REVISITING THE LINEAMENT STUDY OF THE SUDBURY IMPACT STRUCTURE USING RECENT REMOTE IMAGERY. B. Shankar[1] , G. R. Osinski[1], [1]Western University (Dept. of Earth Sciences, 1151 Richmond St., London, ON, N6A 5B7, bshanka@uwo.ca)

Introduction: The Sudbury impact structure is one of three large complex impact basins on Earth that provide unique opportunities to understand the structural characteristics of multi-ring impact basins [1]. The impact event formed ~1.85 Ga, resulting in a ~200 km diameter impact structure [2]. The structural expression at Sudbury is very complex - with evidence of extensive post-impact tectonism [3-5]. The elliptical shape of the basin is the result of tectonic shortening in the northwest-southeast direction, leading to the deformation and folding of the basin, the greatest deformation occurring along the South Range [6]. The deformation process has resulted in the preservation of several impactite units within the main basin area including a differentiated impact melt sheet (the Sudbury Igneous Complex or *SIC*), brecciated rocks, target rocks, and post impact geological processes [7, 8]. However, post impact erosion has removed much of the impactites beyond the SIC, with the exception of offset dykes and parautochtonous [9] rocks from the crater floor [10]. Offset dykes are igneous intrusions that extend metres to hundred metre-scale and occupy roughly radial and concentric structures around the basin.

Previous studies have proposed the presence of several ring structures based on field observations and low resolution remote sensing datasets, including the transient cavity, crater edge, and structural uplift proposing a multiring structure similar to Vredefort [11, 12]. The apparent crater diameter range from 150 – 260 km [13, and references therein]. Assessing the structural characteristics of the Sudbury impact structure using current remote sensing datasets (within improved spatial and spectral resolutions than in previous studies) can help constrain the extent of these proposed ring structures. The improved data resolutions may also provide better tools to identify the extent of offset dykes beyond the main melt sheet (SIC), and the Sudbury breccia providing further context to field observations (e.g. 13, 14).

Methods: This study extends earlier work done by [11] of performing basic lineament analysis on a variety of remote sensing datasets to assess the regional extent of lineaments (e.g. faults). While prior lineament studies for Sudbury have conducted the analyses manually digitizing their results at the end, this study approaches the method by using automated techniques to assess the lineament distribution. Studies using automated extraction techniques have reported a higher lineament number count compared to more traditional methods, minimizing power and saving time [15]. Due to the extensive deformation along the south range of the SIC, the study has focused on areas north northwest of the SIC, beyond the North Range.

This study was done over a region extending ~150 km away from the centre of the Sudbury basin. Automated lineament analyses was done using techniques outlined by [15] on Landsat 7 (ETM+) and digital elevation models (DEMs). Compared to previous studies that used Landsat 4 (MSS), Landsat 7 data has higher spatial and spectral resolution that allowed for a more detailed analyses of the area with wavelength bands not previously available. Table 1 summarizes the resolution details between this study and previous studies. Shaded relief images were derived DEMs with different sun azimuth directions: 0, 45, 90, 135, 180, 225, 270, and 315°. PCI Geomatica was used to derive automated lineament extraction (using the LINE algorithm), and strike measurement (using the DIP algorithm). Furthermore, the EDGE algorithm was applied to enhance lineaments, drainages, and landforms in each of the images. The extracted lineaments were statistically analyzed to determine lengths, densities to generate rose diagram and assess lineament density. The lineaments were compared to known geology, and sets of lineaments were recorded based on their strike direction and length. Rose diagrams were plotted using GeoOrient. using rose diagrams, and lineament density maps. Delineation of drainage system from DEM data was achieved using the ArcHydro tools within the ArcGIS suite.

This study	Data Resolution	Previous studies	Data Resolution
Landsat 7 (ETM+)	30 m/pixel	Landsat 4 MSS	60 m/pixel
Radarsat 1	6.25 m/pixel	C-band radar	30 – 100 m/pixel

Table 1: Data resolution of current and past studies used in lineament extraction for the Sudbury impact structure.

Observations: The analyses indicate that the area has numerous long and short lineaments (Fig. 1, Table 2). The main trends of the extracted lineaments are N-

S, NW-SE, and a minor trend going NE-SW (Fig. 2). While statistics are not available for previous studies, visually, it appears that several more lineaments have been extracted using the automated lineaments technique, thereby removing human bias on structural mapping.

