

Kuruman Moffat Mission: Ground Penetrating Radar survey of selected localities, September 2017.



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4 January 2018

Report revision no: 0

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1. Introduction

Preliminary fieldwork at the Moffat Kuruman Mission in the Northern Cape Province of South Africa in 2017, as part of the larger Re-collecting the Missionary Road project of the University of Cambridge Museum of Archeology and Anthropology was enabled by a grant from the DM McDonald Grants and Award Fund. After initial assessment of historic maps and images in relation to the site as it stands today and of the on-site archive during April of 2017, by Chris Wingfield and Mark McGranaghan from the Museum of Archaeology and Anthropology, together with David Morris from the McGregor Museum and Sol Plaatje University in Kimberley, preliminary agreements were made relating to subsequent fieldwork (Preliminary Fieldwork at Kuruman Moffat Mission 2017).

Between 16 and 24 September 2017 a larger team to survey the site and conduct geophysical investigations (Magnetometry and Ground Penetrating Radar (GPR)) in preparation for the first season of excavation, planned for July 2018, visited the site. The geophysical survey team included Chris Wingfield and David Redhouse from the University of Cambridge, Ceri Ashley, Coen Nienaber and Tyron Hopf from the University of Pretoria and Nick Zachariou from the University of Cape Town (Preliminary Fieldwork at Kuruman Moffat Mission 2017).

This report covers the GPR survey conducted at the site during this field work.

2. Description of the site

2.1. Historical overview

Following the first colonial contact with the people of what is now the Northern Cape Province of South Africa, Cape colonists sought to establish a cattle trade with the Batlhaping. The Batswana also caught the attention of missionaries such as Jan Matthys Kok and William Edwards who accompanied an expedition led by PJ Truter and William Somerville to the Batlhaping. This first mission expedition was unsuccessful, but follow-up expeditions around 1817 achieved more (Snyman 1992). The Kuruman Mission was established by the London Missionary Society in 1816 at Maruping near Kuruman. Robert Moffat and his wife Mary arrived in Kuruman from Scotland in 1820 and relocated the mission to the present position at Seodin in the valley of the Kuruman River. At this mission the Bible was translated in Setswana and the first Setswana Bibles were printed at the site - the first entire Bible printed in Africa. The church at the mission was built in 1838 by Robert Moffat and Robert Hamilton with the help of local men (SA Places 2016). After 49 years at Kuruman, Moffat left in 1870.

During the mid-19th century Kuruman served as the gate to the interior of South Africa and was regarded as a hub for hunting expeditions, trade, missionary work and exploration. With the discovery of diamonds in 1867 near Hopetown and gold in 1868 in Matabeleland political instability in the Kuruman district increased and the development of Kimberly deprived Kuruman of its strategic position (Snyman 1992).

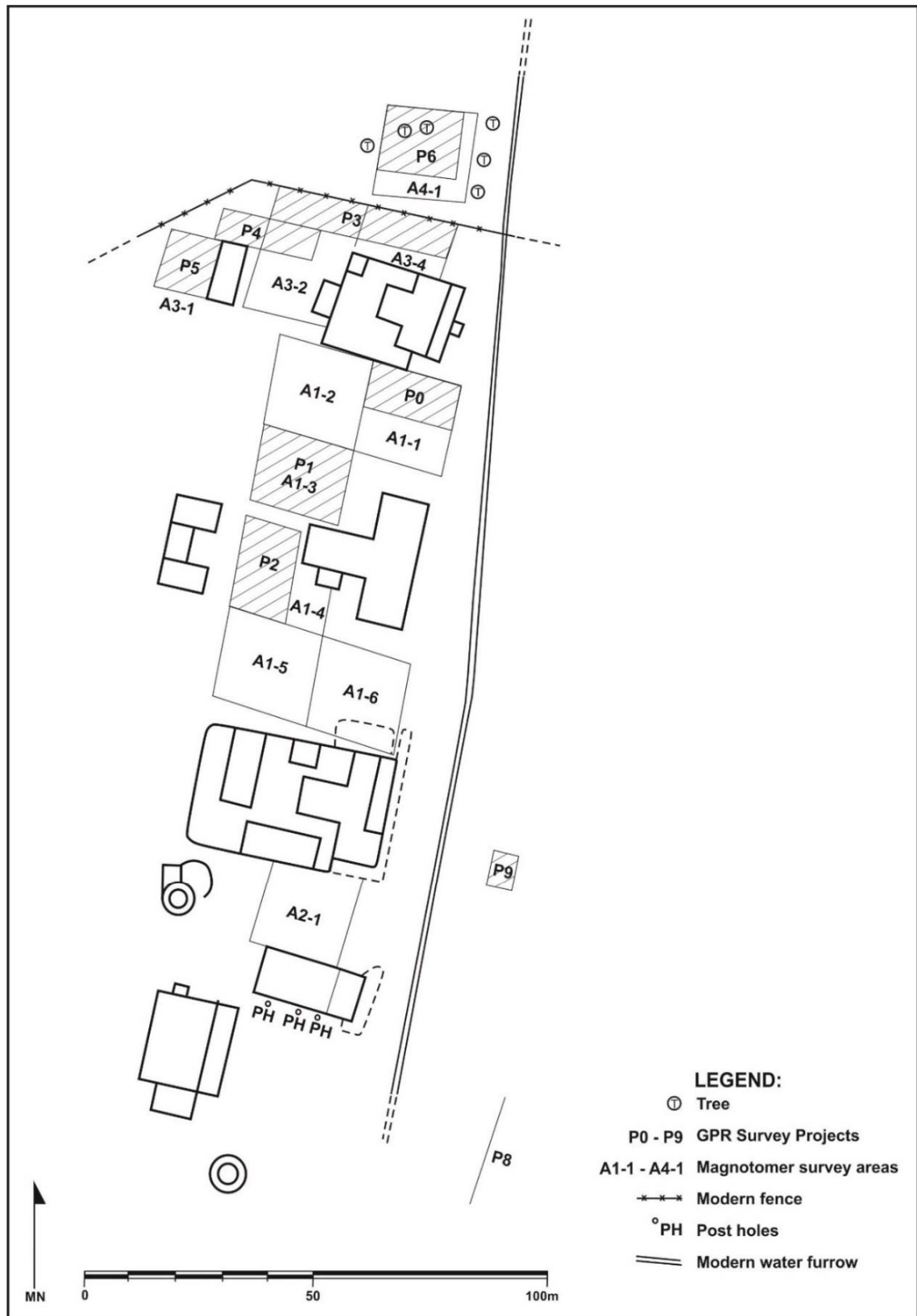


Figure 1. Site map of the Kuruman Mission indicating current buildings and geophysics survey areas conducted during September 2017.

