SAMPLING BY THE NASA PERSERVERANCE ROVER FOR MARS SAMPLE RETURN. C.D.K. Herd[1], T. Bosak[2], K.A. Farley[3], K.M. Stack[3], K.C. Benison[4], B.A. Cohen[5], A.D. Czaja[6], V. Debaille[7], Y. Goreva[3], E.M. Hausrath[8], K. Hickman-Lewis[9], E.N. Mansbach[2], L.E. Mayhew[10], M.A. Sephton[11], N. Randazzo[1], D.L. Shuster[12], S. Siljeström[13], J.I. Simon[14], M. Wadhwa[3,15], B.P. Weiss[2], M.-P. Zorzano[16], A.J. Brown[17]. [1]Dept. of Earth and Atmospheric Sciences, University of Alberta, Edmonton, Canada, herd@ualberta.ca, [2]Dept. of Earth, Atmospheric and Planetary Sciences, Massachusetts Institute of Technology, Cambridge, MA, [3]JPL/Caltech. [4]West Virginia University, Dept. of Geology and Geography, Morgantown, WV, [5]NASA GFSC. [6]Dept. of Geosciences, University of Cincinnati, Cincinnati, OH, [7]Laboratoire G-Time, Université libre de Bruxelles, Belgium, [8]Dept. of Geoscience, UNLV, Las Vegas, NV, [9]Dept. of Earth Sciences, Natural History Museum, London, UK, [10]Dept. of Geological Sciences, University of Boulder, Boulder, CO [11]Imperial College London, London, UK, [12]Dept. Earth and Planetary Science, UC Berkeley, [13]RISE Research Institutes of Sweden, Stockholm, Sweden [14]ARES, NASA Johnson Space Center, [15]SESE, Arizona State University, Tempe, AZ [16]Centro de Astrobiologia, INTA, Madrid, Spain. [17]Plancius Research, Severna Park, MD.

Introduction: A primary goal of the NASA Mars 2020 Perseverance rover mission is to collect and document a suite of scientifically return-worthy martian samples for return to Earth by future missions [1]. Perseverance is currently exploring Noachian-aged Jezero Crater, once the site of a habitable delta-lake system. Perseverance carries 38 identical sample tubes designed for rock cores or regolith, and five "witness tubes" for characterizing contamination from the rover. The Sampling and Caching Subsystem (SCS) is fully described by [2].

As of December 2022, the mission has completed the Crater Floor and Delta Front campaigns, and has sealed 21 tubes: 15 rock cores, 2 regolith samples, one tube that contains a serendipitous sample of ~5 µmol of ambient atmosphere (Table 1) and three witness tubes.

Here we provide an update on the samples collected thus far, their associated documentation (Sample Dossier and Initial Report), and the construction of the first sample depot.

A diverse suite of samples: Table 1 shows the list of samples collected by the end of the Delta Front Campaign. The samples include a suite of igneous rocks from the crater floor [e.g., 3, 4, 5], sedimentary rocks from the Delta Front with diverse grain sizes and compositions [6-9], and a regolith sample [10]. Details of the Delta Front Campaign are provided by [6]. During this campaign, the rover collected the first ever sedimentary and regolith samples for return to Earth.

The three witness tube assemblies (WTAs; see [2] for details) include the witness tube from the Bit Carousel (WTA1; sealed on Sol 120), a tube sealed after sampling at Skinner Ridge on Sol 499 (WTA2), and a tube sealed after sampling at Amalik on Sol 586 (WTA3).

Table 1: List of samples collected by Perseverance as of December 2022

Location	Abrasion Target	Samples	Sampling Sols	Strat. context (fm)	Rock type
Roubion	Guillaumes	*Roubion*	164	Máaz	atm
Rochette	Bellegarde	*Montdenier*, Montagnac	190, 196	Máaz	ign
Brac	Dourbes	Salette, *Coulettes*	262, 271	Séítah	ign
Issole	Quartier	Robine, *Malay*	295, 337	Séítah	ign
Sid	Alfalfa	Hahonih, *Atsah*	371, 377	Máaz	ign
Skinner Ridge	Thornton Gap	Swift Run, *Skyland*	490, 495	Shenandoah	sed
Wildcat Ridge	Berry Hollow	*Hazeltop*, Bearwallow	509, 516	Shenandoah	sed
Amalik	Novarupta	Shuyak, *Mageik*	575, 579	Shenandoah	sed
Hidden Harbor	Uganik Island	Kukaklek	623	Shenandoah	sed
Observation Mountain	N/A	Atmo Mountain, *Crosswind Lake*	634, 639	N/A	reg

Notes: atm = atmosphere; ign = igneous; sed = sedimentary; reg = regolith. Names of samples to be placed in the first depot shown in italics.

