El Salvador

for info. [n.d.]

Magnetic Properties of Rock & Soil Samples, Casa Blanca, El Sal. (Mexico).

Three samples were received:
(1) Mixture soil and small stones (marked "Average Fill") 1.18 Kg.
(2) Pieces of blue-gray rock (unmarked) 1.26 Kg.
(3) Pieces of porous, lava-like stone 1.73 Kg. (marked "Const. Fill Stone").

Test.
Using Elsec Proton Magnetometer. Samples placed on ground directly under (and about 40 cm. from) detector bottle.

Results.
Background (32)622 p.m.u. (average of 4, but consistent over repeated readings).

Sample (1) 619 p.m.u. (average of 4). Field intensity increased 3 p.m.u. When tied adjacent to bottle, read 610 p.m.u. (Increase of 12).

Sample (2) 597 p.m.u. (average of 4). Field intensity increased 25 p.m.u. When tied adjacent to bottle, insufficient signal could be registered for a reading.

Sample (3) Highly erratic readings obtained, even though the signal appeared to be satisfactory. Average of 10 was 33529 p.m.u.. Field intensity decreased by some 900 p.m.u. but with a scatter of up to 450 p.m.u.(±). Holding the material above the bottle gave a poor signal but tended to increase the field intensity.

Conclusions.
The problem was whether the rock (sample 2) could be magnetically located in the presence of the others.
If none of the stone fill (sample 3) is present, pieces of rock like sample 2, weighing a few Kg. or bigger, should give a moderate positive anomaly. A rough inverse-square law calculation suggests that a piece of 1 to 2 Kg. might give an anomaly of a few gammas at a depth of 1/2 metre.(This may be rather pessimistic, since the sample used consisted of a number of pieces jumbled together. Presumably an artifact would be made from one solid lump.)
The only conclusion from the results on sample 3 is that it is a very markedly magnetic material. Presumably the erratic readings were caused by the generation of a steep field gradient at the bottle. The finding of a low field intensity means little as it is known that strongly magnetic materials can give low intensity regions (the "anti-magnetic reaction"). It must therefore be concluded that significant amounts of this stone fill on a site would make the magnetic prospecting of those portions of the site a very difficult proposition.

J. Winter

[Undated]

Possible Archaeochemistry Project II. Organic Residues absorbed in Permeable Ceramics.

Background

Many archaeological pottery finds presumably were used to contain organic materials such as foodstuffs, either during use or, in the case of grave pottery, when it was interred. With permeable wares, i.e. not glazed or otherwise made impervious, it can be expected that organic substances derived from the contents, probably more or less decomposed, will have been absorbed into the ceramic. The problem of getting information about the contents from the absorbed remains has two aspects:

(1) the relation between organic constituents of foodstuffs etc. and the plant or animal species that produced them;

(2) the chemistry of the decomposition of the original contents during burial.

Objectives and Methods.

The objective would be to develop means of deducing as much as possible about the nature of organic material that was associated with a piece of pottery, using a chemical study of the absorbed residues. This is just one example of the general problem of extending the limits of useable archaeological evidence by chemical studies on material that has undergone partial decomposition.

The method falls into three parts.

(1) Extraction of organic material from the pottery.

(2) Separation of the complex mixtures extracted into individual components.

(3) Identification of the components.

A preliminary extraction of a grave pot from Dinkha Tepe has shown that significant amounts of organic material can be removed, though the method used may need some development. Separation and identification would follow methods developed by organic geochemists in their work on the organic ~~extent~~ content of sedimentary rocks.

Inference of the original material from these results would aim to make use of the extensive literature on chemical plant taxonomy and on plant and animal biochemistry. Another conceivable means of assistance here would arise if the probable contents of particular kinds of archaeological pottery could be deduced from the study of reliefs etc., in an Egyptological context especially. If this could be done, the material would form possible "standards" for evaluating known cases.

<u>Requirement in Material</u>

It is envisaged that the U.M. could probably provide most of the pottery for study, at least in the first place. Properly excavated pottery, of completely known provenance, would be needed. Suitable series of material exist in the Near East Section and the Egyptian Section, and no doubt elsewhere also.

<u>Requirement in Facilities</u>

For separation purposes, efficient chromatographic equipment of several different types would be needed. Some of this is already available to a certain extent, but there would be a serious requirement for a good gas chromatograph; this would be the major equipment requirement in the project.

Equipment for the necessary extraction procedures would be built; the cost here would be more in time than in direct expense. In addition there would be a solvents and chemicals requirement for both extraction and separation stages.

At the identification stage, the work would only be reasonably possible through a continuing co-operation with members of the Chemistry Department in order to have access to adequate spectroscopic facilities.

J. Winter

MASCA

Potential Archaeochemistry Project I. Frankincense and Myrrh.

Background

Frankincense and myrrh are two examples of "resinoids" (i.e. gums, resins, waxes and similar materials) that were used for a variety of purposes in the ancient world. A number of excavated samples of both materials apparently survive, chiefly from Egypt, though they seem to be rather scattered, and not necessarily correctly identified. Certain problems are associated with these, viz:-

(1) The correct identification in terms of a plant source.

