THERMAL INFRARED SPECTRA OF CLASTS IN THE MARTIAN POLYMICT BRECCIA NORTHWEST AFRICA 7034 AND COMPARISON TO MARTIAN SURFACE SPECTRA. V. E. Hamilton[1] and A. R. Santos[2], [1]Southwest Research Institute, 1050 Walnut St. #300, Boulder, CO 80302 USA (hamilton@boulder.swri.edu), [2]University of New Mexico, MSC03-2050, Albuquerque, NM 87131 USA.

Introduction: An ongoing, arguably unfulfilled, objective is to identify the specific source locations of Martian meteorites on Mars [e.g., 1, 2]. These meteorites are the only Martian samples available for detailed laboratory analysis of key isotopic, chemical, and mineralogical characteristics that inform our understanding of the origin and evolution of Mars. Unfortunately, they lack crucial geologic context that would improve our interpretations of these characteristics and conversely, permit us to apply those characteristics to our understanding of specific locations on the Martian surface. The meteorite Northwest Africa (NWA) 7034 [3] is a relatively new addition to the collection of Martian meteorites that has been suggested to have originated in the Noachian highlands [4], large portions of which are relatively dust-free and offer a new opportunity to search for the source region or locality of a Martian meteorite and its component lithologies.

Northwest Africa 7034. NWA 7034 is unique among Martian meteorites because it (and paired meteorites, included hereafter where we refer to 7034) is a polymict breccia [4]. It contains many distinct lithologies that are different from those represented by the other Martian meteorites but are chemically similar to terrains measured from orbit and by rovers [4, 5].

Previous spectral studies of NWA 7034. [6-8] have characterized individual phases and/or the bulk spectral properties of NWA 7034, variously covering all or part of the spectrum from the visible to the thermal infrared. Whole-rock spectra are useful for searching for similar bulk materials on the Martian surface, however, spectra obtained from different clast types within the breccia would allow for characterization of additional kinds of Martian crustal rocks, which can then be identified on the Martian surface.

Objectives of this work. We are obtaining new thermal infrared spectra of NWA 7034 to develop a comprehensive spectral library of all individual phases and clasts in NWA 7034. These will be used, in part, for new analyses of Martian remote sensing data.

Samples: To date, we have measured spectra from thin section NWA 7034 3B,2 (Figure 1) and two cut slabs of Northwest Africa 8674 (1A and 1B), all from the collection of the Institute of Meteoritics at UNM, which collectively contain virtually every type of clast observed in NWA 7034, including: basalt; Fe-, Ti-, and P-rich (FTP); trachyandesite; basaltic andesite; melt; and mineral clasts [5]. Optical, microprobe, back-scattered electron (BSE), and/or X-ray data are available. We identified clasts within NWA 7034 for spectral analysis using BSE images and X-ray element maps.

Spectral Measurements: We use a Thermo Scientific iN10 FTIR microscope to measure reflectance from 4,000 - 400 cm^{-1} (2.5 - 25 µm). Automated mapping is enabled via a motorized sample stage. For this study, we mapped NWA 7034 with a 300-µm aperture at 300 µm spatial resolution and 4 cm^{-1} spectral resolution. Individual spectra represent 256 scans.

Results & Discussion: Figure 2 shows the average (bulk) spectrum of NWA 7034 3B,2 and spectra of seven clasts. The individual clasts exhibit a wide range of spectral characteristics that are diagnostic of their mineralogies. Our bulk spectrum of NWA 7034 is virtually identical to that of [8]. The melt clast is very similar to the bulk spectrum, albeit with muted contrast, consistent with the observation that most melt clasts are devitrified [5]. The spectra of the igneous clasts (e.g., basalt, BA) exhibit a transition from low Ca pyroxene-dominated to increasingly plagioclase-bearing (e.g., loss of the 510 cm^{-1} pyroxene minimum, appearance of oligoclase features at 537, 639 cm^{-1} and 1200-1000 cm^{-1}). FTP clasts are comprised primarily of plagioclase, apatite, and Fe– Ti oxides; this clast is dominated by apatite (doublets at 1087/1043 cm^{-1} and 605/568 cm^{-1}). The K-fsp clasts exhibit orientation effects, which also may affect the trachyandesite.

