CAA 2009 Williamsburg

Tracing Leveled Earthworks at Petersburg

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Abstract

A geophysical survey has traced some remnants of the earthen fortifications at the Petersburg battlefield; these earthworks were constructed during the U. S. Civil War in 1864 in the state of Virginia. Trenches and pits that were dug during the year-long battle were revealed by several geophysical instruments.

After the battle at Petersburg, some of the fortifications were leveled so that those areas could be farmed once again; those earthworks are now invisible at the surface and it is these fortifications that were explored with this geophysical survey. Most of the now-refilled ditches and holes that were dug during the battle were detected; however, almost nothing of the parapets (earthen ridges) was revealed, for the soil from those ridges had been removed in order to fill the ditches.

During this geophysical survey, detailed maps were made with many different geophysical instruments and techniques; this test revealed the density of buried features and showed the capabilities of the different methods. The suitability of the different geophysical techniques was as follows (in decreasing order of success): Ground-penetrating radar, resistivity (mapping and pseudosections), electromagnetic induction (conductivity and susceptibility), magnetic (total field and gradient), seismic refraction, self-potential, and finally, aerial photography. This summary emphasizes the findings of the surveys that were done with a ground-penetrating radar and a magnetometer.

Several factors simplified this survey and made it successful: Most of the ground's surface is covered by grass (it was easy to walk in the area of survey); the area has been a park for over fifty years (there is relatively little modern trash); and the natural stratigraphy of the soil is simple and it changes through archaeological depths (refilled holes, with their altered stratigraphy, were readily detected). Because of these favorable factors, the success of this survey was probably in the top ten percent of all surveys that might be done.

Key words: *geophysical exploration, U.S. Civil War*

1 Introduction

During the U.S. Civil War in 1864, a series of short battles was fought between the northern and southern armies as they moved in a southeastern direction across the state of Virginia; see Figure 1. When the armies reached the town of Petersburg, a year-long siege began and the armies constructed elaborate earthworks around the eastern and southern sides of the town.

An example of the fortifications is shown in Figure 2. Fortifications like these continued for many kilometers to the north, and also many kilometers to the west. This map is a tracing of one that was prepared by the military engineers of the northern army during the siege, although it is possible that parts of the southern army’s earthworks were mapped after the battle.

Long lines in Figure 2 show parapets (ridges of soil) along with their adjacent trenches that sheltered the soldiers of the two armies. Cannons and mortars were concentrated in separate fortifications along the battlefield.

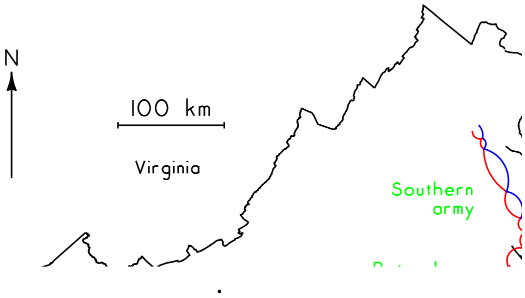

Figure 1. The red line indicates the path of the southern army during the U.S. Civil War in 1864, while the blue line traces the movement of the northern army. The routes of the armies in this map are approximated.[1]

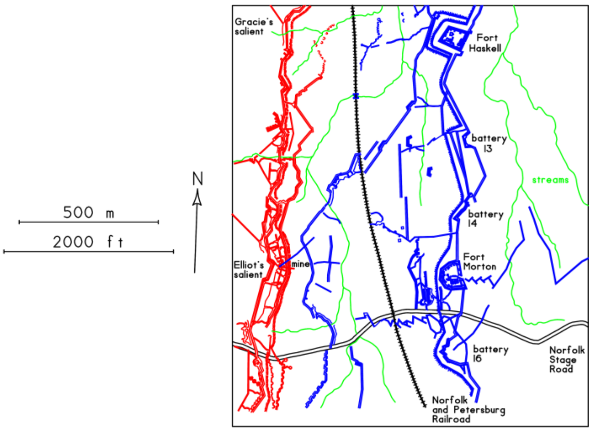

Figure 2. A small part of the Civil War fortifications. The earthworks for the southern army are approximated in red, while the northern fortifications are indicated as blue. The lines of streams are shown as green; these show that the fortifications are on the high ground between stream valleys.

