# Rivers and Rifting: Evolution of a Fluvial System during Rift Initiation, Central Corinth Rift (Greece)*

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## Abstract

Standard models for initiation of continental rifting show normal faults nucleating and growing to form isolated hangingwall depocentres that enlarge and merge due to lateral fault propagation and linkage. Sedimentation rates are usually higher or equal to accommodation during the early, pre-linkage phase with footwall-derived consequent drainage systems supplying fluvial to lacustrine sediments. However, these models do not consider the impact of antecedent river systems on facies and thickness distribution in early rifts. Stratigraphic and sedimentological analysis of the Pliocene-Recent Corinth rift is here used to understand the architecture of early rift alluvial/fluvial systems from source to sink. In the northern Peloponnese, these are preserved in a series of uplifted E-W normal fault blocks incised by present-day north-flowing rivers. By correlation of fluvial successions across normal fault blocks, we propose a new sedimentary model for early rifting. The use of magnetostratigraphy and the determination of burial age using cosmonuclides 26Al/10Be give temporal constraints along four logs. The early rift fining-upward succession thickens and fines from west to east across normal fault blocks. A basal conglomeratic unit infilled an inherited paleotopography. Palaeocurrent and sedimentological data indicate that an antecedent drainage system provided high sediment supply since the onset of rifting. Fluvial sediments were deposited by a NE-flowing low sinuosity gravel-braided river system. Earliest normal faults are sealed by syn-rift sediments as displacement became focused on larger normal faults (15–20 km long, across-strike spacing of >4 km). Little or no consequent sediment supply has been detected and therefore significant footwall relief was not created during early rifting. Spatial variability of facies records displacement gradients along faults. For

example, coarse alluvial conglomerates tend to occur in the centre of hangingwall depocentres while finer floodplain deposits accumulated along strike. At the rift scale, however, normal fault distribution and activity do not solely control facies distribution, being overwhelmed by high sediment discharge of the antecedent river. We develop a tectono-sedimentary model of normal fault growth and potential fluvial-lacustrine reservoir distribution in early rifts with high S:A ratios that involve antecedent drainage systems and distributed normal faulting.

## References Cited


Cowie, P.A., M. Attal, G.E. Tucker, A.C. Whittaker, M. Naylor, A. Ganas, and G.P. Roberts, 2006, Investigating the surface process response to fault interaction and linkage using numerical modelling approach: Basin Research, v. 18, p. 231-266, doi:10.1111/j.1365-2117.2006.00298.x.

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Leeder, M, D. Mark, R. Gawthorpe, H. Kranis, S. Loveless, N. Pedentchouk, E. Skourtsos, J. Turner, J. Andrews, and M. Stamatakis, 2012, A “Great Deepening”: chronology of rift climax, Corinth rift, Greece: Geology, v. 40, p. 999-1002.

# **Rivers and rifting:**
# Evolution of a fluvial system during rift initiation, central Corinth rift (Greece)

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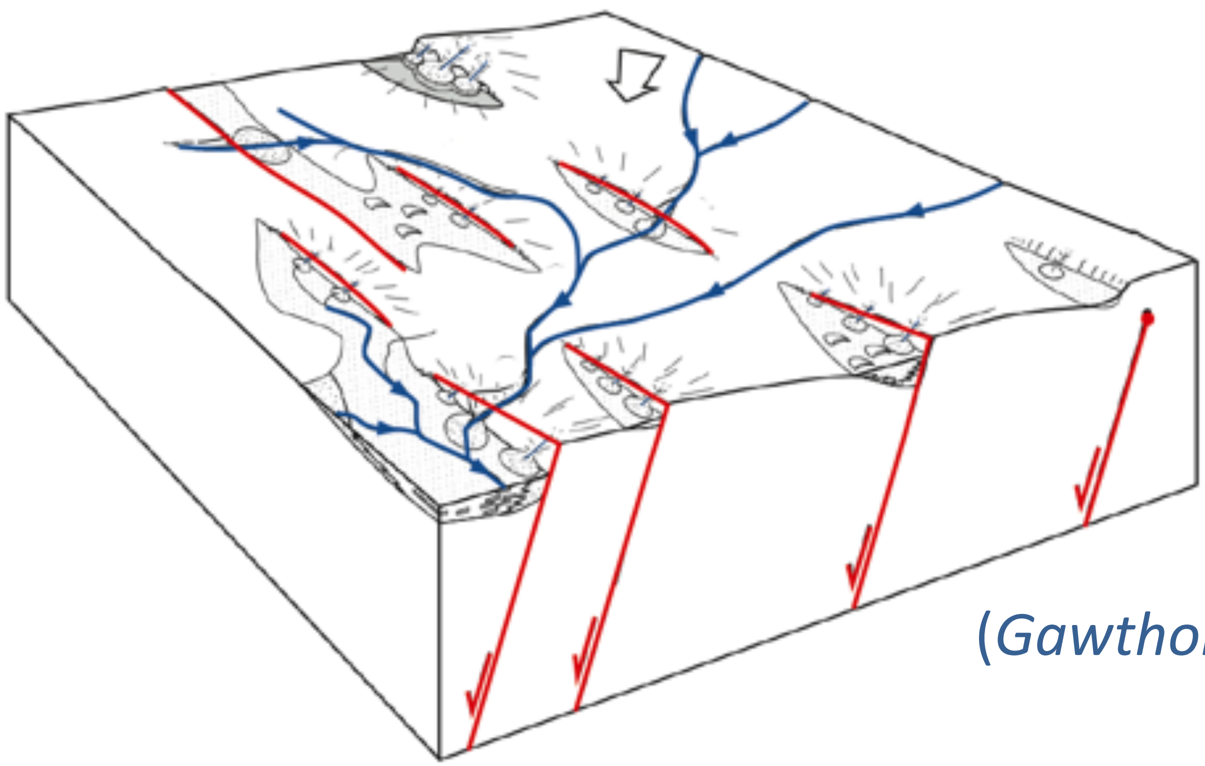
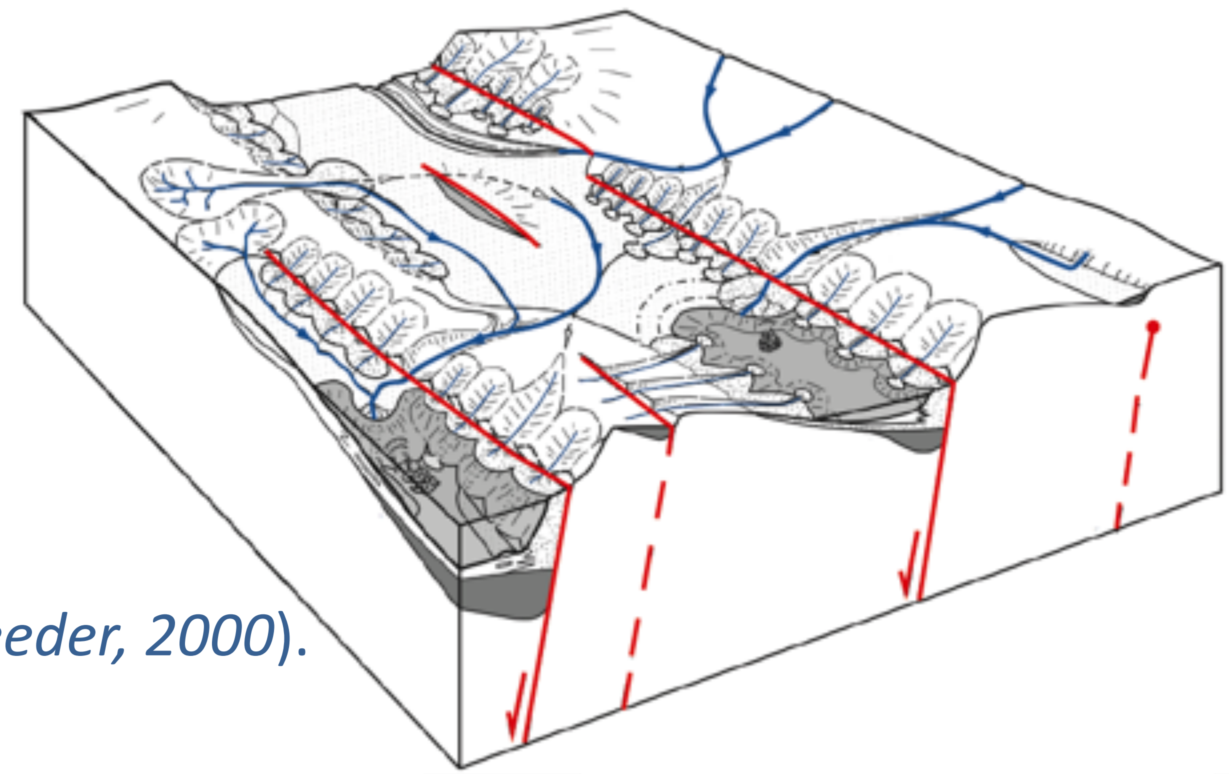
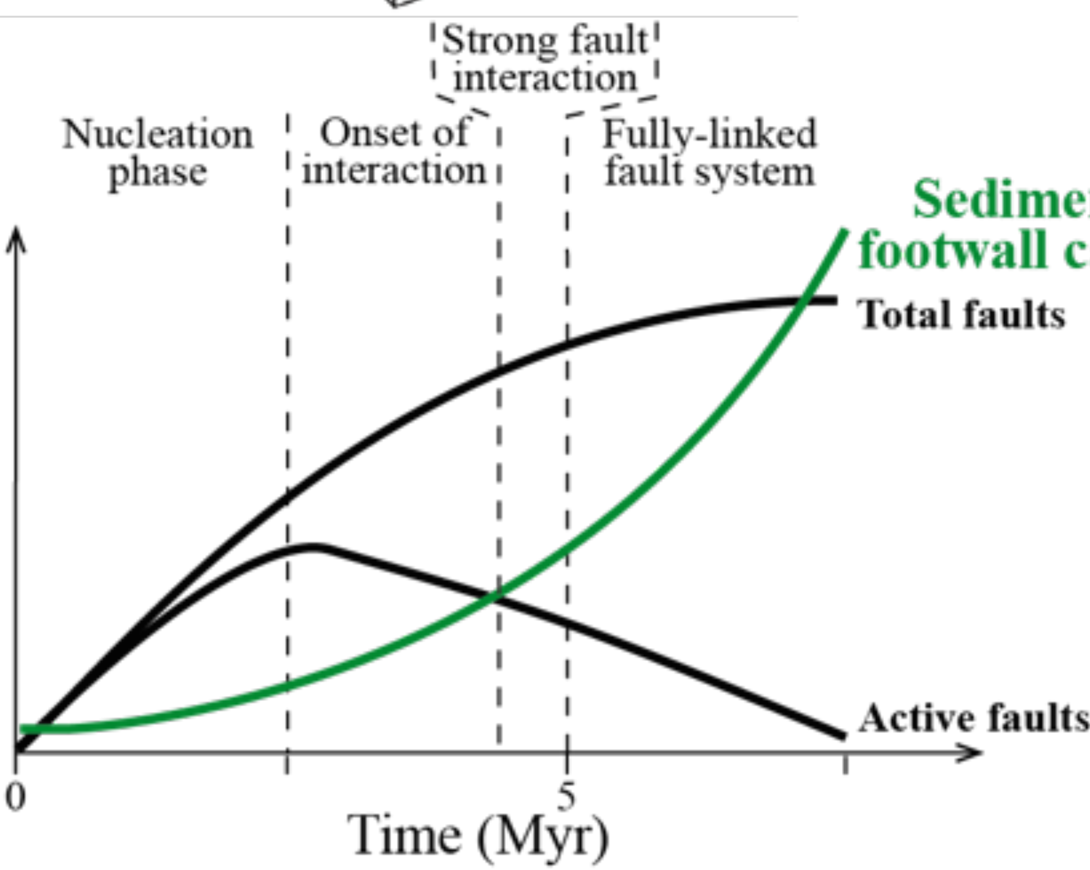
# Tectono-sedimentary model of early rift phase

