Flexural response of the Black Sea to the Messinian Salinity Crisis

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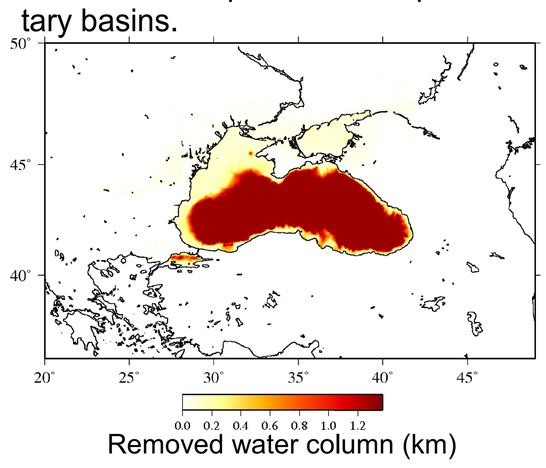
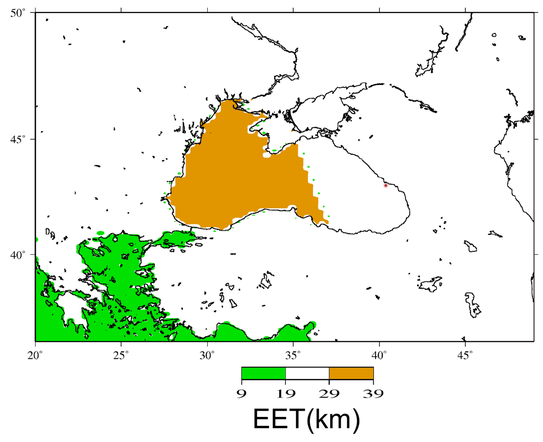
Introduction

Two lines of evidence suggest that there was base level drop of 1300 meters in the Black sea basin coinciding with the Messinian Salinity Crisis (MSC) in the Mediterranean sea; 1) a regional erosional surface in seismic sections correlating with the unusual Miocene-Pliocene lithology in borehole DSDP 42, and 2) the discovery of a low stand sequence in the Dacic basin (Fig 1, DB). If true, the removal of a significant water column from the earth surface is expected to have evoked an isostatic/flexural response of the solid earth that may have influenced the position of depocenters and the connectivity between sedimentary basins.





Using the public domain 3D finite difference code GFLEX, the flexural/isostatic rebound of the Black sea basin in response to the Messinian / intra-Pontian (5.5 Ma) base level drop is calculated. This is done by solving the mechanical equilibrium equations for a thin plate with zero vertical displacement and displacement gradient as boundary conditions. Material properties are inserted by using the Effective Elastic Thickness (EET) which varies lateral in the model as shown in the figure above. The maximum amount of water removed is 1300 meters, depending on the paleowater depth since this controls the height of the water column.

