SAS Bulletin

Society for Archaeological Sciences

Volume 13 Number 1 January - March 1990

George Pitt-Rivers Professorship of Archaeological Science

The Board of Electors to the George Pitt-Rivers Professorship of Archaeological Science invite applications for this Professorship which will be established with effect from 1 October 1990.

The Appointment will be subject to the Statutes and Ordinances of the University. The University follows an equal opportunities policy.

The present pensionable stipend attached to the Professorship is 29,732 pounds a year, or 29,633 pounds a year if the Professor is ordinarily resident in College. The stipend would be subject to deduction on account of certain College emoluments.

Further information may be obtained from the Secretary General of the Faculties, The General Board Office, The Old Schools, Cambridge, CB2 1TT, to whom applications (10 copies) should be sent, together with the names of two referees, so as to reach him not later than 10 November 1989.

The Department of Archaeology has just been designated in the recent review of the Universities Funding Council as one of the six in Britain to be considered a science-based archaeology department. It has about 60 undergraduate students, 20 M.Phil. students and 60 Ph.D. students.

It is envisaged that the appointee will develop the archaeological science side of its activities and bring these to flourish, both in teaching and in research.

The technical assistance available within the Department is at present limited to a single technician, but it will be the Department's intention to apply to the Council of the School of Humanities and Social Sciences for a second technician when the Professor of Archaeological Science is in post.

The laboratory space within the Department consists at present of: a) a materials science teaching laboratory, the Garrod Laboratory, (floor area 60 square metres) used for various practical teaching and research, and b) an Archaeozoology Laboratory (floor area 48 square metres).

In addition there are full mainframe computing facilities, and a Computing Room with ample microcomputing facilities (which will be further developed).

Additional teaching laboratory space is a high priority for the Department. It is hoped that the new McDonald Institute for Archaeological Research will, when it is constructed, offer laboratory space for the research of the George Pitt-Rivers Professor in Archaeological Science. It will not, however, be in a position to provide laboratory teaching space.

Within the university, of course, a full range of 'heavy' equipment is available. There is close collaboration with the Earth Sciences and Botany Departments, as well as the Sub-department of Quaternary Research.

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In This Issue

SAS Midterm Board Meeting

The Executive Committee of the Society for Archaeological Sciences met in a midterm session in conjunction with the American Anthropological Association in Washington D.C. on November 17, 1989. This was the first such midterm meeting, held as an experiment to determine if such a session would be of benefit to the society. Given the results of the Washington meeting, it would seem that there are significant advantages to be made from such planning and organizational forums. The primary agenda items for this meeting included discussions with NSF, organizational changes in the executive structure of the society, continuing improvements in the *Bulletin*, deliberations over the University Consortium for Preservation Science and Technology, and efforts toward the growth and development of the society.

Society members have expressed concern over apparent recent changes in policy at the Division of Instrumentation and Resources regarding the award of instruments to programs in anthropology and archaeology. It appeared that the instrumentation program was requiring matching funding from Universities and, as many of you know, social science programs are generally at a disadvantatge in competition for limited college or university funds. The Board wished to express these concerns and to begin a dialog with the instrumentation program on the subject.

Contact was made with Dr. Harold P. Jones, Director of the Division, through correspondence and an extended conversation. A summary of the letter from Dr. Jones is reproduced below as a statement of current division policy:

> Dr. Yellen passed on to me your letter relative to your concerns about the cost-sharing requirements within our program. You are indeed correct that we require a 30-50% cost-share on all multiuser equipment requests. This, however, is not a new requirement and has in fact been the rule since the inception of the program several years ago. Individual programs, such as the Anthropology program, are allowed to support equipment requests without cost-sharing, however our program has always included cost-sharing as an integral unit.
>
> I am sympathetic with the difficulties that researchers may have in raising the cost-sharing required from their institutions. In that regard we legitimately might have difficulty. These programs are not unique to the social sciences. Many of our proposals come from predominantly undergraduate institutions, from plant science departments, or from other programs which do not have easy access to large pockets of money. Nevertheless, all of these institutions are required to participate in cost-sharing. Some programs, such as the Instrumentation for Laboratory Development (ILI) Program which funds equipment for undergraduate instruction, require a flat 50% cost share.
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> The philosophical reasoning behind the cost-sharing requirement is that it indicates a level of institution support for the research outlined in the proposal. Since these requests are by requirement multiuser, it is viewed that the institution is supporting a body of work, not the project of an individual investigator. The unwillingness or inability of an institution to support these purchases brings into question the institution's ability or willingness to provide the environment and resources necessary to support vigorous disciplinary research in the area of the proposal. Furthermore, when Congress originally mandated the appropriation funds for equipment, they urged the Foundation to seek matching commitments for Foundation funds since equipment needs were viewed to be too extensive to be met by Foundation funds along.

Subsequent conversations with the director reiterated the contents of the letter and offered several very useful suggestions for investigators. Dr. Jones urged PIs who are having difficulties obtaining matching funds to contact him in order to negotiate with their institutions. He indicated that he might be able to encourage institutions to supply such cost-sharing funds. Jones also requested that the society supply names as potential panel members for the instrumentation program so that our interests will be represented. In sum, the interaction with the Division of Instrumentation and Resources was very positive and we hope that it will be of use to society members.

Members can look forward to reports on the other agenda items covered during this meeting as planning unfolds.

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The British Academy Group Research Project: An Aspect of Science & Archaeology in Great Britain

Background

Science-based archaeology employs a battery of increasingly sensitive techniques and equipment to produce ever more precise and accurate isotopic, elemental, or mineral characterizations of material. Statistical methods - from exploratory to multivariate - help to underscore the potential or expose the limitations of high-tech archaeometry. Whereas quantum leaps in technology and techniques will continue to have a major impact on developments in science-based archaeology, it is also important to develop ways to relate scientific analyses to sociocultural and politico-economic interpretation. Ultimately science-based archaeology should help to arbitrate amongst competing cultural hypotheses, particularly as it moves from a hard-science towards a human-science approach.

The use of archaeometric techniques to identify non-local materials, and to isolate or eliminate possible sources, has become a key component in the archaeological reconstruction of trade systems, and in the formulation of hypotheses on mechanisms of exchange. The application of statistical techniques to the analytical results of geochemical research provides another perspective, one that may help to verify or qualify the results, and thus to move towards resolution of analytical as well as cultural issues. It must be borne in mind constantly that the problem is archaeological and must be addressed in a spirit of reciprocity and cooperation between archaeologist and archaeological scientist. To give due consideration to cultural patterns and process, scientific analyses and statistical techniques must be incorporated into an overall reseach design that fosters basic quantitative research and builds bridging arguments between data, analysis and interpretation.

British Academy Group Research Projects

In early 1987, the British Academy and Leverhulme Trust announced a competition for funds to support three projects that would promote interdisciplinary research in the humanities. Nol Gale and Sophie Stos-Gale (University of Oxford) saw in this the chance to broaden their work on ancient metallurgy and metals' provenance by integrating several research strengths in a comprehensive study of trade in the prehistoric Aegean. The resultant team succeeded in gaining funds for a five-year, interdisciplinary, multi-institutional project entitled "Science and Archaeology: Bronze Age Trade Patterns in the Aegean and Adjacent Areas." The following institutions and individuals are involved:

Oxford University: Dr. Nol Gale (Department of Earth Sciences; Committee for Archaeology), Dr. Sophie Stos-Gale (Departments of Nuclear Physics & Earth Sciences), Dr. Andrew Sherratt (Ashmolean Museum), Professor Gerald Cadogan, Dr. Colin Macdonald (Department of Earth Sciences)

Cambridge University: Professor Colin Renfrew (Department of Archaeology), Dr. John F. Cherry (Museum of Classical Archaeology), Dr. A. Bernard Knapp (Museum of Classical Archaeology and Department of Archaeology)

British School at Athens: Dr. E.B. French (Director of the School), Dr. Richard Jones (Director of the Fitch Laboratory)

Polytechnic of East London: Mr. John Evans (Department of Biosciences)

Manchester University: Dr.V.J. Robinson, Dr. G.W.A. Newton (Department ofChemistry), A. Hoffmann (Computing Centre). Manchester University is involved as an adjunct institutional member of BARG that cooperates fully in the exchange of data, analytical results, and interpretation.

The primary (albeit non-exclusive) focus of research conducted at these institutions is :

Oxford University: 1) ongoing archaeometallurgical provenance research, including statistical analyses, and graphical display (Lead Isotope Analysis; Neutron Activation Analysis), 2) exploration of ore deposits, ancient mines and metallurgical sites, 3) creation and maintenance of computer database of archaeo-metallurgical data (analytical) and associated archaeological information (context, date, typology, etc.), 4) verification of archaeological data (context, typology, stylistic/technological comparison); integration of archaeological, textual and analytical evidence for trade, 5) generation of site- and object-distribution maps (using computer-based graphics-mapping software), 6) liaison with other institutions and individuals involved in metals' provenance work

British School at Athens: 1) ongoing provenance work with Aegean and Mediterranean ceramics (Atomic Absorption Spectrometry; thin-section petrography), 2) organic residues analysis, 3) through the Director, the British School also provides an important base for fieldwork in the Aegean, collaboration with Greek Archaeological Service, and with other archaeologists working in Greece; liaison for further sampling of ores, clays and artifacts.

Polytechnic of East London: organic residues analysis (gas/liquid chromotography, Fourier Transformation Infrared Spectroscopy)

Manchester University: provenance work on Mediterranean ceramics (Neutron Activation Analysis); multivariate statistical analysis of geochemical data

Cambridge University: 1) multivariate statistical analyses of a wide range of provenance data (past and current research); comparative assessment of different analytical and statistical techniques, 2) creation and maintenance of computer databases (using MINARK) of metallurgical and ceramic provenance data (analytical), associated archaeological information (context, date, etc.), bibliographic references, 3) development of graphics to portray complex provenance data sets, 4) integration of archaeological and ethnohistoric data; development and assessment of theoretical models of Mediterranean production and exchange, 5) liaison with other institutions/individuals involved in the study of the relationship between provenance work and statistical verification (e.g.Smithsonian; Heidelberg/ Mainz; Penn/Harvard).

