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Trialing Geophysical Techniques in the Identification of Open Indigenous Sites in Australia: A Case Study from Inland Northwest Queensland

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Introduction

The use of geophysical techniques as an aid to archaeological investigations has become common-place, however these methods have only occasionally been applied in Indigenous Australian archaeology. This is despite recognition (and recommendations) since the 1970s that such approaches have the potential to yield positive results in such contexts (e.g. Connah *et al.* 1976; Stanley 1983; Stanley and Green 1976). Australian archaeologists have perhaps been reluctant to embrace these techniques because of their perceived high cost (both of equipment and specialist staff) and the subtle nature of subsurface Indigenous sites as geophysical targets. Nevertheless, there have been a number of recent applications of these techniques in Australia, particularly in relation to burial and hearth sites. We report the results of a pilot study conducted in northwest Queensland. This study aimed to test the applicability of geophysical methods being routinely employed to locate a variety of open site features (particularly hearths and middens) as part of reconnaissance surveys. While not being entirely successful, this study demonstrated that certain archaeological features can be readily identified using geophysical techniques, though further research and trials should be carried out to refine the uses of these techniques to allow their more widespread applicability.

Characteristics of Hearth and Midden Sites

Heat retainer hearths are ubiquitous in many parts of Australia, typically appearing in surface exposures as small mounded features with a locally available raw material – typically stone, clay or termite mound – used as the heat retaining source. While the majority of dated hearths have proved to be Holocene in age (e.g. Holdaway *et al.* 2005; Robins 1996; Wallis *et al.* 2004) hearths of greater age have been dated (e.g. Allen 1998; Smith *et al.* 1991; Veth *et al.* 1990). Their widespread occurrence and ease of dating means that hearths can be extremely useful for establishing chronologies in parts of Australia where few other such possibilities exist. Unfortunately, many decades of cattle and sheep grazing have had a negative effect on the integrity of hearths, with heat retainers sometimes so dispersed that the primary site location can no longer be ascertained. Increased erosion rates caused by ungulates have also accelerated exposure of such sites.

Historical documents reveal that middens composed predominantly of freshwater mussel shells were once another

relatively common site type along watercourses in inland Australia. Such sites also afford archaeologists abundant opportunities to establish regional chronologies, as well as to examine questions related to subsistence strategies, seasonality and resource use. Like hearths, middens exposed at the ground surface are vulnerable to physical destruction through stock treadage, and the chances of finding such sites intact is therefore substantially reduced even when other extensive evidence of Indigenous occupation occurs (e.g. Crothers 1997; Wallis 2007; Wallis *et al.* 2004). Where middens are found, their surface expression is often minimal, with the shell being highly fragmented and dispersed and only the subsurface shell material appearing to be intact (e.g. Wallis 2007). Consequently, such sites are often difficult to identify using standard surface survey methods.

Both hearths and middens are important components of the inland archaeological record, but both site types are prone to destruction when exposed at the ground surface. This ongoing destruction means they are an urgent contemporary heritage management concern. The ability to identify such sites in an intact subsurface context before they have been exposed and disturbed or destroyed would greatly assist archaeologists and heritage managers. Geophysical techniques such as electromagnetic induction (EMI) and magnetometry provide a possible means of accomplishing this.

EMI and Magnetometry Techniques

Magnetometry has a long history of use in European and North American archaeology. It measures local perturbations in the earth's magnetic field caused by accumulations of ferrous material which may be from an anthropogenic or a geological origin (Reynolds 1997). There are a variety of sensor types, sensor configurations and survey methodologies for magnetometry which are variously employed depending on the target material and survey budget.

Electromagnetic induction (EMI) typically measures two components of an induced magnetic field: the quadrature phase, which is linearly related to the ground conductivity, and the in-phase component of the induced magnetic field, which measures magnetic susceptibility. Because each measurement is not solely dependent on ferrous material, EMI is capable of detecting a wide range of features including soil type, sediment type, bedrock location or presence of cultural material, and has been applied with success at archaeological sites for a variety of tasks (Kvamme 2003). Furthermore, EMI can identify changes to soil conductivity caused by both buried objects and associated sedimentary disturbance (Nobes 2000:716; Nobes and Tyndall 1995:266).

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Detecting Hearths and Middens

The results of fires, including hearths, have been a particular target of magnetometer investigations as burning creates magnetic anomalies either through the enhancement of the soil's magnetic susceptibility (e.g. Dalan and Banerjee 1998) and/or the contribution of wood ash (Linford and Canti 2001; McClean and Kean 1993; Peters *et al.* 2001). The type of anomaly produced by an intense, constrained fire such as associated with a hearth is quite different from that associated with bushfires, where 'the very low thermal conductivity of the ground usually results in uniform and insignificantly weak magnetizations' (Stanley and Green 1976:55). Hence there is little possibility that the anomalies likely to be produced by bushfires and hearths could be confused.

