STRATIGRAPHIC RELATIONSHIPS OF THE WESTERN DELTA AND CRATER FLOOR IN JEZERO CRATER FROM RIMFAX GPR OBSERVATIONS.

P. S. Russell[1], D. A. Paige[1], S.-E. Hamran[2], H. Amundsen[3], A. Annex[4], T. Berger[2], L. Carter[5], T. M. Casademont[2], H. Dypvik[2], S. Eide[2], R. Kakaria[1], M. T. Mellon[6], D. Nunes[7], J. I. Núñez[8], E. Shoemaker[5], J. I. Simon[9]. [1]Dept. Earth Planetary & Space Sciences, UCLA, Los Angeles, 90095 (patrick.russell@epss.ucla.edu) [2]Inst. Technology Systems, Univ. Oslo, Oslo, Norway [3]Vestfonna Geophysical, Trondheim, Norway [4]California Inst. Technology, Pasadena, CA [6]Cornell Univ., Ithaca, NY [7]JPL, California Inst. Technology, Pasadena, CA [8]APL, Johns Hopkins Univ., Laurel, MD[19]NASA JSC, Houston, TX.

Introduction: One of the most fundamental questions about the geology of Jezero prior to the arrival of Mars 2020 *Perseverance* rover was the relative sequence of emplacement of the western delta and the adjacent crater floor terrain. Based on orbital evidence, some authors favored delta formation to post-date crater floor emplacement [e.g., 1], though crater floor material appears to exhibit embaying relationships in other areas. An older crater floor would also be inconsistent with the crater floor material consisting of lake or eroded delta sediments, which would be syn- or post-depositional with the delta [e.g., 2].

Unlike previous NASA Mars rovers, *Perseverance* is equipped with a Ground Penetrating Radar (GPR), the RIMFAX instrument [3]. This GPR functionality allows collection of information on subsurface structure, physical properties, and composition. In the first year after landing (during the Crater Floor campaign), RIMFAX illustrated a key relationship of crater floor units, with strongly reflecting interfaces in the exterior of *Seitah* clearly dipping to several meters of depth below overlying *Maaz*, most notably beneath Artuby ridge [4]. This pattern of the subsurface *Maaz*-*Seitah* contact sloping away from major *Seitah*-like surface outcrops has since been confirmed around 3 sides of the *Seitah* geographical feature as well as at the eastern edge of the Seitah-similar cf-f2 unit (bright green in Fig. 1) near *Cannery Passage* (in the early Delta Front campaign). RIMFAX has also contributed to distinction of members within *Maaz* around the periphery of *Seitah* [5].

Here, we bring these demonstrated capabilities of RIMFAX to elucidate Jezero unit relationships to bear on the contact of the body of delta sediments with the surrounding crater floor terrain (comprising both *Seitah* and *Maaz*). The relative age of the delta and crater floor has direct implications for the timing of water-related activity at the martian surface. The floor of Jezero crater is currently dated by crater-counting to ~2.5-3.5 Ga / Hesperian [2, 6], which could be constrained by samples collected by *Perseverance*.

Results: *Perseverance* has explored two distinct lobes of the delta front during its current Delta Front campaign: *Cape Nukshak* to the west and *Hawksbill Gap* to the east [7, 8; Fig 1, 2]. Initial approach to *Cape Nukshak* (*Cannery Passage*, CP), planned with the purpose of studying the crater-floor – delta contact, arrived the toe of the delta (*Enchanted Lake*, EL) but did not cross the contact (sols 417-426). A return trip to the area crossed from the crater floor, over EL, across the lower *Cape Nukshak* plateau, and up to *Yori Pass* (sols 555-609), and then back along a similar route (sols 620-647). RIMFAX GPR data from the *Cape Nukshak* section is shown in Fig 2. RIMFAX GPR data was also collected as *Perseverance* ascended (sols 437-470) and descended (sols 535-539) the *Hawksbill Gap* section (Fig. 1). Notably, the expected contact zone is completely covered by aeolian material at the base of *Hawksbill Gap*, while the base of *Cape Nukshak* is largely aeolian-bedform free but appears to be near an indistinct, darker, outcrop-poor zone in orbital data.

