Solid earth response to the Messinian salinity crisis

Rob Govers, Paul Meijer and Wout Krijgsman (Faculty of Earth Sciences, Utrecht University, govers@geo.uu.nl)

The salinity crisis of the Mediterranean during Messinian time was one of the most dramatic episodes of oceanic change of the past 20 or so million years. The onset at 5.96 Ma was followed by complete isolation from the Atlantic Ocean, causing a large and rapid drawdown of the Mediterranean water level, erosion and deposition of non-marine sediments in a large `Lago Mare' basin. The near instantaneous removal of the water load and the deposition of kilometers thick evaporitic sequences resulted in isostatic/flexural rebound that significantly affected river canyons and topographic slopes. We use flexure models to quantitatively predict possible signatures of the Late Messinian removal of the Mediterranean water load, and of the deposition of Lower Messinian evaporites. The highly irregular shape of the reconstructed Mediterranean basin calls for a three-dimensional model. The typical time scale of dessication events is probably approximately 3000-8000 years, which is similar to the time scale for lithospheric flexure to develop fully. We focus on the resulting uplift/subsidence, basement tilting and stresses. Near basin margins, plate-bending effects are most pronounced which is why flexure is particularly important for a relatively narrow basin like the Mediterranean. We find that regional isostasy may have resulted in vertical deformation of the margins of hundreds of meters, substantial crustal stress changes (tens of MPa near the basement top) and basement tilting up to several ‰. The model further predicts a substantial increase in erosion rates in some regions. Even if we ignore the existing variability of lithospheric properties, uplift patterns are highly variable. Prominent signatures of Late Messinian dessication in onshore geology are predicted in northern Algeria, western Corsica and Sardinia, the Nile Delta and Northern Syria. Uplift of the Gulf of Lions margin is substantially less than previously predicted on the basis of 2D models. Observations at the famous Messinian sequences on Sicily will be difficult to interpret in terms of vertical deformation because of the complexity of the flexural pattern, uncertainties in the tectonic reconstruction, and due to the nearby presence of an active plate boundary.