

Report on the Assessment of reported grave localities at Platreef by means of Ground Penetrating Radar (GPR) during January 2016

Ivanhoe Mines: Platreef Project
FARM Turfspruit 241 KR, Mokopane, Limpopo

Issue Date: 18 March 2016

Revision No.: 1

Client: Ivanplats (Pty) Ltd

SAHRA PERMIT NUMBER: 2099; Case ID: 8274

This report is to be read in conjunction with:

Van Der Walt and Hutten, 2015. REPORT ON TEST EXCAVATIONS OF TWO POSSIBLE GRAVES Ivanhoe Mines: Platreef Project, FARM Turfspruit 241 KR, Mokopane, Limpopo.

Nienaber, 2015. Assessment of reported grave localities at Platreef by means of Ground Penetrating Radar (GPR).

Nienaber, 2015. Consolidated report on the Assessment of reported grave localities at Platreef by means of Ground Penetrating Radar (GPR) and archaeological test excavation during 2015 Ivanhoe Mines: Platreef Project FARM Turfspruit 241 KR, Mokopane, Limpopo

CONSULTANT: Professional Grave Solutions (Pty) Ltd
Trading as PGS Heritage

CONTACT PERSONS: Coen Nienaber
Tel: +27 (012) 332 5305
Cell: +27 (083) 2795738
Email: coen@pgsheritge.co.za

SIGNATURE:



Coen Nienaber

ACKNOWLEDGEMENT OF RECEIPT

CLIENT: Ivanplats (Pty) Ltd

CONTACT PERSON: Mr Werner Botha
Senior Projects Manager, Social & Legal Compliance
Cell: 082 411 1656
Email: wernerb@ivanplats.com

SIGNATURE:

Executive summary

Site (Field allocation)	Position	GPR Assessment	Recommendation
IVNPGS23/01	S24.08168 E28.96444	Possible grave	Test excavation
IVNPGS78/01-04	S24.08391 E28.96106	Possible grave	Test excavation
IVNPGS79/1	S24.09088 E28.96250	Possible grave	Test excavation
IVNPGS80/01	S24.07420 E28.96283	Possible graves	Test excavation
IVNPGS81/01	S24.08618 E28.96692	Possible grave	Test excavation
IVNPGS82/01&02	S24.09224 E28.96449	Inconclusive GPR results	
IVNPGS83/01-06	S24.09003 E28.95761	Conduct relocation after CRM Mitigation is complete	
IVNPGSNEWGRAVEK GOLE	S24.09199 E28.95808	Possible grave	Test excavation

Contents

Executive summary.....	3
1. Introduction	6
2. Legal compliance	6
3. Survey methods	6
4. Data processing and visualization.....	8
5. Assessed localities.....	9
5.1. Site IVNPGS81_01	9
Reported grave locality.....	9
Survey results.....	10
Recommendations	10
5.2. Site IVNPGS80_01	10
Reported grave locality.....	10
Survey results.....	11
Recommendations	13
5.3. Site IVNPGS23_01	13
Reported grave locality.....	13
Survey results.....	13
Recommendations	14
5.4. Site IVNPGS82_01 & 02	14
Reported grave locality.....	14
Survey results.....	15
Recommendations	15
5.5. Site IVNPGS79_01	16
Reported grave locality.....	16
Survey results.....	16
Recommendations	17
5.6. Site IVNPGS78_01 - 04.....	18
Reported grave locality.....	18
Survey results.....	18
Recommendations	19
5.7. Site IVNPGS(NEW GRAVE 1) KGOLE	19
Reported grave locality.....	19
Survey results.....	20
Recommendations	21
5.8. Site IVNPGS83_01	21
Reported grave locality.....	21

Survey results.....	22
Recommendations	22
6. Conclusions.....	22
Literature cited	22
Figure 1. Locality map.....	8
Figure 2. Location IVNPGS80_01.....	9
Figure 3. Site IVNPGS81_01 GPR anomaly visualization.	10
Figure 4. Location IVNPGS80_01.....	11
Figure 5. IVNPGS80_01 GPR anomaly visualization.	12
Figure 6. Location IVNPGS23_01.....	13
Figure 7. IVNPGS23_01 GPR anomaly visualization.	14
Figure 8. Location IVNPGS82_01 & 02.	14
Figure 9. Site IVNPGS82_01 & 02 GPR results visualization.....	15
Figure 10. Location IVNPGS79_01.....	16
Figure 11. Site IVNPGS79_01 GPR results.....	17
Figure 12. GPR anomaly possibly indication a grave flagged on the surface at Site IVNPGS79_01.	17
Figure 13. Location IVNPGS78_01 - 04.	18
Figure 14. GRP results visualization Site IVNPR78_01 - 04.	19
Figure 15. GPR survey site IVNPGS NEWGRAVE1.	20
Figure 16. GPR results at Site IVNPLR NEWGRAVE 1.	20
Figure 17. House ruins on the surface at Site IVNPGS83_01 - 06.....	21

1. Introduction

Ground penetrating radar (GPR) has become an established technique in the field of forensic geoscience. In recent years, several studies, focusing on the application of GPR for detecting graves, have emerged; for example Doolittle and Bellantoni (2010), Fiedler et al. (2009), Hansen et al. (2014), Molina et al. (2015), Novo et al. (2011), Pringle et al. (2008), Schultz (2008) and Schultz and Martin (2012). These studies generally fall into one of two categories, those aimed at detecting and/or monitoring unmarked cemetery graves and those aimed at detecting and/or monitoring clandestine graves.