Normal fault system initiation → Fault propagation and linkage





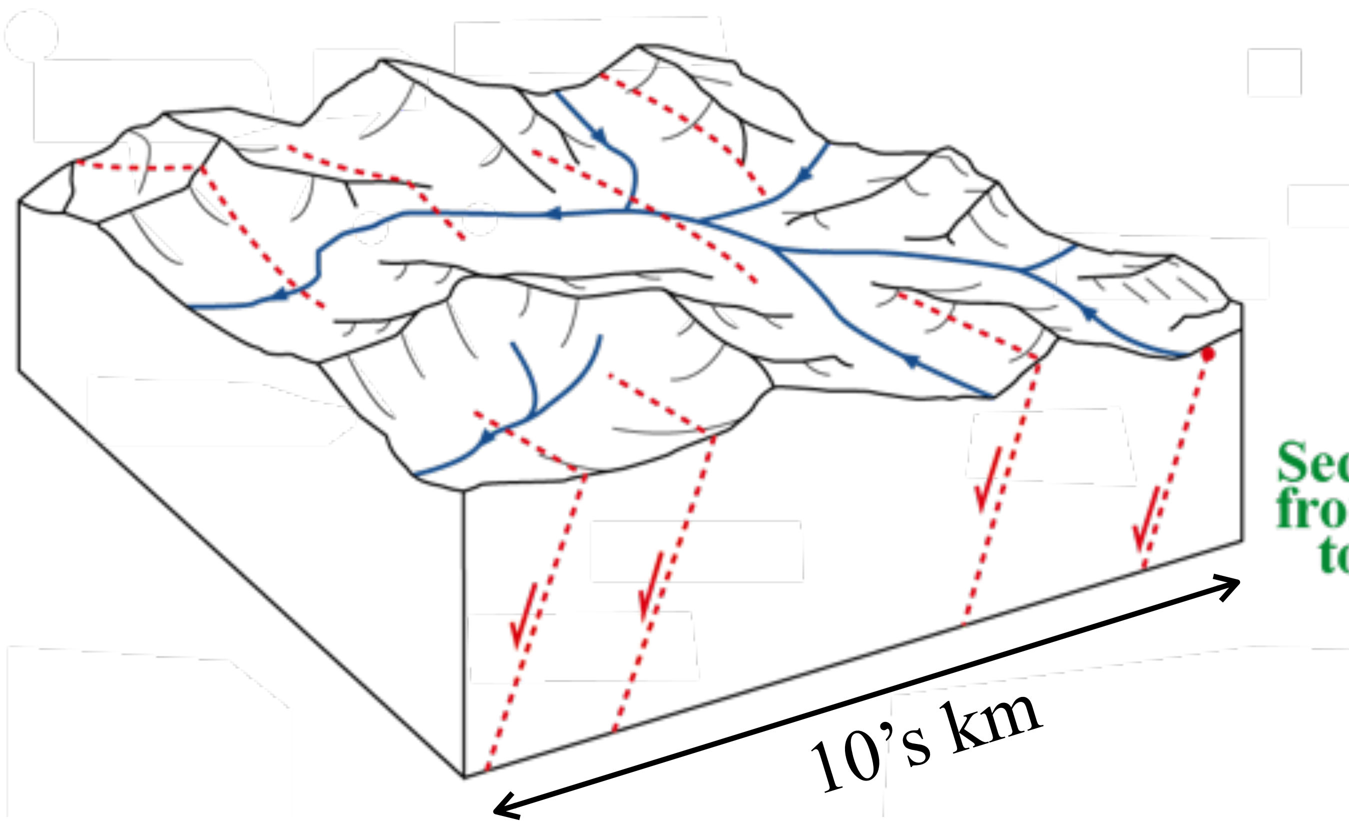
(*Gawthorpe & Leeder, 2000*).

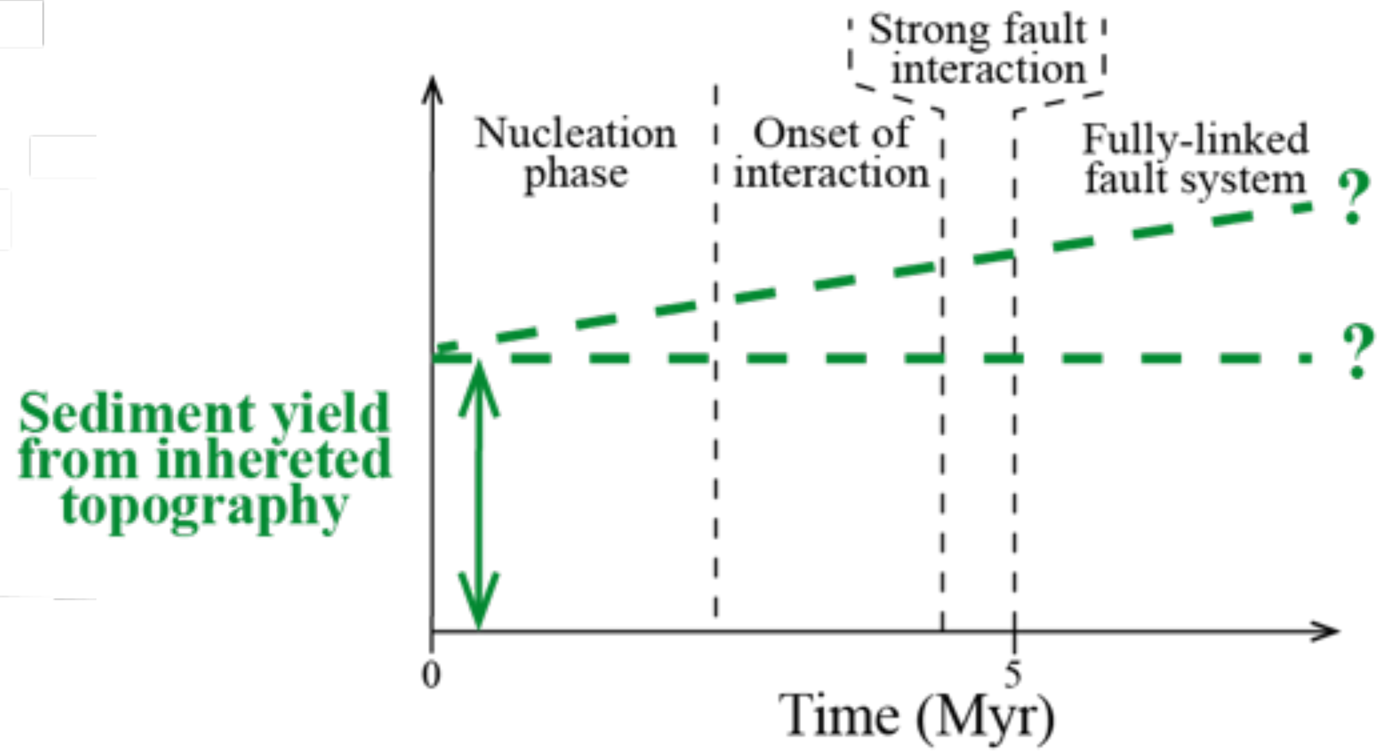



(modified from *Cowie et al., 2006*).

- **Tectono-sedimentary models of the early rift are based on footwall-derived sediments.**
- **Syn-rift sedimentation is the direct response to tectonic activity.**
- **The role of the inherited drainage system is not considered.**

