IPAEB

Volume II

Preliminary Report of the work of the International Pluridisciplinary Archaeological Expedition to Bactria

2007

Directed by

Josep Maria Gurt Esparaguerra
Shakir Pidaev
Anna Maria Rauret
and
Sebastian Stride

With the participation of

Oriol Achón, Ramon Alvarez, Enrique Ariño, Larisa Baratov,
Manuel Cubero, Diego García, Maria Lafuente, Durdona Muradova,
Samariddin Mustafakulov, Veronica Martínez, Pablo Martínez,
Yannick Miras, Roger Sala and Evanthia Tsantini

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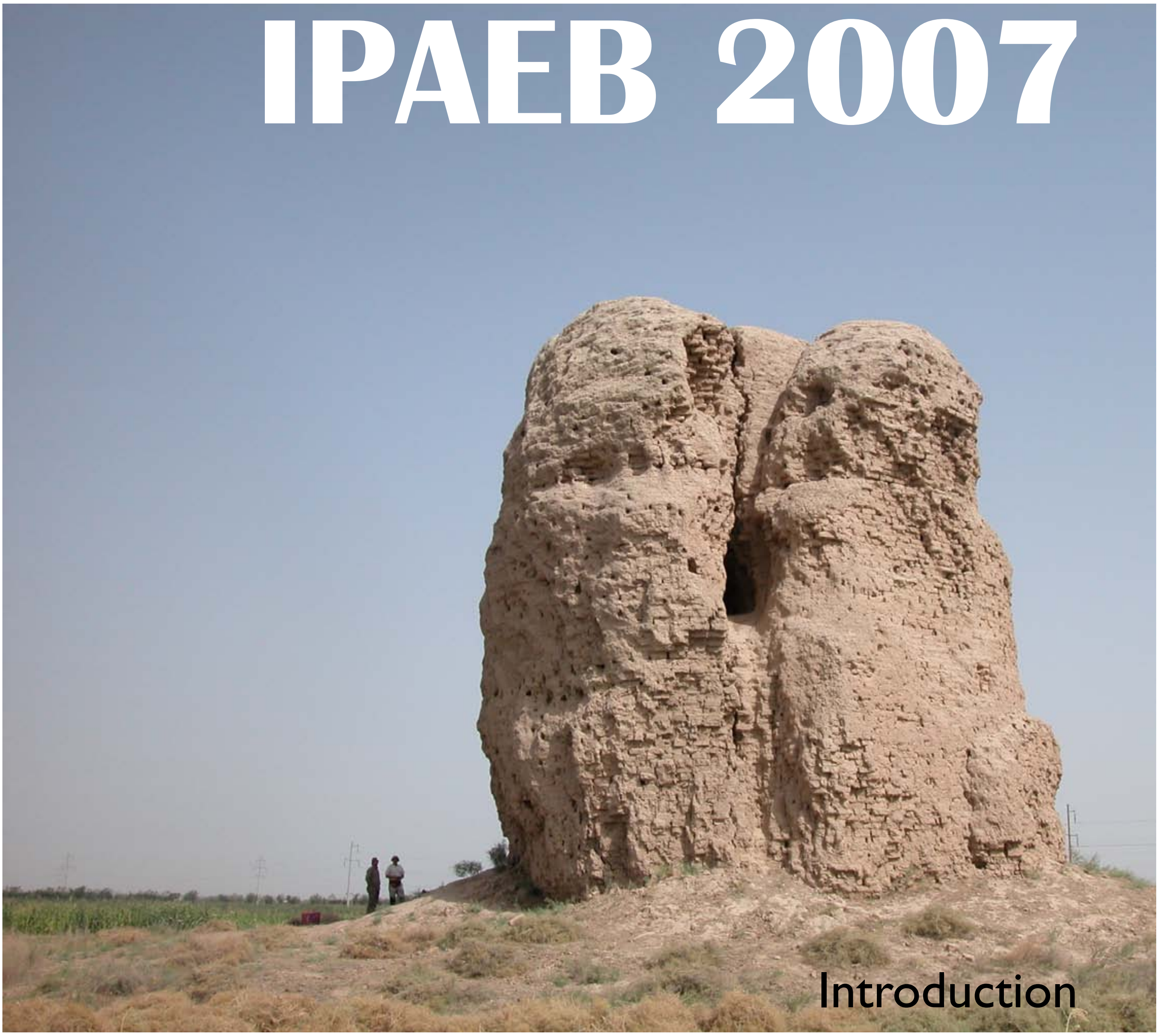


The second field season of the the International Pluridisciplinary Archaeological Expedition in Bactria (IPAEB) took place from the 15th of September till the 15th of October 2007 with the participation of the following members from the Catalan side:

- Oriol Achón (Freelance Archaeologist))
- Enrique Ariño (Professor at the University of Salamanca)
- Diego García Student at the University of Barcelona)
- Josep Maria Gurt (Professor at the University of Barcelona)
- Roger Sala (Director of the Geophysical firm SOT)
- Sebastian Stride (Research Fellow at the University of Barcelona)

and from the Uzbek side:

- Larisa Baratov (Senior Research Fellow at the Institute of Archaeology)
- Durdona Muradova (Junior Research Fellow at the Institute of Archaeology)
- Samariddin Mustafakulov (Senior Research Fellow at the Institute of Archaeology)
- Shakir Pidaev (Director of the Institute of Archaeology)

The archaeological expedition was co-directed by Josep Maria Gurt and Shakir Pidaev with the collaboration of Sebastian Stride and financed in the marc of the grant EXCAVA of the Generalitat de Catalunya.

During the year of 2007 the laboratory based research has been carried out by:
-Veronica Martínez (Associate Professor at the University of Barcelona)
-Yannick Miras (Research Fellow at the University of Barcelona)
-Evanthia Tsantini (Specialised Technical Research Staff at the University of Barcelona)

The illustrations and the final design of the Report have been carried out by:
-Ramon Alvarez
-Manuel Cubero
-Pablo Martínez

We would also like to extent all our gratitude to the following institutions:
- The IFEAC for their logistic help in Uzbekistan.
- The commander of the military camp of Ancient Termez
- The local authorities in Termez and the Surkhan Darya province

A prior long-term and complex evaluation of the already available data on the geophysical prospecting during the first season work carried out at 2006, at the archaeological site of Tchinguiz Tepe of Termez, took place to decide the strategy to follow during the campaign of 2007. This previous evaluation of the information, on one hand, leaded to the decision to increase the geophysical prospecting at Tchinguiz Tepe, on the other hand, to decide the exact location of areas where the archaeological interventions would carry out. The main objective at the beginning of this new season was to crosscheck the reliability of the measurements and, at the same time, to establish the unknown up to the present archaeological and chronological sequence of Tchinguiz Tepe. Meanwhile, the geophysical prospecting also was extended to the outskirts of the city were the localisation of an unknown up to now Buddhist Monastery was possible.

The geophysical prospecting, the measurements with the geo-radar and the archaeological excavation at Tchinguiz Tepe after this second season work permits to understand better the way that the site was formed and its historical "behavior". This work also revealed all the complexity that a geophysical prospecting of site located on a ground rich in loess and built with material mainly characterized by loess present, opening a great discussion on the future methodological approach.

Nevertheless, the archaeological record and the first written greco-bactric sources offered the eldest information, up to now, on the way the that the site of Tchinguiz Tepe was built.

On the other hand, an exhaustive sampling of the ceramic material took place to be able to identify the production and distribution patterns of pottery at the site, from early stages, thus the Hellenistic period, up to the Sassanidan Period. This new sampling together with the sampling of the kiln site of Kara Tepe, during the previous season (2006), permitted to carry out an exhaustive and extraordinarily complex archaeometric study, without any previous record of that kind, at Central Asia.

Additionally, an organic remain dating by C14 of the various stratigraphical sequences of both sites Kara Tepe, recovered and studied during the champagne of 2006 and Tchinguiz Tepe, excavated during this new season of 2007, carried out.

Finally, an evaluation of state of conservation of pollen fossils carried out for the palaeontological study of Termez and its hinterland.

J. Mª. Gurt i Esparraguera

The cartographic base used in IPAEB corresponds to the figures number 2 (p. 183) and number 20 (p. 203) published by:LERICHE, P.; PIDAEV SH. 2007, Termez in Antiquity. After Alexander. Central Asia before Islam (Joe Cribb and Georgina Herrmann edits.) in Proceedings of the British Academy 133, pp. 179-211. British Academy

Geophysical Surveys of Tchinguiz Tepe in the 2006 Season and Archaeological Follow-up Planned for the 2007 Season

Roger Sala, Maria Lafuente and Josep M. Gurt

Reflections on magnetic surveying

The results of the magnetic survey (see IPAEB I, http://www.silkrode.org/SilkRoDE-resources/IPAEB2006.pdf) are clear, and comparing them to the results obtained at Kara Tepe serves to confirm the hypotheses formulated beforehand. They clearly verify that, within its boundaries, Tchinguiz Tepe contains magnetic variations that could correspond to combustion structures, probably belonging to pottery industries.