2.2. Buildings and present layout

The Mission property includes a variety of buildings such as the old Homestead where Robert Moffat and his wife, Mary Moffat lived (and which housed David Livingstone for a time), the foundations of a schoolroom built in 1829, the Moffat Church which was completed in 1838, some 50 years before the town of Kuruman was laid out, as well as other historic buildings. The Moffat Church was designed to seat 800 people, and was fully restored in 1938 to mark its centenary (Visit Kuruman 2012-2013).

The mission fell into disrepair from 1960-70, but in 1981 the United Congregational Church (successor to the London Missionary Society) formed a Trust and all the historic buildings were restored and a conference center built (Encounter South Africa 1997-2014).

The buildings and features currently at the site are indicated on the site map (Figure 1).

3. Location of the site

The Kuruman Mission is located close to the town of Kuruman in the Northern Cape Province of South Africa, in the Kuruman River valley at:

S27° 25' 06.3" E23° 25' 46.8" (Figure 2).

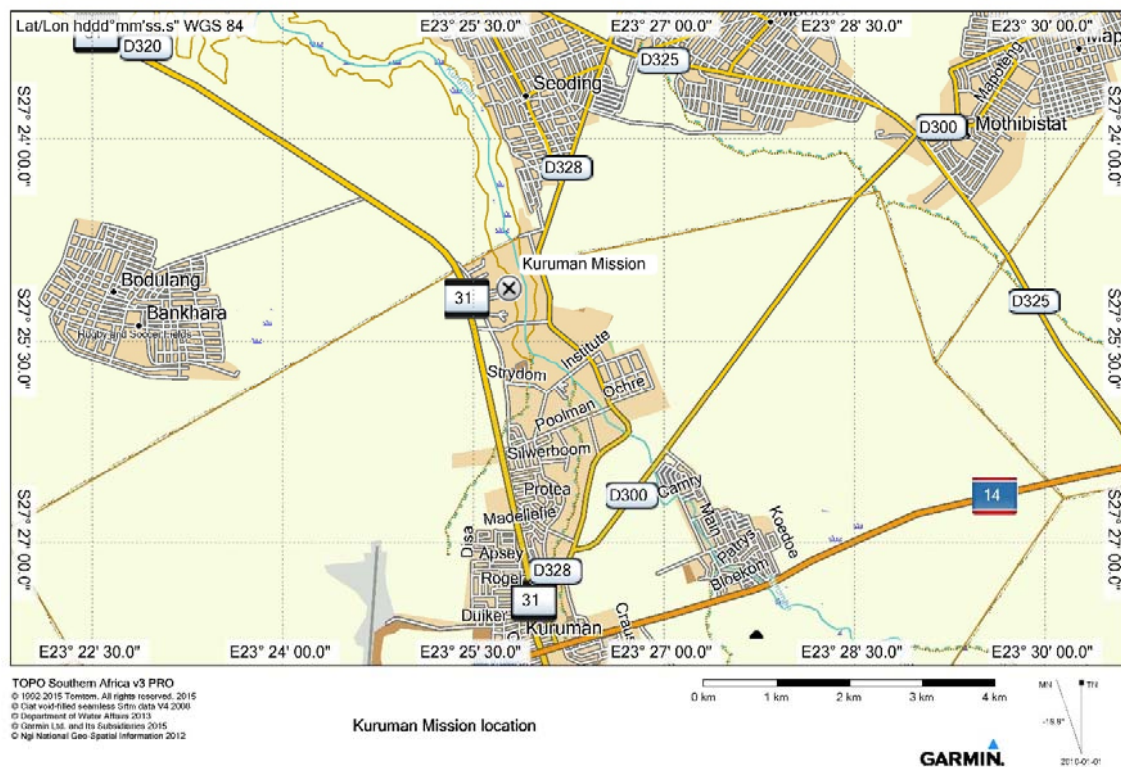


Figure 2. Location map indicating Kuruman Moffat Mission.

4. Aims

The aims of the survey were to ascertain the presence of structures or features, by means of GPR, at localities thought to contain remnants of historical buildings or other site features based on historical maps, drawings and descriptions.

5. Methods of survey and data processing

5.1. Survey approach and equipment

GPR is a widely used and versatile near-surface geophysical method that has been applied to a diverse range of earth science problems, for example, utility detection, concrete and infrastructure studies, mining, and hydrogeophysics. Although the most common fields of application are still utility detection and concrete and infrastructure studies, the use of GPR is on the rise in the field of forensic geoscience (Schultz 2012) (Van Schoor, Nienaber and Marias-Werner 2017) and archaeological geophysics.

The popularity of GPR is due to its capability to survey large areas in relatively short times and at a relatively high (centimeter scale) resolution. Barone et al. (2016) also highlighted the onsite real-time processing capability of modern GPRs as a further key benefit. Most commercially available GPR systems employ a constant-offset transmitter and receiver antennae configuration that can be mounted on a push-cart. A three-dimensional (3D) or grid survey approach is commonly used to cover large areas for the purpose of depth slice extraction and 3D data visualisation. 3D GPR surveys typically involve a grid of equidistant parallel profiles acquired in two perpendicular directions to optimize spatial resolution. Data acquisition is usually conducted at a single operating frequency in the range of 100–1000 MHz, and the resulting depth of investigation is typically limited to the first few metres of the near-surface. In GPR, there is a trade-off between range and resolution: increasing the operating frequency implies a higher resolution, but at the cost of a decreasing range associated with the corresponding increase in attenuation; similarly, a lower operating frequency will enable a greater depth of investigation, but at reduced mapping accuracy (Van Schoor, Nienaber and Marias-Werner 2017).

In archaeological GPR investigations, an operating frequency between approximately 200 and 500 MHz is typically used; even though the highest possible resolution is often desired, local soil conditions and the previously described range–resolution trade-off sometimes make a medium frequency option the most appropriate choice. In this survey, an operating frequency of 500 MHz was selected as it provided a good balance between range, resolution, and survey productivity. Consequently, a Rock Noggin GPR system (by Sensors & Software Inc.), with a SmartCart and 500 MHz shielded antenna, was employed.

For all the 3D GPR surveys, data were acquired in two perpendicular directions to optimise lateral resolution. The survey grids were defined so that the X-lines would be in an easterly direction the Y-lines north (Refer: Figure 1). A profile spacing of 1 m was used. The depth range was set to approximately 2 m and the effective time sampling interval equated to approximately

0.015 m, based on an assumed bulk ground velocity of 0.1 m/ns. In-line positioning accuracy was achieved by using the SmartCart odometer system.