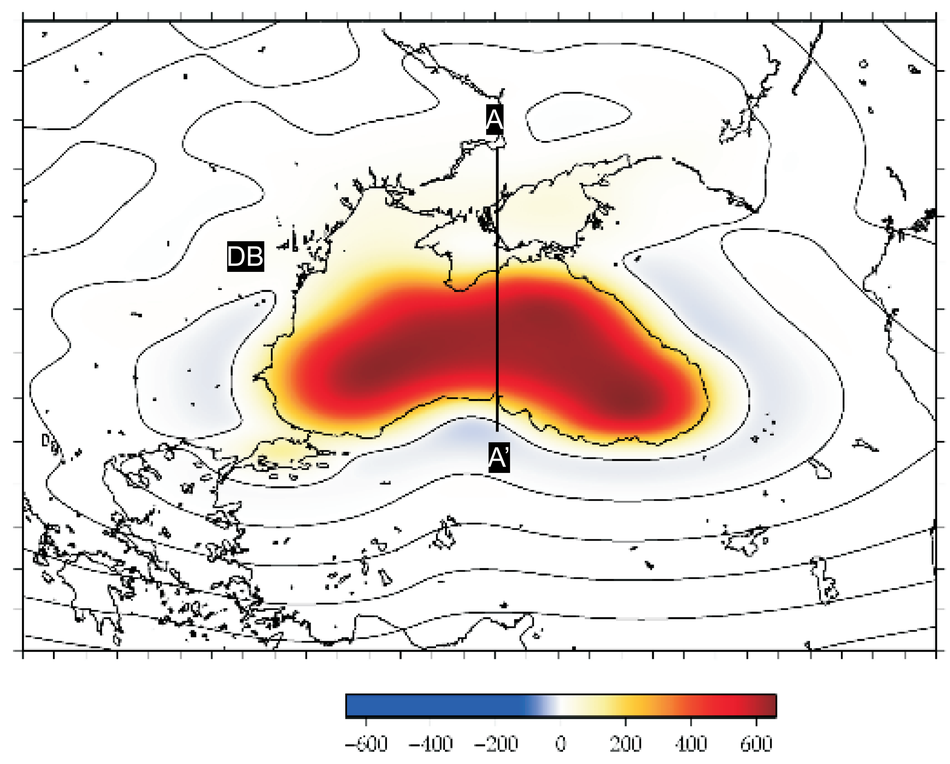
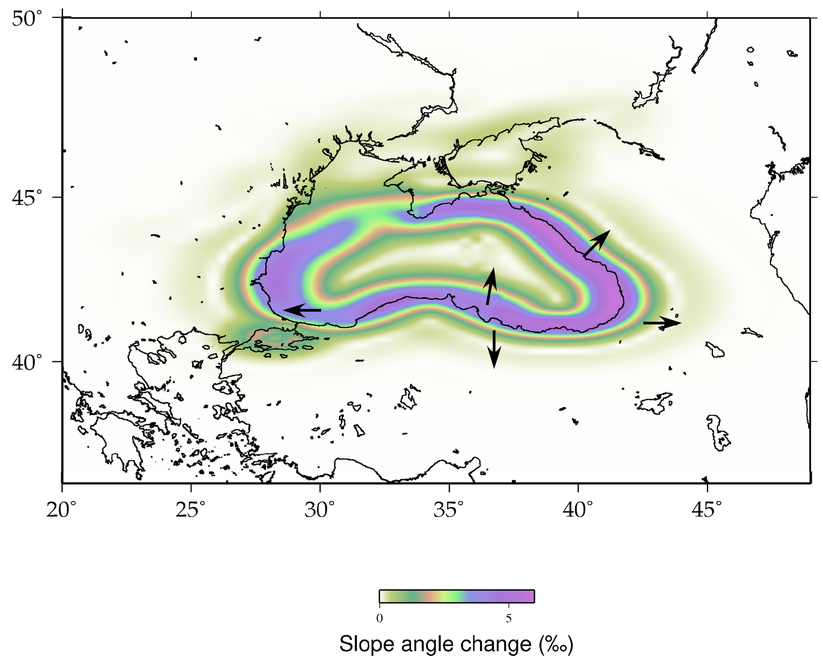


Fig 1) The calculated flexural response of the Black Sea on the Messinian Salinity crisis. The maximum uplift in the center of the basin is 660 meters and the maximum subsidence about 26 meter. DB is the location of the Dacic basin.

Change in basement slope



The flexural response of the Black Sea basin changes the basement slope by more than 5‰. The change in slope may trigger slumping of sediments especially at the basin margin, where the predicted slope increase is the largest.