(2) Identification of the locality in which they were produced. Specifically it would be of interest to know whether these products come from the region around the Horn of Africa or from southern Arabia, the two localities where commercial quantities have been known to be produced.

(3) Possibly, clarification of the use. In the case of myrrh, the use in modern times (as a medicinal) appears to differ from the chief use in ancient times (apparently in embalming and perfumery). This is likely to be connected with the exact plant source, and is therefore connected with the first two questions.

Objectives and Methods

The chief objective would be to attempt to identify the locality of production of any archaeological samples of frankincense and myrrh that could be obtained. This should throw light on the sources of supply to ancient Egypt and, incidentally, on the relevant properties of the materials they were using.

The approach would a detailed chemical investigation of both archaeological samples and of modern authentic samples of material from appropriate places; it is essentially one of chemical plant taxonomy. The exact chemical constituents of a plant product depend in part upon the species of plant concerned and in part upon the environmental conditions of growth. Both frankincense and myrrh are produced by several species (of the genus <u>Boswellia</u> for frankincense, of the genus <u>Commiphora</u> for myrrh) and there seems to be a correlation between the exact species and the region of production. In the case of myrrh, the situation is complicated by the fact that somewhat different materials, with different uses, may go under this name. In both instances, however, the method would consist of:

(1) Separation of the mixture of compounds constituting the original resinoid, using chiefly chromatographic techniques. This can be done largely in the U.M.

(2) Identification of individual constituents. This is only reasonably possible by the extensive use of modern spectroscopic techniques, which are available in the Chemistry Department.

(3) Association of constituent patterns with the plant genus and species and in consequence with the locality producing the original resinoid.

Requirement in Materials.

Materials needed are of two kinds: (1) Archaeological samples likely to be either frankincense or myrrh; (2) Modern samples of known botanical provenance.

(1) The U.M. has one sample of what is probably frankincense, and various samples of embalming materials which may include myrrh. From the literature, University College (London) and the Metropolitan Museum appear to have possible materials. The most valuable source, however, is likely to be the Cairo Museum. A letter from Dr Z. Iskander to J.W. suggests that co-operation on such a project would be potentially available; a visit to the Cairo Museum by J.W., and perhaps a few weeks there to screen interesting from uninteresting samples would probably be involved.

(2) Efforts to locate authentic samples have not so far met with success, though it seems that samples of known provenance do exist in the western world. The Commonwealth Institute Museum and the Museum of Pharmacognosy in London are two places that may possess them, and individuals who have been to the areas concerned have occasionally brought back material. As far as East Africa is concerned, collection on the spot is not ruled out, and Dr F.N. Hepper, of the Kew Botanic Gardens, has offered to put J.W. in contact with a person in Addis Ababa who could arrange this. Collection in southern Arabia would be difficult in present political conditions there, and one may depend on authentic material already brought out of the area.

Requirement in Facilities.

There is no "all or nothing" requirement as far as new laboratory facilities are concerned. However, there would be a need for a reasonable chemicals and solvents budget, and if possible for some improvement in the appointments of room 41, particularly when more space becomes available upon the completion of the new wing. In the course of this and/or other organic chemistry problems, it would be hoped to improve laboratory facilities in a general way, notably by the addition of a fume hood, extra plumbing and an oven, and gradually to improve and diversify apparatus for chromatographic separations. It must again be emphasised that this kind of work depends upon a continuing co-operation with members of the Chemistry Department in order to have available the necessary spectroscopic techniques for compound identification.

J. Winter
MASCA

Dr. Rainey

Brief Report of Electron Microscope Meeting, January 21, 1961.

Place: Institute of Fine Arts of New York University, 1 East 78th Street, New York City, New York.

Organized by: Dr. Helmut de Terra, Department of Geology, Columbia University, New York City 27, New York.

Purpose: Possible applications of electron microscope to archaeological, conservation, etc., problems.

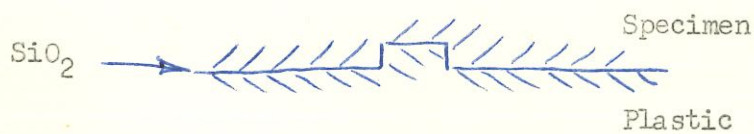
Presented by: Mrs. Althea Revere, Martha's Vineyard, Massachusetts.

Others present:

Edward Sayre, Conservation Laboratory, Institute of Fine Arts, NYU
Lawrence Majeroski, " " " "
Gettens
Dr. Cooney, Curator of Egyptian section, Brooklyn Museum
, Corning Glass
E.K. Ralph, University Museum

Talk by Mrs. Revere:

Replica Technique--



Remove plastic from specimen, sputter with SiO_2, plus Cr or other metal if shadows are desired. Remove SiO_2 layer from plastic for study in microscope.

Hence, technique is nondestructive. Reliability also demonstrated and explained.