5.2. Data processing and visualization

For each of the GPR surveys, the same approach to processing and analysis was followed: individual two-dimensional (2D) profiles were first processed using the REFLEXW software (by Sandmeier Scientific Software). Standard processing steps included:

- (i) time-zero correction;
- (ii) (ii) mean subtraction (dewow) to eliminate unwanted low-frequency components from the data;
- (iii) automatic gain control to amplify low-amplitude ranges; and
- (iv) background removal to suppress horizontally coherent energy and to emphasize anomalies that vary laterally such as diffractions.

In addition to the 2D analyses described above, the respective 3D datasets were processed for the purpose of generating depth slices. To achieve this, Sensors & Software's GFP Edit software was employed for the georeferencing of grid profiles and to produce the 3D input file for Sensors & Software's depth slice module, i.e., Ekko_Mapper. The Ekko_Mapper software can either operate on a dataset that was previously processed in other software (such as REFLEXW), or it can be set up to apply a standard sequence of processing steps to all the data prior to slicing through the volume of data. A typical processing sequence for depth slice generation includes amplitude equalisation gain, velocity-based migration, envelope filtering, and background subtraction. The migration filter is designed to contract diffractions and to move steeply dipping reflectors to their true spatial positions, whereas the envelope filter aims to suppress the oscillatory nature of radar responses and provides a simplified visualization of spatial resolution (Annan 1999).

6. Survey localities

In total 11 localities were surveyed (Refer Figure 1). The shape, size and location of each survey grid (referred to as Projects) was determined by the locality, the buildings currently present at the site and historical indications of the possible presence of structures no longer discernible on the present surface. The GPR survey grids were aligned with the Magnetometry survey grids (referred to as Areas) to enable the direct comparison of results for the different geophysical methods.

6.1. GPR survey: Project 0

Grid size and location

This survey was conducted as a 9 m x 20 m grid oriented north (y) and east (x). It was located 0.8 m south of the compound wall of the Hamilton house and corresponded with the northern half of magnetometry survey area A1-1 (Figure 1).

Historical sources indicated the possible presence of a dairy shed or other structure at this locality. This might be related to stones visible on the surface in this area (Figure 3).



Figure 3. Project 0 GPR survey area.

Results

Radar anomalies indicating the presence of features and deposits in this area were observed. Anomalies consistent with the presence of edges or trenches were visible at the western side of the grid while a distinctly different deposit was present in the eastern half of the surveyed area (Figure 4).

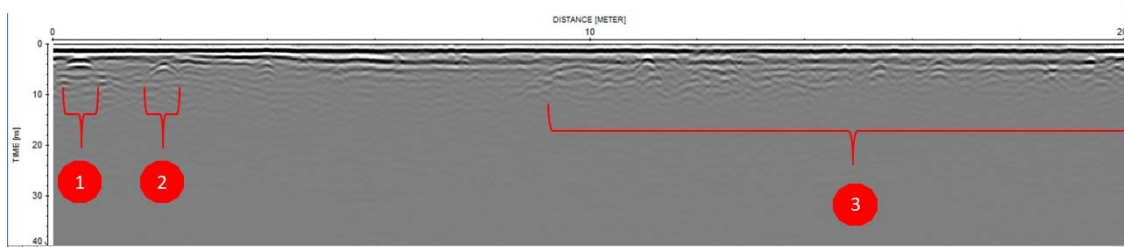


Figure 4. Radargram for Line 25 of Project 0 (representing a west-east profile). Anomalies 1 and 2 indicate possible trenches or edges. Anomaly 3 indicates a distinct deposit.

A 3D visualization of the data shows an irregularly shaped area where this deposit occurred, however, some strong linear features were represented.

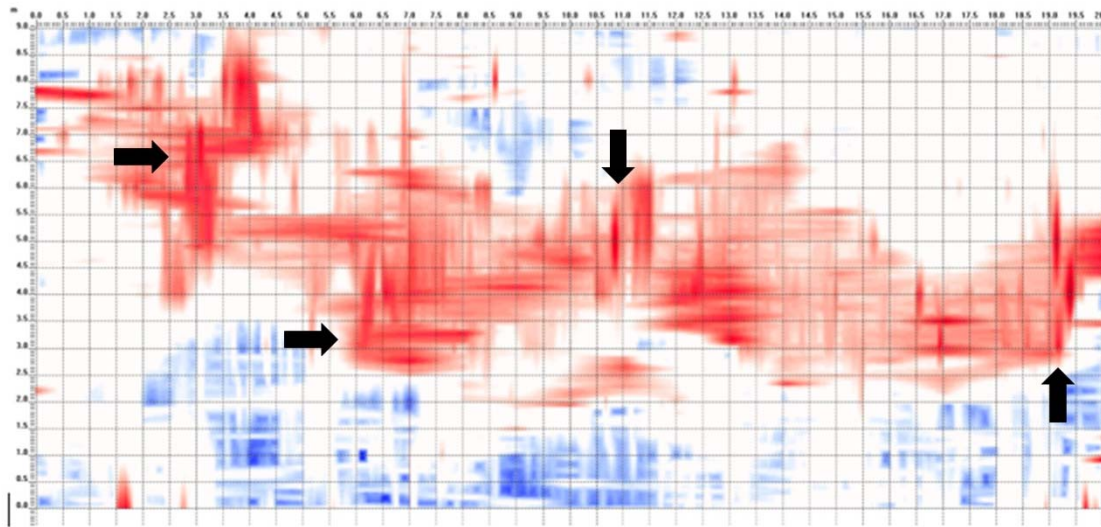


Figure 5. 3D visualization for Project 0. Linear features indicated by arrows. North up.

Discussion and interpretation

The GPR anomalies present in this area indicate the sub-surface presence of the remnants of a building or other structure. It was located next to the Hamilton house on the south side (Figure 6).



Figure 6. GPR anomalies in Project 0 in relation to the Hamilton house. North up.

Archaeological ground-truthing of the indicated features (as represented by the GPR anomalies) could provide more information on the structures, their specific layout and possible use and significance.

6.2. GPR survey: Project 1

Grid size and location

This survey was conducted as a 14 m x 20 m grid oriented north (y) and east (x). It was located north of the church and to the north-east of the school and corresponded with magnetometry survey area A1-3 (Figure 1).

There were no historical indications of the possible presence of structures or buildings in this area, and no indications of the possible presence of sub-surface structures were observed on the surface (Figure 7).



Figure 7. The surface of the Project 1 survey area.

Results

No indications of the possible presence of sub-surface structures were observed in this survey area.

