COMPARING MARTIAN REGOLITH BRECCIA NORTHWEST AFRICA 8171 WITH TERRESTRIAL IMPACT BRECCIAS. M. R. M. Izawa[1], B. J. Hall[2], A. Chanou[3], A. P. Jephcoat[1], D. M. Applin[3], J. M. Stromberg[4], R. A. F. Grieve[3], E. A. Cloutis[4], [1]Institute for Planetary Materials, Okayama University – Misasa, 827 Yamada, Misasa, Tottori 682-0193, Japan, [2]Enthought Inc. 515 Congress Ave. Suite 2100, Austin TX 78701 USA [3]Dept. of Earth Sciences, Western University, London, ON, Canada, N6A 5B7 [4]Hyperspectral Optical Sensing for Extraterrestrial Reconnaissance Laboratory, Dept. Geography, University of Winnipeg, 515 Portage Avenue, Winnipeg, Manitoba, Canada R3B 2E9

Introduction: All Martian meteorites have been affected by impact processes to some degree, but the Martian regolith breccia meteorites [1] (presently consisting of 10 paired samples, including NWA 8171 studied here) are impact-generated ballistic sediments that have many similarities with terrestrial clast-rich impact-melt-bearing breccias. Comparing Martian impact breccias with terrestrial impactites offers an opportunity to compare impact-driven sedimentary processes on Mars with those recorded in terrestrial impact deposits. A possible complication in the case of NWA 8171 and the other Martian regolith breccia meteorites is that they contain clasts that derive from older impact rocks [2]; however, this is not fundamentally different from the presence of any other kind of (meta)sedimentary clast in an impact breccia.

Methods: Two slabs of NWA 8171 totaling ~2.2 g and ~16 cm^2 of available slab surface area were obtained for this study (Fig. 1). Hyperspectral image cubes were collected for NWA 8171 slabs, covering 400-700 nm (1280×1024 pixels in 31 bands) and 610-1100 nm (464×344 pixels in 44 bands), using two light sources irradiating the samples at ~45 degrees on both sides of the principal plane. Each channel is automated to maximize integration time without saturating, and measured relative to a calibrated Spectralon® target. X-ray diffraction was conducted on the slabs, using CoKα radiation, from 5-90º 2θ with an effective step size of 0.02º. The slab was rotated to multiple orientations and the results summed, to produce a qualitatively interpretable diffraction pattern. Reflectance spectra (0.35-2.5 µm) of selected ~2 mm diameter regions of the NWA 8171 slabs were collected with an ASD Field Spec Pro HR spectrometer with a viewing geometry of i=30º and e=0º, relative to a calibrated Spectralon® standard.

Image classification and analysis: Visible light images were analyzed using ImageJ, following the methods of [4]. Manual segmentation and processing in ImageJ were used to construct the training data set for the machine learning stage. Image classification consists of two steps, classification of image pixels using a support vector machine method, and spatial regularization using a Markov random field approach [5]. A training set was created by manually assigning representative pixels from each class, followed by classification and regularization steps. The training regions were selected to represent commonly observed clast types, and matrix.

Results and Discussion: The clasts observed in NWA 8171 are similar to other members of its pairing group [1-3], including an abundance of clast-rich vitrophyre particles, round aphyric impact melts, various crystalline igneous lithologies, clasts of pre-existing sedimentary (including impact sedimentary) lithologies, and mineral fragments. Many of the clasts have distinct rinds or mantles of dark, glassy impact melt. Vitrophyre and impact-melt particles commonly show reaction textures with the surrounding matrix. These melt-clast interaction textures are consistent with interaction between superheated impact melt and cold clastic materials leading to rapid cooling, during the initial stages of crater excavation and modification. Many comparable features have been observed in terrestrial impact breccias. A visual comparison between melt-clast interaction textures in NWA 8171 with texturally (though not mineralogically) similar impact melt-bearing breccias from the Popigai impact structure [4], Siberia, Russia reveals many qualitative similarities including melt mantles on clasts, lithic clasts and mineral fragments, and clast-laden vitrophyres. Like the Popigai breccia samples, NWA 8171 shows flow textures involving both groundmass and clastic debris, accretion of impact melt onto clasts, and a moderate degree of sorting.

Image analysis reveals the presence of bands of aligned particles in the matrix of NWA 8171 consistent with viscous, particulate flow. Qualitatively similar textures have been observed in terrestrial impact-melt-bearing breccias [6]. Some clasts in NWA 8171 show evidence of deformation and agglomeration of melt to form the distinctive rims on many clasts.

Spectral signatures of the NWA 8171 slabs are strongly affected by the very coarse effective "grain size" in the flat slab surfaces. While these spectra are very different from those observed for powders of the Martian regolith breccias [7], reflectance from slab-like, consolidated surfaces may be more common in spectral measurements by rover-based imaging spectrometers. Both hyperspectral imaging and "region of interest" point spectrometer measurements reveal the common presence of ferric oxides (magnetite and maghemite) as well as Fe^{2+} crystal field transitions in pyroxene-group minerals. A pair of weak features near 380 nm and 440 nm associated with light-toned lithic clasts could be consistent with phyllosilicates, which have been documented in paired samples [8].

