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Geophysical remote sensing of a historical aboriginal gravesite in Quairading, Western Australia

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SUMMARY

Burial sites have extreme cultural significance to societies around the world. Until recently, insufficient recognition of Aboriginal heritage in Australia has led to a very poor understanding and documentation of many culturally significant locations, including burial sites. In some cases, sites have been preserved through the efforts of local people; however, others were subsequently redeveloped or even completely destroyed. Local Aboriginal people are usually the best source of information regarding these locations and can identify broad regions with historical significance, but seldom do they provide precise details about individual grave locations. There are still many Aboriginal gravesites throughout Australia where the exact burial locations are unknown. Locating gravesites – and doing so in a way that minimises site disturbance – is paramount to any investigation and preservation program. For efficient investigation of large areas, geophysical remote sensing provides practical and non-invasive tools for investigation of large poorly documented burial areas.

The UWA Society of Exploration Geophysicists Student Chapter, in conjunction with the South West Aboriginal Land and Sea Council, acquired several near-surface geophysical surveys over a known aboriginal burial site near Quairading, Western Australia. Multiple techniques were used to delineate possible grave locations, including ground penetrating radar (GPR), magnetics and conductivity. While work is ongoing with the data processing and integration, and future surveys are planned, early indications show anomalies that may be related to burial locations.

Key words: archaeology, near-surface, graves, GPR, resistivity, conductivity.

INTRODUCTION

Identifying historical burial sites, particularly Aboriginal burial sites, is difficult. Exact locations are seldom documented, surface evidence is rarely discernable and can be affected by changes in the land, both natural and anthropogenic, which can lead to enhanced rates of site degradation. Aboriginal graves sites are traditionally unmarked; the deceased are buried without a casket, usually in a seated position. Burial grounds occur either individually or in small groups. Thus, these site present complex targets of small physical dimension and contrast in material properties for near-surface geophysical surveys.

Legislation to protect culturally significant sites, particularly Aboriginal heritage sites in Australia was only introduced in 1984 [Aboriginal and Torres Strait Islander Heritage Protection Act, 1984 (Commonwealth of Australia)]. Prior to this, little effort was made by the government to protect, mark or document Aboriginal sites, leading to high levels of destruction and degradation, compounding the problem of identification. In recent years a more concerted effort has been undertaken to recognise the significance of these sites with determination of exact burial locations as the first step towards protecting these historic sites. Identifying, marking, documenting and formally recognising these sites will prevent further destruction and mitigate site degradation, affording these sites their deserved appropriate respect.

Geophysical surveying is frequently used in archaeological investigations as it allows much larger areas to be covered, identifying areas of interest that can be prioritised by archaeological teams. The non-invasive nature of most shallow geophysical techniques is particularly important for culturally sensitive areas. Application of multiple geophysical remote sensing methods in archaeological studies has been shown to improve discrimination of areas likely to be gravesite locations (Bevan, 1991; Weymouth & Jensvold, 1996; Nobes, 1999; Dionne et. al., 2010).

In 2013 the South West Aboriginal Land and Sea Council (SWALSC) approached the UWA Society for Exploration Geophysics (SEG) Student Chapter to investigate several sites in south-western WA. Figure 1 shows members of the UWA SEG student chapter, a representative of SWALSC, and local community members whom helped prioritize areas of investigation. In the past year, the student chapter has acquired numerous near-surface geophysical data sets at two sites with ongoing investigations planned. This project has allowed members of the student chapter to learn and apply acquisition, processing and interpretation skills to a cause that benefits the general community.

In this paper we present results from an investigation of a known burial site located near Quairading, WA. Ground penetrating radar (GPR), conductivity, magnetic, resistivity and elevation data were acquired during an initial survey. Here, we present the results of the GPR, magnetic, and conductivity surveys and discuss our integrated analysis and the prognosis for using near-surface geophysical surveying to locate historical gravesites in south-western WA.

Figure 1: Members of the UWA SEG Student Chapter, SWALSC and local Aboriginal representatives at the Quairading site.

QUAIRADING SITE SPECIFICS

The Quairading burial site is located approximately 13 km SE of Quairading town centre in Western Australia. Local Aboriginal groups have worked with the current land owner to preserve an area approximately 100 m by 50 m and supplied an overview of burial site location based on recollection. The exact age of the burial sites is not known, with several generations of family groups thought to be buried there. It is not known how many deceased are buried at this location, although oral histories, passed down through the community, indicate at least nine burial sites had surface expressions (mounds) within recent memory. Earliest burials likely occurred while the site was still native bushland, however over time the land was converted to farmland. Recently the landowner agreed to fence off the area that has known gravesites.