# Importance of antecedent drainage system



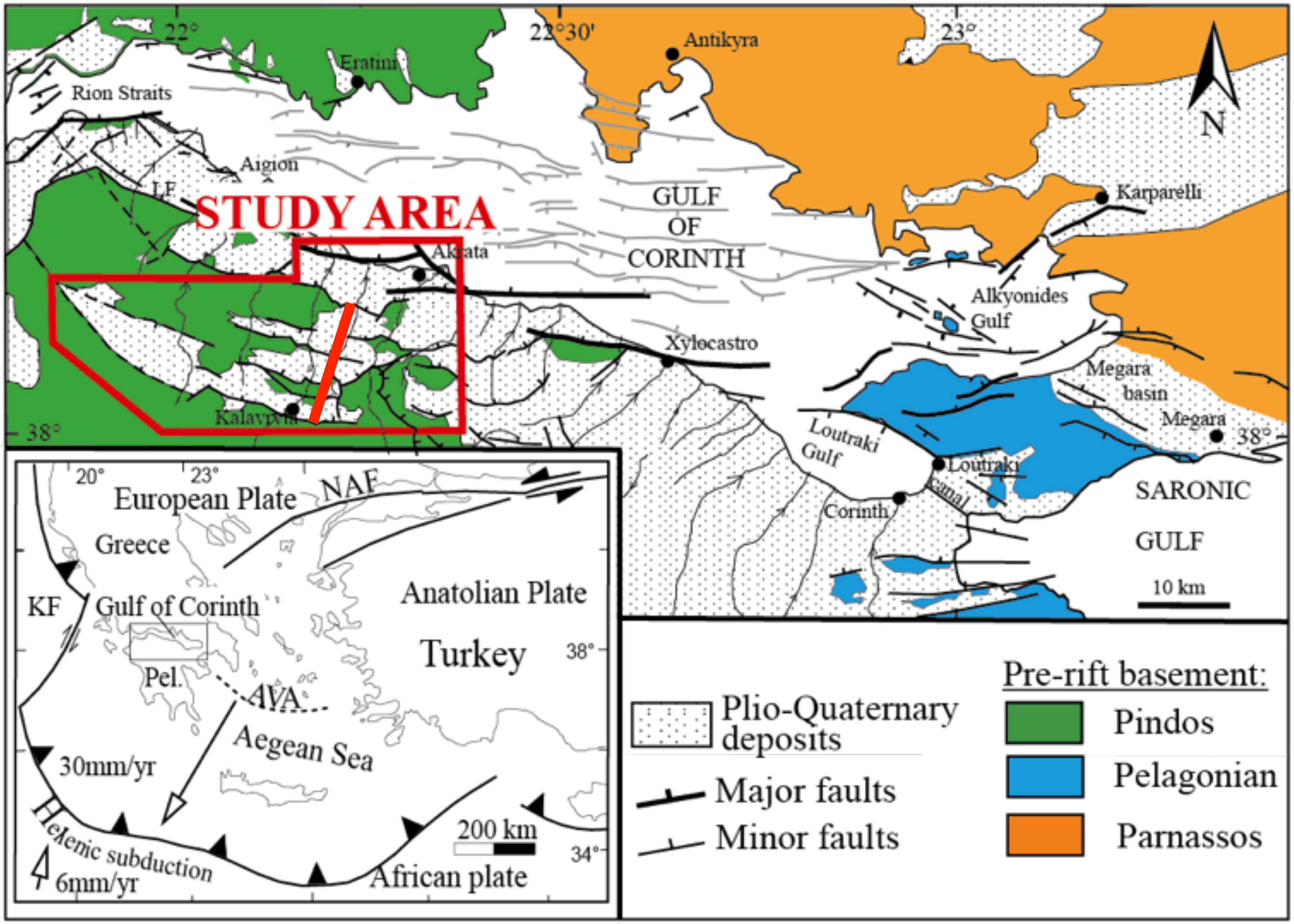




- Implications of a major antecedent drainage system:
  - **Presence of a paleotopography;**
  - **High sediment supply at rift initiation.**

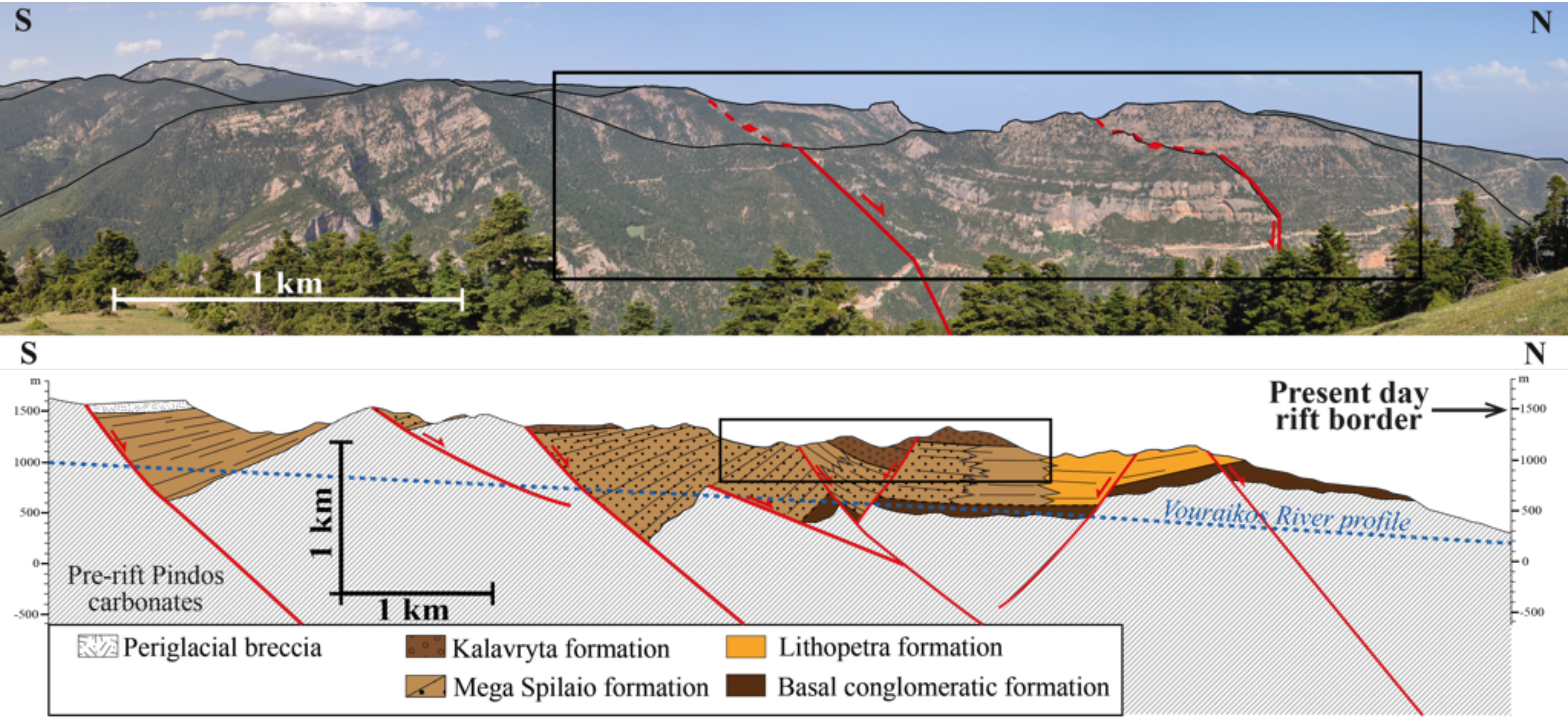
- How do rivers respond to the development of normal fault system?
- How important is it for syn-rift facies distribution and characterization of petroleum reservoirs?

# Study area: southern margin of the Corinth rift

- Inactive and uplifted fault blocks provide good exposures of the early rift deposits.
- The gulf of Corinth mostly defines the seismically active part of the rift.

