Integration of GPR with and magnetics to understand the composition and origin of units to study the interior features and history of earthen mounds, Mapoon, Queensland, Australia

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Summary

Ground-penetrating radar can produce precise images and maps of buried geological and archaeological materials in the ground but has limited ability to determine the composition and origin of these units. When GPR is merged and integrated with magnetics, both the composition and complex geometry of units can be determined. In a geologically simple area of Australia, where the ground is non-magnetic other than when modified anthropogenically, the integration method was applied. Here sand mounds were built over surfaces that were modified prior to mound construction by fire. The constructed mounds were then used for the burials of humans. It was found using these methods that the pre-mound ground surface had been burned perhaps during feasting rituals or cremations, and then covered by sand later in time. The human burials were then emplaced in the sand over what were likely to have been important locations on the ancient landscape.

Introduction

More than 20 mounds have been identified north of the town of Mapoon on the Cape York Peninsula, northern Australia (Figure 1). Many more exist just south of the study area, which have not been studied. Eleven in the Mapoon area have been surveyed geophysically and results from some of them are presented here.

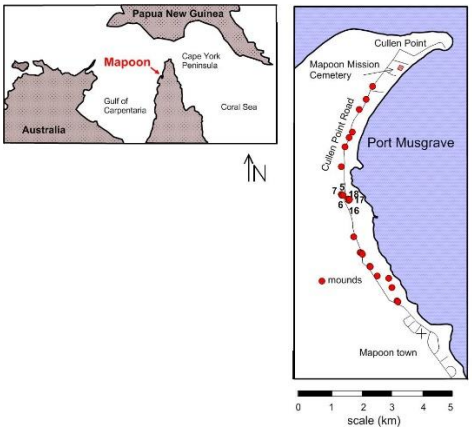

Figure 1: Location of the study area in northern Australia and the mounds that have been studied geologically near Mapoon.

The variability of internal mound features and the presence or absence of "whole human burials", which can be identified geophysically has raised several questions about the antiquity of these features and possibly changes in burial practices and usage of these areas over time. A variety of hypotheses have therefore been developed based on this new knowledge about the earthen mounds, which is not possible without the technology employed for non-invasively looking into the features and mapping the ground surface prior to mound construction. In addition, the integration of GPR and magnetics provides a method for understanding a variety of three-dimensional aspects of these complex packages of sediment, and this analysis is also capable of determining the composition of some of those units (Conyers 2017, Conyers et al. 2018).

Field methods and data processing

All grids of GPR reflections collected with a 400 MHz antenna using a GSSI SIR-3000 system were sliced into 50 cm thick horizontal slices through the mounds, and the surrounding ground. The slice corresponding to the buried ground surface prior to mound construction is displayed overlain by the contours of the present nearby mounds (Figure 2. That surface shows very high amplitude features below the mound fill sediment, concentrated directly under the mound sediment on the pre-mound surface. The fill of one mound was built on a substantial high amplitude GPR-defined feature of this sort. Another mound to the east has only limited reflective materials under its sediment fill. A GPR reflection profile across both mounds, corrected for topography, display the pre-mound ground surface that consists of many large objects [greater than 20 cm or so in diameter, which is the maximum size resolvable using the 400 MHz antennas (Conyers 2013)] on a compacted and possibly burned surface. These objects are preserved on a distinct compacted or burned (or both) ground surface visible as a high amplitude planar reflection.

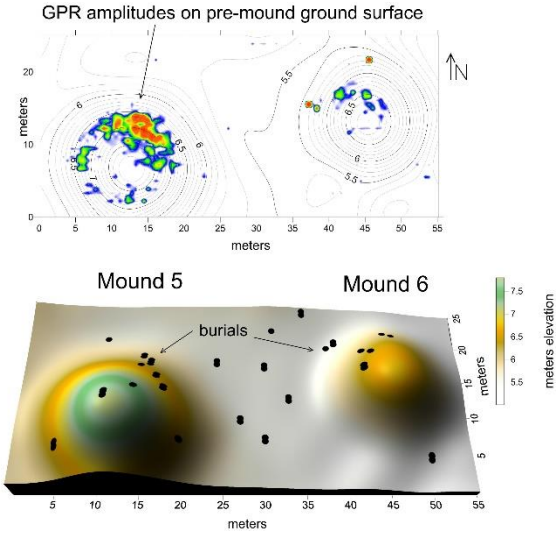

Figure 2: GPR amplitude maps on the surface below mound fill, with the topographic image of the ground surface below. Burials within and between the mounds are shown on the lower image.

