FIELD GEOLOGIC MAPPING OF SAMPLE SITES FROM THE GROUND AND THE AIR WITH PERSEVERANCE ROVER AND INGENUITY HELICOPTER. Crumpler, L.S.[1], Nathan R. Williams[2], J.I. Simon[3], F.J. Calef III[2], and G. Caravaca[4] ; [1] New Mexico Museum of Natural History & Science, Albuquerque, NM 87104, (larry.crumpler@dca.nm.gov) ; [2]Jet Propulsion Laboratory, California Institute of Technology, USA; [3] NASA Johnson Space Center, [4] IRAP, CNRS, CNES, Univ. Toulouse, France

Introduction. One of the primary mission goals for Perseverance is to determine the geologic context of sample sites [1]. Rover-based (in situ) or field geologic context mapping (GXM) based on *Perseverance* rover and *Ingenuity* helicopter observations provides a nearly continuous record of geologic context and exposed surface structure over a 120 m-wide corridor along the traverse of *Perseverance* and the flight path of Ingenuity. Field geologic mapping along the traverse and flight path and outcrop-scale mapping at sample sites provides a *spatial* dimension to ground truth geologic, stratigraphic, and modern environmental context for samples at scales relevant to sample interpretation. Here we provide an abbreviated overview of field mapping as it relates to documenting the architecture of the Jezero fan and geologic context of several examples of sample locations.

In Situ Geologic Mapping Methods and Constraints. GXM was conceived for and was an outgrowth of Mars Exploration Rover geologic exploration [2]. The results here are based on a refined version of GXM implemented for the Perseverance mission in which the maximum mapping radius (60 m) is semi-quantitatively defined based on imaging incidence and distance for a resolution known to be required for geologic field mapping [3]. Additional extreme resolution (outcrop scale) mapping was done within 7.5 m of the rover location at each sample site using front Hazcam and vertically projected MastcamZ image mosaics. The results yield a continuous lithostratigraphic geologic strip map, or geologic transect, generated from rover observations, and are further supplemented with mapping on helicopter images. Mapping from *Ingenuity* low altitude aerial RTE (color, oblique) images provided important insights at several locations, a clear example of which is discussed below. Mapping with Ingenuity RTE images is challenging due to the variable altitude, incidence angle of optic axis, wide-angle optic distortions, and corresponding task of locating, processing, and rectifying the observations.

Mapping Examples. During its transect of the Jezero fan, *Perseverance* documented 10s of meters of exposures sedimentary section [4;5] several types [6] of regolith, and upper fan boulder deposits [4,8] beginning on sol 413 from the lowest section to a point near the crater inlet source after sol 1000. Observed lithologies and geometries are consistent with the three-fold sequence typical of Gilbert deltas: lower bottomset beds, middle clinoform beds, and upper topset beds [4;5;7]. Lithologies range from coarse pebbly, various laminated, and sulfate-cemented sandstone, siltstones, pebble conglomerates, and boulder conglomerates 4;7].

Base of Jezero Fan (sols 716-XXX). A stacked sequence of horizontal to gently dipping laterally continuous sand and silt layers examined in two sections near the base of the exposed fan section (“Cape Nukshak”, ~15 m and “Hawksbill Gap”, ~25-30 m) the lowest of

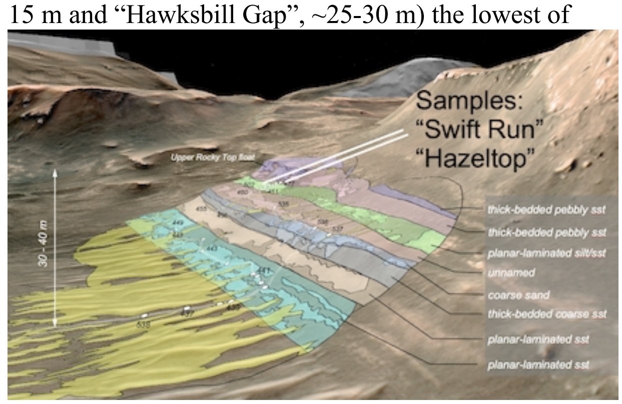

Figure 1. DTM view of in situ mapping documenting sediments layers at Hawksbill Gap near the base of the Jezero fan, site of *Swift Run and Hazeltop samples.*

which rests unconformably on crater floor mafic cumulate rocks (Seitah fm) [8]. The observed sequence and lithologies are consistent with bottomset beds of a classic Gilbert delta **(Fig 1).** *Samples Swift Run and Hazeltop were acquired near the top of this sequence.*