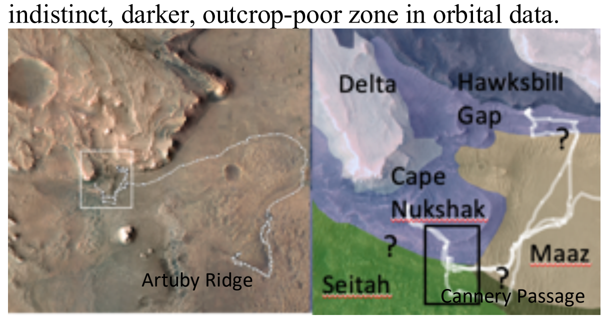

Fig. 1. HiRISE orbital view and pre-landing geologic map of the Delta and Contact zone with the Crater Floor (Maaz, Seitah) [9, 10], with Perseverance traverse and context boxes.

At *Cape Nukshak* (Fig. 2, 3), the strongest reflector clearly identifies the division between the crater floor (with Seitah-like radar characteristics as in [4]) and the delta sediments. The contact occurs at the base of *Enchanted Lake*, southern edge of *Kaguyak* outcrop. Here, internal layering within the delta is seen to be nearly flat lying, and onlapping (rather than paralleling) the basal *Seitah* contact below. This suggests that the earliest stages of delta-sediment deposition apparent in GPR data are not visible at the surface, and that they progressively built up against the flanks of the pre-delta *Seitah* more or less horizontally. The exterior zones of *Seitah* are internally layered, roughly parallel to the delta contact, confirming this pattern to be diagnostic of upper Seitah, suggesting modification from outside rather than within. SCAM has identified this zone as highly altered Seitah [11]. The indistinct, darker zone in orbital data is on the *Seitah* (not-Delta) side of this contact, although sparse outcrops of ridges with apparent differences from Seitah rocks in this zone (visible in Navcam and other images) may allow for them to be some pre-delta, Seitah-transitional unit.

At *Hawksbill Gap* (Fig. 4), the contact configuration and identity of the crater-floor, delta-subjacent formation, are a bit less clear. Delta sediments are clearly distinguished from underlying crater floor material. However, the contact does not intersect the surface as it is buried below a wedge of poorly reflecting debris, interpreted as talus-like material mass-wasted off of the delta front after or during the [most-recent] scarp-wards erosion of the delta front. To the south of this debris, a thin *Maaz*-related layer overlies *Seitah*-like basement; Seitah underlies everything between and including *Cape Nukshak* and *Hawksbill Gap*. It is less clear how far beneath the delta *Maaz* extends, as the contact rises several meters beneath the thickening stack of delta sediments. The slope of this contact is represented as accurately as possible based on single-layer velocity modeling of hyperbola-like reflectors found within delta sediments, which suggest a higher average delta velocity than the 0.10 cm/ns for the crater floor mean [11, 12].

In identifying the Delta-Crater Floor contact and onlapping nature of the delta, RIMFAX also reveals no significant zone of pro-delta, lacustrine sediment accumulation as would be expected both beneath and distal to the coarser sandy members of the lower delta. This may suggest that the duration of any lake prior to arrival of the delta to this point was relatively short.

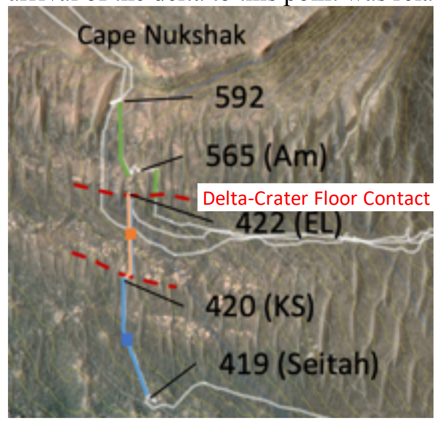

Fig. 2. Context for Cape Nukshak radargram in Fig. 3.

