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Using map view deformation patterns to constrain 3D kinematic models: the Sudbury Basin, Canada

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The Sudbury Igneous Complex (SIC) is the remnant of a layered impact melt sheet and has undergone Proterozoic deformation. The SIC forms an asymmetric basin, the southern limb of which dips steeply and is marked by metamorphic mineral fabrics. Based on surface structural, seismic, aeromagnetic and gravity data, we present a 3D model of the subsurface geometry of the SIC. The surface structural data comprises measurements of planar mineral shape fabrics, brittle shear faults and brittle-ductile shear zones. We use the software Move (Midland Valley) to perform deformation by shearing, folding and displacement along faults with the aim of restoring the pre-deformational geometry of the SIC. We apply both forward and backward modelling of deformation in order to identify the most plausible deformation mechanism and estimate magnitudes of displacement and shear. For the forward models an initially symmetrical bowl-shaped basin is further deformed by folding and faulting of the SIC to match the observed surface exposure of shear zones and the geometry of the SIC. Thereby, the magnitudes of displacement, simple shear and rotation are delimited. Conversely, backward modelling aims to define more closely the geometric boundary conditions, i.e. the basin shape prior to deformation and the current geometry of the SIC at depth. Structures observed at surface, such as zones of pervasive metamorphic mineral fabrics and faults, mark the location of strained rocks on a section. Cross-sections parallel to the principal shortening direction and to the short axis of the elongated basin are used for backward modelling of deformation. By combining these sections to a 3D model, the original shape of the layered igneous complex is inferred. The validity of the 3D models is tested by comparison of strain profiles from forward modelling with observed deformation fabrics. Our modelling approach promises to result in reasonably accurate estimates of the deformation mechanisms, geometry of lithological contacts, orientation of shortening directions, and the location of faults and mineral fabrics.