Additional Analysis on GPR Mapping of the Hominid Trackway, Laetoli, Tanzania

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Abstract

Previously I wrote a paper on the mapping of the hominid tracks at Laetoli Site S, which connected the trackway from two excavations conducted in 2016. In the search for other tracks in other grids, I mapped other features that are not footprints, but could be confused with them. This short paper is that analysis, which discovered and mapped small channels, which were likely water runoff gullies in the T-7 surface. This is not as important as the tracks themselves, but could be confused with trackways features, and need to be considered in any GPR analysis. Here I have also provided a catalog of prints that were defined at Site S, which shows the many different types of prints that vary depending on depth and their post-depositional modifications. Those modifications are natural fractures and root disturbances.

Introduction

GPR was conducted at Laetoli July 13-19, 2023 using a GSSI system with paired 2.6 GHz frequency antennas, typically used for concrete evaluation. This GPR equipment transmits radar waves with a wavelength of about 3 cm into the ground to a maximum depth of about 40 cm. A number of grids were collected at Site A on July 14, 2023, one of which is presented here. This study began with velocity tests where an iron bar was pounded horizontally into the contact between the T-8 and T-7 (Figure 1). This is the exact surface on which the hominid prints and other features were preserved, with the T-8 layer being the ash-lapilli unit that covered the prints and preserved them. The thickness of the T-8 was measured at 13 cm, and the bar was visible on the screen of the control system as the antennas were passed over it. This reflection was measured at 2.1 nanoseconds (two-way travel time), which allowed us to then convert times to depth in all the profiles in this grid.

Figure 1: Conducting a velocity test with an iron bar placed at the T-7-T-8 contact.

The grid presented here is called Grid 2 and is 4.6x1.5 meters in dimension, consisting of 94 two-dimensional reflection profiles spaced 5 cm apart (Figure 2). The T-7 is exposed just to the south of where the grid was collected, and here contains the initial print discovered by the Mary Leakey team in 1978. Additional prints were discovered on this surface in 2023.

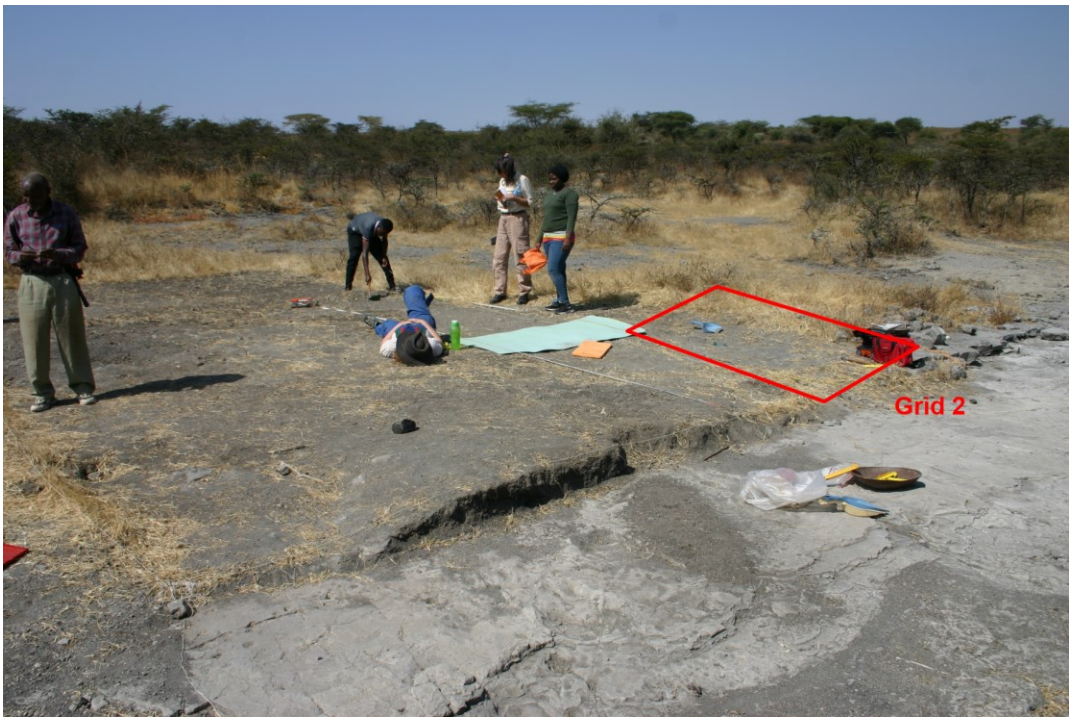


Figure 2: Location of Grid 2, where the results that are presented here were collected.

All profiles were first viewed in two-dimensions as raw and unprocessed reflections. This first analysis was disheartening, as it appeared that the contact we care about (the top of T-7 overlain by T-8) was very poorly recorded and barely be visible (Figure 3). My initial thought was that radar energy had been attenuated in the T-8 and therefore very few waves were passing to the depth necessary to map the top of T-7.

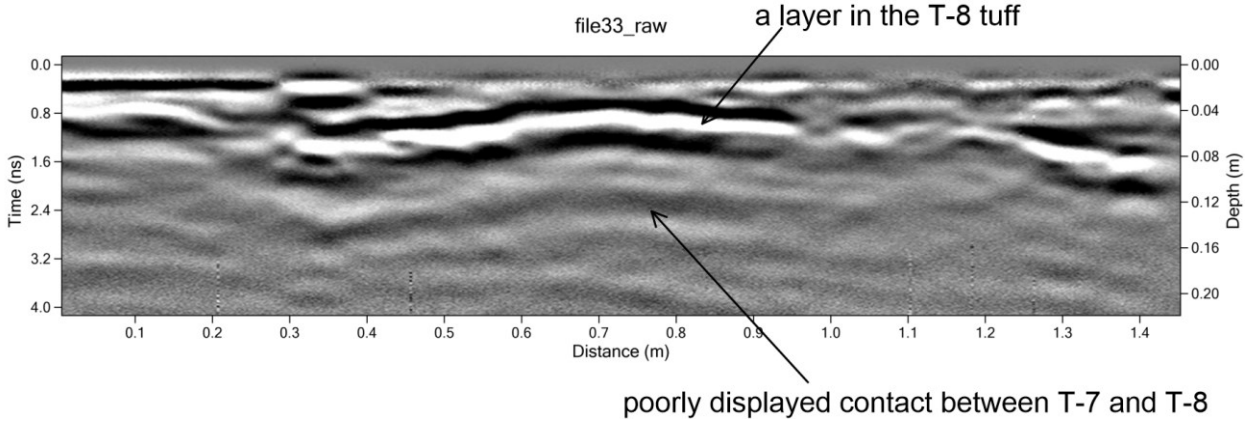


Figure 3: Raw reflections that display only layers in the T-8 tuff but not the contact between the T-7 and T-8.

To overcome this problem all reflections in all profiles were frequency filtered to remove the waves the longer wavelengths, with the result being only the shorter wavelengths remaining that would display the T-7 surface. Several frequency bands were tested, and it was found that the best results were waves between 2,000 and 3,000 MHz. This was then done on all profiles and the T-7 reflection was visible exactly where the iron bar velocity test showed it to be (Figure 4).

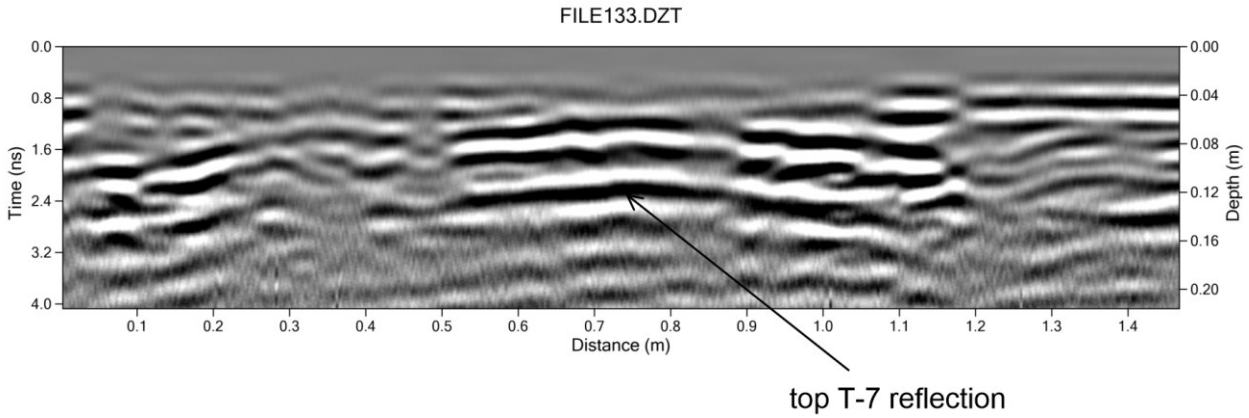


Figure 4: Frequency filtered reflection profile with only the 2,000-3,000 MHz reflections displayed. This shows the top of the T-7 surface very well.

All the processed and filtered profiles were then viewed to see if there were "print-like features" on the T-7. Many months of data analysis had been conducted at Grid 5 to the northeast of this location, so there were models of what prints should look like. Models for the prints in Grid 5 are presented below. All profiles in Grid 2 were then searched for possible prints that were displayed as depressions in the T-7. It was inferred at this point in the analysis that any depressions could be large animal or hominid prints (Figure 5).