The choice of the Aegean and eastern Mediterranean as the principal area of investigationwas obvious: the research interests of most project members revolve around this area, and a long-standing tradition of provenance work exists there. In addition, analytical techniques already employed by the various institutions involved make it possible to integrate the study of changing patterns in metals, ceramics, and comestibles/organic products throughout the Bronze Age Mediterranean.

During the Bronze Age (about 3000-1000 BC), this area experienced unprecedented economic growth, sociopolitical change, and extensive contacts on an interregional scale. The initial, small-scale exchange of prestigious goods or basic resources within the Aegean expanded to include the bulk exchange of metals and other products over an area stretching from the Levant and Cyprus through the Aegean to Sardinia. Access to and control over copper resources, production and exchange were basic to politico-economic development in a metals-hungry Bronze Age world, and central to the formation of well-defined exchange networks. The existence in the Aegean and in Sardinia of bulk-storage containers manufactured on Cyprus (demonstrated by petrographic and elemental characterization work at the Fitch Laboratory, British School at Athens) reflects the extent of long-distance, interregional contacts during the Bronze Age. Pioneering work in organic residues analysis at Northeast London Polytechnic has demonstrated that some Cypriot 'Base-ring' juglets were used to transport opium throughout the eastern Mediterranean. Lead isotope work carried out at Oxford University has for the first time given hard evidence on the provenance of copper oxhide ingots, for instance showing that ingots from Hagia Triada on Crete do not come from Cyprus. Work by the Oxford team has also discovered and dated an important Early Cycladic II copper smelting site on Kythnos and shown its importance as a copper source both within the Cyclades and to Early Minoan Crete. Such details on trade in particular commodities provide important clues to the scope of interregional contact, and to diachronic changes in resource exploitation, production and trade.

The task of integrating this diverse analytical work into one research program is essential in order to extract the maximum amount of information for the reconstruction of Bronze Age trade patterns in the Mediterranean. A sustained archaeological focus will help to contextualize all this information and to use it in reconstructing a systematic picture of politico-economic activity and development in the Bronze Age Aegean and eastern Mediterranean. Consideration of the occurrence of traded items in their settlement context, and the inclusion of evidence from ongoing site survey work in the Aegean are also critical for building models of the economic organization of Bronze Age communities, and for relating site location to routes of transport and communciation. Together with the use of theoretical models related to the social significance of exchanged goods and computer simulation work, this should also allow better understanding of the mechanisms of production and exchange in the Bronze Age Mediteranean. It is also intended to produce, using information from the project's databases, a series of computer-generated maps that portray the distribution of relevant materials and goods on a period-by-period basis, and from these to make inferences relevant to contemporary systems of production and exchange.

All project members, and a series of invited speakers, will take part in a symposium entitled "Bronze Age Trade in the Mediterranean," to be held at Oxford University from 15 - 17 December 1989. The intention of this meeting is to present current views on scientific, archaeological, ethnohistoric, and representational evidence related to Bronze Age trade in the wider Mediterranean world, and to allow members of the British Academy project to present the results of their first year's research. The proceedings of the symposium will be published in the series *Studies in Mediterranean Archaeology* (P. strm's Frlag: Gteborg, Sweden).

Work at Cambridge

Because the compilers of this profile are involved in research at Cambridge, a brief summary of that work is included. Our initial intention had been to approach problems in Mediterranean provenance work by examining the characteristics of analytical data from a relatively "simple" and well-understood example (such as Mediterranean obsidian sources), and by using any insights so obtained as points of departure in the study of more complex situations (such as metal sources). Although it is still our hope to do some work of this sort, it was agreed to begin with a comprehensive examination of metal and ceramic analyses from a well-defined test case: Bronze Age Cyprus.

Cyprus offers the advantages that: i) its insular setting might provide enhanced opportunities for discriminating unambiguously what is local from what is not; ii) the geological context of its metalliferous ore deposits and the archaeology of Bronze Age metal production on the island have been the subject of sustained research for many years; iii) a satisfactory number of analytical samples was known to be available immediately to the Project.

All relevant (Early - Late Bronze Age) data for the Cyprus case study have been entered into MINARK, and thence into a file format (on Cambridge University's IBM-3084) suitable for use with SPSS-X, CLUSTAN and other programs. Using these data, we are currently attempting to re-evaluate the statistical relationship between different geochemical techniques used on the same or similar samples (ores, slags, metal artifacts, ceramics), and to understand and verify (or challenge) those groupings of artifacts, ores, or clays already proposed. Ultimately, this evidence must be considered in the light of diachronic changes in raw material sources, intensity of production, and locus of manufacture, and should provide a well-worked example of the extent to which science-based archaeology can help arbitrate between alternative cultural hypotheses; at present, however, the emphasis remains firmly upon the collation of data and the consideration of statistical approaches to it.

In approaching the statistical analysis (or re-analysis) of the total available corpus of metallurgical and ceramic data, we are especially concerned that the techniques applied should be statistically sound, appropriate to the character of the data, and take adequate account of limitations, uncertainties and error factors arising, for instance, from the archaeometric techniques themselves, from inter-laboratory variation, or from the necessity of dealing with datasets derived from different sources or by different analytical procedures. A small statistical sub-committee of the Project (Cherry, Knapp and Stos-Gale; with co-optation of M. Pollard, University of Wales [Department of Chemistry and Applied Chemistry] and P. Callow, University Computing Centre, Cambridge) has been set up to foster integration between the archaeometric, statistical and archaeological aspects of the work, and to ensure that there is some measure of agreement about procedures applied in Cambridge.

Among the issues currently under consideration are: i) Which statistical techniques are most appropriate for the types of data generated by different forms of analysis (e.g. LIA, NAA, AAS, PIXE etc.)? ii) How can one correlate patterns detected in the same samples analysed by different techniques (e.g. LIA and NAA applied to the same objects), in different samples analysed in different laboratories by the same technique (e.g. NAA results from Berkeley and Manchester), and in different samples analysed by different techniques (e.g. LIA applied to one set of samples, NAA to another)? iii) What allowance should be made for various types of error and to what extent do they undermine the distinctiveness of common patterns or provenance fields? iv) What methods of graphic illustration allow complex multivariate relationships to be displayed simply, yet without serious loss of information?

Other work: a) One general objective of the British Academy Project is the systematic compilation of a comprehensive, key-word indexed, bibliographic database (of Bronze Age Mediterranean archaeology generally, production and exchange systems [including theoretical and anthropological discussion], science-based archaeology), both for the use of the Project as its work develops and in the hope that a topically-organized, annotated bibliography might eventually form one part of the publication program of the Project. Approximately 1500 items have thus far been incorporated in this Cambridge database (in MINARK). b) Project members have agreed that it is desirable to undertake a compilation and review of available cuneiform and other western Asiatic Bronze Age textual references to trade and exchange in organic/perishable/archaeologically-invisible commodities; this is seen as necessary background to Dr. Evans' analytical program on organic residues, and as an important component of the wider perspective on Bronze Age trade systems which the Project hopes to achieve.

In sum, the general aim of the Cambridge arm of the British Academy Project is to investigate the utility of multivariate statistical techniques in the verification, interpretation and graphical presentation of ceramic, metal and other characterization studies, and to consider the validity of groupings already achieved by these means - in short, to establish the geochemical, archaeological and statistical prerequisites of a soundly-based provenance study. We hope to help define the conditions under which certain techniques are reliable, and to assess the relevance of particular analytical and statistical approaches for the construction of trade models appropriate to the Bronze Age Mediterranean.

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Exploratory Analyses of Food Residues from Prehistoric Pottery and Other Artifacts from Eastern Canada

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Introduction

It is well known that organic materials cooked or stored in pottery vessels are likely to leave residues in those vessels, and a variety of techniques have been used in attempting to identify residues from prehistoric vessels (e.g., Andersen and Malmros 1984; Arrhenius 1984; Condamin *et al.* 1976; Hastorf and DeNiro 1985; Patrick *et al.* 1985; Röttlander and Schlichtherle 1983). This paper discusses initial experiments conducted to assess the potential for the study of organic compounds from prehistoric pottery from the Mud Lake Stream site, New Brunswick, Canada, (Deal 1986, 1988). Studies elsewhere had indicated that fatty acids from boiled foods were likely to survive normal aboriginal cooking temperatures (Röttlander and Schlichtherle 1983). It seemed likely that if small quantities of fatty acids were retained in or on the walls of prehistoric vessels, it might be possible to detect them and identify the different food classes they represent, and perhaps even identify the species of animals, fish or plants which were cooked or stored in the vessels. Information might be obtained not only concerning vessel function, but aboriginal diet and cooking practices. This would be particularly useful in areas with poor preservation of organic materials.

Analysis of absorbed residues

The experiments included the production and firing of a set of replica bricks to simulate local prehistoric sherds. Three of these bricks were impregnated with fats from beaver, white-tailed deer and yellow perch to serve as comparative samples. These bricks, along with two unaltered control bricks, five prehistoric sherds, and soil samples associated with three of the sherds (i.e., possible sources of contamination) were submitted for gas chromatography and mass spectrometry (hereafter, GC/MS) analysis. Certain fatty acids found to be significant in previous published reports were targeted in the analysis. The end result was a set of chromatogram profiles, each consisting of a series of peaks and troughs, with areas below each peak being proportional to the amounts of each targeted fatty acid present in a sample. This information could be quantified to give the actual concentration of each targeted fatty acid present.

