Murray Aborn
202-632-4216

UNIVERSITY OF PENNSYLVANIA

PHILADELPHIA, PENNSYLVANIA 19174

PROPOSAL FOR CONTINUING RESEARCH SUPPORT

Museum Applied Science Center for Archaeology
(MASCA)

National Science Foundation

Division of Special Projects

Washington, D.C. 20550

Principal Investigator: Froelich Rainey, Director, University Museum and MASCA Administrator; Dept. of Anthropology, Graduate School of Arts and Sciences; Professor of Anthropology, The College

School: University of Pennsylvania **Department:** University Museum

Starting Date: 1 December 1973 **Duration:** Second Year

FUNDS REQUESTED

Second Year (12/1/73 - 11/30/74): $109,900

Total: $109,900

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

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

Date: 9/7/73

Approved:____________________
D. J. O'Kane, Dean of the Graduate School of Arts and Sciences

Approved:____________________
Froelich Rainey
Principal Investigator
Director, University Museum

Approved:____________________
Reagan A. Scurlock
Director Research Administration

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

Report of NSF Grant GS-36308 X

Museum Applied Science Center for Archaeology
(MASCA)

Re: NSF Notice No. 33, item 1, a summary of scientific progress during the first nine months.

The brief reports which follow are arranged in the order of the outline of the proposal with some interdisciplinary categories grouped together.

Items 2 and 3 (Notice No. 33) follow these summaries. The proposed budget for the ensuing year is the same as that proposed in the original budget for the second year.

Radiocarbon Laboratory

Series of samples from the following sites have been dated by C^{14} this year:

- Hajji Firuz Tepe, Iran
- Cosa, Italy
- Franchthi Cave, Greece
- Selenkahiye, Syria
- Korucu Tepe, Turkey
- Ai-Khanoum, N. Afghanistan
- Chilca Canyon, Peru
- Chalchuapa, El Salvador
- Port Royal, Honduras
- Fotoruma Cave, Guadalcanal Island, British Solomons
- Anangula site, eastern Aleutians
- Dixthada, central Alaska
- Savich Farm, New Jersey

Our efforts in dating samples of known age are summarized in the enclosed special issue of the MASCA Newsletter (Vol. 9, No. 1) entitled "Radiocarbon Dates & Reality."

Also, we have instructed a graduate student in Classical Archaeology, Peter Kuniholm, in the techniques of dendrochronology. Mr. Kuniholm, for the next year, will be doing field work in Turkey in an effort to establish a master tree-ring chronology from wood found at archaeological sites in Turkey.

Applied Science Center for Archaeology

THE UNIVERSITY MUSEUM • UNIVERSITY OF PENNSYLVANIA
33rd & SPRUCE STREETS • PHILADELPHIA, PENNSYLVANIA 19174

Froelich Rainey, Director • Elizabeth K. Ralph, Associate Director

MASCA Newsletter

Volume 9, Number 1 August 1973

RADIOCARBON DATES AND REALITY

by

E. K. Ralph, H. N. Michael, and M. C. Han

INTRODUCTION

The technique of radiocarbon (C^{14}) dating is almost twenty-five years old. In the beginning there was some reluctance to accept C-14 dates; then, there was general reliance upon them. However, we have now learned that one of the basic assumptions of the method—namely, the constancy of the atmospheric inventory of $C^{14}O_2$—is not strictly valid. For various reasons (Olsson, 1970), it has fluctuated during past times. Therefore, for most periods, corrections must be applied to radiocarbon dates to adjust them to true ages. The corrections, presented either in the form of a calibration curve or in tables, have been derived from the C^{14} dating of tree-ring dated samples.

Dendrochronology, by means of the tedious process of cross-dating, has provided samples of known age, accurate to within a year. For the correction of C^{14} dates, the first prerequisite was a series of long-lived trees. It has been found that only the outer growth ring of a tree is in equilibrium with the atmosphere and that the C^{14} content of the adjacent inner ring is one year old and so on until one reaches the maximum age or "pith" of the tree. These long-lived series were first provided by the sequoias, (*S. gigantea*) which afforded a scale reaching 3100 years back in time (Douglass, 1919). More recently, starting in 1954, Schulman (1956) and then Ferguson (1970, 1972) working with bristlecone pines (*P. aristata*) have succeeded in extending the range of known-age trees to approximately 8000 years before the present. However, because of the paucity of wood of this extreme age, precisely dated samples reaching to only 7350 years before present have so far been available for radiocarbon dating.

For the past 15 years, three laboratories have been obtaining C^{14} dates from samples (spanning about 10 years each) of these long-lived dendro-dated trees. The three laboratories are at the University of Arizona in Tucson, the University of California at San Diego in La Jolla, and the University of Pennsylvania in Philadelphia. All three presented results individually, in one form or another at the Twelfth Nobel Symposium held in Uppsala, Sweden in 1969 (Damon, 1970; Suess, 1970; Michael and Ralph, 1970). At Uppsala, it was clear that the C^{14} dates of all three laboratories were in excellent agreement on the <u>average</u>, but that there were differences between individual or small groups of dates. (See Olsson, 1970, pp. 110, 597, 615-618, 619-624, and separate plates I and II.)

At the more recent international C^{14} conference in Lower Hutt, New Zealand, in October 1972, it was anticipated that after three more years spent in obtaining greater numbers of C^{14} dates, from precisely dated wood samples, better agreement could be achieved. With this in mind, the laboratories of Arizona (Damon, Long, and Wallick, 1972) and Pennsylvania (Michael and Ralph, 1972) presented separately composite plots of all C^{14} dates obtained by all three laboratories, with the Arizona laboratory adding a few dates determined by Stuiver some time previously (Stuiver, 1969). La Jolla presented its 1969 (Uppsala) "calibration curve" derived from La Jolla dates only and containing many doubtful short-term deviations based on very few dates. Again, there was good agreement on the <u>average</u>, but no decision was reached as to which calibration method best expressed "true" calendric dates.

METHODS USED

Before entering into the discussion that follows it should be established that all of the radiocarbon dates used in this study have been calculated with the 5730-year half-life. The dates published in *Radiocarbon* are based on the 5568-year half-life and may be easily converted to the 5730-year half-life by multiplying the B.P. (before present) date by 1.030. All samples have been measured with extreme care, and almost every C^{14} date has been corrected for possible fractionation by the mass spectrometric measurement of C^{13}/C^{12} ratios.

In Figs. 1 to 6 and Fig. 8 we are presenting our new MASCA calibration curve. In order to eliminate some of the scatter in the raw data (see Fig. 7), this curve has been derived by 9-cell regression weighted averaging. Our choice of a 9-cell regression to smooth the raw radiocarbon data is based on much experimentation with other methods of smoothing (including a 5-cell regression and various fittings with polynomials). It soon became evident that the 9-cell floating average centered on its mid-point seemed to be the best choice since it resulted in a relatively smooth curve, but it did also preserve the major deviations and most of the minor ones expressed in the raw data of the three laboratories from which they were drawn.

DEFINITIONS

In the explanation of the tables that accompany the curve we shall deal with the terms "crossing", "span", and "range" as they pertain to the relationship of a specific radiocarbon date to the calibration curve. The majority of the corrections for radiocarbon dates (as read horizontally from the left-hand side of the graphs) are found to be single crossings. If the radiocarbon date follows the curve closely for a distance (usually a relatively short one) we designate this distance as a span. In those cases where a radiocarbon date crosses the curve two or more times, we must consider an overall range. This is essentially a range of uncertainty since the correction for the date may be derived from any point at which it crosses the curve. Of course, it is possible for a range to have a span and/or a crossing within the range.

EXAMPLES

An example of the use of the tables for a single crossing is as follows: The radiocarbon date of A.D. 1750 crosses the curve at the dendrochronologically determined date of A.D. 1650. Thus the correction for this date is 100 ± 10 years, the difference between A.D. 1750 and A.D. 1650. The ±10 expresses the statistical uncertainty of the 9-cell regression average of the C^{14} dates and must be added to the standard statistical error (one sigma) of the radiocarbon date.

In Figs. 1 to 6 and 8, this uncertainty is represented by the diameter of the circles—namely, 20 years. In deriving the tables from the graphs, however, the corrected dates have been measured from mid-point to mid-point of the circles (on the horizontal scale). This is because the ±10 uncertainty applies to the C^{14} dates (vertical axes) but not to the dendro-dates.

An example of our definition of range is the radiocarbon date A.D. 1680, which crosses the curve at the dendro-dates of A.D. 1610 and A.D. 1530. The correction in this case is either 70 years (the difference between A.D. 1680 and A.D. 1610) or 150 years (the difference between A.D. 1680 and A.D. 1530). In other words the range of uncertainty is 80 years, but one may not arbitrarily select the mid-point for the purpose of correction. Therefore, in the tables, we have not listed mid-points for these ranges.

An example of a span is the C^{14} date A.D. 1640. The span occurs from A.D. 1600 to A.D. 1510 and thus the true date could fall anywhere within this span.

The C^{14} date for A.D. 1790 has a range which includes both a span and a crossing. The span runs from A.D. 1760 to A.D. 1730 and then there is a crossing at A.D. 1660.

To take account of the uncertainty in a C^{14} date, one should first add and subtract the standard deviation plus the ±10, and then find the maximum possible spread from the tables. For example, if one has a C^{14} date of 2000 ± 50 B.C., this becomes 2000 ± 60 B.C., or from 1940 to 2060 B.C. From Table IV one finds that the corrected spread is from 2190 to 2480 B.C.

The 631 radiocarbon dates of precisely dated woods included in this study spread over 661 C^{14} decades (A.D. 1849 to 4760 B.C.). These radiocarbon dates were determined from dendrochronologically dated samples which covered the total of 723 decades (A.D. 1849 to 5383 B.C.). In 560 (85 percent) of the C^{14} decades the correction is determined within a span of 20 to 50 years because the radiocarbon date crosses the curve only once or spans it for a distance of 50 years or less. These decades present a problem of lesser dimensions than the remaining 101 (15 percent) of the decades in which the radiocarbon date crosses the curve more than once, or has spans, with the resultant range exceeding 50 years.

APPLICATION

In applying the results of this study for the correction or "calibration" of a radiocarbon date, the archaeologist or other user should be aware of both the strengths and weaknesses of the system as presented here. The statistics cited above point out that no difficulty will be encountered in correcting dates which fall into that 85 percent of the chronological period which does not contain deviations or where they are small. In cases of single crossings or short ranges or short spans, it must be remembered that the ±10 years uncertainty of the single crossing is to be added to the standard statistical error of the radiocarbon date. Some of the more extensive ones will (or may) present special problems. Fortunately the two large deviations at the very beginning of the curve (Figs. 1 and 8) are not likely to be of much practical significance since the 17th to 19th centuries are well documented by sources other than radiocarbon dates. The large deviations that occur in the B.C. era, where other documentation is either scarce or non-existent present a greater difficulty. It will in reality be seldom that the archaeologist or historian will be able to find a reference point independent of the C^{14} dates which will pin-point or narrow one's choice of a correction factor within the wider range of a large deviation. The Iron Age of Europe or the Late Bronze Age in many parts of the world may occasionally present separate confirmations for a choice. It is rare, even in the Late Neolithic of Europe, that one can differentiate phases of the period in terms of even, say, 200 years. Thus the amplitude of a deviation and therefore of a range of 90 years as in the period 4450 B.C. becomes less significant even when the standard statistical tolerance (one sigma) is added. With ±60 attached to the date, this means that it falls somewhere between 5100 B.C. and 5240 B.C., a period of 140 years. And, that is all the accuracy that the bristlecone-based radiocarbon dates can provide for this particular period of time.

GEOPHYSICAL IMPLICATIONS

As one can see in the figures presented here, there is no doubt that the long-term trend of deviations with a period of approximately 9000 years and a maximum amplitude (centered at about 4500 B.C.) of 10 percent is real. Curves have been derived by means of various computer programs to fit this trend, such as those of Damon (1972) and Suess (1973). Our best fit, based on 600 radiocarbon dates is shown as a dashed line in Figs. 1 to 6 and Fig. 8. It is derived from the following third order polynomial:

$$T_{C\text{-}14} = -43.96 + 0.918 \times T_D + 7.17 \times 10^{-5} \times T_D^2 + 1.18 \times 10^{-8} T_D^3$$

where $T_{C\text{-}14}$ and T_D are positive for A.D. and negative for B.C.

$T_{C\text{-}14} = C^{14}$ date. T_D = dendro-date.

However, as we can see in the simple regression curve of Figs. 1 to 6 and 8, there are short-term deviations which depart from the main trend. It is our belief that some of the short-term deviations are real and that there is a tendency for cycles of 400 years but that there is no truly sinusoidal periodicity of such short periods. It might be noted, however, that the long-term deviation from a straight line could be close to a sinusoidal curve.

In regard to the basic causes of the deviations in atmospheric C^{14} contents, we think that part, but only part (Ralph, 1972), of the long-term deviation is due to sinusoidal changes in the Earth's dipole moment which, in turn, may follow the recent pole reversal at about 13,000 B.P. (Barbetti and McElhinny, 1972; Blakely and Cox, 1972; Bonhommet and Zähringer, 1969; Mörner, Lanser, and Hospers, 1971); the short-term deviations may be related to variations in the Earth's nondipole field; there may be a contribution from the varying magnetic field of the Sun and the resultant interplanetary fields (Sawyer, 1968) with cycles greater than eleven years; and as a secondary effect, from climatic changes (Houtermans, Suess, and Oeschger, 1973); and there is a slight possibility of a contribution from the explosions of supernovae (Dergachev, 1972).

ACKNOWLEDGEMENTS

The authors are grateful to the following persons who have aided them in the various facets of assembling the materials and preparing the article.

Richard D. Haynes of MASCA carefully checked Tables 1 to 6 and is also responsible for general editing of the *MASCA Newsletter*.

Barbara Lawn, assisted by Raymond L. Costa, Jr. and John D. Hedrick, of the Radiocarbon Laboratory processed the bristlecone samples that have been received by the laboratory over the past six years.

Douglas P. O'Brien of GeoMetrics, Palo Alto, California, derived the formula for the third polynomial used in Figures 1 to 6 and Figure 8.

David Wood of the Radiocarbon Laboratory worked out the smoothing methods and drafted the preliminary graphs indicated by the various methods.

We also acknowledge with gratitude financial support from the National Science Foundation for our known-age dating program. This has been supported since 1957 with NSF grants G-3281, G-5608, G-14094, GP-405, GP-3778, GA-993 and GA-12,572.

MASCA is currently supported by NSF Grant NSF-GS-36308X.

REFERENCES

Barbetti, M., and McElhinny, M., Evidence of a Geomagnetic 1972 Excursion 30,000 BP. *Nature, 239,* pp. 327-330.

Blakely, R.J., and Cox, A., Evidence for Short Geomagnetic 1972 Polarity Intervals in the Early Cenozoic. *Journal of Geophysical Research, 77,* pp. 7065-7072.

Bonhommet, N., and Zähringer, J., Paleomagnetism and 1969 Potassium Argon Age Determinations of the Laschamp Geomagnetic Polarity Event. *Earth and Planetary Science Letters, 6,* pp. 43-46.

Bucha, V., Archaeomagnetic Dating. In Michael, H.N., and 1971 Ralph, E.K. (Coeditors), *Dating Techniques for the Archaeologist.* The M.I.T. Press, Cambridge, Massachusetts, and London, England, pp. 57-117.

Damon, P.E., Climatic versus magnetic perturbation of the 1970 atmospheric C14 reservoir. *Proceedings of the Twelfth Nobel Symposium,* Uppsala, Sweden, August 11-15, 1969. Almquist and Wiksell, Stockholm (Wiley Interscience Division, John Wiley and Sons, New York), pp. 571-593.

Damon, P.E., Long, A., and Wallick, E.I., Dendrochronologic 1972 calibration of the Carbon-14 time scale. Vol. I, Preprint of the *Proceedings of the 8th International Conference on Radiocarbon Dating,* Lower Hutt City, Wellington, New Zealand, 18-25 October 1972, pp. A28-A43.

Dergachev, V.A., and Kocharov, G.E., Ob odnoy vozmozhnos-1972 ti izucheniya variatsiy kosmicheskikh luchey v proshlom (A possible cause of cosmic ray variations in the past). *Izvestiya Akademii nauk SSSR,* XXXVI, No. 11, seriya fizicheskaya, pp. 2312-2318.

Douglass, A.E., *Climatic Cycles and Tree Growth.* Vol. 1, No. 1919 289, Washington, D.C.: Carnegie Institution of Washington.

Ferguson, C.W., Dendrochronology of bristlecone pine, *Pinus* 1970 *aristata. Proceedings of the Twelfth Nobel Symposium,* Uppsala, Sweden, August 11-15, 1969. Almquist and Wiksell, Stockholm (Wiley Interscience Division, John Wiley and Sons, New York), pp. 237-259.

__________, "Dendrochronology of bristlecone pine prior to 4000 B.C." Vol. I, Preprint of the *Proceedings of the 8th International Conference on Radiocarbon Dating,* Lower Hutt City, Wellington, New Zealand, 18-25 October, 1972, pp. A1-A10.

Houtermans, J.C., Suess, H.E., and Oeschger, H., Reservoir 1973 Models and Production Rate Variations of Natural Radiocarbon. *Journal of Geophysical Research, 78,* pp. 1897-1908.

Lamb, H.H., *The Changing Climate.* London, Methuen and 1966 Co., Ltd.

Michael, H.N., and Ralph, E.K., Correction factors applied to 1970 Egyptian radiocarbon dates from the era before Christ. *Proceedings of the Twelfth Nobel Symposium,* Uppsala, Sweden, August 11-15, 1969. Almquist and Wiksell, Stockholm (Wiley Interscience Division, John Wiley and Sons, New York), pp. 109-120.

__________, Discussion of radiocarbon dates obtained from 1972 precisely dated sequoia and bristlecone pine samples. Vol. I, Preprint of the *Proceedings of the 8th International Conference on Radiocarbon Dating.* Lower Hutt City, Wellington, New Zealand, 18-25 October 1972, pp. A11-A27.

Mörner, N.A., Lanser, J.P., Hospers, J., Late Weichselian 1971 Palaeomagnetic Reversal. *Nature, Physical Science, 234,* pp. 173-174.

Olsson, I.U. (Editor), *Radiocarbon Variations and Absolute*
1970 *Chronology, Proceedings of the Twelfth Nobel Symposium,* Uppsala, Sweden, August 11-15, 1969. Almquist and Wiksell, Stockholm (Wiley Interscience Division, John Wiley and Sons, New York).

Ralph, E.K., A cyclic solution for the relationship between
1972 magnetic and atmospheric C-14 changes. Vol. I, Preprint of the *Proceedings of the 8th International Conference on Radiocarbon Dating.* Lower Hutt City, Wellington, New Zealand, 18-25 October 1972, pp. A76-A84.

Sawyer, Constance, Statistics of Solar Active Regions. *Annual*
1968 *Review of Astronomy and Astrophysics, 6,* pp. 115-134.

Schulman, E., *Dendroclimatic Changes in Semiarid America.*
1956 Tucson, The University of Arizona Press.

Stuiver, M., Yale natural radiocarbon measurements IX.
1969 *Radiocarbon,* Vol. 11, pp. 545-658.

Suess, H.E., Bristlecone pine calibration of the radiocarbon
1970 time-scale 5200 B.C. to the present. *Proceedings of the Twelfth Nobel Symposium,* Uppsala, Sweden, August 11-15, 1969, Almquist and Wiksell, Stockholm (Wiley Interscience Division, John Wiley and Sons, New York), pp. 303-311.

________, Natural Radiocarbon. *Endeavour, 32,* pp.
1973 34-38.

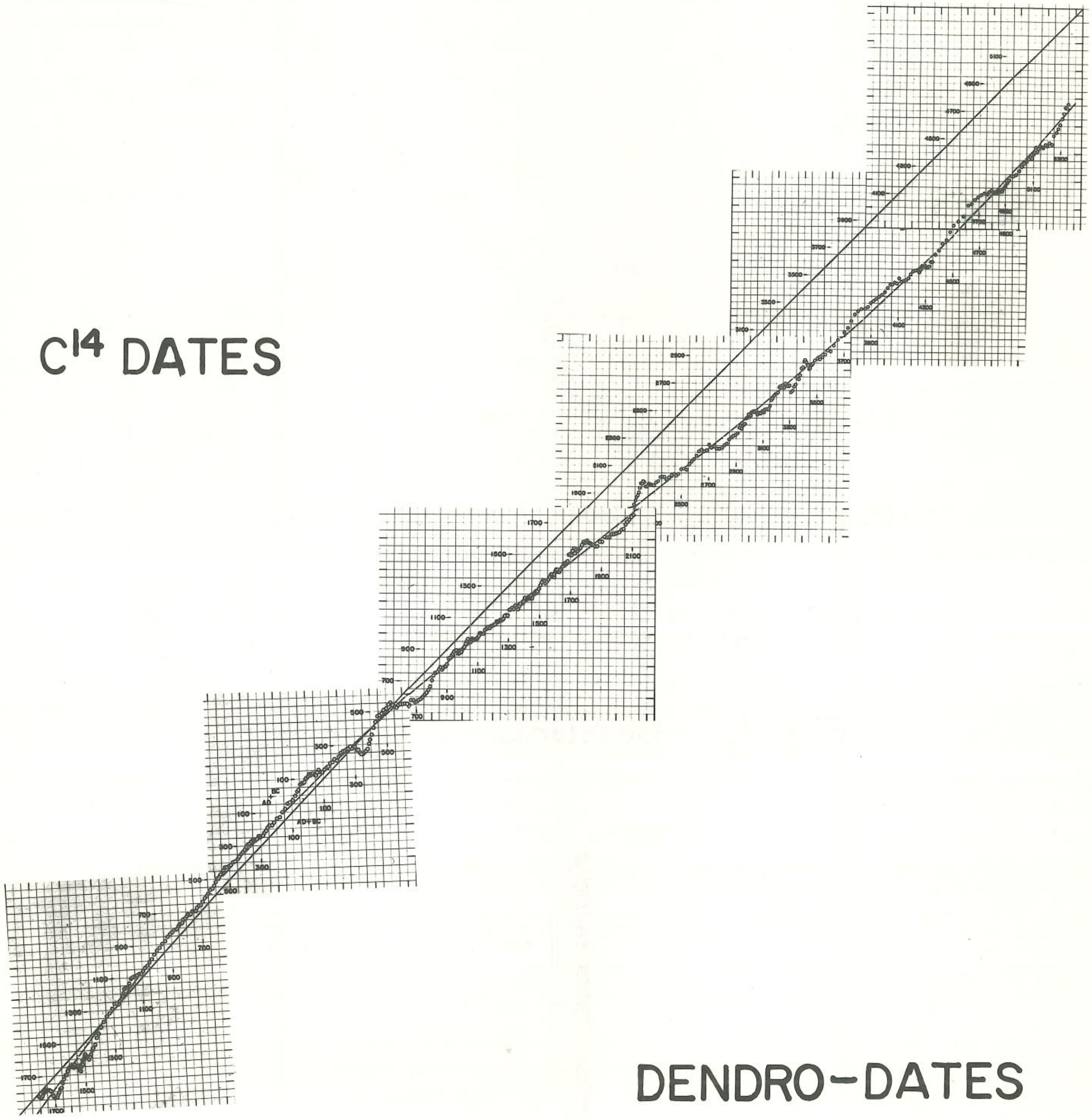


Fig. 8.
COMPOSITE PLOT OF Figs. 1 TO 6

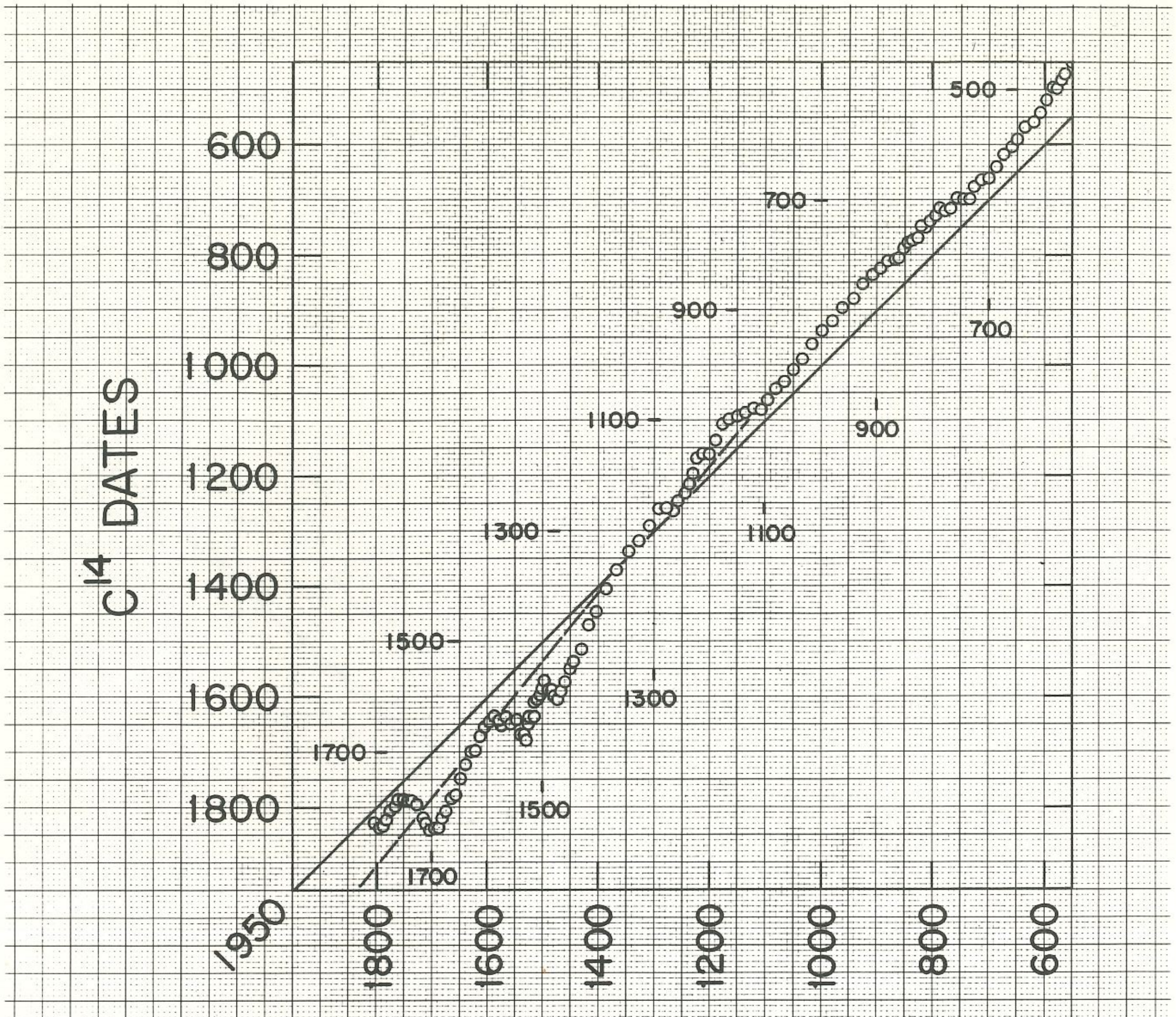


Fig. 1. DENDRO-DATES

SUPPLEMENT TO TABLE 1

C-14 Date	Points in "Range for Corrected Date" in which C-14 date crosses curve or follows it for a distance*	C-14 Date	Points in "Range for Corrected Date" in which C-14 date crosses curve or follows it for a distance*
AD 1840	AD 1790, 1710-1690	AD 1660	AD 1610, 1580-1520
AD 1830	AD 1800-1780, 1710-1680	AD 1650	AD 1610-1520
AD 1820	AD 1800-1780, 1710, 1680	AD 1640	AD 1600-1510
AD 1810	AD 1780, 1720, 1670	AD 1630	AD 1590-1510
AD 1800	AD 1770, 1730, 1670	AD 1610	AD 1520, 1470
AD 1790	AD 1760-1730, 1670	AD 1600	AD 1510-1470
AD 1780	AD 1760-1730, 1660	AD 1590	AD 1500-1470
AD 1690	AD 1630, 1530	AD 1580	AD 1500-1460
AD 1680	AD 1610, 1530	AD 1570	AD 1500, 1460
AD 1670	AD 1610, 1530	AD 1270	AD 1290-1260

(Continued on page 18)

*Simple crossings are indicated with entries separated by commas, spans are indicated with entries connected with hyphens.