In this instance members of the local community indicated locations said to contain graves. Some of which were reportedly indicated by the presence of various surface features, such as rocks or low mounds, while others were reportedly obliterated by the activities on the site. Each of these localities were surveyed and individually assessed for sub surface radar anomalies that could indicate the possible presence of graves.

2. Legal compliance

SAHRA permits were obtained for both the geophysical survey (SAHRA Permit ID 2099). Since the survey was not conducted at sites where there were any heritage resources present the permit was not a legal requirement to continue with the investigation. The assessment was designed and conducted to confirm or disprove claims that graves were present in specific localities. Until such time as the presence of a heritage resource is not proven or confirmed the locality does not comprise a heritage site and is not subject to the requirements of the NHRA (Act 25 of 1999). Due to the social sensitivities relating to claims, spurious and otherwise, of the presence of graves at the mine the permits were obtained to prove due diligence.

3. Survey methods

A GSSI SIR 3000 GPR system (by Geophysical Survey Systems, Inc.), with a Compact Survey Cart and 400 MHz shielded antenna, was employed in the study. The operating frequency was selected on the basis that it provided a good balance between range (depth of investigation), resolution, and survey productivity. GPR profiles were acquired in one direction. A profile spacing of 50 cm or 1m was used, depending on the situation at each locality (as indicated further in this report) and the depth range was set to approximately 2 m, based on an assumed bulk ground velocity of 0.1 m/ns. In-line positioning accuracy was achieved by using the Cart encoder wheel odometer system.

Together with the 400 MHz antenna a T Rate of 100 KHz in Distance Mode was used. Scans were sampled at 1024 at a Bit rate of 16 with a Range (nS) of 83 and a dielectric setting of 8.00 at a Rate of 64 with 50 scans/unit at a Gain setting of 0 dB. Gain setting, throughout, was on Auto at 4 Points and with a GP1 of 20, GP2 50, GP3 50 and GP3 50. Position settings were at Auto with an Offset of 3.67 and a Surface % of 10. Filter settings were as follows: LP_IIR 0, HP_IIR 0, LP_FIR 800, HP_FIR 100 with Stacking at 3 and BGR_RWVL 0.

On board data processing settings were as follows: LP_IIR 0, HP_IIR 0, LP_FIR 800, HP_FIR 100, BGR-RMVL 0 and ACG and Migration at off.





Figure 1. Locality map.

4. Data processing and visualization

For the purposes of data interpretation 2D and 3D analyses were performed on the various GPR data sets. For the initial 2D analyses the REFLEXW software (by Sandmeier Scientific Software) was used. Time-zero corrections were applied to the data, followed by additional standard processing steps, including dewow filtering and automatic gain control (AGC).

In the case of the Utility Scan DF data some processing was done during data collection where suitable and desirable. In these cases the processing steps are given as part of the information for each survey locality below.

The visualizations presented in this report are with GSSI SIR 3000 firmware, by means of screen capture, or alternatively by means of the GSSI Utility Scan DF firmware.

5. Assessed localities

Table 1. Locality positions (Refer **Error! Reference source not found.**).

IVNPGS23/01	S24.08168 E28.96444
IVNPGS78/01-04	S24.08391 E28.96106
IVNPGS79/1	S24.09088 E28.96250
IVNPGS80/01	S24.07420 E28.96283
IVNPGS81/01	S24.08618 E28.96692
IVNPGS82/01&02	S24.09224 E28.96449
IVNPGS83/01-06	S24.09003 E28.95761
IVNPGSNEWGRAVEKGOLE	S24.09199 E28.95808

5.1. Site IVNPGS81_01

Reported grave locality



Figure 2. Location IVNPGS80_01.

A survey grid of 10 m north and 5 m east of the survey datum point (Refer Table 1) was conducted over the area indicated by the Letwala family members present (Figure 2); reportedly this location contains the grave of a still born child in a house floor.

The survey was conducted starting at the datum and proceeding south to north and returning zigzag fashion at 50 cm intervals.

Survey results

Clear indications of sub-surface structures at this location were observed confirming the presence of an old homestead as indicated by the family. However, GPR resolution is not sufficient to locate the burial of a still born child in a house floor (Figure 3).

