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# The Sudbury Igneous Complex, Canada: evidence for large-meteorite impact during Paleoproterozoic orogenic activity

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The main mass of the 1.85 Ga Sudbury Igneous Complex (SIC) in central Ontario is widely accepted as the erosional relic of a deformed impact melt sheet, about 2.5 km in thickness. The synformal shape of the SIC attests to post-impact tectonic modification of the Sudbury Impact Structure by non-cylindrical folding and NW-directed reverse faulting. Deformation of the Impact Structure is generally attributed to the Paleoproterozoic orogeny (1.89 to 1.83 Ga) and the Neoproterozoic Grenvillian orogeny (ca. 1.2 – 1 Ga). Knowledge of the exact timing and effects of post-impact tectonism, notably by the Penokean orogeny, is paramount for assessing impact-related crustal motions. Most critical for assessing post-impact deformation are the states of ductile and brittle strains in the SIC, the overlying Onaping Formation and its granitoid target rocks. Despite the obvious fold geometry displayed by the SIC in plan view, the general absence of pervasive mesoscopic strain fabrics, notably in its NE- and SE-lobes, rendered many structural analysts to regard post-impact folding of the SIC with scepticism. Our reassessment of the structural inventory of the NE-lobe led us to conclude that this lobe indeed represents a fold. Moreover, structural relationships indicate that cooling and solidification of the SIC occurred during orogenic deformation.

The following structural observations support our conclusions: The base of the SIC is characterized by the sporadic presence of cumulate textured plagioclase, amphibole and pyroxene displaying planar fabric geometry. Except in the lobes, these magmatic shape fabrics are concordant to the basal contact of the SIC. In the NE-lobe, however, the strike of planar magmatic fabrics is parallel to its acute bisectrix and, thus, displays an axial-planar geometry typical for fabrics formed in the core of a buckle fold. Foliation surfaces in the Onaping Formation are defined by greenschist-metamorphic

mineral assemblages and are coplanar with magmatic fabrics of the SIC in the NE-lobe. We also confirm the observation made by previous workers that the SIC in the NE-lobe is largely devoid of intracrystalline deformation in quartz and feldspar. Thus, in contrast to the Onaping formation, folding of the SIC cannot have been accomplished by continuous (ductile) deformation. In fact, the NE-lobe of the SIC and its granitoid target rocks are pervasively affected by cataclastic deformation and mm- to km-scale brittle discontinuities. This indicates that deformation and thus generation of the NE-lobe of the SIC by folding was accomplished chiefly by discontinuous deformation. Brittle shear faults are also abundant in the Onaping Formation. Where measured, shortening directions inferred from the inversion of such faults in this formation are orthogonal to the foliation. This suggests that the deformation regime in the Onaping Formation was the same during continuous and discontinuous deformation.

In summary, the (1) sporadic presence of magmatic shape fabrics, axial-planar to the NE-lobe, (2) little intracrystalline strain in quartz and feldspar of the SIC, (3) pervasive brittle deformation in the SIC, its target rocks and in the Onaping Formation and (4) the same deformation regime operating during continuous and discontinuous deformation in the NE-lobe is best explained by (rapid) cooling and solidification of the SIC while it was folded. This is corroborated by our reinterpretation of paleomagnetic data from the thermal aureole of the SIC. The sum of these structural observations indicates that impact occurred in an actively forming orogen.