April 19, 1961

Mr. F. Haydn Morgan
Director, Project Research and Grants
3400 Walnut Street
University of Pennsylvania
Philadelphia 4, Pennsylvania

Dear Mr. Morgan:

We have prepared the enclosed grant proposal for submission to the National Science Foundation, in particular to Dr. Albert C. Spaulding, Program Director of the Division of Anthropology.

We shall appreciate it very much if this can be processed through the University before the May 1st deadline of the National Science Foundation.

Sincerely yours,

FR:ah
Enc.

Froelich Rainey
Director

PRESERVATION COPY
5/2/2014

~~Grant~~ Techniques

UNIVERSITY of PENNSYLVANIA

PHILADELPHIA 4

OFFICE OF PROJECT RESEARCH AND GRANTS

April 21, 1961

National Science Foundation
Washington 25, D. C.

Gentlemen:

Please find enclosed twenty (20) copies of a proposal for a research project entitled "Research and Development in New Techniques for Archaeology". This proposal has been prepared by Froelich Rainey, Director, University Museum, and has been signed on behalf of the University by Dr. Loren C. Eiseley, Provost.

Very truly yours,

Arthur A. Brennan, Jr.
Contracts Administrator

AABrhl

Enclosure
cc: Dr. Rainey

NATIONAL SCIENCE FOUNDATION
WASHINGTON 25, D.C.

April 25, 1961

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 research entitled "Research and Development in New Techniques for Archaeology."

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 and you will be advised sometime in July regarding the Foundation's ability to support your work.

Yours sincerely,

Albert C. Spaulding

Albert C. Spaulding
Program Director for
Anthropology

JUN 19 1961

Dr. Gaylord P. Harnwell, President
University of Pennsylvania
Philadelphia 4, Pennsylvania

Grant NSF-G18571

Dear Dr. Harnwell:

I am pleased to inform you that the sum of $30,900 is hereby granted by the National Science Foundation to the University of Pennsylvania for the continued support of "Research on Archaeological Techniques," under the direction of Froelich Rainey, University Museum, for a period of approximately one year, effective August 1, 1961. Unless otherwise notified, payments under this grant will be made as follows: $8,900 on or about August 15, 1961; $11,000 on or about December 15, 1961 and $11,000 on or about April 15, 1962.

It is a condition of this grant that it may be revoked in whole or in part by the Foundation after consultation with the principal investigator and the grantee, except that a revocation shall not affect any commitment which, in the judgment of the Foundation and the grantee, had become firm prior to the effective date of the revocation; and that funds not committed by the grantee prior to the conclusion of the work contemplated under this grant shall be returned to the Foundation.

It is a further condition of this grant that disposition of patent and other rights in any inventions or discoveries made or conceived during the research, construction of facilities, installation or adaptation of equipment, as may be supported by this grant, shall be the responsibility of the grantee; that the grantee shall give the Foundation reasonable notice of application by the grantee or other person or institution for a foreign or domestic patent on any such invention or discovery; and that upon application for any patent on any such invention or discovery, the patentee shall grant the Government an irrevocable, royalty-free, nonexclusive license for use of such invention or discovery for governmental purposes.

The Foundation desires that this grant be administered in general accordance with the Foundation's policies for research grants as stated in "Grants for Scientific Research," January 1960, as amended, and in conformity with the other understandings reached between the Foundation and the grantee relating to this grant.

Please acknowledge receipt and acceptance of this grant and include a reference to the grant number.

Sincerely yours,

Alan T. Waterman
Director

UNIVERSITY of PENNSYLVANIA
PHILADELPHIA 4

OFFICE OF PROJECT RESEARCH AND GRANTS

June 26, 1961

Dr. Alan T. Waterman
Director
National Science Foundation
Washington 25, D.C.

Re: Grant NSF-G18571

Dear Dr. Waterman:

We acknowledge with thanks your letter of award dated June 19, 1961 which informed the University of a grant in the amount of $30,900 for the support of a research program entitled "Research on Archaeological Techniques," under the direction of Dr. Froelich Rainey for a period of approximately one year. We understand that the grant will be paid as follows: $8,900 on or about August 15, 1961; $11,000 on or about December 15, 1961; $11,000 on or about April 15, 1962.

In accepting this grant in behalf of the University, may we take this opportunity to express our sincere appreciation for the Foundation's support of this program and to assure you that the funds will be expended in general accordance with the Foundation's policies for research grants as stated in "Grants for Scientific Research," January 1960, and established University policies.

Sincerely yours,

James L. Malone
Contract Administrator

JLM:jp
cc: Dr. Harmwell
Dr. Risely
Dr. Rainey

June 29, 1961

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

Dear Al:

This is in effect a personal report on the first year of operations in the Techniques Program, which has been financed by the National Science Foundation. You will receive a more detailed and technical report on progress for the past year from Richard Linnington, together with a Statement of Expenditures.

As you know, most of our work this past year has been concerned with techniques for archaeological exploration, although we have set up the laboratory and established the information center on such techniques. Also, we have done some work on Thermo-luminescence and on chemical techniques for identification and preservation. Moreover, we have begun work on the attempt to apply dendro-chronology in the Near Eastern field. This latter has been done with Museum Funds.

Our research on exploration techniques was initiated by Linnington at the Texas Instruments Company Laboratories in Dallas, and that company itself invested some $15,000 or $20,000 in testing apparatus applicable to the archaeological job. Then it was decided, by Mr. McDermott, President of T. I., that the design of a sonic instrument in archaeology should be worked out in the University rather than in their laboratories; and he contributed $5,000 personally to this work at the University of Pennsylvania. I then employed Mr. McLaughlin, an Electronic Expert, to begin work on a design. He is going strong and is very hopeful that he can develop a high frequency instrument for ground exploration, using a Radar Scope as the recording apparatus. All this is quite new and he has very little literature to guide him.

In the meantime, people at the Sun Oil Company still believe that this instrument can best be developed by a commercial firm, and their engineers have taken up the problem with the Petty Geophysical Instrument Company in San

Antonio, Texas. We now have a proposal from them stating that they believe they can design such an instrument in ten months for $32,000. The Sun Oil Company engineers think this is a reasonable price and three or four men in Sun Oil Company are now debating among themselves as to who will put up the $32,000. I think this will be confirmed in a week or two, before I get off for Italy.