Discussions of photographs and idéntifications accomplished.
Chief impression:

Probably anything can be identified, including ageing of materials, by a skilled person such as Mrs. Revere. Had not worked with wood, but thought that cell deterioration, etc., as measure of age, could be seen. This was questioned by those present. However, electron microscope (as used by skilled person) is very useful for the identification of materials, impurities. It is also possible to see radiation damage (biological materials?). (If this could be extended to natural damage in potsherds, etc., this would be a different approach for thermoluminescence measurements.-- EKR comment.)

Mrs. Revere's Proposal:

Would like to offer her services for Museum, etc., problems and to create a master file of photographs of identifications, etc., both to enable others to benefit from her experience and to publish some results of her work and the capabilities of the electron microscope. In the past the majority of her studies have been classified, restricted, etc.

Needed to carry this out:

Committee or organizer to raise funds for its support, and to advise about problems to be studied. Study and solution of problems to be entirely in hands of Mrs. Revere.

Other results of Meeting:

Conservation Laboratory of Institute of Fine Arts: Tour of new laboratory, supported by 5-year Rockefeller Foundation grant. Teaching facilities and equipment are combination (on a limited scale) of London Institute of Archaeology and British Museum laboratories. Five students (with M.A. in Fine Arts) are enrolled at present time for one-year course. Directed by E. Sayre who did neutron identification of pottery (temporarily on leave from Brookhaven National Laboratories), assisted by Lawrence Majeroski, who specializes in construction. Contains excellent work spaces for students, with microscopes, etc. Equipped with Emission Spectrograph, X-Ray machine, etc.

Egyptian Tree-Ring Dating:

Talked to Dr. Cooney about proposed University Museum project. Dr. Cooney was very enthusiastic about project and possibility of finding adequate wood in Egypt and in scattered museums. Suggested man to contact in Cairo: Zaki Iskander, Laboratory, Egyptian Museum, Cairo. Offered cooperation of Brooklyn Museum. (Visited Brooklyn Museum on Sunday-- saw several plausible wood objects, many more in storage.)

Elizabeth K. Ralph.
1/24/61

H. Carson
2/15/63

Proposals for ASCA Research

Sept. 1963-Sept. 1964

I. Metallurgical Studies

- A. Location maps of all known free state and ore sources used in antiquity
  - 1. Type of source.
    - a. Free state
    - b. Ore
    - c. Meteoric
  - 2. Location
    - a. New World-all prehistoric sites
    - b. Old World-all prehistoric and historic sites used before 300 BC
- B. Identification of techniques used in antiquity
  - 1. Procuring
    - a. Mining
    - b. Smelting (temperatures required, etc.)
  - 2. Working
    - a. Cold: beating, cutting, burnishing, punching, boring, drawing
    - b. Heat: casting, alloys
    - c. Temperature control: soldering

II. Obsidian Studies

- A. Location map of deposits used in antiquity
- B. Studiesof samples from Tikal
  - 1. Identification of different types of natural material (Donovan Clark recognized at least four types in his work on New World obsidian). Since there are no known obsidian deposits in the Guatemalan lowlands such a study may contribute to further knowledge of trade routes and outside contact.
  - 2. Dating of a controlled series using obsidian from caches of the progressively built layers of a single temple.

III. Dendrochronology

A. Sample collecting, counting, and plotting to establish a chronology for the Near East in cooperation with the Tree Ring Laboratory, Tuscon Arizona. University Museum Egyptian Collection is abundant in wood samples.

IV. Instrument Surveys

A. Instruments

1. Geohm resistivity apparatus

a. Devise a rapid calibration technique to speed the vertical differential plotting proceedure

2. Seismograph

a. Devise a method of data interpretation which will discriminate the time values given by shallow anomalies from those values given by the second cycle of the shock wave and by background noise.

b. Devise a method of wall location by sending a wave along the wall longitudinaly. The hammer stations are to be placed at given intervals along a traverse running perpendicular to and across the suspected wall with the geophone placed over a known position of the wall, or directly upon an exposed portion of the wall. The sound travel time should increase as the hammer approaches the wall. This new point could be considered a known wall position and the process repeated for the next wall section.

3. Earth drills and augers

a. Mighty Midget Earth Drill

-Purchase and use of different types of bits for use in different ground conditions

-Devise or purchase attachments which would convert the vacuum and water systems for the purpose of vacuum cleaning, washing, or pumping dry any excavation features.

b. -Purchase of a light power driven auger Soiltest #DR-496 with extra auger bits-total about $330

4. Metal-Detector

a. Purchase of metal detector with single turn solid alluminum detecting loops. Soiltest #DR-749 @ $189.50

5. Underwater Detection

a. Sea bottom surveys using metal detector and proton magnetometer or proton gradiometer in conjunction with the Scuba Diving techniques used by George Bass.

6. Perma-frost surveys and excavation techniques

a. Geohm Resistivity surveys to locate dwelling house pits cut into perma-frost

b. Adapt a one-man chain saw to cut blocks of perma-frost to aid in excavating Arctic sites

B. Sites for Field Surveys

1. U.S. Historic

a. National Park Service

-Region 5, Dr. John Cotter, Archaeological Director

Harpers Ferry; Hopewell Village; Isle Royal, Mich.; and others, consult Dr. Cotter.

