1975-76

MASCA file

STARTING DATE 1/1/1975

UNIVERSITY of PENNSYLVANIA

UNIVERSITY MUSEUM

LEGES SINE MORIBUS VANAE

Philadelphia, Pennsylvania

UNIVERSITY OF PENNSYLVANIA

PHILADELPHIA, PENNSYLVANIA 19174

PROPOSAL FOR CONTINUING RESEARCH SUPPORT

Museum Applied Science Center for Archaeology
(MASCA)

National Science Foundation

Division of Special Projects

Washington, D.C. 20550

Principal Investigator: Froelich Rainey, Director, University Museum and Professor of Anthropology 198-26-6211

School: University of Pennsylvania

Department: University Museum

Starting Date: 1 January 1975

Duration: Two Years

FUNDS REQUESTED

First Year (1/1/75 - 12/31/75):	$154,883.
Second Year (1/1/76 - 12/31/76):	$209,522.
Total, two years:	$364,405.

CORPORATE NAME OF UNIVERSITY: THE TRUSTEES OF THE UNIVERSITY OF PENNSYLVANIA (A Pennsylvania non-profit corporation)

Contracting Office: OFFICE OF RESEARCH ADMINISTRATION, Franklin Bldg., I6, University of Pennsylvania, 3451 Walnut Street, Philadelphia, Pa. 19174

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Outline of Grant Proposal for MASCA

I. INTRODUCTION

The genesis of the Museum Applied Science Center for Archaeology (MASCA) since its inception in 1961 was described in the proposal submitted in 1971 and presumably need not be repeated here. Moreover, that statement also included, in the introduction, definitions of objectives, and the scope of proposed research. In this present request for a continuation of the grant we wish to emphasize results of current research projects, specific new research to be initiated in the coming year, and certain changes in direction which have resulted from archaeological discoveries during the past two years.

MASCA, in collaboration with other research laboratories, has continued to improve the reliability and accuracy of radiocarbon dating through correlation with tree-ring records and has now produced a correction factor table most useful to archaeologists. As the record of tree-ring growth is extended (now to 8,000 years ago) correction for variability in C-14 content in the atmosphere during the past millennia is worked out in MASCA's C-14 laboratory. Hopefully the discovery of more and more ancient bristlecone pines will eventually make it possible to achieve accurate C-14 dates for the past 10,000 years.

Continued research to improve the accuracy and reliability of thermoluminescence dating has been satisfactory. This has also lead to new investigations having to do with the structure and firing temperatures of ancient pottery which not only contributed to improvement in thermoluminescence method but may lead to new methods of determining the source of clays from which the pottery is made and thus to the reconstruction of trade routes and ancient cultural exchanges.

One of the most dramatic and promising results of work on the TL method this past year has been the discovery that it is possible to date metal slags, crucial in dating the origin and development of metallurgy.

In the field of archaeological search instruments and techniques the most important new development in MASCA this past year is the discovery that ground radar can be used in archaeological prospecting. At least three commercial laboratories are now producing instruments of this kind. Discussions with those companies have resulted in arrangements to begin systematic field testing with engineers in southwestern U.S. this fall. We feel confident that light-weight, simplified, and effective instruments for archaeology can be developed. At present the cesium magnetometer (developed by Varian Associates and MASCA) is still the most sensitive and effective search device. Improved models have been produced for MASCA this year and will be tested during the coming year.

Also in this field of search equipment MASCA has carried out successful experiments in aerial photography, utilizing new films, filters, and other remote sensing devices. But the most promising development is MASCA's arrangement with NASA to carry out the first experiment in remote sensing for archaeology from a satellite.

Another research project of MASCA which has produced very satisfactory results this year is the preservation of adobe or mud brick structures which have been exposed by archaeological excavation in many regions of the world. Chemical experiments in the laboratory and field testing, in collaboration with the Park Service and the Rohm and Haas Company, have resulted in chemical treatments which are inexpensive and effective. Additional field testing in the Near East, where there are so many mud brick structures to be preserved, will continue next year. This is one of the major problems in archaeological conservation and, after intermittent experiments over many years, a practical solution has been worked out.

The recent archaeological discoveries that now lead to new research for MASCA have taken place in southeastern Asia.There, at Ban Chiang in northeastern Thailand a University Museum expedition, in collaboration with the Thai Department of Fine Arts, is currently excavating a large cemetery containing what appears to be the earliest bronze objects ever discovered (ca. 4500 B.C.). Moreover it has been discovered that copper and tin were available to ancient people in the same locality, a very rare circumstance which may account for the original development of metallurgy in Thailand. There are many ancient slag deposits in the region, which can now be dated (see above). These early bronzes are high in tin content and demonstrate a sophisticated casting technique. The bronzes and the slag contain other metals, such as lead, which were also utilized by the ancient Thai. Moreover, there is a later iron age at Ban Chiang which may also turn out to be the earliest known work in iron.

The large quantity of metals at Ban Chiang and the slag deposits in Northeast Thailand, as well as the age, are leading MASCA research into analysis and identification of materials in order to learn more about the composition and technique of manufacture by the ancient Thai. This links up with the use and development of new techniques for the analysis of ancient pottery, such as X-ray diffraction studies, and should lead to an understanding of the earliest metallurgy, a fundamental technique in the development of civilized living. Two professors at the University of Pennsylvania, now working with MASCA, Robert Maddin and James Muhly, are specialists in ancient metallurgy and can carry out the interpretation of analysis made by MASCA.

It should be emphasized that the extraordinary discoveries now being made in Thailand are a direct result of MASCA's dating, with thermoluminescence. of a particular kind of pottery, found at Ban Chiang two or three years ago, which was associated in graves with bronze objects. That lead the University Museum to excavate at the site and to the present intensive study of early metallurgy.

II. Explanation of Present and Past Activities of MASCA

A. Radiocarbon Laboratory and Dendrochronology

The foundation of MASCA began in 1951 with the establishment of the radiocarbon dating laboratory, two years after the success of the method was announced by Willard Libby. Since then thousands of C^{14} dates for series of archaeological and anthropological samples have been obtained.

During the past 15 years we have also been dating tree-ring-dated sequoias and bristlecone pines in collaboration with the Laboratory of Tree-Ring Research, University of Arizona. The results of these studies were published both as calibration curves and in tabular form in "Radiocarbon Dates and Reality" (MASCA Newsletter, Vol. 9, No. 1, August 1973). Three thousand copies of this issue have been distributed and the MASCA calibration curve(and tables) are now widely accepted as the best means of correcting C^{14} dates. For example, around 4000 B.C. the discrepancy between C^{14} and dendro-dates is an much as 10 percent. Since publication of the Newsletter, more C^{14} dates for tree-ring-dated bristlecone pines have been obtained. Some of these fill gaps in the calibration curve; others will soon provide a 1000-year extension of the dendro-scale to approximately 8200 B.P. (Before Present).

Henry Michael has conducted extensive field work in the bristlecone pine area of Southeastern California this summer to search for even earlier bristlecone pine remnants that have been washed down the mountainsides and become buried in alluvial fans. For over a month (June-July) he has been sending samples gathered from the canyon floors. From these samples we have been obtaining, almost daily, "quickie" C^{14} dates to determine the "ball park" ages of the bristlecones. So far, none is earlier than 4200 B.P., and indications are that the oldest wood is unlikely to be found in canyons because they are periodically (that is, every several hundred years) cleaned of most accumulated debris by severe cloud bursts that occur over their drainages. (Beaty, C. B., 1970, Age and estimated rate of accumulation of an alluvial fan, White Mountains, California, U.S.A. American Journal of Science, Vol. 268, pp 50-77). This negative information will aid in the search for earlier tree-ring samples during contemplated field work next year when we will examine the alluvial fans upon and into which the canyon debris, including wood, is deposited. (This work is supported by NSF Grant GA-12572, Division of Earth Sciences).

Peter Kuniholm, whom we instructed in the techniques of dendrochronology, has made significant progress toward the creation of a dendrochronological scale for central Anatolia. His interim report is included here.

DESCRIPTION OF RESEARCH PROJECT IN TURKEY 1973-1974: THE DENDROCHRONOLOGY OF GORDION AND THE ANATOLIAN PLATEAU

by Peter Ian Kuniholm

Using the 806-year sequence of tree-rings provided by the logs in the Midas Mound Tumulus at Gordion as a starting point, I have been trying to build a relative (and eventually, perhaps, an absolute) master tree-ring chronology for the Anatolian Plateau. With the cooperation of the Turkish Department of Antiquities and Museums, I have set up equipment (provided by MASCA at the University Museum, Philadelphia,) for tree-ring analysis in the laboratory of the Museum of Anatolian Cultures in Ankara. Over 110 wood and charcoal samples have been collected at the museum during the past five months, and more are promised.

The Turkish Department of Forestry and its Research Institute have supplied information about modern long-lived trees throughout Anatolia. The oldest sample I have collected is 404 years old, and I have just been informed of the arrival of a 750-year old sample at the forestry station at Saimbeyli. This work with modern trees has interested Prof. Burhan Aytuğ of the Forestry Faculty of Istanbul University who has said he will start assigning dendrochronological theses to his students so that Anatolia can be studied on a regional basis. The Turkish Meteorological Service has also shown interest in this project as its records do not antedate 1926. The climatological information provided by systematic collection and analysis of specimens from all over the plateau should enable the Service to make better projections of past climatic conditions.

The Department of Religious Foundations and its Conservation Section have donated a XVth century timber from a mosque door and have promised more Ottoman and even Selcuk examples from their 1974 restoration season. Old houses in the Ankara citadel are being searched for old timbers. This should assure an extension of the tree-ring chronology well into the first millennium, A.D.

Samples have come from the following archaeological excavations: Gordion (Phrygian and Persian periods); Boğazköy and Eskiyapar (both Phrygian); Adilcevaz (Urartian, from a palace erected by King Rusa II, 685-645 B.C.); Masat (Late Hittite); and Acemhüyük (Kültepe Ib period). Samples from Kültepe have arrived in Ankara and are to be delivered shortly. Pieces from the Phrygian tumuli at Ankara are also promised.

Both Hacettepe University and the Middle East Technical University in Ankara are setting up radiocarbon laboratories. Dr. Mehmet Ergin, the director of the Hacettepe laboratory, has assigned one of his assistants to help me twice a week and to learn as much as he can about dendrochronolgoy. Dr. Ergin hopes to have as many samples as possible tree-ring dated before they undergo radiocarbon analysis. We would like eventually to be able to provide a check on the bristlecone pine corrections to radiocarbon dating.

All this is necessarily a long-term project. We will need many Byzantine and Roman samples if we are ever to achieve an absolute chronology. But the machinery of the collection, analysis, and storage system is in operation, and as the "wood library" builds up and the ring readings are filed (some 16,000 so far), local and regional patterns are becoming more recognizable. I expect to be able to supply evidence of cross-dating between sites within the present academic year.

B. Thermoluminescence and Related Studies.

1. TL Dating and Experiments with Pottery.

During the past 18 months,100 thermoluminescence (TL) dates have been obtained. Artifacts and sherds have come from sites in Turkey, Africa, Mexico, China, Iran Thailand, Greece, South Pacific Islands, Cyprus, Italy, Egypt, and the U.S.A.