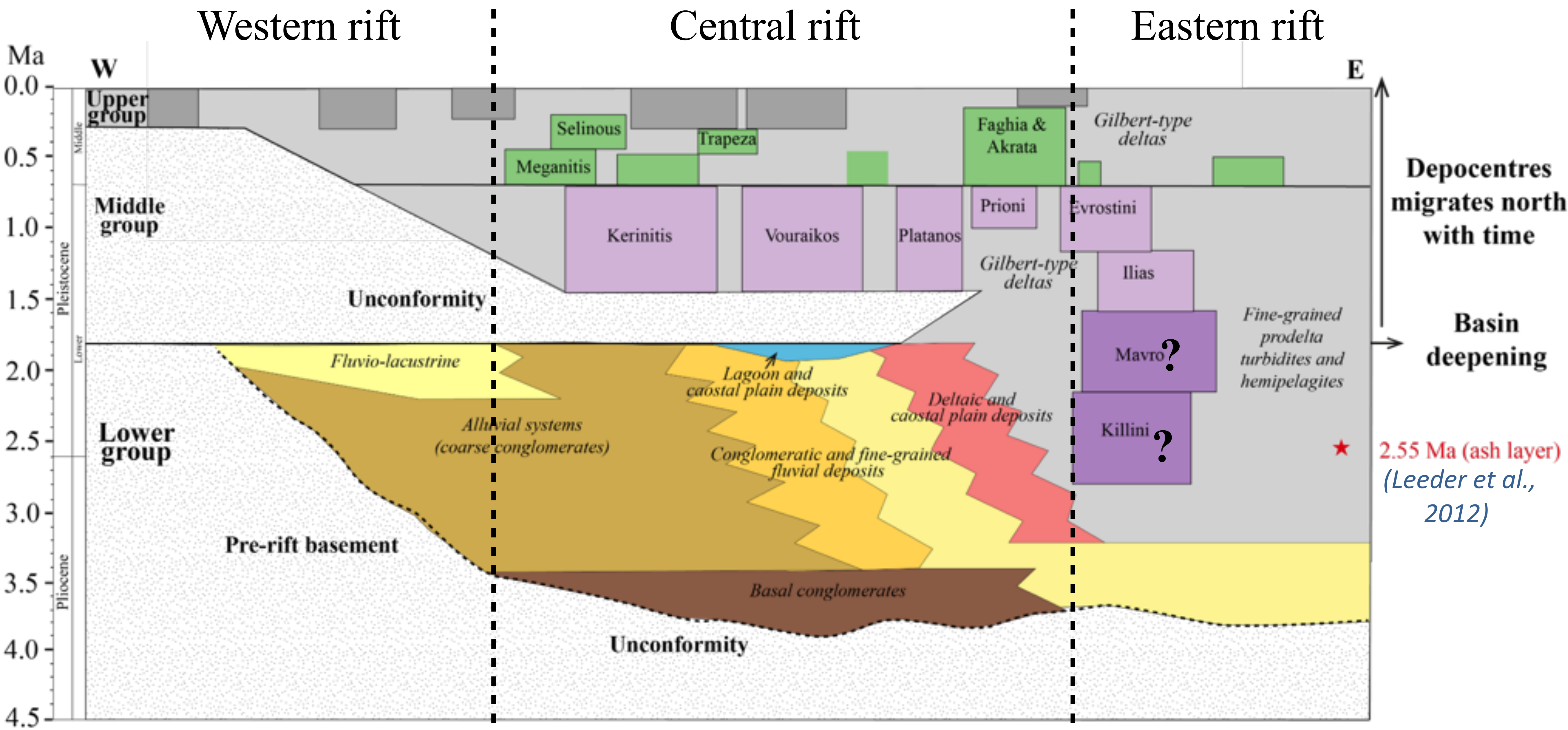


# Structural style in the syn-rift deposits



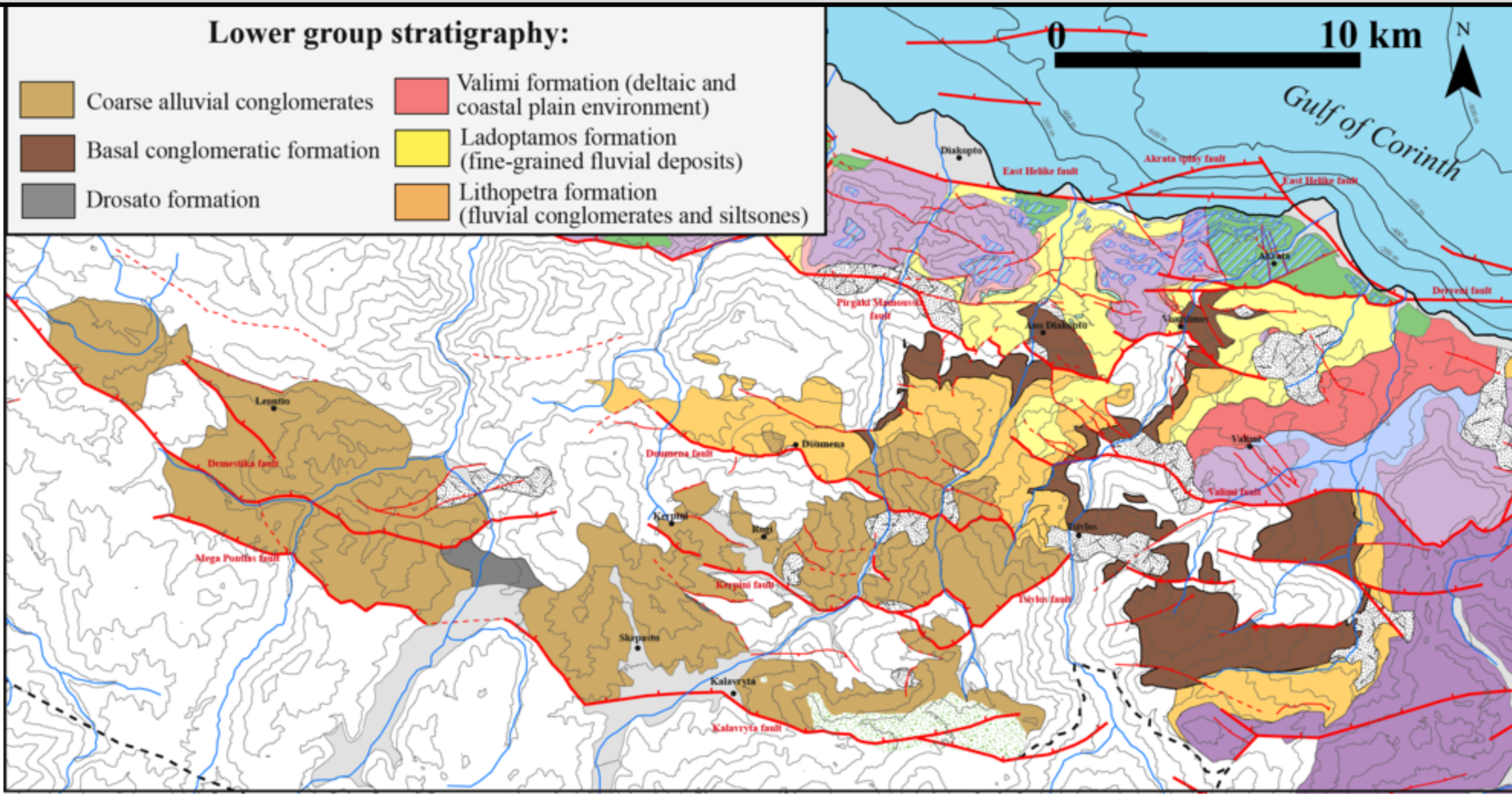

- Incision by the present day rivers provides exposure of the early syn-rift deposits.
- Growth strata along the north-dipping faults: syn-sedimentary tilted block or forced folds.

# Onshore stratigraphy in the central Corinth rift




- The Lower group fluvial system evolve from SW to NE, from coarse alluvial conglomerates and fluvio-deltaic deposits.
- Middle group deposits mark the onset of basin deepening in the central rift.
- In the eastern rift, basin deepening occurs during early rift stage.

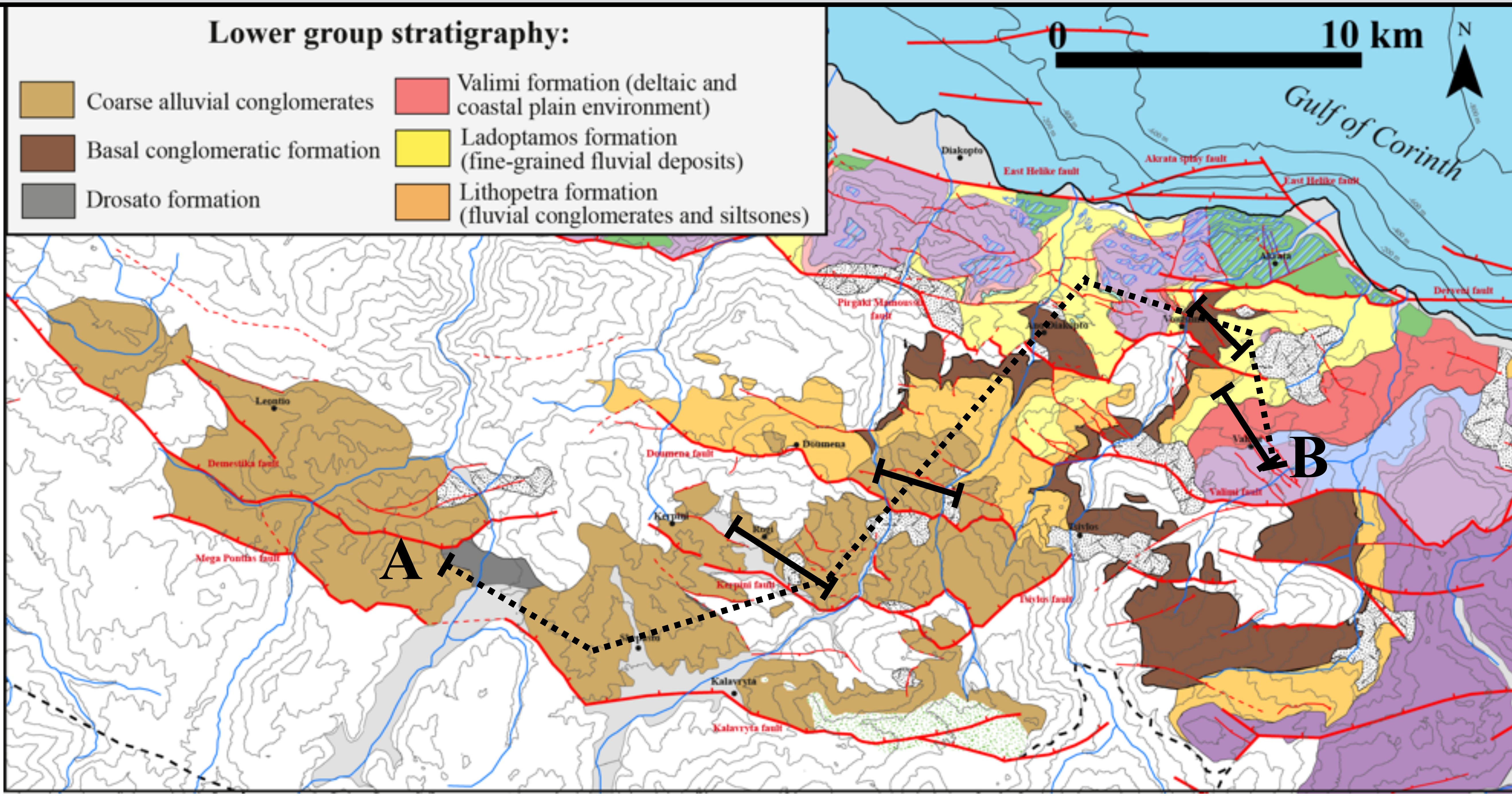
# Lower group stratigraphy




## Approach and methods:

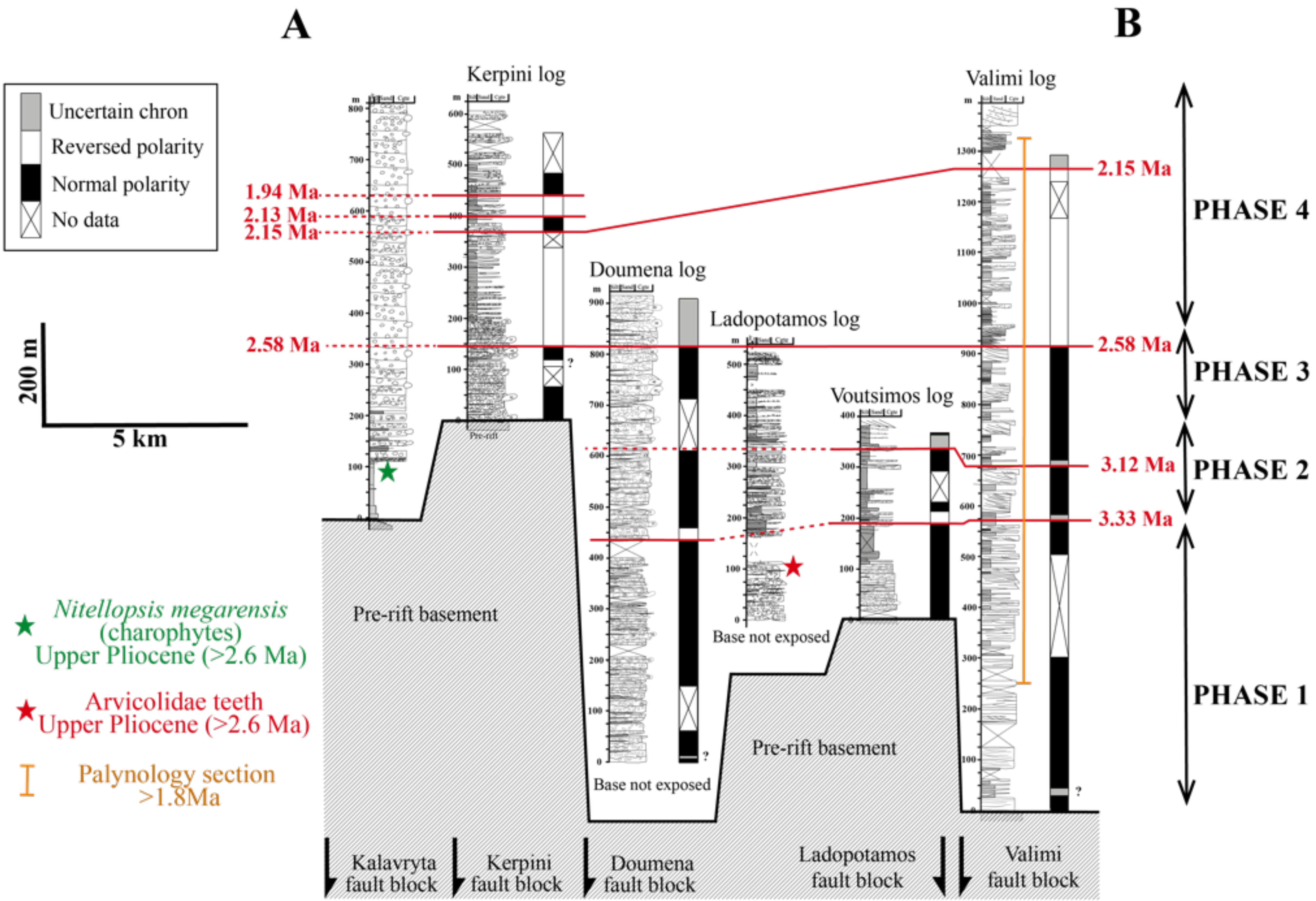
- Facies analysis and distribution in the study area;
- Correlations between fault blocks by combining lithostratigraphy and age constrains.
- Stratigraphic controls: magnetostratigraphy, palynology, rats teeth.

