

Integrating ground-penetrating radar (GPR) and magnetic mapping to understand prehistoric mounds, Mapoon area, Queensland, Australia

Lawrence B. Conyers*, Mary-Jean Sutton ** and Emma St. Pierre ***

*Denver, Colorado, USA, lconyers@gpr-archaeology.com

** Virtus Heritage, Pottsville, NSW, Australia mj.sutton@virtusheritage.com.au

*** RadarArch, Dunedin, New Zealand emma@radarch.co.nz

Abstract

Ground-penetrating radar (GPR) and magnetic surveying of 17 earth mounds on the northern Cape York Peninsula show that prior to the construction of the mound areas were used as food processing or ritual activities that included organic matter and burning. Later, perhaps with increased population and cultural complexity, these areas were transformed into raised mounds, some of which were used for burials. A few mounds do not show evidence of underlying activity areas consisting of burned or organic-rich areas and not all contain burials. Most, however, fit the model of transformation of important places on the landscape into raised structures used for burial of the dead.

Introduction

This is a short summary of a paper we gave to the Australian Archaeological Association (AAA) Meeting, at the Gold Coast, December 2019. At that well-attended presentation the results presented here were received if not coldly, at least with skepticism by some of the attendees and moderate interest from others. Our research project in this area was hampered by Covid lockdowns that occurred just weeks after the conference and stayed in place for several years. Recently, to our surprise, we have been invited to submit a chapter to an edited volume in *Terra Australis* a monograph series edited by the Australian National University (ANU), Department of Archaeology and Natural History, to be published by ANU Press. This volume will presumably include chapters on the archaeology of earth mounds and wetlands throughout Australia. That is a positive step in getting some of our ideas that are presented here more widely viewed, if not accepted by the Australian archaeological community. In this paper we present some of those ideas in an abbreviated way, to get out some thoughts out on paper in preparation for the preparation of a longer chapter that will be generated over the next few months.

Background

At the AAA presentation we made the case that Australia is in the formative stages of studying earth mounds on that continent. It is much like United States archaeologists were confronted with in the early part of the 20th century, when the antiquity of mounds, their functions, and cultural affiliations were just beginning to be appreciated. Often these U.S. mounds in the late 19th and early 20th centuries were considered important as quarries where shells could be

obtained for road building. Sometimes they were chosen as locations for buildings as they were elevated above land that was subject to flooding. Over time, archaeologists understood they were constructed features produced by pre-Columbian people, and many were excavated, and often partially destroyed (Figure 1). Their antiquity was then appreciated, and some archaeological work was put toward a study of them (Marquardt 2010).

Some early U.S. archaeological excavation projects discovered a number of interesting motivations for the ancient construction of these elevated features. Often they were found to be the burial locations of important people (Sears 1958) or in some cases sacrificial victims. Elsewhere they were interpreted as the locations of temples or habitations of high status people (Figure 3). Others note that these mounds were constructed near other use areas that served as feasting locations and associated refuse disposal areas (Marquardt 2010).

After more than a half of a century of archaeological excavations the U.S. mounds were finally appreciated by the archaeological community as important prehistoric sites, leading to their protection and preservation. Unfortunately, during this time, many were destroyed, as the only methods people had for studying them were extensive and often destructive excavations.

In Australia mounds of a similar nature exist in many parts of the continent, which are now being studied. They appear similar in some ways to those in the American Gulf Coast and are interpreted in a non-human context as nests of brush turkeys (Bailey 1994; Stone 1989), or in human contexts as ancient living platforms that provided raised, dry areas for shelters and huts, especially in flood-prone region, places for ceremonial gatherings, or just places to discard shells (Foghlú 2017). There is evidence that some were seasonally occupied sites at the junction of ecological resource areas and perhaps had some social significance as territorial markers between clans or other groups (Brockwell 2006). Radiometric dating of some of the mounds to the south of our study area near Weipa suggests they were constructed starting about 2,200 years BP, with most activity occurring in the last 500 years (Brockwell et al. 2017).



Figure 1: Two mounds in the Mapoon area after the brush has been cleared in preparation for geophysical surveys.

There is an abundance of mounds in the Cape York Peninsula (Figure 2), some to the south of our study area that have been analyzed by the archaeological community (Brockwell et al. 2016;

Foghlú 2017). Here we study some of these mounds geophysically using both ground-penetrating radar (GPR) and magnetics. Our first attempt at geophysical analysis of one of the mounds occurred after a local informant told us that they likely had ancestors buried in it, which they were told about during their childhood, and therefore within living memory. We did a very informal GPR survey on one of these, which to our amazement, showed that there were five well-organized and commonly oriented graves on the top (Figure 3). Our local informant commented that as children, their elders forbade them to play on these and other nearby mounds, as they held special significance to their ancestors. The graves on this first tested mound are visible as distinct reflection hyperbolas, which quickly confirmed the burial idea.

