QUANTITATIVE DIGITAL IMAGE ANALYSIS OF IMPACT MELT-BEARING BRECCIAS ("SUEVITES"). A. Chanou[1*], G. R. Osinski[1,2], R. A. F. Grieve[1], and D. E. Ames[3] [1]Dept. of Earth Sciences and [2]Dept. Physics and Astronomy, University of Western Ontario, 1151 Richmond St., London, Ontario, Canada N6A 5B7, [3]Geological Survey of Canada, 601 Booth St., Ottawa, ON, Canada K1A 0E8 *achanou@uwo.ca

Introduction and motivation: A wide variety of brecciated and impact melt-bearing rocks – collectively termed "impactites" – are produced during meteorite impact events. Accurate and consistent description and classification of impactites from individual craters is important for understanding their origin and for allowing comparative studies of multiple craters to be conducted, which informs our knowledge of the impact cratering process in general.

According to the recommended defintion accepted by the International Union of Geological Sciences (IUGS), so-called "suevites" are polymict, melt-particle bearing breccias with a particulate matrix [1]. This differs slightly from the original definition, which is a polymict impact breccia with a *clastic* matrix/groundmass containing *fragments* of impact glass and shocked mineral and lithic clasts [e.g., 2]. Unfortunately, the term "suevite" has been applied in the literature to a wide variety of rocks, not all of which meet the strict IUGS definition [1,3]. Rocks that have been termed suevites can vary greatly in appearance, composition and occurrence between different impact structures or even within the same impact crater area. Because of this, Osinski et. al. [4], proposed a revised classification system for impact melt-bearing impactites based on groundmass textures. Detailed characterization and classification of fragmental melt-bearing lithic impact breccias (suevites, as defined by [4]), require a broad quantitative analysis of numerous breccia samples. Previous work has employed a variety of quantitative methods such as sedimentological tools [5], High Resolution X-ray Computed Tomography [6], and digital image analysis [7] to deduce modal abundances and other parameters.

Approach: Digital image analysis is a useful and versatile tool, that can produce high quality results in a cost- and time-efficient way, using readily available equipment. The National Institutes of Health (NIH) ImageJ [8] software is an easily accessible and user-friendly digital image analysis package. This study presents the preliminary results of image analysis in a diverse set of samples from a variety of impact structures. Modal abundances of clastic and melt particle content were acquired with minimal manual intervention during particle selection, and the analyzed sample area is that of the whole hand specimen. The systematic approach taken here reduces the effects of human bias and increases the reproducability of the measurements reported.

Image analysis results: The process of image analysis can be defined as the sequence of computational operations required to highlight, segment, and analyze the different image elements [9]. The elements, or regions of interest (ROI), determine which series of operations is required.

Image acquisition. Suevite hand samples were scanned with a standard scanner at a resolution of 600ppi. The resulting RGB images were then directly imported to ImageJ where they were trimmed and the full sample area was selected. A scale in mm was set for each image (Fig.1).

Figure 1: Representative scanned image of Popigai sample 97AV-59.

Image processing and segmentation. In order to highlight ROI the image was adjusted and a series of filters and operations were applied. The ROI were visually isolated and the end product of the processing stage was an 8-bit grayscale image. Segmentation was performed on the final image by thresholding (Fig. 2).

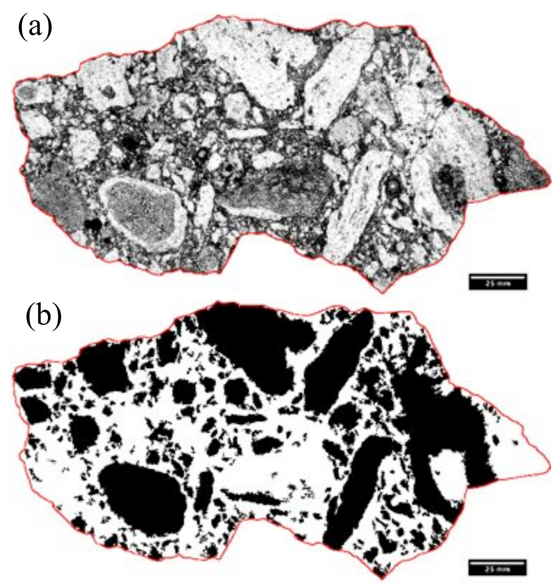

Figure 2: (a) Resulting image after for sample 97AV-59 after processing. Melt particles (bright areas) are highlighted. (b) Segmented melt-particles before analysis.

Particle analysis. The ROI were then analyzed and a set of parameters was recorded, including area, perimeter and aspect ratio between minor and major axis. For textural analysis the edges of the samples were excluded because objects near the edges may have continued beyond the sampled area in a completely unknown manner. For deducing modal abundances, however, the full area of the sample was analyzed.