The chemical analysis, as described here, is taken from Silk and Tan 1988. Residue samples were transferred to a 10 ml test tube and boiled with 3-4 ml of methanol for 1 hour in a hot bath. The methanol was separated and the extraction repeated. The extracts were combined and transesterified by adding one drop of concentrated sulphuric acid and boiled for 1 hour. The mixture was diluted with an equal volume of 10% saline and the methyl esters were extracted twice each with 5 ml of hexane. The extracts were combined and the volume reduced for analysis. The extracts were analyzed on a 30 meter DB225 fused silica capillary column connected to a GC/MS system under the following conditions:

GC: Injector temperature: 250 C. Helium as carrier gas, maintained at 12 psi. Injection was made at 50 C. (After 2 min. the temperature was raised to 120 C. at 25 C./min. and programmed at 8C./min. to 240 C. and held). Injection of sample: splitless, 2 ml injected.

MS: Mass spectrometer was operated under the electron impact mode (70 eV). The data were acquired from 55 to 400 amu at 1 second per scan. The minimum detectable amount of a fatty acid (as methyl ester) was 1 ng. Standard solutions of various methyl esters were used for comparison.

The interpretation of fatty acid distributions of fats in residues must take into account a number of factors which combine to inhibit the identification of specific residues. These included factors related to vessel use-life, the possibility of contamination and the natural deterioration of compounds. In terms of vessel use-life, it is difficult to determine whether the residue represents an homogeneous liquid or a mixture (e.g., a soup or stew), and whether it was produced by one or several cooking and/or storage events. For example, residues absorbed within the porous vessel walls are more likely to represent mixtures than are the thick encrustations often found on vessel rims, which may have resulted from a single event. Experimental studies indicate that some foods are more likely to produce thick residues than others, and especially more viscous mixtures (e.g., McPherron 1967:47; Morton and Schwartz 1988). It is safest to assume that the vessel had been used for more than one function, or that it had contained more than one organic material during its history of use.

It is important to realize the fact that fatty substances recovered from archaeological sites have consisted largely of adipocere (Morgan *et al.* 1973, 1983, 1984; Thorton *et al.* 1970), which is a decomposition product of natural fats produced under virtually anaerobic conditions through the activity of various bacterial species (Mant 1957; den Dooren de Jong 1961). Although adipocere formation involves considerable shifts in the proportion of different fatty acids over time, the combined proportions of the more common fatty acids do not seem to alter dramatically (Röttlander and Schlichtherle 1983:35).

Since we do not yet possess comparative data from de-graded prehistoric fauna or flora, present identifications must depend upon comparisons with data from modern species and our knowledge of fatty acid degradation. In order to facilitate interpretation of the results, a table of tentative values was devised that includes the relative percentages of significant component fatty acids of the major food groups that would have been available to prehistoric North American Indians of northeastern North America (Table 1). Percentages were designated as Low (<10%), Medium (10-20%) and High (20%) in order to account for natural variation found among different species in each food group, as well as individual organisms (i.e., some variation occurs at different stages of an organism's life, as well as in different parts of the organism's body at any given time; [Hilditch and Williams 1964: *passim*]).

*Table 1. Component fatty acids (per cent. wt.) of major food groups: generalized values for selected fatty acids from North American species.**

	SATURATED				UNSATURATED**						
	C12	C14	C16	C18	C16:1	C18:1	C18:2	C18:3	C20:n	C22:n	C24:1
MARINE MOLLUSCA	-	L	M/H	L	L	L/M	L	L	L/M	L	-
MARINE FISH	L	L	M	L	M	M/H	L	L	M[1]	L/M[1]	L
FRESHWATER FISH	L	L	M	L	M	H	L	L	M/H	L/M	L?
SEA BIRDS	-	L	M	L	L	H	-	-	H	M	-
AMPHIBIANS/ REPTILES	L/M	L	M	L	L/M	H	-	-	L	L	-
MARINE MAMMALS	L	L[2]	M	L/M	M[3]	H	L	L	M/H	L/M	L
TERRESTRIAL MAMMALS	L	L	H	L[4]	L[5]	H	L[6]	L	L[7]	L[7]	A?
TERRESTRIAL BIRDS	L/M	L	H	L	L	H	L	L	L	L	-
SEED FATS	L	L	L	L	-	M/H	M/H	M/H	L	-	A

* Based on Hilditch and Williams 1964 and Joseph 1982; percentages are graded as Low (L=<10%), Medium (M=10-20%), or High (H=>20%), with A=absent, and -=insufficient information.
** The various C20 and C22 fatty acids are often not differentiated in the literature.
(1) High in liver fats of some marine elasmobranch fish; (2) Medium in blubber oils; (3) High in common seal, (4) High in ruminants; (5) Medium in rat and High in mink; (6) Medium/High in rodents (e.g., rabbit, porcupine, pig); (7) Medium in badger.

Variations among food groups in the predicted relative percentages for certain fatty acids were used in making tentative identifications of analyzed residues. For example, stearic acid (C18:0) is present in small quantities in most fats and oils but only in high levels in ruminants and quasi-ruminants (Garton *et al.* 1971; Hilditch and Williams 1964:130-132). Further, linoleic acid (C18:2) is only found in significant levels in seed oils (Hilditch and Williams 1964).

Hilditch and Williams (1964:609) indicate that nervonic (or tetracos-15-enoic) acid (C24:1) is not present in species of the vegetable kingdom. They note evidence for its presence in cartilagineous marine fish, and a lack of evidence for its presence in freshwater fish or mammals. More recently, traces of nervonic acid have been found to occur commonly in marine mammals (e.g., Morgan *et al.* 1983; Patrick *et al.* 1985), and it is present in four marine mammal samples used in this study (see below). Patrick, de Koning and Smith (1983:233) use the presence of nervonic acid as an indicator of a marine component in a residue from a South African vessel. However, this is based on a presumed absence of nervonic acid in freshwater fish and terrestrial mammals that has not been firmly established. Indeed, it would not be surprising if traces of nervonic acid were found in freshwater fish fats, since they contain a typically wide range of unsaturated fatty acids (e.g., Hilditch and Williams 1964:11; Joseph 1982).

There are other fatty acids, which have not yet been targeted, that may be useful in future analyses. For example, fats from marine organisms contain high levels of polyenoic acids, and especially eicosapentaenoic acid (C20:5), docosapentaenoic or clupanodonic acids (C22:5) and docosahexaenoic acids (C22:6) (Malins and Wekell 1970:349-352; Morgan *et al.* 1983:Table 3). Eicosapentaenoic acids and docosahexaenoic acids are also found in relatively high proportions in several mollusc species that were exploited in prehistoric times, including oysters, scallops, mussels, and clams (Joseph 1982:123-134). These same fatty acids occur in lower proportions in freshwater fish, while C18 polyunsaturated fatty acids occur at relatively high levels in freshwater fish (Henderson and Tocher 1987:291-292).

Another important factor in residue identification is the fact that adipocere formation involves the replacement of unsaturated fatty acids with two fewer carbon atoms (Morgan *et al.* 1983:359). For example, palmitoleic acid (C16:1) will be replaced by myristic acid (C14:0). The latter rarely makes up more than 5% of any fat or oil, with the exception of milk and palm seed fats and head oil of the sperm whale (Morgan *et al.* 1983:358). Palmitoleic acid is characteristic of cold blooded animals (and especially marine mammals and most fish species), but only occurs in low levels in mammals and birds (Morgan *et al.* 1983-358).

Therefore, high, and possibly medium, levels of myristic acid in residues can represent the replacement of palmitoleic acid by myristic acid during decomposition. Similarly, high levels of stearic acid in residues may result from the decomposition of gadoleic acid (C20:1), which is widely known among marine mammals and fish, as well as freshwater fish.

There are some indications that the ratios of certain fatty acids may be useful for residue identification. For example, oleic acid (C18:1) is replaced by palmitic acid (C16:0) during decomposition, and the ratio of palmitic acid to oleic acid has been used to estimate the relative amount of decomposition of a particular residue (Morgan *et al.* 1983). Before decomposition begins this ratio is generally less than 1 (Hilditch and Williams 1964:*passim*), while in fats from human burials it can be as much as 15 (den Dooren de Jong 1961).

Patrick, de Koning and Smith (1985) have suggested that the ratio of oleic acid (C18:1, n-9) to vacennic acid (C18:1, n-11) may be distinctive for different food groups. Four marine samples that were included in the 1988 analysis (namely, blubber from harbour and harp seals and meat from harbour seal and harbour porpoise) yielded oleic/vaccenic ratios ranging from 1.74 to 2.95 (Silk and Tan 1988). The oleic/vaccenic ratios for 10 prehistoric samples exhibited a wide range of values (i.e., 2.61 to 11.0). However, only two samples had values above 6.8 (namely, 9.3 and 11.0) and these seem to be associated with terrestrial species (see below).

All of the prehistoric residues analysed indicated some degree of adipocere-like formation. In the 1986 analysis, one sample stood out from all of the others in three respects. This included a relatively high fat concentration in the residue, a high percentage by weight of stearic acid, and the presence of an animal steroid. In combination these pointed to some variation in the use of this vessel. It was argued that the stearic acid concentration might represent the boiling of moose or caribou bones to remove edible fat, or the storage of fat prepared in this way, a practice that is well documented in the ethnohistoric literature for the study area (Deal 1989).

Analysis of charred residues

An experiment in 1988 involved the analysis of charred residues encrusted on artifacts, rather than absorbed residues. The author collected samples from five ceramic vessels from New Brunswick, and June Morton collected samples from six vessels from Ontario. In addition, residue samples from two Dorset Eskimo artifacts, a soapstone bowl and a slate knife from the Port aux Choix area, were supplied by M. A. P. Renouf (Memorial University of Newfoundland). Where quantities were sufficient, these samples were divided in half and subjected to both GC/MS and stable isotope (hereafter, SI) analyses. One objective of this exercise was to determine if fatty acids could be detected in the charred residues and if their relative concentrations could be determined, while a second objective was to compare the results of the two analytic techniques. The first objective was achieved, and the resulting distribution of fatty acids in fats from the charred samples are represented in Table 2. It now seems likely that comparative data may be obtained in future from charred faunal and floral specimens from identified species.

