SELECTION AND PREPARATION OF MINERALS FOR TESTING UNDER SIMULATED VENUSIAN CONDITIONS IN GEER. M. Nutt[1] and M. S. Gilmore[2], [1]NASA SUPPR intern, PO Box 4704 White Rock, NM 87547, maranutt@gmail.com, [2]Dept. of Earth and Environmental Sciences, Planetary Science Group, Wesleyan University, 265 Church St, Middletown, CT 06459, mgilmore@wesleyan.edu.

Introduction: The surface of Venus has only been measured seven times by the Venera and Vega landers in the 1970s and 1980s [e.g., 1]. Venera 13, 14 and Vega 2 measured major element chemistry, however the exact mineral characterization of the Venusian can only be inferred. The minerals of the Venus surface lie under an CO_2 and S-rich atmosphere at 460°C and 92 bars in the lowlands. Surface-atmosphere interactions are essential to understand chemical cycling, surface and atmosphere composition and weathering rates over time. This information will help us to reveal why Venus has the climate that it does today, in addition to its geological, hydrological, and possible biological history.

Theoretical and experimental reactions relevant the venusian surface have been done (e.g. [2-5]), but include many differences in experimental type, duration, apparatus and chemistry. The Glenn Extreme Environments Rig (GEER) at NASA, Glenn uniquely provides the opportunity to expose natural materials to a complex mixture of 9 gases that approximate the venusian atmosphere for weeks to months. The nominal atmospheric composition of GEER is: CO_2 96.50%, N_2 3.50%, SO_2 180 ppm, COS 51 ppm, H_2O 30 ppm, CO 12 ppm, H_2S 2 ppm, HCl 0.5 ppm, HF 2.5 ppb. In anticipation of future GEER experiments, we are preparing a suite of well-characterized minerals that will be put into GEER. Our goals were to select a set of relevant, prioritized and standardized Venus minerals that can be used in a variety of experiments by the community. We derived this list initially from an exhaustive search of the literature, selected to more systematically understand solid-gas interactions on Venus that may take place at various altitudes (temperatures). Furthermore, we will collaborate with NASA, Glenn to measure basic electrical properties of the minerals to see if these differences occur, are detectable and are relevant to the radar emissivity anomalies seen by Magellan on the venusian mountaintops [1].

Mineral selection: In order to choose which minerals to prioritize for GEER experiments, we searched through all available theoretical and experimental solid-gas literature from the 1950s to today. We identified 76 minerals and rocks from the literature cited in works that examine interactions relevant to the venusian surface. Of these, 48 have been tested at ~Venus conditions: 19 are summarized in Table 3 of [3], 9 were examined in [5] and 35 were examined in GEER [4].

From these, we selected a variety of samples prioritized according to these criteria: 1) minerals that have been recognized to test specific and important reactions. For example, a non-exhaustive list of possible reactions of magnetite (Fe_3O_4) (summarized in [3]) is:

$$2Fe_3O_4 + CO_2 = 3Fe_2O_3 + CO$$
$$Fe_3O_4 + 6SO_2 + 16CO = 3FeS_2 + 16CO_2$$
$$Fe_3O_4 + 2SO_2 + 5CO = Fe_2O_3 + Fe_2O_3 + FeS_2 + 5CO_2$$
$$Fe_3O_4 + 2COS = Fe_2O_3 + FeS_2 + CO + CO_2$$
$$Fe_3O_4 + 2H_2S = Fe_2O_3 + FeS_2 + H_2O + H_2$$

Magnetite is one of several minerals that is sensitive to oxidation state and chemical composition of the atmosphere. It is also 2) relevant to other observational data, e.g., magnetite and hematite have been cited to explains IR emissivity data [6], of these, pyrite [7] and apatite [8] have been considered as candidates to explain the low radar emissivity anomalies at Venus mountaintops. We also included rocks that have been well characterized and used in other experiments (e.g., The Planetary Emissivity Laboratory in Berlin, LPI experiments), to facilitate comparison and subsequent analyses.

In sum, we have identified, acquired and prepared 21 individual minerals and rock types. Ten samples have not previously been in GEER: bytownite, basaltic andesite, fluorapatite, chlorapatite, granite, dacite, Lassen and Newberry glasses and syenite (Table 1).

