Compositions of mare basalts are major contributors to our notions of overall lunar composition, e.g., relative depletion in volatile and siderophile elements, possible enrichment in lithophile elements, nature of interior source regions (as interpreted by experimental petrologists), compositions of major regions of mare terrain (as inferred from spectral analysis). Our confidence in such notions depends on mundane characteristics of lunar basalt samples that affect assumptions about what those samples represent. To what extent do they represent a broad region as opposed to one or a few local flows? Do any represent primitive liquids from partial melting or have all undergone significant differentiation or assimilation? Do they adequately represent their magma types, or even their flows? Because sampling of lunar basalts had to be done without normal geological control, many characteristics cannot be established directly; some can at best be inferred by comparison with terrestrial analogs, with adjustments for differences in situation between Earth and Moon. To provide adequate data sets for such comparisons, we have begun extensive analyses of suites of terrestrial basalts.

Compositional data require at least three types of analysis. One type is trend analysis, to determine whether compositional trends predicted from models actually appear in nature, or whether observed variations can be accounted for. Extensive work by several investigators has not shown convincingly that anticipated trends are present. (Appropriate and probably valid excuses are given.) A second type is cluster analysis, to determine preferred compositions that might indicate primitive liquids or separate flows or sources. Much informal work of this type is in the literature.

A third type and the topic of this paper is dispersion analysis, which bears on the extent of variability among samples of basalt of known relationship to each other. This might enable us to distinguish among suites of lunar basalts from single flows, related flows, and unrelated flows. This type of analysis, done on terrestrial basalts and applied to lunar basalts, is a necessary complement to the other types. For example, if the dispersion observed for a suite of related basalts exceeds that predicted by models, the models and associated trend analyses are inadequate. If the dispersion crosses boundaries of compositional clusters, those clusters may not represent separate flows or sources.

We categorize our present data base for suites of basalts with known relationships as follows:

I. Samples of single, homogeneous, powdered specimens. This tests effects of analytical uncertainty, inter- and intralaboratory, on measured dispersions. We find these effects to be unimportant for samples discussed here except for interlaboratory systematic error for A-11 and 12 basalts. (Otherwise, only suites done by single analysts are used.)
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II. Separate chips from single hand specimens. Chips of medium-grained 70135 weighing 231, 763, and 1400 mg yielded widely disparate results (range for La, 3.5x) (Haskin and Korotev, GCA, in press). Such variability can strongly affect results for medium-grained lunar rocks but is apparently not present in finer-grained samples. Values in Table 1 are for 6 size fractions of a single, crushed chip of 70135 and are roughly representative of usual variations.

III. Separate hand specimens from a single lava flow. We use 2 suites, an 11 meter thick Icelandic flow (11 samples, Helmke, 1973) and a Cascades flow (6 samples, Brannon, Haskin, Mc Birney, unpublished).

IV. Spatially, temporally, and compositionally related basalts with no trend of relative differentiation. We use 5 suites, Steens Mt. group E (9 samples, Helmke and Haskin, 1973) and Columbia River plateau suites (9, 11, 11, and 7 samples, Osawa and Goles, 1970).

V. Series of related basalts with patterns of relative differentiation. We use 2 suites, Steens Mt. (52 flows, Helmke and Haskin, 1973) and Keweenawan olivine tholeiites (15 flows, Haskin, Brannon, Green, unpublished).

VI. Basalts of similar petrology and geologic setting from a single, broad area. We use Cascades basalts from NE Oregon (54 samples, Brannon, Haskin, Mc Birney, unpublished).

We have compiled observed ranges of concentration and standard deviations from mean concentrations. Ranges indicate extents of dispersion actually observed. They do not indicate probabilities for any unusual concentrations, observed or unobserved; such estimates would require an understanding of distributions of values. Standard deviations soften effects of severely aberrant values on comparisons between suites. We have not shown that the distributions of concentrations within suites are normal, so the meaning of the standard deviations is unclear. We have treated obviously multimodal groups of basalts as separate suites for each mode.

The present treatment is limited to REE. These incompatible elements are among the most variable in concentration of those whose distributions are controlled primarily by igneous rock-forming processes. We have tabulated values for La, Sm, and Yb as typical light, medium, and heavy REE and for Eu as an atypical REE to determine the dispersion in concentrations. We have used ratios (La/Sm, Sm/Eu, and La/Yb) to indicate dispersions in REE relative abundances. Some igneous processes (e.g., gain or loss of olivine) mainly cause uniform changes in concentrations; others (e.g., gain or loss of clinopyroxene, plagioclase) cause changes in ratios as well.

Maximum values for dispersions among basalts of known relationships are given by category in Table 1. Note the striking separation for concentrations between categories II-IV and V and VI. The same distinction is present in ratios but is not as strong. On the average, dispersions of category IV exceed those of II and III.

Table 1 also contains for comparison results for suites of basalts of more or less uncertain relationship. Some are Apollo basalts; the rest are ocean floor basalts from a single drill hole (DSDP leg 37, hole 332B, Blanchard et al., 1976). For Apollo 11 and 12 basalts, each separate analysis was treated as a separate sample in statistical calculations.
Dispersions in REE

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1) A-11, type A (8 specimens, 7 analysts, 19 analyses). Dispersions are most similar to those of category IV but might correspond to those of III if systematic interlaboratory errors were removed.

2) A-11, type B (8 specimens, 6 analysts, 20 analyses). Dispersions are too large for all categories below V (but there are no strong trends) and are lower than those of VI. Duplicate measurements do not indicate severe sampling effects even though these basalts resemble those of A-17.

3) A-12, olivine (8 specimens, 8 analysts, 22 analyses). Dispersions are similar to or slightly exceed those of IV, but are expanded somewhat by interlaboratory systematic error.

4) A-12, ilmenite (4 specimens, 5 analysts, 10 analyses). Dispersions are similar to those of categories III and IV; 4 specimens is a small sample.

5) A-15 (20 specimens, Helmke et al., 1973). Most dispersions exceed those for category IV. There are no simple trends, but there are slightly separable clusters (olivine normative, 13 specimens; quartz normative, 7 specimens). Separate treatment of clusters does not help dispersions.

6) A-17 (16 specimens, Shih et al., 1975). Dispersions greatly exceed those of category IV but the problem of sampling of medium-grained rocks may be an important contributor.

7) A-17, olivinephyric (4 specimens, 6 analysts, 9 analyses). Like 4) above.

8) DSDP plagioclase (15 specimens). Dispersions are similar to those of category IV. Core stratigraphy indicates several flows.

9) DSDP picrite (4 specimens). Dispersions are most similar to category III. Such uniformity is surprising for olivine accumulative basalts, especially from separate flows. Four specimens is a small number.

10) DSDP olivinephyric (4 specimens). Dispersions substantially exceed those of category IV. Two contiguous samples are very similar, two others are significantly different; samples belong to 3 separate petrographic and compositional subtypes (Blanchard et al., 1976).

Obviously, no firm conclusions about the number of separate flows sampled at the various Apollo sites or in DSDP hole 332B can be made from this analysis alone, particularly with such a meager data base for basalts of known relationships. The comparisons are nevertheless useful guides and lend necessary support to some of the ideas expressed in the literature. The consistency of DSDP results with those of better known suites is very encouraging.

Table 1.

<table>
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<th>Cat.</th>
<th>La</th>
<th>Sm</th>
<th>Eu</th>
<th>Yb</th>
<th>La/Sm</th>
<th>Sm/Eu</th>
<th>Yb/Eu</th>
<th>La/Yb</th>
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<th>Sm/Eu</th>
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<td>6.6</td>
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