REFLECTANCE SPECTRA FOR OLIVINE HEATED WITH SUDDEN OXYGEN-FUGACITY CHANGE.
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Introduction: Because bombardments on asteroidal surfaces by meteorites may locally increase surface temperature and change oxygen fugacity by selective evaporation of surface material, we have studied changes of diffuse reflectance spectra in the UV-Visible-Near infrared wavelength region (200-2500 nm) for powder samples of some meteorites heated at 800 - 1200 ^{o}C under different oxygen fugacities [e.g., 1]. The brief summary of the results is as follows. The spectral contrast fairly decreases and the spectra often show strong reddening after heating, especially when the meteorite sample was heated at a different oxygen-fugacity condition from the intrinsic oxygen-fugacity of the meteorite.

We report, in this abstract, spectral changes for olivine heated at high temperature (up to 1300 ^{o}C) with rapid oxygen-fugacity changes, and suggested that the elementary process of space weathering is related to heating with oxygen-fugacity change.

Samples and Experiments: Some grains of San Carlos olivine were ground in a corundum mortar and passed through a 100µm sieve to obtain the <100 µm powder sample. A pellet made by the <100 µm powder sample weighing about 70 mg placed in Pt-foil was heated at a constant temperature in a vertical 1-atm H2/CO2 gas-mixing furnace. Cooling of the charge to room temperature was done by cut of the electricity of the furnace with flowing gas mixtures to avoid oxidation of the charge in air. This procedure of cooling of the charge has been usually used for our heating experiments concerning spectral study.

In order to realize a sudden oxygen-fugacity change, we cooled the run charges in several ways: (1) the charge was taken out of the furnace immediately in air (about 1 sec), (1S cooling) (2) the charge was taken out of the furnace slowly for 20 sec (20S cooling), (3) the charge taken out for 1minutes (1M cooling)

Biconical diffuse reflectance spectra were measured by the use of a UV-Visible-Near IR spectrophotometer with the incident and reflection angles of 30 degrees. Halon was used as a standard. The details of experiments are given in [2].

Results and Discussion: Figure 1 shows the results of diffuse reflectance spectra of San Carlos olivine heated at 1000 ^{o}C under 1.5 log unit below the iron-wüstite (IW) buffer (IW-1.5) for 48 hr and those of heated at 1200 ^{o}C under IW-1.5 and 0.5 log unit above the quartz-fayalite-magnetite (QFM) buffer (QFM+0.5; about IW+4) for 48 hr. The spectra of the 1000 ^{o}C under IW-1.5 sample are almost the same as that of the unheated sample. The spectra of the sample heated at 1200 ^{o}C under IW-1.5 drastically change (Fig. 1). The reflectance at 560 nm decreases from about 90% to 50%. The wavelength position of the UV cut off shifts toward a shorter wavelength. The band strength of the absorption band near 1000 nm relatively becomes weak. Therefore, the spectral contrast drastically reduces. These changes are probably due to the formation of many small Fe grains by reduction. In fact, the scanning electron microscope observation shows the presence of some small Fe grains in the 1200 ^{o}C under IW-1.5 sample. The 1000 ^{o}C under the IW-1.5 sample has the condition that is not enough to reduce olivine. The oxygen fugacity of the 1200 ^{o}C under the QFM+0.5 sample is probably near the condition of the San Carlos olivine formation.

Figure 2 shows the results of spectral changes for the heated samples of sudden oxygen-fugacity changes. First, these samples were heated at 1300 ^{o}C under IW-1.5 for 1 hr. This heating condition is enough to reduce the area of a few micrometers from the surface of olivine considering the interdiffusion coefficient of Mg-Fe in olivine (e.g., Miyamoto et al., 2002). Second, the run charges were cooled under the conditions described above (1S, 20S and 1M). The spectra of these three samples show similar reflectance at 560 nm around 50% that is relatively low compared with that of the unheated sample (about 90%) and also show a relatively low spectral contrast. These features are similar to those of the 1200 ^{o}C under IW-1.5 for 48 hr due to reduction of olivine.

The spectra shown in Fig. 2 show different degrees of reddening in the visible wavelength region. This result is related to the degree of the oxygen-fugacity change, because the 1S cooling gives the largest oxygen-fugacity change and the 1M cooling gives the smallest one.

We calculated the wavelength position, band strength and full width at half maximum (FWHM) of the absorption band near 1000 nm by using the MGM method to study the changes by heating [3]. The results are summarized in Table 1. Because the Fe precipitation in olivine makes olivine more Mg-rich, the wavelength position of the 1000 nm band of the sample heated at 1200 ^{o}C under IW-1.5 is expected to shift toward a shorter wavelength. We cannot, however, obtain such a result. The band strengths of the 1000 nm band for the samples listed in Table 1 are significantly weaker than that of the unheated sample. We cannot find any changes in the FWHM values.

