Evaluation of Faulting Mechanisms by Fracture Analysis of Normal Faults Exposed on the Rock Springs Uplift, Southwest Wyoming

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The Rock Springs Uplift (RSU) in southwestern Wyoming is under evaluation as a site for future carbon sequestration. As part of a thorough site-characterization, normal faults exposed at the surface are being studied to determine timing, initiation, depth, and structural controls on fault orientation. The primary field area for this research is the northeast flank of the uplift, a promising location for CO_2 injection because of its close proximity to the Jim Bridger Power Plant, which emits up to 18 Mt of CO_2 per year. This study seeks to understand ENE-WSW-trending faults that are close to a stratigraphic test well as well as in a potential CO_2 migration pathway. The faulting mechanism(s) (e.g., outer-arc stretching by normal faulting during folding, pre-Laramide extension due to forebulge migration, syn-Laramide strike-slip faulting or post-Laramide rifting) and resulting fractures need to be understood to assess CO_2 seal integrity. The RSU is a doubly-plunging anticline oriented north-south. The uplift is the result of a basement-rooted, north-trending, east-dipping, blind reverse fault that underwent multiple episodes of motion during the Laramide Orogeny (Campanian, Maastrichtian, and Paleocene to early Eocene). Faults exposed at the surface on the western flank are oblique to the fold axis and strike NE; faults systematically rotate towards ENE on the eastern flank of the uplift. Fractures proximal to faults on the RSU were measured to determine paleo-stress and strain orientations. On the NE flank, conjugate geometries (377 fracture measurements) indicate that the average sigma 1 is nearly vertical, average sigma 2 is oriented at an azimuth of 88 degrees, and average sigma 3 is oriented at an azimuth of 178 degrees. Few localities contain strike-slip fracture sets. Seven preserved striations on the NE flank have rakes of 76-86 degrees from east and 88 degrees from west. The orientation of sigma 3 (direction of extension) is almost perpendicular (78°) to the average fault trace, which indicates down-dip movement along with striations. On the SW flank of the uplift, faults are oriented NE-SW with both normal (n= 34) and strike-slip (n =13) conjugate fault geometries. Striations were not found. Horizontal shortening associated with strike-slip faulting parallels the expected Laramide N66E compression. The extensional direction from both strike-slip and normal faulting is WNW-SSE, perpendicular to Laramide compression. Since the RSU is oblique to most Laramide NW-trending structures, hypotheses predict that a strike-slip component should be present. Fractures measured on the SW flank contain a strike-slip component and show compression and are oriented parallel to Laramide compression. Fractures measured on the NE flank are mostly extensional, which is probably the product of outer-arc stretching because paleo-stress orientations show extension perpendicular to the hinge. The rotation of fault orientations across the uplift may indicate the transition between two different faulting mechanisms, strike-slip faulting from Laramide compression on the SW flank and normal faulting due to the combination of extensions roughly perpendicular to both the regional compression and the fold axis. The fact that the faults are related to outer arc extension in the RSU suggests that they might not continue to depth, where deformation may be dominated by thrust faulting related to the master thrust of the RSU.