One other exciting aspect to this whole business, is the Lerici Program in Italy. He expects to convince the Italian Government that a broad program of recording and investigation of Italian sites with these electronic instruments would help to preserve Italian Antiquities from the vandals who are now exploiting most of these sites. He has asked the University Museum to join the Lerici Foundation in this campaign and we expect to have six crews operating in Italy during August, September and October. If we are successful, then the Italian Government will finance the whole long-range program and we will continue to work with the Lerici Foundation. You can see how this will be an ideal way to test and develop all of the techniques which the Italians and ourselves are now working upon.

Moreover, as you know, Mr. Orville Bullitt of Philadelphia is granting us $12,500 to carry on the Italian Program because he is particularly interested in an attempt to find the Tomb of Alaric, the Visagoth. I might add in this connection, that we have just purchased a remarkable high-speed drill which, believe it or not, was developed in California to drill holes on the moon. This will make it possible to test quickly Anomalies we find in the earth with a drill which records the strata penetrated.

What I really want to point out here is the interesting fact that a $27,900 grant from the National Science Foundation has stimulated private contribution which will probably total $69,500 before the end of August. It has also made it possible for the University Museum to join the Italians in what is certainly the most ambitious plan yet conceived for developing archaeological field techniques. Moreover, our meeting here on June 1st with representatives from Harvard, Yale, Princeton and Columbia certainly demonstrates that we have already established a center for this kind of research at the University Museum, and that we will have full collaboration from other archaeologists in the country, both for training and for development work.

You may wish to pass on this information to Dr. Waterman as an example of how a National Science Foundation grant can stimulate private contribution to Research. I happened to meet him briefly at the Cosmot Club with Dr. Carmichael and he struck me as the sort of person who would be interested in this kind of thing from the standpoint of Science Foundation grants in general.

As you know, what we intend here is to cross over various kinds of research now going on in order to discover and utilize all sorts of electronic, atomic, mechanical and chemical techniques in archaeology. We find commercial firms, such as Sun Oil, Texas Instruments and Petty Geophysical, peculiarly interested in archaeology and willing to dig down into their own pockets to help us with this research. Some of their engineers believe that a sonic instrument will have wide spread commercial and industrial application, but I am now sure that is not the reason they are giving us financial support. Also, I would like to emphasize again, that none of this could be done without the National Science Foundation grants which provide the nucleus of such work here in the Museum.

I am leaving for Italy on July 14th and you can reach me at any time through the Lerici Foundation, 108 Via Veneto, Rome.

Very best wishes,

Froelich Rainey
Director

FR:mah

Argel Things file

NATIONAL SCIENCE FOUNDATION
WASHINGTON 25, D.C.

June 30, 1961

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

Dear Fro:

Thanks for your report on the grant. We, of course, were particularly interested and pleased about the response of private donors to your project and will pass the information on to Dr. Waterman at the appropriate time.

Sincerely,

ac

Albert C. Spaulding
Program Director for
Anthropology

E. K. Ralph
NSF G-18571
Fund 36181
Class 4
10100

UNIVERSITY OF PENNSYLVANIA

Philadelphia 4, Pennsylvania

PROPOSAL FOR RESEARCH PROJECT

Submitted to: National Science Foundation

Title of Proposal: Research and Development in New Techniques for Archaeology

Principal Investigator: Froelich Rainey, Director, University Museum

Starting Date: 1 September 1961

Duration: 1 year

FUNDS REQUESTED

Total: ~~$33,817.32~~ $30,900 granted

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

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

APPROVALS

Loren C. Eiseley, Provost
University of Pennsylvania

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

RESEARCH AND DEVELOPMENT IN NEW TECHNIQUES FOR ARCHAEOLOGY

I. Abstract

Funds for the continuation and amplification of the research and development in new techniques for archaeology are requested. The major projects to be undertaken are as follows:

1) Development, testing, and field use of "underground explorers."

2) Enlargement of the information center on new techniques.

3) Development of the thermoluminescence method for dating pottery and other fired objects.

4) Expansion of the chemical laboratory.

5) Student training in techniques.

Au

B. Wailes Problems in Archaeology - adv. sem course in methods, techniques, interpretation

II. Description of Research

The main features of this proposal are envisaged as continuations of the work started under NSF Grant G-13256, a grant with the same title of one year's duration and starting date 1 September 1960. The aims of both are to increase the applications to archaeology of the techniques and instruments developed in the physical sciences, and to assemble pertinent information and equipment for the use of archaeologists and anthropologists, which will serve additionally as a foundation for a teaching program. Progress made and future plans are described by Rainey (1961).

The projects have been started by members of the staff of the University of Pennsylvania-namely, Froelich Rainey, Director of the University Museum and Professor of Anthropology, principal investigator; Elizabeth K. Ralph, Research Associate in Physics, in charge of Carbon-14 Laboratory; and A. E. Parkinson, University Museum chemist. With funds from NFS Grant G-13256, R. E. Linington, physicist from Oxford University with experience in the use of field instruments for archaeological prospecting, has been employed as Research Associate in Archaeological Techniques, University Museum. Hamilton Carson, graduate student in Anthropology, has been employed as a part-time assistant.

The request for the continuation and amplification of this program is outlined in the following order:

A. Research Completed
B. Research in Progress
C. Continuations and New Research

A. Research Completed (1 September 1960-15 April 1961)

1. Development of "Underground Explorers"

Under the direction of R. E. Linington, the three most promising types of instruments were investigated. Two of these---the resistivity instrument and the proton magnetometer---have been developed commercially with suitable sensitivity and portability for archaeological prospecting. It was, therefore, found to be economical and practical to purchase a resistivity instrument made in Germany, a Gossen Erdungsmesser, Type 323, and an Elsec proton magnetometer, made in England.

The resistivity instrument is designed to detect small changes in ground conductivity and is especially suited for the detection of underground configurations such as large stelae and foundations, that is, forms and structures with susceptibilities to moisture which differ from the surrounding earth. The successful use of a resistivity instrument at Cerro de las Mesas in Mexico is described by Stirling, Rainey, and Stirling, Jr. (1960);; see also Lerici (1960). The disadvantages of the resistivity instruments are that four or five prods have to be spaced carefully in the ground, and moved for each reading. Also, the depth of penetration depends upon the spacing so that if the approximate size and depth of the configurations sought are unknown, repeated readings over the same area with different spacings have to be performed. This procedure is time-consuming.