One mound cluster contains many of the interesting sub-mound features that have been seen in other Mapoon area mounds. What is most interesting about these mounds is that detailed GPR analysis of profiles displays no typical burial-generated hyperbolas (Figure 3), which are so prevalent in other mounds in the area. They display other sub-mound features, which may indicate that there were different activities associated with these mounds both before the mounds were built, and afterward.

Data interpretation

An analysis of both profiles and maps generated from GPR and magnetics at many mounds shows that most of the mound sediment is displayed as a negative magnetic area. The ground in the Mapoon area is composed of primarily quartz and carbonate sand, with small additions of organic matter. The decomposed organic material makes the soils developed

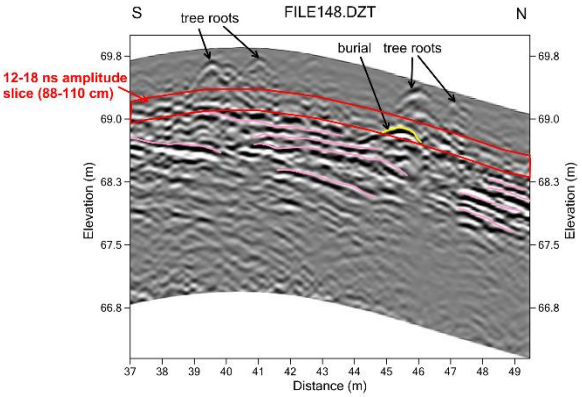

Figure 3: Burials shown as reflection hyperbolas within the mound fill.

on this ground only very slightly magnetic, as the decomposition of A soil zone organics by bacteria produce a very weak magnetic signature (Fassbinder 2015). The magnetometer was calibrated on ground of this sort, and therefore "nulled" on soils that were very slightly magnetic.

The magnetic values then collected over the mounds are either higher (positive) or lower (negative) than this "nulled value" set with the magnetometer system prior to data collection (Conyers 2017). When very slightly magnetic surface material is removed for mound construction, and placed on the mound, whatever very weak magnetic orientations that may have been present "in place" were effectively jumbled, cancelling each other out and producing an overall volume that is slightly lower than the undisturbed ground. On the western side of the mound there is a distinct positive magnetic feature indicating the presence of something that is relatively more magnetic than the surrounding soil where the system was calibrated. This area corresponds in space almost perfectly to the high amplitude GPR reflections derived from materials on the pre-mound ground surface. Those high amplitude objects are very similar in origin to those visible in on the pre-mound ground surface.

A GPR reflection profile displayed with the corresponding magnetic readings at one mound (Figure 4) illustrate mound fill that contains almost no large objects, other than some tree roots at the surface. The mound fill is almost completely negative magnetic, but on the western edge the positive magnetic values are correlative to the area of the pre-mound ground surface that contains a few reflection hyperbolas that were likely generated from small stones. The positive magnetic readings were also collected in that area, indicating that this surface was burned, or contains some burned materials. The magnetic values are in this positive magnetic anomaly are still low (2-4 nanoteslas or so), but significantly different than at the rest of the mound

area.

