Tectonics and geothermal exploration and production

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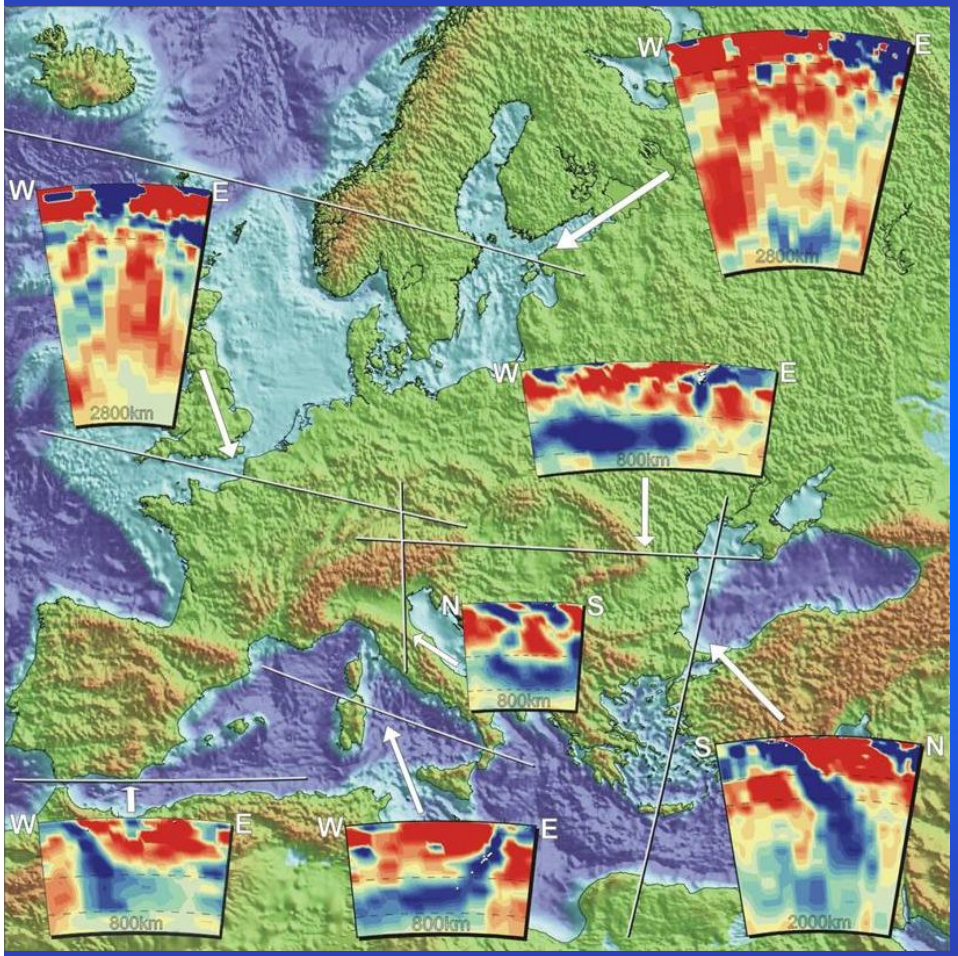
ENGINE mid term meeting

12 Januari 2007

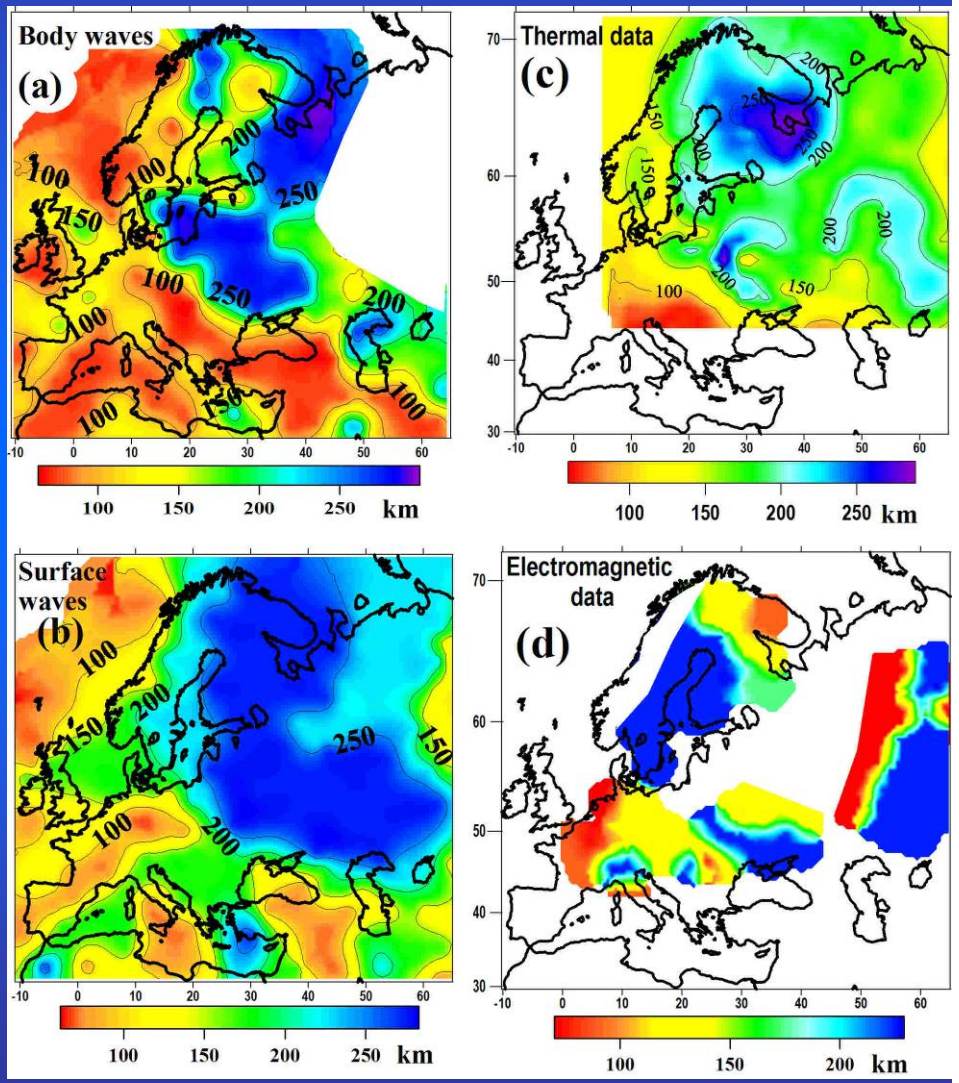
ISES Netherlands Research Centre for Integrated Solid Earth Science

vrije Universiteit *amsterdam*

Europe: heterogeneous crustal and mantle structure

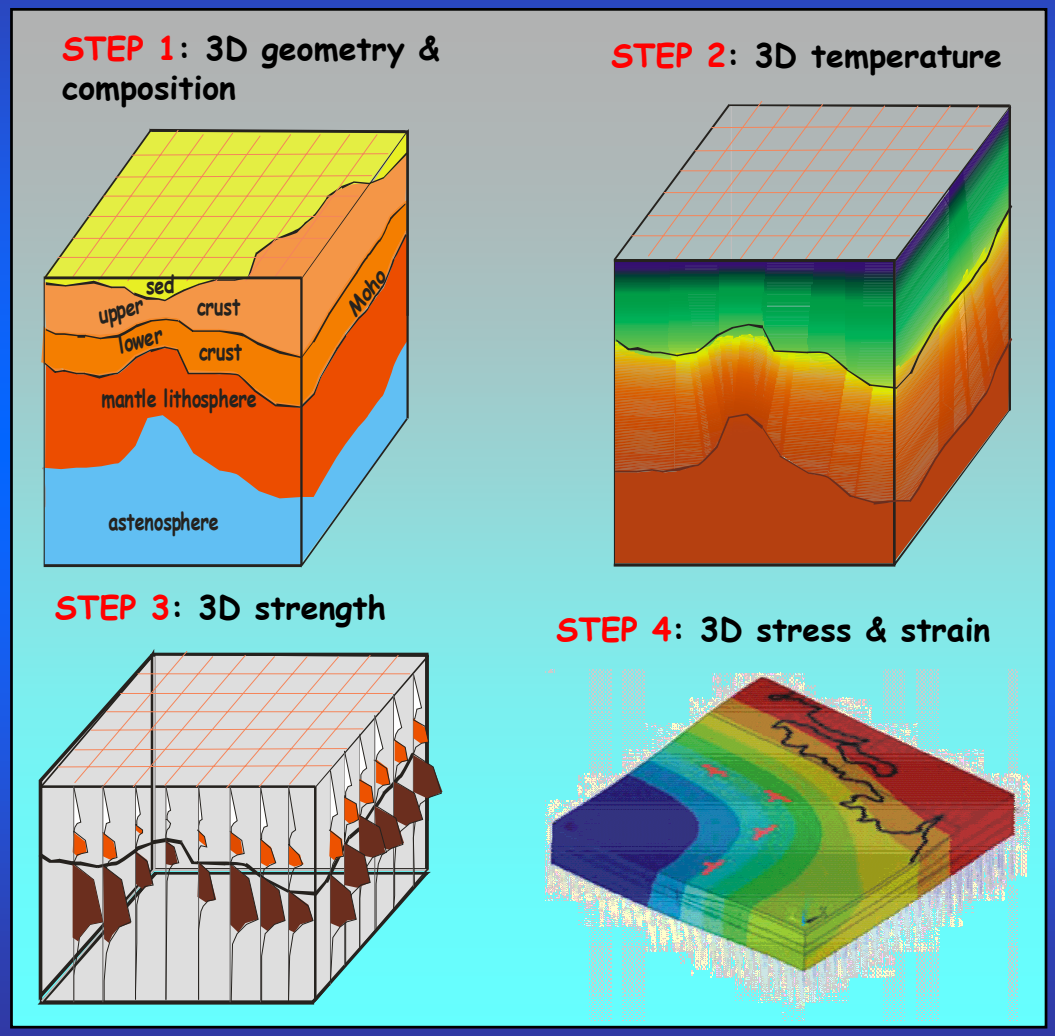


Spakman (2006)



Artemieva et al. (2006)

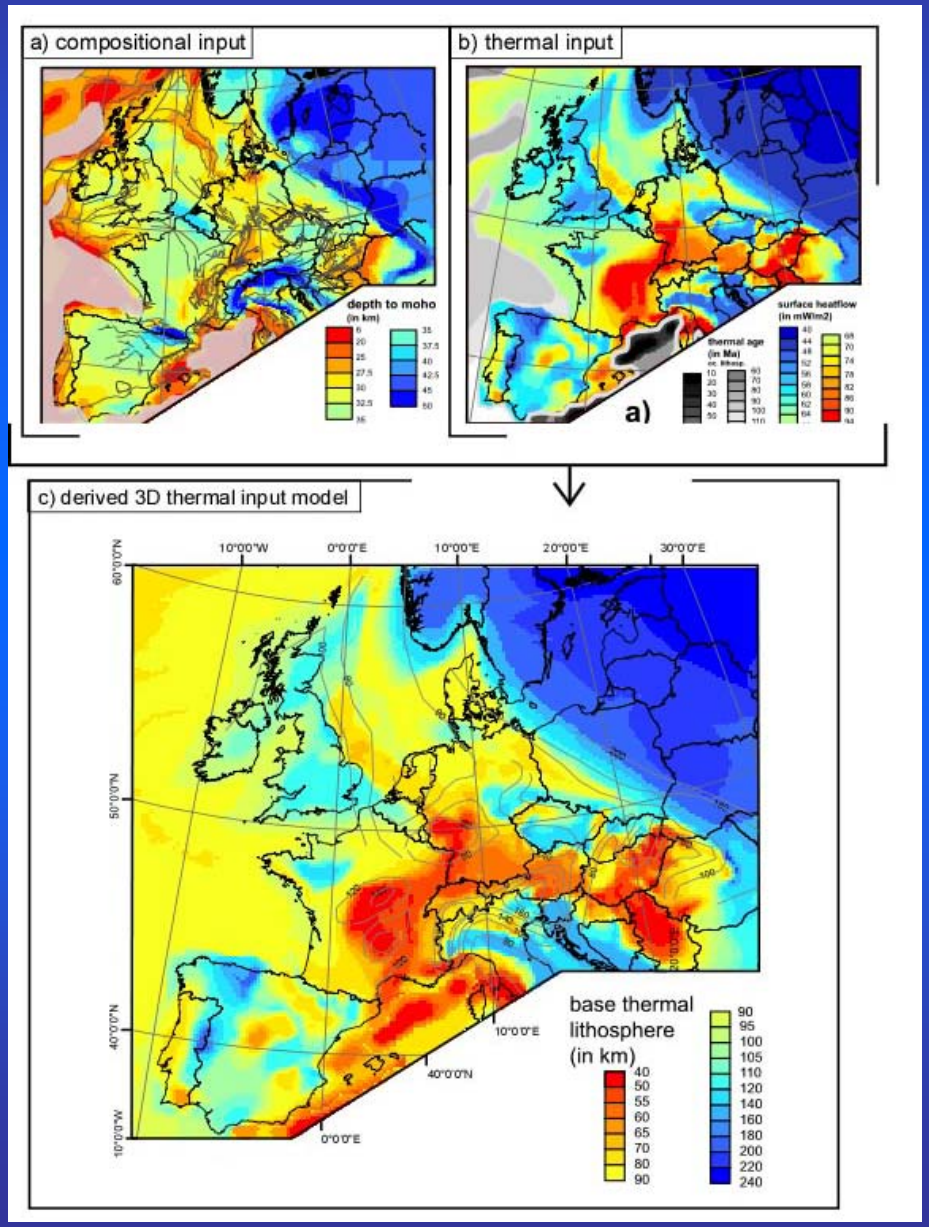
3D models of strength, stress and strain of the European continental lithosphere



