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A mechanical model for complex fault patterns induced by evaporites flowage: a regional case study from the Umbria-Marche Apennines, Italy

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Three main tectonic phases affected the Umbria-Marche Apennines (Central Italy) since the Early Jurassic time: Jurassic extension, driving the dismembering of the regional carbonate platform and the consequent differentiated environments in the pelagic basin; Upper Miocene-Lower Pliocene compression, generating the Umbria-Marche thrust and fold belt; and Upper Pliocene-Quaternary extension, driving the formation of intramountain continental basins and the present-day seismogenesis. During this tectonic evolution, the mechanical behaviour of the Triassic Evaporites, a 1-2 km thick sequence interposed between the Permian-Triassic phyllitic basement and the Meso-Cenozoic carbonate multilayer is a still debated issue: the Evaporites (consisting of alternated anhydrites and dolomites) are generally considered as the main décollément level of the Umbria-Marche thrust and fold belt; however the recent earthquakes of the Umbria region are located within the Evaporites, indicating a brittle behaviour during the still on-going extensional tectonics. The behaviour of the Triassic Evaporites during the Jurassic extensional phase is uncertain. Since Middle Lias extensional fault activity dismembered the regional carbonate platform into several, relatively small (few km), fault bounded blocks. We digitised the jurassic synsedimentary fault pattern at the regional scale on the grounds of the available geological maps, characterising each fault in terms of attitudes, length and throw (i.e. vertical displacement). Statistical analysis of the orientation of the Jurassic faults shows a largely scattered orientation, a high grade of fragmentation and a constant length/displacement ratio with an average length of about 10 km. The measured stratigraphic throw range from 300 m to 700 m leading to very low average slip rates in the order of less than 0.1 mm/yr. The development and evolution of the analysed fault pattern is difficult to

explain in terms of classic bimodal conjugate andersonian fault patterns. In fact, the direction of maximum extension (orthogonal to the faults) does not univocally cluster identifying a specific horizontal direction. We used a mechanical model based on the notion that slip on faults is controlled by the balance between resolved shear stress and the magnitude of frictional resistance to find a stress field that could explain the development of the obtained deformation pattern. The mechanical model is sensitive to a shape factor which is function of the ratio of the principal stress differences (i.e. low values of the shape factor imply a isotropic horizontal stress field). The best fit to our data has been found for very low values of the shape factor, implying that the horizontal stress field was almost isotropic consistent with the lack of a well defined regional extensional field. On the basis of both dataset analysis and the mechanical model results, we propose a scenario where faulting, during the Jurassic extensional episode, has been rather induced by some kind of flowage in the ductile Triassic Evaporites under weak to absent regional extensional field.