From what epoch do they come? We cannot tell without documenting the archaeological record through excavation. The surveys carried out during the 2007 season, however, have shown that at least some of the combustion structures are ovens, although it cannot yet be determined precisely whether the ovens were used in the pottery industry or when the structures were in operation. In fact, contrary to claims, the evidence is increasingly clear that Tchinguiz Tepe was occupied subsequent to the Kushan and Kushan-Sassanian periods.

Georadar survey results

The survey programme carried out by the Catalan team at the Tchinguiz Tepe and Kara Tepe enclaves during the 2006 season focused on the use of magnetic and georadar gradiometry. The choice of these two sensors was partly attributable to their versatility and to the complementary nature of the data typically provided by the two systems of wide-area surveying. The weightiest argument for their use, however, lay in the type of archaeological ruins to be described and the environmental conditions present at the sites.

Excavations undertaken on previous expeditions[1] led by P. Leriche had revealed a construction system based on structures of adobe or uncooked brick without stone foundations. In addition, the site's location in a semi-arid climate on the banks of the Amu Daria river (the ancient Oxus) led to the expectation that its contents would suffer only very low levels of humidity and that its stratigraphy would be more affected by wind than by water erosion. The environmental conditions afford good georadar penetration, which is benefited by conditions of low humidity, and there is a negligible influence on the magnetic sensors. However, the adobe-based construction system, widespread from the Fertile Crescent to Central Asia, represents the main methodological challenge.

1.- P., Pidaev, Ch. Bilan de Campagne 2004 Bilan de Campagne 2005

In this sort of setting, wind is the predominant environmental agent at work in the destruction of built structures. The process can be broadly summarised by wind sweeping particles of sediment across the surface and driving them against obstacles, which are the ruins of buildings in this case. As a result, exposed ruins are eroded by the wind, and sediments form deposits around the structures according to the force and direction of the wind.

One outcome of the process is that a good part of the sediment covering the archaeological ruins is of a composition very similar to the ruins themselves. The main differences between the sediments and the archaeological ruins will be limited to granulometry and compaction, while factors such as humidity and conductivity will be only very subtly different.

Bearing in mind that most geophysical survey systems used in the detection of archaeological ruins ascertain the position and condition of ruins by differentiating subsurface properties, it is clear that both the environmental setting and the type of ruins present difficulties, given the slight physico-chemical difference between the sediments and the ruins to be described.

Beyond these two difficulties, there is another external factor of no less importance. The explored sites are located within the perimeter of an Uzbek military base close to an aerodrome used by German forces associated with NATO. Directly as a result, survey efforts encountered severe sensor interferences generated by communication systems, radar and countermeasures normally used in military operations. Detection of the interferences was not consistent, but it did render useless the data gathered in some of the grids[2].

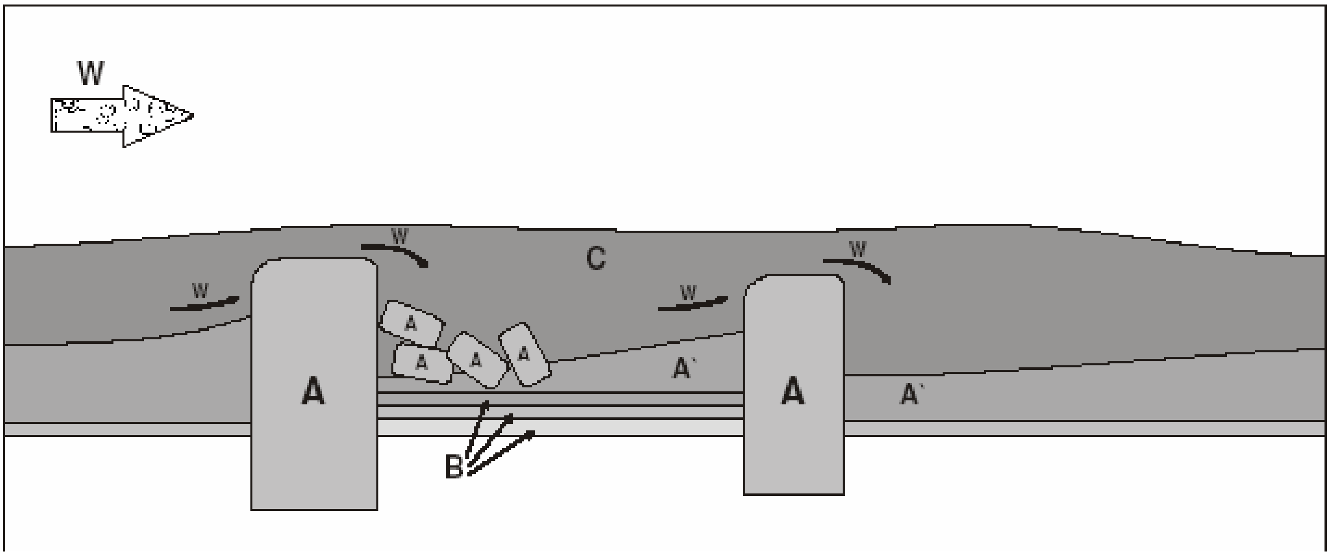


Fig. 1: Diagram showing the destructive processes of the wind at work on adobe structures. The adobe structures (A) are eroded by particles driven by the wind (W), which accumulate according to the prevailing wind direction. Particles from eroding walls (A') then form deposits on floor areas (B). The physico-chemical differences between A and A' are confined to compaction and granulometry.

2.- Southern portion of grid D, grid I, moat grid.

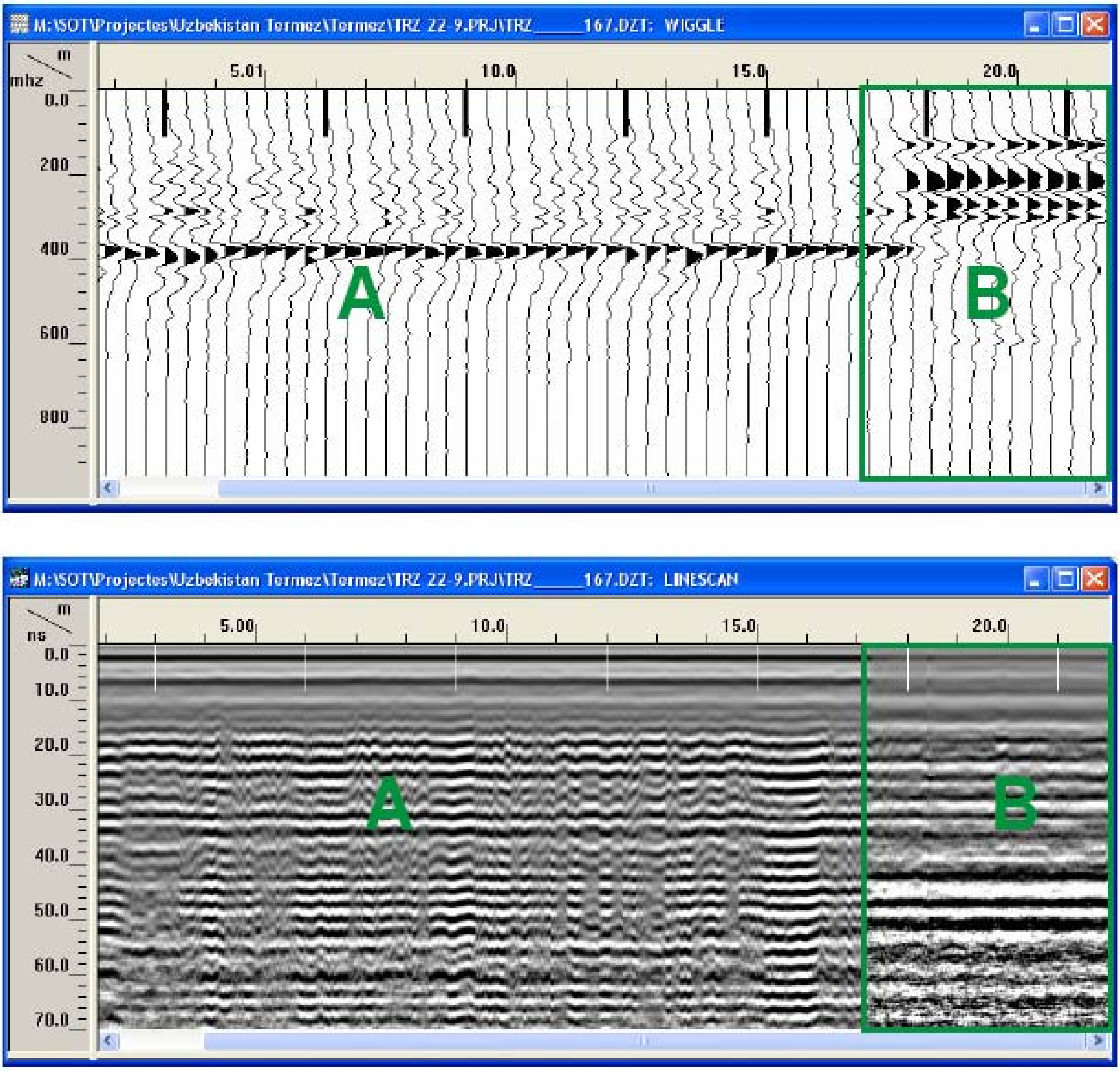


Fig. 2: : Interferences captured by survey equipment. Radargram 167 obtained on 22 September at the beginning of an unidentified transmission. Above, the data's frequency spectrum obtained using a 400MHz antenna. As is to be expected, the initial metres show a spectrum dominated by 400MHz (A). However, at 17m of depth (B), another spectrum can clearly be detected, dominated by three different frequencies (130, 20 and 268MHz). In the lower image, the radargram shows evidence of the effect of the interferences on the radargrams.