Discussion and interpretation

No sub-surface anomalies indicating the existence of any structures or features were present in this survey area.

6.3. GPR survey: Project 2

Grid size and location

This survey was conducted as a 13 m x 26 m grid oriented north (y) and east (x). It was located between the church and the school and corresponded with the western part magnetometry survey area A1-4 (Figure 1).

There were no historical indications of the possible presence of a structure or buildings in this locality and no indications of the possible presence of sub-surface structures were observed on the surface in this area (Figure 8).



Figure 8. The surface of the Project 2 survey area.

Results

No results indicating the possible presence of sub-surface structures were observed in this area.

Discussion and interpretation

No sub-surface indications of any structures or features were present in this survey area.

6.4. GPR survey: Project 3

Grid size and location

The Project 3 GPR survey included a grid of 7 m x 40 m along the (modern) northern fence of the mission site. It was oriented north (y) and east (x) and corresponded with the northern parts of the magnetometry survey Areas A3-2 and A3-4 (Figure 1).

Historical sources indicated that a furnace or other structures were possibly present in this general area. No surface indications of any historical structures were observed in the area (Figure 9). The eastern part of the area (between the Hamilton house and the modern fence) was heavily disturbed by earth works for a garden.



Figure 9. The Project 3 GPR survey area.

Results

Anomalies observed indicated the presence of linear sub-surface structures in this area. The disturbed deposits where the garden was levelled were also visible in the results (Figure 10).

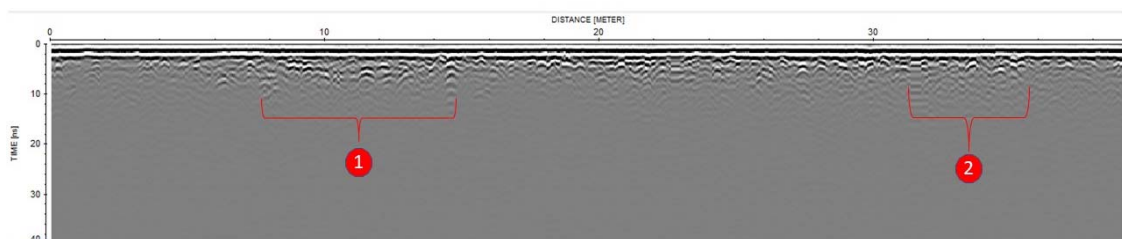


Figure 10. Radargram (2D) for Line 44 of Project 3 (representing a west-east profile). Anomaly 1 indicates possible trenches or edges and anomaly 2 indicates the disturbed garden area.

The 3D visualization of the GPR data indicated the presence of two possible linear sub-surface anomalies that might be the remnants of rectangular buildings. The disturbed garden area was also evident (Figure 11).

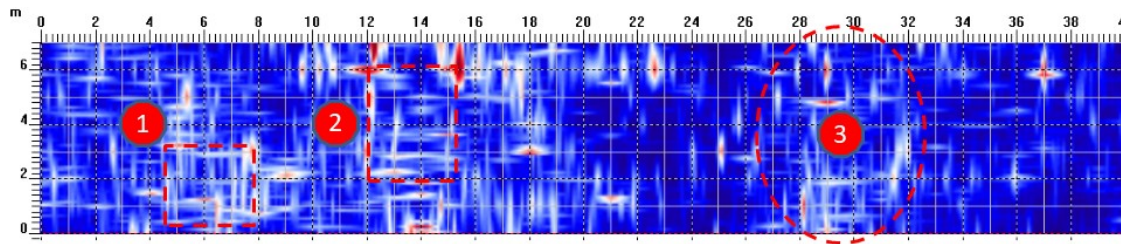


Figure 11. A 3D visualization of Project 3. Anomaly 1 comprises linear anomalies that can indicate the presence of a building (it is possible that it continues to the south), anomaly 2 represents a second possible sub-surface structure and 3 indicates the disturbed garden area. North up.

Discussion and interpretation

The GPR anomalies present in this area represented the sub-surface presence of the remnants of two possible buildings or other structures located next to the Hamilton house on the northern side (Figure 12).

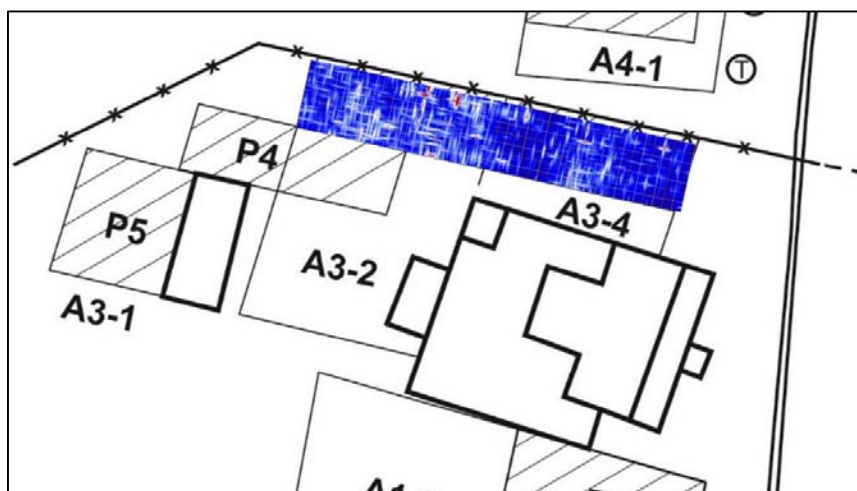


Figure 12. GPR anomalies in Project 3 in relation to the Hamilton house.

Archaeological ground-truthing of the indicated features (as represented by the GPR anomalies) could provide more information on the structures, their specific layout and possible use and significance.

6.5. GPR survey: Project 4

Grid size and location

The Project 4 GPR survey included a grid of 8 m x 21 m behind the Hamilton house and its wagon shed. It was oriented north (y) and east (x) and was part of the magnetometry survey Areas A3-1 and A3-2 (Figure 1).

Historical sources indicated that a furnace or other structures were possibly present in this general area. It is also possible that another wagon house, or buildings different than the current reconstruction of the wagon house occurred here. No surface indications of any historical structures were observed in the area (Figure 13).



Figure 13. The Project 4 GPR survey area.

Results

Several anomalies that might represent sub surface structures occurred in this area (Figure 14).

