ARCHAEOLOGY AND SCIENTIFIC TECHNOLOGY[1]

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While the questions an archaeologist asks may be conditioned by his own experience and reasoning powers, (2) the advent of technological research in our present era has given impetus to more specific questioning within various aspects of archaeological endeavor. In seeking to answer certain questions, the archaeologist now has at his disposal a number of scientific techniques which, when utilized, enable him to arrive at a better understanding of ancient cultural patterns in any particular geographical area. In return, the utilization of applied science in archaeology has given rise to new definitions of archaeology and its relation to other academic disciplines. (3) Although it may be some time before all the implications of applied science in archaeology can be comprehended fully and archaeology finds its own rationale, some present day archaeologists are beginning to rely more heavily upon scientific technology for answers to archaeological questions. Thus let us look briefly at some of these questions and at some of the scientific technology involved in their answers. (4)

Once a site has been selected for excavation, several general archaeological questions occur immediately. Most of these questions deal with an understanding of the natural environment. Why was the site located in a given area and not kilometers away? What raw materials were available in the area? Have there been any drastic changes in the natural ecology of the area which might have influenced settlement patterns? Where was the natural water source? Since most dirt archaeologists are not specialists in those disciplines which study environmental questions, (5) archaeology employs the aid of geography, geology, paleobotany and hydrology.

The physical geographer, with the aid of aerial photography which can produce exact stereoscopic coverage of anygeographical area, can recover precise in-

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1. This article is dedicated to all the young aspiring archaeologists in the Department of Antiquities and the University of Jordan with whom the author has discussed and taught his supject while on leave from Harvard University during the Fall , 1969 .

2. S. Piggott, **Approach to Archaeology** . Cambridge : Harvard University Press, 1959, pp. 1-23.

3. M. B. Nicol' "Archaeological Method : The Last 15 Years, " **Penn.-Pahlavi Lecture Series,** Vol. 2 (1967) ' pp. 89-97 .

4. For more technical and relevant information on the continuing use of scientific technology in archaeology see the following periodicals : **Newsletter** (The Center for Applied Science in Archaeology, University Museum, The University of Pennsylvania, Philadelphia, Pa., U.S.A); **Archaeometry** (The research Laboratory for Archaeology and the History of Art, Oxford University, Oxford England) . Consult also H. O. Thompson, "Science and Archaeology, " **BA,** 29:4, pp. 114-128 .

5 A good introduction is H.W. Butzer, **Environment and Archaeology: an Introduction to Pleistocene Geography.** London. 1964 .

formation concerning such features as mountains, hills, rivers, river meanders, old river courses, alluvium fans and plains, cultivated areas and arid zones. Through the preparation of exact maps, plans and charts relating to various aspects of physical geography, the geographer is able to present the archaeologist with a physical environment in which ancient settlement took place. Such a perspective is necessary for archaeology , especially when an area does not exhibit continuous occupation habits. For example, if present day settlement lies outside the geographical zone in which are found ancient sites, there must have been good reasons for the anciet populations settling where they did. The archaeologist by analyzing the facts about physical geography often can find these reasons.

The geologist, often working in concert with the geographer, can present a three-dimensional picture of the physical environment of an area. Using core borers across the principle geographical lines in an area, a geological section is attained. By analyzing the section, the geologist understands how the geographical features were formed and their age. This knowledge is important to the archaeologist since he needs to know which geological features were in existance when an ancient site was inhabited. In addition to geological sectioning the geologist through petrological analysis, (6) can point out the various types of rock indigenous to an area. Other types of raw materials such as clay deposits, iron deposits or other ore deposits are ferreted out in a geological survey and such information is important in determining possible ancient industrial sites. By knowing the range of raw materials within a given area, the archaeologist has an indigenous control group against which he may compare artifacts excavated in the same area. This comparsion often is important in ascertaining whether certain types of artifacts were locally manufactured or imported, and on the other hand, whether the raw materials used in the manufacture of a site's artifacts were imported.

Such conclusions can, in turn, indicate trade relations between ancient cultures and enlarge our knowledge of ancient cultural contact.