-South East, Region _

-Other Regions

b. State operated parks

c. Mill Creek, Pa. Mr. Oliver Colburn

2. Near East

a. Hasanlu

-Consult Mr. Robert Dyson. Problems in detection of mud-brick structures

b. Gordion

-Location of road near tumulus which lead to and over a river. Road is Roman and probably older and covered by river silt 2m. deep or more. Road consists of a rubble fill topped by large paving stones 15 to 20 cm. thick which may convey a seismic shock wave longitudinally, and/or may be such that it effects moisture distribution enough to be detected by the Geohm vertical differential technique. Presence of road learned in conversation with Dr. Ellen Kohler.

3. Tikal

a. Detection of large stone structures by seismic and differential resistivity methods. Features would include plaza floors, walls, dwelling sites, and caches if large enough.

b. Test probing with earth drill and power auger.

4. Western Alaska in conjunction with Mr. Duane Burnor, Univ. of Penna.

a. Geohm surveys to locate dwelling house pits in perma-frost.

b. Test probing with power auger

c. Use of adapted power saw to aid in the problems of perma-frost excavations.

5. Peru

a. Geohm surveys at sites of large structural complexes in Western Peru. Suggested in conversation by Dr. Alfred Kidder.

5/4/70

MASCA PROJECTS

A. Radiocarbon Laboratory

(supervised by E. Ralph & run by B. Lawn)

The main function of the C-14 lab is the dating of archaeological samples submitted by or of interest to the curators of the University Museum. Samples dated during 1969 are shown on the attached sheets.

During the next year, it is hoped that two long series of samples will be available from:

1) Egypt - samples of "short-lived" materials that are truly representative of the middle and early Egyptian dynasties.

2) Greece - samples of "short-lived" materials that are representative of the early Minoan periods. Samples will be excavated at Thera and related sites.

While waiting for these samples, other series on hand in the C-14 lab are from sites in Peru; Korucu Tepe, Turkey; sites in the Cameroons, Africa; San Salvador; Sesklo and Franchthi Cave, Greece; Unalakleet, Alaska; and other miscellaneous ones.

The NSF supports a second counter for the purpose of dating tree-ring-dated sequoias and bristlecone pines. These samples afford a means of measuring changes in the atmospheric inventory of C-14 in past times. The measurements provide correction factors (see table) for C-14 dates and will help in determining correlations with the possible basic causes of these fluctuations, such as changes in the magnetic field of the earth and in the equilibrium balance between the atmosphere and oceans. Henry Michael (PhD in Anthropology) takes care of the dendrochronological part of the project.

The Foundation for Studies of Modern Science has given us a small grant (total $10,850 for two years) to date samples representative of the 20th and 21st Dynasties. It is also of interest to us to date samples from the early Egyptian dynesties as mentioned previously.

John Winter (PhD in Organic Chemistry) was employed originally with funds from our previous NSF grant to conduct experiments to determine the feasibility of measuring natural C-14 by the thermoluminescence technique. If successful, this would provide an easier and less costly way of dating by C-14 and would be an entirely different way of measuring the half-life of C-14 for which there is a need.

Due to NSF budget cuts, this part of our present grant (GA-12572) was deleted before we were awarded the grant. However, John Winter is pursuing the experiments, at least, to the point of finding out if this would be a workable technique. If this can be demonstrated, there would be some hope of obtaining a new grant to support the continuance of the project.

After numerous studies and tests of dosimeters, J. Winter has found that the most practical system may be the exposure of $CaSO_4$ (a sensitive dosimeter) to liquid CO_2. Therefore, he is now exposing "bombs" of liquid CO_2 to background radiation, both outside of and inside one of the massive iron shields in the C-14 lab. In June and July, he plans tests with hot $C^{14}O_2$, followed by exposure of $CaSO_4$ to natural $C^{14}O_2$ from August to December, 1970. Experiments thereafter will depend upon these results.

Since these experiments do not require full-time attention because of intervals of waiting for thermo-luminescence to accumulate, John Winter has some time available to initiate other chemical projects.

B. Thermoluminescence (TL)

The main emphasis continues to be the improvement of this technique of dating pottery. Therefore, we try to concentrate on the dating of series of samples - some of known age, some with associated C-14 dates or other forms of dating.

As in the C-14 labs, as samples become available, series representative of the Egyptian dynasties and of Minoan periods from Thera and related sites in Greece will be dated. Also, Prof. Watanabe is sending us series of sherds from the Jomon periods of Japan. On the basis of corresponding C-14 dates for the chronology of style changes, there is an apparent gap from 3500 to 6000 B.C.

This may be related to the problems of the changes in the C-14 inventory, and it is hoped that TL dates will answer some of the questions. There is also an apparent gap in the series from Hasanlu, Iran and adjacent sites. Since we now have 79 C-14 dates for the Hasanlu periods, we are endeavoring to obtain more TL dates.

It is planned also to date more samples of early pottery from Çatal Hüyük, Turkey.