# Lower group stratigraphy

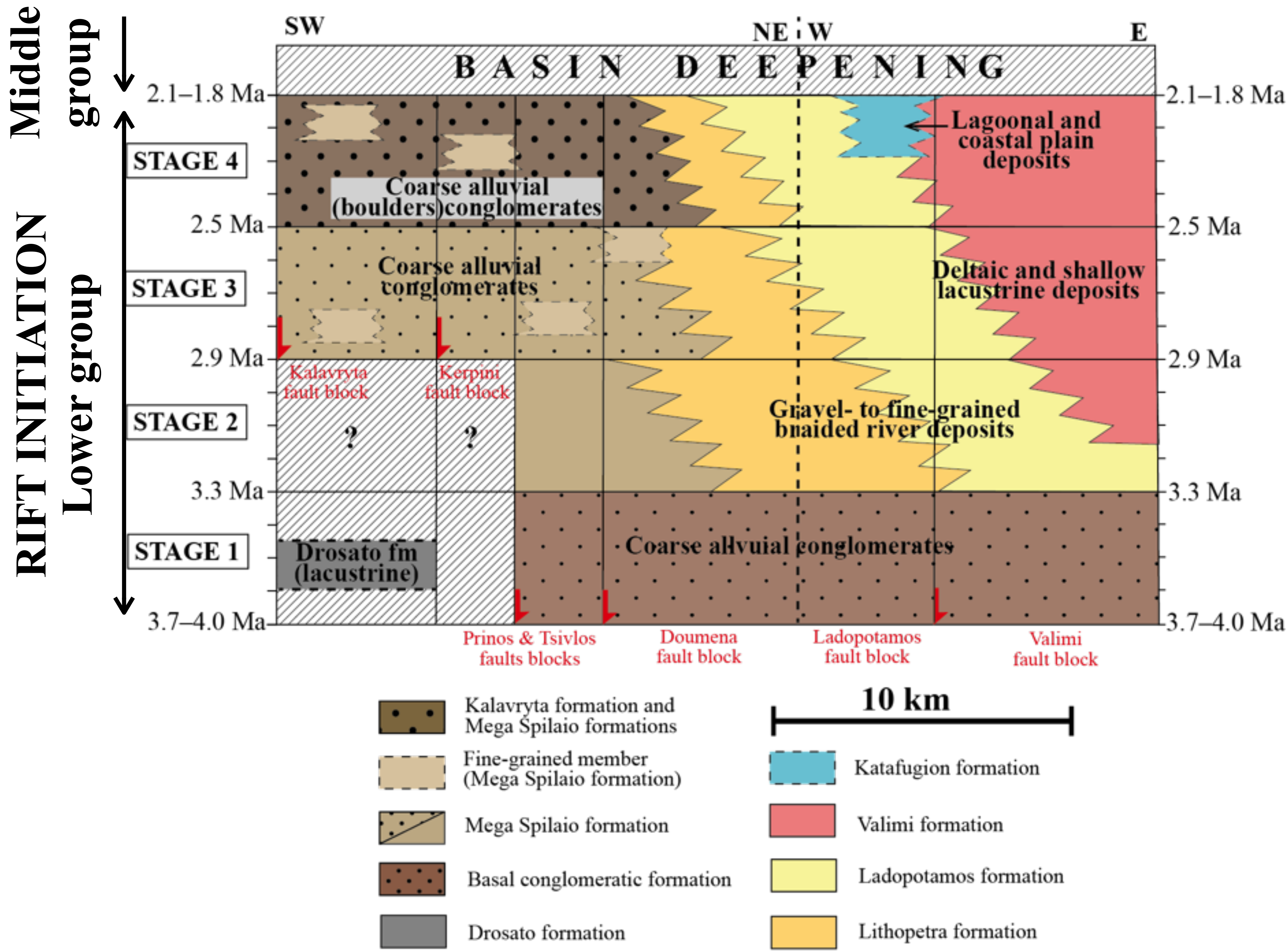



Paleomagnetic section

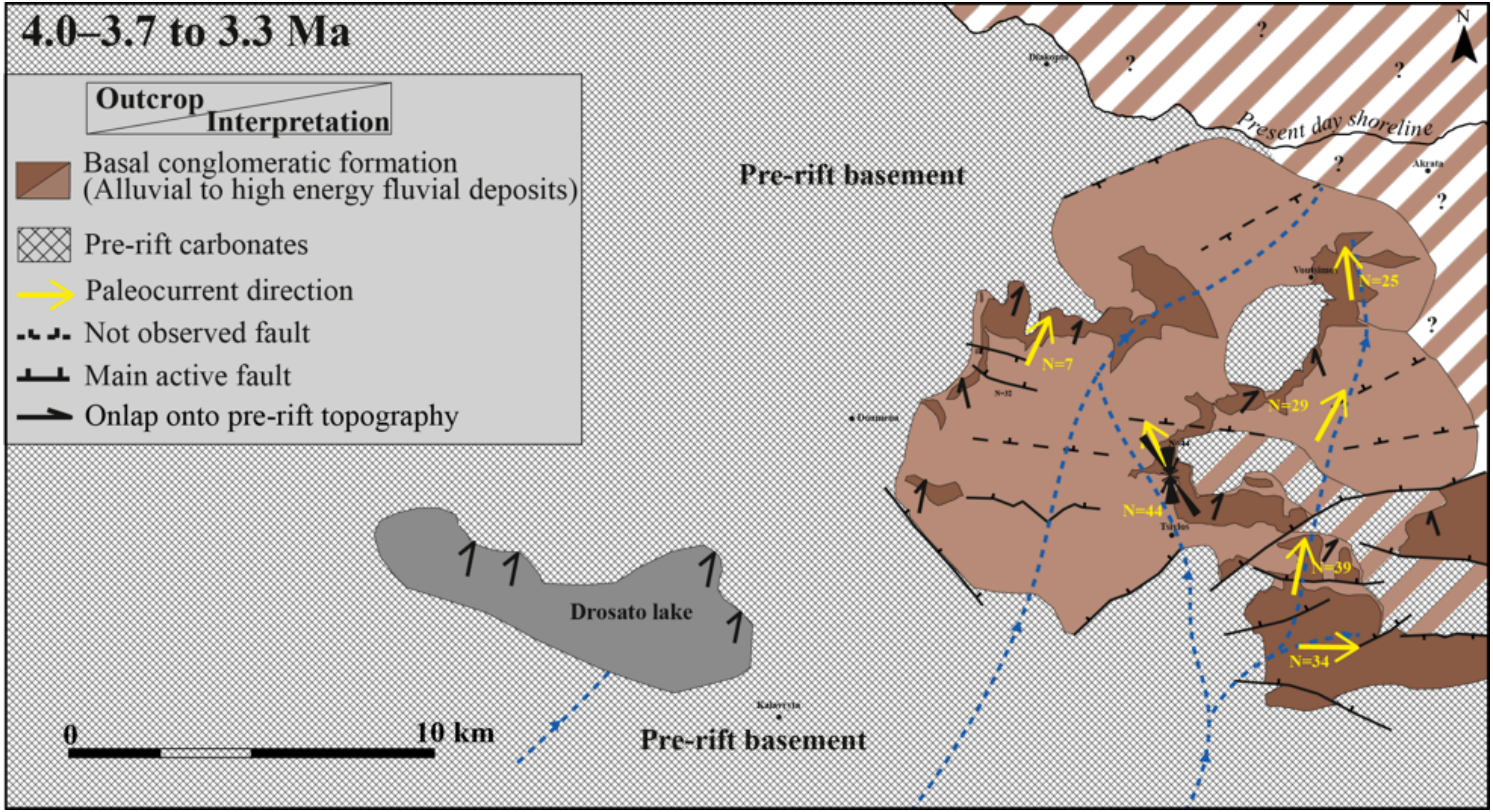
# Magnetostratigraphic correlations

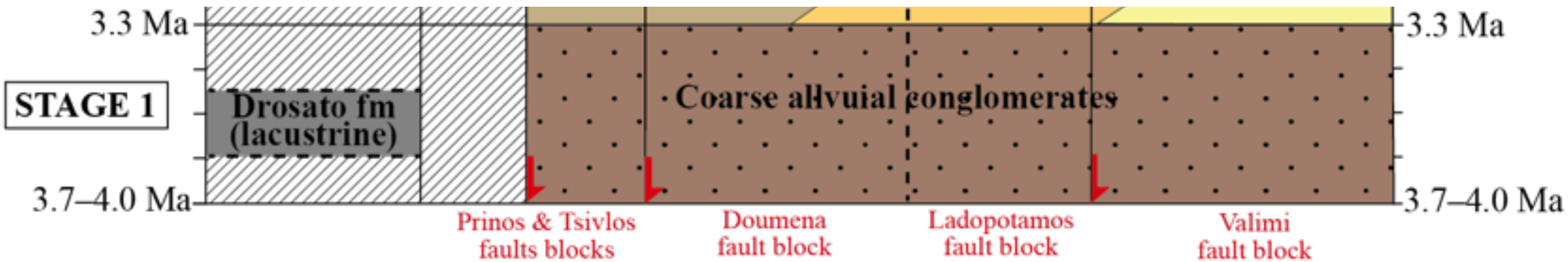


# Chronostratigraphic model

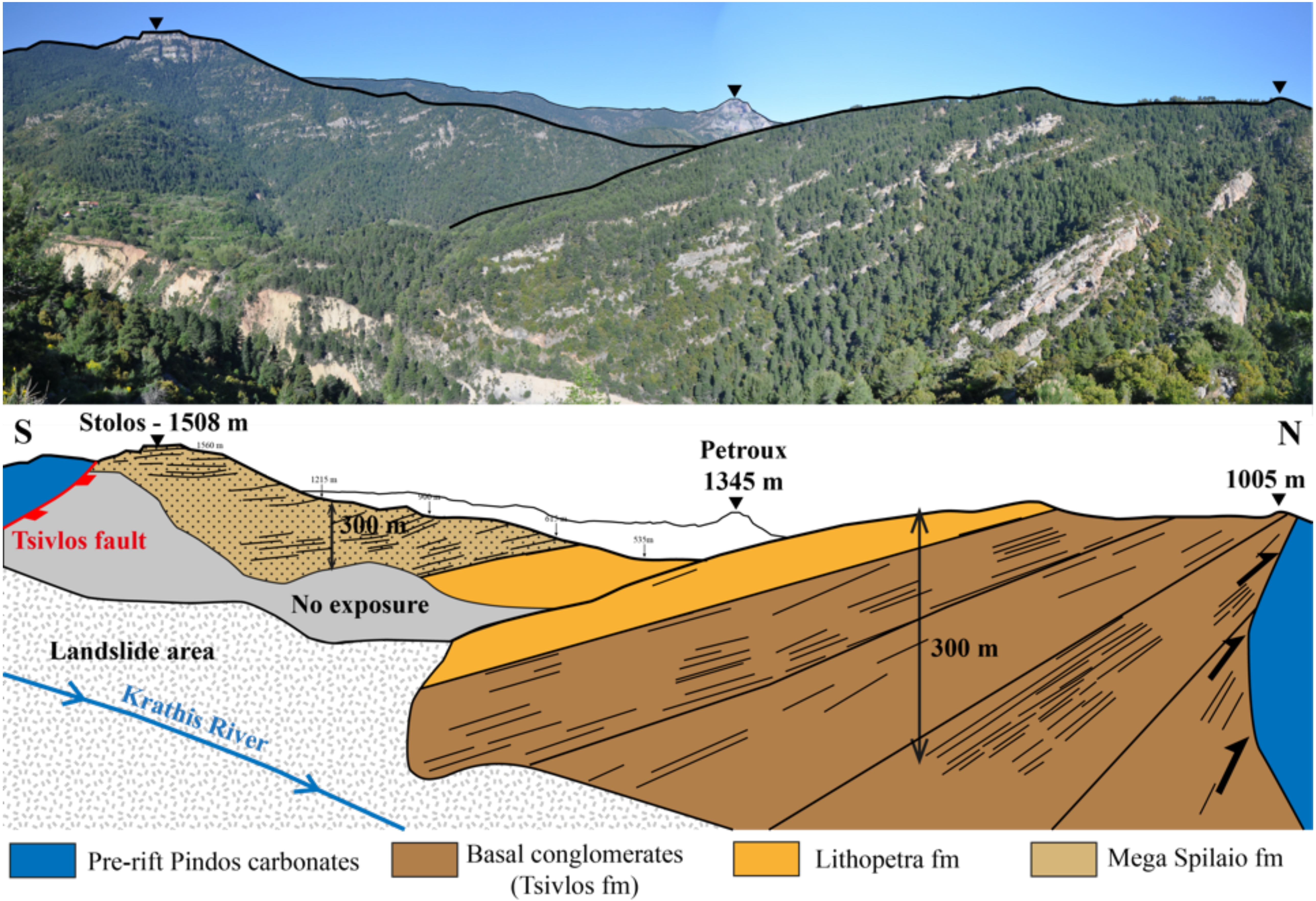