The proton magnetometer detects very small changes in the total magnetic intensity of the earth. It is, therefore, the optimum instrument for the location of "magnetic" objects and structures.

This category is broader than would first appear, and includes kilns, bricks, deposits of pottery and other previously fired objects, and soil disturbances, the latter due to the difference in magnetic susceptibility of disturbed earth. The instrument is described by Waters and Francis (1958), and its application in the field by Aiken (1958, 1959a, 1959b)and others. The instrument is fast, with only a probe to move above the ground. Also, the diurnal variation in magnetic intensity is easily compensated for with the addition of a second probe as a reference standard.

It is apparent from the brief descriptions of these two instruments that the "underground" has not yet been completely covered. It is hoped that the gaps will be minimized with the third type--namely, impulse detection. Research was, therefore, started with seismic, sonar etc. instruments. These principles have been widely employed for deep underground and broad layer detection, but their potentialities for delineated sub-surface prospecting have not been adequately explored. The basic premise of seismic detection is that if a percussive energy source is used to generate shock waves in the earth, then these energy waves will travel out from the shock point in all directions. Of these shock waves, only those that are in some way deflected from their paths, such as by a change in medium, will stand a chance of returning to the surface to be detected by means of their altered velocity. The sonar principle is similar, with sound waves substituted for shock waves. The problem is to find a means of confining the area covered in order to detect the relatively small and shallow archaeological features.

Extended testing of the seismic principle was undertaken with

commercial high-resolution equipment in conjunction with the equipment and personnel of the Texas Instruments Company(Geophysical ServicesInc.). This Company subsidized the work with technical help and funds which are estimated to have cost $10, 000. Help was also received from the Sun Oil Company and the Texas Research Foundation, Dallas, Texas. Field testing was performed at sites near Dallas on large simple modern objects such as bridge abutments, spillways of a reservoir, and parts of the main sewerage works. Although this equipment had not previously been considered appropriate for the detection of buried structures, moderate success was achieved. Tests were then made on archaeological sites near Tucson and Globe, Arizona with this equipment in conjunction with the same engineers of the Texas Instruments Company, and with an additional smaller instrument contributed for the period of testing by Geophysical Specialties Company, Minneapolis, Minnesota.

The experience gained in the field indicated that high-resolution seismic detectors, modified to operate at higher frequencies, show promise for archaeological prospecting. The problem of introducing higher frequency impulses into the ground has not yet been solved.

2. Establishment of an Information Center on New Techniques.

Laboratory rooms have been equipped with file cabinets, shelves, benches, etc. The compilation of card files with extensive cross-indexing and files of pertinent articles, catalogs, reprints, etc., has been started. Books on archaeological techniques and associated subjects have been purchased as well as two series of geophysical publications which were not available in the libraries of the University of Pennsylvania. Radiocarbon IBM cards, purchased previously by the University Museum, are also located in this Center. Comprehensive files on radiocarbon dating are

available in the laboratory.

3. Development of Thermoluminescence Method for Dating Pottery and other Fired Objects.

Little time has been available for work with this technique, but progress has been made in the design and construction of rapid-heating "furnaces" which consist of thin foils of metal through which high currents are passed. Heating rates of 100° C per second have been achieved. This rapid rate will facilitate the detection of the weak luminescence.

4. Expansion of the Chemical Laboratory

In the course of the major work of this laboratory--the preservation and identification of archaeological objects-- many time-consuming qualitative and quantitative analyses are made. A "Spectranal", an instrument designed for rapid, complete qualitative spectroscopic analyses of 61 elements, including almost all common metallic as well as several non-metallic elements, and for semi-quantitative analyses has been purchased.

An "Ultrasonic Decontaminator" has been installed to facilitate the cleaning of bronzes, potsherds, etc. Preliminary tests have been performed to determine optimum solutions, temperatures, etc., for the non-destructive cleaning of Museum objects.

5. Experiments with Beta-Ray Backscattering

The angle of backscattering of beta-rays emitted by a radioactive source is dependent upon the atomic number of the scattering element. This principle, therefore, makes it feasible to identify the elements of pottery glazes, or, at least, to differentiate among widely separated ones such as lead and copper. The technique is non-destructive. It is described

by Hall (1958) and by Asahine, et al. (1957).

Experiments were performed with a one-inch-diameter end window geiger and a C^{14} beta-ray source. Adequate differentiation, as measured by backscattered counting rates, was achieved with flat surfaces, but curved surfaces cause anomalies. Further experiments are required with delineated beta-ray beams, and to determine optimum strength and energy of sources.

B. Research in Progress (15 April-1 September 1961)

1) Development of "Underground Explorers"

Field testing of the resistivity instrument, proton magnetometer, and a standard seismic device is now in process at Tikal, Guatemala. Systematic surveys of certain sections of this site will afford information regarding the suitability of each of the instruments in the terrains studied, and more knowledge of the development required for seismic detection. Analysis of the data taken will aid in the future use and development of these instruments.

Agreement has been reached with the Lerici Foundation in Rome to collaborate during June, July and August of 1961 in the testing of field instruments in Italy. This Foundation has developed a number of new techniques which have not been utilized in the United States. It also maintains a laboratory and staff for experimentation. Additional funds amounting to $15,000 have been contributed by private sources for the Italian work. Moreover, the Italian Air Force is contributing the aerial photographic work. Research will be carried out in the Etruscan area north of Rome and in the south of Italy. This phase of the research

will be under the direct supervision of Dr. Froelich Rainey.

German resistivity equipment purchased under the NSF Grant G-13256 will also be tested by Dr. J. Louis Giddings on the Arctic coast of Alaska during the Summer of 1961. At the same time in Turkey, Dr. Rodney S. Young will utilize additional equipment in an attempt to follow the ancient Persian road which passes the site at Gordion and to locate tombs in the earth mounds at that site.

2)Establishment of an Information Center on New Techniques.

Compilation of cards and files will be continued. Literature and references on new techniques will be assembled from the journals with which we are familiar, and from others, obtained from published indices. Contributions are also being obtained from members of the staff of the University Museum, from visiting scientists, and by correspondence.