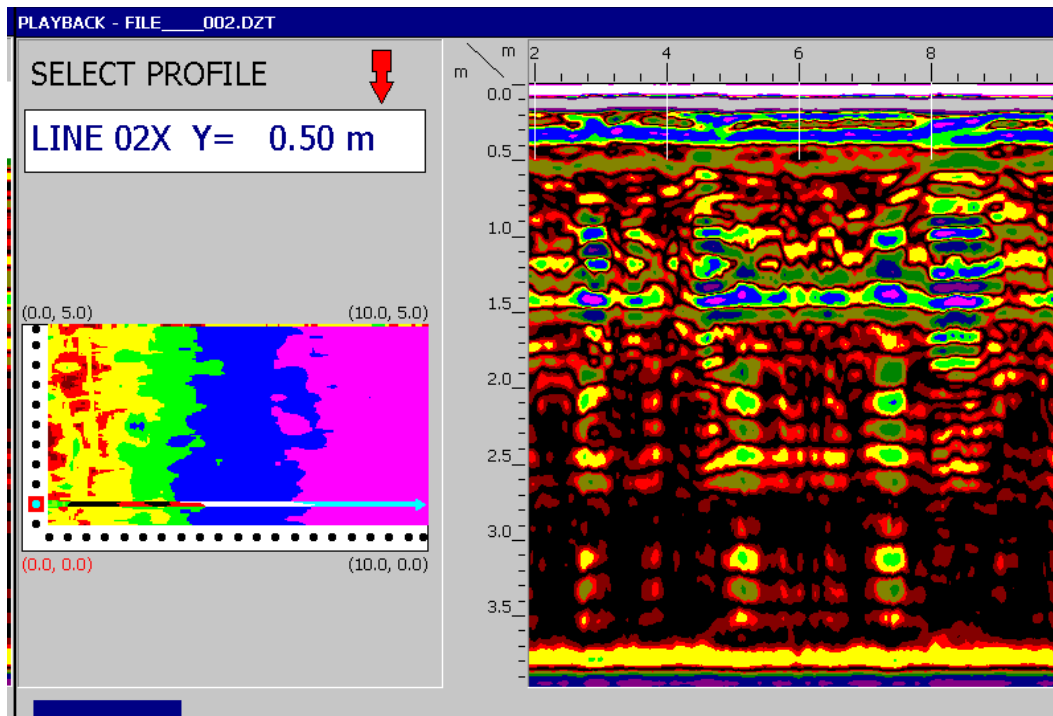


Figure 3. Site IVNPGS81_01 GPR anomaly visualization.

Recommendations

Although the presence of a building was confirmed at the locality the exact location of the grave was not. Test excavation as part of the grave relocation process is recommended to find the specific grave.

5.2. Site IVNPGS80_01

Reported grave locality

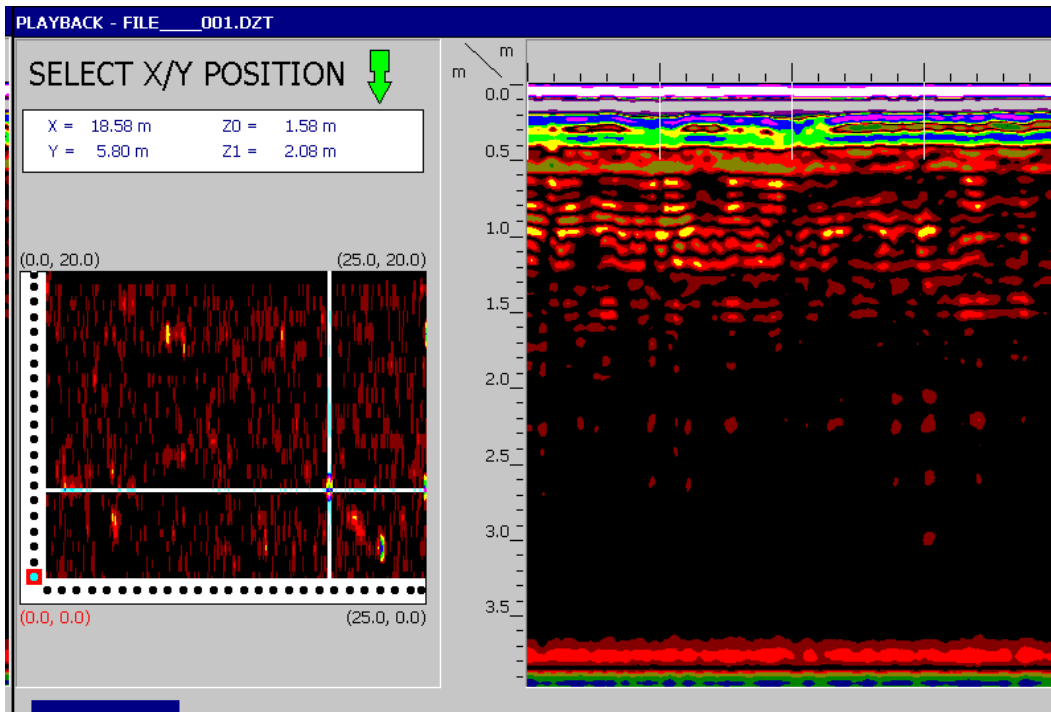
A survey grid of 25 m north and 20 m east of the survey datum point (Refer Table 1) was conducted over the area indicated by the Ndlovu family members present. This area was presumed to contain a single adult grave (Figure 4).

The survey was conducted starting at the datum and proceeding south to north and returning zigzag fashion at 1 m intervals.



Figure 4. Location IVNPGS80_01.