In the case of geomagnetic surveying, similar interferences occur in the data obtained in the interior space between towers 4 and 5.

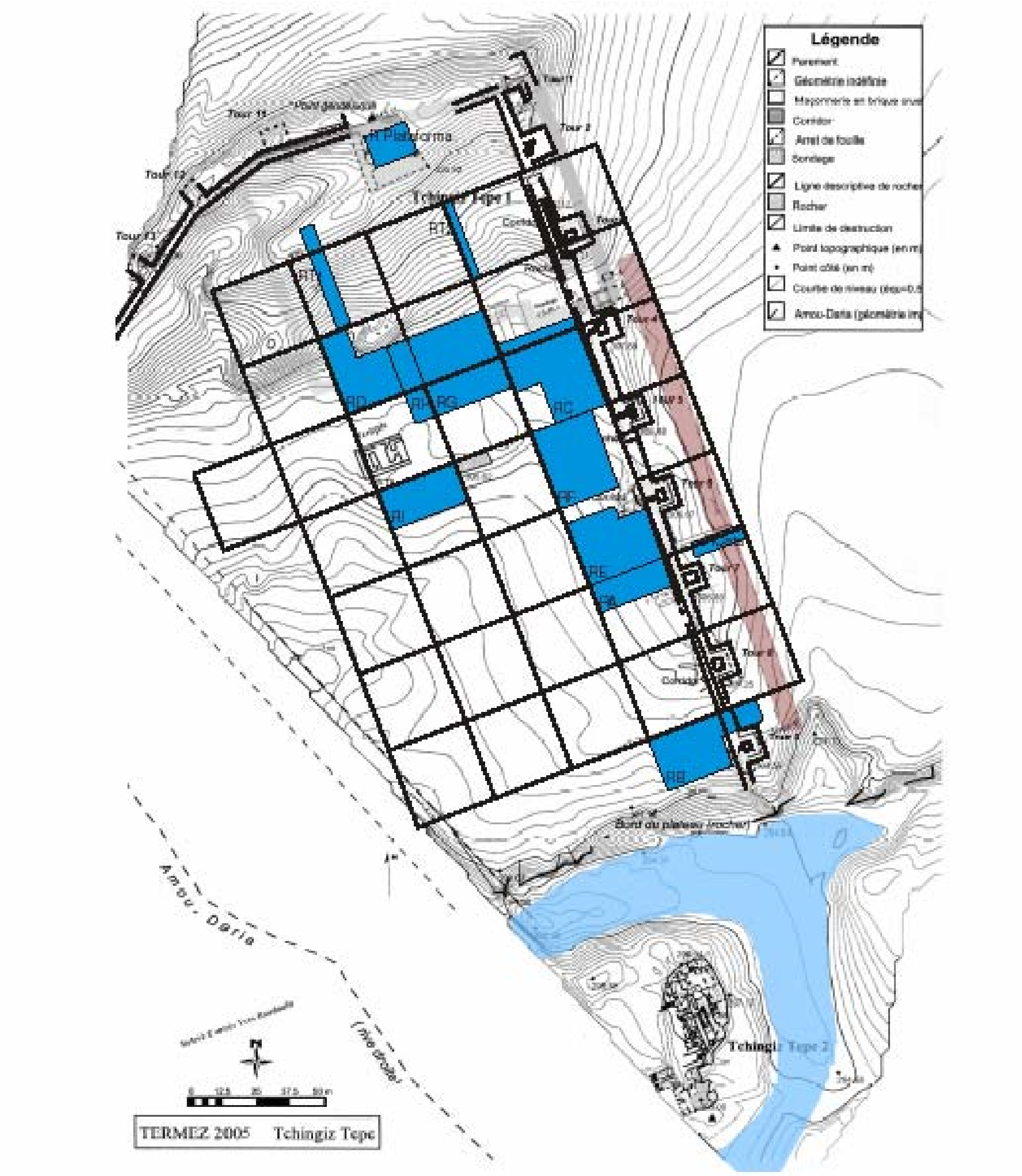


Fig. 3: Layout of the georadar sampling grids or exploration areas within the Tchinguiz Tepe enclave.

Methodology

Most geophysical survey systems applicable in archaeology are based on measuring differences in surface thickness systematically over space (and, in the case of georadar, over time as well). Graphically representing the measures generates maps of subsurface properties to use in identifying archaeological structures.

Measurements are taken by overlaying the area that is to be explored with a quadrant or grid that will serve to situate each sensor reading of a given surface unit. Georadar is a geophysical survey system which uses the emission of electromagnetic pulses into the subsurface to measure variations in amplitude, frequency and speed of propagation over the geological medium. From the data, the physical properties of the subsurface can then be inferred. Survey software generates pulses and transmits them from an antenna, which then captures the resulting reflections and systematically maps them in the direction of the antenna's sweep and in three dimensions. The result is a set of radargrams, which express the movement of the georadar antenna over the terrain on the horizontal axis and the depth of the pulse reflections on the vertical axis, providing a visualisation equivalent to a profile or slice of the explored area. Thanks to the latest innovations in SOT computation, a systematic program of time-slicing is applied to create wide-area surveys that can visualise subsurface properties at different depths, generating plans, cross-sections or three-dimensional representations built up from all the parallel radargram data obtained over the explored surface.

Data collection

The fieldwork was conducted between 15 and 24 September 2006 in heavy winds and temperatures of 25-35º C. As noted earlier, various episodes of electromagnetic interference were encountered. The research depth was set at 70 nanoseconds. At an estimated georadar pulse speed of 0.1m/ns, the vertical reach is approximately 3.5m, although strong results were only obtained between 0 and 40ns (0-2m). Reading density was determined by the sample frequency of the georadar in the direction of the antenna's sweep and by the separation between the parallel transects or radargrams covering the area under study. In each case, radargrams were created from 40 readings taken per metre (i.e., one reading every 2.5cm) with 0.5m between each reading. The survey coordinates strictly reflected the magnetic survey done (see figure 3). A total of 3872 sq metres were explored and 602 radargrams were taken.

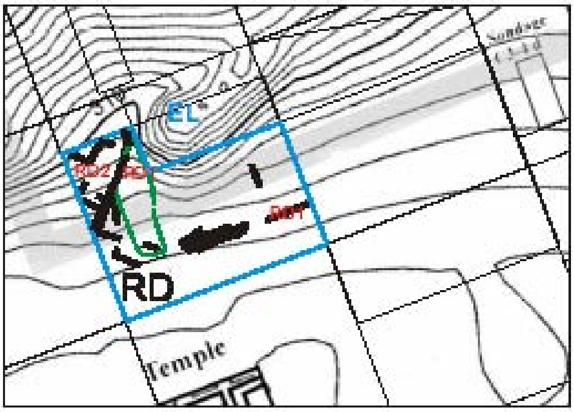
Results from northern grids

The northern sector of the Tchinguiz Tepe perimeter is dominated by a relief elevation of nearly 40m above the central plain of the complex. The entire elevation features a perimeter of fortifications with interconnected towers. Although only a limited survey of the area (16x12m) was carried out at the highest point, it has not provided conclusive results on the disposition of the archaeological structures have been found there[3].

