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Fold-fracture relationships in a Laramide basement-cored fold, Rattlesnake Mountain Anticline, Wyoming

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Folding is one of the main tectonic mechanism that accommodates shortening. Deformation of folded strata in buckle, detachment, fault propagation or forced folds is accommodated by various mechanisms such as fracturing or pressure-solution. Conceptual, physical, and numerical models have attempted to predict the fracture patterns from various fold shapes and kinematics. However, these models remain poorly predictive in terms of spatial distribution and sequence of development of fracture patterns, especially in basement-cored folds. Additional field-based data are therefore required to better constrain models of fold-fracture relationships.

In this contribution, we present new microstructural data collected at Rattlesnake Mountain Anticline (RMA), a basement-cored Laramide fold in Wyoming, USA. RMA is a famous anticline located on the northwest edge of Big Horn Basin, in the Laramide foreland. This asymmetrical fold formed above a high-angle basement thrust during the end of Cretaceous-early Tertiary. The excellent exposures of both the granitic basement and the overlying Paleozoic sedimentary sequence makes it a suitable place to study fracture patterns.
The detailed study of fracture pattern at both meso- and micro-scales in the Precambrian granitic basement and the limestones and sandstones of the Paleozoic cover is used to constrain the chronological sequence of fracture development. Stress tensors determined from inversion of fault-slip data help to relate the different fracture sets either to the pre-Laramide history or to the different stages of Laramide fold evolution (i.e. from Layer-Parallel Shortening – LPS – to late fold tightening).

We propose a new balanced cross-section of the fold and a new kinematic scenario including the constraints provided by the fracture chronology, with special emphasis on the role of pre-existing basement heterogeneities on strain localization in the cover.

Since high fracture densities are observed in fold domains suffering low curvature, and far away from the thrust zone, we also challenge the viability of models predicting the orientation of fractures from fold shape only and the capacity of trishear fault-propagation folding model to reliably account for the strain pattern in basement-cored folds.

We finally compare the fracture pattern at RMA with the fracture pattern at Sheep Mountain Anticline, a similar basement-cored fold located in the eastern part of the Big Horn Basin where the underlying basement thrust remains buried. This comparison thus allows discussion of the possible influence of the amount of displacement along the basement thrust on the fracture pattern.

Our results help to refine the classical models of forced-fold/fracture relationships and highlight the need of considering pre-folding fractures in order to propose more realistic conceptual models.