Archaeological Ground-Penetrating Radar for the St. Thomas Aquinas Cemetery, Ojai, CA

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Prepared for Rincon Consultants, Inc., Ventura, CA

Introduction

In coordination with Rincon Consultants, Inc., archaeologist Scott Byram, of Byram Archaeological Consulting, LLC (BAC), used ground-penetrating radar (GPR) to identify potential unmarked graves in a portion of the St. Thomas Aquinas Cemetery, Ojai, CA. With assistance from Rincon archaeologist Catherine Hornbake, BAC surveyed 13 GPR grids over the course of 3.5 days fieldwork to characterize potential buried features and stratigraphy (see Project Map 1). All work was completed in accordance with the Conditions of Approval (COA) of the Archdiocese's Conditional Use Permit (CUP) No. PL19-0057, specifically Condition 20. The project was completed as due diligence and was not required under the California Environmental Quality Act (CEQA). The CUP was issued by the County of Ventura (County). This report includes a summary of overall archaeological findings, a survey area map showing all GPR grids, and enlargements of slice maps and selected transect profiles. A separate appendix includes all slice maps. A summary table includes reference to the features identified, and shows the data files collected in each grid and their orientation.

Project Description

The project site comprises approximately 2.0-acres and is located north of East Villanova Road and approximately 325 feet south of Highway 33 in the city of Ojai, Ventura County, California.

The surveyed area represents approximately 40% of the two acre cemetery. The goal of the project was to identify unmarked graves within the construction area, which had been bladed and partially excavated. Known, marked graves are present at the site to the west and northwest of the survey area, and a cross in the southern part of the GPR survey area is in the general location of multiple graves according to descendants. Limited GPR was done at the location of the northwestern headstones to confirm that graves were present, where possible, and for comparative purposes.

The survey was conducted by BAC in October, 2023. Areas sufficiently open for grid placement were surveyed using high density GPR transect spacing (3/meter) due to the likelihood that graves were poorly preserved, and reports of at least one solitary infant grave.

GPR survey grid corners and field-identified features were mapped using a Juniper Geode L1 GPS unit. These locations were plotted on aerial images. Due to FAA limitations, aerial imagery acquired with a mini-drone at the end of the project was not from a height suitable for registering the image in GIS, but this imagery is included in an approximate plot in Project Map 2.

A total of 408 individual transect data files (.DZT) were collected. Techniques used are described at www.featuresurvey.com, and in Byram and Sunseri (2021), Sunseri and Byram (2018), Byram et al (2018), Sanchez et al. (2021) and Conyers (2012). A GSSI SIR4000 GPR instrument was used, along with a 350 MHz digital antenna to allow for maximum resolution at depth. Both a cart mounted and tow handle systems were used for survey (see photos). The measured grids were set up with measuring tapes as transect lines that were moved every two transects for consistent parallel data acquisition. All transects within grids were spaced at 33 cm intervals.

Amplitude slice maps (multicolor images in plan view) were generated for most grids using current GPR Slice software. A full set of slice maps appears in Appendix 1. Transect profile "radargram" images (grayscale images in side view) were generated with GPR Viewer software. All GPR data-generated images are annotated with orange or yellow polygons or arrows to show locations of interest such as likely archaeological features.

Note that this was not a utilities or hazards GPR survey. An assessment of possible utilities or hazards should be made before excavating any of the potentially archaeological features described in this report. Buried utilities may be present on the property. These could include gas and pipes, electrical line, sewer pipes, and water lines. Archived data for this survey is available upon request for analysis by civil engineers with GPR expertise.

Neither is geophysical hazard assessment a part of this study, but these data are also available to the client if needed for hazards assessment by a qualified geophysicist. Data processing for these needs may require access to proprietary software, but open source software such as GPR Viewer (Conyers 2012) is available for examining the .dzt files generated with the GSSI equipment.

While GPR is very useful for identifying archaeological features such as graves (Conyers 2012; Byram and Sunseri 2021), there are limitations to the technique based on equipment, soil conditions, surface obstacles, buried utilities, and other site variability such as feature preservation. BAC makes its best effort to identify archaeological site materials and uses state of the art equipment and techniques, but for any project there is no guarantee that a given feature or stratum will be identified.

Figure 1. Start corner (0/0) in Grid 6, facing south towards gate. SIR4000 GPR system in foreground.

GPR Cemetery Assessment

Much of the subsurface variability in the GPR data from the St. Thomas Aquinas Cemetery project appears to be from older geomorphology (e.g., buried cobbles and boulders), rodent burrowing, tree roots and differential moisture content, including pockets of water. Surface compaction changes readings below, and in the main block of grids in the south there are several areas where slice maps show what appear to be the results of compaction and watering.

Buried reflection features likely indicative of graves can vary in their distinctiveness due to grave composition, preservation and surface and soil conditions. Examples of transect profiles showing likely graves at headstone locations are shown below for St. Thomas Aquinas Cemetery.

Within the GPR survey area, previous trenching and buried metal are both present, and in some cases the metal appears to be buried pipe, probably from water lines. More isolated instances of metal may be related to graves. While metal can be brought to depth by burrowing and other noncultural processes, in some cases buried metal is the only indication of a grave that GPR can identify, due to poor preservation of organic materials. Depth below surface in this area prior to grading was likely greater than it is under current conditions. Isolated buried metal were noted during the survey. In some cases, features and buried metal were noted during survey and shown on project maps as recorded by GPS, corresponding to stakes left on site. Subsequent analysis clarified that some of these features are likely related to pipe trenches or other phenomena not grave-related. However, data analysis after fieldwork indicates two additional graves may be present, both in the northern portion of Grid 5. An instance of buried metal in the northern portion of Grid 3 appears to be in a larger pit that is grave shaped. If necessary, archaeological testing may clarify the temporal and cultural origin of these features.

Surface Grave Markers in the Western Portion of Cemetery

The SIR4000 with 350 MHz antenna was used to scan existing graves to the west and northwest of the GPR survey area for comparison with buried features within the GPR survey area (Figure 2). Ten transects were stored and several others deleted as this assessment proceeded. Examples of some of these transects are presented here (Figure 3 and Figure 4).

Figure 2. GPR equipment at the Juan Lopez grave, the southern end of the row of graves extending north between two oak trees (facing northwest). The Archibald McDonnell and Chino Lopez graves are at the northern end of this row, though the two are positioned east-west of each other.

Figure 3. File 209 at 2 meters, Archibald McDonnell, 1918, a large grave with a cross at the top. Yellow arrows mark the top of the coffin or vault at 35 cm depth, underlain by a void at 100 cm depth. The grave to the west, Chino Lopez, also dates to 1918, and shows a distinct hyperbola at the top of the coffin.

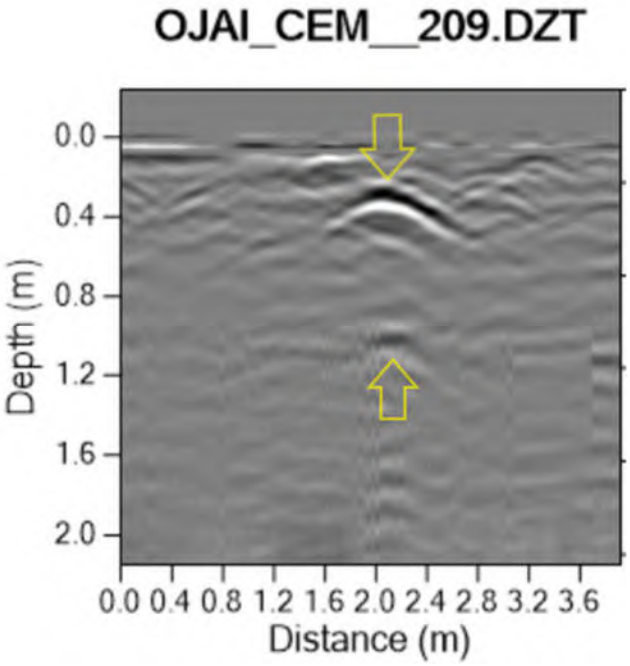
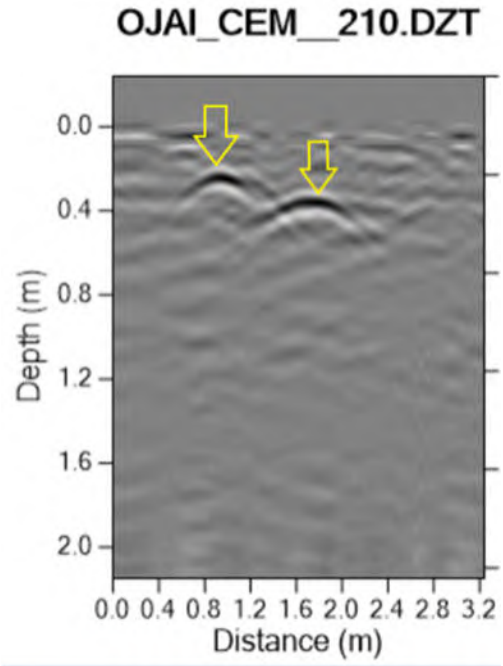


Figure 4. File 212 facing west, at the 35 cm diameter concrete marker in line with the Chino Lopez grave but 3 meters to the south.



Archaeological Findings by Area

Features are shown on Project Map 1, and on selected slice maps and transect profiles presented for each grid below.

Table 1. Table of Grid Coverage and Features of Potential Interest.

Grid Number	Direction from 0/0 corner	Start file #	End file #	Potential Cultural Features Indicated Below Surface
1	N from SW	3	30	Small feature (F1), may or may not be grave related
2	N from SW	33	56	Two likely graves (F2, F3)
3	N from SW	59	92	One likely grave (F4), one possible structural feature (F5)
4	N from SW	93	108	None identified
5	N from SW	109	130	Two possible graves (F6, F7) in the north; possibly pooled water.
6	S from NE	131	160	Planar feature (F8) near gate is likely previous construction.
7	SW from E	163	204	None identified
8	E from NW	215	283	None identified
9	W from SE	285	325	None identified (metal in NE is near surface)
10	W from SE	327	359	None identified
11	N from SW	305	348	None identified
12	NE from S	349	382	None identified
13	E from NW	383	408	None identified (buried metal not confirmed after analysis)

Grid 1

This grid is located in the south-central portion of the GPR survey area, east of the main gate and Grid 5, and west of Grid 4 (Figure 5 and Figure 6). A small feature (F1) at 17 meters north may be a small grave or cairn, but its location along what appears to be a filled east-west trench suggests it could be related to this trench (e.g., junction box along water line). GPR data acquired are insufficient for making this distinction. A pipe appears to be present at 7 meters north running east to west.

Grid 2

This grid is located in the south-central portion of the GPR survey area, between grids 4 and 3 (Figure 7 and Figure 8). Grid 2 includes the concrete pad for the wooden cross that stood in the cemetery. The 7 meters north pipe and the 17 meters north trench are both present. Two likely grave features (F2 and F3) were identified in the slice maps and marked during fieldwork.

Figure 5. File 17, facing west, showing a small feature or burrow (F1) at 17 meters north (yellow polygon), and a planar phenomenon to the right (orange). The small feature also evident in adjacent transects 16 and 18, extends approximately one meter east-west, across the three transects, but it is in line with a likely pipe or trench feature indicated in data from the east and west of this location. The planar phenomenon (lens or stratum) may extend into a buried hump-shaped stratum, which may be a geomorphic phenomenon predating the cemetery. This is not likely to be grave-related, but the smaller feature at 17m north could be a small, shallow grave. Alternatively F1 could be a feature related to an east-west trench that appears to run through this and adjacent grids at 17 meters north of baseline.

