## FROM THE EDITOR

Fourteen months ago as I graduated from SAS president to past president we were beset with one of the frequent mini crises common to organizations such as ours. Our highly regarded and long-term Newsletter Editor, Suzanne DeAtley, stepped down. Since past presidents of most organizations do not have burdensome duties I volunteered to be Newsletter editor for two years while we located someone to assume this responsibility for a three-to-five year period.

More than a year has slipped by so I am calling on the membership for volunteers and/or nominations to assume the editorship beginning with the summer issue 1986. Please respond to President Joe Michels, Executive Secretary Erv Taylor or to me. The editor can assume responsibility for both the text and the printing (as I do) or assume responsibility only for the text with the printing done at the Office of the Executive Secretary.

We all owe some responsible service to our profession. This is a humble but challenging way to fulfill this obligation.

Rip Rapp

RIP RAPP


# SAS NEWSLETTER

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SAS

# RECENT PUBLICATIONS

## ANIMALS IN ARCHAEOLOGY

Brian Hesse. 1984. These Are Our Goats: The Origins of Herding in West Central Iran. In Animals and Archaeology: 3. Early Herders and their Flocks, eds. J. Clutton-Brock and C. Grigson, pp. 243-64. BAR International Series 202.

## PALEOECOLOGY

Curtis M. Hudak. 1984. Paleoecology of an Early Holocene Faunal and Floral Assemblage from the Dows Local Biota of North-Central Iowa. Quaternary Research 21:351-68.

## HOLOCENE

Three recent contributions by Holmes A. Semken, Jr.:

1) 1984. Paleoecology of a Late Wisconsinan/Holocene Micromammal Sequence in Peccary Cave, Northwestern Arkansas. In Contributions in Quaternary Vertebrate Paleontology: A Volume in Memorial to John E. Guilday, eds. H.H. Genoways and M.R. Dawson, pp. 405-31. Pittsburgh: Carnegie Museum of Natural History Special Publication No. 8.

2) 1983. Holocene Mammalian Biogeography and Climatic Change in the Eastern and Central United States. In Late-Quaternary Environments of the United States, Vol. 2: The Holocene, ed. H.E. Wright, Jr., pp. 182-207. Minneapolis: University of Minnesota Press.

3) 1980. Holocene Climatic Reconstructions Derived from the Three Micromammal Bearing Cultural Horizons of the Cherokee Sewer Site, Northwestern Iowa. In The Cherokee Excavations: Holocene Ecology and Human Adaptations in Northwestern Iowa, eds. D.C. Anderson and H.A. Semken, Jr., pp. 67-99. New York: Academic Press.

## THIS ISSUE'S RESEARCH REPORTER

## MORVEN N. LEESE

I was born in Cornwall, England, but educated mainly in Scotland. Following a degree in Mathematics I worked in hydrology for a few years, and then attended an M.Sc. course in Statistics at Imperial College, London. This included a practical project on flint provenancing which led to my interest in archaeological statistics. After working on a Ph.D. at the Institute of Archaeology, London, on statistics applied to analyses of ancient metal, I joined the staff at the British Museum Research Laboratory in 1980, collaborating on a variety of projects, the data ranging from radiocarbon dates to metal and ceramic composition. I am currently interested in extending our use of multidimensional scaling, particularly for qualitative archaeological data, which I feel is sometimes neglected in acientific studies.

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# COMMENTS ON DISCRIMINANT ANALYSIS IN CERAMIC RESEARCH

Morven N. Leese
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Vin Robinson has shown how cluster analysis can make an important contribution to the study of archaeological ceramics (SAS Newsletter, Research Report 6, 8(3):3-4). This note describes situations in which discriminant analysis can also play a useful role. The two techniques are not competitors but are useful in quite different situations that must be distinguished if the best use is to be made of available information. Discriminant analysis may have had a bad press because over-optimistic success rates can be claimed for distinguishing groups that are very unlikely, a priori, to represent distinct sources. A possible solution to this problem is suggested here.

## What is Discriminant Analysis?

Doran and Hodson (1975) describe discriminant analysis as aiming "to discover and emphasize those attributes which discriminate between .... known groups, and to assign fresh, ungrouped units to one or other using this knowledge." Unlike cluster analysis, discriminant analysis is not aimed at finding groups. The statistical model underlying discriminant analysis and the mathematical methods used to estimate the parameters of the model are described in many textbooks, including Cooley and Lohnes (1971).

