GROUND PENETRATING RADAR DETECTION ON POLYGONAL TERRAINS IN THE QAIDAM BASIN: POSSIBLE IMPLICATION FOR LIFE SEARCH ON MARS.

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Introduction: In the past several decades, explorations on Mars have achieved great success. Water ice has been widely found in the Martian polar caps and within the middle to high latitude subsurface deposits [e.g.,1-2]. In 2020, three Mars missions are planned to launch and one of their aims is to search for the evidence that Martian life once thrived. Ground Penetrating Radar (GPR) onboard the Martian rover is a powerful instrument to investigate subsurface structures, seek water ice, and characterize underground deposits [3-5].

Qaidam Basin, which is located in the north of Tibetan Plateau, is a famous analog site as present Martian environments [e.g., 6]. In this study, we present an analogy study of GPR experiments in the Qaidam Basin to test the potential of GPR detection on the paleolake sediments.

Instrument and data: PulseEKKO radar systems (Sensors & Software, Inc.) employing unshielded antennas with a separate transmitter and receiver are used in the investigation. The radar system operated at 100 MHz and 200 MHz and worked in reflection mode.

Three survey lines were set on the surface of the polygonal terrain (Figure 1). Line 1 was on the top of polygonal rim; line 2 was perpendicularly intersected with line 1 and crossed the raised rim; line 3 was on the surface of polygonal interior and parallel to line 1.

Two modes of radar data, common offset (CO) and common midpoint (CMP), are collected in this work. The results of CMP are used to derive in-situ permittivity values of subsurface layers and interpret the CO radargrams. Though CMP cannot be by applied on the GPRs deployed to Mars, it helps the analysis of the terrestrial results and improves our understanding of the stratigraphy of lacustrine deposits revealed by GPR.

Geology of survey site: The survey site is on the surface of a polygon terrain which is a typical morphologic surface feature. The polygonal landforms develop in salt sedimentary deposits and are commonly found in dried salt lakes. The size of the polygonal terrain in our study is about 100 m in diameter. Raised rims, which are resulting from the growth of salt crystals within the salt layers under the conditions of evaporation and capillary upflow, are observed on the surface.

Results and discussions: Four samples were collected on the surface of the polygonal terrain. Then we measured the permittivity values of the samples in the laboratory by using the Keysight PNA N5245A Network analyzer with N1501A dielectric probe kit and N1500A material measurement software. Table 1 shows the values of the relative permittivity of the samples. All samples have close values of the mean permittivity, which imply the similar compositions of the surface materials of the polygonal rim and the polygonal interior.

Figure 2 shows the radargrams of all CO data. All the radar data detected a continuous subsurface interface (black arrows) both under the polygonal rim and polygonal interior. Figure 3 shows the results of velocity analysis based on the CMP data. For line 1, the results of velocity analysis suggest that the subsurface interfaces locate at the depth of ~3.3 m and ~5.2 m. The 200 MHz CMP data reveal two more layers at the depth of 1.75 m and 2.58 m. For line 2, two layers located at the depth of 0-~3.5 m and ~3.5-4.88 m are identified. Three layers are confirmed from the results of line 3. The first layer locates at 0-~2.0 m, the second layer is at the depth of ~2.0-~3.7 m, and the last layer ranges from ~3.7-~5.45 m. In summary, four layers are extracted, however, only the interface at the depth of ~3.5±0.2 m is detected under all three lines. The characteristics of radargrams are summarized as follows:

(a) The uppermost materials of the polygonal rim have similar permittivity values to those in the polygonal interior.

(b) There is a continuous subsurface interface at the depth between 3.27 m and 3.73 m. The depth of the interface under the polygonal rim is ~0.3 m shallower than that under the polygonal interior.

(c) The layers from the surface to the continuous interface have different mean velocity under the polygonal rim and interior. The porosity of these layers under the polygonal rim is ~5-8% higher than that under the polygonal interior.

(d) The layer indicated by the continuous interface with a thickness of 1.37-2.03 m has significantly different permittivity values under the polygonal rim and interior. The most possible interpretation is that either water or brine exist in this layer under the polygonal interior.

The polygonal landforms have been observed at almost all altitudes on Mars. In Qaidam Basin, we observed that the polygonal interior has different subsurface structures and components compared with the polygonal rim. A water-related layer most likely exists beneath the polygonal interior and contributed to the formation of the polygonal terrains, especially the growth of raised rims. The results can contribute to understanding the formation mechanisms of the raised rim polygonal structures on Earth and Mars, which would provide ulterior evidence of the presence of liquid-water-related process in the early history of Mars. Furthermore, the wet interior of salt polygons might have offered refuge to halophilic microbial communities under an increasingly more arid environment. GPR on a Martian rover could be used to detect ancient brine supply channel beneath salt polygons and locate the sample position of the interior material for the detection of possible biological activity on Mars.