Cloetingh et al., 2005, QSR

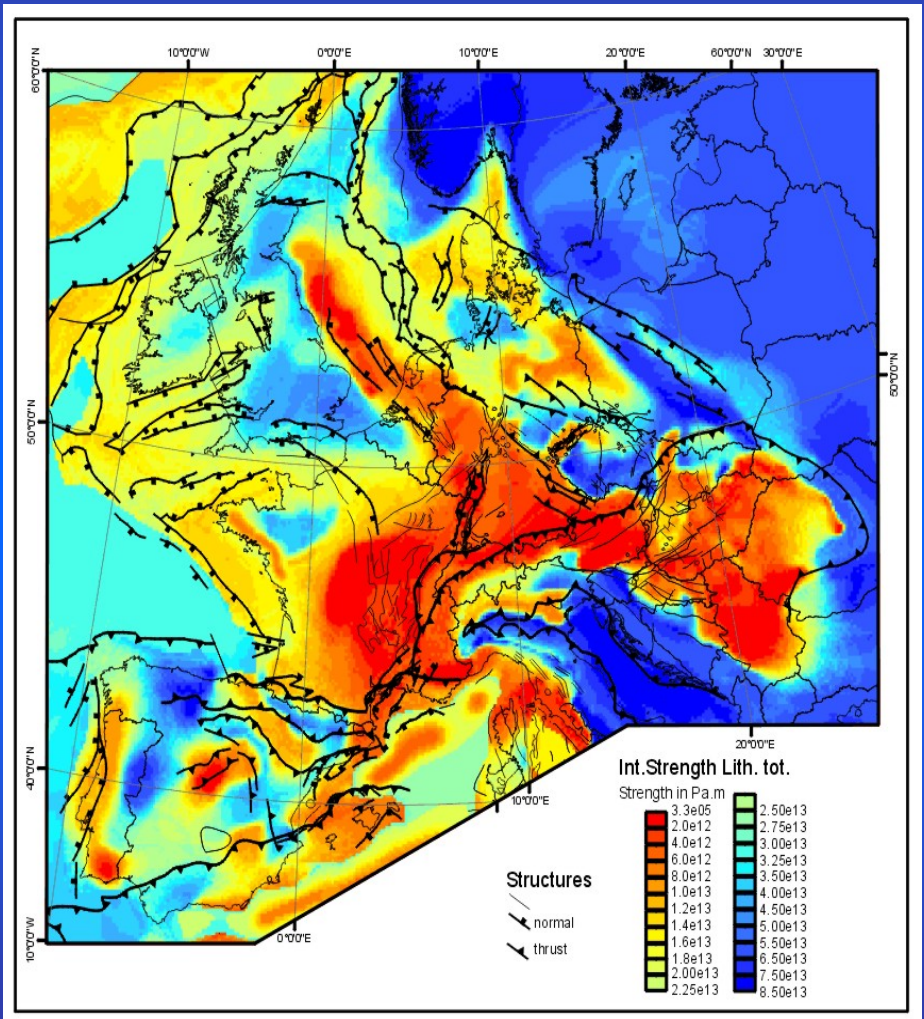
- 3D geometrical & compositional model from digital elevation models, seismic data, gravity, and ENTEC/EUCOR-URGENT/GFZ databases
- Calculations using a mix of in-house developed and commercial software
- Access to LOFAR's "Blue Gene" grid computing network
- Model resolution will increase iteratively during the project
- Grid cells may have a different size
- Final size of the grid cells will depend on the quality of the (geological) input data

Construction of the rheological strength maps



Hardebol et al., 2006

Integrated strength maps of the European lithosphere

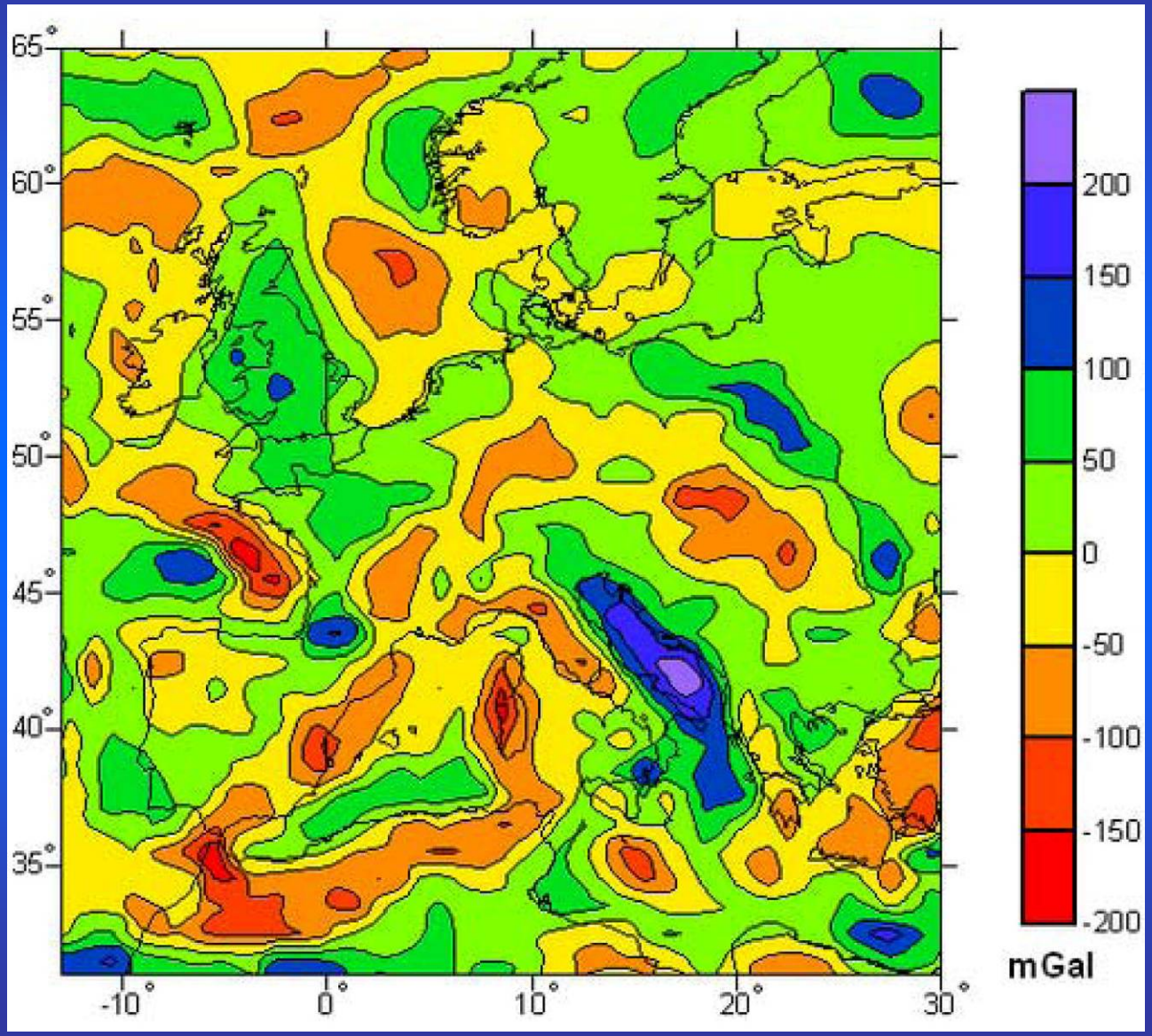


Cloetingh et al., 2005, QSR

Maps of the integrated strength distribution of the European lithosphere will allow to identify zones of intense localized deformation and high risk seismic zones

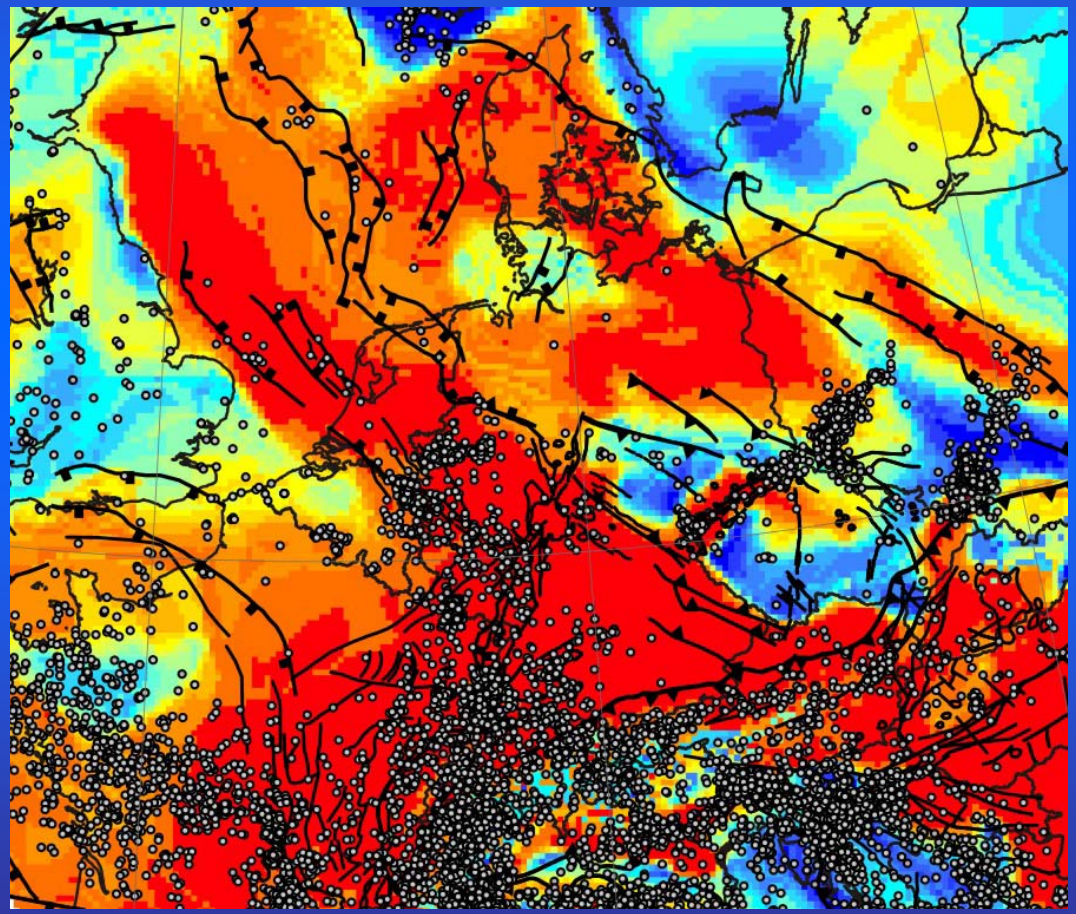
- Distributed versus localized deformation
- Strong eastern European craton versus weak western European lithosphere
- Weak rifts and basins versus strong indentors