X-ray diffraction patterns for slabs of NWA 8171 ~~are~~ show reflections for magnetite (and/or maghemite and/or titanomagnetite – these phases are not distinguishable with our XRD data), pyroxene (augite, pigeonite, and orthopyroxene) and calcic plagioclase and minor chlorapatite.

References: [1] Agee et al., Science, 339, 780–785 (2013); [2] Wittmann et al., *MAPS* 50(2) 326–352 (2015); [3] Santos et al., GCA 157 56–85 (2015); [4] Chanou et al, MAPS 49(4), 621–635 (2014); [5] Izawa & Hall, 48th LPSC 2017 abs. #2125; [6] Meyer et al., GSA Bulletin 23; no. 11/12 2312–2319 (2011); [7] Cannon et al., Icarus 252, 150-153 (2015); [8] Muttik et al., 45th LPSC abs.# 2763 (2014).

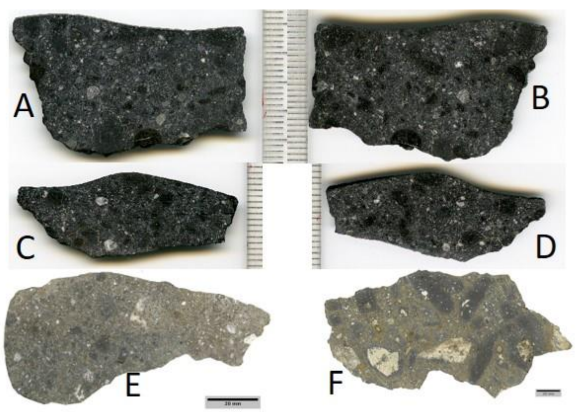

Figure 1: Slabs of NWA 8171 (A-D), showing a wide diversity of clasts including clast-bearing impact melts, rounded impact-melt clasts (ii), lithic fragments, and mineral clasts, in a dark, fine-grained matrix. E, F) Melt-bearing impact breccias from Popigai crater, Siberia, display a striking qualitative textural resemblance to NWA 8171 including the presence of accreted melt rinds on clasts, abundant lithic and mineral fragments, and vitric particles with included clasts. The scale markers in the NWA 8171 images are 1 mm, the Popigai samples are larger, scales in E and F are 20 mm.

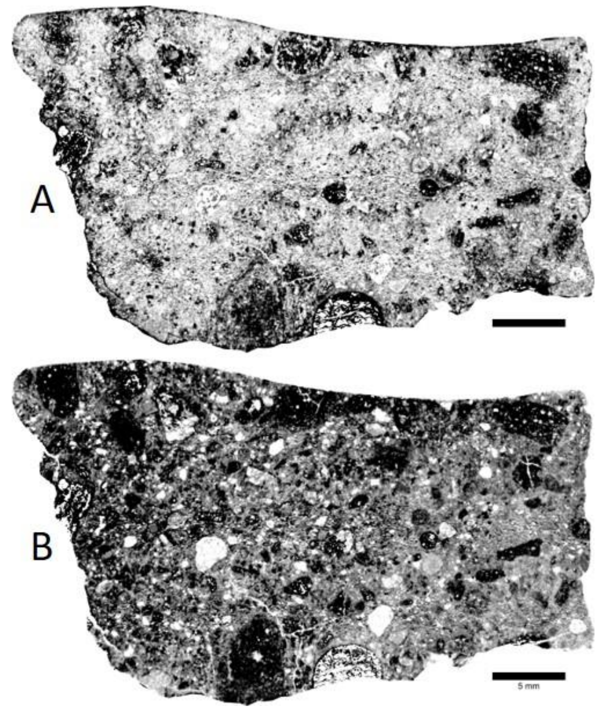

Figure 2: Filtered, processed images of an NWA 8171 scan, created with ImageJ. A) The blue channel reveals bands of flow-textured material, as well as highlighting the common presence of distinctive melt-rich rinds surrounding clasts. B) The red channel highlights the distribution of light-toned lithic and mineral fragments. Scale bar 5mm.

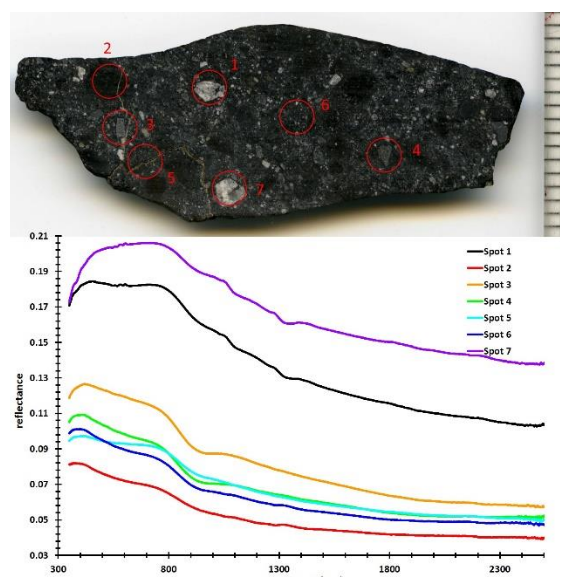

Figure 3: Reflectance spectra of selected clasts and regions in an NWA 8171 slab. Spots 1 and 7 are large lithic clasts rich in plagioclase. Spot 2 is a vitrophyre with moderate clastic load. Spots 3 and 4 are pyroxene-bearing lithic clasts of broadly basaltic nature. Spot 6 is representative of matrix.