This part of the battlefield at Petersburg appears to have had the heaviest fighting during the year of the siege. This was partly due to the fact that the two armies were very close together here; furthermore, there were a large number of cannons and mortars in this span of the fortifications. Much of this battlefield is preserved within the Petersburg National Battlefield that is maintained and interpreted by the National Park Service.

2 A search for Fort Morton

This geophysical survey was done around Fort Morton, which is near the southern side of the map in Figure 3. This D-shaped earthwork was about 100 m long. While there are no topographic clues to the location of the fortifications of Fort Morton, its position was initially approximated, by standard surveying techniques, relative to the fortifications to the north and south that are still visible as earthen ridges and trenches. After Fort Morton was located exactly by this geophysical survey, the error of that initial approximation was found to be about 15 m.

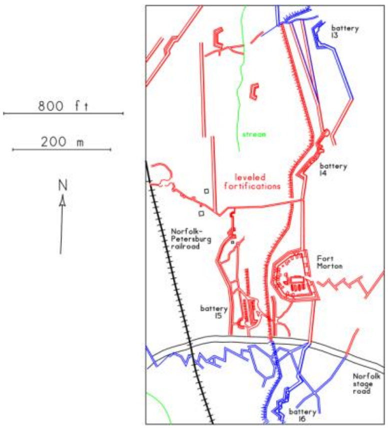

Figure 3. A closer look at part of the fortifications of the northern army. After the Civil War, much of this land was returned to farming, and most of the earthworks that are shown here in red were leveled.

It is possible that Fort Morton is revealed in a photograph that was made a few days or weeks after the end of the siege of Petersburg; see Figure 4. This photograph appears to have been taken from a location west of battery 13, which is at the northern side of the map in Figure 3.

1 Thomas Greiss, editor, *Atlas for the American Civil War* (Wayne, New Jersey: Avery Publishing Group, 1986).

Figure 4. A photograph of the Petersburg battlefield that was taken shortly after both armies left the area. While the location of this photograph is not certain, it appears likely that Fort Morton appears here in the distance below the identifying text, and just below the horizon. An earthen parapet is seen there, along with several embrasures (openings for cannons). The person standing next to the brick chimney is probably a photographer's assistant.

Figure 4 is photograph LC-B815-1075 from the U. S. Library of Congress; the left half of a stereoscopic pair is pictured here. This photograph, and three others, show overlapping parts of the battlefield. Because of the overlap of the photos, it was possible to create a sketch map of the fortifications; the patterns in this sketch map suggest the patterns of the fortifications around Fort Morton. While there are many historical photographs of the Petersburg battlefield, none of these is certain to be a close-up of Fort Morton.

While Figure 4 shows a "lunar" landscape, a modern aerial view of the same area is pictured in Figure 5. Fort Morton is north of the curving road, and this road (and a few cars along it) give an indication of the scale of this photograph. About a quarter of Fort Morton extends into the woods at the upper side of the photo. This photograph was taken in 1980; the location and shape of Fort Morton is now revealed in the meadow with a strip of gravel. Also, the road that is shown here below Fort Morton may now have been moved to the other side of the fort.

Figure 5. An aerial photograph of the grassy field around Fort Morton. The fort is located within the lens-shaped area between the road and the trees in the upper right hand side of this photo. No trace of the fort has been revealed by this photograph, although there are light-colored bands on the left side that approximate the paths of some other earthworks. This oblique photograph is a view to the northeast from an altitude of about 250 m.

A summary of the main findings of the geophysical survey around Fort Morton is given in Figure 6. The areas filled with red in the geophysical map in the left panel of the figure show where a ground-penetrating radar survey detected a rather flat surface where the soil's strata changed at a depth of about 0.7 m. During the Civil War, earth was removed at those locations; that soil was placed on a nearby earthen embankment. After the war, those embankments were leveled by moving the soil back into the depressions. The radar has detected the bottom of the layers of refilled soil.

Note that nothing of the former earthen ridges, mounds, and embankments has been detected by the radar. These must have been scraped level and completely removed; while a thin lens of fill soil may remain at some of the former mounds, it is too thin to be detected by the radar, and soil contrasts there have probably been homogenized by earthworms.

