ARCHAEOLOGY IN NEW ZEALAND

DATING NEW ZEALAND PREHISTORY USING OBSIDIAN HYDRATION

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INTRODUCTION

The attempt to establish the date of first human settlement of New Zealand continues, as this issue is not yet satisfactorily resolved (Anderson 1991; Sutton 1994). One project underway at present is searching palynological and sedimentological evidence from swamps and lakes in Northland-Auckland for evidence of human impact and radiocarbon dating it (Elliott *et al.* 1993, 1994).

However, we are aware that the articulation of palynological-sedimentological dates with archaeological research strategies *per se* is often problematic. Specifically, dates of first impact defined palynologically and archaeologically seldom match (for examples see Kirch *et al.* 1991 and Steadman and Kirch 1990 for Mangaia in the Southern Cooks see also Kirch 1993; Davidson *et al.* 1990 and Southern 1986 for Viti Levu, Fiji; and Spriggs 1989 for an overview).

In order to address that problem in New Zealand we have obtained support for the development of obsidian hydration dating (OHD). Specifically, OHD could be used to date artefacts from a statistically robust sample of archaeological sites within the area of earliest identified human impact, as defined in the palynological-sedimentological research. One year's fully-funded research will be used to develop the method. An initial application will occur, with forty samples dated, as part of a project of archaeological research underway on Matakana Island in the western Bay of Plenty (Felgate *et al.* 1992; Marshall *et al.*, 1994; Sutton 1993; Sutton and McCracken 1991).

The objectives of the OHD work are to develop and apply scientific archaeological methodologies capable of 1) dating Maori arrival based on artifacts from early settlement sites and 2) measurement of the rate and direction of dispersal following first colonisation by developing and applying obsidian hydration dating of New Zealand obsidian.

Archaeology in New Zealand is substantially compromised by the cost and imprecision of radiocarbon dating - its principal means of age determination used at present. High quality Accelerator Mass Spectrometry (AMS) dates cost *c.*\$800 (NZ) each and although the radiocarbon measurement may be very accurate the resulting 'date' of human activity may still suffer from problems of inbuilt age (Anderson 1991), marine reservoir effect (McFadgen and Manning 1990; Stuiver, Pearson and Braziunas 1986) and uncertainty in the calibration curve during the crucial periods of New Zealand prehistory (Stuiver and Pearson 1986).

At present the cost of radiocarbon dating and the problems associated with it (see Taylor (1987) for a review) mean that the development of chronological control and debates over interpretation of dates are issues which often seem to dominate the literature (Anderson 1991; Anderson and McGovern-Wilson 1990; McGlone et al. 1994; Sutton 1987a,b, 1994). This has led to calls for the development of alternate dating methods (Anderson 1987). Other techniques have been attempted but none has yet worked adequately.

Elsewhere archaeologists use obsidian hydration dating (OHD) successfully (Friedman and Smith 1960; Taylor 1976; Michels and Tsong 1980; Clark 1984; Meighan and Scalise 1988; Hughes 1989; Hatch *et al.* 1990). It appears that recent technical advances in hydration measurement, elemental analysis and experimental control make it possible for this to be done in New Zealand, building on pioneer work in the field which is briefly reviewed below.

Successful application of obsidian hydration dating here would allow: the rapid and accurate age assessment of large numbers of sites, thorough dating of crucial sites (Anderson and Smith 1992:333), positive identification of sites of the colonization phase (Anderson 1991:768), the fine-grained time scaling of environmental impact (Anderson and McGlone 1992; McGlone *et al.* 1994) and real time control on processes of human dispersal (McFadgen 1982; Caughley 1988; Anderson and McGovern-Wilson 1990) and regional diversification, which are only very generally dated at present (Davidson 1984; Green 1975; McEwen 1966; Mead 1984).

Obsidian is found in many pre-European archaeological sites, in all regions of the country (Seelenfreund and Bollong 1989). Obsidian from Mayor Island is the most common and widely distributed of the more than twenty obsidian sources which exist (Leach and de Souza 1979; Seelenfreund 1985) Therefore, we are developing OHD of this material initially, while noting that the method once developed could be applied to each of the other obsidians. This reduces the number of potential geochemical error sources to a minimum while not compromising the potential of OHD. Obsidian was transported to archaeological sites for use in the manufacture of small hand-held tools and surfaces which were flaked for that purpose and fissures formed near points of precussion at the time of flaking (Ambrose pers. comm. 1993) can be identified. Therefore, OHD dates human activity directly, whereas in many cases radiocarbon dating does not (Taylor 1987).

Obsidian Hydration Dating has been shown to be capable of providing inexpensive, rapid, and accurate relative and absolute dating in parts of the world where obsidian is common (Meighan and Scalise 1988). In California there are over eight OHD laboratories, most of which are associated with departments of Anthropology, and these have provided over 13,000 hydration readings since 1960 (Meighan 1988:3).

Research on OHD in New Zealand was first undertaken by Ambrose and Green (1962; Green 1964). They reported seeing and making hydration measurements on Mayor Island obsidian and we have recently confirmed the existence of hydration bands on their samples using our equipment (Nikkon Optiphot POL microscope with 100X oil immersion lens and 1.4 NA oil immersion substage condenser). Leach continued the work (Leach 1977; Leach and Naylor 1981; Leach and Hamel 1984) by attempting to measure hydration optically, studying variation in New Zealand wide effective hydration temperatures and considering the effect of geochemical variation on hydration rates. After experiencing difficulty seeing and optically measuring hydration bands Leach began an important series of experiments using equipment to measure elemental profiles across the hydration front using nuclear methods and then sputter induced optical spectroscopy (Leach and Hamel 1984). These methods, although potentially very accurate, have not been routinely used since the late 70's (Tsong *et al.* 1978; Leach 1983), partly due to cost of specialized equipment.