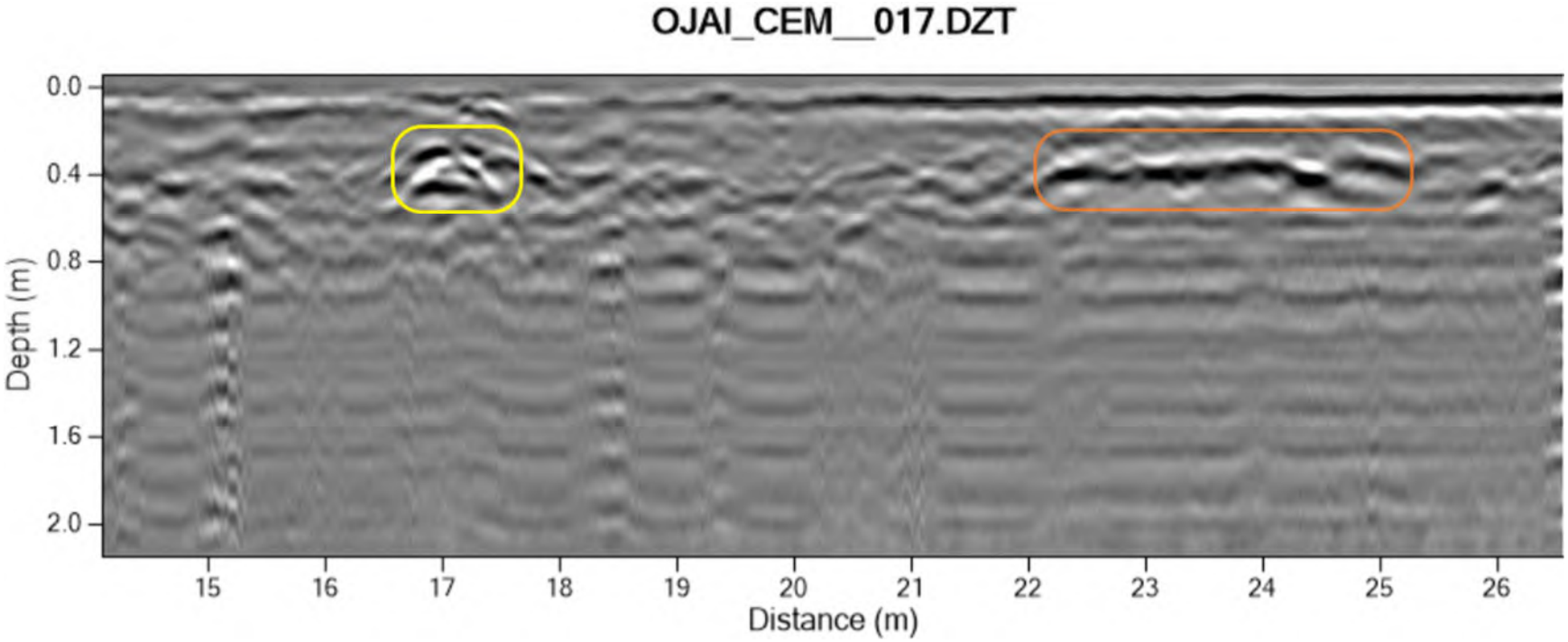


Figure 6. Feature and stratum appearing in the preceding GPR transect profile (File 17) are visible in slice maps from 15-70 cm depth. The black arrow at left points to the planar or shallow dome-shaped stratum in the north in Slice 1 (15 cm depth) *(far left)*. The white arrow points to the small nearby feature (F1) at 30 cm depth *(center left)*, which may be in a pit, as outlined in the two deeper slices to the right *(center and far right)*. This may be related to an east-west trench at 17 meters north. Much of the remaining variability in the grid is likely due to differential compaction and moisture content, and possibly rodent burrowing.

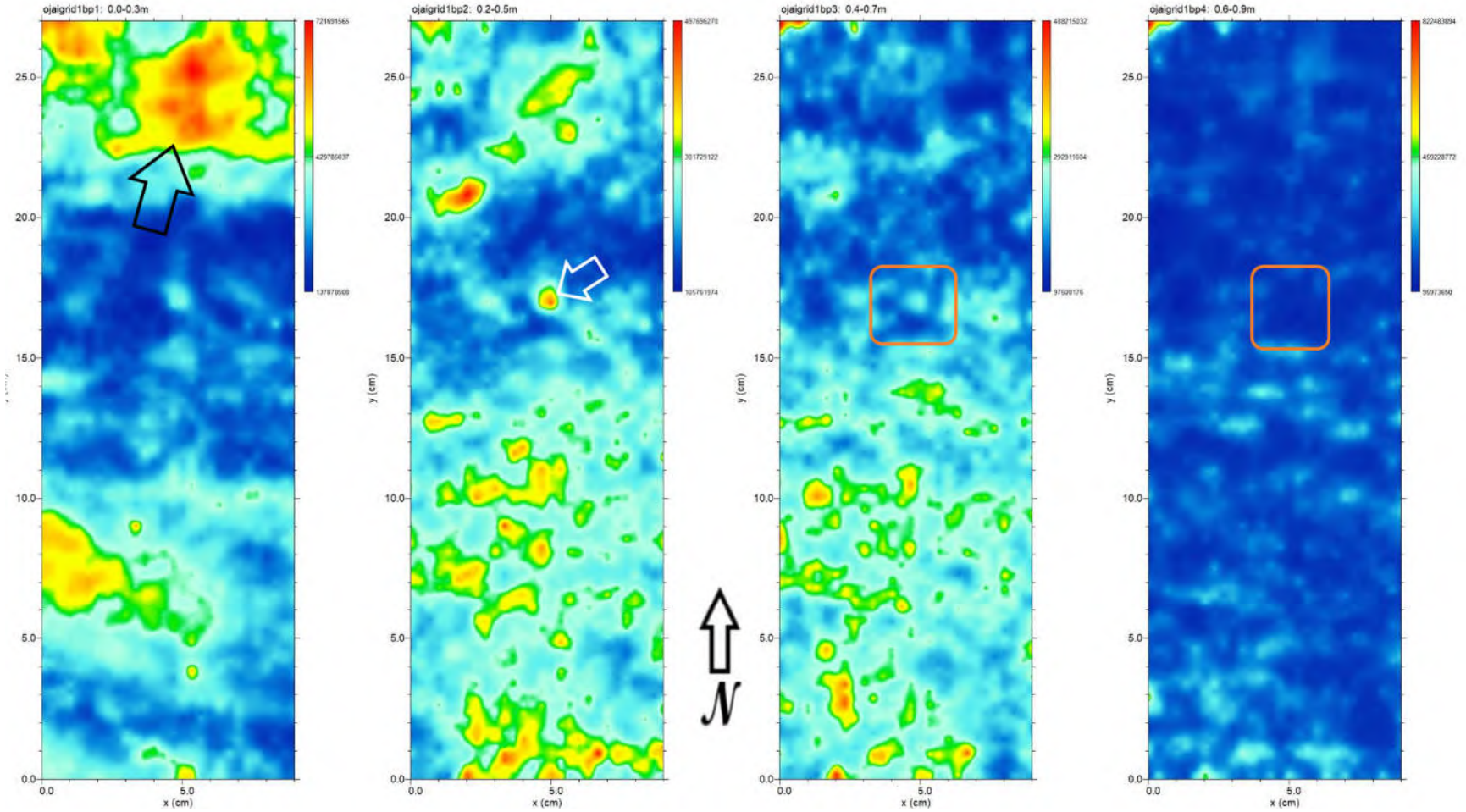


Figure 7. Southern portion of file 35 in Grid 2, facing west. Shallow hyperbolae in orange box are likely one or more water line pipes.

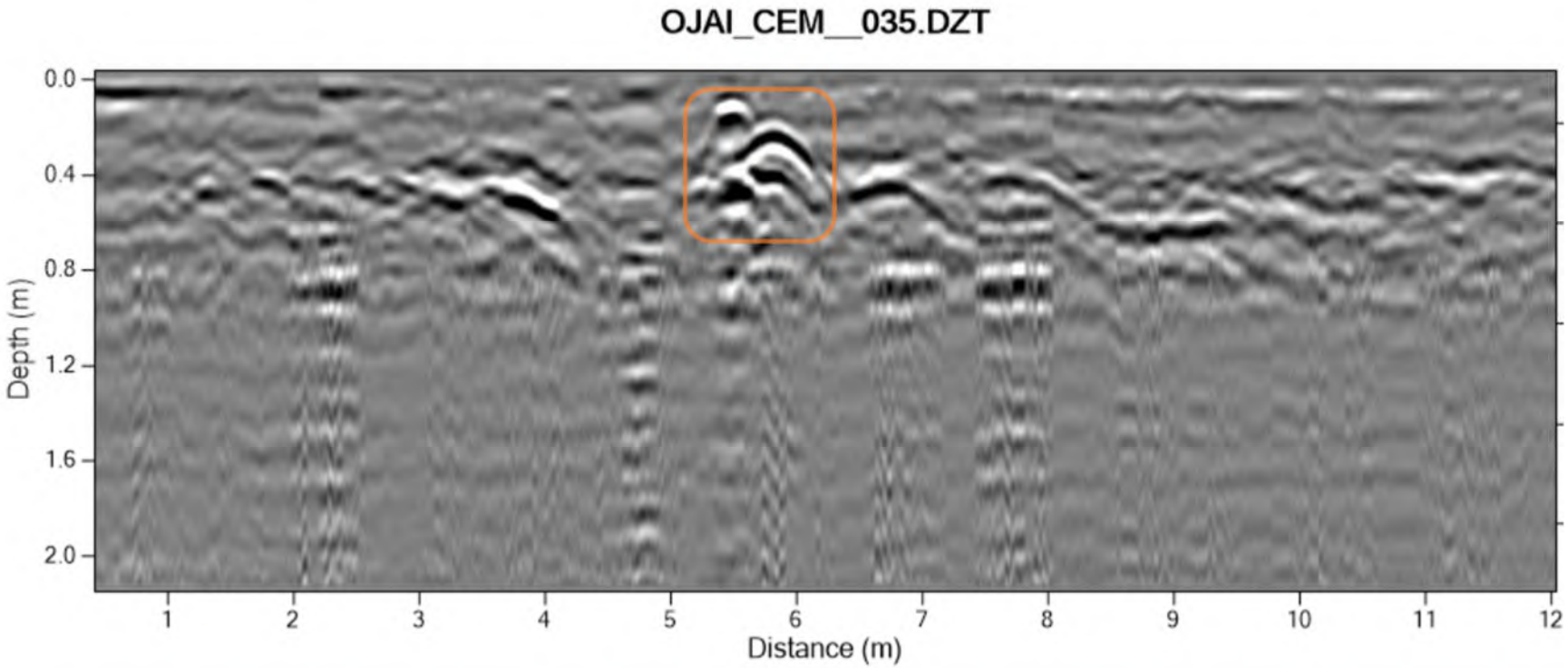
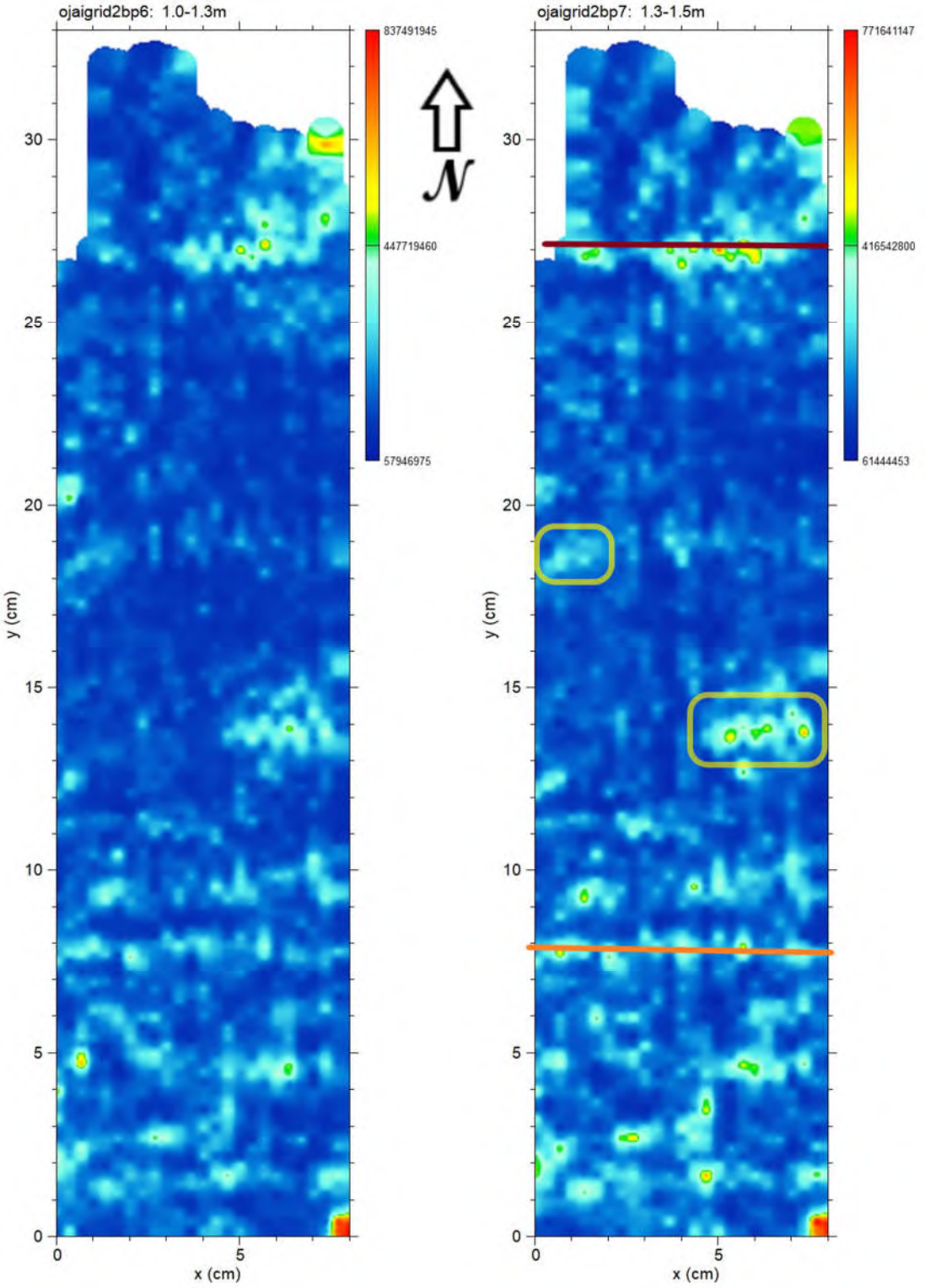


Figure 8. Two slices from Grid 2 showing features. The two yellow boxes are likely graves, although the northern one (F2) is adjacent to the east-west trench feature identified in this and adjacent grids. The southern yellow polygon (lower right) is F3. The red line is a slope break in the northern portion of the grid, and the orange line appears to be a buried pipe in a trench (see Figure 7).