3)Development of Thermoluminescence Method of Dating Pottery and Other Fired Objects.

With the rapid-heating "furnace", measurements of luminescence of clays of various ages will be made to determine the requirements for amplification and recording devices which will be needed for quantitative measurements and determinations. Alpha rates of emission from the clays will be measured.

4) Expansion of Chemical Laboratory

Chemical analyses will be performed with the "Spectranal", and continued use made of the "Ultrasonic Decontaminator".

C. Continuations and New Research

1) Development of "Underground Explorers".

The success of the preliminary experiments with "impulse" detection indicates that a suitable portable instrument may be designed within the next year. This work will be continued in collaboration with and, it is hoped, supplemental funds contributed by the Texas Instruments Company; and with the assistance of electronics specialists at the University of Pennsylvania. The main projects will be the design of a high frequency source-either impact or continuous wave, transmitter and receiver, and the ground coupling device.

Field testing of the three different methods--resistivity, magnetometer, and seismic--will be extensive. Studies will be made at local archaeological sites in New Jersey and in the southwestern United States. Testing, and perhaps rewarding use, of the instruments is anticipated in Nubia, Italy, Iran, the Arctic coast, Guatemala, Peru and Bolivia--sites at which excavations sponsored by the University Museum are planned. The prospects for success with one or more of these techniques in the highlands of Peru and Bolivia are described by Kidder II (1961).

An important phase of the program will be the study and interpretation of the field results. This will be facilitated by concurrent and subsequent excavations at the sites. Laboratory studies with models will also be carried out.

2) Establishment of an Information Center on New Techniques.

Expansion of card indices, technical files, etc., and active use of the information by faculty and students is anticipated.

3) Development of Thermoluminescence Method of Dating Pottery and Other Fired Objects.

With equipment for quantitative measurements of luminescences, the existing heating apparatus and alpha counter, experiments will be performed to establish time scales in terms of the parameters measured with potsherds of known age. Some of the obstacles, such as differing retentions of metastable electrons, susceptibilities and transparencies of clays, have been overcome by Dr. George C. Kennedy (University of California, Los Angeles) by means of X-ray and 20 mev proton bombardments. His advances may be copied here, notably X-ray bombardment with equipment available in the Department of Physics. A new approach is anticipated in lieu of the 20 mev proton bombardment--to duplicate the original alpha bombardment of the clay constituents in a short time with a highly radioactive alpha source. It is hoped that chronologies consistent with the ages of the potsherds can be obtained.

4) Expansion of Chemical Laboratory.

With the purchase of a Vickers Projection Microscope (similar to that used in the British Museum), many new studies may be undertaken. This instrument enables one to see or photograph objects (up to 50 pounds in weight) with magnification ranges of from x10 to x2000. This improved "visibility" frequently eliminates the necessity for chemical analyses for identifications and comparisons of objects or fragments, and has the additional advantage of being non-destructive. It is an invaluable instrument for the study of materials and structures. Many of the corallary techniques--the study of obsidian and glass surface layers as methods of dating, etc. -- may be performed with the projection microscope.

5) Student Training in Techniques.

It is anticipated that a course in archaeological techniques for graduate students will be initiated. This will include instruction in dating, field survey, identification, conservation, and other techniques. Some active participation in the laboratories of Carbon-14 and tree-ring dating, in the varied activities of the chemical laboratory, and with the use of field instruments is planned. Studies of the diverse techniques now in existence or under development will be facilitated by the references and files in the Information Center.

PERSONNEL

DR. FROELICH RAINEY

PERSONAL HISTORY:

Birth: June 18, 1907, Black River Falls, Wisconsin
Wife: Penelope Lewis Rainey
Children: Penelope, Jr. Age - 19
Pamela Age - 16

EDUCATION:

University of Chicago, Graduated in 1929, Ph. B. in English

Yale University, Graduated in 1935, Ph. D. in Anthropology

American School in France-Pre-historic Archaeology, 1930

POSITIONS HELD IN THE PAST:

Professor of Anthropology, University of Alaska, 1935 - 42

Financial Grants in Aid for Research at American Museum, 1934-42

Assistant Professor of Anthropology at the University of Puerto Rico, 1935

Director of Quinine Mission in Ecuador, 1943-44

State Department:

Foreign Service Officer assigned to Berlin, 1945-46

Office of Transport and Communications in charge of inland transportation, 1946-47

Consultant, State Department, 1948-52

U. S. Representative to International Rhine Commission, 1949.

Anthropological Research in West Indies and Alaska

Director, University Museum, University of Pennsylvania, 1947 to present.

ACTIVITIES:

Prof. of Anthropology - University of Pennsylvania

Chairman, Organizing Committee, 29th International Congress of Americanists, 1940

Philadelphia Committee of Foreign Relations

Treasurer, Society for Applied Anthropology 1947 - 1950

Carbon 14 Committee

Chairman, Committee on International Relations in Anthropology 1951-1956

American Anthropological Association, Executive Committee 1951

Moderator of Television Program WHAT IN THE WORLD

President, International Congress of Anthropological and Ethnological Sciences, 1956

Foreign Policy Research Institute 1954 to present

Chairman, Science Planning Board, 21st Century Exposition Seattle, Washington

BIBLIOGRAPHY OF PUBLICATIONS OF FROELICH RAINEY DIRECTOR, UNIVERSITY MUSEUM 1959

"Archaeology in Central Alaska," Anthropological papers of the American Museum of Natural History, Volume XXXVI, Part IV, New York, 1939

"Eskimo Prehistory: The Okvik Site on the Punuk Islands," Anthropological papers of the American Museum of Natural History, Volume 37, Part IV, New York, 1941

"The Ipiutak Culture at Point Hope, Alaska," American Anthropologist, Volume 43, No. 3, July - September, 1941

"Puerto Rican Archaeology," The New York Academy of Sciences- Scientific Survey of Puerto Rico and the Virgin Islands, Volume XVIII, Part I, New York, February 13, 1940

"The Whale Hunters of Tigara," Anthropological papers of the American Museum of Natural History, Volume 41, Part 2, New York, 1947

"Native Economy and Survival in Arctic Alaska," Applied Anthropology, Volume 1, No. 1, October - December, 1941

FROELICH RAINEY

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"The University Museum, Its Collections and Expeditions, " Fairmount Park Art Association, 78th Annual Report, Philadelphia 1950

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"Eskimo Archaeology in 1950, " Bulletin of the National Research Council-Proceedings of the Alaskan Science Conference of the National Academy of Sciences, National Research Council, No. 122, April 1951, Washington, D. C.

