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Polyphase tertiary fold-and-thrust tectonics in the Belluno Dolomites: new mapping, kinematic analysis, and 3D modelling

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The Belluno Dolomites are comprised in the eastern sector of the Southern Alps, which corresponds to the fold-and-thrust belt at the retro-wedge of the Alpine collisional orogen. They are characterized by a complex and polyphase fold-and-thrust tectonics, highlighted by multiple thrust sheets and thrust-related folding. We have studied this tectonics in the Vajont area where a sequence of Jurassic, Cretaceous and Tertiary units have been involved in multiple deformations. The onset of contractional tectonics in this part of the Alps is constrained to be Tertiary (likely Post-Eocene) by structural relationships with the Erto Flysch, whilst in the Mesozoic tectonics was extensional. We have recognized two contractional deformation phases (D1 and D2 in the following), of which only the second was mentioned in previous studies of the area and attributed to the Miocene Neoalpine event. D1 and D2 are characterized by roughly top-to-WSW (possibly Dinaric) and top-to-S (Alpine) transport directions respectively, implying a 90° rotation of the regional-scale shortening axis, and resulting in complex thrust and fold interference and reactivation patterns. Geological mapping and detailed outcrop-scale kinematic analysis allowed us to characterize the kinematics and chronology of deformations. Particularly, relative chronology was unravelled thanks to (1) diagnostic fold interference patterns and (2) crosscutting relationships between thrust faults and thrust-related folds. A km-scale D1 syncline, filled with the Eocene Erto Flysch and "decapitated" by a D2 thrust fault, provides the best map-scale example of crosscutting relationships allowing to reconstruct the faulting history. Due to the strong competence contrast between Jurassic carbonates and Tertiary flysch, in this syncline spectacular duplexes were also developed during D2. In order to quantitatively characterize the complex interference pattern resulting from two orthogonal thrusting and folding events, we performed a dip-domain analysis that allowed to categorize the different fold limbs and reduce the uncertainty in the reconstruction of the fault network topology in map view. This enabled us to reconstruct a high-quality, low-uncertainty 3D structural and geological model, which unambiguously proves that deformations with a top-to-WSW Dinaric transport direction propagate farther to the west than previously supposed in this part of the Southern Alps. Our new structural reconstruction of the Vajont valley have also clarified the structural control on the 1963 catastrophic landslide (which caused over 2000 losses). Besides being a challenging natural laboratory for testing analysis and modelling methodologies to be used when reconstructing in 3D this kind of complex interference structures, the Vajont area also provides useful clues on the still-enigmatic structures in the frontal part of the Friuli-Venetian Southern Alps, buried in the Venetian Plain foredeep. These include active seismogenic thrust-faults and, at the same time, represent a growing interest for the oil industry.