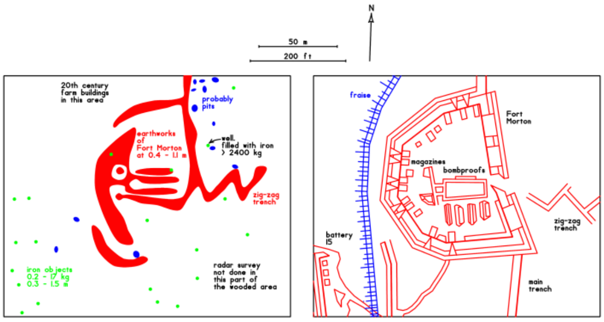

Figure 6. The panel on the left summarizes the findings of the geophysical survey, while the panel on the right shows the fortifications as they were mapped during the Civil War. A comparison suggests that Fort Morton has been detected, but the differences between the two maps are more interesting than their similarities.

The thinner red bands in the left side of Figure 6 reveal former trenches or ditches that are now refilled with soil. The broader red bands in the left side of that figure show where soil was scraped from just inside and outside the fort in order to build the ridge of soil where the fort faced the southern army (which was to the west). This arc-shaped earthen parapet, which was between the inner and outer scraped areas, was completely undetected by this geophysical survey.

The small areas that are filled with blue in the geophysical summary of Figure 6 locate where refilled pits are likely. Those at the upper right are reasonably shelters for small groups of soldiers; while these shelters are not marked on the historical maps of the fortifications, they are apparent in the historical photographs of the battlefield.

The shape of the zig-zag trench on the right hand side of the fort in Figure 6 is different in the geophysical map as compared to the map that was prepared during the Civil War. While most features in the historical map are very accurate, some are not. In the right-hand panel of Figure 6, V-shaped patterns along the arc of the fort's earthwork show where cannons were placed. Because of the woods, the southeastern corner of the fort was not explored with the radar.

A smaller fortification was situated in the southwestern (lower left) corner of the maps in Figure 6. The radar did not delineate any refilled earthworks there, although a magnetic survey detected iron objects there that have masses of 1 kg or more.

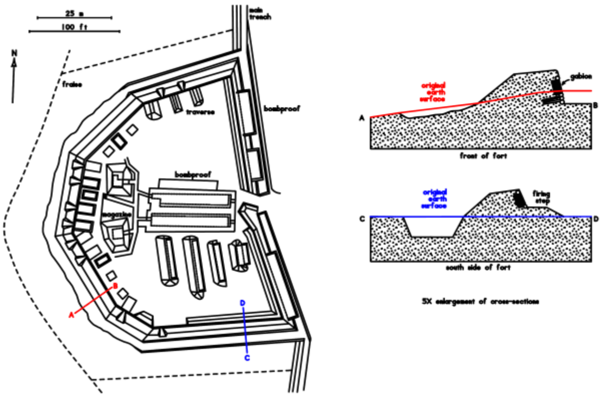

Figure 7. A detailed map of Fort Morton. This historical map also includes two cross-sections of the fort; these are enlarged on the right hand side. The colored lines in those cross-sections mark the original surface of the soil.

Excellent maps were prepared of Fort Morton during the Civil War. Figure 7 shows a map that is even more detailed than the one in Figure 6. The two cross-sections (on the right in Figure 7) clarified the findings of the radar survey. Note that the soil inside the fort was scraped away at the location of one cross section (A - B, near the front of the fort), but remained unchanged at another location C - D, on the south side of the fort). Two basic principles of excavation have always been: The volume of the cut (excavated soil) must equal the volume of the fill (mounded soil); and the soil must be moved the minimum distance possible. This was clearly true at Fort Morton.

The historical map of Fort Morton (Figure 7) shows parapets (embankments) clearly, but it is not completely clear about where trenches and pits were dug. The deepest pits were probably dug below the two powder magazines (for storing explosives) near the left side of the figure (the front of the fort). In this area, the soil changes from mostly sand to mostly clay at a depth of 1 m or so; the powder magazines were likely dug rather deep into the clay here, and this clay would have been mounded over the roof of each magazine. The geophysical survey appears to have revealed what became of the mounds of clayey soil over the powder magazines: This soil was shifted to the east. This clayey soil (which is a good electrical conductor) was revealed by high values that were found with the conductivity survey of the fort. Furthermore, radar profiles in that area were attenuated, and this is also a good indicator of clay.