Likewise, the physical properties of middens make them amenable to subsurface detection using non-invasive geophysical techniques. Direct detection of midden material is based on its difference from background levels of response using such techniques as magnetometry, EMI, ground penetrating radar, direct current resistivity or seismic methods (Steinberg *et al.* 2007; Whiting *et al.* 2001). Furthermore, the relationship that often exists between middens and burning has been exploited to locate middens in the same manner as is used for hearths (e.g. Frederick and Abbot 1992).

Fanning *et al.* (2005) recently reported a pilot study in western New South Wales using a gradiometer (a multisensor magnetometer) to confirm that hearths produced a magnetic signal. They demonstrated that these features produce a magnetic response substantially higher than that of the surrounding ground surface, confirming the experimental findings of others (e.g. Linford and Canti 2001). Their results suggested a wider application for these methods; however, the gradiometer was used only to assess the presence and magnitude of the magnetic response from known hearths rather than as a tool to locate them. Because the methodology employed did not interrogate areas away from known hearths or incorporate any positioning information it is unsuitable to test the application of magnetometry as a reconnaissance tool. Nevertheless the results suggested that with an alternative survey methodology a gradiometer might well be a useful tool to detect previously unlocated hearths.

A Pilot Study in Inland Northwest Queensland

In order to assess whether EMI and magnetometry techniques could be successfully applied in an open survey context, a pilot study was undertaken in an area known to contain hearths and middens (Domett *et al.* 2006; Wallis 2007), as well as the partial skeletal remains of an 'Old Person' (the preferred term for a burial) wrapped in paperbark which had been recently reinterred in the vicinity. These archaeological features, along with non-cultural mudstone eroding at the surface and substantial erosion gullies, provided an ideal study site to test the potential of geophysical techniques. The hypothesis was that if these techniques could successfully relocate and identify such known features, they might also be employed in the search for such sites below the surface where a surface expression was not visible.

The study area is located approximately 100km south of Richmond in inland northwest Queensland, in a region of

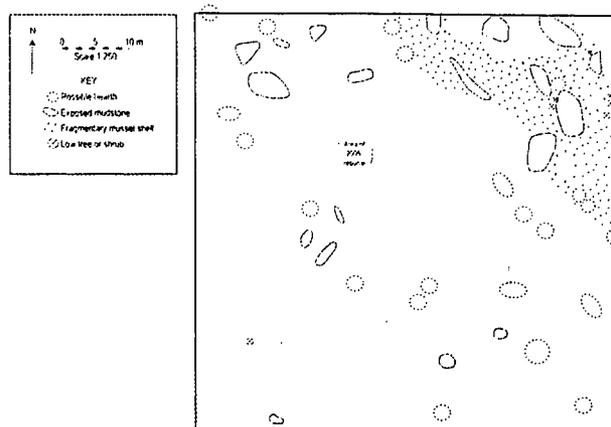


Figure 1 Plan showing recorded surface features within the 50m x 50m survey grid.

gently flat to undulating plains of low relief. The regional geology is dominated by surface exposures of Allaru Mudstone, with small outcrops of siliceous pebbles, gravelly deposits and silcrete occurring on terraces and low ridges. Major watercourses and creeks are dominated by deep, fine-textured Quaternary alluvium consisting of sand, silt and clay, with the dominant soil type being calcareous black clay.

Methodology

A 50m x 50m survey grid was established over an area encompassing a range of archaeological and non-cultural features, using an automatic level and survey tapes (Figure 1). Survey lines were located within this grid using tapes, with station locations collected using a Garmin 12XL navigation GPS with an external antenna. The geophysical surveys were conducted over the course of a single day using a line spacing of 1m orientated in an east-west direction.

Both magnetometry and EMI techniques were employed, chosen on the basis of their inexpensive nature, wide availability, ease of execution and the nature of the anomalies we expected to encounter. Data were collected with:

- A Geometrics G-856 proton precession single sensor magnetometer tuned to a background level of 40000 nT. Data were automatically collected along each survey line at intervals of 5 seconds while the operator walked at a slow, constant rate, with the sensor oriented north at a consistent height.
- A Geophex GEM-2 EMI instrument. Data were collected at a rate of 10 per second at frequencies of at 7875 Hz, 17575 Hz, 26275 Hz, 35275 Hz and 47975 Hz (with higher frequencies representing shallower depths of penetration for the same ground conductivity).

