THE NATURE AND DISTRIBUTION OF SILICA AT HOME PLATE IN GUSEV CRATER, MARS: EVIDENCE FOR A HYDROTHERMAL SYSTEM.

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Introduction: An extensive exploration campaign using the Athena instrument payload on the Mars Exploration Rover *Spirit* in Gusev Crater has identified materials remarkably enriched in silica (>90% SiO_2) adjacent to the low-lying, layered plateau known as Home Plate [1] (Fig. 1). Previous results demonstrate that the Home Plate structure is the product of explosive volcanism, probably the result of magma coming in contact with ground ice or water [2]. Here we highlight results from the Miniature Thermal Emission Spectrometer (Mini-TES; ~1800-380 cm^{-1}) that are consistent with a hydrothermal origin for the silica, perhaps the product of the same magma/water system that ultimately led to the creation of Home Plate.

Mini-TES Observations: During a return visit by *Spirit* to the “Tyrone” light-toned soil deposit some 50 m from Home Plate, two Mini-TES observations were acquired of a nearby nodule-like outcrop on sols 1100 and 1101 (Fig. 1). Although heavily contaminated by soil and dust, these spectra were the first to show evidence of features attributable to amorphous (opaline) silica (Fig. 2). Subsequent observations on similar nodular outcrops yielded notably similar spectra. Light-toned soil exposed by the rover’s immobilized wheel and ultimately named Gertrude Weise (Fig. 1), also shows similar spectral features (Fig. 2).

All of these spectra have features found in opaline silica but also ones that depart significantly (Fig. 2). A relatively deep and narrow feature at ~470 cm^{-1} is recognizable in all of the Mini-TES spectra as well as in opal and can be attributed to a bending mode of Si-O [e.g., 3]. Similarly, a feature near 1100 cm^{-1} is evident in the Mini-TES spectra and opal, although muted in the outcrop spectra. In opal, this is due to a Si-O stretching mode [e.g., 3]. Some of the departures from the opal spectrum can be attributed to contamination and particle size effects, but the feature near 1260 cm^{-1} cannot. Instead, it is consistent with phase angle effects observed in amorphous silica. First identified in reflectance spectra of synthetic vitreous silica [4], we have observed the same effects in emissivity spectra of both synthetic and natural forms of amorphous silica (Figs. 3-4.). The shoulder near 1250 cm^{-1} transitions to a strong absorption minimum near 1260 cm^{-1} with increasing viewing angle where 0° is normal to the surface. The rest of the spectrum is little changed. Because the Mini-TES observations were made with emission angles from ~50° to ~80°, the strong feature near 1260 cm^{-1} can be expected.

Misfit from ~800-1050 cm^{-1} in the Mini-TES spectra is due to soil and dust contamination in the case of the outcrops. At the location of outcrop dubbed Clara Zaph (Fig. 1), Mini-TES observations were acquired both on and off of the outcrop to allow for correction of the former. Corrected for contamination, the Clara Zaph spectrum is well fit by a spectrum of siliceous sinter from Steamboat Springs measured at a 60° angle (Fig. 4). The Kenosha Comets soil target (Fig. 1) has very little contamination but shows the effects of fine particles in the form of a transparency feature [e.g., 5] centered near 950 cm^{-1} (Fig. 2). The spectrum of a crushed version of the same Steamboat Springs sinter measured at a 45° angle (the maximum achievable) provides a good fit to the Kenosha Comets spectrum (Fig. 4). In this case, the transparency feature of the sinter shows two minima where the Mini-TES spectrum only has one. The cause of this is as yet unknown.

Discussion: On Earth, opaline silica is a common feature of hydrothermal systems where it can be precipitated from silica-rich alkaline fluids or leached from host rock by acidic steam fumaroles [e.g., 6]. Given that Home Plate appears to be a depression buried by pyroclastic materials [2] partially surrounded by sinter-like materials, the possibility exists that Home Plate is a buried and eroded hot spring. However, evidence for Ti enrichment of the high silica materials tends to support fumarolic leaching resulting in silica residue [1]. Both modes of origin are possible in the same system [e.g., 6] and either is evidence of hydrothermal fluids in the vicinity of Home Plate. Given that silica producing hydrothermal systems on Earth harbor and preserve evidence of microbial life [e.g., 7], the discovery of opaline silica on Mars is significant.

References: [1] Squyres, S.W. and Athena Science Team, (2007) *Eos Trans. AGU, 88*(52), Fall Meet. Suppl. Abstract P21C-01. [2] Squyres, S.W., et al., (2007) *Science, 316* 738-742. [3] Michalski, J.R., et al., (2003) *Geophys. Res. Lett., 30*(19) doi: 10.1029/2003GL018354. [4] Almeida, R.M., (1992) *Physical Review B, 45*(1) 161-170. [5] Salisbury, J.W. and J.W. Eastes, (1985) *Icarus, 64* 586-588. [6] Rodgers, K.A., et al., (2002) *Clay Minerals, 37* 299-322. [7] Farmer, J.D. and D.J. Des Marais, (1999) *J. Geophys. Res., 104*(E11) 26,977-26,995.