Grid 3

This grid is located in the southeastern portion of the GPR survey area (Figure 9 and Figure 10). It is adjacent to Grid 2 in the west, and its northern and eastern edge are bounded by a slope and gravel. One possible grave (F4) was noted at 24.5 meters north in file 64, where there is buried metal at roughly 20 cm depth within a possible filled pit extending to the east. Depth here prior to grading was likely greater than 20 cm. While metal can be brought to depth by rodent burrowing and other noncultural processes, in some cases buried metal is the only indication of a grave that GPR can identify, due to poor preservation of human remains, wood and other organic materials.

In addition, a possible structural foundation or similar feature (F5) is present in the southeast corner of the grid. There is also evidence of rodent burrowing in the southwest portion of this grid, at approximately 10 meters north. Stratigraphically there is more variability between 40-60 cm depth than in the upper 40 cm, suggesting either a buried geomorphic stratum or roots and other biotic activity at a depth where the soil holds more moisture.

Grid 4

What appears to be a buried pipe running east-west through Grid 2 at 6-7 meters north appears to be present in Grid 4 as well, though more visible in profiles than the slice maps (Figure 11). During fieldwork a possible buried metal object was observed at 10 meters north as well, but further examination indicates this is a buried cobble or rodent burrow. Because it does not clearly extend into adjacent transects it is not designated as a feature. Additionally there appears to be a filled east-west trench at 17 meters north, as seen in other southern grids. What was thought to be a small pit feature during the survey appears to be a section of the filled trench. Water pooling near a parked water truck created a pronounced reflection resembling a feature in the southern portion of the grid, evident in all slice maps (Appendix A).

Figure 9. File 64 in Grid 3, facing east, showing buried metal, probably a water pipe.

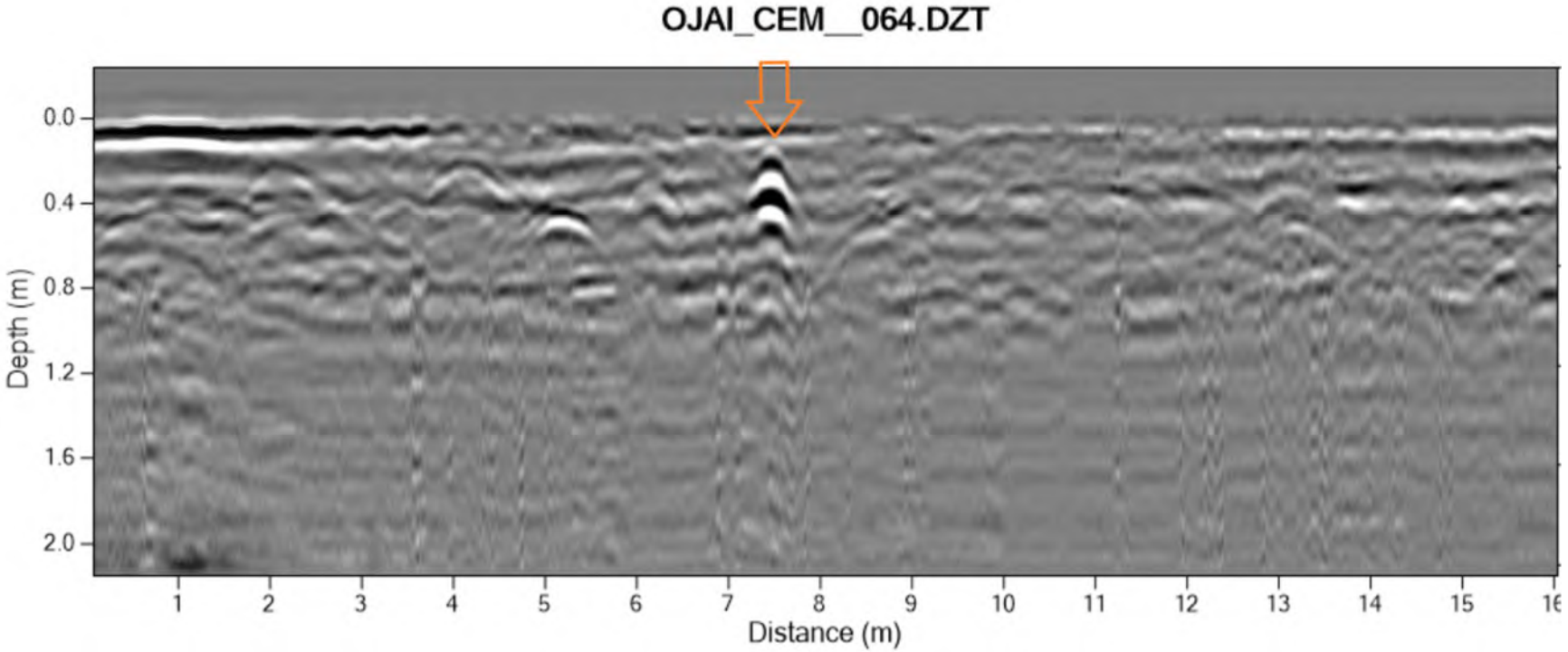


Figure 10. Three slices (30, 60 and 80 cm depth) from Grid 3 showing a possible grave (F4) at 25 meters north (yellow polygon) *(right)* and what appears to be a structural feature (F5) in the southeast corner of the GPR survey area (orange polygon) *(left)*. The structural feature may extend east into an area covered by a thick layer of gravel, adjacent to the grid.

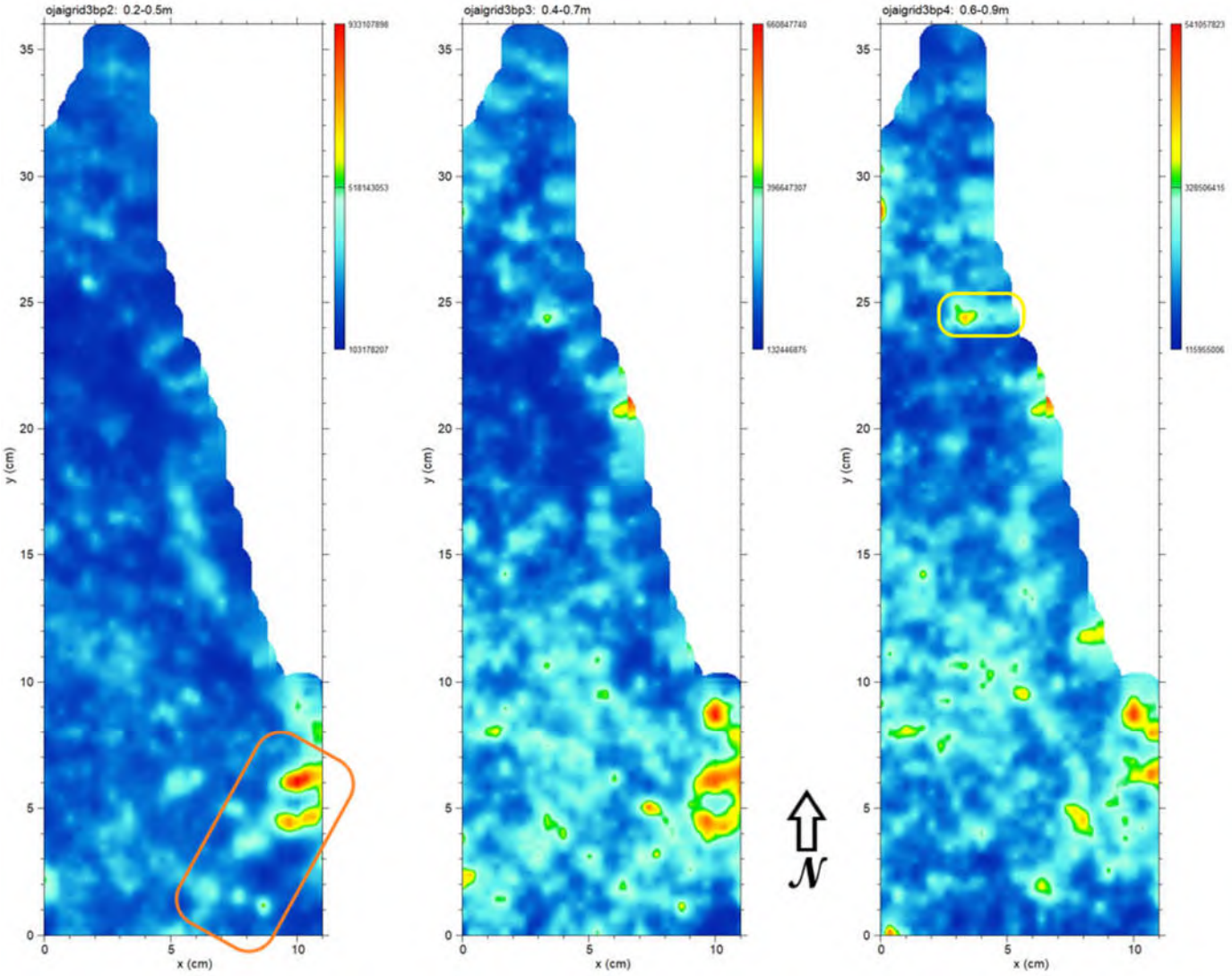
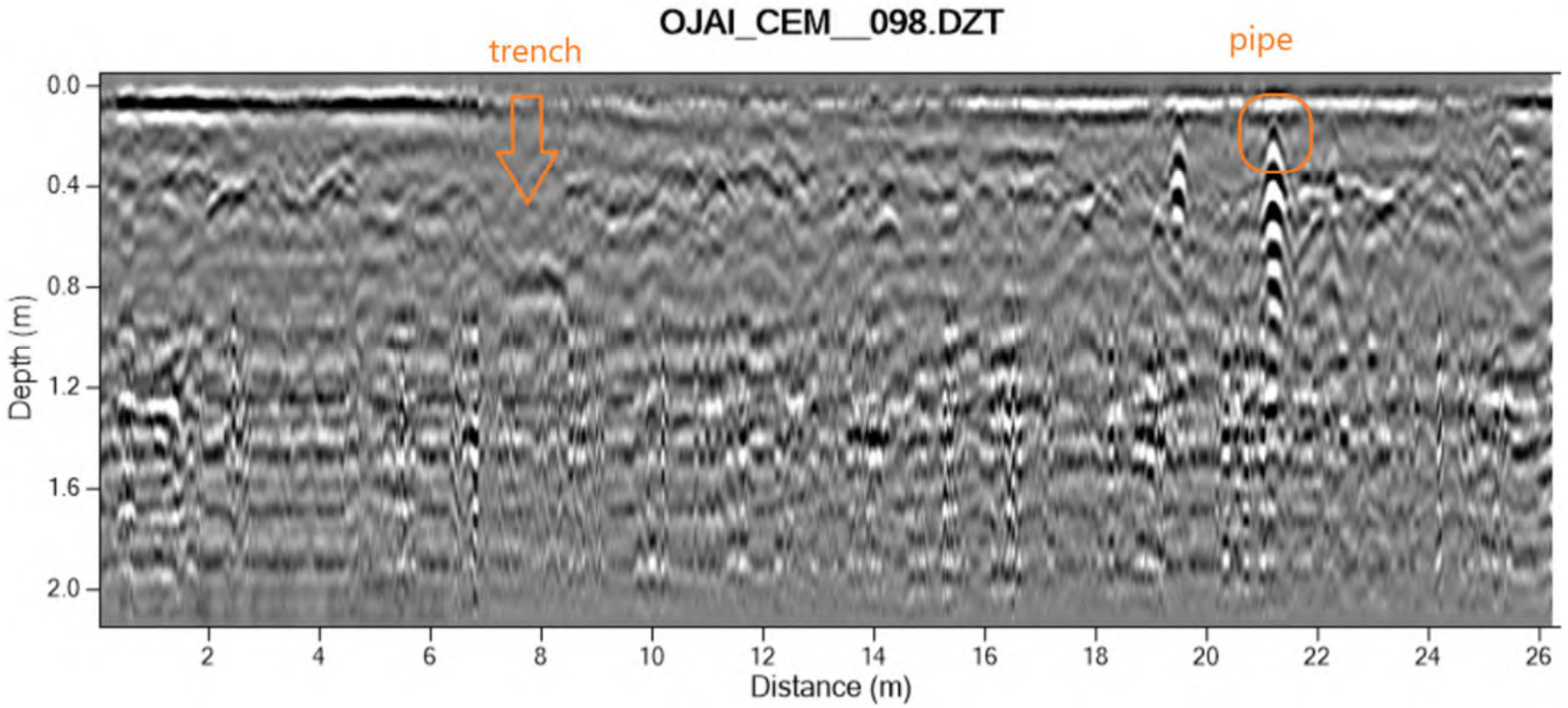


Figure 11. File 98 in Grid 4, facing east, showing a filled trench at 18 meters north and a buried metal object at 7 meters north, corresponding to the east-west linear pipe indicated in adjacent grids.



Grid 5

This is the westernmost grid in the southern block of large grids (Figure 12 and Figure 13). It is bordered in the west by a temporary fence bounding the construction GPR survey area, and in the east by Grid 6. The 17 meters north pipe appears to be present but there is no evidence of the 7 meters north pipe.

Figure 12. Two possible graves (F6 to the west and F7 to the east) are evident in the northern portion of Grid 5 below 25 cm depth (*center*). F6 is more distinct than F7. Rodent burrowing accounts for much of the high amplitude variability in the southern part of the grid, and exposed burrows and backdirt piles were evident on the surface during the survey *(left)*.