The map of Figure 7 shows that the central part of the fort has a large number of bombproofs. These are long trenches that are roofed with a layer of soil; this thick roof protected soldiers that sheltered inside from mortar shells, for these shells fell almost vertically from the southern army's position. The map in Figure 7 indicates that there were two or three bombproof trenches that went east-west, and perhaps four that went north-south in the middle of the fort.

While the north-south bombproofs were in the woods and outside the area of the radar survey, the trenches of the east-west bombproofs were readily traced; see Figure 8. In the cross-section at the top of the figure, it appears that log benches for the soldiers are drawn in two of the bombproof shelters.

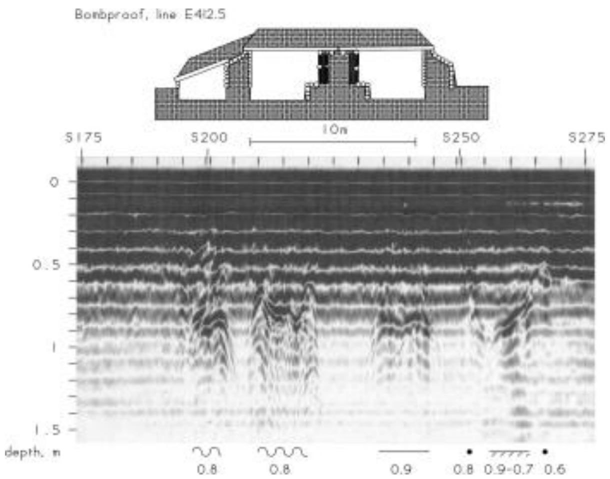

Figure 8. The central bombproof trenches within Fort Morton. The cross-section at the top is from the historical map of Fort Morton; it shows the broad trenches that are roofed with logs and covered with soil. The radar profile below reveals the bottoms of these now-filled trenches.

The radar profile at the bottom of Figure 8 reveals the bottoms of the trenches by rather flat echo bands at a depth of about 0.7 m. The radar profile also reveals a fourth trench, on the right (near S260), that was not included in the historical map; this fourth trench may therefore be an addition after the historical map was prepared. The vertical scale of the radar profile in Figure 8 is magnified by a factor of about ten relative to the horizontal scale; this makes very shallow slopes along the echo profile appear to be steep.

The radar profile in Figure 8 was recorded with an antenna having a predominant frequency of about 315 MHz, although a lower frequency antenna (180 MHz) was also excellent for mapping the refilled trenches here. As a quick test on the first day of the radar survey, a profile was made across the assumed location of the bombproof; when a pattern like that in Figure 8 was revealed, it was immediately known that the fort was preserved and that its exact location could be determined. For some geophysical surveys, only that single line would have been sufficient, and no further work would be necessary.

The bombproof trenches in Figure 8 were clearly revealed by a seismic refraction survey also; a sound wave traveled slower in the soil that fills the trenches. Since a seismic survey takes much more time than a radar survey, it was not practical to apply this technique further at Fort Morton. A resistivity survey traced most of the bombproof trenches; however, these trenches were invisible to two different conductivity surveys. These successes and failures are due to the exact stratification of the soil at these locations and also to the specific depth sensitivities (or depth weightings) of the different instruments. The bombproof trenches were invisible to a magnetic survey. This failure may have been caused by the many anomalies that resulted from the high density of iron artifacts that are scattered in the area; tests have shown that the soil at the fort has a distinctive stratification in its magnetic susceptibility.

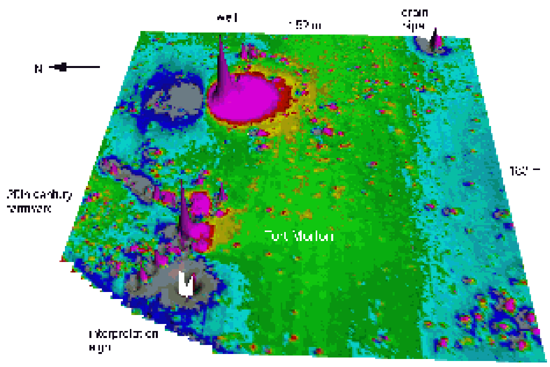

Figure 9. A magnetic map of the area around Fort Morton. It reveals features that are primarily modern. The area of this survey is about 150 m on each side (see the dimensions on the map); this oblique view is to the east and Fort Morton is to be found just above its label in the map. The anomaly of the now-underground well was greater than 2000 nT.