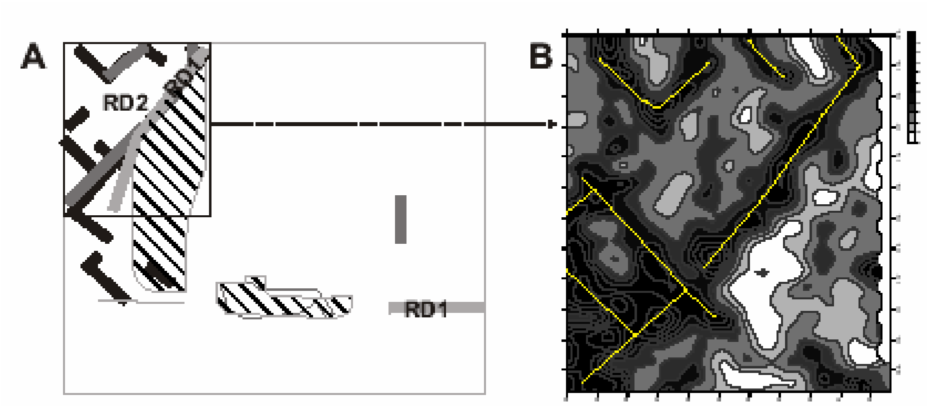
Grid RD

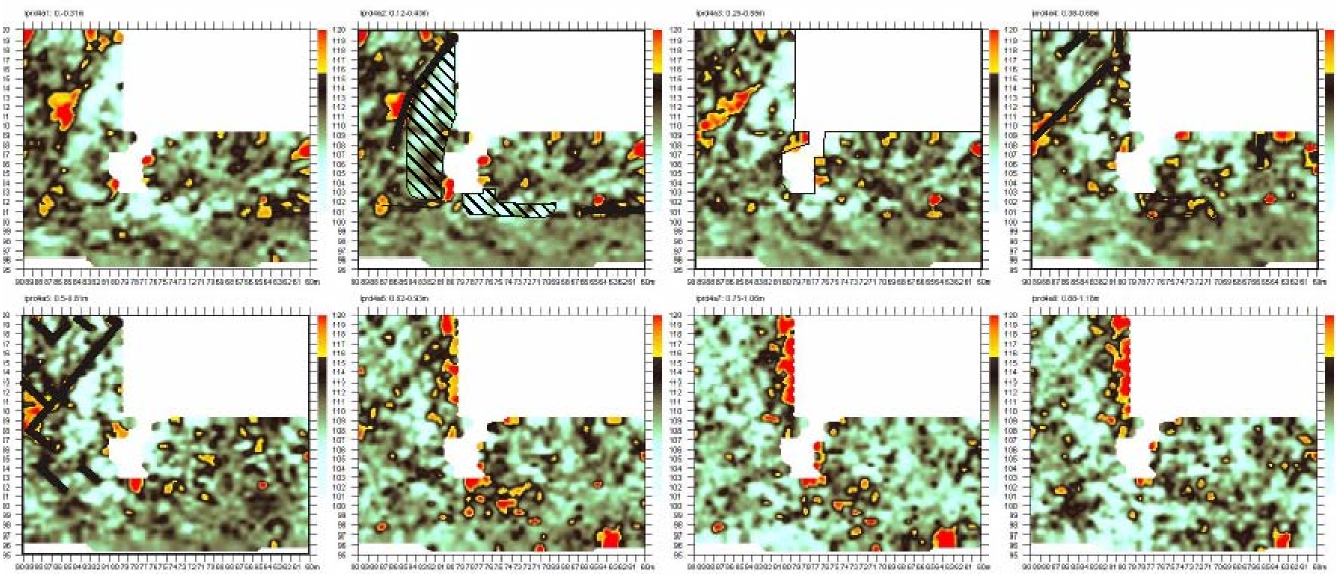
Grid RD covers an irregular area of 30x25m located at the foot of the elevations to the north of the Tchinguiz Tepe enclosure. The sequence of maps obtained from the process of individual radargrams can be seen in the corresponding graphic, together with a legend. In the first three slices (0-0.55m), they show the configuration of a perimeter structure, RD1, around elevation EL, which bounds an interior (striped) space between the hill and the structure. The low-lying areas could correspond to sediments coming from the elevated contents of structure RD1. From slices 4 and 5 (0.5-0.8m) onwards, structure RD2 can be defined. Formed by a group of possible walls creating an interior space of roughly 9x4m, it would appear to extend beyond the surveyed area in a westerly direction. Although some of the structures can clearly be seen (e.g. RD2), grid RD is one of the grids most affected by the electromagnetic noise caused by the telecommunications of the military base and nearby airport (see figure 2).

3.- As with the other rejected grids, no signal processing within the equipment's range has enabled recovery of the data adversely affected by external interferences.



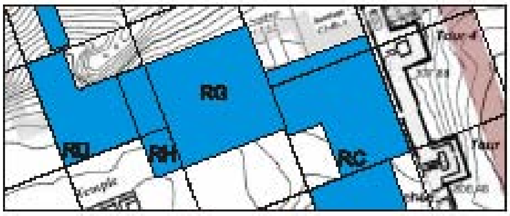
Location of grid RD and detected structures



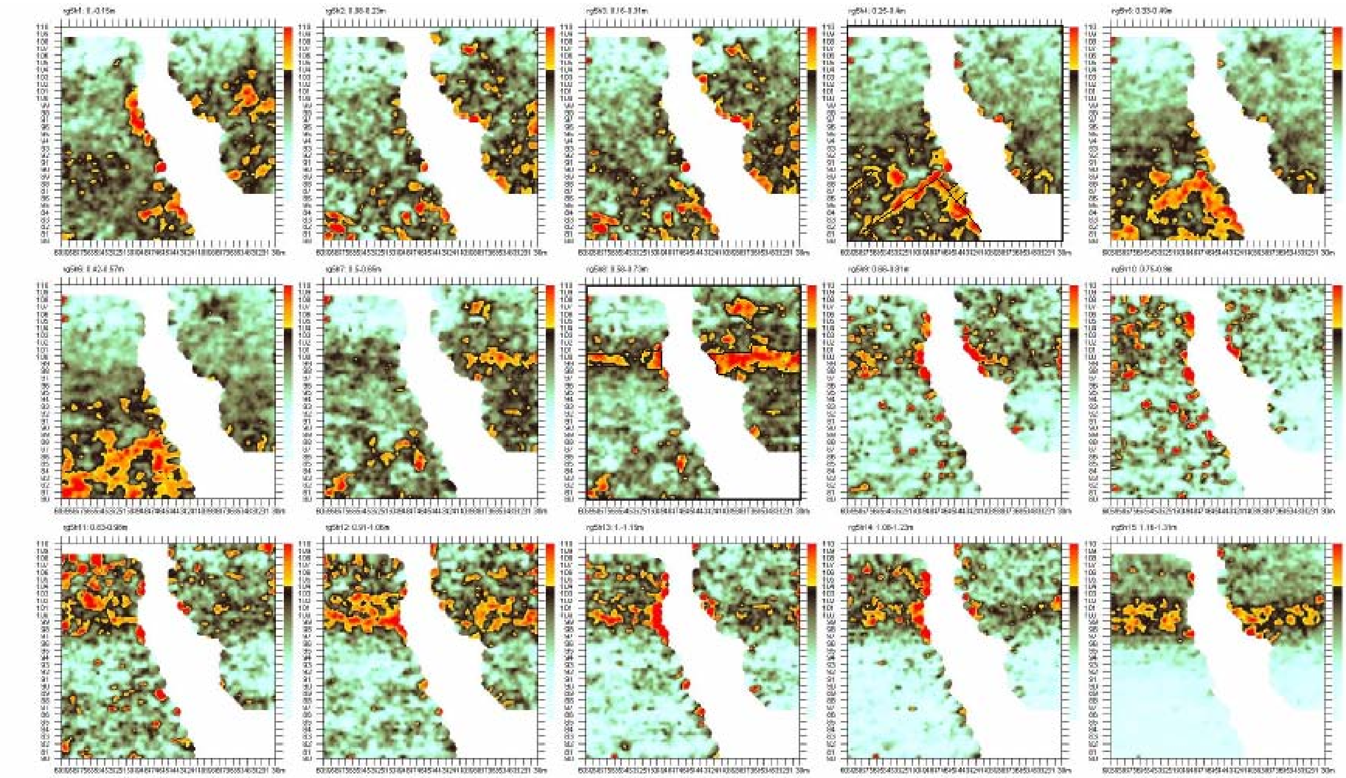


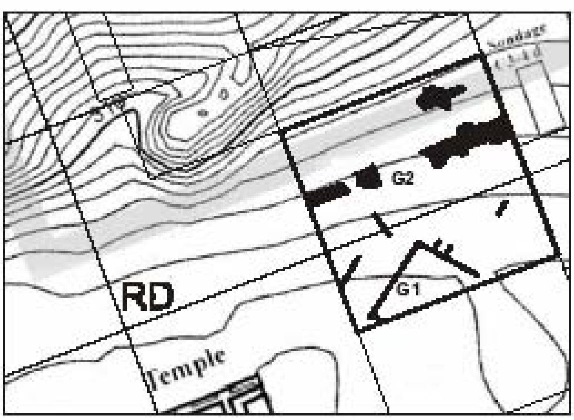
Grid RG

Contiguous with grid RD, grid RG measures roughly 30x30m and is interrupted in its central area by a dumping ground resulting from military activities in the area. Data collection has provided a sequence of slices shown in graphics 4 and 5. Firstly, evidence can be seen of a difference in the response obtained in the northern and southern halves of the grid. To the south there is a group of right-angled structures, G1, which describes a space lying obliquely to the survey axes. The group reaches nearly 0.8m in depth. Below the group, a new anomaly appears, named G2. G2 is a linear structure that cuts diagonally across the grid from SE to NW, almost perpendicularly to the survey grid. G2 would appear to be flanked to the north by a parallel ditch. Because of its orientation parallel to the direction of the georadar readings, however, the attribution of the anomaly calls for prudence. It could also, for example, identify a temporary interference similar to the interferences detected in points of grid RD.