"The Significance of Recent Archaeological Discoveries in Inland Alaska, " American Antiquity, Memoirs of the Society for American Archaeology, Volume XVIII, No. 3, Part 2, Utah, 1953

"Afghanistan, " Bulletin, University Museum, Volume 17, No. 4, Philadelphia, 1953

"Tradition and Change, " Bulletin, University Museum, Volume 18, No. 4, Phila., 1954

"The New Museum, " Bulletin, University Museum, Volume 19, No. 3, Philadelphia, 1955

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"Archaeology in the American Arctic, " Published in Russia, 1958

"The Vanishing Art of the Arctic, " Expedition Winter 1959, Volume 1, No. 2

"Radiocarbon Dating in the Arctic, " American Antiquity, Volume 24, No. 4, April, 1959, p. 365-374 (with E. K. Ralph).

"Archaeological Salvage in Egypt, An Example of International Cooperation, " Expedition, 1960, Volume 2, No. 4, pp. 2-3.

"Electronics and Archaeology, " Expedition, 1960, Volume 2, No. 4, pp. 19-29 (with M. W. Stirling and M. W. Stirling, Jr.).

"Techniques Program of the University Museum," Bulletin of the Philadelphia Anthropological Society, 1961, Vol. 14, No. 1, pp. 1-4.

ELIZABETH K. RALPH

Born: February 5, 1921, Trenton, New Jersey

Education: Wellesley College, 1938-42, B.A.
University of Pennsylvania, 1949-51, M.S.

Positions: August 1942-49, Junior Electronics Engineer, then Chemist, then Assistant to Chief Radio Engineer, then Project Engineer at Foote, Pierson and Company, and Kearfott Manufacturing Company, Newark, New Jersey.

1951, Research Assistant, Carbon 14 Laboratory, Physics Dept., University of Pennsylvania.

1955, Research Associate, Carbon 14 Laboratory, Physics Dept., University of Pennsylvania

Scientific Organizations: American Association for the Advancement of Science, Sigma Xi - Chapter Member 1956

Other Activities: As Member of the United States Field Hockey Touring Teams - Trip to South Africa and South Rhodesia, 1950.
C-14 Laboratory visits and field hockey trips to the British Isles, 1953, and to Australia, New Zealand and Fiji, 1956.

ELIZABETH K. RALPH

PUBLICATIONS

University of Pennsylvania, Radiocarbon Dates I, Science, 121, 149-151, 1955.

Radiocarbon Dates for Kara Kamar, Afghanistan, University of Pennsylvania, II, Science, 122, 921-922 (with C. W. Coon), 1955.

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University of Pennsylvania, Radiocarbon Dates IV, Amer. J. Sci. Radiocarbon Supplement, in press, (with R. Ackerman).

C-14 Dates for Sites in the Mediterranean Area, American Journal of Archaeology, in press (with E. Kohler).

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Education: Wellesley College, 1938-42, B.A.
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Other Activities: As Member of the United States Field Hockey Touring Teams - Trip to South Africa and South Rhodesia, 1950.
C-14 Laboratory visits and field hockey trips to the British Isles, 1953, and to Australia, New Zealand and Fiji, 1956.

BUDGET

		~ Spent → 12/31/61	Remainder
Salaries			
R. E. Linington, Research Associate in Archaeological Techniques	$6,500	2167	
Research Assistant, part-time	2,000	443	
Student Assistant, part-time	1,500		
Total Salaries	$10,000	2610	7390
Employee Benefits (8.2% of salaries)	820		
Equipment			
1. Parts and development costs of impulse survey instrument (The work which may be done at the University of Pennsylvania in the Department of Physics by electronics engineers and technicians is estimated to cost $2000. It is hoped that the work done in collaboration with Texas Instruments Company will be subsidized by that firm. At the present time it is difficult to be specific regarding financial breakdown between the two groups.)	5,500		
2. Vickers Projection Microscope M5000	3,500		
3. Recorder for Thermoluminescence	2,000		
4. Reference books and periodicals	400	30	
5. Expendable equipment and supplies	1,000	818	
Total Equipment	$12,400	1348	11,052

Additional Seismic Fund = 5943.75 ? (5000 + int.) Spent by MacLaughlin = 5220

Revere ——— 500

Travel

(This is estimated on the basis of air travel for one person to the sites listed below. One or more may not be visited, or a few may be combined, but no funds have been allowed for "local" travel.)

Travel (cont)From Philadelphia and return:			
Dallas, Texas		135.60	
Tuscon, Arizona		203.40	
Nubia, Egypt			
to Cairo		882.70	
to Khartoum		170.70	
Rome, Italy		639.00	
Teheran, Iran		1020.40	
Arctic coast			
to Anchorage		430.80	
to Kotzebue		160.00	
Guatemala City, Guatemala		251.50	
Lima, Peru		567.00	
	Total Travel	< $4,461.10	2688 (1773)
Shipping costs		500.00	
	Sub-Total	$28,181.10	
Overhead (20%)		5,636.22	5150 ~~466~~
	TOTAL	$33,817.32	11,796 19,104

file — Techniques

UNIVERSITY OF PENNSYLVANIA
Office of Project Research and Grants
Digest of Terms of Contract or Grant for Research Project

CONTRACT NO: NSF-G18571
ACCOUNT CODE NO: 4-10100-3-6181
SPONSOR: National Science Foundation
TITLE: Research on Archaeological Techniques.
DURATION OF CONTRACT: 8-1-61 to 7-31-61
PRINCIPAL INVESTIGATOR: Dr. Rainey
UNIVERSITY DEPARTMENT: University Museum
TYPE OF CONTRACT: Grant
CLASSIFICATION: None
AMOUNT OF CONTRACT: $30,900

REPORTS, INVOICES: OVERHEAD: 20% of cost ($5,150)
Financial reports: 6 mo. interim & final
Technical reports: final

BUDGET: A University budget covering these funds should be prepared and submitted through regular channels. Budget 8.2% for employee benefits.

