Deformation mechanisms in the eastern Sudbury Igneous Complex, Canada: Evidence for meteorite impact into an active orogen *Vortrag*

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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 melt breccias of the Onaping Formation and post-impact metasedimentary rocks overlie the layered SIC, which in turn rests on shocked Archean basement and Paleoproterozoic cover rocks. The main mass of the Igneous Complex is subdivided from top to bottom into granophyre, quartz-gabbro and norite layers. 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 in map view and seismic section. Structural studies support this model in the southern part of the impact structure, where greenschist-facies metamorphic tectonites of the South Range Shear Zone (SRSZ) accomplished structural uplift of the southern SIC by NW-directed reverse shearing. However, little evidence for pervasive ductile strain has been reported from the weakly metamorphosed eastern part of the SIC, the East Range, which is characterised by steep basal dips and maximal curvature in plan view. The objective of this study is to assess the structural inventory of the East Range in terms of post-emplacement deformation mechanisms. Our interpretation is based on published and newly acquired structural data.

Planar mineral shape fabrics of cumulate plagioclase and pyroxene are developed in the intermediate quartz-gabbro and lower norite layers of the southern East Range SIC. Microstructures show little intracrystalline deformation in quartz. Euhedral cumulate plagioclase retains an angular outline indicating magmatic mineral fabric development. This magmatic foliation is concordant to SIC contacts or large-scale discontinuities in their vicinity (Fig. 1). Magmatic fabrics are observed rarely in the northern portion of the East Range. Here, 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 via a 105° arc. This foliation grades into a shape-preferred orientation of primary, i.e., magmatic, mafic minerals observed in the lower granophyre and underlying layers of the SIC. Mineral fabrics observed in the NE-lobe SIC are concordant to metamorphic foliations developed in the overlying Onaping Formation breccias. Both foliations strike parallel to the NE-Lobe's acute bisectrix and, thus, display an axial-planar geometry typical for fabrics formed in the core of a buckle fold (Fig. 1). Brittle structures including centimetre-scale shear-fractures to kilometre-scale fault-zones are observed in the eastern