All collected data were gridded with MagPick software using a spline interpolation (Smith and Wessel 1990) with an X and Y interval of 0.1, a tension of 0.25 for 4000 iterations with a convergence limit of 0.1 using the highest and lowest data values as data limits. Results are displayed as simple contour maps with 250 non-equalised colour points and overlain contours.

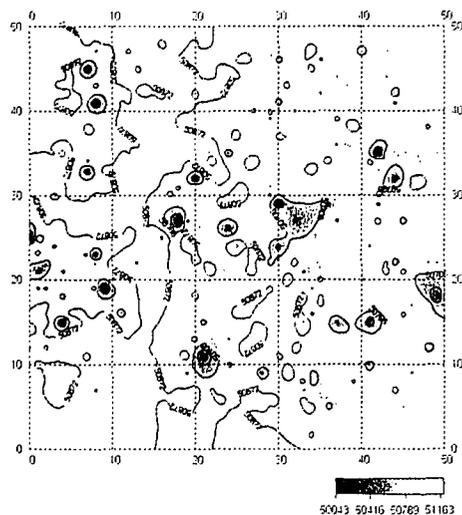


Figure 2 Geophysical survey results: Single sensor proton precession magnetometer.

Results

No *in situ* archaeological material, such as known hearths or middens, were reliably detected using either of the techniques employed in the survey area (Figures 2-3). However, the reburied skeletal material was detected using both techniques (although only at some frequencies of EMI) suggesting a significant disturbance to the physical properties of the soil in this area caused by the digging of the reburial grave. Non-archaeological features were somewhat better identified using the geophysical techniques. The eroded area in the northeast of the survey area is shown in all EMI frequencies, but is most evident in the higher frequency maps. Exposed bedrock appears detectable, although poorly spatially resolved in the higher EMI frequencies. Several magnetometer anomalies not associated with any obvious causes at ground surface were also observed. These anomalies have not yet been ground-truthed and therefore may or may not represent subsurface archaeological features.

In summary, using a routine field survey strategy, the trialled methods did not successfully locate surface hearths and middens in the study area despite there being a previously established correlation between these features and a detectable geophysical response. One possible reason is that the survey methodology was not sufficiently robust to locate these features reliably.

Discussion

As noted elsewhere (Connah *et al.* 1976:153), successfully identifying targets of this nature will depend largely on the distance between survey transects. We have shown that attempts to identify hearths using a survey grid spacing of 1m will not result in the universal detection of the features. To be confident of identifying hearths in open contexts survey transects would need to be carried out every 10–20cm (Connah *et al.* 1976:153; Stanley 1983:84). This suggested survey density was not used in our survey because decreasing the line and station spacing increases survey time required over a given area (i.e. a halving of line and station spacing would result in a four-fold increase in survey duration). Geophysical surveys are not likely to be employed as a reconnaissance tool

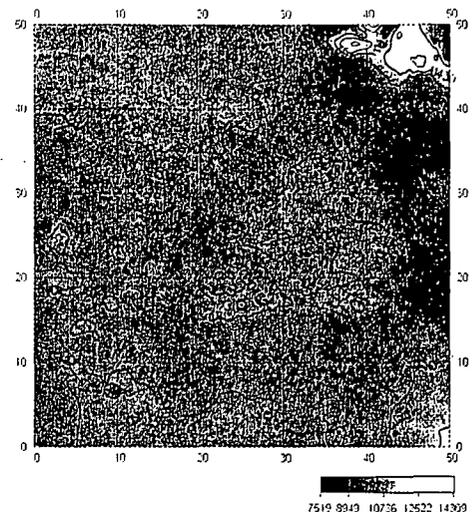


Figure 3 Geophysical survey results: Electromagnetic Induction, Quadrature Response 47975 Hz.

if they are excessively time intensive and therefore expensive. As hearths and middens are extremely subtle the survey needs to be both expedient and comprehensive, a balance we hoped to achieve with 1m line spacings. This has been demonstrated to be erroneous, since the surveys, while conducted relatively quickly with this methodology, were not successful in detecting the known targets.

Similarly we thought the increased survey speed available from using a handheld GPS rather than a tightly controlled survey grid would overcome the disadvantages of decreased positioning accuracy. Despite the strong correlation between the reburial location and recorded anomalies – suggesting the positioning system used was not entirely ineffective – this does not appear to be the case. We therefore think another positioning system (e.g. differential GPS, submetre GPS or survey tapes) may have yielded a better result, due to the ability of these techniques to provide a higher degree of spatial accuracy to located anomalies.

We suggest that further investigation of the application of such techniques to hearths and midden sites in the Australian context should be pursued, to develop a robust methodology that can be rapidly deployed with a high level of confidence and success. The authors intend to pursue further research on the applicability of these techniques to such sites with a focus on the most appropriate survey methods to achieve a robust result in the least amount of field time.

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