MORVEN N. LEESE

Suppose that in ceramic research we have sampled the products of well defined sources, for example kiln wasters, and wish to assign sherds of unknown origin to one or another of these sources. If it were reasonable to suppose, at least initially, that the unknown sherds were made in one of the kilns, discriminant analysis rather than cluster analysis would be appropriate. However, if the kiln products did not correspond to chemically distinct sources or if the unknown sherds were consistent with none of the known groups, then we could try cluster analysis.

## Can Cluster Analysis be Used Instead of Discriminant Analysis?

As shown in simulation studies by Ganesalingam and Mclachlan (1978), cluster analysis is very good at identifying completely separated groups but very poor at identifying groups that overlap to any extent. A practical experiment on atomic absorption analyses of eighty flints from four known sources confirms these findings. An independent investigator was asked to perform a cluster analysis. He took care to use the most appropriate methods and aimed for about four clusters. He found two clusters corresponding exactly with two of the groups but failed to separate the others, which were mixed together in a third cluster. This was in spite of the fact that the groups had a 100% cross-validatory reclassification rate (see below) showing that all four could be completely distinguished given the right combinations of elements.

We have concluded that it is important to identify situations in which cluster analysis is inappropriate. Admittedly, these are relatively uncommon in ceramic research because material that can be grouped a priori to form reference groups is not usually available. Nevertheless, to ignore the distinction between cases where we can group together sherds of common origin, and those where we cannot, could waste valuable information and give rise to misleading results.

## Resubstitution Reclassification Rate

The resubstitution/reclassification success rate is a widely used, commonsense measure of the distinctiveness of groups used in discriminant analysis. It can also be interpreted as an estimate of the success with which future unknowns will be classified correctly. It is computed by performing the discriminant analysis once and using the resulting classification rule to reclassify the known sherds as if they were unknown, the success rate being the percentage correctly reclassified. Unfortunately, the resulting estimate can be drastically over-optimistic. For example, in an experiment, discriminant analysis was applied to NAA data on twenty-four sherds, divided at random into four subgroups, and this gave an apparently high success rate (83%).

The validity of discriminant analysis when it apparently confirms obviously nonsensical groups might appear questionable. However, the problem lies not with discriminant analysis per se but with the reclassification rate, as recognized for some time in the statistical literature (Lachenbruch and Mickey 1968). It has also appeared in a slightly different guise as the "stretchability" phenomenon described by Harbottle (1976). One can think of it in simple terms as follows. If the sample size (number of sherds) is small compared with the number of variables (elements), each sherd has a large effect on its group parameters. The classification rule (computed from the group parameters) naturally works well on the items that have contributed to its definition, so the success rate is almost bound to be high.

## Cross-validatory Reclassification Rate

One way around the problem is to use a "leave-one-out" or cross-validatory reclassification where the group parameters are recomputed each time an item is removed for reclassification (Stone 1974). The item goes back into the sample before the next one is removed, so only one item is lost from the sample at a time. In contrast to resubstitution, in cross-validation each known item is treated realistically as an "unknown" since it has no effect on the classification rule used for its own test. In the experiment mentioned above, cross-validation gave a rate of 33%, well within the bounds of what is expected from random allocation.

In spite of its extra computation, cross-validation is much more realistic than resubstitution--particularly for small samples, where the problem is most severe. In view of the typical numbers of elements that are regularly analysed, we can safely assume that compared to the number of parameters to be estimated, sample sizes will almost always be small in ceramic studies. It therefore makes sense to use cross-validation as a matter of routine, thus avoiding the risk of confirming archaeological prejudice. This may involve extra programming, but a so-called "jackknife" option is included in some packages, such as BMDP, as pointed out by Vitali (1984).□

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Ganesalingam, S. and G.J. McLachlan. 1978. The efficiency of a linear discriminant function based on unclassified initial samples. Biometrika 65(3):658-62.

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# SPECIAL INTEREST

## JOIN ARCHAEOLOGICAL EXPEDITION LAS CRUCES, NEW MEXICO FEBRUARY 1 – MAY 10, 1986

The Organ Mountain Project will be investigating the Origins of Agriculture (i.e., the Archaic) in the U.S. Southwest. This means two exciting cave digs as well as lab. work using the most up-to-date interdisciplinary techniques. The project is sponsored by AFAR (Andover Foundation for Archaeological Research), under the field direction of Dr. Richard S. MacNeish (Scotty) with his skilled and experienced staff (8) working in conjunction with Dr. Steadman Upham of the Dept. of Anthropology, directed by Dr. Fred Plog of New Mexico State University.

