THE CURRENT STATUS OF THE MARS SAMPLE RETURN PROGRAM AND SAMPLE COLLECTION BY THE PERSEVERANCE ROVER. M. Wadhwa1,2 and K.A. Farley3,5 (on behalf of the MSR Program and Mars 2020 Mission Teams) 1School of Earth and Space Exploration, Arizona State University, Tempe AZ 85287, 2Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA 91011, 3Division of Geological and Planetary Sciences, California Institute of Technology, Pasadena, CA 91125.

Introduction: Mars Sample Return (MSR) has been a scientific priority of the planetary science community in the last two decadal surveys [1,2]. This is because analyses of carefully selected and documented samples from Mars in Earth-based laboratories are required to address some of the highest priority science questions relating to Mars [3], and more broadly to the formation and evolution of rocky habitable worlds in our Solar System and beyond. The MSR campaign is already underway with the ongoing collection of samples in Jezero Crater by the Mars 2020 Perseverance rover [4,5]. The next phase of the campaign, retrieval of samples collected by Perseverance, is currently being planned as part of the joint NASA/ESA MSR program.

Status of the Mars Sample Return program: In 2020, the Science Mission Directorate (SMD) at NASA chartered an Independent Review Board (IRB) to inform Key Decision Point A (KDP-A) for the Mars Sample Return (MSR) Program. Following KDP-B (in 2021), NASA tasked a second IRB to re-evaluate the technical, cost, and schedule plans for the MSR program last year. As a follow-up to the report of the IRB-2 [6], NASA established the MSR IRB Response Team (MIRT) that is expected to make its recommendation by spring of 2024 regarding a path forward for MSR.

Status of Sampling by Perseverance: Since landing at the Octavia E. Butler landing site on Mars in February of 2021, the Perseverance rover has explored terrains within Jezero Crater as part of four distinct campaigns focused on the following regions: 1) the crater floor; 2) the delta front; 3) the upper fan, and 4) the crater margin. During this time a total of 26 (of the 43) sample tubes have been sealed: 20 filled with rock samples (8 igneous and 12 sedimentary), 2 with regolith, 1 with Mars atmosphere, and 3 witness tubes. The full inventory of sample tubes sealed so far, and their sampling locations in Jezero Crater, are shown in Table 1 and Fig. 1 of [7]. Following every successful sample acquisition, the Mars 2020 Science Team creates a preliminary data assessment for that target along with its geologic context and the scientific rationale for sampling it in an Initial Report that is made publicly available at the NASA Planetary Data System (PDS) [8].

For the entire crater floor campaign (during which two igneous units were sampled, one composed of basaltic lava flows and the other an olivine cumulate that underlies the flows [9]) and for part of the delta front campaign (during which different sedimentary rocks recording fluvial, lacustrine and deltaic environments were sampled [10]), the Mars 2020 team followed a paired sampling strategy. In this strategy, a pair of samples from each of 7 rock targets (4 igneous and 3 sedimentary) and of a regolith target was collected. One tube each of these 8 rock and regolith samples, along with one tube filled with Mars atmosphere and one witness tube (for a total of 10 tubes) were deposited at the Three Forks depot during December 2022 and January 2023 as a contingency measure [11]. The second member of each pair is currently being carried onboard Perseverance.

For the remainder of the delta front campaign, and for the following upper fan and margin campaigns, only singleton samples were acquired. This approach retains the possibility of 33 unique sample tubes for possible Earth return. From this point forward the nominal plan is to keep all sample tubes aboard Perseverance.

The newly acquired samples during the upper fan and margin campaigns consist of a diversity of sedimentary lithologies including fluvial sandstones, pebble conglomerates, and a poorly understood unit on the inner crater margin that has been interpreted as a beach deposit [12]. Detrital components in these rocks include mafic igneous grains and clasts dominated by olivine and altered olivine, as well as Mg, Fe carbonates. Carbonates, hydrated (?) silica, phyllosilicates, and sulfates document extensive diagenetic modification after deposition.

In this presentation, we will summarize the geologic context and the mineralogic and chemical composition of the igneous and sedimentary rocks collected thus far by Perseverance [9,13-15], and why these samples meet many of the key objectives of a Mars Sample Return effort (e.g. [16]).

Future Outlook for Sampling by Perseverance: The Jezero landing site was originally chosen because it allowed access to a diversity of sedimentary and igneous lithologies (recording a variety of environments
on ancient Mars, including those of astrobiological interest) within the crater, as well as at the crater rim and beyond, that would maximize the scientific return for future sample return [4]. Indeed, one of the key findings of the IRB-2 report was that while Mars 2020 has been successful in acquiring samples of high scientific value, there exists the potential for substantially increasing the cumulative science value by additionally collecting samples from the crater margin and rim. As such, a key recommendation of this report was that material from the Jezero Crater rim should be included [6]. Indeed, it is likely that the crater rim includes exposures of key geologic units that are not exposed within the crater including spectrally distinct types of the ~4 Ga Noachian basement units (including Isidis/Jezero megabreccia blocks), the slightly younger olivine-carbonate unit (possibly the rock unit richest in carbonates in this region of Mars), as well as other units potentially resulting from impact processes such as hydrothermal deposits and impact melt lithologies [17]. Sampling of such materials has the potential to greatly enhance the diversity of samples onboard Perseverance, with the associated potential of more comprehensively addressing important questions relating to the earliest evolution of Mars’ interior, climate, and habitability.

Acknowledgments: The decision to implement Mars Sample Return will not be finalized until NASA’s completion of the National Environmental Policy Act (NEPA) process. This document is being made available for information purposes only.