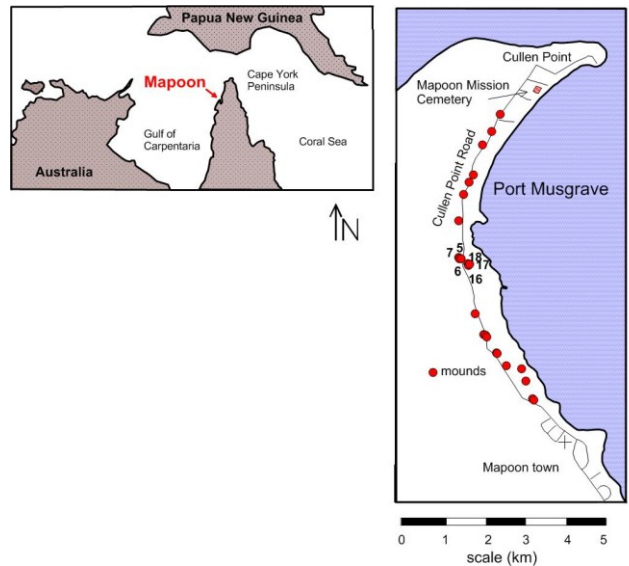


Figure 2: Location of the study area just north of Mapoon on the Cape York Peninsula, Australia.

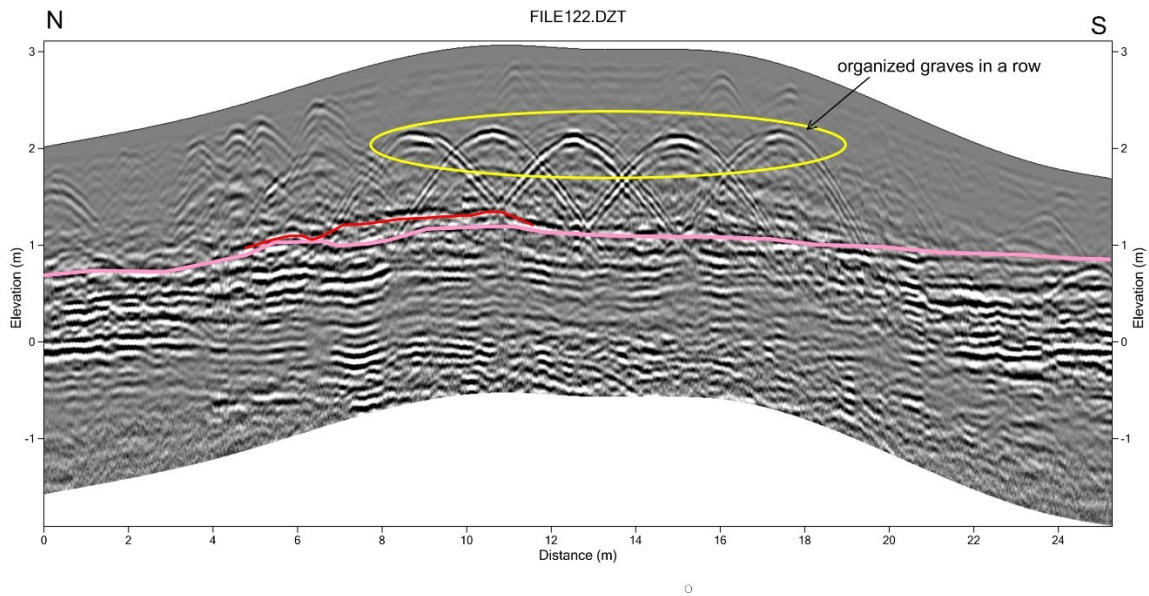


Figure 3: Five burials on the top of one mound near Mapoon, our first test survey with GPR.

A more involved set of surveys were then conducted over many of the mounds between Mapoon town and Cullen Point. In these surveys GPR profiles were collected within grids with 400 MHz antennas (Figure 4). Profiles were spaced 50 cm apart and ground elevations corrected using total station readings.



Figure 4: Collecting 400 MHz GPR reflection profiles.

Topographically corrected reflection profiles showed a well-defined horizontal pre-mound living surface below mound fill sediment. Within some of the mounds were distinct reflections of hyperbolic shape, which for confirmation needed to be visible in at least 3 adjacent profiles, indicative of a human burial consistent with the size of a human body (Figure 5). Only those mapped below about 50 cm in the ground were interpreted as burials, as there were many shallow reflections from tree roots that could be confused with burials (Conyers 2023). Many were found randomly arranged within the mounds, while others contained no burials at all.