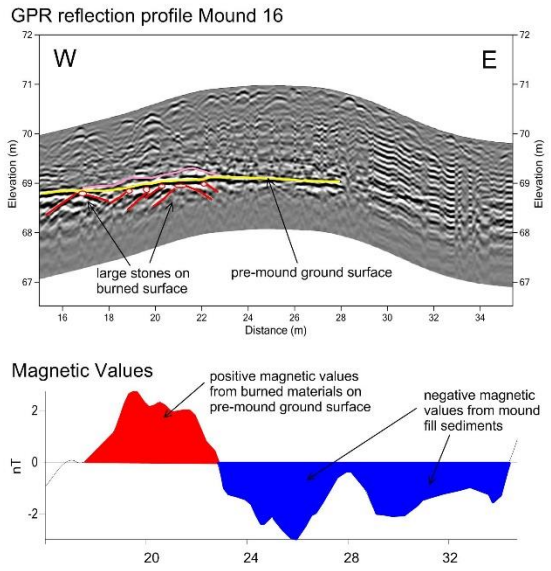

Figure 4: GPR reflection profile and corresponding magnetic readings indicating the composition of the materials on the pre-mound surface.

A GPR profile crossing one mound (Figure 4) shows the distinctive planar reflection generated from the pre-mound ground surface, but here there are no distinctive objects on it to produce hyperbolic point-source reflections. There is a 20-30 cm layer of some sort of material on the original ground surface along the western edge of the mound, and whatever this material is likely produced the high positive magnetic values. That layer resting on the original ground surface is likely responsible for the higher magnetic values averaging between 4 and 8 nanoteslas. These nanoteslas values are indicative of burning, as there is no other materials in this area of Mapoon that could conceivably produce these higher positive magnetic values. The usual ground in the Mapoon area is neutral or very slightly positive magnetically, and the coral and quartz sand without soil development is very slightly negative or neutral. It is possible that the bedrock here, which is bauxite, could be contributing a small amount of magnetism from the trace amounts of iron found in this geological unit. However, those layers are more than 2 meters below the mound top, at a distance from the surface sensors that would make that potential component of the magnetic readings almost non-existent (Conyers 2017).

At another nearby mound the pre-mound ground surface was burned on the west side of the grid under what would become the mound, and perhaps some of those burned materials were swept or moved in some other fashion to the east. More intensive burning on the west and sweeping the remains of that fire to the east would have produced the two positive magnetic features visible in the magnetic map. An analysis of the very subtle stratigraphic layers within the
mound fill shows some eastward sloping laminae, indicative of wind-blown deposits (Conyers 2017). That mound fill may therefore be partially aeolian in origin, which could indicate that this burned surface was first covered by sand dune deposits, and only later converted into the constructed mound we see today. This is very speculative, but an interesting hypothesis, as it could show that some time elapsed between when the ground was burned, presumably by humans, and when this area was converted into a mound.

Conclusions

The geophysical results from mounds surveyed in the Mapoon area indicate that these mounds are much more complicated than previously thought. The GPR and magnetic results show that some mounds contain whole human burials, but some do not. Some mounds were built over features on an original ground surface that had been burned, with large stones moved into the area for some reason. How long ago that burning and modification of the ground surface too place cannot be determined until excavations are conducted. It is hypothesized that some of these burning events could have been cremation rituals, or ritual smoke-purification of the deceased. It is also possible that these areas were locations of cooking and feasting, perhaps associated also with funerary rituals. Oral histories obtained by the Elders in the Mapoon area still attest to some of these types of rituals that took place in these mound areas. This type of possible activity in all cases took place prior to mound construction.

It is important to take into consideration when generating hypotheses about human behavior that many of these burned and modified areas on the original ground surface were later transformed into “monumental architecture” by the construction of the earthen mounds. These mounds were sometimes built directly on the previously burned areas, but other times offset a few meters. Also, it may be important that some mounds were not constructed over burned features on the original ground surface at all, which may show that they had some other function.

It is also possible the function of some of the mounds was unrelated to burial the mounds and many may have had multiple functions over time. Or perhaps the burials in these mounds are only recent phenomena and these areas were used for some other very different purpose in the past, the memory of which was retained as important places on the landscape. The diversity of the pre-mound ground surface seen in these six clustered mounds indicates that

there were likely very different behaviors that led to these differences. Perhaps certain mounds were reserved for certain activities? Or perhaps certain mounds were reserved for certain clans or families, which performed different activities here? These are interesting ideas that can be potentially be tested with excavations in the future.

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