EXPLORING THE PHYSICAL DIVERSITY OF IMPACT BRECCIAS. A. Chanou[1], G. R. Osinski[1,2], R. A. F. Grieve[1], and D. E. Ames[3] [1]Dept. of Earth Sciences/Centre for Planetary Science and Exploration and [2]Dept. Physics and Astronomy, Western University, 1151 Richmond St., London, Ontario, Canada N6A5B7, [3]Geological Survey of Canada, 601 Booth St., Ottawa, ON, Canada K1A 0E8 *achanou@uwo.ca

Introduction: Hypervelocity impacts result in the formation of a wide range of brecciated rocks. Impact breccias are highly diverse in both compositional and textural characteristics. A challenging subgroup of impact breccias is the melt-bearing breccias with particulate matrix [1] or 'suevites' according to the recommended definition by the International Union of Geological Sciences (IUGS) [2]. The physical characteristics of impact breccias vary not only on the basis of components and their modal abundance but also in their physical appearance. Detailed description of the physical parameters could potentially distinguish impact breccias into groups. Shape descriptors like sorting, preferred orientation and particle complexity reflect aspects of the dynamic regime of the rock's fragmentation, transportation and emplacement mechanisms. Differences in these parameters may reflect the diversity of major conditions of the cratering dynamic environment.

Here, we present results of a study on the macroscopic scale comparing and contrasting textural differences between impact breccias. We quantitatively analyzed a set of impact melt-bearing breccias of variable groundmass compositions. This is to strictly investigate and compare them on the macroscopic scale, similar to what a field description of these rocks would include.

Approach: For the purpose of this study the samples are distinguished in two major components the clastic population and the groundmass (or matrix). Because the scale of focus is macroscopic and our samples have been at one point characterized as 'suevitic' (i.e., of particulate matrix), we use a groundmass definition that agrees with both the sedimentological and volcaniclastic approach for groundmass definition. The term groundmass is used for particles with sizes smaller than 2 mm or finer than coarse sand, according to Fisher and Wentworth classifications [3,4]). The clastic populations are made of impact-melt fragments, mineral fragments and lithic fragments. As a first step, we focus on the overall clastic population, regardless of the nature of the fragments (melt, mineral or lithic). This way, we attempt to characterize the overall rock texture. In the next step, we refine the description by focusing solely on the apparent complexity and orientation of impact-melt fragments.

Samples and methods: The choice of samples was based on their apparent textural differences. Samples in this study include the Sandcherry member of the Onaping Formation, Sudbury, Canada; breccias from Popigai impact structure, Russia; Ries impact structure, Germany; and Mistastin impact structure in Labrador, Canada. The physical parameters (e.g., shape, sorting, box dimensions etc.) are measured using digital image analysis [5]. In order to quantify the level of sorting, we applied image analysis on a standard sorting scale similar to those used in the field. Parameters like the 'Nearest-neighbour Distance' (NnD) give a measure of compaction. Values, such as sorting and compaction, are not absolute and are only relative within the comparison of different samples.

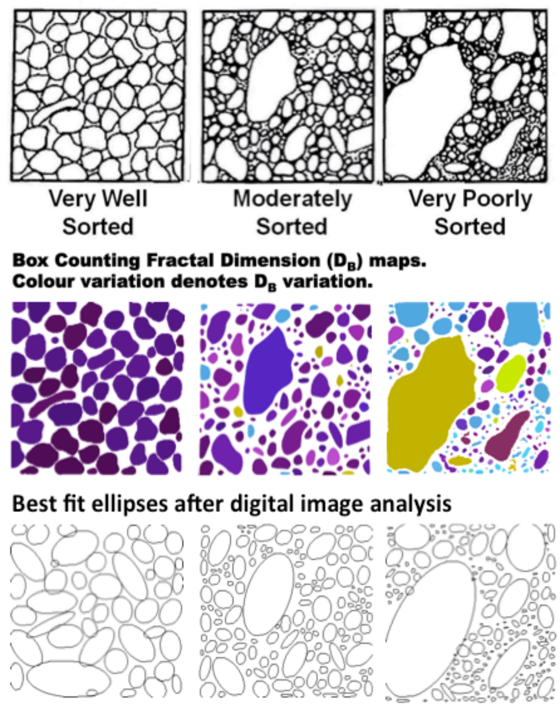

Figure 1: A sorting scale was analyzed with image analysis and used as a control sample for quantifying the breccia sorting. Top panel shows the sorting scale [6]; Middle panel displays the colour-coded maps of box counting dimensions (D_B) for all particles; Bottom panel shows all drawings of the best-fit ellipses for all the particles measured.

The box counting dimension (D_B) is used as a measure of particle complexity. Finally, particle preferred orientation of the major clastic components are measured as the angle between the major axis (measured from the best fit ellipse) and the horizontal of the image. The particle orientation results are plotted in rose diagrams to better display possible preferred orientations.