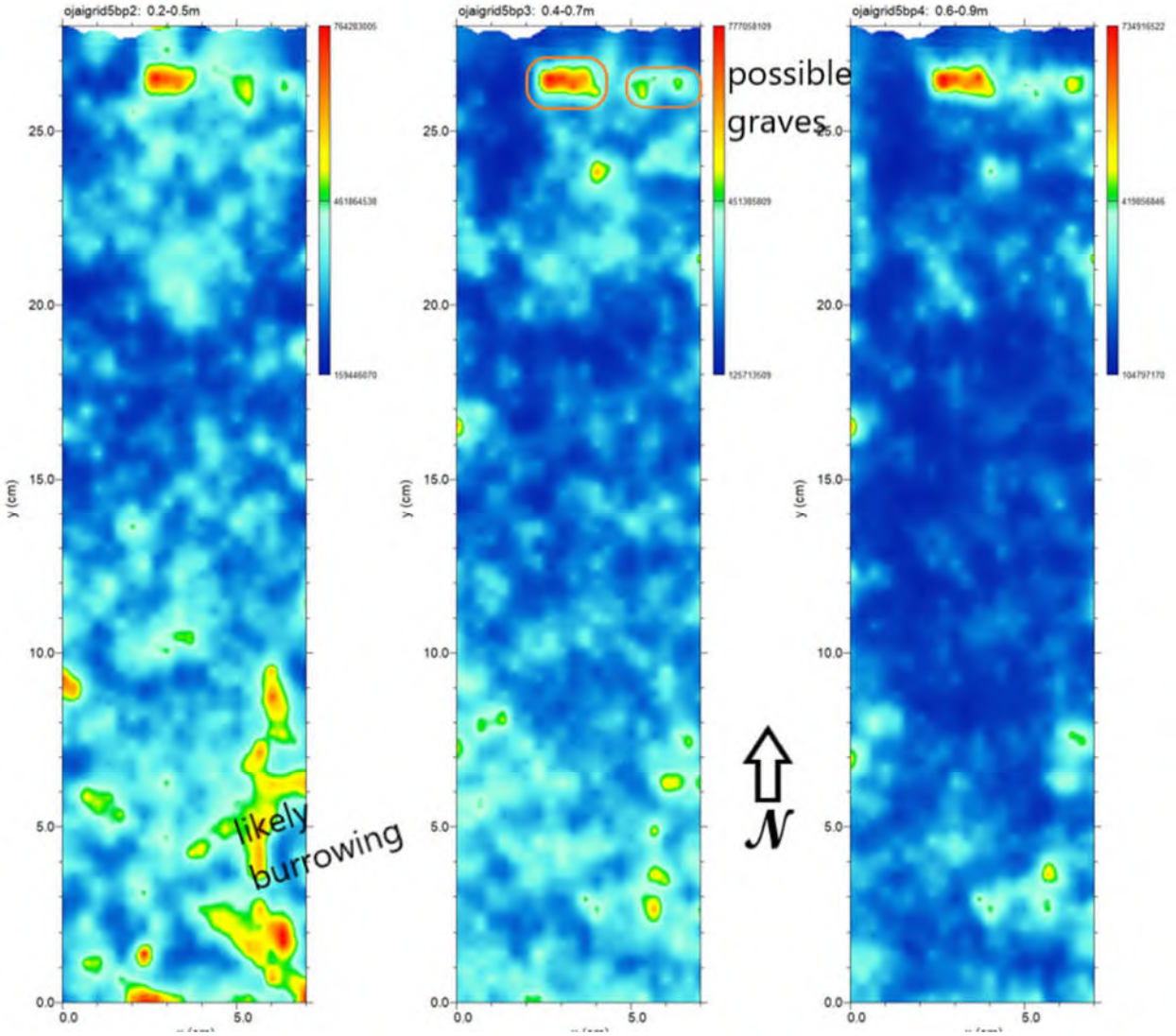
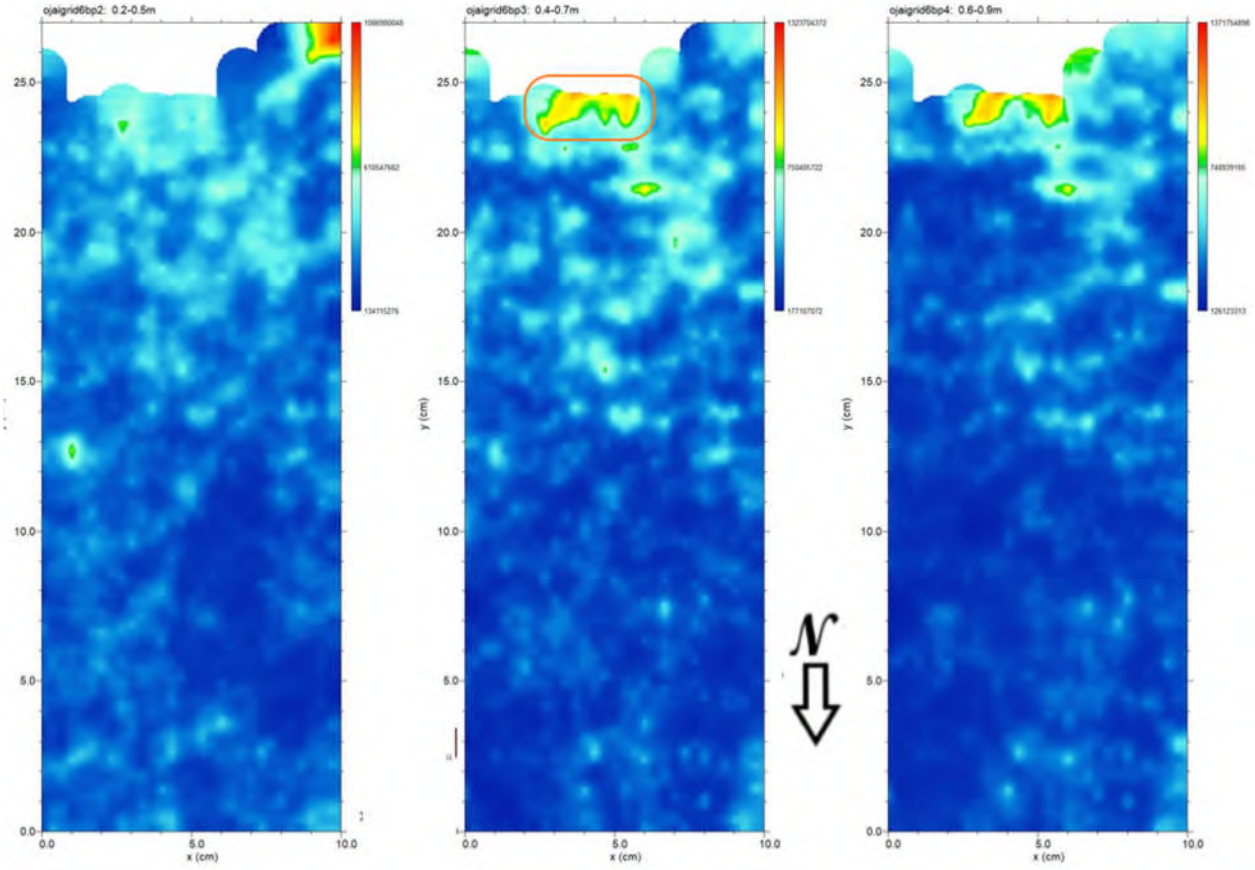


Figure 13. A buried water line is exposed in the cut bank near the northern edge of Grid 5. Water lines likely account for at least two east-west linear features in the southern grids, and may be present in other parts of the site as well. Moisture may partially account for one or both of the grave-like features in the northern portion of Grid 5.

Grid 6

The 7 m north pipe and possibly the 17 meters north trench appear to be present as they are to the east, but other parallel linear phenomena likely related to surface compaction and variable moisture make these linear features less evident (Figure 14). There is a shallow feature (F8) just north of the gate that may be pavement or drainage related, or an older gate foundation.

Figure 14. Planar feature F8 along north edge of gate in Grid 6 at 50 cm depth (orange polygon).



Grid 7

This grid is located north of grids 2 and 4 on a higher surface bordered by a cut bank on the south (Figure 15). No cultural features were noted. Rodent burrowing seems to have produced a group of reflection features in the north.

Figure 15. Start corner for Grid 7, facing west. Yellow stakes represent the center point between two transects the antenna followed.

Grid 8

This grid is in the central eastern portion of the GPR survey area. No features were identified here.

Grid 9

Grid 9 is in the northeastern portion of the GPR survey area, and its northernmost transects extend west along the northern boundary fence. During the survey, one piece of buried metal was noted near the northeast corner, but post-survey analysis showed this to be near-surface metal, which could have originated from recent surface activity. There is extensive burrowing in Grid 9, and transects meandered around a large pile of boulders in the center of the grid. No other features were identified.

Grid 10

This grid was surveyed in the northwestern portion of the GPR survey area and includes the large circular concrete slab and portions of the northern ADA corridor. No buried features were identified.

Grid 11

This grid is the northern of two ADA corridor grids, also including the area to the east of the grid, to the base of a large spoil pile. No likely graves were identified during this survey.

Grid 12

This grid is the southern of two ADA corridor grids. No likely graves were identified during this survey.

Grid 13

This grid is located in the east and northeast portions of the GPR survey area, consisting of the interior of a wide, arcing construction trench approximately 1.2 meters deep. Because of the arc shape of the trench it was not possible to generate slice maps from the data. During survey a possible piece of buried metal was identified at 12 meters south in File 386. However, analysis of the transect data suggest this is a buried void rather than metal, possibly a deep section of a rodent burrow.

Authorship

Scott Byram, Ph.D. is a registered, professional archaeologist and a research affiliate at the University of California, Berkeley Archaeological Research Facility. He has conducted GPR surveys since 2009 within the U.S. and abroad, with the majority of his projects in California. In 2006 he established Byram Archaeological Consulting, LLC in Oregon and the firm is now based in El Cerrito, California. In addition to numerous reports on California GPR research Byram regularly publishes academic journal articles on this archaeological scanning technique (e.g. Sanchez et al. 2021; Byram et al. 2018; Sunseri and Byram 2017). For more information about Scott Byram's previous GPR projects and landscape archaeology see pages at www.featuresurvey.com and https://berkeley.academia.edu/ScottByram.

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Attachments

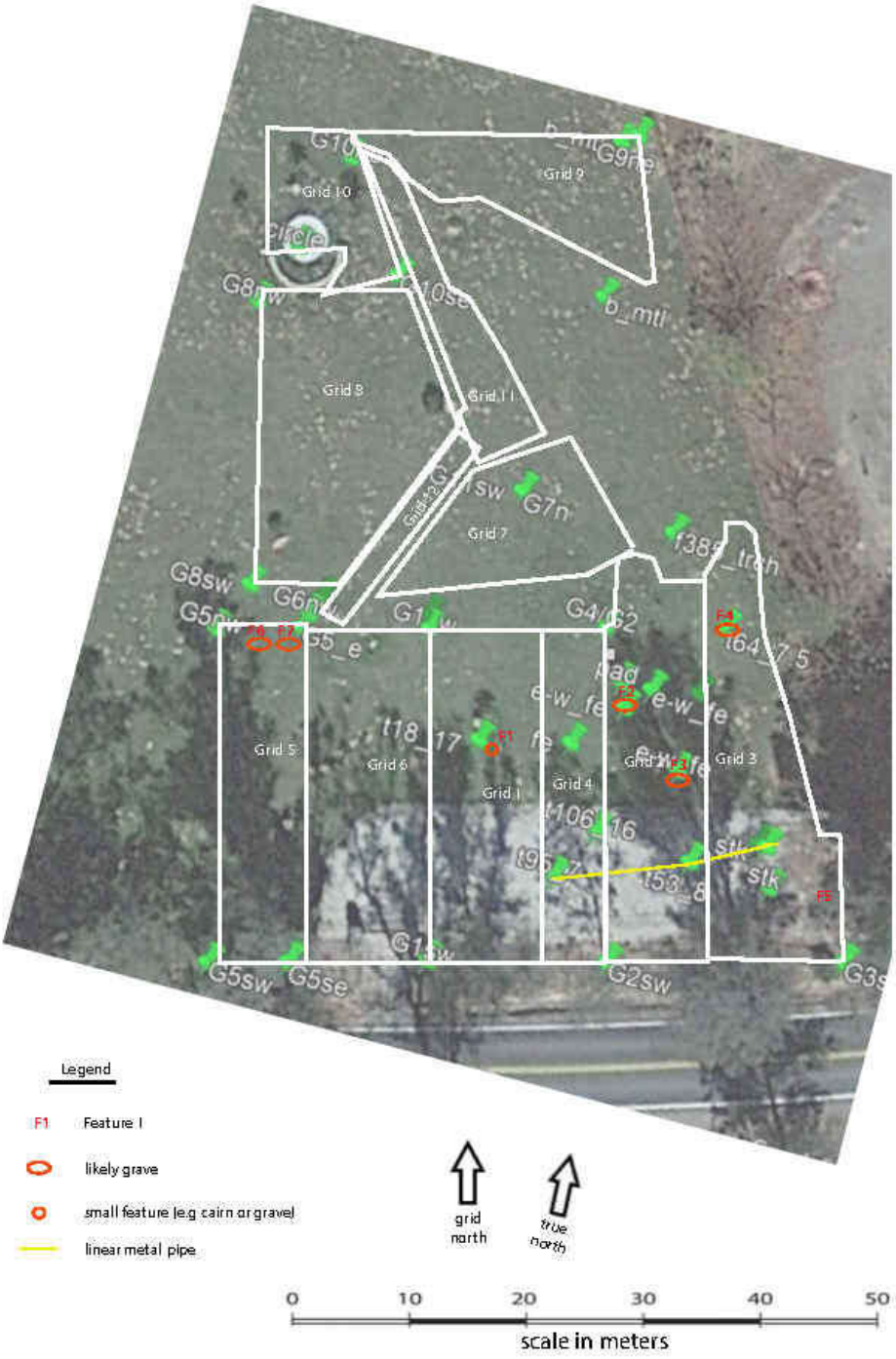
Attachment A Project Maps

Attachment B GPR Amplitude Slice Maps

Attachment A

Project Maps

St. Thomas Aquinas GPR Survey Oct. 2023 Project Map 1



Project Map 2:
Not to scale due to parallax.
Grids in rough position over 10/2023 image