The counting capacity for inherent alphas (an essentail part of TL dating) has been increased with the replacement of three non-functional scalers (loaned by Harshaw Chemical Co. for demonstration) by four new ones (purchased from the same company). We now have a total of nine operational counters, which has greatly speeded up the number of samples that can be counted simultaneously. Since the rates of natural alpha emissions are low (normally, 10 to 30 counts per hour), this is the "slowest" step of the total TL measurement. Each sample must be counted for about one week to reduce the statistical uncertainty in the counting rate.

Various minor experiments directed toward the reduction of the size of the sample required for alpha counting have been conducted. So far none has succeeded without loss in counting precision. Experiments are continuing with a new and more uniform type of ZnS screen.

A second TL apparatus has been installed with an especially selected EMI photomultiplier. With this the sensitivity of detection of TL is increased 4-fold. This enables us to detect weaker TL signals. However, with the greater sensitivity, there is a problem in suppressing background noise.

About 20% all thermoluminescent (TL) dates are outside of statistical expectations and a few are extremely deviant, mostly on the too-early side. Therefore, we are continuing to conduct a number of experiments to find out why. The main ones so far fall under two headings:

1. Response of quartz, etc. (The components of clays which produce the TL) to different types of radiation.

2. Determination of the firing temperatures of ancient clays (if fired at too low a temperature ceramics would retain some of the geologic TL of the clays).

1. Response of Quartz

Samples of both clay (which contains quartz) and beach sand (mostly pure quartz and feldspar) were exposed to varying doses of both alpha particles (from a Po^{210} source) and X-rays. Exposures were given to un-annealed samples and to ones annealed at 500°C and 900°C. The purpose of the experiments with pure sand was to determine if any change in susceptibility was the result of accumulated natural alpha dosage (from the traces of uranium and thorium in clays) that the samples had experienced throughout their archaeological time-scale. The results are as follows:

a. Quartz mixed with pottery

1) α(alpha) doses - from 2 to 13 krads (and to 48 krads for the 900°C sample). Response of all was linear, and there were no significant changes in sensitivity as determined with a 100 - rad test dose, before and after each large dose.

2) X-ray doses - from 1 to 60 krads. Not annealed: response was non-linear and increased up to 70%. 500° and 900°. annealed: response was not linear: the sensitivity increased 50 to 60% at 10 krads and then levelled off.

b. Beach sand.

1) α doses from 6 to 33 krads; not annealed: no increase in sensitivity. 500° annealed: possible 20% increase in sensitivity, but barely significant. 900° annealed: no increase in sensitivity.

2) X-ray doses - from 1 to 30 krads not annealed: no significant increase in sensitivity. 500° and 900° annealed: response was not linear and the sensitivity increased 40 to 50% between 3 and 10 krads and then levelled off.

We conclude from these experiments that the response to alpha doses is linear and that there is no increase in sensitivity due to radiation damage (from alphas) in the ranges covered. Since the majority of the radioactive particles in clays are alphas, it does not appear that these effects (or lack of them) are the sources of error in dating pottery. It is interesting to note, however, that when both types of samples are exposed to X-rays there is a non-linear response.

We note also that there was no significant difference between the quartz in clays and fairly pure beach sand. Therefore, doses of alphas over long periods of time apparently do not cause a non-linear effect. The difference between the quartz in clays and beach sand samples, so-called "not annealed," is not surprising since the clay was fired (or annealed) at the time when the pottery was made.

II. B 2. Determination of Annealing Temperatures

Experiments directed toward the determination of annealing (or firing) temperatures of ancient pottery are described by Gary Carriveau in the attached MASCA Newsletter, vol. 10, No. 1 (July 1974), p 3.

II. B 3. Determination of Potassium in Pottery

For the determination of the radioactive isotope K^{40} (a fixed fraction of the total K content) in pottery, a flame photometer has been acquired. In this technique the light emitted by the desired elements at their characteristic wavelength is measured. Physically, the electrons in the outer orbit of the atom are raised to higher energy states by the heat and, as they return to their original ground state, energy is released in the form of light. The measurement is made electronically, calculated against a standard, and the concentration is shown on a read-out scale. This technique is universally agreed to be the best for determination of potassium and sodium in all materials. The overwhelming majority of routine potassium determinations are done on human blood serum, and flame photometers for this purpose have been brought to a high degree of accuracy and ease of use.

Because of the difficulty of achieving an absolutely constant flame due to minor variations in ambient conditions, all modern flame photometers use the principle of the internal standard. A specified amount of lithium diluent is added to each sample, including the standards and blanks, and the ratio of the lithium to potassium is measured. This procedure eliminates many sources of error.

It is fortuitous, perhaps, that clay contains approximately one tenth the potassium found in an equivalent amount of blood serium. By making a 1:20 dilution of the fused sample solution and reading it against the classical 1:200 serum standard dilution, the readings are brought into the best range of the scale, final calculations are simplified, and the performance of the instrument can be checked, if necessary, against easily available samples of known potassium content. Since the fusions are made with lithium metaborate, this must be accounted for in the aliquot of lithium diluent added.

Four U.S.G.S. samples of known potassium content, fused and diluted exactly as were the unknowns, are run with each batch as quality control.

To date, about 120 samples have been fused and analysed for potassium concentration. Several of the fusions have been checked two or three times, and the readings are very consistent, with the variation usually only in the second decimal place. The percentage of total potassium measured usually falls in the range of 1 to 2%, but levels as low as 0.4% and as high as 3.83% have been encountered.

From this information for samples of known age, we are now evaluating the relative effects of K^{40} (a beta emitter) versus the combined alpha rate from U^{238} and Th^{232} in clays in order to apply these analyses as corrections in the calculation of specific TL for samples of unknown age.

II. B. 4 TL Dating of Metal Slags

The new technique of dating metal slags by TL is described by Gary Carriveau in the attached MASCA Newsletter Vol. 10, No. 1 (July 1974), pp. 1-2.

II. C. Studies of Prehistoric Metallurgy and Metallography.

Great interest in prehistoric metallurgy in Southeast Asia has prompted us to establish a project dealing with elemental analysis and metallography of ancient metals and slag.

Using a variety of analytical techniques, including emission spectroscopy, X-ray fluorescence, electron probe and scanning electron microscopy, we have analyzed a large number of metal and slag samples from Thailand. The results of analyses of chemical compositions indicate that there existed a good knowledge of bronze metallurgy at a very early date, perhaps the earliest is the Old World.

In addition, metallographic studies were performed using the scanning electron microscope and optical microscopy. Results indicate that most objects studied were cast and that sulfide ores were used to smelt the copper in some cases.

The results of these analyses are being employed to determine the 'recipe' of bronze alloying; trace element analysis will be used to study the source of the metals. Metallographic studies give a clear indication of how the objects were manufactured.

II. D. Archaeological Prospecting

North America

At the nearby Valley Forge State Park, a geophysical instrument test site has been selected in an area of possible buried earthworks and living quarters from the time of the Revolutionary War. Our cesium magnetometer was used first to test a 30 meter square grid. The same grid was then mapped with a gamma ray spectrometer,Geometrics Model DISA-300. The Geonics Electromagnetic Detector, Model EM15, was also tried but was found to lack sensitivity and repeatability. The pattern of anomalies in the radioactivity map as measured with the gamma ray spectrometer appears to be completely uncorrelated with the pattern of the magnetic map; since this region may be excavated this summer, we hope to be able to compare the detection capabilities of the two instruments.

A geophysical survey was conducted in collaboration with Dr. Mary Ellen Wagner of the Department of Geology in Chester County, Pa., near Sugartown. We detected enormous anomalies, sometimes greater than 100,000 gammas. (The Earth's normal field is approximately 50,000 gammas.) These were probably caused by magnetite bodies in Precambrian dikes of diabase. Since the anomalies were so strong it is anticipated that they are close to the surface; test excavations this summer will provide the answer.

Our two cesium magnetometers are now being rebuilt in order to replace obsolete components and others that have broken down in the course of use in the field. (We had planned to purchase at least one new magnetometer, but we found the cost to be four times the amount that we had budgeted.)

In the interim of the rebuilding, we conducted a resistivity survey on the grounds of the Corbit-Sharp House in Odessa, Delaware to detect buildings and paths that had disappeared. We plan to do a more extensive survey there with the magnetometers later this summer.

One of the purposes of these three local surveys was to train our graduate students and other staff members in the use of geophysical prospecting instruments.

In collaboration with the Canadian National Historic Parks and Sites Branch, we plan to survey three promising sites with the cesium magnetometers during the summer - namely, Fort George National Historic Park, Les Vieilles Forges, and Fort Walsh National Historic Park.

Egypt and Greece

The extensive cesium magnetometer survey conducted at Malkata, Egypt was summarized in our nine-month report. It is now presented in greater detail, with figures, in our attached MASCA Newsletter, Vol. 9, No. 2 (December 1973).

In September we are planning to do a magnetometer survey on the island of Paros in Greece, to search for the capital of ancient Paros. This is an exciting challenge at a site that seems to be suitable for magnetic prospecting. The request was initiated by Demetrius Schilardi (a PhD candidate at Princeton University) who has worked at and studied the site. He expects to obtain the approval of Professor N. Kontoleon, the new Director General of Antiquities, when he returns to Greece in July.

New Instruments

A new and potentially valuable instrument for archaeological reconnaissance is based upon soil-penetrating radar. While radar is about 25 years old now, it is only now that very portable, high resolution radars are being designed with antennas for transmission into the ground. These radar systems are, in principle, like the older atmospheric radars except that the antennas are very near the surface of the soil: a very short electromagnetic pulse is transmitted into the earth; discontinuities in the soil caused by buried walls and earthworks reflect part of the pulse back to the radar receiver. The echo time indicates depth and the pattern of echoes over an area indicates the shape of whatever is below.

Several companies are currently developing these radar systems. The Calspan Corporation in Buffalo, New York has a subsurface radar which gives precise indications of buried objects in the top meter of soil. The Electromagnetic Subsurface Profiling system developed by Geophysical Survey Systems in North Billerica, Massachusetts has its best detection range between one and four meters beneath the surface. The electromagnetic sounder which has been built by the Stanford Research Institute in Menlo Park, California appears to be suitable for depths of up to 50 meters.

While the use of these radar systems may be slower than magnetic prospecting, one big advantage is the capability of detecting tombs, voids, etc. in non-magnetic rock formations, or other features where there is not a magnetic contrast between structures and soil.

The radar systems may even have such diverse capabilities as the detection of ancient bristlecone pine trunks buried under alluvial fans in the White Mountains of California. Bill Beatty, senior geologist at Stanford Research Institute, joined our colleague Henry Michael in this area this summer to collect samples of the alluvial fans to assess RF losses and the feasibility of using the new equipment for this purpose.

II. E. Aerial Photography.

A camera-lofting kite has been constructed; it is a suitcase-portable technique for aerial photography from 500 feet above archaeological excavations. A new tetrahedral suspension for the camera allows nearly vertical photos with minimum swaying of the camera. In further work we will try to make this equipment even more portable and inexpensive.

One of the most difficult jobs in aerial photography is the reconnaissance for archaeological sites beneath cultivated grass, but this is a common problem with much of colonial archaeology and at many of our national parks. The difficulty is a result of the shallow roots of the grass which do not usually penetrate into the archaeological zone; therefore the growth of the grass is less affected by the altered soil there.

The maximum detectability of these faint traces has been found to be possible by combining a panchromatic black and white film with a dark red filter. This has been found to be superior to other filter combinations; it is also better than infrared film. Two nearby locations have been the primary test sites for these experiments in aerial photograph: Valley Forge State Park, and near the Lemon Hill mansion of Fairmount Park in Philadelphia. Four flights over these sites have been made already; several more will be required for a check on the time and weather factors which also influence the visibility of the markings in the vegetation.