Regional component of residual gravity mantle anomaly



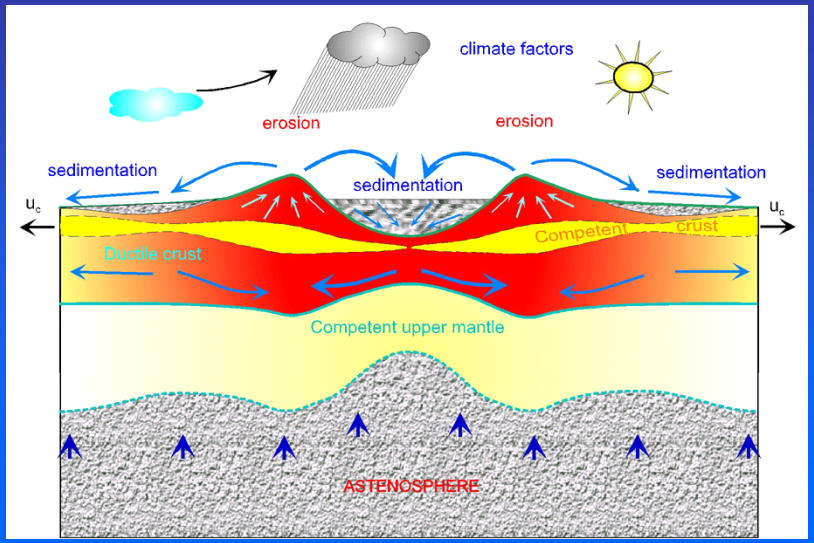
Tesauro et al., 2007

Correlation between seismicity and crustal strength

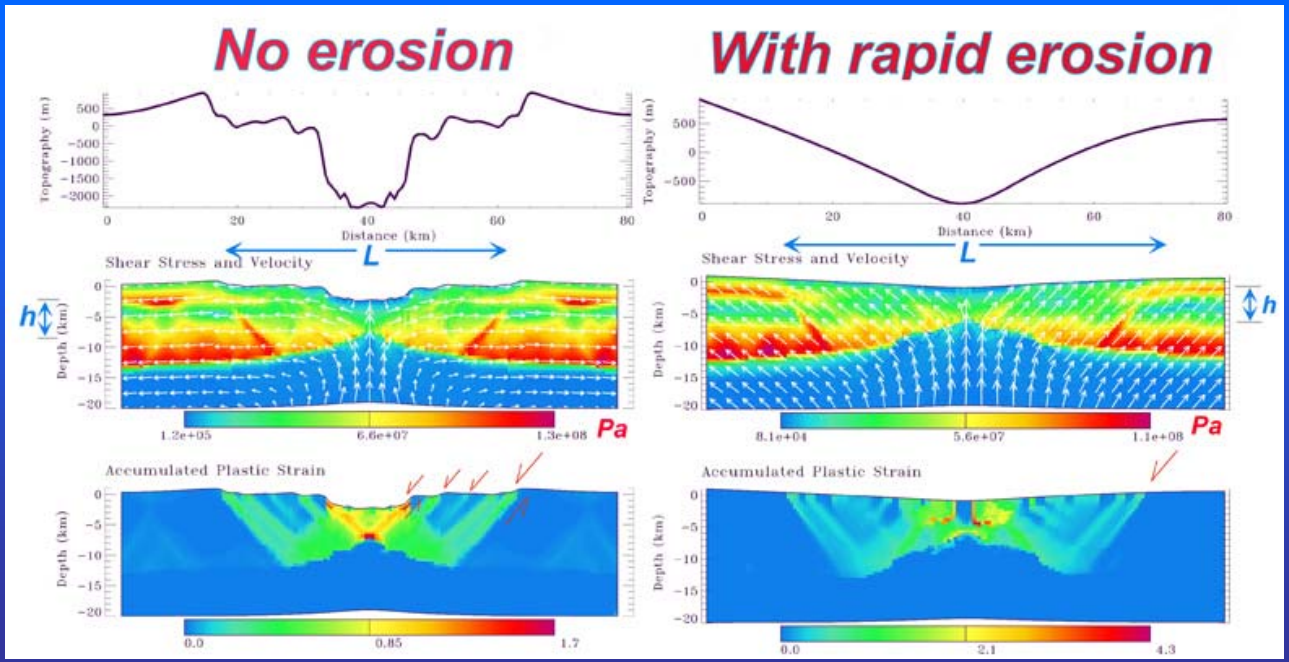


Cloetingh et al., 2006, ESR

Innovative Modeling of Mantle-to-Lithosphere-to-Surface Processes

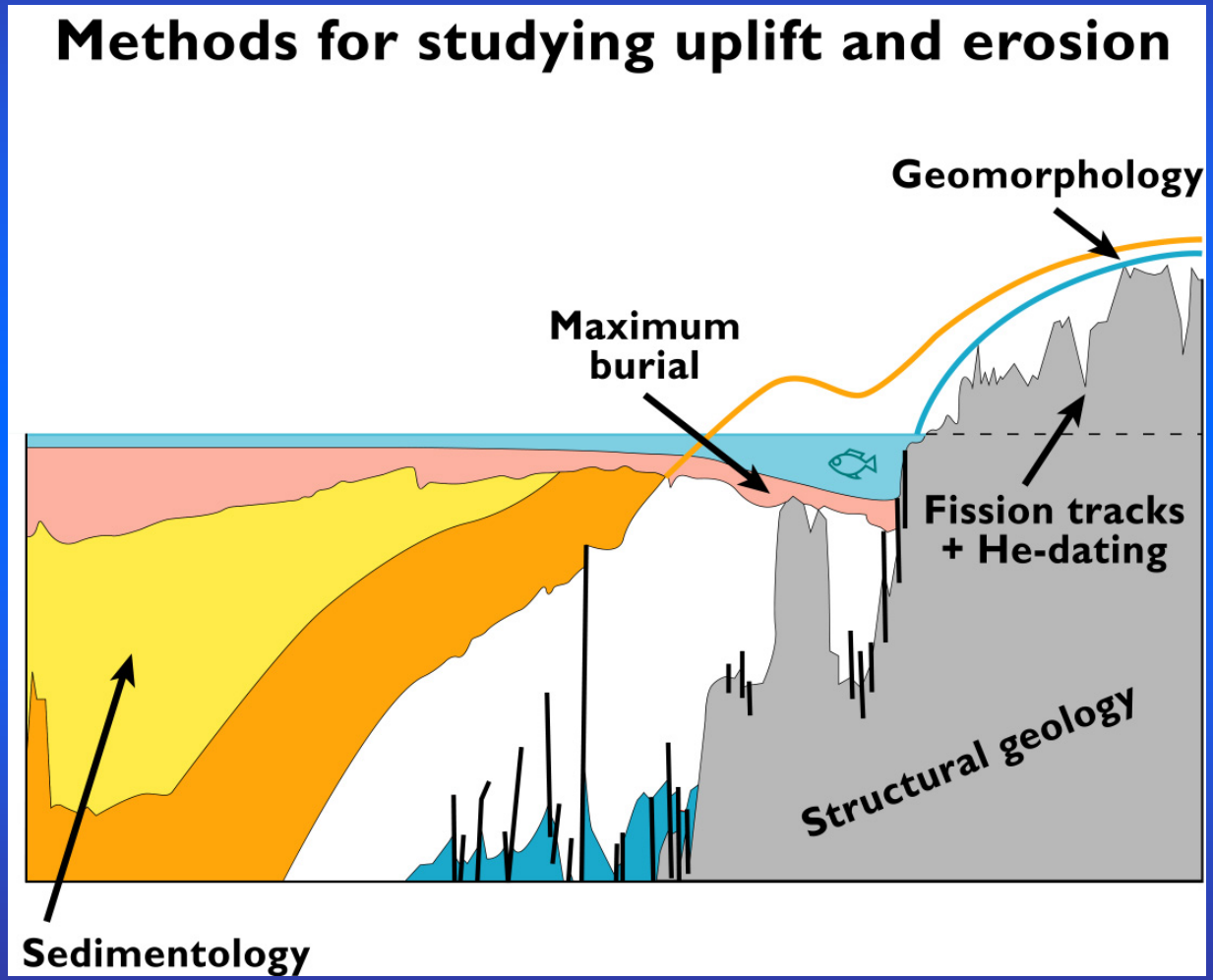


Burov and Cloetingh, 1997, EPSL



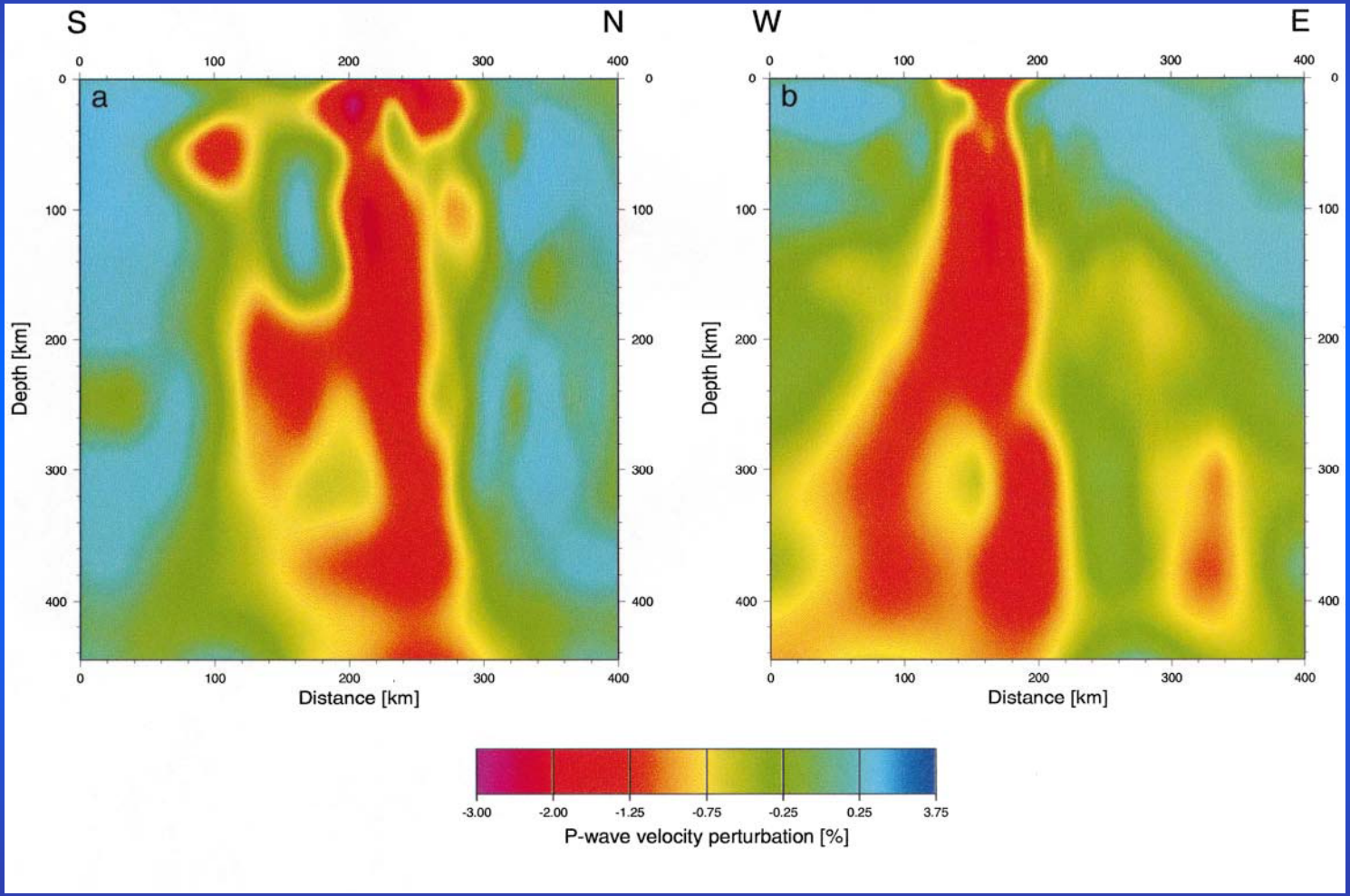
Burov, 2007, GPC