TRAVEL: To be authorized by: Dr. Rainey Per Diem $ 12 on a quarter day basis or, actual subsistence not to exceed $ 15 per day if supporting receipts accompany claim.
Automobile reimbursement: 10 ¢ per mile.

APPROVALS: Prior approval must be obtained for subcontracts and purchase orders that fall in categories checked below:

_____ Insurance
_____ Exceed $500., $1,000.
_____ Involve research or development.
_____ Provide for building alteration or construction.
_____ Overtime pay.
_____ Foreign purchases.
_____ Travel to Scientific Meetings and all foreign travel.

SPECIAL BUDGET INSTRUCTIONS ATTACHED

PUBLICATIONS: Copyrighted material shall carry byline granting sponsor royalty-free right of reproduction and shall acknowledge sponsor's support. X

PATENTS: Any patentable invention to be reported to sponsor. X
Sponsor to receive royalty-free license under patents. X
Sponsor to retain ownership of patents. License to University _____
Foreign patent rights rest with sponsor. _____

PROPERTY: Title to property purchased with sponsor's funds rests with University
Accurate records must be kept of all non-expendable items purchased with contract or grant funds.

OTHER: Payment: $8,900 on 8/15/61; $11,000 on 12/15/61; $11,000 on 4/15/62
4 copies of reprints to NSF.

Federal transportation taxes may not be paid with grant funds. Exemption certificates available at Comptroller's Office

NOTE: Accounting Code 4-10100-3-6181 has been assigned to this project. Please use this number on all requisitions, invoices, etc. to be charged against these funds.

DISTRIBUTION:
Comptroller, Attn: Miss Rennard, w/cy contract
Dr. Rainey

JLM: jp 6/26/61

OFFICE OF PROJECT RESEARCH AND GRANTS

Rev
561

IMPORTANT NOTICE CONCERNING UNIVERSITY BUDGETS

In order that a clear picture of the actual costs of sponsored research projects might be obtained, the following procedures should be used in the preparation of budgets covered by contracts and grants.

On the "Current Expense and Equipment" page of the University Budget, on the line in the overhead section labelled "Full" Rate", the overhead costs of the project are to be entered. These must be in an amount equal to 50 per cent of all salaries and wages included in the budget.

If the overhead allowance provided by the sponsor is less than 50 per cent of salaries and wages, the difference will be shown as a contribution from the University. Steps will be taken by the Office of Project Research and Grants to secure an appropriation from University funds to cover this contribution.

The following illustrates the procedure outlined above. In this example it has been assumed that the salary budget amounts to $10,800 and that 15 per cent overhead on $11,900 of total direct expenses has been allowed by the sponsor.

CURRENT EXPENSE AND EQUIPMENT page of budget

Code No.	Current Expense		Expl. Ref. No.	Amount Approp. Current Year	Amount Propos. for Next Year
ϟ	ϟ		ϟ	ϟ	ϟ
8940	Overhead:			XXXXX	XXXXX
	"Full" Rate (50% Salaries)	$5,400		XXXXX	XXXXX
	Less: Univ. Contr.	3,615		XXXXX	XXXXX
	Overhead Allowed				1,785

This procedure was established in January 1958 to implement an action of the Trustees. It is not intended in any way to curtail research efforts of the faculty, nor is it indicative of any intent on the part of the University to reduce its contribution toward the cost of research programs. The procedure was developed to assure that indirect costs of our various programs will be more clearly recognized and more appropriately distributed.

F. Haydn Morgan
Director

Activities of the Applied Science Center for Archaeology

by E.K. Ralph

NSF Grant G-18571

1 Sept. 1961 - 31 Aug. 1962

RESEARCH & DEVELOPMENT IN NEW TECHNIQUES FOR ARCHAEOLOGY

Final Report

1) Development, testing, and field use of "underground explorers".

During this "grant" year, tests were carried out with instruments developed previously (three resistivity units and one proton magnetometer) and trials were made with several new ones. These are summarized on the enclosed ASCA (Applied Science Center for Archaeology) schedule.

As the chart demonstrates, the most extensive tests were made in Italy by F. Rainey and others in collaboration with members of the Lerici Foundation.

The comparative tests made in the fall at several sites with proton magnetometer, geohm, and seismic instruments are described by R. Linington in Quaderán di Geofisica Applicata, vol. 22 (1960) and by C. M. Lerici, "New Archaeological Techniques and International Cooperation in Italy", Expedition, vol. 4, no. 3 (Spring, 1962). Six copies of both publications are enclosed.

In the spring, greatest success was achieved at Sybaris with the proton magnetometer. Due to the fact that the thick clay deposits (approximately 6 meters deep) overlying the original surface of the plain of Sybaris are highly magnetic, Greek and Roman walls and foundations were detected with the magnetometer as comparatively strong "anti-magnetic" anomalies down to depths of 5 meters. Additionally, a few magnetic anomalies due to massive brick walls and concentrated deposits of potsherds were recorded.

ASCA INSTRUMENT SCHEDULE 1961 - 1962

DATES	Resistivity Instruments, Geohms made by Gossen Co., Germany			Proton Magnetometer "Elsec" made by Littlemore Scientific Co., Oxford, England	Gradiometer made by MacLaughlin Electronics, Perkiomenville Pa.	Metal Detector made by Goldak Co., Glendale, Calif.	Sonic Device	
	Unit #1	Unit #2 (Also Seismic Instrument made by Geophysical Specialties Co. Minnesota)	Unit #3				Prototype made by MacLaughlin Electronics Perkiomenville, Pa.	Research
FALL 1961			Both instruments used by F. Rainey and R. Linington in collaboration with Lerici Foundation at Tarquinia, Cervetri, and Sybaris, Italy. (Tests were made also with Seismic Instrument).				Development and construction	
WINTER 1961-62	Taken to Guatemala by MichaelCoe (Yale Univ.) for use on west coast alluvial sites.	Trials over known walls by ASCA staff and students at Independence Square, Phila.	Italy	Italy			Construction and preliminary tests over known walls by ASCA staff at Independence Square, Phila.	
SPRING 1962	"	"	Both instruments used by F. Rainey and E. Ralph in collaboration with Lerici Foundation in search for Sybaris, Italy		Initial trials by E. Ralph & M. Aitken (Oxford Univ.) at Sybaris, Italy	Tests by E. Ralph and Carabelli (Lerici Polytechnic Inst., Milan) at Sybaris, Italy	Field trials by F. Rainey & E. Ralph at Sybaris, Italy	Texas Instruments Co. and MacLaughlin Electronics and Petty Geophysical Co., Texas
SUMMER 1962		Both instruments used by H. Carson in collaboration with J. Cotter and E. Larrabee and other members of the National Park Service at Site of U.S. Rifle Works, Harpers Ferry, W. Va.		Repaired at Oxford				"

