File
ASCA

UNIVERSITY of PENNSYLVANIA

PHILADELPHIA 4

OFFICE OF PROJECT RESEARCH AND GRANTS

April 9, 1962

National Science Foundation
Washington 25, D. C.

Gentlemen:

Please find enclosed twenty (20) copies of a proposal entitled "Applied Science Center for Archaeology" under the direction of Dr. Froelich Rainey, Director, University Museum.

The proposal has been approved by appropriate University officials and signed on behalf of the University by Dr. David R. Goddard, Provost.

If further information is needed, please let us know.

Very truly yours,

Arthur A. Brennan, Jr.
Contracts Administrator

AAB:hl

encl.
cc: Dr. Rainey

NATIONAL SCIENCE FOUNDATION
WASHINGTON 25, D.C.

ASCA

April 11, 1962

Dr. Froelich Rainey
Director, University Museum
University of Pennsylvania
Philadelphia 4, Pennsylvania

Dear Dr. Rainey:

We have received your application for a grant in support of the research named below.

Your proposal has been assigned to the Anthropology Program of the Division of Social Sciences of the Foundation for study and evaluation. It will be reviewed by our Advisory Panel at its spring meeting. Processing requires approximately three months after the May 1 closing date, and you will be advised sometime in early August regarding the Foundation's ability to support your work.

We would appreciate being informed of any financial support for this research that you receive from other sources.

Sincerely,

Albert C. Spaulding / m

Albert C. Spaulding
Program Director for
Anthropology

"Applied Science Center for Archaeology"

UNIVERSITY of PENNSYLVANIA
PHILADELPHIA 4

OFFICE OF PROJECT RESEARCH AND GRANTS

ASCA Techn

2

March 29, 1963

National Science Foundation
Washington 25, D. C.

Gentlemen:

Submitted herewith are twenty (20) copies of a proposal for support of research entitled "Applied Science Center for Archaeology" to be conducted under the direction of Dr. Froelich Rainey, Director, University of Pennsylvania Museum.

The proposal has been approved by appropriate University officials and signed on behalf of the University by Dr. Gaylord P. Harnwell, President.

"I certify that the distribution of costs between the direct and indirect categories as shown in the proposal conforms to the usual accounting practices of this institution and to the distribution used by the cognizant Federal audit agency".

If any further information is needed, please let us know.

Very truly yours,

Arthur A. Brennan, Jr.
Contracts Administrator

AAB:hl

encl.

cc: Dr. Rainey ✓

This letter replaces letter which says the proposal was signed by the Provost.

File
Arch Techniques

NATIONAL SCIENCE FOUNDATION
WASHINGTON 25, D.C.

April 15, 1963

Dr. Alfred Kidder II
The University Museum
University of Pennsylvania
33rd and Spruce Streets
Philadelphia 4, Pennsylvania

Dear Ted:

Thank you for your letter of April 9. The information it contains will be very useful to us, and you may be assured that we will keep it confidential.

Sincerely,

Al

Albert C. Spaulding
Program Director for
Anthropology

Ralph

NATIONAL SCIENCE FOUNDATION
WASHINGTON, D.C. 20550

June 10, 1964

Dr. Froelich Rainey
The University Museum
University of Pennsylvania
33rd & Spruce Streets
Philadelphia 4, Pennsylvania

Dear Dr. Rainey:

Thank you for the information contained in your recent letter. It will be helpful to us in considering your proposal.

Sincerely,

Allan

Allan H. Smith
Program Director for
Anthropology

Fro: Thanks for the additional information about the latest progress in your thermoluminescence research.
Allan

343-1100
-6511

C-14 :
P-1867[illegible]

Bert Rough

July 11, 1963

Dear Al:

I am submitting a revised budget for the request entitled APPLIED SCIENCE CENTER FOR ARCHAEOLOGY, submitted to the National Science Foundation on March 26, 1963.

You will note I reduced this request from $63,844 to $25,314.37. I have not altered the statement for proposed research, hoping that we can raise funds from other sources to support the program as orginally stated. Thus the general statement of the project for the Applied Science Center remains the same and I hope we can simply substitute this page on the budget in the copies you now have on hand.

In essence I have cut out the salary for Research Chemist as well as money for two Student Assistants, reducing the salary section from $25,000 to $13,500. I have also cut out a good deal of equipment reducing that figure from $20,650 to $4,450. Finally, I have also reduced the Travel budget from $3,200 to $1,100. As you know in the past we have raised a good deal of outside money particularly for the development of new instruments. It is going to be rough to make up the balance of our proposed budget from these outside sources, but we will at least have a try during the next few months.

I am also enclosing a repfint of our statement about the Center in the AMERICAN JOURNAL OF ARCHAEOLOGY. This same statement has gone to several journals in this country. With publication of this statement in various journals we are getting many requests for assistance and suggestions for collaboration in research from various people in this country and abroad. I do think it was a good idea to publish such a statement and the result certainly reflects a growing interest in the very thing we are trying to do.

As ever,

Froelich Rainey
Director

Dr. Albert C. Spaulding
National Science Foundation
Washington 25, D. C.

Beth Rolfe

Applied Science Center for Archaeology
University of Pennsylvania
University Museum

VI. BUDGET

Salaries			
Research Physicist	$8 000		
Two Research Assistants, part-time (or one full-time)	5 500		
Total Salaries		$13,500.00	
Employee benefits (8.9% of salaries)		1,201.50	
Equipment			
Miscellaneous tools and small instruments	500		
Ultraviolet light source	150		
Pottery thin-sectioning tools, microscope and polaroid light source	800		
Books and periodicals	500		
Expendable Supplies and Materials	2 500		
Total Equipment		4,450.00	
Travel			
Instrument Tests in Texas (4 round trips)	800		
Local Travel	300		
Total travel		1,100.00	
Sub-Total			$20 251.50
Overhead - 25%			5 062.87
TOTAL			$25,314.37

July 11, 1963

NATIONAL SCIENCE FOUNDATION
WASHINGTON 25, D.C.

July 15, 1963

Dr. Froelich Rainey
The University Museum
University of Pennsylvania
Thirty-third and Spruce Streets
Philadelphia 4, Pennsylvania

Dear Fro:

Thank you for the new budget. It looks fine, except that we need a breakdown for the "Expendable Supplies" item. Also, am I right that the Research Physicist (E. Ralph?) is salaried on a calendar year basis and the research assistants on an academic year?

I also thank you for the reprint.

Sincerely,

Al

Albert C. Spaulding
Program Director for
Anthropology

Funds requested for the Research Physicist have no connection w. E. Ralph. Her salary is paid on a full year basis by the University.

EKR just returning
bringing in need to dig. material

July 18, 1963

Dear Al:

Thank you for your letter of July 15th concerning the budget for our grand request entitled APPLIED SCIENCE CENTER FOR ARCHAEOLOGY. I have enclosed a copy of our revised budget which, as you will see, has been changed from that submitted with my preeious letter.

Elizabeth Ralph returned today from Eurppe with the news that Mr. Michael Tite, a physicist trained at the Research Laboratory for Archaeology and the History of Art in Oxford may be available to fill our proposed post of Research Physicist in the early part of 1964. Therefoee, if Mr. Tite comes, our staff will be better qualified to pursue our sonic instrumentation development and to accelerate experiments with thermoluminescence. With this in mind, I have changed the equipment items listed in the budget. With the emphasis changed from chemical to physical research, the amount needed for expendable supplies and materials is consequently reduced. The few remaining items are itemized in the budget.

