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A natural fiber composite in a pelagic limestone-chert sequence. The importance of mechanical stratigraphy for fracture type development in carbonate anticlines.

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Thrust fault-related folds in carbonate rocks are characterized by deformation accommodated by different kinds of structures, such as joints, faults, pressure solution seams (PSSs), and deformation bands, which may form at various stages during the folding process. Defining the distribution, orientation, and the type of fold-related structures and understanding the relationships between folding and fracturing is significant both for theoretical and practical purposes. Furthermore, as the deformation related to the folding process influences fluid flow through rocks, identifying the types of structures formed during folding is as important as predicting their geometries.

To unravel the relationship between mechanical stratigraphy and folding process, the well-exposed Cingoli anticline (Northern Apennines), has been studied in detail. The Upper Cretaceous-Middle Eocene stratigraphy of the Cingoli anticline is characterized by a pelagic multilayer made up of fine-grained pelagic limestones and, marly limestones, in places alternated with thin continuous chert layers. The presence of several outcrops located in different structural positions of the anticline makes the Cingoli anticline an excellent natural laboratory to investigate relationships between folding, fracturing, and mechanical stratigraphy relative to the structural setting of the fold.

The field data collected show that high angle to bedding PSSs, which formed before tilting and during the first stage of folding, are not homogeneously distributed in the pelagic limestones. Generally, high angle to bedding PSSs form in the marly pelagic limestones and they have been observed in several outcrops and in different structural positions except where the marly limestones are inter-bedded with stiffer chert layers.

In order to analyse theoretically what observed in the field, we compared the deformation of limestones and chert layers with the deformation acting on fiber composites. In the mechanics of materials, composites refer to a matrix reinforced with particles, fibers, or laminae. During the early stage of folding, when the compressive stress is almost bedding parallel, chert layers act as a stiff lamina embedded in a weak limestone matrix. As a result, the stress is partitioned and the chert layers bear the greatest stress. Considering the mechanical properties (Poisson and Young's modulus) of the two materials (chert and limestone), and the estimated tectonic stress acting at the onset of the folding process, the stress magnitude in the limestone beds does not reach the expected value for the onset of pressure solution. For this reason, pelagic limestones containing chert layers are mainly characterized by joints whereas PSSs form in pelagic limestones without the stiffer phase (chert).

This study suggests that within the same fold, and even within the same formation, different mechanical units can be characterized by different fractures types and fluid flow behaviour as a result of mechanical stratigraphy distribution.