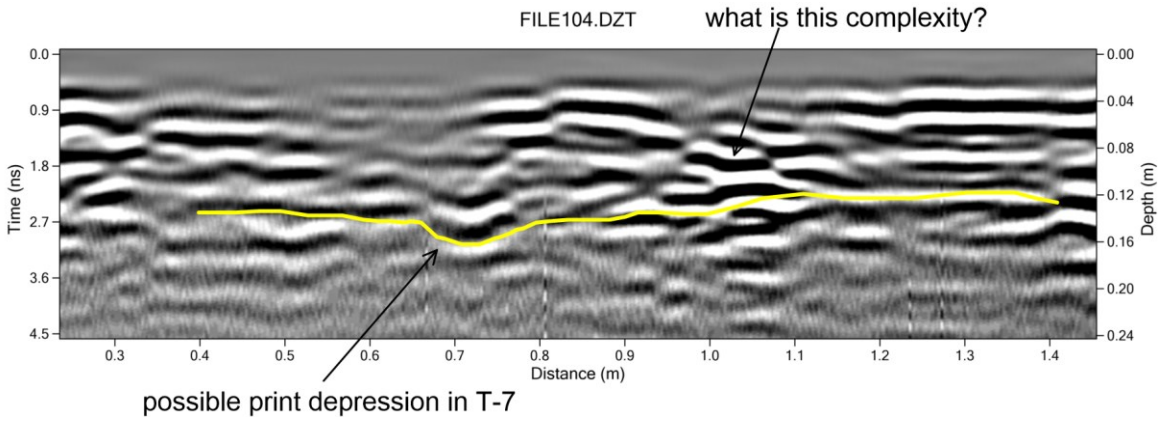


Figure 5: A frequency-filtered reflection profile showing a possible print in the T-7, with various other reflections of unknown origin within the T-8.

Many print-like depressions were visible such as this one In Figure 5. They were displayed in profile with the standard focusing of the reflected waves at the bottom of the depression, as had been noticed in many prints from Site S in Grid 5 (displayed below). Here, however, many other strange features within the T-8 were visible that were difficult to interpret in two-dimensions. Some were thought to be

volcaniclastic layering in the T-8 and others perhaps gullies or other natural features that were formed soon after the T-7 was emplaced and then later preserved after the T-8 was deposited. An example of this complexity is shown in Figure 6, which appears to show a cut and fill channel, which truncates into the T-7, perhaps soon after it was emplaced, or during the deposition of the T-8 tuff.

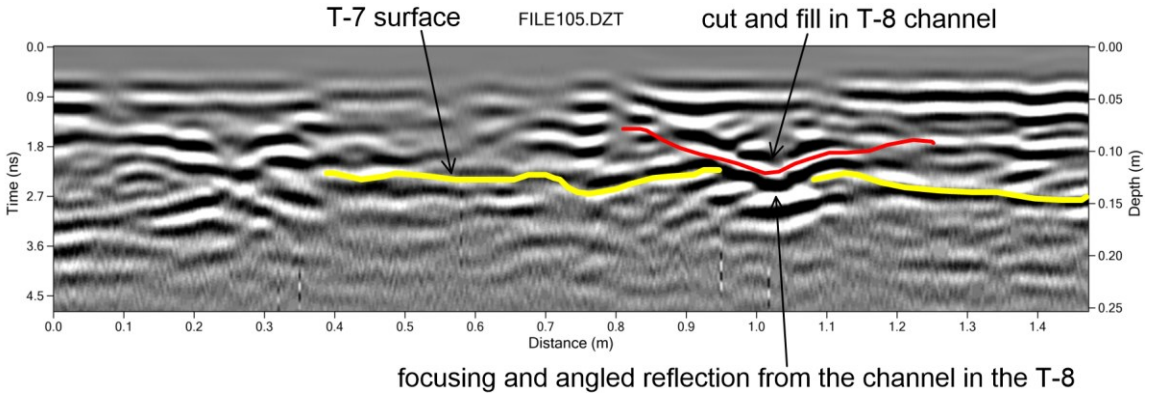


Figure 6: Reflection profile showing a channel cut into the T-7, perhaps during the deposition of the T-8 tuff, or just before it was emplaced.

To understand the three-dimensional topography of the T-7 surface just before (or during?) the emplacement of the T-8 tuff an x,y,z data set of the top of the T-7 surface was compiled by an analysis of all profiles in the grid. That surface was then gridded and mapped to produce a contour map and a 3-D image (Figures 7 and 8). The contour map shows that what was first thought to be a print (Figure 5) is actually the extension of the channel-like feature that extends across the grid. In a 3-D view this is even more evident.

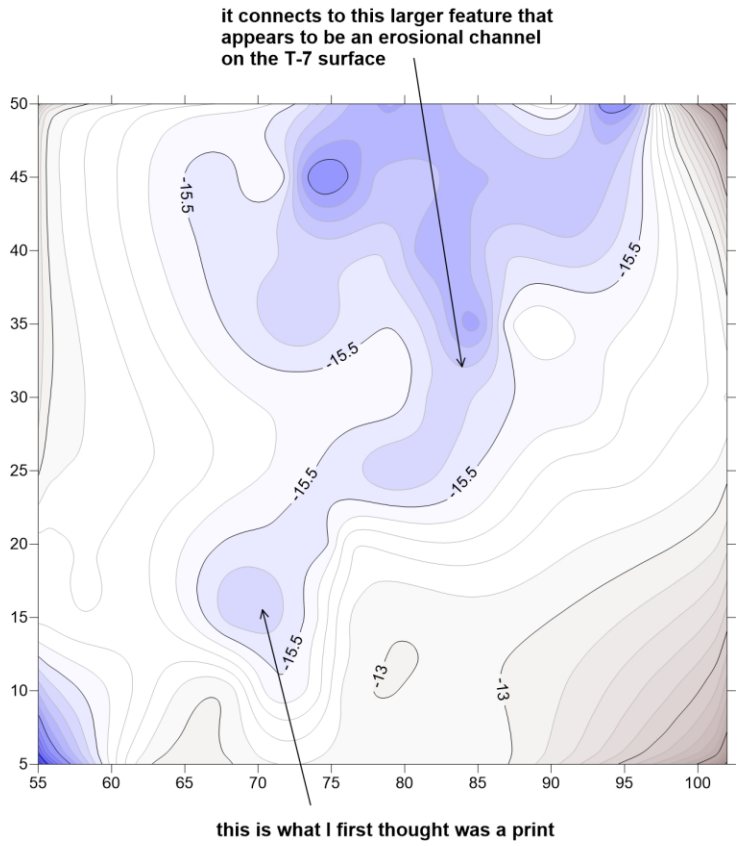


Figure 7: Contour map of the top T-7 surface in Grid 2, showing a series of small gullies that were cut into the tuff before (or during) the emplacement of the T-8 unit.

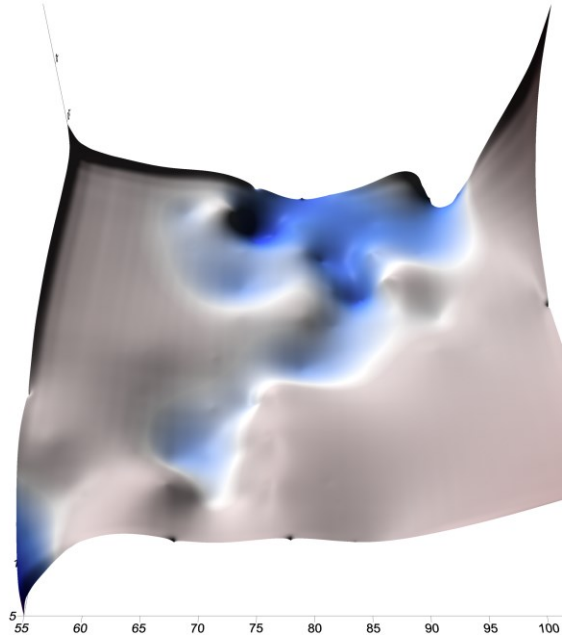


Figure 8: A three-dimensional image of the top T-7 surface in Grid 2.

Conclusion of mapping in Grid 2

This detailed analysis of Grid 2 demonstrates how possible prints can be differentiated from natural features when mapping possible hominid prints. It appears that the T-7 surface was modified here by rainwater run-off while it was still wet, producing small gullies. These features were then preserved by the deposition of the T-8 tuff soon after they were formed. This is important when exploring for prints, as they can be confused with the hominid print targets, and only three-dimensional analysis can resolve the origin of features on the T-7 surface.

A portfolio of GPR prints, Laetoli Grid 5, Site S

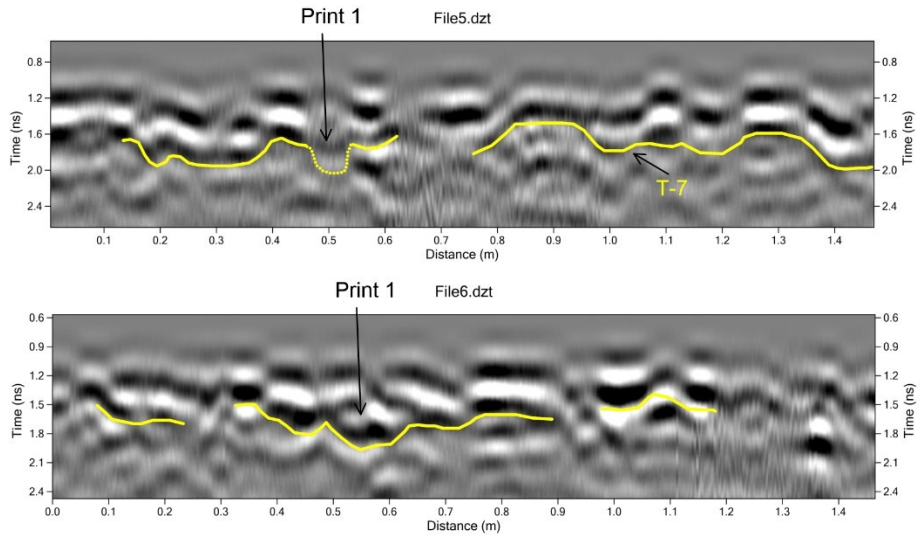
Here I present a number of GPR images from Site S where the trackway was mapped between two excavations. The variety of different images is important, as "one size does not fit all" when it comes to mapping prints with GPR. This variation should not be unusual, as can be seen in the photos from the excavations at Site S where a variety of print shapes and sizes are exposed (Figure 9). This image in Figure 9 (from Masao et al. 2016) shows various shapes of prints, all disturbed in various degrees by fractures, roots or the prints of other animals.