Middle Jezero Fan. From sol 716 to 788 *Perseverance* traversed exposures of variably dipping, arcuate beds of coarse to pebbly sandstone, the “curvilinear unit” of the middle fan surface. There are competing

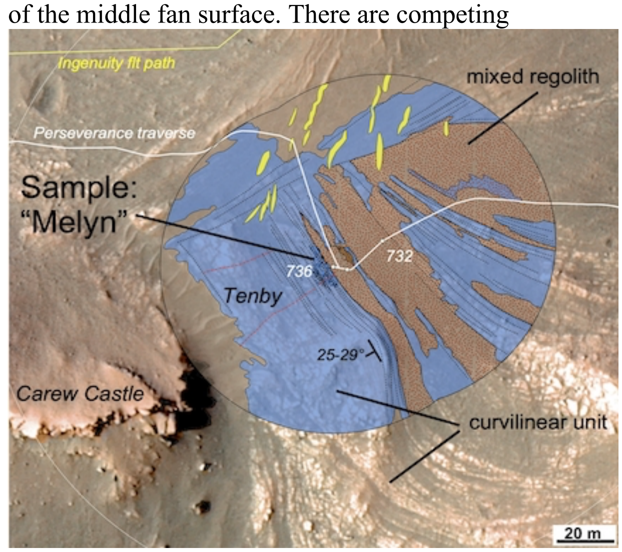

Figure 2. In situ mapping of the middle fan curvilinear unit at “Tenby”, the site of the sample Melyn.

emplacement models [9, 10]. (Fig. 2). The sample M*elyn* was acquired in this enigmatic unit.

Upper Jezero Fan. Between sols 768 and 821 investigations focused on a pebbly conglomerate at an unconformable contact between the upper fan boulder unit and middle fan curvilinear unit (Fig 3). The sample *Otis Peak* was acquired in this pebbly conglomerate.

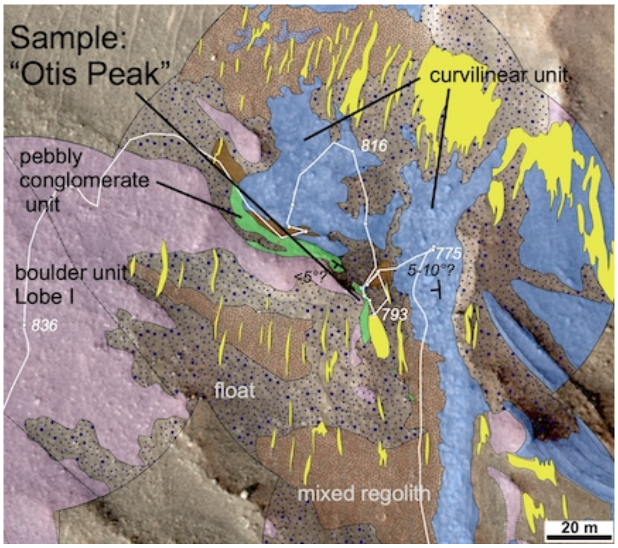

Figure 3. In situ geologic mapping on the western margin of Belva crater where the middle fan curvilinear unit is unconformably overlain by upper fan boulder and pebbly conglomerate units (*Otis Peak* sample).

Ingenuity Flight 52 approached and landed in the floor of a late fan lobe (Lobe M [11]), "Willow Park & Dream Lake", prior to Perseverance's arrival there. Geologic mapping in the approach and landing images (Fig. 4a) together with in situ mapping from *Perseverance* (Fig 4b) from sols 870 to 886 extended these observations up channel to Dream Lake providing detailed context for a

