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Role of kilometer-scale weak circular heterogeneities on upper crustal deformation patterns: evidence from scaled analogue modeling and the Sudbury Basin, Canada

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The Sudbury Basin is a non-cylindrical fold basin occupying the central portion of the Sudbury Impact Structure. The impact structure lends itself excellently to explore the structural evolution of continental crust containing a circular region of long-term weakness. In a series of scaled analogue experiments various model crustal configurations were shortened horizontally at a constant rate. In mechanically weakened crust, model basins formed that mimic several first-order structural characteristics of the Sudbury Basin: (1) asymmetric, non-cylindrical folding of the basin, (2) structures indicating concentric shortening around lateral basin termini and (3) the presence of a zone of strain concentration near the hinge zones of model basins. Geometrically and kinematically this zone corresponds to the South Range Shear Zone of the Sudbury Basin. According to our experiments, this shear zone is a direct mechanical consequence of basin formation, rather than the result of thrusting following folding. Overall, the models highlight the structurally anomalous character of the Sudbury Basin within the Paleoproterozoic Eastern Penokean Orogen. In particular, our models suggest that the Basin formed by pure shear thickening of crust, whereas transpressive deformation prevailed elsewhere in the orogen. The model basin deformed by thickening and non-cylindrical synformal buckling, while conjugate transpressive shear zones propagated away from its lateral tips. This is consistent with pure-shear deformation of a weak circular inclusion in a strong matrix. The models suggest that the Sudbury Basin formed as a consequence of long-term weakening of the upper crust by meteorite impact.