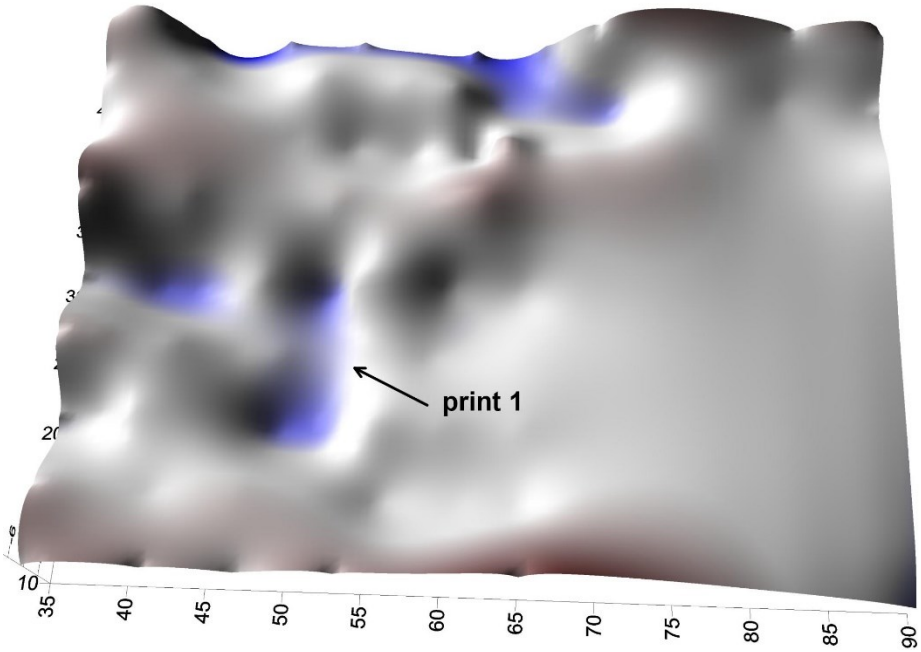
Figure 9: Photo of the excavated prints at Site S, illustrating the differences in shapes and the coomplexity of the T-7 surface (from Masao et al. 2016).

Below I show all the GPR images of prints from Site S:

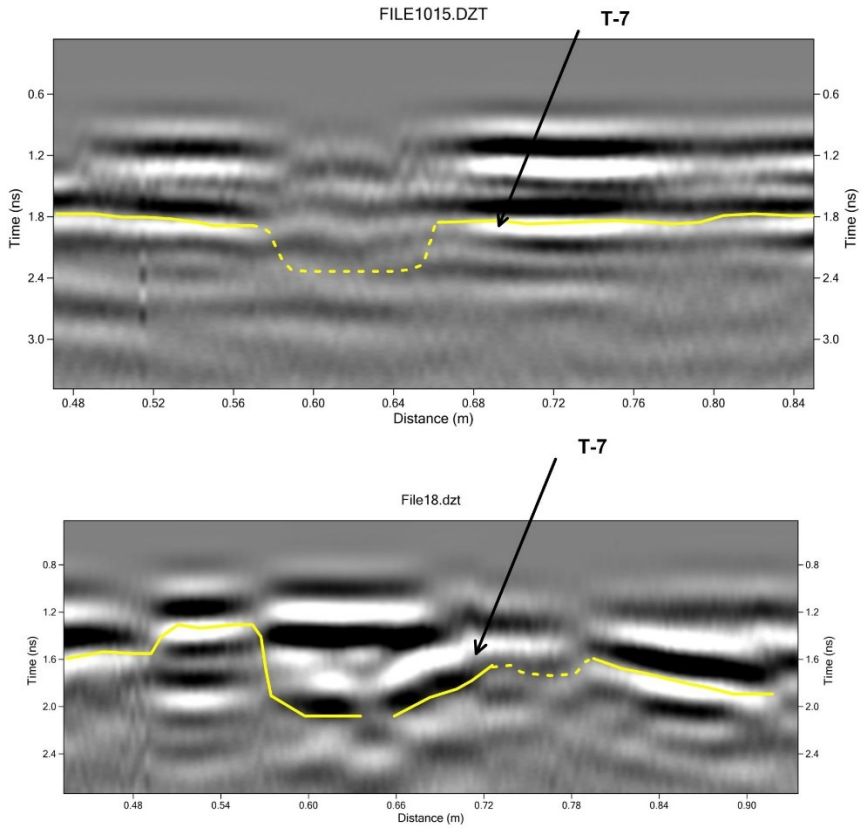
The images of prints are directly below their discriptions, with explanations for each.

Print 1: Here the undulation of the T-7 surface shows how complex this can get. In the 3-D image there are many other "bumps" and depressions, and the print is difficult to differentiate without knowing the stride of these folks, and working back from Print 2 to know where #1 "ought" to be based on stride distance.

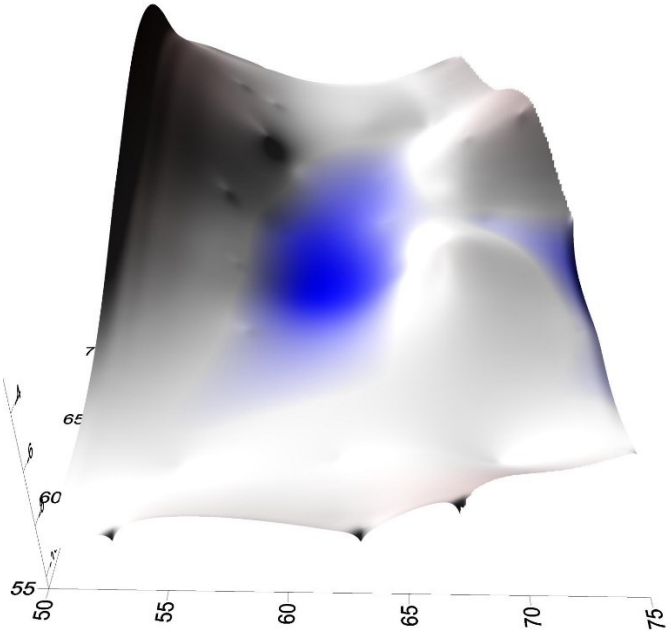




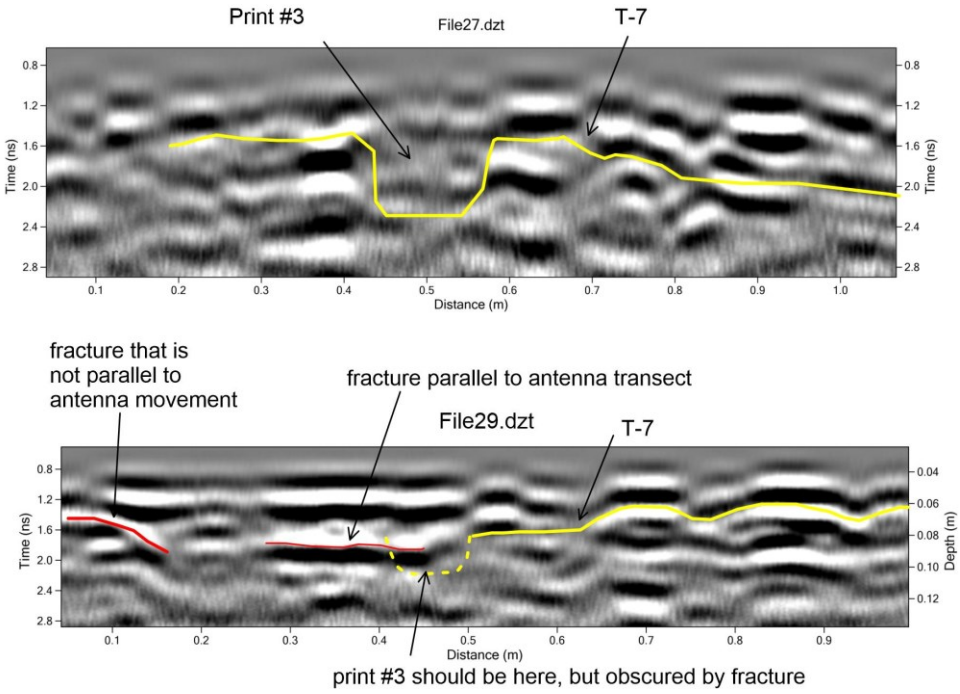
Print 2: This shows the difference that just 5 cm in profile offset can make. The top profile shows the print as a non-reflective depression, but 5 cm away the profile shows it distinctly with highly reflective fill sediment inside the print.



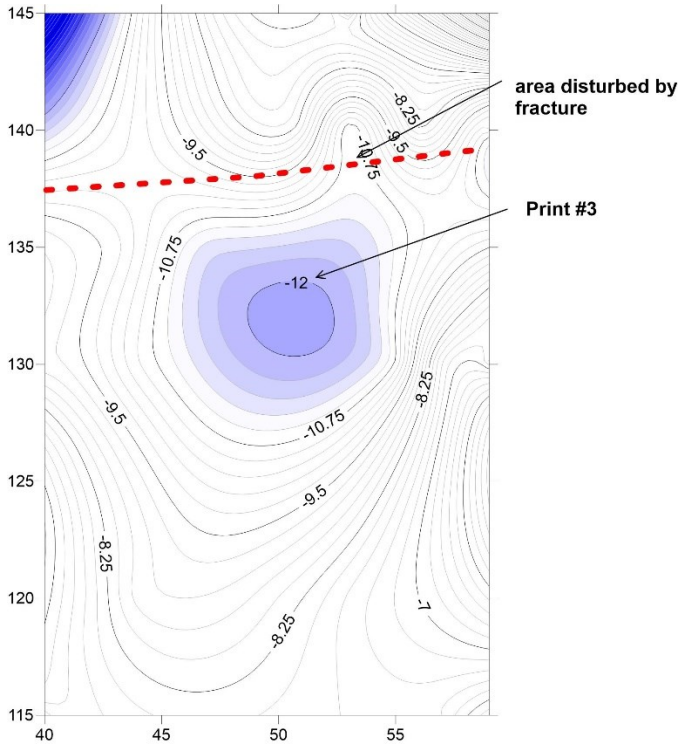
Zooming in on just the print, the toe and heel drags can be seen in this 3-D image:



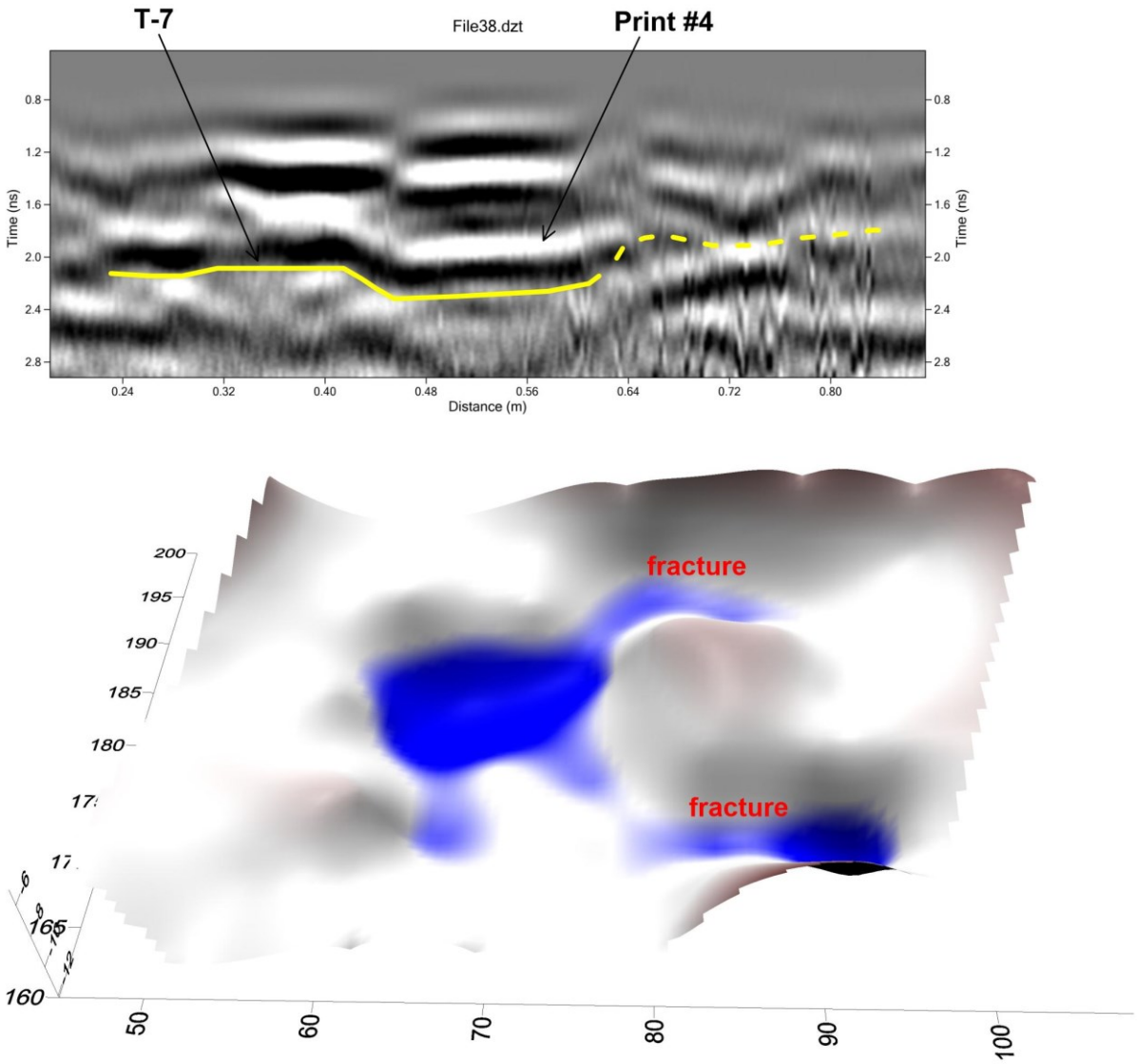
Print 3: The top profile is a variation on Print 2 with a depression, but no high amplitude sediment filling in the print. 10 cm away the print is obscured by a fracture, and only a hint of it is visible.



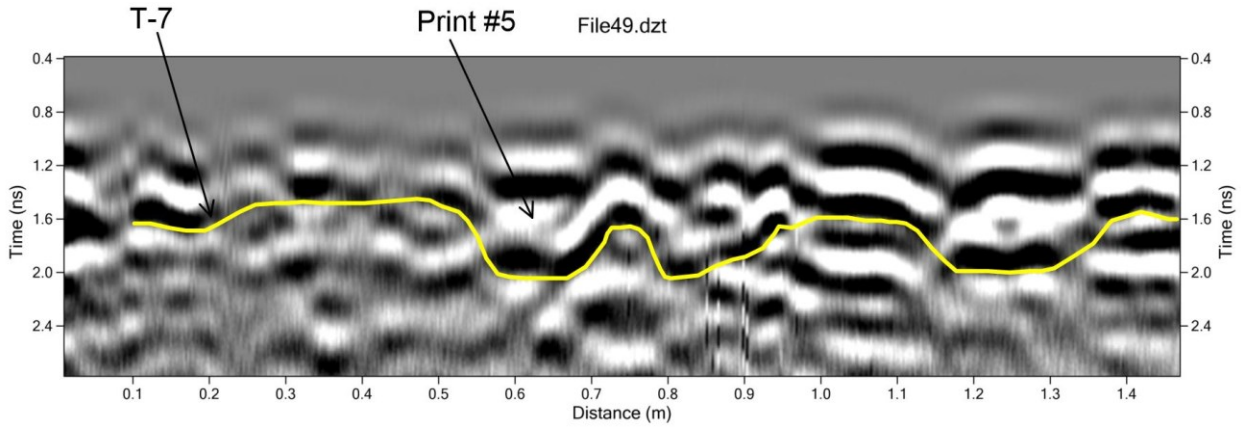
A contour map of Print #3 shows a depression, but it is not a complete print as a fracture disturbs it.

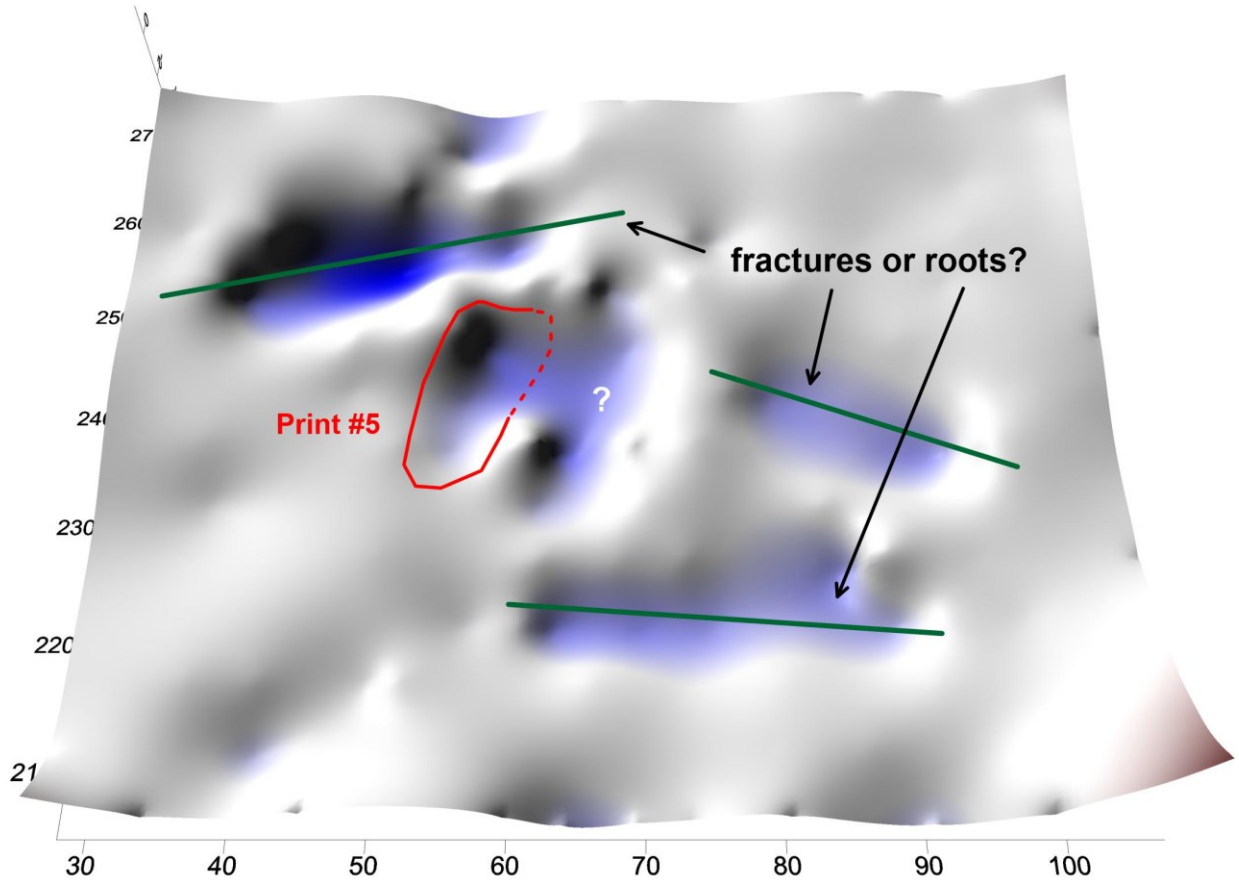


Print 4: This is a shallow depression with a distinct print. It shows up well in 3-D with many nearby fracture or root features.

