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Thermal evolution of the Meso-Cenozoic pelagic basin of Mt. Judica (Eastern Sicily) by means of FTIR spectroscopy on organic matter and X-ray diffraction analysis on clay mineral assemblages: implications for burial and exhumation history

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In southern Sicily, the Neogene-Quaternary Apenninic-Maghrebian orogenic front forms a wide salient convex towards the South extending offshore along the Sicily Channel in the Mediterranean Sea. The salient evolves onshore towards the East into a recess in the area of Castel di Judica, to the West of Catania. In this area, a thin Mesozoic-Cenozoic succession, in pelagic basin facies, crops out as three thrust sheets in a tectonic window, surrounded by a thick overburden made up of allochthonous tectonic units derived from the deformation of the Numidian Flysch and Sicilide Complex.

Most of the geologic factors controlling curvature geometry and kinematics in fold-and-thrust belts have been widely investigated in the literature. For example, the arcuate origin of the Sicilian thrust front has been related to the piggy-back thrust migration towards the foreland that shows a highly articulated Meso-Cenozoic paleogeography. The main salient evolved in front of a Mesozoic thin and well-bedded pelagic succession that favours thrust propagation whereas the eastern recess developed in front of the foreland that is made up of a few km thick Mesozoic carbonate platform succession (Hyblean Plateau). On the other hand, minor attention has been given to the evolution of burial and exhumation processes along the strike of the belt moving from recesses to salients. Furthermore, relationships among burial-exhumation amounts, crustal shortening and thrust wedge thickness along the external portion of fold-and-thrust belts have been rarely quantitatively investigated. This contribution investigates the Sicilian thrust front case history in order to shed new light into the understanding of recess to salient geometries and kinematics of curved fold-and-thrust belts in the Mediterranean area.

We integrated X-ray diffraction data concerning the illite content in mixed layers illite-smectite with data derived from Fourier Transform Infrared spectroscopy (FTIR) on type II organic matter to constrain 1-D thermal modelling of the burial-exhumation path of the Mt. Judica sedimentary succession in the recess area. The maximum burial calculated in the tectonic window and the restoration of balanced cross-sections along the curvature allowed us to reconstruct the wedge paleo-geometry in the recess area, to investigate the along-strike variations of the tectonic overburden, and to discuss the geodynamic causes of these changes.

Specifically, thermal constraints derived from X-ray diffraction of clay minerals and FTIR spectroscopy of type II kerogen show that the Mt. Judica succession experienced paleo-temperatures in the range of 100-130°C in late diagenetic conditions and early mature stage of hydrocarbon generation. A general trend of increasing thermal maturity as a function of depth has been recognized in the three thrust sheets with illite content in mixed layers I-S ranging from 50 to 76%. FTIR-derived indexes for the Mt. Judica succession suggest thermal maturity equivalent to Ro values of at least 0.5-0.7%, in agreement with clay mineralogical data. As a whole, the Mt. Judica succession experienced maximum tectonic burial (ranging between 2.4 and 3.2 km) during the Middle Miocene as a result of the emplacement of the allochthonous Sicilide Complex and the Numidian Flysch atop it. The subsequent breaching of the Mt. Judica succession by up-thrust geometries and erosion during Pliocene times rules out its exhumation and did not appear to affect thermal maturity because the extent of overthrusting is negligible when compared with the magnitude of vertical movements. Restoration of balanced cross-sections revealed an increase of shortening from the salient to the Mt. Judica recess with values from 12.3 km to 23.9 km, consistent with the increase of tectonic thickening of the fold-and-thrust belt. These results have been compared with theoretical models of wedge dynamics.