Survey results



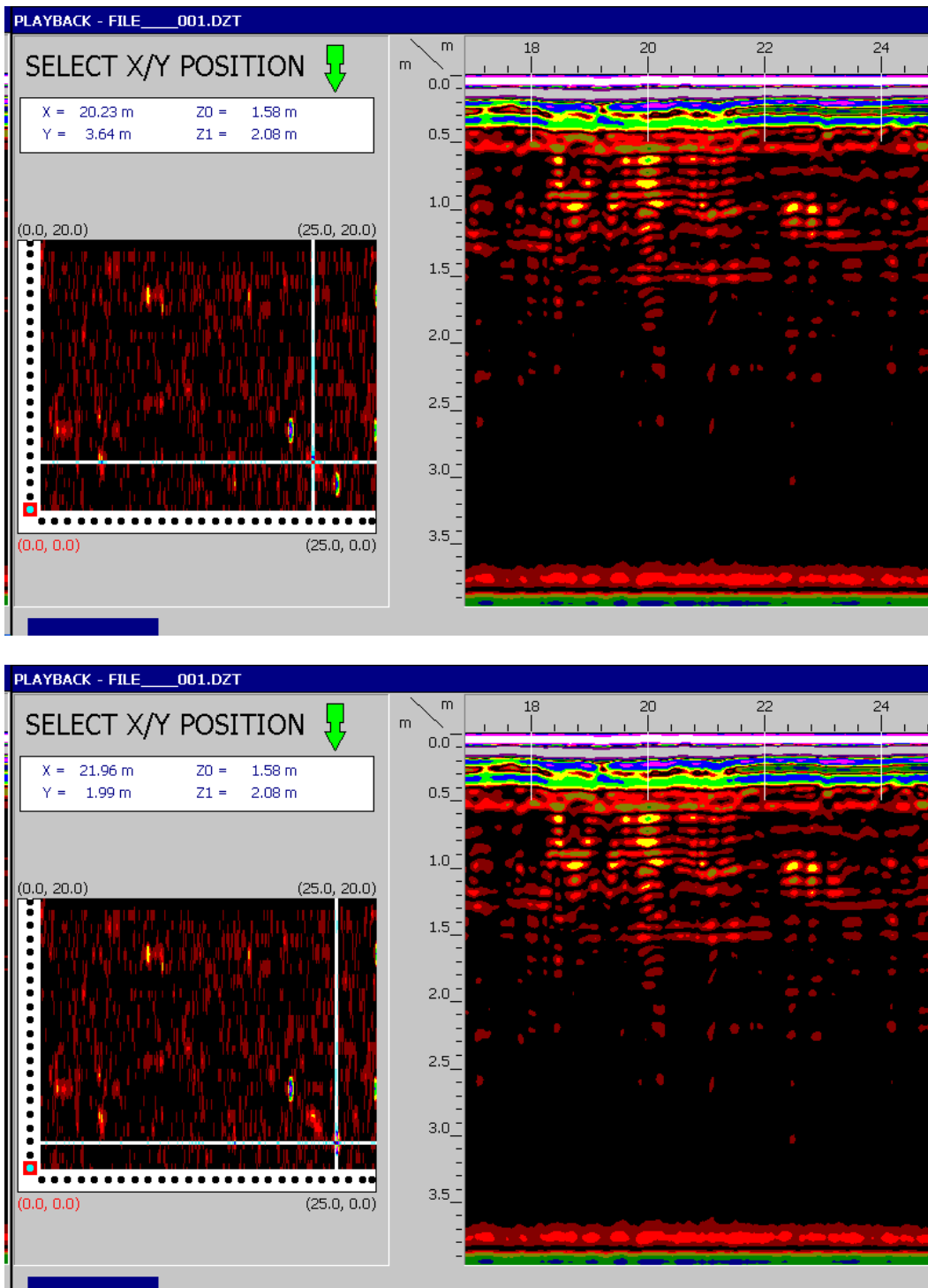


Figure 5. IVNPGS80_01 GPR anomaly visualization.

Anomalies consistent with the possible presence of graves were observed between approximately 1.06 m and 1.55 m below the present surface at the following locations (North and east of grid datum):

- 1) N 18.49m E 5.89 m
- 2) N 21.96 m E 1.99 m
- 3) N 24.83 m E 5.71 m (Figure 5).

These anomalies were pinned and flagged for future investigation.

Recommendations

It is recommended that the indicated anomalies be ground truthed by archaeological test excavation during the grave relocation process.

5.3. Site IVNPGS23_01

Reported grave locality

A survey grid of 7 m north and 10 m east of the survey datum point (Refer Table 1) was conducted over the area indicated by the Manamela family members present (Figure 6); reportedly this location contains the grave of an adult conventionally buried.

The survey was conducted starting at the datum and proceeding south to north and returning zigzag fashion at 1 m intervals.



Figure 6. Location IVNPGS23_01.

Survey results

A sub-surface anomaly consistent with the possible presence of a grave was observed at 3.89 m north and 0.95 m east of the grid datum at a depth of between approximately 1.32 m and 1.82 m below the present surface (Figure 7).

This anomaly was flagged and marked for future investigation as per the recommendations of this report.