*Table 2. Fatty acid (as metyhl ester) distribution in the fats of samples (per cent wt.).**

										SAMPLES**	
	A	B	C	G	H	I	J	K	L	M1	M2
FATTY ACID:											
C8:0	-	1.2	-	0.4	3.3	1.0	4.2	0.8	6.6	NT	2.1
C10:0	2.9	2.4	-	2.3	1.4	0.5	1.7	0.3	3.8	0.2	1.0
C12:0	3.0	4.3	2.9	9.0	0.9	0.4	2.4	0.2	16.2	0.7	6.4
C14:0	32.2	24.9	13.1	21.8	11.1	1.4	7.6	4.0	14.3	4.5	10.3
C16:0	49.1	40.7	46.2	28.5	33.7	34.6	28.6	33.2	25.0	72.9	45.1
C18:0	9.9	15.8	33.1	6.8	20.8	48.8	32.9	45.7	31.5	20.1	27.6
C18:1 (n-9)	1.2	8.0	4.4	24.8	21.7	9.3	6.0	13.5	1.7	1.6	4.6
C18:1 (n-11)	0.3	1.8	0.4	6.3	6.7	1.0	2.3	2.0	0.3	NT	1.4
C18:2	1.3	T	-	-	0.2	3.0	7.6	-	-	-	-
C18:3	-	-	-	-	-	-	6.2	-	-	NT	-
C20:n	L	?	L	L	L	-	-	-	-	NT	L
C24:1	-	-	-	-	-	-	0.5	0.4	0.5	NT	1.4
RATIOS:											
C16:0/C18:1	32.7	4.2	9.3	0.9	1.2	3.4	3.5	2.1	12.5	45.6	7.5
C18:1(n-9) /C18:1(n-11)	4.0	4.4	11.0	3.9	3.2	9.3	2.6	6.8	5.7	NT	3.3
CONCENTRATION:											
FAT (µg/gm)	693	183	200	40	1510	48	700	370	400	274	520

*Values taken from Silk and Tan 1988, except for M1, which was analyzed in 1986 and the relative values for unsaturated C20 fatty acids, which are S. H. Tan 1989: personal communication; T=trace; -=no trace, NT=not targeted; L=low; ?=not retrievable.

** Sources: A=Dorset soapstone bowl; B=Dorset slate knife; C-F=New Brunswick pottery; G-L=Ontario pottery; M1 and M2 are residues from vessel #106, Mud Lake Stream Site, New Brunswick.

The tentative identifications of the 1988 samples are summarized in Table 3, along with a summary of the results of the stable isotope analysis. The results of each analysis were interpreted independently, and therefore are directly comparable in the eight cases where the residues samples could be divided in half and analysed using both methods. The key indicators used in the identifications based on fatty acid analysis, were the presence/absense of nervonic, linoleic and linolenic acids, the percentage composition of myristic and stearic acids in the residues and ratio of oleic

*Table 3. Tentative residue identifications based on GC/MS and SI analyses.**

SAMPLE	*SOURCE*	*GC/MS***	*SI*
A	Soapstone bowl	Fish (2,3,6,7,9,12,13)	Migratory Bird
B	Slate knife	Fish (2,3,6,7,9,10,12)	Freshwater Fish
C	Pottery (N.B.; Fulton Island)	Terrestrial Mammal (2,5,8,12,13)	C3 Plants or C3 Herbivore
D	Pottery (N.B.; Mud Lake Stream)	Not tested	C3 Plants
E	Pottery (N.B.; Fulton Island)	Not tested	Freshwater Fish or Migratory Bird
F	Pottery (N.B.; Mud Lake Stream)	Not tested	Marine Bird
G	Pottery (Ontario; Verden)	Freshwater Fish (2,3,6,7,10,12,13)	Freshwater Fish or Migratory Bird
H	Pottery (Ontario; MacMurphy)	Freshwater Fish (2,5,7,9,12,13)	Fish or Bird
I	Pottery (Ontario; Roland)	Terrestrial Mammal (2,4,5,8,9,12,14)	C3 Plants
J	Pottery (Ontario; Yaworski)	Fish (& Plant?) (1,4,5,7,9,11,14)	Freshwater Fish or Migratory Bird
K	Pottery (Ontario; McKeown)	Fish (1,4,5,7,10,12 14)	Freshwater Fish
L	Pottery (Ontario; Donaldson)	Fish (1,5,7,10,12,14)	Not tested
M1	Pottery (N.B.; Mud Lake Stream)	Terrestrial Mammal (4,5,9,10)	Not tested
M2	Pottery (N.B.; Mud Lake Stream)	Fish (1,5,7,10,12,13)	Not tested

* M1 and M2 are residues from vessel #106, Mud Lake Stream Site, New Brunswick. M1 is an absorbed residue examined in 1986, while M2 is a charred exterior residue examined in 1988.

** Indicators used for identifications of residues analysed by GC/MS: (1) Presence of C24:1 (nervonic acid), (2) Absence of C24:1, (3) High levels of C14:0 (myristic acid), (4) Low levels of C14:0, (5) High levels of C18:0 (stearic acid), (6) Low/Medium levels of C18:0, (7) Low ratio of C18:1(n-9)/C18:1(n-11) (oleic/vaccenic), (8) High ratio of C18:1(n-9)/C18:1(n-11), (9) Presence of C18:2 (linoleic acid), (10) Absence of C18:2, (11) Presence of C18:3 (linlenic acid), (12) Absence of C18:3, (13) Presence of C20:n, (14) Absence of C20:n.

to vaccenic acid in each sample. Fats from four residues exhibit an aquatic component (A, B, G, H, J-L, and M2) and two others a terrestrial component (C and I). One of these residues (J) may have both aquatic and seed plant components, based on the presence of both linoleic and lenolenic acids. The remaining sample in Table 3, namely M1, was one of the absorbed residue samples analysed in 1986, which was tentatively identified as being of terrestrial mammal origin. It produced a somewhat different profile than that of M2, which is a charred residue from the rim of the same vessel (#106 from Mud Lake Stream). This was not surprising, since it is likely that this vessel had been used for cooking and storing more than one food during its history of use.

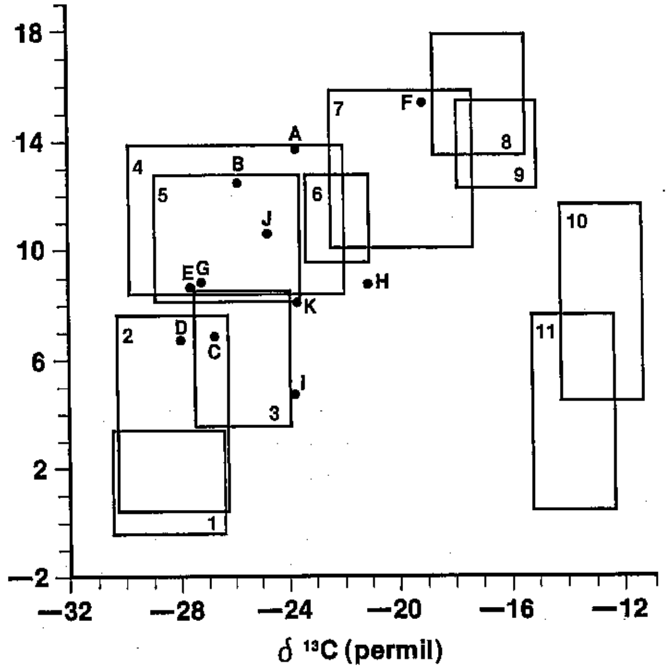
Silk and Tan (1988) also reported the presence of unsaturated C20 fatty acids in some samples, but lacked reference standards that would permit more precise identifications. Tan (1989, personal communication) was able to make an estimate of the level of the C20 fatty acid compound in each sample, based on the relative response of the compound to the stearic acid in the same sample. Relatively small amounts (i.e., less than .6% by weight) were indicated in five of the residue samples. While unsaturated C20 fatty acids are major components of fats of aquatic origin (Hilditch and Williams 1964:11), such low levels might represent any of the major food groups. However, the presence or absence of the compound relative to nervonic acid seems to be significant (in 7 of 9 cases), as well as its presence in association with the lower levels of stearic acid (see Table 2). This may be indicative of the more complete replacement of C20 fatty acids by stearic acid for those samples where C20 fatty acids were not detected (J, K, and L).

Michael DeNiro and Christine Hastorf were the first to demonstrate that stable isotope analysis could be applied successfully to the identification of organic residues from ceramic vessels (DeNiro 1987; Hastorf 1985; Hastorf and DeNiro 1985). More recently, June Morton has used their method to analyse residues from prehistoric Ontario pottery (Morton and Schwarcz 1988). The basic premise behind the SI analysis is that organic residues can be assigned to general food groups based on a comparison of their carbon and nitrogen isotope ratio values. These values for the residues in this study are compared in Figure 1, in which the boxes represent established mean values for different food groups +/- one standard deviation. Areas of overlap between boxes reflect the relationship between different species within the food chain (e.g., see Schoeninger and DeNiro 1984). The most significant overlaps occur between C3 plants and C3 herbivores, freshwater fish and migratory birds, marine fish and marine mammals, and C4 plants and C4 herbivores. C3 plants include all legumes, such as beans and peas, along with many nonleguminous plants, such as tomato and *chenopodium* species. C4 plants include food plants such as maize and amaranth (DeNiro 1987:184).

Due to the overlap, some samples can only be identified as one of two possibilities. Five of the residues in this study are identified as freshwater fish (A, B, G, J, and K), while there is one sample representing each of C3 plants, C3 herbivore, C3 plant or C3 herbivore, migratory bird, marine bird, and unidentified marine group (D, I, C, A, F, and H, respectively). Significantly, none of the residues are associated with C4 plants or C4 herbivores; it is unlikely that they represent domesticates.

