IMPACTITES EAST OF THE SUDBURY IGNEOUS COMPLEX – A RECONNAISSANCE STUDY

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Introduction: The Sudbury Igneous Complex (SIC), Canada, is considered to be the remnant of a crustal melt sheet in the center of one of the largest known terrestrial impact structures, possibly created by a chondritic bolide [1] 1.85 Ga ago [2]. Uniquely endowed with world-class ore deposits and exposed in remarkable detail and preservation, this ca. 200 km-wide impact basin has been extensively studied. For economic reasons, however, most studies have concentrated on the SIC itself, where the majority of mining activity takes place. Less is known about the effects of the impact event in more distal and remote areas of the proposed peak- [3] or multi-ring [4] basin. As part of a multidisciplinary project, we conducted extensive geological mapping and sampling over ca. 350 km^2 in the eastern, underexplored periphery of the SIC in order to assess its metallogenetic potential and to better understand the area in the context of the Sudbury impact.

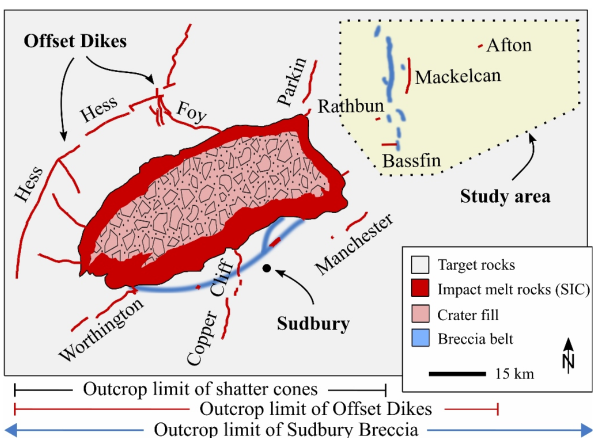

Fig. 1: Schematic overview of the Sudbury impact structure.

Results: The study area (Fig.1) lies 15 to 50 km east of the outer margin of the SIC, and 5 km outside the zone of shock phenomena such as shatter cones and planar deformation features. Its surface geological make-up comprises thick pre-1.85 Ga siliciclastic sedimentary rocks (Huronian Supergroup) with only little post-depositional deformation, and regional metamorphism not exceeding the lower greenschist facies. In contrast to previous assumptions, impactites are spatially extensive and can be divided into two groups:

Pseudotachylitic breccia. Locally referred to as Sudbury Breccia (SUBX) and equivalent to the breccia famously known from the Vredefort impact structure, South Africa, this rock is generally attributed to in-situ comminution and frictional melting during the early stages of crater formation [4,5,6]. SUBX occurs in all country rocks between Wanapitei and Temagami Lake, extending up to 80 km east of the SIC. A decrease in the abundance and intensity of brecciation with increasing distance from the SIC was observed. In many places, SUBX is developed along contacts between host rocks of varying competence or utilizing planes of prior weakness such as faults. Unambiguous identification of SUBX strongly depends, however, on the outcrop quality and this compromises any adequate assessment of their exact spatial distribution. Veinlets of ultracataclasite and recrystallized pseudotachylite turned out to be ubiquitous between 80°39'W and 80°23'W but may be macroscopically mistaken for hydrothermal features. A massive (megaclastic) type of SUBX (Fig.2) is more easily recognized in the field, with continuous exposure over 14 km along a N-trending lineament from Matagamasi as far as Chiniguchi Lake, with an additional 15 km's of discontinuous SUBX exposure further north and south. This breccia belt bears strong resemblance to the so-called South Range Breccia Belt around the SIC that hosts the giant Frood-Stobie deposit and which has been interpreted as a listric superfault that was active during the crater modification stage [4].

SUBX east of the SIC shows significant petrographic diversity despite relatively uniform host rocks. Mono- and bilithic, matrix- and clast supported varieties exist; clasts range in diameter from a few mm to at least 12 m and have a nearly fractal grain size distribution. They are typically sub-rounded with aspect ratios <2. Most clasts are of very local derivation and underwent little displacement or rotation. This is evident from cross-cutting quartz veins (Fig.2) and other stratigraphic markers such as bedding and pre-impact diabase dikes. Some exceptions of allochthonous or even exotic clasts do, however, occur in the center of the breccia belt. These could not be linked to any lithology in the vicinity, or in some cases, are entirely exotic. This not only raises the question of their provenance but suggests in some instances transport over hundreds of meters (laterally and/or vertically) to their current position, which is clearly at odds with the widely accepted in situ origin of this type of breccia [5,6]. The texture of the breccia matrix ranges from homogeneous to flow-banded, cataclastic, devitrified, intersertal, to vesicular and amygdaloidal. En echelon-like protrusions of SUBX matrix into dilational sites within the ambient host rock were also observed.

