



NEW ZEALAND  
ARCHAEOLOGICAL  
ASSOCIATION

**NEW ZEALAND ARCHAEOLOGICAL ASSOCIATION NEWSLETTER**



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samples were accordingly taken at various levels and subsequent tests revealed the PH count (sic) of one sample to be 4.9 and of the other 5.5. Both thus show a fairly high acidity and would support the theory that had been propounded."

The central idea is that the soil within the hut sites is too acid for acacias. However, before one is entitled to say this, one must show that the soil where they will grow is, in fact, less acid. In terms of the paradigm:-

E group	Measurement E1 (PH inside living site before site lived on)	Procedure X (Being lived on)	Measurement E2 (PH inside living site after site lived on)
C group	Measurement C1 (PH outside living site before site lived on)	—————	Measurement C2 (PH outside living site after site lived on)

Measurements E2 and C2 are, of course, the only ones available to the archaeologist.

It can be seen that we are able to test the hypothesis that the use of bracken has acidified the soil because we do have a control: an area which has not been subjected to the process which has prevented the growth of vegetation inside the hut sites. We can use the information which this will give us simply by sampling the areas around, as well as within, the hut sites.

If we take these two parallel series of samples from within and without the hut sites we will find, if we measure each member of each set, that each set tends to group itself about a mean or average value, with a certain spread among the values. The means of the two sets will also differ. It is by comparing the difference between groups with the variability within groups that one can assess the stability of this difference. If the difference is likely to arise by chance, one can say that the difference is not significant, and that the experimental treatment X produced no effect: if the difference is sufficiently large, the treatment may be said to have produced a real effect. If there is no effect the hypothesis must be re-examined. For instance, in our case it is conceivable that habitation could compact the floor of the hut sufficiently to make it unattractive to plants.

The point is that only by making comparison measurements is one meaningfully able to place one group as high and another as low. We do not know, and we are not told, what the basis was for describing PHs of 4.9 and 5.5 as "fairly

high acidity": until we do know, there is the possibility that another worker, given the same data, might describe these values as showing low acidity.

There is here an implied control group which does not in fact exist. It is by making this group a reality that the archaeologist will reduce his chances of misleading himself and others.

#### Reference

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## OBSIDIAN ITS APPLICATION TO ARCHAEOLOGY.

By R.C. Green

The December 1958 issue of this Newsletter carried an appeal to members of the Association for obsidian flakes from archaeological sites for study. The response then was gratifying and allowed the study to commence. Again, however, I issue the same appeal, for our collections are still inadequate for solving fully the problems encountered. At the Department of Anthropology of the University of Auckland we are endeavouring gradually to build obsidian collections from every source and sample collections of waste flakes from fully documented and adequately recorded archaeological sites. I emphasise the need for samples, not one or two scattered surface flakes, and for adequate recording, because without this information, the material has little or no value. Eventually we hope to have materials which will be adequate for investigation of the two goals discussed more fully below.

In the 1958 article it was noted that several American scientists, while investigating the nature of obsidian, had become interested in its properties as a dating tool for the archaeologist. They have since published their results.<sup>1</sup> In addition, an archaeologist, using their methods, made a detailed analysis of obsidian in central Californian sites.<sup>2</sup>

Preliminary results from both investigations were sufficiently encouraging for the National Science Foundation to provide funds for two years additional research. This research is being carried out at a centre in Washington D.C., but is making use of materials from all over the world.

The researchers' project has the following objectives:

"(1) to determine the nature of all possible factors which control or modify rates of hydration; (2) to classify obsidian artifacts and obsidian rock from natural sources on a worldwide basis according to differences in composition and texture, with the possibility that these identifications can give evidence of quarry sources, as well as trade routes and diffusion among aboriginal peoples; (3) to establish definitively regional rates of hydration from which absolute dating can be derived; and (4) to standardize the techniques of the method for routine use in the fields of archaeology and geochronology".<sup>3</sup>

Of these four objectives, one is already being carried out in New Zealand and a second should be undertaken. Firstly, we are at present studying the differences in composition and texture, which identify different quarry sources, with a view to determining the centres and directions of the obsidian trade in New Zealand at different periods. Secondly, as I hope to show below, we should be seeking to establish definitive regional rates of hydration for New Zealand obsidians which will certainly provide relative, and possibly absolute, dates for many of our archaeological sites.

