EXPLORING THE JEZERO DELTA FRONT: OVERVIEW OF RESULTS FROM THE MARS 2020 PERSEVERANCE ROVER'S SECOND SCIENCE CAMPAIGN.

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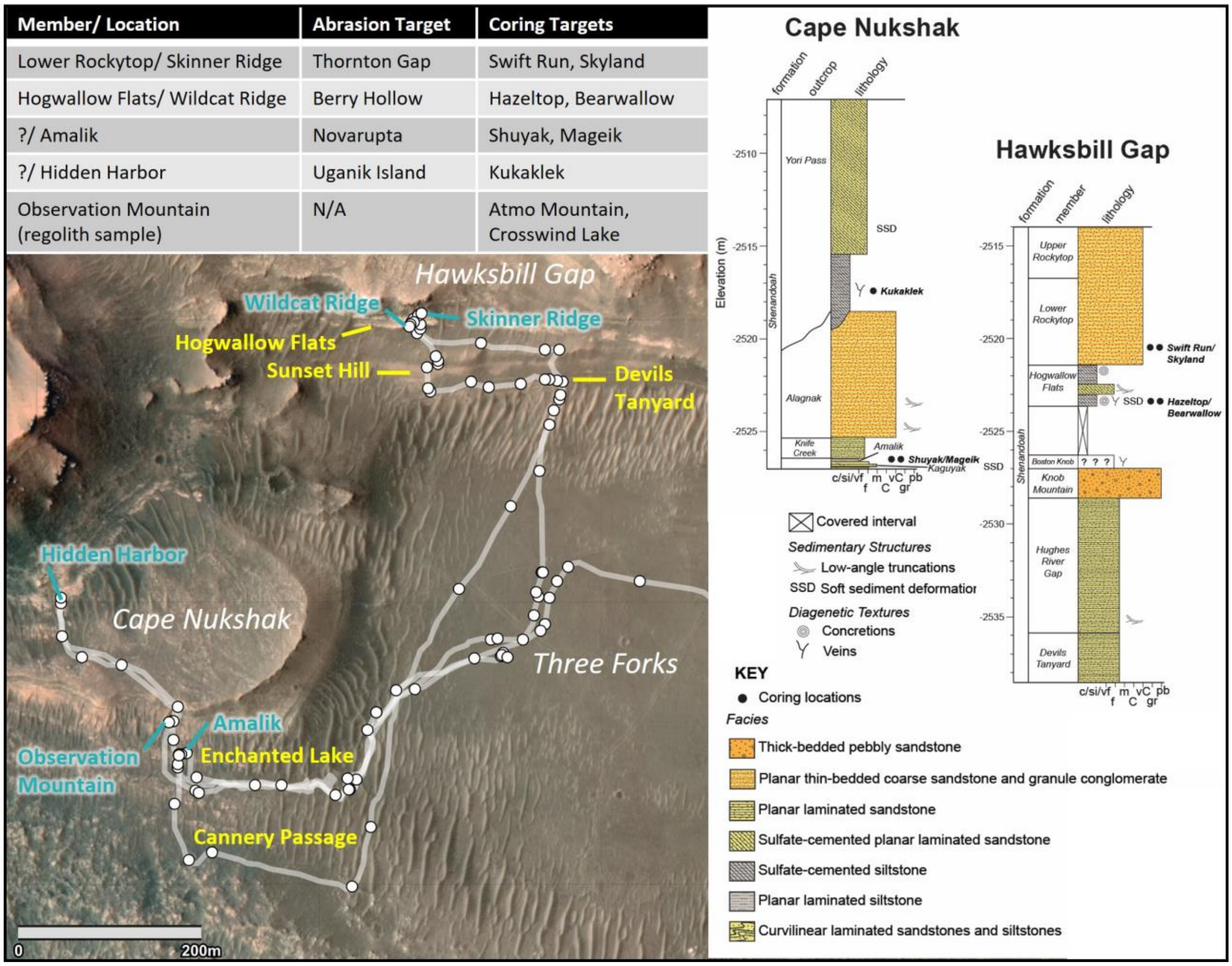