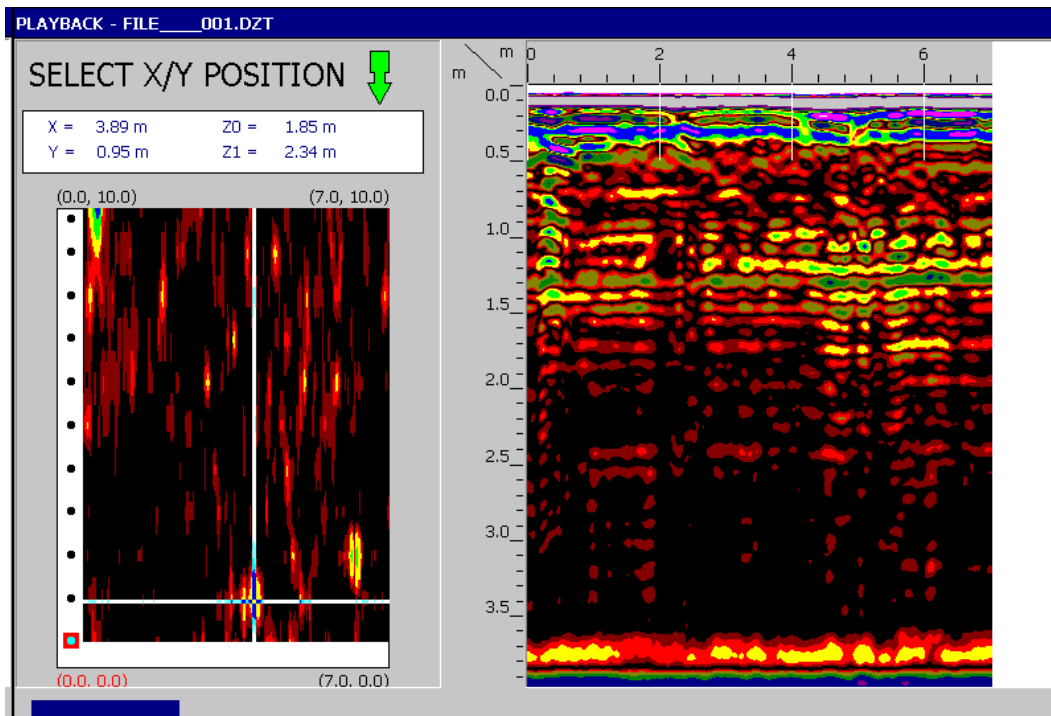


Figure 7. IVNPGS23_01 GPR anomaly visualization.

Recommendations

Test excavation as part of the grave relocation process is recommended to confirm whether the observed anomaly is a grave.

5.4. Site IVNPGS82_01 & 02

Reported grave locality



Figure 8. Location IVNPGS82_01 & 02.

Four 25m single line surveys oriented 240° East of North of the survey datum point (Refer Table 1) was conducted over the area indicated by the Kgole family members present (Figure 8); reportedly this location contains the graves of two still born children in a house floor.

The survey was conducted starting at the datum and proceeding east to west and returning zigzag fashion at 1m intervals.

The indicated area is on a exploration drill site and was extensively disturbed. It appears that this area was graded or bulldozed to prepare the drill site. All possible surface features have therefore been obliterated and it is unknown to what depth the disturbance occurred.

Survey results

No deeper lying sub-surface anomalies were visible. There were, however, clear indications of surface disturbance with homogeneous natural layers below that (Figure 9). The GPR results are inconclusive due to the disturbed nature of the site. It is possible that the house remains reported to have been at this location was destroyed by the exploration drilling activities at the site.

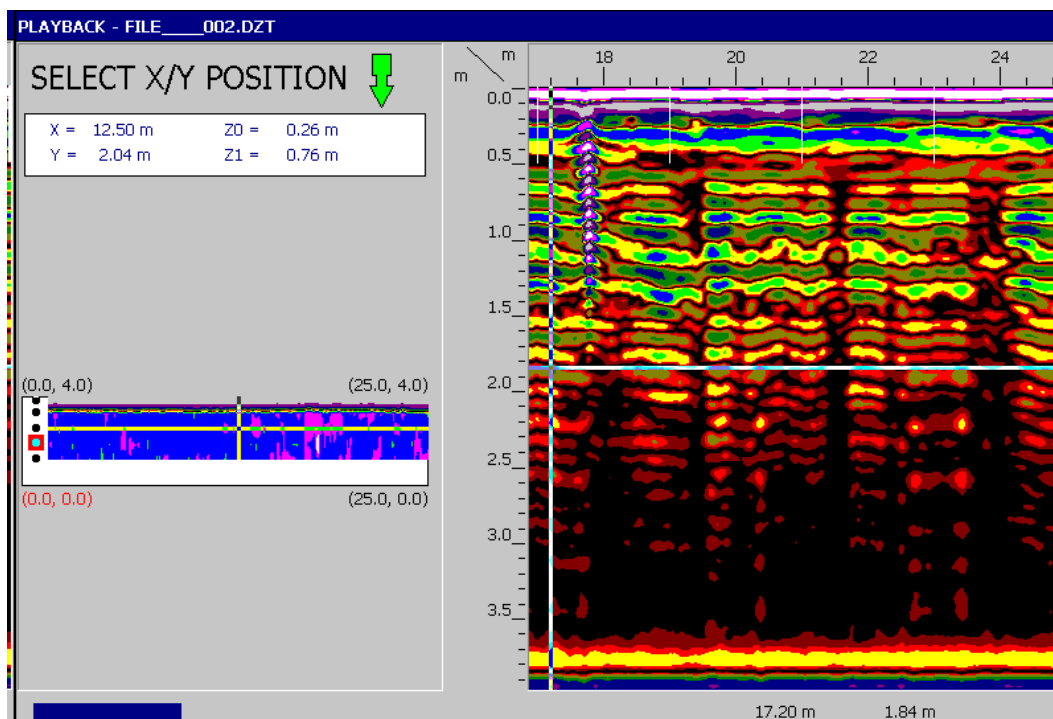


Figure 9. Site IVNPGS82_01 & 02 GPR results visualization.

