Al/Si intensity ratios calculated from Apollo 15 and 16 x-ray fluorescence data exhibit substantial variations corresponding to transitions between different lunar physiographic provinces; Adler et al. (1,2), for example, find that low ratios (corresponding to concentration ratios less than 0.45) show a good correlation with mare areas, and that high ratios (corresponding to concentration ratios greater than 0.55) are associated with highlands. Prior to the present study, however, this new well-documented regional pattern of Al/Si intensity variation has not been employed for lunar geochemical mapping.

Eight relatively small (> 25 km in shortest dimension) areas in the Tranquillitatis/Serenitatis region coincide with anomalous Al/Si residuals from fourth-order trend surfaces (3). This suggests that Al/Si intensity ratios can be useful not only for large-scale, regional--but also for small-scale, local--geochemical mapping. In our work, we have used the most apparent distinction in lunar surface chemistry as revealed by Al/Si ratios--that of the above-mentioned difference between highland and mare--to test the concept that variations in Al/Si concentrations can define highland-mare boundaries within relatively narrow limits.

By the techniques of Podwysocki et al. (3), we identified anomalous residuals from fourth-order trend surfaces for 16-second sliding averages of Apollo 15 8-second Al/Si ratios in the region from 15 to 24° N and 28 to 33° E, where the southern Taurus Mountains border Mare Serenitatis. The approximate location of the highland-mare boundary in this region was then inferred from (1) transitions from consistently positive fourth-order trend surface residuals (corresponding to the highlands) to consistently negative fourth-order trend surface residuals (corresponding to the mare), and also from (2) variations in such residual values of at least one-fourth the full range of these values for a given orbit. (Use of the latter criterion is consistent with the observations (1,2) that average Al/Si concentrations drop by a factor of one-fourth from the Taurus Mountains to Serenitatis, and also that Al/Si concentrations can drop by a factor of one-half from highland to mare areas.) The boundary so inferred is denoted in the Figure by dashed lines.

Along the flight-lines that cross the region from southeast to northwest, this estimated highland-mare boundary is displaced from the actual boundary (reproduced on the Figure from 1:1,000,000 USGS maps of the Mare Serenitatis region and the Macrobius Quadrangle) by only 2-35 km (orbits 22, 25, 27, and 38). The greatest deviation (35 km along orbit 22) probably reflects the presence of high-Al/Si ray material overlying the dark mantling unit in this area (4); excluding this largest discrepancy, the inferred...
The Serenitatis/Taurus Mts. region from 16 to 23° N and 26 to 33° E. Highland-mare boundaries as reproduced from USGS 1:1,000,000 maps is shown by solid lines; highland-mare boundaries as inferred from Al/Si data are denoted by dashed lines. Information from two additional Apollo 15 orbits, (16 and 42), (not shown here) were used to extend the estimated boundary, respectively, to 23 and 16° N. Values given at data points along flight-lines are residuals from fourth-order trend surfaces for 16-second sliding averages of 8-second data.
mare-highland boundary coincides with the actual boundary within about 2-15 km. The location of the estimated boundary between 18 and 21°N (orbits 30 and 46) is indeterminate within flight-line path-lengths of, respectively, about 45 and about 60 km; the four most probable locations for the mare-highland boundary between these latitudes are shown in the Figure. The areas crossed by orbits 30 and 46 between 17 and 21°N consist of mixed terrain; and it is notable that the westernmost mare-highland boundary as inferred from Al/Si ratios corresponds closely to the border between mixed terrain and mare, and the easternmost boundary, to the border between mixed terrain and highlands.

Two very low residual values, -0.24 and -0.26, occur where orbit 46 passes between 19-20°N and 28-29°E. These values are appreciably less than all other residuals for this orbit (including those located in the mare proper); and they appear to reflect a genuine highly negative anomaly, since another orbit (33, not shown) that crosses the area slightly north of orbit 46 is also characterized by abnormally low residuals in this region. One possible explanation for these exceptionally low values would be the presence of substantial amounts of orange glass, which has a considerably lower Al/Si ratio than other soil types at the Apollo 17 site.

On the basis of this initial investigation, we conclude (1) that statistical analysis of Al/Si intensity ratios can distinguish highland-mare boundaries with a resolution of approximately 15-30 km; and, therefore, (2) that such analysis of Al/Si data constitutes a valid technique for lunar geochemical mapping.

REFERENCES