Experiments with the dating of porcelain and other materials are planned.

A more basic experiment is also scheduled - namely, the measurement of the effectiveness of alpha particles versus beta, gammas, and x-rays in producing radiation damage. This is still an unknown factor that has been bothering TL workers for many years.

Mark Han (Research Chemist for the TL project) has Masters degrees in Chemistry and in Chemical Engineering.

C. <u>Information Center</u>

This center continues to compile abstracts and publications of articles (which appear mostly in the journals of the physical sciences) that are applicable to archaeological and anthropological research. It also publishes the MASCA Newsletter twice a year, and assists in the answering of the numerous inquiries which we receive.

Miss Flamm plans to leave in June and it is hoped that Mrs. Giegengack (B.A. in biology) can contribute more time.

This year MASCA is also editing and writing some of the chapters (E. Ralph, C-14; J. Winter and M. Han, TL; H. Michael, Dendrochronology) for a Handbook on Laboratory Techniques, to be published by the M.I.T. press. The deadline for this manuscript is Sept. 1, 1970.

D. <u>Archaeological Prospecting Instruments and Surveys</u>

1. <u>New Instruments</u>

a) A new fluxgate magnetometer (Schonstedt Model GMB-2, $2400) has recently been acquired. It weighs a total of 5 lbs., is very portable, and very fast to use where only an audio signal is required - such as for preliminary runs at a new site. Its sensitivity is comparable to a proton magnetometer (about 2 gammas). However it may have more limited depth penetration because the 2 fluxgate elements in the sensor are located only 8 inches apart. (Two, plus compensating coils are required to make it insensitive to changes in orientation.)

The first field test of it locally was encouraging. The individual brick walls of a cess pool about 1/2 meter deep were detected very clearly. Also, there was no difficulty in locating an iron water pipe 1 meter deep.

b) The Lockheed Aircraft Co. (Palo Alto) has now developed a workable fluxgate-type of magnetometer that is even smaller - the size of a small Japanese radio. Two of these units can be used to take differential readings as with our cesium magnetometer. Lockheed plans to loan us two units for trials in June and July.

c) Suggestions for the manufacture of a smaller cesium magnetometer have been proposed. It is hoped that Varian Associates will be receptive to this idea.

2. Field Surveys

Alan McPherron, archaeologist from the University of Pittsburgh, plans to use the new Schonstedt fluxgate magnetometer at neolithic sites in Yugoslavia in June and July. Many of the burned house floors at these sites are very magnetic (200 gammas or more) as determined by E. Ralph last June. Also, they are not more than a meter deep so that it is anticipated that the fluxgate will be suitable.

Magnetometer surveys are scheduled for Betty Bell's site in western Mexico in the fall.

Turkey ?

Other sites ?

We plan to train the 3 new student assistants in the use of magnetometers and in the techniques of archaeological prospecting at local sites as soon as possible - probably June or July.

E. Aerial Photography

This involves the photographing and interpretation of aerial photographs at archaeological sites. It will be a preliminary study in preparation for the photos to be taken from the Eros satellite.

It is anticipated that one student assistant (probably David Evans) will be employed at the start of this project.

NASA, Park Service, etc. - (Fro, please fill in).

F. NEW PROJECTS

1) THE METHODS OF ORGANIC CHEMISTRY IN ARCHAEOLOGY J. WINTER

The last 20 or so years have seen a quite remarkable development in the practical techniques used by the organic chemist, in particular for the investigation of mixtures and messes of previously intractable complexity. Curiously, little advantage has been taken of this so far in archaeology: such few examples of the use of modern organic chemical techniques as exist seem to be either sporadic or applied in a rather limited way. In the cognate field of sedimentary geology, on the other hand, modern methods are being applied to such questions as the origin of organic compounds in rocks and the fate of the organic component of fossils. One is therefore driven to ask if it would be advantageous to develop a capability for investigating such archaeological remains as fall in the realm of organic chemistry, taking full advantage of the sophisticated techniques now available.

General Possibilities

(1) Straight identification of "found" materials, such as gums, resins, varnishes, adhesives, pot residues. Further objectives would be: suggestion of possible sources, obtaining knowledge of old technological methods.

(2) Obtaining new kinds of evidence. E.g. the extraction of pottery finds to get information on what they were used to contain.

(3) Pushing back present limits on "the survival of the evidence" in the case of highly decomposed organic remains. This might range from trying to find "what was there" in the case of soil spots and stains to such things as systematic soil analyses in connection with studies of agriculture. It is worth noting that archaeologists are currently taking much interest in questions of ancient environment and studies of a generally "biological" nature. Since surviving material evidence must be organic in origin, it is likely that the organic chemist will find a part to play here. It is also true that work of this nature is at once long-term and more difficult to define in tangible form at the moment (though a careful and detailed study of possibilities might change this).. It is therefore suggested that, to develop laboratory capability, problems be sought at first under heads (1) and (2).

Particular possibilities that are immediately available.

(1) Identification work on vegetable resins found in Egypt, where survival conditions are particularly good. Particular interest in finding materials that had been imported.

