E A R T H M A P S   C O N S U L T I N G

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Environmental Compliance Consultancy

Ground Penetrating Radar (GPR)

Survey:

Twin Hills Grave Site

Report 1/1

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10.08.2023

Contents

1. Introduction

Environmental Compliance Consultancy (‘ECC‘) requested Earthmaps Consulting CC (‘Earthmaps‘) to carry out a Ground Penetrating Radar (GPR) survey over four established graves and one suspected grave site at the Twin Hills Gold Project near Karirib, GPS locality 601176, 7584879 (WGS84 UTM33S).

A survey was carried out at the site on the 7th of August 2023.

The aim of the survey was to:

i. Establish the GPR responses from four differently demarcated, known grave sites in the Twin Hills area.

ii. To determine whether a fifth, possible grave site nearby was indeed a grave site.

2. Instrumentation and Method

GPR is routinely used in archeological investigations and assessments, and this includes the examination of grave sites, as is shown in the example in page 4.

The benefit of GPR is its non-intrusive nature and its high spatial resolution, compared to other geophysical survey techniques, resulting from its use of high frequency radio waves. However it must be pointed out that due to natural electrical ground conductivities, radio signals quickly loose intensity as they penetrate the ground. The higher the radio wave frequency, and the higher the spatial resolution, the more dramatic is this loss of signal. Therefore there is a strong trade-off between effective depth of penetration and the resolution of the radio-signal. In order to achieve penetration depths of between 1 and 2 m in most substrates, a signal frequency range as low as 300 to 200 MHz is required. The spatial resolution at this frequency range is no better than the size of a small gymnast ball (diameter of 40 cm). This means that smaller features than this will not be detectible by GPR at these frequencies. This means that contrary to popular perceptions, bones will not be visible in graves by using GPR, however a coffin will be detectible, provided that it is still in its original shape.

It must also be noted that as GPR is sensitive to electrical impedance constrasts, a void in the ground, created by a burried coffin, will be readily detected, however a burried body without a coffin, possibly only draped in a shroud, will be extremely difficult to detect, as its impedance contrast with the ground will be very low. Disturbed ground profiles may also be detectible however the soil profile gradually blends and settles back into the natural stratification, and therefore with passing years, graves will become more and more difficult to detect. In summary, recent, western-style graves with burried, intact coffins will be much more easy to detect and identify with GPR compared to ancient, traditional African graves without coffins. The substrate also influences the detectibility of graves, with homogenous, sandy substrate offering a clean GPR background wheras a rocky, inhomogenous substrate will return complex signals that can make the identification of burial sites difficult.

A Pulse EKKO PRO GPR system with a shielded 250 MHz antenna was used to survey three profiles at the grave site (see Figure 1, 4). The shielded nature of the 250 MHz antenna is an important benefit as it does not suffer from above-surface reflections such as from trees or bushes, which can create strong radar reflections in un-shielded antennas. The 250 MHz antenna was moved along the survey lines in the standard parallel broadside (PL-BD) configuration.

The data was processed in Sensors & Software Inc. software and the GPR sections are displayed in Section 7 at the end of this report.

Note that in the absence of a depth calibration point in this area (such as open soil profile or pit) a radar velocity of 0.06 m/ns has been assumed for the processing, representing the radar velocity in clay-rich soil.