Our request for funds for the Research Physicist have no connection with the salary of Elizabeth Ralph. She is employed as a Research Associate in the Department of Physics and her salary (on a calendar year basis) is paid by the University of Pennsylvania. Therefoee, in her new post as Associate Director of ASCA, no additional funds are required for her salary. Our research assistants are usually employed on a calendar year basis and work half-time during the academic year, and full-time in the summer months.

Very best wishes,

Froelich Rainey
Director

Dr. Albert C. Spaulding
National Science Foundation
Washington 25, D. C.

FR/vg

NATIONAL SCIENCE FOUNDATION
WASHINGTON 25, D.C.

July 19, 1963

Dr. Froelich Rainey
The University Museum
University of Pennsylvania
Thirty-third and Spruce Streets
Philadelphia 4, Pennsylvania

Dear Fro:

Thanks for the revised revised budget. Hopefully, you will hear something definite within a month or so.

Sincerely,

Al

Albert C. Spaulding
Program Director for
Anthropology

UNIVERSITY OF PENNSYLVANIA

Philadelphia 4, Pennsylvania

Rice

Submitted to: National Science Foundation

Title of Proposal: Applied Science Center for Archaeology

Principal Investigator: Froelich Rainey, Director, University Museum

Starting Date: 1 September 1962

Duration: 1 year

FUNDS REQUESTED

Total: $55,774

Corporate Name of the University: THE TRUSTEES OF THE UNIVERSITY OF PENNSYLVANIA (a Pennsylvania non-profit corporation)

Contracting Office: OFFICE OF PROJECT RESEARCH AND GRANTS
3400 Walnut Street, Philadelphia 4, Pennsylvania

Date:

Approvals:

David R. Goddard, Provost
University of Pennsylvania

Froelich Rainey, Principal Investigator
Director, University Museum
University of Pennsylvania

I. ABSTRACT

Funds for the continuation and acceleration of the research and development in new techniques for archaeology are requested. The main projects of this program are as follows:

A. Development and use of instruments for underground exploration.

B. Establishment of information center.

C. Application of various chemical, metallurgical, and physical techniques for analyses, identifications and dating.

APPLIED SCIENCE CENTER FOR ARCHAEOLOGY

II. DESCRIPTION OF RESEARCH

This proposal comprises an interim report of the research started under NSF Grants G-13256 (Sept. 1, 1960-61) and G-18571 (Sept. 1, 1961-62) and a request for its continuation. The aims of the first grants as embodied in their titles, namely "Research and Development in New Techniques for Archaeology", have been fulfilled in some respects so that a new title of "Applied Science Center for Archaeology" (abbreviated ASCA) has been adopted. The main goal continues to be the application and adaptation of techniques which have been developed in the physical sciences to the problems of and the acceleration of research in archaeology and anthropology.

The program is administered by Froelich Rainey, Director of the University Museum and Professor of Anthropology, principal investigator, and is assisted by Elizabeth K. Ralph, Research Associate in Physics. Mr. A. E. Parkinson continues as University Museum Chemist. Mr. Bernard Wailes from Cambridge University now in Department of Anthropology, University of Pennsylvania is serving as archaeological advisor. With funds from NSF Grants G-13256 and G-18571, R. E. Linington, Physicist from Oxford University was employed through December 1961. The present staff, supported by NSF Grant G-18571, consists of Mark Han, research chemist, and graduate students, Hamilton Carson and Jeanette Flamm.

The research projects in progress are described in the following order:

A. Development and Use of Instruments for Underground Exploration.

B. Establishment of Information Center.

C. Application of various chemical, metallurgical, and physical techniques for analyses, identification, and comparative dating.

A. Instruments for Underground Exploration.

1. Development and Purchase

The most significant advance in instrumentation has been the development and construction by Gray MacLaughlin (MacLaughlin Electronics, Perkiomenville, Pa.) under contract with the University Museum, of a new sonic device. This instrument embodies features which are radical departures from standard low frequency seismic units, and it is anticipated that it will prove to be a long stride ahead in the process of developing an "ideal" instrument for archaeological prospecting based on wave-reflection principles. Its basic components are an indicator unit with transistorized circuits, long-persistence-screen cathode ray tube indicator, and sealed nickel cadmium batteries. The ground probes consist of an electric transmitter unit, two receiver units, plus various probe tips for frequency selection (up to 15kc) for different ground conditions. With this instrument reflections from the underground features appear in the trace on the cathode ray screen. Their presence and depth are then determined. The necessity for a departure from standard seismic techniques was indicated by the experiments performed by R. E. Linington in collaboration with Texas Instruments, Co., Inc., Dallas, Texas in the winter of 1961. More recently, this collaboration has been resumed with MacLaughlin and Texas Instruments for the development of a device to study the behavior of ultrasonic waves in earth. This is expected to be another step in the development of an "ideal" instrument. Texas Instruments Co., has financed also more than half of the cost of the completed instrument. Collaboration has been initiated also and is being financed by (up to $32,000) The Petty Laboratories, Inc., of San Antonio, Texas. This company is undertaking the study of the behavior of continuous waves in earth.

Two other new instruments have been constructed by Gray MacLaughlin. The first is a Gradient Magnetometer, that is, a differential type proton magnetometer. It measures the difference between the total magnetic intensity recorded by a probe close to the ground and one (both mounted on the same rod) approximately 5 feet above it. It overcomes the need for a reference probe and corrections for diurnal variations. Because it is a differential-type unit rather than one capable of taking absolute measurements, the circuitry is also simplified. Surveys may be made more quickly than with the standard proton magnetometer because changes in magnetic intensity which are due only to varying underground conditions are indicated. This obviates the necessity of laying out grids and recording all readings for subsequent correction with the reference readings. It is anticipated that readings at depths slightly greater than those taken with the proton magnetometer will be significant.

One instrument is being constructed by MacLaughlin Electronics and is scheduled for completion on April 11962. It will be used by Rainey and Ralph at Sybaris.

The second instrument is a transistorized metal detector, which operates as a sensitive induction balance. It is designed to have greater sensitivity than the standard military devices.

These and the purchase of the following commercial instruments have been financed with NSF funds.

1) Three "Geohms", manufactured by the Gossen Co., Germany - light-weight, reasonably-priced, sturdy resistivity-type survey instruments.

2) One "Elsec" proton magnetometer, made by the Littlemore Scientific Engineering Co., Oxford, England.

3) One seismic instrument, manufactured by Geophysical Specialties Co., Hopkins, Minnesota.

4) One BAV 100 "Mighty Midget Drill", manufactured by the Houston Tool Co., Santa Susana, Calif. This is a mobile drill (designed originally for use on the moon), which can be carried by 3 people and can penetrate to a depth of 100 ft. It has the additional feature that, in the process of drilling, pulverized cores may be collected for simultaneous examination.

2. Use of Instruments

Use of the instruments has been widespread, both geographically and in application. The focal point of operations, however, is Italy. There are many reasons for the initial explorations in Italy. Foremost among these is the presence of innumerable known archaeological sites. In addition, Mr. Carlo M. Lerici has pioneered in the use of equipment for archaeological prospecting. During the past 5 years, the Lerici Foundation has developed a battery of instruments for the discovery and exploration of Etruscan tombs. These include an electrical potentiometer, produced by the Milan Polytechnical School, a power-driven auger for exploratory drilling up to seven meters of depth, a periscope for investigating tombs without excavation, cameras and lights for underground photography. and various additional apparatus for geophysical exploration. It seemed obvious to us that research in exploration techniques should be carried out in collaboration with the Lerici Foundation. In addition, the Lerici Foundation is paying a large part of the costs of the joint venture. Another reason for work in Italy is the fact that the antiquities laws are favorable and allow some sharing of artifacts.

