Flexure in the Corinth rift: reconciling marine terraces, rivers, offshore data and fault modeling

G de Gelder, D Fernández-Blanco, J Jara-Muñoz, D. Melnick, Guillaume Duclaux, Rebecca E. Bell, Robin Lacassin, Rolando Armijo

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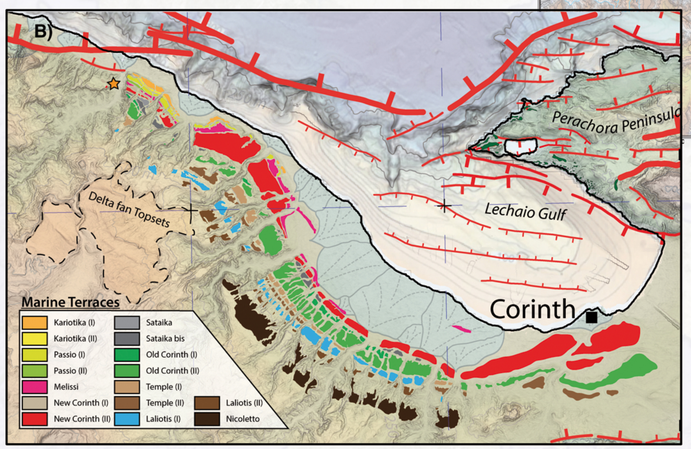
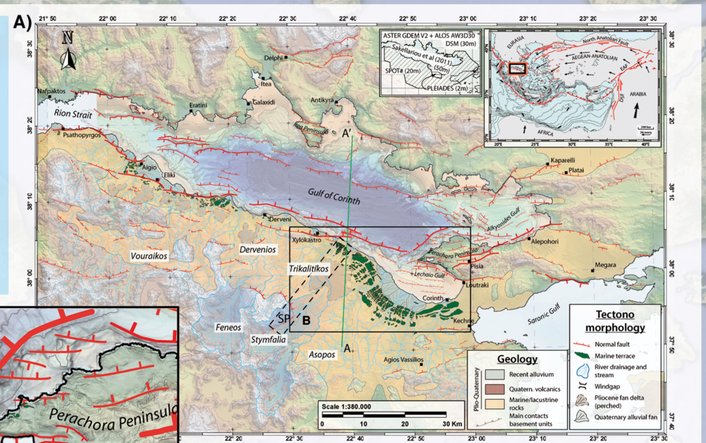
G. de Gelder[1], D. Fernández-Blanco[1], J. Jara-Muñoz[2], D. Melnick[2], G. Duclaux[3], R. Bell[4], R. Lacassin[1], and R. Armijo[1]

contact: gelder@ipgp.fr 1) Institut de Physique du Globe de Paris, France, 2) Universität Potsdam, Germany, 3) University of Bergen, Norway, 4) Imperial College, United Kingdom

1. Introduction

The Corinth rift (Greece) is an exceptional area to study the large-scale mechanics of a young rift system due to its extremely high extension rates and fault slip rates. Middle-Late Pleistocene activity of large normal faults has created a mostly asymmetric E-W trending rift, mainly driven by N-dipping faults that shape the southern margin of the Corinth Gulf in an en echelon pattern.
We improve the onshore record of footwall uplift by analysing the most extensive sequence of **marine terraces** in the SE margin, combine this dataset with the **offshore seismic record** of hanging wall subsidence, and present **simple numerical models** to fit the observations.

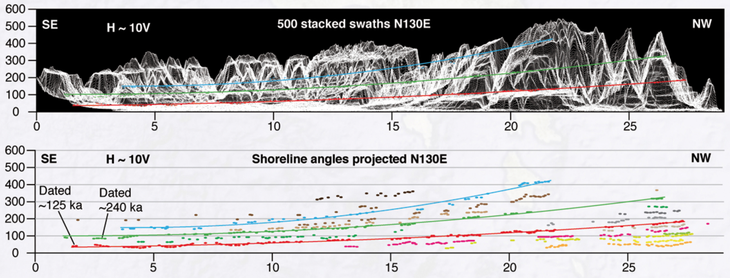




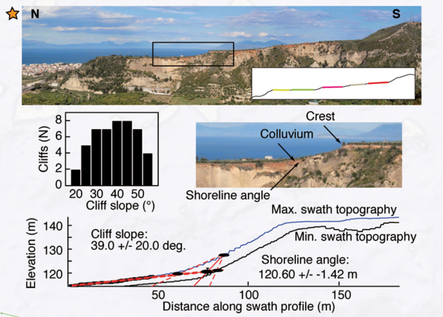
A) Active tectonics in the Gulf of Corinth
B) Map of the deformed marine terraces in the SE margin

