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Deformation mechanisms during folding of the eastern Sudbury Igneous Complex, Canada.

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The 1.85 Ga Sudbury Igneous Complex (SIC) in central Ontario is now widely considered to be the erosional remnant of a deformed paleo-horizontal impact melt sheet, about 2.5 km in thickness. Deformed impact breccias of the Onaping Formation and post-impact metasedimentary rocks overlie the layered SIC, which in turn rests on shocked Archean and Paleoproterozoic country rocks. Previous workers considered non-cylindrical folding and NW-directed reverse faulting as the main structural processes that formed the asymmetric syn-formal geometry of the SIC apparent today in combined map view and seismic section. Structural studies support this model in the southern part of the impact structure, where greenschist-facies metamorphic tectonites accomplished structural uplift of the southern SIC by NW-directed reverse shearing. However, little evidence for fold-induced strain has been reported from the weakly metamorphosed eastern part of the SIC, characterised by steep basal dips and strong curvature in plan view. The objective of this study is to assess the structural inventory of the NW-SE trending eastern SIC, the East Range, in terms of post-emplacement deformation mechanisms. The study is based on published and newly acquired structural data.

Planar mineral shape fabrics of cumulate plagioclase and pyroxene are developed in the intermediate gabbroic and lower noritic layers of the southern East Range SIC. Microstructures show little intracrystalline deformation in quartz, cumulate plagioclase retains an angular outline indicating magmatic mineral fabric development. The magmatic foliation is concordant to SIC contacts or large scale brittle structures in their vicinity. In the northern East Range tectonic foliations and S-C fabrics are developed sporadically at and concordant to brittle structures striking N-S. A weak tectonic foliation defined by chlorite that replaces magmatic minerals is developed in the upper granophyric SIC of the NE-lobe that connects the SIC's North and East Ranges in a 105° arc. This foliation is grading into a shape-preferred orientation of primary mafic minerals observed in the lower granophyre and underlying layers of the SIC. Mineral fabrics observed in the NE-lobe are parallel to ductile foliations developed in the overlying Onaping Formation breccias and axial-planar to the presumed fold axis of the NE-lobe.

The concordance of magmatic and tectonic mineral shape fabrics in the NE-lobe indicates continuous deformation of the SIC throughout cooling from the magmatic state to greenshist-facies metamorphic conditions. Furthermore, maximum principal stress directions inferred from inversion of fault-slip data collected in the Onaping Formation are orthogonal to ductile foliation at the same localities. This points to a similar deformation regime during ductile and brittle deformation. Concordance of magmatic and solid state, ductile and brittle fabrics can be explained best by one progressive deformation event. The syn-magmatic deformation of the SIC indicates the emplacement into a tectonically active orogen. The lack of pervasive ductile deformation fabrics in the East Range SIC can be explained by rapid cooling of the impact melt sheet (within 100-500 ka) with reference to natural tectonic strain rates, as well as efficient strain localisation in the partially solidified SIC. The geometry of mineral fabrics in the study area is compatible with large-scale, non-cylindrical folding of the eastern Sudbury Structure. This deformation mechanism may accomplish bulk NW-SE shortening that is accommodated by reverse shearing in the western part of the impact structure.