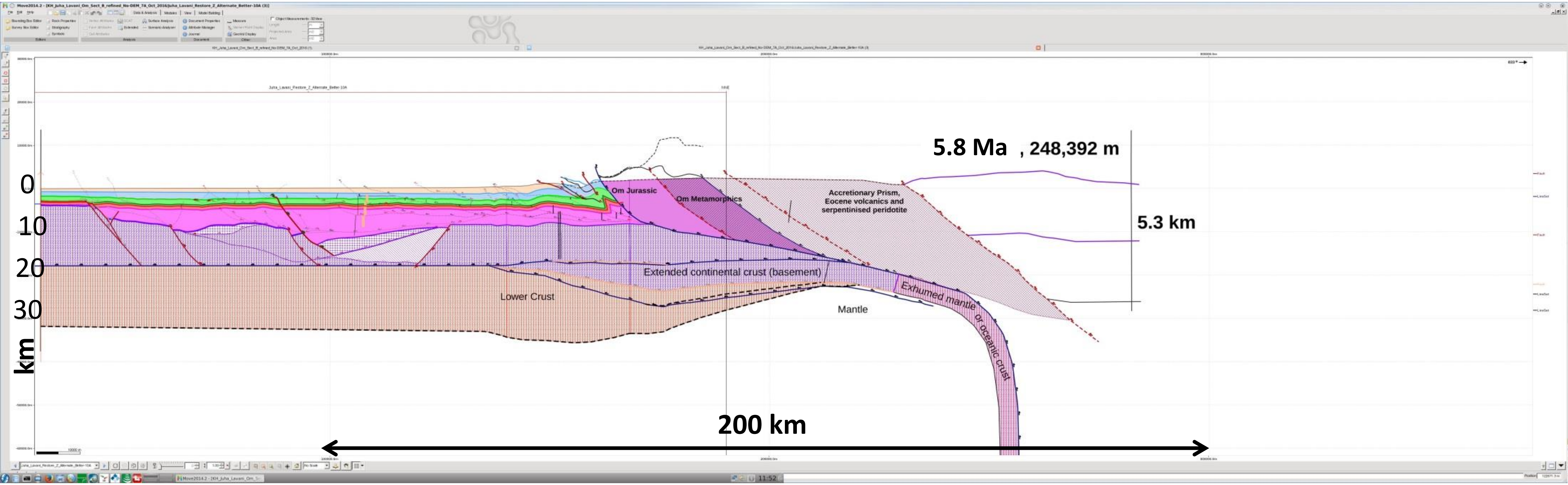
5.8 Ma



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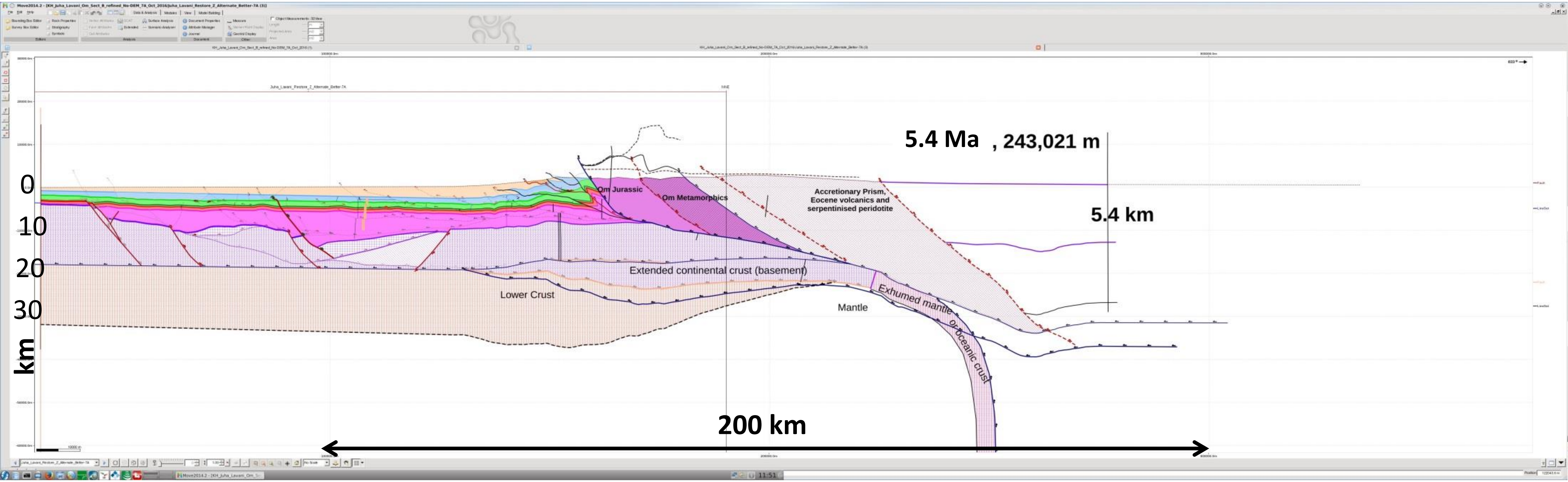
5.4 Ma



