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Cross-cutting relationships between the Sibillini Mts. Thrust and Mt. Vettore normal fault system (Central Apennines, Italy)

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We present the results of a detailed geological mapping project performed in the southernmost part of the Sibillini Mts., where the Sibillini Thrust (ST), one of the longest compressional structures of the Central Apennines, crops out. In the studied area the Meso-Cenozoic Umbria-Marche carbonate succession overthrusts the Messinian siliciclastic deposits of the adjacent Laga foredeep Basin. After the Messinian/Pliocene compressional tectonic phase, linked with the development of essentially W-dipping thrust systems, the E-verging Apennines accretionary wedge was affected by a Quaternary extensional tectonic phase during which SW-dipping normal fault systems developed. Among these normal faults, the Mt. Vettore extensional system (which includes the Castelluccio Plain fault (CPF) and the Mt. Vettoretto fault (MVF)) is one of the most important, being capable to produce destructive earthquakes (Mw 6.5 October 20, 2016). A long-lasting debate exists in literature concerning the cross-cutting relationships between the ST and the Mt. Vettore normal fault system: i.e., the thrust was alternatively considered as being nondisplaced by the normal faults or variously displaced with throws ranging between ~200 m and >2 km. Unfortunately, where normal faults should cut the thrust, a thick debris cover hides the tectonic structures and only speculative hypotheses can, thus, be done about this issue. In addition, important evidence of pre-thrusting extension is known in the area, that make difficult to discriminate the effective Quaternary activity of faults if the intersection with the compressional structures is not exposed. The aim of this study is to constrain the position of the ST under the debris cover and its relationship with the CPF and MVF, based on the following field data: i) thrust plane attitude; ii) position of the Laga Fm. outcrops, representing the footwall of the ST; iii) hanging wall anticline geometry; iv) geometry of normal faults and their recent activity; v) thickness of the Castelluccio Plain Quaternary infill at the hanging wall of the ST. The thrust position under the debris cover has been determined considering the variation of the hanging wall anticline geometry. In fact, where the Jurassic-Paleogene basinal formations crop out, the hanging wall anticline is well developed with vertical to overturned forelimb and fold axis essentially parallel to the thrust trend. This is crucial, because the occurrence in the field of an incomplete anticline (i.e., lacking the vertical to overturned forelimb) juxtaposed to the Laga Fm. (originally the footwall of the thrust) suggests the displacement of the anticline by a normal fault, allows us to infer the cross-

cutting relationship between the tectonic lineaments and to estimate Quaternary normal fault throws. We conclude that the ST was displaced by the CPF with max throw ~250 m, which is consistent with the thickness of the Quaternary infill of the Castelluccio Plain. Both the CPF and the ST are in turn cut by the MVF (the youngest fault of the area, active in the 2016 earthquake) with a ~50 m throw, and is also inferred to partly reuse with negative inversion the ST plane where the plane geometry was favorable to extension.