For any given temperature and geochemistry the diffusion of water into the surface of freshly fractured obsidian will occur at a constant determinable rate creating over time a hydration layer which can be observed under polarized light using a high powered microscope. Therefore, hydration dating requires control of the following: a) effective hydration temperature (EHT); b) obsidian source geochemistry; c) the development of a source specific hydration rate or rates; and, d) the ability to accurately measure very thin hydration bands.

In what follows we outline the research steps necessary to the successful application of OHD in New Zealand and the means by which we are attempting to achieve them.

EFFECTIVE HYDRATION TEMPERATURE (EHT) AND HUMIDITY

We are extending work by Leach using the method developed by Ambrose (1980, pers. comm., 1993) (Friedman *et al.* 1990; Trembour *et al.* 1988). This will involve the placement of pairs of zeolite diffusion cells in 60 (Jones et al. nd) sites (archaeological and non-archaeological) in the region between North Cape, the western Bay of Plenty and Kawhia Harbour. The range of effective hydration temperature (EHT) will be determined using two, six month cycles at each location. This will improve our knowledge of the range of EHT in the region and provide precise data for a substantial number of sites. A more detailed experiment will be conducted in one site in Northland, to establish intra-site variation.

In this area examination of within site variation in EHT will be carried out by placing multiple sets of cells at varying depths (10 cm, 30 cm, 90 cm) and locations within a series of 5 sites This was done during early November 1993 (Jones *et al.*n.d.)

OBSIDIAN SOURCE GEOCHEMISTRY

Hydration rates vary between sources, due to inter-source geochemical variation, and this has led to our concentration on Mayor Island obsidian. Leach suggested that variation in the amount of fluorine may cause significant variation in hydration rates (1981:38). We are attempting to control very carefully for these possible effects by using the Proton Induced X-Ray Emission (PIXE) elemental analysis facility at the University of Auckland to define sample geochemistry. This will identify the geological source of obsidian artefacts, allowing non-Mayor Island specimens to be eliminated (Neve, Holroyd, Barker and Sheppard n.d.). Combined with Proton Induced Gamma Emission (PIGME) this analysis will also identify any anomalies (e.g., fluorine variation) in the elemental compositions of the analyzed artefacts which could influence hydration rates.

THE DEFINITION OF A SOURCE SPECIFIC RATE

We will attempt this using two independent methods; an experimental approach and one based on recent work by Ambrose and Stevenson (n.d.) which shows a strong correlation between hydration rate and water content of the obsidian.

Recently developed experimental methods for creating hydration at temperatures between 100 and 200°C while controlling relative humidity using Parr stainless steel reaction vessels (Michels, Tsong and Smith 1983; Stevenson, Carpenter and Scheetz 1989; Mazer, Stevenson, Ebert and Bates 1991) are being applied by Chris Stevenson, who is a FoRST-funded researcher on this project. The application of these recently developed methods will allow more accurate determination of an experimental hydration rate for Mayor Island obsidian than was obtained after limited early experimentation (Ambrose 1976).

Recent work by Ambrose and Stevenson (n.d.) suggests that it is now possible by accurately measuring density to develop specific rates for individual pieces of obsidian. This means that sourcing is not a required first step using this approach.

ACCURATE MEASUREMENT OF HYDRATION BANDS

The ability to measure hydration rims with a high degree of accuracy and precision is fundamental to OHD, particularly in New Zealand where the duration of human settlement is relatively short (for a review see Anderson 1991; Sutton 1994). Leach and Naylor (1981:46) have measured rims on New Zealand obsidian of between 0.9 and 1.5 microns using elemental profiling and have indicated rims should range from 0 to 3.0+ microns over the last 1000 years in the Bay of Plenty to Houhora region, where effective hydration temperature is by their calculation 17.1-17.9°C. This range is routinely measured optically in California. In fact, recent research on obsidian flakes which were struck by Ishi, 'the Last of the Yahi' (Kroeber 1961) in 1915 AD, has shown that it is possible to measure hydration rims under 1 micron with a high degree of accuracy (Origer 1990).

Leach and Naylor reported considerable difficulty in defining the 'fronts' or inner margins of hydration bands and concluded (1981:34) that Mayor Island obsidian produces diffuse fronts which were impossible to measure accurately using optical methods. However, a new technique is now available which will overcome this problem. Sheetz and Stevenson (1988:116) have noted that diffuse fronts are common in California and that the use of an image splitting eyepiece with specific focusing techniques results in measurement error which is less (by a factor of 10) than the resolution of the best optical system (0.21 microns). In a second major advance, Ambrose (n.d.; pers. comm., 1993) has recently applied computer image analysis technology to the problem of rim measurement and achieved a measurement resolution error of 0.11 ± 0.002 microns. Furthermore, the Ambrose image analysis technique can produce a statistical sample of measurements for a hydration band rapidly and at a very modest cost per specimen. The image analysis equipment necessary to this task have been bought by the Centre for Archaeological Research.

CONCLUSION

Given recent technical and experimental improvements in OHD, and rigorous control over the variables discussed above, we will be able to provide a dating method capable of solving a number of the previously intractable problems in New Zealand archaeology. The research plan we have developed is designed to overcome the effects of poor control over effective hydration temperature, volcanic glass chemistry and in-built age in radiocarbon dates which have limited the usefulness of OHD in Hawaii (Graves and Ladefoged 1991).

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