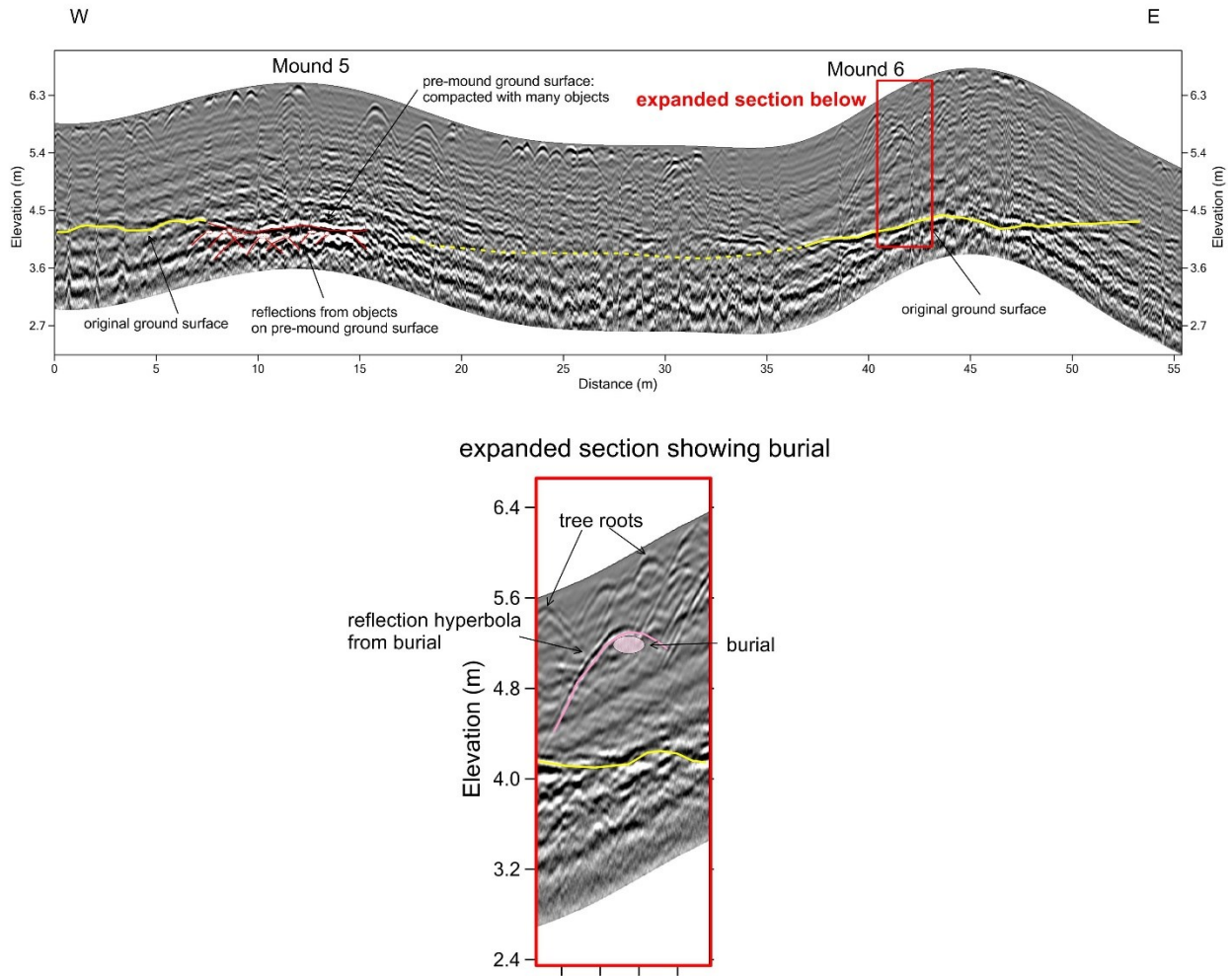


Figure 5: Topographically adjusted GPR reflection profile over two mounds showing the pre-mound ground surface and one burial. The burial is visible as a distinct reflection hyperbola.

To obtain additional information about possible burned areas, or perhaps metal objects in the ground, magnetic gradiometry data were also collected on the mounds. A two-instrument gradiometer was employed (Figure 6) with sensors spaced 50 cm apart and the lower sensor 50 cm above the ground surface. Plotting both the positive and negative magnetic readings produces a two-dimensional map of how the Earth’s magnetism varies both positively and negatively from a mean (Conyers 2017). The mean was calibrated as “average” ground away from the mounds in a “neutral” area prior to data collection. Positive values in this case are areas that have some remnant magnetism, likely from a burning event or multiple events that polarized magnetic minerals in the ground. The positive magnetic areas may also be denoting areas that had bacterial action in the past due to high organic matter, which created a somewhat elevated (above the mean) magnetic susceptibility (Conyers 2017).