References: [1] Awlmark S. et al., 2021. [2] Goudge T. et al., 2012. [3] Hamran S.-E. et al., 2020. [4] Hamran S.-E. et al., 2022. [5] Horgan B.N. et al., 2022. [6] Shahrzad S. et al., 2019. [7] Russell P.S. et al., AGU, 2022. [8] Williams A.J. et al., LPSC, 2023. [9] Stack K.M. et al., 2020. [10] Sun V.Z. and Stack, K.M., 2020. [11] Beyssac O., et al., LPSC, 2023. [12] Casademont T., et al., 2022. [13] Casademont T. et al., LPSC, 2023.

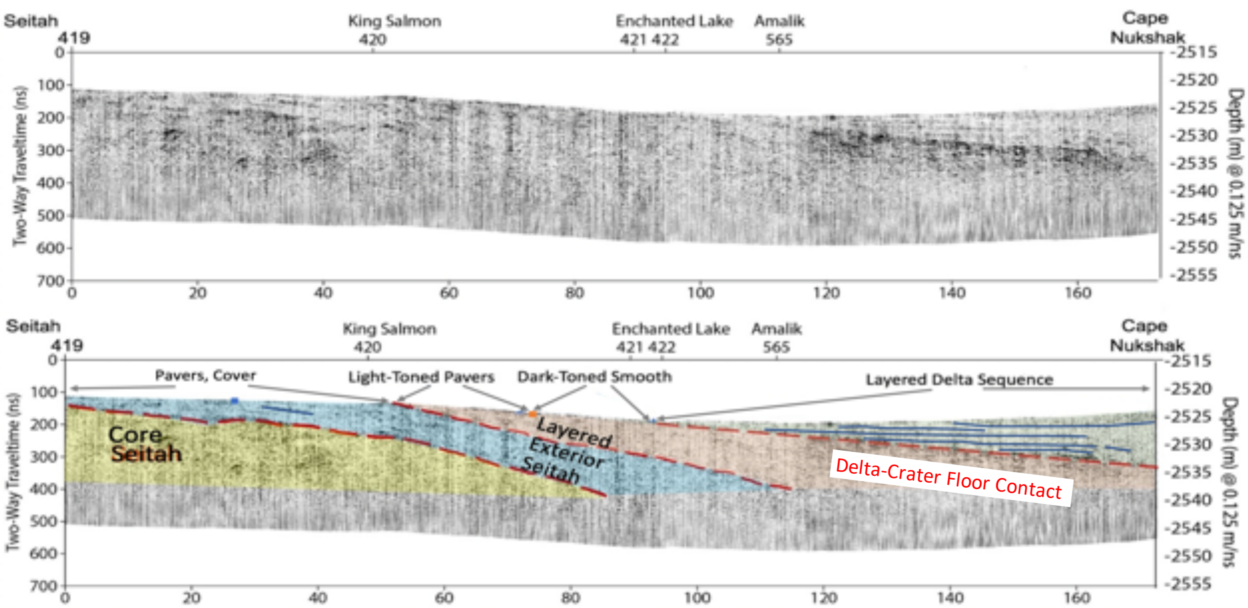

Fig. 3. RIMFAX radargram of *Cape Nukshak* section – see Fig. 2 for surface traces of radar-derived zones and Delta-Crater Floor Contact; Sol numbers and locality names along top axis also provide context.

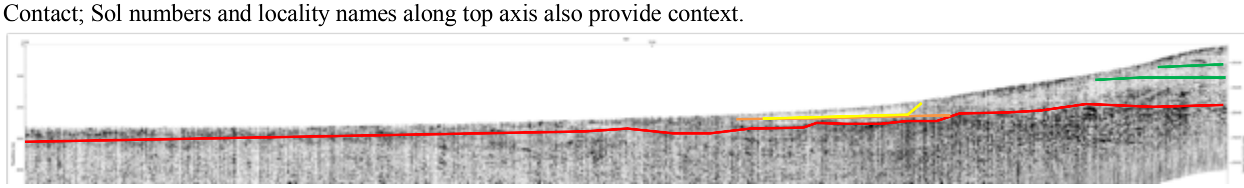

Fig. 4. RIMFAX radargram of *Hawksbill Gap* section. Red = Top of Seitah; Orange = Top of Maaz; Green = Delta-internal layers; Yellow = Mass-wasted debris/talus. Radargram is 185 m long.