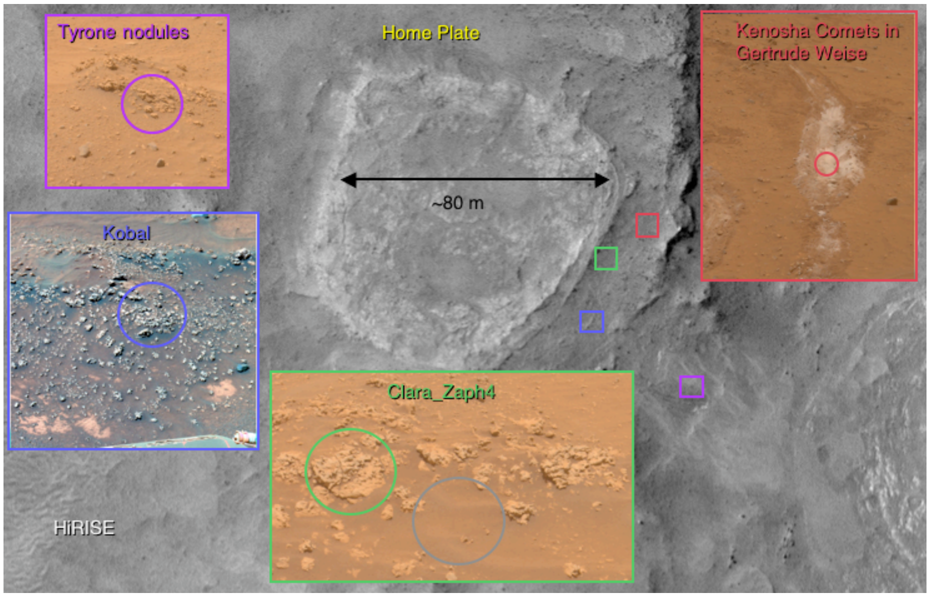

Figure 1. Cropped HiRISE scene showing Home Plate with superimposed Pancam color images of some of the silica-rich materials observed by Mini-TES. Colored circles represent the approximate field of view of the Mini-TES instrument. Colors are keyed to locations in the HiRISE scene and accompanying spectra (Fig. 2).

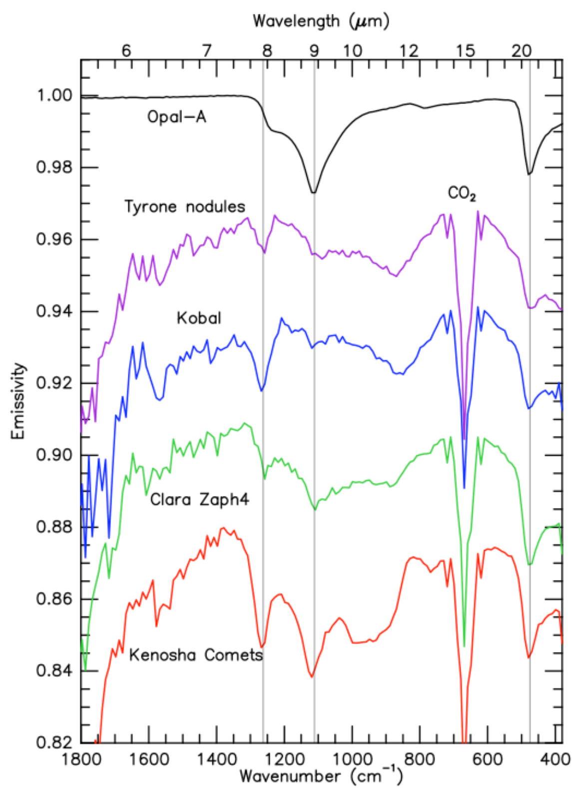

Figure 2. Opal-A compared to Mini-TES spectra. The prominent feature at ~1260 cm^{-1} in the Mini-TES spectra that is absent in opal-A can be explained by viewing angle effects (Fig. 3). Other mismatches are the result of contamination and particle size effects (Fig. 4).

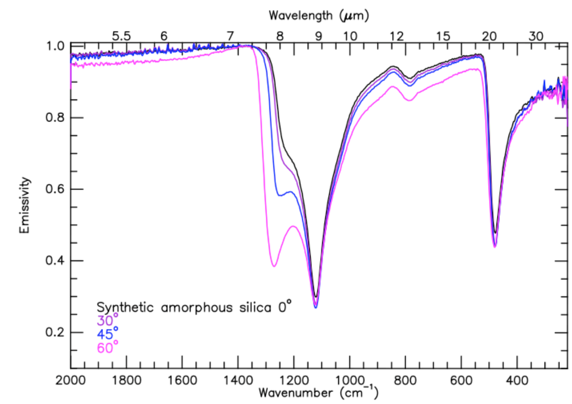

Figure 3. Viewing angle effects in amorphous silica account for the pronounced feature at ~1260 cm^{-1}.

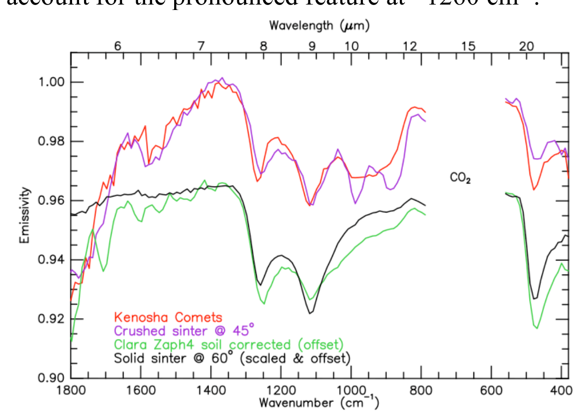

Figure 4. Kenosha Comets soil resembles crushed sinter at 45° emission angle. Clara Zaph outcrop corrected for contamination resembles solid sinter at 60°