TABLE 1

C-14 Date	Range or Mid-Point for Corrected Date	C-14 Date	Range or Mid-Point for Corrected Date	C-14 Date	Range or Mid-Point for Corrected Date	C-14 Date	Range or Mid-Point for Corrected Date
AD 1840	AD 1800-1690	AD 1540	AD 1440	AD 1240	AD 1260	AD 940	AD 1000
AD 1830	AD 1800-1680	AD 1530	AD 1440	AD 1230	AD 1250	AD 930	AD 1000-980
AD 1820	AD 1800-1680	AD 1520	AD 1430	AD 1220	AD 1240	AD 920	AD 980
AD 1810	AD 1780-1670	AD 1510	AD 1430	AD 1210	AD 1240	AD 910	AD 970
AD 1800	AD 1770-1670	AD 1500	AD 1430	AD 1200	AD 1230	AD 900	AD 960
AD 1790	AD 1760-1670	AD 1490	AD 1420	AD 1190	AD 1230	AD 890	AD 950
AD 1780	AD 1760-1660	AD 1480	AD 1420	AD 1180	AD 1220	AD 880	AD 940
AD 1770	AD 1660	AD 1470	AD 1420	AD 1170	AD 1220-1200	AD 870	AD 940
AD 1760	AD 1650	AD 1460	AD 1410	AD 1160	AD 1220-1200	AD 860	AD 930
AD 1750	AD 1650	AD 1450	AD 1410	AD 1150	AD 1210	AD 850	AD 920
AD 1740	AD 1650	AD 1440	AD 1410	AD 1140	AD 1190	AD 840	AD 910
AD 1730	AD 1640	AD 1430	AD 1400	AD 1130	AD 1190	AD 830	AD 910-890
AD 1720	AD 1640	AD 1420	AD 1390	AD 1120	AD 1180	AD 820	AD 890
AD 1710	AD 1630	AD 1410	AD 1390	AD 1110	AD 1180	AD 810	AD 880-860
AD 1700	AD 1630	AD 1400	AD 1390	AD 1100	AD 1180-1150	AD 800	AD 880-860
AD 1690	AD 1630-1530	AD 1390	AD 1380	AD 1090	AD 1170-1110	AD 790	AD 850
AD 1680	AD 1610-1530	AD 1380	AD 1380	AD 1080	AD 1140-1110	AD 780	AD 850-830
AD 1670	AD 1610-1530	AD 1370	AD 1370	AD 1070	AD 1120-1090	AD 770	AD 850-830
AD 1660	AD 1610-1520	AD 1360	AD 1360	AD 1060	AD 1100	AD 760	AD 820
AD 1650	AD 1610-1520	AD 1350	AD 1350	AD 1050	AD 1090	AD 750	AD 820-800
AD 1640	AD 1600-1510	AD 1340	AD 1350	AD 1040	AD 1080	AD 740	AD 820-800
AD 1630	AD 1590-1510	AD 1330	AD 1340	AD 1030	AD 1070	AD 730	AD 800-780
AD 1620	AD 1520	AD 1320	AD 1330	AD 1020	AD 1060	AD 720	AD 790-770
AD 1610	AD 1520-1470	AD 1310	AD 1320	AD 1010	AD 1050	AD 710	AD 790-770
AD 1600	AD 1510-1470	AD 1300	AD 1310	AD 1000	AD 1040	AD 700	AD 760-730
AD 1590	AD 1500-1470	AD 1290	AD 1310	AD 990	AD 1030	AD 690	AD 760-730
AD 1580	AD 1500-1460	AD 1280	AD 1300	AD 980	AD 1030	AD 680	AD 730
AD 1570	AD 1500-1460	AD 1270	AD 1290-1260	AD 970	AD 1020	AD 670	AD 730-700
AD 1560	AD 1450	AD 1260	AD 1290-1260	AD 960	AD 1020	AD 660	AD 720-700
AD 1550	AD 1450	AD 1250	AD 1290-1260	AD 950	AD 1010	AD 650	AD 690

See opposite page and text for explanation of the tables.

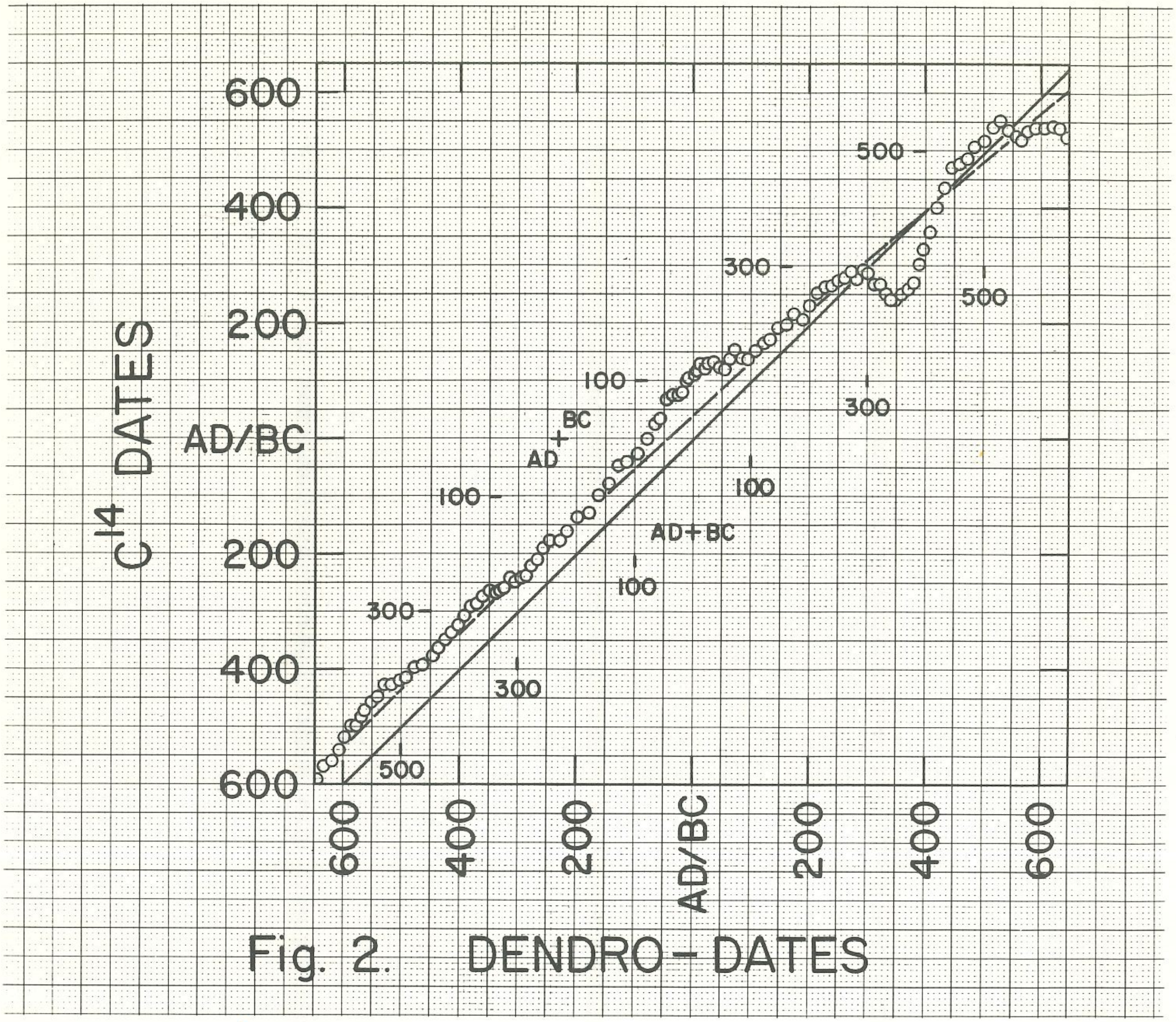


Fig. 2. DENDRO-DATES

SUPPLEMENT TO TABLE 2

C-14 Date	Points in "Range for Corrected Date" in which C-14 date crosses curve or follows it for a distance*	C-14 Date	Points in "Range for Corrected Date" in which C-14 date crosses curve or follows it for a distance*
AD 610	AD 670-650	AD 290	AD 390-370
AD 570	AD 640-620	AD 280	AD 380-360
AD 560	AD 640-620	AD 270	AD 360-320
AD 500	AD 590-570	AD 260	AD 350-320
AD 490	AD 590-570	AD 250	AD 320-290
AD 430	AD 530-510	AD 240	AD 320-290
AD 420	AD 530-490	AD 180	AD 250-230
AD 410	AD 510-490	AD 170	AD 250-220
AD 400	AD 480-460	AD 130	AD 200-180
AD 390	AD 480-460	AD 50	AD 130-110

(Continued on page 18)

*Simple crossings are indicated with entries separated by commas, spans are indicated with entries connected with hyphens.

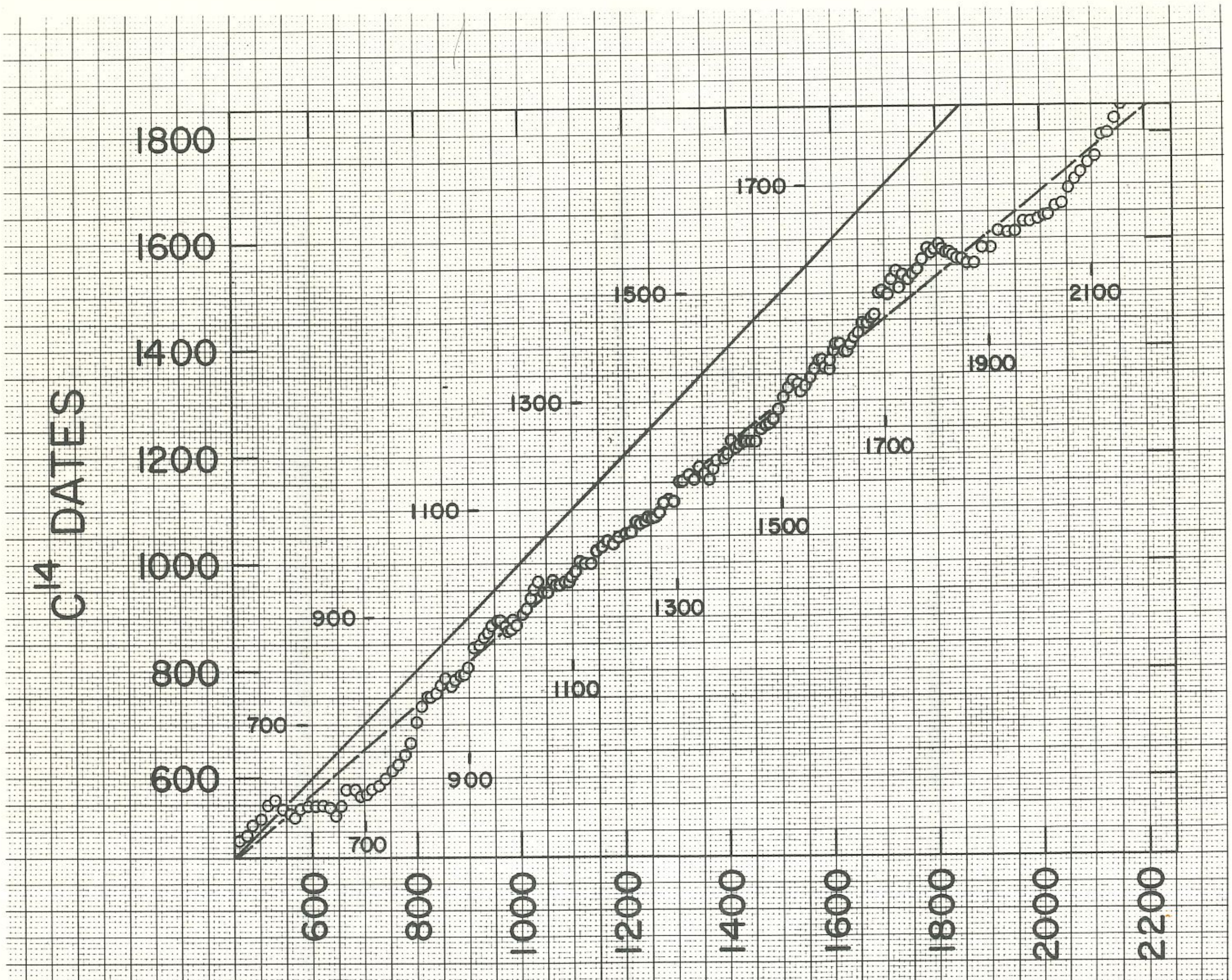


Fig 3. DENDRO-DATES

SUPPLEMENT TO TABLE 3

C-14 Date	Points in "Range for Corrected Date" in which C-14 date crosses curve or follows it for a distance*
560 BC	530, 690-710 BC
570 BC	660-720 BC
580 BC	660-730 BC
590 BC	710-730 BC
750 BC	810-840 BC
760 BC	820-840 BC
770 BC	850-870 BC
780 BC	850-880 BC
790 BC	850-890 BC
800 BC	880-900 BC
850 BC	910-930 BC
870 BC	940, 980 BC
880 BC	940, 970-990 BC
890 BC	940-990 BC
900 BC	960, 980-1010 BC
940 BC	1020, 1050 BC
950 BC	1030-1080 BC
960 BC	1030, 1060-1100 BC
970 BC	1030, 1060-1100 BC
1000 BC	1110-1140 BC

(Continued on page 20)

*Simple crossings are indicated with entries separated by commas, spans are indicated with entries connected with hyphens.

TABLE 3

C-14 Date	Range or Mid-Point for Corrected Date	C-14 Date	Range or Mid-Point for Corrected Date	C-14 Date	Range or Mid-Point for Corrected Date	C-14 Date	Range or Mid-Point for Corrected Date
560 BC	530-710 BC	860 BC	930 BC	1160 BC	1310-1360 BC	1460 BC	1680 BC
570 BC	660-720 BC	870 BC	940-980 BC	1170 BC	1320-1370 BC	1470 BC	1690 BC
580 BC	660-730 BC	880 BC	940-990 BC	1180 BC	1340-1370 BC	1480 BC	1690 BC
590 BC	710-730 BC	890 BC	940-990 BC	1190 BC	1370-1390 BC	1490 BC	1690-1710 BC
600 BC	740 BC	900 BC	950-1010 BC	1200 BC	1380-1400 BC	1500 BC	1690-1710 BC
610 BC	750 BC	910 BC	1010 BC	1210 BC	1400-1420 BC	1510 BC	1690-1730 BC
620 BC	760 BC	920 BC	1010 BC	1220 BC	1400-1450 BC	1520 BC	1710-1750 BC
630 BC	770 BC	930 BC	1020 BC	1230 BC	1400-1450 BC	1530 BC	1710-1750 BC
640 BC	780 BC	940 BC	1020-1050 BC	1240 BC	1460 BC	1540 BC	1720-1760 BC
650 BC	780 BC	950 BC	1030-1080 BC	1250 BC	1460-1480 BC	1550 BC	1720-1870 BC
660 BC	790 BC	960 BC	1030-1100 BC	1260 BC	1480 BC	1560 BC	1770-1870 BC
670 BC	790 BC	970 BC	1030-1100 BC	1270 BC	1490 BC	1570 BC	1770-1850 BC
680 BC	790 BC	980 BC	1100 BC	1280 BC	1500 BC	1580 BC	1780-1900 BC
690 BC	800 BC	990 BC	1110 BC	1290 BC	1500 BC	1590 BC	1780-1910 BC
700 BC	800 BC	1000 BC	1110-1140 BC	1300 BC	1510 BC	1600 BC	1800 BC
710 BC	800 BC	1010 BC	1110 BC	1310 BC	1500-1540 BC	1610 BC	1920-1950 BC
720 BC	800 BC	1020 BC	1150 BC	1320 BC	1510-1540 BC	1620 BC	1920-1950 BC
730 BC	810 BC	1030 BC	1160-1180 BC	1330 BC	1510-1550 BC	1630 BC	1960-2000 BC
740 BC	810 BC	1040 BC	1170-1190 BC	1340 BC	1520-1560 BC	1640 BC	1960-2020 BC
750 BC	820-840 BC	1050 BC	1170-1210 BC	1350 BC	1520-1590 BC	1650 BC	2000-2020 BC
760 BC	820-840 BC	1060 BC	1190-1210 BC	1360 BC	1560-1590 BC	1660 BC	2020-2040 BC
770 BC	850-870 BC	1070 BC	1220-1240 BC	1370 BC	1570-1600 BC	1670 BC	2040 BC
780 BC	850-880 BC	1080 BC	1220-1260 BC	1380 BC	1570-1600 BC	1680 BC	2050 BC
790 BC	850-890 BC	1090 BC	1240-1270 BC	1390 BC	1600-1630 BC	1690 BC	2050 BC
800 BC	880-900 BC	1100 BC	1270 BC	1400 BC	1600-1640 BC	1700 BC	2060 BC
810 BC	900 BC	1110 BC	1270-1300 BC	1410 BC	1600-1640 BC	1710 BC	2070 BC
820 BC	900 BC	1120 BC	1270-1300 BC	1420 BC	1640 BC	1720 BC	2080 BC
830 BC	900 BC	1130 BC	1290 BC	1430 BC	1650 BC	1730 BC	2080 BC
840 BC	910 BC	1140 BC	1300 BC	1440 BC	1660 BC	1740 BC	2090 BC
850 BC	910-930 BC	1150 BC	1300-1360 BC	1450 BC	1660-1680 BC	1750 BC	2110 BC

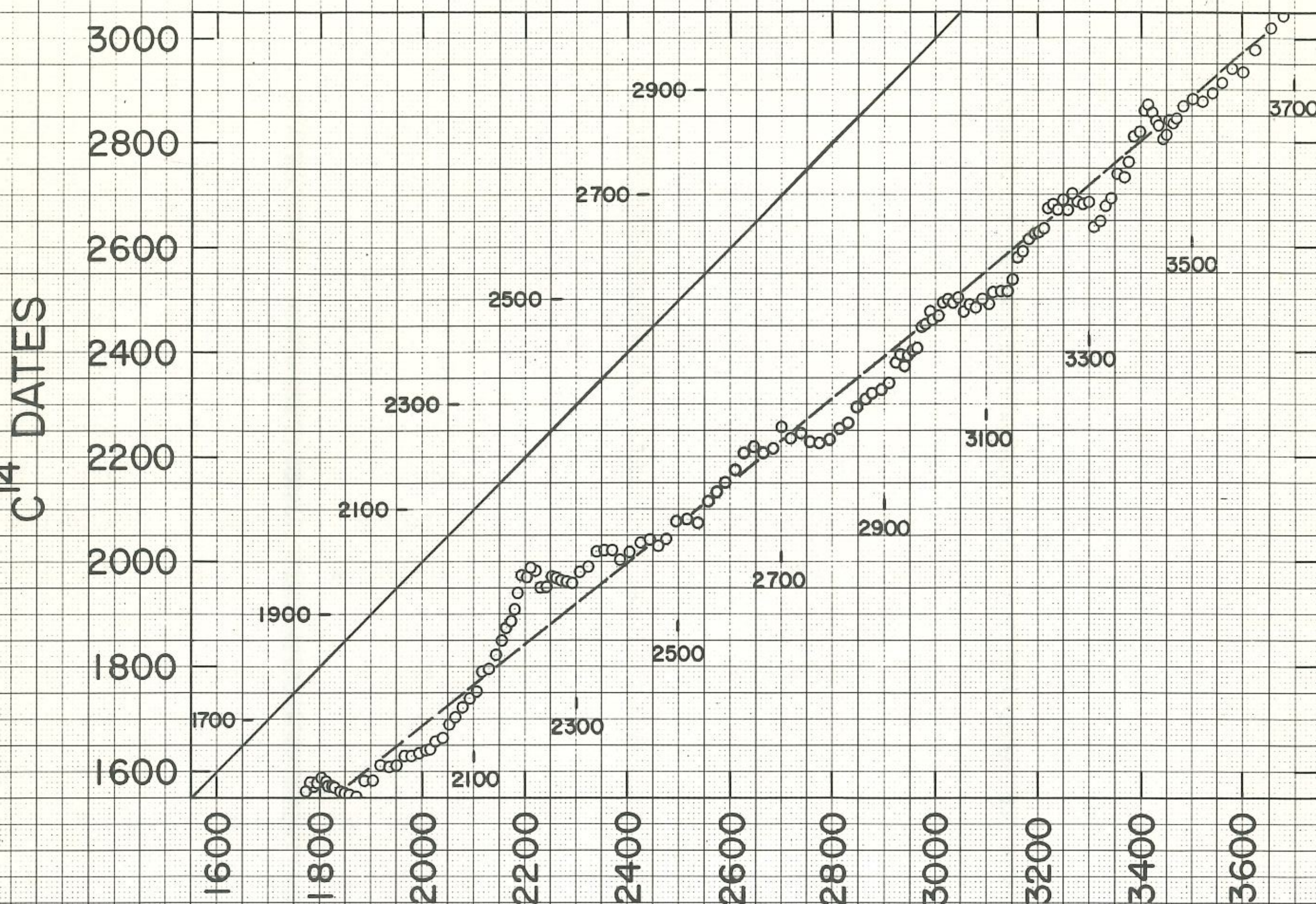


Fig. 4. DENDRO-DATES

SUPPLEMENT TO TABLE 4

C-14 Date	Points in "Range for Corrected Date" in which C-14 date crosses curve or follows it for a distance*	C-14 Date	Points in "Range for Corrected Date" in which C-14 date crosses curve or follows it for a distance*
1790 BC	2110-2130 BC	2030 BC	2350-2370, 2430-2460 BC
1800 BC	2120-2140 BC	2040 BC	2420-2480 BC
1950 BC	2190, 2230, 2290 BC	2050 BC	2440, 2480 BC
1960 BC	2190, 2230-2290 BC	2070 BC	2490-2540 BC
1970 BC	2190-2210, 2250-2300 BC	2080 BC	2490-2540 BC
1980 BC	2190-2220, 2250, 2310 BC	2090 BC	2520, 2540 BC
1990 BC	2210, 2330 BC	2200 BC	2630, 2670 BC
2000 BC	2330, 2440 BC	2210 BC	2630-2680 BC
2010 BC	2340-2410 BC	2220 BC	2650, 2680, 2760-2780 BC
2020 BC	2340-2370, 2410, 2460 BC	2230 BC	2690, 2720, 2760-2800 BC

(Continued on page 20)

*Simple crossings are indicated with entries separated by commas, spans are indicated with entries connected with hyphens.

TABLE 4

C-14 Date	Range or Mid-Point for Corrected Date	C-14 Date	Range or Mid-Point for Corrected Date	C-14 Date	Range or Mid-Point for Corrected Date	C-14 Date	Range or Mid-Point for Corrected Date
1760 BC	2110 BC	2060 BC	2480 BC	2360 BC	2920 BC	2660 BC	3240-3330 BC
1770 BC	2110 BC	2070 BC	2490-2540 BC	2370 BC	2920-2940 BC	2670 BC	3220-3330 BC
1780 BC	2110 BC	2080 BC	2490-2540 BC	2380 BC	2920-2940 BC	2680 BC	3220-3330 BC
1790 BC	2110-2130 BC	2090 BC	2520-2540 BC	2390 BC	2930-2950 BC	2690 BC	3230-3340 BC
1800 BC	2120-2140 BC	2100 BC	2550 BC	2400 BC	2930-2960 BC	2700 BC	3250-3340 BC
1810 BC	2140 BC	2110 BC	2560 BC	2410 BC	2950-2970 BC	2710 BC	3270-3350 BC
1820 BC	2140 BC	2120 BC	2560 BC	2420 BC	2970 BC	2720 BC	3350 BC
1830 BC	2150 BC	2130 BC	2570 BC	2430 BC	2970 BC	2730 BC	3350-3370 BC
1840 BC	2150 BC	2140 BC	2580 BC	2440 BC	2970 BC	2740 BC	3350-3370 BC
1850 BC	2160 BC	2150 BC	2590 BC	2450 BC	2970-2990 BC	2750 BC	3370 BC
1860 BC	2160 BC	2160 BC	2600 BC	2460 BC	2980-3010 BC	2760 BC	3380 BC
1870 BC	2160 BC	2170 BC	2610 BC	2470 BC	2990-3060 BC	2770 BC	3380 BC
1880 BC	2170 BC	2180 BC	2610 BC	2480 BC	2990-3110 BC	2780 BC	3380 BC
1890 BC	2170 BC	2190 BC	2620 BC	2490 BC	3010-3110 BC	2790 BC	3380 BC
1900 BC	2180 BC	2200 BC	2630-2670 BC	2500 BC	3010-3110 BC	2800 BC	3390-3440 BC
1910 BC	2180 BC	2210 BC	2630-2680 BC	2510 BC	3030-3140 BC	2810 BC	3390-3450 BC
1920 BC	2180 BC	2220 BC	2650-2780 BC	2520 BC	3110-3140 BC	2820 BC	3390-3450 BC
1930 BC	2180 BC	2230 BC	2690-2800 BC	2530 BC	3150 BC	2830 BC	3400-3470 BC
1940 BC	2190 BC	2240 BC	2690-2800 BC	2540 BC	3150 BC	2840 BC	3400-3470 BC
1950 BC	2190-2290 BC	2250 BC	2700-2820 BC	2550 BC	3150 BC	2850 BC	3400-3470 BC
1960 BC	2190-2290 BC	2260 BC	2700-2830 BC	2560 BC	3160 BC	2860 BC	3400-3470 BC
1970 BC	2190-2300 BC	2270 BC	2830 BC	2570 BC	3160 BC	2870 BC	3410-3520 BC
1980 BC	2190-2310 BC	2280 BC	2840 BC	2580 BC	3160 BC	2880 BC	3410-3520 BC
1990 BC	2210-2330 BC	2290 BC	2850 BC	2590 BC	3170 BC	2890 BC	3500-3540 BC
2000 BC	2330-2440 BC	2300 BC	2850-2870 BC	2600 BC	3180 BC	2900 BC	3540 BC
2010 BC	2340-2410 BC	2310 BC	2860 BC	2610 BC	3180 BC	2910 BC	3560 BC
2020 BC	2340-2460 BC	2320 BC	2880-2900 BC	2620 BC	3180-3200 BC	2920 BC	3560 BC
2030 BC	2350-2460 BC	2330 BC	2880-2910 BC	2630 BC	3190-3310 BC	2930 BC	3570-3600 BC
2040 BC	2420-2480 BC	2340 BC	2910 BC	2640 BC	3210-3310 BC	2940 BC	3580-3600 BC
2050 BC	2440-2480 BC	2350 BC	2920 BC	2650 BC	3210-3320 BC	2950 BC	3580-3610 BC