**WE NEED:**

1. Young aspiring archaeological professionals (12 students) to join us for 14 weeks. The donation to the Foundation of $2000 covers room and board. Send in your CV or transcripts now; selection of students will be made by Nov. 1, 1985. Course credits, if needed, may be obtained through New Mexico State University

and

2. Friends of the Foundation who may join our expedition for 2 weeks (contribution of $1000) or a month ($1500). Get your applications in, indicating preferred dates NOW so we can schedule your visit down here where it will be warm.

**TO APPLY, WRITE:** DR. RICHARD S. MACNEISH, AFAR, BOX 83, ANDOVER, MA 01810
TEL: (617) 470-0840

# CONFERENCE REPORT

## THE SECOND PHYTOLITH RESEARCH WORKSHOP

George Rapp, Jr. and Susan Mulholland

The second Phytolith Research Workshop was held in Duluth, Minnesota, on April 27-28, 1985. George Rapp, Jr. and Susan Mulholland of the Archaeometry Laboratory, University of Minnesota-Duluth, organized and hosted the meeting. Funding was provided by the Graduate School of the University of Minnesota.

Two basic sections were included. Phytoliths in Plant, the first section, included diverse papers on identification of plants and phytolith types, both in dicots and grasses. Discussion and microscope demonstrations indicate that some problems still exist in classification, although great progress has been made. Papers on geochemical problems and environmental reconstruction lead into the second session, Phytoliths in Sediments. Quantification by visual estimation, two archaeological case studies, and phytoliths in deep-sea cores rounded out the formal presentations. The wrap-up discussion led to the conclusion that an atlas is needed to act as a guide to phytolith forms.

# A NEW FEATURE--PROFILE

In this issue, the SAS Newsletter inaugurates a new feature - a PROFILE of a distinguished SAS member. It is a pleasure to begin with Dr. Robert Maddin. In order to continue this feature on a regular basis, your contributions are invited for subsequent issues. In addition to a photo, profiles may include standard biographical information, recent publications and awards, and current research interests, but should also provide an opportunity for more informal airings of opinions and professional concerns: new directions envisioned for archaeological sciences, conferences that would meet a need, delineations of special problems that should be addressed.

# PROFILE

ROBERT MADDIN

## MADDIN'S MUSINGS

A number of questions have concerned me in recent years. What is the best education for the future archaeometrist? Can a student pursue both the graduate curriculum in archaeology and enough rigorous courses in the hard sciences to become the sort of archaeometrist who will develop necessary new techniques? For example, could an archaeology graduate student have developed the accelerator method of radiocarbon dating or lead isotope analysis? Is it the role of the physical or biological scientist to be left alone to develop a technique so that it can be turned over to the archaeologist when it becomes a shelf item, a black box with dials that churn out the results?

Another related subject that has been of concern to me for a number of years is the proper format for both national and international meetings of hard scientists. Should such meetings be constructed primarily for the archaeometrist? Isn't it more meaningful for both archaeologists and hard scientists to congregate for discussion of results and problems? Or is it better to leave hard scientists to themselves to work out their own problems?

How and when should the hard scientist begin to interact with the archaeologist? Should a fresh Ph.D. in, say, physics try to find a proper role alongside the humanist so that his/her pursuits can be aimed towards anthropological subjects? Where would he/she find such a position and who would be his/her peers in judging performance? Physicists? Anthropologists?

I am concerned also by the tendency of a few towards secrecy in archaeometric studies as if there is a Nobel prize at the end of the rainbow. In some respects there is more reticence among archaeometrists than I remember among materials scientists. For the most part, however, collaboration among archaeometrists is far more common than secrecy. This collaboration is necessary if results are to be accepted by the archaeological community. The plea here is for more laboratory cross-checking to insure accuracy of results and, hence, acceptability. This approach worked well in the early days of radiocarbon dating and appears to be working equally well in the area of accelerator dating. This is certainly not so in the field of lead isotope analysis.□

### ROBERT MADDIN

Born in Hartford, Connecticut, Robert Maddin received the B.S. degree in Metallurgical Engineering from Purdue University. Following service as a Communications Officer during World War II, he studied at Yale University, obtaining the Dr. Eng. degree in Physical metallurgy. His first academic appointment was at The Johns Hopkins University, followed by a position as Professor of Metallurgy and Acting Director of the School of Metallurgical Engineering at the University of Pennsylvania. Maddin served as director of the school until 1972 when he was appointed a University Professor at Penn. During these years he was Visiting Professor at England's University of Birmingham, and at Oxford.