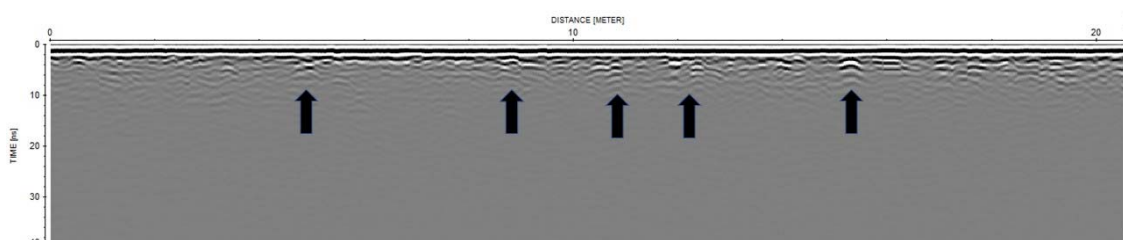


Figure 14. Radargram (2D) for Line 26 of Project 4 (representing a west-east profile). Observed anomalies are indicated by arrows.

3D visualization of the data indicated the possible presence of a sub-surface structure (Figure 15). This might continue from the anomalies observed in the southern part of Project 3 (Refer: Figure 16).

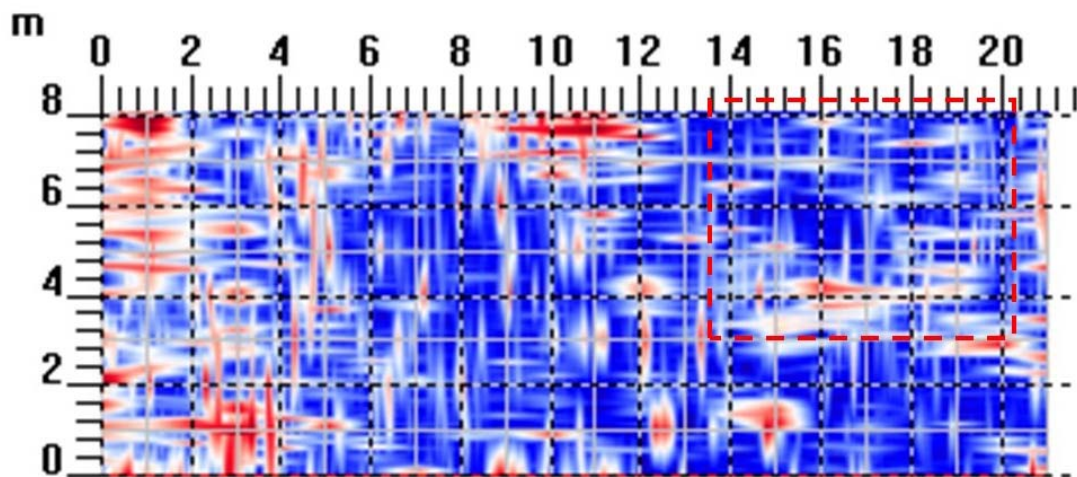


Figure 15. 3D visualization of data for Project 4. Possible linear anomaly indicated in red. North up.

Discussion and interpretation

The GPR data indicated a possible rectangular sub-surface disturbance occurring in this area (Figure 16).

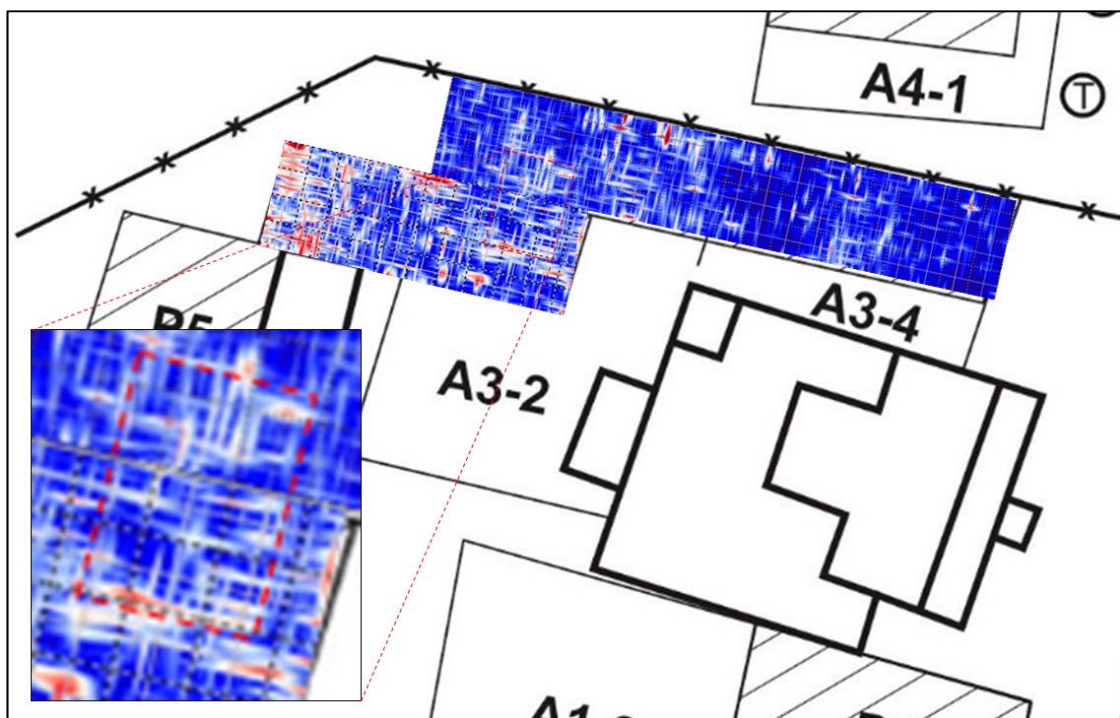


Figure 16. GPR anomalies in Project 3 in relation to the Hamilton house. Possible rectangular anomaly indicated in red. North up.

Archaeological ground-truthing of the indicated features (as represented by the GPR anomalies) could provide more information on the structures, their specific layout and possible use and significance.

6.6. GPR survey: Project 5

Grid size and location

The Project 5 GPR survey included a grid of 13 m x 13 m to the west of the wagon shed west of the Hamilton house. It was oriented north (y) and east (x) and corresponded with the south-eastern part of the magnetometry survey Area A3-3 (Figure 1).

Historical sources indicated that a furnace or other structures were possibly present in this general area. It is also possible that another wagon house, or buildings different than the current reconstructed wagon house occurred here. No surface indications of any historical structures were observed in the area (Figure 17).



Figure 17. The Project 5 GPR survey area.

Results

No results indicating the possible presence of sub-surface structures were observed in this area.

Discussion and interpretation

No sub-surface anomalies indicating the existence of any structures or features were present in this survey area.

