MICROBIAL SIGNATURES FROM THE DUNE FIELD AT WHITE SANDS NATIONAL MONUMENT, NEW MEXICO. M. Glamoclija[1], M. L. Fogel[1], A. Kish[2] and A. Steele[1], [1]Geophysical Laboratory, Carnegie Institution of Washington, 5251 Broad Branch Rd, Washington, DC 20015 (e-mail: mglamoclija@ciw.edu), [2]Institut de Génétique et Microbiologie, Paris, France.

Introduction: Sulfates have been found as a constitutive part of sedimentary formations exposed to the surface of Mars at different latitudes [e.g. 1, 2, 3, 4]. At the north polar region, gypsum minerals have been identified within dunes at the Olympia Undae [1, 2, 5], with a stronger gypsum signature detected along the dune crests than in the interdune areas [6, 7]. A variety of sulfate minerals have been detected at lower latitudes within the ancient playa-like deposits and within outcrops with preserved interdune deposits at the Meridiani Planum [3, 4, 8]. The origin of these deposits is still unknown, however, they were most likely produced by a combination of hydrothermal processes and/or groundwater upwelling which could have brought sulfur compounds into the system, and later on they were weathered by atmospheric and eolian processes [4, 1, 2, 5]. Even though terrestrial geology resembles Martian geology in many ways, a direct terrestrial analog to these types of deposits has not been identified. Since White Sands National Monument (WSNM) (New Mexico) has been proposed as an analog to the dunes of Olympia Undae [9], we investigated the dune field at the WSNM in order to find different microbial habitats and assess their ecological characteristics through identification of mineral assemblages, pigments, and extractable nitrogen. Additionally we extracted DNA from environmental samples for PCR-based characterizations of the microbial communities.

Materials and Methods: The WSNM contains one of the largest known gypsum dune fields on Earth. The dune field is dominated by transverse dunes, which are cemented by a high groundwater table (approximately 0.3 m [10]). The dunes are approximately 7000 yrs old [9], and formed from deflated material of the Pleistocene Lake Otero. Comparative remote sensing of historical aerial images revealed a trend in migration of the dunes [9]. The average rate of dune migration is estimated to be about 3.4 m per year, and the interdune areas within the dune field may be approximately 50 yrs old [9]. The preserved interdune structures found west of the dune field are estimated to be approximately 400 yrs old [9].

The sampling strategy included the collection of samples from the surface and a depth of 10 cm at the same sampling spot. The samples were collected along a dune profile, including dune slopes and interdunes. Further, different types of interdune surfaces were collected, including 400 yr and 50 yr old interdunes, and the crust formed by degassing processes, most likely after the flooding of the dune field in 2007.

The main minerals were identified by powder diffraction using the InXitu Terra XRD instrument. The nitrogen content from the deposits was assessed through the colorimetric analyses of ammonium (NH_4) and nitrate + nitrite (NO_3+NO_2) concentrations. Both 90% acetone and methanol/ethylacetate (vol. 1:1) were used to extract microbial pigments for analyses of pigments under both visible and UV spectral ranges using a Spectrophotometer (GENESYS 10Bio) in the range of 200 to 800 wavelengths. DNA extractions were carried out on ~ 0.5 g of powdered sample using Power Soil DNA isolation kit (MoBio Laboratories Inc., CA) using a modified protocol allowing for the extractions of gypsum-rich sediments. PCR analysis was performed using a Dyad Peltier Thermal Cycler with puReTaq™ Ready-To-Go™ PCR Beads (Amersham Biosciences, NJ). Universal primers specific to the small subunit rDNAs from all three domains of life were used to determine the microbial diversity of each environmental sample. Functional gene analyses were performed to further determine the metabolic processes represented in the metagenome of the WSNM evaporite environments.

Results and Discussion: Sand from the dune field is mainly composed of gypsum and bassanite. The mineral variation at the dune sides largely occurs as a function of gypsum dehydration, with surface samples composed mainly of bassanite (Ca(SO4)x0.5H2O) and the subsurface composed of gypsum (Ca(SO4)x2H2O). The interdune areas show higher mineral diversity. A common type of interdune area consists of gypsum, bassanite, calcite and quartz, while the subsurface consists only of gypsum and bassanite. The interdune surfaces with incrustations that were formed by degassing processes have gypsum, magnesium sulfo-salts, hexahydrite, and minor quartz and bassanite. The subsurface is composed of bassanite, minor quartz and carbonate minerals. Unlike the interdune areas from the dune field, the interdunes that have been estimated to be 400 yrs old have surface crusts composed of gypsum and kutnohorite (dolomite) minerals, whereas the 10 cm deep sediment is mostly gypsum.

A green layer composed of microbial mats was found at all interdune areas, ~ 0.5 cm beneath the surface.

The extractable N content shows a general predominance of N from NO_3+NO_2 over NH_4 (2.8 : 1.4) within surface layers, indicating an oxidative surface environment with more N available from sand at the interdunes than from sand collected from the dune sides. In contrast, the 10 cm deep subsurface samples collected along a dune profile show a predominance of N from NH_4 over NO_3+NO_2 (1.2 : 0.3). Comparison of N values from different types of interdunes showed that interdunes with degassing incrustations and ~ 400 yr old interdunes have more available N from both NH_4 and NO_3+NO_2 than the common type of the interdune surfaces, with a predominance of N from NO_3+NO_2 over NH_4. The ratio NO_3+NO_2 : NH_4 varies in subsurface samples, probably due to different quantities of water and the presence of microbes.

Chlorophyll-a, chlorophyll-b, bacterioruberin, β-carotene, scytonemin, and carotenoids which overlap in the spectra with photo-protective chlorophyll were present in interdune samples. No pigments were found in the dune samples. Based on spectral characteristics, cyanobacteria as well as red/brown pigmented microbes were found. The presence of carotenoids and scytonemin indicate that the microbes from the dune field have a well-developed protective mechanism against solar radiation [11, 12]**.**

There was a notable absence of DNA from samples collected from the sides of the dunes. The microbial content from the interdune areas varied, with DNA from the older surfaces showing the presence of eubacteria, archaea and eukaryota, whereas the younger surfaces had only eubacteria.

From the collected sets of data, we can conclude that most of the microbial mat was found within the interdune areas and none was found in sand from the dune sides. Since the interdune areas provide the most stable substrate and hold most of the moisture within the dune field, they provide desirable habitats for microbial communities. Further, we observed that zones with microbial mats often have higher mineral diversity, which is frequently associated with the occurrence of different calcite and dolomite minerals. However, details of this association require further investigation.

The pigment analyses revealed that microbial communities found approximately a cm beneath the surface contain spectral signatures of carotenoids and scytonemin pigments which are used as protective mechanisms from UV radiation. Additionally, almost all microbial mats were found below the surface at the interfaces between moist and dry areas which protect them from desiccation. The desert environments at the WSNM appear to be inhabited by diverse microbial communities well-adapted to arid conditions.

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