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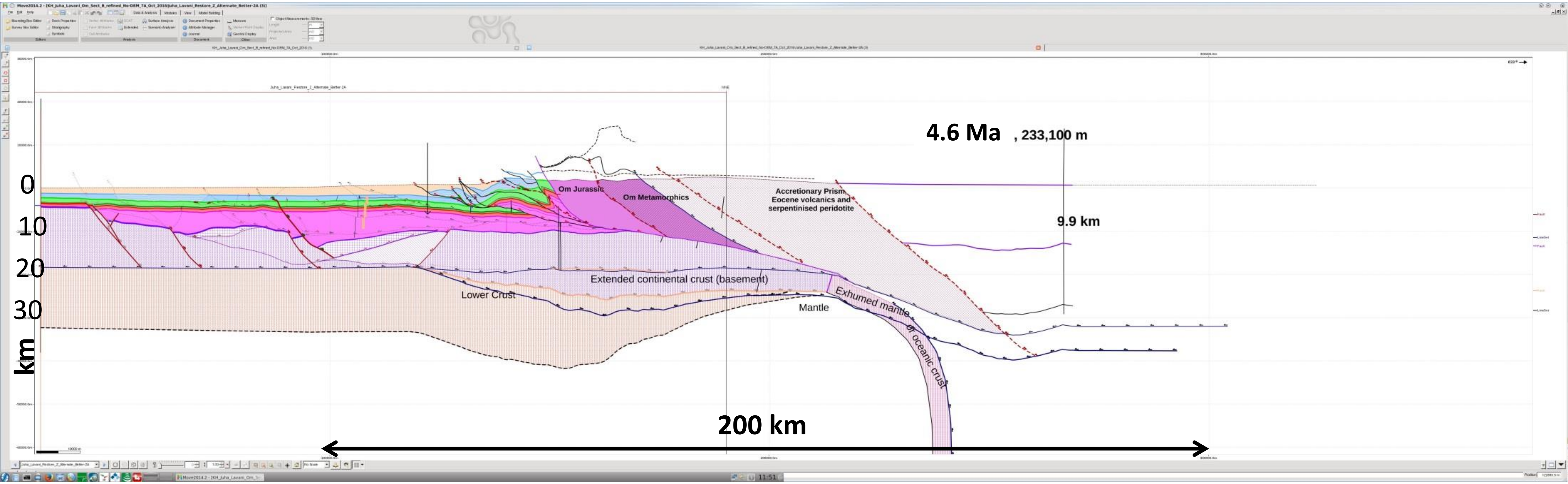
4.6 Ma



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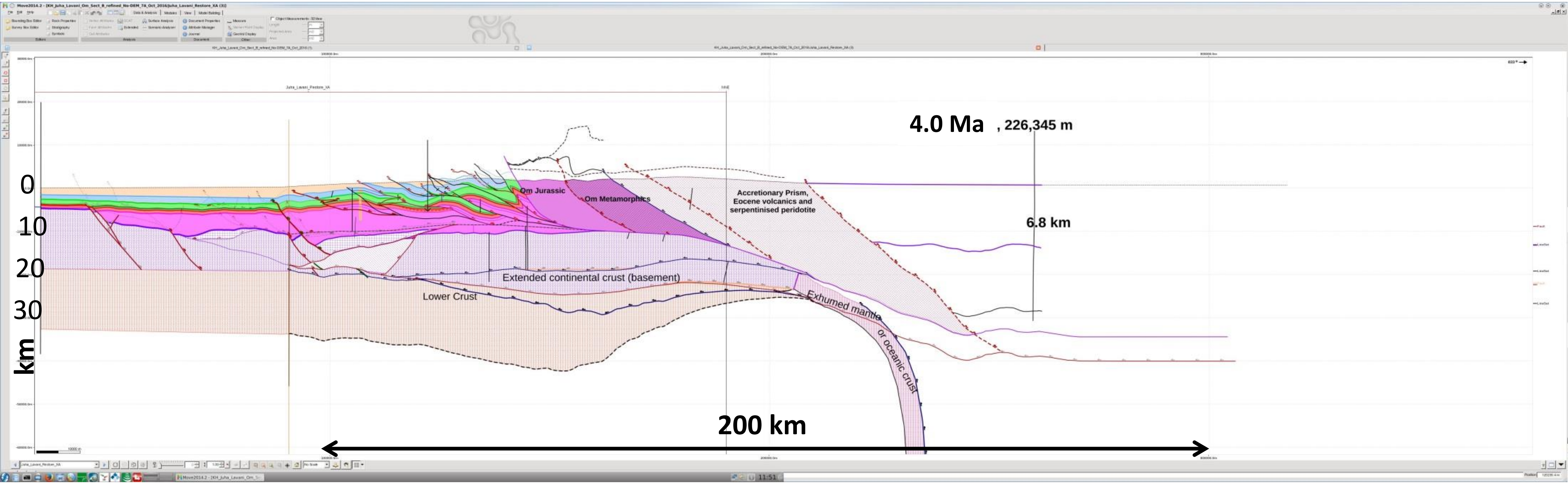
4.0 Ma



