HIGHLY DIFFERENTIATED BASALTIC LAVAS EXAMINED BY PIXL IN JEZERO CRATER. M. E. Schmidt[1], A. Allwood[2], J. Christian[3], B. C. Clark[4], D. Flannery[5], J. Hennecke[6], C. D. K. Herd[7], J. A. Hurowitz[8], T. V. Kizovski[1], Y. Liu[2], S. M. McLennan[8], M. Nachon[9], D. A. K. Pedersen[6], D. L. Shuster[10], J. I. Simon[11], M. Tice[9], N. Tosca[12], A. H. Treiman[13], A. Udry[14], S. VanBommel[3], M. Wadhwa[15]. [1]Brock U. (St. Catharines, ON L2S 3A1 Canada, mschmidt2@brocku.ca), [2]JPL-Caltech (Pasadena, CA 91125), [3]Wash. U. (St. Louis, MO 63130), [4]Space Sci. Inst. (Boulder, CO 80301), [5]Queensland U. Tech (Brisbane QLD 4000, Australia), [6]DTU Space, Tech Univ. of Denmark (Kongens Lyngby, Denmark), [7]U. Alberta (Edmonton, AB T6G 2E3 Canada), [8]SUNY Stony Brook (NY 11794), [9]Texas A&M (College Station, TX 77843),[10]Univ. CA (Berkeley, CA 94720-4767) [11]NASA JSC (Houston, TX 77058), [12]Univ. Cambridge (Cambridge CB2 1TN United Kingdom) [13]Lunar Planet. Inst. / USRA (Houston, TX 77058), [14]U. Nevada, Las Vegas (Las Vegas, NV 89154), [15]Arizona State U. (Tempe, AZ 85281).

Introduction: Textural, bulk chemical, and mineralogical data collected by PIXL (Planetary Instrument for X-ray Lithochemistry) indicate that the first rock unit (Cf-fr, Crater Floor-Fractured rough) examined by the M2020 Perseverance rover in Jezero crater is from a basaltic lava flow. This unit was originally mapped as volcanic flow [1] but has been reinterpreted as a clastic or volcaniclastic sediment [2]. We here present evidence that it is a basalt flow, with implications for its petrogenesis as a highly differentiated basalt.

Methods: PIXL is an X-ray Fluorescence (XRF) spectrometer that maps fine-scale (~120 µm spot) elemental compositions of martian surface materials [3]. Elements reported include Na to Ni when present above detection limits. PIXLISE [3] is data visualization software to analyze X-ray spectral, spatial, and compositional variations. We present the results of two PIXL map scans (6x6 mm) on abraded rock targets (Guillaumes, sol 167; Bellegarde, sol 187) that provide insights to textures and mineralogy of the Cf-fr.

Rock textures are characterized in microscopic images by SHERLOC Watson and ACI (Autofocus Context Imager) cameras [4], and by PIXL's MCC (Micro Context Camera). Raw and corrected bulk compositions for Guillaumes and Bellegarde were calculated as the averages of spot PIXL analyses where SO_3<2 wt% and Cl<2 wt%. Corrected bulk compositions were recast as CIPW norms to indicate what igneous minerals they would form at low pressure (1 atm) anhydrous conditions for Fe^{3+}/Fe_T=0.1. Mineral endmember compositions are quantified by defining expressions in PIXLISE and from stoichiometries.

Textures: Images of abraded patches show that both rocks are holocrystalline with interlocking, blocky light- and dark-toned crystals with consistent grain sizes of ~0.5 to 1 mm. From elemental composition and color, they are interpreted to be plagioclase and augite pyroxene. Irregular cracks follow mineral grain boundaries, but do not define boundaries of distinct clasts, as a sediment might show (Fig. 1). No obvious intergranular porosity and(or) material (i.e., cement) are identified. Holes are irregular to rounded and could be primary vesicles. Mineral grains surround or project into many holes, which (if vesicles) suggests that a crystalline framework existed prior to their formation.

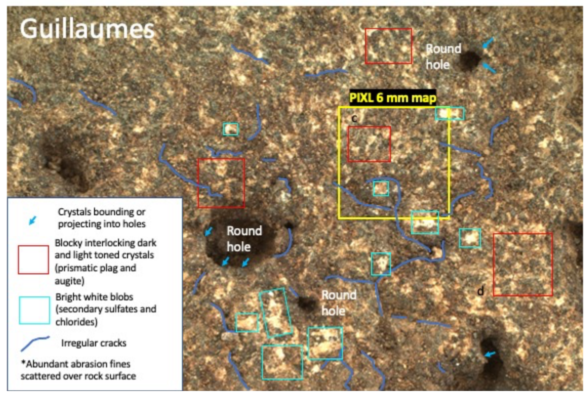

Fig. 1. Annotated SHERLOC Watson microscopic image of the Guillaumes abraded patch.

The interlocking pyroxene and laths of feldspar and pyroxene are displayed well in elemental abundance maps (Fig 2). The primary mineral assemblage includes Fe-rich augite (purple), plagioclase (green), and Fe-silicate (red). This assemblage indicates formation at high temperature. Apatite and titanomagnetite (also red) occur at interstices between pyroxene and feldspar, which is consistent with a late-stage formation [5].