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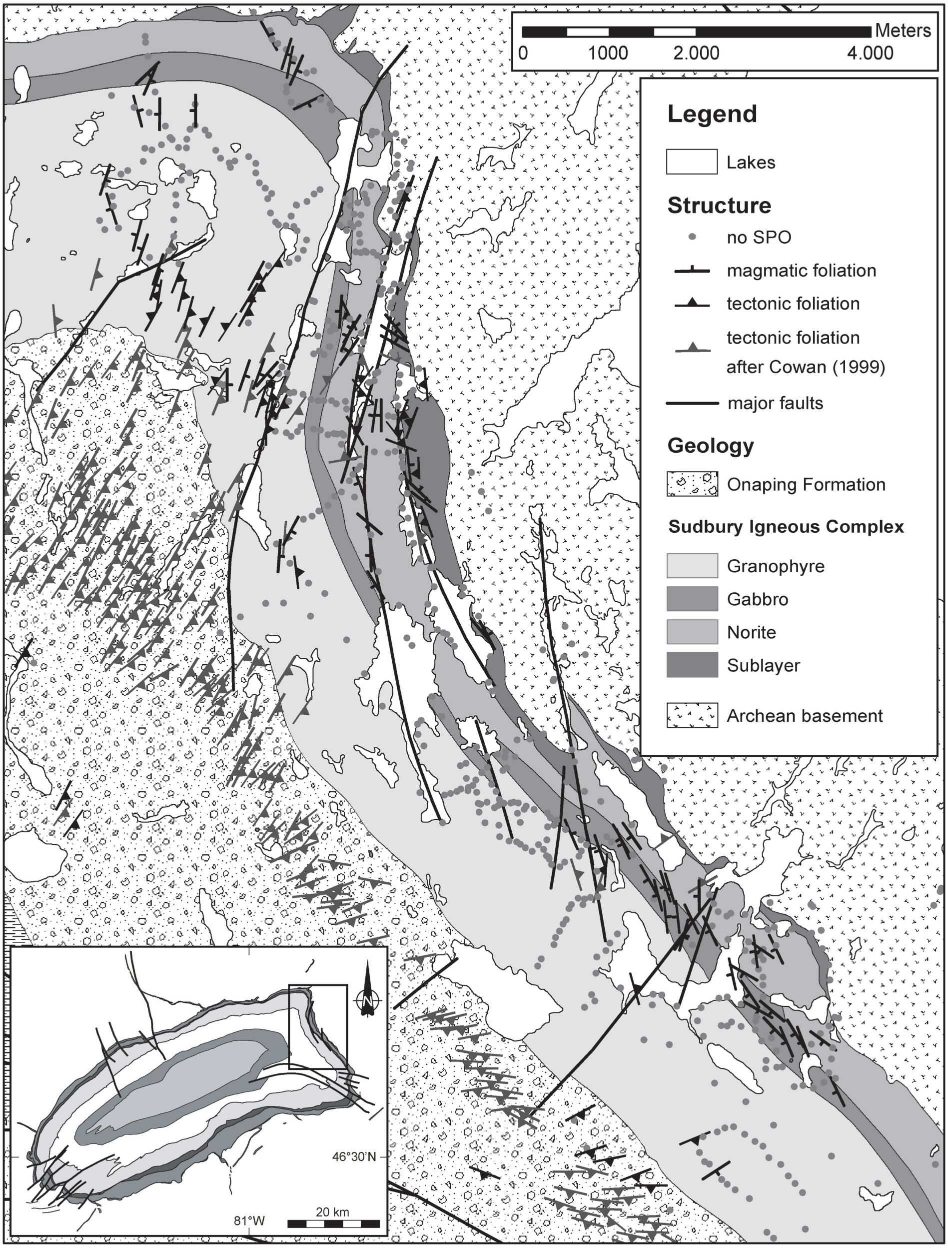

Figure 1: Strike and dip directions of magmatic and tectonic foliations in the East Range SIC and overlying Onaping Formation.

SIC and its host rocks. Large-scale faults striking N–S cut the NE-lobe's eastern limb causing variable magnitudes of strike separation of SIC contacts. Centimetre- to metre-scale, brittle faults and chlorite-filled brittle-ductile shear-zones occur pervasively in the eastern SIC, often causing centimetre-scale offset of markers. Microstructures from first-order fault-zones indicate deformation at, and below, greenschist-facies metamorphic conditions.

The concordance of magmatic and tectonic mineral shape fabrics in the NE-lobe indicates progressive deformation of the SIC during cooling from the magmatic state to lower greenschist-facies metamorphic conditions. Synmagmatic deformation of the SIC suggests that it was emplaced during ongoing orogenic deformation. Furthermore, maximum principal stress directions inferred from inversion of fault-slip data collected in the Onaping Formation are orthogonal to metamorphic foliation surfaces at the same localities. This points to a similar deformation regime in the Onaping Formation during ductile and brittle deformation. The concordance of magmatic, metamorphic and brittle fabrics is explained best by a single progressive deformation event that was active while the SIC cooled and solidified. 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 respect to natural tectonic strain rates. While the geometry of mineral fabrics in the study area is compatible with large-scale, non-cylindrical folding, the low levels of ductile deformation suggest that shape-change of the eastern SIC has been accomplished mainly by discontinuous deformation. This deformation mechanism may have accomplished bulk NW-SE shortening that was accommodated by reverse shearing within the SRSZ, resulting in large strike separations of SIC contacts observed in the western part of the impact structure. By contrast, the eastern SIC may have accomplished such shortening by brittle-ductile, non-cylindrical folding at the eastern terminus of the SRSZ. The complex post-impact deformation pattern of the central Sudbury Structure results from impact into an active orogen.

References

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