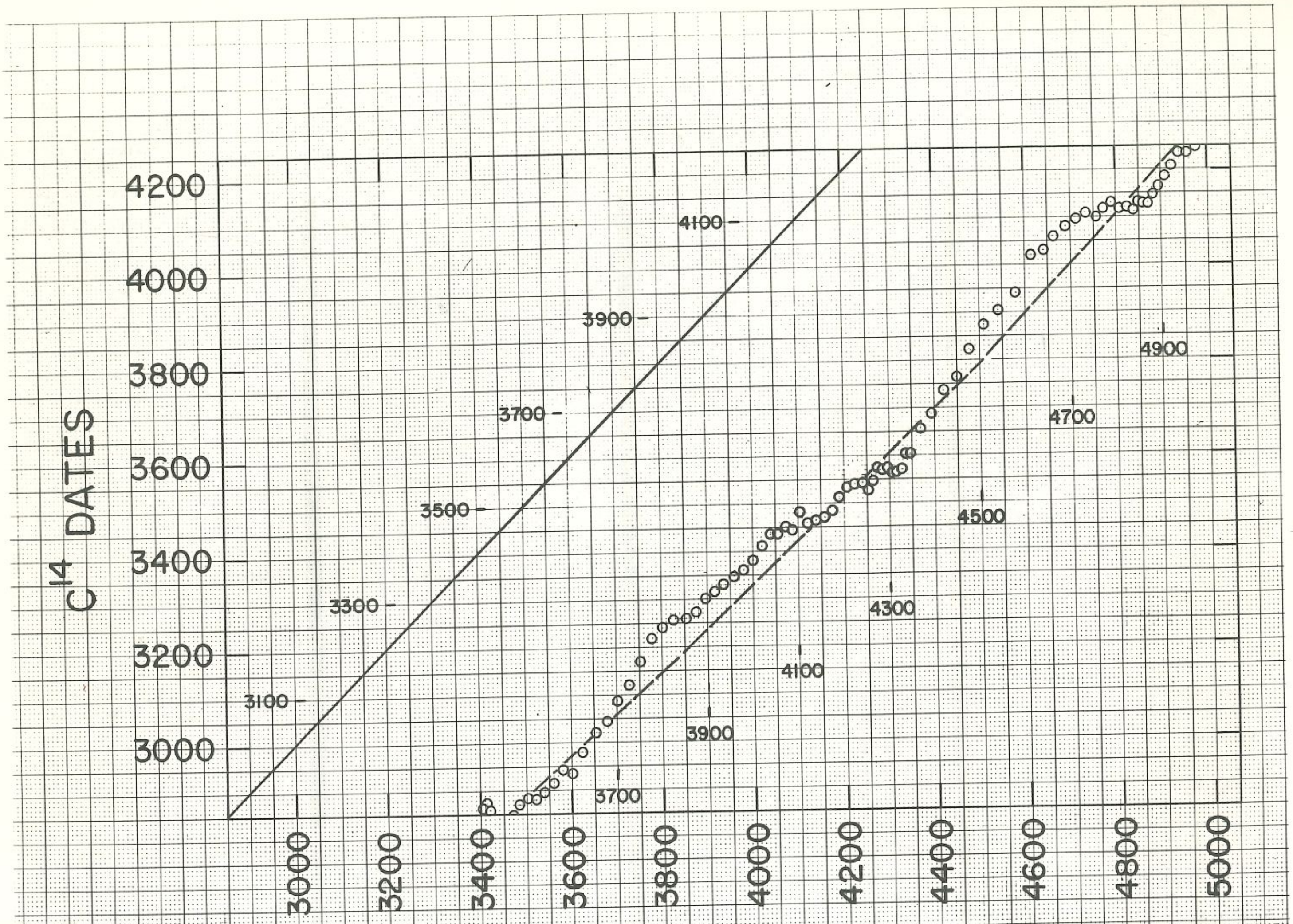


Fig. 5. DENDRO-DATES

SUPPLEMENT TO TABLE 5

C-14 Date	Points in "Range for Corrected Date" in which C-14 date crosses curve or follows it for a distance*
3250 BC	3800-3850 BC
3260 BC	3820-3850 BC
3270 BC	3850-3880 BC
3310 BC	3900-3920 BC
3340 BC	3940-3960 BC
3350 BC	3960-3980 BC
3430 BC	4040-4060 BC
3440 BC	4040-4060, 4090 BC
3450 BC	4070-4090, 4120 BC
3460 BC	4070, 4090, 4120-4160 BC
3470 BC	4090, 4110, 4140-4160 BC
3480 BC	4100, 4160-4180 BC
3490 BC	4100, 4180 BC
3520 BC	4190, 4250 BC
3530 BC	4210-4250 BC
3540 BC	4210-4260 BC
3550 BC	4220-4270 BC
3560 BC	4270, 4280-4330 BC
3570 BC	4270-4330 BC
3580 BC	4270-4300, 4330 BC

(Continued on page 18)

TABLE 5

C-14 Date	Range or Mid-Point for Corrected Date	C-14 Date	Range or Mid-Point for Corrected Date	C-14 Date	Range or Mid-Point for Corrected Date	C-14 Date	Range or Mid-Point for Corrected Date
2960 BC	3610 BC	3260 BC	3820-3850 BC	3560 BC	4270-4330 BC	3860 BC	4500 BC
2970 BC	3620 BC	3270 BC	3850-3880 BC	3570 BC	4270-4330 BC	3870 BC	4510 BC
2980 BC	3620 BC	3280 BC	3880 BC	3580 BC	4270-4330 BC	3880 BC	4520 BC
2990 BC	3630 BC	3290 BC	3890 BC	3590 BC	4330 BC	3890 BC	4530 BC
3000 BC	3640 BC	3300 BC	3900 BC	3600 BC	4330-4350 BC	3900 BC	4540 BC
3010 BC	3650 BC	3310 BC	3900-3920 BC	3610 BC	4330-4350 BC	3910 BC	4550 BC
3020 BC	3650 BC	3320 BC	3920 BC	3620 BC	4350 BC	3920 BC	4560 BC
3030 BC	3660 BC	3330 BC	3940 BC	3630 BC	4360 BC	3930 BC	4570 BC
3040 BC	3670 BC	3340 BC	3940-3960 BC	3640 BC	4360 BC	3940 BC	4580 BC
3050 BC	3680 BC	3350 BC	3960-3980 BC	3650 BC	4370 BC	3950 BC	4580 BC
3060 BC	3690 BC	3360 BC	3980 BC	3660 BC	4380 BC	3960 BC	4590 BC
3070 BC	3690 BC	3370 BC	3980 BC	3670 BC	4380 BC	3970 BC	4590 BC
3080 BC	3700 BC	3380 BC	4000 BC	3680 BC	4390 BC	3980 BC	4600 BC
3090 BC	3700 BC	3390 BC	4000 BC	3690 BC	4400 BC	3990 BC	4600 BC
3100 BC	3710 BC	3400 BC	4010 BC	3700 BC	4400 BC	4000 BC	4600 BC
3110 BC	3720 BC	3410 BC	4020 BC	3710 BC	4410 BC	4010 BC	4610 BC
3120 BC	3730 BC	3420 BC	4030 BC	3720 BC	4410 BC	4020 BC	4610-4640 BC
3130 BC	3730 BC	3430 BC	4040-4060 BC	3730 BC	4420 BC	4030 BC	4610-4640 BC
3140 BC	3740 BC	3440 BC	4040-4090 BC	3740 BC	4430 BC	4040 BC	4650 BC
3150 BC	3740 BC	3450 BC	4070-4120 BC	3750 BC	4430 BC	4050 BC	4660 BC
3160 BC	3750 BC	3460 BC	4070-4160 BC	3760 BC	4440 BC	4060 BC	4660 BC
3170 BC	3750 BC	3470 BC	4090-4160 BC	3770 BC	4450 BC	4070 BC	4670-4690 BC
3180 BC	3760 BC	3480 BC	4100-4180 BC	3780 BC	4460 BC	4080 BC	4690 BC
3190 BC	3760 BC	3490 BC	4100-4180 BC	3790 BC	4460 BC	4090 BC	4690-4760 BC
3200 BC	3770 BC	3500 BC	4190 BC	3800 BC	4470 BC	4100 BC	4710-4760 BC
3210 BC	3780 BC	3510 BC	4190 BC	3810 BC	4470 BC	4110 BC	4730-4840 BC
3220 BC	3780 BC	3520 BC	4190-4250 BC	3820 BC	4480 BC	4120 BC	4770-4870 BC
3230 BC	3790 BC	3530 BC	4210-4250 BC	3830 BC	4480 BC	4130 BC	4790-4870 BC
3240 BC	3800 BC	3540 BC	4210-4260 BC	3840 BC	4490 BC	4140 BC	4790-4880 BC
3250 BC	3800-3850 BC	3550 BC	4220-4270 BC	3850 BC	4490 BC	4150 BC	4880 BC

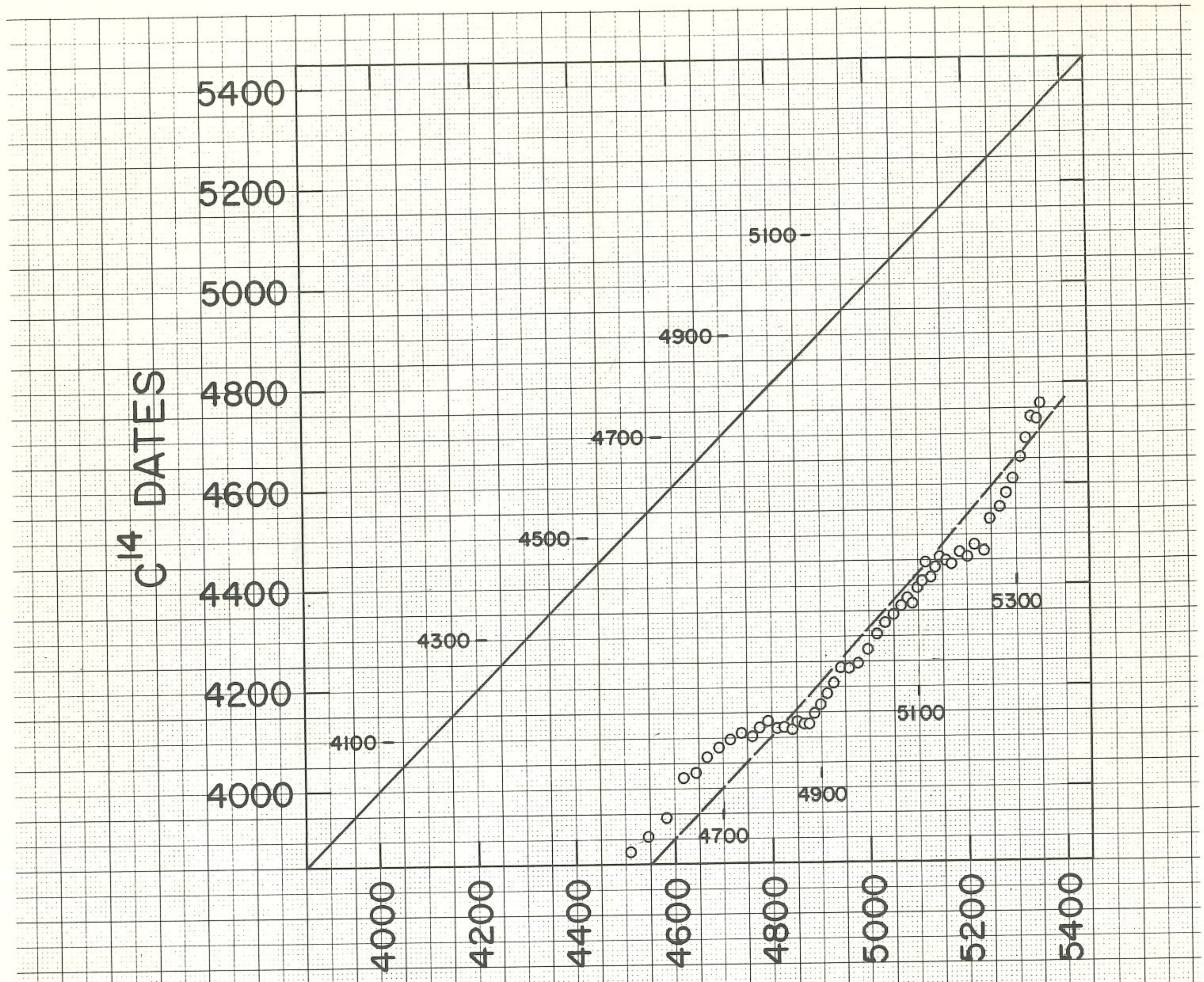


Fig. 6. DENDRO-DATES

SUPPLEMENT TO TABLE 6

C-14 Date	Points in "Range for Corrected Date" in which C-14 date crosses curve or follows it for a distance*	C-14 Date	Points in "Range for Corrected Date" in which C-14 date crosses curve or follows it for a distance*
4230 BC	4940-4960 BC	4450 BC	5110, 5140-5170, 5200 BC
4240 BC	4940-4980 BC	4460 BC	5140, 5180-5200, 5240 BC
4360 BC	5060-5090 BC	4470 BC	5180-5240 BC
4370 BC	5060-5090 BC	4480 BC	5210-5240 BC
4410 BC	5110-5130 BC	4490 BC	5210, 5240 BC
4420 BC	5110-5130 BC	4720 BC	5330-5350 BC
4430 BC	5110-5130 BC	4730 BC	5330-5350 BC
4440 BC	5110-5170 BC	4740 BC	5330-5350 BC

*Simple crossings are indicated with entries separated by commas, spans are indicated with entries connected with hyphens.

TABLE 6

C-14 Date	Range or Mid-Point for Corrected Date	C-14 Date	Range or Mid-Point for Corrected Date	C-14 Date	Range or Mid-Point for Corrected Date	C-14 Date	Range or Mid-Point for Corrected Date
4160 BC	4900 BC	4360 BC	5060-5090 BC	4560 BC	5270 BC	4760 BC	5350 BC
4170 BC	4900 BC	4370 BC	5060-5090 BC	4570 BC	5280 BC		
4180 BC	4910 BC	4380 BC	5080 BC	4580 BC	5280 BC		
4190 BC	4910 BC	4390 BC	5100 BC	4590 BC	5280 BC		
4200 BC	4920 BC	4400 BC	5100 BC	4600 BC	5290 BC		
4210 BC	4930 BC	4410 BC	5110-5130 BC	4610 BC	5290 BC		
4220 BC	4930 BC	4420 BC	5110-5130 BC	4620 BC	5300 BC		
4230 BC	4940-4960 BC	4430 BC	5110-5140 BC	4630 BC	5300 BC		
4240 BC	4940-4980 BC	4440 BD	5110-5170 BC	4640 BC	5310 BC		
4250 BC	4980 BC	4450 BC	5110-5200 BC	4650 BC	5310 BC		
4260 BC	4990 BC	4460 BC	5140-5240 BC	4660 BC	5310 BC		
4270 BC	5000 BC	4470 BC	5180-5240 BC	4670 BC	5320 BC		
4280 BC	5000 BC	4480 BC	5210-5240 BC	4680 BC	5320 BC		
4290 BC	5010 BC	4490 BC	5210-5240 BC	4690 BC	5320 BC		
4300 BC	5020 BC	4500 BC	5240 BC	4700 BC	5330 BC		
4310 BC	5020 BC	4510 BC	5240 BC	4710 BC	5330 BC		
4320 BC	5030 BC	4520 BC	5250 BC	4720 BC	5330-5350 BC		
4330 BC	5030 BC	4530 BC	5250 BC	4730 BC	5330-5350 BC		
4340 BC	5050 BC	4540 BC	5260 BC	4740 BC	5330-5350 BC		
4350	5050 BC	4550 BC	5270 BC	4750 BC	5350 BC		

SUPPLEMENT TO TABLE 1 (Cont.)

C-14 Date	Points in "Range for Corrected Date" in which C-14 date crosses curve or follows it for a distance*	C-14 Date	Points in "Range for Corrected Date" in which C-14 date crosses curve or follows it for a distance*
AD 1260	AD 1290-1260	AD 780	AD 850-830
AD 1250	AD 1290-1260	AD 770	AD 850-830
AD 1170	AD 1220-1200	AD 750	AD 820-800
AD 1160	AD 1220-1200	AD 740	AD 820-800
AD 1100	AD 1180-1150	AD 730	AD 800-780
AD 1090	AD 1170-1110	AD 720	AD 790-770
AD 1080	AD 1140-1110	AD 710	AD 790-770
AD 1070	AD 1120-1090	AD 700	AD 760-730
AD 930	AD 1000-980	AD 690	AD 760-730
AD 830	AD 910-890	AD 670	AD 730-700
AD 810	AD 880-860	AD 660	AD 720-700
AD 800	AD 880-860		

SUPPLEMENT TO TABLE 2 (Cont.)

C-14 Date	Points in "Range for Corrected Date" in which C-14 date crosses curve or follows it for a distance*	C-14 Date	Points in "Range for Corrected Date" in which C-14 date crosses curve or follows it for a distance*
AD 40	AD 130-110	230 BC	200, 350 BC
AD 30	AD 120-90	240 BC	210, 340-360 BC
70 BC	AD 50-30	250 BC	210, 330-370 BC
80 BC	AD 40-20	260 BC	210, 330, 380 BC
110 BC	AD 10-20 BC, 60 BC	270 BC	230-380, 310-330, 380 BC
120 BC	AD 10-60 BC	280 BC	250-300, 380 BC
130 BC	10-100 BC	290 BC	270-300, 390 BC
140 BC	10-40, 60-100 BC	300 BC	270-290, 390 BC
150 BC	70-110 BC	470 BC	440-460 BC
160 BC	70, 120 BC	480 BC	440-470 BC
170 BC	120-140 BC	520 BC	500, 570, 640 BC
190 BC	140-160 BC	530 BC	500, 570, 640 BC
200 BC	140-160, 190 BC	540 BC	510, 540-660 BC
210 BC	170-190 BC	550 BC	510-540, 570-660 BC
220 BC	170, 200 BC		

SUPPLEMENT TO TABLE 5 (Cont.)

C-14 Date	Points in "Range for Corrected Date" in which C-14 date crosses curve or follows it for a distance*	C-14 Date	Points in "Range for Corrected Date" in which C-14 date crosses curve or follows it for a distance*
3600 BC	4330-4350 BC	4100 BC	4710-4760 BC
3610 BC	4330-4350 BC	4110 BC	4730-4780, 4800-4840 BC
4020 BC	4610-4640 BC	4120 BC	4770-4870 BC
4030 BC	4610-4640 BC	4130 BC	4790-4870 BC
4070 BC	4670-4690 BC	4140 BC	4790, 4850-4880 BC
4090 BC	4690-4710, 4760 BC		

*Simple crossings are indicated with entries separated by commas, spans are indicated with entries connected with hyphens

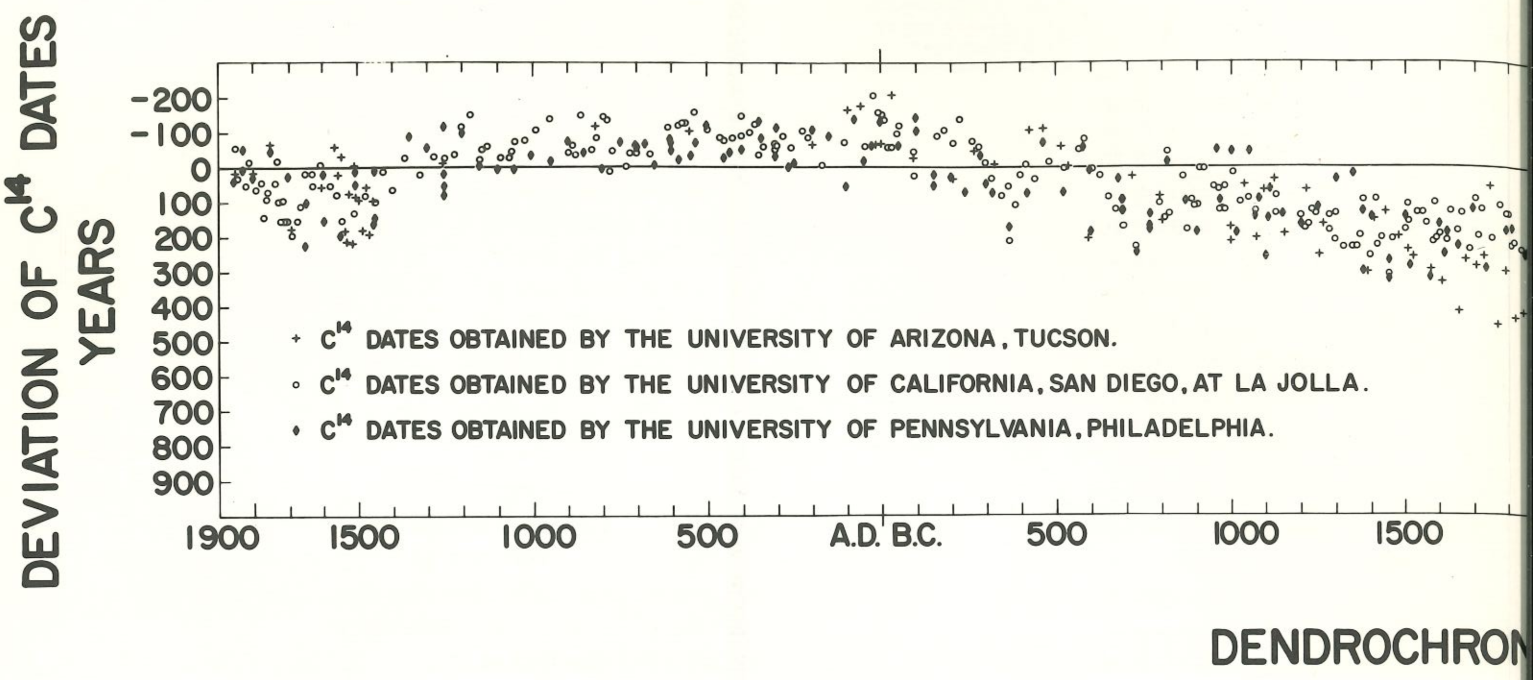
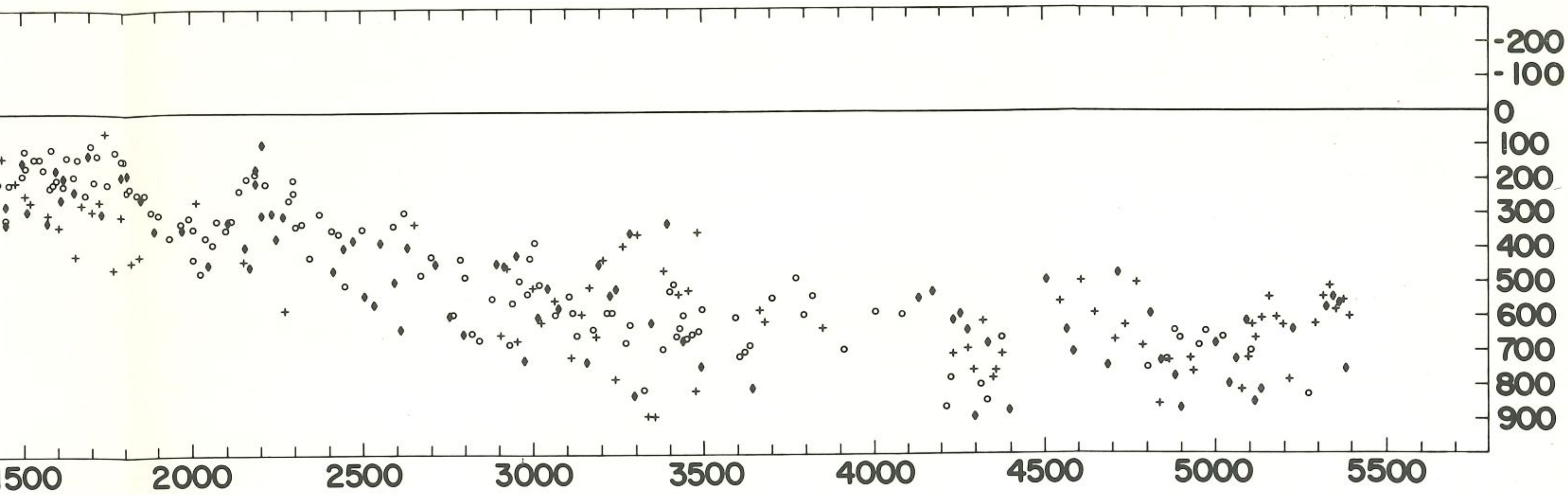


Fig. 7. INDIVIDUAL C^{14} DATES

This is a special issue of the *MASCA Newsletter* mailed to many individuals and institutions not on our normal mailing list. Inquiries about subscriptions to the *Newsletter* should be addressed to: Richard D. Haynes, University Museum, 33rd and Spruce Sts., Philadelphia, Pennsylvania, 19174, U.S.A.



OCHRONOLOGICAL DATES

ATES FOR DENDRO-DATED SAMPLES

ur
es,

SUPPLEMENT TO TABLE 3 (Cont.)

C-14 Date	Points in "Range for Corrected Date" in which C-14 date crosses curve or follows it for a distance*	C-14 Date	Points in "Range for Corrected Date" in which C-14 date crosses curve or follows it for a distance*
1030 BC	1160-1180 BC	1370 BC	1570-1600 BC
1040 BC	1170-1190 BC	1380 BC	1570-1600 BC
1050 BC	1170-1210 BC	1390 BC	1600-1630 BC
1060 BC	1190-1210 BC	1400 BC	1600-1640 BC
1070 BC	1220-1240 BC	1410 BC	1600-1640 BC
1080 BC	1220-1260 BC	1450 BC	1660-1680 BC
1090 BC	1240-1270 BC	1490 BC	1690-1710 BC
1110 BC	1270-1300 BC	1500 BC	1690-1710 BC
1120 BC	1270-1300 BC	1510 BC	1690, 1730 BC
1150 BC	1300-1330, 1360 BC	1520 BC	1710-1750 BC
1160 BC	1310-1360 BC	1530 BC	1710-1750 BC
1170 BC	1320-1370 BC	1540 BC	1720-1760 BC
1180 BC	1340, 1370 BC	1550 BC	1720, 1760, 1870 BC
1190 BC	1370-1390 BC	1560 BC	1770, 1840-1870 BC
1200 BC	1380-1400 BC	1570 BC	1770, 1830-1850 BC
1210 BC	1400-1420 BC	1580 BC	1780-1820, 1880-1900 BC
1220 BC	1400-1450 BC	1590 BC	1780-1800 BC, 1890-1910 BC
1230 BC	1400-1450 BC	1610 BC	1920-1950 BC
1250 BC	1460-1480 BC	1620 BC	1920-1950 BC
1310 BC	1500, 1540 BC	1630 BC	1960-2000 BC
1320 BC	1510, 1540 BC	1640 BC	1960-2020 BC
1330 BC	1510-1550 BC	1650 BC	2000-2020 BC
1340 BC	1520-1560 BC	1660 BC	2020-2040 BC
1350 BC	1520, 1560-1590 BC	1750 BC	2090-2120 BC
1360 BC	1560-1590 BC		

SUPPLEMENT TO TABLE 4 (Cont.)

C-14 Date	Points in "Range for Corrected Date" in which C-14 date crosses curve or follows it for a distance*	C-14 Date	Points in "Range for Corrected Date" in which C-14 date crosses curve or follows it for a distance*
2240 BC	2690, 2710-40, 2800 BC	2650 BC	3210, 3320 BC
2250 BC	2700, 2740, 2820 BC	2660 BC	3240-3260, 3300, 3330 BC
2260 BC	2700, 2810-2830 BC	2670 BC	3220-3260, 3290, 3300, 3330 BC
2300 BC	2850-2870 BC	2680 BC	3220-3250, 3280-3300, 3330 BC
2320 BC	2880-2900 BC	2690 BC	3230-3300, 3340 BC
2330 BC	2880-2910 BC	2700 BC	3250-3270, 3340 BC
2370 BC	2920-2940 BC	2710 BC	3270, 3350 BC
2380 BC	2920-2940 BC	2730 BC	3350-3370 BC
2390 BC	2930-2950 BC	2740 BC	3350-3370 BC
2400 BC	2930-2960 BC	2800 BC	3390, 3440 BC
2410 BC	2950-2970 BC	2810 BC	3390, 3450 BC
2450 BC	2970-2990 BC	2820 BC	3390, 3450 BC
2460 BC	2980-3010 BC	2830 BC	3400, 3430, 3470 BC
2470 BC	2990-3010, 3060 BC	2840 BC	3400, 3430-3470 BC
2480 BC	2990, 3050-3080, 3110 BC	2850 BC	3400, 3430, 3450-3470 BC
2490 BC	3010-3040, 3070-3110 BC	2860 BC	3400-3420, 3470 BC
2500 BC	3010-3050, 3090-3110 BC	2870 BC	3410, 3480, 3520 BC
2510 BC	3030-3050, 3090-3140 BC	2880 BC	3410, 3500-3520 BC
2520 BC	3110-3140 BC	2890 BC	3500, 3540 BC
2620 BC	3180-3200 BC	2930 BC	3570, 3600 BC
2630 BC	3190-3210, 3310 BC	2940 BC	3580-3600 BC
2640 BC	3210, 3310 BC	2950 BC	3580, 3610 BC

*Simple crossings are indicated with entries separated by commas, spans are indicated with entries connected with hyphens.

THERMOLUMINESCENCE (TL)

1. Separation Experiments with Six Samples of Pottery of Known Age.

Samples selected were ones that had produced deviant results using our standard bulk-material technique. They were first treated ultrasonically to separate the fine-grained clay fraction. The remainder was then separated magnetically to isolate the quartz (non-magnetic) from the magnetic mineral fraction. The fine-grained fraction (still containing both quartz and other minerals), and the separated quartz fraction produced TL results in agreement with the original measurements of the bulk material. In other words, the cause of the deviant results was not due to grain size nor to lack of sufficient alpha irradiation of the comparatively larger quartz grains.

2. Alpha Irradiation Experiments

a) With the Non-Magnetic (quartz and feldspar components) of pottery.

Samples of quartz of two types, extracted previously from pottery, were exposed to a calibrated Po^{210} source (an emitter of pure alphas). The purpose was to determine if a dose of alphas, much greater than the inherent natural dose of pottery, would change the susceptibility to radiation damage.

After each alpha irradiation, the samples were tested with small fixed doses of X-rays and the subsequent TL read to measure possible changes. It was found that even after 40 Kilorads of alpha dose, there was not a significant change in susceptibility.

b) Alpha Experiment with Beach Sand.

Since quartz isolated from sherds has been embedded in the clay matrix for a given length of time, it should have experienced certain amounts of radiation from the clay. However beach sand (mostly quartz)

can be considered as free from such experiences, especially from alpha irradiation. If the susceptibility of a given sample is related to its radiation history, then the study of quartz from sand with alpha radiation would give further information as to what extent the crystals are being affected. So far a type of sand of pure quartz (from New Jersey) and another type of a mixture of quartz and feldspar (from Denmark) have been tried. We are now beginning to interpret the results.