Figure 2 shows the area where the geophysical data was acquired. The yellow triangle is a local geodedic marker. The red square defines the 60 m by 40 m area that is fenced off from the rest of the farm. The blue boxes are gravesites identified by a historical document, show in Figure 3. Guided by the local elders we defined a primary area of interest, 40 m by 20 m in extent to be surveyed, which is shown as a yellow box in Figure 2. The ground gently slopes to the north-west, has been used for grazing and potentially was ploughed in the past for crops. There are scattered rocks, with a couple of small rock piles dispersed across the site.

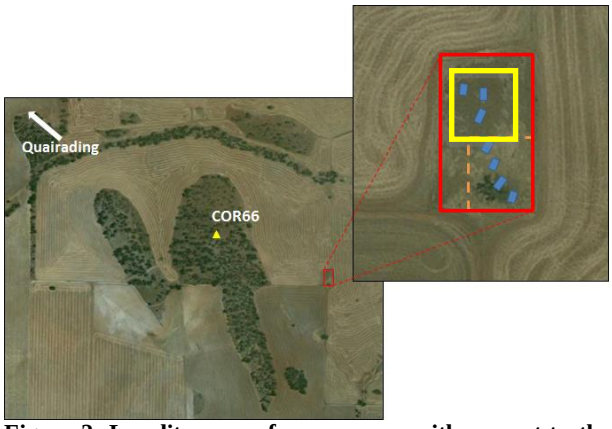

Figure 2: Locality map of survey area with respect to the local geodetic marker. Overlay illustrates details digitised from an historic map, including burial sites, and the survey area selected.

GEOPHYSICAL METHODS

There are several case studies published which have highlighted the importance of using a combination of geophysical methods to delineate imprecise grave locations (e.g., Bevan, 1991; Nobes, 1999; Powell, 2003). It is important to use a combination of measurements as the types of physical contrast in material properties between graves and the background soil and rock is not always known from the outset of the survey – nor is there guaranteed for any material contrast to exists for any particular method. We show the results of GPR, magnetic, and conductivity over portions of the site.

Ground Penetrating Rader

GPR is frequently applied to archaeological surveys due to its very high resolution and ease of acquisition. GPR is an electromagnetic (EM) method which pulses EM waves into the Earth, recording energy scattered and reflected back from variations in material dielectric. The depth of investigation is governed by the skin-depth equation, relying on the frequency of the transmitted signal and resistivity of the subsurface.

We acquired 120 GPR lines using a Mala ProEx GPR system and shielded antennae. 80 lines are acquired at 500 MHz and 40 at 250 MHz along east west transects. The 500 MHz survey data have an inline spacing of 0.04 m and a line spacing of 0.5 m, while 250 MHz dataset has an inline spacing of 0.08 m and a line spacing of 1.0 m. Data processing included applying statics, estimating and applying a de-wow filter. The data were regularised to conform to the same number of traces per survey line.

We generated a 3D volume by concatenating the 2D sections. Figure 4 shows a depth slice averaged over 0.7- 0.8 m in depth from a volume time-to-depth converted assuming a constant velocity. The bottom panel is a profile extract at 8 m along the NS-axis. There are two anomalies circled in the depth slice.

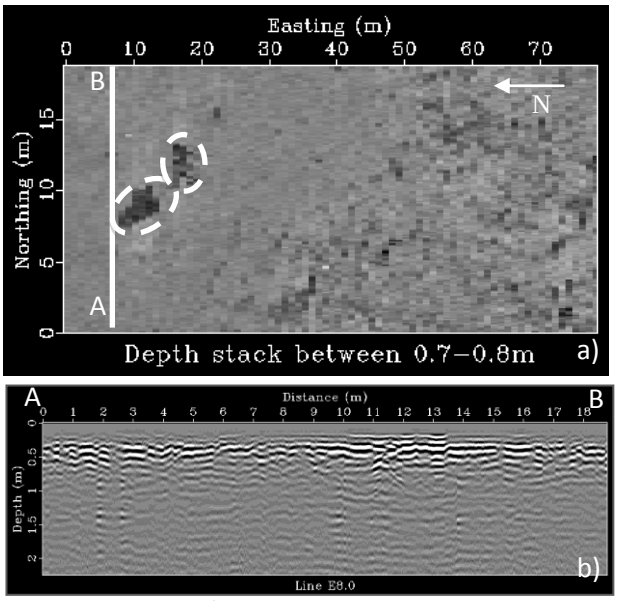

Figure 4: Results from the GPR surveys: (a) averaged depth slice between 0.7-0.8m, A to B denotes the cross line plotted below in (b). The circles indicate anomalies.