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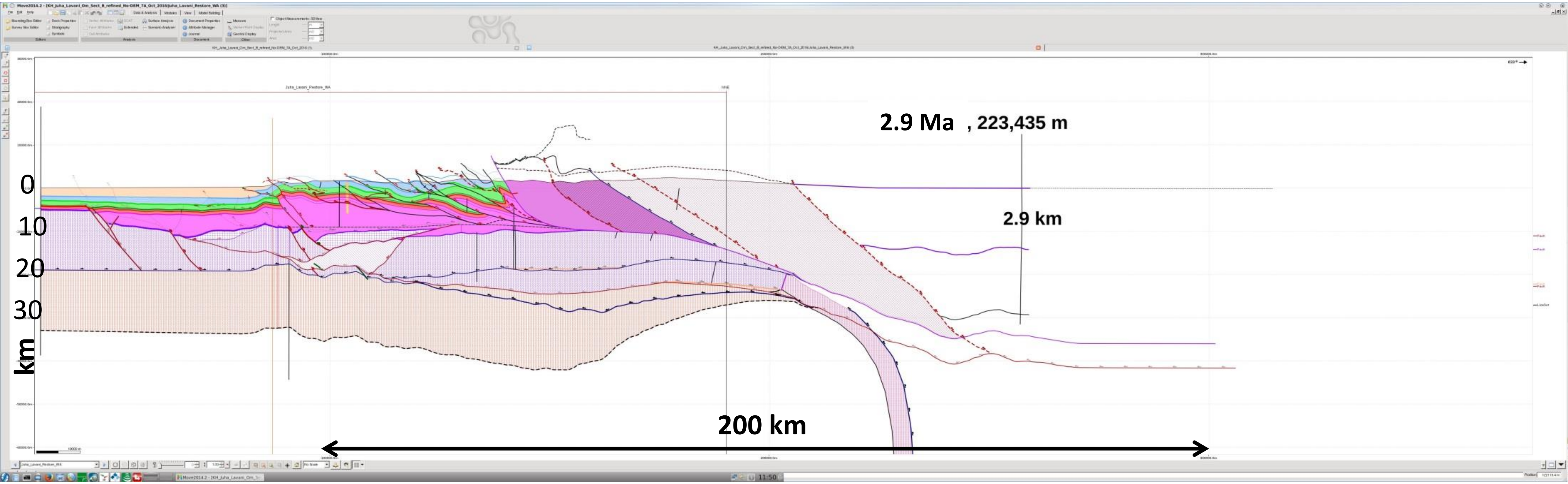
2.9 Ma



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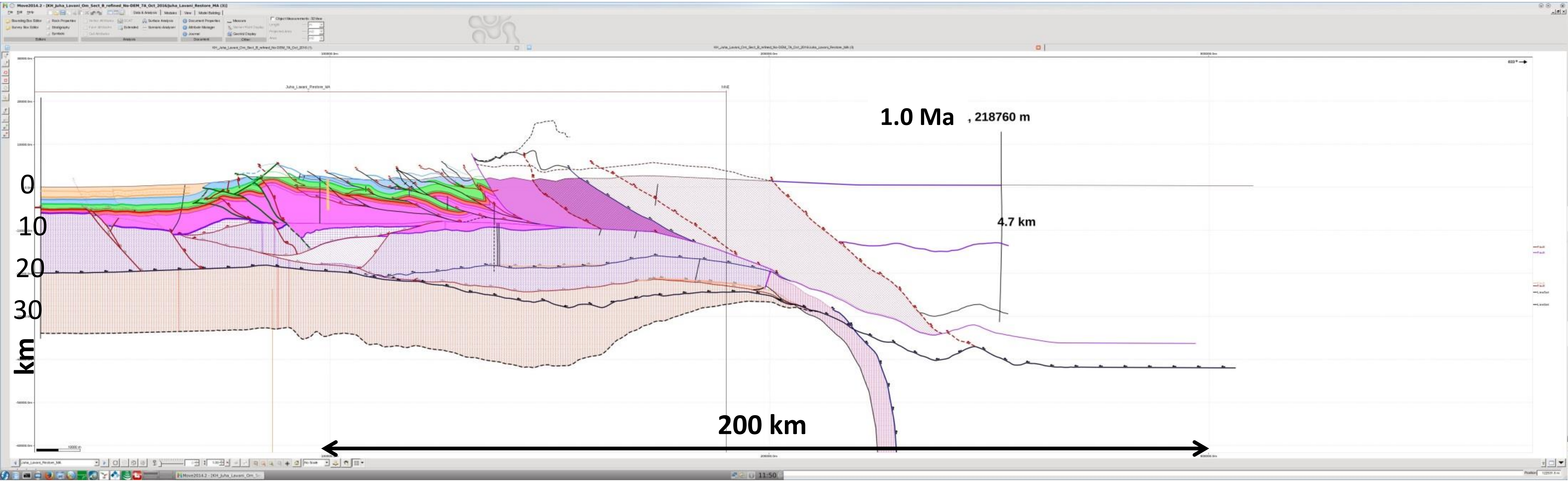
1.0 Ma