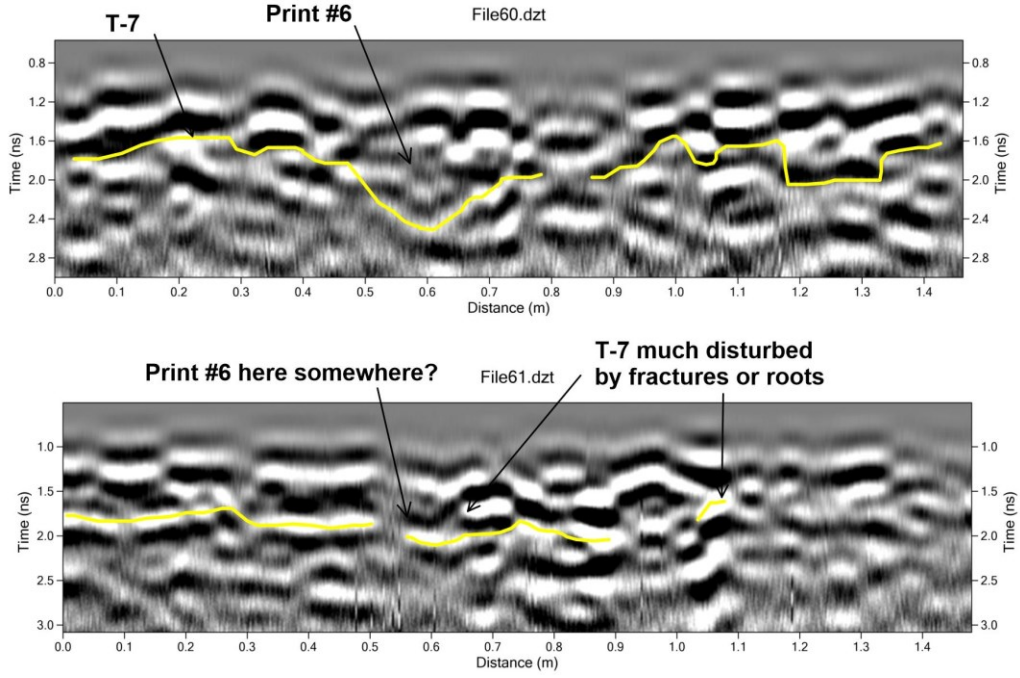


Print 5: A very distinct depression with a "squish" upward on one side. There are other depressions here that may be prints from other animals or fractures and roots, making for a depression-filled 3-D image.

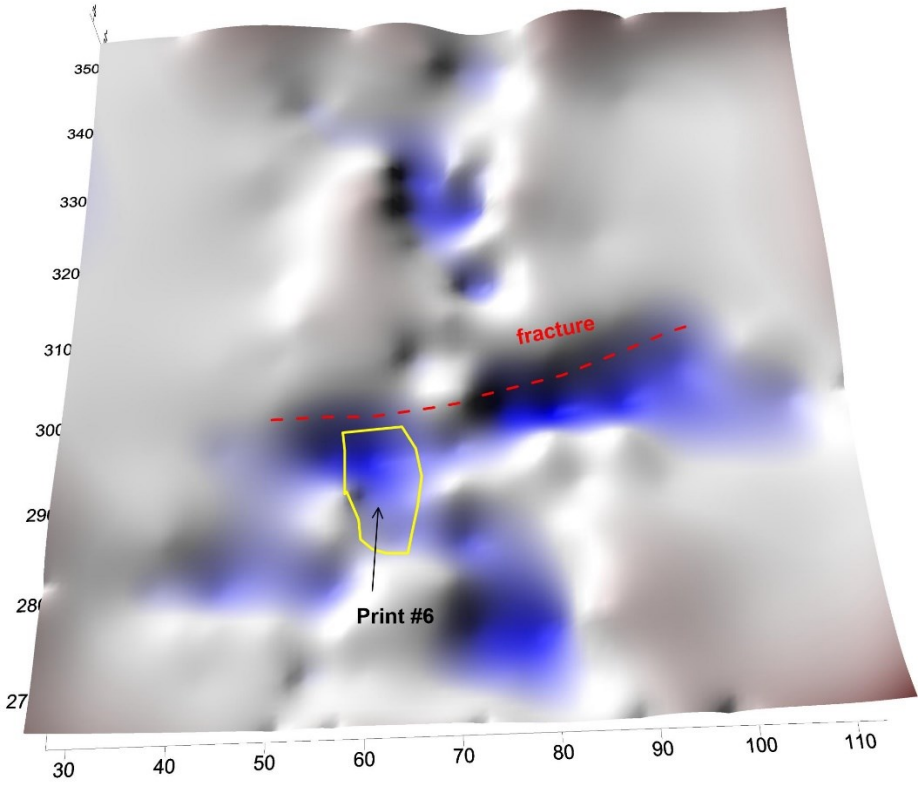




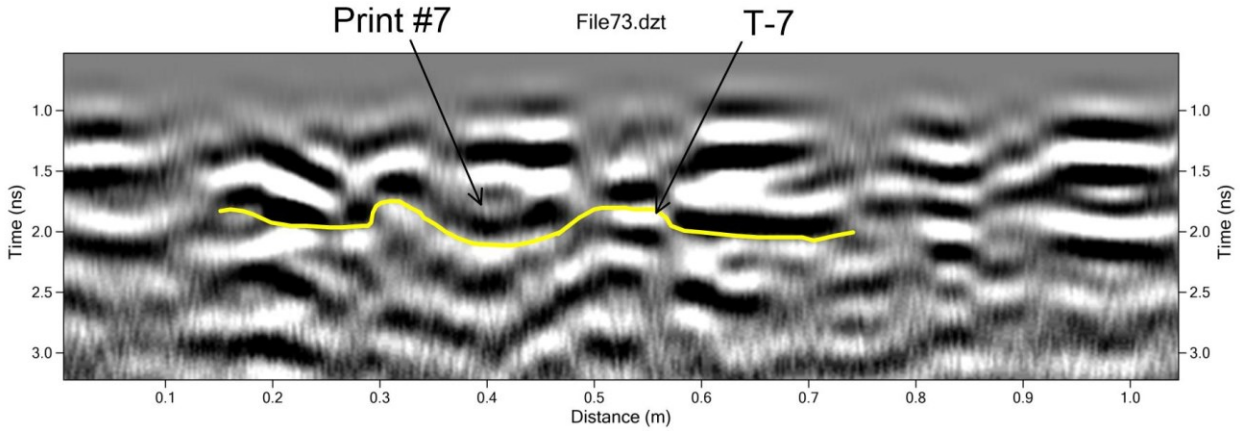
Print 6: Another complicated surface with many small depressions that could be other animal prints. The hominid print is barely visible as a depression, but only 5 cm away it is invisible.

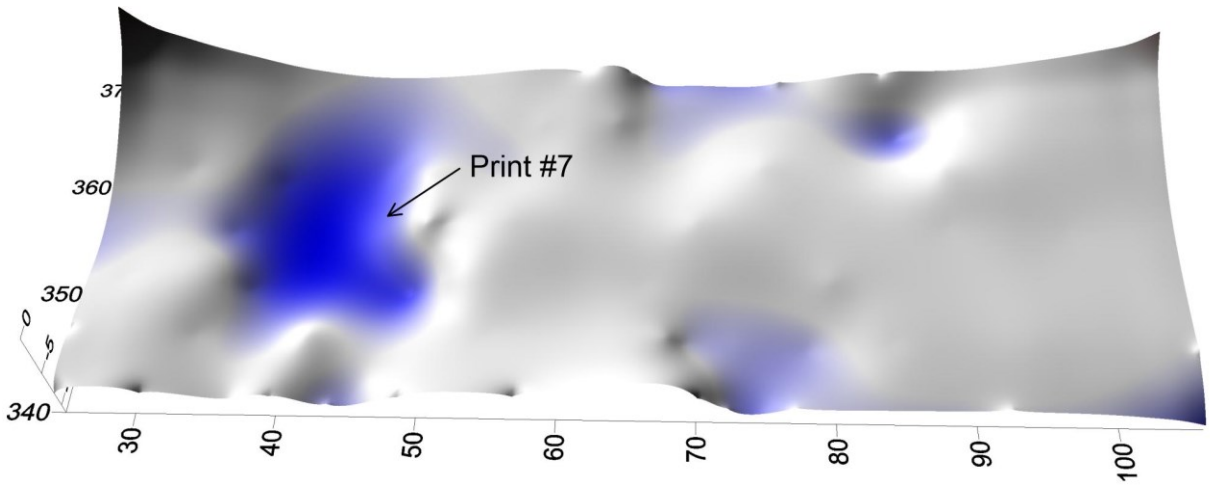


The 3-D surface of Print #6 shows how “busy” this area is, with the print well hidden, surrounded by other depressions and fractures.

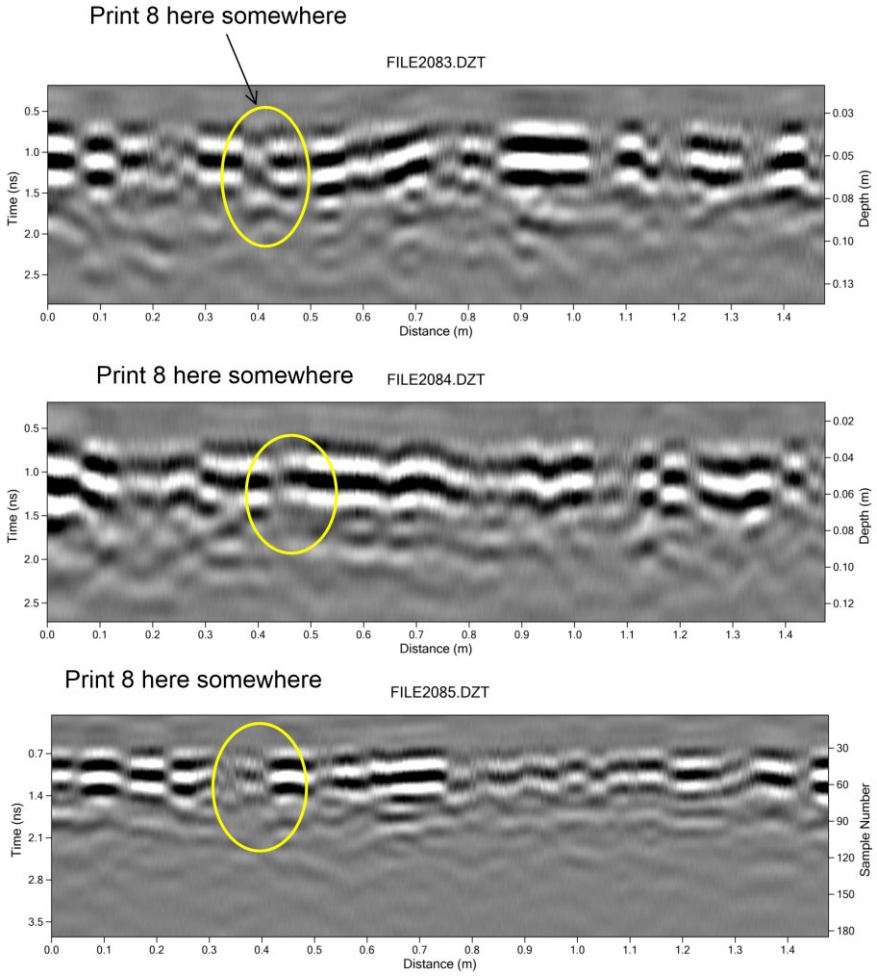


Print 7: This is the nicest of all the prints. There are sideways “squish” marks visible on the profile, and the 3-D image shows a well-outlined print.