Observations: Macroscopically, it is easy to observe which samples have fundamentally different physical appearances. The most basic field description of the members of the Sandcherry Onaping breccia used in this study would have to include the equant and equidimensional shapes of its clastic component (Fig. 2). Popigai breccias, on the other hand, have variable particle shapes and sizes. Less sorted and more complex the particles of the Popigai samples do not display an equally mature mechanism of particle processing (transportation, deposition and/or reworking of clastic material) as the Onaping samples [7]. In addition, particles of the Onaping breccia show no preferred orientation. This is not the case for other breccias. A case example of which is the Mistastin breccia-dyke sample (Fig. 2). This unique impact-melt bearing breccia dyke found at Steep Creek, Mistastin impact structure, is presumably formed due to the intrusion of impact induced material (e.g., cataclastic and impact-melt) into the fractured basement rock [8]. The rock exhibits a strong preferred orientation of its clastic population that aligns with the contact to the hosting wall rock. The Mistastin breccia definitely stands out as a special case not just against Onaping, Popigai or Ries breccias but also against other Mistastin breccias. We call this 'crater internal' variation, intracrater variation.

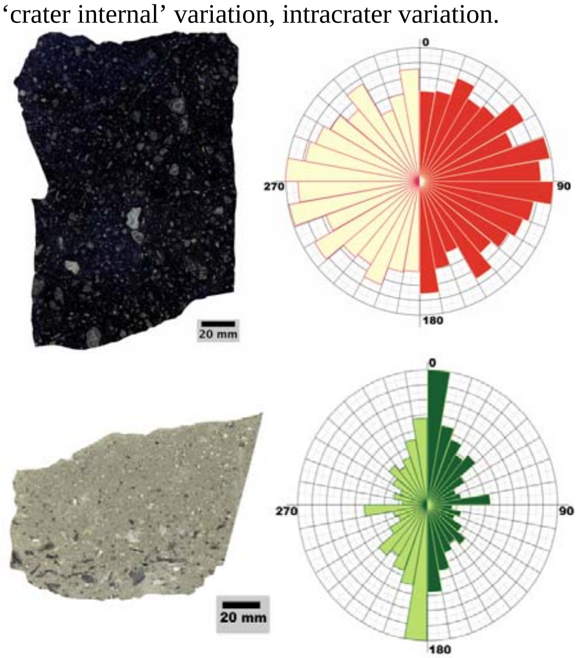

Figure 2: (Top panel) Scanned image of an Onaping breccia sample and the rose diagram showing the angles of the major axes. There is no apparent strong preferred orientation. (Bottom panel) Melt bearing breccia sample from Mistastin crater. The sample is part of a dyke outcrop [7].

Another example of intracrater variation is observed in Popigai breccias, where the relative compaction and sorting between samples 97AV-59 and 97AV-51 are evidently different (Fig. 3). Sample 97AV-59 a 'suevite', found next to the contact with the impact-melt (or tagamite), is less sorted and not as compacted as sample 97AV-51, another melt-bearing breccia related to a 'suevite' formation.

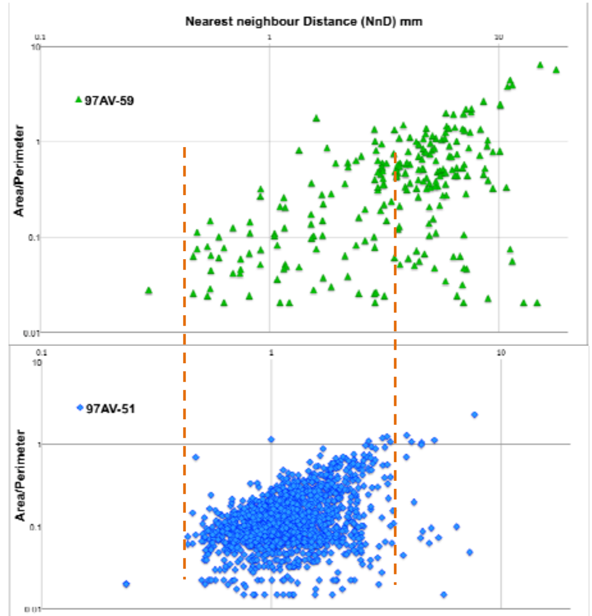

Figure 3: Log-log plots of area/perimeter against NnD for samples 97AV-59 (top) and 97AV-51 (bottom) display the spread in relative sorting and compaction values.

Discussion: We suggest that the diversity of the physical parameters reflects different geological histories for the breccia samples studied. The variations revealed by these analyses are not limited between samples of different impact structures, but are found within a single structure as well. We refer to these as intra- and inter-crater variations. Both intra- and inter-crater variability could represent either localized conditions that are specific to a given structure and are not widely found in other structures or locality. Alternatively, variations may represent a geological setting that constitutes a principal component of terrestrial impact cratering as a geological process. Further studies are imperative to establish a more systematic approach to the types of different impact breccias.

References: [1] Osinski G. R. et al. (2008) *MAPS 43*, 1939–1954. [2] Stöffler D. & Grieve R. A. F. (2007) IUGS Subcommission on Metamorphic rocks, Ch. 11, Blackwell. [3] Fisher R. V. (1958) Geol. Soc. America Bull., 69, 1071-1073. [4] Wentworth C. K. (1922) *Journ. Of Geol., 30*, 377–392. [5] Chanou A. (2011) LPSC XLII #2164 [6] Web Source: http://www.geocaching.com [7] Grieve R. A. F. (2010) *MAPS*, 45, 759-782. [8] Pickersgill A. E. (2012) *LPSC XLIV* #2473