GPR Principles, Procedures & Applications 10-Case Studies

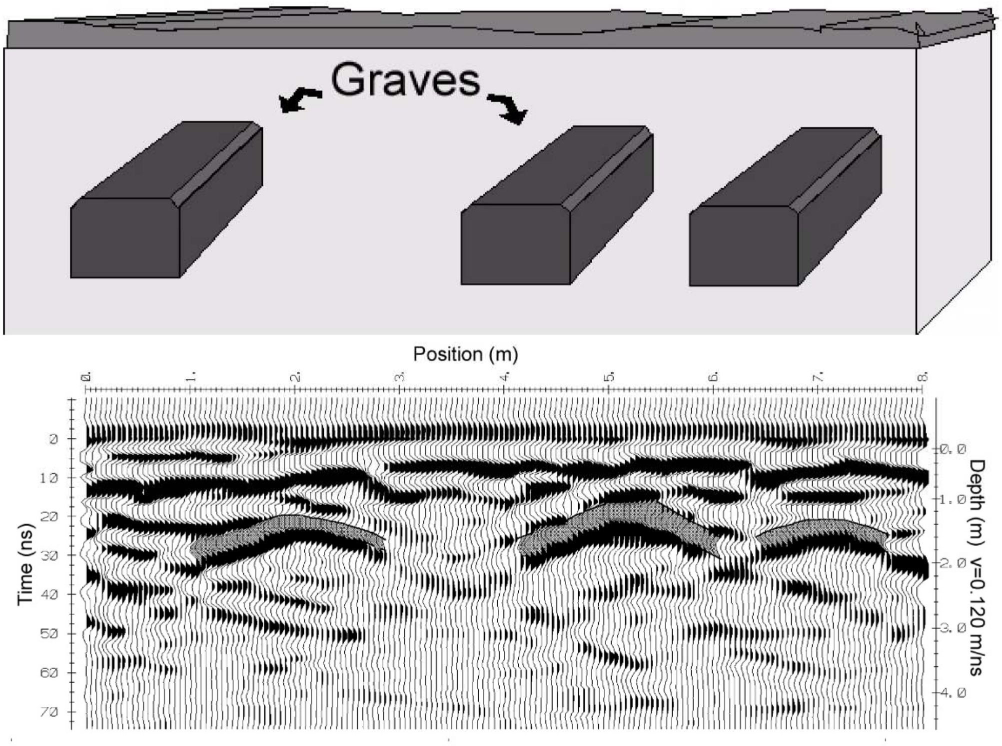
GRAVE LOCATION

Location of unmarked graves in cemeteries is an unusual but regular application of ground penetrating radar. Where there are no markers or indications of grave locations development, construction projects can be quickly brought to a halt until the history of the site is evaluated.

Ground penetrating radar (GPR) systems respond to buried objects as well as disturbed soil, providing a powerful method to define unmarked grave locations. Other applications include forensic investigations and archaeological site evaluations.

In this case a pulseEKKO GPR system was used with a 200 MHz antenna. The data were acquired by students at the University of Calgary. The portable nature of the pulseEKKO system made data acquisition quick and easy. The soil at the site was silty sand.

Data compliments of University of Calgary, Department of Geography, Canada



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Source: Ground Penetrating Radar Principles, Procedures and Applications. A.P. Annan 2004

3. Results

3.1. Line 1: 250 MHz

The GPR results are shown in Figure 1.

Close contact with the ground surface (called ‘coupling‘) is important in GPR to get good depth penetration and good quality data. As the most prominent grave at the grave site, grave 2, has a raised, cemented perimeter rim, it was decided to survey a longitudinal line within the perimeter of the grave.

- The data shows a very clear reflector at a depth of between 58 cm and 60 cm from surface, indicating the top of a more or less intact coffin.
- At a depth of 88 cm from surface another, less continuous reflector indicates the base of the grave.

3.2. Line 2: 250 MHz

This line is a transverse GPR line crossing all four clearly demarcated graves from the south-west to the north-east. The loose perimeter stones were carefully removed at the GPR traverse, and replaced after the survey was completed. At grave 2 the GPR antenna was lifted and slid over the top of the cemented perimeter rim (Figure 5). This led to the loss of coupling with the surface and poor data over grave 2.

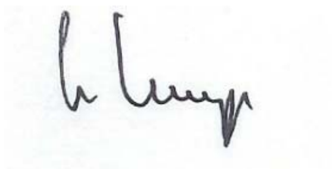
- At grave 1 there is a clear disturbance in the ground at depths between 65 cm and 90 cm, with two reflectors detectible within the grave perimeter which appear to indicate the presence of a coffin, or of its remains. It is noted though that the reflectors are not that dissimilar from natural, probably calcrete reflections at the onset of the line.
- At grave 2 there are small, irregular reflectors visible only. These are at the same depths as the strong reflectors in Line 1, however they are indistinct due to the loss of coupling with the ground surface at this particular grave site (Figure 5).
- Graves 3 and 4 show no clearly identifiable GPR signatures that would indicate the presence of graves. This however may be due to the fact that from the length of these graves (1.3 m and 1.2 m respectively) they must be children’s graves and possibly no coffins were used. Their clear demarcation on surface suggest that they must indeed be graves, despite the fact that the GPR is not able to distinguish any sub-surface features within them.

3.3. Line 3: 250 MHz

This GPR line crosses the suspected grave site 5, which is situated 5 m west of grave 2 and was partially hidden by a fallen bush.

