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Thick versus thin crustal models of Central Apennines: results and insights from an integrated structural restoration and petroleum system modelling project.

Andrea D'Ambrosio (1), Sabina Bigi (1), Lorenzo Lipparini (1), Teodoro Cassola (2), and Jan Frederik Derks (2)

(1) Sapienza University of Rome, Department of Earth Sciences (DES), Rome, Italy (a.dambrosio@uniroma1.it), (2) Software Integrated Solutions (SIS), Schlumberger, Aachen, Germany

The study area is located in Central Italy, including the Central Apennines fold-and-thrust belt front and its adjacent foredeep/foreland system.

To explain the geodynamic evolution of this orogeny, different structural crustal models have been historically proposed, a major point of discussion being the possible involvement of the basement (thin- versus thick-skinned models).

The thin-skin model considers a regional detachment level above the basement to be represented by the well-known anhydritic interval of the Burano formation (Upper Triassic), as a key element in the orogeny evolution. The Burano anhydrites are indeed known to have played a key role for the tectonic evolution of the area since the early Jurassic rifting phase, but their role in the orogeny itself it has not been clearly demonstrated.

The thick-skin structural model, viceversa, consider the involvement of the basement and a reduced shortening for the orogeny.

The study area has also been an important target for the oil&gas exploration since the last century, with several hydrocarbon occurrences found and oil&gas field discovered. This produced an important dataset of subsurface data today publically available, that we used to build different Petroleum System Models and verify which structural scenario (thin vs thick) could better explain the observed present-day hydrocarbons distribution.

We built and balanced a 2D regional section across the front of the Central Apennine and the Central Adriatic foredeep/foreland system, implementing both the two structural scenarios (thin/thick), and studying the thermal evolution of the area through the geological time following both models.

The present-day sections were built using MOVE (TM Midland Valley) and Petrel softwares, while for the structural restoration we used Dynel2D. The basin modelling work was carried out using PetroMod1D/2D (Petrel, Dynel2D and PetroMod are Schlumberger software).

As one of the results, the two models require quite different basal heat flows to calibrate and match the present-day temperature data, being necessary to assume a lower value, of 35 mW/m^2, in the the thin-skinned model in respect of 45 $mW/m^2$for the thick-skinned model. On the other hand, from the comparison with other 1D/2D models built both on-shore and off-shore in the same area, we could demonstrate that a quite homogeneous thermal evolution for the whole area is more likely associated to a present-day basal-heat-flow of 35 mW/m^2, in better agreement with the thin-skinned model.

Significant differences also emerged in terms of hydrocarbons production between the two structural scenarios, with a lower hydrocarbons production in the thick-skinned model that is not able to explain the known present-day hydrocarbon distribution.

This and other observations allow hence to calibrate not only the thermal evolution of the area, but also to define the most likely structural model, demonstrating the effectiveness of integrating structural restoration rigorous work from one side, with basin modelling exercises.

We believe that such approach resulted in a very effective way of integrating a wide range of subsurface data and produce a predictive tool to be used for example to support and de-risk future exploration efforts in this area and in the regions.