6.7. GPR survey: Project 6

Grid size and location

The Project 6 GPR survey included a grid of 14 m x 18 m directly north of the Hamilton house on the other side of the modern fence. It was oriented north (y) and east (x) and corresponded with the north-western part of the magnetometry survey Area A4-1 (Figure 1).

Historical sources indicated that a trading post was previously located in this area. This was supported by trees and packed stones visible at the site (Figure 18).



Figure 18. The Project 6 GPR survey area.

Results

Several linear anomalies related to each other were observed in this area (Figure 19).

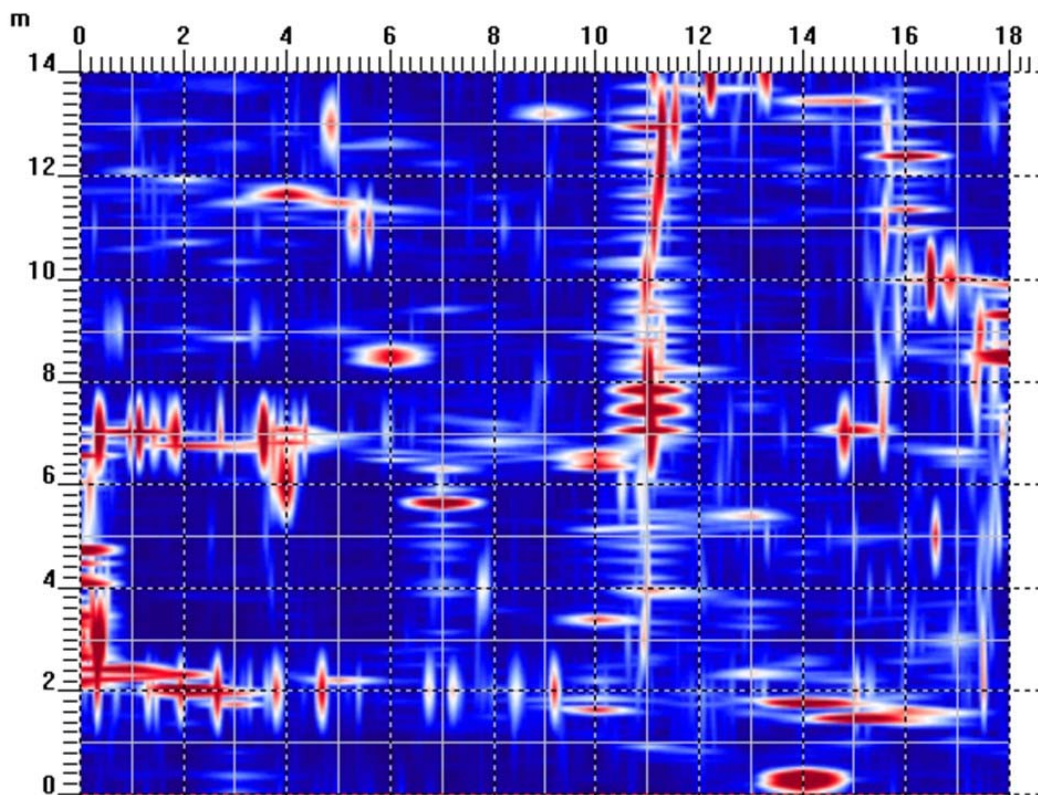


Figure 19. 3D visualization of data for Project 6. North up.

Discussion and interpretation

Radar anomalies in this area clearly indicated the sub-surface presence of an L-shaped structure comprising several rooms or divisions (Figure 20).

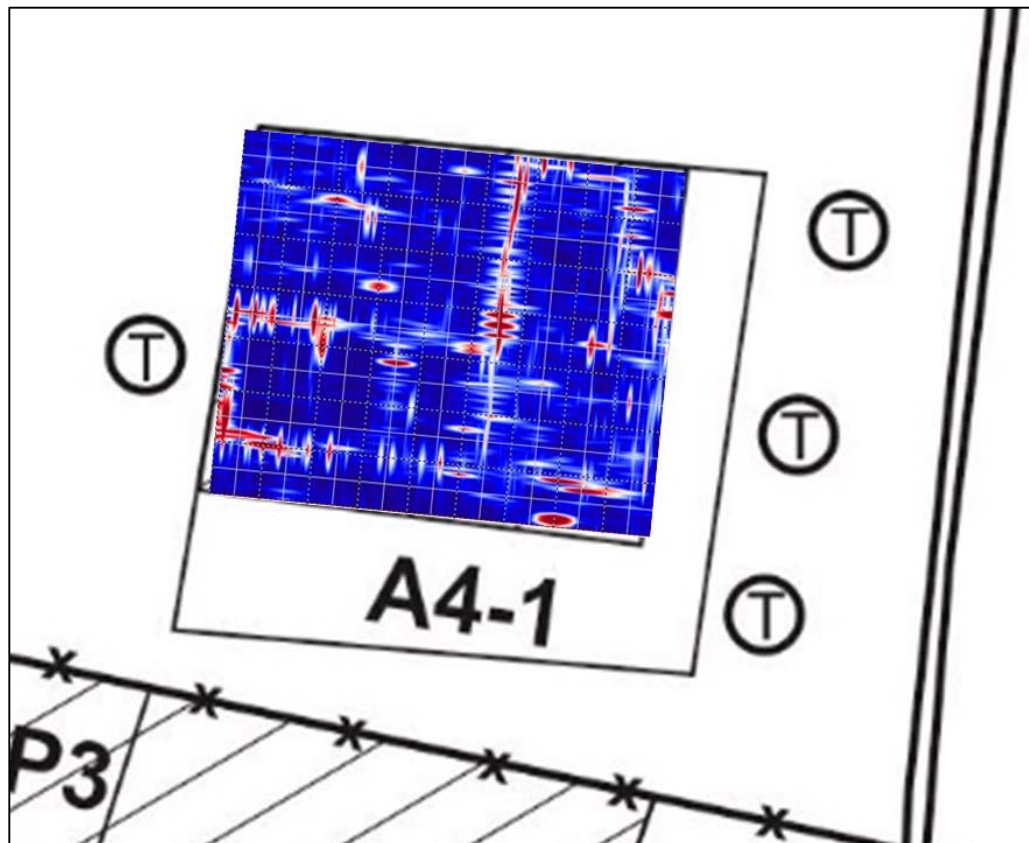


Figure 20. 3D GPR results superimposed on the site features at Project 6. North up.

Archaeological ground-truthing of the indicated features (as represented by the GPR anomalies) could provide more information on the structures, their specific layout and possible use and significance.