Linking the sedimentary record to the underlying lithosphere



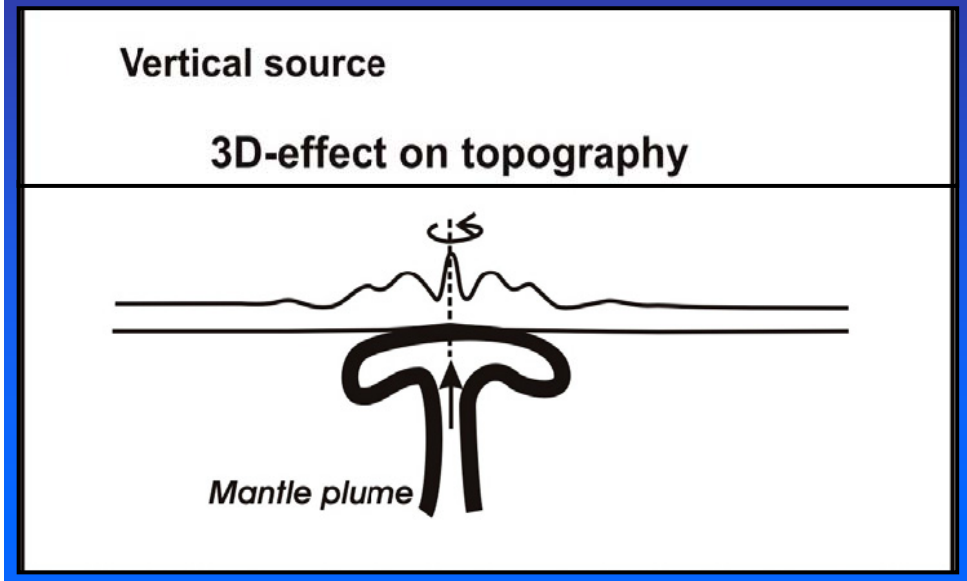
Japsen, 2007

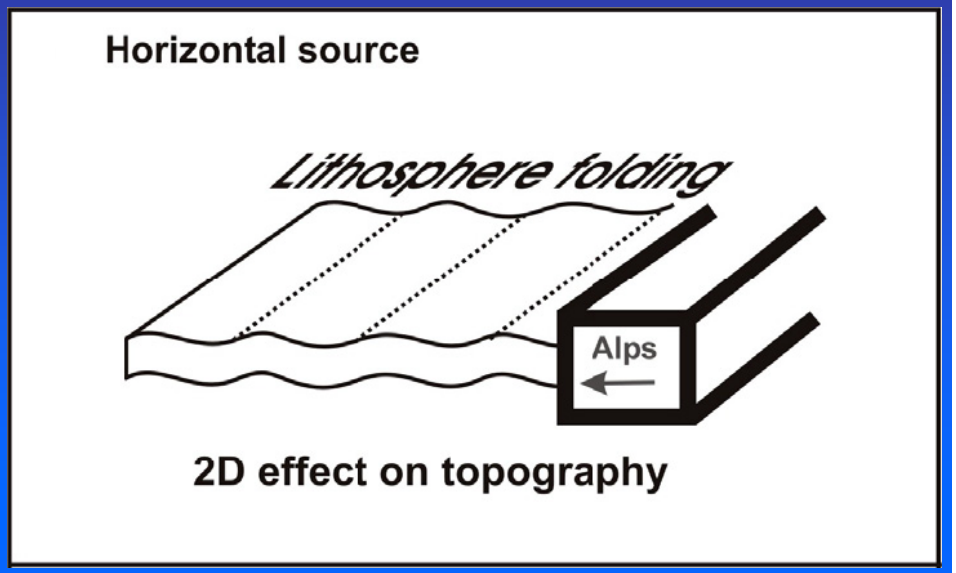
Tomographic sections across the Eifel plume

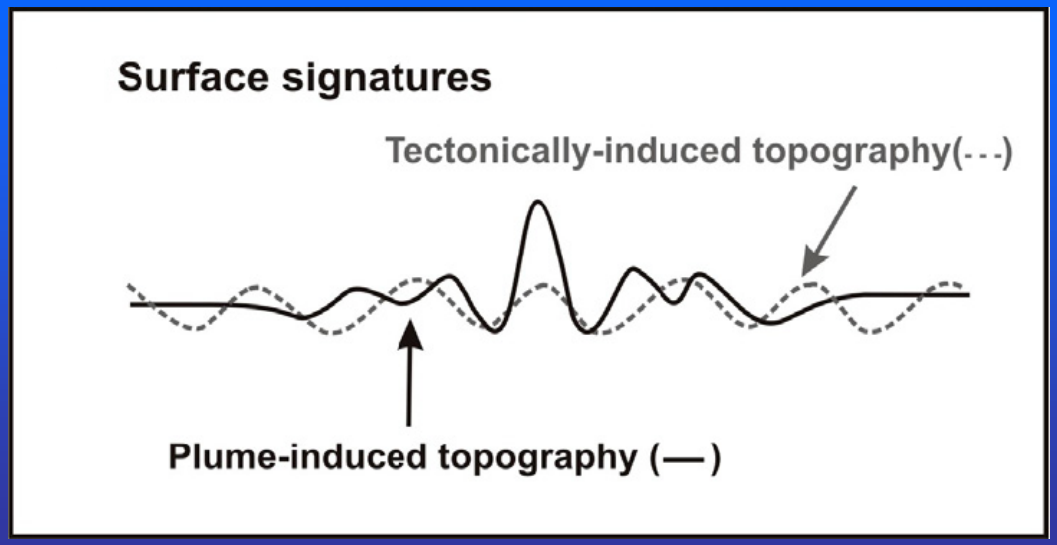


Ritter et al., 2001

Coupling between deep Earth and surface processes

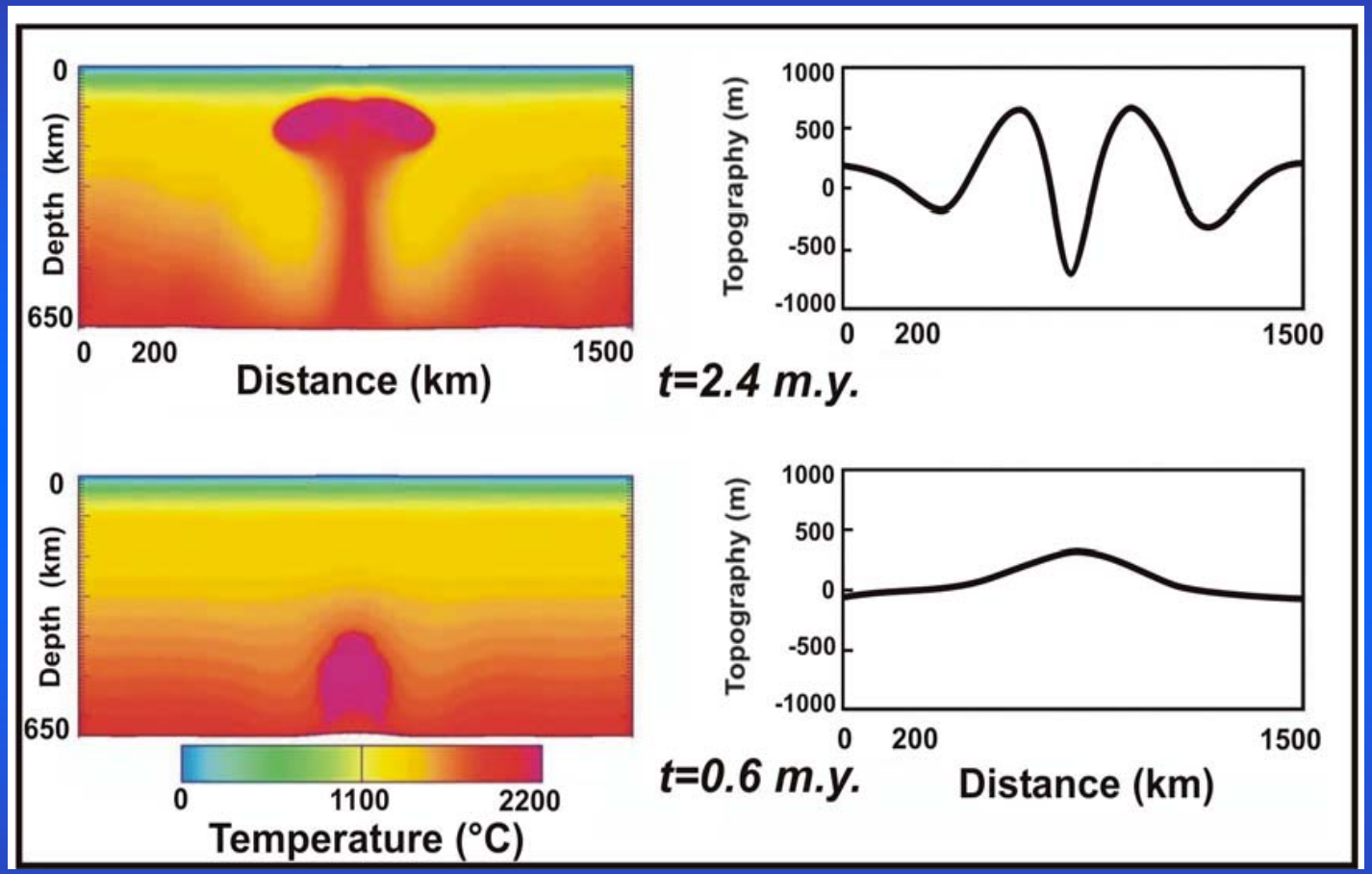






Guillou-Frottier et al., 2007

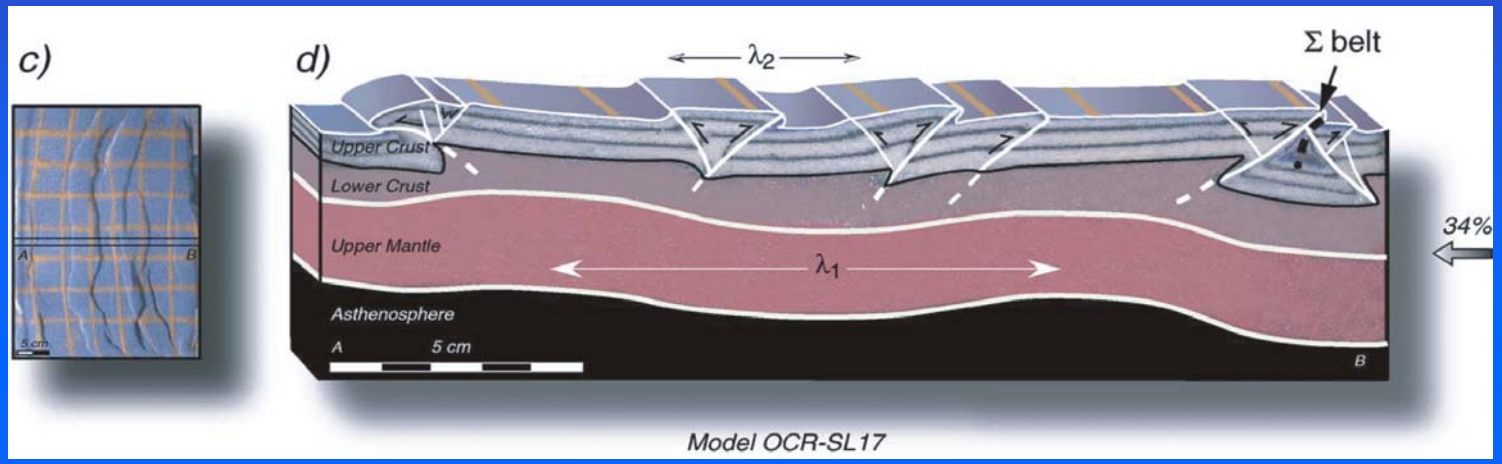
Coupling between mantle and surface processes