Mineral Preparation: The minerals and rocks that we chose were selected from personal collections, from the Joe Webb Peoples Museum at Wesleyan and from reputable mineral dealers (Excalibur, Wards). All samples have been cut down the C-axis to 5x5x3mm and/or 15 mm diameter by 3mm thick disks, with 0.5 µm polished parallel surfaces. All samples were photographed after preparation (Fig. 1). The size was dictated by providing a standard distance (3 mm) over which to measure electrical properties at ~2.385 GHz (Magellan frequency) on the Material Analyzer and Network Analyzer at NASA Glenn. Standard sizes and surface treatments allow measurement of changes in surface texture and mineralogy with SEM, electron probe, VNIR and Raman spectroscopy, XRD and other techniques. Duplicates were made in order to compare unreacted to reacted minerals. These goals translated into an experimental protocol shown in Table 2.

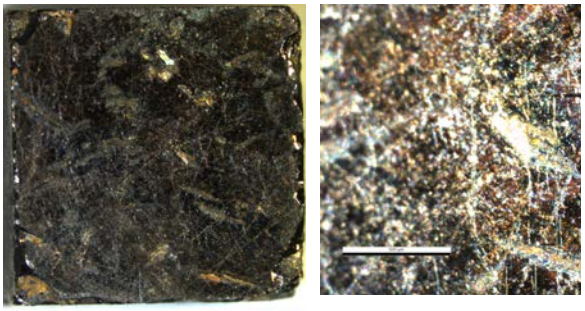

Figure 1. Left: macroscope image of pyrrhotite, 5x5mm square. Right: a magnification of left, scale bar is 500µm.

Table 1. Current sample list and their general experimental history from literature ([2-4])

Our minerals	**Other Experiments ([3,5])**	**Previously in GEER ([4])**
Olivine	Y	Y
Diopside	Y	Y
Augite	M	N
Labradorite	Y	Y
Magnetite	Y	Y
Hematite	Y	Y
Pyrite	Y	Y
Pyrrhotite	Y	Y
Calcite	Y	Y
Anhydrite	N	Y
Chlorapatite	N	N
Fluorapatite	N	N
Alkaline basaltic glass	Y	N
Oligioclase	N	Y
Bytownite	N	N
Granite	N	N
Dacite	N	N
Newberry Glass	N	N
Basaltic Andesite	N	N
Lassen Glass	N	N
Syenite	N	N

Experimental protocol. The selected samples will nominally be placed in GEER at Venus surface conditions for 60 days. The experiments have two main goals: 1) to examine any changes in mineralogy and chemistry of samples, and 2) to determine whether there are any detectable changes in the electrical properties of the samples. Both goals benefit from the standard size and preparation of mineral duplicates. The first goal requires samples that sit in the chamber as is (bare) that can be compared to duplicates that never enter GEER. The second goal requires measurement of the electrical properties of the sample before and after GEER. Some measurements require that the sample undergo a metallization procedure, where two parallel surfaces are coated with gold. To test this process, we plan to examine minerals that have been metallized before and after GEER.

Table 2. Example mineral sample protocol for pyrrhotite.

Sample ID	Mineral	Size (mm)	Pre-GEER	Post-GEER
4a	Pyrrhotite	5x5x3	Bare	Bare
4b	Pyrrhotite	5x5x3	Bare	Metallized
4c	Pyrrhotite	5x5x3	Metallized	Metallized
4d	Pyrrhotite	5x5x3	Duplicate	
4e	Pyrrhotite	5x5x3	Duplicate	
4m	Pyrrhotite	5x5x3	Wes	
5a	Pyrrhotite	15x3 disc	Bare	Bare
5b	Pyrrhotite	15x3 disc	Bare	Metallized
5c	Pyrrhotite	15x3 disc	Metallized	Metallized
5m	Pyrrhotite	15x3 disc	Wes	

Conclusions: Due to the size and nature of GEER, these experiments will give us another look at how the surface and a complex simulated Venus atmosphere interact. We have selected a standard set of high-priority minerals for GEER that we hope will facilitate future interpretation of these experiments. We have also designed a protocol to explore electrical measurements of Venus minerals that may have relevance to radar emissivity anomalies and future landed measurements.

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