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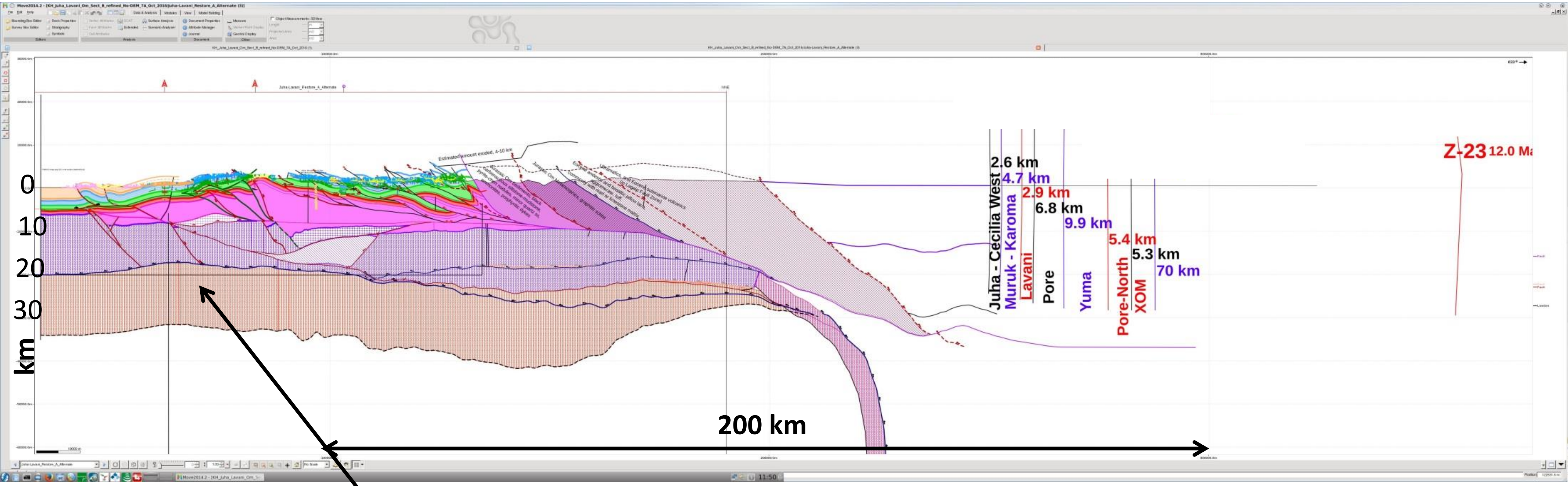
0 Ma



Ongoing Research, what is causing this dynamic topography? Slab break-off???

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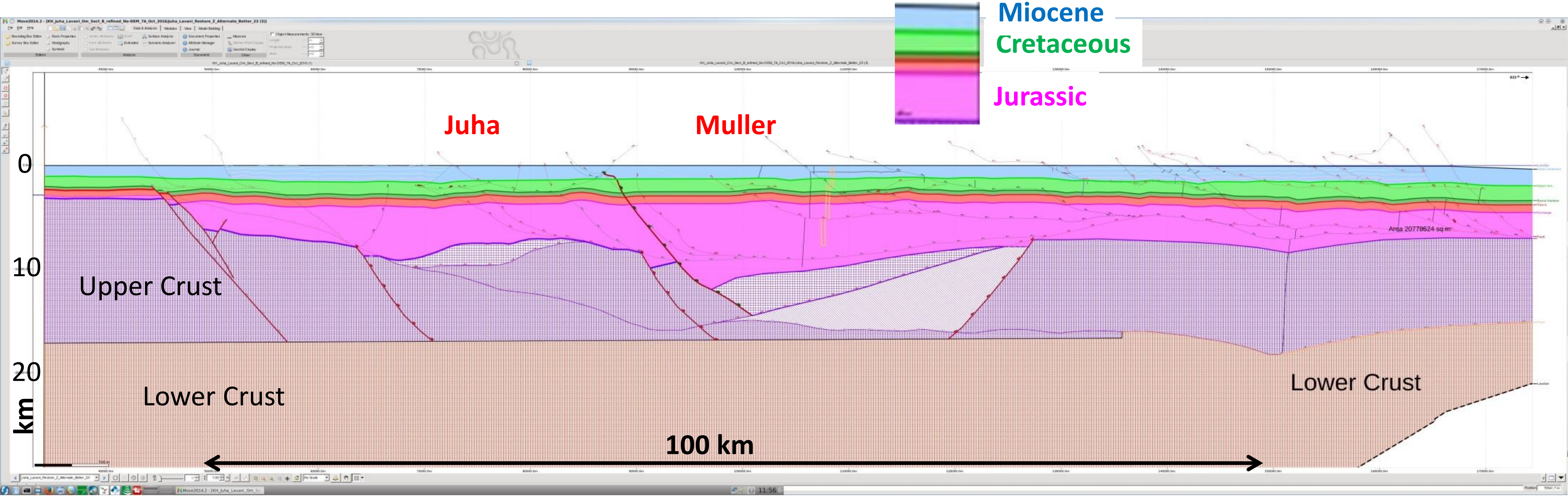
12 Ma