In September, 1961, experiments with the Lerici and our new instruments were carried out at the Etruscan sites of Tarquinia and Cervetri. In the first place, it was apparent immediately that our small Geohm instrument was equally as good if not more sensitive than the more complex electrical potentiomenter. Secondly, it was found that a given area could be explored with the proton magnetometer in a fraction of the time required to explore the same area with resistivity (or potentiometric) equipment. This is a region of volcanic origin and of high magnetic intensity. The tombs, therefore, were located with pinpoint precision as regions of lower magnetic intensity.

These experiments were continued in October at Sybaris, Calabria with equally gratifying results. There, in addition to constructions and tombs, the proton magnetometer was used to locate and trace a buried wall for 800 meters. At some points the top of the wall lay only a meter under the surface but at other points it was buried as deep as three meters.

The standard seismic instrument was tried out also on these features but the results were less determinate than with the resistivity and magnetic techniques. The new "Mighty Midget Drill" proved to be satisfactory for test-drilling to confirm the presence of features indicated by the electronic instruments.

It is anticipated that, with the new sonic instrument, the limitations, which are primarily those of depth, of the magnetic and resistivity instruments will be overcome. The new gradiometer may also be capable of greater depth penetration. All of these will be used in April and May, 1962 at Sybaris with the goal of locating the ancient Greek city of Sybaris which is believed to lie at depths of approximately 7 meters. Since the ancient city is at such great depth and is below the present water table, its excavation is not practical by ordinary techniques. Power-driven earth moving equipment and pumps will be used to uncover the features detected by the instruments and drills. If successful, these explorations will demonstrate the potentialities of field exploration with electronic devices. There are, in many regions of the world, rich alluvial plains, such as that at Sybaris, where river-borne and wind-blown sediments have buried the ruins of ancient settlements and other remains of ancient cultures. These new techniques of exploration will provide the means for discovery when nothing is visible on the surface. It is anticipated that a new field of archaeology will be opened.

The Geohm, proton magnetometer, and seismic instruments were tested also by R. Linington (1961, pp. 287-289) in the spring of 1961 at Tikal, Guatemala. It was found that the resistivity method was the most suitable for the conditions at Tikal. With the Geohm, extensive surveys of the North Acropolis, West Plaza and on the steps of Temple I were made. Subsequent excavation of the West Plaza (reported by Robert H. Dyson, Jr. and Peter Harrison) has revealed the following:

The resistivity readings provided a map reflecting a major change in compaction from upper loose to lower compact deposits, but did not indicate bedrock. Several types of deposits combined to create the compaction surface. Retaining walls buried in the compact materials were not differentiated by the readings. By testing an area, depth values for groups of resistance lines may be established and used in reading the map as a guide to the location of deeper superficial deposits (or conversely to indicate a buried compact mass). Identification of buried masses as to component material depends upon excavation.

A Geohm is in use at the present time (under the direction of Michael Coe of Yale Univ.) on the south Pacific coast of Guatemala to aid in the location of stelae on this alluvial plain.

Tests of the new instruments have been conducted during this winter in the Independence Hall area in Phila. The presence of walls there of known location and depth has facilitated these tryouts.

During the spring and summer (1962), one of the Geohms will be used by John Cotter and M. Larabie for exploration of sites of old canal houses along the C and O Canal (up the Potomac River from Washington, D. C.) and at other eastern locations in the U. S. A.

B. Establishment of Information Center.

A card file of references to "scientific aids for archaeology" is being compiled. This will include reports of analyses (chemical and otherwise) of ancient objects, lists of laboratories where various facilities are available, facilities for and results of dating and other techniques which are pertinent to archaeology, etc. Appropriate books, periodicals and other publications are also being obtained. The purpose of this center is to facilitate the research work of members of the staff and students --to assemble information that is often difficult and time-consuming to find--elusive information that is widely scattered or absent in convenient libraries or that is occasionally obtained fortuitously by personal communication.

To date (March, 1962), the ASCA files include a subject index (arranged alphabetically by authors within each subject category) which cites author, title, and provides a summary of the article, --an author index with title, and publication information, --and a file of laboratories concerned with techniques that aid archaeology and where analyses and information are made available. The subject index (which will continue to be sub-divided as it grows) presently includes the following classifications:

Astronomical information--solar radiation
Botanical information such as wood identifactions
Ceramic studies
Chemical analyses
Climatology
Conservation, preservation, restoration
Dendrochronological analyses
Ecological information
Field survey techniques, land, sea, air (photography, electronic equipment, periscope, magnetometer, etc.)
Fluorine dating
Geological and geophysical information
Geological and Geophysical methods of dating
Glacial information
Gold, copper, bronze analyses
History of technology
Magnetic dating
Metallurgical studies
Obsidian and glass dating
Other radioactivity dating methods (rubidium-87, xenon-129 dating, etc.)
Pollen analyses
Potassium-argon dating
Radiocarbon dating
Radiocarbon laboratory methods
Statistical treatments
Summaries and survey reports concerned with archaeological techniques used
Thermoluminescence dating
Trace element analyses

The selection of references added to the ASCA files, up to the present writing, has been made on the basis of accumulated previously unfiled materials, staff suggestions, and a systematic search through various periodicals (including ICC Abstracts, COWA Bibliog., Abstracts of New World Archaeology).

Articles and reports of analyses have been chosen for various subjects concerned with archaeological techniques; no direct attempt has been made as yet to investigate as fully as possible, references for one particular subject. This is the intention:-- that future searching will concentrate on a given topic, for example, potassium argon dating, and an attempt will be made to classify references concerning it before transferring attention to successive topics.

C. Application of Various Chemical, Metallurgical, and Physical Techniques for Analyses, Identification and Dating.

In this category, the expansion of the chemical laboratory has proceeded at a modest rate.

A.E. Parkinson has found the "spectranal" to be a useful instrument for rapid trace analyses of metals and for comparisons of metals and other more complicated materials. Standard solutions of almost every metal available have been prepared to facilitate and improve the accuracy of these determinations. For example, the study of 4 bronze mace heads from Iran with this instrument provided excellent agreement with more elaborate analyses performed commercially with an emission spectrograph. It is being used presently for the comparison of glazes on pottery. Another current project with this instrument is the trace analysis of 50 samples of copper ingots from the Late Bronze Age ship excavated by G. Bass of the University Museum, off Cape Gelidonya, Turkey in 1960 and 1961. It is anticipated that there may be a correlation between ingot markings and place of manufacture or the source of the ores. Published data concerning ancient and modern copper mines in Cyprus will be used as comparanda.

10, 1 w
over year 63-64

The Ultrasonic Decontaminator has been used for the cleaning of bronzes, pottery, and other delicate objects with some encouraging results.

An additional small room is being equipped for expansion of the existing chemical laboratory.