During the historical periods of ancient cultural activity, one of the most important questions is what kinds of flora were natural inhabitants in a given geographical area. In order to understand the flora the archaeologist enlists the aid of paleobotany. (7) Core borings containing stratified samples of soil bearing spores when presented to a botanist's laboratory for analysis enable the archaeologist to recover the flora history of an area. With this knowledge the archaeologist can discover when certain types of flora were existant and perhaps contributive to the everyday life of ancient cultures. Since it is rare when an archaeologist recovers all the organic materials used by an ancient culture, new horizons of interpretation are opened through the microscope of the botanist. The paleobotanist often can point out the demise of certain species of flora and the reasons for that demise. If botanical analyses suggest a general change in environment, the archaeologist is alrrted to the possibility of a change in occupation patterns. For example, if certain species of trees disappear within a geogra-

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6. A good reference work which spells out certain laboratory techniques such as petrological analysis is E. Pyddoke, **The Scientist and Archaeology** . London: Phoenix House , 1963 .

7. G. W. Dimbleway, **Plants and Archaeology.** London: John Baker, 1967 .

phical area due to the lack of a water supply there may be a direct correlation between this natural phenomenon and stratified archaeological evidence at a site in the same area for population change or shift.

Of additional help in archaeological research is hydrology. (8) Once an understanding of the exact pattern of ancient river beds, the location of ancient springs and the continuation or discontinuation of water supplies is known through the use of applied physical geography, the hydrologist can help answer the question of what kind of water supply was available to the inhabitants of sites in a certain geographical area. By setting up hydrographic stations the water supply can be analyzed. The amount of water flow, chemical consistency, seasonal variation of force and flow and potential irrigation capability can be known and are relevent to the study of an ancient natural environment. Through measurements of down cut river chanels, when correlated with water force and flow, the general age of a particular river can be calculated. With the information supplied by the hydrologist, the archaeologist is in a better position to understand the potential size of occupation patterns at any site and within any geographical area. The population of any ancient city, of course, must have been dependant upon that city's ability to provide water and food for its inhabitants. The archaeologist also is better prepared to answer certain side questions based on hydrographic information. For example, if chemical analysis has shown a water supply contains harmful bacteria which may have been existant during the occupation of a site, the archaeologist may have discovered one reason for certain gaps in occupation at that site. In addition, an understanding of the chemical consistency of a water source leads to the further question concerning the action and reaction of water supply and the soil through which the water has run. In an attempt to understand the reaction or interaction of the natural environment and its relation to occupation debris, the archaeologist also makes use of soil chemistry. If the soil chemist can understand the pH of soil (9) (whether or not a soil is acid or alkaline and to what extent), and at the same time the interaction of water and soil in an area, the possibilities of natural chemical action upon buried artifacts can be postulated and eventually understood.

With information from hydrology and soil chemistry the archaeologist can better understand whether or not an artifact represents the finished product originally produced by its manufacturer.

For example, the artistic decoration on an artifact may or may not be representative of the potter-artist's intention, depending upon the interaction of soil pH and the artifact's internal chemistry.

Moving from the realm of natural evironment to the site itself, many strides have been made in excavation technique during the last decade. (10) The most

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8 R.E. Linington, "The Application of Geophysics to Archaeology, " **American Scientist,** Vol. 51 (1963) , pp. 48-70 ; R. Raikes , **Water, Weather and Prehistory.** London: John Baker, 1967.

9. J. Deetz and E.S Dethlefsen, "Soil PH as a Tool in Archaeological Site Interpretation, " **American Antiquity** , Vol. 29:2 . 1963 .

10. Cf. , C. C. Lamberg-karlovsky, "Selected Aspects of Archaeologe, " **The Annals of the American Academy of Political and Social Science,** Vol. 379 (1968) , p. 137 .

important understanding for technique is the fact that the basic unit within a site is the individual layer of soil in which are found the artifacts left by ancient occupation, and into which later intrusions may be dug (for example, a foundation trench or rubbish pit) . While, generally speaking, the layers of soil usually were deposited in a steady build-up of debris, fills do occur as well as leveling of restricted sites to make way for "avant garde" city planning. As the archaeologist excavates these superimposed layers of debris and soil, his most important question is:

How old are the artifacts which I am recovering from any particular layer? Thanks to modern technology there are two main ways which can answer the question of absolute chronology. The first method is well known-C14 date determination. The sample used for dating purposes is any organic material recovered from a site. In practice, due to statistical verity, the best sample is carbon from fireplaces or burned areas. The archaeologist, by collecting at least ten samples from any single part of the site, (11) can with a precision unknown during the early years of C14 dating establish an absolue chronology for his mound which cannot be refuted. (12) The second method is known as thermoluminescence. (13) While carbon samples may or may not be found at any particular site, pottery is abundant at most of the sites which fall within the chronological limits of c.7000 B.C. to the present. This second method of dating uses as its test sample a sherd of pottery. The archaeologist by collecting stratified sherds from every part of his site is able to abtain dates from laboratories using thermoluminescence dating techniques. Ttese dates, while still containing a rather large margin of statistical error, allow the archaeologist to date absolutely any and all layers in which ceramic artifacts are found. Instead of dating occupations at a site via a preconceived pottery chronology, the archaeologist now may date pottery by the pottery itself. The dates recovered from this second method of dating, in turn, give positive dates for all the superimposed cultures at a site. The application of this method of dating to cross correlation between sites located in different parts of the ancient Middle East is obvious. If similar absolute dates are found at several sites, then the sites are contemporary and were occupied during the same period of time. No loger does the archaeologist have to guess about cross correlation. The absolute dates are proof in themselves.

Apart from questions concerning the natural environment in which various ancient cultures exsited and questions concerned with absolute dating of ancient cultures in the ancient Middle East, there is a third major question the archaeologist asks. This question deals with the excavated artifacts. Since an artifact cannot tell us its relation to historical, ethnical or linguistic events,(14)or specific

11. Collected samples should be sequential in each area and one or two extra samples should be taken from a single layer in the sequence as a control .

12. For Palestine only a few C 14 dates are published. It is hoped in the future more attention will be given to this method of absolute dating in the area . **Cf.** , R:W. , Ehrich, (ed .) . **Chronologies in Oid World Archaeoligy** . Chicago : University Press, 1965 .

13. E. K. Ralph and M. C. Han' "Dating Pottery by Thermoluminescence , " **Nature**, Vol. 210 , No. 5033 (1966) ' pp. 245-257 .

14. M. B. Nicol' **White-On-Black Painted Ware. A Case Study in the Relation of Artifact Groups to Historical Events.** Ann Arbor : Microfilms, Inc. ' 1965 .

functions at the practical, social and political level, more pertinent questions are being asked about artifacts to day. (15) Of what material (s) was the artifact manufactured? How was the artifact manufactured? How "similar" are artifacts which "look" alike? To answer these questions the archaeologist has a large range of applied scientific techniques upon which to rely. Archaeology enlists the services of chemistry for an analysis of the materials used in the manufacture of artifacts. (16) Studies in ancient technology are beginning to appear more frequently. (17) Spectographic analysis of pottery can answer often the question of how similar individual ceramics may be. (18) The use of computer techniques often can be of assistance in classifying and identifying similar groups of artifacts across wide geographical areas. (19) Through these analyses, when compared and contrasted with environmental research, the archaeologist is in a much better position to trace cultural movements via a more scientific method than ever before in the history of archaeological research.

In the next decade we may expect archaeology to become more closely tied to scientific technology, since with each passing day new scientific techniques are being applied to archaeological research. The day when an archaeologist could pick up an artifact from an ancient mound in the Middle East and immediately call it "Hurrian", "Roman", "Byzantine", or "Early Bronze", "Chalcolithic", or "Intermediate EB-MB" is fast drawing to a close. Present archaeological research is beginning to be based upon hard facts produced in our scientific laboratories, and not upon **a priori** assumptions. Future possibilities for archaeology are boundless.

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15. H. Hodges' **Artifacts.** New York: Frederick A. Praeger, 1964 .

16. M. Levey (ed.) , **Archaeological Chemistry : A Symposium.** Philadelphia : University of Pennsylvania, 1967 .

17. Hans E. Wulff, **THE Tradional Crafts of Persia.** Cambridge: MIT Press, 1966; H. Neuninger, R. Pittioni, and W. Siegl, "Fruhkeramikzeitliche kupfergewinnung in Anatolien, " **Archaeologica Austriaca,** Vol. 35 (1964) , pp. 98-110 .

18. H. W. Catling, A. E. Blin Stoyle, E. E. Richards, "Spectographic Analysis of Mycenaean and Minoan pottery, " **Archaeometry** Vol. 4 (31) , 1961: F. R. Matson, **Ceramic and man** . "Viking Fund Publications in Anthropology," No. 41. New York: Viking Fund, 1965 .

19. G. L. Cowgill, "Computer Applictations in Archaeology." **Computers and the Humanities** , (1967) , pp. 1-8 .