Recommendations

GPR results inconclusive due to previous disturbance of the site.

5.5. Site IVNPGS79_01

Reported grave locality

A survey grid of 18 m north and 10 m east of the survey datum point (Refer Table 1) was conducted over the area indicated by the Manamela family members present (); reportedly this location contains the grave of a child buried at the back of a house.

The survey was conducted starting at the datum and proceeding south to north and returning zigzag fashion at 1 m intervals.



Figure 10. Location IVNPGS79_01.

Survey results

Sub-surface anomalies possibly consistent with the presence of house ruins were observed in the northern part of the survey. In addition two anomalies, that cannot be excluded as possible graves on the grounds of GPR only, were observed in the southern part of the survey area.

These anomalies occurred at a depth of between approximately 1.06 m and 1.55 m below the present surface at the following locations (North and east of grid datum):

- 1) N 10.63 m E 4.61 m
- 2) N 11.13 m E 8.20 m (Figure 11).

These anomalies were pinned and flagged for future investigation (Figure 12).

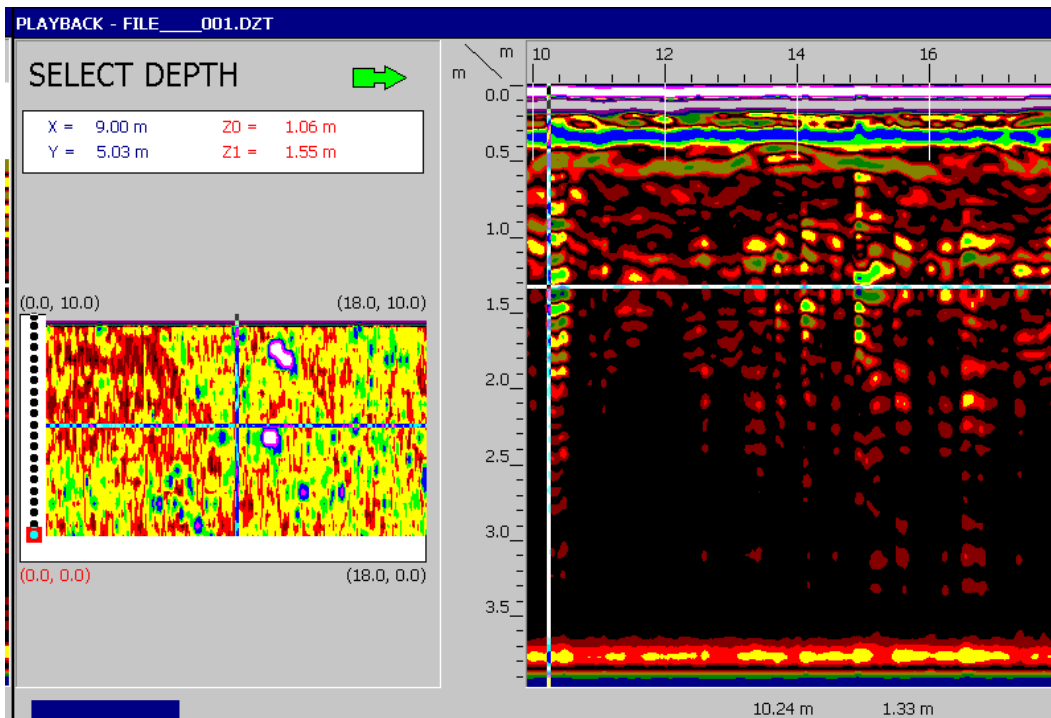


Figure 11. Site IVNPGS79_01 GPR results.



Figure 12. GPR anomaly possibly indication a grave flagged on the surface at Site IVNPGS79_01.

Recommendations

Although the presence of a building was confirmed at the locality the exact location of the grave was not. Test excavation as part of the grave relocation process is recommended to find the specific grave.

5.6. Site IVNPGS78_01 - 04

Reported grave locality

A survey grid of 10 m north and 5 m east of the survey datum point (Refer Table 1) was conducted over the area indicated by the family members present (); reportedly this location contains 4 adult graves.

The survey was conducted starting at the datum and proceeding south to north and returning zigzag fashion at 50 cm intervals.



Figure 13. Location IVNPGS78_01 - 04.

The indicated area was on low berm, presumably the result of clearing for the Box-cut wall.

Survey results

Several sub-surface anomalies were observed at this location, but many of these were not consistent with the possible presence of graves. The following anomaly could not be excluded as a possible grave on the grounds of GPR alone; it occurred at a depth of approximately 1.35 m below the present surface at the following location (North and east of grid datum):

- 1) N 7.73 m E 3.11 m (Figure 14).