It is anticipated that greater strides will be made in the near future as a result of interdepartmental collaboration. We are fortunate in having the active support of Prof. Robert Maddin, Director of the School of Metallurgical Engineering. Similar collaboration with the Depts. of Chemistry and Physics affords a great expansion of the facilities of ASCA. For example, in the School of Metallurgy a great deal of equipment is, or will be, available - apparatus such as metallographs, electron microscopes (both for reflected and transmitted light), x-ray machines, mass spectrographs, kilns, furnaces, and polishing equipment. Analyses with poloragraphs and a mass spectrometer are being conducted also in collaboration with the Dept. of Chemistry.

Through the kind cooperation of Mrs. Althea Revere, a specialist in electron microscopy, studies of gold objects have been made. The purpose of these is to determine whether or not electron microscopy will provide a means to distinguish between ancient and modern gold objects. This is a serious problem for archaeologists because of the increasing production of fakes. Preliminary results of 4 ancient and one modern object show the appearance of octahedral-type forms (possibly due to the presence of impurities) on the surfaces of the ancient gold and greater irregularity of surface scratches. More objects are presently being studied to obtain a more comprehensive statistical analysis.

In regard to thermoluminescence dating, work is just being resumed on the photon detection phase of this technique. This includes the development of a rapid-heating "furnace", detection of the photons emitted with suitable photomultiplier tube, and simultaneous recording of the light output and heating rate.

Progress has been made by Mark Han with the alpha counting phase of the project. Special ZnS screens in shapes suitable to hold powdered potsherds have been perfected by him. Alpha counting rates, which will afford measures of the rates of bombardments of the potsherds, are being determined for samples of known ages.

With knowledge of these bombardment rates, it is planned to duplicate the "dose" in a short time with a strong source to obtain a correction factor for the varying susceptibilities and transparencies of clays.

III. SUMMARY AND FUTURE PLANS

Funds are requested for the continuation of the projects described in Section II. It is hoped that, within the next few years, the instruments for underground exploration will be perfected to a greater degree, more knowledge will be acquired in the use and capabilities of the various types, and that as a result, a new field of archaeology will be opened up and field explorations will be accelerated. In the laboratory, the files of the information center will complement field explorations, providing guides for the vital "background" research and basic source material for instruction. The apparatus of the laboratory and that of other departments in the University may form the physical foundation of a Department of Applied Science for Archaeology in the University of Pennsylvania.

An additional new, but related project is proposed for this year - namely, the "technological review of sites", specifically large city sites that are too expensive to re-excavate now but have been excavated and recorded in the past, prior to the development of modern "peeling techniques". The plan is to take a small team with instruments and knowledge of present-day technology to collect representative samples for dating by C^{14} and other means, to survey excavations and surrounding areas with instruments to detect significant features that may have been missed, and to make up-to-date studies of stratigraphy, geomorphology, etc. Possible sites are as follows:

Iraq: Teppe Gawra, Ur, Hassuna, Arpachia

Iran: Tureng Tepe, Teppe Hissar, Rayy

Turkey: Alişar Hüyük, Alaca Hüyük.

Publications (since Sept. 1961)

R. E. Linington. "Physics and Archaeological Salvage", Archaeology, vol. 14, No. 4, p. 287-292, Dec. 1961.

C. M. Lerici and Froelich Rainey. "Archaeological Techniques and International Cooperation", paper to be presented at International Congress on Techniques and Direction in the Archaeological Problems of Today, in Venice, May 1962.

__________ and __________. "New Archaeological Techniques and International Cooperation in Italy", Expedition (The Bulletin of the University Museum), in press.

IV. FACILITIES

Facilities now available at the University of Pennsylvania are the radiocarbon, chemical, and the new laboratories of the Applied Science Center for Archaeology; also, equipment available in the Departments of Metallurgy, Chemistry, and Physics. Experiments with tree-ring dating are also being carried out in conjunction with the radiocarbon program. (This work is presently supported by NSF Grant G-14094). The major equipment items have been mentioned in the Description of Research.

V. PERSONNEL

Biographical sketches and bibliographies of the persons actively engaged in this program are attached:

Dr. Froelich Rainey, Principal Investigator, Director of ASCA

Miss Elizabeth K. Ralph, Associate Director of ASCA

Mr. Bernard Wailes, Research Associate

Mr. A. E. Parkinson, Chemist

Mr. Mark C. Han, Research Chemist

In addition, as part-time specialists there are:

Mr. Gray MacLaughlin, Electronics and Instrumentation

Mrs. Althea Revere, Electron Microscopy

Collaborating Archaeologists from the University of Pennsylvania are:

Dr. Alfred Kidder II - South America and Mesoamerica

Dr. Linton Satterthwaite - Mesoamerica

Dr. William R. Coe - Mesoamerica

Mr. William Haviland - Mesoamerica

Dr. Rodney S. Young - Anatolia

Dr. Ellen Kohler - Anatolia

Mr. Robert H. Dyson - Middle East

Dr. Rudolf Anthes - Egypt

Mr. Alan R. Schulman - Egypt

Dr. Carleton S. Coon - Middle East

Dr. Samuel Noah Kramer - Mesopotamia

Collaborating Archaeologists from other institutions:

Dr. J. Louis Giddings - Arctic (Brown University)

Dr. Machteld J. Mellink - Anatolia (Bryn Mawr College)

Dr. Michael D. Coe - Mesoamerica (Yale University)

Collaborating Scientists from Departments of the University of Pennsylvania are:

Dr. Robert Maddin, Chairman, School of Metallurgical Engineering

Dr. Charles C. Price, Chairman, Department of Chemistry

Dr. William E. Stephens, Professor, Department of Physics

BUDGET

Salaries		
Research chemist, Mark Han	$ 6600	
Research assistant, full-time	5000	
Research assistant, part-time, information center	3000	
Research assistant, part-time	2000	
Total salaries		$16600
Employee benefits (8.3% of salaries)		1378
Equipment		
Underground Instruments -- continuation of sonic device development including ground coupling and transducer problems and development of more sensitive metal detectors	10000	
Information center Books, references, periodicals	500	
Laboratory projects		
Thermoluminescence recorder, etc.	3000	
Vickers projection microscope	3500	
Special study costs - emission spectograph, electron microscope, mass spectrometer, etc. service charges	2000	
Expendable supplies and materials and small apparatus	2500	
		21500
Travel		
Technological site review, 3 people to Near East	5000	
Other instrument tests	1500	
Collaboration with and trips to Texas companies	500	
		7000
TOTAL		$46478
Overhead, 20%		9296
GRAND TOTAL		$55774

Dr. Rainey

VI. BUDGET

Salaries			
Research Physicist	$8 000		
Two Research Assistants, part-time (or one full-time)	5 500		
Total Salaries		$13,500.00	
Employee benefits (8.9% of salaries)		1,201.50	
Equipment			
Miscellaneous tools and small instruments	500		
Ultraviolet light source	150		
Pottery thin-sectioning tools, microscope and polaroid light source	800		
Books and periodicals	500		
Expendable Supplies and Materials	2 500		
Total Equipment		4,450.00	
Travel			
Instrument Tests in Texas (4 round trips)	800		
Local Travel	300		
Total travel		1,100.00	
Sub-Total			$20 251.50
Overhead - 25%			5 062.87
TOTAL			$25,314.37

July 11, 1963

Extra ASCA

UNIVERSITY OF PENNSYLVANIA
Philadelphia 4, Pennsylvania

PROPOSAL FOR RESEARCH PROJECT

Submitted to: National Science Foundation
Washington 25, D. C.