Figure 6: A Bartington 601-2 Fluxgate gradiometer used for magnetic data collection.

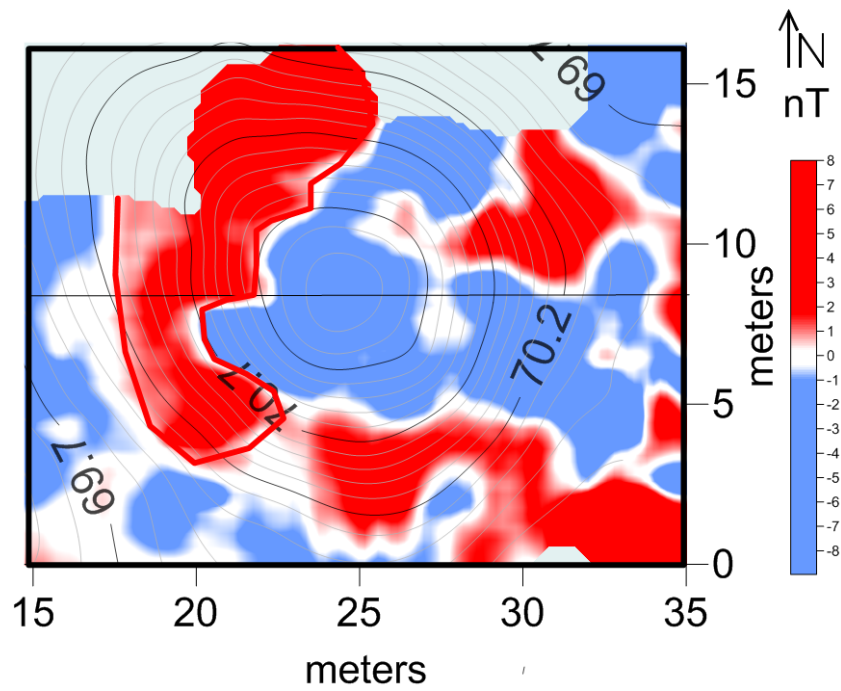


Figure 7: Magnetic values plotted on top of contours of one mound, with values ranging from positive and negative 8 nanoteslas.

The magnetic values, when plotted in map form, at first glance, only appeared to show some vague high values around the edges of the mounds, which were difficult to interpret. With a magnetic map alone, nothing immediately came to mind using pattern recognition. To compare magnetic values directly to the strata of the mound, and the buried living surface beneath it, topographically adjusted GPR reflection profiles were viewed in two-dimensions after being corrected for elevation. The magnetic values that are directly along the traverse of each reflection profile were then plotted and compared to the topographically adjusted GPR profiles. This method of data integration (Conyers 2017) proved to be very interesting as there were areas along the pre-mound ground surface that contained large stones, visible as distinct reflection hyperbolic reflections in the GPR profiles. These areas are directly correlative to the positive magnetic values (Figure 8). Areas with no stones on the pre-mound surface display negative magnetic values. While the positive magnetic values were relatively low (2-3 nanoteslas in most cases, with a few somewhat higher, approaching 8), the correlation is most important. The bedrock in this area is bauxite, which is aluminum ore. Natural or human-generated fire in tropical areas, such as those that occur in this area of Australia, can turn bauxite slightly magnetic. Fire acts as a reducing agent (often in combination with burning organic matter), dehydrating iron oxyhydroxides into maghemite which is slightly magnetic (Crowther 2003; Fassbinder 2023). This process would produce elevated positive magnetic values. Another hypothesis is that there was organic matter preserved near these buried surface stones, which enhanced bacterial action after burial, producing slightly elevated positive values (Fassbinder 2015). Or it could be both fire and preserved organic matter which led to the positive magnetism of the ground surface in these stony areas.

An analysis of one reflection profile from Mound 16 displays this phenomenon quite well (Figure 8). The individual stones that produced hyperbolic radar reflections are annotated in red. These occur on or just below a distinct flat living surface layer, annotated in yellow. A thin layer of unknown material shown in pink is visible directly on the living surface and spatially the same as the areas where the stones are visible. This surface is likely anthropogenic in origin.

The positive magnetic values are directly correlative to the area where both the stones and the thin layer on the living surface are visible. This is good evidence that some type of human activity took place on the ground here, leaving stones, perhaps organic material, and a layer of some unknown human-caused material. The possible activities that produced these layers and objects will be discussed below.

The remainder of the mound construction material shows a negative magnetic signature, which indicates it is slightly less magnetic than the “mean soil” where the magnetometer was calibrated. This material is likely beach sand, which is composed of almost wholly carbonate sand grains, which are not magnetic.