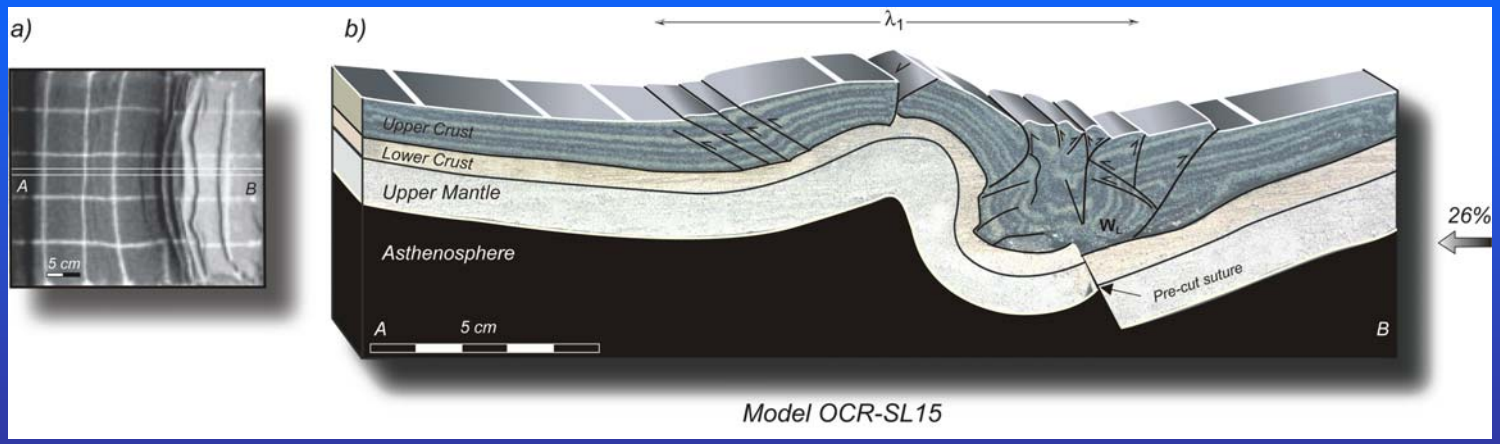


Guillou-Frottier et al., 2007

Analogue modelling of intraplate deformation

Type-1 model representing a cold lithosphere with a strong upper mantle



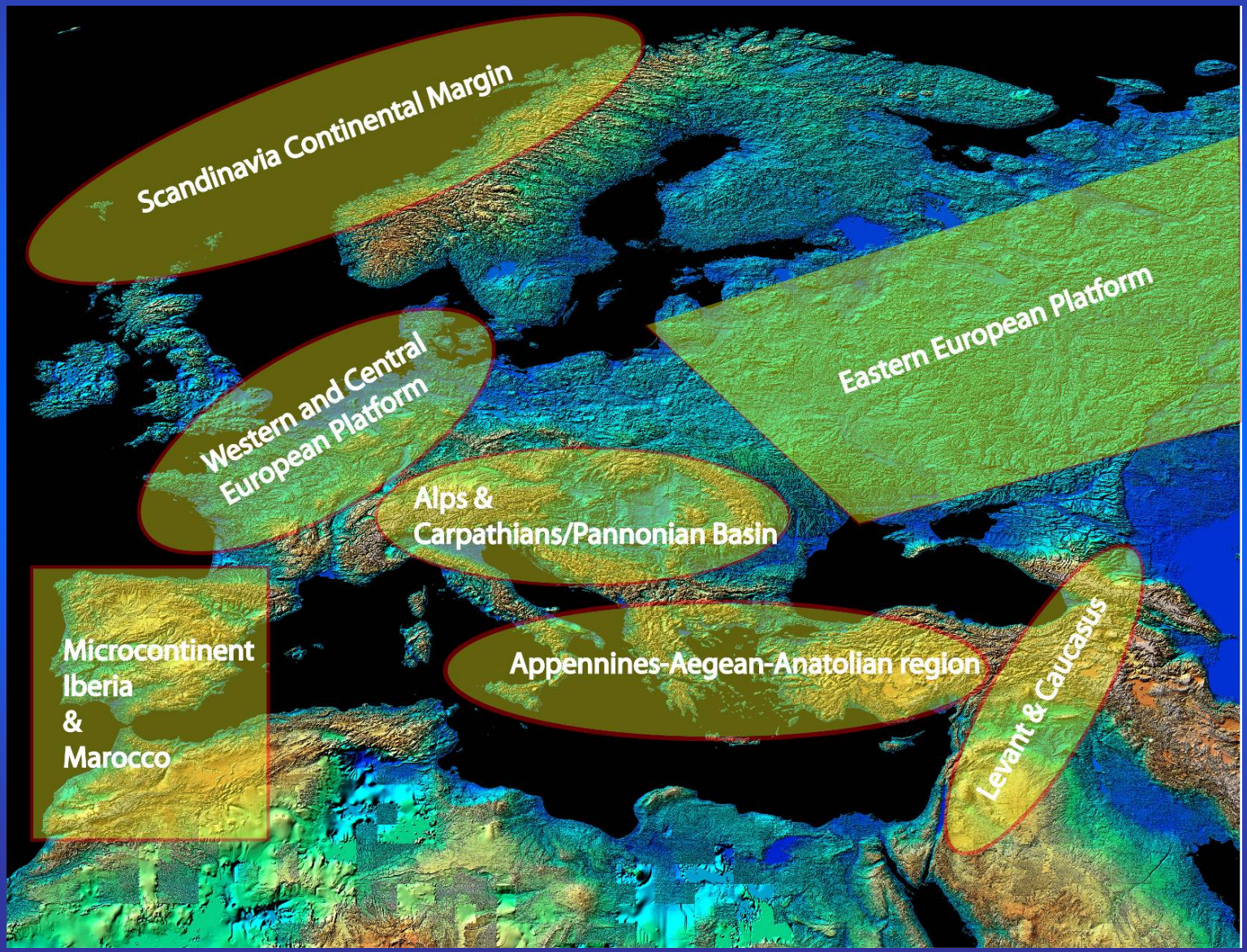


Type-2 model simulating the collision between two different lithospheric blocks

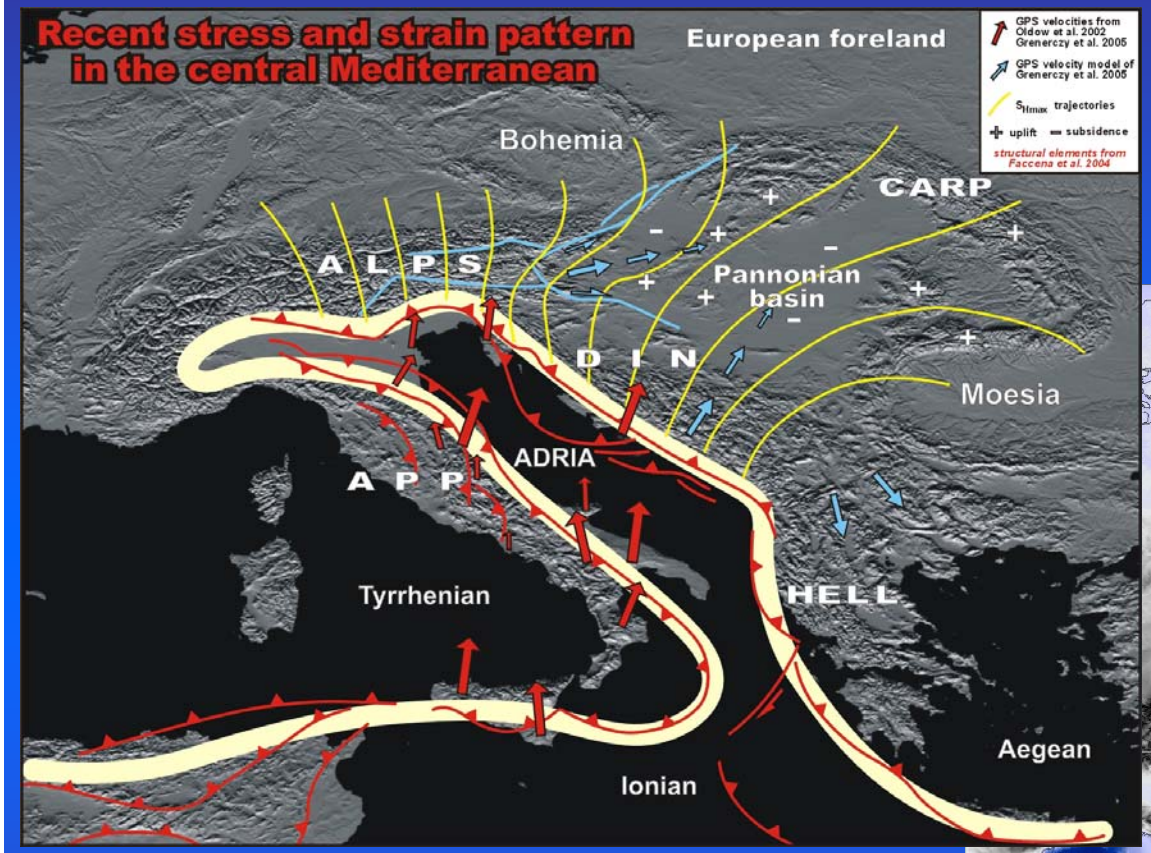
Sokoutis et al., 2005. Tectonophysics

ESF EUROCORES TOPO-EUROPE

The Natural Laboratory Concept on coupled deep Earth – surface processes