(2) Investigation of funerary pottery in Near Eastern Section to try to identify what it was used to contain. Examples available over a range of periods.

(3) Various "isolated" identification problems are available from several sections.

Timetable

(a) The present radiocarbon lab. project involving JW extends to mid-1971; the period up to this point can be regarded as transitional. Some preliminary experimentation can be done in this time, given the purchase of at least a bare minimum of apparatus.

(b) From mid-1971, a properly funded project would be necessary.

Apparatus

The more sophisticated, and expensive, apparatus needed to apply the above techniques should be available on a time-paid basis by arrangement with members of the Chemistry Department. The Museum would need to acquire "bench" apparatus (glassware etc.), this being largely missing at present. Much of this can wait for a properly funded project, but any preliminary work would still require some purchasing during the present year.

2) Fission Track Dating

Dr. Gunther Wagner in the Department of Geology under the direction of Dr. Henry Faul (Chairman) is now pursuing studies and experiments with the technique of fission track dating. Heretofore, the precision of the method has been limited by lack of knowledge of the decay constant for the spontaneous fission of U^{238}. This can be determined with samples of glass of known age of manufacture that contain a sufficient amount of uranium. Some have already been located and others are being solicited.

This measurement and the completion of other related studies will greatly enhance the precision of fission track dating. It can be applied to archaeological dating as appropriate samples are found. For example, a pot was found recently with a piece of obsidian embedded in it. A fission track date for the obsidian would then date the firing time of the pot. In this case, it is an ideal means of cross-checking fission track and TL dating.

3) Enlargement of Radiocarbon Facilities

Also, in collaboration with the Department of Geology, it is hoped that funds can be found to add a third counter for the purpose of dating geological samples by C-14. Dr. Robert Geigengack is now preparing a grant proposal for submission to the NSF. One specific project will be the comparative dating of wood and travertine, found on encrusted logs in stream beds in the Grand Canyon.

[4/17/73]

Rock & Soil Samples from Quirigua, Guatemala

Subm. by Bill Coe & Bob Shaw
Meas. w. fluxgate magnetometer 4/17/73

QT4 - gneiss - quartz & chlorite banding
No magnetism

QT4(?) ~ decomposed granite -
very slight magnetism

QT3 - sandstone - micaeous
Practically no magnetism

QT3(?) - rhyolite with biotite
Slight magnetism

Q - soil - Front of Z #9, D = 1m
No magnetism
Rich brown, clayey soil, no sand

Only one sample, the rhyolite, had measurable magnetism. The soil too was "clean." The site may be suitable for magnetic prospecting, especially, if structures made of rhyolite are sought.

E. K. Ralph
MASCA

January 1975

MASCA

HISTORICAL BACKGROUND AND INTRODUCTION

The Museum Applied Science Center for Archaeology of the University Museum, Philadelphia, Pa., U.S.A. was initiated in 1961 by Froelich Rainey. Its aim is to apply new principles and technologies developed in the physical sciences to archaeological and anthropological research. The successful application to archaeology of carbon-14 dating, in the laboratory here (established in 1951) and in others, suggested the possibility that many other technological advances might have applications in this field. The investigation of this possibility began with work on thermoluminescent dating of pottery and on the development and use of instruments for archaeological prospecting. An information center ~~and a newsletter were~~ has been established, and a MASCA Newsletter, in which new techniques are reported, is published twice a year,

RADIOCARBON (C^{14})

An explanation of C^{14} dating and the application of tree-ring dating to the problems of radiocarbon dating are described in the attached reprint from American Scientist, Vol. 62, by E.K. Ralph and H.N. Michael entitled "Twenty-five Years of Radiocarbon Dating" (September-October 1974).

The radiocarbon laboratory, one of the few in the world that has devoted itself almost exclusively to the dating of archaeological and anthropological samples, has published over 2000 C^{14} dates, representing more than 200 archaeological sites and contributing to the establishment of chronologies for four main regions of the world--the Near East and Mediterranean regions, Central America, South America, and the Arctic. Among its intensive studies have been the correlation of the Mayan calendar with the Christian, the dating of some of the earliest sites and the elucidation of human migrations in the western Arctic, the dating of occupations and climatic sequences for what is apparently the earliest site in eastern North America, and comprehensive dating programs permitting archaeological interpretation of Mesolithic-Neolithic-Chalcolithic transitions in the Near East and the Anatolian Plateau.

A program in dendrochronology (tree-ring dating), being conducted in collaboration with the University of Arizona, is providing samples of *Sequoia gigantea* and *Pinus aristata* of known ages (back to 5400 B.C.) for C^{14} dating in an attempt to detect fluctuations in the atmospheric C^{14} inventory in the past. When the magnitude and duration of these fluctuations are known, it may be possible to correlate them with changes in cosmic-ray intensity, the intensity of the magnetic field of the earth, and/or the equilibrium conditions (the balance between the atmosphere and oceans). The C^{14} dates for these samples of known age are also providing correction factors for the dating of archaeological specimens of unknown age.

