Broadband Dielectric Characterization of Water Inclusions in Evaporites at Martian Conditions

Principal Investigator: Daniel Nunes (322)

Jonathan Batres (356), Scott Perl (397), David Steinfeld (356), Martin Barmatz (382)

Program: Innovative Spontaneous Concept

Project Objective:

• Develop and implement the capability of measuring broadband permittivity of geologic materials at relevant planetary conditions.

• Measure the dielectric behavior of naturally water-bearing evaporites under Martian conditions for a broad range of frequencies, from 10 MHz to 3 GHz. Such a band that encompasses frequencies used by current sounders (e.g., SHARAD) and upcoming GPR instruments (e.g., RIMFAX).

Samples:

• We have analyzed two types of evaporitic minerals: halite and gypsum. Both arise from and trap in their structure saline fluids.

• Fluid inclusions offer access to more direct evidence to geological, climatological, hydrological and biological investigations, and that such inclusions are relatively common in evaporites, they would be a treasure trove to investigators if found in evaporitic deposits on other planetary bodies.

• Previously collected from marginal deposits around the Great Salt Lake, UT.

• Measured both finely powdered and coarse crystals versions of the samples.

Sample Number	Mineral	Line Number	Physical State	Packing	Thermal Treatment
1	halite	602	powder	compact	none
2	halite	602	powder	compact	none
3	gypsum	815	powder	compact	none
4	halite	602	powder	loose	none
5	halite	602	powder	compact	none
6	gypsum	815	powder	loose	none
7	halite	602	powder	compact	baked
8	halite	602	coarse	medium	none
9	gypsum	815	coarse	medium	none
10	halite	602	coarse	medium	baked
11	gypsum	815	Coarse	Medium	baked

Project Objective:

• Density effect on permittivity is similar than that observed for silicates, though with slope specific to mineral species.

• Permittivity of halite and gypsum are relatively frequency independent.

• Effect of baking is not clear in the data.

• Highest Imaginary part (loss tangent) is in crystals, suggesting potential preservation.