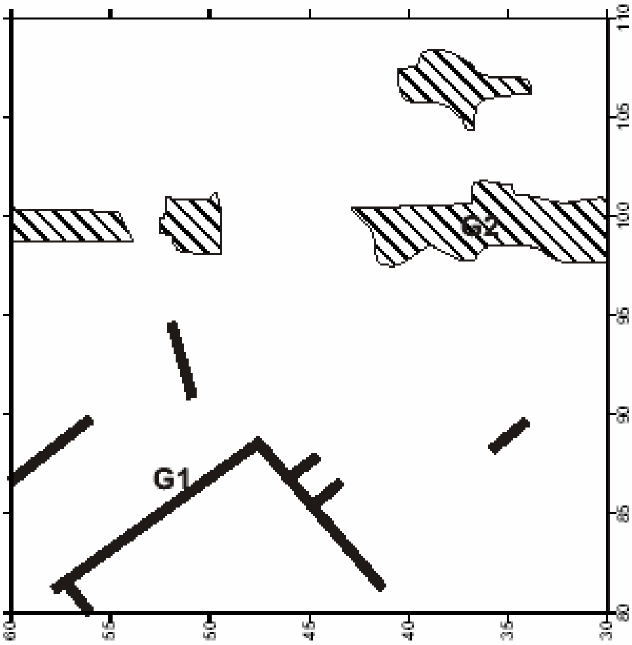


Location of grid RG

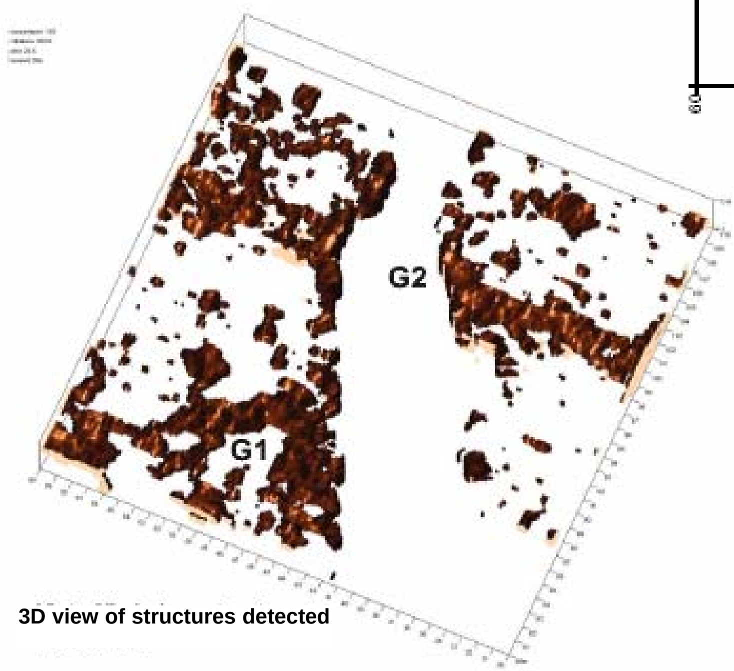




Location of grid RG

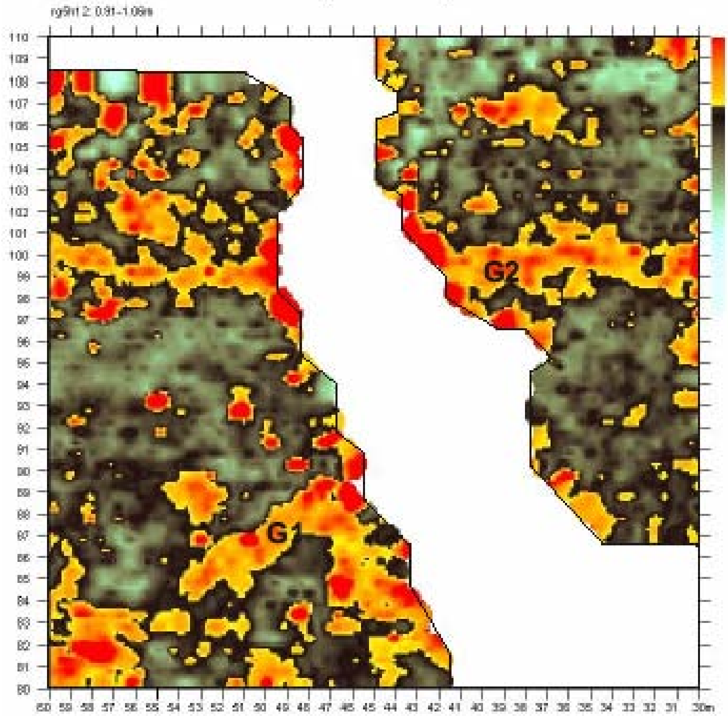


Layout of detected structures



3D view of structures detected

Superimposition of slices 10-12 (0.75-1.06m)



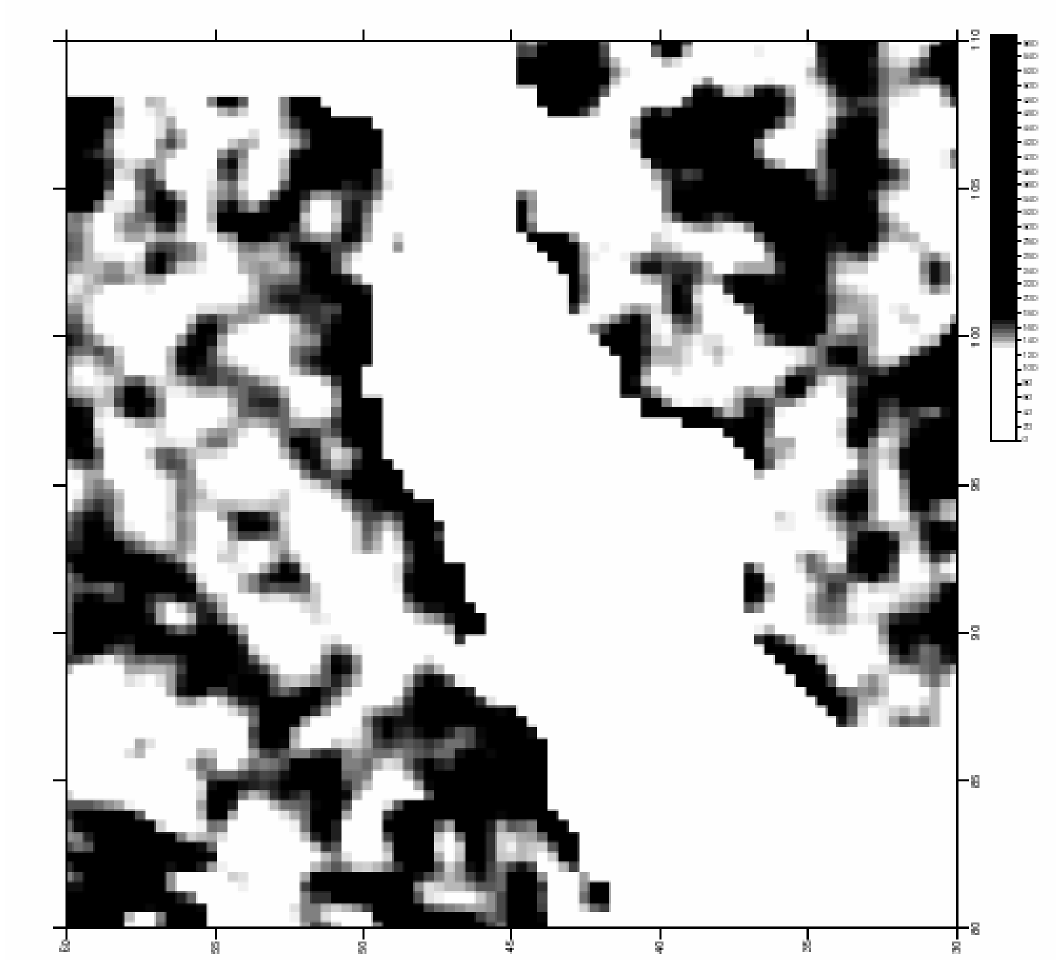


Fig. 4: Grid RG, slice 2 (0.08-0.21m below the surface). Image obtained by calculating the zero-mean line. The image provides evidence of a greater number of structures than can be seen through the process used on the other grids, although the process may magnify the value of non-built elements.

