Integration of thermal and thermo-chronological constraints in thermal modeling of fold-and-thrust belts: the case history of the Eastern Sicily wedge

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Methods
The optical and infrared study of the organic matter dispersed in sediments and the X-ray diffraction assay of clay minerals, subordinated by apatite fission track analyses, allows the quantification of maximum sedimentary and/or tectonic loads the studied successions underwent. Furthermore, the apatite fission track analysis provided the definition of the exhumation timing, rates and magnitudes of exposed successions. Basin Model 5.1 software applications, allowed the creation of non-dimensional thermoburial models (Fig. 2).

Peloritani Mts.
Thermal, thermostructural and stratigraphic data

Paleosapopach reconstruction and thermal modelling of the SDC basin

Fig. 3 - Geological sketch map of Eastern Sicily with samples sites, red/linnet and modified after Corrado et al. (2003) and correnti et al. (2009).

Conclusions
In the decontemplative area of SDC basin, thermal parameters increase as function of depth indicating that the thermal evolution is ruled by sedimentary burial. Thermal indicators reveal a decrease in paleo-geothermal gradient values from fore-arc (55-60 essay) to thrust (17-23 essay) setting due to the geodynamic evolution from convergence to collision. In the northern area of the basin, the thermal evolution was controlled by tectonic burial related to middle Miocene out-of-sequence thrust tectonics. The emplacement of a thrust stack with maximum thickness of 3.5 km, quickly removed from late Miocene onwards by extensional tectonics and erosion only affected organic matter thermal maturity. The short time at maximum temperature (2.5 Ma) and the slow kinetic response at low temperatures of clay minerals are the reason why mixed layer I-S did not record heat emplacement (Adage et al., 2013).

Sicilide Complex

Numidian Flysch

Fig. 4 - A map of the SDC basin; b) taphoch map of the paleo-distribution of the SDC basin with samples; c) burial and thermal history of the SDC deposits; d) heating rates values for the SDC flms, e) extracted from the correlation of mineral refections and exibullity (evidence of this content is in d) data on hillmen in 1995).

For the Numidian Flysch thrust stack an increasing level of diagenesis from the uppermost to the lowermost tectono-stratigraphic units has been observed. The Nicosia Unit showed the lowest N1 values in I-S mixed layers in the range of 20-50 and Vm data between 0.36 and 0.42 in the immature stages of hydrocarbon generation. The Mt. Soro Unit displayed random oriented mixed layers I-S with an oil content of 0.5-10%. The Marsilone Unit revealed mixed-layered ordered structures with % of I-I between 66 and 79% indicating the highest levels of thermal maturity for the Numidian Flysch (Adage et al., 2007; Di Paola, PhD thesis 2011).

Mt. Judica Unit
Thermal modelling and restoration of Late Miocene wedge geometry

Wedge tapers evolution

Fig. 5 - Schematic evolution of burial exhumation of the Peloritani Mts. since Miocene

Thermal data

Fig. 6 - a) SA plateau track ages; b) Compilation of organic and inorganic thermal indicators in different geodynamic settings; c) Schematic evolution of burial exhumation of the Eastern Sicily sedimentary wedge in Aquitanian-Langhian times. A decreasing thermal maturity trend have been identified from the core of the accretionary wedge (Mt. Soro and Triona Units) to the northern backthrust Antsiscilde and southern far-traveled Sicilide Units. In detail, Mt. Soro and Triona Units record late diagenetic conditions with maximum paleotemperatures between 100 and 130°C and late Aquitanian to Langhian exhumation age. The Antsiscilde and far-traveled Sicilide Units are in the early diagenetic zone with maximum paleotemperatures of 60-100°C (Corrado et al., 2009).

Thermal and structural modeling showed that the Mt. Judica Unit experienced paleo-temperatures in the range of 94-132 °C, in deep diagenetic conditions and early mature stage of hydrocarbon generation, during the Middle Miocene as a result of the emplacement of the Sicilide Complex and the Numidian Flysch atop the Unit. From late Torritonian to Messinian, the wedge from subcritical condition evolved to a critical state thickening internally. Erosion and gravity-driven processes ruled out the last evolutionary stage leading the wedge to the present-day subcritical condition (Di Paola et al., 2012).

Final Remarks

Thrust wedge evolution vs eustasy

Fig. 7 - Synthetic stratigraphic map of the Numidian Flysch Units with sample sites red/linnet and marked after Bianchi et al. (1987).

Fig. 8 - Schematic cross-section through the Mt. Judica tectonic window after Correndi et al. 1990.

Fig. 10 - a and b: Strata thickness of the Mt. Judica Unit; b) Selected FTIR spectra of concentrated lagergon for unaltered (a) and altered (b) samples; c) selected FTIR patterns of the 12µm granoxide fraction.

Fig. 12 - a) Observed parameters; b) Simplified model for Late Miocene time; c) Schematic showing the present-day internal geometry; d) Schematic model of the wedge calculated on derived from literature.

Fig. 14 - a) Role of a and b) at the front of the Sicilide Complex; c) Thermal history of the Sicilide Complex and the Numidian Flysch (Adage et al., 2007; Di Paola, PhD thesis 2011).

Thermal and thermo-chronological data along the Eastern Sicily fold and thrust belt

The integration of organic and inorganic thermal parameters with thermo-chronological, structural and stratigraphic data performed in the main outcropping tectono-stratigraphic Units of Eastern Sicily allowed to: - create a database of 373 thermal and thermo-chronological data including those already existing in the literature (Fig. 14); - define the thermal maturity of the studied organic and inorganic materials; - reconstruct the thermal evolution of the study area using basin modelling software; and - reconstruct the 3D evolution of the Sicilide Complex and the Numidian Flysch deposits.