818-393-5317

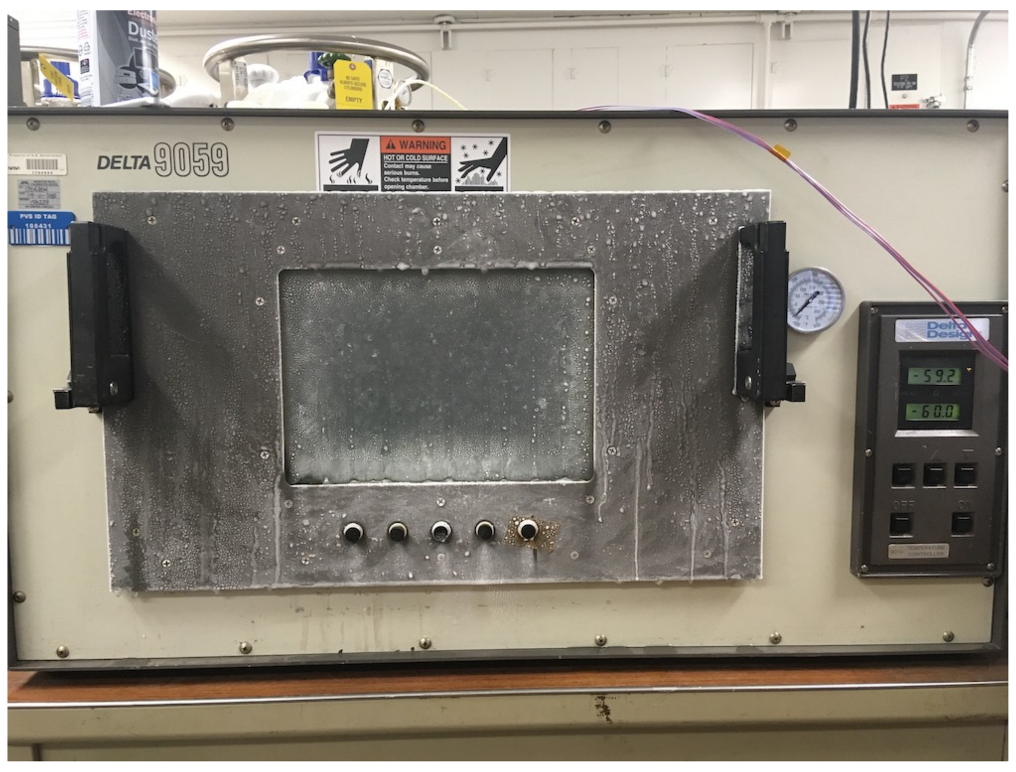
Daniel.Nunes@jpl.nasa.gov

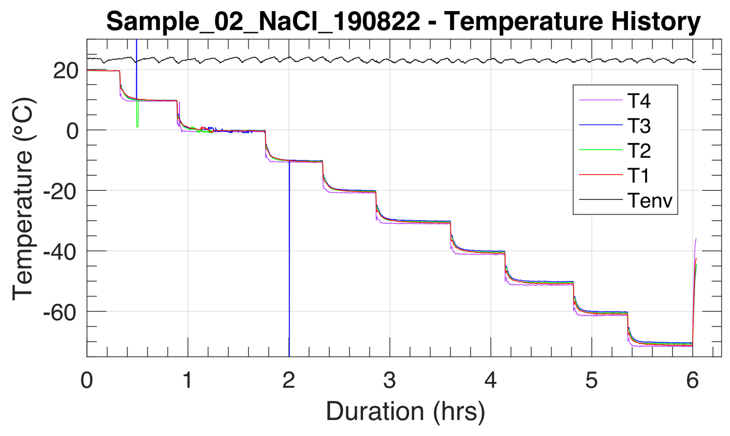
Set Up:

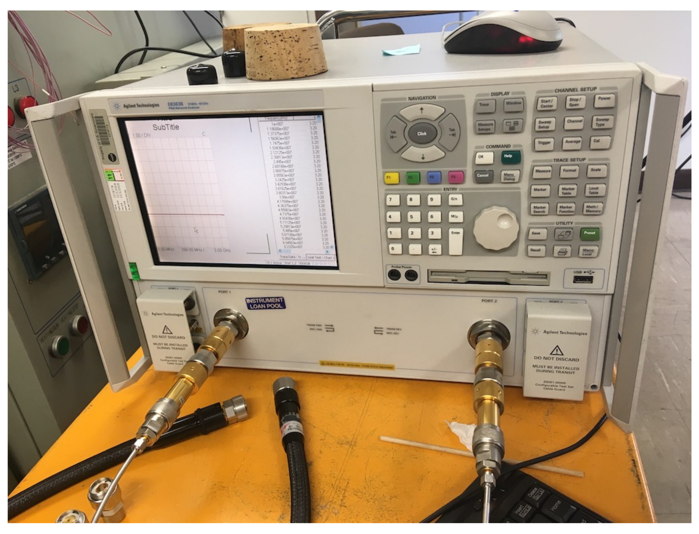
• Network analyzer: Agilent E8364B network analyzer from the Metrology tool pool. This analyzer controlled the frequency sweep across our desired 10 MHz to 3 GHz band while recording S-parameters. A pair of high-quality, extreme-temperature tolerant cables extended, one from each port, to each end of the sample fixture in the thermal chamber.

• Sample Fixture: Hewllet-Packard/Keysight 85081 7-mm coaxial airline fixtures with 50Ω center conductors. Samples were hand-packed. To mitigate potential cross contamination issues, we assigned each airline unit to a specific sample mineral type.

• Chamber: Delta 9059 thermal chamber held in its interior the sample-loaded airline for measurement while controlling the temperature via automated metering of LN2 from an external tank. We measured permittivity and permeability at every 10˚ C between the starting temperature of 20˚ C and -70˚ C. After each down step in temperature we awaited approximately 30 to 45 minutes for thermal stabilization.