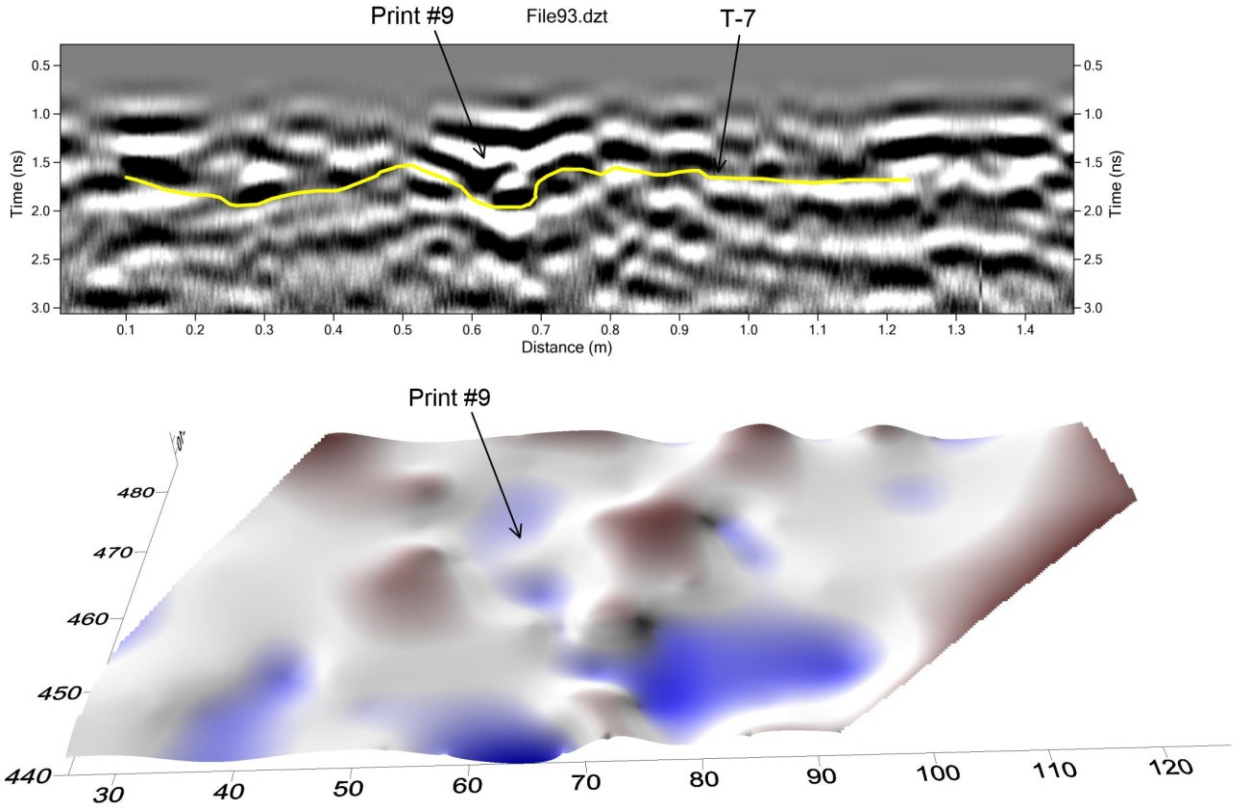




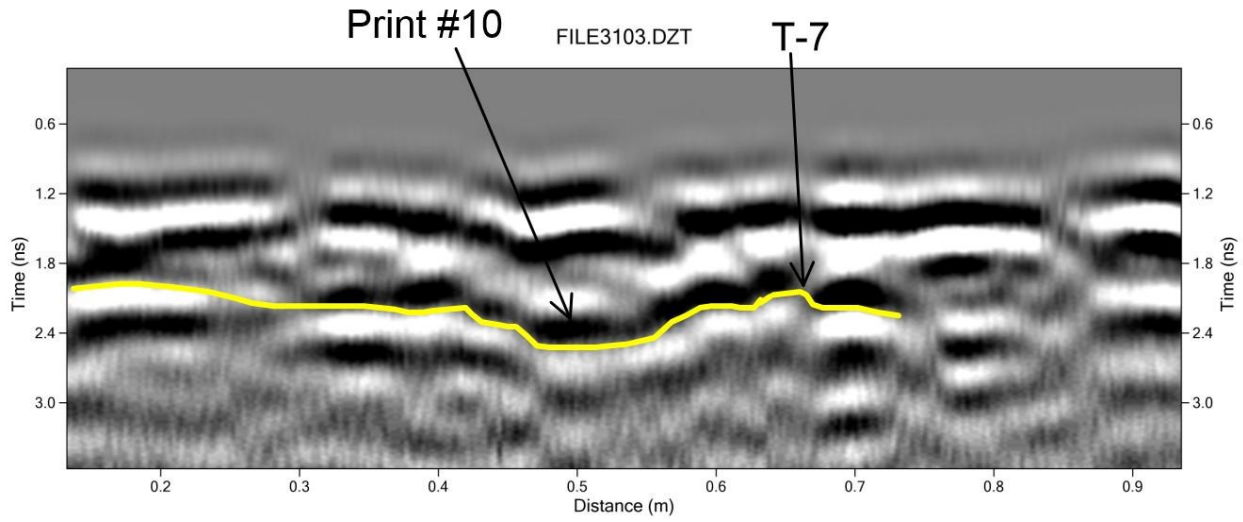
Print 8: you can see why this print is almost invisible. I see hints of a depression, but just 5 cm away it is gone. It has to be in there somewhere, but my confidence in mapping it is low.

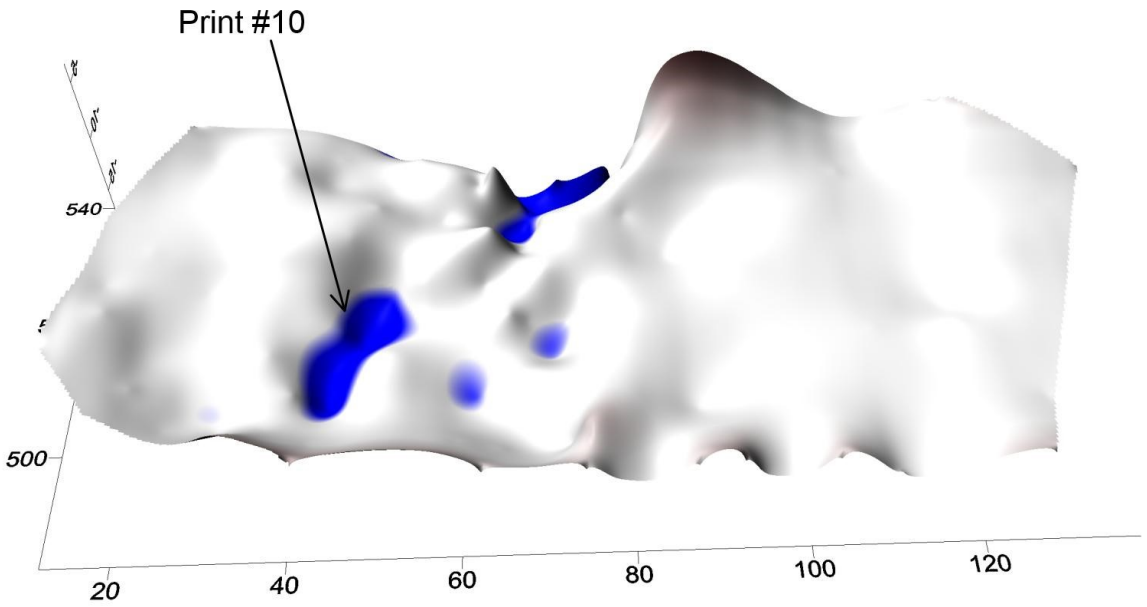


Print 9: This is a very nice depression with the overlying sediments and their reflections being "focused" and therefore show up as high amplitudes. There is a good heal and ball of the foot in 3-D.

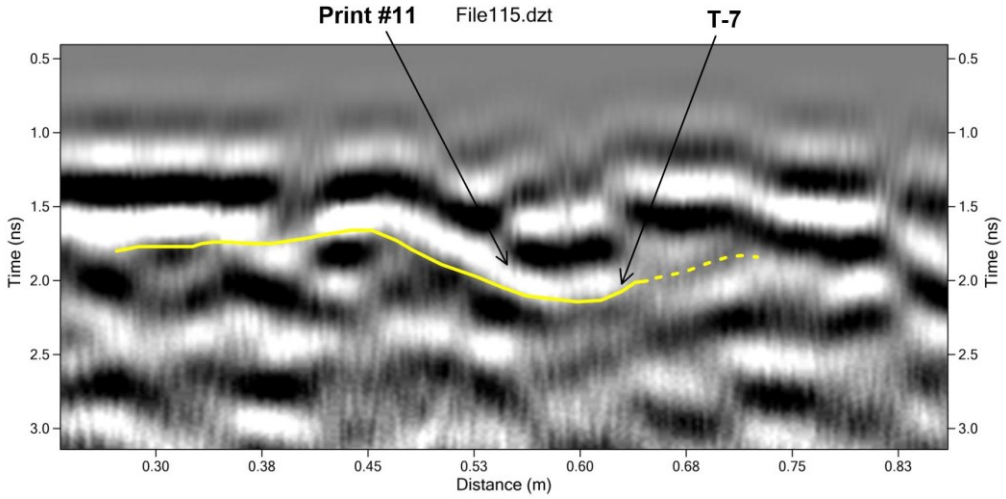


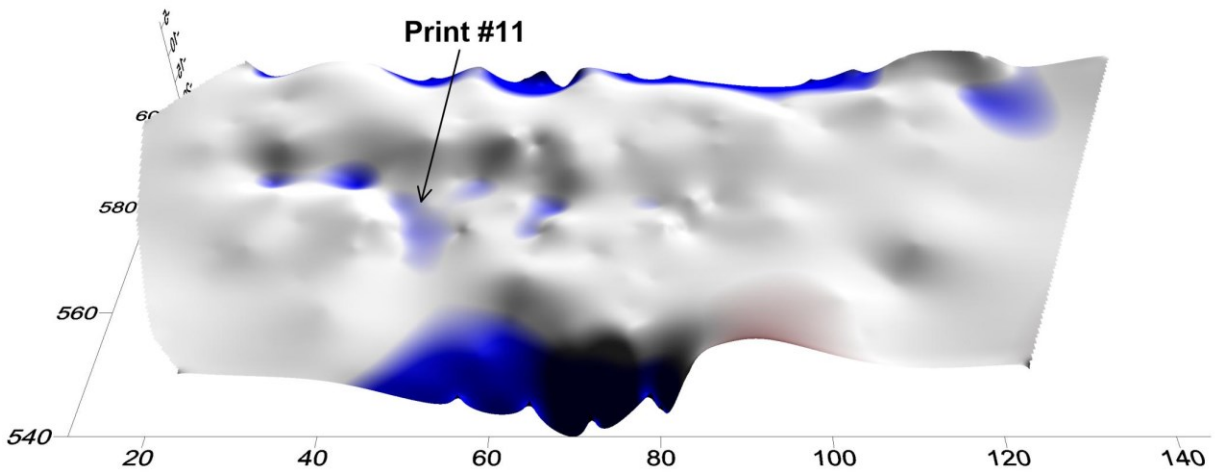
Print 10: another nice depression with only a little obstruction by roots or fractures.