Stereo viewing of oblique aerial photographs has normally been found to be difficult. Some simple rules have been developed for stereo photography; for example, when flying at 100 miles per hour and 1000 feet above the ground, an interval between photos of one second is desirable.

A session on technical photography was presented at this Museum's Kintner Photographic Workshop. Aerial photography, stereo photography, and infrared and ultraviolet photography were discussed in a four hour lecture.

In addition to the rental of small aircraft, funds for aerial photography have gone toward the purchase of equipment for taking photographs from a kite. This included the Jalbert Airfoil, the Robot Royal spring-advanced camera, and both radio and electrical cable remote triggers for the camera.

II. F. Mud Brick Project.

The search continues for a method of protecting and conserving mud brick structures, walls, and remnants thereof. Chemical modification of adobe mud for brick manufacture or wall restoration is also a part of the project. Work has been done in an attempt to preserve soft sandstone, marble, and bricks.

Acrylic emulsions sprayed on baseball-sized chunks of adobe blocks in laboratory tests have produced rubbery surface coatings that adhere tightly, resist destruction by heavy showering for 30-40 hours, and have withstood outside exposure in Philadelphia for 22 months (two winters).

Incorporation of these emulsions into powdered adobe soil to make a mud cake gives a hard, tough, water-repellent dried mud cake that is not destroyed by heavy showering for hours and continues to withstand outdoor exposure after more than ten months.

Field trials of these emulsions have indicated excellent performance in mud incorporation. The Ruins Stabilization group at Chaco Canyon has done extensive testing with Rhoplex E-330 and is currently planning to adopt it for their restoration work.

As a spray-on treatment for existing structures the acrylic emulsions were only partially successful. Where there was a firm foundation soil the film anchored fairly well and is holding up through the first year even under serious erosion adjacent to the test area. Where the walls were soft (at Pecos National Monument) the film did not anchor adequately and the test failed.

Spray-on emulsions on soft Chaco sandstone walls gave good protection above ground but did not stop the serious deterioration of the soft foundation stones at the bottom of the walls. It should be noted that freeze-thaw cycling of this soft, untreated sandstone in the laboratory gives a firm stone after 10 cycles but a soft and mushy stone after 25 cycles. On the other hand, Rhoplex E-826 emulsion-treated stone shows no deterioration after 57 cycles of freezing and thawing.

Emulsion-treated soft underfired bricks from the Park Service show no deterioration after 57 freeze-thaw cycles. Untreated samples begin to show failure between 25 and 57 cycles.

It appears that ground water is a serious cause of destruction of both stone and adobe walls. A ground water simulator was set up in the laboratory to study this problem. Water was drawn through stone and adobe samples by means of capillary action and then evaporated in a warm air current. Thirty days of continuous evaporative action showed that untreated adobe grows typical salt deposits on the surface and produces a friable, powdery surface that dusts off readily when dry, much as does an adobe wall in the desert.

Emulsion-soaked adobe clods do not transmit water and do not grow salt crystals. Emulsion-soaked adobe clods when cut in half to expose the untreated cut side to "ground water" grew crystals on the outside of the resin film, but the film remained intact and firm after drying. Untreated Chaco sandstone degrades to little more than hard-packed sand in 30 days. In contrast, acrylic emulsion-treated stone did not transmit water or grow salt crystals. If a cut piece of stone with an untreated core was exposed, a small amount of salt growth occurred on the surface but the stone surface was hard and firm when the salt was dissolved away.

While these laboratory ground water tests were not borne out in the single field trial at Chaco Canyon, there still appears to be hope of success if we can devise a better method of application.

Emulsion-sprayed adobe clods have been subjected to abrasion testing with a small laboratory sand blaster. Untreated pieces were eroded rapidly, in 5-10 seconds. Sprayed pieces withstood the abrasive jet action for more than three minutes, showing only a slight darkening of the surface.

Several deteriortating stone sculpture pieces are undergoing an outdoor test in the Museum courtyard. These have been sprayed with acrylic emulsion of very small particle size. No appreciable gloss was imparted, and after 10 months of exposure to the weather no dusting off of stone particles is occurring, even though untreated companion pieces are continuing to dust off. A city soiling effect is being experienced because of the soft polymer used in this small particle size formulation. A harder polymer variety is to be used in subsequent tests.

With all of the spray-on tests with emulsion, depth of penetration has not been enough to fully anchor the film. New field trials were set up at Chaco Canyon this summer, using more dilute materials and a "soak in place" technique. We may find that adequate surface rain resistance will still be achieved but the deeper penetration (1/2 to 3/4 inch) will help hold the surface layers in place.

Another approach that is under investigation in the laboratory and is under field test at Chaco Canyon is a surface soak with a catalyzed mixture of methacrylate monomers. These soak in readily to a depth of 1.5 - 2.0 inches before polymerization sets in (about 15-20 minutes). After 30-60 minutes the adobe test clod is hard and rock-like. It is generally non-wetting and is completely resistant to showering at 1200 inches of rainfall per hour. A subsequent soak or spray with dilute acrylic emulsion produces a clod that should be quite resistant to all weathering.

While this technique is relatively easy to use in the laboratory, it does present a few problems for field use. Heavy rains at Chaco Canyon produced damp soil under the first one-half inch of dry surface. For proper penetration bone dry soil is a requirement. Either a water tolerant monomer system or a method of keeping the test area dry will need to be worked out for subsequent tests.

Summary - Mud Brick Conservation Project. Author: D. J. Butterbaugh

The Ruins Stabilization group at Chaco Canyon is very pleased with the use of Rhoplex E-330 in their grouting mud and wall capping mud. They have purchased one ton of emulsion concentrate and are conducting large scale trials, expecting to adopt this chemical as a standard material for all their ruins stabilization and restoration work.

Rhoplex E-330 alone and in conjunction with silicone water proofer has given promising performance for one year on the walls of the pit house dug last year. Rhoplex E-826 and E-863 are both failing after one year and will not be adequate.

II. G. Information Center.

The purposes of the Information Center are: (1) to cover current publications for new ideas and new applications of the physical sciences in anthropology and archaeology, (2) to obtain copies of the most useful articles in current journals for the files in the Information Center, (3) to write abstracts of those articles and keep a card file which gives details of the abstracts and articles available in the Center, (4) to operate and enlarge the Center's library, (5) to conduct library research on topics requested by staff members, and (6) to edit a Newsletter concerned with new techniques.

Since the last report, the following has been accomplished. Four new journals are being surveyed routinely. This brings the total number to thirty-nine. These include journals in French, German, Spanish, Portugese, and Italian.

We have subscribed to a computer service (ASCA) which surveys over 2500 journals for titles of articles which contain one of fifteen key words selected by the bibliographer. A weekly report which lists all such articles is received by the Information Center so that the articles can be located and abstracted. With the aid of the computer, almost all literature in the physical sciences, written in the major western languages, is covered by the Information Center. The computer service has located approximately 150 articles of interest to the Center during the seven months the service has been in operation. An estimated total of 300 articles have been collected and abstracted since the period of the last grant report.

Since the last report thirty additional books have been purchased for the Center's library. There has been special attention to an enlarged section on analytical techniques and more material on the history of human ecology and on climatology.

Three library searches have been conducted. One was concerned with analytical techniques for determining the level of lead in the human body; this was with reference to changing levels of lead in different cultures and varying ancient technologies. Another search was an effort to find geological, magnetic or astrophysical periodicities which might affect the levels of radiocarbon in the atmosphere. A third search sought information on indicators of past climate contained in arctic tree-rings.

Another Newsletter (Vol. 9, No. 2) has been published since the last report, and Vol. 10, No. 1 is in press for publication in the summer of 1974. The Newsletters have been larger than were previous issues and they have contained significant, original reports, as well as reviews of developments in the field of science in archaeology. New requests for copies of the Newsletter have been averaging ten a week, and the number of subscribers has grown from about 2000 to over 2500.

In addition to these activities of the research bibliographer and the administrative assistant, the latter has assisted with many diverse activities. One main project was the search for, evaluation, and the plotting of 140 C^{14} dates for samples representative of Egyptian dynasties. As a result of this, it was found that approximately 85% of the C^{14} dates corrected with the MASCA factors are in agreement with the Egyptian chronology.

III. Plans for the Future

A. Radiocarbon Laboratory and Dendrochronology

We plan to continue the dating of series of samples from University Museum - sponsored and other excavations. This archaeological dating program and the dating of a few geological samples are supported by the University of Pennsylvania.

With the expectation that NSF Grant GA-12572 (Earth Sciences Division) will be renewed, we plan to continue the dating of bristlecone pines, especially, samples in the range of 8200 B.P. and earlier.

A more extensive search for earlier bristlecone pines including excavation will be conducted next summer (1975). We have just received word from Stanford Research Institute that the dielectric constant of bristlecone pines is sufficiently lower than the surrounding soil and other debris of alluvial fans. This means that there is a good chance of finding more deeply buried and older bristlecone pines with the new soil-penetrating radar equipment.

Among new activities in the C^{14} laboratory are the setting up of a benzene train for liquid scintillation counting and the construction of a 1-liter carbon dioxide counter for the counting of small samples, ones which contain only 2 grams of carbon.

B. Thermoluminescence and Related Studies

The dating of sherds from archaeological excavations as well as fired ceramic artifacts from known provenience will be continued. Also, the basic experiments directed toward finding the cause of deviant TL dates, of improving the certainty of the dates and of determining firing temperatures will be conducted. For each TL date, potassium analyses are now done routinely.

The determination of firing temperatures by X-ray diffraction as well as basic experiments to learn more about the structures of clays are described as follows:

1. X-Ray Diffraction

X-ray diffraction patterns afford a means of studying the atomic structure of crystalline materials. Crystals form three-dimensional diffraction gratings for x-rays, and a pattern can be interpreted in terms of the atomic arrangement of the crystal. A powder of crystalline particles in random orientation or a single crystal rotated through multiple orientations will produce a diffraction pattern which is registered on photographic film as sharp lines, or on recorder chart paper as a series of peaks. The positions of the lines or peaks correlate with planes of atoms in the cyrstal, the symmetry and spacing of these being unique to each pure chemical or compound.

X-ray diffraction analysis has been used extensively in the study of clay minerals, but infrequently has it been applied to prehistoric pottery. However, one may discern the changes in and destruction of the crystal structure of clays upon heating. As different types of clay minerals exhibit characteristic types of decomposition and recrystallization at various elevated temperatures, x-ray diffraction analysis can be used to define upper and lower limits in the firing temperature of the potsherds under study. In some cases, x-ray diffraction may also be used to identify a particular clay mineral as well as the aplastic tempering material, and thus sources of the raw material may be determined. Where only very small samples are available, or where a single grain of aplastic material must be characterized, the Gandolfi camera, which produces an x-ray diffraction powder pattern from a single crystal, is essential.