Quartz diorite. Igneous-textured, xenolith-bearing rocks, known locally as Offset Dikes, and interpreted as products of a superheated (>1,600°C) impact melt with regional crustal composition that was forcefully injected or passively drained into the crater floor [7,8,9]. Offset Dikes are a well-documented phenomenon around the SIC and occur in radial and concentric patterns typically associated with SUBX. We have mapped, and geochemically confirmed the existence of, 4 new Offset Dikes in 3 different townships. Quartz diorite at northern Rathbun Twp. is exposed over a small area 15 km east of the SIC [10]. It is strongly mineralized with respect to PGE-Cu±Ni. The Bassfin Offset (southern Rathbun / northern Scadding twp.), also located 15 km east of the SIC, has been traced along an E-W strike for >1.5 km. Weakly mineralized, this dike is hosted by massive, partially recrystallized SUBX to which it shows complex cross-cutting field relations, including textures interpreted as mingling and multiple intrusive events. The Laura Creek Offset Dike (Mackelcan Twp.), located 25 km NE of the SIC, has been traced for 4 km along a N-S strike sub-parallel to the East Range Breccia Belt; the dike is locally hosted by SUBX and dips subvertical. The strike of the Bassfin Offset Dike makes it a possible analogue to other ore-hosting radial offsets, such as Copper Cliff or Parkin (Fig.1), whereas the Mackelcan Offset Dike resembles the concentric Hess and Manchester offsets but may also occupy a second, more distal ring structure within the Sudbury impact basin; the relationship of each dike with large SUBX bodies further supports these analogies. The Offset Dike at Afton Twp., 45 km NE of the SIC, has only been intersected in drill core [11]. It appears barren throughout and lacks any surface expression but may provide an indication of the initial size of the Sudbury impact melt sheet.

Conclusions: Our study has revealed not only the existence but widespread occurrence of autochthonous and allochthonous impactites east of the SIC, viz. Sudbury Breccia and Offset Dikes. Both are principal hosts of Ni-Cu-PGE sulfide elsewhere around Sudbury and are strong indicators that SIC-related ore deposits may also be present in the study area. These preliminary observations expand the zone of potentially mineralized rocks surrounding the SIC to a hitherto unknown extent. The next step of the project will therefore address whether sulfide mineralization also affected the newly discovered impactites. Additional studies are underway concerning the primary structural controls on their distribution in light of existing emplacement models and proposed crater morphologies; the spatial and temporal relation between SUBX and Offset Dikes; the regional and more local controls on their metal endowment. Further, we plan to elaborate on the observation that Offset Dikes east of the SIC appear relatively discontinuous and sparse in outcrop (Fig.1) and whether this is just a reflection of an immature exploration state, or maybe a consequence of a much deeper level of erosion and/or higher structural complexity of the area than previously assumed.

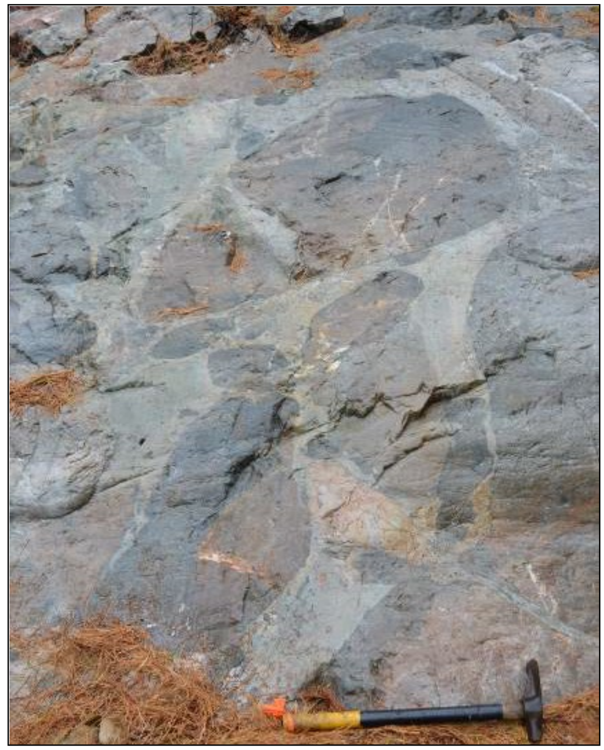

Fig. 2: Glacially polished outcrop in the East Range Breccia Belt showing massive arkose-hosted pseudotachylitic breccia (50 km NE of Greater Sudbury, 46°52’02”N 80°36’56”W); hammer length = 50 cm; note the indent clasts in the lower-right corner indicative of gravitational settling.

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