Grid RC

Grid RC has afforded more complex results than the rest of the explored area partly because of the superior quality of the data collected, but also because of the greater number of well-defined subsurface anomalies. The results obtained from low-resolution imaging (i.e., data-collection process B) can be seen in the sequence of horizontal slices in the corresponding graphic. Putting the results obtained from this process into visual form enables us to identify the main archaeological structures in the explored area. In descending order from the surface, there is a top layer of sediment that covers the crowns of the most superficial structures, between 0 and 11ns (slices 1 to 3, 0-55cm). The first level is notable for a low-lying area, C2, which we have identified as an area silted over by sediments that may correspond to a possible military access road running along the inside of the fortifications. Structures C3 and C4 run parallel to this anomaly and they appear to correspond to building ruins from the last phases of occupation. In slices 1 to 3 (0-55cm), group C3 identifies various interconnecting walls and horizontal structures, which indicate that this superficial zone may be in a poor state of preservation because of military activity in the vicinity. In the diagram showing the results of slices 2 and 3, the superficial zone shows evidence of visible spots covering more defined structures immediately underneath. By contrast, structure C4 defines a sizeable triangular form that could indicate the shape of the final phase of the settlement within the walled perimeter. The structure contains the same angles that reappear in most of the detected structures, running parallel to the walls and at oblique angles.

Slices 4 and 5 (0.7-0.9m) mark a transition toward a new layout of the detected structures. The anomaly C2, which we have connected to the military access road buried under sediments, offers a contrasting response, i.e. a high-amplitude response, appearing to situate us at the height of the access road's floor. No notable anomalies, however, were detected immediately to the west of the access road, in the space occupied by the structures of group C3. The group of structures C5, farther to the north, has been diagrammed as a high-amplitude zone, given that the structures forming it cannot be distinguished clearly but may be a group of buildings.

From slice 6 onwards (0.7 to 1.1m), new structures appear. Notable among them is the continuation of C5 and the groups C6 and C7. Eventually, after a new translation slice with few clear structures (slice 9, 1.2-1.5m), two groups of structures were detected in slice 10 (1.4-1.7m). These two groups, C8 and C9, lie at oblique angles to the wall visible on the surface.

Termez Project. Georadar Survey. Tchinguiz Tepe
Grid RC. Slices 1-15 (0-2.1)

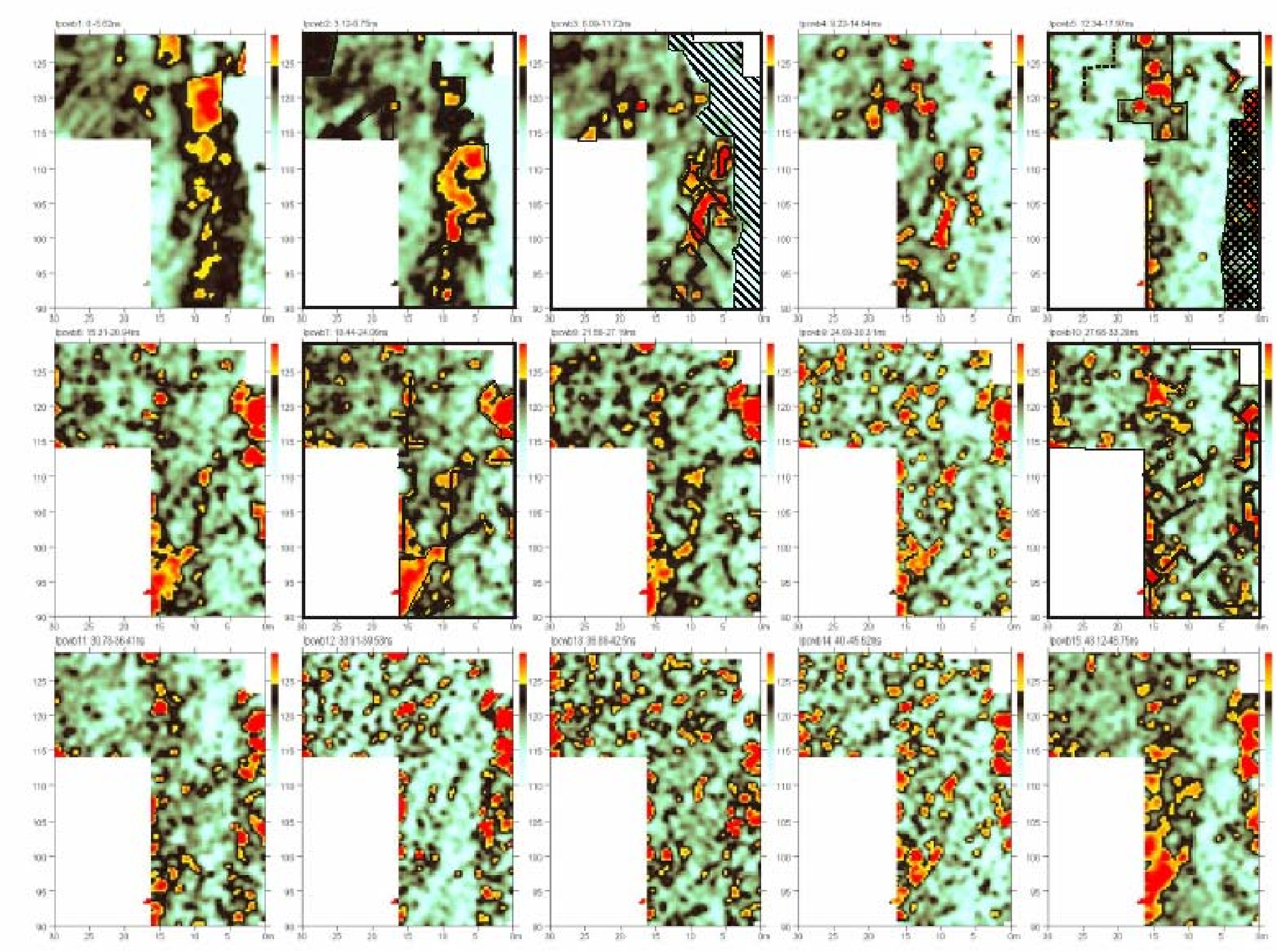
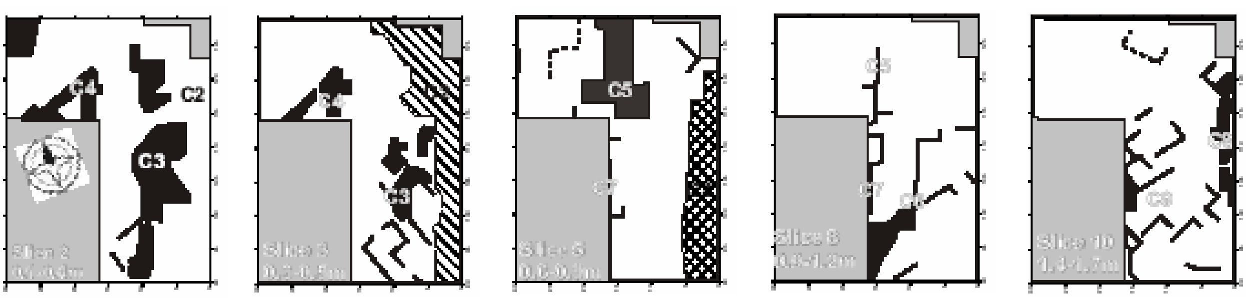


