GEOMETRICAL CHARACTERIZATION OF QUARTZ CLASTS IN IMPACT MELT BRECCIA FROM THE EL'GYGYTGYN DRILL CORE. Lidia Pittarello[1], Christian Koeberl[1,2], and the El'gygytgyn Scientific Party. [1] Department of Lithospheric Research, University of Vienna, Althanstrasse 14, A-1090 Vienna (lidia.pittarello@univie.ac.at, christian.koeberl@univie.ac.at), [2] Natural History Museum, Burgring 7, A-1010 Vienna.

Introduction: The study of clast size distribution (CSD) in melts has been used to confirm the melting origin of pseudotachylites [1,2], to estimate the energy involved in melting and crushing processes, e.g., [3], to distinguish seismic and aseismic faults [4], and recently it was also proposed as a way to distinguish impact melts from basalts on the Moon [5]. Here we suggest using the CSD method, together with other geometrical parameters, to quantitatively characterize impact lithologies and obtain information about their origin, applying image analysis to samples from the El'gygytgyn drill core.

The 3.6 Ma old and 18-km-diameter El'gygytgyn crater, in northeastern Siberia, is the only known impact structure on Earth that was excavated in siliceous volcanic rocks. The target is mostly composed of ignimbrite, tuff, and rhyolite lava [6]. Recently, the El'gygytgyn structure was drilled in an ICDP (International Continental Scientific Drilling Program) project [7], and samples from the core, starting at 318.83 m below the lake floor, underlying the post-impact sedimentary sequence, and ending at 517.30 m, still in what appears to be suevite, were studied.

As the target is volcanic, the distinction between volcanic and impact melt is not obvious, if there are no clear evidence of shock metamorphism in the minerals. Some information about a possible distinction could be provided by considering a series of geometric parameters of quartz clasts. As a first try, here we consider only quartz clasts included in both impact melt breccia and melt fragments; a comparison with the target material will follow later.

Methods: The study was focused on ten selected thin sections of the breccia and melt, cut as much as possible perpendicular to the anisotropy plane, generally marked by a fluidal fabric. The used parameters were estimated by simple statistical and mathematical calculations on output data from image analysis, performed with the free software Image SXM. We considered only quartz clasts because they are best preserved from alteration and because they are easily detected in thin section scans by the image analysis software, thanks to their clear white color. The measured parameters for each clast are: area, perimeter, length of major and minor axis of the best fit ellipse, and anticlockwise angle between the major axes of the best fit ellipse and the horizontal. In each thin section, we also measured the investigated area and the angle between the anisotropy plane and horizontal. To avoid artifacts due to color selection on thin section scans, only clasts with a corrected area (area less perimeter) larger than 20 square pixels were considered. The parameters taken into account are: (i) relative abundance of quartz clasts (percentage of the investigated area covered by quartz clasts on the investigated area), (ii) CSD, estimated as frequency distribution for exponential bins and plotted in a log-log graph, with the clast size reduced to the equivalent radius r of the clasts (calculated from $r = \sqrt{A/\pi}$, where A is the corrected area); (iii) aspect ratio (A.R.) of the clasts, which is the ratio between the major and minor axes of the best fit ellipse that approximates the clast shape; and (iv) shape preferred orientation (SPO), which expresses the preferred orientation of clast elongation by considering the angle between the major axes of the best fit ellipse and the main anisotropy in the thin section (fluidal fabric, compaction, etc.). An example is shown in Fig. 1. Further details on the method and the applicability of 2-D analysis for 3-D considerations are given in [8].

Lithology: The characteristics of the impact melt breccia change over the length of the core, but there are some general features. The impact melt breccia has a fine-grained matrix that varies from clastic to glassy, gray-greenish in color and is mostly represented by clay minerals, resulting from alteration, especially in the upper part of the core, or cryptocrystalline quartz, resulting from recrystallization of glass, mainly in the lower part of the core. Clasts are abundant and are mainly composed of quartz, highly altered feldspar, rare altered biotite and amphibole, and elongated melt fragments. The shape of clasts varies from angular to amoeboid, depending on the resistance of the mineral and the experienced level of shock.

The melt clasts are elongated and vary in size from mm to tens of cm. They appear brown to green in color, depending on the alteration of the glassy groundmass. In some samples, dendritic mafic minerals are present in the siliceous groundmass, and schlieren are common. Quartz and feldspar grains are abundant. Some melt clasts, large enough to be analyzed separately, were also studied (e.g., Fig. 1).