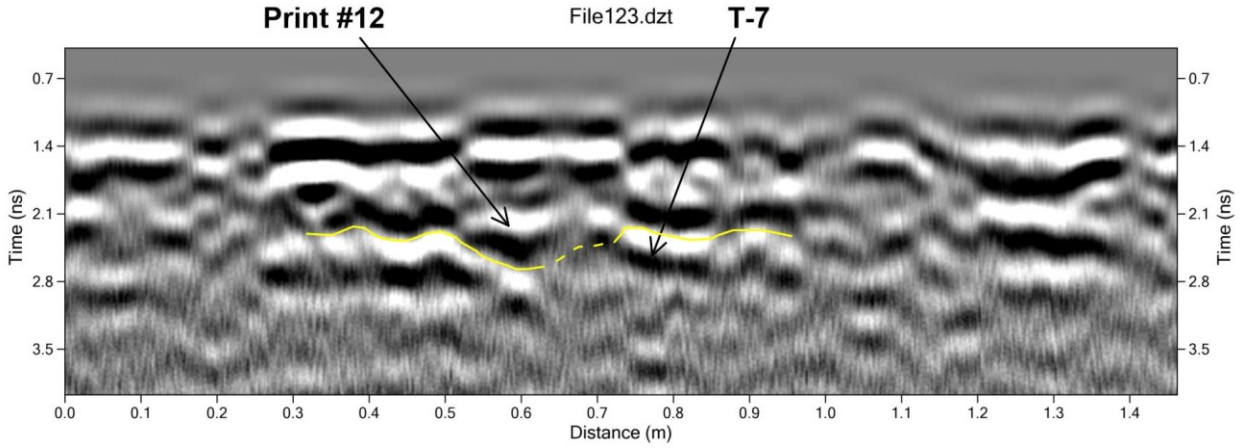


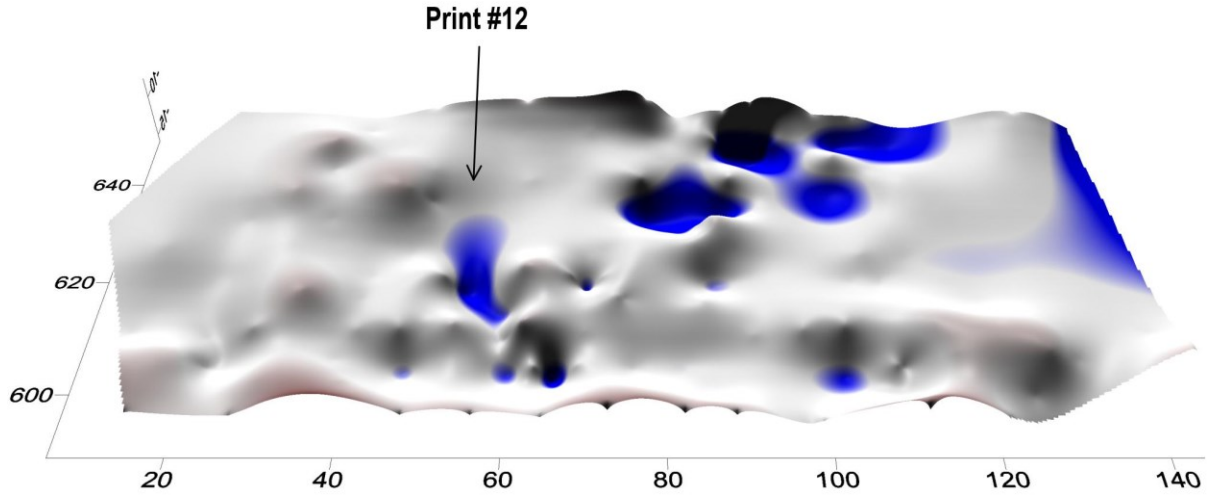
Print 11: Also a good depression with a separate layer of sediment that produces a distinct reflection at the bottom of the depression.





Print 12: much like #11 with the print depression fill as a separate reflection.





Prints 13: a very good depression with high amplitude waves at the base due to focusing.