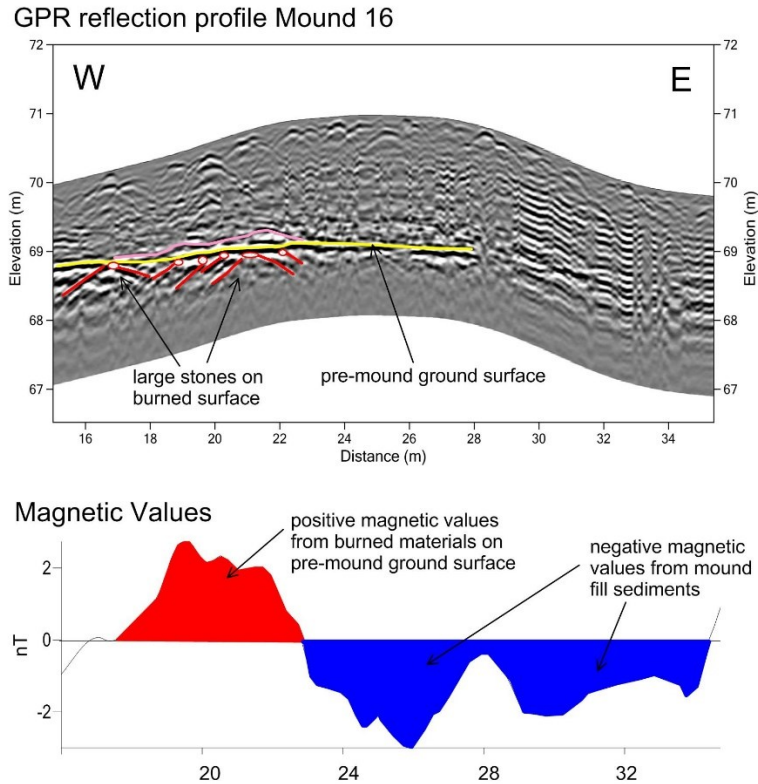


Figure 8: Comparison of a topographically adjusted GPR reflection profile with magnetic values collected along the same transect. The area of stones on the pre-mound surface exhibit positive retained magnetism or susceptibility.

Another way to test the correlation between the stones on the pre-mound ground surface, and the positive magnetic areas, is to produce a GPR amplitude slice-map directly on and a few centimeters above this surface. When this is done each of the individual stones, which produced the distinct reflection hyperbolas in the reflection profiles (Figure 9) are displayed, as they produced high amplitude radar wave reflections that were recorded.

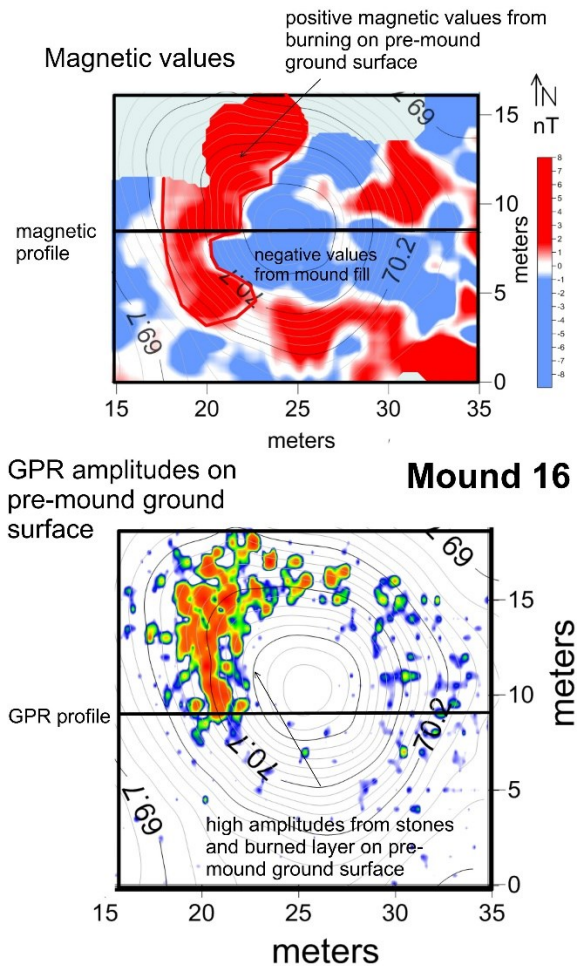


Figure 9: Comparison of GPR reflection amplitude map (lower) with the magnetic values on Mound 16.

