MULTIVARIATE STATISTICAL ANALYSIS OF COMPOSITIONAL DATA FROM ORDINARY Chondrites; M. E. Lipschutz and S. M. Samuels, Dept. of Chemistry and Depts. of Mathematics and Statistics, Purdue Univ., W. Lafayette, IN 47907

Important information on the origin and evolution of equilibrated ordinary (H and L) chondrites has been obtained from data on the volatile/mobile (labile) trace elements, Ag, Au, Bi, Cd, Co, Cs, Ga, In, Rb, Sb, Se, Te, Tl and Zn. In part, this information has been inferred from comparison of data for various populations using univariate (element-by-element) statistical tests, mainly the t-test. Comparisons have shown, for example, that among non-Antarctic L4-6 chondrite falls, samples strongly shocked (i.e. to >22 GPa), have significantly lower concentrations of many labile trace elements than do mildly shocked (<22 GPa) samples, hence shock-induced loss of these elements occurred [e.g. 1]. Other comparisons have shown that H4-6 or L4-6 chondrite falls differ compositionally from the corresponding groups recovered from Antarctica [1,2]. The nature of this and other differences imply to us that Antarctic and non-Antarctic ordinary chondrite (and other meteorite) populations differ in preterrestrial thermal history. But, this conclusion is controversial.

As a first step to resolve this controversy, it is essential to establish such compositional differences beyond any reasonable doubt. To do this, we decided to re-assess the compositional data using multivariate techniques, thus comparing all elements simultaneously. We chose to make no assumptions whatever about: the nature of the parent population from which each parent population derives; normality of data or equal covariance matrices for populations; sampling, except to eliminate highly weathered samples or those paired with a chondrite already included in the population.

In our comparisons, we use two metrics - Linear Discriminant Analysis and Logistic Regression - borrowed from standard multivariate methods. In standard fashion, we use these metrics to classify samples (i.e. Antarctic vs. non-Antarctic or strongly vs. mildly shocked) and determine the number of misclassifications. We then extend the two standard metrics by the non-standard approach of a randomization technique to obtain a distribution-free significance level. Here, we compare the actual number of misclassifications with those obtained by randomly labeling samples. By computer, we run 1000 comparisons of random samplings for each pair of populations.

We compare 1000 random samplings with the true sampling for the following sample population-pairs: Antarctic L4-6, mildly vs. strongly shocked; Non-Antarctic L4-6, mildly vs. strongly shocked; Strongly Shocked L4-6, Antarctic vs. non-Antarctic; All L4-6, Antarctic vs. non-Antarctic; All H4-6, Antarctic vs. non-Antarctic. At present, we have completed work on the last two of these population-pairs (and are working on the other three pairs now). In these two cases, at least, not a single one of the 1000 randomly labeled sets produced as few misclassifications as did the truly labeled sets. Thus, we can confidently assert that the compositional difference between the components of each pair tested is statistically significant at the 0.001 level for these two cases. We will report these data and those for the other three population-pairs now being tested.
The purpose of this study was to establish these compositional differences between Antarctic and non-Antarctic H (and L) chondrite populations beyond any reasonable doubt and that, we have done. It remains for future studies to demonstrate as conclusively that differences between Antarctic and non-Antarctic populations are preterrestrial and not terrestrial in origin, a situation supported by the current weight of evidence.

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References