Title of Proposal: Applied Science Center for Archaeology

Starting Date: September 1, 1963

Duration: 1 year

FUNDS REQUESTED

Total: $63,844.00

Corporate Name of University: THE TRUSTEES OF THE UNIVERSITY OF PENNSYLVANIA
(A Pennsylvania non-profit corporation)

Contracting Office: Office of Project Research and Grants
3400 Walnut Street
Philadelphia 4, Pennsylvania

Date Submitted: March 26, 1963

APPROVALS

____
Froelich Rainey, Principal Investigator
Director, University Museum
University of Pennsylvania

____
David R. Goddard, Provost
University of Pennsylvania

APPLIED SCIENCE CENTER FOR ARCHAEOLOGY

I. ABSTRACT

Funds for the continuation and improvement of the facilities and techniques of the Applied Science Center for Archaeology are requested. The main projects of this program are as follows:

A. DEVELOPMENT AND USE OF INSTRUMENTS FOR UNDERGROUND EXPLORATION.

1. Sonic Device
2. Metal Detectors
3. Magnetometers
4. Probes and Drills

B. DATING TECHNIQUES

1. Carbon-14
2. Dendrochronology
3. Thermoluminescence
4. Relative Dating Methods

C. ANALYTICAL TECHNIQUES

1. Chemical
2. Others
3. Pottery Studies

D. COMPILATION OF DATA AND BACKGROUND MATERIAL

E. STUDENT TRAINING

II. DESCRIPTION OF RESEARCH

This proposal comprises a request for funds for the continuation of the current projects of the Applied Science Center for Archaeology (abbreviated ASCA) and for the initiation of supplemental ones. The main goal continues to be the application and adaptation of techniques which have been developed in the physical sciences to the problems of and the acceleration of research in archaeology and anthropology.

Progress made in the various projects up to September 1, 1962 was described in detail in the "Final Report" submitted at the conclusion of NSF Grant G-18571. Since many of the projects now in process are in interim stages, it is somewhat difficult to differentiate at this time (February, 1963) between experiments which will be successful and, therefore, concluded and those for which continued research and development will be required. In order to present a clearer picture of the overall program, however, projects in process as well as ones to be considered for the future are included in the following descriptions.

The program is administered by Froelich Rainey, Director of The University Museum and Professor of Anthropology, and is assisted by Elizabeth K. Ralph, Research Associate in Physics. A. E. Parkinson continues as University Museum chemist; and Bernard Wailes, Instructor in Anthropology, as archaeological advisor. With funds from the current grant (NSF GS-16), Mark Han is employed as research chemist; and Hamilton Carson and Jeannette Flamm as student assistants.

A. DEVELOPMENT AND USE OF INSTRUMENTS FOR UNDERGROUND EXPLORATION

1. Sonic Device

The ideal "sonic device" will be an instrument capable of transmitting a wave or impulse into the ground with sufficient force for it to be reflected or refracted from a buried ruin, then detected without ambiguity. As explained previously, this is not possible with ordinary geophysical seismic techniques, and our research has been directed toward the development of an instrument which will operate at higher frequencies such that the wavelengths approximate more closely the size of the buried archaeological features, and their reflections, therefore, may be interpreted.

The difficulty in the development of the instrument is due to the fact that the higher frequency sound waves are attenuated in the ground more severely than the lower frequency seismic waves, and it is more difficult to introduce them efficiently or couple them to the ground. These impediments were encountered in the field tests at Sybaris (Spring 1962) of the MacLaughlin sonic prototype (designed and constructed by MacLaughlin Electronics, Perkiomenville, Pa. under contract for ASCA). The transmitter (commonly called a "transducer") did not impart sufficient power into the ground for the pulsed waves emitted by it to be transmitted more than 2 meters, let alone be reflected. An improved transducer is presently being constructed by Grey MacLaughlin and will be tested at Sybaris this year.

In the meantime, the Petty Laboratories, Inc. in San Antonio, Texas have been conducting basic experiments with sonic waves, both continuous and pulsed. (This work is supported by a gift of $32,000 to The University Museum by an anonymous foundation and members of the Sun

Oil Company). First of all, the Petty engineers have constructed a requisite testing ground near San Antonio which includes receivers (commonly called "geophones") planted at various depths and manufactured "ruins" -- concrete blocks, also at various depths. These "plants" enable direct transmission of waves to be measured and also reflections (over the blocks). Secondly, requisite items of equipment have been constructed and assembled by the Petty engineers for the measurement of ground attenuation characteristics at various frequencies and for experimentation with various transducers, both for continuous wave transmission and at selected pulse repetition rates.

The preliminary experiments of the Petty engineers indicate that attenuation is not too severe until the frequency exceeds 600 to 800 cycles, but that driver powers of some hundreds of watts will be required for reliable indications of buried objects at depths of 25 to 30 feet.

The study of seismic and sonic wave behavior in the weathered layer near the surface of the earth is under consideration also by Frederick Romberg, Texas Instruments Co., Inc., Dallas, Texas. For use in this study, a portable multi-channel high frequency oscillograph (up to 2000 cps) with associated high frequency geophone pickups is being designed and built by MacLaughlin Electronics (with funds contributed by Eugene McDermott, Chairman of the Executive Committee of Texas Instruments Co.). The instrument will permit the use of analytical methods that have been developed both for prospecting and for the detection and identification of large explosions at a distance.

These basic studies along with the flexible components assembled by the Petty Co. and the improved MacLaughlin prototype to be tested at Sybaris this Spring (1963), where walls and building foundations are covered with

5-6 meters of homogenous clay deposits, will eventually provide the information required for the construction of the "ideal" sonic instrument for archaeological prospecting. It is hoped that enough information will be obtained to start the construction of a workable model in 1963-64.

2. Metal Detectors

Various instruments, including ones designed for military purposes, for utility companies, and for amateur treasure hunters have been tried over buried ferrous and non-ferrous metals. All of these tested so far have limited depth penetration which decreases with the size of the objects sought. These instruments include the Army Detecting Set AN/PRS-3, the Goldak 599T Metal and Mineral Locator, and the Fisher Research Laboratory Type T-10 Electronic Single-Loop Treasure-Metal Detector and the Fisher M-Scope. Of these, the M-Scope exhibited the greatest depth penetration, but is limited to 8 feet for an object with 2 x 2 foot cross-section and reduced to 6 inches for 2 x 2 inch cross-section. There continues to be an urgent need for the development of a more sensitive instrument to assist the search for the relatively small archaeological deposits of metal. At the same time, up-to-date transistorized and miniaturized construction techniques can readily be applied to these instruments.

3. Magnetometers and Telluric Current Measurements

The successful applications of the Elsec proton magnetometer (manufactured by the Littlemore Scientific Engineering Co., Oxford, England) have been reported in numerous articles. (Archaeometry, vols. 1, 2, 3, 4; M. J. Aitken, Physics and Archaeology, 1961; E. K. Ralph, Sybaris Field Report, 1962, and others.) We plan to continue (Spring 1963) the search for Sybaris with the proton magnetometer, and to experiment there also with metastable helium magnetometers which have recently been developed by Texas Instruments, Inc. (Apparatus Division, Dallas, Texas). The TI helium magnetometer is 100 times more sensitive (detects changes in magnetic intensity as small as 0.01 gamma) than the proton magnetometer. Because of this great sensitivity, two instruments would be required, one to be used as a fixed monitor of variations due to natural phenomena and the other, to be moved about to locate "anomalies" or changes in magnetic intensity due to buried archaeological features or possibly, soil layer changes. Since the TI helium magnetometer is capable of detecting the natural magnetotelluric micropulsations, we plan to monitor simultaneously the telluric field of the earth (changes in the magnetic field of the earth and in the electric currents measured in the ground are closely related), and to experiment with the introduction of small currents into the earth, which in combination with the sensitive magnetometers, may provide a technique for the location of deeply buried archaeological features.