2. X-Ray Diffraction Studies and Hydrothermal Reconstitution of Clay Minerals in Primitive Pottery

The clay minerals are a complex group of hydrous alumino-silicates whose thermal behavior forms the basis of ceramic technology. Clays will lose interlayer water (if present) and physically adsorbed water at 100-200^{o}C; at 400-600^{o}C chemically bound water (hydroxyl) is driven off and the crystal structure partially collapses. Between 800 and 1000^{o}C thermal energy is sufficient to allow recrystallization into the stable refractory oxides, and mullite, spinel, cristobalite, and γ-Al_2O_3 may appear. From 1000-1300^{o}C vitrification occurs. The precise temperatures at which these various reactions take place will vary according to the identity of the clay minerals present. Firing to 500-800^{o}C, the range typical of most primitive pottery (earthenware), is usually sufficient to dehydroxylate the clays but insufficient to recrystallize them into oxides. They are left in a "meta-" state characterized by lack of long-range crystalline order but presence of a high degree of short-range atomic order.

We propose to study the progressive thermal decomposition of clay minerals and of mixtures characteristic of potters' clays by observing changes in the precise X-ray powder diffraction patterns of clays fired at different temperatures. In addition, we will attempt to reconstitute the original clays by hydrothermal recrystallization and to study their refiring characteristics. These studies may provide a method for determining the mineralogy and relative proportions of clays in the original potter's clay of ancient sherds. This in turn will be valuable in locating source areas for the raw materials and, combined with X-ray and refiring data, will enable limits to be placed on the original firing temperature of sherds.

References:

Grim, Ralph E. (1968)
Clay Mineralogy, second edition
McGraw-Hill Book Company, New York

Brown, George (ed.) (1961)
The X-ray Identification and Crystal Structures of Clay Minerals
Mineralogical Society, London

Roy, R. and G. W. Brindley (1956)
A Study of the Hydrothermal Reconstruction of the Kaolin Minerals
Nat. Acad. Sci. Publ. 456, 125-132.

3. Irradiations

Since we did find (section II.B.1) that the response of quartz in clays was non-linear for X-rays, but linear for alphas these experiments will be continued with exposures to a strong beta source (Sr^{90}). The natural doses in clays come from both alphas and betas plus a small contribution from cosmic rays. In the initial experiments, X-rays were used for convenience since an X-ray generator is available.

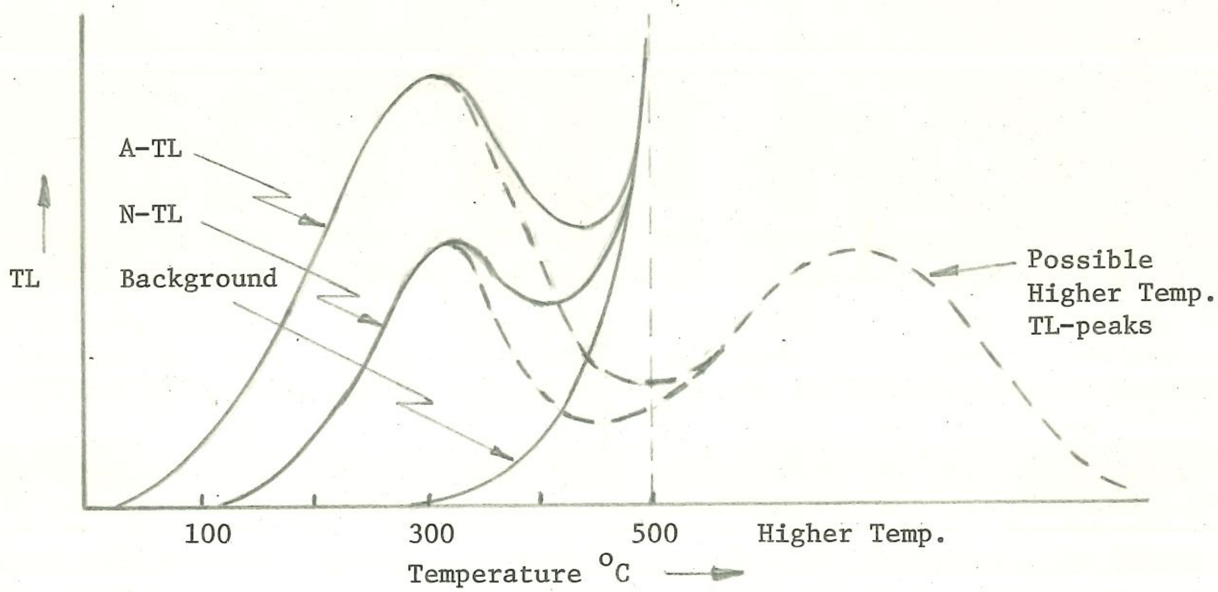
4. Photon Counting

Because the background noise is one of the main causes of the statistical uncertainty of the TL measurements we have ordered (in August 1974) equipment for photon counting. With this technique, only the photons of light (emitted as the pottery is heated) are counted and in this way the noise is negated. (With the present apparatus, the photon ouput is amplified and recorded as a D.C. current).

It will be necessary to experiment initially with the new photon equipment to determine the most reliable ways to schedule the timing, the method of recording the output, etc. We anticipate that by greatly increasing the signal to noise ratio that we shall be able to detect much weaker TL signals such as those from slags; and for all measurements the statistical uncertainties will be reduced. With increased sensitivity, filters can be installed to reduce the background of infrared heat radiation.

5. Cause of Deviant TL Dates

We plan to continue the vital search for the cause of deviant TL dates. One new approach is to look for higher temperature peaks, which we expect to be possible with the photon counting equipment. This is illustrated in the sketch below:



The theory postulated is that over long periods of time, there may be a reallocation of trapping centers that are radiation-induced, or some form of optical bleaching.

We plan to give samples artificial doses and then bleach them with UV (ultraviolet light). If there are deeper traps, UV tends to make them more sensitive to artificial doses.

6. Determination of Firing Temperatures of Ancient Clays

Some basic experiments which we performed are described by Gary Carriveau in the attached MASCA Newsletter vol. 10, no. 1 (July 10, 1974) p. 3.

More recently we have found that measuring weight loss and possibly also changes in dimensions is not a true indicator of past firing temperatures. The heating up to $100^{\circ}C$ removes absorbed water vapor, but at higher temperatures it removes the more rigidly fixed hydroxyl ions. However even when the pottery is stored thereafter at room temperature, the hydroxyl ions reappear within a matter of months. Therefore, the removal is temporary and not an indicator of firing temperatures in the past.

We are now starting X-ray diffraction studies as described in section III B. 2 .

7. TL Dating of Metal - Working Tools and Metal Slags

The dating of slags by TL is an entirely new technique at MASCA, and it may become a significant "breakthrough" in the dating of metals or at least metal slags.

The results and the method of dating a sample of slag from Spain are described by Gary Carriveau in the attached Newsletter, vol. 10, no. 1 (July 10, 1974) p.1-2 . The specific results of dating an iron slag and sherds for comparison from Thailand (mentioned in the article) are as follows:

Iron slag TL date = 870 ± 420 B.C.

Pottery sherd TL date = 510 ± 370 B.C.

Crucible sherd TL date =1040 ± 370 B.C.

More recently two halves of a ceramic crucible from Non Nok Tha, Thailand gave an average date of 1020 ± 520 B.C. An associated C^{14} date (MASCA corrected) is 965 ± 100 B.C. In this case, the agreement is excellent.

C. Archaeological Prospecting

1. Radar

In addition to the possible use of the new soil-penetrating radar to locate bristlecone pines, we plan to test the equipment at Chaco Canyon this fall (1974) at archaeological sites. If successful, other tests will be made with the hope that portable equipment can be developed for our archaeological applications.

2. Cesium Magnetometers

The reconstructed cesium magnetometers will be employed extensively in the U.S.A., Canada, Egypt, and at other sites.

3. Other Prospecting Equipment

We plan to continue the search for other techniques suitable for archaeological prospecting.

D. Aerial Photography

Experiments are now underway to develop photographic techniques for mapping the contour lines which show the depth of small archaeological objects. This accurate way of showing shapes and volumes has normally required elaborate and costly photogrammetric instruments; several novel techniques which have recently been published would also be valuable for archaeologists.

For the very best aerial photos of vegetational patterns, it is planned to try either a specifically-designed filter or a multiband camera. The measurement of the reflectance of these anomalous growth patterns with a spectroradiometer is an important step in optimizing the filter characteristics.

A further improvement in the resolution of the aerial photos of national park and early American sites would be possible by using a camera with a larger film size, possibly a four by five inch format.

A detailed report on aerial photography is now being prepared; this publication describes new procedures which will aid archaeological reconnaissance and mapping using kites, balloons, airplanes, and satellites. While as much aerial photography as possible will continue to be done by MASCA, distribution of this report may enable an even greater number of archaeologists to benefit from these techniques.

E. Mud Brick Project

Penetration and consolidation under the surface with an aqueous polymer system still remains a problem for future investigation. It is economical and easy to use in the field and should, with further research, give useful results. A more reliable and simpler monomer system for field use needs to be developed. Long-term testing of both types of products needs to be conducted before risking a precious monument to this method of stabilization. It may take a combination of both chemical and engineering approaches to solve the ground water problem. The laboratory testing to date on isolated stone and brick samples holds promise for eventually protecting these materials in their natural setting, in the field.

ADDENDUM

While this proposal was being typed, we received the results of 4 DTA measurements. DTA stands for differential thermal analysis. The sample and an inert reference sample are heated together in a furnance, usually from room temperature to 1000°C, and the difference in temperature between the two is recorded versus the temperature of the furnace. As the sample is heated, reactions involving crystallization, oxidation, and possibly other chemical reaction produce exothermic peaks, whereas changes in phase, dehydration, decomposition and crystalline inversions are usually endothermic. (J. Zussman, Ed., 1967, Physical Methods in Determinative Mineralogy, Academic Press, London and N.Y., pp. 405-431).

There were 4 trial samples - PT-1, 50, 73, and 371. Samples 1, 50, and 73 had associated charcoal which was dated by C^{14}. The results are as follows:

PT-1 and PT-50 from Hasanlu and Susa, Iran respectively, produced a large endothermic peak between 650° and 700°C. This indicates that they were not fired originally above 700°C and this may explain why they both had extremely deviant TL dates, that is, some of the geological age of the clays contributed TL to produce dates which are too old.

PT-73 from Çatal Hüyük, Turkey. This sherd had a very small endothermic peak between 650° and 700°C, which indicates that it had been fired above 700°C. The TL date was in exact agreement with C^{14} dates - namely, 5000 B.C.

PT-371 from Acambaro, Mexico.

This pottery had no peak and from TGA (thermogravimetric analysis) had only a 2 % weight loss whereas nos. PT-1 and PT-50 had 14% losses. These results are so new that we have not yet analyzed the cause of the "no" peak, but this odd behavior indicates that there is something very peculiar about this pottery. This is part of the Julsrud collection which archaeologists have judged to be fakes. However, we have obtained TL dates ranging from 2500 B.C. to 500 B.C.

In summary, DTA appears to be a promising technique for the explanation of deviant TL dates and will be pursued further.

IV. Collaboration

In our previous grant proposal, (1972 - 1974) we outlined our collaboration with other institutions and with other departments within the University in detail. Rather than repeat this, we shall just mention that collaboration and exchanges of information are vital to both us and to others. For examples, the X-ray diffraction and reconstitution of clay mineral studies are being conducted in collaboration with the Department of Geology; and electron microscopy, with the Department of Metallurgy.

V. Facilities

A. MASCA Laboratories, University Museum

1. Space

MASCA has adequate laboratory and office space. This includes seven rooms for the regular staff plus a large well-equipped laboratory for visiting scientists, volunteers, and for conferences. With funds from NSF Grant GS 36308X, all of the rooms are now air-conditioned by means of a central water-cooled system.