Member/ Location	Abrasion Target	Coring Targets
Lower Rockytop/ Skinner Ridge	Thornton Gap	Swift Run, Skyland
Hogwallow Flats/ Wildcat Ridge	Berry Hollow	Hazeltop, Bearwallow
?/ Amalik	Novarupta	Shuyak, Mageik
?/ Hidden Harbor	Uganik Island	Kukaklek
Observation Mountain (regolith sample)	N/A	Atmo Mountain, Crosswind Lake

Figure 1. (Left) Overview map of campaign, showing *Perseverance*'s traverse in the Delta Front Campaign. Annotations are unit names (white text) member and formation names (yellow text), and target names (blue text). **(Left inset table)** Summary of abrasion and coring targets. (Right) Stratigraphic columns for Cape Nukshak and Hawksbill Gap, modified from [6].

Introduction: The *Perseverance* rover landed in Jezero crater on February 18, 2021, with the mission goals to explore the geology, astrobiological potential, and modern environment of the crater floor and delta, and to collect and cache well-documented samples for Mars Sample Return. After completion of the "Crater Floor" science campaign [1], the rover conducted a rapid traverse (sols 379-414) to the *Three Forks* region of the crater floor adjacent to the delta front. From here, *Perseverance*'s second "Delta Front" science campaign (DFC) began on Sol 415, April 20, 2022. The DFC has explored two lobes of the delta front, the neighboring crater floor, and their contact zone, focusing on the lowest geologic exposures composing the Jezero delta (largely mapped within the delta "thin layered unit" [2]). As of January 1, 2023, *Perseverance* has covered 14325 km of traverse distance and collected 15 rock sample cores, 2 regolith samples, 1 atmospheric sample, and 3 witness tubes, employing a sample pair strategy where each unique sample is paired with a companion sample core from the same location, to enable the construction of two different caches [3]. After sample depot construction at *Three Forks*, the DFC will conclude upon re-ascent of the delta front, and the next "Delta Top" science campaign will start.

Campaign Overview (Figure 1): The first part of the DFC explored the contact between the crater floor and delta along the *Cannery Passage* loop (sols 415-

421). The contact is not well resolved at the surface due to regolith cover and highly eroded outcrops, but it appears from subsurface radar data that the delta progrades over the crater floor units [4]. On sol 422 the rover approached the *Cape Nukshak* delta lobe and *Enchanted Lake*, a series of outcrops identified as one of the lower-most sedimentary units of the delta. With the desire to collect samples from a continuous stratigraphic sequence, the rover left *Enchanted Lake* and drove northeast to *Hawksbill Gap* and its first sampling location in the *Shenandoah* fm. After traversing west across the crumbly outcrop of *Devils Tanyard*, an abrasion attempt was made at *Rose River Falls* in *Sunset Hill (*stratigraphic equivalent to *Hughes River Gap)* on sol 452. The abrasion resulted in fracturing and subsidence of the outcrop, making it unsuitable for proximity science and coring. The rover then drove north to *Hogwallow Flats* and on sol 471 attempted another abrasion at *Elkwallow Gap*. This abrasion resulted in a cracked and tilted target also unsuitable for proximity science and coring. Between sols 477-496 the rover approached *Skinner Ridge* in lower *Rockytop* and successfully abraded *Thornton Gap* and cored *Swift Run* and *Skyland*. Another attempt to sample at *Hogwallow Flats* over sols 501-517 proved successful, resulting in the abrasion at *Berry Hollow* and cores *Hazeltop* and *Bearwallow*. The decision was made to collect the third of four sample pairs at *Enchanted Lake*, so the rover returned to *Cape Nukshak* to successfully abrade *Novarupta* and core *Shuyak* and *Mageik* at the *Amalik* location over sols 557-581. An anomaly with sealing the *Mageik* core meant that regolith sampling was delayed, so the rover drove to *Yori Pass* (lateral equivalent of *Hogwallow Flats*) and abraded (*Uganik Island*) and collected its first singleton core (*Kukaklek*) at the *Hidden Harbor* location over sols 606-627. Finally, over sols 593-641, the regolith samples *Atmo Mountain* and *Crosswind Lake* were collected from a large ripple named *Observation Mountain* [5] near the base of *Cape Nukshak*.