The anomaly was pinned and flagged for future investigation.

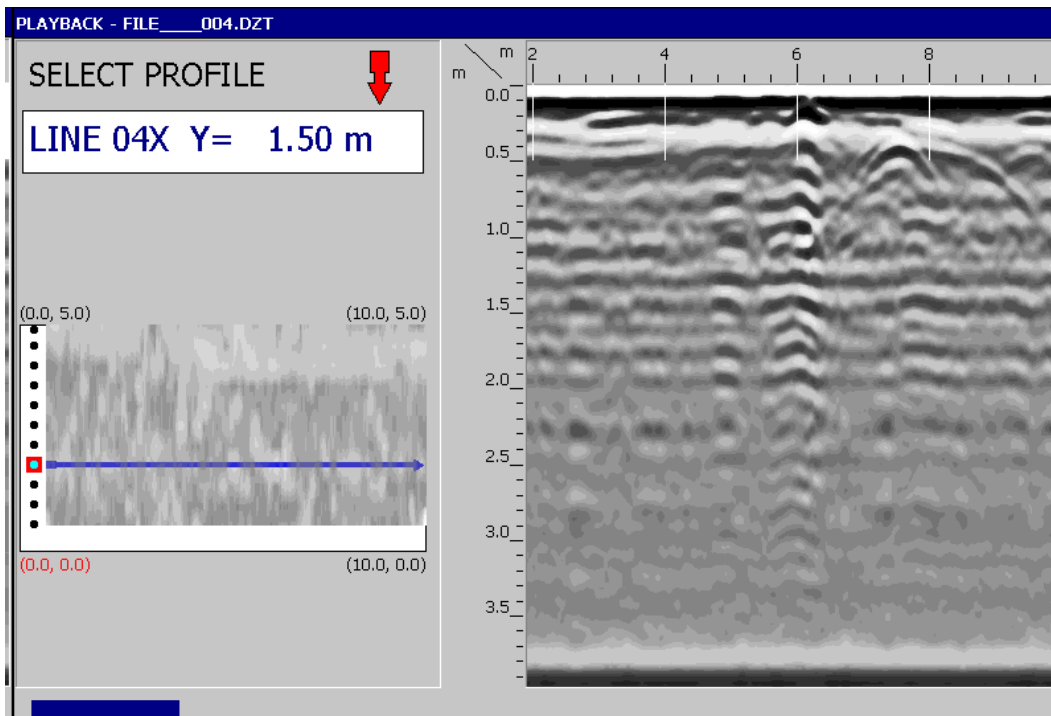


Figure 14. GPR results visualization Site IVNPR78_01 - 04.

Recommendations

It is recommended that the site be included in the relocation program and be test excavated at that time to confirm whether the observed anomaly represent a grave, keeping in mind that for graves were indicated here, but also that the site was possibly disturbed by grading the berm..

5.7. *Site IVNPGS(NEW GRAVE 1) KGOLE*

Reported grave locality

The area indicated by the Kgole family as the location of 2 children's graves in a house floor was insufficiently cleared to conduct a well-structured and accurate GPR survey. In addition the surface at this site was previously disturbed by grading and this was probably an exploration drilling site. Large rocks and several rock pikes also impeded the GPR survey.

Signs of previous habitation of the area such as potsherds and grinding stones in the graded berms were observed.

A survey grid of 12 m north and 12 m east of the survey datum point (Refer Table 1) was conducted over the area indicated by the family members present (Figure 15).

The survey was conducted starting at the datum and proceeding south to north and returning zigzag fashion at 1 m intervals.



Figure 15. GPR survey site IVNPGS NEWGRAVE1.