Magnetics

Magnetic data were acquired over the 40 m x 20 m grid with line and inline spacing of 1 m. We used two Geometrics G-858 units to acquire basestation and vertical magnetic field (TMI) data. The recorded Magnetic field data were corrected for diurnal variation using the base station readings and then krigged to a regular grid.

Figure 5a shows the total magnetic field data recorded by the upper sensor, while 5b shows the magnetic field gradient between the two sensors. Large anomalies observed at the origin and (17 m, 20 m) are due to exposed rocks near the survey area. Anomalies of interest are circled. The anomalies on the left side of the Figure 5 are spatially consistent with those from the GPR data in Figure 4.

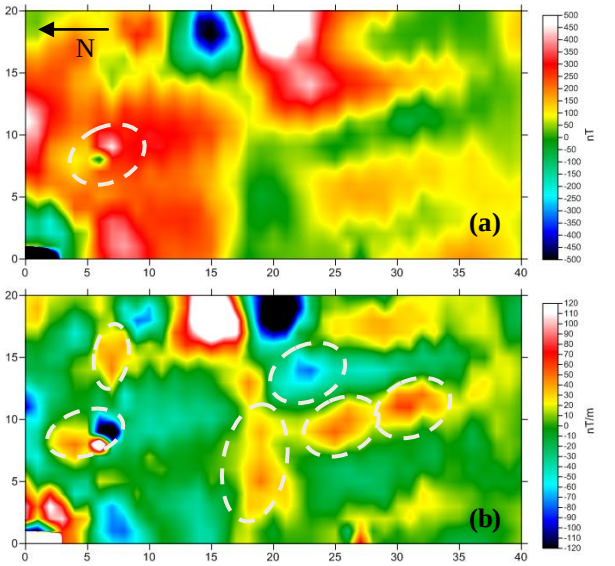

Figure 5: Results from magnetic survey outlining anomalies of interest. (a) Diurnally corrected magnetic field from the top sensor. (b) Vertical magnetic gradient between the two sensors. We interpret the anomalies centred around (1 m, 0 m) and (17 m, 20 m) as effects from outside the survey area.

Conductivity

Conductivity data were acquired using a GSSI EMP-400 profiler, which is an inductive EM tool commonly used for shallow investigation. A time-varying current is applied to the transmission loop, forming a magnetic field, which in turn induces eddy currents in the ground. A receiver coil measures the decay of the secondary magnetic field to calculate in-phase and quadrature field components. The depth of penetration depends on the frequency of the transmitted signal and the resistivity of the Earth sampled at that frequency, with lower frequencies corresponding to greater depth penetration.

Conductivities were observed to be quite low in the survey with the observed anomalies close to the noise floor of the instrument. Figures 6a-c show the results for the 5 kHz, 10 kHz and 15 kHz quadrature data, respectively. Anomalies consistent with the magnetic and GPR data are circled in the 5 kHz plot.

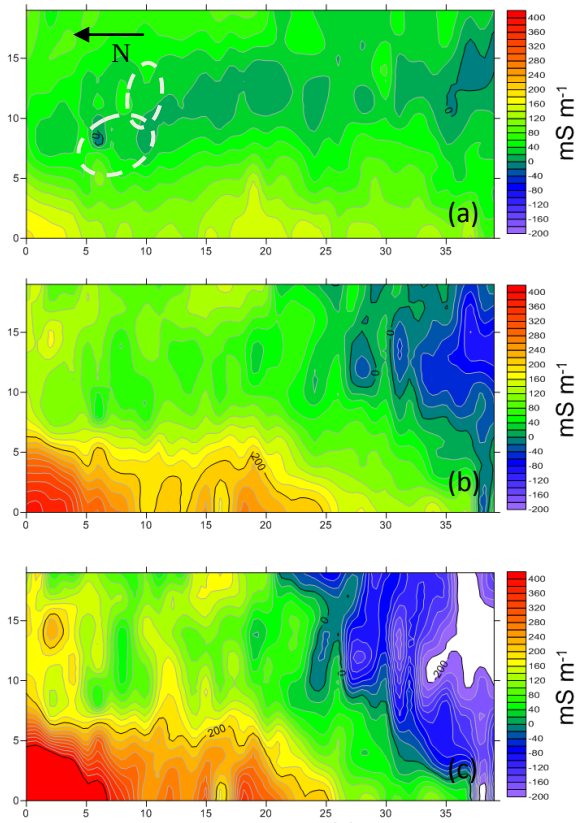

Figure 6: Conductivity maps of for (a) 5 kHz, (b) 10 kHz, and (c) 15 kHz. Anomalies consistent with the GPR and magnetic datasets are circled in the 5 kHz plot (a).