A visual analysis of these two maps, which display very different properties of the ground, shows that there is a distinct concentration of stones in the northwest part of the grid on the pre-mound surface, as shown in the GPR amplitude map. The positive magnetic values in that area directly correlate with these stones. There are a few scattered stones on the east side of the grid, and none in between. The stones in the northwest are in an area that was either burned or had residual organic matter integrated with them (or both). One hypothesis is that people gathered here on the flat ground surface and engaged in food preparation, feasting, organic matter processing or other activities of this sort that included organic matter and the importation of some cobble-size stones. There are a few thin layers of unknown material that overlay the stones and burned ground (Figure 10), visible in reflection profiles. All these layers and objects are likely related in some way to the activities that happened here, which included fire and the import of stones and organic materials. We can only speculate what these activities were, but some working hypotheses are feasting, perhaps related to funerary rituals, and everyday activities

such as basket making, food processing or cooking. Elsewhere nearby excavations have shown that these activities took place on and around earthen mounds (Foghlú 2017).

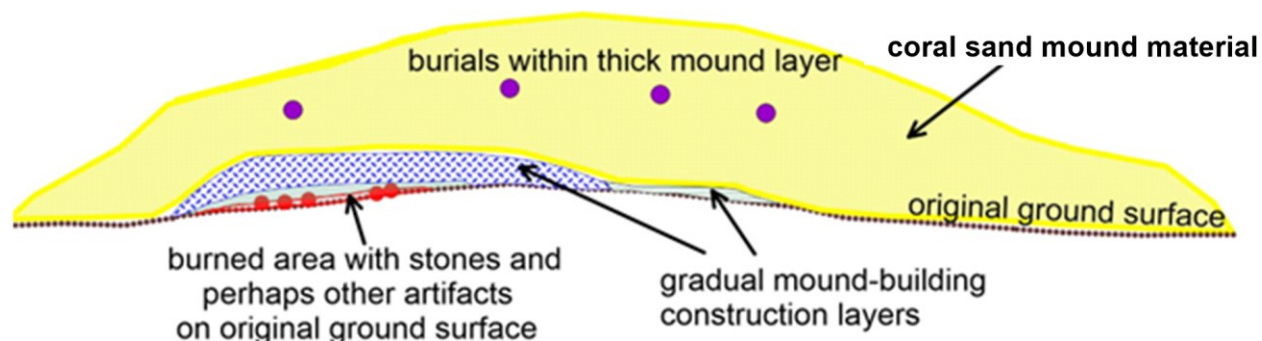


Figure 10: Annotated cross section of Mound 16 showing the strata and burials within the mound material, based on an interpretation of the profile shown in Figure 8.

Later these activity locations were transformed by the construction of earthen mound directly over these spots. Did the locations where these activities occurred retain some cultural significance, which prompted the construction of the mound in these locations? One important clue that may shed light on this question is that within the mound were placed individual graves, as can be seen by the reflection hyperbolas in GPR profiles (Figure 8).

This basic anthropological model is not perfect, as not all the mounds studied in the Cullen Point area are underlain by the cobble concentrations (Figure 11). And not all contain burials. There are also burials at ground level around the mounds. No surveys were undertaken far away from the mounds, so we are not sure if graves are found everywhere in the area and not just associated with the mounds.

An interesting observation is that of the mounds studied, those that contain burials show concentrations of internments on the north flanks, but not the south. This is somewhat interesting and moderately puzzling. We can pose a variety of hypotheses as to the grave placements, but they are impossible to test without excavations or other information. Perhaps there is some astronomical connection, or something else to do with these people's understanding of their landscape.

One thing we can say is that people performed a variety of activities in this mound-concentration area, perhaps over many years. These began with simple tasks such as food or other organic preparations, which may have used fire. Or perhaps related to funeral activities. These activities were aurally distinct and likely performed by several people. Over time, these areas were transformed to a very different use, which was the burial of what was likely a few "special" people within mounds build on the areas. Some of the dead were buried within the mounds, and others (perhaps those of less status?) near the mounds but not within them. For unknown reasons the north flanks of the mounds used for burials were chosen for burials, and not the south.