An area of approximately 9½ square kilometers was traversed with the magnetometer and the regions of concentrations of remains of the 4th century B. C. Greek city and later Roman city weredetermined (more surveys will be required to locate the exact limits). Buildings of the 6th century B.C. Greek city, believed to be at depths of 6 meters or more, were not detected with the magnetometer. This campaign is described by F. Rainey in an article entitled "Electronics in the Search for Sybaris", London Illustrated News, in press. The instrument work, in particular, is reported by E. Ralph, in press.

It is hoped that a device based on the sonic principle will complement the magnetometer and resistivity instruments, especially, in the achievement of greater depth penetration. This was not the case, however, with the prototype (built by MacLaughlin Electronics) which was tested at Sybaris this year. This consists of transducer, geophone, and detector. The last is an oscilloscopic type instrument with long persistence screen to provide additional amplification. It was anticipated that reflections from buried structures would be seen as distortions of the normally straight line trace of the detector. This unit functioned well, but the transducer did not transmit an impulse into the ground with sufficient force to be reflected. For this initial trial, the unit consisted of an electromechanical hammer which produced impulses of 20 ms duration and frequency spectra ranging from 500 to 10,000 cps. This and the geophone (with frequency selectivity) were coupled to the ground with conical spikes of various lengths. Even though this first prototype was not successful, it helped to clarify the real problems inherent in this technique - the need for development of a means of creating and transmitting into the ground an impulse of sufficient

force. First of all, more data are needed on the behavior of these higher frequency waves at shallow depths and it is hoped that this information will be obtained by the research being conducted on behalf of this project by the Texas Instruments and Petty Geophysical Companies. During the summer, the construction of a recording device was started by MacLaughlin Electronics. This will then be used by Texas Instruments Co. to study the behavior of surface (or shallow) waves in earth. Petty Geophysical Co. has started their research by conducting experiments and obtaining specific data for lower frequency continuous waves.

In Italy the Goldak metal detector was tested also, but did not function well - was difficult to balance, in this region of high magnetic intensity. This and an Army single detector "vacuum cleaner" type were also tested locally during the winter. The main purpose of these trials was to determine the limitations of these instruments and obtain information which will guide us in the development of more sensitive metal detectors.

A successful resistivity survey was conducted by H. Carson at an eastern historical site - namely, the site of the U. S. Rifle Works, Harpers Ferry, W. Virginia. This was done at the request of and in collaboration of J. Cotter, E. Larrabee, and other members of the National Park Service. Subsequent test trenches revealed that the most specific find of the "geohm" was a stone turbine pit 9 ft. in diameter and 5 ft. deep (resistivity readings were taken at 10 ft. and 5 ft. intervals). Other anomalies of the survey are presently being studied. Over the same area Carson conducted a survey with the seismic instrument, but plots of the data reveal

that the low-frequency sound waves were reflected by a layer change approximately 17 ft. deep rather than the more shallow archaeological features. This is another example of the inadequacy of standard geophysical seismic techniques for archaeological prospecting.

2) Enlargement of the information center on new techniques.

Within the year 9/61-9/62 the index of scientific techniques of value to Archaeology has expanded and its organization developed by J. Flam.

The files permit both an author index, including title and source of article, date of publication, and where it may be found, and a subject index with the title of article and a summary of it, filed alphabetically by the author's name. Whenever an entry is pertinent to several classifications, a card has been placed in all subsidiary categories, noting the principle category, that in which the summary of the article may be found.

The subject card file presently includes reports of the ff. types:

I Laboratory Studies

1. Analyses

a) Bone
b) Chemical
c) Glass
d) Spectroscopic
e) Metallurgic
f) Pollen
g) Textile
h) Trace Element

2. Conservation-Restoration

II Dating Methods - Survey Methods

a) Dendrochronology
b) Fluorine
c) Geochronology
d) Thermoluminesce
e) Magnetometer
f) Radiological
g) Photography

III Field Studies

a) Botanical
b) Ecological
c) Electronic-Magnetic Exploration Techniques

IV Conservation Methods

V Basic Archaeological Information

a) General Analytical Techniques
b) Survey Reports

Also organized is a file of research establishments, laboratories where facilities are available for dating, and the results of analyses.

In addition, new books and reprints have been added to the ASCA library providing source material in the ff. categories:

I Survey Methods

a) Resistivity Surveying
b) Magnetic Surveying
c) Seismic Methods

II Conservation-Restoration

III Laboratory Studies

a) Metallurgy
b) C-14
c) Pollen Analysis
d) Dendrochronology

IV Geologic-Climatic Dating.

3) Development of the thermoluminescence method for dating pottery and other fired objects.

This project was resumed this year by M. Han and his first efforts were devoted to the perfection of the alpha counting apparatus. Numerous minor problems were tackled and solved - the preparation of ZnS screens, their decontamination, the determination of the optimum sample size, calibration with sources, etc. Routine determinations of potsherd alpha emissions are now being made.

Experiments with luminescence detection were started by Han in August and the requisite major items of equipment - x-y recorder, D.C. Amplifier, and Light Source have been borrowed from the Dept. of Physics for the initial trials. Small special items are being constructed by Han.

4) Expansion of the chemical laboratory.

A) Use of the Fisher Duo-Spectranal

The following experiments were conducted with this instrument by A. E. Parkinson.

1. In order to have a reference catalogue of spectra as produced by the Duo-Spectranal the spectra of fifty-one elements were obtained from solutions containing an element in concentrations 100 times, 10 times and twice the minimum useable concentration, according to the sensitivity of the element concerned.

2. Comparison of the glazes on three ceramic pieces from Hasanlu: The glazes were found to be very similar both in composition and the concentration of the constituents observed, with the important exception that the glaze from the sherd contained titanium in addition to Si, Ca, Mg, Cu, Fe, Zn and Na, which were common to all three pieces (the other two were a bead and a tile). This was a case where it was very useful to be able to observe the spectra of two unknowns simultaneously.