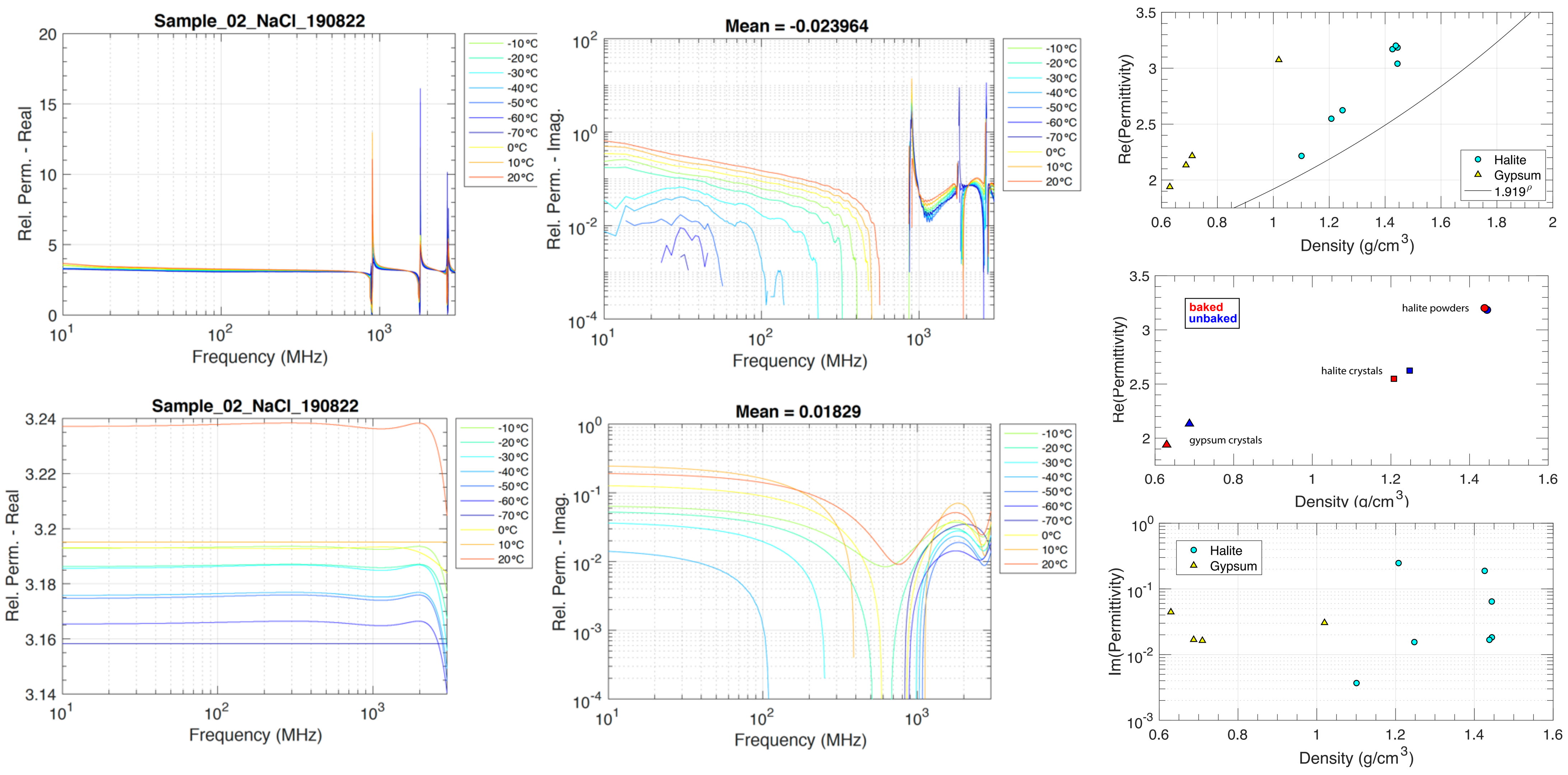
Measurements:

• We acquired permittivity and permeability measurements immediately prior to each thermal down step, and all of the measurement runs the S-parameters are automatically converted into “raw” dielectric permittivity and magnetic permeability.

• Frequencies where the sample length corresponds to half-wavelength integer multiples, as the S11 parameter tends to zero and the conversion to permittivity depends on (1/S11). Such resonances are indeed seen in our raw permittivity data.

• Observed a decrease in permittivity values with either a decrease in (i) sample density or (ii) sample temperatures.

• Differences in real permittivity observed after baking are either within margin of error or difficult to assess due to variability in density. Effects in imaginary part are detectable with the highest value seen in halite crystals.



Benefits to NASA and JPL (or significance of results):

Broadband permittivity data on evaporite minerals such as halite and gypsum would enable more profound science analyzes of existing datasets from missions as MRO and Mars Express as well those from the upcoming Mars 2020 and Europa Clipper.

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Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

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