The magnetic field around Fort Morton is plotted in Figure 9. There is almost no evidence of the earthwork in this magnetic map; however, a good colleague (John Weymouth, University of Nebraska) has pointed out that an irregular line of magnetic anomalies marks the trench on the southern side of the fort. The patterns on the near left side of the map are caused by a former farm house that stood there about 100 years ago; a large sign for the fort was also in that area at the time of this magnetic survey.

The huge bipolar anomaly toward the rear of the map in Figure 9 is caused by a well that was dug for water, and which is now filled with iron debris. This well was revealed by this magnetic survey and it has been verified by the excavations of David Orr (National Park Service). Because of the large amount of modern iron at the top of the well's fill, it may never be known if this well was dug during the Civil War. While the location of the well behind Fort Morton suggests that it may have been dug during that battle, this is far from certain.

The major anomaly in Figure 9 could be identified as being caused by a well because of its pattern in the magnetic map. A mass of iron that extends in a vertical direction causes a unique magnetic anomaly; it is the anomaly of a monopole, and it is revealed by its shape and the relative amplitudes of its high and low. This well was also readily detected by all of the other surveys in this area: Radar, conductivity, magnetic susceptibility, resistivity, and self-potential. With the self-potential survey, voltages are measured at the Earth's surface; the metal that fills the well acts like a large battery, and a clear pattern of voltages was detected. An analysis of this pattern allowed an estimate of the rate of corrosion of the iron in the well.

Conductivity surveys were surprisingly poor at detecting the filled trenches at Fort Morton. However, a deep-exploring conductivity survey (with a Geonics EM31) was the best technique for detecting the filled-in powder magazines.

3 Conclusion

The radar survey was unusually successful here because of four factors: Soil stratification, length of the battle, ground cover, and topography.

Soil stratification: Trenches and pits were dug through the sandy soil at the surface and into the rather clayey soil below. When these holes were refilled, the natural stratification was completely altered; these changes were readily revealed. The sandy soil allowed a high resolution radar antenna to give clear evidence of small objects and thin strata.

Length of the battle: Since these trenches were open for a year, there was time for sandy topsoil to wash into the bottoms of the trenches, and this increased the soil contrast at those bottoms. Furthermore, many metallic artifacts must have been lost by soldiers in the trenches, particularly when they were muddy.

Ground cover: The uniform cover of grass in most of the area of survey made the survey fast and simple. Trees and bushes slow a survey, and the roots of large trees can create unwanted patterns in a geophysical survey.

Topography: If a geophysical survey is done where earthworks have not been leveled, that topography confuses a survey. Because of the leveling here, almost everything that was detected was important to find.

A detailed report (656 pages) about this geophysical survey is available at no cost by contacting the author. There are three volumes to this report. The first volume is written for cultural resource managers; the second is for individuals who are beginning to do geophysical surveys; the third is for workers who are already experienced with geophysics. A version of the second volume is available on the web at: http://www/cr.nps.gov/mwac/publications/pdf/spec1.pdf.

Acknowledgements

The first study of this area was done by David Orr (then with the National Park Service, but now at Temple University in Philadelphia). He and his colleague, Brooke Blades, excavated parts of the original Taylor House, which is just to the west of Fort Morton, in 1978; this house was destroyed on the first day of the

battle at Petersburg. In 1979, Dave asked me to check if ground-penetrating radar could detect Fort Morton; that initial test failed, for the radar antennas at that time could detect almost nothing that was shallower than about 1 m underground. In the span between 1991 and 1993, I explored around Fort Morton with a higher resolution radar antenna, and many other geophysical instruments.

That recent survey at the Petersburg National Battlefield was successful in locating the fort. My work during that period was coordinated by John Davis, then the Chief of Interpretation for the park. Chris Caulkins, a historian at the park, was a great help to my understanding of the battle and its historical records. The maintenance staff of the park kindly altered their schedule for mowing the grass so that they would not interfere with all the ropes and wires that I placed for my surveys.

Geophysical investigations at Petersburg continue, thanks to the ongoing work of Julia Steele and Dave Shockley, Cultural Resource Managers for the park.

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Bibliography

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