2. Equipment

a. Thermoluminescence

Equipment purchased with NSF grants GS-566, 1028, 1568, 2716 and 36308X is available in MASCA. This includes two sets of glow curve apparatus with linearly controlled heating programmers and nine functional alpha counters. X-ray apparatus is available in the Department of Physics. Beta and gamma sources are available through the cooperation of Dr. Suntharalingam at Jefferson Medical College. However, for convenience we plan to purchase a Sr^{90} beta source; and two more Po^{210} sources per year to continue the alpha experiments. Grinding equipment, dosimeters, and other minor components have also been purchased.

b. Dendrochronology

A dendrochronograph and low-power microscope, for measuring the widths of tree rings, were purchased several years ago. H. N. Michael has collected and tree-ring-dated an adequate number of sequoia and bristlecone pine samples for MASCA's studies, for exchange and exhibit. The collection also includes other woods that were at one time or another processed in the laboratory, such as Lebanon cedar, black pine from

Anatolia, and zapote from Central America.

c. Equipment for Archaeological Prospecting

As described previously, we possess two cesium magnetometers, one proton, and one fluxgate magnetometer; four Geohms; metal detectors; and seismic-sonic components. We have also tools and test equipment including a battery-powered oscilloscope.

d. Aerial Photographs

As a result of the flights in Southern Italy, we have two different sets (2000 each) of photographs of the plain of Sybaris and surrounding hills. From more recent experiments, we have 1000 prints taken over various archaeological sites in England, and 8 rolls of transparencies of the Snaketown, Arizona region.

Only minor items of equipment have been acquired so far - such as a hand stereoscope and a light table.

e. Information Center

This contains a small library of books and articles from periodicals, extensive card files of abstracts indexed both by author and subject, and also the central MASCA files.

It is now located in a larger room (No. 43). One end is reserved for work space, and the center portion of it is now equipped with a sizeable table and chairs for those using the files.

B. Radiocarbon Laboratory, David Rittenhouse Laboratory, Department of Physics

1. Space

The C^{14} laboratory was located in two connecting rooms (BW4 and BW6), each 20 x 20 ft. With funds from NSF GS 36308X, a large adjacent room (BW8) measuring 20 x 50 ft. which had been a storeoom was equipped as a laboratory room and air-conditioned. There is now adequate space for the radiocarbon laboratory.

2. Equipment

Major items of equipment, at present, are the two carbon dioxide proportional gas counters and associated electronic components, a liquid scintillation spectrometer, carbon dioxide combustion and purification train, and benzene conversion train. There are also benches and tools for the construction and repair of equipment in the C^{14} laboratory, as well as a student and a staffed Machine Shop in the Department of Physics.

C. Equipment Available in Other Departments of the University of Pennsylvania

1. School of Metallurgy and Materials Science and the Laboratory for Research on the Structure of Matter

a. Electron Microscopy

1) Transmission Types

a) Philips Em 300

b) Siemens Emiskop I

2) Scanning Type

JEOL JSM-U3

Accessories include a non-dispersive X-ray detector which permits the analysis of chemical composition with the differentiation of about one micron.

b. Analytical Chemistry

In this center, experiments can be carried out in the following areas of chemical analysis: electroanalytical measurements (including high and low impedance potentiometric titration, polarography, amperometric titration, controlled potential and controlled current coulometry), analytical absorption measurements in the ultraviolet and visible regions of the spectrum and flame photometric analysis. The center also has available a Jarrel-Ash Mark IV emission spectrograph (3.5 meter, photographic), a Perkin Elmer Model 303 atomic absorption, a Perkin Elmer Model 900 gas chromatograph, and Picker radio chemical counting equipment capable of scintillation counting and geiger counting.

c. Metallograph and Photography

This facility now has new fixtures to facilitate the grinding of epoxy mounted specimens. These fixtures will enable one to surface grind non-magnetic samples prior to using the lapping machine. The center also now makes its own diamond paste, at a great saving over the commercial product. The photography lab has also acquired a 35-mm Pentax camera for production of 35-mm slides.

Not mentioned previously is the fact that we have the excellent services of the photographic laboratory in the University Museum.

d. X-ray Diffraction

The X-ray Diffraction Research Center provides the facilities to pursue many different types of studies using X-rays as a tool in materials research. Some of these studies are the determination of crystal and molecular structures using powder and single crystal techniques, precision determination of lattice constants, elemental analysis by fluorescence of substances with elements of atomic number greater than twelve, identification of materials, crystal orientation, crystal perfection, small angle scattering and phase changes at high temperatures.

A major piece of equipment in the center is a Picker four circle single crystal automatic diffractometer with an incident beam graphite monochromator. The diffractometer is controlled by a Digital Equipment Corporation PDP-8 computer equipped with a disk file and control and an expander disk.

The Center plans to acquire a scanning digital microdensitometer in the near future.

2. Department of Geology, Hayden Hall

The following is a list of equipment that we have used or plan to utilize as the need arises.

a. Mirror Stereoscope

(For viewing aerial photographs)

b. X-ray Fluorescence Apparatus

c. X-ray Diffraction

d. Potassium-Argon Dating

e. Rubidium-Strontium Dating

f. Equipment for Petrographic Examinations

g. " " Fission-Track Dating including Microscopes

h. Magnetic Anisotropic Separator and Vibration and Wilfley Tables

i. Rock Crushers, Saws, etc.

3. Department of Chemistry

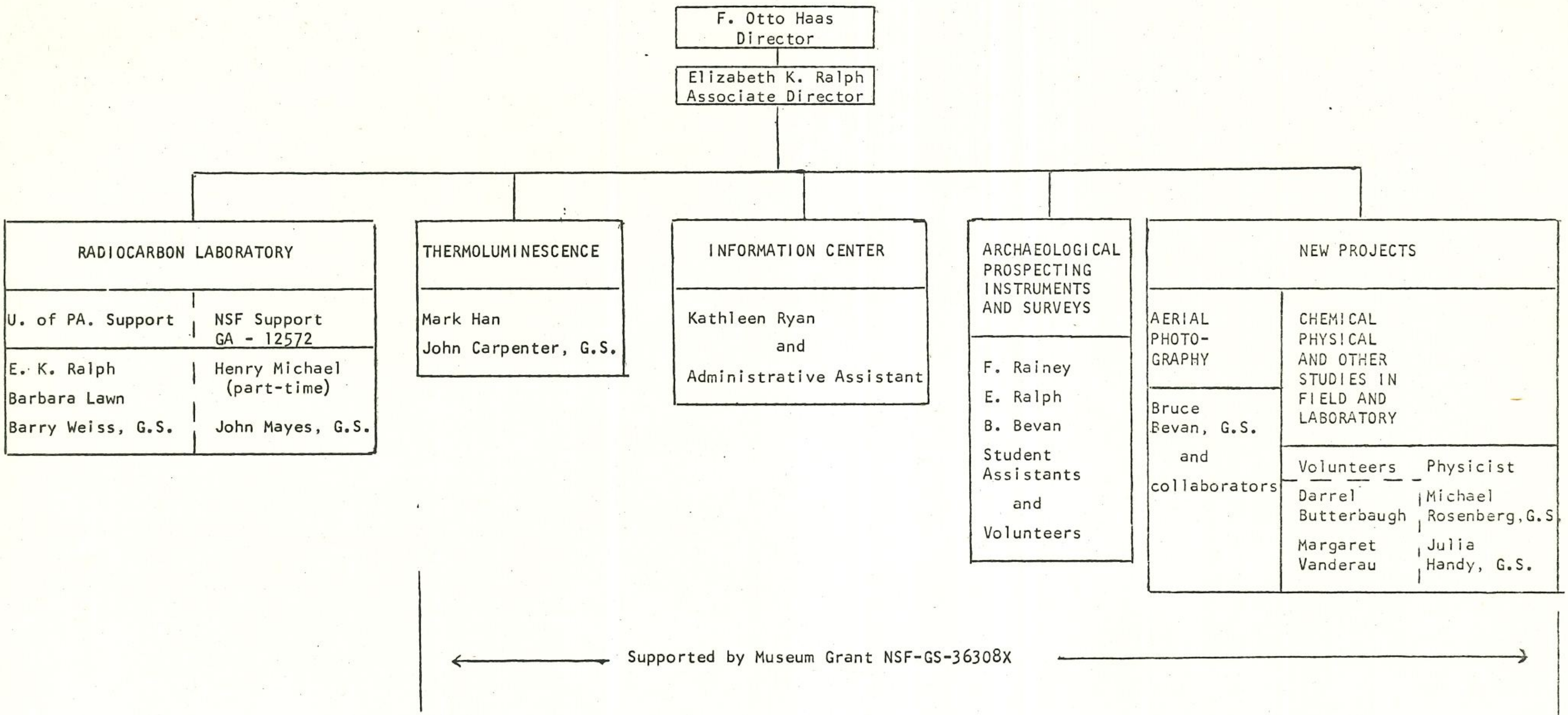
A mass spectrometer, suitable for the measurement of C^{13}/C^{12} ratios (for the minor correction of C^{14} dates due to fractionation) is available in the Department of Chemistry.

VI. Personnel

A. The organization of MASCA is shown in the attached block diagram entitled "MASCA Personnel".

B. Curricula vitae of the principal members of the staff are attached.

MASCA PERSONNEL



G.S. = Graduate Student
1/2-time in academic year ,
Full-time for 3 summer months

August 1974

VII BUDGET - First Year

1. Salaries and Wages

   a. Research Personnel (A-2)

      1. Four Research Fellows — $19,200.
         Three summer months full time
         Academic year - half time
         FTE - 8 months (4 x $4,800)

   b. Other Professional

      1. Research Chemist (A-1) Mark Han — $14,300.
         Full time - 12 months
         FTE - 12 months

      2. Research Physicist (A-1) — $13,930.
         Full time - 12 months
         FTE - 12 months

   c. Secretarial, Clerical, and Administrative

      1. Research Bibliographer II (A-3) — $8,600.
         Full time - 12 months
         FTE - 12 months

      2. Secretarial, Clerical and Administrative Assistant (A-3) — $4,800.
         Half time - 12 months
         FTE - 6 months

TOTAL SALARIES — $60,830.

   d. Employe Benefits - First Year

	A-1	A-2	A-3
January 1, 1975 to June 30, 1975	$14,115 x 12.2% = $1,722.	$9,244 x 20.5% = $1,895.	$6,700 x 15%= $1,005.
July 1, 1975 to December 31, 1975	$14,115 x 13.2% = $1,863.	$9,956 x 21.5% = $2,141.	$6,700 x 16% = $1,072

TOTAL EMPLOYE BENEFITS — $9,698.

2. Expendable Equipment and Supplies

   a. For Thermoluminescence
      Two Po^{210} alpha sources — $500.
      (These are listed under expendable equipment because Po^{210} is short lived.)

      Nitrogen and other chemical supplies — $1,000.

      Photomultiplier tubes and other minor electronic components — $500.

   b. For Archaeological Prospecting, Spare parts, cables and tools — 500

   c. For Aerial Photography
      Kites, filters, and other minor components — 500.
      Films and film processing — 500.

   d. Information Center - Books, Journals and supplies — 1,000.

TOTAL EXPENDABLE EQUIPMENT AND SUPPLIES — $4,500.

3. Services

Machine shop	$750.
Electronics repair	500.
Rental of experimental prospecting instruments, including soil-penetrating radar, gamma ray spectrometer, etc.	5,000.
Rental of field spectrometer for aerial photography	1,000.
Aircraft rental (for aerial photography)	1,500.
Printing of MASCA Newsletter	1,500.
Other printing and duplicating	500.
TOTAL SERVICES	$10,750.