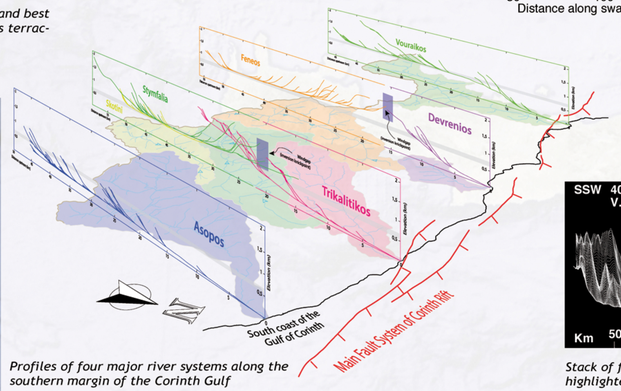
2. Onshore flexure

We developed 2m-resolution digital surface models from Pleiades satellite imagery using MicMac software (Rosu et al. 2015, http://logiciels.ign.fr/?Micmac) to define with **high accuracy** the **shoreline angles** of the terraces using the graphical Matlab interface TerraceM (Jara-Muñoz et al. 2016, www.terracem.com).
The detailed record of flexure provided by this analysis is in good agreement with the (nearly) inverted river geometry of the major systems along the south coast, indicating that **flexure occurs on the scale of the whole rift.**



Top: topography parallel to the coast with the shoreline angles and best fit quadratic curve for the New Corinth, Old Corinth and Laliotis terraces.
Bottom: all determined shoreline angles





From top to bottom: View of terraces near Xylokastro, histogram of Holocene cliff slope measurements, detail of terrace morphology and example of TerraceM shoreline angle analysis

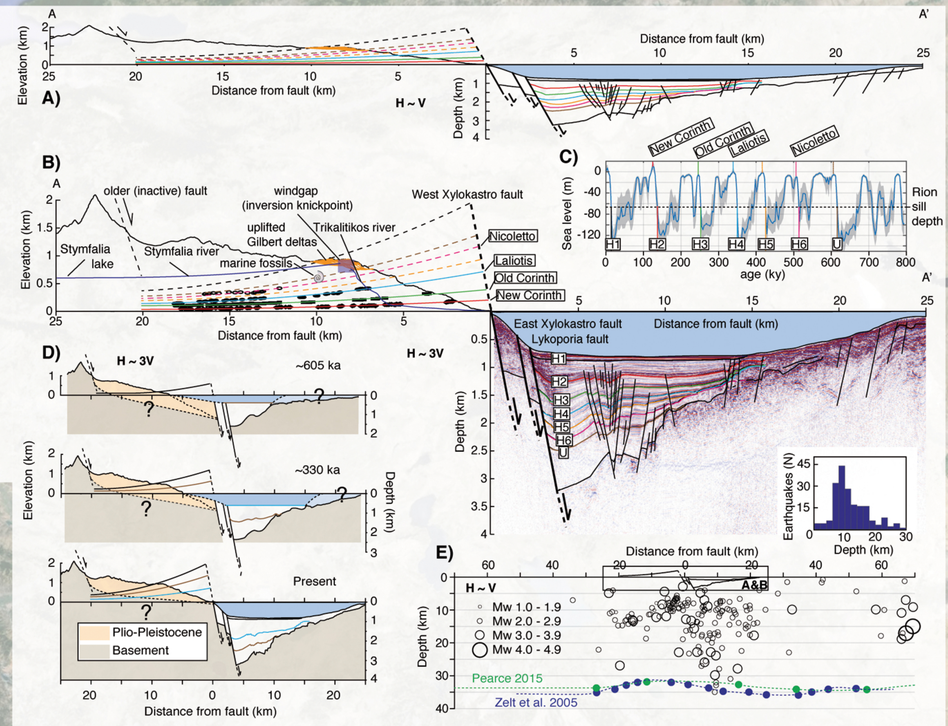
Profiles of four major river systems along the southern margin of the Corinth Gulf