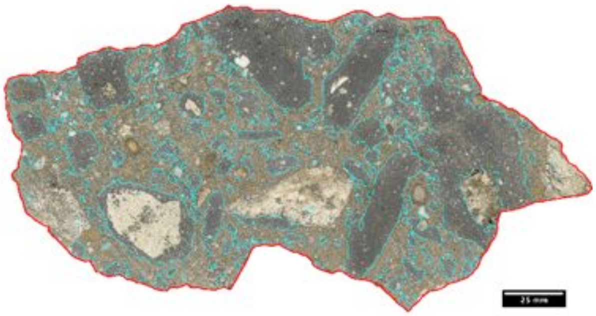

Figure 3: Overlay of analyzed ROI (in this case melt-particles) highlighted by cyan outlines.

Modal abundance results: Using digital image analysis with ImageJ, we have produced a set of preliminary results on a set of suevite samples from the Popigai impact structure. Modal abundance of 'suevite' components have been calculated for a small set of samples (Figs. 4-6).

Summary: Image analysis of suevites (*sensu lato*) using ImageJ shows promise for determining important petrologic data including modal abundances (of minerals, melt particles, lithic clasts, and vesicles), as well as textures of suevite constituents. These preliminary results illustrate the first stages of applying digital image analysis to 'suevites' with minimal manual intervention. Additional forthcoming results will refine the method, and improve the quality and reliability of the analysis. A database of samples from multiple impact structures will be constructed for comparative study. These data will help inform studies of terrestrial impactites and may aid in the interpretation of *in situ* imagery returned by landers and rovers.

References: [1] Stöffler D. & Grieve R. A. F. (2007) IUGS Subcommission on Metamorphic rocks, Ch. 11, Blackwell. [2] Stöffler et al. (1979) *MAPS 32,* A74. [3] Reimold W. U. (1997) *Earth-Science Reviews 43* 25–47. [4] Osinski G. R. et al. (2008) *MAPS 43*, 1939–1954. [5] Kalleson E. et al. (2010) *MAPS* 45, 798–827. [6] Koeberl C. et al. (2002) *JGR 107,* 5089. [7] Meyer C. et al. (2008) *Large Meteorite Impacts & Planetary Evolution IV,* Abs. #3066. [8] http://rsbweb.nih.gov/ij/ [9] Coster M. & Chermant J.-L. (2001) *Cement & Concrete Composites, 23,* 133–151.

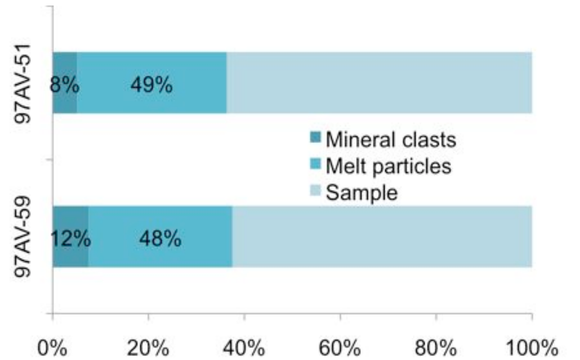

Figure 4: Modal abundances of mineral clasts and melt particles were calculated. Groundmass content can be estimated within specified grain-size limits, here particles <1mm^2 are considered groundmass.

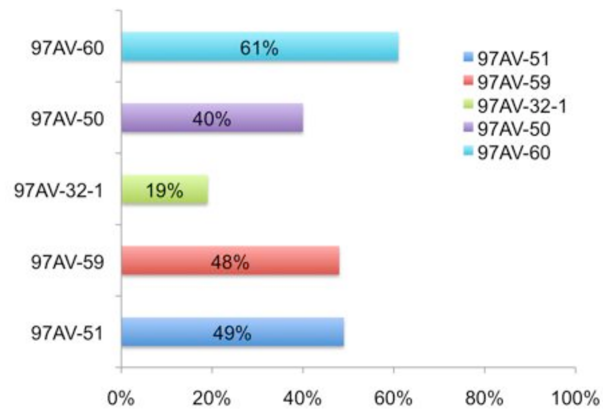

Figure 5: Melt content (areal percent) for a set of five suevite samples from Popigai impact structure. Melt-particle size >1mm^2.

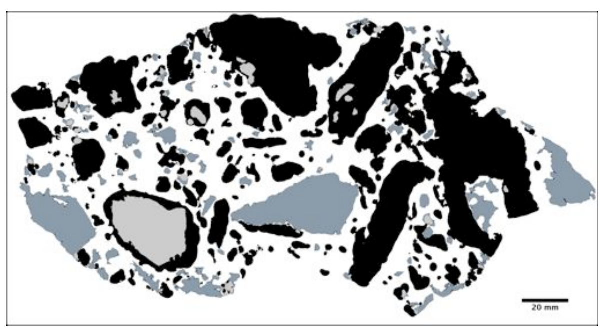

Figure 6: Particle base map of measured components. Dark gray: mineral clasts; light gray: mineral clasts included in melt particles; black: melt particles.