4. Travel

For instrument, aerial surveys, other experiments in the field such as mud brick preservation, and to attend conferences

Domestic	$3,000.
Foreign	2,000.
TOTAL TRAVEL	$5,000.

5. Other Expenses — $2,900.

Radiological Consultant, Dr. N. Suntharalingam
5% of full time, FTE 1 man month

6. Sub-total for the calculations of overhead

Salaries	$60,830.
Employee Benefits	9,698.
Expendable Equipment and Supplies	4,500.
Services	10,750.
Travel	5,000.
Other expenses	2,900.
SUB-TOTAL	$93,678.

7. Overhead

January 1, 1975 to June 30, 1975 44.5% of $46,812.	$20,831.
July 1, 1975 to December 31, 1975 45.5% of $46,866.	21,324.
TOTAL OVERHEAD	$42,155.

8. Sub-Total Plus Overhead — $135,833.

9. Equipment

For Thermoluminescence	
Sr^{90} beta source (half-life = 29 years)	$ 400.
Hydraulic press (for sample preparations and better grinding equipment)	600.
Replacement programmer and furnace	3,000.
For Archaeological Prospecting	
Excess cost of redesigning and upgrading of cesium magnetometers	8,000.
For Aerial Photography	
Aerial Cameras	1,500.
Mapping equipment, sketchmaster	1,000.

9. Equipment

For X-ray diffraction and new experiments with clays	
Focusing Monochromator (for improvement of present X-ray diffraction apparatus)	$ 2,200.
Gandolfi Camera (X-ray diffraction camera for producing powder photographs from single crystals	1,750.
Parr High Pressure Bomb No. 4740 and associated components for reconstituting clays	600.
TOTAL EQUIPMENT	$19,050.

10. Total First Year

Sub-Total	$93,678.
Overhead	42,155.
Equipment	19,050.
TOTAL FIRST YEAR	$154,883.

VII BUDGET - Second Year

1. Salaries and Wages

   a. Research Personnel (A-2)

      1. Three Research Fellows — $14,400.
         Three summer months - full time
         Academic year - half-time
         FTE - 8 months (3 x $4,800)

   b. Other Professional

      1. Research Chemist (A-1), Mark Han — $15,375.
         Full-time - 12 months
         FTE - 12 months

      2. Research Physicist (A-1) — $14,975.
         Full-time - 12 months
         FTE - 12 months

      3. Research Specialist II (A-1) — $12,100.
         Full-time - 12 months
         FTE - 12 months

   c. Secretarial, Clerical, and Administrative

      1. Research Bibliographer II (A-3) — $ 9,250.
         Full-time - 12 months
         FTE - 12 months

      2. Secretarial, Clerical, and Administrative Assistant (A-3)
         Half-time - 12 months — $ 5,160.
         FTE - 6 months

TOTAL SALARIES $71,260.

   d. Employee Benefits - Second Year

	A-1	A-2	A-3
January 1, 1976 to June 30, 1976			
	$21,225 x 13.2% = $2,802	$6,940 x 21.5% = $1,492	$7,205 x 16% = $1,153
July 1, 1976 to December 31, 1976			
	$21,225 x 13.7% = $2,908	$7,460 x 22% = $1,641	$7,205x16.5% = $1,189

TOTAL EMPLOYEE BENEFITS $11,185.

2. Expendable Equipment and Supplies

   a. For Thermoluminescence
      Two Po^{210} alpha sources — $ 500.
      (These are listed under expendable equipment because Po^{210} is short-lived)
      Nitrogen and other chemical supplies — $ 1,000.
      Photomultiplier tubes and other minor electronic components — $ 500.

b. For Archaeological Prospecting	
Spare parts, cables and tools	$ 500.
c. For Aerial Photography	
Kites, filters, and other minor components	$ 500.
Films and Film Processing	$ 500.
d. Information Center	
Books, Journals, and Supplies	$ 1,000.
TOTAL EXPENDABLE EQUIPMENT AND SUPPLIES	$ 4,500.

3. Services

Machine Shop	$ 750.
Electronics repair	$ 500.
Rental of experimental prospecting instruments, including soil-penetrating radar, gamma ray spectrometer, etc.	$ 3,000.
Rental of field spectrometer for aerial photography	$ 1,000.
Aircraft rental (for aerial photography)	$ 1,500.
Printing of MASCA Newsletter	$ 1,500.
Other printing and duplicating	$ 500.
TOTAL SERVICES	$ 8,750.

4. Travel

For instrument, aerial surveys, other experiments in the field such as mud brick preservation, and to attend conferences

Domestic	$ 3,000.
Foreign	$ 2,000.
TOTAL TRAVEL	$ 5,000.

5. Other Expenses

Radiological Consultant, Dr. N. Suntharalingam 5% of full-time, FTE 1 man month	$ 3,100.

6. Subtotal for the Calculation of Overhead

Salaries	$71,260.
Employee Benefits	$11,185.
Expendable Equipment and Supplies	$ 4,500.
Services	$ 8,750.
Travel	$ 5,000.
Other Expenses	$ 3,100.
SUB-TOTAL	$103,795.

7. Overhead

45.5% of $103,795	$ 47,227.

8. Sub-Total Plus Overhead — $151,022.

9. Equipment

For Thermoluminescence	
Replacement amplifiers, scalers, and minor new components	$ 4,000.
For Archaeological Prospecting	
Development of Soil-Penetrating radar and other new equipment	$50,000.
For Aerial Photography	
Replacement Cameras, etc.	$ 1,500.
For New Techniques in Laboratory and in the Field	$ 3,000.
TOTAL EQUIPMENT	$58,500.

10. Total Second Year

Sub-Total	$103,795.
Overhead	$ 47,227.
Equipment	$ 58,500.
TOTAL SECOND YEAR	$209,522.
TOTAL 2 YEARS	$364,405.

MASCA GRANT PROPOSAL

VII BUDGET - First Year	Proposed NSF Funds	University Contribution	Total Project Funds
1. Salaries and Wages		$9,000	$9,000
a. Research Personnel			
1) Froelich Rainey (A-1) Principal Investigator 25% of full-time-12 months FTE - 3 man months			
2) Elizabeth K. Ralph (A-2) Faculty Associate 50% of full-time-12 months FTE - 6 woman months		$9,500	$9,500
3) Four Research Fellows (A-2) Three summer months full time Academic year - half time FTE - 8 months (4 x $4,800)	$19,200.		$19,200
b. Other Professional			
1) Research Chemist (A-1) Mark Han Full time - 12 months FTE - 12 months	$14,300.		$14,300
2) Research Physicist (A-1) Full time - 12 months FTE - 12 months	$13,930.		$13,930
c. Secretarial, Clerical, and Administrative			
1) Research Bibliographer II (A-3) Full time - 12 months, FTE -12 mos.	$8,600.		$8,600
2) Secretarial, Clerical and Administrative Assistant (A-3) Half time - 12 months FTE - 6 months	$4,800.		$4,800
TOTAL SALARIES	$60,830.	$18,500	$79,330

CALCULATIONS OF EMPLOYEE BENEFITS

FIRST YEAR	A-1	A-2	A-3 / PROPOSED NSF FUNDS	UNIVERSITY CONTRIBUTION	TOTAL PROJECT FUNDS
Jan. 1, 1975 to June 30, 1975	$14,115 x 12.2% = $1,722.	$9,244 x 20.5% = $1,895.	$6,700 x 15% =$1,005.		
				A-1 $4,500 x 12.2% = $549	
				A-2 $4,750 x 20.5% = $974	
July 1, 1975 to December 31, 1975	$14,115 x 13.2% = $1,863.	$9,956 x 21.5% = $2,141.	$6,700 x 16% =$1,072.		
				A-1 $4,500 x 13.2% = $594	
				A-2 $4,750 x 21.5% = $1,020	
		TOTAL EMPLOYEE BENEFITS	$9,698.	$3,137	$12,835
SECOND YEAR					
Jan. 1, 1976 to June 30, 1976	$21,225 x 13.2% = $2,802	$6,940 x 21.5% = $1,492	$7,205 x 16% =$1,153		
				A-1 $4,838 x 13.2% = $639	
				A-2 $5,105 x 21.5% = $1,098	
July 1, 1976 to December 31, 1976	$21,225 x 13.7% = $2,908	$7,460 x 22% = $1,641	$7,205 x 16.5% =$1,189		
				A-1 $4,838 x 13.7% = $663	
				A-2 $5,105 x 22% = $1,123	
		TOTAL EMPLOYEE BENEFITS	$11,185.	$3,523	$14,708

VII BUDGET - First Year (Cond't)	Proposed NSF Funds	University Contribution	Total Project Funds
2. Expendable Equipment and Supplies			
a. For Thermoluminescence	500.		500
Two Po^{210} alpha sources (These are listed under expendable equipment because Po^{210} is short lived.)			
Nitrogen and other chemical supplies	1,000.		1,000
Photomultiplier tubes and other minor electronic components	500.		500
b. For Archaeological Prospecting, Spare parts, cables and tools	500.		500
c. For Aerial Photography Kites, filters, and other minor components	500.		500
Films and film processing	500.		500
d. Information Center - Books, Journals and supplies	$1,000.		1,000
	$4,500.		$4,500.
3. Services			
Machine shop	750.		750
Electronics repair	500.		
Rental of experimental prospecting instruments, including soil-penetrating radar, gamma ray spectrometer, etc.	5,000.		5,000
Rental of field spectrometer for aerial photography	1,000		1,000
Aircraft rental (for aerial photography)	1,500.		1,500
Printing of MASCA Newsletter	1,500.		1,500
Other printing and duplicating	500.		500
TOTAL SERVICES	$10,750.		$10,750
4. Travel			
For instrument, aerial surveys, other experiments in the field such as mud brick preservation, and to attend conferences			
Domestic	$3,000.		$ 3,000.
Foreign	2,000.		2,000.
TOTAL TRAVEL	$5,000		$5,000.