3. Dating of Faience.

After a year-long delay caused by Egyptian authorities, $CaSO_4$.Dy. dosimeters have now been installed in selected Egyptian Tombs. After a year in place, they will be brought back to the laboratory to give a measure of the cosmic ray and other background radiation in the tombs. This is a necessary prerequisite for dating faience since it does not contain inherent radioactivity as does pottery.

4. On August 9th, 1973 a lecture on "Methods of Pottery Research as it is carried out by the Applied Science Center, University Museum, Pennsylvania." was given by Mark Han at the "Symposium on the Technology of Ancient Egyptian Ceramics." held on the 8th - 11th August, 1973 in the Technical High School for Ceramics in Höhr-Grenzhausen, West Germany. The symposium was sponsored by the Volkswagen Foundation.

5. Publication.

"A Thermoluminescence series from Thailand" by Bennet Bronson and M. C. Han in Antiquity, Vol. 46, No. 184 (1972)

Aerial Photography

A system for photographing archaeological excavations from a camera suspended beneath a kite is nearing completion. This camera is triggered by radio, an electrical cable, or a time delay; the film is automatically advanced so that a sequence of photos may be taken before lowering the camera from its elevation of 10 to 500 meters. While this is a very inexpensive and portable technique of aerial photography, a predictable wind is necessary.

A detailed how-to-do-it manual on stereo photography for archaeological illustration has been prepared and distributed to interested archaeologists. This report describes the technique of publishing three-dimensional pictures of excavations, statues, small finds, and architecture.

A multiband camera was used for oblique aerial photography in western Montana. It was found that the Indians who occupied this region apparently left few traces of their culture visible from the air. While artifacts which indicate Indian camp sites were found on the ground, only indirect, ecological, clues were detected from the photographs.

Archaeological Prospecting

During this grant year (February & March, 1973) an extensive cesium magnetometer survey was conducted at the 18th Dynasty site of Malkata on the west bank of the Nile River, opposite Luxor, Egypt. (Travel and living costs were financed by counterpart funds administered by the Smithsonian Institution). Because the Nile alluvium is unusually magnetic, good success was achieved in locating mud-brick structures in desert areas. However, for the same reason, it was not possible to pinpoint the ancient harbor which was presumed to have been on the alluvial plain between the desert and the present bed of the Nile. Between the plain and the desert there are two parallel rows of mounds, each row about 2 km long. These were presumably piled up from the dredging of the harbor. All but two were found to be magnetic and, therefore, made from the Nile alluvium. The two non-magnetic mounds at the southwestern limit must consist of sand only (all are now mostly covered with sand), and this fact may provide a clue as to the location of the original harbor. Hopefully, this area will be excavated during the next field season.

A brief magnetometer survey was conducted at Chaco Canyon, New Mexico to investigate an anomaly that had been detected with a seismograph. It was found to be a geological feature.

Just before the start of this grant-year (October, 1972), a cesium magnetometer survey was conducted at Tepe Malyan in southern Iran. Due to accidental firing in past times, mud-brick structures were detected which contained tablets that indicate that this site was the ancient capitol of the Illemites. Because of its importance, we plan to do a magnetic survey of the whole site, possibly in 1975.

Information Center

The information center and its bibliographer, Richard D. Haynes, are supported by NSF Grant NSF-GS-36308X. The functions of the information center are: to survey current literature for ideas for new applications and examples of new applications of applied science in archaeology, to abstract relevant articles and maintain a file of the most useful of them, to maintain a library organized around applied science in archaeology, to do library searches on topics requested by researchers, and to publish a Newsletter dealing with new developments in archaeology.

Under the current grant the following have been accomplished: eleven new journals are routinely surveyed, including journals in French, German, Spanish and Portugese as well as continuing coverage of twenty-four journals, including one in Italian. An estimated two hundred articles have been abstracted. Sixteen new books have been purchased for the library, and a card file by author and title has been prepared for the library. Five thorough library searches have been conducted. Also an issue of the MASCA Newsletter is in the process of being printed for publication in August.

The administrative assistant, Kathleen Ryan, is responsible for most of the secretarial work in the department, i.e. such things as taking dictation, typing letters and filing. In addition, she assisted with several special projects: drawing of maps for reports, plotting of radiocarbon vs. dendrodates for the calibration curve contained in the recent MASCA Newsletter, and assisted in the re-organization of the Information Center Library.

New Techniques

These have been carried out or supervised by Gary W. Carriveau, PhD., a physicist who joined our staff this year.

Firing Temperature

To insure valid thermoluminescence dates, the dated artifact must have been fired at a temperature sufficiently high and for a long enough period of time to drain (anneal) all thermoluminescence accumulated since the clay and inclusions were formed. In other words, the clock to be read with TL dating must be set to zero when the ceramic is fired. Several techniques have been developed at MASCA to check for 'proper' firing. These include hardness testing, color changes, weight loss, X-ray diffraction pattern changes and alteration of physical dimensions. These changes are measured during systematic reheating of the ceramic materials. Through results of this work, suspect dates on a collection of Mexican figurines were found to result from insufficient firing. The techniques have been developed in collaboration with the Department of Geology (X-ray diffraction), Laboratory for Research on the Structure of Matter (scanning electron microscope) and in consultation with Professor F. Matson, Pennsylvania State University.

An outgrowth of the firing temperature program, directly related to the basic theory of TL dating, deals with the incomplete annealing of ceramics and its effect on the TL date. A study is underway to define quantitatively the effect of incomplete annealing and, wherever possible, to use the results of firing temperature measurement to correct dates on low-fired wares.

Potassium Analysis

A further addition to the TL dating project is the development of a method to measure the amount of potassium in ceramic material. The radioactive isotope, K^{40}, contributes to the total radiation dose creating thermoluminescence. Quantitative measurement of potassium ensures the most accurate date. Techniques of high temperature fusions and direct measurement of K using flame photometry are now in general use at MASCA. Results of these measurements are of high accuracy and the techniques and apparatus are

available for the potassium-argon dating project in the Department of Geology.

X-ray Fluorescence

Elemental composition, through X-ray fluorescence analysis, of Hawaiian basaltic artifacts has been used to determine their provenance. This technique has also been used on South Pacific and Mexican ceramics. The program will be greatly expanded upon purchase, by the University Museum, of the latest computer controlled apparatus. A symposium was held at MASCA on X-ray fluorescence analysis techniques; those attending included representatives from the Boston Museum of Fine Arts, the Freer Gallery of the Smithsonian Institution, the Winterthur Museum, the Maritime Museum, and our own staff.

Obsidian Dating

Two non-destructive techniques for the dating of obsidian artifacts are being developed. These are namely, the analysis of interference patterns of infra-red radiation produced by the thin hydration rim in obsidian and secondly, the study of recoil alpha-particle energy distributions from the hydrated and non-hydrated regions in obsidian. The experimental work is being done in co-operation with the Moore School of Electrical Engineering and the Tandem Van de Graaff Laboratory, Department of Physics, University of Pennsylvania.

Radiocarbon Dating

A theoretical study and feasilility analysis on a new method of radiocarbon dating has been completed. Experimental apparatus employing a new dosimetry technique will be assembled from existing components in collaboration with the Cryogenics Laboratory in the Department of Physics. Results may enable the counting time for radiocarbon dating to be reduced by at least a factor of ten. The apparatus will use benzene, now being produced in the Radiocarbon Laboratory

Additional New Techniques

Mud Brick Project

Objective

A search has been initiated for a method of protecting and conserving mud brick structures, walls and remnants thereof. The method is to be essentially a surface treatment to existing structures. Protection against rain, heat, freezing, thawing, sand abrasion and ground moisture are a part of the objective. The method of application is to be simple and suitable for a remote field application.

Results

Baseball sized chunks of adobe blocks from Tucson, Arizona, are being spray treated in the laboratory. Evaluation of these treated chunks is made by a forced water spray (from a shower-head) equivalent to a driving rain of 900-1200 inches per hour.

Under the test conditions, untreated samples disintegrate completely in 1-2 minutes. Silicone resin in mineral thinner treated samples, one of the current preferred methods by the U.S. Park Service, can withstand the shower for 45-70 minutes. Acrylic emulsion treated samples can withstand the shower up to 10 hours with a single coating and up to 35-40 hours with a double coating. An acrylic emulsion treatment and after drying followed by a silicone in mineral thinner treatment withstands the shower for up to 35 hours.

Chunks of adobe blocks treated by the spray-on technique with these acrylic resins have been on weathering tests on the Museum roof for ten months. Some of the double coated samples show no deterioration from the natural elements of rain, sun, snow and freezing in the Philadelphia climate for the ten-month period.

Field tests at Chaco Canyon and Pecos National Monuments in New Mexico have been established in a freshly excavated pit house, Kiva, on ancient stone wall and ancient adobe walls. Uses of these resin materials in mud mortar and in present-day adobe blocks are also under test at Pecos.

This project is being conducted by our visiting scholar, Dr. Darrel Butterbaugh, a retired research chemist.

NSF Grant GS-36308X

Re: NSF Notice No. 33, item 2

Our review of the budget indicates that no funds will be uncommitted at the end of the first grant year. Since most salaries are on a monthly basis and the grant was not actually received until the end of November 1972, we have projected expenditures to November 30, 1973 instead of November 15, 1973 as specified on NSF Form No. 99-R0013.

As of now, projected expenditures for Salaries, Employee Benefits, and overhead are exactly in line with the Budget.. Also, spending for Expendable Equipment and Supplies is as anticipated. In regard to Other Direct Costs (Item I), the $35,000 for Laboratory Renovations has been spent (plus $2000 contributed by the University). Purchased Research Services are being expended at the $2500 level as specified. Some funds remain for Shop Services and Equipment Rental. However, Publication Costs may exceed the $1500 slightly due to the issuance of a much larger <u>MASCA Newsletter</u> than usual; also, we have exceeded our budget for Domestic Travel. More than half the funds for Equipment have not yet been spent due to the delay in building a new cesium magnetometer. We expect to have this underway in September.

NSF Notice No. 33, item No. 3

IX. C. Budget Proposal - Second Year

1. Salaries and Wages

a. Research Personnel (A-2)

1) Physicist, Geologist, Engineer, or Chemist $ 12,960

Full-time - 12 months

FTE - 12 months

2) Four Research Fellows

Three summer months - full-time

Academic year - half-time

FTE - 8 man months

(4 x $4150) 16,600

Total A-2 $ 29,560

b. Other Professional

Research Chemist (A-1), Mark Han 12,960

Full-time - 12 months

FTE - 12 months

c. Secretarial, Clerical, and Administrative

1) Research Bibliographer II (A-3) 7,560

Full-time - 12 montns

FTE - 12 months

2) Secretarial, Clerical, and Administrative Assistant (A-3) 4,320

Half-time - 12 months

FTE - 6 months

Total A-3 $ 11,880

Total Salaries $ 54,400

IX. C. (Cont'd)

d. Employee Benefits

15.5% of A-2 ($29,560)	$ 4,582	
8.5% of A-2 ($12,960)	1,102	
7.9% of A-3 ($11,880)	938	
Total Employee Benefits		$ 6,622
e. Overhead (37% of Salaries)		$20,128
Total - Salaries, Benefits, and Overhead		$81,150

2. Equipment

a. For Thermoluminescence - Replacement Components		
2 High Voltage Power Supplies	$ 1,500	
Fluke Model 415B		
2 Linear Amplifiers	1,200	
Keithley Model 160		
Patch Heater	600	
Research, Inc. Model 5066-3		
sub-total		3,300
b. For Archaeological Prospecting		
Minor Components and Replacements		1,000
c. For Aerial Photography		
Vertical Sketchmaster	500	
(Gordon Enterprises Type 260-GE)		
Stereo-Microscope and Light Table	3,100	
(Laser Sciences, Inc. Model LT 630)		
sub-total		$ 3,600
Total - Equipment		$ 7,900

IX. C. (Cont'd)

3. Expendable Equipment and Supplies

a. For Thermoluminescence

One calibrated Po^{210} source	300
Nitrogen and other chemical supplies	700
Electronic components	400
Miscellaneous Supplies	500

b. For Archaeological Prospecting

Spare Parts, cables, connectors, and tools	800

c. For Aerial Photography

Balloon lifting gas	1,750
Films and Film Processing	300

d. Information Center

Books, Journals, and Supplies	1,200
Total - Supplies	5,950

IX. C. (Cont'd)

4. Services

Machine Shop	750	
Electronics Shop	550	
Rental of Prospecting Instruments	1,200	
Rental of a Field Spectrometer for Aerial Photography	1,200	
Rental of Aircraft when volunteer ones are not available nor suitable	3,500	
Printing of MASCA Newsletter	1,600	
Other Printing and Duplicating	400	
Total - Services		9,200

5. Travel

For Instrument and Aerial Surveys and to attend Conferences		
Domestic	800	
Foreign	2,200	
Total - Travel		3,000

6. Expenses

Consultant	2,700	
Dr. N. Suntharalingam (or another person) 5% of full-time FTE - 1 man-month		
Total Expenses		$ 2,700
Total - Second Year		$ 109,900
Total - Two Years		$ 253,564

IX BUDGET

A. Private Support

During the 1970-1971 fiscal year, the University Museum received gifts totalling $600,000 from private sources and non-government grants. This sum includes $62,000 from the Ford Foundation which supported 50 graduate students at excavations abroad.

The major part of the $600,000 was used to support the other costs of expeditions which numbered 20 during the past year and research in the Museum.

The specific budget for MASCA is shown in Table IV. In this Table, three of the smaller sums ($7100, $3000, and $5000) were obtained from the above mentioned gifts or Museum endowments.

In the following pages we have included precise budget proposals for the next 2 years. An estimated budget for the subsequent 3 years and a rough guess for the following 5 years were included in Section V.

We have not submitted this or a similar proposal to any agency other than the National Science Foundation.

IX. B. Budget Proposal - First Year

1. Salaries and Wages

a. Research Fellows (A-2)

Three summer months - full-time

Academic year - half-time

FTE - 8 man months

1) Douglas Hancock		$ 4,150
2) Bruce Bevan		4,150
3) Graduate Student		4,150
4) Graduate Student		4,150
Total A-2		16,600
b. Other Professional		
Research Chemist (A-1), Mark Han		12,000
Full-time - 12 months		
FTE - 12 months		
c. Secretarial, Clerical, and Administrative		
1) Research Bibliographer II (A-3)	7,000	
Full-time - 12 months		
FTE - 12 months		
2) Secretarial, Clerical, and Administrative Assistant (A-3)	4,000	
Half-time - 12 months		
FTE - 6 months		
Total A-3		11,000
Total Salaries		39,600

IX. B. Budget Proposal - First Year (Cont'd)

d. Employee Benefits

15.5% of A-2 (16,600)	2,573	
8.5% of A-1 (12,000)	1,020	
7.9% of A-3 (11,000)	869	
Total - Employee Benefits		4,462
e. Overhead (37% of Salaries)		14,652
Total - Salaries, Benefits, and Overhead		$58,714

IX. B. (Cont'd)

2. Equipment

a. For Thermoluminescence - New Components

TL Integrator (for dosimetry)	2,500	
Spectrometer (for 9th alpha counter) Baird-Atomic Model 530	3,500	
sub-total		6,000

b. For Archaeological Prospecting

New Cesium Magnetometer Readout	10,000	
2 new Césium Sensors (Varian Associates Model 49-554)	10,000	
Susceptibility Meter (Bison Instruments Model 3101)	1,300	
Metal Detectors and Components for Seismic and other experiments	500	
sub-total		21,800

c. For Aerial Photography

3 Electrically-driven Hasselblad Model 500 El Cameras Mounted Together for Simultaneous Picture Taking. (One of the 3 cameras is being donated by J. Whittlesey)		4,000 Bruce

Total - Equipment		31,800
		13,000
		18,800

IX. B. (Cont'd)

3. Expendable Equipment and Supplies

a. For Thermoluminescence

Calibrated Radioactive Sources: One Sr^{90} (beta) Two Po^{210} (alpha)	950
Nitrogen and Other Chemical Supplies	600
Photomultiplier tubes and other electronic components	500
b. For Archaeological Prospecting	
Spare parts, cables, and tools	500
c. For Aerial Photography	
Camera Light Meter, Wind Meters, Pantograph, etc.	200
Balloon lifting gas	1,500
Films and Film Processing	250
d. Information Center	
Books, Journals, and Supplies	1,000
Total Supplies	5,500

IX. B. (Cont'd)

4. Services

Machine Shop	750
Electronics Shop	500
Rental of Prospecting Instruments	1,000
Rental of an Isodensitometer	400
Rental of a Field Spectrometer (possibly, Perkin-Elmer) for Aerial Photography	1,000
Printing of MASCA Newsletter	1,200
Other Printing and Duplicating	300
Total - Services	5,150

5. Travel

For instrument and aerial surveys and to attend conferences

Domestic	750
Foreign (This includes round-trip air-fare for two persons to attend the International Radiocarbon Conference in New Zealand, October 1972)	4,250
Total - Travel	5,000

6. Expenses

a. Building Renovations

1) Enlargement of Radiocarbon Laboratory, DRL by the addition of room BW8. This includes the sealing of the room, the supply of filtered and cooled air, and the installation of doorways. (The estimate for the air-conditioning is approximately $3500 and the detailed estimate of the other work is now being prepared. — $ 25,000

2) MASCA Laboratories

Installation of a water-cooled air-conditioning system — $ 10,000

b. Radiological Consultant — 2,500

Dr. N. Suntharalingam

5% of full-time

FTE - 1 man-month

$ 37,500

TOTAL FIRST YEAR $143,664

IX. C. Budget Proposal - Second Year

1. Salaries and Wages

a. Research Personnel (A-2)

1) Physicist, Geologist, Engineer, or Chemist		$ 12,960
Full-time - 12 months		
FTE - 12 months		
2) Four Research Fellows		
Three summer months - full-time		
Academic year - half-time		
FTE - 8 man months		
(4 x $4150)		16,600
Total A-2		$ 29,560
b. Other Professional		
Research Chemist (A-1), Mark Han		12,960
Full-time - 12 months		
FTE - 12 months		
c. Secretarial, Clerical, and Administrative		
1) Research Bibliographer II (A-3)	7,560	
Full-time - 12 montns		
FTE - 12 months		
2) Secretarial, Clerical, and Administrative Assistant (A-3)	4,320	
Half-time - 12 months		
FTE - 6 months		
Total A-3		$ 11,880
Total Salaries		$ 54,400

IX. C. (Cont'd)

New	d. Employee Benefits		
15.7	15.5% of A-2 ($29,560)	$ 4,582	
9.9	8.5% of A-1 ($12,960)	1,102	
10.3	7.9% of A-3 ($11,880)	938	
	Total Employee Benefits		$ 6,622
	e. Overhead (37% of Salaries)		$20,128
	Total - Salaries, Benefits, and Overhead		$81,150
	2. Equipment		
	a. For Thermoluminescence - Replacement Components		
	2 High Voltage Power Supplies	$ 1,500	
	Fluke Model 415B		
	2 Linear Amplifiers	1,200	
	Keithley Model 160		
	Patch Heater	600	
	Research, Inc. Model 5066-3		
	sub-total		3,300
	b. For Archaeological Prospecting		
	Minor Components and Replacements		1,000
	c. For Aerial Photography		
	Vertical Sketchmaster	500	
	(Gordon Enterprises Type 260-GE)		
	Stereo-Microscope and Light Table	3,100	
	(Laser Sciences, Inc. Model LT 630)		
	sub-total		$ 3,600
	Total - Equipment		$ 7,900

IX. C. (Cont'd)

3. Expendable Equipment and Supplies

a. For Thermoluminescence

One calibrated Po^{210} source	300
Nitrogen and other chemical supplies	700
Electronic components	400
Miscellaneous Supplies	500
b. For Archaeological Prospecting	
Spare Parts, cables, connectors, and tools	800
c. For Aerial Photography	
Balloon lifting gas	1,750
Films and Film Processing	300
d. Information Center	
Books, Journals, and Supplies	1,200
Total - Supplies	5,950

TABLE I

Summary of MASCA Instrument Surveys

Site	Buried Features Sought	Magnetometers	Resistivity Instruments	Supplementary Instruments
THE NEW WORLD U. S. A.				
Independence Square Philadelphia, Pa.	house foundations	excessive magnetic disturbances due to city location	good detection	
Rifle Works, Harpers Ferry, W. Virginia	structure of Rifle Works	excessive disturbances from modern iron	located turbine pit	seismograph provided some indication of turbine pit
Isle Royal, Lake Superior, Michigan	copper ore deposits	not suitable	not suitable	some hot spots were found with metal detectors
Fort Loudon, near Chambersburg, Pa.	trenches and embankments of fort	indications of location of trenches and embankments	not suitable	
Caleb Pusey House, Chester, Pa.	house and other building foundations	excessive magnetic disturbances due to location near town	excellent detection of eastern extension of house - later confirmed by excavation	
Hagley Mills, Wilmington, Del.	structures of powder works	located large conduit and many large iron fragments	some indication of location of conduit	metal detector confirm[ed] presence of many large iron fragments and metal pipes

Site	Buried Features Sought	Magnetometers	Resistivity Instruments	Supplementary Instruments
Eleutherian Mills, near Wilmington, Del.	features of the garden of former residence of E. I. duPont	pieces of modern iron caused confusion	good detection of well, drain, and other features	
Hope Lodge, Whitemarsh, Pa.	foundations of mansion and out-buildings	not tested	good detection of foundations	
Snaketown, near Chandler, Arizona	features from period of A.D. 1 to 1400	excellent detection of large firepits - confirmed by excavation	not suitable	
Salvage site, near San Xavier, Arizona	small features representative of Indian occupation	test site for new cesium magnetometer; site was not especially suitable for magnetometers	not suitable	
Buttes Dam Site, no. of Tucson, Arizona	Indian occupation site	presence of magnetic volcanic rocks negated usefulness of magnetometer	not suitable	
Camden, South Carolina	wooden structures of Revolutionary Fort Camden	remains of structures sought did not offer magnetic contrast; located unsuspected gas pipeline	sandy soil and hence poor coupling to ground provided false anomalies	standard aerial photograph show small variation in vegetation wh may correlate w structures sou
Harvard Forest, Petersham, Mass.	collaboration with soil scientists to find out if different types of soil in this region differed in magnetism	magnetic bedrock at variable depths negated usefulness of magnetometer	not suitable	

Site	Buried Features Sought	Magnetometers	Resistivity Instruments	Supplementary Instruments
St. Croix Island, near Calais, Maine	former structures of early French settlement, A.D. 1604	detected a number of anomalies, probably representative of structures and graves	numerous ant hills and looseness of the soil due to the activity of ants or other causes, such as excess sand, caused false anomalies.	
Beverick Manor, New Jersey	Foundations of original Manor House	anomalies found		
Mount Clare House, Baltimore, Md.	Tunnel leading from house	not suitable	found foundations extending from house	
CANADA				
Fort Louisbourg, Nova Scotia	graves and tunnels under embankments	excellent detection of graves; vague indications of tunnels	grave detection confused by proximity of bedrock; some indication of tunnel locations	seismograph confirmed that bedrock was only 4 ft. deep; many iron objects detected with metal detector
Fort Lennox, Île-aux-Noix, Quebec	many structures and graves	good indication of region of structures, but not so precise as resistivity; good detection of graves	excellent pinpointing of structures-confirmed by excavation	metal detector located various metal objects at shallow depths; seismograph gave vague indication of bedrock
Campbellton, New Brunswick	Sunken ships	trial survey made on ice; good anomalies over known locations of two ships; to be continued this winter over unknown ships	not suitable	

Site	Buried Features Sought	Magnetometers	Resistivity Instruments	Supplementary Instruments
CENTRAL AMERICA				
Tikal, Guatemala	buried structure in N. Acropolis, W.Plaza, and Temple I	unable to tune proton magnetometer for magnetic field in this region	anomalies confused by structures too complex; could not distinguish structures from pits	
San Lorenzo, Veracruz, Mexico	Olmec monuments 1200-900 B.C.	excellent detection of monuments due to the fact that they were made of magnetic basaltic rock	not needed	
NEW WORLD Etzatlan, Jalisco, Mexico	Jalisco shaft tombs	top soil too magnetic		Experiments with new Bison Signa Enhancement Seismograph, but no difference in velocity between loose top soil and shafts.
THE OLD WORLD IRELAND				
Novan Fort, near Armagh, N. Ireland	mound site	indecisive results	not suitable	
Dun Ailinne, near Kilcullen, County, Kildare.	traditional royal site; possible seat of the "High Kings"	detected large anomaly representative of center of Iron Age occupation	anomalies confused by proximity of bedrock and boulders	
TURKEY				
Gordion	location of tombs under tumuli; structures on city mound; Persian road	variable magnetic earth caused anomalies much larger than ones anticipated from archaeological	located Persian road where it existed; and structures on city mound to depth of 2-3 meters	

Site	Buried Features Sought	Magnetometers	Resistivity Instruments	Supplementary Instruments
ITALY				
Sybaris	the 7th - 6th century B.C. city	See Rainey, F. and Lerici, C. The Search for Sybaris, 1967 MASCA used magnetometers at this site for a total of 2 years (over an 8-year period)		
Tarquinia and Cervetri	Etruscan tombs	reasonably good detection of tombs	approximately 50% detection of tombs, but very slow	seismograph not useful
Artena	city walls and structures	magnetic earth negated usefulness of magnetometer	good detection of foundation walls of structures	
Foce del Sele, near Paestum	6th century, B.C. Greek sanctuary	no archaeological features were detected although most of the zone of interest was surveyed	not suitable on alluvial plain	
Metapontum	6th century, B.C. and later Greek city	excellent detection of walls and structures	not suitable	magnetometer anomalies helped to confirm and to clarify anomalies detected in aeria photographs
Gravina	structures from many periods	many anomalies, but correspondence was confused because of presence of structures almost everywhere	not tested	

site	Buried Features Sought	Magnetometers	Resistivity Instruments	Supplementary Instruments
Veii	city site	erroneous anomalies, due to magnetic earth	ground was too dry in summer	
Siris	6th century B.C. Greek city	no true anomalies found; confirmed by drilling	not suitable	anomalies seen in infrared aerial photographs proved to be erroneous
GREECE				
Helice	7th - 6th century B.C. city	whole area covered with modern iron	not suitable	
Porto Cheli	4th century B.C. harbor walls	structures not detected due to lack of contrast in magnetism	ground was too dry in August; should be tried in wetter season	
Thera	Bronze Age structures	presence of magnetic volcanic gravel negated usefulness of magnetometer	not suitable due to loose pumice and great depth of structures	seismograph provided some indication of depth of bedrock and, hence, thickness of pumice layer
Elis	5th and 4th century B.C. city	excellent detection of walls which will enable reconstruction of part of the city plan	not suitable	
YUGOSLAVIA				
Divostin and other sites near Kragujevac	Neolithic houses	excellent detection of burned Neolithic house floors, and even of "city" plan at Grivac	not suitable	

Site	Buried Features Sought	Magnetometers	Resistivity Instruments	Supplementary Instruments
ITALY				
Ciro	other structures in region of Greek temple	several anomalies that may represent buried structures	not suitable	
Cosa	Roman harbor	magnetic earth	detection of some anomalies	
Gravina di Puglia	Neolithic occupation sites	good success in finding pits in tufa bedrock, pits representative of occupations	not required	
FRANCE				
Aleria, Corsica	Etruscan tombs	found Roman kiln with roof intact, and very early (possibly) Etruscan tombs	not suitable	
Wissant, near Calais	Roman fortress	promising anomaly found within the high enclosure	not required	
ENGLAND				
Kingscote, Gloucestershire	Roman structures	found many promising anomalies	not required	Anomalies were in exact correspondence with ones detected in aerial photographs

Revised 10/19/71

Table IV , MASCA BUDGET AT PRESENT

PROJECTS	SUPPORT FOR FISCAL YEAR 1971 - 72	FUNDS EXPECTED TO BE AVAILABLE FOR NEXT FISCAL YEAR 1972 - 73
A. RADIOCARBON LABORATORY University of Pennsylvania (Physics-Museum-Radiocarbon Budget)	$32,850	$33,000
University Museum	7,100	3,100
NSF Grant, GA-12572, E. Ralph, Principal Investigator	23,050	23,050
Foundation for Studies of Modern Science	3,620	
B. THERMOLUMINESCENCE Continuation of NSF Grant, GS-2716, F. Rainey, Principal Investigator	34,000	
C. INFORMATION CENTER Harrison Fund	3,000	
D. ARCHAELOGICAL PROSPECTING INSTRUMENTS AND SURVEYS Italian Expedition Fund and Others	5,000	
E. AERIAL PHOTOGRAPHY - NATIONAL PARK SERVICE	1,500	
TOTAL	$110,120	$59,150

Table IV , MASCA BUDGET AT PRESENT — Revised 10/19/71

PROJECTS	SUPPORT FOR FISCAL YEAR 1971 - 72	FUNDS EXPECTED TO BE AVAILABLE FOR NEXT FISCAL YEAR 1972 - 73
A. RADIOCARBON LABORATORY University of Pennsylvania (Physics-Museum-Radiocarbon Budget)	$32,850	$33,000
University Museum	7,100	3,100
NSF Grant, GA-12572, E. Ralph, Principal Investigator	23,050	23,050
Foundation for Studies of Modern Science	3,620	
B. THERMOLUMINESCENCE		
Continuation of NSF Grant, GS-2716, F. Rainey, Principal Investigator	34,000	
C. INFORMATION CENTER		
Harrison Fund	3,000	
D. ARCHAELOGICAL PROSPECTING INSTRUMENTS AND SURVEYS		
Italian Expedition Fund and Others	5,000	
E. AERIAL PHOTOGRAPHY - NATIONAL PARK SERVICE	1,500	
TOTAL	$110,120	$59,150

UNIVERSITY OF PENNSYLVANIA

PHILADELPHIA, PENNSYLVANIA 19174

PROPOSAL FOR CONTINUING RESEARCH SUPPORT

Museum Applied Science Center for Archaeology
(MASCA)

National Science Foundation

Division of Special Projects

Washington, D.C. 20550

Principal Investigator: Froelich Rainey, Director, University Museum and MASCA Administrator; Dept. of Anthropology, Graduate School of Arts and Sciences; Professor of Anthropology, The College

School: University of Pennsylvania   Department: University Museum

Starting Date: 1 December 1973   Duration: Second Year

FUNDS REQUESTED

Second Year (12/1/73 - 11/30/74):	$109,900
Total:	$109,900

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

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

Date:______________________

Approved:______________________
D. J. O'Kane, Dean of the Graduate School of Arts and Sciences

Approved:______________________
Froelich Rainey
Principal Investigator
Director, University Museum

Approved:______________________
Reagan A. Scurlock
Director Research Administration

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

Radiocarbon Laboratory

Series of samples from the following sites have been dated by C^{14} this year:

Hajji Firuz Tepe, Iran
Cosa, Italy
Franchthi Cave, Greece
Selenkahiye, Syria
Korucu Tepe, Turkey
Ai-Khanoum, N. Afghanistan
Chilca Canyon, Peru
Chalchuapa, El Salvador
Port Royal, Honduras
Fotoruma Cave, Guadalcanal Island, British Solomons
Anangula site, eastern Aleutians
Dixthada, central Alaska
Savich Farm, New Jersey

Our efforts in dating samples of known age are summarized in the enclosed special issue of the MASCA Newsletter (Vol. 9, No. 1) entitled "Radiocarbon Dates & Reality."