# Paleogeographic reconstructions: STAGE 1

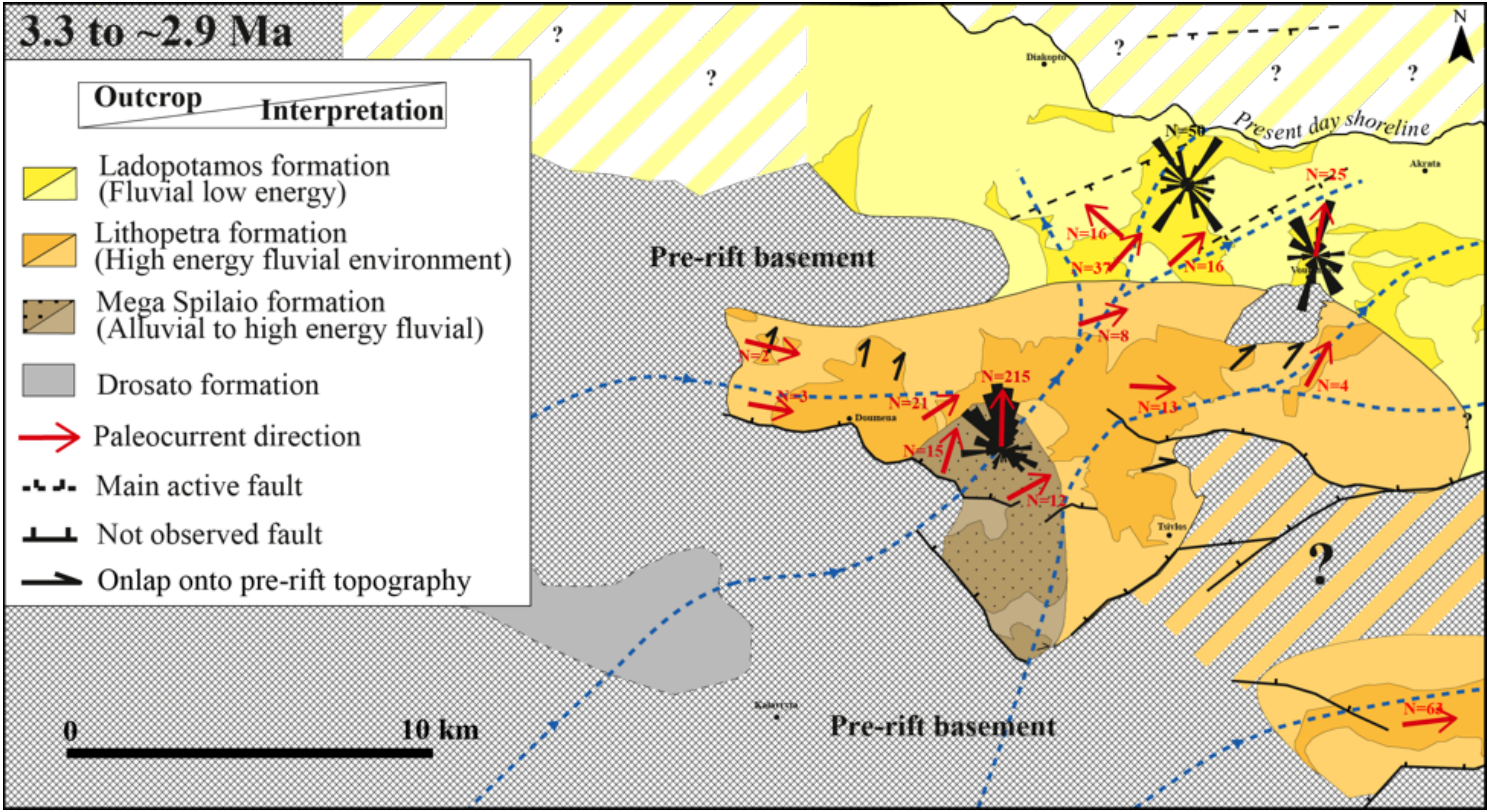


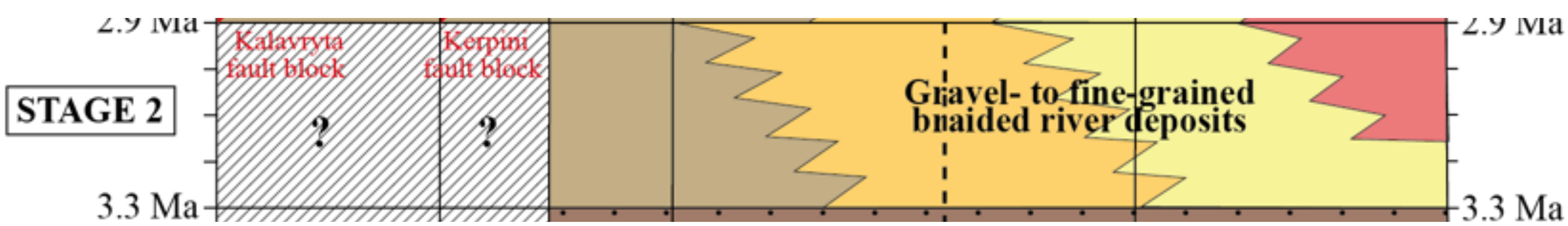



# STAGE 1: Basal conglomerates infilling paleotopography



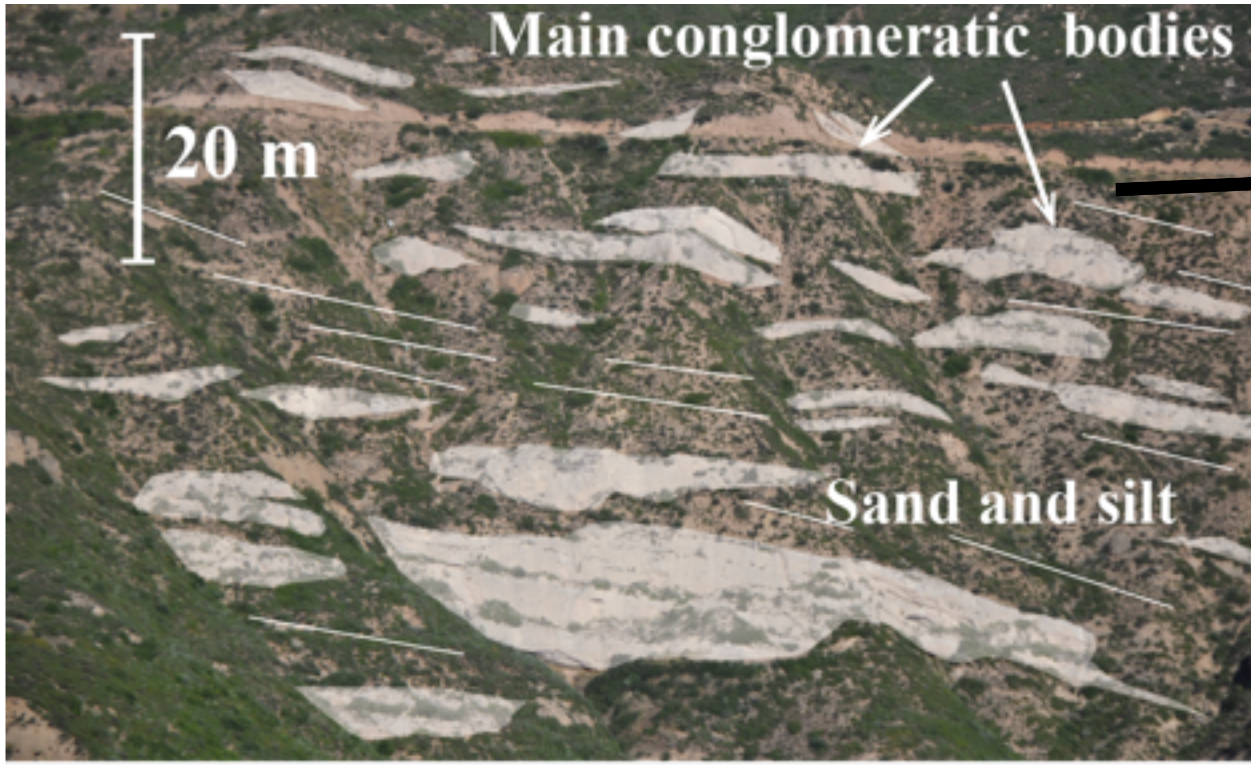
# Paleogeographic reconstructions: STAGE 2