The equipment for the measurement of telluric currents is relatively simple and has been purchased with funds from the present grant. We hope to borrow the two helium magnetometers plus an engineer from Texas Instruments for these initial tests at Sybaris. If successful, however, funds will be required for continued experimentation with helium magnetometers.

4. Probes and Drills

It is frequently necessary to confirm the presence of, ascertain the characteristics of, and to determine the depth of anomalies found with the instruments. This can most easily be accomplished with rods and drills. Experiments with the following types have been conducted.

(a) Pointed rod (1/2 inch diameter), 1 meter long with screw threads at end, additional sections 1 meter long, and detachable cross-bar handle. This is suitable for probing through homogenous clay for the location and depth determination of buried solid objects. Depth limit for reliable information is 6 meters maximum.

(b) Hand auger, such as Soiltest, Inc. 1-1/2 inch diameter screw type with extension sections. Performs same functions as (a) and permits sampling of soil and associated small artifacts which collect in the leading part of the spiral bit (approximately 10 in. long) if withdrawn without rotation. Penetration generally limited by force of extraction required (unless supplemented with tripod, chain hoist, etc.).

(c) Spiral auger sections (3-1/4 inch diameter) powered with a McCullogh gasoline engine (Model DR-450 Power Earth Auger sold by Soiltest, Inc, 4711 W. North Ave., Chicago 39, Ill.) These auger bits when supplemented with a tripod and chain hoist (for extraction without rotation) enable the precise stratigraphy of potsherds, chips of building blocks and other small artifacts to be determined if the ground is sufficiently wet so that the mud adheres between the flanges of the bits and holds the potsherds in place during extraction. Samples may be obtained from depths of 10 meters or more, but for the determination of the location of solid objects with certainty, depth limitation is approximately 6 meters.

(d) Jeep mounted drill with forced water circulation. This drill (furnished by the Lerici Foundation of Rome and Milan), with 3 inch diameter bores, is a standard prospecting rig and is capable of forceful penetration to great depths; and with core sampling attachments, it may be used to sample building blocks and other hard features. An indication of pottery and small object stratigraphy may be obtained by rapid collection and careful notation of the sherds washed up as the drill penetrates the earth.

(e) Mighty Midget Earth Drill BAV 100 (made by Houston Tool Co., Santa Susana, California). This is a portable prospecting drill (may be carried by 3 people) with 1 inch diameter bore which may be used with forced water circulation and performs the same functions (except for rock sampling) as the Jeep mounted drill. It is provided, also, with a vacuum pump which may be used when drilling in very dry earth, and it is equipped for the collection of powdered cores.

B. DATING TECHNIQUES

1. Carbon-14

The radiocarbon laboratory is an integral and basic part of ASCA. The main program, that of dating archaeological samples, is supported by the University of Pennsylvania; methodological studies are financed by NSF grant GP-405 (Elizabeth K. Ralph, principal investigator).

2. Dendrochronology

In conjunction with the methodological studies of the carbon-14 laboratory, tree-ring dating of sequoias (*Sequoia gigantia*) and bristlecone pines (*Pinus aristata*) is being pursued in the ASCA laboratories by Henry Michael and student assistants. This work is supported also by NSF grant GP-405, and is conducted in collaboration with the Laboratory of Tree-Ring Research, University of Arizona. Sections of cross-dated trees afford samples of known age for the C-14 studies. Since it is now evident that there have been small fluctuations in the atmospheric C-14 inventory in past times, it becomes more important to find means of extending the range of samples of known age. The bristlecone pines, when the cross-dating is completed, will afford samples dating back to 4000 years and possibly further (by the cross-dating of "floaters", trees which have died in the past, with living trees).

Another possibility for extension of the range may be afforded by the creation of a master log for samples of cedars of Lebanon and other "sensitive" trees which were imported into Egypt during the early dynasties.

3. Thermoluminescence

Experimentation with the thermoluminescence method of dating pottery and other fired objects is being pursued by Mark Han and E. K. Ralph. The work this year has been concentrated upon the design of suitable "furnaces" and filter arrangements so that the glow curves (from the photons emitted with heating) may be recorded precisely before the onset of black body radiation due to the heating. When this is accomplished, experiments may then be conducted to learn more about the problems which will arise due to the varying susceptibilities and transparencies of clays. Close contact is being maintained with Martin Aitken, Associate Director of the Research Laboratory for Archaeology and the History of Art, Oxford University, where similar experiments are being performed.

4. Relative Dating Methods

If equipment for metallurgical studies becomes available in ASCA, it is proposed to study the feasibility of its use for relative dating methods such as obsidian layer determinations.

C. ANALYSES

1. Chemical

(a) Trace Elements

Numerous examples of the successful applications (performed by Eric Parkinson) of the Fisher Duo-Spectranal for the identification and comparison of trace elements in metals and in ceramics were described in the "Final Report" of NSF Grant G-18571. Since then other analyses have been completed and more are scheduled.

More recently, several groups of analyses performed by Mark Han with an emission spectrograph (made available through the kind cooperation of Prof. J. T. Peters and Mrs. M. Lalevic of the Department of Physics at Drexel Institute) have been completed or are in process. This more elaborate instrument affords greater sensitivity for the detection of trace elements and provides semi-quantitative results as well. A partial list of the analyses for trace elements undertaken by M. Han is as follows:

(1) Gold objects from the Near East, Russia and Central America. These analyses were performed to supplement the microscopic and electron probe studies being conducted in an attempt to find a means of differentiating between the real objects of antiquity and the fakes.

(2) A series of copper ingots and copper-tin alloys from a sunken ship off the coast of Turkey excavated by George Bass, University Museum. Purpose of the analyses is to determine whether or not similar markings on the ingots and similar shapes have significant correspondence.

(3) Ambers from various regions of the world and the Near East, in particular. The first part of the program is to determine variations in composition among groups from one source, then variations between groups, and then assess the usefulness of this approach as applied to the tracing of source materials (and migration routes) for amber objects found at Hasanlu, Iran and related Near Eastern sites.

(b) Major Elements

For the determination of the major elements in compounds, the standard "wet" quantitative analyses continue to be the best in many instances. The basic techniques change little from year to year but speed and precision in their performance may be improved through the use of more modern equipment. A fundamental up-to-date instrument is now lacking in the

ASCA chemical laboratories - namely, an Electro-Analyzer for the rapid and accurate determination of metallic elements. An instrument such as the Fisher Controlled-Potential Electro-Analyzer Cat. No. 9-264 has the additional advantage of enabling the operator to plate out one metal in the presence of others by automatic control of the operating potential.

Primary among the many needs for an Electro-Analyzer, is that for the analysis of ancient bronze objects in which the variations of copper and tin contents frequently afford useful information.

2. Other Analytical Techniques

(a) X-Ray Examination

Several samples of iron and bronze objects from Hasanlu, Iran (excavated by Robert Dyson, University Museum) have been submitted to Erwin Parthé, Department of Metallurgy, for X-Ray examination. The purpose in most cases is to find out if the original structures and design patterns can be "seen" in badly corroded objects.

(b) Ultraviolet Light.

