B. Applications of Palynology to Archæological and Environmental Problems in the Pacific

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Palynology includes all studies dealing with pollen and spores. It is not a method for dating cultures or strata in itself. But where pollen and spores have stratigraphic and environmental significance, and are associated with material datable by the radiocarbon method, whether it be in archæological sites, or geological deposits such as bogs or other sediments, then palynology becomes a cross-dating device as well as an environmental indicator.

Research in New Zealand and the Hawaiian Islands has shown that the analyses of pollen in bogs will tell the story of past vegetation of the area, and indicate thereby, the climatic history. Von Post and Cranwell (1936) have demonstrated climatic change in New Zealand by study of the pollen of forest types preserved in the bogs. Conifers and southern beeches have been very important there in all sediments.

The pollen work of Sellings (1946–48) on Hawaiian mountain-bog material is the most comprehensive so far in the Pacific. Sellings was unable to shed any light on the time when Polynesian food plants were first introduced because he did not work with material from archæological sites. The lack of all conifers in Hawaii makes the identification of climatic change difficult and uncertain. Other workers in New Zealand and Australia are now carrying on pollen studies.

That there have been climatic fluctuations in the Pacific that appear to correlate with dated climatic sequences in other parts of the world we know from published studies; but confirmation of this world-wide correlation awaits radiocarbon dating.

Is there a possible correlation between migrations and climatic fluctuation in the Pacific? Trace element studies recently completed on soil samples from several archæological sites in Oceania tend to suggest this. How did the variations in climate affect, directly or indirectly, the levels of the island populations? These are the sort of problems we expect future pollen work to throw light on. Pollen from earlier periods of Pacific climates indicate it was always warm.

No reports on pollen analyses of archæological sites in the Pacific have appeared except for New Zealand. Others are in progress, including that by myself under the supervision of Dr Cranwell, on material from Sarawak, Marquesas, and Hawaiian Islands, which I shall discuss below.

My purpose in this paper is to make the archæologists aware of the potential help they may get from pollen analysis in Pacific archæology. By the study of the distribution of flora by man, through the identification of food plants it may provide evidence of the migration routes. Through the use of statistical analysis in the use of floral complexes, it helps to correlate cultural sequences; for important factors of cultural evolution often are illuminated by a detailed knowledge of native diet; and climatic and environmental problems.

An example of how palynology could be of immediate help to archæology is in the New Guinea Highlands. Susan Bulmer has recently worked in the Wahgi and Baiyer valleys, which consists of extensive grasslands. The important question is whether these grasslands are wholly or partly due to natural causes, or the progressive clearing for gardens, with forest regeneration discouraged by the use of fire. The taking of pollen samples from various profiles throughout these valleys, and analyses made from them, would in all probability solve the problem.

It will be necessary to determine which pollen types are useful in vegetational-prehistory studies, that is, which floras are sensitive to climatic change, and which represent plants introduced by man. According to the literature, over twenty species of plants were introduced by man into the Pacific in prehistoric times.

If pollens of cultigens introduced by the early colonists in the Pacific can be *recovered*, *recognized*, and dated by radiocarbon, it will be possible, not only to establish the time of arrival of the people and plants, but the plants used, and by what routes they came. Before we reach this point, there is much to do.

Vegetative versus sexual propagation is a consideration in the recovery of food plants. Plants such as sweet potato, taro, banana, and breadfruit are generally propagated vegetatively, which makes the recovery of the pollen of these plants difficult, as the frequency would be low. However, it is possible to have sexual reproduction of the sweet potato and taro. We have found a few taro pollen, but the frequency is low.

The nature of tropical soils, and pollen preservation are two important factors in the pollen analysis of this area. It is important to have a description of the matrix or parent material, so as to know the mineralogical and chemical composition of the soil. This information is useful in the extraction method used to recover the pollen.

An understanding of the soil forming process is desirable, as this can suggest time range as well as climatic influence and effect. Some of the variables are: parent material, climate, biotic, and slope factors. Carter and Sokoloff (1952), and Norman Taylor (personal communication with Lacy Cramwell Smith, 1961) of New Zealand are examples of those who have contributed to this aspect of soil science.

Dimbleby (1957), at Oxford, has been working on the correlation of the pH of soils and the frequency of pollen grains. His findings indicate that soils whose pH is above 6 are virtually useless for pollen analysis; the problem here is that alkaline soils cause decomposition of the pollen. In the pH range 5 to 6, pollen is present in small numbers though generally still too scarce to produce a reliable count without use of some form of concentration. Below pH 5 the frequencies are of the same order as, and even much in excess of the counts obtained on peats. We shall see how these conclusions compare with our pilot study.

Other factors that have to be contended with are: differential breakdown of types, and selective recovery of pollen grains by size during the extraction process.

Types of sites that best preserve pollen is an important consideration. Although it is necessary to search for the old agricultural plots to try and recover pollen to determine what they were growing, dry caves generally provide the best conditions for preservation of pollen, as do bogs. It is the areas of successive wetting and drying that are so destructive to pollen grains, due to oxidation. Peat bogs and lake bottoms provide the greatest precision for the establishment of pollen sequences, but pollen studies on ordinary soils can be useful.