3. Cross-section

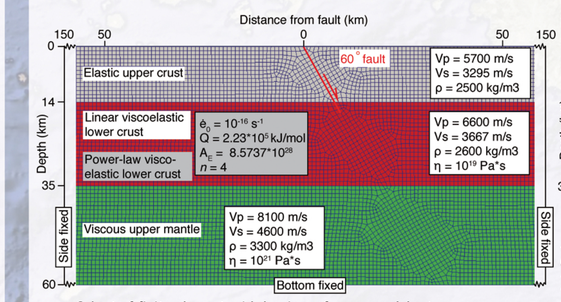
The 100ky climate cycles that shaped the most extensive terrace levels are, by glacial-interglacial interaction with the Rion strait, also responsible for the marine-lacustrine alternation inferred for the offshore stratigraphy.
We depth-converted the multi-channel seismic section L35 (Taylor et al. 2011) and combine this with the onshore record to **obtain a full profile of the Xylokastro/Lykoporia fault geometry and its associated deformation pattern**. We obtain a symmetric geometry with an uplift/subsidence (u/s) ratio of 1:0.9-1:1.5 after sediment decompaction, and an average cumulative slip rate of ~5 to ~7 mm/yr.
In the deeper section, microseismicity is mainly concentrated in a broad region below the main faults, and the moho is thinnest below the main fault system or ~10km to the south.

4. Fault modeling

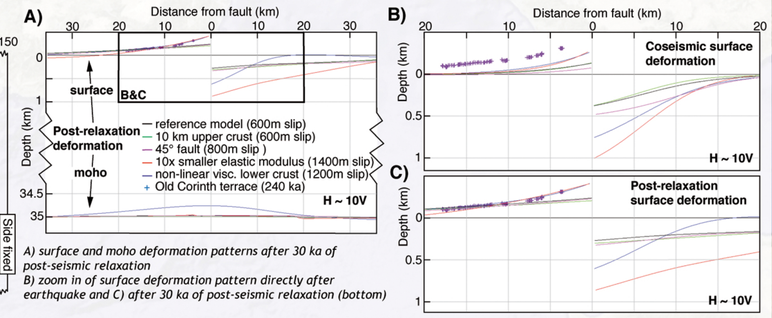
We use the full cross-section as constraint for **2D fault modeling**. We use Pylith, a finite element code for quasi-static viscoelastic simulations, to model 45-60° planar normal faulting in an elastic upper crust overlying a viscous lower crust and mantle **to reproduce the derived terrace uplift pattern**.
The models reproduce the observed geometry best by either reducing the elastic modulus of the upper crust by a factor of ~10 or using a non-linear viscous rheology for the lower crust (power law), in which the latter is in better agreement with the observed u/s ratio and interpreted moho geometry.



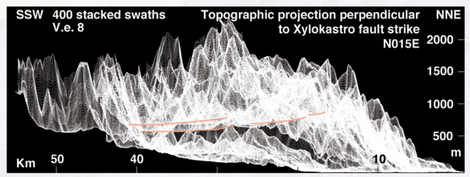
A) and B) are the projection of topographic maxium swath profile SP, shoreline angles and Trikalitikos/Stylfalia rivers on profile A-A' without and with 3x vertical exaggeration. Seismic interpretation adapted from Nixon et al. (2016); C) Inferred ages of terrace levels and offshore seismic horizons plotted on the Pacific sea level curve of Bates et al (2014); D) Schematic geological restoration for the last ~605ka and; E) Microseismicity from the University of Athens 1996-2008 earthquake catalog measured within 2.5 km of profile A-A' and moho depth estimates from Ps receiver functions (Pearce 2015) and tomographic inversion of PmP reflection times (Zelt et al. 2005)



Subset of finite element grid showing reference model set-up



A) surface and moho deformation patterns after 30 ka of post-seismic relaxation
B) zoom in of surface deformation pattern directly after earthquake and C) after 30 ka of post-seismic relaxation (bottom)



Stack of fault-perpendicular swath profileswith inverted river profiles highlighted

Acknowledgements

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5. Conclusions

1) The terrace sequence in the SE Gulf of Corinth provides a detailed record of footwall flexure and the (nearly) inverted river profiles suggest it happens at the scale of the rift
2) Similar climate-driven strain markers within the offshore section indicate a symmetric deformation pattern and u/s ratios of 1:0.9-1:1.5
3) Our best fitting numerical models contain an elastic upper crust overlying a viscous lower crust with powerlaw viscosity.

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