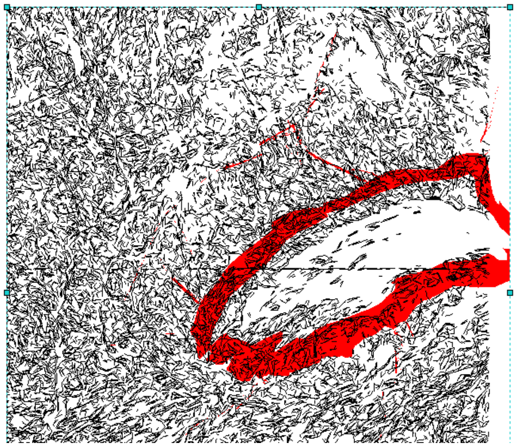

Figure 1: Automatic lineament extraction map for the regional Sudbury area using Landsat 7 and DEM data. Red polygons outline the SIC melt unit and mapped offset dyke compilation using field observations.

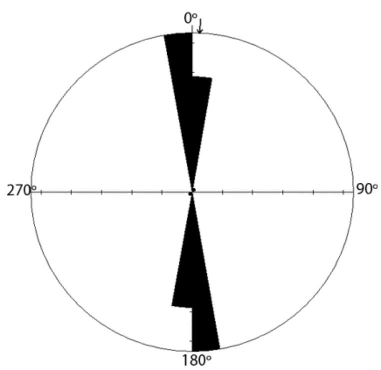

Figure 2: Rose diagram of lineament map combining DEM derived shaded relief images with variable sun angles. Similar trends were observed using Landsat imagery.

	Automatic DEM derived lineaments map	**Automatic Landsat 7 (ETM+) derived lineaments map**
Count	61576	12670
Min length (m)	600	900
Max. length (m)	53401	49718
Average (m)	1140.96	1596.97

Table 2: Statistical summary of automatic lineament extraction for the study area using a combination of several remote sensing datasets.

Future Work: The next step will be to explore the lineament patterns in more detail, determine what type of lineaments they are, determine if all the lineaments are linked to the main impact event or post-impact modifications. Future work also involves exploring concentrations of fractured lineaments to determine the edge of the rim. It remains to be seen if remote sensing datasets can aid in the identification of more offset dykes beyond the immediate SIC-footwall contact for future field mapping. Determining the extent of offset dykes can help in economical mining of Cu-, Ni-, and PGE-rich sulphides ore deposits typically associated with the SIC, footwall, and offset dykes [5].

We also propose to conduct multispectral assessments of the area using the Landsat and ASTER data suites to determine, if possible, the extent of Sudbury breccia. Previous studies have proposed breccia development upto radial distances 100 km beyond the North Range of the SIC [e.g. references within 13].

Acknowledgments: We thank the Wallbridge Mining Company Limited in Sudbury for providing access to the offset dyke field data compilation.

References: [1] Grieve, R. A. F. et al. (1981) *LPS 12A*, 37–57. [2] Krogh, T. E. et al. (1984) *The geology & Ore deposits of the Sudbury structure*, 431–448. [3] Rousell, D. H. (1984) *The geology & Ore deposits of the Sudbury structure*, 83–96. [4] Riller, U. (2005) *MAPS*, *40*, 1723–1740. [5] Grieve, R. A. F. (2005) *Mineral deposits and Earth Evolution*, *248*, 1–29. [6] Milkereit, B. et. al. (1992) *Geology*, *20*, 807–811. [7] Grieve R. A. F. et al. (1991) *JGR*, *96*, 22,753–22,764. [8] Giblin, P. E. (1984) *Geol. & Ore Deposits of the Sudbury structure*. 3–24. [9] Osinski et al. (2011) *Impact Cratering Processes and Products*, Chapter 7. [10] Dressler, B. O. (1984) *The geology & Ore deposits of the Sudbury structure*, 97–136. [11] Butler, H. R. (1994) *GSA Special Paper*, *293*, 319–329. [12] Grieve, R. A. F. et al. (2008) *MAPS*, *43*, 5, 855–882. [13] Pilles, E. et. al. (2014) *GSA*, Paper 290–11. [14] Weirich, J. R. et. al. (2014) *LPS XLV* Abstract 1838. [15] Abdullah, A. et al. (2013) *Global Journals of Human Social Science*, *XIII*, 3, 1, 35–38.