In relation to archæology, we are interested in the presence of food plants. So the habitation and agricultural plots, as well as bogs and swamps must be examined. It is only necessary to find one pollen grain of the plant or plants introduced for food to demonstrate that the area or site was occupied by man. For this purpose, a statistical analysis is not necessary.

I have obtained soil samples from the Niah Cave in Sarawak, the Marquesas, and a few of Emory's Hawaiian sites (personal communication, 1961). My objective in doing this was to carry on a pilot study of an exploratory nature to find out if pollen could be recovered from archæological sites, and the nature of the problems that invariably develop with the introduction and application of any new technique.

Some success has been obtained in extracting pollen from these samples; and it is clear that the principal problem is to be sure there is no pollen in those levels that so far have produced none. A low frequency of pollen grains is evident in those levels that have pollen. Both for climatic studies and the identification of food plants, some method of pollen concentration is needed. The nature of the matrix is an important factor and therefore careful observations and an understanding of the soil are necessary in pollen analysis. Such information may give clues to the possible presence of pollen in the sample, and indicate the means whereby the matrix can best be cleaned and the grains recovered.

A brief discussion of the samples tested will illustrate the problems just mentioned. Few identifications have been made as yet.

Eight soil samples from different levels of Niah Cave, Trench E, from 3 to 84 inches in depth were run. So far I have at least one grain from all levels except Sample S, the 54–57 inch level. The frequency is low, and before a statistical analyses can be made, the number of grains will have to be increased per slide. The pH of all samples is over 7, except Sample U, the 78–84 inch level, which is 6·15. If Dimbleby is correct, we have an explanation of the low frequency of the grains. It may not be possible to increase the number of grains, but further work will be carried on to try to do so. If we are able to reconstruct the past climate, it will be possible to build a climatic chronology, as there are radiocarbon dates for the Niah Cave deposit.

Trace element studies by Dr Bruno Sabels indicate a definite climatic change in the area of Niah Cave over the last 40,000 years. A tropical environment is suggested for the 3–33 inch level; a less wet and cooler one for the 42–72 inch level; and a warm and wet climate for the 78–84 inch level. It will be interesting to see how the pollen analysis correlates with this interpretation.

From the Marquesas four samples from 5 inch levels of Site NBM–1, on the southeast coast of Nuka Hiva were run. The 0–5 inch level has numerous pollen grains. Not many different types, but the frequency is encouraging. One type has been identified as a *Malvaceae*, which is related to the *Hibiscus*. The 5–10 inch level, and 15–20 inch level has produced no pollen so far. There is one grain from the 10–15 inch level. The presence of pollen in the top level, and almost lack of it in the other three, suggests that it is trapping the present pollen rain. Complete identification will confirm or deny this.

When soil samples for pollen analysis are submitted, a description of how the samples were collected, and the present vegetation of the area should be included. This information is important to the palynologist in interpreting his results.

Soil of the upper three levels of the Marquesas site is a dark colour, possibly due to smoke or tar. Soil of the 15–20 inch level is a lime base, and contains chert and sand, and is a rusty colour. All samples contain charcoal and traces of bone.

Trace element studies indicate a climate for the top three levels essentially the same as today, while that of the 15–20 inch level may have been wetter and cooler. Two radiocarbon dates place the time of this level between A.D. 1198 and 1478.

Six samples from the Hawaiian sites have been run. These are from the Moomomi Bluff shelter, depth 26 inches; the Pu'u Ali'i, South Point, Hawaii, 14–17 inches depth; Site 60, Nihoa Island, 14–18 inches depth; and three from Site K3, on Kauai, 36, 70 and 85 inches depth. Although of very low frequency, pollen occurs in three of the samples. The Moomomi Bluff shelter, and the 36 and 85 inch levels of Site K3 on Kauai.

The sandy nature of these samples, together with charcoal, volcanic material, and coral is not conducive to the preservation of pollen grains. In some cases they may have been blown or washed out, which may account for the lack of, or low frequency of grains in these samples.

While we are getting pollen from archæological samples, the frequency is low. However, pollen of food plants should appear when used, and as mentioned above, a single grain is sufficient to establish the presence of the plant.

Wind pollinated versus insect pollinated types are a problem as the insect pollinated types produce less pollen. The finding of the pollen of such plants as sugar-cane, breadfruit, paper mulberry, gourd, candlenut, taro, yam, sweet potato, will tell us it was associated with man. Dating of the levels in which they occur will tell us when.

The potential use of pollen analysis to archæology is great, but the problems are many. However, I do not think they are insurmountable.

To make best use of the technique of pollen analysis in the Pacific, and to help resolve the problems under discussion, interdisciplinary approach is the most desirable. The ideal team would contain an archæologist who understands the technique involved, a palynologist, an ecologist, and a geochemist who specializes in soils and trace element work.

By combining their specialized knowledge in properly applying and interpreting the results of pollen analyses, and correlating these results with artifacts and radiocarbon dating, we shall add one more chronological and environmental tool to the many lines which we use to define the climatic and human history of the Pacific.

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