- The suspected grave site 5 shows no indications of a buried void that could suggest an intact coffin.
- However there is a clear discontinuity of the soil profile on the north-eastern edge of the suspected grave site, the position indicated by framing stones at surface. It appears that a calcrete bank was truncated at a depth of 67 cm, creating a characteristic sloping limb of a reflection parabola.
- Strong reflectors probably due to large, buried calcrete banks or rocks are visible in the profile away from the grave site.
- Even though no evidence of a coffin signature is present, based of the following evidence it is concluded that this site is indeed a grave site:
- a. The truncated soil profile on the one side of the site, below the framing stone line
- b. The mound measuring 1.8 m x 0.9 m which is clearly evident.
- c. The surrounding, framing stone line, including an upright ‘’headstone’’, all in the same orientation and alignment as the other four graves

Respectfully submitted,



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7. Figures

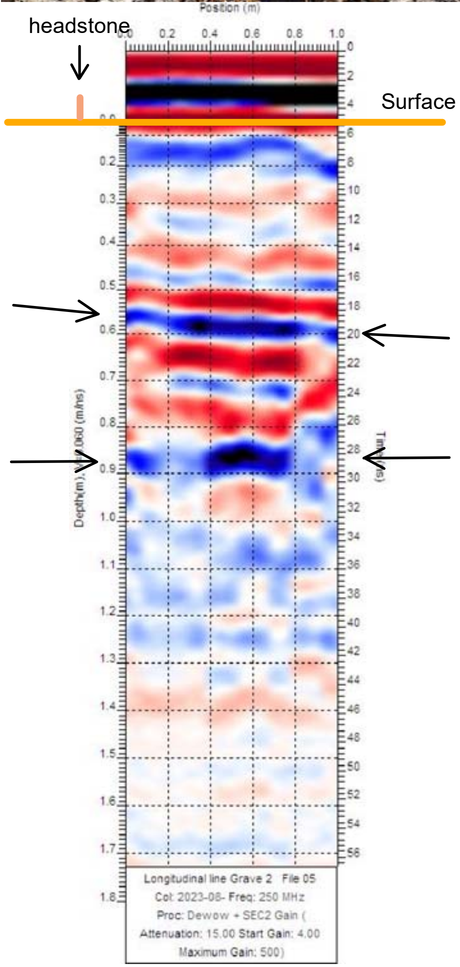
Ground Penetrating Radar

Site of Five Graves

Line 1

locality:

601176, 7584879
WGS84 UTM33S



Twin Hills Project

250 MHz

Earthmaps Consulting Aug 2023

Figure 1

Radar File: Line 05

Ground Penetrating Radar

Site of Five Graves

Line 2

Twin Hills Project

250 MHz

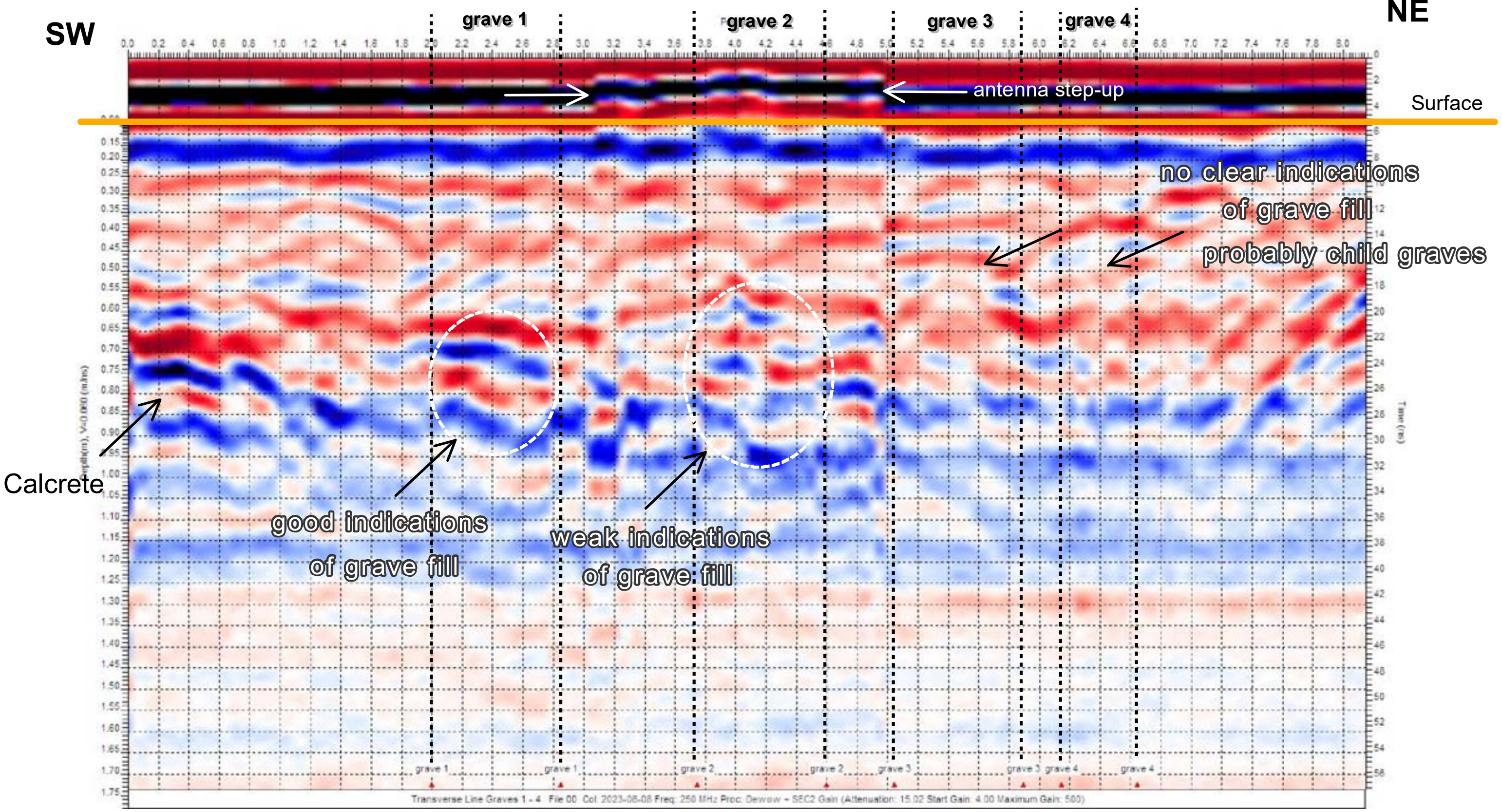


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Figure 2 **Radar File: Line 00**

Ground Penetrating Radar

Site of Five Graves

Line 3

Twin Hills Project

250 MHz

locality:

601170, 7584878
WGS84 UTM33S

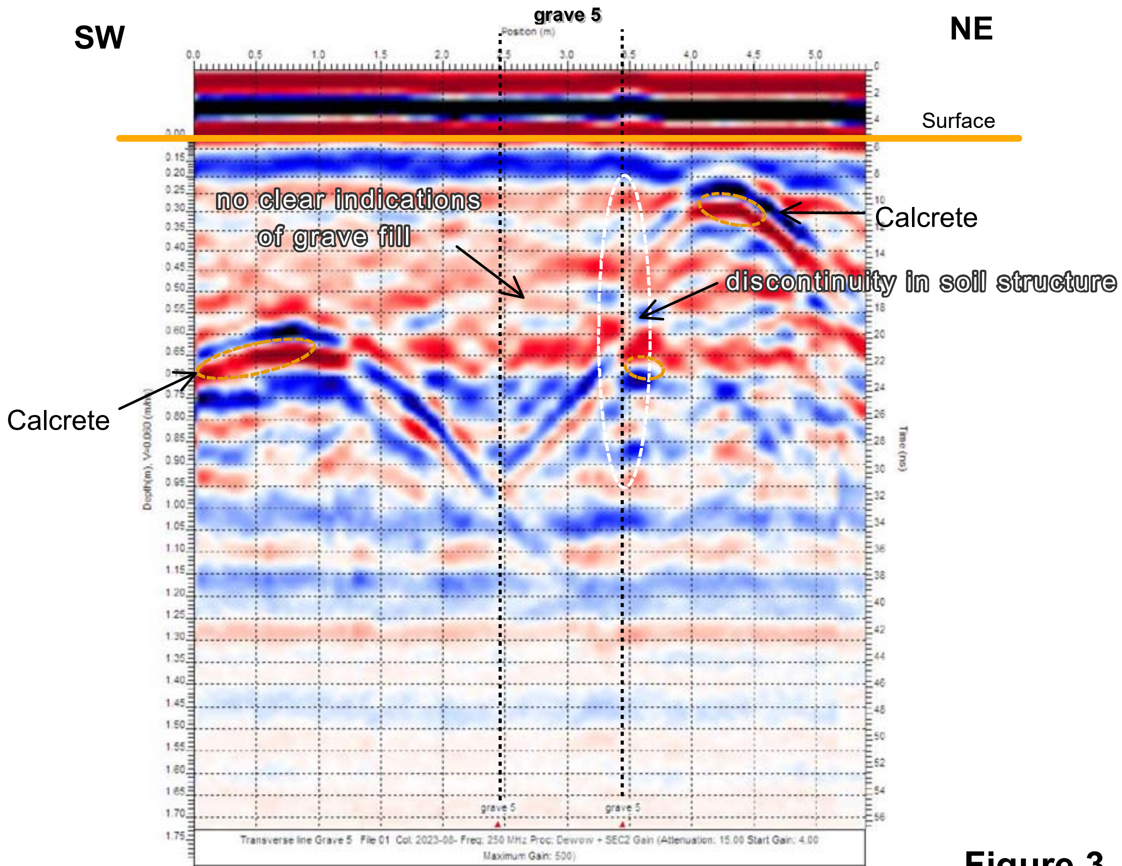

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Figure 3 **Radar File: Line 01**