The work on the first goal has progressed very satisfactorily thanks to the considerable assistance of Association members in spotting new sources and supplying samples, as well as an abundance of information supplied by various local people.<sup>4</sup> We have also had the aid of geologists from the D.S.I.R., and most important, the active participation of Dr. R.N. Brothers of the Geology Department at the University of Auckland. While the ultimate success in achieving our second objective will in part be dependent on the results of the scientists in the Washington project, their findings will not furnish actual or relative dates until the technique is applied to materials from New Zealand itself. The application of their techniques here will require the combined efforts of geologists, and archaeologists, as well as assistance from the D.S.I.R. radio-carbon laboratory. To date, no such project has materialised. However, in the discussion which follows, the feasibility of such a project may be evaluated from the information already available. Such discussion will also serve to introduce information about the general properties of obsidian which is a precondition for the understanding of both objectives.

### 1. Obsidian Dating

The following summary is from the two sources already noted (1,2) which cover the principal points concerning obsidian investigations.

Where molten magmas are exuded from the earth's interior, along zones of weakness such as fissures and faults, they pour out on to the surface as viscous lavas. The surface of these lavas may, under certain conditions, be chilled or quenched so rapidly by exposure to the atmosphere, that the process of mineral crystallisation is inhibited and a volcanic glass results. From this viewpoint obsidian is then a volcanic glass in a stage of "arrested development". As a rock it is chemically and physically unstable, consequently it tends to alter through time by devitrification (gradual crystallisation) or hydration (the diffusion of meteoric water from the surrounding environment into the surface of the obsidian). Of the two processes, only the second, hydration, proceeds with sufficient rapidity to be useful archaeologically.

The state of "arrested development", or chemical disequilibrium which characterises non-hydrated obsidian, is under normal conditions balanced or equilised by the surface of the obsidian taking up water from the surrounding air or soil with which it is in contact. Even the most arid conditions provide sufficient water for this process to occur. However, the process does not lead to a complete equilibrium being established with the environment, because of the physical and chemical alterations of the obsidian itself. Thus the end point of this process is another petrological substance known as perlite. Since the process of hydration is carried out by the gradual diffusion of the water deeper into the surface of the obsidian, this results in the continual growth of a layer of hydration or "water saturated" zone in process of chemical and physical change. This zone can be identified and measured.

Hydration begins whenever a freshly exposed or newly flaked surface appears. Thus hydration begins anew whenever man, in the process of manufacturing a tool from a piece of obsidian, exposes a new surface. It continues thereafter at a fairly constant rate under a given set of temperature conditions. For this reason, if we can identify a surface flaked by man and calculate the rate of hydration from its thickness, we can date the artefact.

While it may come as a surprise to some people that it is the temperature, and not the relative humidity of the

environment that is important, there are good theoretical reasons why this is so. As we have noted, the absorption of water into the obsidian is a uniform diffusion process, and the rates of diffusion processes generally are expected to be dependent on temperature. The investigations to date have supported this expectation and shown temperature to be the crucial factor in determining the rate of hydration in any environment.

For these reasons an evaluation of the temperature conditions in New Zealand will provide an estimate of the expected rate of hydration, while archaeological knowledge will provide an estimate of the length of settlement in New Zealand. The two together will in turn, give us an approximation of the range in thickness of the hydration layer we may expect on artefacts fashioned by Polynesians settled in New Zealand, and permit a general evaluation of the method's potential for dating archaeological sites in this country.

Eventually it will be desirable to know the soil temperatures of New Zealand sites, since it is those artefacts with stratigraphic contexts that we will most often wish to date. However, at present such information is not recorded, and we are forced as the previous investigators were, to refer to the mean annual temperature records.

For the purposes of obsidian dating New Zealand, fortunately, displays no extreme temperature variations. With the exception of high mountain areas and the driest part of Central Otago, the country can be placed within a single climatic category characterised by a temperate rainy climate with warm summers and no marked dry season.<sup>5</sup> Mean annual temperatures in the North Island range from 53 to 59 degrees Fahrenheit, and those in the South Island from 49 to 54 degrees. Moreover the lowest and highest temperatures for settled parts of New Zealand seldom exceed 20 and 90 degrees Fahrenheit.<sup>6</sup> As a consequence, New Zealand may be expected to have only one, or at the most two, provinces for which the hydration rate would need to be established, and both would lie in the general range of temperature zone rates which have already been calculated.