Also, we have instructed a graduate student in Classical Archaeology, Peter Kuniholm, in the techniques of dendrochronology. Mr. Kuniholm, for the next year, will be doing field work in Turkey in an effort to establish a master tree-ring chronology from wood found at archaeological sites in Turkey.

THERMOLUMINESCENCE (TL)

1. Separation Experiments with Six Samples of Pottery of Known Age.

Samples selected were ones that had produced deviant results using our standard bulk-material technique. They were first treated ultrasonically to separate the fine-grained clay fraction. The remainder was then separated magnetically to isolate the quartz (non-magnetic) from the magnetic mineral fraction. The fine-grained fraction (still containing both quartz and other minerals), and the separated quartz fraction produced TL results in agreement with the original measurements of the bulk material. In other words, the cause of the deviant results was not due to grain size nor to lack of sufficient alpha irradiation of the comparatively larger quartz grains.

2. Alpha Irradiation Experiments

a) With the Non-Magnetic (quartz and feldspar components) of pottery.

Samples of quartz of two types, extracted previously from pottery, were exposed to a calibrated Po^{210} source (an emitter of pure alphas). The purpose was to determine if a dose of alphas, much greater than the inherent natural dose of pottery, would change the susceptibility to radiation damage.

After each alpha irradiation, the samples were tested with small fixed doses of X-rays and the subsequent TL read to measure possible changes. It was found that even after 40 Kilorads of alpha dose, there was not a significant change in susceptibility.

b) Alpha Experiment with Beach Sand.

Since quartz isolated from sherds has been embedded in the clay matrix for a given length of time, it should have experienced certain amounts of radiation from the clay. However beach sand (mostly quartz)

can be considered as free from such experiences, especially from alpha irradiation. If the susceptibility of a given sample is related to its radiation history, then the study of quartz from sand with alpha radiation would give further information as to what extent the crystals are being affected. So far a type of sand of pure quartz (from New Jersey) and another type of a mixture of quartz and feldspar (from Denmark) have been tried. We are now beginning to interpret the results.

3. Dating of Faience.

After a year-long delay caused by Egyptian authorities, $CaSO_4$.Dy. dosimeters have now been installed in selected Egyptian Tombs. After a year in place, they will be brought back to the laboratory to give a measure of the cosmic ray and other background radiation in the tombs. This is a necessary prerequisite for dating faience since it does not contain inherent radioactivity as does pottery.

4. On August 9th, 1973 a lecture on "Methods of Pottery Research as it is carried out by the Applied Science Center, University Museum, Pennsylvania." was given by Mark Han at the "Symposium on the Technology of Ancient Egyptian Ceramics." held on the 8th - 11th August, 1973 in the Technical High School for Ceramics in Höhr-Grenzhausen, West Germany. The symposium was sponsored by the Volkswagen Foundation.

5. Publication.

"A Thermoluminescence series from Thailand" by Bennet Bronson and M. C. Han in <u>Antiquity</u>, Vol. 46, No. 184 (1972)

Aerial Photography

A system for photographing archaeological excavations from a camera suspended beneath a kite is nearing completion. This camera is triggered by radio, an electrical cable, or a time delay; the film is automatically advanced so that a sequence of photos may be taken before lowering the camera from its elevation of 10 to 500 meters. While this is a very inexpensive and portable technique of aerial photography, a predictable wind is necessary.

A detailed how-to-do-it manual on stereo photography for archaeological illustration has been prepared and distributed to interested archaeologists. This report describes the technique of publishing three-dimensional pictures of excavations, statues, small finds, and architecture.

A multiband camera was used for oblique aerial photography in western Montana. It was found that the Indians who occupied this region apparently left few traces of their culture visible from the air. While artifacts which indicate Indian camp sites were found on the ground, only indirect, ecological, clues were detected from the photographs.

Archaeological Prospecting

During this grant year (February & March, 1973) an extensive cesium magnetometer survey was conducted at the 18th Dynasty site of Malkata on the west bank of the Nile River, opposite Luxor, Egypt. (Travel and living costs were financed by counterpart funds administered by the Smithsonian Institution). Because the Nile alluvium is unusually magnetic, good success was achieved in locating mud-brick structures in desert areas. However, for the same reason, it was not possible to pinpoint the ancient harbor which was presumed to have been on the alluvial plain between the desert and the present bed of the Nile. Between the plain and the desert there are two parallel rows of mounds, each row about 2 km long. These were presumably piled up from the dredging of the harbor. All but two were found to be magnetic and, therefore, made from the Nile alluvium. The two non-magnetic mounds at the southwestern limit must consist of sand only (all are now mostly covered with sand), and this fact may provide a clue as to the location of the original harbor. Hopefully, this area will be excavated during the next field season.

A brief magnetometer survey was conducted at Chaco Canyon, New Mexico to investigate an anomaly that had been detected with a seismograph. It was found to be a geological feature.

Just before the start of this grant-year (October, 1972), a cesium magnetometer survey was conducted at Tepe Malyan in southern Iran. Due to accidental firing in past times, mud-brick structures were detected which contained tablets that indicate that this site was the ancient capitol of the Illemites. Because of its importance, we plan to do a magnetic survey of the whole site, possibly in 1975.

Information Center

The information center and its bibliographer, Richard D. Haynes, are supported by NSF Grant NSF-GS-36308X. The functions of the information center are: to survey current literature for ideas for new applications and examples of new applications of applied science in archaeology, to abstract relevant articles and maintain a file of the most useful of them, to maintain a library organized around applied science in archaeology, to do library searches on topics requested by researchers, and to publish a Newsletter dealing with new developments in archaeology.

Under the current grant the following have been accomplished: eleven new journals are routinely surveyed, including journals in French, German, Spanish and Portugese as well as continuing coverage of twenty-four journals, including one in Italian. An estimated two hundred articles have been abstracted. Sixteen new books have been purchased for the library, and a card file by author and title has been prepared for the library. Five thorough library searches have been conducted. Also an issue of the MASCA Newsletter is in the process of being printed for publication in August.

The administrative assistant, Kathleen Ryan, is responsible for most of the secretarial work in the department, i.e. such things as taking dictation, typing letters and filing. In addition, she assisted with several special projects: drawing of maps for reports, plotting of radiocarbon vs. dendrodates for the calibration curve contained in the recent MASCA Newsletter, and assisted in the re-organization of the Information Center Library.

New Techniques

These have been carried out or supervised by Gary W. Carriveau, PhD., a physicist who joined our staff this year.

Firing Temperature

To insure valid thermoluminescence dates, the dated artifact must have been fired at a temperature sufficiently high and for a long enough period of time to drain (anneal) all thermoluminescence accumulated since the clay and inclusions were formed. In other words, the clock to be read with TL dating must be set to zero when the ceramic is fired. Several techniques have been developed at MASCA to check for 'proper' firing. These include hardness testing, color changes, weight loss, X-ray diffraction pattern changes and alteration of physical dimensions. These changes are measured during systematic reheating of the ceramic materials. Through results of this work, suspect dates on a collection of Mexican figurines were found to result from insufficient firing. The techniques have been developed in collaboration with the Department of Geology (X-ray diffraction), Laboratory for Research on the Structure of Matter (scanning electron microscope) and in consultation with Professor F. Matson, Pennsylvania State University.

An outgrowth of the firing temperature program, directly related to the basic theory of TL dating, deals with the incomplete annealing of ceramics and its effect on the TL date. A study is underway to define quantitatively the effect of incomplete annealing and, wherever possible, to use the results of firing temperature measurement to correct dates on low-fired wares.

Potassium Analysis

A further addition to the TL dating project is the development of a method to measure the amount of potassium in ceramic material. The radioactive isotope, K^{40}, contributes to the total radiation dose creating thermoluminescence. Quantitative measurement of potassium ensures the most accurate date. Techniques of high temperature fusions and direct measurement of K using flame photometry are now in general use at MASCA. Results of these measurements are of high accuracy and the techniques and apparatus are

available for the potassium-argon dating project in the Department of Geology.

X-ray Fluorescence

Elemental composition, through X-ray fluorescence analysis, of Hawaiian basaltic artifacts has been used to determine their provenance. This technique has also been used on South Pacific and Mexican ceramics. The program will be greatly expanded upon purchase, by the University Museum, of the latest computer controlled apparatus. A symposium was held at MASCA on X-ray fluorescence analysis techniques; those attending included representatives from the Boston Museum of Fine Arts, the Freer Gallery of the Smithsonian Institution, the Winterthur Museum, the Maritime Museum, and our own staff.

Obsidian Dating

Two non-destructive techniques for the dating of obsidian artifacts are being developed. These are namely, the analysis of interference patterns of infra-red radiation produced by the thin hydration rim in obsidian and secondly, the study of recoil alpha-particle energy distributions from the hydrated and non-hydrated regions in obsidian. The experimental work is being done in co-operation with the Moore School of Electrical Engineering and the Tandem Van de Graaff Laboratory, Department of Physics, University of Pennsylvania.

Radiocarbon Dating

A theoretical study and feasilility analysis on a new method of radiocarbon dating has been completed. Experimental apparatus employing a new dosimetry technique will be assembled from existing components in collaboration with the Cryogenics Laboratory in the Department of Physics. Results may enable the counting time for radiocarbon dating to be reduced by at least a factor of ten. The apparatus will use benzene, now being produced in the Radiocarbon Laboratory

Additional New Techniques

Mud Brick Project

Objective

A search has been initiated for a method of protecting and conserving mud brick structures, walls and remnants thereof. The method is to be essentially a surface treatment to existing structures. Protection against rain, heat, freezing, thawing, sand abrasion and ground moisture are a part of the objective. The method of application is to be simple and suitable for a remote field application.

Results

Baseball sized chunks of adobe blocks from Tucson, Arizona, are being spray treated in the laboratory. Evaluation of these treated chunks is made by a forced water spray (from a shower-head) equivalent to a driving rain of 900-1200 inches per hour.

Under the test conditions, untreated samples disintegrate completely in 1-2 minutes. Silicone resin in mineral thinner treated samples, one of the current preferred methods by the U.S. Park Service, can withstand the shower for 45-70 minutes. Acrylic emulsion treated samples can withstand the shower up to 10 hours with a single coating and up to 35-40 hours with a double coating. An acrylic emulsion treatment and after drying followed by a silicone in mineral thinner treatment withstands the shower for up to 35 hours.

Chunks of adobe blocks treated by the spray-on technique with these acrylic resins have been on weathering tests on the Museum roof for ten months. Some of the double coated samples show no deterioration from the natural elements of rain, sun, snow and freezing in the Philadelphia climate for the ten-month period.

Field tests at Chaco Canyon and Pecos National Monuments in New Mexico have been established in a freshly excavated pit house, Kiva, on ancient stone wall and ancient adobe walls. Uses of these resin materials in mud mortar and in present-day adobe blocks are also under test at Pecos.

This project is being conducted by our visiting scholar, Dr. Darrel Butterbaugh, a retired research chemist.

NSF Grant GS-36308X

Re: NSF Notice No. 33, item 2

Our review of the budget indicates that no funds will be uncommitted at the end of the first grant year. Since most salaries are on a monthly basis and the grant was not actually received until the end of November 1972, we have projected expenditures to November 30, 1973 instead of November 15, 1973 as specified on NSF Form No. 99-R0013.

As of now, projected expenditures for Salaries, Employee Benefits, and overhead are exactly in line with the Budget.. Also, spending for Expendable Equipment and Supplies is as anticipated. In regard to Other Direct Costs (Item I), the $35,000 for Laboratory Renovations has been spent (plus $2000 contributed by the University). Purchased Research Services are being expended at the $2500 level as specified. Some funds remain for Shop Services and Equipment Rental. However, Publication Costs may exceed the $1500 slightly due to the issuance of a much larger MASCA Newsletter than usual; also, we have exceeded our budget for Domestic Travel. More than half the funds for Equipment have not yet been spent due to the delay in building a new cesium magnetometer. We expect to have this underway in September.

NSF Notice No. 33, item No. 3

IX. C. Budget Proposal - Second Year

1. Salaries and Wages

a. Research Personnel (A-2)

1) Physicist, Geologist, Engineer, or Chemist			$ 12,960
Full-time - 12 months			
FTE - 12 months			
2) Four Research Fellows			
Three summer months - full-time			
Academic year - half-time			
FTE - 8 man months			
(4 x $4150)			16,600
	Total A-2		$ 29,560

b. Other Professional

Research Chemist (A-1), Mark Han			12,960
Full-time - 12 months			
FTE - 12 months			

c. Secretarial, Clerical, and Administrative

1) Research Bibliographer II (A-3)		7,560	
Full-time - 12 montns			
FTE - 12 months			
2) Secretarial, Clerical, and Administrative Assistant (A-3)		4,320	
Half-time - 12 months			
FTE - 6 months			
	Total A-3		$ 11,880
	Total Salaries		$ 54,400

IX. C. (Cont'd)

d. Employee Benefits

15.5% of A-2 ($29,560)	$ 4,582	
8.5% of A-2 ($12,960)	1,102	
7.9% of A-3 ($11,880)	938	
Total Employee Benefits		$ 6,622
e. Overhead (37% of Salaries)		$20,128
Total - Salaries, Benefits, and Overhead		$81,150

2. Equipment

a. For Thermoluminescence - Replacement Components		
2 High Voltage Power Supplies Fluke Model 415B	$ 1,500	
2 Linear Amplifiers Keithley Model 160	1,200	
Patch Heater Research, Inc. Model 5066-3	600	
sub-total		3,300
b. For Archaeological Prospecting		
Minor Components and Replacements		1,000
c. For Aerial Photography		
Vertical Sketchmaster (Gordon Enterprises Type 260-GE)	500	
Stereo-Microscope and Light Table (Laser Sciences, Inc. Model LT 630)	3,100	
sub-total		$ 3,600
Total - Equipment		$ 7,900

IX. C. (Cont'd)

3. Expendable Equipment and Supplies

a. For Thermoluminescence

One calibrated Po^{210} source	300
Nitrogen and other chemical supplies	700
Electronic components	400
Miscellaneous Supplies	500
b. For Archaeological Prospecting	
Spare Parts, cables, connectors, and tools	800
c. For Aerial Photography	
Balloon lifting gas	1,750
Films and Film Processing	300
d. Information Center	
Books, Journals, and Supplies	1,200
Total - Supplies	5,950

IX. C. (Cont'd)

4. Services

Machine Shop	750	
Electronics Shop	550	
Rental of Prospecting Instruments	1,200	
Rental of a Field Spectrometer for Aerial Photography	1,200	
Rental of Aircraft when volunteer ones are not available nor suitable	3,500	
Printing of MASCA Newsletter	1,600	
Other Printing and Duplicating	400	
Total - Services		9,200

5. Travel

For Instrument and Aerial Surveys and to attend Conferences		
Domestic	800	
Foreign	2,200	
Total - Travel		3,000

6. Expenses

Consultant	2,700	
Dr. N. Suntharalingam (or another person) 5% of full-time		
FTE - 1 man-month		
Total Expenses		$ 2,700
Total - Second Year		$ 109,900
Total - Two Years		$ 253,564

NSF Grant GS-36308X

Re: NSF Notice No. 33, item 2

Our review of the budget indicates that no funds will be uncommitted at the end of the first grant year. Since most salaries are on a monthly basis and the grant was not actually received until the end of November 1972, we have projected expenditures to November 30, 1973 instead of November 15, 1973 as specified on NSF Form No. 99-R0013.

As of now, projected expenditures for Salaries, Employee Benefits, and overhead are exactly in line with the Budget. Also, spending for Expendable Equipment and Supplies is as anticipated. In regard to Other Direct Costs (Item I), the $35,000 for Laboratory Renovations has been spent (plus $2000 contributed by the University). Purchased Research Services are being expended at the $2500 level as specified. Some funds remain for Shop Services and Equipment Rental. However, Publication Costs may exceed the $1500 slightly due to the issuance of a much larger MASCA Newsletter than usual; also, we have exceeded our budget for Domestic Travel. More than half the funds for Equipment have not yet been spent due to the delay in building a new cesium magnetometer. We expect to have this underway in September.

return to MASCA

NATIONAL SCIENCE FOUNDATION

WASHINGTON, D.C. 20550

October 30, 1974

Renewal of NSF GS-36308X
Proposal No. SOC-7504203

10:30
Wed. A.M.
1800 G. St
room 203

Dr. Elizabeth K. Ralph
Museum Applied Science Center
for Archaeology
University of Pennsylvania
Philadelphia, Pennsylvania 19174

Dear ~~Elizabeth:~~ Beth -

We have no objection to your shifting unexpended international travel funds into the domestic travel category. The question of unexpended travel funds brings up a matter of more general concern, however.

This is a very bad year financially speaking, and I think you should take seriously the possibility that we may not be able to continue our support of MASCA beyond the term of the current grant. If your renewal proposal were to be declined, it might change your present priorities for utilizing funds remaining in the current grant.

I dislike having to caution you in this way, but the fact is that general-support type grants are apt to get hardest hit in a budgetary crunch.

Sincerely yours,

Murray

Murray Aborn
Program Director for
Special Projects

202-632-4216

FACILITIES STATEMENT

for

SPONSORED PROJECT

This form must accompany all proposals submitted to the Office of Research Administration for approval of the Vice Provost for Research or other University Authority.

1. Title of Project: Museum Applied Science Center for Archeology

2. Sponsor: National Science Foundation

3. Type of Project: Research primarily Training Secondarily

   Other (explain) ______

4. Space Requirements (Brief description): Space in University Museum is adequate. In DRL we need the addition and renovation of room BW8.

5. Special Facilities Requirements (Brief description): In Museum, we need air-conditioning. In DRL we need renovation and air-conditioning of BW8, including a fume hood and large sink.

6. Space & Facilities Available:

   See attached list and floor plan.

   (Building) (Room No.) (size) (type, i.e. office, lab, etc.)

7. a. Are the space and facilities shown in 6 adequate (size, utilities, ventilation, etc.) for the period of this proposal?
   YES ______ NO X

   b. If NO, is additional space required?
   YES X NO ______ If YES, how much and what type
   Room BW8 (approximately 600 sq. ft.) in DRL

   c. Are renovations required? YES X NO ______
   If YES, identify source of funds. National Science Foundation

   d. If c is yes, what is estimated cost? $ 25,000 in DRL (Radiocarbon Laboratory)
   Source of estimate (B&G, Hospital, etc.) Buildings and Grounds
   and $10,000 for air-conditioning of MASCA Labs in University Museum (outside contractors)

8. Is this space adequate for future requirements of this program?
   YES X NO ______

(see other side) November 1, 1971

9. Is additional equipment required for this program?
YES X NO
If YES, identify source of funds National Science Foundation

10. If additional equipment is required, will acquisition involve installation costs or building modification? YES NO X
If YES, identify source of funds

I certify that the above information is accurate and complete as of this date.

Froelich Rainey 1/21/72
(Principal Investigator) Date
per Elizabeth K. Ralph, Faculty Associate

APPROVED: [signature] 1/24/72
Building Administrator DRL Date

C.B. Canyon 1/21/72
University Museum Building Administrator Date

If additional space or facilities are required (this budget period or future budget periods) then application must be approved by the Vice-President for Facilities Management and Construction or his representative.

APPROVED:
Vice President for Facilities Management and Construction
Date

Supplement to <u>FACILITIES STATEMENT</u> for <u>SPONSORED PROJECT</u>

6. Space and Facilities Available:

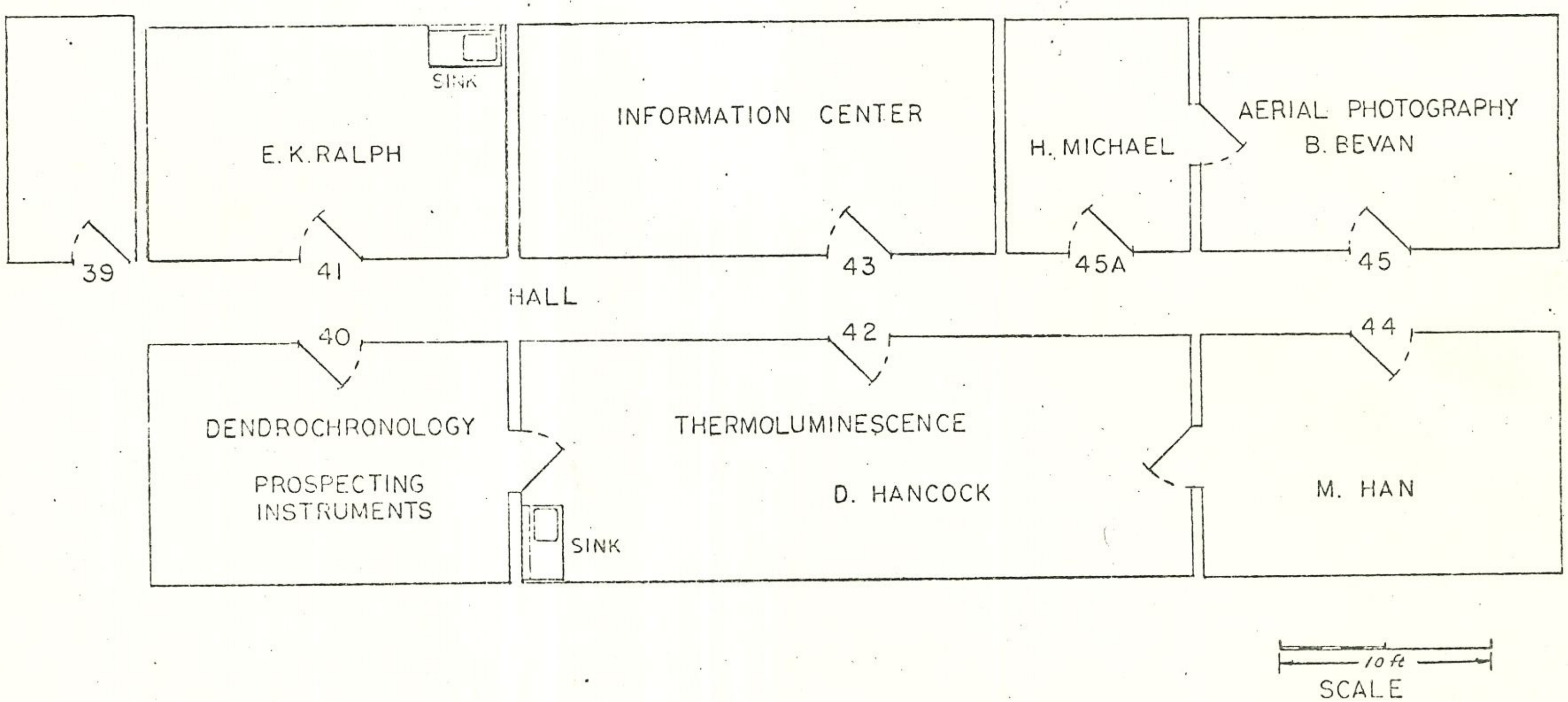
(Building)	(Room No.)	(Size)	(Type)
a. Museum (MASCA)	39	6' x $11\frac{1}{2}$'	small lab at present
	40	11' x 17'	lab.
	41	11' x 17'	lab.
	42	11' x 32'	lab.
	43	11' x 22'	lab.
	44	11' x 17'	lab.
	45-A	8' x 11'	office
	45	11' x 17'	lab.

MASCA floor plan is attached.

b. DRL - Radiocarbon Laboratory

	BW4	20' x 20'	lab.
	BW6	20' x 20'	lab.

Table II. MASCA LABORATORIES, UNIVERSITY MUSEUM



NATIONAL SCIENCE FOUNDATION
Washington, D.C. 20550

RESEARCH GRANT BUDGET & FISCAL REPORT

Form Approved
Budget Bureau No. 99-R0013

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

INSTITUTION AND ADDRESS	NSF PROGRAM	GRANT PERIOD
University of Pennsylvania Philadelphia, Pennsylvania	Soc/Special Projects	from 11/15/72 to 4/30/75 REPORTING PERIOD from to
GRANT NUMBER: GS-36308X1 — BUDGET DUR. (MOS.) 12	PRINCIPAL INVESTIGATOR(S): Rainey	GRANTEE ACCOUNT NUMBER

	NSF Funded Man Months Cal.	Acad.	Summ.	NSF AWARD BUDGET	CUMULATIVE GRANT EXPENDITURES *Do Not Round*
A. SALARIES AND WAGES					
1. Senior Personnel					
a. (Co)Principal Investigator(s)				$	
b. Faculty Associates					
Sub-Total				$	$
2. Other Personnel (Non-Faculty)					
a. Research Associates—Postdoctoral					
b. 6 Non-Faculty Professionals	56			42,520	
c. Graduate Students					
d. Pre-Baccalaureate Students					
e. 2 Secretarial—Clerical				11,880	
f. Technical, Shop, and Other					
TOTAL SALARIES AND WAGES				$ 54,400	$
B. STAFF BENEFITS IF CHARGED AS DIRECT COST				6,622	
C. TOTAL SALARIES, WAGES, AND STAFF BENEFITS (A + B)				$ 61,022	$
D. PERMANENT EQUIPMENT As listed in referenced request				7,900	
E. EXPENDABLE EQUIPMENT AND SUPPLIES				5,950	
F. TRAVEL 1. DOMESTIC (INCLUDING CANADA)				800	
*2. FOREIGN				2,200	
G. PUBLICATION COSTS				2,000	
H. COMPUTER COSTS IF CHARGED AS DIRECT COST					
I. OTHER DIRECT COSTS Shop Services, $1,300; Equipment Rental, $2,400; Aircraft Rental, $3,500; Consultant, $2,700				9,900	
J. TOTAL DIRECT COSTS (C through I)				$ 89,772	$
K. INDIRECT COSTS ** As Requested				20,128	
L. TOTAL COSTS (J plus K)				$ 109,900	$
M. AMOUNT OF THIS AWARD (ROUNDED)				$ 109,900	
N. CUMULATIVE GRANT AMOUNT				$ 249,300	
O. UNEXPENDED BALANCE (N. BUDGET MINUS L. EXPENDITURE)					$

REMARKS: Use extra sheet if necessary *Each foreign trip must have prior approval in writing by the Foundation.
**44.5% of TDC less items of Equipment, major sub-contracts, alterations and renovations, hospitalization and other fees related to patient care = $36,433

FOR NSF USE ONLY
Final Fiscal Report Accepted
Grant Closed ______ Remains Open ______
By ______ Date ______
Grants Administration Section, Area ______

SIGNATURE OF PRINCIPAL INVESTIGATOR	TYPED OR PRINTED NAME	DATE

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

SIGNATURE OF AUTHORIZED OFFICIAL	TYPED OR PRINTED NAME & TITLE	DATE

FOR NSF USE ONLY

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

INSTRUCTIONS FOR RESEARCH GRANT
BUDGET AND FISCAL REPORT

(NSF Form 98)

GENERAL

This dual purpose form is designed (1) to furnish the grantee with a summary of the budgetary items on which the Foundation's award is based, and (2) to transmit to the Foundation the grantee's cumulative accounting for grant funds expended. Budget entries are not cumulative and relate only to the specific award (grant or grant amendment). This form is not intended to be used for submitting proposals to NSF.