6.8. GPR survey: Project 7

Grid size and location

The Project 7 GPR survey included a grid of 17 m x 13 m at S27° 25' 19.0" E23° 25' 36.2". It was oriented north (y) and east (x). No magnetometry survey was conducted at this locality (Figure 21).

Historical sources indicated that this was the location of the cemetery for Black people associated with the mission. Surface features and vegetation differences indicated the presence of graves at this locality (Figure 22).



Figure 21. The location of Project 7 (Survey area indicated in grey).



Figure 22. The Project 6 GPR survey area.

Results

Several anomalies consistent with graves were observed at this locality.

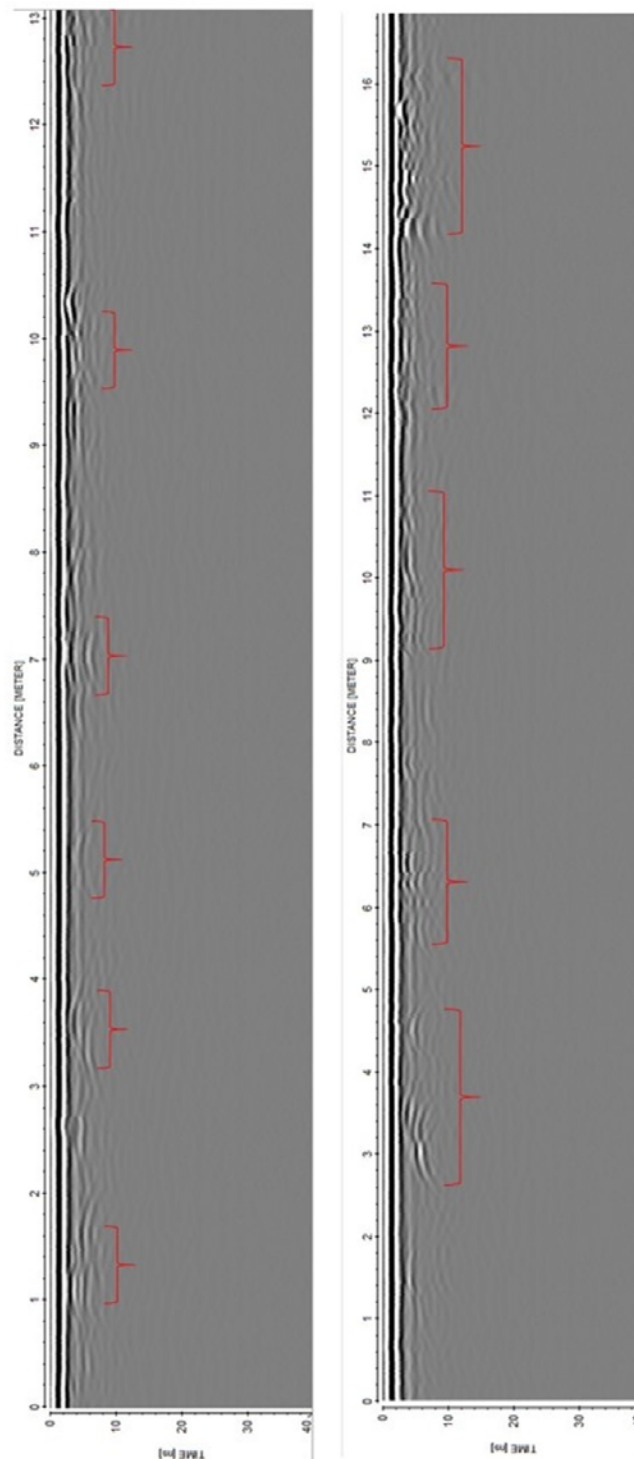


Figure 23. Radargrams for Project 7 Line 18 (left) and Line 4 (right) showing anomalies in the west-east and south-north aspects respectively. Anomalies consistent with possible graves indicated in red.

Due to the surface conditions at the site the geometry of the survey was not sufficiently accurate to enable 3D visualization of the data.

Discussion and interpretation

At least 30 anomalies consistent with graves were present in the survey area. These anomalies were oriented east-west and appear to be rectangular. This is consistent with a Christian-Western burial style. The cemetery appears to be larger than the surveyed area and it should be assumed that there are more graves present.

These results and interpretations should be ground-truthed by bio-archaeological methods. Specific legislation applicable to graves and ethical considerations should be considered. Excavation and analysis of the human remains could provide information on the identity and lifeways of the people buried here.

6.9. GPR survey: Project 8A

Survey and location

The Project 8A GPR survey included 3 lines of 30 m in length, east of the current water furrow at the entrance to the Mission. The lines were oriented in a south-westerly direction and no magnetometry survey was conducted at this location (Figure 1).

Historical sources indicated that a mill and mill run were previously located in this general area, some remnants of a building (possibly the mill) and an old furrow (the mill run) were visible at the site (Figure 24).



Figure 24. The Project 8A GPR survey area

Results

Radar anomalies consistent with the sub-surface presence of a trench or furrow were observed (Figure 25).

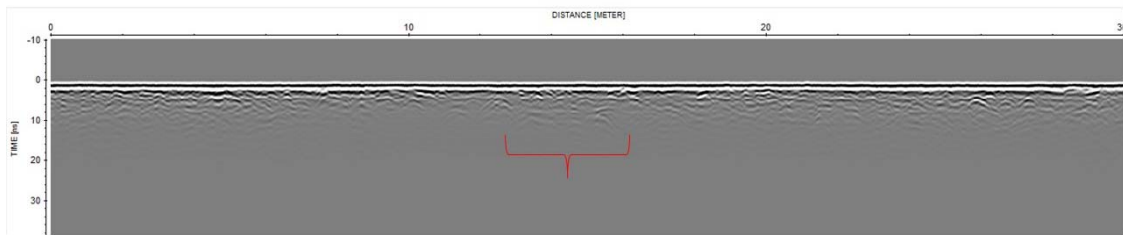


Figure 25. Radargram for Project 8A Line 2 showing the north-east to south-west aspect. Sub-surface anomalies indicated in red.

Discussion and interpretation

The visible evidence and radar data indicated that an old furrow was present under the road at this locality. This might be the mill run associated with the historical mill at the site.

Archaeological ground-truthing of the indicated features (as represented by the GPR anomalies) could provide more information on the structures, their specific layout and possible use and significance.

6.10. GPR survey: Project 8B

Grid size and location

The Project 8B GPR survey included a grid of 20 m x 3 m at S27° 25' 16.6" E23° 25' 41.5". It was oriented north (y) and east (x). No magnetometry survey was conducted at this locality (Figure 26).