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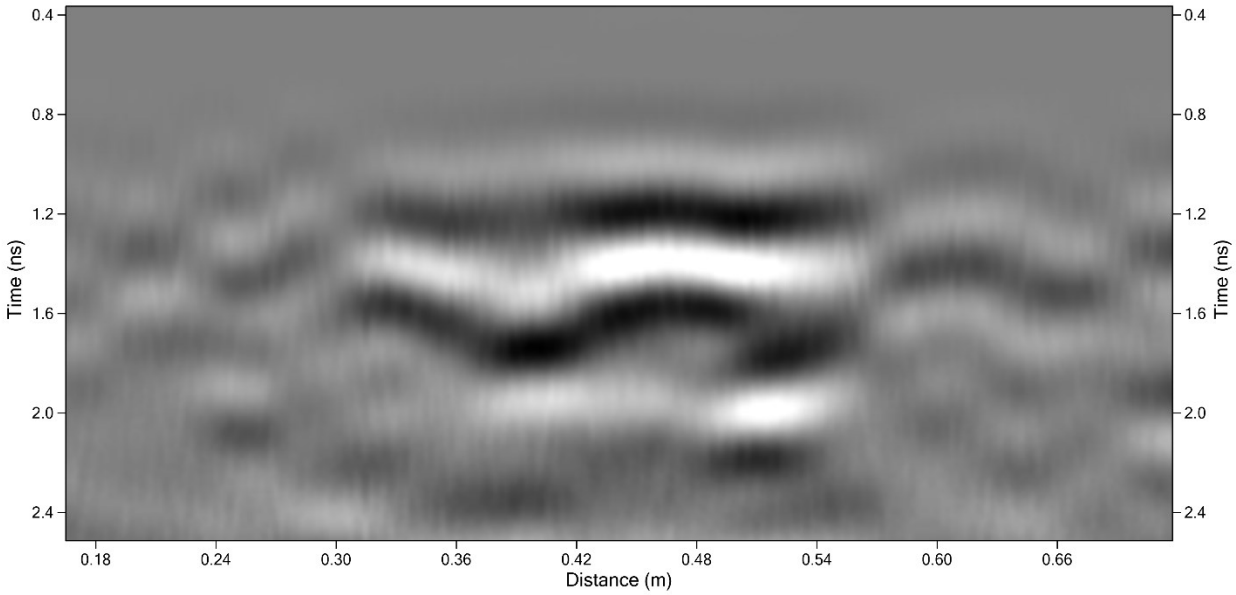
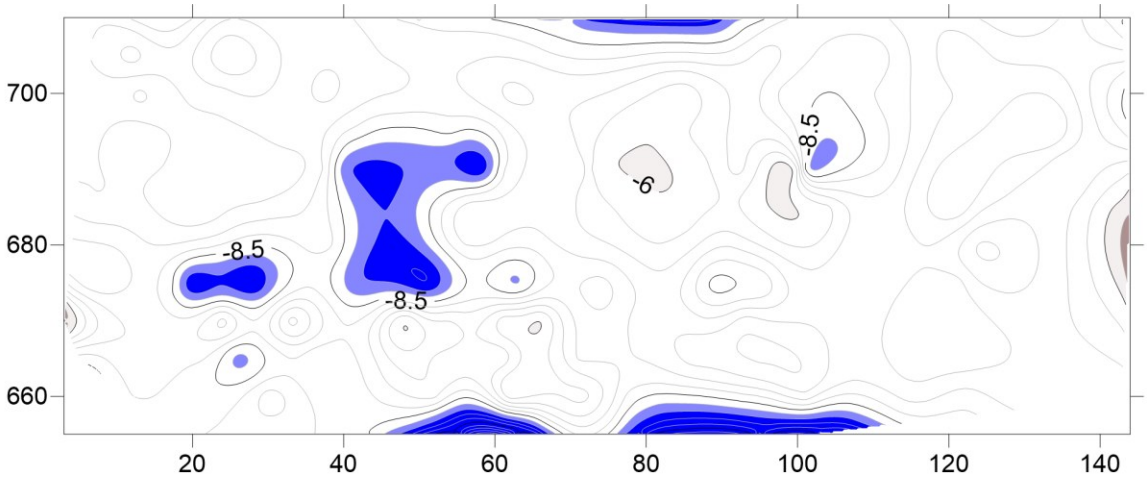
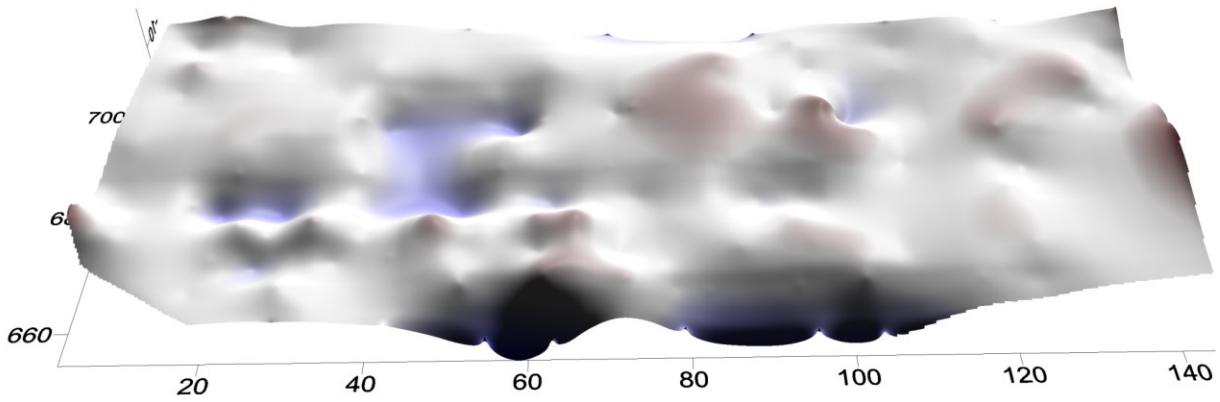
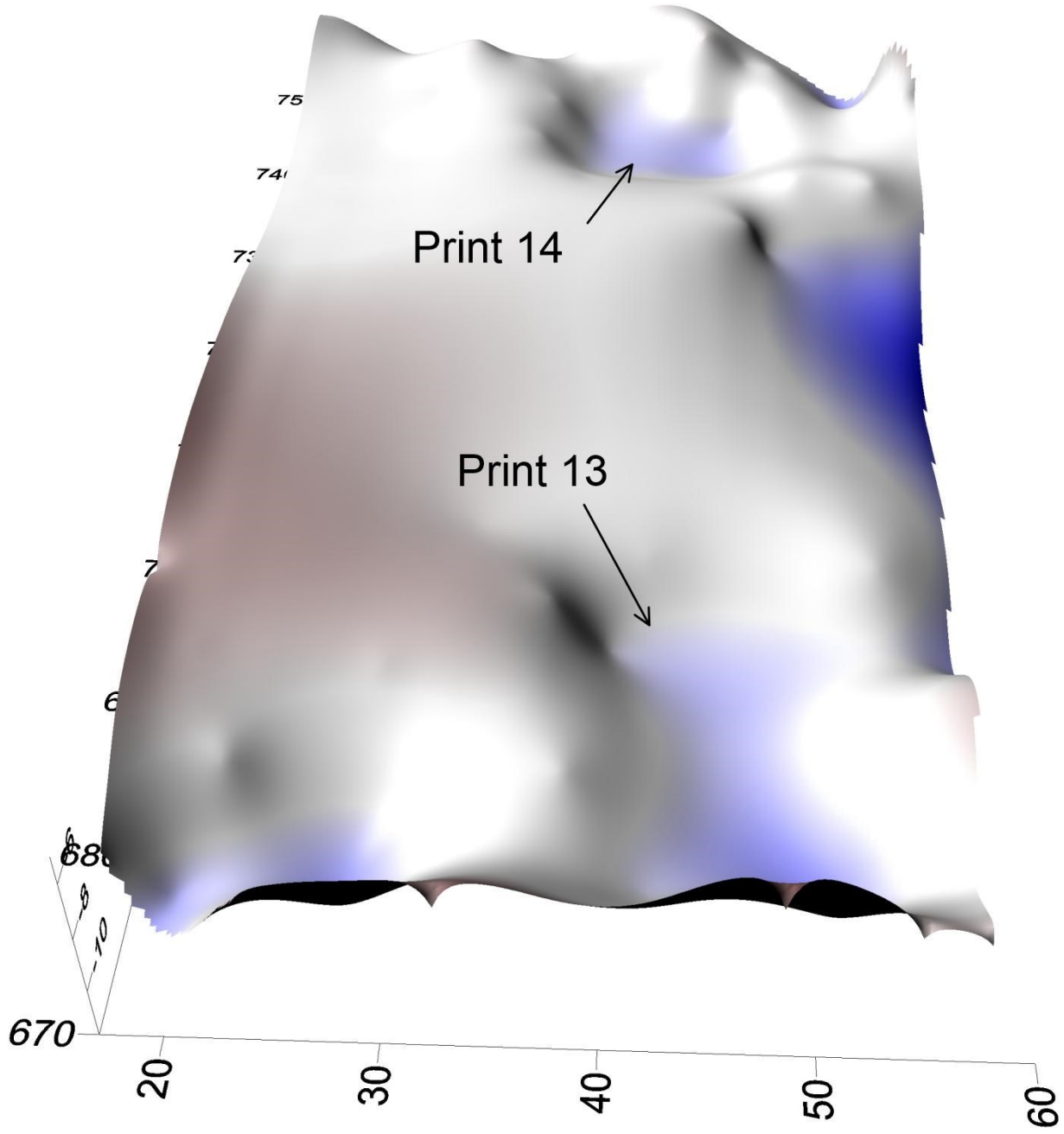
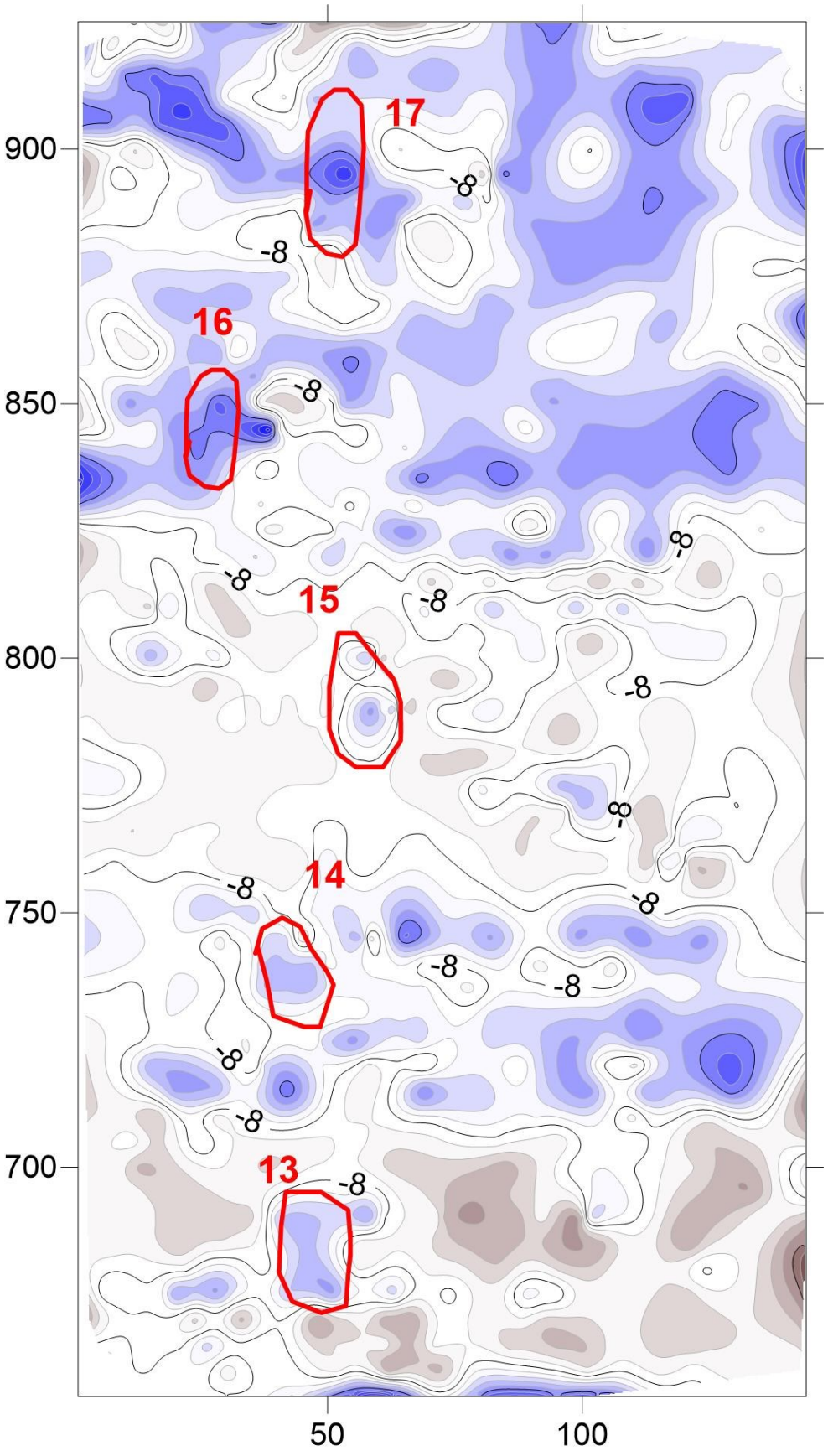








More of the same with prints 15, 16, 17 up through 12. Prints 22, and 23 are much like #8 and very difficult to see.


900
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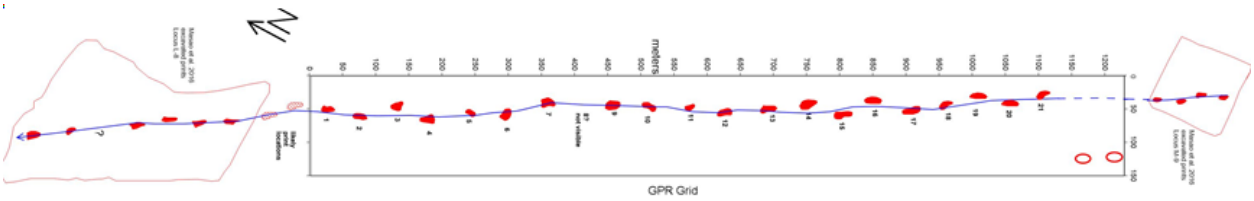
Here are all the prints below:



References

Masao, F.T., Ichumbaki, E.B., Cherin, M., Barili, A., Boschian, G., Iurino, D.A., Menconero, S., Moggi-Cecchi, J. and Manzi, G., (2016). New footprints from Laetoli (Tanzania) provide evidence for marked body size variation in early hominins. Elife, 5, p.e19568.