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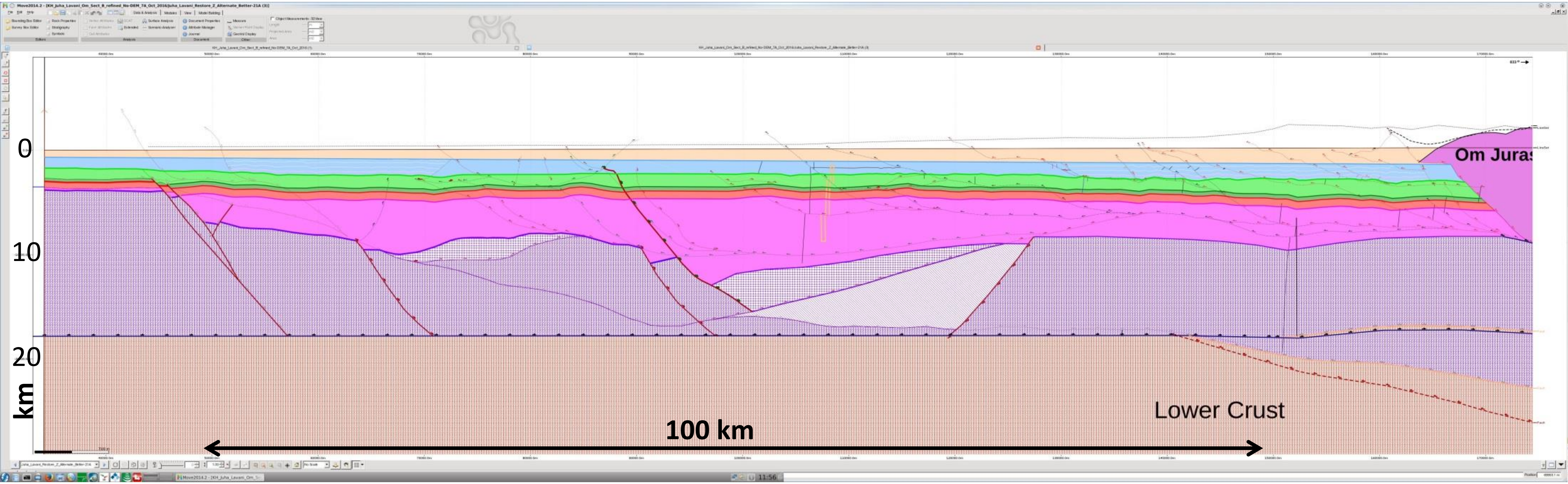
6.2 Ma



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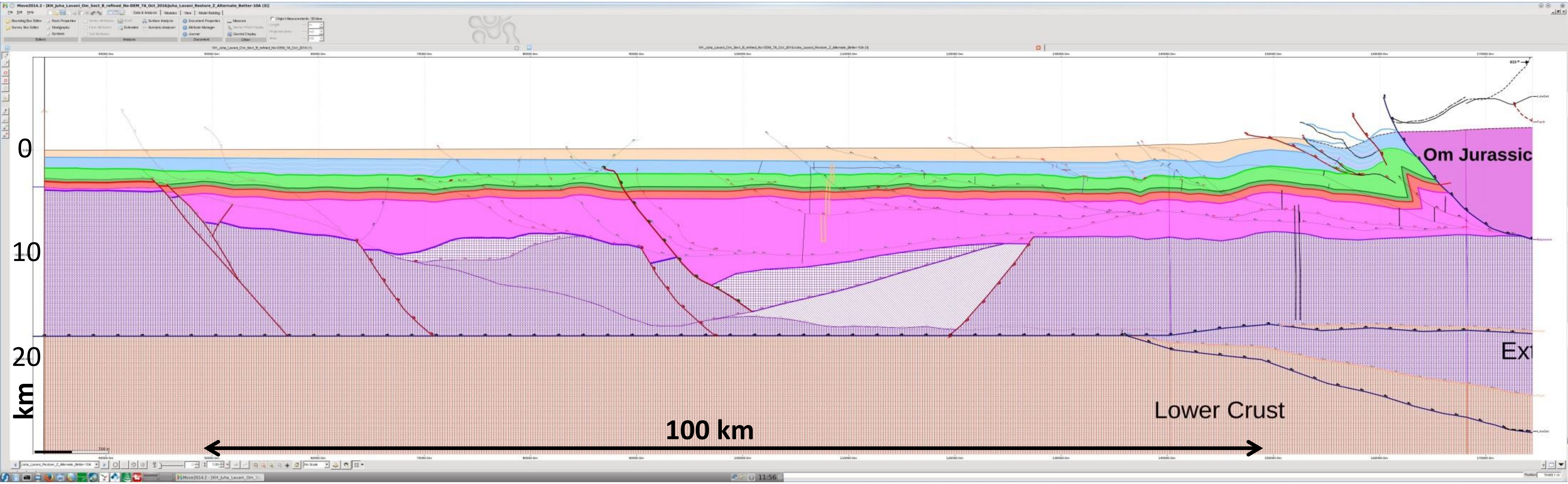

