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Growth mechanisms and scaling properties of the Monte Alpi fault network, Southern Apennines (Italy): implications for the evolution of the Messinian foreland basin system

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The Monte Alpi massif is predominantly made up of Mesozoic carbonates pertaining to the Inner Apulian Platform, which are topped by a mixed carbonate-terrigenous sedimentary succession representing the infill of a Messinian foreland basin system. The present work integrates the results of a detailed field survey with those after 3D geological reconstruction of the Monte Alpi massif and surrounding areas. Field analyses focused on the textural, compositional and overall stratigraphic properties of the exposed Messinian succession, and on the structural setting of outcropping syn-sedimentary Early Cretaceous, Early Messinian, and Late Messinian extensional faults. 3D geological reconstruction, obtained by mean of the Gocad software, aimed at modelling both stratigraphic horizons and faults of the Monte Alpi Unit, permitted to compute individual throw profiles for all faults pertaining to the Monte Alpi network, and hence assess their dimensional properties.
Results of the aforementioned work are expressed as Displacement-Length values (D/L) of individual faults computed for pre-Messinian (ca. 1*10-2), Early Messinian (ca. 5*10-2), and post-Early Messinian times (ca. 1.5*10-1), and as slopes of the fault growth line during the same time intervals. Both pre-Messinian and Early Messinian fault growth lines are characterized by slope of ca. 1, whereas the post-Early Messinian line is significantly steeper (ca. 1.5). This discrepancy could be due to slip localization along laterally restricted extensional faults, which hence developed by linking originally isolated fault segments during the earliest stages of foreland basin formation. This deformation gave thus birth to half-graben depocenters, which modified their orientation through time due to activity of an orthogonal fault system.
Based upon the results of combined field and laboratory analyses, we propose a conceptual model of foreland basin system evolution, in which the progressive, foreland-directed migration of the Southern Apennines orogenic wedge caused first the development of an Early Messinian back-bulge basin by predominant NW-SE and minor ENE-WSW striking extensional faults. Then, as recorded by the angular unconformity between Early and Late Messinian deposits, extensional faulting localized in the forebulge area causing uplift, exhumation, and tilting of both Mesozoic and Early Messinian rocks. Nucleation and subsequent development of the Upper Messinian foredeep basin, due to along-foredeep stretching, was characterized by isolated half-graben depocenters mainly bounded by NW-SE faults, in which up to 600 m-thick terrigenous sediments were deposited. Compared to the 1,000's m-thick Lower Pliocene and Upper Pliocene – Lower Pleistocene foredeep infills, the Upper Messinian succession is interpreted as due to a first-order stage of forebuldge progradation, which occurred during a rapid migration of the southern Apennines fold-and-thrust belt.