VII BUDGET - First Year (Cond't)	Proposed NSF Funds	University Contribution	Total Project Funds
5. Other Expenses Radiological Consultant, Dr. N. Suntharalingam 5% of full time FTE 1 man month	2,900.		2,900.
6. Sub-total for the calculation of overhead			
Salaries	60,830.	18,500	79,330
Employee Benefits	9,698.	3,137.	12,835
Expendable Equipment and Supplies	4,500.		
Services	10,750.		
Travel	5,000.		
Other expenses	2,900.		
SUB-TOTAL	$93,678.	21,637	$115,315
7. Overhead			
Jan. 1, 1975 to June 30, 1975 44.5% of $46,812.	20,831.	4,814	25,645
July 1, 1975 to Dec. 31, 1975 45.5% of $46,866.	21,324.	4,922	26,246
TOTAL OVERHEAD	$42,155.	$9,836	$51,891
8. Sub-Total Plus Overhead	$135,833.	$31,473	$167,206
9. Equipment			
For Thermoluminescence			
Sr^{90} beta source (half-life = 29 years)	400.		400
Hydraulic press (for sample preparations and better grinding equipment)	600.		600
Replacement programmer and furnace	3,000.		3,000
For Archaeological Prospecting			
Excess cost of redesigning and upgrading of cesium magnetometers	8,000.		8,000
For Aerial Photography			
Aerial Cameras	1,500.		1,500
Mapping equipment, sketch-master	1,000		1,000
For X-ray diffraction and new experiments with clays Focusing Monochromator (for improvement of present X-ray diffraction apparatus)	2,200.		2,200
Gandolfi Camera (X-ray diffraction camera for producing powder photographs from single crystals	1,750		1,750

VII BUDGET - First Year (Cont'd)

	Proposed NSF Funds	University Contribution	Total Project Funds
Parr High Pressure Bomb #4740 and associated components for reconstituting clays	600.		600
TOTAL EQUIPMENT	$19,050.		$19,050
10. Total First Year			
Sub Total	93,678.	21,637	115,315
Overhead	42,155.	9,836	51,991
Equipment	19,050.		19,050
TOTAL FIRST YEAR	$154,883.	$31,473	$186,356

UNIVERSITY OF PENNSYLVANIA

PHILADELPHIA, PENNSYLVANIA 19174

REVISED

PROPOSAL FOR CONTINUING RESEARCH SUPPORT

Museum Applied Science Center for Archaeology
(MASCA)

National Science Foundation

Division of Special Projects

Washington, D.C. 20550

Principal Investigator: Froelich Rainey, Director, University Museum and Professor of Anthropology 198-26-6211

School: University of Pennsylvania

Department: University Museum

Starting Date: March 1, 1975

Duration: Two Years

FUNDS REQUESTED

First Year (3/1/75 - 2/29/76:	$ 100,000
Second Year (3/1/76 - 2/28/77:	$ 75,000
Total, two years:	$ 175,000

CORPORATE NAME OF UNIVERSITY: THE TRUSTEES OF THE UNIVERSITY OF PENNSYLVANIA (A Pennsylvania non-profit corporation)

Contracting Office: OFFICE OF RESEARCH ADMINISTRATION, Franklin Bldg., I6, University of Pennsylvania, 3451 Walnut Street, Philadelphia, Pa. 19174

Approved: ____________________

Approved: Froelich Rainey
Froelich Rainey
Principal Investigator
Director, University Museum and MASCA

Approved: William E. Stephens
William E. Stephens
Professor of Physics
Associate Director for Research

Approved: F. Otto Haas
F. Otto Haas, Associate Director for Development

Date: February 6, 1975

Approved: Elizabeth K. Ralph
Elizabeth K. Ralph, Faculty Associate, Associate Director of MASCA, Research Associate in Physics

VII Budget - First Year

1. Salaries and Wages
   a. Research Personnel (A-2)
      1. Three Research Fellows — $ 14,400.
         Three summer months full time
         Academic year - half time
         FTE - 8 months (3 x $4,800)
   b. Other Professional
      1. Research Chemist (A-1) Mark Han — $ 14,300.
         Full time - 12 months
         FTE - 12 months
   c. Secretarial, Clerical and Administrative
      1. Research Bibliographer II (A-3) — $ 8,600.
         Full time - 12 months
         FTE - 12 months
      2. Secretarial, Clerical and Administrative Assistant (A-3)
         Half time - 12 months — $ 4,800.
         FTE - 6 months

   TOTAL SALARIES — $ 42,100.

   d. Employee Benefits - First Year

   March 1, 1975 to February 29, 1976

A-1	A-2	A-3
$14,300 x 13.2% = $1,888.	$14,400 x 21.5% = $3,096.	$13,400 x 16% = $2,144.

   TOTAL EMPLOYEE BENEFITS — $ 7,128.

2. Expendable Equipment and Supplies
   a. For Thermoluminescence
      Two Po^{210} alpha sources — $ 500.
      (These are listed under expendable equipment because Po^{210} is short-lived.)
      Nitrogen and other chemical supplies, expendable electronic components — $ 750.
   b. For Archaeological Prospecting, Spare parts, cables and tools — $ 500.
   c. For Aerial Photography
      Kites, filters, and other minor components — $ 500.
      Films and film processing — $ 500.
   d. Information Center - Books, Journals and Supplies — $ 1,000.

   TOTAL EXPENDABLE EQUIPMENT AND SUPPLIES — $ 3,750.

3. Services
   Rental of experimental prospecting instruments, including soil-penetrating radar, gamma ray spectrometer, etc. — $ 2,000.
   Aircraft rental (for aerial photography) — $ 500.
   Printing of MASCA Newsletter — $ 1,500.
   Other printing and duplicating — $ 500.

   TOTAL SERVICES — $ 4,500.

4. Travel

For instrument, aerial surveys, other experiments in the field such as mud brick preservation

Domestic, collaboration with Stanford Research Institute, etc. (travel expenses) mud brick experiments in U.S.A.	$ 2,000.
Foreign, Mud-brick and magnetometer, etc. experiments in Iran, Egypt, and other sites in the Near East, possibly Far East	$ 3,000.
TOTAL TRAVEL	$ 5,000.

5. Sub-total for the Calculations of Overhead

Salaries	$42,100.
Employee Benefits	$ 7,128.
Expendable Equipment and Supplies	$ 3,750.
Services	$ 4,500.
Travel	$ 5,000.
SUB-TOTAL	$62,478.

6. Overhead

March 1, 1975 to February 29, 1976 44.5% of $62,478.	$27,803.

7. Sub-Total Plus Overhead $90,281.

8. Equipment

For Thermoluminescence	
Hydraulic press (for sample preparations and better grinding equipment)	$ 600.
For Archaeological Prospecting	
Excess cost of redesigning and upgrading of cesium magnetometers	$ 8,000.
For Aerial Photography	
Mapping equipment	$ 134.
Portable Oscilloscope, Dual Trace, Storage	$ 985.
TOTAL EQUIPMENT	$ 9,719.

9. Total First Year

Sub-Total	$ 62,478.
Overhead	$ 27,803.
Equipment	$ 9,719.
TOTAL FIRST YEAR	$100,000.

VII Budget - Second Year

1.	Salaries and Wages	
	a. Research Personnel (A-2)	
	1. Three Research Fellows Three summer months - full time Academic year - half-time FTE - 8 months (3 x $4,800)	$ 14,400.
	b. Other Professional	
	1. Visiting Scientist Approximately 4 months	$ 4,840.
	c. Secretarial, Clerical, and Administrative	
	1. Research Bibliographer II (A-3) Full-time - 12 months FTE - 12 months	$ 9,250.
	2. Secretarial, Clerical, and Administrative Assistant (A-3) Half-time - 12 months FTE - 6 months	$ 5,160.
	TOTAL SALARIES	$ 33,650.

d. Employee Benefits - Second Year

March 1, 1976 to February 28, 1977

A-1	A-2	A-3
$ 4,840 x 13.7% = $ 663.	$14,400 x 22% = $3,168.	$14,410 x 16.5% = $2,378.

TOTAL EMPLOYEE BENEFITS $ 6,209.

2.	Expendable Equipment and Supplies	
	a. For Thermoluminescence Nitrogen, other chemical supplies, expendable electronic components	$ 1,000.
	b. For Archaeological Prospecting Spare parts, cables and tools	$ 500.
	c. For Aerial Photography Kites, filters, and other minor components, and Films and Film Processing	$ 500.
	d. Information Center Books, Journals, and supplies	$ 600.
	TOTAL EXPENDABLE EQUIPMENT AND SUPPLIES	$ 2,600.

3.	Services	
	Machine Shop	$ 250.
	Rental of experimental prospecting instruments, including soil-penetrating radar, gamma ray spectrometer, etc.	$ 1,000.
	Aircraft rental (for aerial photography)	$ 500.
	Printing of MASCA Newsletter	$ 1,500.
	Other Printing and Duplicating	$ 500.
	TOTAL SERVICES	$ 3,750.

4. Travel

For instrument, aerial surveys, other experiments in the field such as mud brick preservation etc.

Domestic	$ 2,000.
Foreign	$ 2,000.
TOTAL TRAVEL	$ 4,000.

5. Subtotal for the Calculation of Overhead

Salaries	$ 33,650.
Employee Benefits	$ 6,209.
Expendable Equipment and Supplies	$ 2,600.
Services	$ 3,750.
Travel	$ 4,000.
SUB-TOTAL	$ 50,209.

6. Overhead

44.5% of $103,795	$ 22,343.

7. Sub-Total Plus Overhead — $ 72,552.

8. Equipment

For Thermoluminescence	
Replacement amplifiers, scalers or minor new components	$ 1,000.
For New Techniques in Laboratory and in the Field	$ 1,448.
TOTAL EQUIPMENT	$ 2,448.

9. Total Second Year

Sub-Total	$ 50,209.
Overhead	$ 22,343.
Equipment	$ 2,448.
TOTAL SECOND YEAR	$ 75,000.
TOTAL 2 YEARS	$175,000.

NATIONAL SCIENCE FOUNDATION
Washington, D.C. 20550

RESEARCH GRANT
BUDGET & FISCAL REPORT

Form Approved
Budget Bureau No. 99-R0013

MASCA — *Please read instructions on reverse side carefully before completing this form.*

INSTITUTION AND ADDRESS	NSF PROGRAM	GRANT PERIOD / REPORTING PERIOD
University Museum University of Pennsylvania Philadelphia, Pennsylvania	Social Sciences Special Projects	GRANT PERIOD *from* 3/1/75 to 2/28/77 REPORTING PERIOD *from* *to*

GRANT NUMBER	BUDGET DUR. (MOS.)	PRINCIPAL INVESTIGATOR(S)	GRANTEE ACCOUNT NUMBER
	24	Froelich Rainey	

	NSF Funded Man Months Cal.	Acad.	Summ.	NSF AWARD BUDGET	CUMULATIVE GRANT EXPENDITURES *Do Not Round*
A. SALARIES AND WAGES					
1. Senior Personnel					
a. (Co)Principal Investigator(s)				$	
b. Faculty Associates					
Sub-Total				$	$
2. Other Personnel (Non-Faculty)					
a. 1 Research Associates—Postdoctoral					
b. Non-Faculty Professionals	16			19,140	
c. 1 Graduate Students	48			28,800	
d. Pre-Baccalaureate Students					
e. 2 Secretarial—Clerical	36			27,810	
f. Technical, Shop, and Other					
TOTAL SALARIES AND WAGES				$ 75,750	$
B. STAFF BENEFITS IF CHARGED AS DIRECT COST				13,337	
C. TOTAL SALARIES, WAGES, AND STAFF BENEFITS (A + B)				$ 89,087	$
D. PERMANENT EQUIPMENT *					
As listed in revised proposal budget				12,167	
E. EXPENDABLE EQUIPMENT AND SUPPLIES				6,350	
F. TRAVEL 1. DOMESTIC (INCLUDING CANADA)				4,000	
2. FOREIGN				5,000	
G. PUBLICATION COSTS				4,000	
H. COMPUTER COSTS IF CHARGED AS DIRECT COST					
I. OTHER DIRECT COSTS					
Services minus Publication Costs				4,250	
J. TOTAL DIRECT COSTS (C through I)				$ 112,687	$
K. INDIRECT COSTS					
44.5% of Modified Total Direct Costs				50,146	
L. TOTAL COSTS (J plus K)				$ 175,000	$
M. AMOUNT OF THIS AWARD (ROUNDED)				$	
N. CUMULATIVE GRANT AMOUNT				$	
O. UNEXPENDED BALANCE (N. BUDGET MINUS L. EXPENDITURE)					$

REMARKS: Use extra sheet if necessary

* Excluded from indirect cost base

FOR NSF USE ONLY
Final Fiscal Report Accepted

Grant Closed______ Remains Open______
By______ Date______
Grants Administration Section, Area______

SIGNATURE OF PRINCIPAL INVESTIGATOR	TYPED OR PRINTED NAME	DATE

I CERTIFY THAT ALL EXPENDITURES REPORTED ARE FOR APPROPRIATE PURPOSES AND IN ACCORDANCE WITH THE AGREEMENTS SET FORTH IN THE APPLICATION AND AWARD DOCUMENTS

SIGNATURE OF AUTHORIZED OFFICIAL	TYPED OR PRINTED NAME & TITLE	DATE

FOR NSF USE ONLY

Organ. Code	F.Y.	Fund ID	Prog. Code	Ob. Class	O/Dres.	Award No.	Amd.	Inst. Code	Unexpended Balance	Trans.	Lot
									$		

SUPERSEDES ALL PREVIOUS EDITIONS

PROPOSAL SOC - 7504203

MUSEUM APPLIED SCIENCE CENTER FOR ARCHAEOLOGY
(MASCA)

UNIVERSITY OF PENNSYLVANIA SUPPORT

Froelich Rainey, Principal Investigator

FTE - 3 man months for MASCA

Elizabeth K. Ralph, Associate Director of MASCA

FTE - 6 woman months for MASCA
3 woman months for Radiocarbon
3 woman months for NSF GA-12572

Barbara Lawn, Radiocarbon Laboratory

FTE - 1 woman month for MASCA,
11 woman months for Radiocarbon and NSF GA-12572

Rainey is supported by the University of Pennsylvania's Administrative Budget.