The grantee's fiscal (expenditure) report is required within 90 days after (1) all funds awarded under the grant (as amended) have been expended, or (2) the final expiration date of the grant, whichever occurs first. The report is to be submitted in triplicate to: Grants and Contracts Office, National Science Foundation, Washington, D.C. 20550. The report must be certified by the business officer or other authorized official of the grantee institution. The signature of the principal or a co-principal investigator acknowledges his awareness of the report's submission. Space is provided for the grantee to insert an internal account number, if desired. (All NSF records are based on the NSF grant number.) The grantee should also indicate the period covered by the report.

The **NSF FUNDED MAN MONTHS** columns are filled in by NSF. Salary support provided for personnel in each category is shown in terms of full-time-equivalent (FTE) man months. FTE man months for an individual are calculated as the fraction of his normal full-time effort for which salary reimbursement will be made with project funds, multiplied by the duration in months for which salary support is to be provided.

BUDGET AND EXPENDITURE ITEMS

The **CUMULATIVE EXPENDITURES** column is filled in by the grantee and reports expenditures of grant funds in actual, not rounded, figures. Entries are not required in shaded areas. Detailed definitions of the cost categories are contained in the NSF brochure "Grants for Scientific Research" (NSF 69-23), as modified by Important Notice No. 40, dated July 6, 1971.

INDIRECT COSTS. The rate and base used in computing indirect costs must be the same as that authorized by the award. More than one indirect cost rate may be authorized during the total grant period in the case of grants that are amended. In such instances, the fiscal report should reflect the total of the amounts properly allocable to indirect costs. While a detailed breakdown of the several rates is not necessary for purposes of the fiscal report, the grantee's accounting records should clearly differentiate the rates authorized by the various awards.

UNEXPENDED BALANCE. Those institutions not holding other active grants should remit unexpended funds by check, made payable to the National Science Foundation. For those institutions holding other active grants the Foundation will offset the amount of the unexpended balance against the amount due the institution for other active grants.

NSF Notice No. 33, item No. 3

IX. C. Budget Proposal - Second Year

Dept. physics will pay for 4 1/2 mos. at 1/2 salary

1. Salaries and Wages

a. Research Personnel (A-2)

Carriveau

1) Physicist, Geologist, Engineer, or Chemist $ 12,960

Full-time - 12 months 11,900

FTE - 12 months

Bevan Carpenter

2) Four Research Fellows

Three summer months - full-time

Academic year - half-time

FTE - 8 man months

(4 x $4150) now 4 x 4500 ~~16,600~~ 18,000

Total A-2 $ 29,560

b. Other Professional

Han

Research Chemist (A-1), Mark Han 630 ~~12,960~~ 13,300

12,600 / 13,230 / 630 / 340

Full-time - 12 months

FTE - 12 months

1st full amt +8%

c. Secretarial, Clerical, and Administrative

Haynes

1) Research Bibliographer II (A-3) 7,560 7625 + 610 = 8235 + 675

Full-time - 12 months ~8%

FTE - 12 months

Ryan

2) Secretarial, Clerical, and Administrative Assistant (A-3) 4,320 4350 + 350 = 4700 +380

Half-time - 12 months

FTE - 6 months

Total A-3 $ 11,880

Total Salaries $ 54,400

IX. C. (Cont'd)

4. Services

Machine Shop	750	
Electronics Shop	550	
Rental of Prospecting Instruments	1,200	
Rental of a Field Spectrometer for Aerial Photography	1,200	
Rental of Aircraft when volunteer ones are not available nor suitable	3,500	
Printing of MASCA Newsletter	1,600	
Other Printing and Duplicating	400	
Total - Services		9,200

5. Travel

For Instrument and Aerial Surveys and to attend Conferences		
Domestic	800	
Foreign	2,200	
Total - Travel		3,000

6. Expenses

Consultant	2,700	
Dr. N. Suntharalingam (or another person) 5% of full-time FTE - 1 man-month		
Total Expenses		$ 2,700
Total - Second Year		$ 109,900
Total - Two Years		$ 253,564

UNIVERSITY of PENNSYLVANIA

JOURNAL ENTRY

SECTION A

ITEM	DEBIT ACCOUNT NUMBER (1-9)	DESCRIPTION (22-41)	AMOUNT (42-51)	P/F (52)	ADDITIONAL NUMERIC REFERENCE (53-58)	CREDIT ACCOUNT NUMBER (59-67)
1	2-11022-213	Inventory metals	$ 47.15		# 2778	0-12502-142
2	5-26796-213	" "	32.84			0-12502-142
3	3-40101-290	" "	30.00			0-12502-142
4	3-40099-290	" "	35.00			0-12502-142
5		To charge for metal w/d during May 1974				
6	2-11022-290	Storeroom Sal.	$ 4.72			2-11188-400
7	5-26796-290	" "	3.28			"
8	3-40101-290	" "	3.00			"
9	3-40099-290	" "	3.50			"
10		To charge for storeroom time May 1974 (metals)				
11						
12						
13						
14						
15						
16						

For your record!

DO NOT KEY PUNCH

ENTER THE FOLLOWING DATA, FROM YOUR MONTHLY TRANSACTION REPORT, FOR EACH LINE WHICH IS CORRECTING A PREVIOUS POSTING.

SECTION B

ITEM	ACCOUNT NUMBER	TRANSACTION IDENTIFICATION NUMBER	DATE	AMOUNT
1	Astronomy			
2	Museum NSF 36308X			
3	Graduate Towers B Mr.A.Capuano			
4	Nichols House Mr.ACApuano			
6	Astronomy			
7	Museum NSF 36308X			
8	Grad.Towers B Mr.A.Capuano			
9	Nichols House Mr.A.Capuano			

PREPARED BY

NAME SIGN: ____

NAME TYPE OR PRINT Stanley W.Cohen

ADDRESS Physics DRL

EXTENSION 8181 eb DATE 6/4/74

2778

APPROVED ____

POSTED ____

COMPTROLLER'S DEPARTMENT USE ONLY

ENTRY REFERENCE NUMBER		DATE
10-11	12 - 17	18 - 21

NSF Grant GS-36308X

Re: NSF Notice No. 33, item 2

Our review of the budget indicates that no funds will be uncommitted at the end of the first grant year. Since most salaries are on a monthly basis and the grant was not actually received until the end of November 1972, we have projected expenditures to November 30, 1973 instead of November 15, 1973 as specified on NSF Form No. 99-R0013.

As of now, projected expenditures for Salaries, Employee Benefits, and overhead are exactly in line with the Budget. Also, spending for Expendable Equipment and Supplies is as anticipated. In regard to Other Direct Costs (Item I), the $35,000 for Laboratory Renovations has been spent (plus $2000 contributed by the University). Purchased Research Services are being expended at the $2500 level as specified. Some funds remain for Shop Services and Equipment Rental. However, Publication Costs may exceed the $1500 slightly due to the issuance of a much larger MASCA Newsletter than usual; also, we have exceeded our budget for Domestic Travel. More than half the funds for Equipment have not yet been spent due to the delay in building a new cesium magnetometer. We expect to have this underway in September.

UNIVERSITY of PENNSYLVANIA

OFFICE OF RESEARCH ADMINISTRATION

DIGEST OF TERMS OF GRANT FROM NATIONAL SCIENCE FOUNDATION

GRANT NO. GS -36308 X1

PRINCIPAL INVESTIGATOR Dr. F. Rainey

ACCOUNT NUMBER 5-26796

DEPARTMENT University Museum

TITLE "Applied Science Center for Archiology"

AMOUNT OF AWARD Increased by $109,900
New Total: $249,300

* INDIRECT COST Increased by $20,128 (37% S&W)

Budget period from 11/15/73 to 4/30/75. Future Commitment 0 yrs.

DIGEST OF TERMS FOR: New Award ☐ Continuation Award ☒ Supplement Award ☐ Research ☒
Training ☐ Other______. Original Digest ☐ Revision of digest dated ______
Change of dates only ☐

REPORT DATES: Financial Final within 90 days ~~after termination~~. Scientific Annual and Final report within 90 days ~~after termination.~~

COST SHARING: A contribution of $ 34,493 from non-federal sources will be made to this project as provided in the cost-sharing statement presented with the proposal for this grant.

BUDGET: Employee benefits should be budgeted as follows: A-1 9.9% A-2 15.7% A-3/4 10.3%.

DOMESTIC TRAVEL: To be authorized by Dr. Rainey if included in grant award. Reimbursement claims for Travel Costs must be fully documented unless at an established per diem rate. Travel by private automobile reimbursed at 10¢ per mile.

REBUDGETING OF FUNDS: Prior approval must be obtained from NSF for rebudgeting funds for the following purposes (1) Purchase of office equipment, furniture, air conditioners and motor vehicles. (2) Purchase of equipment in excess of 125% of the total amount approved by NSF for permanent equipment. (3) Purchase of any item of equipment costing $1000 or more (if not in approved budget). (4) Foreign travel when not listed in the proposal. (5) Domestic travel in excess of 125% of approved budget or $500 whichever is greater, if funds not budgeted for travel up to $500 may be expended. (6) Salary of Principal Investigator or other senior personnel in excess of that provided in the approved budget.

PUBLICATIONS: Copyrighted material shall carry by-line acknowledging sponsor's support and shall grant to the Government royalty-free right to reproduction. Four (4) reprints of each publication to be forwarded to the sponsor.

PATENTS: Any patentable invention or discovery shall be reported to the National Science Foundation.

PROPERTY: Title to property purchased with grant funds rests with the University.

OTHER:

* Special rate approved

DISTRIBUTION:
Principal Investigator Dr. Rainey w/cy grant award.
Comptroller, Attention: Mr. Campbell w/cy grant award.
Dean: Stephens, Attn: Mr. Doxer
Business Administrator Mr. Stan Cohen w/cy award
File
Dean O'Kane
Dr. Elizabeth Ralph w/cy grant

AWK/ra
10/24/73

FILE

MAY 17, 1973

NATIONAL SCIENCE FOUNDATION
Washington, D.C. 20550

RESEARCH GRANT BUDGET & FISCAL REPORT

Form Approved
Budget Bureau No. 99-R0013

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

INSTITUTION AND ADDRESS		NSF PROGRAM	GRANT PERIOD / REPORTING PERIOD
University of Pennsylvania Philadelphia, Pennsylvania		SOC/Special Projects	from 11/15/72 to 4/30/74 REPORTING PERIOD from ___ to ___
GRANT NUMBER: GS-36308X	BUDGET DUR. (MOS.): 12	PRINCIPAL INVESTIGATOR(S): Rainey	GRANTEE ACCOUNT NUMBER:

	NSF Funded Man Months Cal.	Acad.	Summ.	NSF AWARD BUDGET	CUMULATIVE GRANT EXPENDITURES (Do Not Round)
A. SALARIES AND WAGES					
1. Senior Personnel					
a. (Co)Principal Investigator(s)				$	
b. Faculty Associates					
Sub-Total				$	$
2. Other Personnel (Non-Faculty)					
a. Research Associates—Postdoctoral					
b. 3 Non-Faculty Professionals	28			20,300	12,600
c. 2 Graduate Students				8,300	16,600
d. Pre-Baccalaureate Students					
e. 2 Secretarial—Clerical				11,000	11,000
f. Technical, Shop, and Other					
TOTAL SALARIES AND WAGES				$ 39,600	$ 39,600
B. STAFF BENEFITS IF CHARGED AS DIRECT COST				4,462	4,462
C. TOTAL SALARIES, WAGES, AND STAFF BENEFITS (A + B)				$ 44,062	$
D. PERMANENT EQUIPMENT *				31,800	31,800
E. EXPENDABLE EQUIPMENT AND SUPPLIES				5,500	5,500
F. TRAVEL 1. DOMESTIC (INCLUDING CANADA)				750	750
2. FOREIGN					4250
G. PUBLICATION COSTS				1,500	1500
H. COMPUTER COSTS IF CHARGED AS DIRECT COST					
I. OTHER DIRECT COSTS Laboratory Renovations $35,000; Shop Services - $1,250; Equipment Rental $2,400; Purchased Research Services $2,500 = Suntha				41,150	41,150
J. TOTAL DIRECT COSTS (C through I)				$ 124,762	$
K. INDIRECT COSTS 37% of Salaries and Wages				14,652	14,652 (.378)
L. TOTAL COSTS (J plus K)				$ 139,414	$ 143,664
M. AMOUNT OF THIS AWARD (ROUNDED)				$ 139,400	less 4250 = 139,414
N. CUMULATIVE GRANT AMOUNT				$	
O. UNEXPENDED BALANCE (N. BUDGET MINUS L. EXPENDITURE)					$

REMARKS: Use extra sheet if necessary

As listed in referenced proposal budget

FOR NSF USE ONLY
Final Fiscal Report Accepted

Grant Closed ______ Remains Open ______
By ______ Date ______
Grants Administration Section, Area ______

SIGNATURE OF PRINCIPAL INVESTIGATOR	TYPED OR PRINTED NAME	DATE

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

SIGNATURE OF AUTHORIZED OFFICIAL	TYPED OR PRINTED NAME & TITLE	DATE

FOR NSF USE ONLY

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

NATIONAL SCIENCE FOUNDATION
Washington, D.C. 20550

RESEARCH GRANT BUDGET & FISCAL REPORT

Form Approved
Budget Bureau No. 99-R0013

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

INSTITUTION AND ADDRESS: University of Pennsylvania, Philadelphia, Pennsylvania	NSF PROGRAM: Soc/Special Projects	GRANT PERIOD from 11/15/72 to 4/30/75 REPORTING PERIOD from to
GRANT NUMBER: GS-36308X1 / BUDGET DUR. (MOS.) 12	PRINCIPAL INVESTIGATOR(S): Rainey	GRANTEE ACCOUNT NUMBER

	NSF Funded Man Months Cal.	Acad.	Summ.	NSF AWARD BUDGET	CUMULATIVE GRANT EXPENDITURES *Do Not Round*
A. SALARIES AND WAGES					
1. Senior Personnel					
a. (Co)Principal Investigator(s)				$	
b. Faculty Associates					
Sub-Total				$	$
2. Other Personnel (Non-Faculty)					
a. Research Associates—Postdoctoral					
b. 6 Non-Faculty Professionals	56			42,520	
c. Graduate Students					
d. Pre-Baccalaureate Students					
e. 2 Secretarial—Clerical				11,880	
f. Technical, Shop, and Other					
TOTAL SALARIES AND WAGES				$ 54,400	$
B. STAFF BENEFITS IF CHARGED AS DIRECT COST				6,622	
C. TOTAL SALARIES, WAGES, AND STAFF BENEFITS (A + B)				$ 61,022	$
D. PERMANENT EQUIPMENT					
As listed in referenced request				7,900	
E. EXPENDABLE EQUIPMENT AND SUPPLIES				5,950	
F. TRAVEL 1. DOMESTIC (INCLUDING CANADA)				800	
*2. FOREIGN				2,200	
G. PUBLICATION COSTS				2,000	
H. COMPUTER COSTS IF CHARGED AS DIRECT COST					
I. OTHER DIRECT COSTS Shop Services, $1,300; Equipment Rental, $2,400; Aircraft Rental, $3,500; Consultant, $2,700				9,900	
J. TOTAL DIRECT COSTS (C through I)				$ 89,772	$
K. INDIRECT COSTS ** As Requested				20,128	
L. TOTAL COSTS (J plus K)				$ 109,900	$
M. AMOUNT OF THIS AWARD (ROUNDED)				$ 109,900	
N. CUMULATIVE GRANT AMOUNT				$ 249,300	
O. UNEXPENDED BALANCE (N. BUDGET MINUS L. EXPENDITURE)					$

REMARKS: Use extra sheet if necessary *Each foreign trip must have prior approval in writing by the Foundation.
**44.5% of TDC less items of Equipment, major sub-contracts, alterations and renovations, hospitalization and other fees related to patient care = $36,433

FOR NSF USE ONLY
Final Fiscal Report Accepted
Grant Closed ______ Remains Open ______
By ______ Date ______
Grants Administration Section, Area ______

SIGNATURE OF PRINCIPAL INVESTIGATOR	TYPED OR PRINTED NAME	DATE

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

SIGNATURE OF AUTHORIZED OFFICIAL	TYPED OR PRINTED NAME & TITLE	DATE

FOR NSF USE ONLY

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

NSF Form 98, JULY 1971

SUPERSEDES ALL PREVIOUS EDITIONS

INSTRUCTIONS FOR RESEARCH GRANT
BUDGET AND FISCAL REPORT

(NSF Form 98)

GENERAL

This dual purpose form is designed (1) to furnish the grantee with a summary of the budgetary items on which the Foundation's award is based, and (2) to transmit to the Foundation the grantee's cumulative accounting for grant funds expended. Budget entries are not cumulative and relate only to the specific award (grant or grant amendment). This form is not intended to be used for submitting proposals to NSF.

The grantee's fiscal (expenditure) report is required within 90 days after (1) all funds awarded under the grant (as amended) have been expended, or (2) the final expiration date of the grant, whichever occurs first. The report is to be submitted in triplicate to: Grants and Contracts Office, National Science Foundation, Washington, D.C. 20550. The report must be certified by the business officer or other authorized official of the grantee institution. The signature of the principal or a co-principal investigator acknowledges his awareness of the report's submission. Space is provided for the grantee to insert an internal account number, if desired. (All NSF records are based on the NSF grant number.) The grantee should also indicate the period covered by the report.

The NSF FUNDED MAN MONTHS columns are filled in by NSF. Salary support provided for personnel in each category is shown in terms of full-time-equivalent (FTE) man months. FTE man months for an individual are calculated as the fraction of his normal full-time effort for which salary reimbursement will be made with project funds, multiplied by the duration in months for which salary support is to be provided.

BUDGET AND EXPENDITURE ITEMS

The CUMULATIVE EXPENDITURES column is filled in by the grantee and reports expenditures of grant funds in actual, not rounded, figures. Entries are not required in shaded areas. Detailed definitions of the cost categories are contained in the NSF brochure "Grants for Scientific Research" (NSF 69-23), as modified by Important Notice No. 40, dated July 6, 1971.

INDIRECT COSTS. The rate and base used in computing indirect costs must be the same as that authorized by the award. More than one indirect cost rate may be authorized during the total grant period in the case of grants that are amended. In such instances, the fiscal report should reflect the total of the amounts properly allocable to indirect costs. While a detailed breakdown of the several rates is not necessary for purposes of the fiscal report, the grantee's accounting records should clearly differentiate the rates authorized by the various awards.

UNEXPENDED BALANCE. Those institutions not holding other active grants should remit unexpended funds by check, made payable to the National Science Foundation. For those institutions holding other active grants the Foundation will offset the amount of the unexpended balance against the amount due the institution for other active grants.

Museum Applied Science Center for Archaeology

Froelich Rainey, Director   Elizabeth K. Ralph, Associate Director

THE UNIVERSITY MUSEUM • UNIVERSITY OF PENNSYLVANIA
33rd & SPRUCE STREETS • PHILADELPHIA, PENNSYLVANIA 19104
386-7400 (Area Code 215)   Cable Address "Antique"

NSF GS-36308 X

2nd YEAR 11/15/73 - 4/30/75

UNIVERSITY CONTRIBUTION:

Salary of Principal Investigator (A-1) 25% of full-time - 12 months FTE 3 man months		8375
Salary of Faculty Associate (A-2) 50% of full-time - 12 months FTE 6 woman months		9050
Research Fellow (A-2) 10% of part-time - 8 months		450
Research Specialist II (A-1) 10% of full-time - 12 months FTE 1 woman month		1100
Secretaries		3000
Employee Benefits		
15.7% of A-2 ($9500)	$ 1492	
9.9% of A-1 ($9475)	938	
10.3% of A-3 ($3000)	309	2739
Overhead (44.5% of salaries)		9779
	Total	$34,493

10 copies

UNIVERSITY of PENNSYLVANIA

REQUEST FOR EMPLOYEE SERVICES

DEPT. and/or SCHOOL University Museum JOB TITLE Research Specialist II

STARTING DATE Oct. 1, 1974 BUDGET or GRANT NSF-GS-36308X POS NO. 2

PERMANENT POSITION [x] (dependent upon grant) TEMPORARY POSITION [ ]

IF TEMPORARY, LENGTH OF TIME REQUIRED

FULL-TIME [x] PART-TIME [ ]

IF PART-TIME, AMOUNT OF TIME REQUIRED

REASON FOR JOB OPENING:

NEW POSITION

TERMINATION OF Gary Carriveau (NAME) DATE (late) Sept. 1974

TRANSFER OF (NAME) DATE

DUTIES TO BE PERFORMED IN THIS PARTICULAR POSITION: RESEARCH SPECIALIST II responsible to a principal research investigator, and to faculty and non-faculty associates for conducting professional level scientific research within a broad field. Duties include thermoluminescent dating and all other techniques of the Museum Applied Science Center as well as the development and use of new techniques derived primarily from the physical sciences but are applicable to archaeological and anthropological research. Must collaborate with faculty members and technicians in other departments of the University and from other institutions. Must have the ability to write well, to express ideas clearly, and to report research activities accurately.

QUALIFICATIONS DESIRED:

SPECIAL SKILLS: Recently acquired Ph.D. in physics or chemistry preferred and some practical experience in solid state and/or nuclear physics.

TRAINING AND EXPERIENCE $12,000. - $13,000.

TO BE INTERVIEWED BY Dr. Froelich Rainey (NAME) Museum (LOCATION) 241 (EXT.)

REQUESTED BY Elizabeth Ralph (NAME)

Assoc. Director MASCA (TITLE)

8/6/74 (DATE)

UNIVERSITY of PENNSYLVANIA

REQUEST FOR EMPLOYEE SERVICES

DEPT. and/or SCHOOL University Museum JOB TITLE Administrative Assistant ~~II~~ I

STARTING DATE Sept. 16, 1974 BUDGET or GRANT NSF-GS-36308X POS NO. 5

PERMANENT POSITION [X] (dependent upon grant) TEMPORARY POSITION [ ]

Hired Gail Weinstein 10/9/74

IF TEMPORARY, LENGTH OF TIME REQUIRED

FULL-TIME [ ] PART-TIME [X] 7925 ÷ 2 = 3963 ~ $4.35/hr.

IF PART-TIME, AMOUNT OF TIME REQUIRED 18 hours per week

REASON FOR JOB OPENING:

NEW POSITION

TERMINATION OF ______ (NAME) DATE ______

TRANSFER OF Kathleen Ryan to Research Bibliographer II (NAME) DATE September 1, 1974

DUTIES TO BE PERFORMED IN THIS PARTICULAR POSITION: ADMINISTRATIVE ASSISTANT II, University Museum, to assist the Research Bibliographer in the Applied Science Center for Archaeology, and to perform diverse duties for other members of the staff. Responsible for abstracting, cross indexing, requisitions for purchases, budget summaries, compilation and plotting of research results and graphs. May perform advanced secretarial duties including the taking of dictation (manually or by mechanical means), and difficult typing, e.g., manuscripts, letters, reports, grant proposals, etc.

QUALIFICATIONS DESIRED: Graduation from college desired; two years of college education or business school required. Shorthand necessary; good typing.

SPECIAL SKILLS: Familiarity with the physical sciences and/or archaeology desired.

TRAINING AND EXPERIENCE:

$7050-$8600 for full time. Note that this is a half-time position.

TO BE INTERVIEWED BY Dr. Froelich Rainey — Museum — 24-241

Dr. Otto Haas (NAME) — Museum (LOCATION) — 24-270 (EXT.)

REQUESTED BY Elizabeth K. Ralph (NAME)

Associate Director MASCA (TITLE)

4 September 1974 (DATE)

NSF-GS-36308X-1

1974

Name	Salary	Employee Benefits	Overhead (37% of salaries)	Total	Per Month
Mark Han	13,300	1130	4921	19,352	1613
Students					
Bruce Bevan	4,800	744	1776	7,320	610
John Carpenter	4,800	744	1776	7,320	610
Julia Handy	4,800	744	1776	7,320	610
Michael Rosenberg	4,800	744	1776	7,320	610
Information Center					
Kathleen Ryan	8,375	662	3099	12,135	1011
Gail Weinstein	4,000	316	1480	5,796	483

Total per month	$5,547
(November and December 1974)	$11,094

NATIONAL SCIENCE FOUNDATION
WASHINGTON, D.C. 20550

[SEE P 8.]