By employing the three temperate rates established by the American investigators, and assuming, as I believe the present archaeological evidence suggests, that New Zealand has been occupied for up to 1500 years, we may expect samples to fall within the following range of micron thicknesses (one micron equals 0.001 mm):

500 years	-	1.25	and	1.75	microns
1000 years	-	2.00	and	2.5	microns
1500 years	-	3.45	and	3.3	microns
2000 years	-	3.3	and	3.6	microns

As errors in measurements of hydration layers between two observers are not more than 0.2 microns<sup>7</sup> no difficulty should be experienced in observing significant differences in the hydration layers of artefacts from New Zealand sites. Also the rate of hydration in New Zealand can be expected to be sufficient for the observed differences to be capable of classification by 200 or 250-year intervals, and the total sample collections from one site or layer tested statistically against those from another to determine whether these differences are significant. Thus whether or not we can determine a precise age scale for individual samples, we should be able to order sample collections and the sites or layers they date in a relative sequence. We hope to test, with reasonable chances of success, these expectations on the materials from the Kauri Point site in the next few months.

The composition of obsidian is a mixture of some eight major components, plus a great number of minor components, but even the proportions of the major components may vary.<sup>8</sup> Therefore, as in many countries, obsidians in New Zealand occur in a range of reflected colours, both pure and mottled, or banded. For similar reasons the character of specimens seen by transmitted light also varies widely. However, experience has shown that the variation within a petrographic province is usually small, the greater variation occurring between provinces. To date this generalisation seems to hold for New Zealand as well. Thus the materials from several sources in the Taupo-Rotorua-Mangakino area are difficult to distinguish, but are quite distinct from those of Mayor Island. Specimens from both of these provinces differ in turn from those thought to belong to the Whitianga group of rhyolites on Great Barrier, Fanal, Arid and Mokohinau Islands. These differences are probably all due to differences in chemical composition or to physical properties relative to cooling.<sup>9</sup> Their importance lies in the fact that obsidians of different composition may have different rates of hydration, a different temperature coefficient of the rate of hydration<sup>10</sup> and different refractive indices.

For these reasons separate hydration rates for obsidians from each province or source will have to be determined. They can then be compared to determine whether or not there are significant differences in their hydration rates, and whether or not these are of an order that must be taken into account. However, we cannot assume either position at the outset of our investigations.

On the other hand these differences do allow us to trace more accurately the source of each obsidian. Moreover, we have found that we can check conclusions based on hand specimen and microscopic differences with the aid of the refractive index. The only warning here is that if one gets material from the hydrated layer, it will possess, because of greater water content, a higher index of refraction. Consequently any single microscopic shard which exhibits an unusually high refractive index in a sample preparation is suspect for these reasons.

## 2. Obsidian Sources

The progress in attaining the second objective, of specifying the differences in composition, texture and refractive indices which indicate quarry sources, and the pinpointing of the locations of these sources, has been slowed by the author's absence from the country for two years. However, investigations in the last six months have added a considerable amount of information. In 1960 Dr. R. N. Brothers made microscopic examinations of specimens from 117 localities in the North and South Islands, and several hundred refractive index determinations were recorded for samples from these localities. From this data some broad-scale patterns of trade emerged, but these are in need of further refinement. At the same time all the source materials then available to us were studied. These results, plus those from the more recent source samples, will be presented in a future paper. The comments that follow are general ones only, covering work in progress, and are not to be considered as final conclusions.

The use of refractive indices as an aid in identifying sources has been applied in the south-western portion of the United States and in Japan with some success. Its aim is to assist in the identification of materials from different sources, and to serve as a check on differences which can be observed in a hand specimen or under the microscope. If the refractive indices consistently correlate with selected features that are more readily observable, we may assume after sufficient testing that these features alone are adequate to indicate the source, and dispense with the more laborious laboratory process. To date our results indicate a fair success in this direction where different geological provinces are involved, but less success within a province. This in accordance with the expectation of greater variation between the provinces than within them.

We have tentatively defined three provinces in which obsidians are known or thought to occur. They are as follows:

Mayor Island

Because the geology of Mayor Island was studied by Dr. Brothers, there is an excellent range of obsidian source samples from it. These and others gave a distinctive, clear yellowish-green colour to transmitted light. They also exhibited a distinctive range of refractive indices from 1.507 to 1.497.