The spectral changes of reddening and low spectral contrast by heating with oxygen-fugacity change are similar to those by space weathering. This implies that the elementary process of space weathering is related to heating with oxygen-fugacity change. The study of the spectral change by heating with oxygen-fugacity change is important to study the properties of space weathering.

References: [1] Miyamoto M., Komatsu M., and Mikouchi T. (2000) *LPS XXXI*, #1109. [2] Miyamoto M. and Mikouchi T. (2000) *Antarct. Meteorite Res.*, 13, 93-99. [3] Ueda Y., Hiroi T., Pieters C. M. and Miyamoto M. (2002) *LPS XXXIII*, #1950.

Table 1. Band parameters of the spectra for heated olivine obtained by MGM analysis.

	Band parameter		
	Band Center (nm)	FWHM (nm)	Strength
Unheated	1031	196	-0.39
1200 °C IW-1.5	1035	170	-0.2
1M Cooling	1029	193	-0.24
20S Cooling	1027	187	-0.27
1S Cooling	1031	184	-0.21

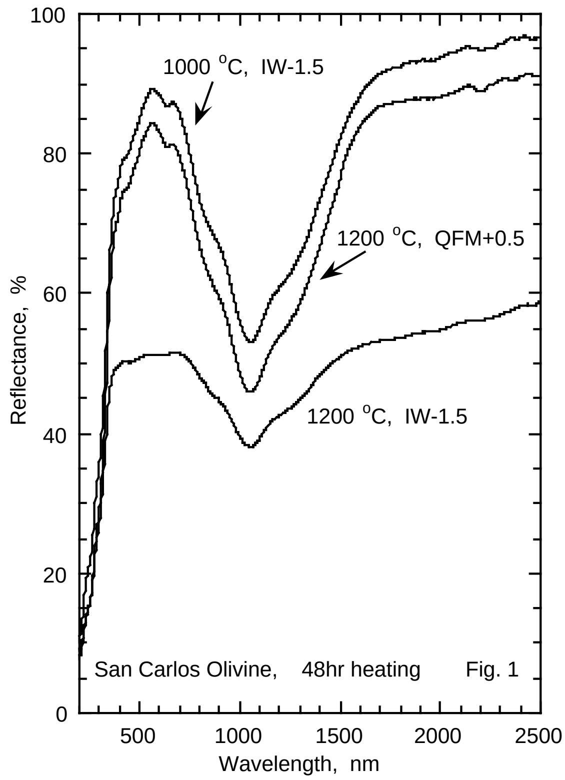

Fig. 1. Diffuse reflectance spectra of San Carlos olivine heated at different oxygen fugacities and temperatures. Reflectance is shown in the value (%) relative to the standard.

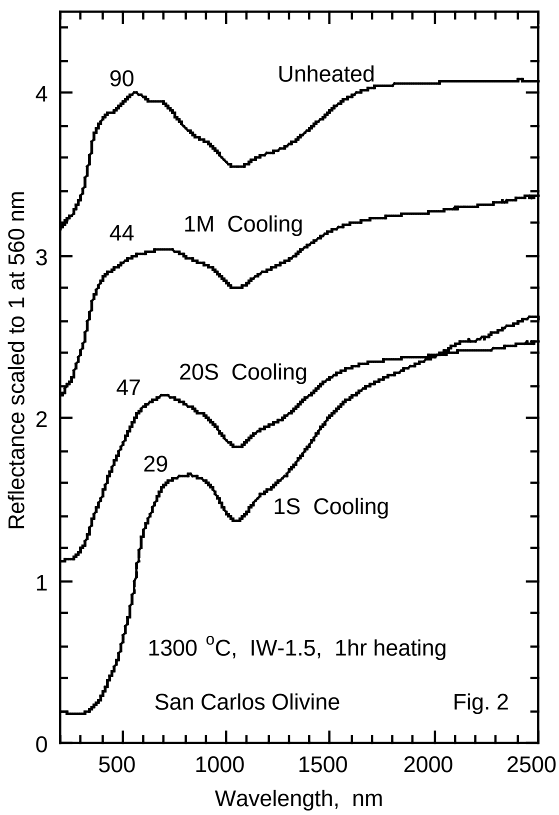

Fig. 2. Diffuse reflectance spectra of San Carlos olivine heated with different oxygen-fugacity changes. The samples are heated at 1300 °C for 1 hr under IW-1.5 and then different cooling. See text. The spectra are scaled to 1.0 at 560 nm and offset for clarity. Numbers on curves show reflectance at 560 nm (%). The spectra of the unheated <100μm sample of San Carlos are also shown.