Figure 3 shows Martian meteorites and spectra measured by the Thermal Emission Spectrometer (TES) and Mini-TES at Mars. The bulk spectrum of NWA 7034 exhibits stronger pyroxene features than ST1 or ST2 and also differs from pigeonite-rich Martian meteorites (Zagami & Los Angeles). Wishstone-class rocks (which resemble plagioclase-phyric basalt) are not a good match to the igneous clasts as they contain much less pyroxene (~15 vol%) [9]. Clinopyroxene- and olivine-rich meteorites (e.g., Nakhlites, lherzolites) and rocks on Mars (Adirondack olivine basalts, not shown) are not represented among these clasts.

The bulk chemistry of NWA 7034 exhibits strong similarities with Gusev soils and we are isolating Mini-TES spectra for comparison to NWA 7034. Evidence of orientation effects confirms that although we are isolating spectra of different clasts, comprehensive characterization of the clast lithologies and individual mineral spectra requires measurement of many different clasts. Identifying a suite of co-located clast-like rock units on Mars could provide insight into the location/size of the area sampled by the breccia.

References: [1] Hamilton V. E. et al. (2003) *MAPS, 38,* 871-885. [2] Ody, A. et al. (2015) *Icarus, 258,* 366-383. [3] Agee C. B. et al. (2013) *Science, 339,* 780-785. [4] Humayun M. et al. (2013) *Nature, 503,* 513-516. [5] Santos A. R. et al. (2015) *Geochim. Cosmochim. Acta, 157,* 56-85. [6] Muttik N. et al. (2014) *GRL, 41,* 8235-8244. [7] Beck P. et al. (2015) *EPSL, 427,* 104-111. [8] Cannon K. M. et al. (2015) *Icarus, 252,* 150-153. [9] Ruff S. W. and Hamilton V. E. (in press) *Am. Min.*