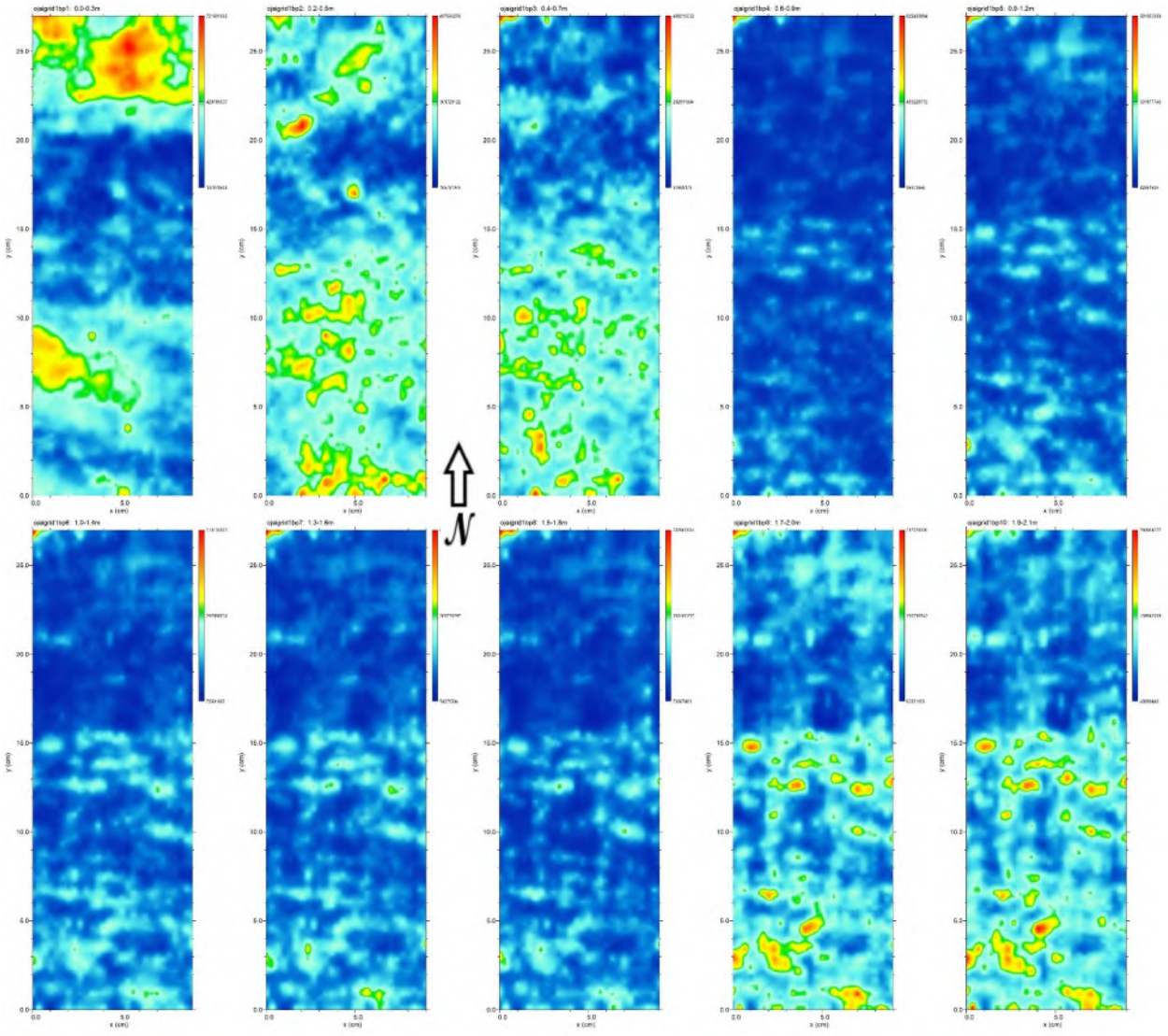
Attachment B

GPR Amplitude Slice Maps

Attachment B

GPR Amplitude Slice Maps for St. Thomas Aquinas Cemetery, Ojai, CA

Grid 1



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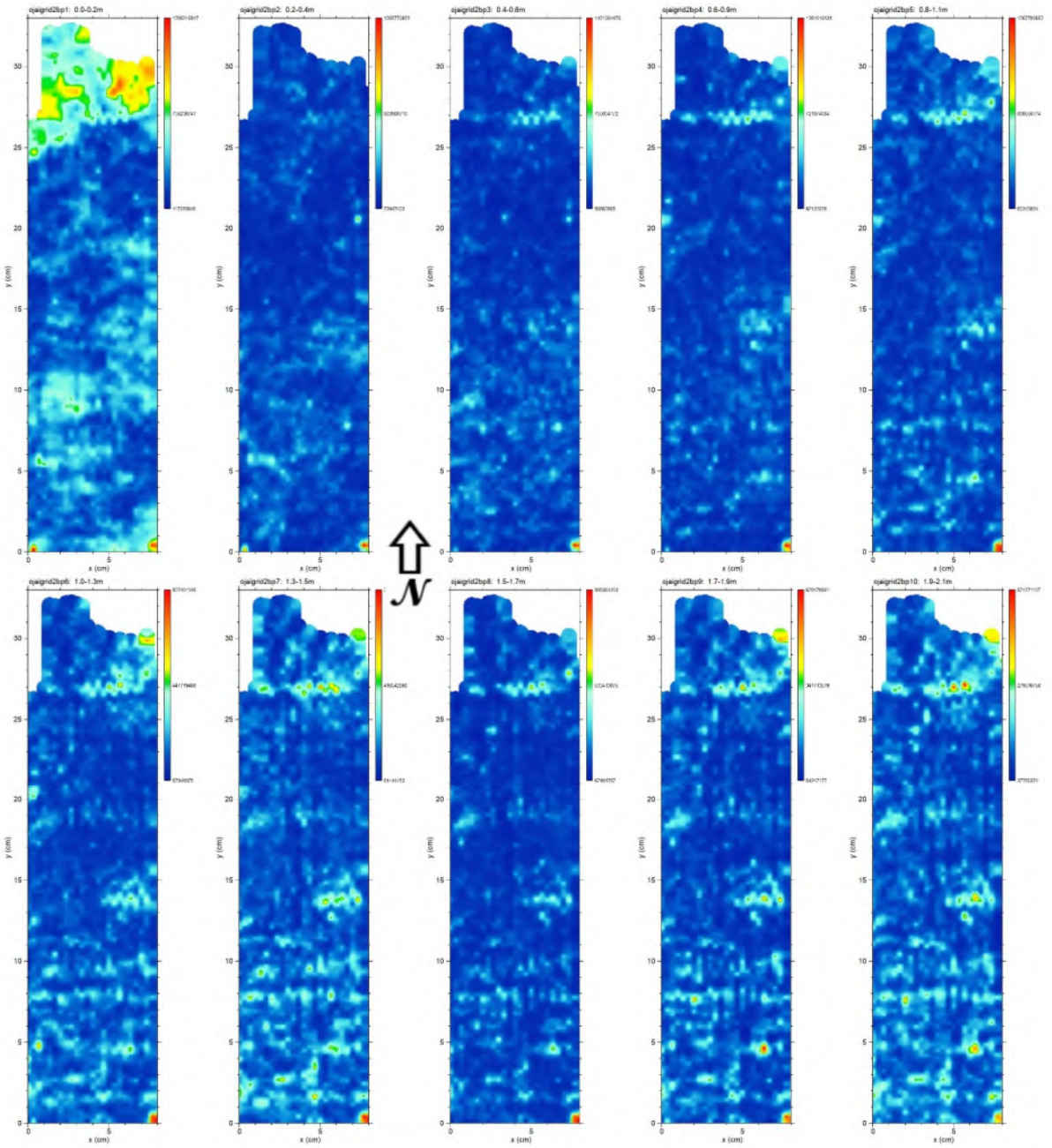
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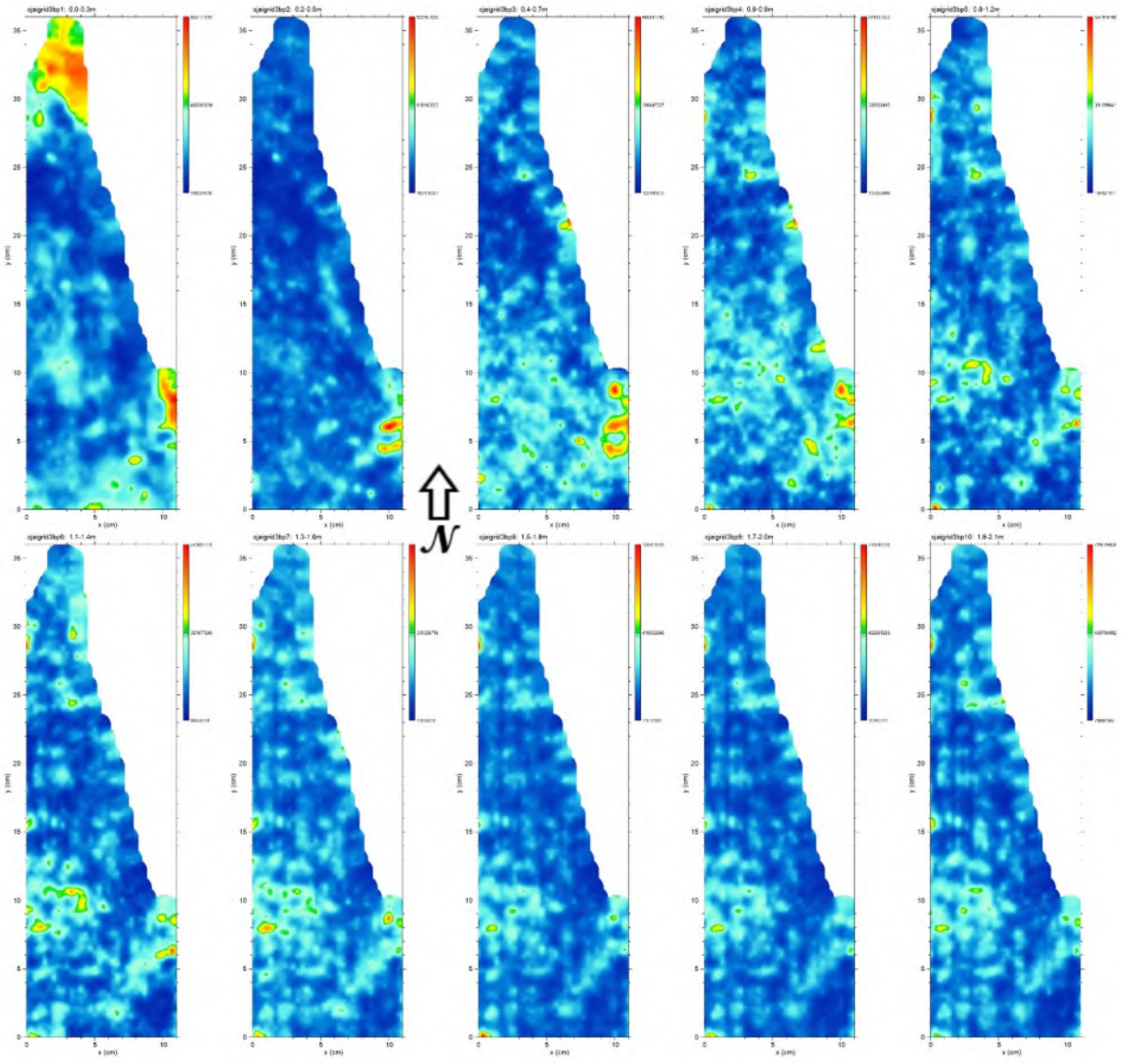