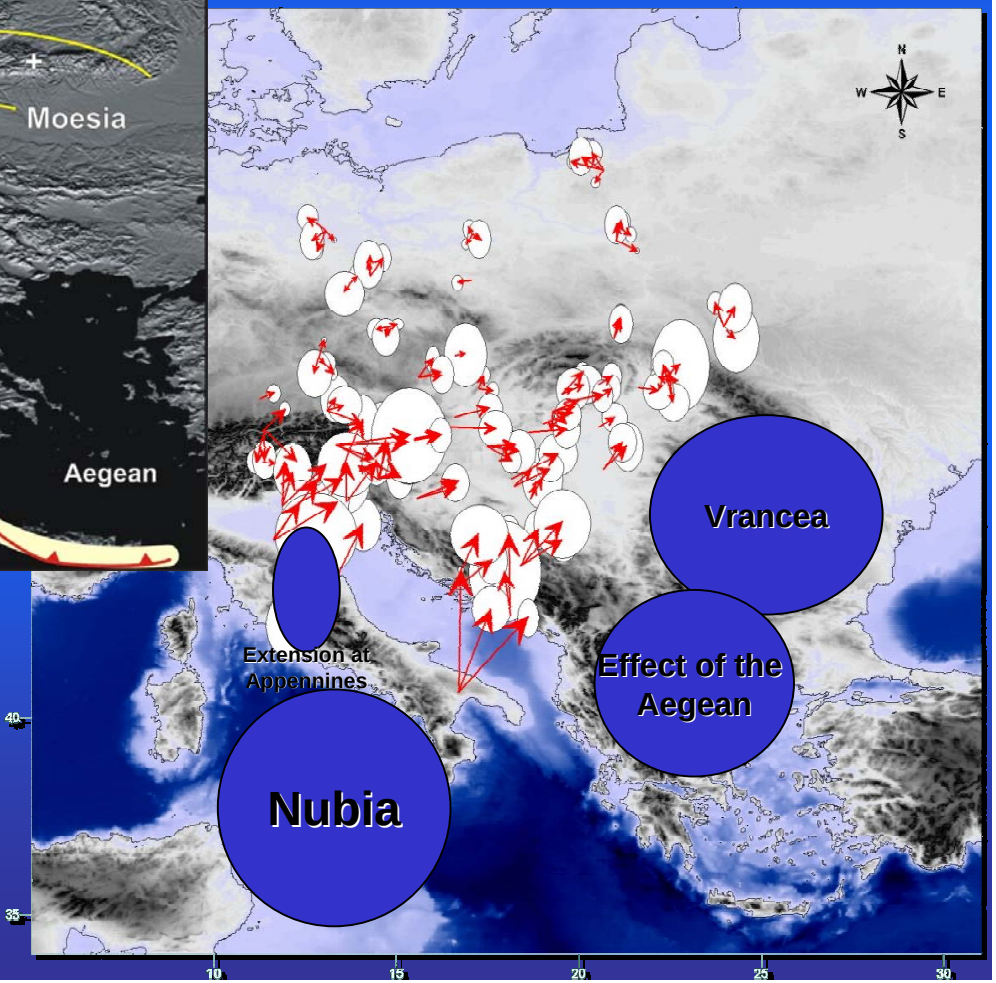


Within the orogen: the Alps/Carpathians–Pannonian Basin System

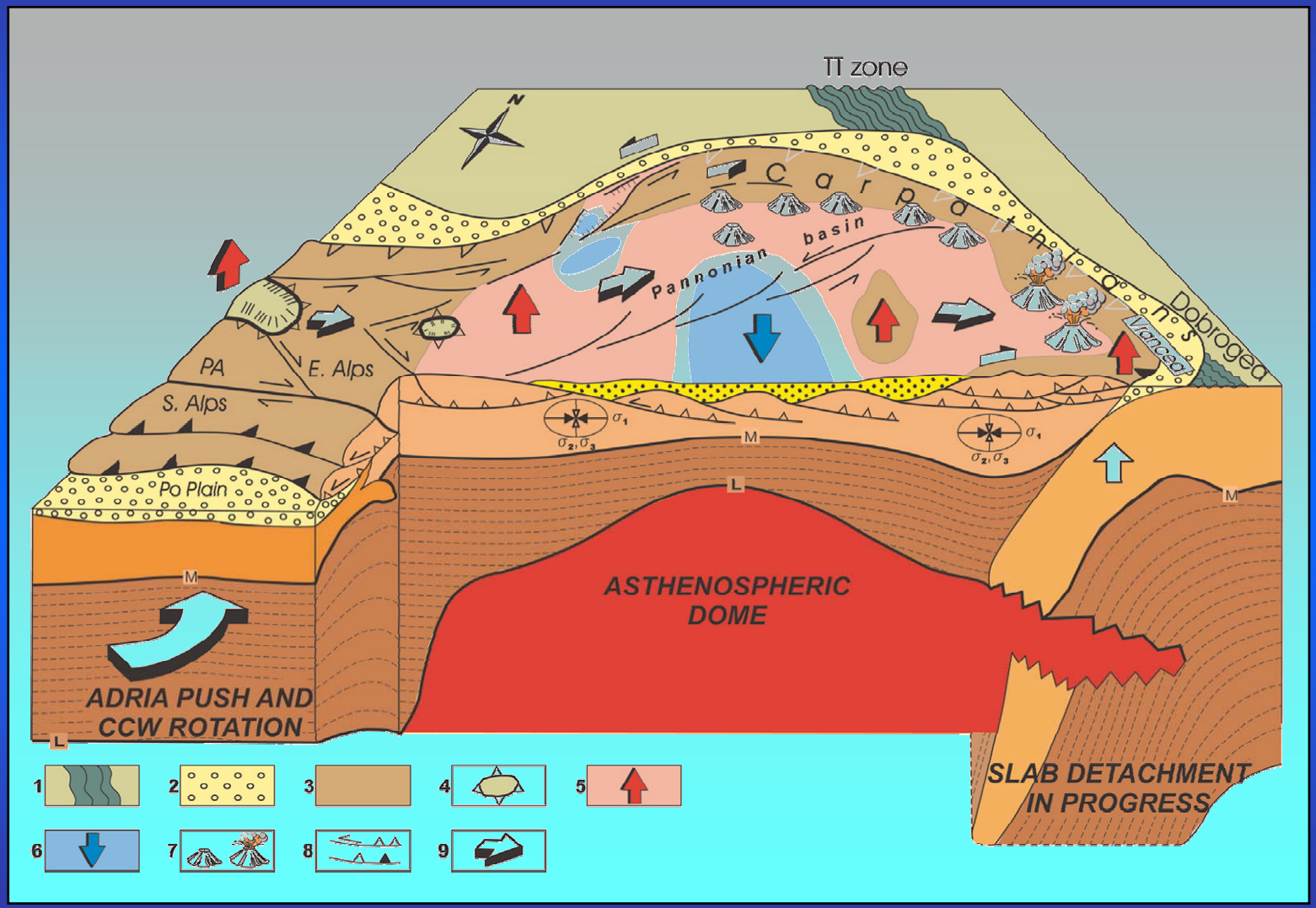


Grenerczy et al. 2005

Surface velocity map

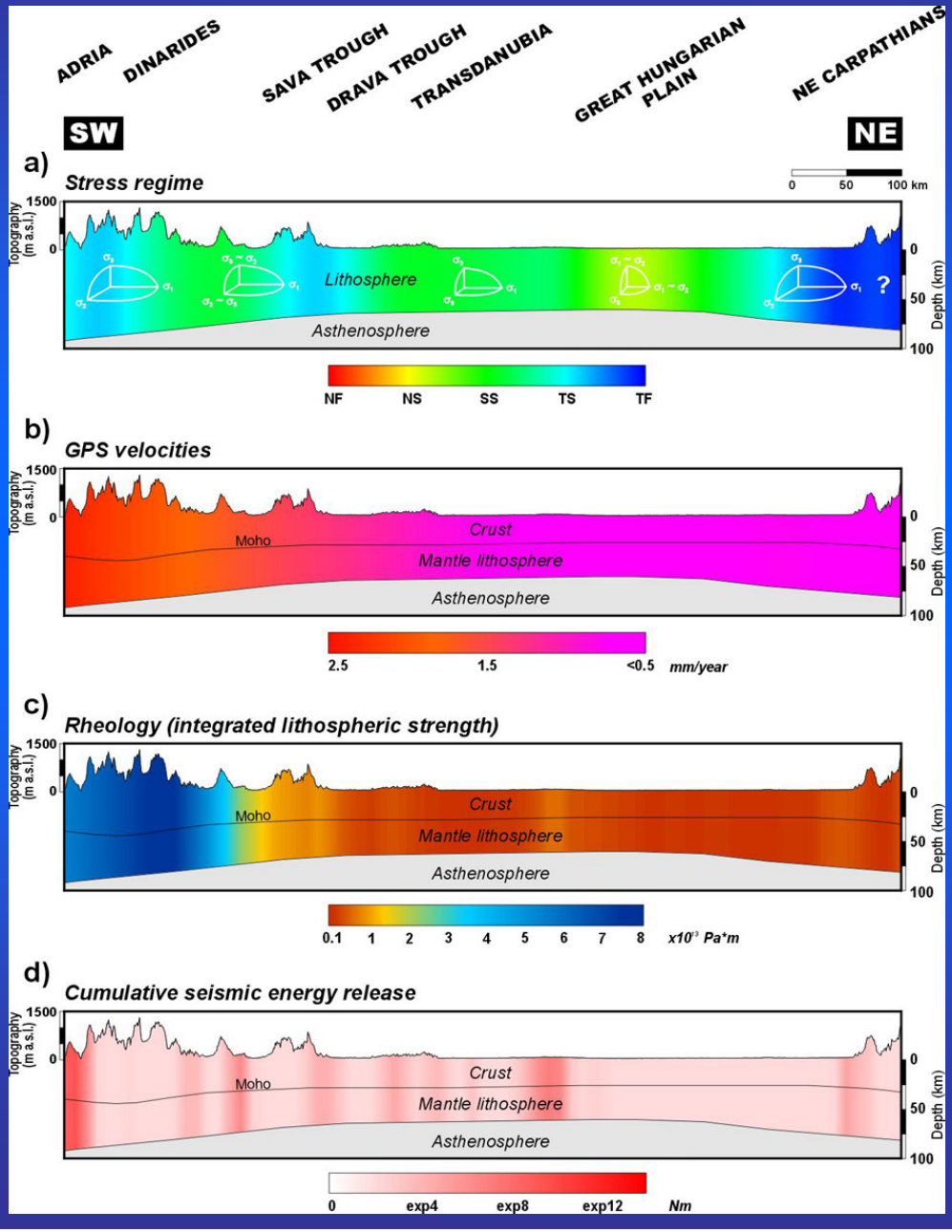


Basin formation and evolution in a back-arc setting



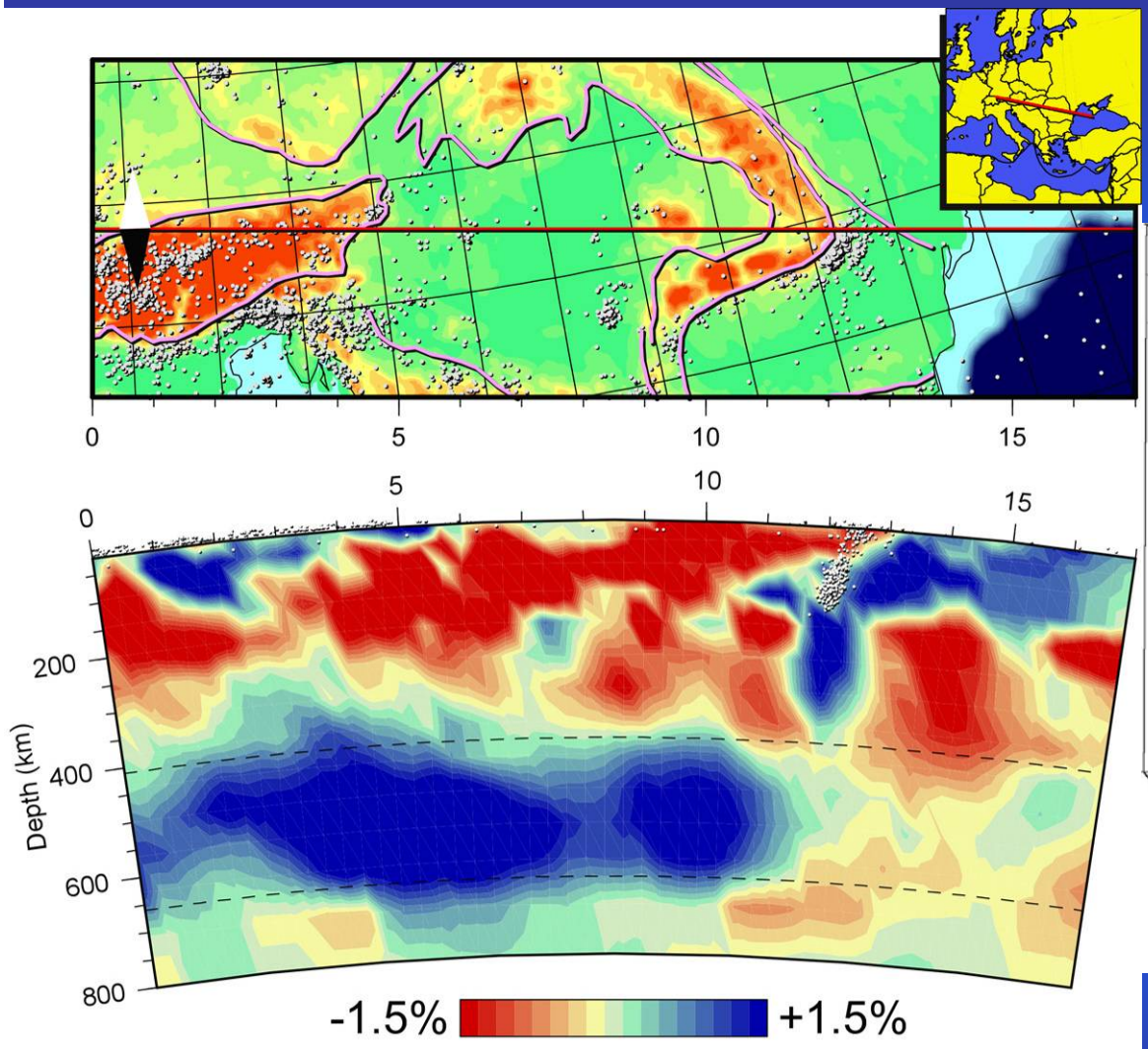
Horvath et al. 2006

Stress distribution transect across the Pannonian basin