The "STOP" List: A standardized set of required activities and observations accompanies the collection of each sample, with the intention of documenting these samples in a standardized manner. These activities are called the Standardized Observation Protocol, or STOP list. The STOP list includes imagery at multiple scales along with chemical and mineralogical analyses of the outcrop surface. Because rock surfaces are frequently coated with dust or other materials, a ~1 cm deep and 5 cm diameter abrasion target is acquired within a few tens of cm of the sample target within the same lithology (Table 1). In this "sample proxy" patch, high-resolution images and detailed maps of elemental composition, Raman and luminescence spectra, LIBS spectra, <60 μm resolution visible images and VISIR spectra are obtained. After coring, an image is taken of the sample in the tube [e.g., 11], the amount of sample is estimated, and the tube is hermetically sealed [2]. Unique serial numbers are readily visible on the tube and seal exteriors to ensure confident identification of samples even decades after acquisition [e.g., 11].

Sample documentation: The Sample Dossier and an Initial Report document each sample. The *Sample Dossier* contains all observations from the STOP list, along with relevant rover data (e.g., temperatures, rover location, rover arm position and actions, etc.). Uploaded regularly to the NASA Planetary Data System (PDS), the *Sample Dossier* primarily consists of pointers to instrument-specific and engineering data products. These data are independently delivered to the PDS, and thus the dossier acts as a "one stop shop" for sample-specific results. The *Initial Report*, a description of each sample in a standardized narrative format, is led by Return Sample Science Participating Scientists and other members of the Science Team. Written within three weeks of sample acquisition, this report captures the reasons for sampling and presents the interpretations available at the time of sampling and completion of the STOP list.

The *Initial Report* is essentially a set of field notes associated with each sample and WTA and does not include extensive assessment and interpretation of the collected samples; such information is included in peer reviewed publications. For example, the mineralogy, petrology and geochemistry of the first several samples collected during the Crater Floor Campaign, as well as the stratigraphy of crater floor units, can be found in [3, 4], as well as forthcoming [12].

Initial Reports are archived in the NASA PDS as an element of each *Sample Dossier*. The first two volumes of the Mars 2020 *Initial Reports* have been delivered to the NASA PDS; included in these volumes are all of the samples collected during the Crater Floor Campaign, and the Bit Carousel WTA.

Depot Construction: The creation of the first sample depot in the Three Forks area began on Sol 653 with the successful placement of the sample tube containing Malay onto the martian surface. The composition of this depot includes one of each pair of samples from the Crater Floor and Delta Front Campaigns, including a regolith sample and the atmospheric sample (Roubion). The samples to be included in the first depot are shown in italics in Table 1; the depot also includes WTA3, for a total of 10 tubes. Details of the depot are presented by [11]. The criteria used for selecting and certifying the Three Forks depot site are described by [13].

The criteria for determining which samples were to be included in the first depot were established by the MSR Campaign Science Group, through the Mars 2020/MSR Sample Depot Science Community Workshop, held September 28th and 30th, 2022 [14]; the 10 tubes that will be included in the Three Forks depot meet these criteria. As such, the workshop also confirmed that the community deems this collection of samples "return-worthy". Thus, the samples collected by Perseverance represent the diversity of the exploration area and could be used to address outstanding questions concerning the astrobiological potential, geologic history, and evolution of Mars as reflected in the Jezero Crater region upon their return to Earth. Furthermore, sufficient documentation was acquired during surface operations to constrain the geological and environmental context and sampling conditions (i.e., the Initial Reports and Sample Dossier), and the sample suite includes at least one witness sample.

Future Sampling: Although the Three Forks depot represents a collection of return-worthy samples, it is nevertheless a contingency depot. Once the Three Forks depot is complete, Perseverance will climb to the delta top, carrying representative samples and WTAs from the Crater Floor and Delta Front campaigns. Other samples of the delta top (notionally 3-4), samples of the carbonate-bearing rocks of the interior margin of Jezero crater, and the diverse, ancient lithologies accessible in Nili Planum will be added to the current samples. This expanded collection of samples after an extended mission would more fully address the objectives of MSR as outlined by [15].

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