Diagram of detected structures



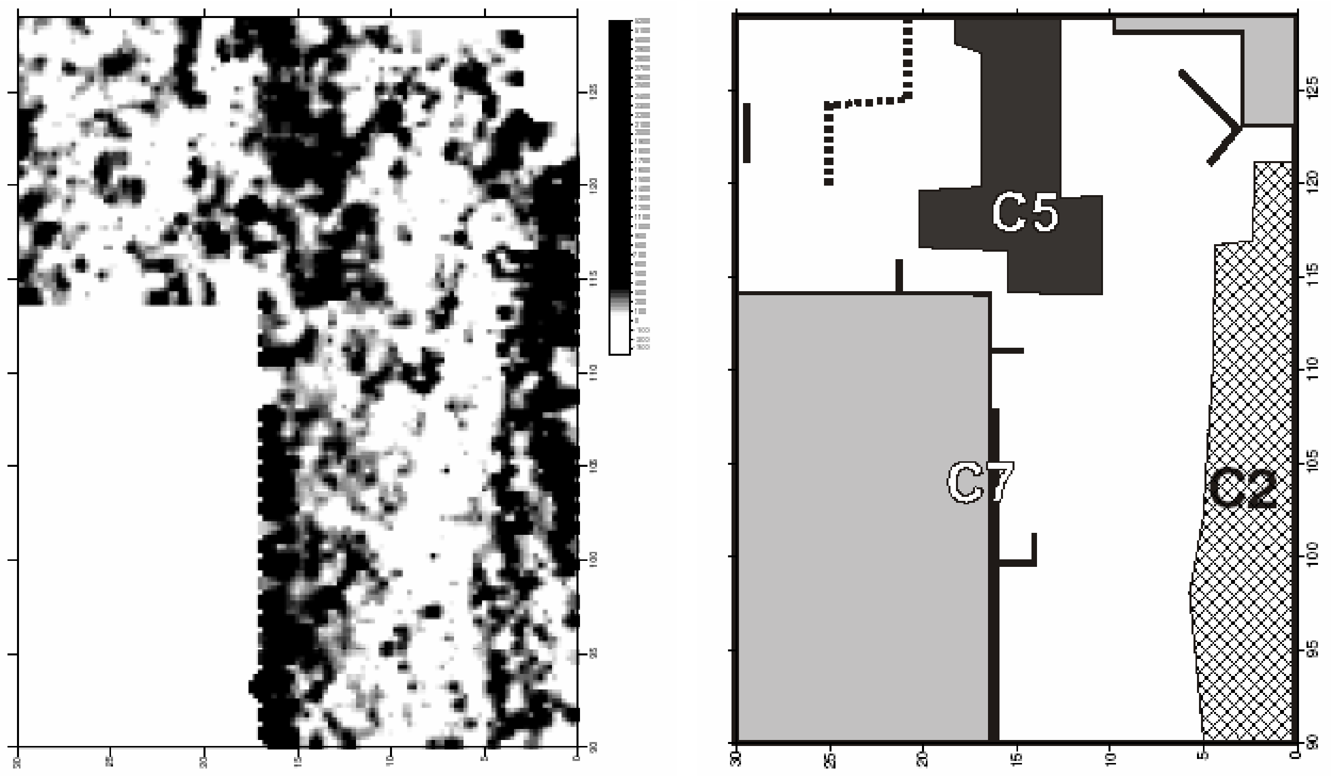
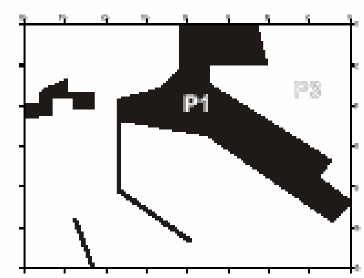


Fig. 5: Grid RG, slice 2 (0.08-0.21m below the surface). Image obtained by calculating the zero-mean line. The image provides evidence of a greater number of structures than can be seen through the process used on the other grids, although the process may magnify the value of non-built elements.

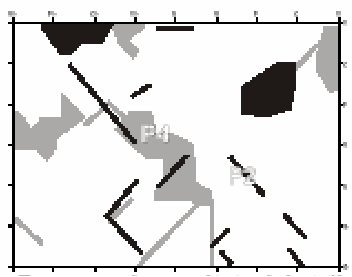
Platform grid

The platform grid covers a 16x12m space at the northern edge of the Tchinguiz Tepe enclave. The exploration area there is interrupted by the concrete foundations of an ancient guard tower. From the grid, information was sought on the internal structure of the northern portion of the walled enclosure, given that a levelled area detected at this spot abuts the partially excavated wall.

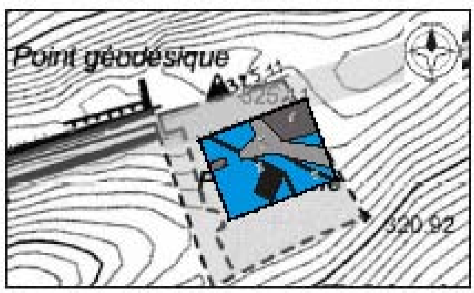
The results in the graphic show evidence of a linear structure which crosses the explored space diagonally from west to east. We have designated it P1 and located its height at between 0 and 0.5m of depth. It appears to be connected to a wall, which we have named P3, and it bounds the space to the north linked with the wall and the military access road. The current topographic survey reveals a level change in the areas nearest to the anomaly. Below 0.7m and to almost one metre under the surface, a new level can be detected. The structures there are arranged differently and there is evidence of two linear, rather ill-defined anomalies.



Results layout of slice 1 (0-0.25m)

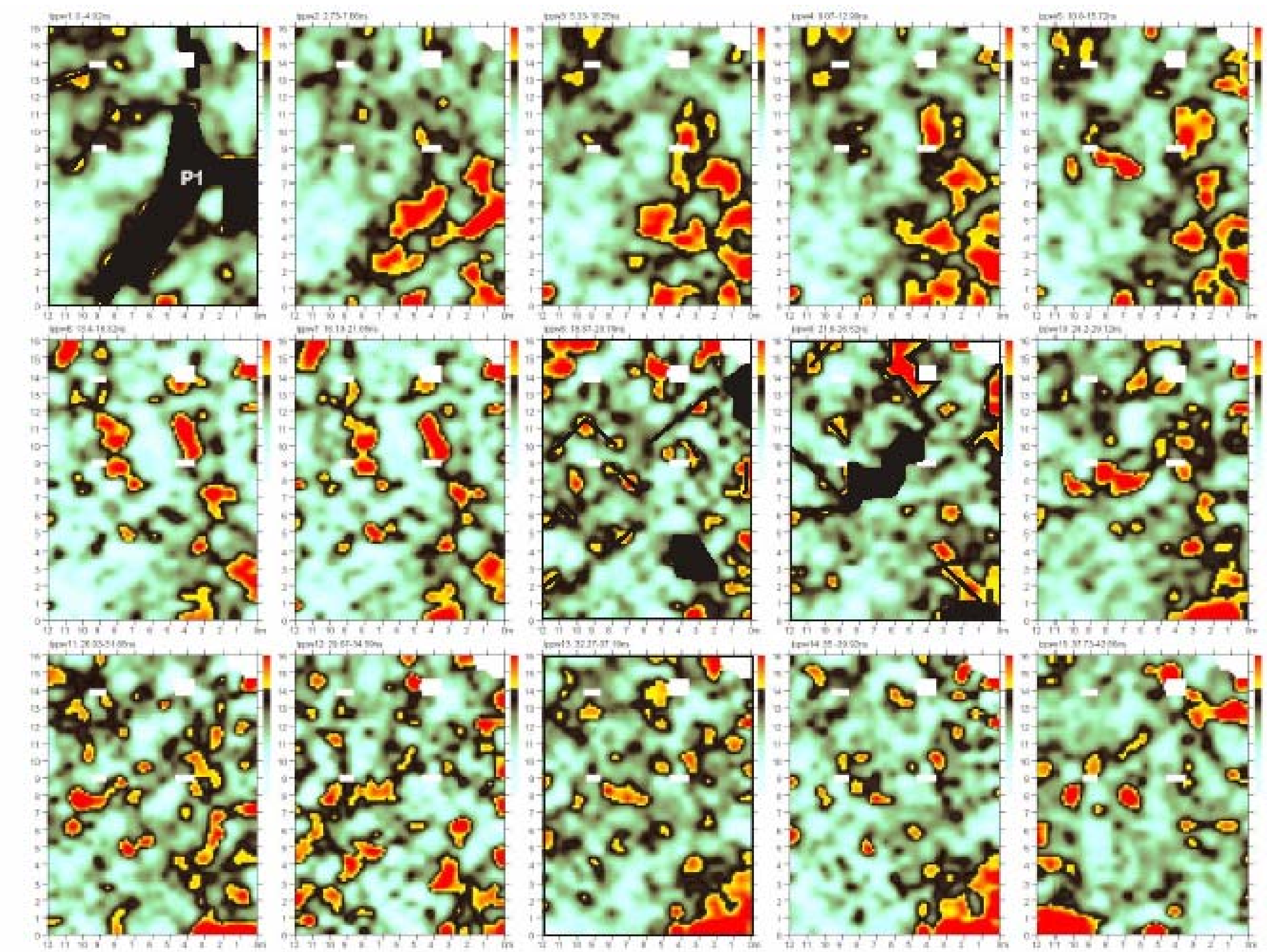


Results layout of slices
8 and 9 (0.9-1.3m)



Location of Plattform grid

Termez Project. Georadar Survey. Tchinguiz Tepe
Platform grid.