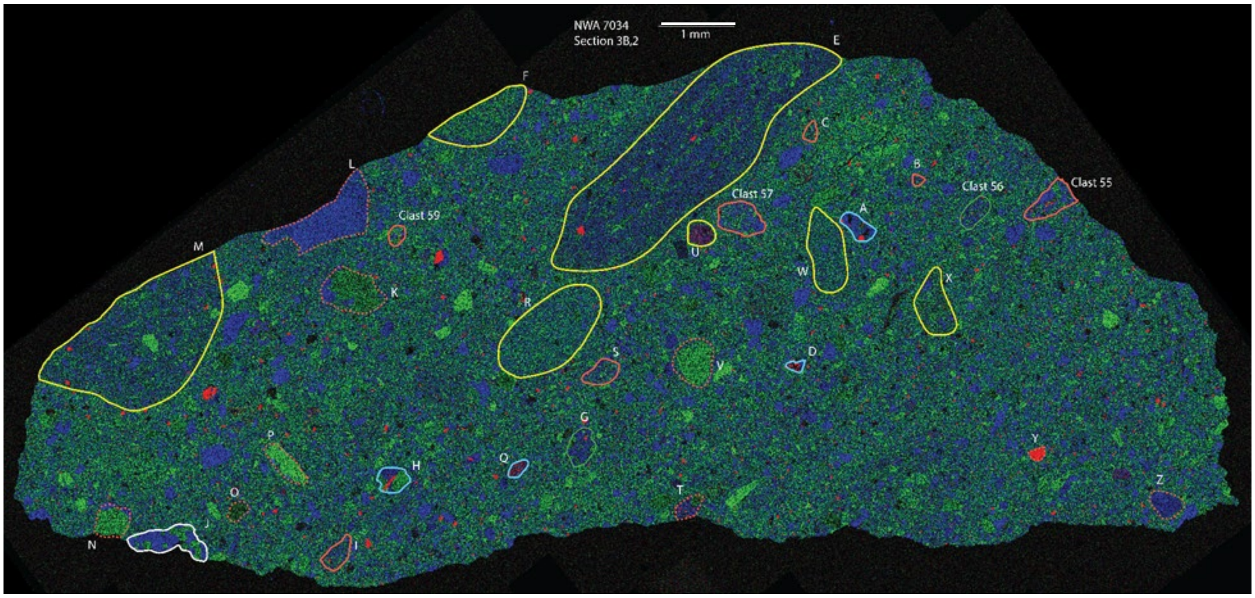

Figure 1. X-ray map of NWA 7034 3B,2 showing P, Mg, and Al in red, green, and blue. Clasts are outlined: red = basalt, blue = FTP, green = trachyandesite, white = basaltic andesite, yellow = melt clast, red dashed = mineral clast of interest. Scale bar at top is 1 mm across. From [5].

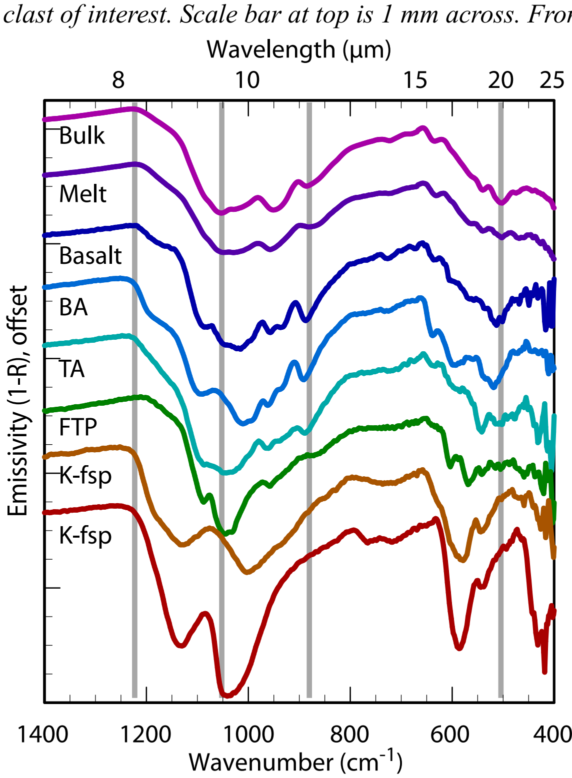

Figure 2. IR spectra of NWA 7034 ("bulk") and clast types. BA = basaltic andesite; TA = trachyandesite; FTP = Fe-, Ti-, P-rich; K-fsp = alkali feldspar.

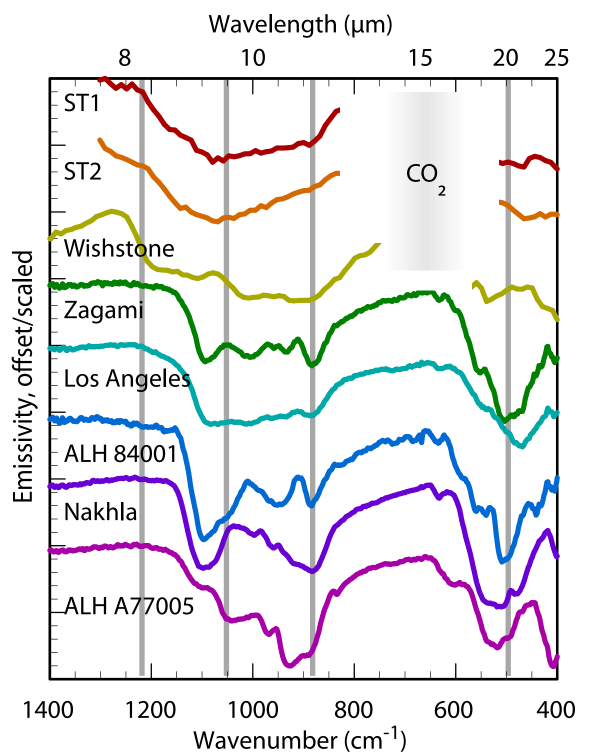

Figure 3. TES spectra of surface types 1 and 2; Mini-TES spectrum of Wishstone class average (Gusev crater), and Martian meteorites.