GEOCHEMICAL VARIATIONS IN SUDBURY BRECCIA OF THE SUDBURY IMPACT STRUCTURE, CANADA. J.W. O'Callaghan[1], J. R. Weirich[2], G. R. Osinski[1], and P.C. Lightfoot[3], [1]Dept. of Earth Sciences & Centre for Planetary Science and Exploration, University of Western Ontario, London, ON, N6A 5B7, Canada, [2]Planetary Science Institute, 1700 East Fort Lowell, Tuscon, AZ, 85719-2395, USA [3]Brownfield Exploration Office, Vale, 337 Power St, Copper Cliff, Sudbury, ON P0M 1N0, Canada. (jocalla@uwo.ca)

Introduction: The 1.85 Ga Sudbury impact structure straddles the Superior Province to the north, and the Southern Province to the south, and is thought to be a multi-ring impact structure >200 km in diameter [1, 2]. The Superior Province is an older craton (>2.5 Ga) consisting of granitic and gneissic rocks, whereas the Southern Province is younger (2.4–2.2 Ga) and contains mostly metavolcanics and metasedimentary rocks of the Huronian Supergroup [3]. Some of these younger sedimentary units are found in the Superior Province and are referred to as Huronian outliers. Sudbury Breccia (SDBX) is found in the footwall of the impact melt sheet, known as the Sudbury Igneous Complex (SIC). SDBX consists of a dark grey, aphanitic matrix containing angular or rounded clasts derived from the surrounding country rock (figure 1). It is similar in appearance to pseudotachylite found at the Vredefort Dome in South Africa [4]. In this work we present the results of a detailed geochemical study of SDBX from localities in both the North and South Ranges of the SIC with the aim of elucidating its formation conditions. We present preliminary data from localities along Highway 144 in the North Range Superior Province, and the Creighton Pluton and Metasedimentary rocks of the Huronian in the South Range.

Sudbury Breccia formation: The most popular scenarios of SDBX formation are 1) frictional melting/cataclasis during crater collapse [5], 2) shock induced melting or cataclasis [2], or 3) injection of SIC derived melt into the surrounding footwall [6]. Cataclasis (i.e. mechanical grinding of rock into powder) and frictional melting are typically viewed as two end-members of a continuous progression from initial shearing (when the rock is cold) to late stage shearing (when the rock is hot). Scenario 1) is similar to tectonic pseudotachylite found in earthquake fault zones, albeit on a much larger scale. Scenarios 1) and 2) predict the composition of the breccia to be a mix of the composition of the surrounding country rock; whereas scenario 3) requires the composition of the breccia to have a component from the SIC melt sheet. Lafrance and Kamber [2] showed that a contact between sandstone and diabase near the SIC in the Southern Province has no contribution from the SIC, casting doubt on scenario 3). However, that study was only at one location and may not be applicable to the entire basin. Scenario 2) works well for small (~1 cm) SDBX occurrences, but it is unlikely that large fluctuations in shock pressure would be present at the scale of 100's of metres. A criticism of a mechanism involving frictional melting is that once melting begins it will lubricate the sliding surface, which would inhibit further production of melt. Melosh [7] suggests that melt could extrude into adjacent low pressure zones in the country rock, thus keeping the sliding surfaces unlubricated, or that the melt was viscous enough to sustain shear, though both of these processes require strict conditions which may that matched by the conditions of SDBX formation.

Figure 1: One of the Sudbury breccia sample sites located near Halfway Lake, exhibiting gneiss clasts within a dark grey, aphanitic matrix.

Samples and Methods: Since SDBX has a large clast content a previous study by our group attempted to improve upon the quality of SDBX data presented in other studies by picking out these clasts [9]. Although samples were collected to avoid larger clasts and fragments, it was found that removal of finer fragments (>1mm) through clast picking had little effect on the silica and mafic element concentrations; all other elements had similar small differences. As a result clast picking was not applied to samples collected from the South Ranges and no 'matrix enriched' results will be presented here.