DATING OF POTTERY BY THERMOLUMINESCENCE

Research on the possibility of using thermoluminescence for dating pottery was started at the University Museum in 1959 and has been pursued actively since 1962. Significant progress made during the past few years indicates that the method will be a reliable one, possibly as good as C^{14} dating or better. It has the advantage that it dates the artifact itself (a few milligrams of pottery) rather than a charcoal or other carbon sample that is merely (and sometimes erroneously) associated with the occupation level to be dated. The method is based on the fact that particles from traces of radioactive elements in clays bombard the other constituents and raise electrons to metastable levels. When the clay is heated, enough extra energy is supplied to enable the electrons to return to normal states. In this transition each one emits a photon of light. The final heating of a ceramic is, therefore, the starting point of the metastable electron accumulation. In the laboratory, a few milligrams are ground, mounted, and heated very rapidly so that as much of the light output as possible is detected before the onset of heat radiation. The light output is detected by a photomultiplier tube, amplified, and recorded against the temperature on an X-Y recorder. The rate of radioactive bombardment is also measured. The variations among clays in susceptibility to radiation damage is corrected for by artificial bombardment with X-rays and subsequent remeasurement of the glow curve.

GEOPHYSICAL PROSPECTING INSTRUMENTS

The work of MASCA on the development of instruments for archaeological prospecting was undertaken in the light of the great need for the acceleration of locating sites and for the delineation of structures within sites already found. The destruction of many sites is imminent, due to the rapid encroachment of modern civilization. Also, with the cost of labor increasing all over the world, it is becoming impractical to excavate unless there is a certainty that structures or levels of habitation will be found. MASCA has tested a number of instruments designed for archaeological exploration.. These enclude the Elsec proton magnetometer, the Gossen Geohm, and various metal detectors and seismographs. In the course of the search for the ancient Greek city of Sybaris, buried at depths of 4-6m., it was found that proton magnetometers were not sufficiently sensitive for the detection of structures or archaeological deposits at these depths. At MASCA's request, Varian Associates designed and developed a more sensitive portable cesium magnetometer, with digital readout and differential mode of operation. This has now been tested in many field seasons and has proved to be the ideal instrument for archaeological prospecting in regions that are normally magnetically quiet and where the features sought present some contrast in magnetism. Again, it was found that the wavelengths of standard seismographs were too long to be used in finding archaeological features, usually located above much more massive geological ones. Experiments directed toward the development of a sonic instrument have produced much more information about the problems involved, but a successful portable design has not yet been achieved.

SOIL-PENETRATING RADAR

The Stanford Research Institute (SRI), Menlo Park, California has developed several sets of portable soil-penetrating radar systems. In collaboration with SRI and the National Park Service, we tested one of these systems at archaeological sites in Chaco Canyon, New Mexico. An initial analysis of the pattern of radar echoes has shown that it may be possible to detect buried walls with this new technique.

The equipment is composed of a pair of antennas which are pulled along the ground on a small cart and a portable transmitter, receiver, and data recorder. The resulting soil profiles indicate buried discontinuities within a range of depths between 0.5 and 10m. In the Spring of 1975, we plan to use this equipment to locate bristlecone pine wood buried in alluvial fans of the White Mountains in California.

INFORMATION CENTER

The MASCA Information Center maintains a catalogue of scientific techniques of value to archaeology and anthropology, consisting of abstracts of articles, references, and information on new developments culled from many publications in diverse fields, as well as unpublished material gathered from correspondence and experimental notes. A Newsletter, in which current developments in the field of techniques are reported, is published approximately two times a year. Copies are made available, free of charge, to all interested persons. The mailing list and the roster of contributors are international.

AERIAL PHOTOGRAPHY

Since 1970 we have supplemented our geophysical prospecting on the ground with experiments in aerial photography.

Aerial photographs are valuable for exploration and illustration. Undiscovered surface, underwater, or buried structures such as earthworks or building foundations can sometimes be located by aerial reconnaissance. Our primary application in this country is the search for buried remains from colonial and Indian times. These sites are often in parks and covered with grass; we can detect changes in the growth of the grass caused by underground structures best with camera filters which are dark red. Both in theory and practice, infrared photography has usually been found to be inferior.

Some of our work requires the simple recording of an archaeological site or excavation from an aerial perspective. We have used aircraft, manned and unmanned balloons, and kites for this purpose.

Shortly we will be using photographs from a satellite, ERTS-B, to help us coordinate the timing of photography from aircraft. For example, the detectability in photographs from aircraft of ancient earthworks buried beneath cultivated fields in the Thames River Valley will be synchronized with the appearance in Satellite photos of geological patterns due to old river channels.

MUD BRICK PROJECT

In many parts of the world there is a need to consolidate mud brick structures or to find a way to construct mud brick buildings in such a way that they will remain intact for long periods of time. There are also needs to preserve soft sandstone, marble, and bricks.