DIVISION OF SOCIAL SCIENCES

QUARTERLY GRANT LIST

FISCAL YEAR 1974

October 1973
through
December 1973

Grant No.	Institution	Investigator	Title	Amount	Duration

ANTHROPOLOGY

GS-3041 Amend II	Stanford U	A P Wolf	Family Organization and Population Processes in Rural Taiwan	66,300	9/73—9/74
GS-28607 Amend II	U California (B)	G Ll. Isaac	Early Hominid Fossils in the East Rudolf Area	2,700	6/72—6/74
GS-28609 Amend III	CUNY - Queens C	P Tolstoy	Archaeological Investigations in the Lake Chalco Basin, Mexico	2,900	1/73—1/74
GS-28815 Amend II	Brandeis U	C Morris	Inca Urbanism at Huanuco Pampa	64,100	9/73—9/75
GS-30626X2	Stanford U	A P Wolf	Land Distribution Processes in Rural Societies	23,500	9/73—9/74
GS-30657X2	Duke U	J Buettner-Janusch	Primate Hemoglobins	2,500	9/73—11/73
GS-32741 Amend I	Yale U	D Pilbeam E L Simons	Behavioral and Morphological Study of Chimpanzee (Pan Paniscus)	7,900	3/72—3/75
GS-32986X1	SUNY - (Binghamton)	N J van der Merwe	Archaeology of the Iron Age in the Phalaborwa Area	12,200	9/73—9/74
GS-35744X1	U Puerto Rico	D S Sade	Monitoring of the Cayo Santiago Primate Population	58,000	9/73—9/74
GS-36262 Amend I	Colgate U	A F Aveni	Astronomical Orientations in Ancient Mesoamerica	9,400	12/73—12/75
GS-36415 Amend I	SUNY - (Buffalo)	S Milisauskas	Analysis of Data from an Early Neolithic Site in Poland	2,100	1/73—1/74
GS-36482 Amend I	Washington U	S Molnar	Comparative Histology of Primate Teeth	17,200	9/73—9/74
GS-36891 Amend I	Fordham U	W W Swidler	The Human Ecology of Nomadism	20,200	10/73—7/74
GS-37002 Amend I	The Los Angeles County Museum of Natural History Fdn	E L Davis	Paleo-Indian Land Use Patterns, China Lake, California	2,000	1/73—1/75
GS-39624	Case Western Reserve U	D C Johanson	Paleoanthropology of the Lower Awash Valley	44,400	7/73—7/75
GS-39625	U Chicago	R G Klein	The Middle Stone Age in the Southern Cape	57,000	9/73—9/75
GS-39633X	U Arizona	M A Stokes	Dendrochronology in Northern Mexico	33,200	7/73—7/74
GS-39634 †	U Missouri	L Campbell	Languages of Central America	30,700	9/73—9/74
GS-39635X	New York U	J Buettner-Janusch	Primate Hemoglobins	61,800	9/73—9/74
GS-39660	U Missouri	J A Gavan	Interdisciplinary Conference on Medical Anthropology	4,100	9/73—2/74
GS-39703 †	U Arizona	A C Chandola	An Ethnomusicolinguistic Study	39,500	9/73—9/74
GS-39721	Columbia U	R S Solecki	Prehistory in the Near East	31,300	9/73—9/74
GS-39736	New York U	C J Jolly	Symposium on the African Hominidae of the Late Neogene	20,900	8/73—9/74
GS-39776	Washington State U	H T Irwin R Fryxell	Thermoluminescent Dating of Non-Ceramic Archaeological Materials	35,500	8/73—8/75
GS-39835	U Missouri	R M Rowlett H L Thomas	Life and Technology in the Titelberg Settlements	21,000	9/73—6/75
GS-39927X	SUNY - (Buffalo)	C R Duggleby	Group Structure and Population Genetics: A Study of Macaca Mulatta of Cayo Santiago	17,200	9/73—9/74
GS-40410	Illinois State U	J E Reyman	Archaeoastronomy in the Anasazi Area	27,400	9/73—9/74

Grant No.	Institution	Investigator	Title	Amount	Duration
GS-40461 †	U Chicago	N A McQuown	Huastec (Mayan) Texts, Grammar, and Dictionary	71,300	10/73—10/75
GS-40588	U California (B)	J D Clark	Palaeoanthropological Investigations in Ethiopia	76,900	11/73—11/74

Doctoral Dissertation Research in Anthropology

Grant No.	Institution	Investigator	Title	Amount	Duration
GS-39626	CUNY - (Graduate Ctr)	M J Meggitt	Student: Gillian Gillison	6,550	7/73—7/74
GS-39627	U Washington	J Watson	Edwin L. Wade	4,700	7/73—7/74
GS-39629	Rutgers U	W Shapiro	Michele Teitelbaum	5,750	7/73—2/75
GS-39630	Columbia U	E P Skinner	Stephen C. Maack	4,350	7/73—12/73
GS-39631	Princeton U	M G Silverman	Frederick H. Damon	5,000	8/73—2/75
GS-39663	CUNY - (Graduate Ctr)	S McLendon	Daniel A. Bradburd	6,750	10/73—6/75
GS-39665	Princeton U	V B Crapanzano	David J. Hurvitz	5,350	9/73—9/74
GS-39666	Northwestern U	F L K Hsu	Barbara A. Jones	3,900	9/73—3/75
GS-39667	U Michigan	V Carroll	Jocelyn S. Linnekin	5,850	9/73—3/75
GS-39668	Cornell U	A T Kirsch	Tim G. Babcock	5,650	8/73—9/75
GS-39669	U Rochester	A Harris	Lawrence B. Breitborde	4,600	9/73—9/74
GS-39670	Northwestern U	O Werner	John Farella	8,450	8/73—2/75
GS-39719	Columbia U	C M Arensberg	Thomas V. Belmonte	3,650	9/73—9/75
GS-39749	Princeton U	V B Crapanzano	Anthony B. van Fossen	3,150	10/73—10/74
GS-39777	U Wisconsin	D A Baerreis	Lawrence A. Conrad	4,850	9/73—6/75
GS-39878	U Hawaii	A G Dewey	John B. Thomas	1,500	8/73—8/75
GS-40155	U Rochester	W H Sangree	Glenn D. Webb	4,500	9/73—9/74
GS-40165	U Chicago	R T Smith	Allen W. Batteau	5,000	9/73—12/74
GS-40202	Columbia U	M Harris	Nira Reiss	5,650	9/73—3/75
GS-40206	U California (B)	G Ll. Isaac	Diane P. Gifford	2,650	9/73—9/74
GS-40215	U Connecticut	J S Aigner	Alan M. Bieber, Jr.	1,900	9/73—9/74
GS-40216	Columbia U	H Pitkin	Anne Farber	5,000	9/73—2/75
GS-40294	Yale U	K C Chang	Patrick V. Kirch	4,900	12/73—4/75
GS-40318	Harvard U	M E Moseley	Geoffrey W. Conrad	3,000	10/73—4/74
GS-40325	U Michigan	K V Flannery	Michael E. Whalen	4,200	2/74—2/75
GS-40326	Harvard U	M E Moseley	Robert A. Feldman	6,700	9/73—9/74
GS-40345	U Michigan	C Kottak	Judith Kingsley	1,000	9/73—9/74
GS-40429	Columbia U	C M Arensberg	Neil M. Foran	3,600	10/73—1/75
GS-40462	U Rochester	A T Carter	Nancy E. Levine	4,100	9/73—9/74
GS-40480	U Illinois	N E Whitten, Jr.	John P. Ekstrom	3,000	9/73—11/75
GS-40627	U Chicago	L G Freeman	Lawrence G. Straus	2,050	9/73—7/75
GS-40736	Stanford U	C R Barnett	Janice C. Reid	7,450	1/74—6/75
GS-40775	Stanford U	J F Collier	Caroline H. Bledsoe	5,600	11/73—2/75

ECONOMICS

Grant No.	Institution	Investigator	Title	Amount	Duration
GS-2440 Amend II	Yale U	R W Goldsmith	Financial Development and Economic Growth	20,400	9/73—9/74
GS-2502 Amend IV	Northwestern U	R Eisner	Investment Theory and Technical Progress	12,300	9/71—2/74
GS-3306 Amend II	U California (B)	B Rosenberg	Stochastic Parameter Regression and the Pricing of Capital Assets	58,200	9/73—9/75
GS-3314 Amend III	National Bureau of Economic Research	W M Landes R A Posner	Economic Analysis of Law	121,400	9/73—9/74
GS-28287 Amend I	Northwestern U	M I Kamien N L Schwartz S D Deshmukh	Determinants and Consequences of Technical Advance	70,300	9/73—9/75
GS-30377 Amend I	Stanford U	A S Manne M K Majumdar	Multisector Development Planning	88,000	9/73—9/75
GS-31253 Amend I	Rand Corp	L S Shapley	Mathematical Economics Using Game Theory	48,400	9/73—9/75
GS-31400X3	Thomas Jefferson Center Fdn (U Virginia)	R N McKean	Implications of Different Resource Rights	53,100	11/73—11/74
GS-31426 Amend I	Ohio U	S Pejovich	Analysis of the Yugoslav Economic System	22,100	11/73—11/74
GS-31688 Amend I	Harvard U	J R Green	Toward A Behavioral Theory of Economic Equilibrium	47,900	2/74—7/76
GS-32271 Amend I	U Texas	D Kendrick	Stochastic Control in Macroeconomic Models	4,800	2/72—9/73
GS-32383X2	U Pennsylvania	A K Ando	Econometric Analysis of the U.S. Economy	28,600	2/74-2/75
GS-32773 Amend II	National Bureau of Economic Research	F M Fisher R M Solow	Aggregate Production Functions and the Explanation of Wages	16,700	9/73—9/74
GS-35159X2	Harvard U	M S Feldstein	Effects of Taxation on Capital Accumulation	45,300	9/73—9/74
GS-35681 Amend I	U Chicago	D McCloskey	Seminars on British Econometric History	4,000	9/72—9/74
GS-35682X1	U Minnesota	M K Richter	Economic Choice Theory and Empirical Analysis	34,600	9/73—9/74
GS-35972X1	The Urban Institute	C C Holt	Labor Markets, Inflation and Manpower Policy	124,000	10/73—10/74
GS-36000X1	Brandeis U	A P Carter	Input-Output Analysis	87,000	10/73—10/74
GS-39671	U Pennsylvania	S R Ackerman	Black Housing Patterns	5,800	9/73—9/74
GS-39701	Northwestern U	R J Gordon	Labor Market Models and the Rate of Inflation	68,100	9/73—9/75
GS-39702	U Rochester	R W Jones	New Models in the Theory of International Trade	71,100	9/73—9/75
GS-39718	U Michigan	R F Dernberger A Eckstein	China's Development Experience	167,200	9/73—9/75
GS-39864X	Northwestern U	H Sonnenschein	Price and Non-Price Allocation Mechanisms	28,500	9/73—9/74
GS-39865X	Harvard U	Z Griliches	Econometric Studies of Human Resources and Technological Change	90,700	9/73—9/74
GS-39872	U Chicago	M Nerlove	Econometric Methods and Applications Population and Family Decision Making	143,700	9/73—9/75
GS-39906	Stanford U	T W Anderson T Amemiya	Selected Topics in Econometric Theory	142,000	9/73—9/75
GS-39937	Stanford U	D K Foley	Public Policy and Uncertainty	49,800	9/73—9/75

Grant No.	Institution	Investigator	Title	Amount	Duration
GS-39939	U Illinois	D R Hodgman	Monetary and Economic Integration within the European Economic Community	44,800	8/73—8/75
GS-39942	U Pittsburgh	J G Chapman	International Comparative Study of Income Distribution	24,900	9/73—9/74
GS-39995	U Wisconsin	D J Aigner A S Goldberger	Structural Modelling with Unobserved Variables	146,100	9/73—9/75
GS-40033	U Chicago	A Zellner	Bayesian Inference in Econometrics	122,400	9/73—9/75
GS-40038	Princeton U	M Rothschild	Imperfect Information and Equity in Economic Systems	37,100	9/73—9/75
GS-40039	Stanford U	D A Starrett	Intertemporal Allocation, Indivisibilities and Externalities	9,600	9/73—9/74
GS-40072	SUNY - (Stony Brook)	E Ames	General Equilibrium Systems	22,300	9/73—9/74
GS-40073	U Wisconsin (Milwaukee)	T Hun Lee	Economic Analysis of Racial Discrimination in Housing Markets	63,300	9/73—9/75
GS-40104	Stanford U	M Kurz L J Lau R Wilson	Behavioral Patterns and the Functioning of Markets	182,100	9/73—9/75
GS-40114	U California (B)	G Grossman	Chinese Price Structure and Policy	43,000	9/73—9/74
GS-40190	U Michigan	E P Howrey	Spectral Estimation and Analysis of Stochastic Economic Systems	40,300	9/73—9/75
GS-40251X	Brookings Inst	G L Perry A M Okun	The Brookings Panel on Economic Activity	98,000	9/73—9/74
GS-40430X	U Pennsylvania	P J Taubman	Genetic and Environmental Effects on Earnings and Occupational Mobility	67,100	9/73—9/74
GS-40431	Brookings Inst	K Gordon	Development of Wage-Price Policy in the United States	75,900	9/73—9/75
GS-40478X	Cornell U	S Saltzman T Liu	Integrated National and Regional Econometric Models	82,000	9/73—9/74
GS-40587X	Yale U	W C Brainard	Economic Theory and Econometrics	353,000	9/73—9/74
GS-40760	SUNY - (Stony Brook)	R E Kihlstrom L J Mirman	Economics of Uncertainty	30,200	10/73—5/75
GS-40761	Social Science Research Council	L R Klein	International Linkage of National Econometric Models	140,300	10/73—10/75
GS-40769	Massachusetts Inst of Tech	J Rothenberg	Microeconomic Models of Metropolitan Housing Markets	87,700	10/73—10/74

Doctoral Dissertation Research in Economics

Grant No.	Institution	Investigator	Title	Amount	Duration
GS-39656	U Pennsylvania	J Margolis	Student: Andrew Reschovsky	1,600	7/73—7/74
GS-39657	U Pittsburgh	R E Slesinger	Patrick J. Welch	500	7/73—7/74
GS-39699	SUNY - (Albany)	E F Renshaw	Erik J. Stenehjem	2,300	7/73—7/74
GS-39700	U Pennsylvania	F R Root	Taghi Saghafi-nejad	2,100	8/73—8/74

SOCIOLOGY

Grant No.	Institution	Investigator	Title	Amount	Duration
GS-2674 Amend III	U Michigan	C Tilly	Collective Violence in Large-Scale Social Change	13,800	1/72—1/74
GS-3191X2	U Michigan	L Kish	Analytical Statistics for Complex Samples	20,100	8/73—8/74
GS-30905X2	U South Carolina	T E Smith	Parental Power and Influence Upon Adolescents	53,700	9/73—9/74

Grant No.	Institution	Investigator	Title	Amount	Duration
GS-31082X3	National Opinion Research Center	J A Davis	A National Data Program for Sociology	107,200	10/73—10/74
GS-35828X1	Teachers C	C Kadushin	Comparative Study of National Leaders Networks	53,400	9/73—9/74
GS-39632	Vassar C	C Griffen	Occupational and Residential Mobility	14,400	9/73—9/74
GS-39636	U Chicago	E O Laumann	A Cross-National Study of Social Networks and Community and Organizational Stratification	37,500	9/73—1/75
GS-39637	U California (R)	M W Meyer	A Longitudinal Study of Bureaucracies	37,900	8/73—2/75
GS-39750	U Nevada	C W Backman	Role of Phenomenological Variables in Norm Violation and Self Concept-Behavior Congruency	13,500	9/73—9/74
GS-39751	U Michigan	A S Tannenbaum	Conditions Affecting the Effects of Hierarchy in Organizations	39,400	9/73—9/74
GS-39778	Carnegie-Mellon U	S Leinhard	New Mathematical Methods for the Analysis of Social Structure	82,500	9/73—9/75
GS-39779	Florida State U	C B Nam	Residential Mobility Perspectives of Young People	28,300	9/73—9/74
GS-39780	U Michigan	H Schuman	Effects of Survey Question Wording on Survey Results	104,200	9/73—9/75
GS-39827X	Vanderbilt U	W R Gove	Psychological Correlates of Status and Roles	166,300	9/73—9/74
GS-39877X	Princeton U	L Stone	The Role of the University in English Social Change	24,000	9/73—9/74
GS-40168	U Pennsylvania	R B Ginsberg	Testing the Extended Semi-Markov Model on Mobility	69,300	9/73—9/75
GS-40295	Western Washington State C	D P Mazur	Ethno-Demography of the Soviet Union	46,700	10/73—10/75
GS-40500X	National Opinion Research Center	J S Coleman	Corporate Actors and the Structure of Power in Society	90,900	9/73—9/74

Doctoral Dissertation Research in Sociology

Grant No.	Institution	Investigator	Title	Amount	Duration
GS-39662	Iowa State U	J R Stratton	Student: Robert Leger	1,300	9/73—9/74
GS-39672	U California (B)	A L Stinchcombe	W. Russell Neuman	3,000	8/73—8/74
GS-39673	U Michigan	H Schuman	Edward J. Walsh	3,550	8/73—8/74
GS-39674	U California (B)	D Matza	Richard Weisman	1,000	8/73—8/74
GS-39747	Northwestern U	A S Feldman	Paul Lubeck	2,000	8/73—8/74

SOCIAL PSYCHOLOGY

Grant No.	Institution	Investigator	Title	Amount	Duration
GS-3171 Amend II	Wayne State U	G S Leventhal	Modes of Response to Inequity	49,900	9/73—9/75
GS-27422 Amend II	Harvard U	Z Rubin	Patterns of Interpersonal Attraction	66,900	9/73—9/75
GS-28847 Amend III	U Texas	E Aronson	Interpersonal Relations in the Laboratory and in Educational Settings	81,900	9/73—9/75
GS-30514X2	Yale U	I L Janis D M Quinlan	Influence of Dyadic Relationships on Adherence to Stressful Decisions	49,200	9/73—9/74
GS-30822X2	U Wisconsin	E Walster	Studies Testing a Theory of Positive Affect	63,500	9/73—9/74
GS-30952X2	University City Science Center	D Landis	Cross-Cultural Skills and Interpersonal Effectiveness in an Urban Environment	70,100	9/73—9/74

Grant No.	Institution	Investigator	Title	Amount	Duration
GS-31020X2	U Connecticut	A Farina	Effects of Deviance on Interaction	26,700	10/73—10/74
GS-31085X2	Swarthmore C	K J Gergen	The Effects of Aid on Recipient Attitudes	52,900	10/73—10/74
GS-31450X2	U Wisconsin	H Leventhal	The Control of Emotional and Instrumental Acts through Information and Self Observation	59,300	11/73—11/74
GS-32779 Amend I	U Cincinnati	D C Lundgren	Developmental States in Human Relations Training Groups	6,500	5/72—5/75
GS-35157X1	U Minnesota	E Berscheid	Dependency in Interpersonal Attraction	44,300	9/73—9/74
GS-35495X1	U Michigan	R B Zajonc	Exposure, Attitudes, and Attachment	55,500	9/73—9/74
GS-39774X	Yale U	W J McGuire	Social Perception, Belief Systems and Historical Values	46,700	8/73—8/74
GS-39938	U Illinois	R S Wyer, Jr.	Factors Affecting Attitudes Toward Others	32,000	8/73—8/74
GS-40001	U Wisconsin	L Berkowitz	Research on Help-Giving	68,200	9/73—9/75
GS-40074	Cornell U	L Cobb D P Hayes	Periodicities in Long-Term Interaction	40,600	9/73—9/74
GS-40085	U Michigan	R E Nisbett	Attribution Processes: Their Nature and Application	64,200	9/73—9/75
GS-40166X	Columbia U	J L Freedman	Crowding and Human Behavior	40,000	9/73—9/74
GS-40167	U Massachusetts	A H Eagly	Source Variables, Attributions, and Attitude Change	60,300	9/73—9/75
GS-40171	U Missouri	R G Geen	Effects of Observing Aggression on Aggressive Behavior	51,400	9/73—9/75
GS-40192X	U Illinois	J H Davis	Group Decision Making and Problem Solving	45,900	9/73—9/74
GS-40194	Ohio State U	B Latane	Theory of Social Impact	103,000	9/73—9/75
GS-40231	U Illinois	C E Osgood	Studies on Comparative Psycholinguistics	75,000	9/73—9/74
GS-40265	Rutgers U	S Rosenberg B D Cohen	Verbal Behavior as Interpersonal Communication	82,800	10/73—1/75
GS-40329	Purdue U	D Byrne	A Reinforcement Model of Interpersonal Attraction	21,400	9/73—9/74

Doctoral Dissertation Research in Social Psychology

GS-39755	Harvard U	L Kohlberg	Student: John M. Broughton	1,300	8/73—8/74
GS-39775	Johns Hopkins U	J C Stanley	Daniel P. Keating	2,400	8/73—8/74

HISTORY AND PHILOSOPHY OF SCIENCE

GS-28478 Amend I	U Pittsburgh	A R Anderson N D Belnap	Intensional Logics and their Applications in the Social Sciences	10,800	6/73—6/74
GS-33742 Amend I	The Franklin Inst	B Sinclair A M McMahon	The Franklin Institute and the Development of American Technology	64,300	9/73—9/75
GS-39659	Yale U	M J Klein	History of Thermodynamics, Statistical Mechanics and Quantum Physics	30,800	9/73—9/75
GS-39664	U Texas	R L Causey	Unity of Science: Requirements and Prospects	17,500	9/73—9/74
GS-39675	California Inst of Tech	D J Kevles	The Development of Science During World War II	11,300	9/73—9/74
GS-39676	Johns Hopkins U	D Gottlieb	Ontological Reduction	11,000	9/73—9/74

Grant No.	Institution	Investigator	Title	Amount	Duration
GS-39677	U Maryland	F Suppe	Functions of Theories in the Scientific Enterprise	15,000	9/73—9/75
GS-39680	Duke U	S H Mauskopf	Collaborative Research on the History of Experimental Parapsychology 1930-1947	22,400	1/74—8/74
GS-39681	U North Carolina	M R McVaugh	Collaborative Research on the History of Experimental Parapsychology 1930-1947	19,700	1/74—8/74
GS-39682	Southern Illinois U (Edwardsville)	K W Collier R G Wolf	Conference on Relevance Logics	4,600	11/73—11/74
GS-39697	Yale U	G M Clemence	Problems of Time Measurement	19,300	9/73—9/74
GS-39704 †	U California (LA)	D B Kaplan	Philosophy of Language	18,100	9/73—9/74
GS-39705	U Iowa	H Rouse	Hydraulics in the United States	11,100	11/73—11/74
GS-39723	U Colorado	E G Ruestow	Origins of Microscopy	15,600	9/73—9/74
GS-39724	Indiana U	J A Winnie	Physical Conventions in Special and General Relativity Theory	10,900	9/73—9/74
GS-40698 †	U Pittsburgh	R H Thomason	Linguistic Application of Formal Logic	18,000	10/73—10/75

Doctoral Dissertation Research in the History and Philosophy of Science

GS-39678	SUNY - (Buffalo)	J Corcoran	Student: Susan B. Wood	1,000	9/73—9/74
GS-40652	U New Hampshire	R I Watson	Ronald H. Mueller	800	10/73—10/74

GEOGRAPHY

GS-35640X1	U Pennsylvania	W Isard	Analysis and Models of Economic, Political and Social Distributions Over Space and Time	80,300	9/73—9/74
GS-39837	U Pennsylvania	S Gale	Processes of Change in Occupancy Patterns	78,700	9/73—1/75
GS-39876	U Kansas	R E Nunley	Experimentation with the Multi-Dimensional Analysis Processing System	64,400	8/73—8/74
GS-40077	U California (B)	H O Sternberg	Frontier Settlements in Amazonia	29,000	1/74—1/75

Doctoral Dissertation Research in Geography

GS-40346	U Pennsylvania	T A Reiner	Student: William A. Cozzens	3,500	9/73—9/74

POLITICAL SCIENCE

GS-3224 Amend II	SUNY - (Cortland)	D E Leon	Collaborative Research on Professionalization	2,500	12/72—12-73
GS-30674 Amend II	Northwestern U	T R Gurr	Studies of Political Conflict and Change	69,400	9/73—9/75
GS-33965X2	Northwestern U	H Jacob	A Comparative Study of the Disposition of Felony Cases	7,700	6/73—6/74
GS-35254X1	U Michigan	J P Crecine	Organization Planning and Adaptation in the Public Sector	73,100	9/73—9/74
GS-35282X1	Stanford U	R C North	Causal Modelling and Prediction in the International System	33,700	9/73—9/74
GS-36755 Amend I	Drew U	B G Salmore	Testing the Validity of Events Data	2,722	3/73—3/74

Grant No.	*Institution*	*Investigator*	*Title*	*Amount*	*Duration*
GS-38050 Amend II	U North Carolina	J D Martz E A Baloyra	Politicization and Participation in a Developing Nation	2,300	5/73—8/74
GS-39754	Rutgers U	R S Sigel	Comparative Study of Adolescent Political Involvement	109,900	7/73—10/74
GS-39941	U Wisconsin	J C Scott	Theory of Rural Class Relations in Asia	34,800	9/73—9/74
GS-39994	Western Washington State C	J Martin	Dynamics of Roll-Call Voting	7,600	10/73—10/74
GS-39996	Indiana U	F W Hoole	A Computerized International Organization Data Archive	7,800	8/73—8/74
GS-40023	Harvard U	W Schneider	Comparative Analysis of Issues and Electoral Change	17,200	9/73—9/74
GS-40319	U Colorado	M I Midlarsky	Probabilistic Models and Political Behavior	55,200	9/73—9/75
GS-40347	U Kentucky	M A East	Collaborative Research on the Foreign Events of Nations	49,000	10/73—10/75
GS-40348	Rutgers U	S A Salmore	Collaborative Research on the Foreign Events of Nations	46,800	10/73—10/75
GS-40356	Ohio State U	C F Hermann	Collaborative Research on the Foreign Events of Nations	61,400	10/73—10/75

Doctoral Dissertation Research in Political Science

GS-40113	U Michigan	M K Jennings	Student: Ronald B. Rapoport	4,500	9/73—9/74
GS-40115	Columbia U	A J Nathan	Stephen J. Butts	1,730	9/73—9/74
GS-40195	U Michigan	A S Whiting	Edward T. Fei	3,100	9/73—9/74

SPECIAL PROJECTS

GS-2386 Amend II †	U California (B)	W S-Y Wang J Ohala	Program of Research on the Processes of Phonological Change	29,800	9/73—3/74
GS-3081 Amend III †	U Texas	W P Lehmann	Theoretical Investigation of Diachronic Syntax	43,100	10/73—10/75
GS-3197X2 (Interdis-ciplinary)	Syracuse U	R G Gregory	Acquisition of Social Science Data on Africa	35,000	9/73—9/74
GS-30040 Amend I †	Stanford U	E V Clark	Acquisition of Semantic Distinctions in Children's Speech	51,400	9/73—9/75
GS-31494 Amend II †	Ohio State U	I Lehiste	Rhythmic Units and Syntactic Units in Speech	24,800	3/74—3/75
GS-31730X2 (Interdis-ciplinary)	The Institute for Advanced Study	C Geertz	Advanced Study on the Processes of Social Change	135,700	12/74—12/75
GS-36308X1 (Anthropology)	U Pennsylvania	F Rainey	Applied Science Center for Archaeology	109,900	11/73—11/74
GS-39748 †	U Hawaii	D Bickerton	Language Variation and Change in Hawaiian English	95,600	9/73—9/75
GS-39752 †	U Massachusetts	B Partee T Parsons	Formal Syntax and Semantics for Natural Languages	51,500	9/73—9/75

Grant No.	Institution	Investigator	Title	Amount	Duration
GS-39814X †	CUNY (Graduate Ctr)	W A Stewart	Gullah - A Case Study of Linguistic Socialization	99,700	9/73—9/74
GS-39834 †	Harvard U	W A Woods	Computational Syntax and Semantics	35,000	9/73—9/75
GS-39836 †	Harvard U	E Wanner	Experiments in Sentence Comprehension	30,500	9/73—5/75
GS-40097 (Interdis-ciplinary)	U California (B)	K Craik D Appleyard	Environmental Dispositions and the Simulation of Environments	314,800	9/73—9/74
GS-40110 †	U Texas	P F MacNeilage	Program of Speech Research	70,200	9/73—9/75
GS-40203 †	U California (B)	C H Frederiksen	Semantic Information Processing in Comprehension of English Discourse	53,600	10/73—10/75
GS-40503 †	U California (SD)	B K T'Sou	International Conference on Sino-Tibetan Linguistics	10,800	10/73—10/74
GS-40576 †	Stanford U	C A Ferguson J H Greenberg	Phonology Archiving Project	53,200	10/73—10/74
GS-40628 (Interdis-ciplinary)	U Chicago	L I Rudolph S H Rudolph	Courtierly Politics and Partrimonial Administration in India	25,100	10/73—10/74

SOCIAL INDICATORS

Grant No.	Institution	Investigator	Title	Amount	Duration
GS-29032 Amend I (Interdis-ciplinary)	National Planning Association	N E Terleckyj	Developing a Goals Accounting System	141,600	9/73—9/74
GS-30273X2 (Social Psychology)	Northwestern U	D T Campbell	Measurement and Experimentation in Social Settings	73,100	9/73—9/74
GS-30624X2 (Sociology)	U Wisconsin	J Hage E Gargan	Comparative Study of Societal Stability	94,600	9/73—9/74
GS-32436 Amend II (Social Psychology)	Duke U	K W Back	Social Indicators for Self Realization	60,800	2/74—2/76
GS-34219 Amend I (Interdis-ciplinary)	Social Science Research Council	E B Sheldon	Center for the Coordination of Research on Social Indicators	41,200	7/73—1/74

LAW AND SOCIAL SCIENCES

Grant No.	Institution	Investigator	Title	Amount	Duration
GS-33825 Amend I	U Chicago	H Zeisel	Analysis of the Traditional Voir Dire System	16,400	7/72—7/73
GS-40601	U North Carolina	L Walker J Thibaut	Adversary System of Legal Decision Making	130,000	6/74—6/76
GS-40624	Washington U	G L Dorsey	Workshop on Legal and Social Philosophy	6,000	10/73—10/74

SCIENCE POLICY RESEARCH

Grant No.	Institution	Investigator	Title	Amount	Duration
GS-39830	Yale U	D de Solla Price	Quantitative Research in Science Policy Studies	26,600	9/73—9/74

National Science Foundation
Washington, D.C. 20550

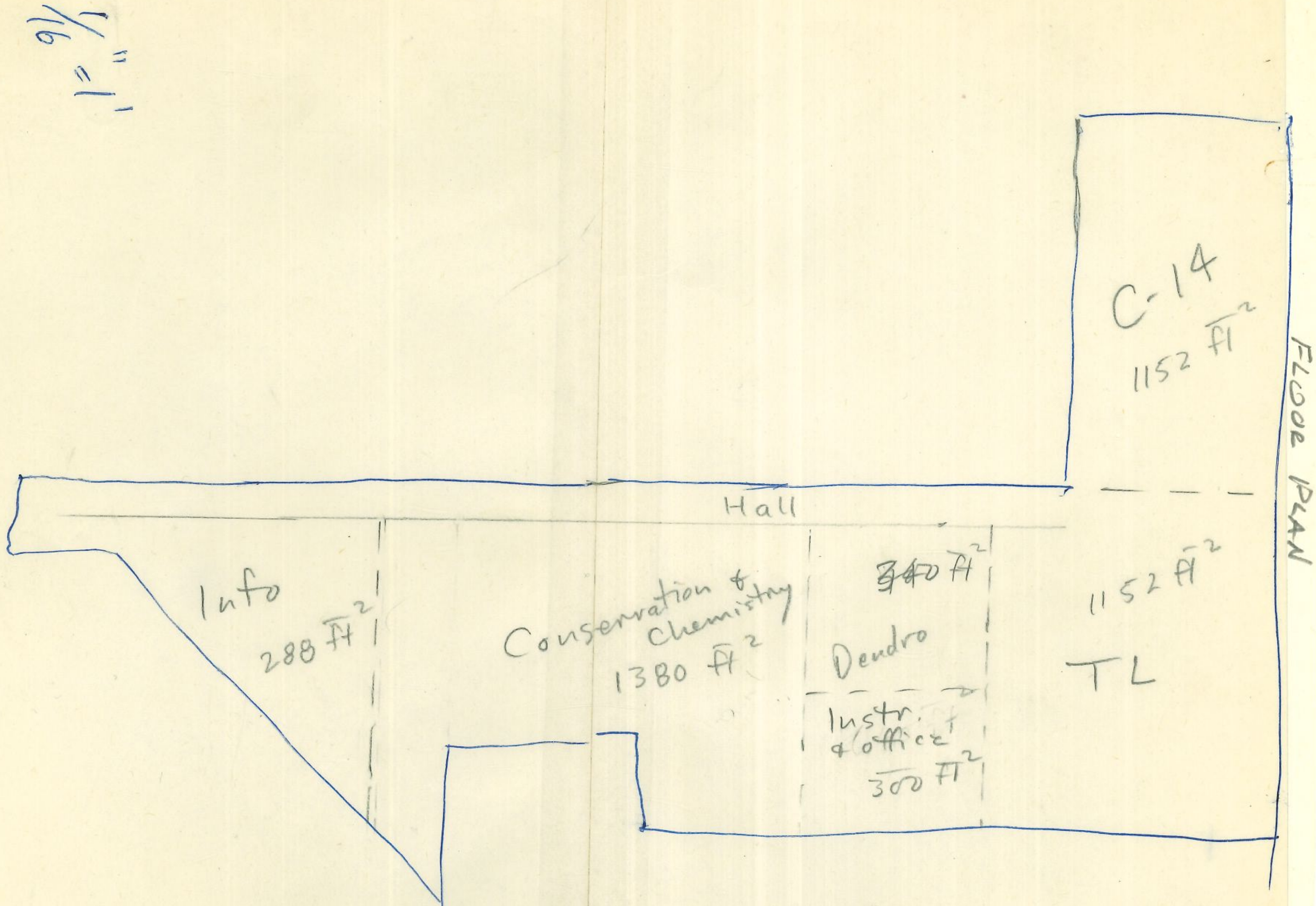
Official Business
PENALTY FOR PRIVATE USE, $300

Postage and Fees Paid
National Science Foundation

U.S.MAIL

THIRD CLASS
Bulk Rate

ELIZABETH K RALPH A 36458
UNIVERSITY MUSEUM
UNIV OF PENNSYLVANIA
PHILADELPHIA PA 19104


1" = 1/16"
FLOOR PLAN
C-14
1152 ft²
Hall
Info
288 ft²
Conservation & Chemistry
1380 ft²
340 ft²
Dendro
Instr. & office
300 ft²
1152 ft²
TL

Report of NSF Grant GS-36308 X

Museum Applied Science Center for Archaeology
(MASCA)

Re: NSF Notice No. 33, item 1, a summary of scientific progress during the first nine months.

