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Deformation bands and their relationship to faults associated with unconformity-related uranium deposits; a case study and comparison of the C1 and WS fault zones in the eastern Athabasca Basin

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Summary

In northern Saskatchewan, world-class uranium deposits are associated with the unconformity between the Proterozoic Athabasca Basin and underlying Archean-Paleoproterozoic basement rocks. Many deposits exhibit a strong spatial association with post-Athabasca faults formed by reactivation of basement-rooted structures. Deformation bands are products of localized strain in highly porous sediments and are commonly associated with fault damage zones; they can modify porosity due to grain rotation and granular flow and can act as fluid baffles or conduits. In this study we investigate deformation bands in the sandstones of the basal Manitou Falls Group in eight drill-hole fences transecting two prominent fault corridors in the eastern Athabasca Basin: the NNE-trending (025°–035°) C1 fault corridor, which comprises three main faults (Offset, G, and Basal) and hosts the Gryphon deposit; and the WS shear zone, one of several faults defining a 055°–060°-trending splay of the main C1 trend, and which hosts the Phoenix deposit. Our results indicate that compaction and cataclastic bands increase in abundance close to projected damage zones, and are especially evident in the hanging wall of the faults. The proportion of cataclastic bands also increases with depth. Paleostress analysis performed using orientation data from basement and sandstone-hosted brittle structures from respective corridors identified two major stress regimes. In the first case (Stress regime A) $\sigma1$ and $\sigma3$ lie in the horizontal plane, consistent with strike-slip faulting, and $\sigma1$ is perpendicular to the strike of the corridor. For this regime, $\sigma1$ shifts in orientation from the C1 to WS corridors, in each case maintaining a roughly perpendicular relationship to the fault. The second case (Stress regime B) is also compatible with strike slip motion, but in this case $\sigma1$ lies close to parallel to the fault; a similar adjustment in stresses to the local fault orientation is also observed. While theoretically strike-slip, the first of these regimes (A) would have been favourable for reverse/thrust reactivation of pre-existing basement-rooted structures, and this is independently corroborated by reverse offset of the unconformity, especially along the C1 corridor. Stress regime B may have been associated with younger sinsitral strike-slip motion but supporting evidence is lacking. Under a given regional stress regime, it thus appears that pre-existing basement-rooted faults exerted a strong influence on the local stresses encountered in each corridor and controlled deformation. Further work aims to improve understanding of deformation band genesis its relationship to faulting and fluid movement associated with uranium mineralization.