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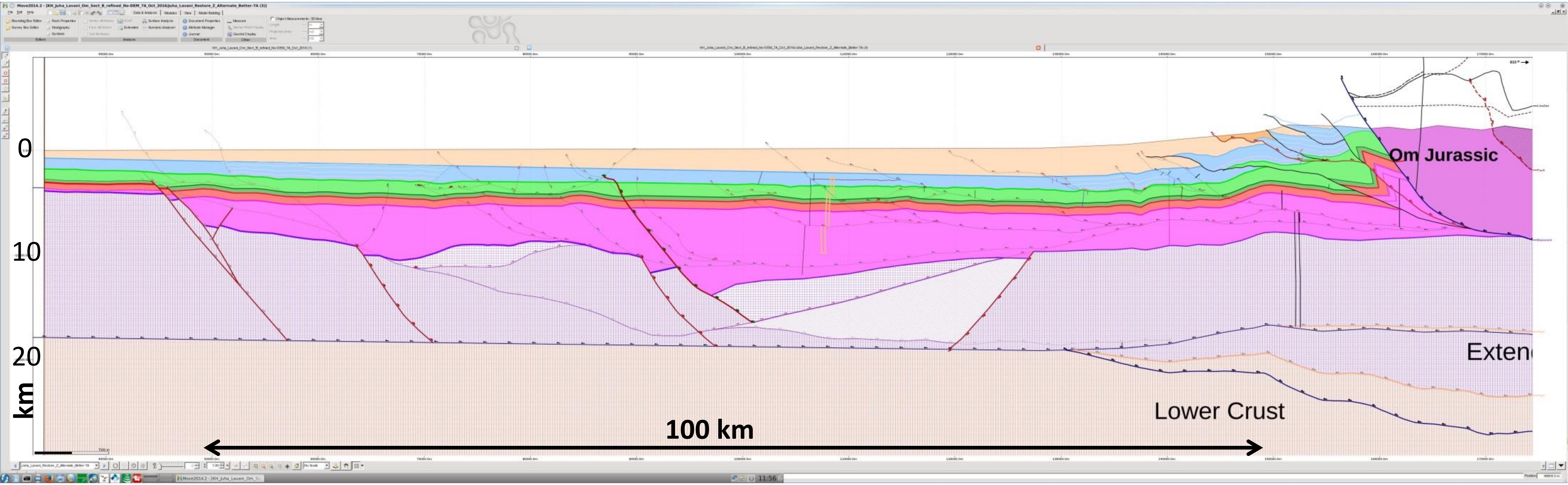
5.4 Ma



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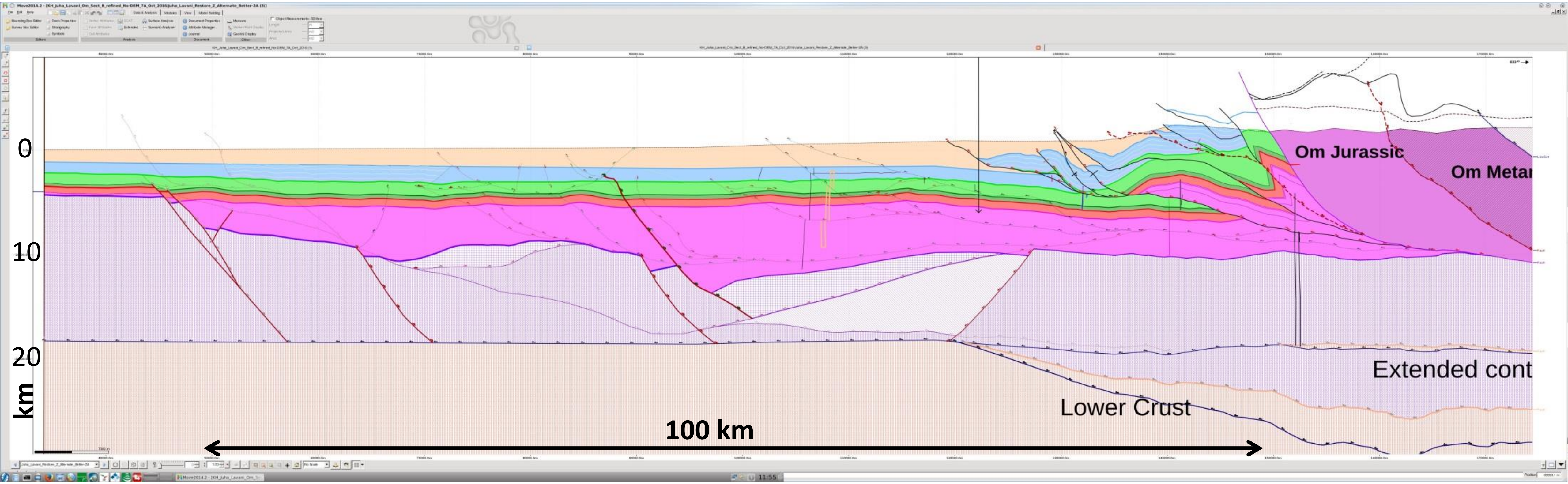
4.6 Ma