Experiments have been conducted both in the laboratory and in the "field" (Museum roof, Chaco Canyon, New Mexico, and at other sites in the Southwest) with acrylic emulsions and with catalyzed mixtures of methacrylate monomers. The latter show more promise for use with existing walls that are attached to damp ground and cannot be protected underneath. The acrylic emulsions, however, are cheaper and safer to use. Rhoplex E-330 (manufactured by Rohm and Haas) seems especially effective when mixed with mud in the construction of new bricks for structures or for the repair of old structures when mud is added.

PRESENT ACTIVITIES

CARBON 14 LAB

Among new activities in the C^{14} laboratory are the setting up of a benzene (C_6H_6) train and associated liquid scintillation spectrometer, and the construction of a 1-liter carbon dioxide (CO_2) counter.

Since 1956, we have been using two large (8-liter) CO_2 counters. These provide the largest practical precision in counting statistics. However, the associated electronic components consist of 20-year-old vacuum tube circuits, and even though reparable, they are subject to frequent breakdowns. Therefore, we have purchased a liquid scintillation spectrometer (Intertechnique SL-20) since these types of units are now available commercially and cost less than the electronic components and massive shielding which are necessary for gas counting, such as CO_2. However, three additional chemical steps are required to convert CO_2 to C_2H_6, and we are presently trying to perfect this conversion to obtain consistant yields. The benzene system will afford counting statistics slightly better than the 8-liter CO_2 systems.

However, with our 8-liter systems we cannot convert small samples to benzene efficiently. Therefore, we have constructed a 1-liter CO_2 counter which can be utilized to count samples of charcoal or wood that weigh only 4 grams. The counting precision will be decreased, but we shall be able to obtain "ball park" figures for these important undersized samples.

In regard to our bristlecone pine project, mentioned earlier, we plan to accelerate the finding of ancient bristlecones, ones earlier than 7400 years, in the spring (1975) field season. In collaboration with Stanford Research Institute (SRI), we plan to use their soil-penetrating radar equipment to locate fragments of bristlecone pines buried in alluvial fans of the lower slopes of the White Mountains, California-wood that has been washed down from the higher slopes and subsequently buried in past times.

Measurements made this year (1974) indicate that the dielectric constants between the pines and the surrounding alluvium are sufficiently different to provide a contrast for soul-penetrating radar.

THERMOLUMINESCENCE

Recent findings about thermoluminescent (TL) dating indicate that the process is not as simple as described previously. There are numerous complications about which we are just beginning to learn. It has been known for some time that there is the basic difficulty of particle sizes. If large and inhomogeneous, the quartz or other components which are susceptible to radiation damage will not receive the full dose of alpha irradiation because of the limited range (22 microns) of alphas in pottery. Some laboratories have circumvented this problem by separating coarse and fine grains, but with limited success.

About 20% of our TL dates for pottery earlier than classical times, that is before 1000 B.C., are deviant for other reasons. We suspect that the main cause is that the original firing temperatures were too low. Since the TL peak that we measure occurs at 350°C, we had assumed that firing temperatures of 500°C were sufficient. However, by means of Differential Thermal Analysis (DTA), we are learning that samples of pottery with deviant TL dates produce large endothermic peaks between 650° to 700° C whereas ancient pottery with TL dates consistant with C^{14} dates have very small peaks. In other words, the latter were fired originally above 650°C whereas the former were not. This problem is not insurmountable, but it means that additional calibration curves based upon original firing temperatures as well as specific TL will have to be determined.

In regard to the TL response to different types of irradiation, we have conducted a number of experiments. We found initially that betas (β) were 16% efficient and alphas (α), 10% compared with equivalent X-ray doses. More recently, we conducted a more detailed comparison of alphas (from a Po^{210} source) versus X-rays. For both we irradiated quartz separated from pottery and beach sand. The purpose of the sand was to test for any possible effect from previous radiation damage that the quartz would have received from the mineral components of the clay or pottery. None was found. For both the quartz and the sand the TL response from alpha irradiations was linear in the range tested (150 rads to 30 krads), but with X-rays it became non-linear above 10 krads and showed signs of saturation between 20 and 30 krads. We anticipate that the response to betas (inherent in pottery as well as alphas) would be similar to that of X-rays. These results are encouraging since the natural dose rarely exceeds 1 krad.

We conducted these experiments with unannealed samples (except for the original firing of the quartz from pottery) and ones annealed at 500°C and 900°C. The important result of the experiment as mentioned previously, was that we found that TL sensitivity increases with higher annealing (or firing) temperature.

Corallary studies are presently being conducted to learn more about the mineralogy of ancient clays. These include X-ray diffraction measurements and the rehydroxylation of clays.

MUD - BRICK PROJECT

As a result of MASCA's experiments with the consolidation of mud bricks and friable stone materials, Rhoplex E-330 has now been adopted by the National Park Service for use at sites in the south-western U.S.A. As a start the Park Service has purchased two tons which cost only $. When diluted to about %, this quantity will cover square meters of mud brick walls.

This same technique could be applied to mud brick structures in many parts of the world where the inhabitants are dependent upon this type of construction. If mixed with the water used to make new mud bricks, we estimate that the bricks would last times as long. This or other polymers could also be mixed with the mud used for annual patching of roofs and walls, which would probably negate the need for annual patching.