References: [1] Plaut J.J. et al. (2007) *Science*, 316, 92-95. [2] Bramson A.M. et al. (2015) *GRL*, 42, 6566-6574. [3] Ciarletti V. et al (2017) *Astrobiology*, 17, 565-584. [4] Hamran S.E. et al (2015) 8th IWAGPR, 1-4. [5] Zhou B. et al (2016) 16th International Conference on GPR, 1-4. [6] Xiao L. et al (2017) Earth-Sci. Rev., 164, 84-101.

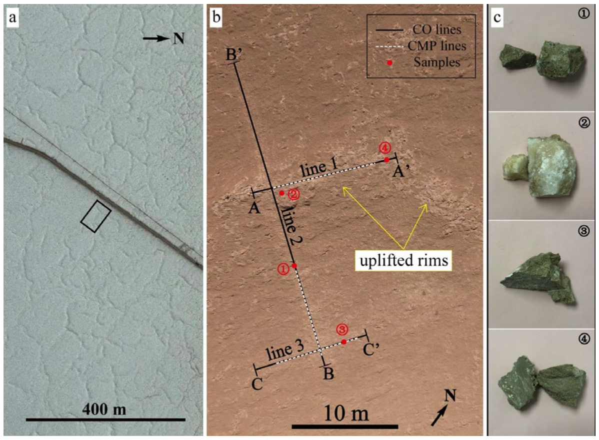

Figure 1. (a) Spatial patterns of polygonal surface structures. Black frame indicates the location of (b). (b) Drone photo of polygonal terrains. (c) Images of the samples from the polygonal terrains. The locations where the samples were collected are marked by red points in (b).

Table 1
Minimum, maximum, and mean values of the relative permittivity of samples measured in the laboratory.

Sample #	$\varepsilon'_{\text{min}}$	$\varepsilon'_{\text{max}}$	$\varepsilon'_{\text{mean}}$	Description
1	4.07	4.43	4.24	Mainly halite. Colors depend on the contents of clay minerals in the samples.
2	4.35	4.73	4.56	
3	4.15	4.58	4.35	
4	3.43	4.73	4.05	

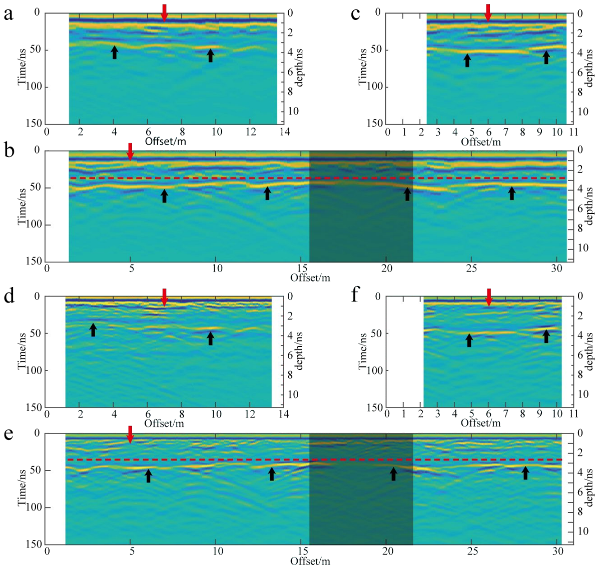

Figure 2. (a–c) Radargrams of 100 MHz CO data of Line 1, Line 2, and Line 3. (d–f) Radargrams of 200 MHz CO data of Line 1, Line 2, and Line 3. Red arrows denote the location of the center position of CMP gather. Black arrows denote the bottom of a subsurface layer (Layer 3 in Figure 3) which is observed at all the radargrams. Shadow regions in (b, e) are the range of the polygonal rim along the survey line. Dashed red lines in (b, e) indicate the continuous subsurface interface rise in the polygonal rim range.

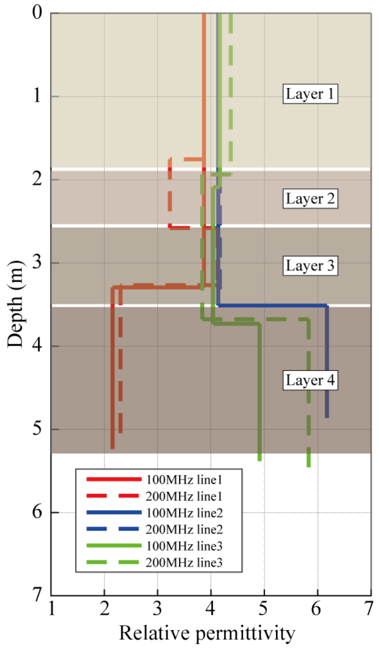

Figure 3. Subsurface structures under the survey lines. The depths and permittivity values of the layers are obtained from the velocity analysis of CMP data.