AN ERROR ANALYSIS OF ORBITAL X-RAY FLUORESCENCE DATA. Norman Hubbard and James E. Keith, NASA Johnson Space Center, Houston, TX 77058.

The orbital x-ray fluorescence data produced by Apollo 15 and 16 (1) have been reexamined (2) and improvements have been made in the reduction of these data (3). Specifically, the signal-to-noise ratio was improved and unwanted solar effects were removed. The major results of this has been that the Mg/Si data can now be used on par with the Al/Si data to study the moon (3, 4). In this abstract we show the errors associated with the A-15 data for Al/Si and Mg/Si. The reproducibility of the data can be derived from Figure 1, which shows the standard deviations for populations of data that are produced by averaging the individual 8 sec data points for multiple (3 or more) passes over a homogeneous geologic unit. Note that the range and average of the standard deviations for Al/Si and Mg/Si are indistinguishable in these data and that there is little if any relationship of standard deviation to the value of the ratio. Additional data (not shown) suggest that the average standard deviation for Mg/Si is slightly larger than for Al/Si and may be a weak function of the value of the ratio. However, the Mg/Si data have more geological scatter than the Al/Si, leading to confusion in interpretation of this result. The average phase angles (angle from the subsolar point) for the data in Figure 1 range up to 50° from the subsolar point, which we take as the acceptance limit for Mg/Si data (for Al/Si this limit is 60°). There is no correlation of phase angle with standard deviation. A photometric analysis of these data (2, 3) shows that at 50° from the subsolar point the intensity is 1/2 of that at the subsolar point. This difference in signal intensity results in less than a 1.5 fold increase in the statistical uncertainty due to counting statistics of a single 8 sec. data point for Mg and this difference will be obscured by the averaging of 10 or more data points per orbit and the averaging across multiple orbits. The data in Figure 1 indicate an average one sigma uncertainty on the mean of 10 or more data points of ± 0.025. This has been verified by comparing the means of individual orbits with the mean of a set of orbits for several homogeneous units.

Thus far this error analysis has not addressed additional sources of error that are associated with the intercomparison of data for two or more areas. This can be done in part using the data in Figure 2, which is a semi-log plot of the solar intensity index vs the Mg/Si intensity ratio for multiple passes over a set of 5 chemically homogeneous areas. This graph defines the change in observed Mg/Si intensity ratio that resulted from a change in the intensity of solar x-radiation incident on the moon, and is used as the basis for removing this effect from the lunar data. The data for four areas have been normalized to those for one area by assuming that only the Mg/Si concentration ratios differ between the 5 areas. Each data point is the average of 10 or more 8 second data points from one orbit. These data are for one high-Ti mare (Tranq.), one low-Ti mare (Seren.) and three terra areas. Thus, the errors in these data include those arising from normalization of these separate areas into a composite and errors arising from differences in chemical and physical matrix effects among the diverse areas, as well as the errors estimated in Figure 1. Therefore, the error estimate derived from the scatter of points around the best fit line is a conservative estimate of the sum of all errors that affect the intercomparison of our solar corrected intensity ratios. The data in Figure 2 were fitted with a weighted least-squares routines where both variables are weighted by the inverse of their variances (5). The measure of fit ($\chi^2_{\nu}=1.4$)

suggests that the original estimates of error of the mean (one sigma for Mg/Si=0.035 and SII=5.0%) are approximately correct. Any excess variation ($E(\chi^2_\nu=1)$) may be due to an inappropriateness of the exponential function used, or to true scatter caused by imperfect reproducibility of the conditions from orbit-to-orbit, or to an underestimation of the individual errors or to errors associated with the normalization. Inspection shows no evidence of systematic deviation from the function chosen. Assignment of all the scatter to individual error gives an average one sigma error of $\pm$0.050 for the mean for Mg/Si. Data for Al/Si vs. SII yield an almost identical a result with a similar degree of fit ($\chi^2_\nu=1.5$).

From this error analysis, we conclude that the error (one standard deviation) of the mean of 10 or more data points is somewhere between $\pm$0.025 and $\pm$0.050. Extensive use of the data indicates an intermediate value. Preliminary examinations are consistent with the existence of a small systematic error between the data for terra and mare that is not directly addressed by this analysis. We currently deal with this error in the conversion to Al and Mg concentrations.

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Figure 1

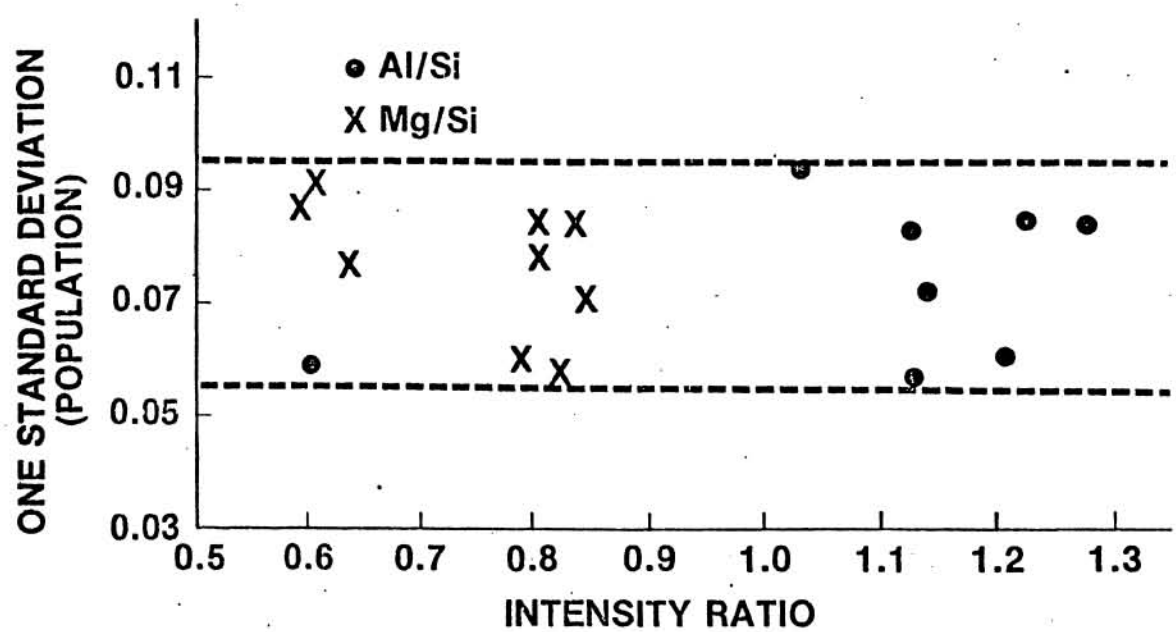

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Figure 2