In general, the results of the two analyses are quite comparable. Both methods distinguished residues on the basis of C3 plant/C3 herbivore (or terrestrial mammal) and fish. Several of the GC/MS results were originally interpreted as having a marine component (J, K, L, and M2) due to the presence of nervonic acid, and that this marine component

Figure 1: δ^{13} C versus δ^{15} N for various food groups. Boxes are mean values +/-1. Points A to K are analyzed residues and the boxes represent (1) legumes, (2) C3 plants, (3) C3 herbivores, (4) migratory birds, (5) freshwater fish, (6) anadromous fish, (7) marine birds, (8) marine mammals, (9) marine fish, (10) C4 herbivores, (11) C4 plants. This figure was prepared by June Morton (after Bender 1971; DeNiro 1985; Katzenberg 1987; Schoeninger and DeNiro 1984; H. Schwarcz 1989, Personal Communication; Shearer and Kohl 1978; and Virginia and Delwiche 1982).



might represent anadromous fish. This may in fact be the case for sample M2, since anadromous fish were important to the aboriginal diet in the Maine-Maritimes region. However, it is unlikely that the three residues from Ontario vessels have a marine component, since anadromous fish species were not included in the inshore fishery of the Great Lakes region (see Cleland 1982:766; Rostlund 1952:73-74). As mentioned above, polyunsaturated fatty acids are generally common in aquatic species, and it therefore seems likely that the nervonic acid in these samples could represent either marine or freshwater fish. Further, McPherron's (1967:47) suggestion that the thick residues on vessels from the Upper Great Lake sites are associated with fish cookery may indicate that the majority of vessels from that area with sufficient residues for analysis are those that had been used for boiling fish.

The most surprising result of the analyses was the association of residues A and B with fish or migratory birds. Residues on Dorset soapstone bowls and slate knives are commonly believed to be from the processing and cooking of seal, since the faunal remains from sites in the area are almost exclusively seal (M. A. P. Renouf, personal communication 1988). However, the lack of traces of nervonic acid in the residues and the correlation of stable carbon and nitrogen ratios are not indicative of marine mammal. It is possible the nervonic acid from the samples has been replaced during the degradation process. The stable carbon and nitrogen isotope ratios are not expected to change dramatically, although some regional variation does occur (e.g., relatively high nitrogen ratio values for Great Lakes fish; Katzenberg 1989:327). On the other hand, enough evidence of fish was found at Port aux Choix 2 to lead Harp to suggest the seasonal exploitation of landlocked salmon (Harp 1976; Renouf 1986). The only other freshwater fish species that would have been available in any quantity in the area is the American eel, which ranges as far north as northern Labrador (Jessop 1984). Perhaps more significant, is the possibility that the residues on these artifacts were acquired in the postdepositional context, and may therefore not be associated with the original use of the tools (also see Harp 1964:68). In any case, it would be premature to discard the seal fat hypothesis on the basis of the analysis of only two samples.

Conclusions

The results of these analyses are encouraging, yet the identifications must be considered tentative until we gain a better understanding of the nature of residue formation on ceramics. In a previous paper the author suggested two alternate approaches for continued research into residue studies (Deal 1986). The first was to replicate residue formation in the laboratory, and develop simulation models to represent formation under varying depositional situations. The second approach was an ethnoarchaeological study of extant pottery using groups, monitoring vessel use and collecting raw and cooked foods and residues. James Skibo, University of Arizona, recently conducted such a study among the Kalinga of the Phillipines, and is currently analyzing his collected samples (Skibo, 1989). Hopefully, Skibo's analysis will provide a useful guide for archaeologists examining prehistoric residues. The combination of these two approaches, along with the possibility of using charred prehistoric faunal and floral remains for comparison, make the practical application of GC/MS and SI analyses for residue identification seem inevitable.

Acknowledgements

The Archaeological Services Branch of the Province of New Brunswick has been sponsoring a series of exploratory studies into the identification of organic residues from prehistoric pottery vessels since 1985. Residue samples

from pottery of two New Brunswick sites have been submitted to Peter Silk and See Hua Tan, Chemical and Biotechnical Services, Research and Productivity Council of New Brunswick, for gas chromatography and mass spectrometry analysis, and the results have been interpreted by the author. More recently, residue samples from New Brunswick pottery, along with others from Ontario have undergone stable isotope analysis by June Morton, a graduate student at the Department of Geology, McMaster University.

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CAA90

Computer Applications and Quantitative Methods in Archaeology
2nd Call for Papers

The 1990 CAA conference will take place at the University of Southampton, sponsored by the Department of Electronics and Computer Science, the Department of Archaeology, and by the Royal Commission on Historic Monuments (England) National Archaeological Record. A main theme of the conference will be "The Development and Use of Large Scale Resources," but papers on any topics relating to computer applications or quantitative methods will be very welcome.

Proposals for papers (either to be presented, or as part of poster sessions) are requested now; abstracts (at least 1 side of A4, please) should be sent to Sebastian Rahtz at the address below.

Anyone interested in organizing complete theme sessions during the conference should contact the organisers as early as possible.

When?: 21st—23rd March 1990
Where?: Southampton University
Submission of abstracts?: end of 1989
Acceptance of papers?: January 28th 1990

Steering Committee: Ben Booth, Science Museum; Roger Leech, RCHM (E); Jef Maytom, York Archaeological Trust; Clive Orton, London University (Chairman); Sebastian Rahtz, Southampton University; Julian Richards, York University; Clive Ruggles, Leicester University; Gary Lock, Oxford University.

Contact: *Sebastian Rahtz Department of Electronics and Computer Science, University of Southampton S09 5NH. Email: spqr@uk.ac.soton.ecs*

Meetings Calendar

New listings are marked by a *. The Meetings Calendar editor receives additional information for many of the listed meetings. You may contact him, preferably by Bitnet, for further details.

Most entries in the meetings calendar are gleaned from similar calendars in other journals. We are pleased to directly receive information on meetings, although is not yet common. Therefore it is not always possible to give notice here far in advance, particularly for abstract deadlines (which are listed even if past). The calendar is constrained by the journals that we review, and by what we think might be of interest to our membership and readers. The general philosophy is to concentrate on (in approximate order): meetings that are clearly relevant to archaeometrists; scientific meetings in North America of potential relevance; international, continental (e.g., European societies), and some national meetings held elsewhere. We would like to hear of any omissions of meetings/disciplines of which you are aware, and for that matter any listings which you feel are irrelevant or fields that are overrepresented.

January

***Jan. 10-13. International Conference on Differential Equations and Applications to Biology and Population Dynamics.** Claremont, California. Differential Equations Conference, Mathematics Department, Harvey Mudd College, Claremont, CA 91711. Topics iclude: dynamic systems, epidemic models.

Jan. 11-13. Society for Historical Archaeology Conference on Historical and Underwater Archaeology. Tucson. Edward Staski, SHA Program Chair, Department of Sociology/Anthropology, Box 3BV, New Mexico State University, Las Cruces, NM 88003. Abstract deadline: 8/15/89.

***Jan. 14-23. 3rd International School and Workshop of Crystallography on X-ray Powder Diffraction and its Application;** sponsored by European Crystallographic Commission. Cairo. Prof. Karimat El-Sayed, National Commission of Crystallography, Academy of Scientific Research and Technology, 101 Kasr Al-Ainy Street, Cairo, Egypt.

February

***Feb. 4-9. American Meteorological Society, 70th Annual Meeting: Global Change.** Anaheim. AMS, 1755 Massachusetts Avenue NW, Suite 700, Washington, DC 20036-2102. Symposia include: Climate variation; Hydrology and climate variations; Biometeorology and global change.

***Feb 4-9. 17th International Symposium on the Chemistry of Natural Products.** New Delhi, India. Prof. Sukh Dev, Malti-Chem Research Centre, Nandesari, Baroda-39340, India.

Feb. 5-9. Topical Meeting on Laser Applications to Chemical Analysis. Incline Village, NV. Optical Society of America, Meetings Department, 1816 Jefferson Place NW, Washington, DC 20036 (202-223-0920).

Feb. 11-16. SPIE (International Society for Optical Engineering)/SPSE (Society for Imaging Science and Technology) Symposium on Electronic Imaging. Santa Clara, California. SPIE/SPSE Technical Program Committee: E190, PO Box 10, Bellingham, WA 98227-0010 (206-676-3290). Abstract deadline: 7/31/89. Twenty-six conferences include: Image storage and retrieval technologies; Stereoscopic displays and applications; Image workstations sytems integration issues; Extracting meaning from complex data - processing, display, interaction; Sensing and reconstruction of 3D objects and scenes.

Feb. 15-20. American Association for the Advancement of Science, Annual Meeting. New Orleans. AAAS, 1333 H Street NW, Washington, DC 20005. Evolution sessions include: evidence for Eve; emergence of modern humans. Archaeology sessions are: Mississippi Valley before 1492; evolutionary biology and behavior - race and gender; Chaco Canyon people and drought; Archaeological dating methods; How archaeologists know.

Feb. 18-24. Mathematische Modelle in Der Biologie. Oberwolfach, Federal Republic of Germany. Mathematisches Forschungsinstitut Oberwolfach Geschaftsstelle, Alberstrasse 24, D-7800 Feiburg im Breisgau, Federal Republic of Germany. By invitation only.

Feb. 19-22. Annual Meeting of the Minerals, Metals, and Materials (TMS) Society. Anaheim. TMS Society, 420 Commonwealth Drive, Warrendale, PA 15086. 150 sessions will update metallurgists and materials scientists with the latest scientifife and technical developments.

***Feb. 26-28. Canadian Ceramic Society, Annual Meeting.** Toronto. Michael Rigaud, Ecole Polytechnique, Campus Université de Montréal, Montréal, PQ H3C 3A7 Canada (514-340-4253; fax 514-340-3440). Abstract deadline: 9/15/89.

March

March 5-7. SIAM (Society for Industrial and Applied Mathematics) Conference on Applied Probability in Science and Engineering. New Orleans. SIAM Conference Coordinator, Suite 1400, Architects Building, 117 S. 17th Street, Philadelphia, PA 19103-5052 (215-564-2929). Abstract deadline: 9/27/89.