DISCUSSION

Members of the SWALSC uncovered documentation of the burial site, shown in Figure 3, after data acquisition. This historic document illustrates the location of the Aboriginal site in relation to the paddock boundaries and the local high point where CORR 66 is currently located. Seven burial sites within the site are mapped; however, the scale of the map as well as the accuracy and precision of the effort that went into accurately documenting these sites is unknown.

Anomalies are identified in all of the geophysical surveys undertaken. We identify several strong, spatially consistent anomalies between (2,7) and (10,15). This sites exhibit changes in conductivity and magnetic susceptibility on the order of size expected. GPR anomalies indicate high concentrations of small diffractors, which may be indicative of edges of the disturbed ground or items interned in a grave, Local elders identified these are key areas of interest and stones at the surface may be indicative of traditional grave site marking.

Very low conductivity values throughout the survey area hamper interpretation. Negative conductivity anomalies correlate with subdued GPR response in the south-east corner, making delineation of anomalies difficult. Possible SP response in the near-surface, could account for these negative conductivities.

Magnetic field data exhibit anomalies towards the south which could be indicative of other burial sites identified in the historic map. Future experiments will focus on the southern

end of the site, incorporating different techniques to test these anomalies.

The survey area focussed on the north western part of the site, as local elders identified this as a key area of interest. If the markings on the map are roughly accurate, we can conclude that 3-4 sites may be located within our survey area, however, those to the south were not investigated. Future work will more thoroughly examine the area to the south where additional graves are indicated.

This project builds the relationship between the UWA SEG Student Chapter, the SWALSC, local Aboriginal groups and communities. These projects have cultural significance and the need for better protection of these sites is very important. The application of near-surface geophysical techniques in the search for these challenging targets builds the capabilities at UWA for further archaeological applications.

CONCLUSIONS

The UWA SEG student chapter collected geophysical data over a known Aboriginal burial site near Quairading, Western Australia. The data show two consistent anomalies in the GPR, magnetic and conductivity measurements. These anomalies are consistent with the documentation of the known burial sites provided by the SWALSC. Further investigation within this area is hoped to better delineate burial sites with a higher degree of certainty. Drawing on the learnings from this project, the UWA SEG student chapter and SWALSC will acquire geophysical datasets at other suspected aboriginal sites throughout south-western WA that are less well documented and preserved.

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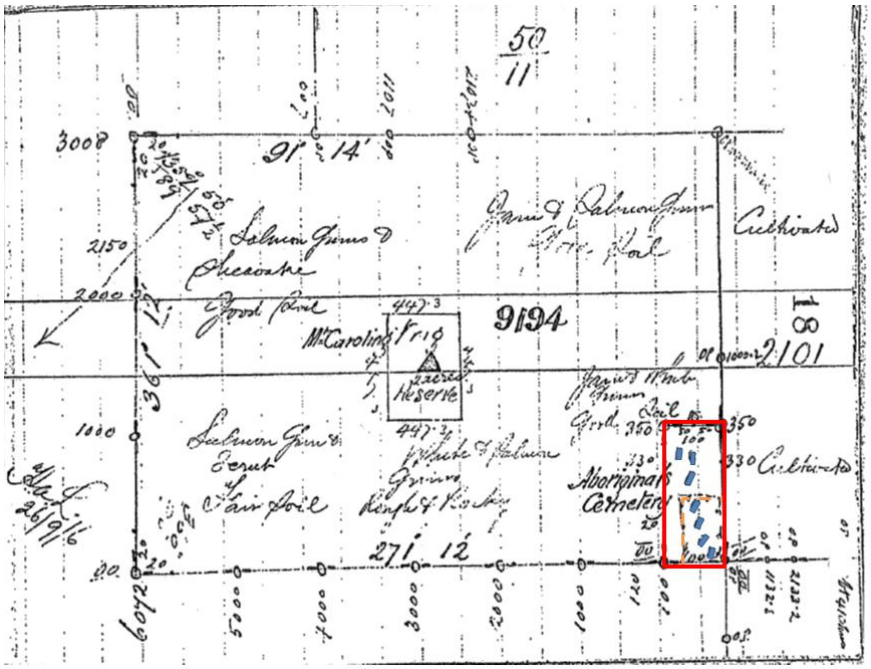

Figure 3. Copy of a historical document mapping the Aboriginal gravesites at Quairading, WA. The red box outlines the area designated as a cemetery that is fenced off, the blue markers represent suspected gravesite locations (colours correspond to Figure 2).