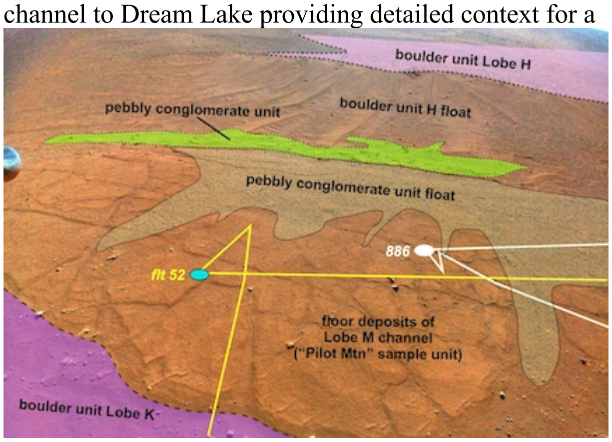

Figure 4a. Photogeologic mapping on Ingenuity flight 42 RTE image of the channel floor of fan lobe M. Debris from the pebbly conglomerate, viewed obliquely on the western margin of the channel, stream across the channel floor. This floor lithology that was sampled 180 m to the north (*Pilot Mountain* sample).

lithology later sampled (*Pilot Mountain)* within the floor of this channel associated with a late fan lobe.

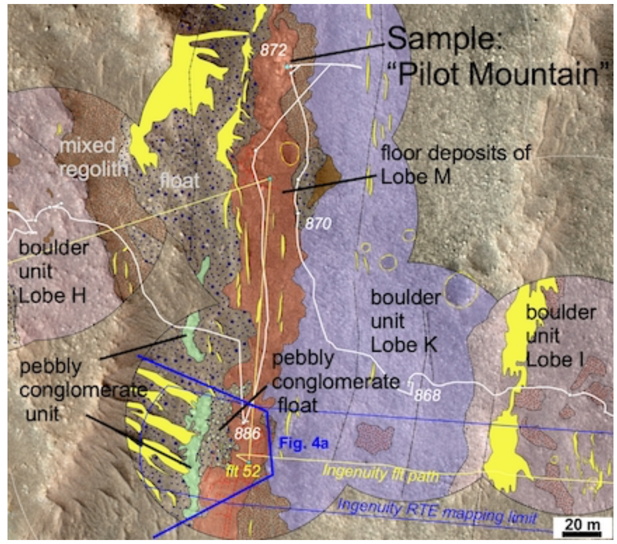

Figure 4b. In situ geologic mapping of the floor of fan lobe M identifying the contact between the floor deposit sampled at *Pilot Mountain* and the surrounding pebbly conglomerate and boulder units. Note area of Fig. 4a.

Summary Comments. GXM in situ geologic mapping along the rover traverse and aerial geologic context from the helicopter provide an unprecedented level of *spatial geologic context* for collected Mars samples. This information is in addition to the petrologic and elemental (SHERLOC, PIXL [12], mineralogical/spectral [MastcamZ [13]; Supercam [14], stratigraphic context determined from contact science and nested imaging. Based on in situ geologic context, the geologic history and environments of resulting sample suite is constrained at levels approaching that attainable from terrestrial sampling sites. GXM also demonstrates methods that will be applicable to future robotic and human mission traverses of planetary surfaces.

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References. [1] Mustard et al. (2013) M2020 Sci Def. Team Rept,, http://mepag.jpl.nasa.gov/reports/MEP/Mars_2020_SDT_Report_Final.pdf; MEPAG E2E-iSAG, 2011; [2] Crumpler et al., (2015) *JGR-Planets,120,* doi.10.1002/2014JE004699; (2020), *Geology*, 48,252, doi.org/10.1130/G46903.1; [3] Crumpler et al., (2023), *JGR-Planets,* doi.org/10.1029/2022JE007444; [4] Stack et al (2024) JGR, in review; [5] Gwizd et al (2024) *LPSC52,* abstract ; [6] Vaughn et al, (2023), *JGR-Planets,* doi.org/10.1029/2022JE007437; [7] Gupta et al, (2024) *LPSC 55*, abstract ; [8] Paige et al (2024*) Sci. Advances*, in proof; [9] Caravaca et al., (2024*) LPSC 55*, abstract [10] Mangold et al. 2024, *LPSC 55*, abstract; [11] Kronyak et al, (2023), *LPSC54,* abstract 2806; [12] Bharti et al. (2021) *Space sci. rev*, 217, 58,; Allwood et al. (2021 *Space sci. rev*, 217, 8; [13] Bell et al.(2021) *Space sci. rev*, 217; 1; [14] Wiens et al. (2021) *Space sci. rev*, 217, 4.