Results and discussion: The abundance of quartz clasts is generally higher in melt clasts (~8%) than in the breccia (~5%). The clast content in the breccia seems to be constant throughout the length of the core. The CSD shows a higher D factor in melt clasts (~2.8) than in the breccia (~1.7). This means that in the melt clasts the number of smaller fragments is higher. The higher content of quartz clasts in the melt clasts might be an artifact: as clasts are generally less altered than in the breccia, some feldspars could have been selected by the software as quartz. The value obtained in the breccia is consistent with the value expected in a 2-D distribution of cataclastic material [9]. Unfortunately the method did not allow for the correct detection of clasts smaller than ~1 mm and the CSD is estimated only over about one order of magnitude. Further analyses on optical and electron microscope images will be performed soon. At this scale, we did not observe a bimodal CSD in melts as described by [5], but (i) these authors considered plagioclase and olivine clasts, which may have a different behavior and (ii) they investigated smaller clasts. The aspect ratio seems to be constant, with an average of 1.9, and a maximum between 1 (circle) and 2, which means that the shape of clasts is only slightly elongated and is independent from the location, i.e., in breccia or melt. A shape preferred orientation is evident. Generally one or two maxima are present. In the melt the maxima are at low angle with respect the anisotropy, generally fluidal direction, indicating alignment of clasts. In the breccia, the presence of two maxima, generally at 60 and 120°, suggests a flatting component in the development of the anisotropy of the breccia, probably due to compaction.

Conclusions: Image analysis applied to quartz clasts in selected samples from the El'gygytgyn drill core allows a better characterization of the impact lithologies. The shape, preferred orientation, and abundance of quartz clasts may provide a basis for differentiating various types of impact melt breccia and melt clasts. The method has implicit limitations that have to be improved by detailed optical and electron microscopic observations. From these studies, it appears that the impact melt breccia was subsequently deformed by compaction and that the melt fragments generally contain a larger amount of clasts. The clasts are better preserved in the melt fragments, thus an error in the CSD estimate can be induced by the image analysis technique. In any case, a larger D factor in the melt suggests reworking of previously fragmented material.

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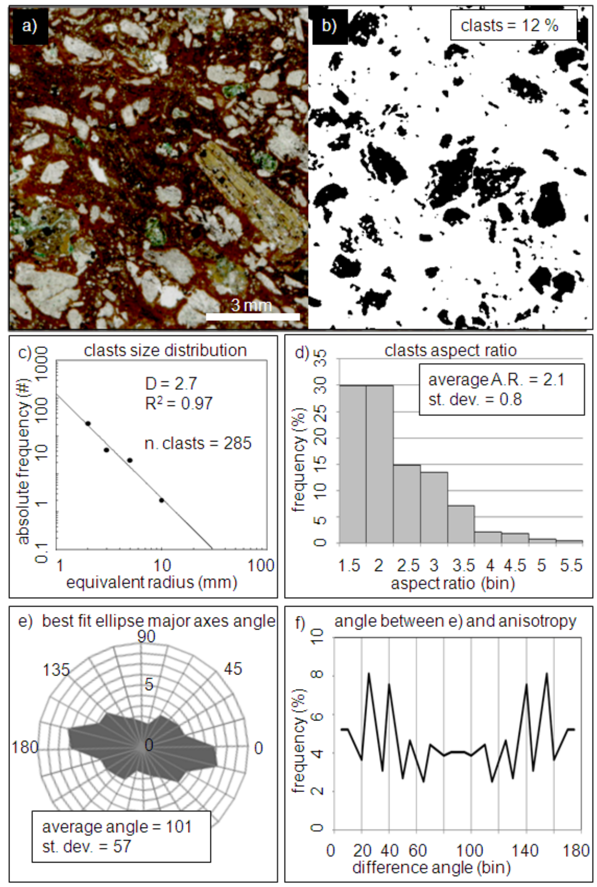

***Figure 1**. Example of image analysis of a large melt fragment. a) Plane-polarized light image of a melt clast included in an impact melt breccia (sample 147Q2W32-35, 431.80 m depth blf). b) First stage of quartz clast selection overlain on image (a). The percentage of quartz clasts is reported. c) CSD of the quartz clasts after filtering with a threshold of 20 square pixel. The CSD is plotted as equivalent radius bin vs. absolute frequency (i.e., the frequency of clasts with an equivalent radius between the lower and the upper limits of the bin are plotted vs. the upper limit of the bin). The D value (exponent) and the R^2 of the best fit curve are given. d) A.R. of quartz clasts plotted as frequency vs. bin. The arithmetic average and the standard deviation are also reported. e) SPO as angle of the best-fit ellipse major axes with respect to the horizontal vs. absolute frequency in percentage. f) Frequency of the angle between the best-fit ellipse major axis and the anisotropy in the thin section, in this case defined by fluidal fabric orientation (see a).*