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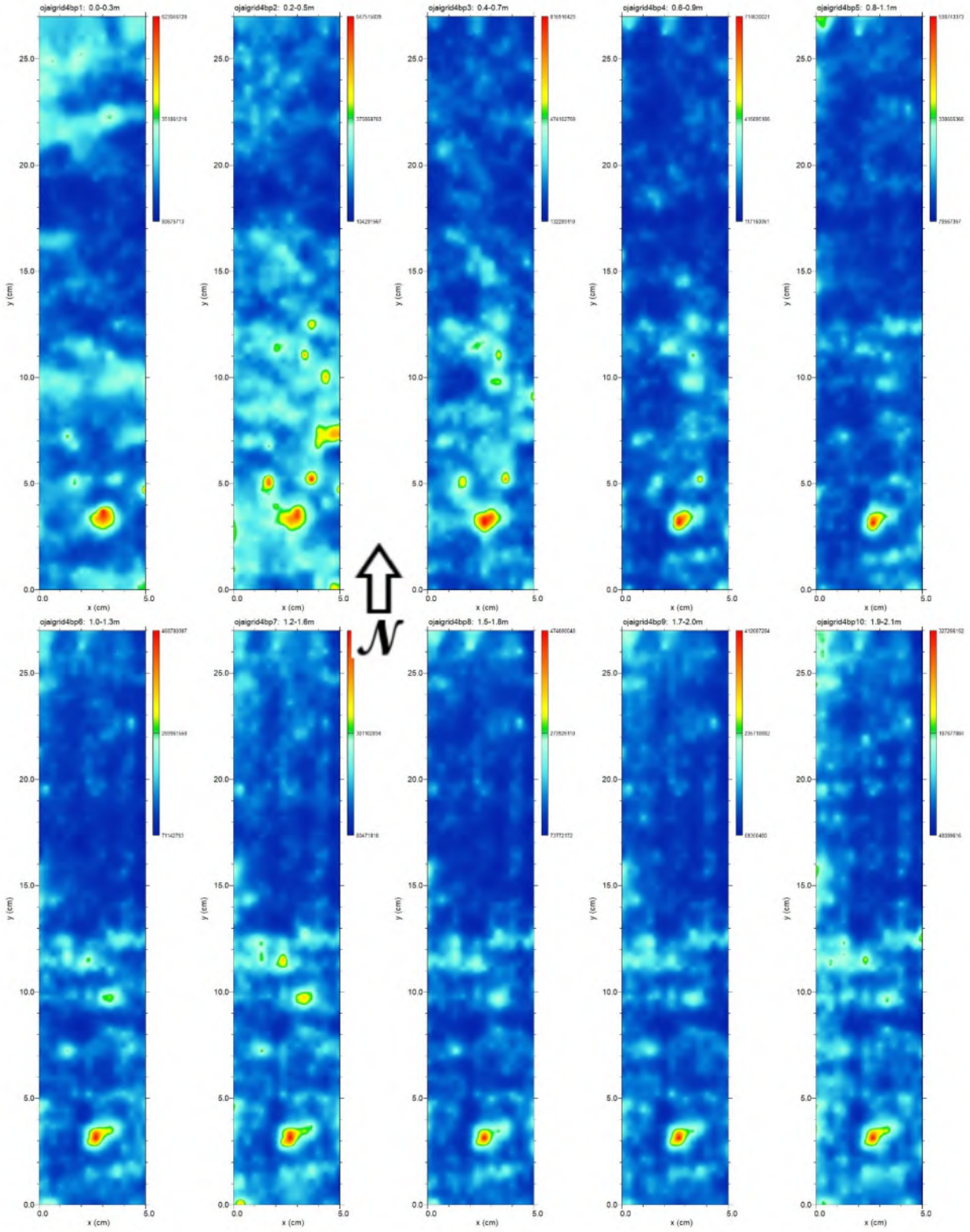
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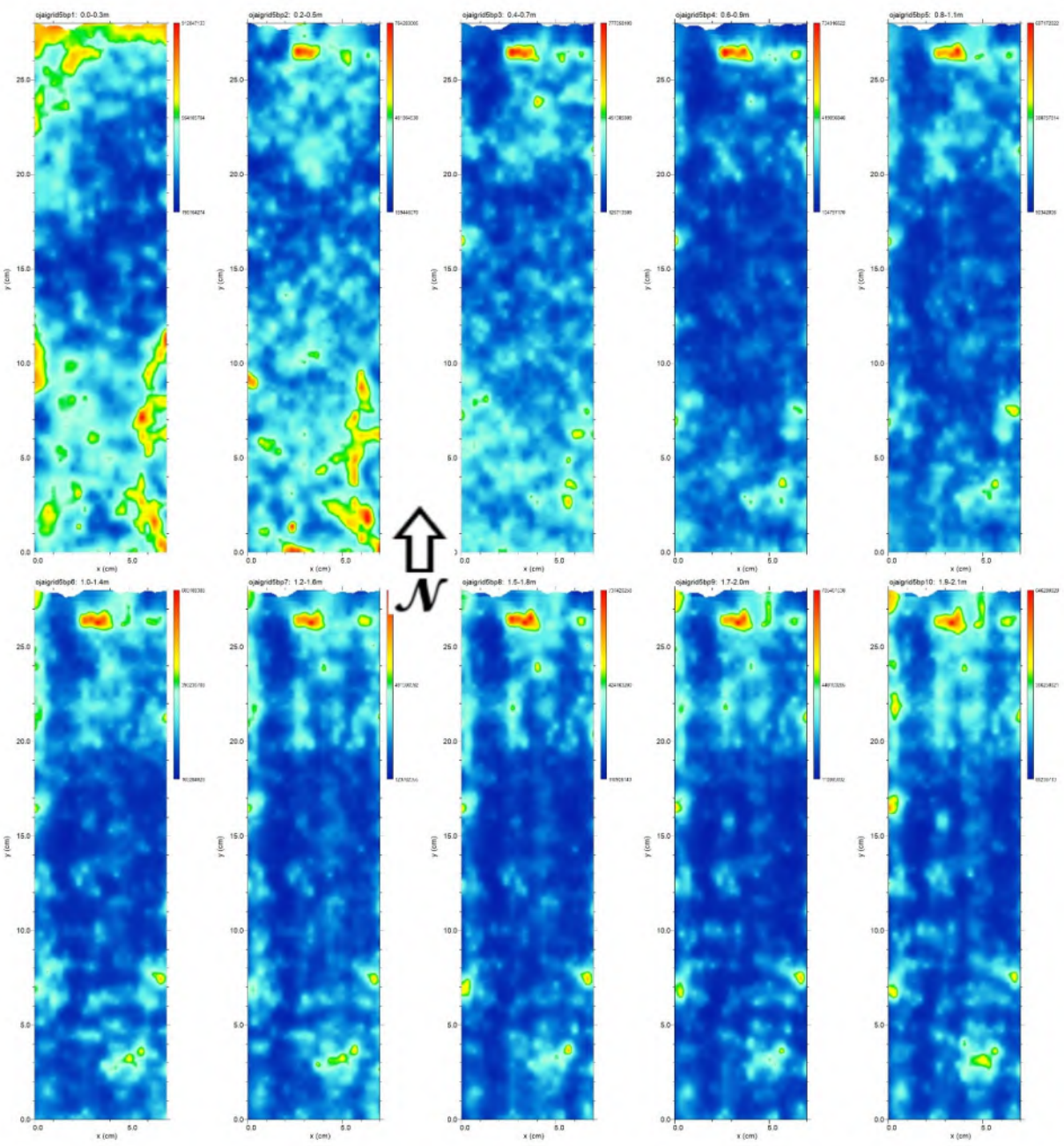
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y (cm)
x (cm)
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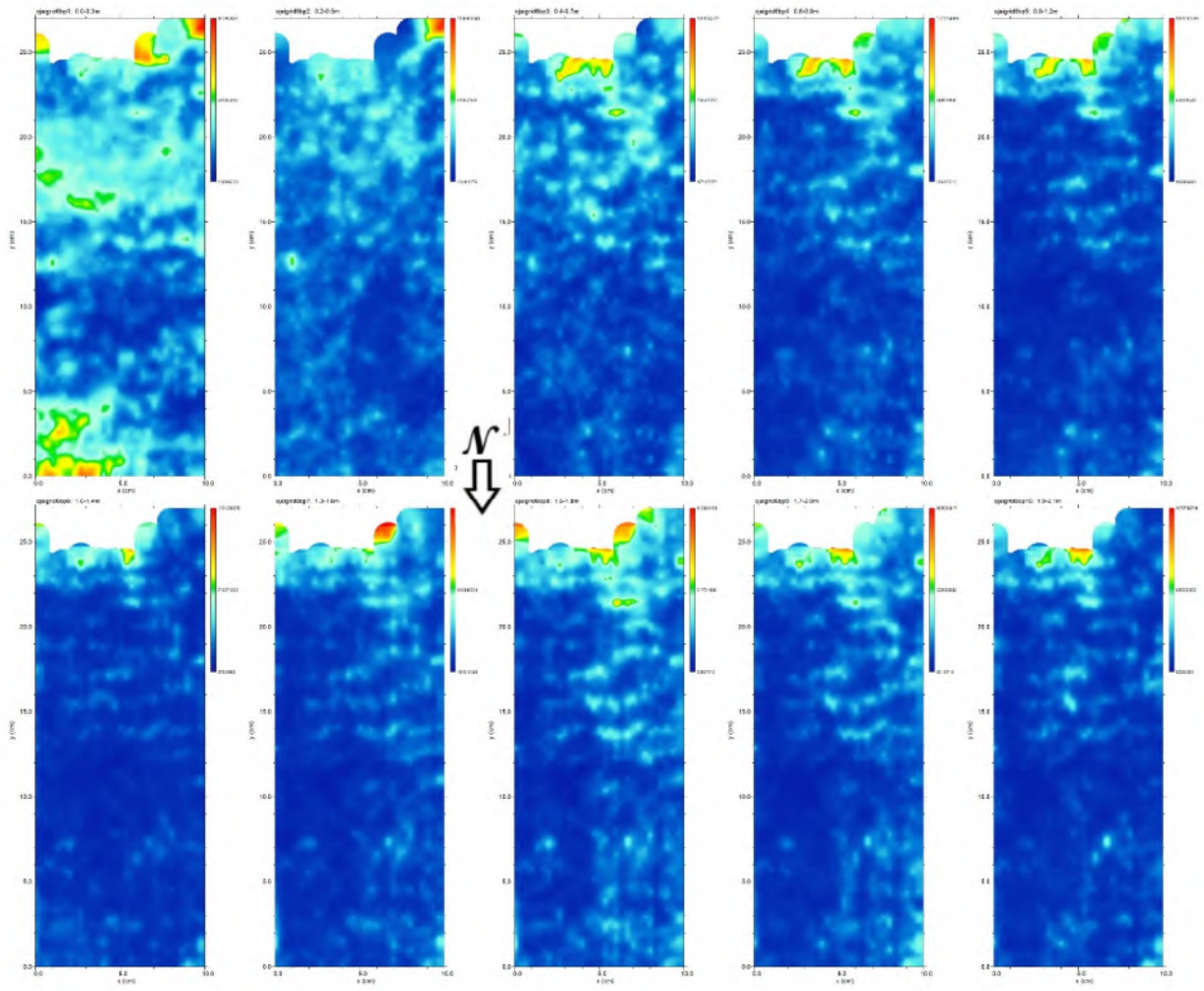
Grid 6