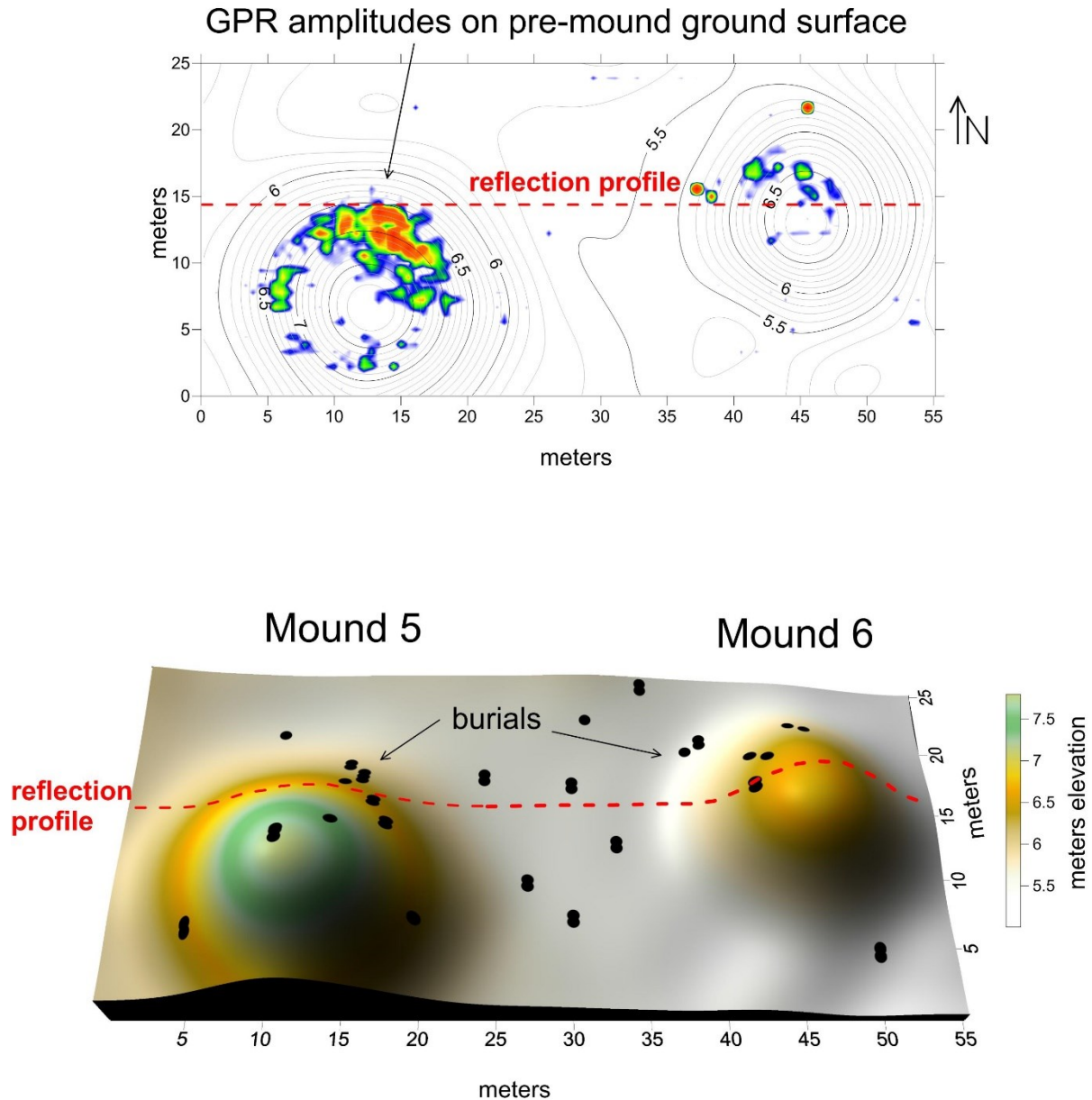


Figure 11: Location of burials (lower map) within Mounds 5 and 6, with the location of the high amplitude reflections on the pre-mound surface.

The mounds continued to hold some cultural significance for people who resided in this area until historic times. Our informants' memories of being told not to play on the mounds by their parents, as they were the location of ancestors' graves, is one important data point.

At another mound studied in the area, a near-surface map constructed from the GPR reflection data shows the distinct outline of a rectangular structure between a large and a small mound (Figure 12). The function of this structure, which now is outlined only by stones that likely supported a brush-wood structure, is unknown to our informants. Perhaps it was a temporary windbreak or shade structure, or more intriguingly, a shelter for the deceased (Memcott 2007:

164). There are historical photos of similar structures still used for this type of ritual activity elsewhere in Australia (Figure 13). The location of the remains of this structure adjacent to two mounds, and near the location of burials tends to support this idea.