Maddin's research concerned the effect of defects on the strength and ductility of metals and alloys, the role that atomic scale defects play in the deformation and diffusion of metals, and the structure/property relation in amorphous metals. Sensing the need to bridge the science and engineering of materials, in 1965 Maddin initiated an international journal, Materials Science and Engineering, and edited it through more than 60 volumes.

(continued on page 8)

# COMMENT

## FURTHER COMMENTS ON CLUSTER AND DISCRIMINANT ANALYSES IN PROVENANCE STUDIES

by

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As my research report (SAS Research Report 4, Vol. 8, No. 1, 1984) was the first of a series in the SAS Newsletter on statistical analyses and their usefulness to archaeological and archaeometric research, I would now like to make a few general comments that are intended to place in a broader context some of the points which have been raised in subsequent articles.

First, I want to emphasize that no one particular statistical method is the best method, as proposed by V. Robinson (SAS Research Report 6, Vol. 8, No. 3, 1985). The usefulness and applicability of various statistical procedures depend very much on the general nature as well as the specific details of the problem under study. A number of statistical techniques which have been developed (and are constantly being developed) testify to the need for various tools to deal with different problems.

Provenance studies are based on the characterization of artifacts (or their sources of raw material) of known origin and the comparison of artifacts of unknown origin to the known objects in order to establish the likelihood that an unknown object belongs to any of the known groups. Strictly speaking, for this purpose, multivariate discriminant procedures should be considered, as they provide a means of both characterizing and classifying artifacts in a true statistical sense. However, in certain situations, particularly when no prior knowledge of any grouping exists, cluster analysis has been shown to be a particularly useful exploratory tool. All statistical procedures have their strong points as well as shortcomings. For example, M. Leese (SAS Research Report 7, this issue) has pointed out some advantages and disadvantages concerning the two mentioned techniques, and ways to resolve some of their problems. Therefore, the choice between various statistical procedures has to be made with care and with an awareness of their characteristics. Very often, problems in archaeometry may require the use of more than one technique.

It is this second point which I particularly want to stress. Under no circumstances should any statistical technique be used as a simple "black box" (V. Robinson, SAS Research Report 6, Vol. 8, No. 3, 1985). The ease of inputting information and obtaining a statistical output should not be confused with the interpretation of statistical results. A great deal of knowledge, statistical as well as archaeological, is essential for obtaining meaningful results. The development of data analysis as a separate field within various scientific disciplines (e.g., biometrics, chemometrics) points to the complexity of data analysis procedures. Perhaps these discussions on the use of statistical techniques in archaeology and archaeometry are an indication of the need for the new field of archeometrics. □

# ANCIENT TL NEWSLETTER

A newsletter titled Ancient TL (Thermoluminescence) is now being produced by the TL Laboratory, University of Durham, England. The newsletter publishes several articles on aspects of thermoluminescence in each of three to four issues per year. A recent issue (September 1984) included these papers: 1) TL Behaviour of Some Limestone Rocks, by G.W. Berger and H. Marshall; 2) Rapid Thick Source Alpha Counting, by M.L. Readhead; 3) Unusual Features of the Thermoluminescence Signal Profile for Sediments from Beneath Lake George NSW, by A.J. Mortlock and D.M. Price; 4) A Cautionary Note on the Measurement of Quartz TL Immediately After Irradiation, by B.L. Smith and J.R. Prescott. Subscription rates for Ancient TL are L 6/year or L 10/2 years. For further information, write: Ancient TL, Department of Archaeology, Fulling Mill, The Banks, Durham, DH1 3EB, United Kingdom.

SAS ROBERT MADDIN (continued from page 6)

Having the freedom as University Professor to pursue studies other than modern materials science, Maddin became interested in the history of metals technology: in how, when, and where metals technology began to replace lithic technology, alloying began, and iron began to replace bronze. He retired from Penn in December 1983 and was appointed Visiting Professor of Anthropology and Director of CARD (Center of Archaeological Research and Development) at Harvard University at the Peabody Museum of Archaeology and Ethnology. At Harvard he teaches a laboratory-and-lecture course on the beginning of the use of metals and alloys. In addition to editing, Maddin has written more than 125 papers and several books.

Maddin is a Fellow of both the Metallurgical Society and the American Society for Metals; an honor member of the Birmingham Metallurgical Society and the Maryland Institute for Metals; designated a Distinguished Alumnus of Purdue University. He is a member of the Executive Committee for the annual international symposium in Archaeometry and has been a member of the SAS board since its organization. He is, in addition, a member of the Visiting Committee for the Research Laboratory of the Boston Museum of Fine Arts and has served on many government committees.

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