Taupo - Mangakino - Rotorua

Trevor Hosking has furnished most of the obsidian samples and the precise location of obsidian outcrops in the Taupo area. Those along the Whangamata Fault, which lie on its upthrown side in the area of the Ben Lomond Station, have been investigated. Boulders in Whangamata Bay derived from this source, before we could place it precisely, yielded the following range of refractive indices: 1.4894 - 1.4867.

Less than 18 miles to the north, on the north-eastern side of Lake Maraetai, Mr. G.P. Drummond has pinpointed a second outcrop source covering a sizable area. Presumably the river boulder samples sent by Mr. T.D. Kershaw, from a river terrace immediately downstream from the confluence of the Waikato and Waipapa Rivers, is related to this source. If so, the refractive indices of the river boulder samples support the hand specimen results, for the source samples supplied by Mr. Drummond, and those from the river are very similar in hand specimen to those from Whangamata. The refractive indices for the river terrace specimens of 1.4940 to 1.4866 parallels the Whangamata range of 1.4894 to 1.4867.

Other obsidian sources have been pinpointed in Hemo Gorge and on the shores of Lake Rototiti, but to date neither has furnished flake quality obsidian. In hand specimen however, both are distinguishable from the Taupo-Mangakino examples. Still other sources of obsidian have been reported throughout this province, but at present they are not sufficiently well localised to qualify for discussion here.

Whitianga Rhyolite Group

The formations of this group are found on Great Barrier, Fanal, Arid and Mokohinau Islands. The precise locations of sources in this province are at present unknown, but there is considerable evidence to indicate that obsidian sources are to be expected. Thompson notes a minor green-black obsidian slightly amygdaloidal, and lacking perfect conchoidal fracture on Fanal Island, but its position is uncertain.<sup>10</sup> Mr. J. Schofield provided samples of a clear light-grey

obsidian from Arid Island, again without precise geological context. Finally Hayter,<sup>11</sup> in his report on the geology of Great Barrier Island, noted that previous investigators had found obsidian on Te Ahumata, a suggestive Maori name, and in the Hobson formation. He, however, found no samples in situ.<sup>11</sup>

The Hobson formation on Great Barrier will be further explored over the Easter vacation to see if any sources can be pinpointed. Both the obsidians from Great Barrier and Arid Island yield lower refractive indices than those of other provinces, the Arid Island samples ranging between 1.4873 and 1.4857. The material is a light grey in hand specimens, and very clear when held to the light. A slight brownish-purple cast appears when a specimen is held to strong transmitted light.

The problems of identifying sources and assigning samples from archaeological sites to these sources may be outlined as follows. First it is necessary to pinpoint a source precisely, and obtain sufficient samples from it to be sure they are representative of the full range of specimens that can be found there. Second, it must be demonstrated that flake quality<sup>12</sup> obsidian can be obtained from the source. A number of obsidian sources may not have been used by the Maori for this reason, even when they were known to him. Third, the availability of the obsidian must be demonstrated. Sources like those in the road cutting at Lake Rotoiti may not always have been exposed, for instance, while in other areas the source may not be completely exposed, but obsidian boulders derived from it may be plentiful. Fourth, it must be shown that the Polynesian settlers of New Zealand used a source, either by finding a mine or quarry, or demonstrating that obsidian from that source is found in archaeological sites. Finally, it must be demonstrated that obsidians from one source are not being mistaken for those from another. Clearly the determination of obsidian sources and preparation of an analysis which will present a true picture of the trading patterns that developed around them, is fraught with difficulties. But the sources of quality obsidians in New Zealand seem to have been sufficiently restricted, so that a solution to most of these problems is possible. It may be concluded then, that the study of obsidian in New Zealand has a potential that we can no longer afford to ignore.

#### References

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- (4) I wish to thank especially Mr. Trevor Hosking, Mr. T.D. Kershaw, Mr. R. Cook, Mr. D. Stafford, Mr. G.G. Hunt, and Mr. G.P. Drummond for especially valuable contributions.
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- (6) Ibid, Map 8.
- (7) Friedman et al. 1960. p481.
- (8) Ibid, 484.
- (9) Ibid, 485.
- (10) Thompson, B.N. 1960. Sheet 2B - Barrier (1st Ed.) "Geological Map of New Zealand 1:250,000". D.S.I.R. Wellington.
- (11) Hayter, I.B. 1954 The Geology of the Southern and Central Portion of Great Barrier Island. M.Sc. Thesis. Auckland.
- (12) I owe this term to Dr. Brothers.