Samples were collected from several locations to test the variations in SDBX within different country rocks. For the North Range, samples collected at Halfway Lake are situated in tonalitic and diortic gniesses, those at Crab Lake are in Cartier granite, those from Ministic Lake are in Levack gneiss. In the South Range, samples from Creighton and Worthington townships include granites, metavolcanics and sedimentary lithologies. Here we adopt the term "country rock" since we are attempting to sample host rock, but acknowledge this may not always be the case. At each outcrop, SDBX and adjacent country rock was sampled. Outcrop samples from the South Range were supported by publically available geochemical data provided by the Ontario Geological Survey [10].

Geochemistry: Major and trace elements, including the Rare Earth Elements (REE) were determined for each sample using four acid digestion and ICP-MS.

Figures 2a and 1b show REE signature, respectively, of the matrix and country rock, from samples collected at highway 144 and Creighton. In both cases the SDBX appears to be intermediate to the country rocks in both major and trace elements, though some samples along highway 144 have a higher REE concentration than both the diabase and granite/gneiss, which may be from eroded metasedimentary rocks that are no longer abundant in the area.

At Halfway Lake the model granite/gneiss is 38–55%, diabase is 22–44%, and metasediment is 16–23% of the breccia. In the Ministic Lake models felsic gneiss is 68–84%, diabase is 11–25%, and mafic gneiss is 3–15%. Crab Lake has a higher light REE composition than the SIC or any of the nearby country rocks, perhaps indicating later alteration. At Creighton Hill the modelled SDBX is Granite at 49–60%, Granodiorite at 1–18%, and Dacite at 30–40% of the breccia matrix. Although there is no dacite present at the sampled outctop, Elise Mountain Formation volcanics are present in the area and were likely to have been more extensive at the time of the Sudbury event. In addition, SDBX is known to preferentially form at pre-existing anisotropies such as lithological contacts [11], which may explain the higher than expected Huronian component at this locality.

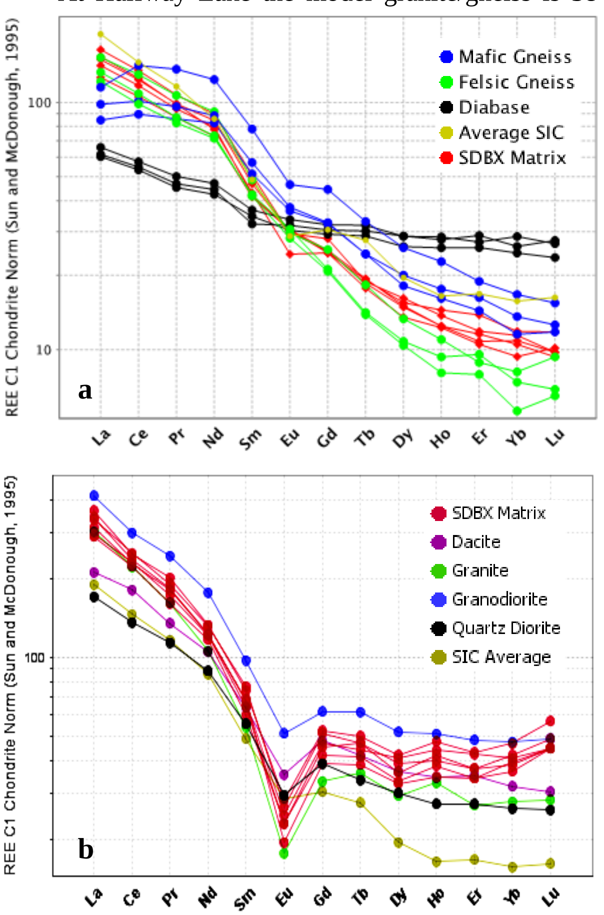

Figure 2: REE plots for samples from **a** Ministic Lake and **b** Creighton Hill, demonstrating the intermediate composition of Sudbury breccia compared with the local country rock.

Conclusions: Our working hypothesis is that the breccia melt formed in-situ through cataclasis or frictional melt processes within major faults and failure planes in the footwall of the impact structure during the crater excavation and modification stages. The requirement for metasedimentary or volcanic rock components in the breccia matrix at localities which contain limited outcrops of such units, could be explained by injection and mixing of the frictional melt into damage zones adjacent to the main fault zones. This would be in agreement with previous work on the formational processes for SDBX [2,7] and implies that there is no need for an SIC impact melt component in the SDBX.

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