Survey results

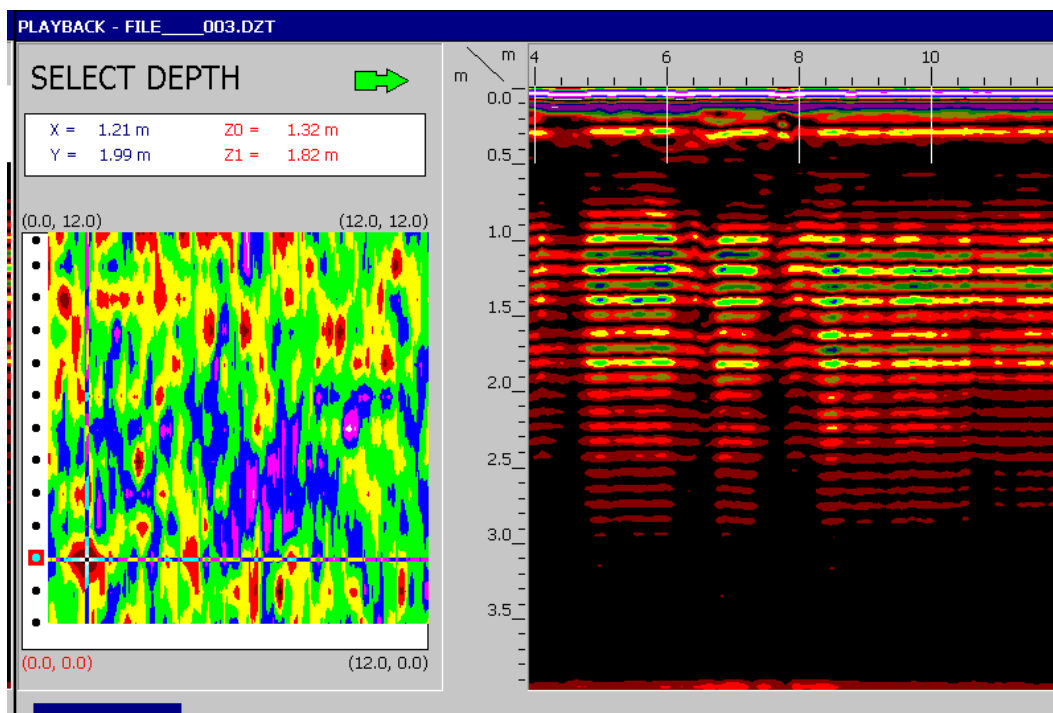


Figure 16. GPR results at Site IVNPLR NEWGRAVE 1.

Due to the rocks and rock piles on the surface of the survey area several instances of antenna lift occurred which might have influenced the reliability of the results. It was also impossible to conduct straight survey lines for all grid

positions due to the shrub and other vegetation present. This could have influenced the reconstruction of the data.

Within the limitations mentioned above the following anomaly could not be excluded as a possible grave on the grounds of GPR alone; it occurred at a depth of between approximately 1.32 m and 1.82 m below the present surface at the following location (North and east of grid datum):

- 1) N 1.21 m E 1.99 m (Figure 16).

The anomaly also corresponded with surface features and was pinned and flagged for future investigation.

Recommendations

It is recommended that the site be included in the relocation program and be test excavated at that time to confirm whether the observed anomaly represent a grave.

5.8. Site IVNPGS83_01

Reported grave locality

The Motupi family claims the presence of 6 child graves in house floors or otherwise associated with structures at this location. The houses in question are clearly visible on the surface and the site was designated as a Heritage Site in the HIA (Figure 17).



Figure 17. House ruins on the surface at Site IVNPGS83_01 - 06.

Survey results

No GPR survey was conducted at this site.

Recommendations

It is recommended that the graves be relocated as part of the larger Graves Relocation Project as soon as the Heritage Mitigation for the site is concluded. Grave excavation will only be possible on an identified heritage site after a Destruction permit is issued by SAHRA. Once the destruction permit is issued general excavations to search for graves and exhume remains will be legally possible. It is suggested that the CRM Archaeologist be instructed to not exhume any human remains that are encountered during mitigation, but that such graves be marked for relocation.

6. Conclusions

Several areas were surveyed and good results were achieved. The use of GPR to assess sub-surface anomalies at this site was able to conclusively indicate the absence of sub-surface anomalies due to the well-established and known soil geology in the general area. It was therefore possible to conclusively state at which of the above localities no graves were present. It was, however not possible to distinguish between graves and other general anomalies that are similar in size and extent. Where these are present additional ground truthing and archaeological test excavation was recommended to confirm whether the observed anomalies represent graves.

It is suggested that these excavations be conducted as part of the larger Graves Relocation project scheduled activities.

Literature cited

Doolittle, J. A., and N. F. Bellantoni, 2010. The search for graves with ground-penetrating radar in Connecticut, *Journal of Archaeological Science*, 37, 941-949.

Fiedler, S., B. Illich, J. Berger, and M. Graw, 2009. The effectiveness of ground-penetrating radar surveys in the location of unmarked burial sites in modern cemeteries, *Journal of Applied Geophysics*, 68, 380-385.

Hansen, J. D., J. K. Pringle, and J. Goodwin, 2014. GPR and bulk ground resistivity surveys in graveyards: Locating unmarked burials in contrasting soil types, *Forensic Science International*, 237, e14-e29.

Ivanplats; EH_IVPGT_011_20150522_Geotechnical_Investigation_Pit_Latrines, A Geotechnical Investigation to Confirm the Presence of Soil Conditions in the Mogongoa and GaKgobudi Project Areas. Eduan Hattingh, 2015.

Molina, C. M., J. K. Pringle, M. Saumett, and O. Hernández, 2015. Preliminary results of sequential monitoring of simulated clandestine graves in Colombia, South America, using ground penetrating radar and botany, *Forensic Science International*, 248, 61-70.

Novo, A., H. Lorenzo, F. I. Rial, and M. Solla, 2011. 3D GPR in forensics: Finding a clandestine grave in a mountainous environment, *Forensic Science International*, 204, 134-138.

Pringle, J. K., J. Jervis, J. P. Cassella, and N. J. Cassidy, 2008. Time-Lapse Geophysical Investigations over a Simulated Urban Clandestine Grave, *Journal of Forensic Science*, 53, 1405-1416.

Schultz, J. J., 2008. Sequential Monitoring of Burials Containing Small Pig Cadavers Using Ground Penetrating Radar, *Journal of Forensic Science*, 53, 279-287.

Schultz, J. J., and M. M. Martin, 2012. Monitoring controlled graves representing common burial scenarios with ground penetrating radar, *Journal of Applied Geophysics*, 83, 74-89.