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Constraints on deformation mechanisms during folding provided by rock physical properties: Case studies from Laramide uplifts (Wyoming, USA)

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Two original examples of exploitation of Anisotropy of Magnetic Susceptibility (AMS) for rocks with weak magnetic susceptibility are used to unravel the history of strain during folding in the Southern Rocky Mountains. The Sheep Mountain anticline (Wyoming, USA) and the Split mountain anticline (Utah, USA) are two well-exposed, basement-cored folds that formed during the Laramide orogeny in the early Tertiary. Combined assessments of anisotropy of magnetic susceptibility (AMS), anisotropy of P-wave velocity (APWV) and Fry strain analyses at the matrix scale, were carried out to reconstruct the framework of the diagenetic and macroscopic fracture network evolution.

At Sheep Mountain, the results are compared to previously published stress–strain data from calcite twins at the microscopic scale and from fracture sets at the mesoscopic scale. We observe a good agreement between (1) the principal axes of the AMS and APWV tensors, (2) stress–strain tensors derived from calcite twins, (3) Fry strain axes and mesoscopic fracture sets. Furthermore, tensors's principal axes are compatible with the orientation of the main structural trends of the anticline. The differences between AMS and APWV fabrics on one hand and the differential stress values of the forelimb and the backlimb on the other hand, emphasize how the macroscopic asymmetry of Sheep Mountain anticline affects the strain pattern at the microscopic scale.

In the symmetric Split Mountain anticline, results are compared to the diagenetic evolution of the rock petrophysical characteristic and to the evolution of the fracture network. A scenario of strain record is proposed based on the correlation of (1) fracture sets orientation, (2) diagenetic cementation, (3) paleostresses and (4) distribution of magnetic susceptibility anisotropy. Following the Sevier orogeny and N120 fracture set emplacement, the N035 fracture network and AMS signal were recorded during the Laramide Layer Parallel Shortening phase, with local deviation along pre-existing structures, and recorded a partitioning of the strain during early folding, with a maximum horizontal stress axis perpendicular to the fold bounding faults within the fold. Mechanical modeling of the folding of the Weber sandstone demonstrates the need for an evolving constitutive law, which integrates the role of preexisting fracture set during folding.