March 5-9. 41st Pittsburgh Conference and Exposition on Analytical Chemistry and Applied Spectroscopy. New York. Mrs. Alma Johnson, Program Secretary, The Pittsburgh Conference, 300 Penn Center Boulevard, Suite 332, Pittsburgh, PA 15235. Abstract deadline: 8/4/89. Symposia include: Data tools for solving analytical chemistry problems; New frontiers in mass spectrometry; Catastrophic environmental problems.

***March 12-16. American Physical Society March Meeting.** Anaheim. W.W. Havens, Jr., APS, 335 E. 45th Street, New York, NY 10017 (212-661-9404).

March 14-16. 3rd Latin American Conference on Chromatography. Fernando M. Lancas, University of Sao Paulo, Institute of Physics and Chemistry of Sao Carlos, 13560 Sao Carlos, SP Brazil. Topics: fundamental and practical aspects of all modes of chromatography.

*March 18-21. **1990 Symposium on Interactive 3D Graphics;** sponsors include NSF, Digital Equipment Corporation, Hewlett-Packard, NeXT. Snowbird, Utah. Rich Riesenfeld, 1990 Symposium on Interactive 3D Graphics, Department of Computer Science, 3190 Merrill Engineering Building, Salt Lake City, UT 84112 (801-581-8224).

*March 21-24. **13th Annual Ethnobiology Confererence.** Phoenix. Sponsored by Arizona State University and the Desert Botantical Garden. Deadline for abstracts: January 15. Gary Nabhan, Desert Botanical Garden, 1201 North Galvin Parkway, Phoenix, AZ 85008. (602) 941-1225.

*March 24. **7th Annual Natural Science Symposium: Lake Pleisticene Environments of the California Desert.** Palm Springs. James W. Cornett, Natural Science Department, Palm Springs, CA 92263.

March 28-31. **Society of Human Genetics, 2nd Annual Meeting.** Bonn. Prof. Peter Propping, Institut fur Humangenetik der Universitat, Wilhelmstrasse 31, D-5300 Bonn 1, Federal Republic of Germany. Abstract deadline: 1/8/90.

March 29-April 1. **Northeastern Anthropological Association Annual Meeting.** Burlington. Stephen Pastner, Program Chair, Department of Anthropology, University of Vermont, Burlington, VT 05405-0168 (802-656-3884). Proposal deadline: 12/15/89.

*March 30-April 2. **Central States Anthropological Society Annual Meeting.** Cincinnati. Clara Tichards, Program Chair, Transylvania University, 300 North Broadway, Lexington, KY 40505.

April

April 2-4. **9th ACM (Association for Computing Machinery) Symposium on Principles of Database Systems.** Nashville. Daniel Rosenkrantz. General Chair, PODS, Department of Computer Science, State University of New York, Albany, NY 12222 (E-mail: djr@albanycs.albany.edu). Abstract deadline: 10/9/89. New developments in theoretical and practical aspects of database and knowledge-based systems.

April 2-6. **International Symposium on Archaeometry.** Heidelberg. Archaeometrie, E. Pernicka, Max-Planck-Institut fur Kernphysik., Postfach 10 39 80, D-6900 Heidelberg, Federal Republic of Germnay. Abstract deadline: 11/1/89. Symposia include: Dating of organic and inorganic materials; Prospecting; Provenance studies; Technology; Mathematical and statistical methods; one-day theme session on Chronology and Environment of Early Man - The Archaeometric Approach.

April 3-5. **5th International Conference on Statistical and Scientific Database Management;** sponsors include International Association for Statistical Computing. Charlotte, North Carolina. Zbigniew Michalewicz, General Chair, Department of Computer Science, University of North Carolina, Charlotte, NC 28223 (E-mail: zbyszck@comp.VUW.AC.NZ). Paper deadline: 5/31/89. Major topics of interest include: modeling and semantics; scientific databases; temporal and spatial data; applications.

April 4-6. **2nd International Meeting of ASSESS (International SPSS User Group).** Glasgow, U.K. Evelyn Benett, ASESS, Department of Statistics, Huddersfield Polytechnic, Huddersfield HD1 3DH, United Kingdom.

April 4-6. **Climate Change on the Great Plains.** Lincoln. Ken Dewey, Center for Great Plains Studies, 1213 Oldfather Hall, University of Nebraska, Lincon, NE 68588-0314. Proposal deadline: 7/1/89.

April 16-20. **Materials Research Society Spring Meeting: Material Issues in Art and Archaeology.** San Francisco. Pamela Vandiver, Research Physical Scientist, Smithsonian Institute Conservation Analytical Lab, Museum Support Center, Washington, DC 20560 (301-238-3700). Topics: Ancient technology - Processing evidence from workshops and industrial debris; Analysis of properties to interpret function; Materials degradation; Characterization through compositional and structural analysis.

*April 18-22. **Pan-American Association of Biochemical Societies, 6th Congress.** Sau Paulo. PAABS VI Congress, Meeting Planejamento e Organizacao de Eventos S/C Ltda., Rua Jusseape, 40 04542 Sao Paulo, SP Brazil.

April 18-22. **SAS Annual Meeting,** in conjunction with SAA. Details in Volume 13, Number 2 of SAS Bul*letin*.

April 18-22. **Society for American Archaeology, 55th Annual Meeting.** Las Vegas. James Moore, Program Chair, Department of Anthropology, Queens College, 65-30 Kissena Boulevard, Flushing, NY 11367. Abstract deadline: 10/1/89.

April 19-22. **American Association of Geographers, 86th Annual Meeting.** Toronto. AAG, 1710 16th St. NW, Washington, DC 20009 (202-234-1450). Abstract deadline: 9/22/89.

*April 20-22. **4th Conference of the Society for Human Ecology.** East Landsing. SHE Conference Planning Committee, c/o M. Suzanne Sontag, 204 Human Ecology, Michigan State University, East Lansing, MI 48824.

*April 22-26. **American Ceramic Society, 92nd Annual Meeting.** Dallas. ACS, 757 Brooksedge Plaza Drive, Westerville, OH 43081-6136.

*April 22-27. **American Chemical Society Annual Meeting. Boston.** ACS Meeting Department, 1155 16th Street NW, Washington, DC 20036.

April 23-27. **European Geophysical Society, 15th General Assembly.** Copenhagen. EGS Office, Postfach 49, D-3411 Katlenburg-Lindau, Federal Republic of Germany. Abstract deadline: 1/31/90.

May

*May 1-3. **First Circumpolar Symposium on Remote Sensing of Arctic Environments.** Yellowknife, Northwest Territories, Canada. Contact Helmut Epp, NWT Remote Sensing Centre, Government of the NWT, P.O. Box 1320, Yellowknife, NWT, Canada X1A 2L9. (403) 920-3329: FAX (403) 873-0221.

*May 3-4. **21st Annual Pittsburgh Conference on Modeling and Simulation.** Sponsors include: University of Pittsburgh School of Engineering; Society for Computer Simulation; Systems, Man and Cybernetics Society. Pittsburgh. W.G. Vogt, Modeling and Simulation Conference, 348 Benedum Engineering Hall, University of Pittsburgh, Pittsburgh, PA 15261. Abstract deadline: 1/31/90. Topics include: personal computer applications and software; social and economic models, regional science; global modeling and simulation.

May 3-5. Population Society of North America, Annual Meeting. Toronto. PAA, 1429 Duke Street, Alexandria, VA 22314. Abstract deadline: 11/10/89. Session include: Indigenous populations of North and South America; Historical demography; Mathematical demography; Demography of various regions.

*May 4-5. **Future of the Past: American Archaeology in AD 2001.** 7th Annual Center for Archaeological Investigations' Visiting Scholar's Conference, Carbondale, IL. Contextual, methodological and theoretical issues that will influence the future conduct of American archaeology. Abstract deadline: December 15, 1989. Contact LuAnn Wandsnider, CAI, Southern Illinois University, Carbondale, IL 62901. (618) 536-6651. BITNET: GA3784@SIUCVMB.

*May 5-10. **23rd Annual Meeting on Scanned Image Microscopy, Related Techniques, and Applications.** Maryland. Dr. Om Johari, Scanning Microscopy 1990 Meeting, PO Box 66507, AMF O'Hare, IL 60606-0507.

*May 8-11. **12th International Conference on Biochemical Analysis.** Munich. Biochemische Analytik 90, Nymphenburger Strasse 70, D-8000 Munich 2, Federal Republic of Germany.

*May 13. **13th Annual Spring Systematics Symposium.** Chicago. "History and Evolution." Contact Kristine L. Bradof, Department of Geology, Field Museum of Natural History, Roosevelt Road at Lake Shore Drive, Chicago, IL 60605-2496. (312) 922-9410, x298.

*May 14-15. **Symposium on Analysis of Paints and Related Materials.** Pittsburgh. Dorothy Savini, American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103 (215-299-5413).

May 16-18. Geological Association of Canada, Annual Meeting. Vancouver. GAC-MAC '90, 801-750 Jervis Street, Vancouver, BC, Canada V6E2A9.

*May 20-25. **7th International Symposium on Trace Elements in Man and Animals.** Dubrovnik, Yugoslavia. TEMA International Secretariat, Rowett Research Institute, Bucksburn, Aberdeen AB2 95B, United Kingdom.

May 20-25. Society for Imaging Society and Technology (SPSE), 43rd Annual Conference. Rochester. Prof. Rodney Shaw, Rochester Institute of Technology, Center for Imaging Science, One Lomb Memorial Drive, Rochester, NY 14623. Abstract deadline: 12/1/89. Sessions will include: Computer imaging and digital graphics; Advances in image processing techniques; electro-optical imaging systems.

*May 21-24. **7th Symposium on Radiation Measurements and Applications.** Ann Arbor. Helen Lumm, 3034 Phoenix Memorial Laboratory, University of Michigan, Ann Arbor, MI 48109 (313-764-6214). Topics include: data acquisition; analysis systems and methods; particle-induced X-ray emission; radiation-induced fluorescence; analytical standards and elemental analysis.

May 21-25. 6th International Conference on Archaeozoology. Washington, DC. The International Council for Archaeozoology, c/o Department of Anthropology, National Museum of Natural History, Smithsonian Institution, Washington, DC 20560. Theme: The nature and implications of human/animal interactions over time. See SAS Bulletin, 12(1), for details.