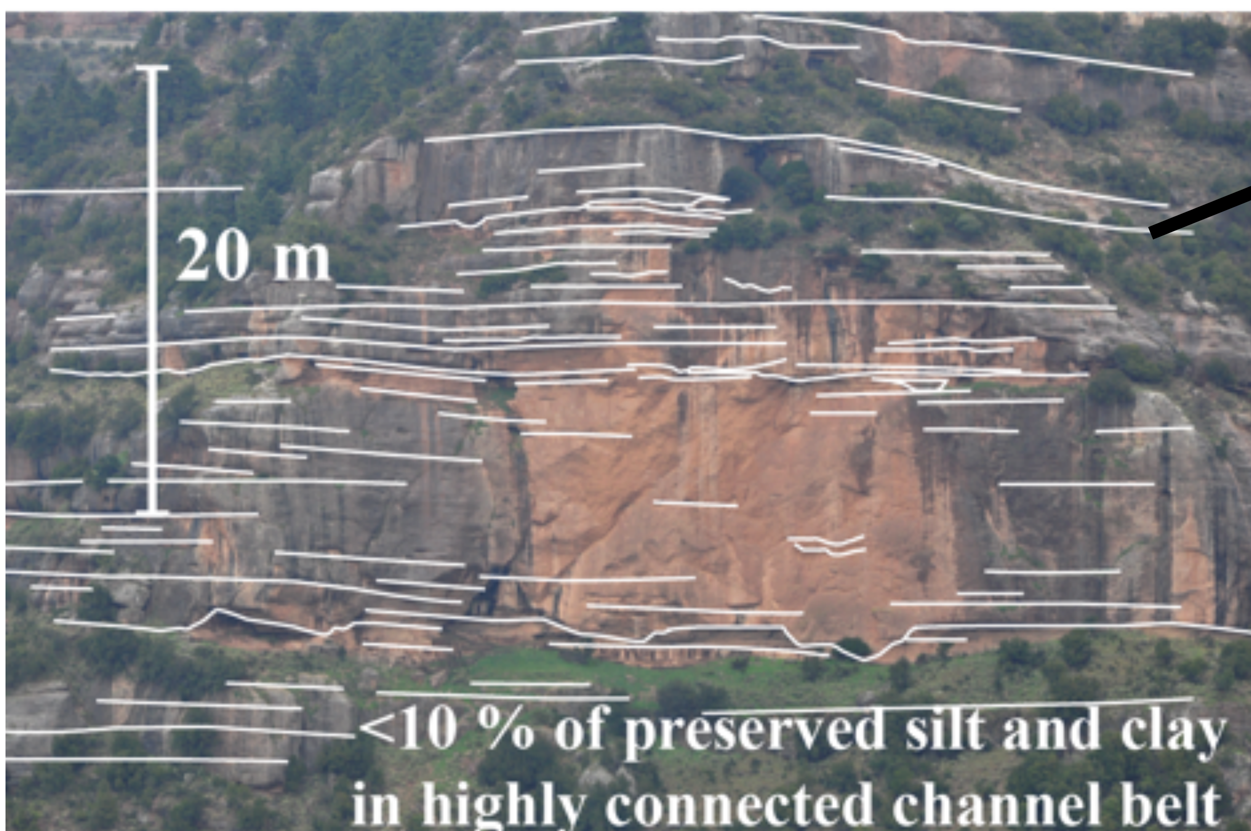


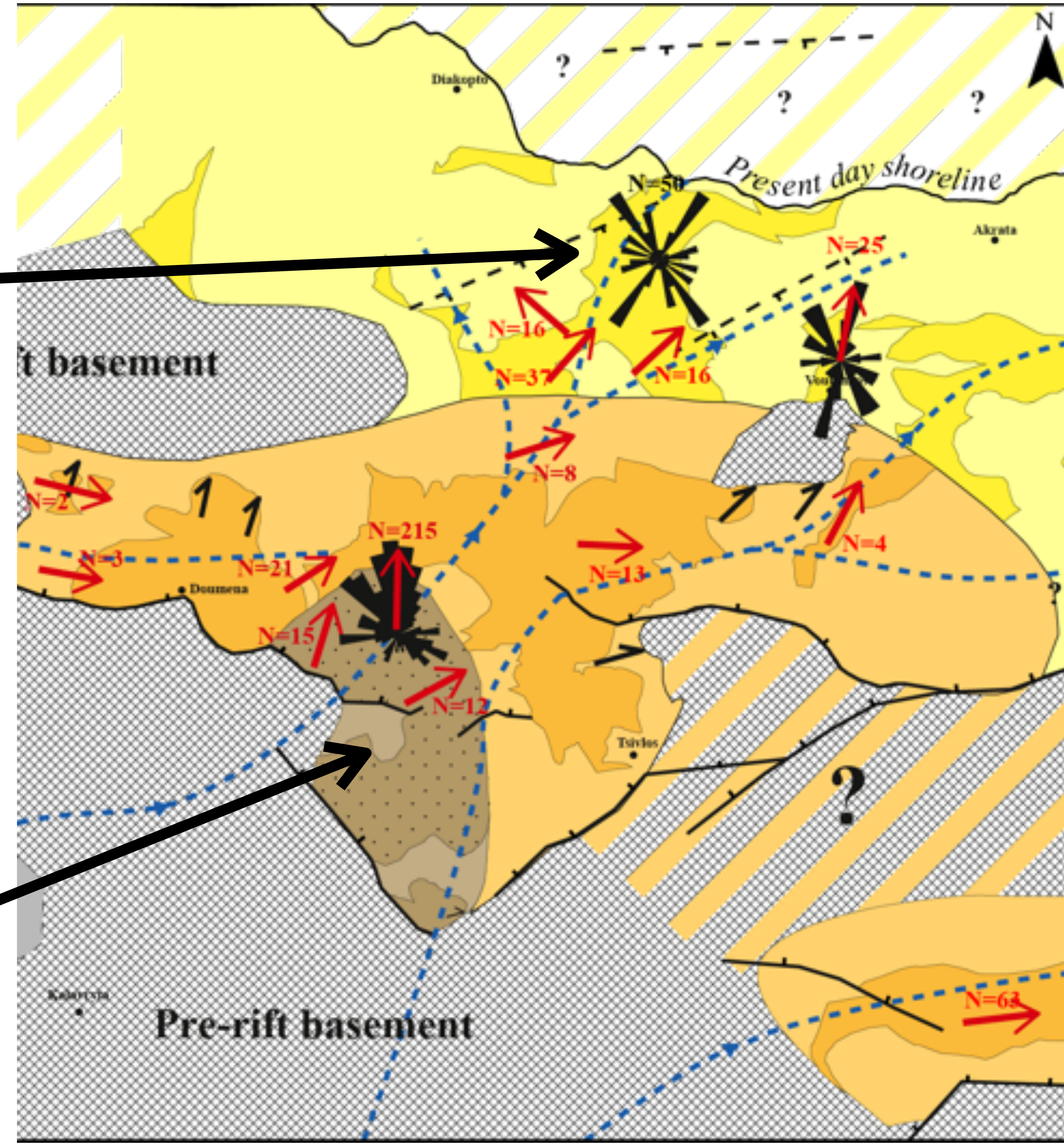



# Lateral facies change

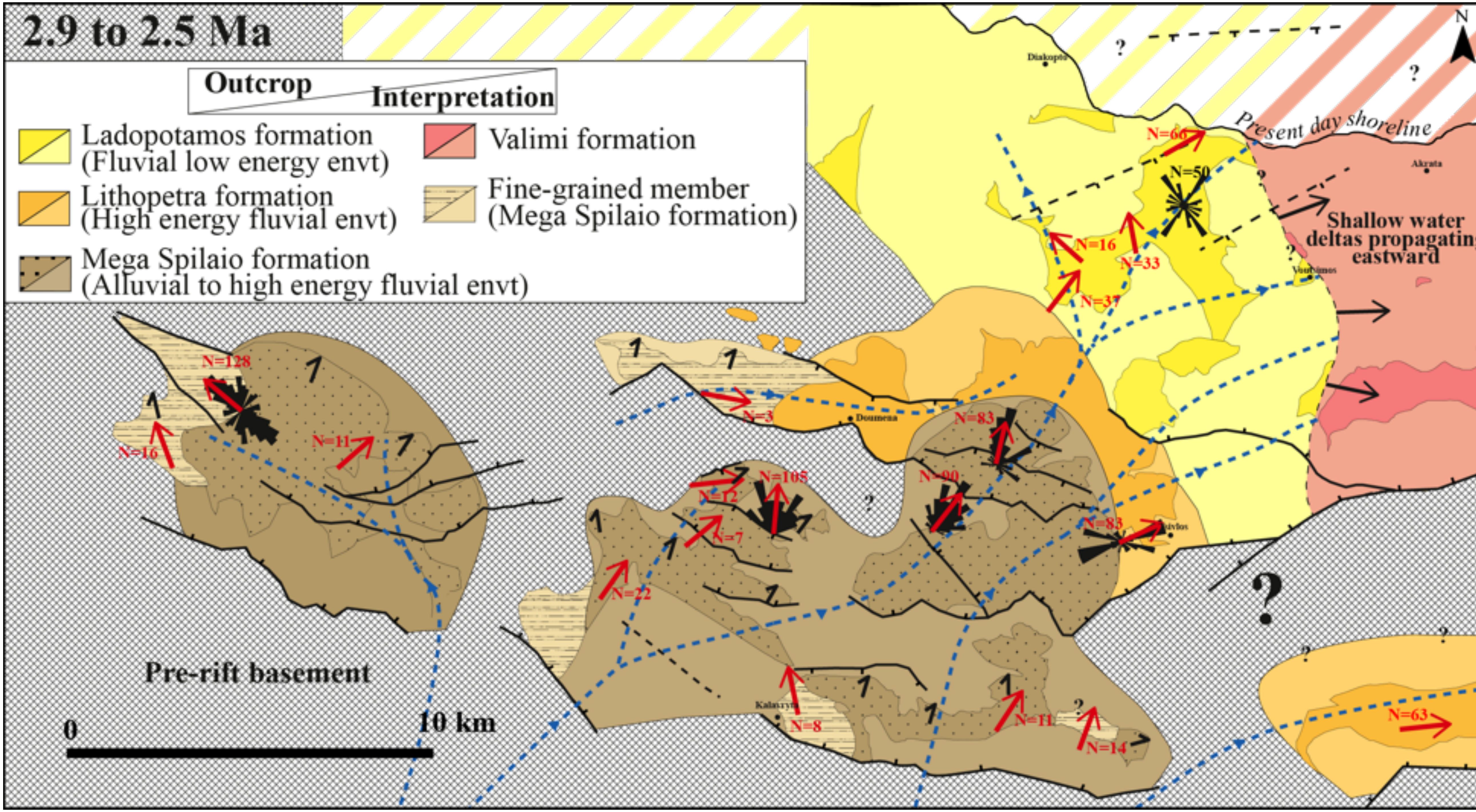
50–80% of sand and silt preserved
within the Ladopotamos formation

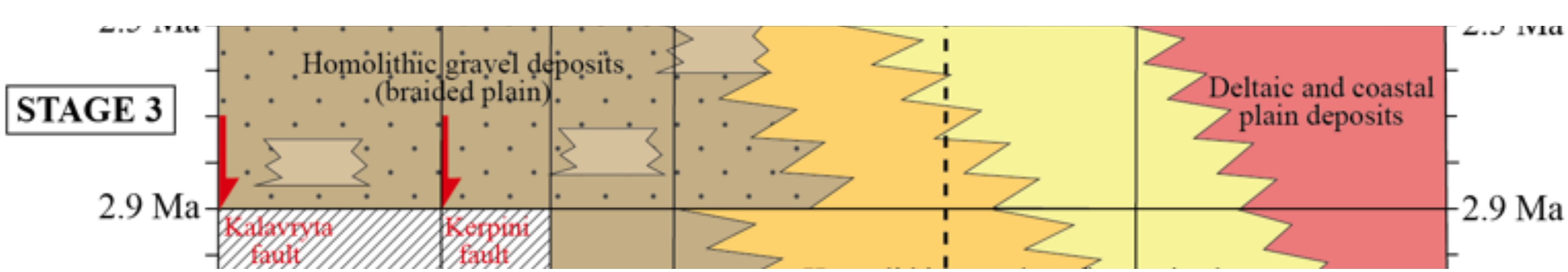


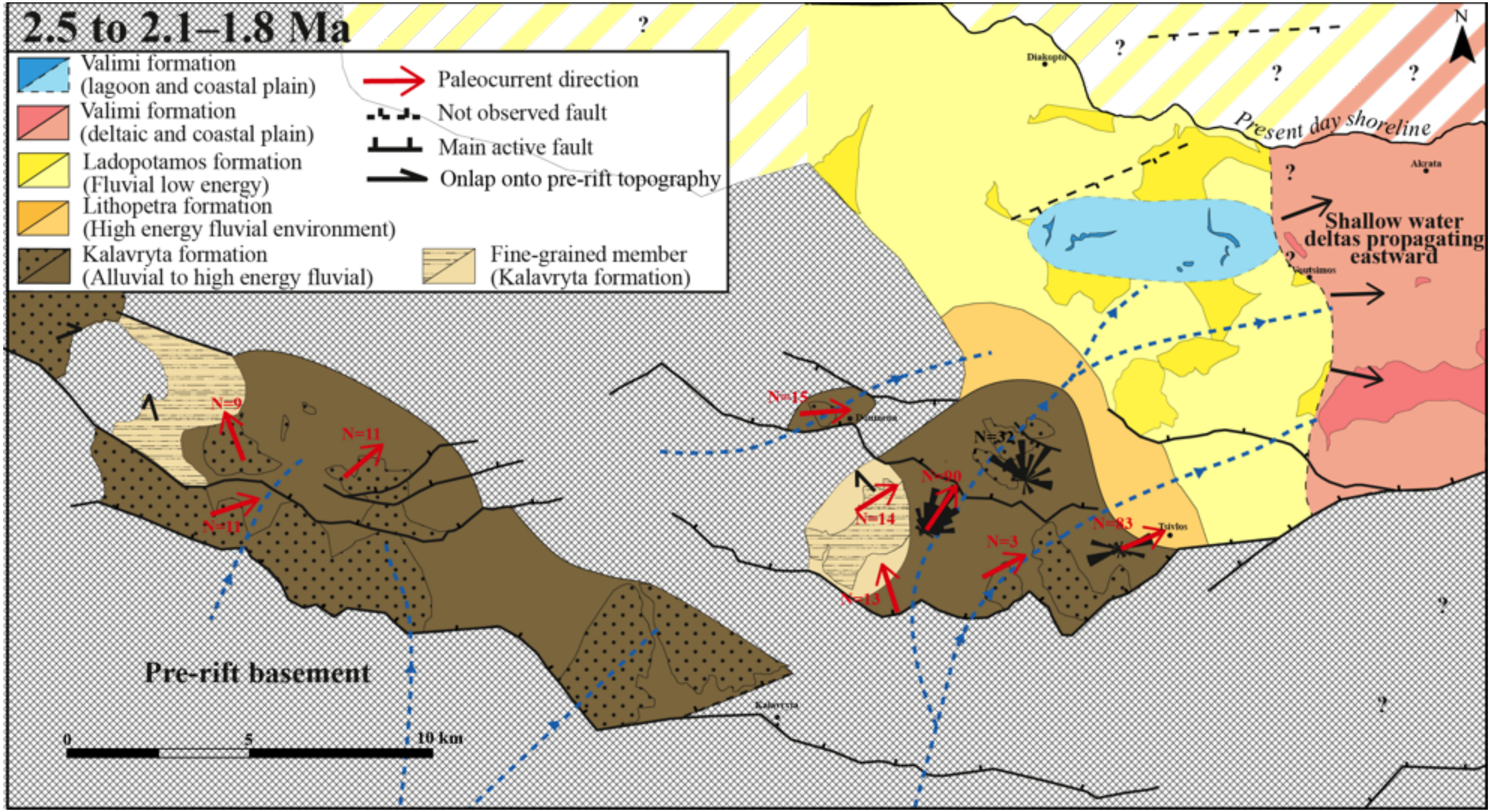



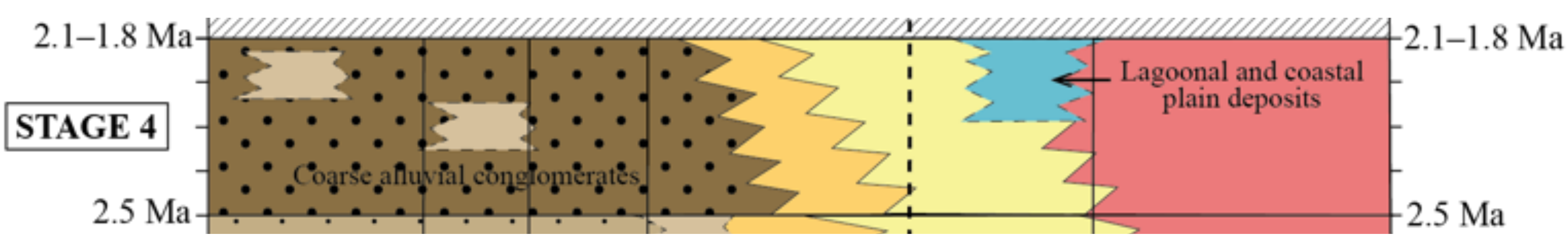
# Paleogeographic reconstructions: STAGE 3



# Paleogeographic reconstructions: STAGE 4



# Conclusions

- **Sediment supply is dominated by a large-scale antecedent drainage system.**
- **Limited evidence of local footwall-derived sediments** during rift initiation.
- The **fluvial depositional system** extends > 50 km **across several active tilted fault blocks.** There is no existing facies model at this scale.
- **Grain size and facies variations** do not occur at the scale of individual fault blocks (5–10 km) but **at the scale of the antecedent fluvial system.**
- During rift initiation times**, the main axis of fluvial transport** crosscuts the major faults and **remains constant.**
- These observations from the Corinth rift emphasize the role of antecedent drainage systems in the tectono-stratigraphic evolution of rift basins.