3. Composition of a Hasanlu medallion: The white material contained barium, so was probably barite.

4. Analysis of bright red pigment from a Mayan stone yoke: Only strong mercury lines were observed, proving that the pigment was cinnabar.

5. In connection with a problem involving the darkening of parts of the glaze on a Han vase, a fleck of glaze was analyzed and found to contain Pb, Ca, Mg, Fe and probably Al. As a comparison a piece of glaze from another Han object was analyzed and found to contain Cu, Pb, Ca, Mg and Fe.

6. During an investigation of the contents of certain Cypriote-type vases from Egypt analyses were made of the ash after ignition of samples of the material. In each case Ca, Mg and Li were present, and in addition one sample contained Fe, Na and possibly Tl and Al, another Fe and Tl, and a third possibly Na and Tl.

7. In an attempt to obtain evidence as to whether the head and body of an Egyptian bronze statuette actually belonged together (the two had obviously been joined and there were doubts on stylistic grounds), analyses were made of samples from the two parts. While each sample contained Cu, Sn and Pb, the head sample also contained Zn, Ba and possibly Ca, and Sn and Pb appeared higher in the body sample. A second body sample, however, taken close to the head part, showed a composition much closer to that of the head, including the presence of Ba, so no certain conclusion could be drawn and as it was not deemed advisable to take more samples at this time the question is left unresolved.

8. Analysis of a brown anodic deposit which formed during the electrolytic cleaning of a corroded bronze showed the presence of Ni, Cu, Pb, Ca and Sr (the anodes were sheet nickel).

9. It was thought that the black surface layer on the handle of an Egyptian bronze sistrum might have been formed from some other metal, but analysis of a chip established that only copper was present.

10. A crystalline efflorescence on the surface of a Nubian sherd was found to contain mainly calcium with some sodium and possibly very small amounts of lithium, zirconium and titanium. Chemical tests showed chloride, so it was concluded that the efflorescence was a calcium chloride.

11. Only iron was found in the analysis of an iron breastplate of unknown origin, but bearing a Mediterranean-Section number.

12. Analysis of a bronze duckbill axehead from Beisan substantially corroborated a chemical quantitative analysis made outside the Museum in 1961, with one important difference. The spectroscopic analysis showed Cu, Sn, Zn, Pb, all reported from the chemical analysis, but also Ni, which was specifically reported as absent in the chemical analysis, and Fe, Ca, Mg, Si, not mentioned in the chemical analysis but probably contained in the "insoluble" reported. Arsenic, reported as a "small amount", was spectroscopically doubtful.

13. Incrustation on the surface of a bowl from Beth Shemesh, Palestine: Ca, P, Mg, Li, Na, Cu and Fe were noted. This largely duplicated the results of an analysis of a similar incrustation on another bowl from Beth Shemesh made in 1961, but copper was not found in the previous analysis.

Thus the Duo-Spectranal has been found very useful in giving a relatively quick picture of the composition of substances, in revealing the presence of elements present in very small amount or others which normally are not found in the usual wet chemical analysis, and in establishing the presence or absence of specific elements, which otherwise would have required going through a long

chemical procedure or the application of specific tests. It has also been very useful in direct comparisons of two or more unknowns.

B) Use of the Circo Ultrasonic Cleaner

This has been used in many cleaning operations, including removal of calcitic incrustations from ceramic objects and sherds (in acid solution), and in removal of reduced corrosion products from metal, particularly bronze, objects. It has been especially useful where the object has been porous or has had a deeply pitted surface, or the shape has been such that brushing was not feasible. It has also been used in cleaning radioactive-contaminated ZnS scintillation screens.

C) Other Chemical Activities

Experiments were conducted by M. Han with a Polaragraph (borrowed from the Dept. of Chemistry) in an effort to find a better method for the analysis of the major elements in ancient bronze and copper objects. Due to the low concentration of a sample solution (10^{-6} to 10^{-2} molar) needed by this method, it was our hope to use it for the determination of bronze and copper ingots. It was found that the procedure for copper is rapid with error of $\pm 3\%$. But for the determination of tin in the presence of copper, time-consuming separation is needed in order to obtain the voltage vs. current curve. It was found to be rather difficult for such a small amount of sample. For copper ingots containing high percentages of copper, the inherent error of the instrument negated its usefulness.

As others have found previously, the best instrument for many metal analyses, especially for the trace elements, is the emission spectrograph. Since one of these instruments is not available at the present time at the Univ. of Penna., collaboration with several European laboratories has been initiated. M. Han has collected 300 bronze samples from Middle Eastern specimens (from objects in the University Museum)-namely, Tepe Hissar, Hasanlu (Iran) and Tepe Gawra (Iraq). In cooperation with Ufuk Esin (Edebiyat Fakültesi, Arkeologi Bölümu, Beyazlt, Istanbul, Turkey) it has been arranged for these analyses to be performed by S. Junghans at Wurttembergisches Landes Museum, Stuttgart, Altes Schloss, Germany. Several hundred bronze samples have been obtained by A. Steinberg from objects in Etruria, Italy and have been submitted to E. T. Hall at the Research Laboratory for Archaeology and the History of Art, Oxford, England, for analysis with their emission spectrograph.

D) Gold Studies

In an effort to find a means of differentiating between ancient gold objects and modern fakes - an urgent need for objects from Iran, studies of the surface structure of ancient gold objects have been made by A. Revere (Vineyard Haven, Martha's Vineyard, Mass.) with an electron microscope. The photographs taken suggest the possibility that some change in structure may have taken place with time, which would, in all probability, be due to the presence of impurities. The results at present, however, are inconclusive and arrangements were made at Oxford (Research Laboratory for Archaeology and the History of Art) in July for studies to be made

with their electron probe microanalyser. In addition, R. Maddin, Dir. of the Dept. of Metallurgy, Univ. of Penna., has offered his full cooperation in the solution of this problem.

5) Student training in techniques.

A graduate course entitled "Problems in Archaeology" was given by B. Waites in the spring term. It was an advanced seminar course in methods, techniques, and interpretation and included student training in the use of the field instruments.

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