*May 21-26. **37th American Society for Mass Spectrometry Conference on Mass Spectrometry and Allied Topics.** San Francisco. Judith Watson, ASMS, PO Box 1508, East Lansing, MI 48823.

May 24-27. Geological Society of Greece, 5th Congress. Thessaloniki. Prof. D. Mountrakis, Aristotle University of Thessaloniki, Department of Geology, Thessaloniki 54006, Greece.

May 28-June 1. 6th International Conference on Hunting and Gathering Societies. Fairbanks. Linda Ellanna, CHAGS 6, Anthropology Department, University of Alaska, Fairbanks, AK 99775. Abstract deadline: 7/30/89. Sessions include: Past and present health and nutrition patterns; Ethnoarchaeology.

*May 28-June 8. **8th International Conference on Modern Trends in Activation Analysis;** co-sponsored by National Natural Science Foundation of China and the Chinese Nuclear Society. Beijing. Chai Chaifang, Institute of High Energy Physics, Academia Sinica, PO Box 2732, Beijing, People's Republic of China.

May 29-June 1. American Geophysical Union Spring Meeting. Baltimore. AGU Meetings, 2000 Florida Avenue NW, Washington, DC, 20009 (202-462-6900).

May 29-June 1. European Association of Exploration Geophysics, 52nd Annual Meeting. Copenhagen. J. Tychsen, Miljoministeriet, Amaliegade 13, DK-1265, Copenhagen K, Denmark.

June

*June 3-6. **Statistical Society of Canada, Annual Meeting.** St. John's, Newfoundland. C.A. Field, Program Chairperson, Department of Mathematics, Statistics, and Computing Science, Dalhousie University, Halifax, Nova Scotia, B3H 4H8 Canada.

*June 3-8. **38th American Society for Mass Spectroscopy Conference on Mass Spectroscopy and Allied Topics.** Tucson. Judith Watson, ASMS, PO Box 1508, East Lansing, MI 48826 (517-337-2548).

*June 4-6. **Symposium on Optical Spectroscopic Intrumentation and Techniques for the 1990s: Applications in Astronomy, Chemistry, and Physics.** Las Cruces, New Mexico. International Society for Optical Engineering (SPIE), PO Box 10, Bellingham, WA 98227 (206-676-3290).

June 4-6. Canadian Quaternary Association and American

Quaternary Association, 1st Joint Meeting. Waterloo. A.V. Morgan, Quaternary Sciences Institute, Department of Earth Sciences, University of Waterloo, Waterloo, Ontario, N2l 3G1 Canada (519-885-1211, ext. 3231; fax 519-746-2543; Bitnet: FOSSIL@WATDCS). Theme: Rapid change in the Quaternary record. Short courses include: Techniques in shallow geophysical methods; Examples and critiques of Quaternary dating methods. Field trips include a visit to Crawford Lake, the most accurately documented prehistoric Indian settlement in Canada.

***June 6-7. Nuclear Magnetic Resonance Imaging: Recent Developments and Future Prospects.** London. Scientific Meetings Secretary, Royal Society of Chemistry, 6 Carlton House Terrace, London SW1Y 5AG, United Kingdom (01-839-5561, ext. 278).

June 13-15. Hydrologic Aspects of Global Climatic Change; Chapman Conference. Sponsored by the American Geophysical Union. Lake Chelan, Washington. Meetings, AGU, 2000 Florida Ave NW, Washington, DC 20009 (202-462-6900).

June 14-16. International Colloquium on Surface Colouring and Plating of Metals. London. Mrs. S. La Niece, Research Laboratory, British Museum, Great Russell Street, London Wc1B 3DG United Kingdom (01-636-1555).

June 21-22. International Symposium on Mapping and Geographic Information Systems; sponsored by American Society for Testing and Materials. San Francisco. Dorothy Savini, ASTM, 1916 Race Street, Philadelphia, PA 19103 (215-299-5413). Abstract deadline: 11/15/89. Main topics: maps of all types, remote sensing, geographic information systems.

***June 21-23. Classification and Clustering: Perspectives and Prospects;** sponsored by Classification Society of North America. Logan. Michael P. Windham, Department of Mathematics and Statistics, Utah State University, Logan, UT 84322-3900. Abstract deadline: 3/1/90. Topics include: applications, classification, data analysis, factor analysis, pattern recognition, scaling, statistical methods.

***June 24-28. 7th World Ceramic Congress.** Rimini, Italy. 7th CIMTEC, Satellite Symposium 1, PO Box 174, 48018 Faenza, Italy.

June 24-29. 4th International Conference on Geoscience Information; co-sponsored by: Geological Society of Canada, International Union of Geological Sciences, Geoscience Information Society. Ottawa, Canada. David Reade, GeoInfo IV Secretary-Treasurer, GEOSCAN Centre, 601 Booth Street, Ottawa, K1A 0E8 Canada (613-992-9550). Themes include: Geographic and expert systems; Constructing and managing databases; Managing collections and archives. Abstract deadline: 9/1/89.

July

July 1-7. Society for the Study of Evolution Annual Meeting. Dr. Barbara A. Schaal, SSE Executive Vice-President, Department of Biology Washington University, St. Louis, MO 63130 (314-889-6822).

***July 2-6. State of the Art in Computer Graphics;** co-sponsored by British Computer Society and Association for Computing Machinery. Edinburgh, Scotland. David F. Rogers, Program Chair, U.S. Naval Academy, Annapolis, MD 21402-5000 (301-267-3283; E-mail: dfr@usna.mil).

***July 2-6. 14th Congress of the Council of Mining and Metallurgical Institutions.** Edinburgh, Scotland. The Secretary, The Institute of Miinag and Metallurgy, 44 Portand Place, London W1N 4BR, United Kingdom.

***July 16-20. International Conference on Luminescence.** Lisbon. Sebastiao Formosinho, Secretariat of ICL 90, Centro de Quimica Fisica Molecular da Universidade Tecnica de Lisboa, Instituto Superior Tecnico, Av. Rovisco Pais, 1096 Lisboa Codex, Portugal.

July 23-27. 4th International Symposium on Spatial Data Handling; sponsored by International Geographic Union Commission on Geographic Information Systems. Zurich. Symposium Secretariat, Department of Geography, University of Zurich (Irchel), Winterthurer Strasse 190, CH-8057 Zurich, Switzerland (E-mail: K505820@CZHRZU1A.bitnet; fax 0041-1-257 4004).

***July 29-Aug. 2. Ecological Society of America, 75th Anniversary Meeting.** Snowbird, Utah. Dr. Marjorie M. Holland, The Ecological Society of America, Public Affairs Offics, 9650 Rockville Pike, Bethesda, MD 20814.

August

Aug. 6-9. Annual Statistical Meetings; co-sponsored by the American Statistical Association, the Biometric Society, and the Institute of Mathematical Statistics. Washington, DC. ASA, 1429 Duke Street, Alexandria, VA 22314-3402 (703-684-1221).

Aug. 6-10. 17th Annual ACM Conference on Compuer Graphics and Interactive Techniques (SIGGRAPH 90). Dallas. Lois Blankenstein, SIGGRAPH Conference Liaison, Association for Computing Machinery, 11 West 42nd Street, New York, NY (212-869-7440; E-mail: lois blankenstein@um.cc.umich.edu).

***Aug. 12-16. International Conference on Optics in Life Sciences;** sponsored by International Commission for Optics. Garmisch-Partenkirchen, FRG. G. von Bally, Laboratory of Biophysics, Institute of Experimental Audiology, University of Munster, Kardinal-von-Galen-Ring 10, D-4400 Munster, Federal Republic of Germany.

***Aug. 12-18. 12th International Congress on Electron Microscopy.** Seattle. Dr. J.K. Koehler, University of Washington, Biostructire SM-20, Seattle, WA 98195.

Aug. 19-25. 20th Meeting of the Federation of European Biochemical Societies. Budapest. 20th FEBS Meeting Secretariat, Hungarian Biochemical Society, MTESZ, Budapest 1368, PO Box 240, Hungary.

***Aug. 26-31. Austceram '90.** Perth, Western Australia. Austceram '90, PO Box 515, South Perth, WA 6151, Australia (619 474 1699; fax 619 474 1460). Session on Ceramic arts and crafts includes archaeological ceramics, raw materials, kilns and firing, pottery glazes.

Aug. 26-31. Euroanalysis VII - European Conference on Ana-

lytical Chemistry. Vienna. Prof. Dr. M. Grasserbauer, c/o Interconvention, A-1450, Vienna, Austria (43-222-2369-2647).

Aug. 26-Sept. 1. 13th International Association of Sedimentology Congress. Nottingham, U.K. I.N. McCave, Department of Earth Sciences, Cambridge University, Downing Street, Cambridge CB2 3EQ, United Kingdom

Aug. 27-Sept. 1. International Association of Hydrology, 22nd Congress; Symposium on Water Resources in Mountainous Regions. Lausanne. Dr. A. Parriaux, Laboratory of Geology EPFL (GEOLEP), CH-1015 Lausanne, Switzerland.

Aug. 28-30. IMACS European Simulation Meeting on Problem Solving by Simulation. Esztergom, Hungary. A. Javor, Central Research Institute for Physics of the Hungarian Academy of Sciences, H-1525 Budapest 114, PO Box 49, Hungary. Abstract deadline: 9/30/89.

September

***Sept. 3-7. 3rd International Symposium on X-ray Microscopy.** London. Dr. A.G. Michette, Department of Physics, King's College, Strand, London, WC2R 2LS, United Kingdom.

Sept. 3-8. International Congress on Volcanology. Mainz. G. Brey, Max Planck Institut fur Chemie, Abtl. Kosmochemie, Saarstrasse 23, 6500 Mainz, Federal Republic of Germany. Abstract deadline: 4/1/90. Symposia include: Volcanic aerosols, climate and tephrochronology; Current volcanic activity and hazards.