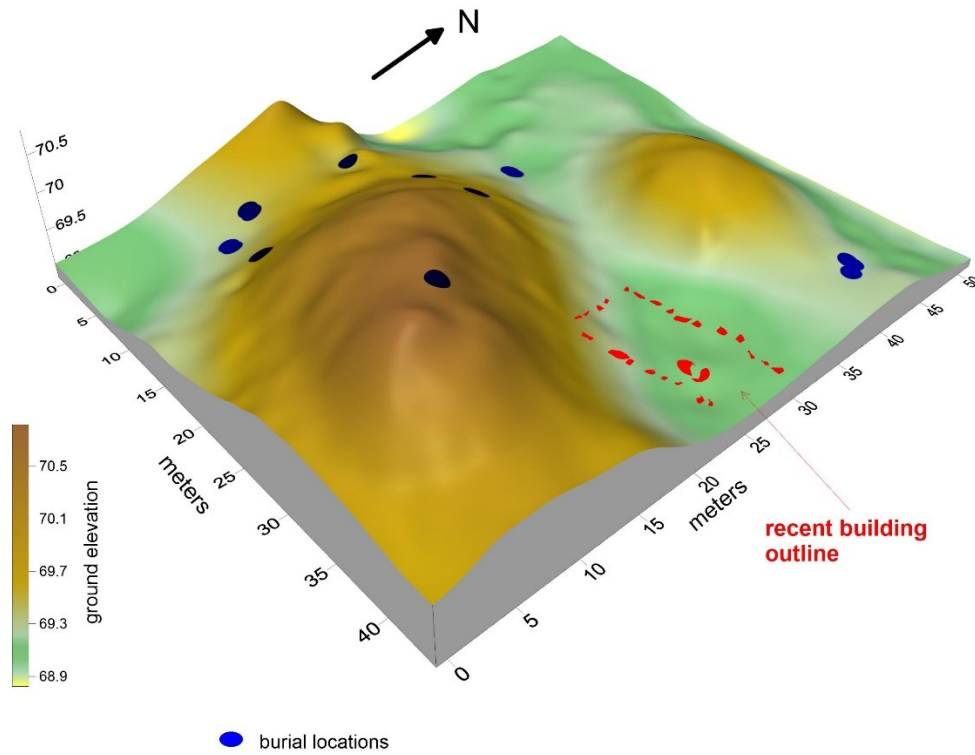


Figure 12: Location of a small rectangular structure foundation visible in GPR slice-mapping adjacent to two mounds.

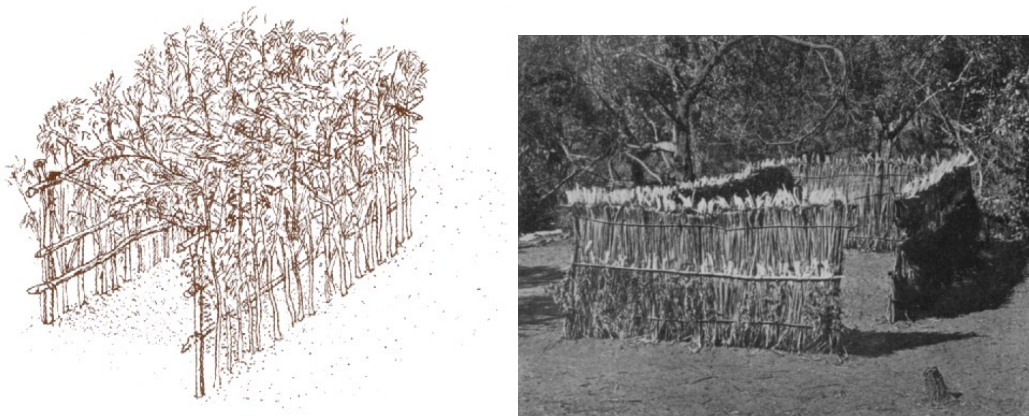


Figure 13: Sketch of a funeral structure of Aboriginal origin, with a historic photo of one from the early part of the 20th century in northern Australia.

Conclusions

Geophysical analysis of mounds in the northern Cape York Peninsula can map and interpret layers and objects within them, and to understand their composition based on magnetic properties. This allows for the identification of objects, layers of sediment, and their properties. Three-dimensional analysis allows for some basic conclusions regarding the function and changes in the use of the landscape over time, which can be expanded on with minimal excavations or coring. Multiple working hypotheses can be proposed based on three-dimensional analysis.

Our analysis of 17 mounds south of Cullen Point shows that many were constructed on areas that were used first for possible food or vegetable processing, feasting, or other social gatherings. Those activities included the import of cobble-size stones that may have been used for fire containment, hearths, earth oven baking or other activities related to fire. Over time the ground was baked and with the inclusion of organic matter, retained a slight magnetic signature. These places in the landscape were later transformed by the import of nearby beach sand to construct mounds over the locations where these activities took place. Many, but not all the mounds studied, were used as burial locations, perhaps for higher status people, with other individuals buried on the margins and surrounding the raised structures. This may indicate an increase in social complexity, with motivation by people with more power and influence to organize their construction and then using them for the burial of their kinfolk (reference). These areas continued to be known as special places until modern times is indicated by our local informants who told stories of their childhood and being warned off playing on or near the mounds by their elders.

One large mound contains a rectangular structure constructed on its flank, with the remaining stones that held the superstructure preserved and mapped with GPR. This structure may have been a structure built for the deceased, or perhaps simply a windbreak or other type of ceremonial enclosure. All these data, in conjunction with the stories from local elders, shows a longevity of use of special areas, and a time-depth showing how these important areas on the landscape were modified over time, retaining their significance.

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