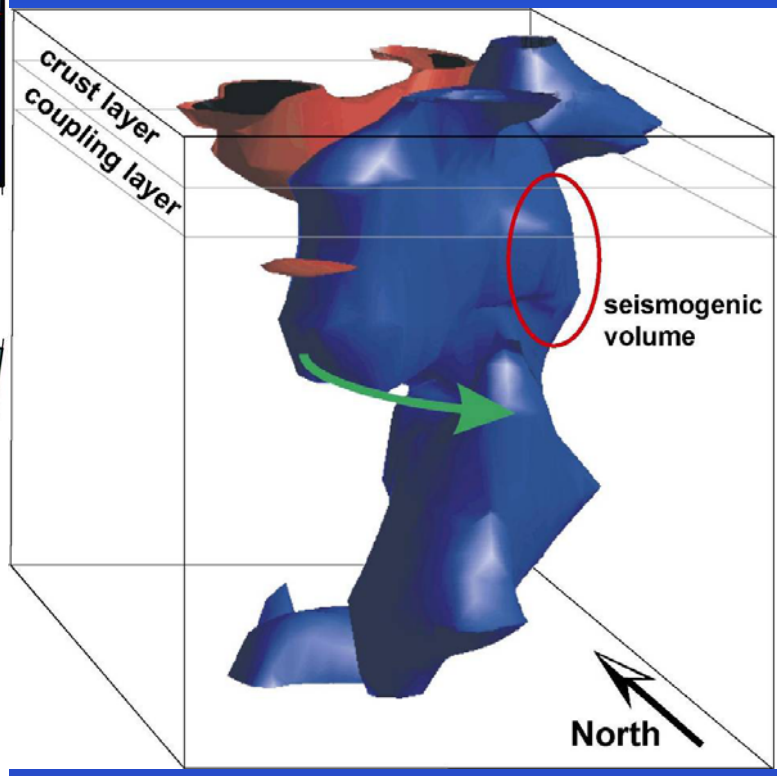
Bada et al. 2007

Seismic tomography



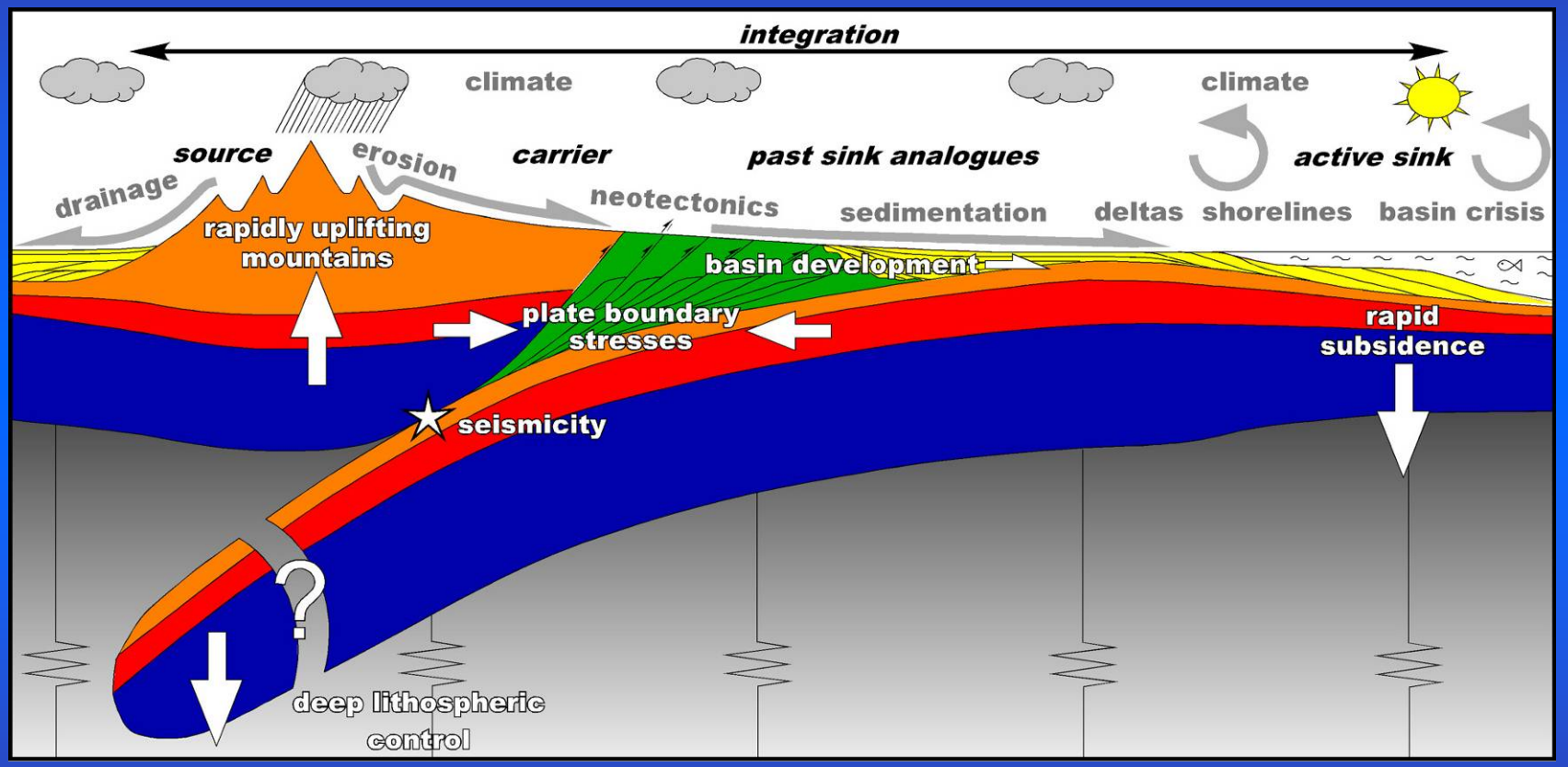
Bijwaard and Spakman, Geoph.J.Int, 2000

Wortel and Spakman, Science, 2000

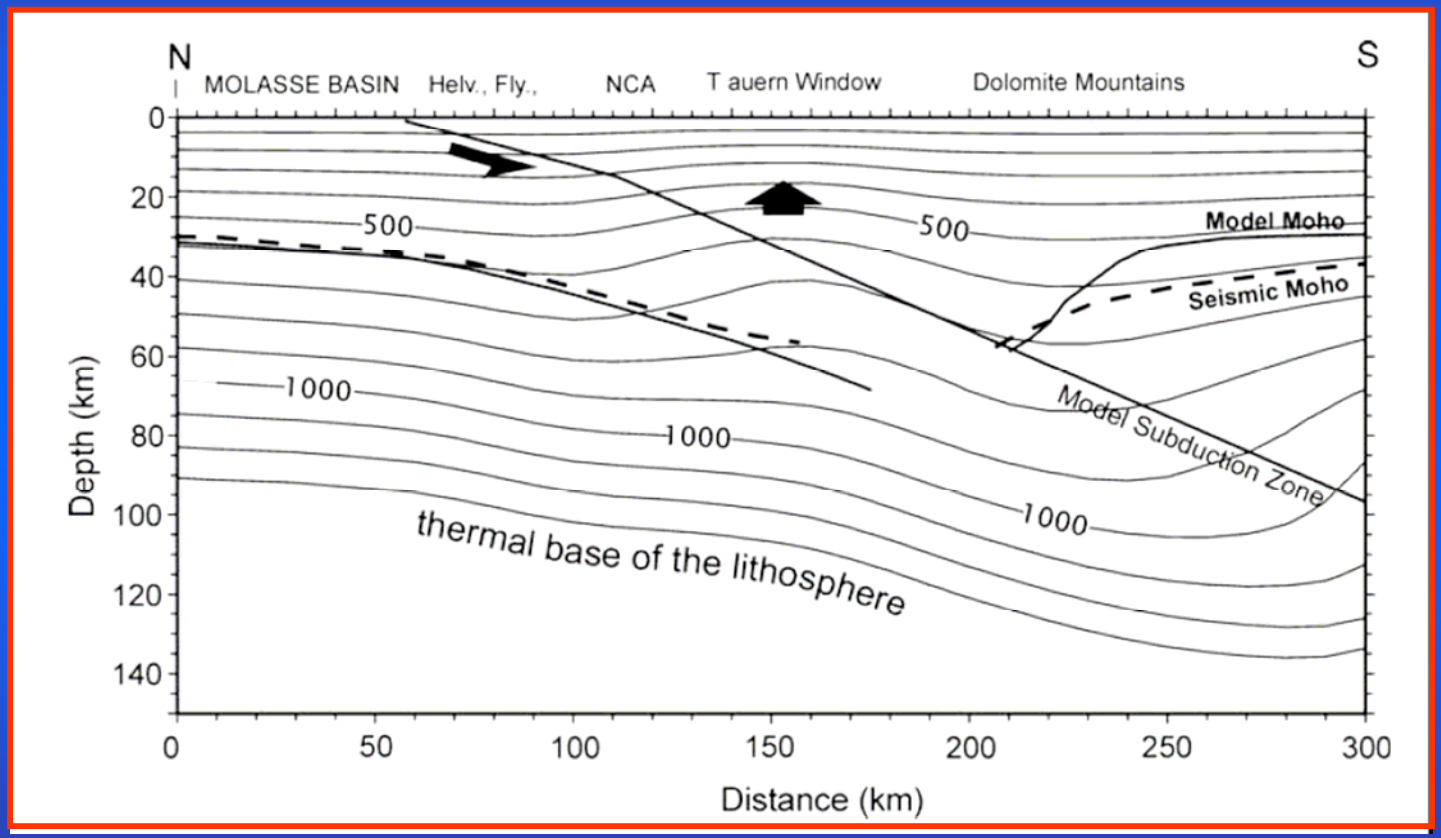


Martin et al. 2006

TOPO-EUROPE: From Source to Sink

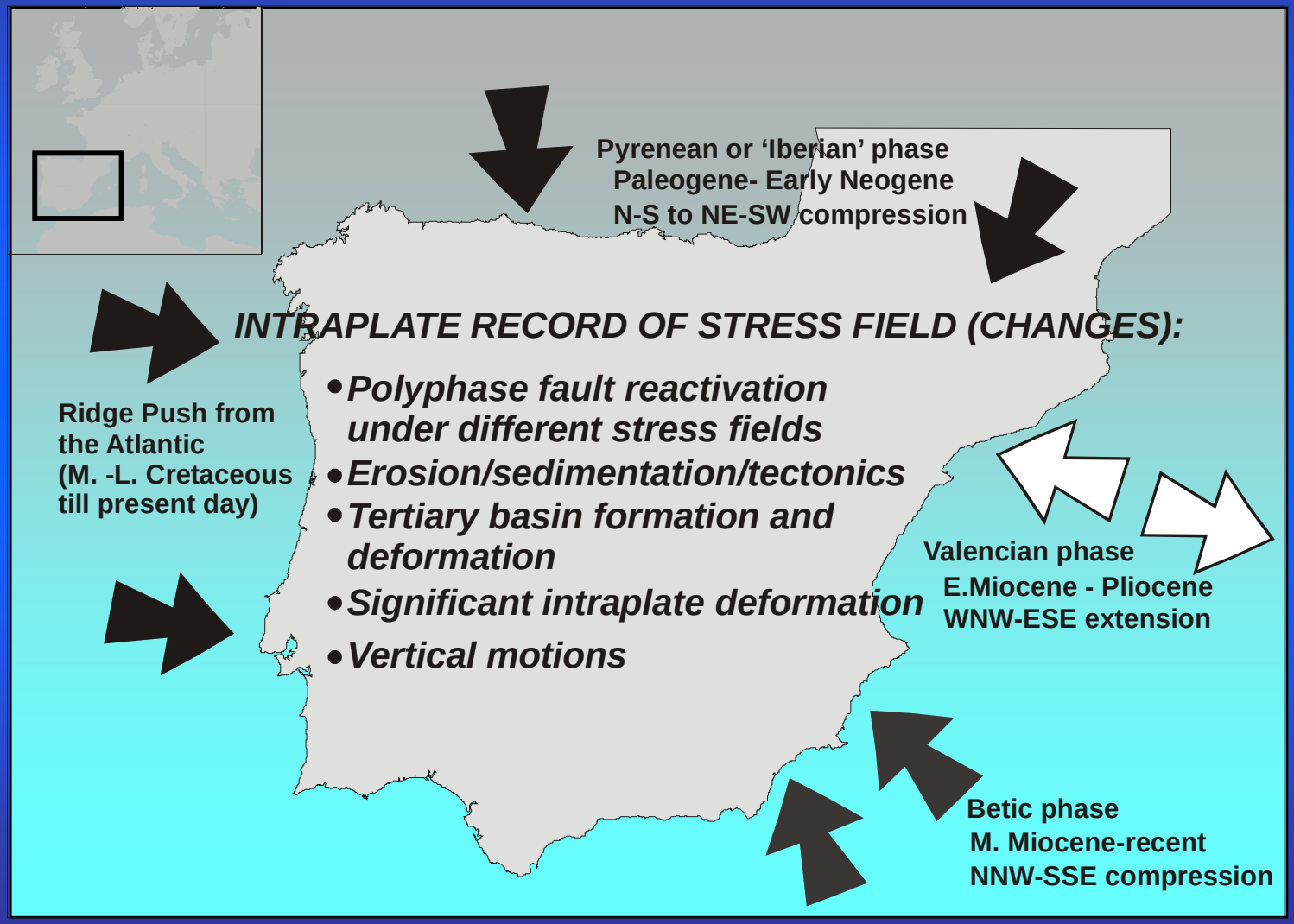


Alpine tectonics and present thermal structure



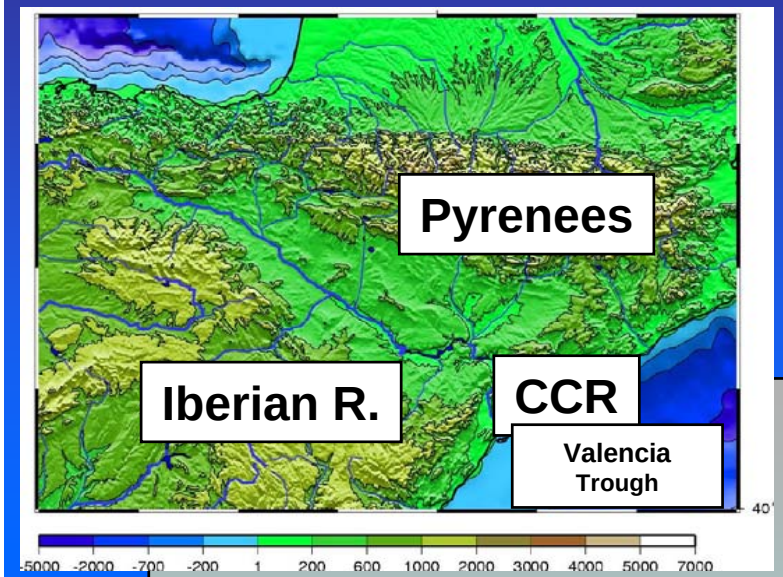
Willingshofer and Cloetingh, Tectonics 22, 2003