Key Findings: Sedimentary Origins. Remote and proximity science on the rocks of the Jezero delta front reveal a suite of sedimentary rocks consistent with subaqueous deposition by a series of broadly unconfined density currents in a distal deltaic setting [6]. The prevalent mode of sedimentary deposition in most lithofacies is by turbidite-related processes, in which sediment-gravity flows move down slope and deposit grains in relation to decreasing flow energy with distance. Current interpretations suggest construction of the delta by similar yet different lobes, possibly closely related in time (although this is uncertain).

At *Hawksbill Gap*, the lowest members of *Devils Tanyard* and *Hughes River Gap* are interbedded very fine-to-medium sandstones and inferred siltstone. Both units exhibit VISIR spectra attributed to Fe/Mg-bearing phyllosilicates [7] and *Devils Tanyard* had a strong crystalline hematite absorption [8]. Upsection are the bedded fine-to-coarse grained sandstones of *Knob Mountain* and *Lower Rockytop*. *Upper Rockytop* is a bedded pebbly sandstone, and this transition to coarser grains is consistent with deposition by turbidity currents [7,9]. Unique in the stratigraphy is the *Hogwallow Flats* hydrated sulfate-cemented siltstone.

At *Cape Nukshak* the lowest layers are interbedded medium sandstone and inferred siltstone, overlain by siltstone and then interbedded medium sandstone and inferred siltstone again [10]. These rocks are relatively rich in MgO compared to other delta rocks. Primary mineral phases (olivine, pyroxenes) were detected by SCAM LIBS and VISIR [11].

Outcrop *Amalik* is unique in VISIR, with spectral signatures most consistent with a Mg-rich serpentine [11]. Further upsection is the apparent lateral equivalent of *Hogwallow Flats* at *Yori Pass*.

Aqueous Alteration. Features indicative of aqueous alteration and diagenesis are present within both delta sections [12]. These include fracture-filling anhydrite veins and veinlets [13], Mn-rich rock coatings [14] and dust coatings [15], spherical and irregular concretions, serpentine spectral signatures [11], and desiccation and/or syneresis cracks. Carbonate and/or sulfate, interpreted as alteration minerals, are observed in the delta front abrasion targets [16,17].

Post-Depositional Erosion. Long distance remote observations of the eastern-most lobe reveal the presence of a basal layer with inclined sandstone beds interpreted as deltaic deposits formed in a closed lake system. Corresponding bottomsets are eroded suggesting that the delta front has receded substantially. Boulder-rich conglomerates on top of the sequence are consistent with high-energy floods and boulder rounding indicates river transport [18].

Next Steps: As of this writing, *Perseverance* is in the process of sample depot construction, caching 10 tubes at *Three Forks* for Mars Sample Return [19]. After depot construction the rover will reascend the delta and begin the Delta Top Campaign, exploring the delta upsection from *Rockytop* toward the Marginal Carbonate Unit.

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References: [1] Sun, V. et al. (submitted) *JGR Planets.* [2] Sun & Stack (2020) *Sci. Investig. Map* 3464. [13] Lanza et al. (2023) *EGU*. This meeting (*LPS LIV*): [3] Herd et al. [4] Russell et al. [5] Hausrath et al. [6] Stack et al. [7] Dehouck et al. [8] Nunez et al. [9] Barnes et al. [10] Tebolt et al. [11] Beyssac et al. [12] Kalucha et al. [13] Lopez-Reyes et al [15] Beck et al. [16] Phua et al. [17] Roppel et al. [18] Mangold et al. [19] Maki, J. et al.