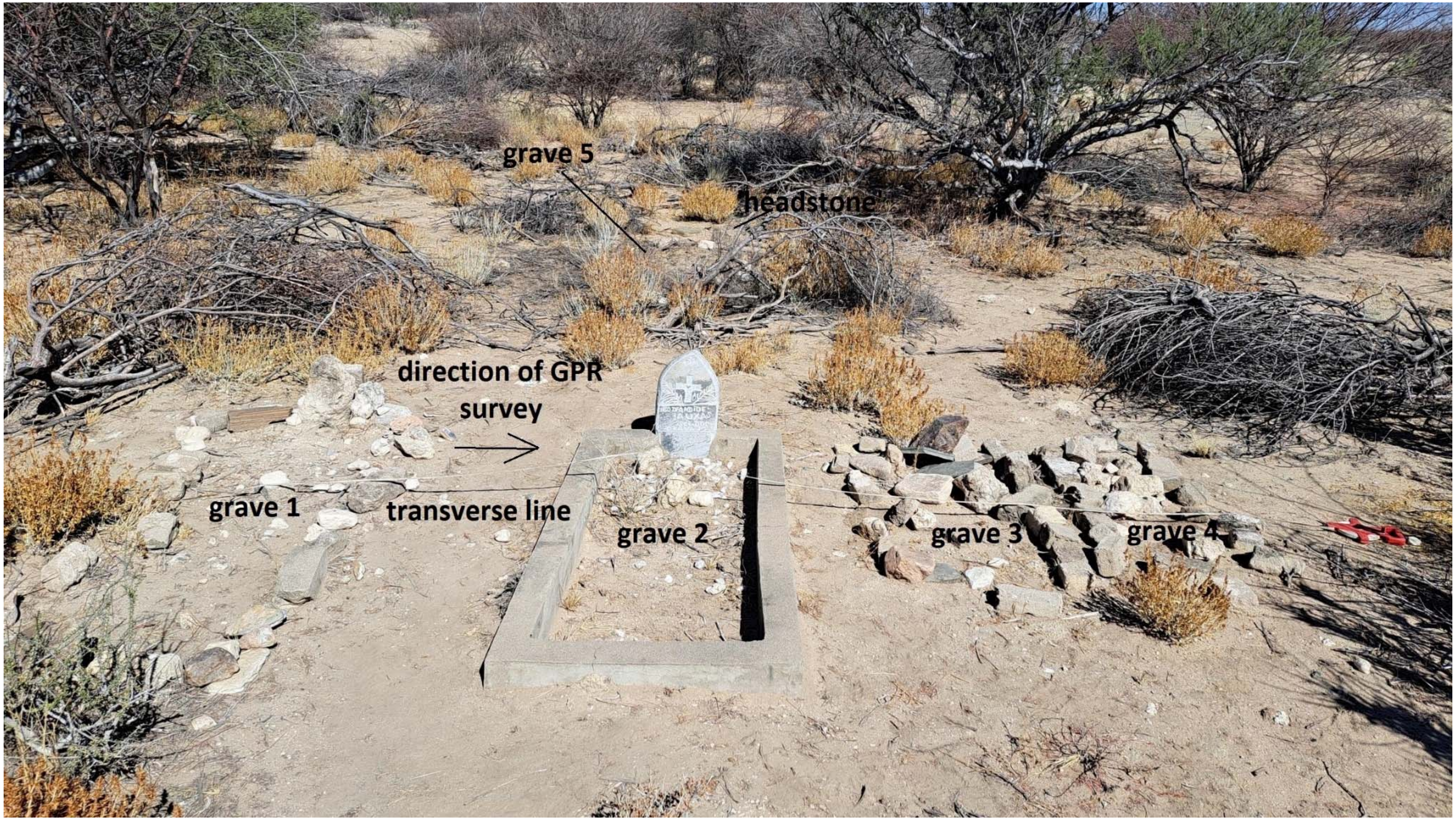

Figure 4: Grave Site, Twin Hills. View to the south-west

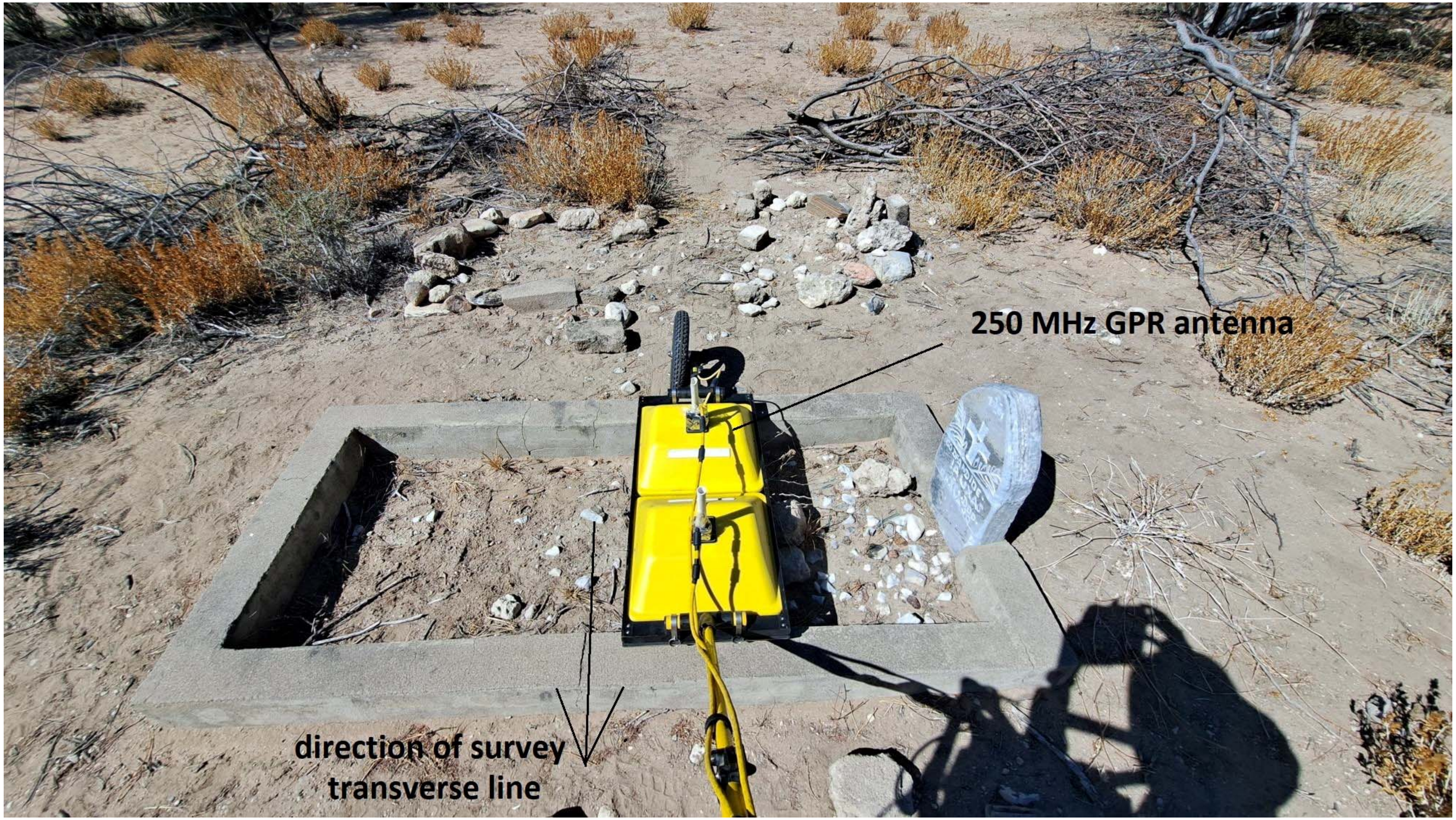

Figure 5: GPR Line 2 crossing grave 2. Note the loss of contact (coupling) with the ground