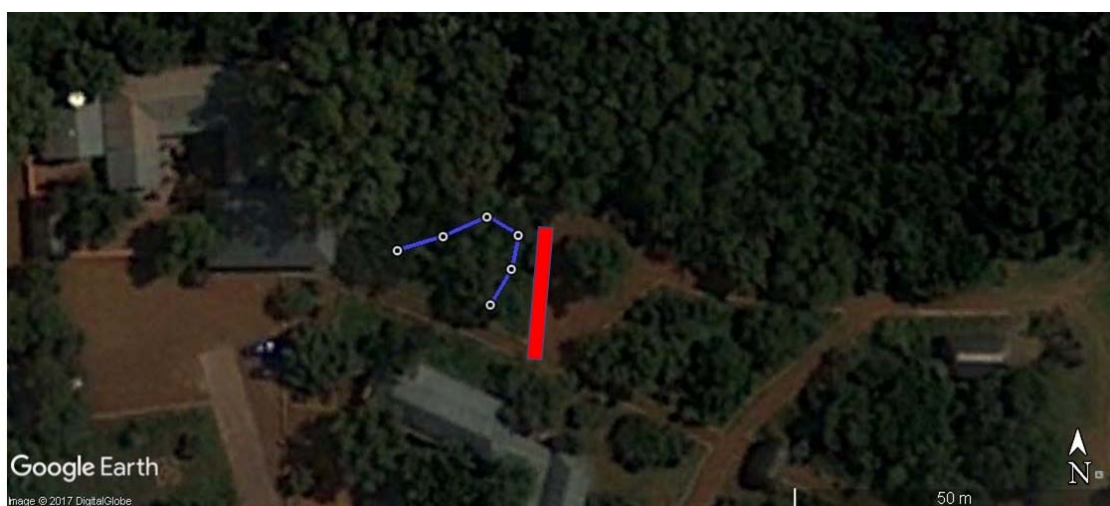


Figure 26. Location map Project 8B. Stone wall indicated in blue. Survey locality in red.

The presence of a stone wall immediately west of the surveyed area and historical sources indicated that this was possibly the location of an African village associated with the Mission.

Results

No radar anomalies indicating any significant sub-surface features were observed at this location.

Discussion and interpretation

Although no radar anomalies were observed; it should be kept in mind that the surveyed area was heavily disturbed and modified due to the construction of the modern buildings at the site. A survey of only 3 m wide is also insufficient to conclude the absence or presence of the types of deposits usually associated with a traditional African village.

6.11. GPR survey: Project 9

Grid size and location

This survey was conducted as a 7 m x 6 m grid oriented north (y) and east (x). It was located in the garden of the Moffat house east of the water furrow (Figure 1). No magnetometry survey was conducted in this area.

Historical sources indicated the possible presence of a shed or other structure that was used for the original printing press. No surface indications of the presence of a structure could be observed at this locality (Figure 27).



Figure 27. The Project 9 survey area.

Results

Sub-surface linear anomalies to the west of the garden path were observed (Figure 28).

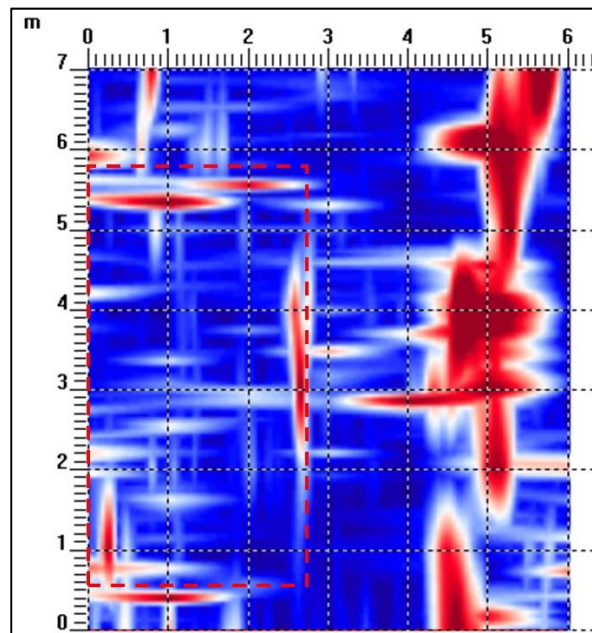


Figure 28. 3D visualization for Project 9. Linear anomalies indicated in red.

Discussion and interpretation

Radar data for this survey indicated the sub-surface presence of a rectangular structure at the location.

Archaeological ground-truthing of the indicated features (as represented by the GPR anomalies) could provide more information on the structures, their specific layout and possible use and significance.

7. Conclusion

In total 11 GPR surveys were conducted at the Kuruman Moffat Mission in areas where historical information indicated the possible presence of structures or features no longer visible on the present surface. The locations and extent of the cemetery for Black people and the several African villages associated with the mission were unknown. Based on historical information, likely sites where these features and structures could have occurred were also included.

In all but three localities (Projects 1, 2 and 5) results indicated the presence of sub-surface features or structures. In one instance the results were inconclusive (Project 8B)(Refer Figure 1). The other localities, where results indicated the presence of sub-surface features or structures, should be investigated archaeologically in order to ground truth the GPR findings.

Bibliography

- Annan, AP. 1999. "Practical processing of GPR data." *Proceedings of the Second Government Workshop on Ground Penetrating Radar*. Columbus, OH: Sensors & Software, Inc.
- Barone, PM, KJ Swanger, N Stanley-Price, and A. Thursfield. 2016. "Finding graves in a cemetery: preliminary forensic GPR investigations in the Non-Catholic Cemetery in Rome (Italy)." *Measurement* 80: 53-57.
- 1997-2014. *Encounter South Africa*. Accessed 12 16, 2017. <http://www.encounter.co.za/moffat-mission.html>.
2017. *Preliminary Fieldwork at Kuruman Moffat Mission*. Accessed 12 16, 2017. <http://maa.cam.ac.uk/kmm-prelims/>.
2016. *SA Places*. Accessed 12 16, 2017. https://www.places.co.za/html/moffat_m.html.
- Schultz, JJ. 2012. "The application of ground-penetrating radar for forensic grave detection." In *A Companion to Forensic Anthropology*, by D Dirkmaat.
- Snyman, PHR. 1992. *Kuruman: Vervloë pad na Afrika*. Pretoria: Raad vir Geesteswetenskaplike Navorsing.
- Van Schoor, M, WC Nienaber, and A Marias-Werner. 2017. "A controlled monitoring study of simulated clandestine graves using 3D ground penetrating radar." *Near Surface Geophysics* 15: 274-284.
- 2012-2013. *Visit Kuruman*. Accessed 12 16, 2016. <http://visitkuruman.co.za/moffat-mission>.