MECHANICAL PROPERTIES OF ROCK ANALOGS FOR THE MARS2020 MISSION. Lara T. Panossian[1], Gregory H. Peters[2], Elizabeth M. Carey[2], Lori R. Shiraishi[2], [1]California State Polytechnic University, Pomona, Department of Geological Sciences, 3801 West Temple Avenue, Pomona, California, 91768, [2]California Institute of Technology – Jet Propulsion Laboratory, 4800 Oak Grove Drive, Pasadena, Calfornia, 91109.

Introduction: The upcoming Mars2020 rover mission will be the next step in understanding the geological processes and ancient environments to answer relevant astrobiological questions about Mars. The rover will study diverse Martian rocks and soils to characterize the geology and atmosphere, understand past habitable conditions, and prepare for potential future human exploration. The sample acquisition system is comprised of a coring drill with the ability to cache core samples for potential return to Earth.

A set of rocks were selected by the Geo-Analogs team at Jet Propulsion Laboratory with input from the the project scientists. This current set of Mars analogs were collected based on the mechanical properties of the rocks and availability, not necessarily on their mineralogical properties. These rocks allow us to better understand and prepare for the strength ranges that may be encountered on Mars. The Mars analog rock set varies in strength and composition and are used to develop the Mars2020 Sampling and Caching Subsystem (M2020 SCS). On the scale at which the SCS drill bit interacts with the material, these rocks are considered to be generally homogeneous. Measurements of Uniaxial Compressive Strength (UCS) are determined via direct unconfined compressive strength tests and Point Load Index (PLI) values.

Name of Mars Analog	Acronym	Collection Site
Old Dutch Pumice	ODP	Ridgecrest, CA
Kramer Massive Mudstone	KMM	Boron, CA
Bishop Tuff Intermediate	BTI	Bishop, CA
China Ranch Gypsum	CRG	Pahrump, NV
Napa Basaltic Sandstone	NBS	NapaValley, CA
Uniform Saddleback Basalt	USB	Boron, CA
New Jersey Database	NJD	New Jersey

Table 1. Current set of Mars analog rocks utilized by M2020 SCS.

Methods: Compressive strengths are measured with either a GeoTest Instrument Corp Compression Machine with Agilent software or a Gilson Concrete Compression Machine. Samples are cut into either 1-inch or 2-inch cubes, depending on strength regime and fracture population as prescribed in the ASTM standard [1]. Since KMM exhibits Plumose fractures, it cannot be cut into cubes and thus the compressive strength was obtained using the field Geotechnical Consulting and Testing Systems Point-Load Tester. KMM was broken into irregular lumps according to the ASTM standards of 50 mm ±35 mm thickness [2]. The Point-Load tester provides an point-load index value, which then is converted to a UCS measurement.

Discussion: *Rock Composition and Structure.* The following are descriptions of the composition and basic structure of the set of Mars analog rocks.

- **ODP**: fine grained, weakly lithified, bedded ash-fall
- **BTI**: pyroclastic flow, porous, welded, glassy
- **KMM**: fine grained, poorly sorted with low clay content
- **CRG**: massive, chemical sediment with lenses of clay
- **NBS**: basaltic grained sandstone, detrital sedimentary rock
- **USB**: igneous extrusive, aphanetic
- **NJD**: plutonic crystalline rock, non-porous, interlocking crystal structure.

Uniaxial Compressive Strength Results. This set of current Mars analog rocks range in UCS from ~5 to 320 MPa (Figure 1). Because of the impracticalities of collecting rocks weaker than ~5 MPa for use as Mars analogs, we have implemented manufacturing rocks in the laboratory known as Manufactured Weak Rocks (MWR). Mix designs of MWR are composed of basaltic aggregates, Portland cement and a foaming agent. These rocks can be tailored for specific strength and density by varying the amount of a foaming agent and binder to aggregate ratio within the mixture. The rocks can also be customized to include voids, layered inclusions, and differing strength zones.

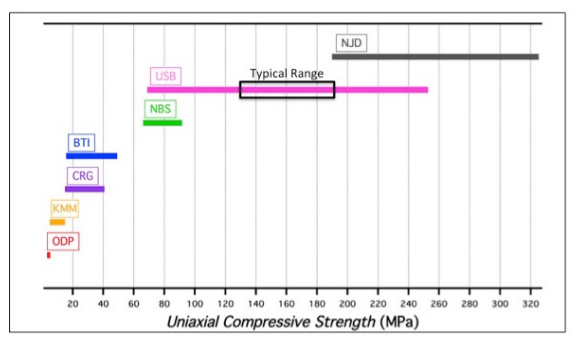

Figure 1. Measurements of Uniaxial Compressive Strength (MPa) for the current Mars Analog set. Measurements have been taken by Unconfined Compression Testers, except KMM, which is measured by a point-load tester.

Test articles were made for the M2020 SCS team by bonding individual rocks to aluminum plates. Prior to delivering test articles to the M2020 SCS team, cubes from each test article were sampled for UCS measurements. Compressive strength ranges seen in Figure 1 represent one standard deviation about the mean of all measurements taken per rock type. Surprisingly, it was found that the range of compressive strengths for ODP, KMM, BTI, CRG and NBS remained relatively narrow among all test articles, compared to the ranges exhibited by USB and NJD where strength ranges varied significantly from rock to rock. For USB, most test articles sampled and measured fell into the typical range of 130-190 MPa, as highlighted in Figure 1. Analysis of the relationship between UCS and macroscopic structure of the rocks within this set of Mars analogs will be will be further investigated. Schematics of this analysis will be presented.

References: [1] ASTM (2008) C109 [2] ASTM (2008) D5731

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