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Significance of first-order faults in folding mechanically isotropic layers: evidence from the Sudbury Basin, Canada.

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The Sudbury Basin in Canada is a fold basin demarcated by the Sudbury Igneous Complex (SIC). Folding of the SIC is particularly notable due to its petrographically distinct but mechanically similar layers that are hardly strained when compared to folded strata in other deformed terranes. The Sudbury Basin has three ranges, the North Range, the South Range, and the East Range. The East Range differs from the other ranges by inclosing a remarkably shorter SIC segment with a strong concave curvature. Lacking significant mechanical anisotropy and solid-state strain within the SIC brings to question how the SIC in the East Range acquired its curvature.

To address this question, we analyzed the orientation of prominent km-scale faults and their slip vectors. These faults transect the SIC at low angles and mimic its plan view curvature suggesting that the faults were folded along with the SIC. We have developed a G.I.S.-based workflow to address this problem that harnesses high-resolution LiDAR data to generate near surface fault geometries, and combines these geometries with local fault-slip inversions of slickensides to identify slip vectors of prominent curved faults. Analysis of slip vectors along curved faults yields clusters of slip vectors with normal and reverse slip motion in the northern and southern fault segments, respectively. The variation in slip vectors is interpreted to be non-primary and thus shows a temporal relationship between faulting and folding of the SIC. Therefore, prominent curved faults in the East Range must have occurred as a pre-folding brittle response to horizontal shortening. These faults later assumed the role of mechanical anisotropic elements necessary for folding of the SIC layers to occur. This interpretation is corroborated by two sets of principal strain axes inferred from fault-slip inversions. The first set is characterized by its principal axis of shortening oriented NW-SE, comparable in orientation to regional shortening as inferred from the orientation of large-scale folds and faults as well as from fault-slip inversions of brittle shear faults. The second set is characterized by its principal axis of shortening oriented sub-vertically, interpreted as the result of rotation around a progressively inclining fold axis associated with the concave curvature of the SIC. We conclude that the variability in slip on these prominent faults is an effect of progressive deformation rather than a result of multiple deformation increments. These results are significant not only to describe the structural evolution of the eastern portion of the SIC but also to outline an efficient and non-invasive method to analyze structures in rocks of any age.