The brief reports which follow are arranged in the order of the outline of the proposal with some interdisciplinary categories grouped together.

Items 2 and 3 (Notice No. 33) follow these summaries. The proposed budget for the ensuing year is the same as that proposed in the original budget for the second year.

No.: NSF Grant GS-36308X

Title: Museum Applied Science Center for Archaeology (MASCA)

Subject: Final Report for 11/15/72 to 4/30/75

Principal Investigator: Froelich Rainey

For this two-year grant, we wrote a fairly extensive report after nine months of the grant period which served as the first-year report. Therefore, in this report, we shall summarize the earlier report and then describe the events of the second grant year.

A. Radiocarbon Laboratory

1. Archaeological and Geological Samples

A summary of the samples dated in 1972-1973 was included in the nine-month report. During 1974, we dated samples from the following archaeological sites:

Egypt
- 19th Dynasty tombs excavated by the University Museum (6)

Greece
- Achilleion (11)
- Franchthi Cave (18)
- Halieis or Porto Cheli (6)
- Athenian Agora (1)

Crete
- Pyrgos (4)

Israel
- Arad (3)

Kuwait
- Failakah Island (1)

Turkey
- Karatas (1)

Iran
- Shahr-I Sokhta (14)
- Hasanlu (8)
- Tepe Malyan (2)

West Pakistan
Rana Ghundai (2)
Aligrama (3)

Azores
Ribeira Grande, San Miguel (1)

Guatemala
El Porton (7)
Los Mangales (2)

Camerroons
Doulami (2)

Thailand
Ban Chiang (5)

Arctic
Baffin Island (1)
Intrepid Bay (1)
Feniak Lake (4)

The following geological samples were dated:

Havasu Canyon (Grand Canyon, Colo.) (10)
both travertine and wood samples

Among laboratory activities, a small 1-liter counter was constructed (the two existing ones hold 8 liters of CO_2). This was done primarily for the dating of undersized samples from the important site of Ban Chiang, Thailand. C^{14} dates range from 3660 to 200 B.C.

2. Known-Age Dating Program

Descriptions and results of the tree-ring and C^{14} dating of sequoias and bristlecone pines were described in the MASCA Newsletter, vol. 9, no. 1 (August 1973). Since then we have dated thirty more bristlecone pine samples of known age to fill some of the gaps in the 7400-year chronology. Six samples extending to 8200 years have also been dated by C^{14}, but the precise tree-ring chronology of these has not yet been determined.

There is a very good possibility that earlier wood can be found in the form of bristlecone pines that have slid down the slopes of the White Mountains during heavy rains and eventually have been buried in alluvial fans. These fans were examined surficially in June-July 1974 by Henry Michael (MASCA) in collaboration with geologists Robert Giegengack (University of Pennsylvania) and William Beatty (Stanford Research Institute, SRI).

Samples of thirty-four of these "floaters" found in the canyons and alluvial fans were air-mailed to the C^{14} laboratory to obtain "quickie" ball-park ages. None was greater than 4000 years, but this is not too discouraging since they were found on the surface. Plans for this season (spring-summer 1975) call for the use of mechanical excavating equipment to dig into the fans.

Tests of the dielectric constants of bristlecone pines and the surrounding alluvium indicate that there is sufficient contrast for the use of SRI's soil-penetrating radar equipment to locate the buried wood (See "Archaeological Prospecting" for the explanation of soil-penetrating radar).

3. The radiocarbon laboratory was primarily supported by the University of Pennsylvania and NSF Grant GA-12572 (Earth Sciences Division). However, we are extremely grateful to the Social Sciences Division of the NSF for funds awarded in this grant which enabled us to enlarge the radiocarbon facilities by the addition of an adjacent 20 x 50 ft. room and to convert this room from a storeroom to a laboratory. This has provided space for a benzene train, liquid scintillation spectrometer, and other equipment.

B. Dendrochronology

In addition to the birstlecone pine and other programs, we instructed Peter Kuniholm, a graduate student in Classical Archaeology at the University of Pennsylvania and now Director of the American Research Institute in Turkey, in the techniques of dendrochronology. He has had better success and collaboration than anticipated in the collection of datable sections of wood, and now has several floating chronologies for the Anatolian plateau with the possibility that at least some of them will become absolute as more cross-dating is completed.

C. Thermoluminescence (TL)

Separation experiments as well as alpha irradiations of both quartz from pottery and beach sand (which had not been subjected to a previous alpha dose) were performed. We found that the response to both types was linear up to 30 Krads. Also, potassium analyses, which give us a measure of radioactive K^{40} in pottery are now being done routinely. This is in addition to the alpha counting of uranium and thorium.

In the course of studying the causes of deviant TL dates, which amount to about 20 per cent of the total, we have performed a number of subsidiary experiments. The most useful have been DTA (differential thermal analyses) and TGA (thermal-gravimetric analyses). Both methods provide indications of the firing temperatures of the pottery, and are accomplished by stepwise controlled heating. For DTA the sample is heated simultaneously with an inert sample and the difference in temperature between the two is recorded. TGA provides an accurate measurement of weight loss due to the evolution of absorbed water and at higher temperatures, of bonded hydroxyl ions.

For pottery with deviant dates, DTA revealed large endothermic peaks between 600 and 750°C; and TGA, significant weight losses. Both indicate that the pottery was not fired above 600°C. Previously, we had assumed that firing temperatures of 450°C were sufficient, but we now suspect that the susceptibility of clays to radiation damage increases with firing temperatures. (See preprint, M.C. Han, "Effects of Alpha Dose and Annealing Temperature upon Pottery Dating by Thermoluminescence.") This problem may be circumvented by constructing different calibration curves for pottery that has not been fired sufficiently.

X-ray diffraction measurements of the clay and quartz inclusions tend to confirm the DTA and TGA analyses. The decomposition of kaolin clays occurs in the 400-600°C range, whereas the micas and montmorillonites retain some of their hydroxyl ions until about 800°C. As seen by X-ray diffraction, upon loss of the hydroxyls, the clay structure collapses and is no longer crystalline. Clays fired in excess of 1000°C will ultimately form an amorphous material.

Experiments directed toward the recrystallization of fired clays by means of high-pressure hydrolysis have just been initiated. These may provide additional information about the mineralogy of fired clays and their firing history in the past.

The dating of slags and their crystal inclusions by TL is described in MASCA Newsletter, vol. 10, no. 1, pp. 1-2 (July 1974).

List of samples dated by TL include artifacts and pottery sherds from other museums and from curators of the University Museum.

1. Artifacts:

    Several terra-cotta heads from African (Upper Volta) for possible donation to the University Museum, TL dates younger than expected.

    Additional figurines from Acambaro, Mexico

    Gifts to the University Museum from Mr. Hapgood.

    Figurines and statue from the Tang Period, TL dates show reasonable placement in that period.

    A collection of objects pruchased in Iran by R. Dyson, including animals, cups, goblets, pitchers and jars. TL dates range from 400 B.C. to 1800 B.C.

2. Pottery sherds:

    Ban Chiang, Thailand, range from 400 B.C. to 3600 B.C.

    Glazed Pottery from Bankruat, Thailand .

    Most of this group dated from A.D. 1200 to recent.

    From University Museum's collection

    Additional Egyptian pottery of known age, supplement to an earlier project.

    Additional painted ware from Hasanlu, Iran for use as known age samples with corresponding C^{14} dates.

    Sherds from the following sites were found to be not datable by TL due to extremely low internal radioactivity contained within the clay material.

    Malo Island, New Hebrides

Santa Ana Island, British Solomon Island

Babeloaob, Palau Island

Kyrenia shipwreck from Cyprus

Progress on Dating of Faience:

With the return of a first set of the dosimeters placed in the Egyptian tombs for 15 months, we found that the accumulated radiation dosage is nearly the same as that placed in laboratories at ground level for the same length of time, with one exception; the dosimeter from the deepest tomb in Egypt (Seti I) showed a dosage 3-4 times greater than all of the others. This may have been due to the placement of this particular sample above an iron beam which may have contained CO^{60} (Steel companies in the 1950's placed CO^{60} sources in their tanks to monitor the linings). As a result batches of steel became contaminated with gamma's from CO^{60}. Unfortunately, this negated the "deep tomb" experiment.

D. Archaeological Prospecting

1. Cesium Magnetometer

The cesium magnetometer survey that was conducted at Malkata, Egypt is reported in the enclosed MASCA Newsletter (vol. 9, no. 2, December 1973, pp. 3-5).

Other cesium magnetometer surveys were conducted at Tepe Malyan in southern Iran, at Chaco Canyon, New Mexico, as well as at local colonial sites.

2. Soil Penetrating Radar

In collaboration with Stanford Research Institute (SRI), we are experimenting with the technique of soil-penetrating radar.

The method of radar detection was developed during World War II, but now Stanford and at least two other companies have made breakthroughs in the design of new antennas and in the use of variable frequencies that enable the radar to penetrate into the ground. The equipment is composed of a pair of antennas which are pulled along the ground on a small cart and portable transmitter and receiver, and data recorder. The resulting soil profiles indicate buried discontinuities within a range of depths between 0.5 and 10 meters.

In collaboration with SRI we tested one of these systems (SRI has developed several sets which differ slightly) at Chaco Canyon, New Mexico. An initial analysis of the patterns of radar echoes has shown that it is possible to detect buried walls. This technique will be a significant supplement to magnetic prospecting at sites where there is no magnetic contrast or where the earth is too magnetic.

As mentioned under the Known-Age program, SRI's radar equipment will be used also to detect buried bristle-cone pines.

In collaboration with MASCA another set of SRI's soil-penetrating radar will be used at various sites in Egypt in the fall of 1975. (This set is already in Egypt.)

E. Aerial Photography

A kite and associated camera and controls for low-altitude photography have been assembled. Photographs from low-flying aircraft were taken at a number of archaelogical and historical sites in northeastern U.S.A. and in western Montana. Repetitive photography at some sites illustrated how the visibility of patterns in vegetation varies with time and rainfall.

NASA has now begun to take photographs for us from the satellite, Landsat-2. These photographs of a region along the Thames River near Dorchester, England, may help us determine the optimum time to try aerial photography from an airplane.

F. Information Center

The index of cards of references to publications derived mainly from the physical sciences that are pertinent to anthropological and archaeological research has continued to be increased.

Also, two MASCA Newsletters were published in 1973 and one in 1974. (The second in 1974 was postponed due to lack of funds.) The plans for two are again in force for 1975.

G. Chemical Techniques

The mud-brick project has become an important branch of our activities. Experiments have been conducted both in the laboratory and in the "field" (Museum roof and objects in gardens, Chaco Canyon, New Mexico, and at other sites in the Southwest). Both acrylic emulsions and catalyzed mixtures of methacrylate monomers are being tested.

Field trials at sites in the southwest U.S.A. show that a spray-on system with a dilute emulsion of Rhoplex-330 (acrylic) shows promise. The cost of this treatment is about 2 1/2 cents per square foot for two applications.

The same emulsion can be used quite effectively diluted with water to make a chemically stabilized mud for grouting walls, plastering and repairing old walls and even forming mud bricks for new construction. Cost to treat 100 pounds of dry soil is about $3.00. This modified mud is resistant to severe weathering conditions and should be useful for application to mud brick structures in many parts of the world where the inhabitants are dependent upon this type of construction, or where there is a need to preserve mud-brick structures exposed by excavation such as the University Museum's sites in Iran and Egypt. Such material can be used for patching roofs and walls thereby negating the need for annual repairs of this type.

H. Publications

1. MASCA Newsletters

   a. Vol. 9, No. 1, E.K. Ralph, H.N. Michael, and M.C. Han, Radiocarbon Dates and Reality (August, 1973).

   b. Reprinted with special permission in Archaeology of Eastern North America, Vol. 2, No. 1 (Spring, 1974), pp. 1-20.

   c. Vol. 9, No. 2 (December, 1973)

   d. Vol. 10, No. 1 (July, 1974)

2. Other Publications

   a. E.K. Ralph and H.N. Michael, Twenty-five Years of Radiocarbon Dating. American Scientist, Vol. 62, No. 5 (September-October 1974), pp. 553-560.

   b. H.N. Michael and E.K. Ralph, Co-editors, Dating Techniques for the Archaeologist. The M.I.T. Press, Cambridge, Mass. and London, England. Second printing, September 1973.

   c. B.A. Lawn, University of Pennsylvania Radiocarbon Dates XV. Radiocarbon, Vol. 15, No. 2, 1973, pp. 367-381.

d. H.N. Michael and E.K. Ralph, University of Pennsylvania Radiocarbon Dates XVI. Radiocarbon, Vol. 16, No. 2, 1974, pp. 198-218.

e. B.A. Lawn, University of Pennsylvania Radiocarbon Dates XVII. Radiocarbon, in press.

f. M.C. Han, Effects of alpha dose and annealing temperature upon pottery dating by Thermoluminescence. To be published in the Proceedings of the International Seminar on "Application of Science to the Dating of Works of Art," held at the Museum of Fine Arts, Boston, Mass. September 23-25, 1974, in press.

g. E.K. Ralph, Calibration of Radiocarbon Dates, ref. "2.f."

h. B. Bronson and M.C. Han, A Thermoluminescence Series from Thailand. Antiquity, Vol. 46, No. 190 (December 1972) pp. 322-326.

i. B. Bevan, Stereo Photography for the Archaeologist, a MASCA report, May 15, 1973.

Publications by Froelich Rainey

Archaeology. Encyclopaedia Britannica Yearbook of Science and the Future (1973), pp. 163-166.

Archaeology. Encyclopaedia Britannica Yearbook of Science and the Future (1974), pp. 163-166.

Archaeology. Encyclopaedia Britannica Yearbook of Science and the Future (1975), pp. 161-165.

Archaeology. Encyclopaedia Britannica Yearbook of Science and the Future (1976), in press.

Stolen History. Science Year, the World Book Science Annual (Field Enterprises Educational Corporation, 1973), p. 260.

Science and Archaeology. Archaeology, Vol. 27, No. 1, pp. 10-21.

Science is Forcing History to Change. New York Times (August 25, 1974), p. 20.

How Technology is Revolutionizing Modern Archaeology. Spectrum, in press.

Speculations on the Future of Archaeology, Festshrift for Helge Larsen. Folk (Copenhagen), in press.

Two copies of reprints which are available are included with this report.

9-month report

Archaeological Prospecting

During this grant year (February & March, 1973) an extensive cesium magnetometer survey was conducted at the 18th Dynasty site of Malkata on the west bank of the Nile River, opposite Luxor, Egypt. (Travel and living costs were financed by counterpart funds administered by the Smithsonian Institution). Because the Nile alluvium is unusually magnetic, good success was achieved in locating mud-brick structures in desert areas. However, for the same reason, it was not possible to pinpoint the ancient harbor which was presumed to have been on the alluvial plain between the desert and the present bed of the Nile. Between the plain and the desert there are two parallel rows of mounds, each row about 2 km long. These were presumably piled up from the dredging of the harbor. All but two were found to be magnetic and, therefore, made from the Nile alluvium. The two non-magnetic mounds at the southwestern limit must consist of sand only (all are now mostly covered with sand), and this fact may provide a clue as to the location of the original harbor. Hopefully, this area will be excavated during the next field season.

A brief magnetometer survey was conducted at Chaco Canyon, New Mexico to investigate an anomaly that had been detected with a seismograph. It was found to be a geological feature.

Just before the start of this grant-year (October, 1972), a cesium magnetometer survey was conducted at Tepe Malyan in southern Iran. Due to accidental firing in past times, mud-brick structures were detected which contained tablets that indicate that this site was the ancient capitol of the Illemites. Because of its importance, we plan to do a magnetic survey of the whole site, possibly in 1975.

Aerial Photography

A system for photographing archaeological excavations from a camera suspended beneath a kite is nearing completion. This camera is triggered by radio, an electrical cable, or a time delay; the film is automatically advanced so that a sequence of photos may be taken before lowering the camera from its elevation of 10 to 500 meters. While this is a very inexpensive and portable technique of aerial photography, a predictable wind is necessary.

A detailed how-to-do-it manual on stereo photography for archaeological illustration has been prepared and distributed to interested archaeologists. This report describes the technique of publishing three-dimensional pictures of excavations, statues, small finds, and architecture.

A multiband camera was used for oblique aerial photography in western Montana. It was found that the Indians who occupied this region apparently left few traces of their culture visible from the air. While artifacts which indicate Indian camp sites were found on the ground, only indirect, ecological, clues were detected from the photographs.

Radiocarbon Laboratory

Series of samples from the following sites have been dated by C^{14} this year:

Hajji Firuz Tepe, Iran
Cosa, Italy
Franchthi Cave, Greece
Selenkahiye, Syria
Korucu Tepe, Turkey
Ai-Khanoum, N. Afghanistan
Chilca Canyon, Peru
Chalchuapa, El Salvador
Port Royal, Honduras
Fotoruma Cave, Guadalcanal Island, British Solomons
Anangula site, eastern Aleutians
Dixthada, central Alaska
Savich Farm, New Jersey

Our efforts in dating samples of known age are summarized in the enclosed special issue of the MASCA Newsletter (Vol. 9, No. 1) entitled "Radiocarbon Dates & Reality."

Also, we have instructed a graduate student in Classical Archaeology, Peter Kuniholm, in the techniques of dendrochronology. Mr. Kuniholm, for the next year, will be doing field work in Turkey in an effort to establish a master tree-ring chronology from wood found at archaeological sites in Turkey.

THERMOLUMINESCENCE (TL)

1. Separation Experiments with Six Samples of Pottery of Known Age.

Samples selected were ones that had produced deviant results using our standard bulk-material technique. They were first treated ultrasonically to separate the fine-grained clay fraction. The remainder was then separated magnetically to isolate the quartz (non-magnetic) from the magnetic mineral fraction. The fine-grained fraction (still containing both quartz and other minerals), and the separated quartz fraction produced TL results in agreement with the original measurements of the bulk material. In other words, the cause of the deviant results was not due to grain size nor to lack of sufficient alpha irradiation of the comparatively larger quartz grains.

2. Alpha Irradiation Experiments

a) With the Non-Magnetic (quartz and feldspar components) of pottery.

Samples of quartz of two types, extracted previously from pottery, were exposed to a calibrated Po^{210} source (an emitter of pure alphas). The purpose was to determine if a dose of alphas, much greater than the inherent natural dose of pottery, would change the susceptibility to radiation damage.

After each alpha irradiation, the samples were tested with small fixed doses of X-rays and the subsequent TL read to measure possible changes. It was found that even after 40 Kilorads of alpha dose, there was not a significant change in susceptibility.

b) Alpha Experiment with Beach Sand.

Since quartz isolated from sherds has been embedded in the clay matrix for a given length of time, it should have experienced certain amounts of radiation from the clay. However beach sand (mostly quartz)

can be considered as free from such experiences, especially from alpha irradiation. If the susceptibility of a given sample is related to its radiation history, then the study of quartz from sand with alpha radiation would give further information as to what extent the crystals are being affected. So far a type of sand of pure quartz (from New Jersey) and another type of a mixture of quartz and feldspar (from Denmark) have been tried. We are now beginning to interpret the results.

3. Dating of Faience.

After a year-long delay caused by Egyptian authorities, $CaSO_4$.Dy. dosimeters have now been installed in selected Egyptian Tombs. After a year in place, they will be brought back to the laboratory to give a measure of the cosmic ray and other background radiation in the tombs. This is a necessary prerequisite for dating faience since it does not contain inherent radioactivity as does pottery.

4. On August 9th, 1973 a lecture on "Methods of Pottery Research as it is carried out by the Applied Science Center, University Museum, Pennsylvania." was given by Mark Han at the "Symposium on the Technology of Ancient Egyptian Ceramics." held on the 8th - 11th August, 1973 in the Technical High School for Ceramics in Höhr-Grenzhausen, West Germany. The symposium was sponsored by the Volkswagen Foundation.

5. Publication.

"A Thermoluminescence series from Thailand" by Bennet Bronson and M. C. Han in <u>Antiquity</u>, Vol. 46, No. 184 (1972)

Information Center

The information center and its bibliographer, Richard D. Haynes, are supported by NSF Grant NSF-GS-36308X. The functions of the information center are: to survey current literature for ideas for new applications and examples of new applications of applied science in archaeology, to abstract relevant articles and maintain a file of the most useful of them, to maintain a library organized around applied science in archaeology, to do library searches on topics requested by researchers, and to publish a Newsletter dealing with new developments in archaeology.

Under the current grant the following have been accomplished: eleven new journals are routinely surveyed, including journals in French, German, Spanish and Portugese as well as continuing coverage of twenty-four journals, including one in Italian. An estimated two hundred articles have been abstracted. Sixteen new books have been purchased for the library, and a card file by author and title has been prepared for the library. Five thorough library searches have been conducted. Also an issue of the MASCA Newsletter is in the process of being printed for publication in August.

The administrative assistant, Kathleen Ryan, is responsible for most of the secretarial work in the department, i.e. such things as taking dictation, typing letters and filing. In addition, she assisted with several special projects: drawing of maps for reports, plotting of radiocarbon vs. dendrodates for the calibration curve contained in the recent MASCA Newsletter, and assisted in the re-organization of the Information Center Library.

New Techniques

These have been carried out or supervised by Gary W. Carriveau, PhD., a physicist who joined our staff this year.

Firing Temperature

To insure valid thermoluminescence dates, the dated artifact must have been fired at a temperature sufficiently high and for a long enough period of time to drain (anneal) all thermoluminescence accumulated since the clay and inclusions were formed. In other words, the clock to be read with TL dating must be set to zero when the ceramic is fired. Several techniques have been developed at MASCA to check for 'proper' firing. These include hardness testing, color changes, weight loss, X-ray diffraction pattern changes and alteration of physical dimensions. These changes are measured during systematic reheating of the ceramic materials. Through results of this work, suspect dates on a collection of Mexican figurines were found to result from insufficient firing. The techniques have been developed in collaboration with the Department of Geology (X-ray diffraction), Laboratory for Research on the Structure of Matter (scanning electron microscope) and in consultation with Professor F. Matson, Pennsylvania State University.

An outgrowth of the firing temperature program, directly related to the basic theory of TL dating, deals with the incomplete annealing of ceramics and its effect on the TL date. A study is underway to define quantitatively the effect of incomplete annealing and, wherever possible, to use the results of firing temperature measurement to correct dates on low-fired wares.

Potassium Analysis

A further addition to the TL dating project is the development of a method to measure the amount of potassium in ceramic material. The radioactive isotope, K^{40}, contributes to the total radiation dose creating thermoluminescence. Quantitative measurement of potassium ensures the most accurate date. Techniques of high temperature fusions and direct measurement of K using flame photometry are now in general use at MASCA. Results of these measurements are of high accuracy and the techniques and apparatus are

available for the potassium-argon dating project in the Department of Geology.

X-ray Fluorescence

Elemental composition, through X-ray fluorescence analysis, of Hawaiian basaltic artifacts has been used to determine their provenance. This technique has also been used on South Pacific and Mexican ceramics. The program will be greatly expanded upon purchase, by the University Museum, of the latest computer controlled apparatus. A symposium was held at MASCA on X-ray fluorescence analysis techniques; those attending included representatives from the Boston Museum of Fine Arts, the Freer Gallery of the Smithsonian Institution, the Winterthur Museum, the Maritime Museum, and our own staff.

Obsidian Dating

Two non-destructive techniques for the dating of obsidian artifacts are being developed. These are namely, the analysis of interference patterns of infra-red radiation produced by the thin hydration rim in obsidian and secondly, the study of recoil alpha-particle energy distributions from the hydrated and non-hydrated regions in obsidian. The experimental work is being done in co-operation with the Moore School of Electrical Engineering and the Tandem Van de Graaff Laboratory, Department of Physics, University of Pennsylvania.

Radiocarbon Dating

A theoretical study and feasilility analysis on a new method of radiocarbon dating has been completed. Experimental apparatus employing a new dosimetry technique will be assembled from existing components in collaboration with the Cryogenics Laboratory in the Department of Physics. Results may enable the counting time for radiocarbon dating to be reduced by at least a factor of ten. The apparatus will use benzene, now being produced in the Radiocarbon Laboratory

Additional New Techniques

Mud Brick Project

Objective

A search has been initiated for a method of protecting and conserving mud brick structures, walls and remnants thereof. The method is to be essentially a surface treatment to existing structures. Protection against rain, heat, freezing, thawing, sand abrasion and ground moisture are a part of the objective. The method of application is to be simple and suitable for a remote field application.

Results

Baseball sized chunks of adobe blocks from Tucson, Arizona, are being spray treated in the laboratory. Evaluation of these treated chunks is made by a forced water spray (from a shower-head) equivalent to a driving rain of 900-1200 inches per hour.

Under the test conditions, untreated samples disintegrate completely in 1-2 minutes. Silicone resin in mineral thinner treated samples, one of the current preferred methods by the U.S. Park Service, can withstand the shower for 45-70 minutes. Acrylic emulsion treated samples can withstand the shower up to 10 hours with a single coating and up to 35-40 hours with a double coating. An acrylic emulsion treatment and after drying followed by a silicone in mineral thinner treatment withstands the shower for up to 35 hours.

Chunks of adobe blocks treated by the spray-on technique with these acrylic resins have been on weathering tests on the Museum roof for ten months. Some of the double coated samples show no deterioration from the natural elements of rain, sun, snow and freezing in the Philadelphia climate for the ten-month period.

Field tests at Chaco Canyon and Pecos National Monuments in New Mexico have been established in a freshly excavated pit house, Kiva, on ancient stone wall and ancient adobe walls. Uses of these resin materials in mud mortar and in present-day adobe blocks are also under test at Pecos.

This project is being conducted by our visiting scholar, Dr. Darrel Butterbaugh, a retired research chemist.