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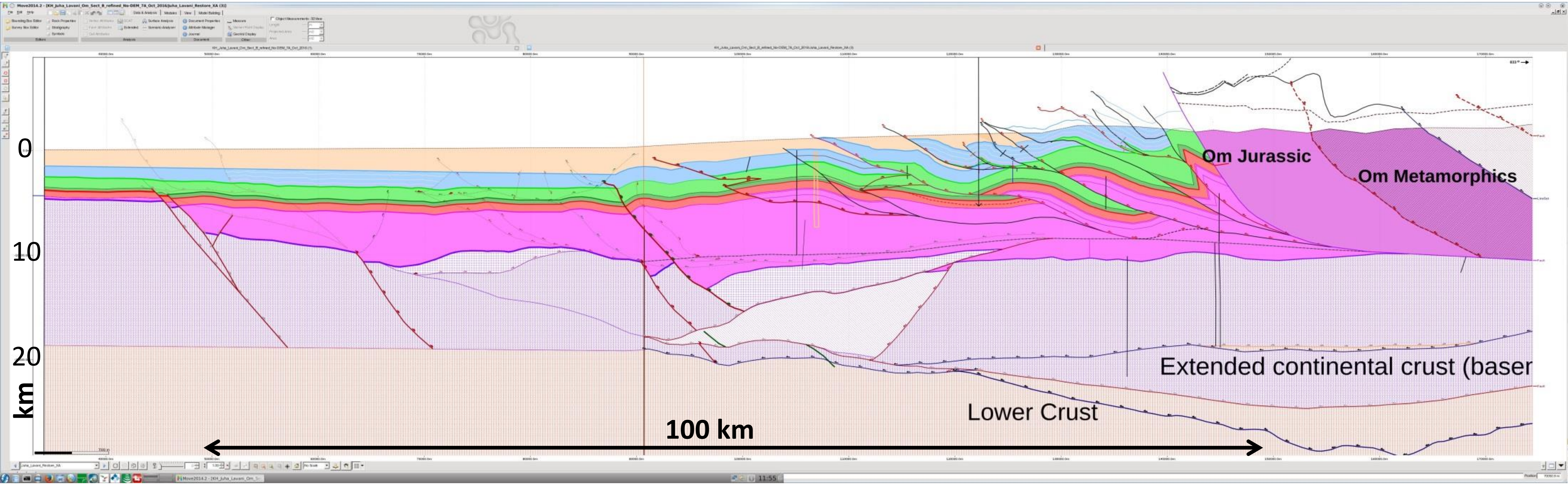

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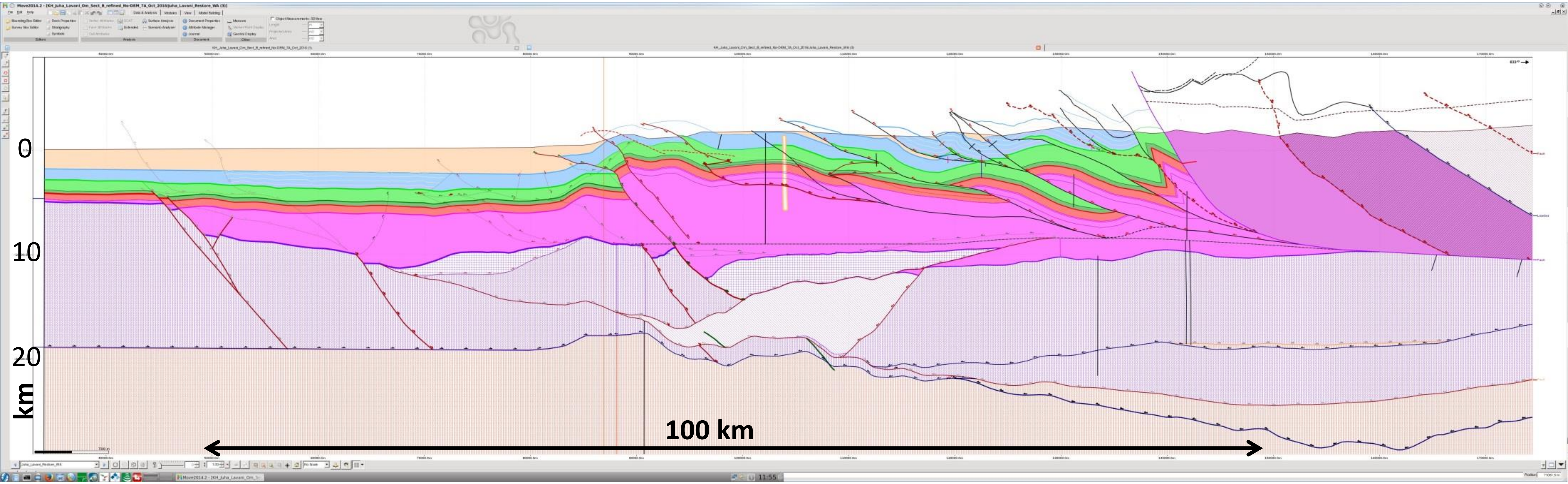