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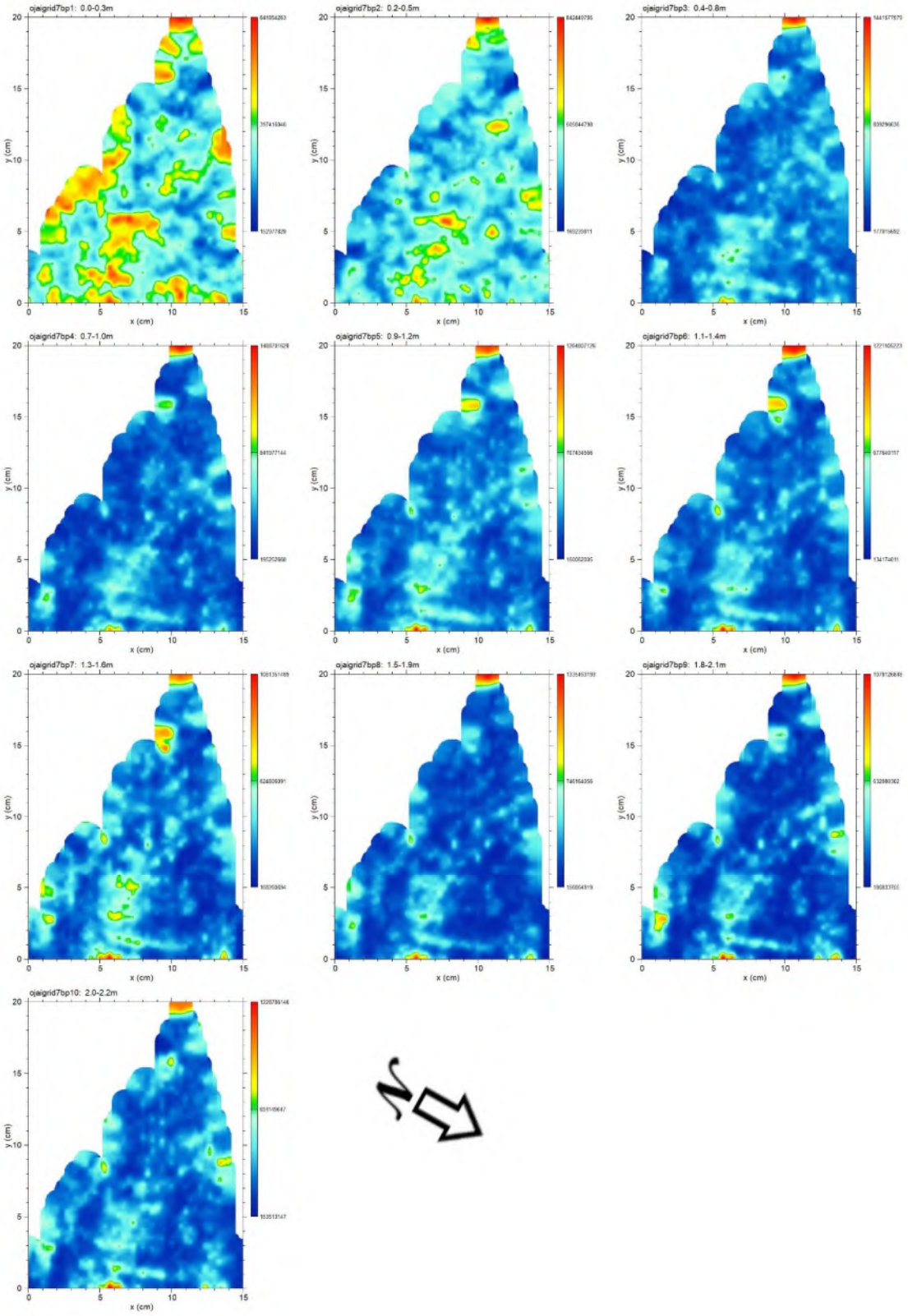
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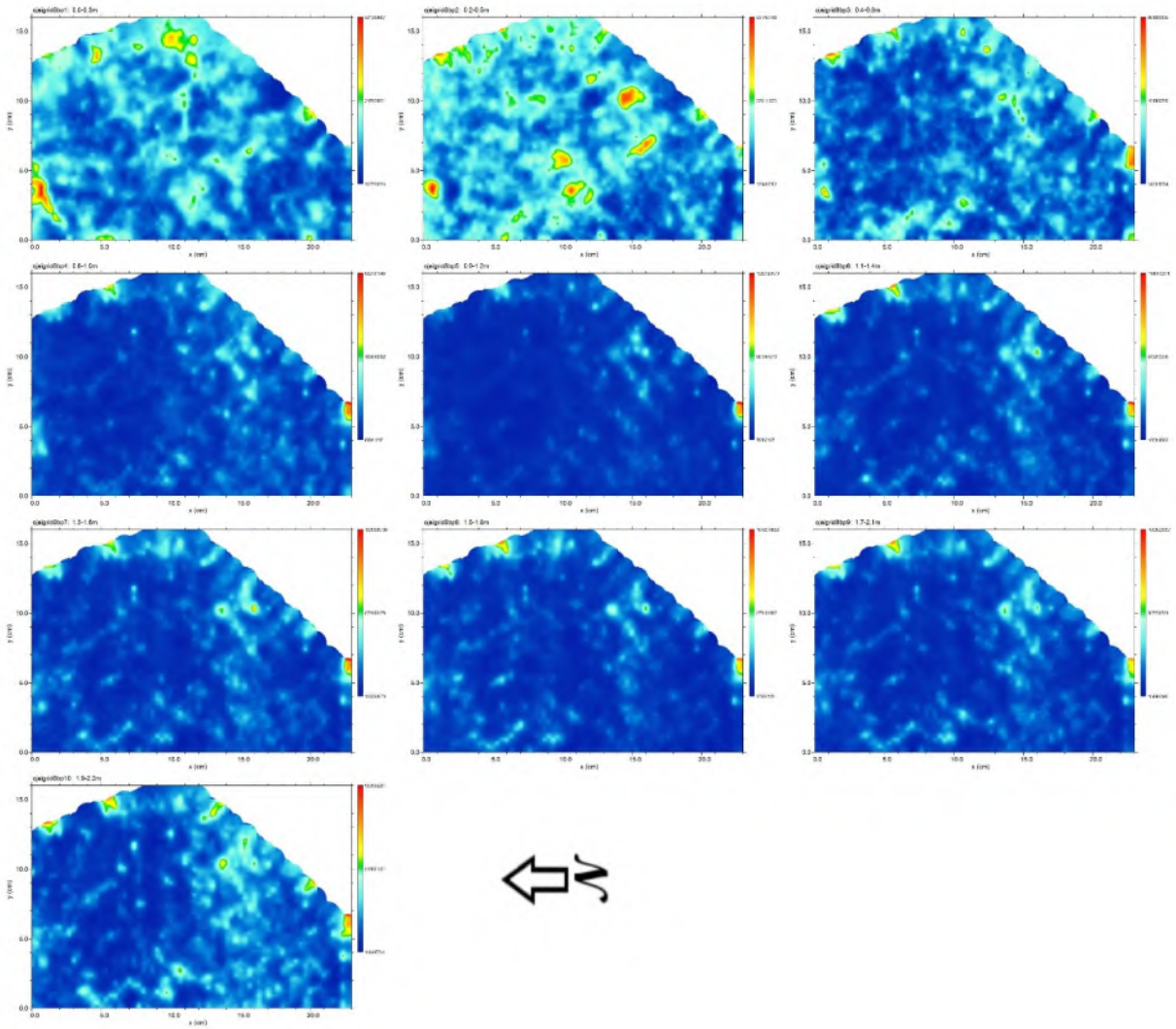
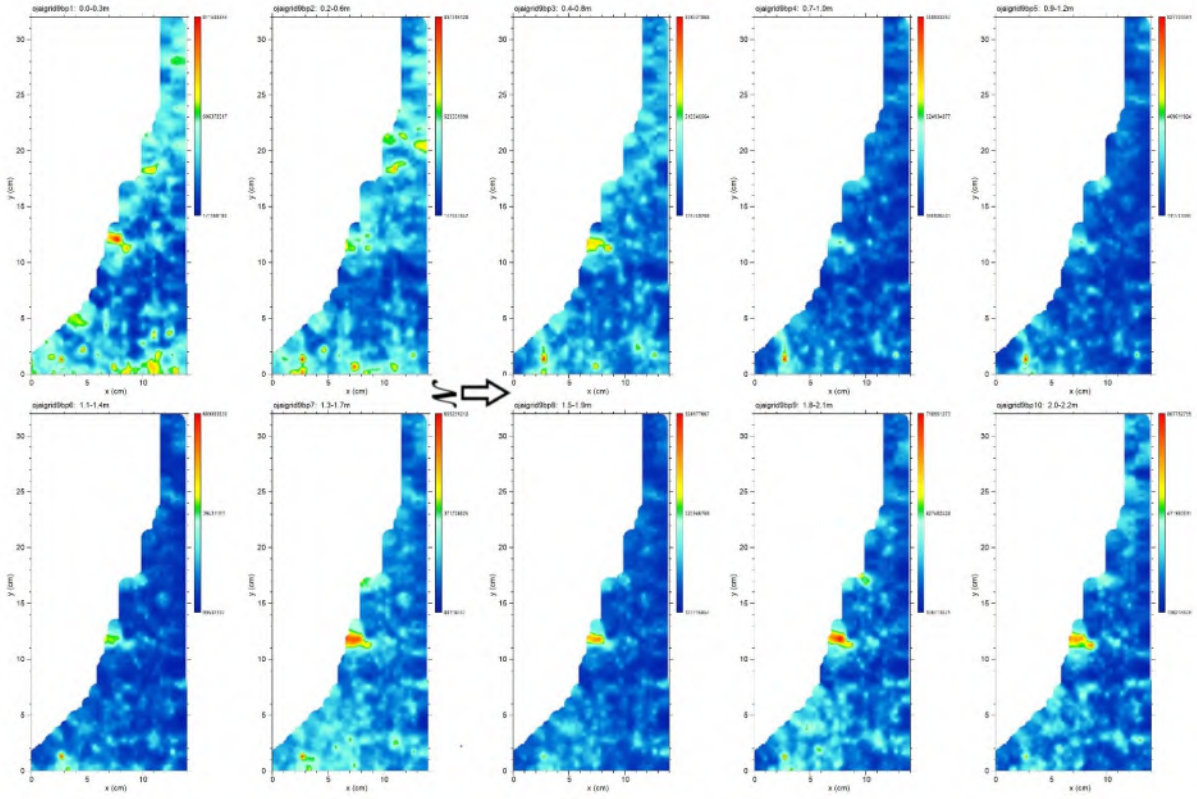
ojaigrid7bp6: 1.1-1.4m
ojaigrid7bp7: 1.3-1.6m
ojaigrid7bp8: 1.5-1.9m
ojaigrid7bp9: 1.8-2.1m
ojaigrid7bp10: 2.0-2.2m
y (cm)
x (cm)