Sept. 4-8. 8th General Conference of the European Physical Society. Amsterdam. L. Roos, FOM-Institute for Atomic and Molecular Physics, PO Box 41883, NL-1009 DB Amsterdam, The Netherlands.

Sept. 9-13. Large Lakes and Their Stratigraphic Record; Geological Society of America Penrose Conference. Lake Tahoe, California. Andrew S. Cohen, Department of Geosciences, University of Arizona, Tucson, AZ 85721 (602-621-4691). Application deadline: 4/1/90. Conference concerned with the genesis, diagenesis and interpretation of lake sediments, the processes that influence them, the basins that contain them, and their record of global change. Field trips to Lake Tahoe and Mono Lake, California.

Sept. 10-13. African Geology, 15th Colloquium; co-sponsored by CIFEG. Nancy, France. Marc Deschamps, Universite de Nancy 1, Laboratoire de Petrologie, BP 239, F-545006 Vandoeuvre-les-Nancy Cedex, France.

***Sept. 18-23. 4th International Symposium on the Mesolithic of Europe.** Leuven, Belgium. Pierre M. Vermeersch, Mesolithic Symposium, Redingen-straat 16bis, B-3000 Leuven, Belgium.

***Sept. 20-24. 5th Nordic Conference on the Application of Scientific Methods in Archaeology.** Stockholm. Arkeologiska Forskningslaboratoriet, Greens villa, Stockholm Universitet, 106 91 Stockholm, Sweden (08/16 21 77; Bitnet: P396220QZCOM.BITNET. Theme: Transition and change as illustrated in the scientific and archaeological source material.

Sept. 23-27. Society of Exploration Geophysicists, 60th International Meeting. San Francisco. Convention Assistant, SEG, PO Box 3098, Tulsa, OK 74101.

Sept. 24-29. 7th International Conference on Geochronology, Cosmochronology, and Isotope Geology. Canberra. Organizing Committee, IGOC7 , Research School of Earth Sciences, Australian National University, Box 4, Canberra, ACT 2601, Australia. Sessions include: Dating of the Quaternary period; Low-temperature geochemistry; Paleoenvironmental studies; Innovative techniques in isotope geochemistry.

***Sept. 25-28. Symposium on Time and Environment;** sponsored by the Department of Archaeology and the Dating Laboratory of the University of Helsinki, and Group PACT. Themes: Dating, time, and the environments of ancient people. The Dating Laboratory, University of Helsinki, Snellmaninkatu 5, SF-00170 Helsinki, Finland.

Sept. 29-Oct. 7. 6th Meeting of the European Geological Societies. Lisbon. MEGS 6, Sociedade Geologica de Portugal, Apartado 2361, P-1109 Lisbon Codex, Portugal. Abstract deadline: 3/31/90.

October

***Oct. 7-12. 17th Annual Meeting of the Federation of Analytical Chemistry and Spectroscopy Societies.** Cleveland. Charles J. Belle, Lucas Aerospace PEC, 4259 W. 192nd Street, Fairview Park, OH 44126 (216-062-1001).

Oct. 8-12. 5th Australasian Remote Sensing Conference. Perth. Dr. Norman Campbell, Technical Paper Coordinator, 5th Australian Remote Sensing Conference, PO Box 411, West Perth, Western Australia 6005. Abstract deadline: 10/89.

***Oct. 15-20. Association for the Study of Marble and Other Stones in Antiquity (ASMOSIA), 2nd Biennial Meeting.** Leuven, Belgium. Norman Herz, Department of Geology, University of Georgia, Athens, GA 30602. Principal theme: Ancient building and statuary stones - quarrying and provenance determination techniques.

***Oct. 21-25. 2nd International Congress of Ethnobiology. Kunming, China. Theme: Challenges of Ethnobiology in the 21st Century.** Abstract deadline: December 1, 1989. Contact International Society for Ethnobiology, 2220 Piedmont Avenue, University of California, Berkeley, CA 94720.

Oct. 21-26. Soil Science Society of America Annual Meeting. San Antonio, Texas. SSA, 677 S. Segoe Road, Madison, WI 53711 (608-273-8080).

Oct. 29-Nov. 1. Geological Society of America Annual Meeting. Dallas. GSA Meeting Department, PO Box 9140, Boulder, CO 80301 (303-447-2020).

November

Nov. 14-18. American Anthropological Association Annual Meeting. New Orleans. AAA, 1703 New Hampshire Ave. NW, Washington, DC 20009 (202-232-8800).

*Nov. 27-Dec. 2. **Materials Research Society, Fall Meeting.** David Sours, Materials Research Society, 9800 McKnight Road, Pittsburgh, PA 15237 (412-367-3003; fax 412-367-4373).

December

Dec. 2-9. 20th International Ornithological Congress. Christchurch, New Zealand. Ben D. Bell, Secretary-General, XX International Ornithological Congress, Zoology Department, Victoria University, Private Bag, Wellington, New Zealand. Symposia themes include: Systematics, evolution and ornithogeography; Ecology. Abstract deadline: 3/31/90.

1991

May 20-24. 14th International Radiocarbon Conference. Tucson. Dr. Austin Long, Department of Geosciences, University of Arizona, Tucson, AZ 85721 (fax 602-621-2672; Bitnet: C14@ARIZRVAX).

***July 7-11. 47th International Conference of Americanists.** New Orleans. Secretariado ICA 1991, Roger Trayer Stone Center for Latin American Studies, Tulane University, New Orleans, LA 70118-5698.

Aug. 2-9. 13th INQUA International Congress on Quaternary Research. Beijing. Secretariat, 13th INQUA Conference, Chinese Academy of Sciences, 52 Sanlihe, Beijing 100864, People's Republic of China.

Aug. 18-23. International Symposium on Engineering Geology in a Desert Environment, Rock-Water Interaction. Jerusalem. The Secretariat, International Symposium on Engineering Geology in a Desert Environment, Rock-Water Interaction, PO Box 50006, Tel Aviv 61500, Israel. Theme is based on engineering geological problems in semi-arid to arid regions where water is not obviously abundant in the environment, and yet remains a major factor affecting geotechnical properties of rocks.

Aug. 26-30. 12th International Mass Spectrometry Conference. Amsterdam. RAI Organisatie Bureau Amsterdam, Europaplein 12, NL-1078 GZ Amsterdam, The Netherlands.

***Sept. 1-7. International Union of Prehistoric and Protohistoric Sciences, 12th Congress.** Bratislava, Czechoslovakia. Archeologicky ústav Slovenskij Akadémie Vied, Sekretariát XII Kongresu UISSP, 949 21 Nitra-hrad, Czechoslovakia. Theme: Archaeology - Present - Future.

Sept. 6-11. Paleoecology, 2nd International Congress. Nanjing. Ma Yu-Ying, Nanjing Institute of Geology and Palaeontology, Academia Sinica, Chi-Ming-Ssu, Nanjing 210008, People's Republic of China.

Oct. 6-11. 8th International Congress on Human Genetics. Washington, DC. John J. Mulvihill, M.D., Secretary-General ICHG, 9650 Rockville Pike, Bethesda, MD 20814.

Rob Sternberg, Department of Geology, Franklin and Marshall College, PO Box 3003, Lancaster, PA 17604-3003. Bitnet: R_STERNBERG@FANDM. Phone: (717) 291-4134
(1989-90: Jacob Burckhardt Strasse 20, D-7750 Konstanz, Federal Republic of Germany, 011-49-7531-54687, Bitnet: PHSTERN@DKNKURZ1).

Book Review

***Archaeometry*. ULRICH LEUTE. VCH Publishers, Weinheim, FRG, 1987. xi + 176pp., index. $26.50, cloth.**

Reviewed by Joseph B. Lambert, Northwestern University.

This book describes the quantitative instrumental methods of the physical sciences that are used in the service of archaeology and art history. The physical basis of each method is described, usually with a key equation or two. The treatment is brief but not superficial. The reader can expect to obtain a basic understanding of any given subject. Moreover, the book lends itself well for use as a reference source, to which one can turn for an introduction to a specific subject.

The subject matter is divided into the traditional Oxford archaeometric groupings of prospection, dating, and characterization. The treatment of prospection begins with the nonmathematical subject of aerial survey and moves on to more quantitative resistivity and magnetic methods. The introduction to magnetic prospection is especially thorough, even including some experimental tips. Brief treatment is given of chemical and underwater methods.

The discussion of dating methods begins with the topic of magnetization. This section is enhanced by several specific examples, which often are lacking for other subjects. The section on thermoluminescence contains a particularly strong description of the physical basis and an appreciation of limitations. The section on radioactivity is thorough and up to date (including accelerator methods). I am unsure of the author's distinction between "chemistry" and "physical chemistry" (pp. 89, 91, and 98), since one is a subdiscipline of the other. This general category of dating methods includes amino acid racemization, hydration layers, electron spin resonance, and elemental levels.

Characterization begins with optical examination, continues with determination of physical properties, and ends with chemical analysis. All methods are represented, with emphasis on elemental methods such as atomic absorption but with decent coverage of molecular methods such as infrared spectroscopy. Recent techniques such as PIXE and inductively coupled plasma are included, as are more esoteric methods such as Auger spectroscopy.

Very seldom does the prose suggest composition in a nonnative tongue ("Since a few decades" [p. vii], "fluor" consistently for the element "fluorine," "something has to happen with these molecules" instead of "happen to" [p. 94]). There are quite a few typographical errors. Neither type of error is distracting. I would have preferred a larger number of specific examples of applications of these techniques to archaeology. The strength of this book is its clear and up-to-date presentation of the various methodologies.

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SAS BULLETIN

Society for Archaeological Sciences

Deadlines for Submissions:

No. 1 November 15 No. 2 February15
No. 3 May 15 No. 4 August 15

Published quarterly by the Society for Archaeological Sciences. Distributed to subscribers: $10.00/year individual, $5.00 student, $15.00 institution, $150.00 lifetime. Payable with American Express: provide cardnumber and expiration date. ISSN 0899-8922.