A STATISTICAL STUDY OF MERCURIAN CRATER CLASSES APPLIED TO THE EMPLACEMENT OF THE INTERCRATER PLAINS; Alex Woronow and Karen Love, Geosciences Department, University of Houston, Houston, TX 77004

Studies of crater classes have been few in number and disappointing in result. Perhaps this stems from the difficulties in statistically treating a nonstationary, multivariate data set, or from the propensity to treat all crater data phenomenalogically rather than statistically. In either case, recent statistical innovations (Aitchison, 1982) afford new opportunities to exploit crater-class data. The origin of the Mercurian intercrater plains is one problem amenable to the new approach.

Two principal processes have been invoked for emplacement of the intercrater plains: 1) basin ejecta and autochthonous surface materials reworked by that ejecta, or 2) volcanic flows. Previous studies directed at discriminating between these origins have used two general approaches: analyzing crater size/density statistics, and searching for diagnostic landforms. For several reasons, neither approach has substantiated the origin of the plains units nor persuaded very many skeptics to a new point of view. Therefore, we undertook a new approach; namely, the multivariate comparison of crater-class on the intercrater plains and the densely cratered terrain. The results of this approach constrain the process of intercrater plains emplacement to have affected craters on both terrains in a similar manner, although, obviously, to different extents. Any emplacement process considerably restricted in space and time (such as basin ejecta) violates this constraint.

In order to apply standard crater size/density methodologies to the comparison of the two terrains, class by class, one must achieve good counting statistics. That is, the number of craters in a given class in a given diameter interval should be as large as possible so that sampling errors (proportional to the square root of the number of craters counted) are held as small as possible. In order to achieve this one must include large expanses of each terrain type in the study. But if the terrain occurs in small patches, and the individual patches have not experienced extremely similar episodes of intercrater plains emplacement (similar in both the magnitude and nature of the effects on their crater populations), then amalgamating the patches into a single sample may blur the signature of the emplacement process beyond recognition. Therefore, small regions provide homogeneous crater populations, but inadequate sampling statistics. Faced with this conundrum, the most common approach has been to amalgamate the data from different regions and simply hope that heterogeneities do not frustrate the analysis. But amalgamation of samples has clear traps not only in diluting the homogeneity of the signatures of processes, but also in the difficulty of establishing meaningful and reproducible crater densities because the locations of terrain boundaries are often ill-defined.

The densely cratered terrains of Mercury occur in widely separated patches with ill-defined boundaries, that are not constrained to constitute a homogeneous data set. However, each patch has only a relatively small number of craters. All of the potential pitfalls are present--this data set begs for a new approach.

We have classified the craters in eleven regions of densely cratered plains and eleven regions of intercrater plains into four classes based on their degree of filling (from 1 = pristine to 4 = totally filled). The percentage of craters in each class in each region was then recorded, thus eliminating the problem of nonstationarity--but introducing the problem of induced correlations. Induced correlations arise in percentage data because as the percentage of craters in one class increases, the percentage in at least one other class must decrease--without the necessary intervention of any geologic process. This is commonly alluded to as King's law: "Some of it plus the rest of it equals all of it."

By standard statistical analyses, the correlation matrix (below) formed from percentage data seems to indicate a very significant (less than 1% level) negative correlation between class 2 and class 4 craters. A simple story could be constructed to account for this; namely, a pulse emplacement of intercrater plains material degrades about 70% of the craters in each class to the next class. Therefore, the final number of craters in each class is 30% of the original number plus 70% of the number in the next-freshest class. A tale that makes reasonable geologic sense, but, in fact, is no more than fancy if not supported by the statistical attributes of the data. In fact, when the algorithm suggested by Aitchison (1982) and developed by Woronow and Butler (1986) is applied to these data, the correlation between class 2 and 4 is found to lack significance--no significant correlations (at the 5% level) exist anywhere in these data, nor a more extensive set of data divided by crater diameters and terrain types. (Preliminary examination of the strength of this test indicates it to be substantially stronger than either the chi-square or the Kolmogoroff-Smirnov test.) This implies that the crater classes are indistinguishable on the two different terrains--that each responded identically (or not at all) to the emplacement of the intercrater plains.

Among the processes that satisfy this constraint would be a protracted period of volcanic emplacement during the period of heavy bombardment with the craters (since last resurfacing) on both terrains being affected in a similar manner although to different degrees, or the filling process could be linked to the impact bombardment itself so that craters would progress through the classes in proportion to the cumulative intensity of the bombardment on both surfaces. Processes that cannot account for the emplacement of the intercrater plains include pulse emplacement of volcanic deposits or of basin ejecta, because each of these is highly directed at the crater population on the intercrater plains alone and would spawn real differences between the two populations.

Aitchison, J. (1982). The statistical analysis of compositional data sets. J.R. Statis. Soc., **B44**, 139-177.

Woronow, A. and Butler, J.C. (1986). Complete subcompositional independence testing of closed data. Comp. & Geosci., **12**, 267-280.

Correlation Matrix for Percentage Data

	CLASS II	CLASS III	CLASS IV	TOTAL
CLASS I	-0.11	-0.39	-0.20	-0.09
CLASS II		-0.25	-0.63	-0.13
CLASS III			-0.37	-0.25
CLASS IV				-0.04