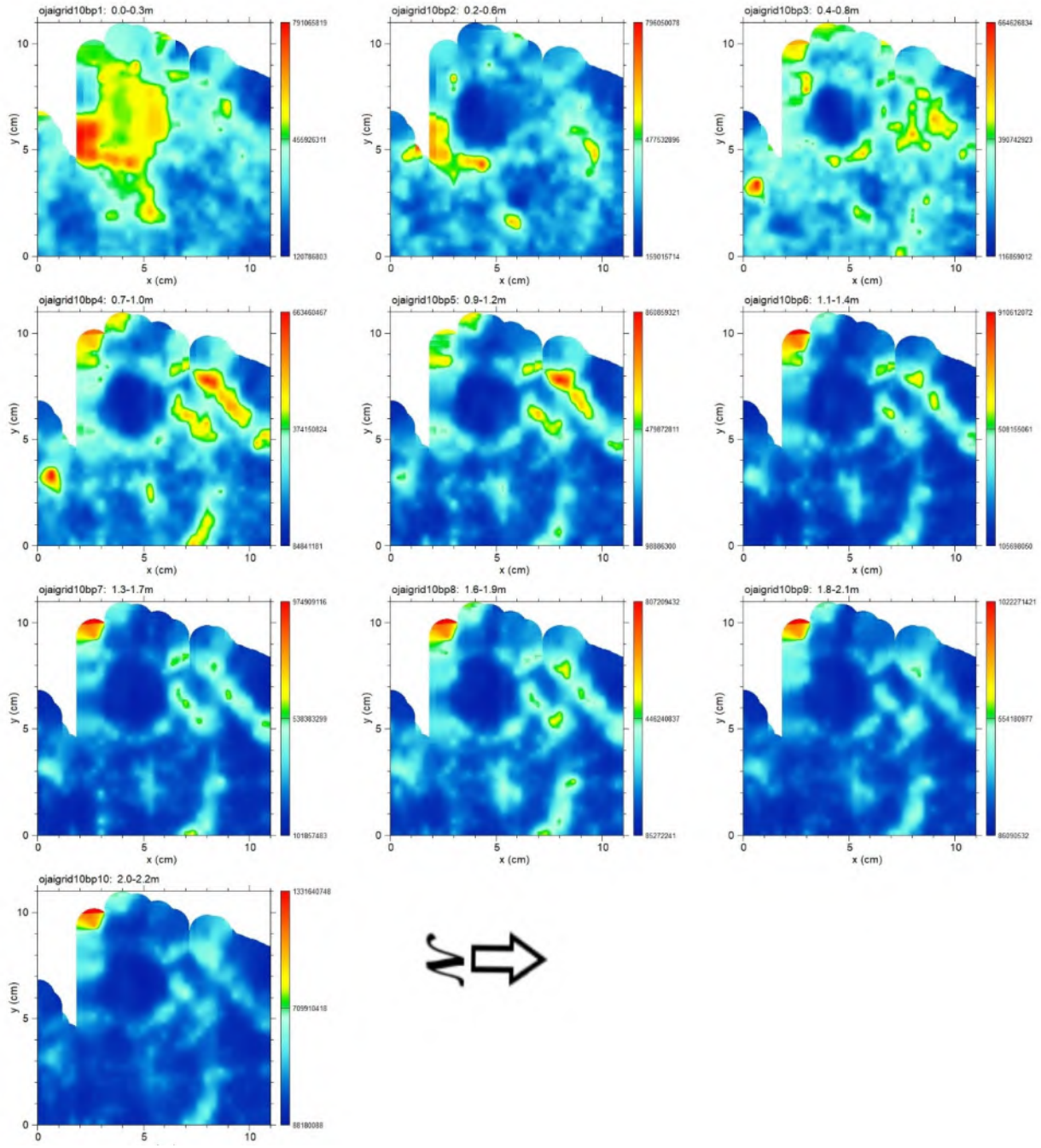
Grid 8



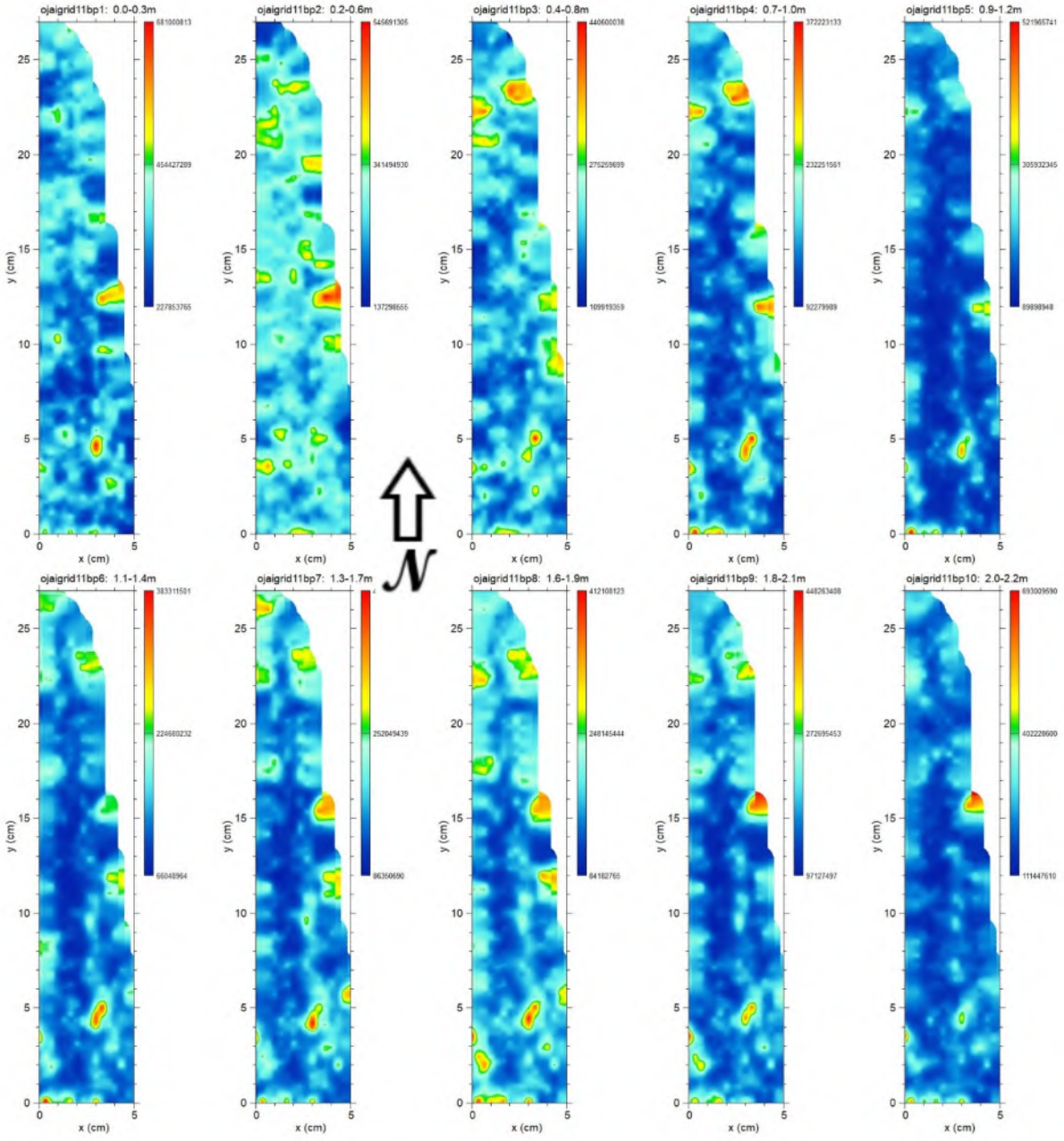
Grid 9



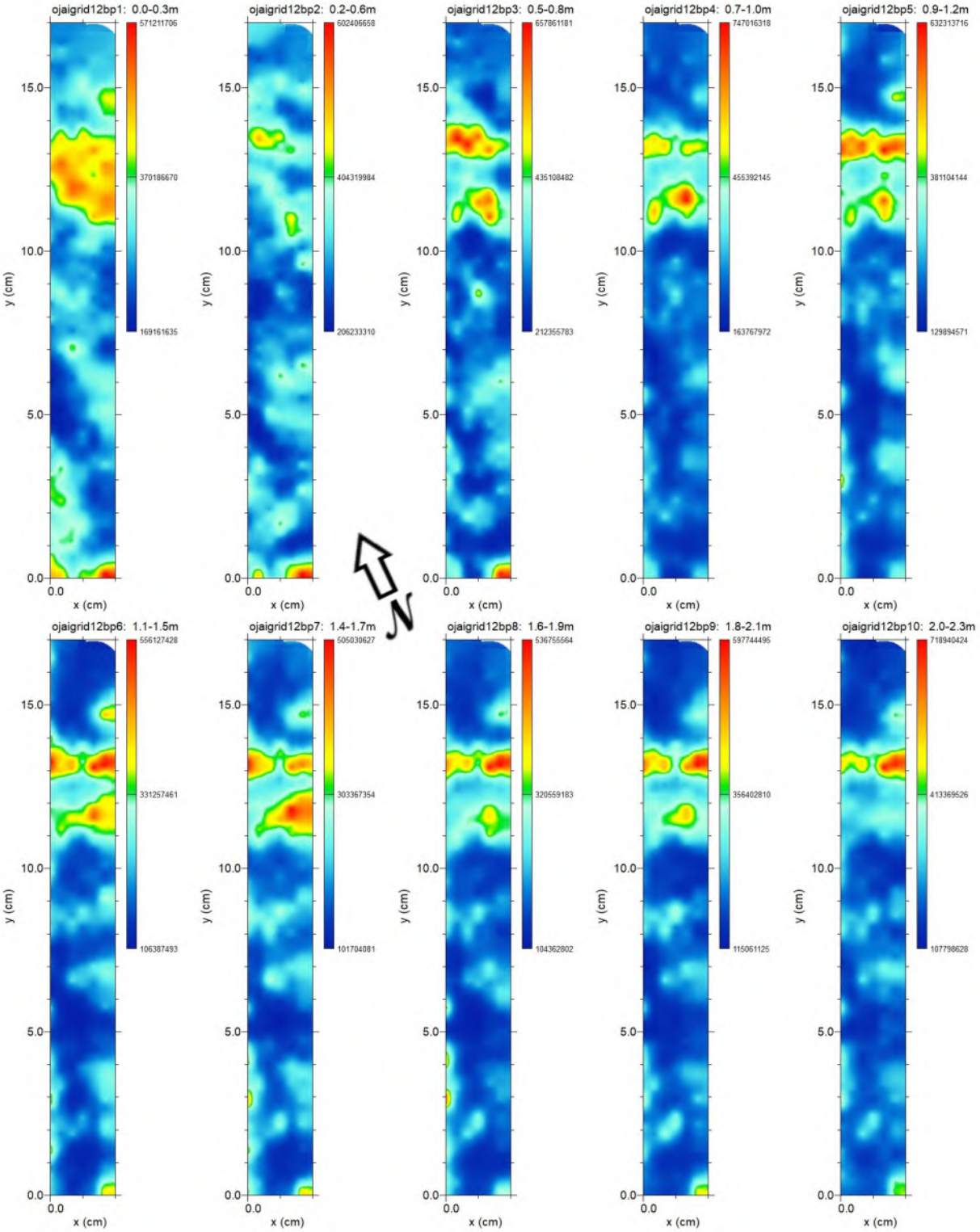
Grid 10

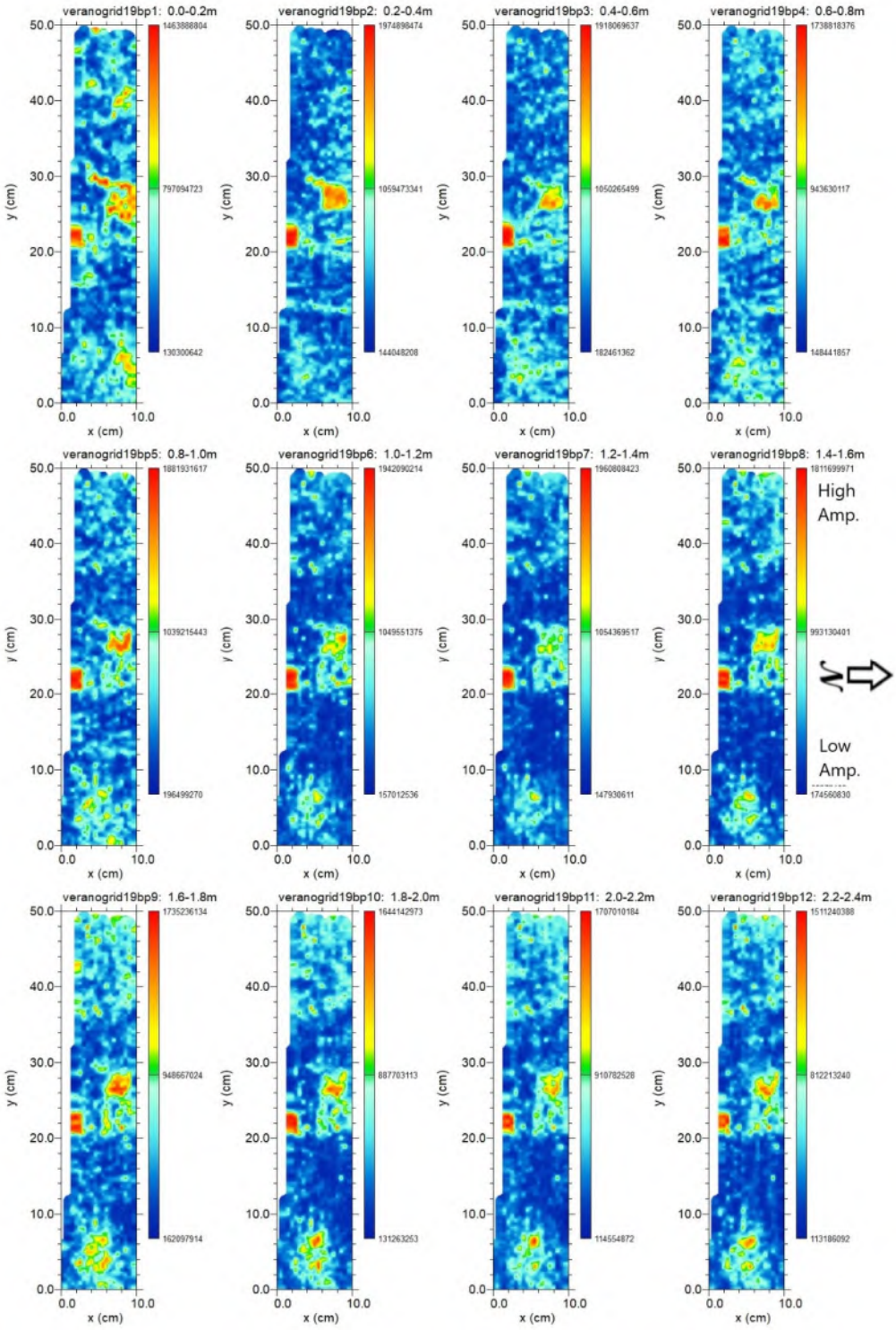

ojaigrid10bp1: 0.0-0.3m
ojaigrid10bp2: 0.2-0.6m
ojaigrid10bp3: 0.4-0.8m
ojaigrid10bp4: 0.7-1.0m
ojaigrid10bp5: 0.9-1.2m
ojaigrid10bp6: 1.1-1.4m
ojaigrid10bp7: 1.3-1.7m
ojaigrid10bp8: 1.6-1.9m
ojaigrid10bp9: 1.8-2.1m
ojaigrid10bp10: 2.0-2.2m
x (cm)
y (cm)

Grid 11


ojaigrid11bp1: 0.0-0.3m
ojaigrid11bp2: 0.2-0.6m
ojaigrid11bp3: 0.4-0.8m
ojaigrid11bp4: 0.7-1.0m
ojaigrid11bp5: 0.9-1.2m
ojaigrid11bp6: 1.1-1.4m
ojaigrid11bp7: 1.3-1.7m
ojaigrid11bp8: 1.6-1.9m
ojaigrid11bp9: 1.8-2.1m
ojaigrid11bp10: 2.0-2.2m
x (cm)
y (cm)
N

Grid 12


ojaigrid12bp1: 0.0-0.3m
571211706
370186670
169161635
ojaigrid12bp2: 0.2-0.6m
602406658
404319984
206233310
ojaigrid12bp3: 0.5-0.8m
657861181
435108482
212355783
ojaigrid12bp4: 0.7-1.0m
747016318
455392145
163767972
ojaigrid12bp5: 0.9-1.2m
632313716
381104144
129894571
ojaigrid12bp6: 1.1-1.5m
556127428
331257461
106387493
ojaigrid12bp7: 1.4-1.7m
505030627
303367354
101704081
ojaigrid12bp8: 1.6-1.9m
536755564
320559183
104362802
ojaigrid12bp9: 1.8-2.1m
597744495
356402810
115061125
ojaigrid12bp10: 2.0-2.3m
718940424
413369526
107798628
y (cm)
x (cm)
0.0
5.0
10.0
15.0
N


veranogrid19bp1: 0.0-0.2m
1463888804
797094723
130300642
veranogrid19bp2: 0.2-0.4m
1974898474
1059473341
144048208
veranogrid19bp3: 0.4-0.6m
1918069637
1050265499
182461362
veranogrid19bp4: 0.6-0.8m
1738818376
943630117
148441857
veranogrid19bp5: 0.8-1.0m
1881931617
1039215443
196499270
veranogrid19bp6: 1.0-1.2m
1942090214
1049551375
157012536
veranogrid19bp7: 1.2-1.4m
1960809423
1054369517
147930611
veranogrid19bp8: 1.4-1.6m
1811699971
993130401
174560830
High Amp.
Low Amp.
veranogrid19bp9: 1.6-1.8m
1735236134
948667024
162097914
veranogrid19bp10: 1.8-2.0m
1644142973
887703113
131263253
veranogrid19bp11: 2.0-2.2m
1707010184
910782528
114554872
veranogrid19bp12: 2.2-2.4m
1511240388
812213240
113186092
y (cm)
x (cm)
0.0
10.0
20.0
30.0
40.0
50.0