OXYGEN FUGACITY IN THE LUNAR REGOLITH: A SYSTEMATIC STUDY OF THE RELATIONSHIP BETWEEN COMPOSITION, OXYGEN FUGACITY AND OPTICAL SPECTRA OF LUNAR AND SYNTHETIC GLASSES., P. M. Bell and H. K. Mao, Geophysical Laboratory, 2801 Upton St., N. W., Wash., D. C. 20008.

Glass fragments in the lunar regolith have frozen evidence of their previous liquid state and contain keys to the oxygen fugacity and composition of their parent rocks or soils at the instant of cooling (1). Appropriate silicate liquids and their glasses have high solubilities for ions of iron and titanium in various oxidation states that crystals cannot accommodate, and therefore are better samples for determining the chemical environment of the moon's surface at the time of their formation.

It has been demonstrated that the abrupt freezing is a direct quench of composition, oxygen fugacity, and temperature as all three variables are changing rapidly (2), so knowledge of their interrelationships can be used in the interpretation of lunar glasses.

In the present study glass fragments from soil samples from all of the Apollo sites have been analyzed chemically, and their crystal-field spectra measured. A study of synthetic glasses has been conducted simultaneously in which the oxygen fugacity, temperature, and composition at the quench were determined. Comparison of optical spectra makes it possible to relate the experimental conditions to those at the Apollo sites.

The compositions of the synthetic glasses are given in Table 1. They were selected as follows:

- OG - equivalent to orange glass sampled at every Apollo site; intersection of the chemical joins FOG-TIO_2 and TOG-FeO;
- FOG - identical to OG except titanium free;
- TOG - identical to OG except iron free;
- F_3T_1 - 1/3 along join FOG-OG;
- F_3T_2 - 2/3 along join FOG-OG;
- F_1T_3 - 1/3 along join TOG-OG;
- F_2T_3 - 2/3 along join TOG-OG.

The compositions fall on the plane Al_2O_3 + CaO + MgO + SiO_2 as it intersects components FeO and TiO_2 in the six component system. The system is close to, but in no case identical with, average lunar basalt composition.

The compositions ("end members") OG, FOG, TOG were subjected to a range of oxygen fugacities at 1400°C as shown in Table 2, to provide the extreme range of formation of lunar colored glasses. The intermediate compositions F_3T_1, F_3T_2, F_1T_3, and F_2T_3 were studied at $-\log PO_2 = 0.7$ (air) and $-\log PO_2 = 9.1$. The latter oxygen fugacity is deemed "average" for the lunar regolith.

The results of this study show the limits of oxygen fugacity in the lunar soils from the Apollo sites. They indicate also the compositional variations. The ranges—both of oxygen fugacity and composition—for each site are related to optical spectra, which may be useful in the interpretation of telescope spectra of the moon's surface. The present data are used to distinguish "regolith" processes that may have altered the intrinsic oxygen fugacity of lavas that originated in the moon's interior.

Table 1. Compositions of synthetic glasses

	OG	FOG	TOG	F_3Ti_2	F_3T_2	F_1T_3	F_2T_3
FeO	22.48	24.71	0	23.97	23.22	7.49	14.99
TiO_2	9.04	0	11.66	3.01	6.03	10.79	9.91
Al_2O_3	6.35	6.98	8.19	6.77	6.55	7.58	6.96
CaO	7.74	8.51	9.99	8.25	8.00	9.24	8.49
MgO	14.91	16.46	19.31	15.96	15.47	17.86	16.42
SiO_2	39.42	43.34	50.85	42.03	40.73	47.04	43.23

Table 2. Fugacity of Oxygen, Synthetic Composition, at 1400°C

$-\log PO_2$	Composition (See Table 1)					
0.7	OG	FOG	F_3T_1	F_3T_2	F_1T_3	F_2T_3
6.6	OG	FOG				
7.5	OG	FOG				
9.1	OG	FOG	F_3T_1	F_3T_2	F_1T_3	F_2T_3
10.0	OG	FOG				
11.6	OG	FOG				

References

(1) Bell, Peter M., and H. K. Mao, 1972, Proc. Lunar Sci. Conf. 3rd, P. 545-553.

(2) Bell, Peter M., A. El Goresy, and H. K. Mao, Proc. Lunar Sci. Conf. 5th, P. 342-347.