Ralph and Lawn and one graduate student are supported by the Radiocarbon budget in the College of the University. Total budget for this fiscal year 7/1/74 to 6/30/75 is $42,500 of which $3100 was donated by the Museum (Harrison Fund).

NSF GRANT GS-36308X-1 Current Support

(11/30/73 to 12/1/74 $109,900)

Museum Applied Science Center for Archaeology

Mark Han, Thermoluminescence Research and Dating -

FTE - 12 man months

Research Physicist, New Research Projects (Replacement of Gary Carriveau)

FTE - 12 man months

Kathleen Ryan, Research Bibliographer

FTE - 12 woman months

Four Research Fellows (Graduate Students)

FTE - 8 man months each

and one half-time Administrative Assistant are supported also on this budget.

NSF GRANT GA-12572, Division of Earth Sciences

C^{14} Measurements of Known Age Samples

Current Support (9/30/73 to 10/1/74, $30,178)

Henry N. Michael, Known-Age C^{14} and Dendro-Dating program

FTE - 5 man months

One Research Fellow, FTE - 8 man months

Renewal of this grant is expected in mid-October 1974

1st year	$44,046
2nd year	34,809
Total	$78,855

The proposal SOC-7504203 has been submitted only to the National Science Foundation.

B. Budget Proposal - First Year	Proposed NSF Funds	University Contribution	Total Project Funds
1. Salaries and Wages			
a. Research Personnel			
1) Froelich Rainey (A-1) Principal Investigator 25% of full-time - 12 months FTE - 3 man months		$7,625	$7,625
2) Elizabeth K. Ralph (A-2) Faculty Associate 50% of full-time - 12 months FTE - 6 woman months		8,100	8,100
3) Research Fellows (A-2) 3 summer months - full-time Academic Year - half-time FTE - 8 man months			
a) Douglas Hancock	$4,150		4,150
b) Bruce Bevan	4,150		4,150
c) Graduate Student	4,150		4,150
d) Graduate Student	4,150		4,150
e) John Hedrick 10% of part-time - 8 months		415	415
Totals - Research Fellows	16,600	415	17,015
b. Other Professional			
1) Mark Han Research Chemist (A-1) Full-time - 12 months FTE - 12 months	12,000		12,000
2) Barbara Lawn Research Specialist II (A-1) 10% of full-time - 12 months FTE - 1 woman month		960	960

	NSF	University	Total
c. Secretarial, Clerical, and Administrative			
1) Research Bibliographer II (A-3) Full-time - 12 months FTE - 12 months	$7,000		$ 7,000
2) Secretarial, Clerical, and Administrative Assistant (A-3) Half-time - 12 months FTE - 6 months	4,000		4,000
3) Secretaries		3,000	3,000
Total Salaries	39,600	20,100	59,700
d. Employee Benefits			
15.5% of A-2	2,573	1,320	3,893
8.5% of A-1	1,020	730	1,750
7.9% pf A-3	869	237	1,106
Total - Employee Benefits	4,462	2,287	6,749
e. Overhead (37% of Salaries)	14,652	7,437	22,089
Total - Salaries, Benefits and Overhead	$58,714	$29,824	$88,538
2. Equipment			
a. For Thermoluminescence - New Components			
TL Integrator (for dosimetry)	2,500		2,500
Spectrometer (for 9th alpha counter) Baird-Atomic Model 530	3,500		3,500
Sub-total	6,000		6,000

	NSF	University	Total
b. For Archaeological Prospecting			
New Cesium Magnetometer Readout	10,000		10,000
2 New Cesium Sensors (Varian Associates Model 49-554)	10,000		10,000
Susceptibility Meter (Bison Instruments Model 3101)	1,300		1,300
Metal Detectors and Components for Seismic and other experiments	500		500
Sub-total	21,800		21,800
c. For Aerial Photography			
3 Electrically-driven Hasselblad Model 500 EL Cameras Mounted Together for Simultaneous Picture Taking. (One of the 3 cameras is being donated by J. Whittlesey)	4,000		4,000
Total - Equipment	31,800		31,800
3. Expendable Equipment and Supplies			
a. For Thermoluminescence			
Calibrated Radioactive Sources:			
One Sr^{90} (beta)			
Two Po^{210} (alpha)	950		950
Nitrogen and Other Chemical Supplies	600		600
Photomultiplier tubes and other electronic components	500		500
b. For Archaeological Prospecting			
Spare parts, cables, and tools	500		500

	NSF	University	Total
c. For Aerial Photography			
Camera Light Meter, Wind Meters, Pantograph, etc.	200		200
Balloon lifting gas	1,500		1,500
Films and Film Processing	250		250
d. Information Center			
Books, Journals and Supplies	1,000		1,000
Total Supplies	5,500		5,500
4. Services			
Machine Shop	750		750
Electronics Shop	500		500
Rental of Prospecting Instruments	1,000		1,000
Rental of an Isodensitometer	400		400
Rental of a Field Spectrometer (possibly, Perkin-Elmer) for Aerial Photography	1,000		1,000
Printing of MASCA Newsletter	1,200		1,200
Other Printing and Duplicating	300		300
Total - Services	5,150		5,150
5. Travel			
For instrument and aerial surveys and to attend conferences			
Domestic	750		750
Foreign (This includes round-trip air-fare for two persons to attend the International Radiocarbon Conference in New Zealand, October 1972)	4,250		4,250
Total - Travel	5,000		5,000

	NSF	University	Total
6. Expenses			
a. Building Renovations			
1) Enlargement of Radiocarbon Laboratory, DRL by the addition of room BW8. This includes the sealing of the room, the supply of filtered and cooled air, and the installation of doorways. (The estimate for the air-conditioning is approximately $3500 and the detailed estimate of the other work is now being prepared.)	$25,000		25,000
2) MASCA Laboratories Installation of a water-cooled air-conditioning system	10,000		10,000
b. Radiological Consultant Dr. N. Suntharalingam 5% of full-time FTE - 1 man-month	2,500		2,500
	37,500		37,500
TOTALS - FIRST YEAR	$143,664	$29,824	$173,488

C. Budget Proposal - Second Year	Proposed NSF Funds	University Contribution	Total Project Funds
1. Salaries and Wages			
a. Research Personnel			
1) Froelich Rainey (A-1) Principal Investigator 25% of full-time - 12 months FTE - 3 man months		8,044	8,044
2) Elizabeth K. Ralph (A-2) Faculty Associate 50% of full-time - 12 months FTE - 6 woman months		8,546	8,546
3) Physicist, Geologist, Engineer or Chemist Full-time - 12 months FTE - 12 months	12,960		12,960
4) Four Research Fellows Three summer months - full-time Academic year - half-time FTE - 8 man months (4 x $4150)	16,600		16,600
5) Fifth Research Fellow 10% of part-time - 8 months		415	415
b. Other Professional			
1) Mark Han Research Chemist (A-1) Full-time - 12 months FTE - 12 months	12,960		12,960
2) Barbara Lawn Research Specialist II (A-1) 10% of full-time - 12 months FTE - 1 woman month		1,013	1,013

	NSF	University	Total
c. Secretarial, Clerical and Administrative			
1) Research Bibliographer II (A-3) Full-time - 12 months FTE -12 months	7,560		7,560
2) Secretarial, Clerical, and Administrative Assistant (A-3) Half-time - 12 months FTE - 6 months	4,320		4,320
3) Secretaries		3,165	3,165
Total Salaries	54,400	21,183	75,583
d. Employee Benefits			
15.5% of A-2	4,582	1,389	5,971
8.5% of A-1	1,102	770	1,872
7.9% of A-3	938	250	1,188
Total Employee Benefits	6,622	2,409	9,031
e. Overhead (37% of Salaries)	20,128	7,838	27,966
Total - Salaries, Benefits and Overhead	81,150	31,430	112,580

2. Equipment

	NSF	University	Total
a. For Thermoluminescence - Replacement Components			
2 High Voltage Power Supplies Fluke Model 415B	1,500		1,500
2 Linear Amplifiers Keithley Model 160	1,200		1,200
Patch Heater Research, Inc. Model 5066-3	600		600
Sub-total	3,300		3,300

	NSF	University	Total
b. For Archaeological Prospecting			
Minor Components and Replacements	1,000		1,000
c. For Aerial Photography			
Vertical Sketchmaster			
(Gordon Enterprises Type 260-GE)	500		500
Stereo-Microscope and Light Table			
(Laser Sciences, Inc. Model LT 630)	3,100		3,100
Sub-total	3,600		3,600
Total-Equipment	7,900		7,900
3. Expendable Equipment and Supplies			
a. For Thermoluminescence			
One calibrated Po^{210} source	300		300
Nitrogen and other chemical supplies	700		700
Electronic components	400		400
Miscellaneous Supplies	500		500
b. For Archaeological Prospecting			
Spare parts, cables, connectors, and tools	800		800
c. For Aerial Photography			
Balloon lifting gas	1,750		1,750
Films and Film Processing	300		300
d. Information Center			
Books, Journals, and Supplies	1,200		1,200
Total-Supplies	5,950		5,950

	NSF	University	Total
4. Services			
Machine Shop	750		750
Electronics Shop	550		550
Rental of Prospecting Instruments	1,200		1,200
Rental of a Field Spectrometer for Aerial Photography	1,200		1,200
Rental of Aircraft when volunteer ones are not available nor suitable	3,500		3,500
Printing of MASCA Newsletter	1,600		1,600
Other Printing and Duplicating	400		400
Total - Services	9,200		9,200
5. Travel			
For instrument and aerial surveys and to attend conferences			
Domestic	800		800
Foreign	2,200		2,200
Total - Travel	3,000		3,000
6. Expenses			
Consultant			
Dr. N. Suntharalingam (or another person)			
5% of full-time			
FTE - 1 man month	2,700		2,700
Total Expenses	2,700		2,700
Totals - Second Year	$ 109,900	$ 31,430	$141,330
Totals - Two Years	253,564	61,254	314,818