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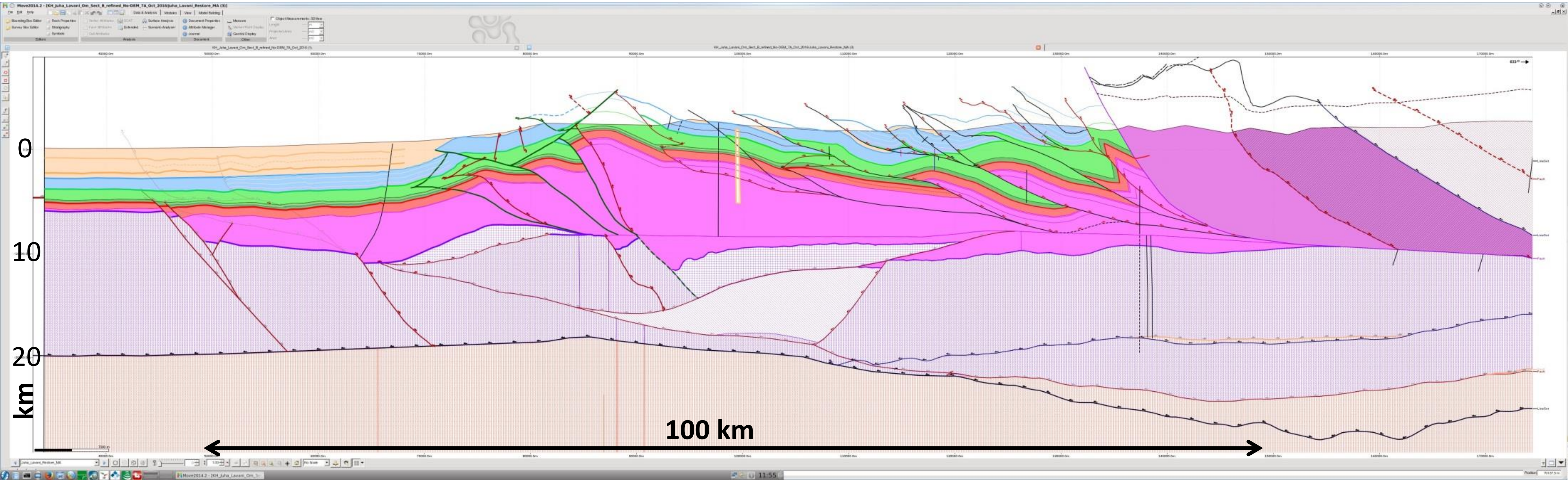

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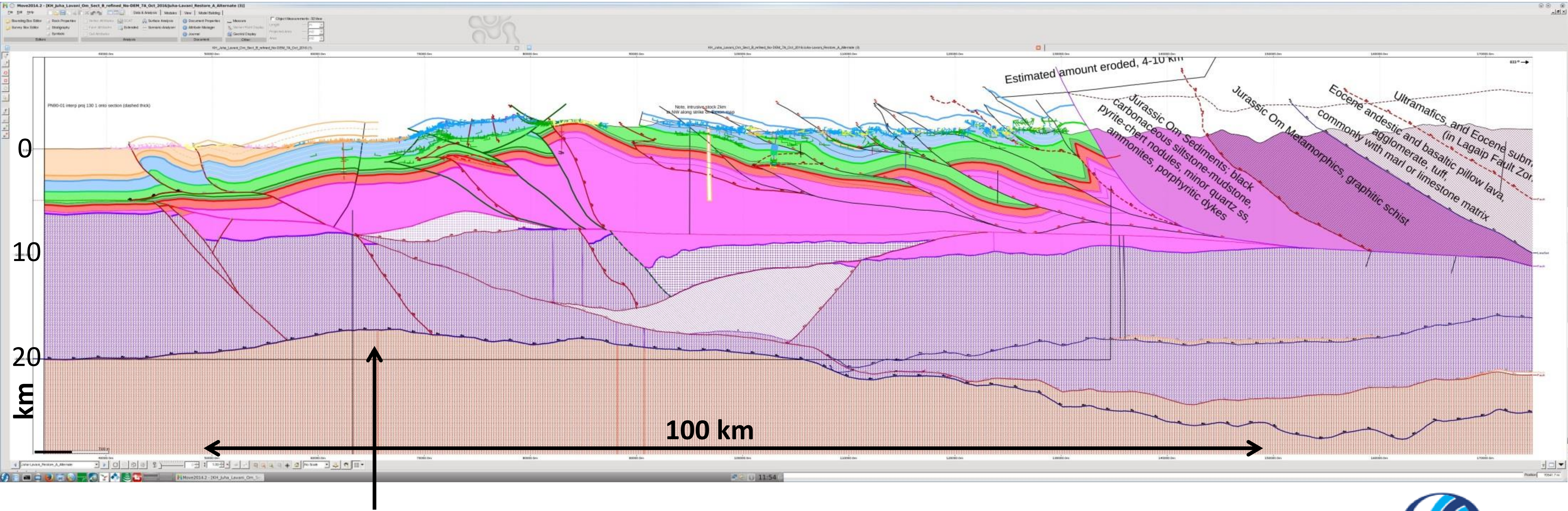
0 Ma



Ongoing Research, what is causing this dynamic topography? Slab break-off???

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Conclusions

- 1-2 km Late Cretaceous to Eocene burial of the Muller Ranges
  - Maximum burial? Early hydrocarbon generation?
- Oligocene suturing of the Sepik Terrane, causing inversion but not major compression
- Muller Ranges uplifted and eroded in the Oligocene – cooling
  - Early inversion to create large structural traps, hydrocarbon remigration?
- Early Miocene extension and subsidence, metamorphic core complexes in the north, Darai graben in the south
- Compression from 12-0 Ma, both thin-skinned and inversion.

- To be investigated further with distal strat holes, thermochronology, margin-scale sections and finite element modelling.

Thank You

Acknowledgements

Oil Search

midland valley

the structural geology experts

move™

Academic Software Initiative

Luke Mahoney

luke.mahoney@oilsearch.com

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