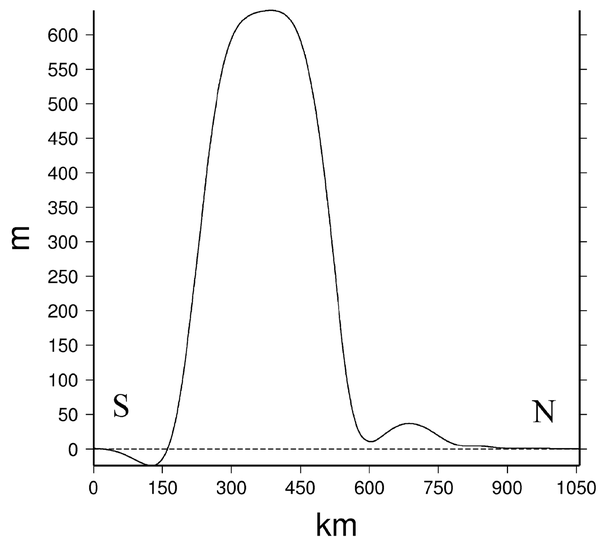
Change in Erosion/ Sedimentation rate

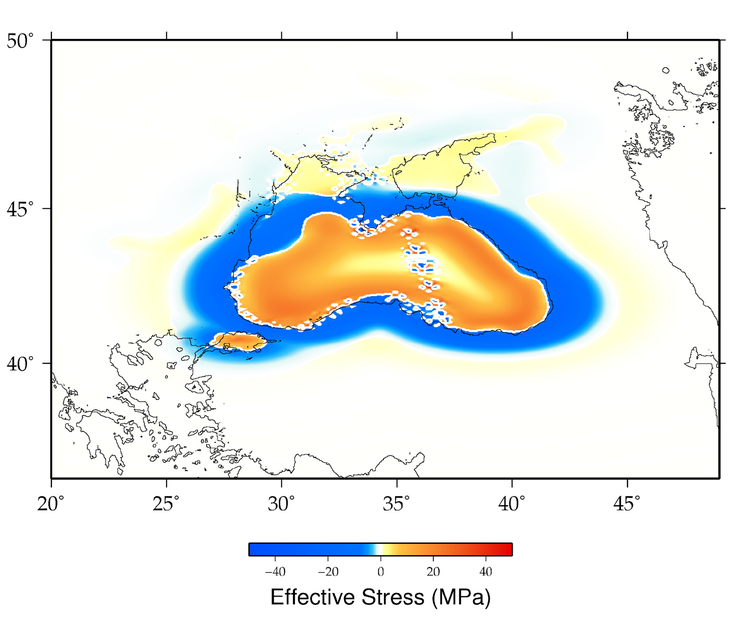
The flexural change in basement curvature may evoke a change in erosion and sedimentation. We predict strong changes in the southern and eastern margin of the Black Sea and only a limited change is recorded in the northern and western part and Dacic basin. The prediction agrees with increased sedimentation rate of intra-Pontian sediments in the Dacic and Romanian margin of the Black Sea.

Results

Profile A-A'

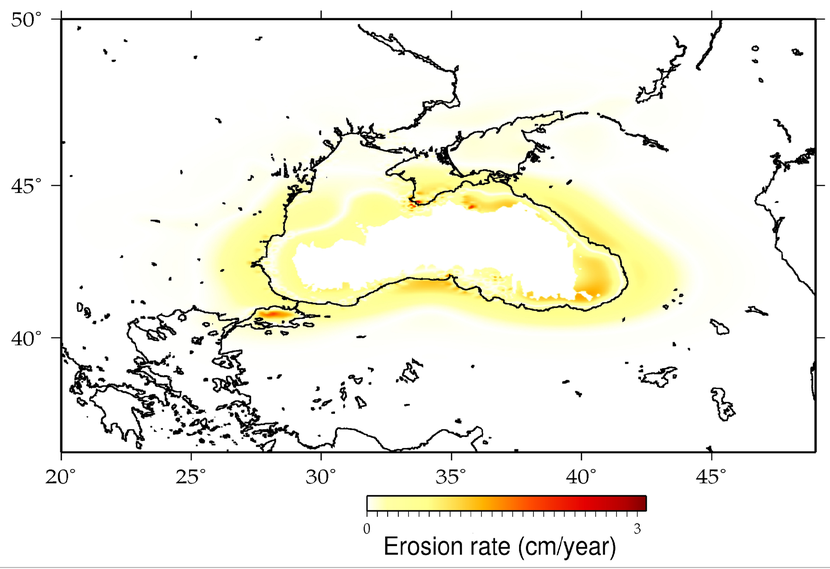
Subsidence in the south represents the flexural bulge. A similar bulge is absent in the north due to the tapering of the load (see load figure).





The effective stress distribution in the model with the negative stresses being compression and positive being extensional. In general, the highest compressive stress are recorded at the margins of the Black Sea and highest tensile stresses in the center of the basin. Also notice that the stress are symmetrical around the east-west basin axes in contrast to the flexural uplift and subsidence.

Sediment diffusivity = 10^4 m²/yr



Conclusions

- Our model results predict an uplift of about 660 meters in the center of the Black Sea and subsidence of 28 meter at its margins due to sea level drop of 1300 meter in the Black Sea.
- The flexural response causes changes in basement slope angles up to 5‰.
- Our model predict an change of erosion, or sedimentation, in especially the southern and eastern Black Sea.
- Significant marginal compression may be expected to have had an imprint on the deformation field during the Intra-Pontian.

References

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