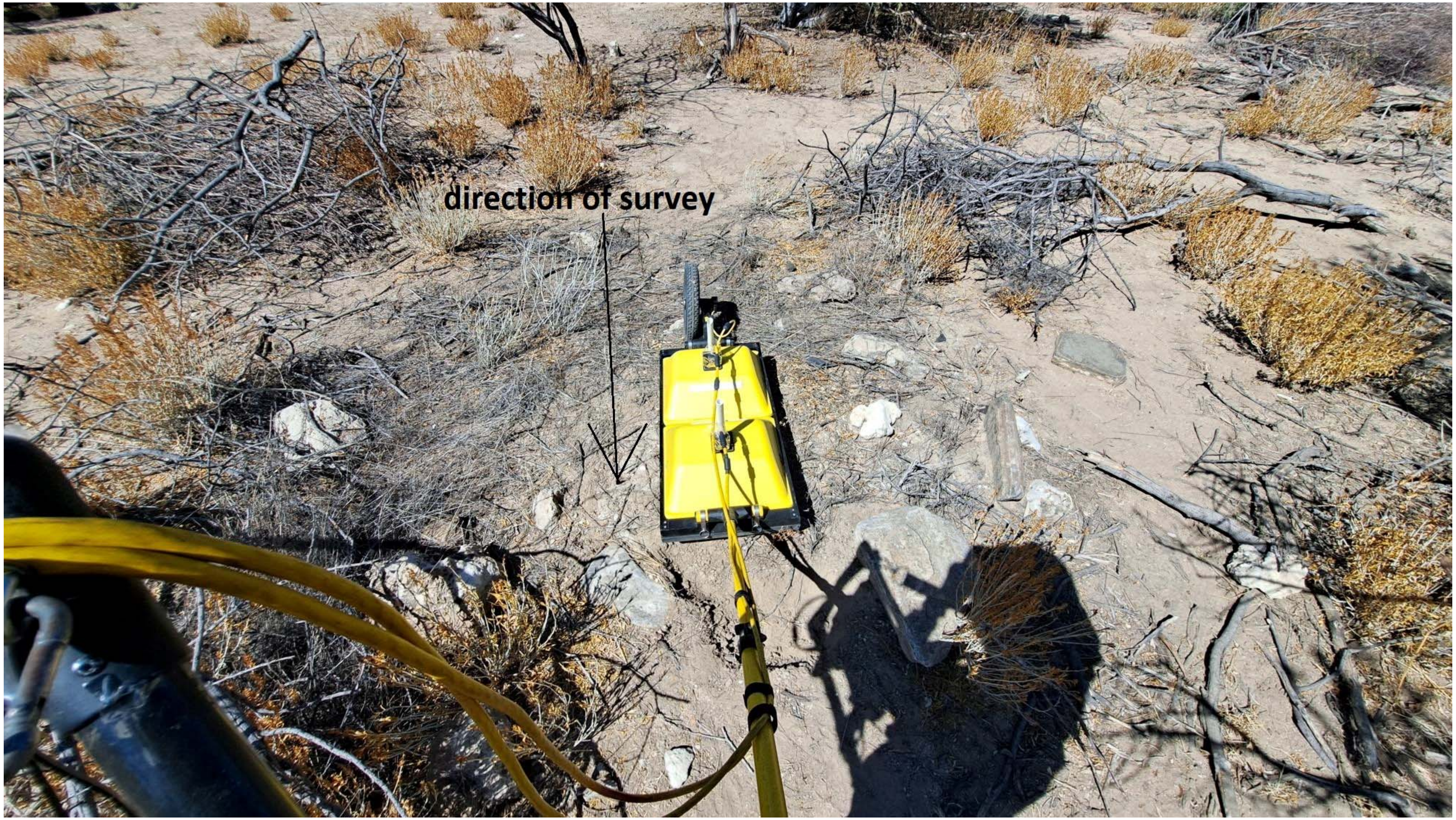

Figure 6: GPR Line 3 crossing the mound of grave 5.