Plaster objects from Gordion, Turkey are to be studied under ultraviolet light and other sources, by Han and Parkinson as a means of revealing painted designs which are now obscure.

Ultraviolet lamps are useful also in the examination of marble objects for cracks, repairs, etc.

3. Pottery Studies

In addition to the methods of analysis already mentioned, the technique of neutron irradiation of pottery and subsequent determination of the original trace elements present (now being performed at several institutions) has provided an excellent non-destructive means for pottery analyses. Another method, useful for surface analysis, is that of beta ray back scattering.

Frequently, however, there is a need to examine the structure of pottery by means of thin sectioning and microscopic techniques (including the use of polarized light). It has not been possible to perform these studies in the University Museum because of the lack of equipment.

D. COMPILATION OF DATA AND BACKGROUND MATERIAL

For the results of the analytical studies to be useful, it is frequently necessary to compare them with ones performed previously. For this reason a "center" for files of completed analyses and indexed references to published ones is invaluable.

The value of the center as a source for the most recent information concerning archaeological techniques comes into focus through its organization of as yet unpublished material. In our correspondence with the British Museum we have received instructions concerning the conservation of bones and delicate objects that are not yet published or soon to be published in Museum News. Likewise, our files include correspondence and experimental notes concerning seismic equipment and its recent applications, and entries applicable to C-14 dates which supplement the IBM cards and provide leads to dates that appear in archaeological journals.

In addition to the continuation of the author and subject indices which catalogue scientific techniques of value to Archaeology and include analyses reports, dating methods, field studies, and conservation methods, it is proposed that our compilation of resistance and survey reports be extended to include copies of reports of the surveys being made by other expedition groups. These would be filed according to the type survey and cross-referenced to the instruments used as well as to the geographic location of the tests.

E. STUDENT TRAINING

A graduate course entitled "Problems in Archaeology" is being given by B. Wailes in both terms. It is an advanced seminar course in methods, techniques, and interpretation, and includes student training in the use of field instruments.

The information center has been used by students and visiting scholars for source material and references.

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Note: Articles published (or submitted for publication) about some of the projects described in the preceeding pages are listed with the curricula vitae of the persons engaged actively in the ASCA program.

III. SUMMARY OF GRANT REQUEST

Funds are requested for the continuance of the projects (now supported by NSF Grant GS-16) which will not be concluded this year and for the addition of a few new undertakings. The equipment required for both is itemized in the BUDGET.

In regard to field tests and the program of instrument development, a summary of current work is as follows:

Local Sites

Student instruction in the use of resistivity, seismic apparatus, and metal detectors; demonstration of MacLaughlin sonic device.

Harper's Ferry - Site of U.S. Rifle Works

Resistivity and seismic surveys conducted by H. Carson; followed by test trenching (H. Carson, Archaeometry, vol. 5, in press)

Isle Royal (in Lake Superior)

Surveys to be made in summer 1963 by H. Carson with metal detectors, resistivity, and seismic apparatus for location of natural copper deposits, and other features.

Sybaris, Italy, Spring 1963.

Surveys to be continued with proton magnetometer, resistivity, and new tests to be made with MacLaughlin sonic prototype, Petty Laboratory sonic apparatus, and Lerici Foundation sonic apparatus; if made available, Texas Instruments Helium Magnetometers, in conjunction with measurements of telluric currents; extensive use of rods and drill.

N. Ireland, Navan Fort (July 1963)

Surveys to be made with most of the instruments listed in Italy at a site to be excavated by B. Wailes.

Our instrument and survey plans for 1963-64 are as follows:

(1) Surveys in Bulgaria for location of Iron Age and possibly Greco-Roman tombs.

(2) Surveys in Ireland or N. Ireland at Bronze Age Sites.

(3) Surveys in Jordan at site to be excavated by James B. Pritchard, Curator of Biblical Archaeology.

(4) Possibility of surveys in Egypt.

(5) Surveys at Louisburg Fortifications, Canada in collaboration with Edward Larrabie.

(6) Miniaturization and assembly of portable sonic instrument.

(7) Construction of improved metal detector.

In addition to the present staff (supported by the NSF), there is a need for a physicist. It is anticipated that a recent graduate of Oxford University who has been trained in the Research Laboratory for Archaeology and the History of Art under the direction of Drs. E. T. Hall and M. J. Aitken will be available in September, 1963.

IV. FACILITIES

Facilities now available at the University of Pennsylvania and sponsored by the University are the radiocarbon, chemical and the new laboratories of the Applied Science Center for Archaeology. Space for the latter two and for the expansion of the last has been provided in The University Museum. In addition, equipment is available in the Departments of Metallurgy, Chemistry, and Physics. The facilities contributed by the University will be greatly expanded by the addition of the new Materials Center (presently under construction) in which a large well-equipped Analytical Laboratory, including all of the latest equipment for metallurgical, physical and chemical analysis, will be located.

V. PERSONNEL

Biographical sketches and bibliographies of the persons actively engaged in this program are attached :

Dr. Froelich Rainey, Principal Investigator, Director of ASCA

Miss Elizabeth K. Ralph, Associate Director of ASCA

Mr. Bernard Wailes, Research Associate

Mr. A. E. Parkinson, Chemist

Mr. Mark C. Han, Research Chemist

In addition, as part-time consultants there are:

Dr. Henry Michael, Dendrochronology

Mr. Grey MacLaughlin, Electronics and Instrumentation

Mrs. Althea Revere, Electron Microscopy

Collaborating Archaeologists from the University of Pennsylvania are:

Dr. Alfred Kidder II	- South America and Mesoamerica
Dr. Linton Satterthwaite	- Mesoamerica
Dr. William R. Coe	- Mesoamerica
Dr. Rodney S. Young	- Anatolia
Dr. G. Roger Edwards	- Anatolia
Dr. Ellen Kohler	- Anatolia
Mr. George F. Bass	- Underwater Archaeology
Mr. Robert H. Dyson, Jr.	- Middle East
Dr. W. Kelly Simpson	- Egypt
Dr. Carleton S. Coon	- Middle East
Dr. Samuel Noah Kramer	- Mesopotamia
Dr. James B. Pritchard	- Biblical Archaeology

Collaborating Scientists from Departments of The University of Pennsylvania are:

Dr. Robert Maddin, Chairman, Department of Metallurgy

Dr. William E. Stephens, Professor, Department of Physics

Dr. John G. Miller, Professor, Department of Chemistry

Collaborating scholars from other institutions are:

Dr. Martin J. Aitken:	Associate Director of the Research Laboratory for Archaeology and the History of Art, Oxford University, England.
Ing. Carlo M. Lerici:	Director of the Lerici Foundation, Rome, Italy
Dr. Bryant Bannister: Dr. Wesley Ferguson:	Laboratory of Tree-Ring Research University of Arizona, Tuscon, Arizona
Dr. Zaky Iskander:	Director of the Laboratory of the Cairo Museum, Department of Antiquities, Cairo, Egypt.