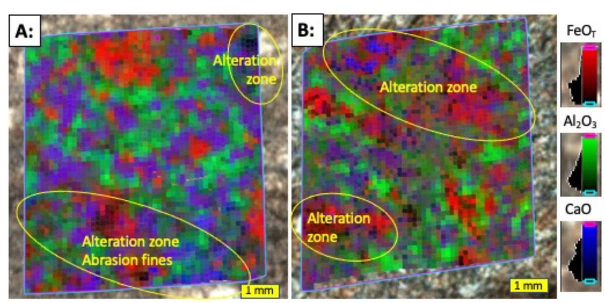

Fig 2. PIXL RGB maps for A: Guillaumes and B: Bellegarde. Alteration zones where secondary Fe-silicate and chloride and sulfate salts are abundant are indicated.

Bulk chemistry: Corrected, salt-free compositions for Guillaumes and Bellegarde are basaltic and trachy-basaltic, respectively (Fig 1). Their low Mg#s (molar $Mg/(Mg+Fe_{Tot})*100$; 17.9 and 13.8 for Guillaumes and

Bellegarde respectively) suggest high degrees of fractionation. CIPW norms are consistent with evolved basalts with quartz and no olivine. The norms lack Al-rich minerals (e.g., corundum) that (for a basaltic composition) imply significant chemical weathering.

Low abundances of igneous compatible elements (MgO=2.8 and 1.9 wt% for Guillaumes and Bellegarde, respectively; Cr, Ni below detection) and high FeO_T and Al_2O_3 are consistent with fractional crystallization of basaltic magma and not with sedimentary sorting. Of the Martian meteorites, Guillaumes and Bellegarde are most like, but more differentiated than the evolved shergottite Los Angeles [6]. Incompatible/compatible element variations are consistent with Bellegarde being more fractionated than Guillaumes.

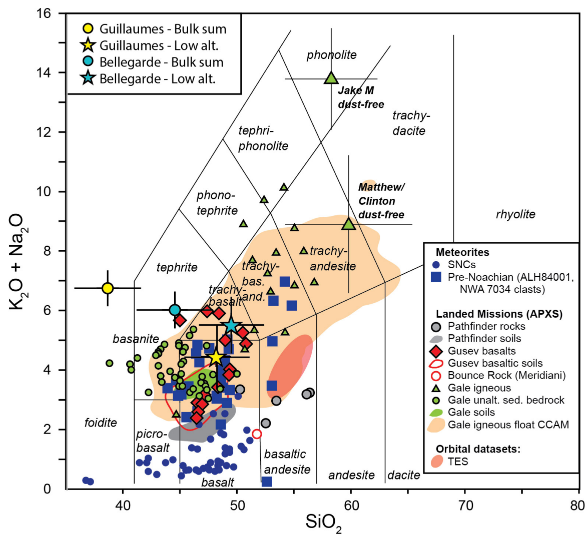

Fig 3. Total alkali vs. silica diagram after [7] with initial raw composition (Quicklook BS) and salt-free compositions for Guillaumes and Bellegarde. Error bars on Jezero PIXL analyses represent absolute error, plus 10% relative.

Mineralogy: Guillaumes and Bellegarde contain the same few minerals (as above), but with slightly different compositions. Higher Na in feldspar and Fe in augite in Bellegarde than in Guillaumes (Fig. 4) are consistent with higher degree fractionation, as is indicated by bulk chemistry. The augites' Fe contents are notably high and overlap the range of last crystallizing pyroxenes of Los Angeles meteorite [8].

The Fe-silicates in both targets are interpreted to be primary fayalitic olivine with a secondary, hydrous phase like the serpentine greenalite. Larger Fe-silicate patches show x-ray diffraction peaks in their XRF spectra, indicating they are relatively large crystals or clusters (~3 mm), which is consistent with olivine but not serpentine. The dark tones of these grains suggest presence of, and partial replacement by serpentine. The rocks' normative mineralogy does not include olivine, which is possible for highly fractionated basalts.

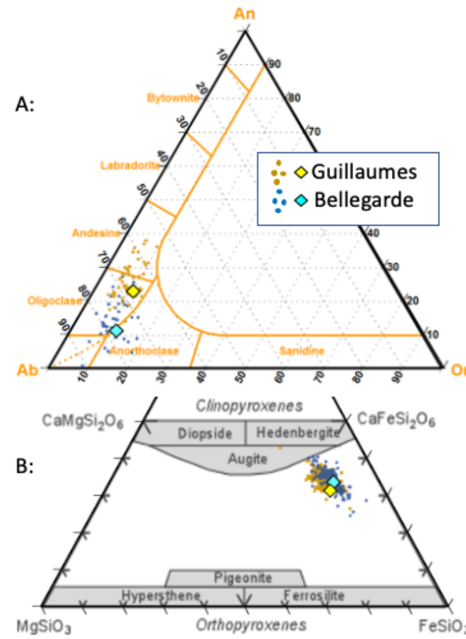

Fig. 4A: Feldspar ternary and B: pyroxene quadrilateral diagrams for mineral endmember classification.

Discussion & Conclusions: The homogeneity of mineral compositions and textures across the PIXL scan areas, and absence of recognizable clast boundaries, are consistent with an igneous origin [9]. In the PIXL and image data, we find no evidence that Guillaumes and Bellegarde are sedimentary rocks.

Cf-fr rock targets Guillaumes and Bellegarde are classified as micro-gabbros on the basis of their holocrystalline, interlocking textures, small grain sizes, and modal mineralogy. Their small grain sizes suggest that both rocks formed in lava flows.

The high degree of fractionation implied by the Cf-fr bulk chemistry and mineral assemblage implies the existence of complementary high-Mg crystalline lithologies. While it is possible the Mg-rich materials are the Jezero crater floor olivine-rich lithology of Séítah [9,10] the relative timing of Séítah and Cf-fr are not clear, and they may instead reside in subsurface chambers. Additional observations along the traverse or eventual sample return may resolve this geologic riddle.

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