Intraplate deformation in micro-continent Iberia



Cloetingh et al., 2002, Tectonics

Ebro Basin: From a typical foreland basin to a closed drainage system



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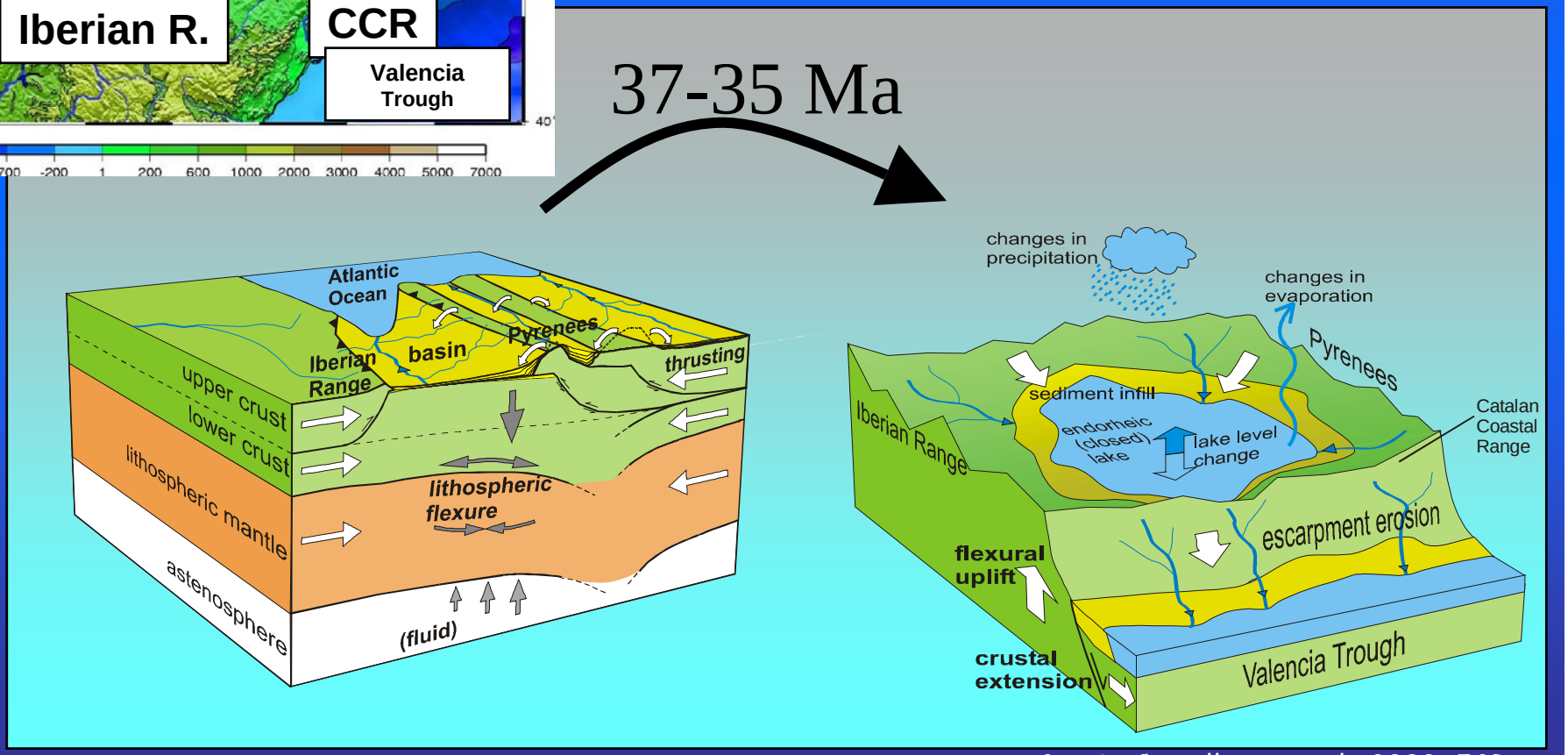
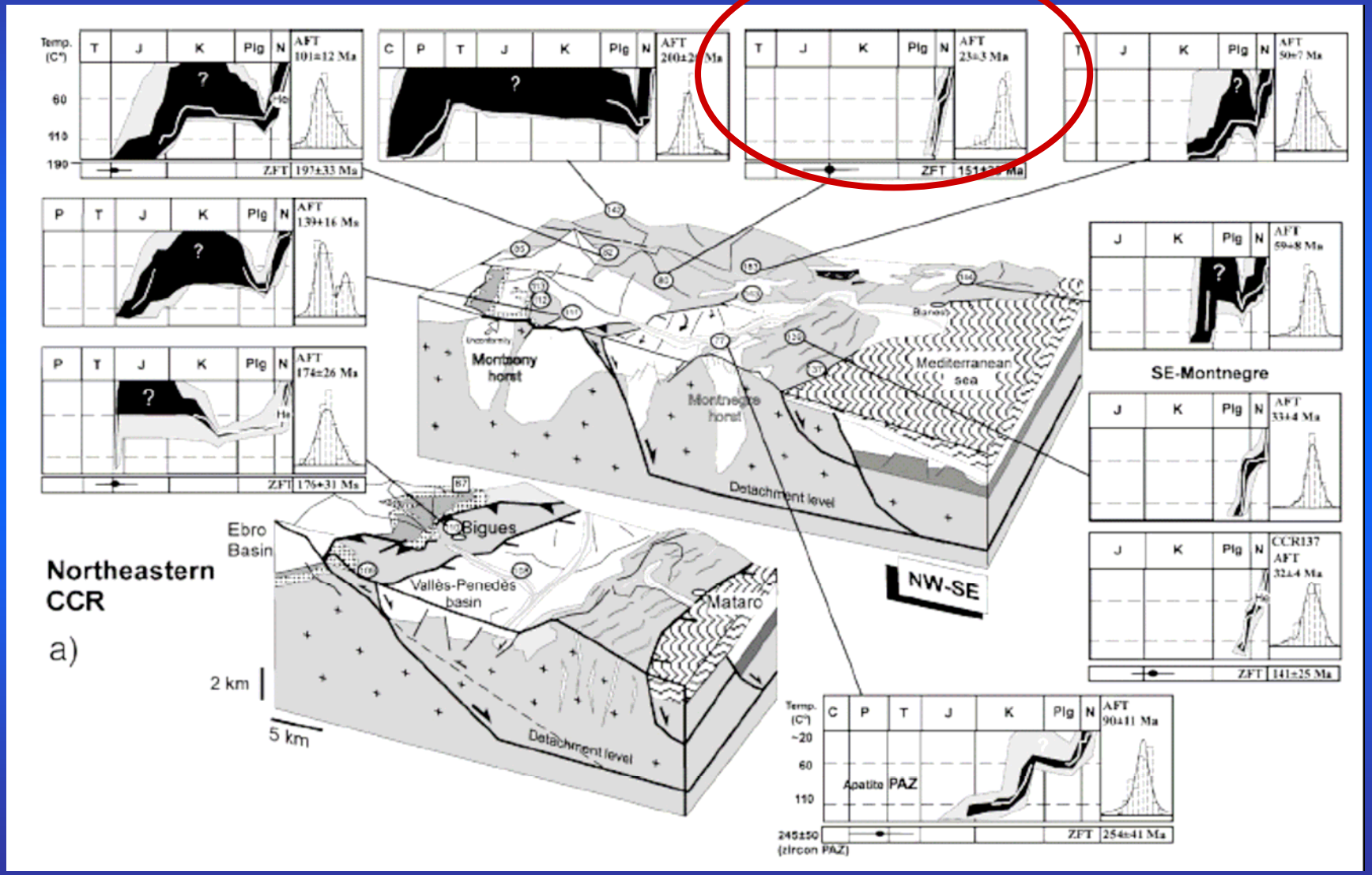


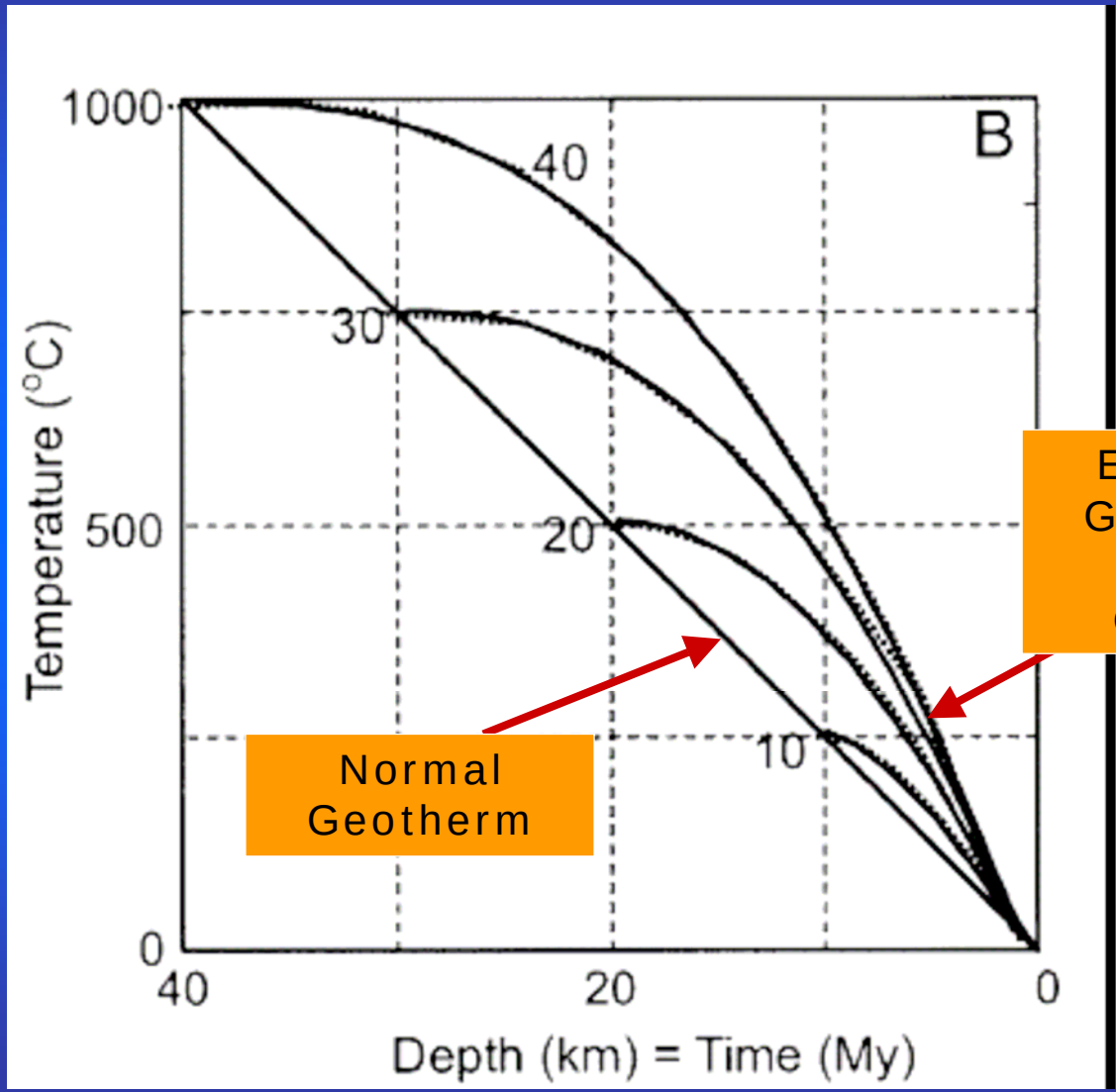
Garcia-Castellanos et al., 2003. JGR

Catalan Coastal Range Granites marked by recent Erosion related to opening of Valencia Trough



Larre and Andriessen, 2006

Catalan Coastal Ranges: numerical modelling of effect of recent erosion on heat flow in granites



Ter Voorde et al., EPSL, 2004

Conclusions and Perspectives

- Tectonic modelling provides key constraints on crustal stress and temperature, helpful for geothermal exploration beyond well control
- Late Tertiary tectonics have strong influence on spatial variation of crustal heat flow and stress
- Interplay of lithospheric and surface processes operating at multiple scales need to be taken into account for understanding and prediction of crustal stress and heat flow
- Analogue-numerical modelling applied in natural laboratories provide a set of world class opportunities to develop a new generation of models for crustal stress and heat flow evolution