UNIVERSITY OF PENNSYLVANIA — SOCIAL SCIENCES

RAINEY — ANTHROPOLOGICAL SCIENCES

BUDGET

TWELVE MONTH BUDGET

A. SALARIES

Senior Personnel:		
(1) Principal Investigator	$ -----	
(2) Faculty Associate	-----	$ -----
Other Personnel:		
Two Research Assistants (full time)		13,000
Fringe Benefits		1,170
		$14,170
B. EXPENDABLE EQUIPMENT AND SUPPLIES		2,500
TOTAL DIRECT COSTS		$16,670
Indirect Costs (20% of Direct)		3,334
TOTAL		$20,004
ROUNDED TO		$20,000

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UNIVERSITY OF PENNSYLVANIA — SOCIAL SCIENCES

RAINEY — ANTHROPOLOGICAL SCIENCES

BUDGET

TWENTY-FOUR MONTH BUDGET

	NSF Grant	Grantee Share
A. SALARIES		
Senior Personnel:		
(1) Principal Investigator, 2 calendar years, 10%	---	$ 5,100
(2) Faculty Associate, 2 calendar years, 10%	---	$ 2,450
Other Personnel:		
(3) Research Associate, 2 calendar years, full time	$17,500	---
(4) Research Assistant, 1 academic year, half time, 1 summer, full time	$ 3,600	---
TOTAL SALARIES	$21,100	$ 7,550
A' Fringe Benefits	$ 1,755	$ 627
B. PERMANENT EQUIPMENT	$ 3,700	---
C. EXPENDABLE EQUIPMENT AND SUPPLIES	$ 4,000	---
D. TRAVEL (Domestic)	$ 1,500	---
E. OTHER	$ 850	---
TOTAL DIRECT COSTS	$32,905	$ 8,177
INDIRECT COSTS (37% of Item A)	$ 7,807	$ 2,794
TWENTYFOUR MONTH TOTAL	$40,712	$10,971
ROUNDED TO	$40,700	

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8/21/64

Final Report for NSF Grant GS-294

Applied Science Center for Archaeology
University Museum, Univ. of Penna.
Froelich Rainey, Principal Investigator

A. Development and Use of Instruments for Underground Exploration.

A report of the sites which have been surveyed with instruments by ASCA and brief descriptions of the various types and their applicability under differing conditions is contained in the enclosed preprint of an article entitled "New Frontiers in Archaeological Exploration" by F. Rainey and E. Ralph. In this article, the progress made toward the development of a sonic instrument is mentioned on page 14, and experiments with the Varian Associates rubidium magnetometer and a different type of seismograph, the Soiltest Terra-Scout, are summarized on page 18.

More recently, the portable multi-channel high frequency (up to 2000 cps) oscillograph designed and built by MacLaughlin Electronics (with the majority of the funds contributed by Eugene McDermott, Chairman of the Executive Committee of Texas Instruments Co.) has been field-tested in Texas. Even though the high summer temperatures there affected the transistors and sensitive crystal geophones adversely, the engineers of Texas Instruments were pleased with the possibilities that the new design of this instrument offers. It may be only another step along the way toward the ultimate instrument for archaeological prospecting, but it affords a new approach to the problem with chances of success. Requisite changes in the circuits are now being made by MacLaughlin and subsequent field tests in Texas are scheduled for September.

B. Dating Techniques - Thermoluminescence.

Experiments with thermoluminescence, the possible new technique for dating pottery, (supported by this and previous NSF grants), have advanced significantly this year. Our progress is described in the enclosed preprint of an article entitled "Dating of Pottery by Thermoluminescence" by E. Ralph and M. Han.

A C. Analytical Techniques

Use of the Duo-Spectranal from August, 1963, to August, 1964

The Duo - Spectranal continued to be used by E. Parkinson for the identification of cations in analyses of various specimens, as follows:

1. Two yellowish beads, identified as limonite containing crystals of calcium sulphate and a copper salt plus traces of compounds of several other elements.

2. White crystals which were identified as calcium sulphate containing a trace of iron.

3. Plaster, which was found to be calcium sulphate containing silica, titanium dioxide and compounds of several other metals.

4. Lumps and powder tentatively identified as lime but found to contain 82% of silica, major amounts of titanium and aluminum and small amounts to traces of several other metallic elements, therefore not lime but possibly a clay with a high silica content.

5. A yellow powdery substance, identified as limonite containing calcium sulphate and traces of several metallic elements.

6. Carbonized lumps which were thought to be possibly bread remains were found to be carbonaceous material mixed with sand, titanium dioxide and compounds of several metals; possibly a partly carbonized bitumen mixture.

7. An antimony bead was confirmed as antimony containing various other metals.

8. An apparently completely corroded ring tentatively listed as antimony was found to be lead containing tin and various other elements.

9. A corroded bead tentatively listed as antimony was found to be lead with traces of calcium and magnesium.

10. A partly corroded ring tentatively listed as antimony was identified as lead with calcium and magnesium and traces of other metals.

11. Fragments tentatively listed as leather were identified as partially decomposed and partly mineralized leather containing silica and six or possibly eight metallic elements.

12. Fragments composed of cloth and possibly leather contained, in addition to carbon, sandy material, compounds of several metals, and phosphorus, but no organic nitrogen so the identification of leather was apparently erroneous.

13. Fragments tentatively identified as leather were found to be partly mineralized leather containing compounds of several metallic elements.

All the above specimens were from Hasanlu, Iran

14. A specimen composed of bright red powder and crystals with a steel-grey luster from Tikal, was confirmed as cinnabar, not specular haematite.

15. Material from the concave head of a bronze punch from the Bronze Age shipwreck off Cape Gelidonya, Turkey, was found to contain copper and a trace of calcium, and was therefore concluded to be a corrosion product of the bronze, not remains of leather as had been postulated.

16. A specimen of brittle, black material from a burial at Tell es-Sa'idiyeh, Jordan, thought to be bitumen, was found to contain in the inorganic residue various metallic elements including nickel and vanadium, said to be characteristic of bitumen from that area. Molybdenum, also said to be characteristic, was not found.

17. A corroded link of chain from the burial at Tell es-Sa'idiyeh, assumed to be silver, was identified as electrum containing copper.

18. A small sample of corroded metal from a quiver cover from Iran, of doubtful authenticity, contained copper and tin and traces of other metals. A sample of a grey deposit on the surface of the cover was identified as a calcium-magnesium carbonate.

19. Black powdery coating on a small pair of gold lions from Hasanlu, Iran, was found to contain silver and small amounts of several other metals; probably a corrosion product of the gold, which was in reality electrum.

20. Some brownish-black, porous lumps, supposed to be iron slag, from the Necropolis of S. Montano, Ischia, were found to have a very high (63.4%) iron content and relatively low (21.2%) silica content, with only small amounts of calcium and magnesium; these results are indicative of iron ore, such as haematite or limonite, rather than a slag.

21. A black deposit from the inside surface of a sherd contained carbon, alkaline earth metals and silica; possibly remains of organic material but the results were not specific enough to draw conclusions.

The B.D.H. Spot Test Outfit has been used several times to test for trace elements.

A.E. Parkinson

8/7/64

A.E.P.

D. Compilation of Data and Background Material.

Additions to the author and subject indices concerning scientific techniques which are pertinent to archaeological dating have continued throughout this year by J. Flam. New categories have been added to them to include information regarding seismic and sonic techniques which correspond with ASCA's experiments with instruments based on these principles.

Survey reports have been organized separately as was previously outlined, and as we and other institutions continue with this work reports are added to the file.

The library has been enlarged to include new books appearing this year that concern science in its application to archaeology, and we hope to publish a news bulletin which will include brief synopses of the current work at laboratories concerned with new archaeological dating methods and techniques, and instrument surveying methods and techniques. This bulletin would be sent to various institutions and groups to inform them of new facilities and ideas concerned with the discovery, analysing, dating, and care of archaeological evidence.