Geophysical Research Abstracts
Vol. 20, EGU2018-15879, 2018
EGU General Assembly 2018

The kinematics of the Tyrrhenian-Apennines System

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The formation of the mountain belts surrounding the Mediterranean basin has been attributed to the interaction between the African plate and Eurasia since the works of Argand (1924). Nevertheless, numerous studies demonstrated that the genesis of the Apennine chain and the simultaneous opening of the Tyrrhenian basin could not be described by the simple Argand's scheme. Since the 1970s, many authors describe the formation of the Tyrrhenian Sea in the geodynamic context of back-arc basin processes; however, most of these models did not adequately take into account the plate kinematics constraints.

Traditionally, plate kinematics has been used to describe the motion of tectonic plates at global scale, starting from a data set of marine magnetic anomalies and fracture zones but, in complex collisional tectonic settings, where the oceanic lithosphere has been almost completely subducted, the basic data set for determining plate motions is mostly missing. In this scenario, another limitation of classic plate kinematics is represented by the assumed rigidity of the tectonic elements during their motion, with well-defined boundaries. Conversely, the formation of mountain chains is a process that can be described in terms of ductile behavior of the rock systems, without any possibility to identify rigid blocks.

In this work, we present a new approach to the structural and tectonic analysis of the Tyrrhenian–Apennine system since the early Burdigalian, based on a non-rigid plate kinematics approach. In this framework, the tectonic structures within a deformable region are used to determine both the finite strain of the block and its motion with respect to a reference frame. Our approach, therefore, allows to determine finite rotations for the tectonic blocks involved in the evolution of the Apennine chain.

We divide the Apennine chain into six deformable sectors: 1) Tuscany-Emilian Apennine; 2) Umbria-Marche Apennine; 3) Lazio-Abruzzi Apennine;4) Southern Apennine; 5) Calabrian Arc; 6) Maghrebide-Sicilian Chain.

The reconstruction of the Apennine chain at the onset of Tyrrhenian Sea opening (19 Ma) shows that the Tuscany-Emilian chain was crossed by a left-lateral transpressional structure linking the Calabrian arc to the western Alpine trench. The formation of a new extension centre to the East of Sardinia followed shortly cessation of sea-floor spreading in the Ligurian-Provencal Basin. This new extensional phase determined the onset of shortening in the Umbria-Marche domain. At the same time, the Calabrian arc overthrust the Panormide, Lagonegro, and Imerese domains.

The relative motion between the 1-2-5-6 sectors determined transversal extension along the mountain belt, with exhumation of deep portions the chain and formation of wedge-top deposits. The formations associated with this process are the Marnoso-Arenacea fm in Romagna and the Irpinian unitse, which bound the Umbria-Marche sector respectively to the North and to the South. The latter extensional center, in origin placed between the Calabrian Arc and the Umbria-Marche sector, propagated southwards within the Calabrian Arc, with exhumation of northern Calabria (Lagonegro Units) and formation of the Catanzaro Trough, Crati and Crotone basins.