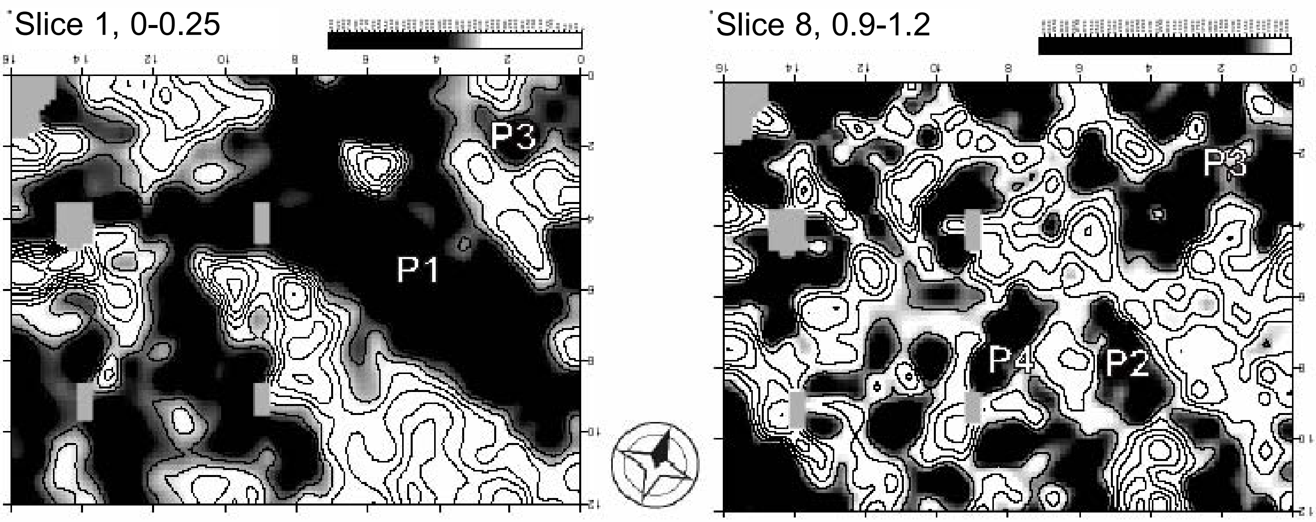


Fig. 6: Contour lines from slices 1 and 8 of the platform grid.

Slices 8 and 9 (0.9-1.3m) show evidence of two anomalies, P2 and P4, which are parallel and run diagonally across the grid (see figure 6).

As shown in figure 7, a structure appears to the north and south sides of structure P1 and it seems to be an extension made to the interior perimeter of the wall. To the south, on a lower level (0.7-0.9m), a space with interior divisions abuts structure P4.

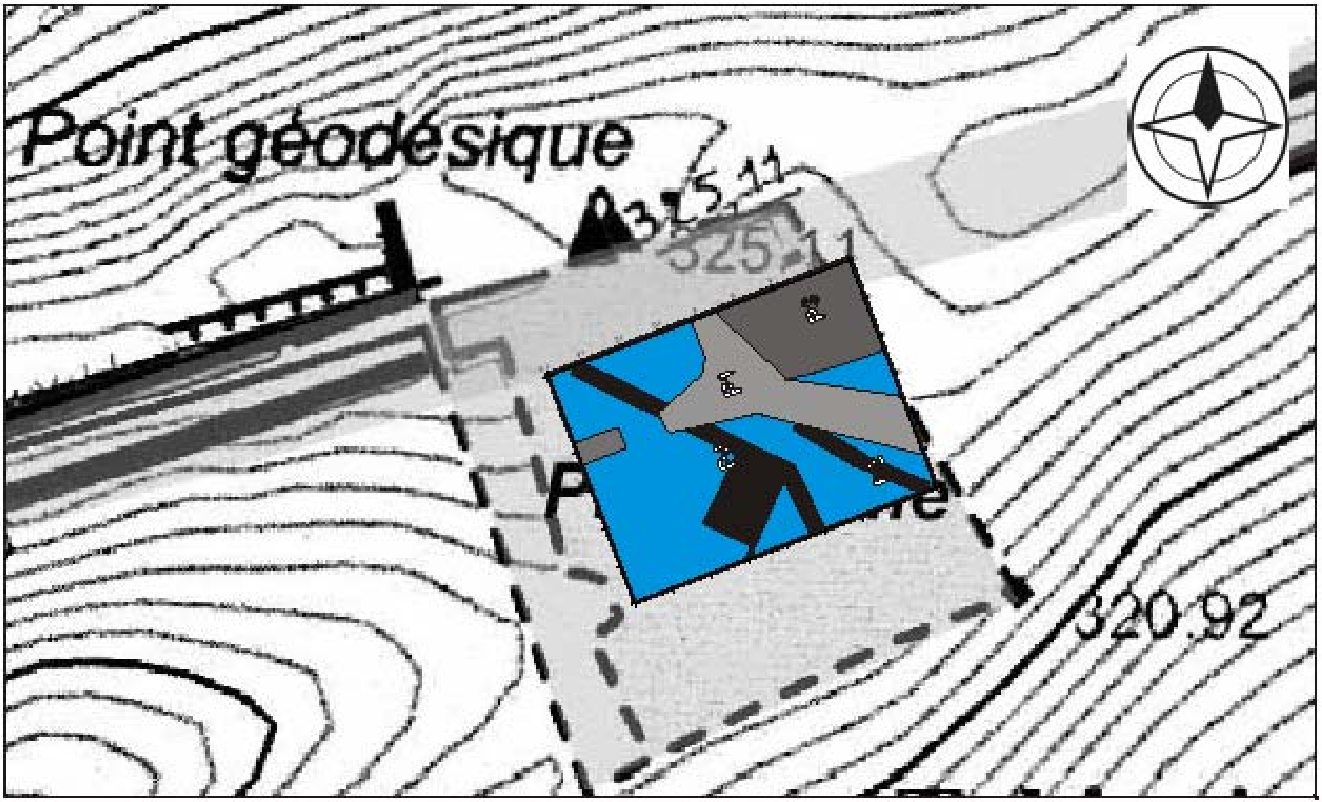


Fig. 7: : Interpretative diagram of the platform grid.

Grids on the slope

Given the complex topography of the northern extreme of the walled perimeter of Tchinguiz Tepe, two surveys were conducted against the slope to verify the existence of any potential terraces used for construction that is no longer visible.

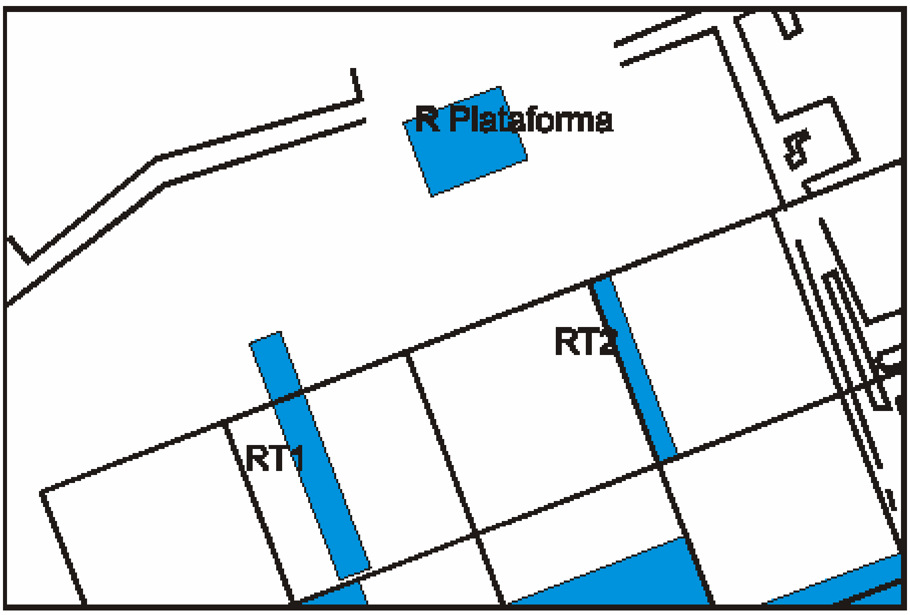


Fig. 8a: .Topographical location of grids RT1 and RT2.

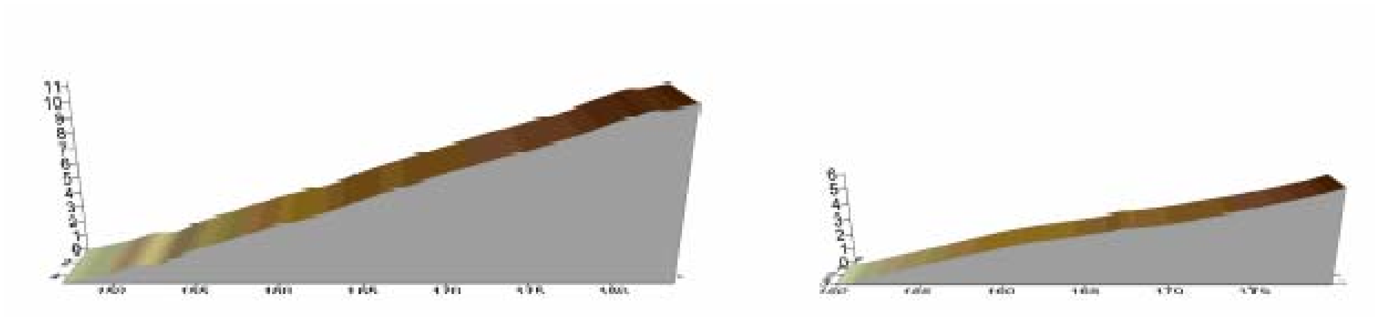
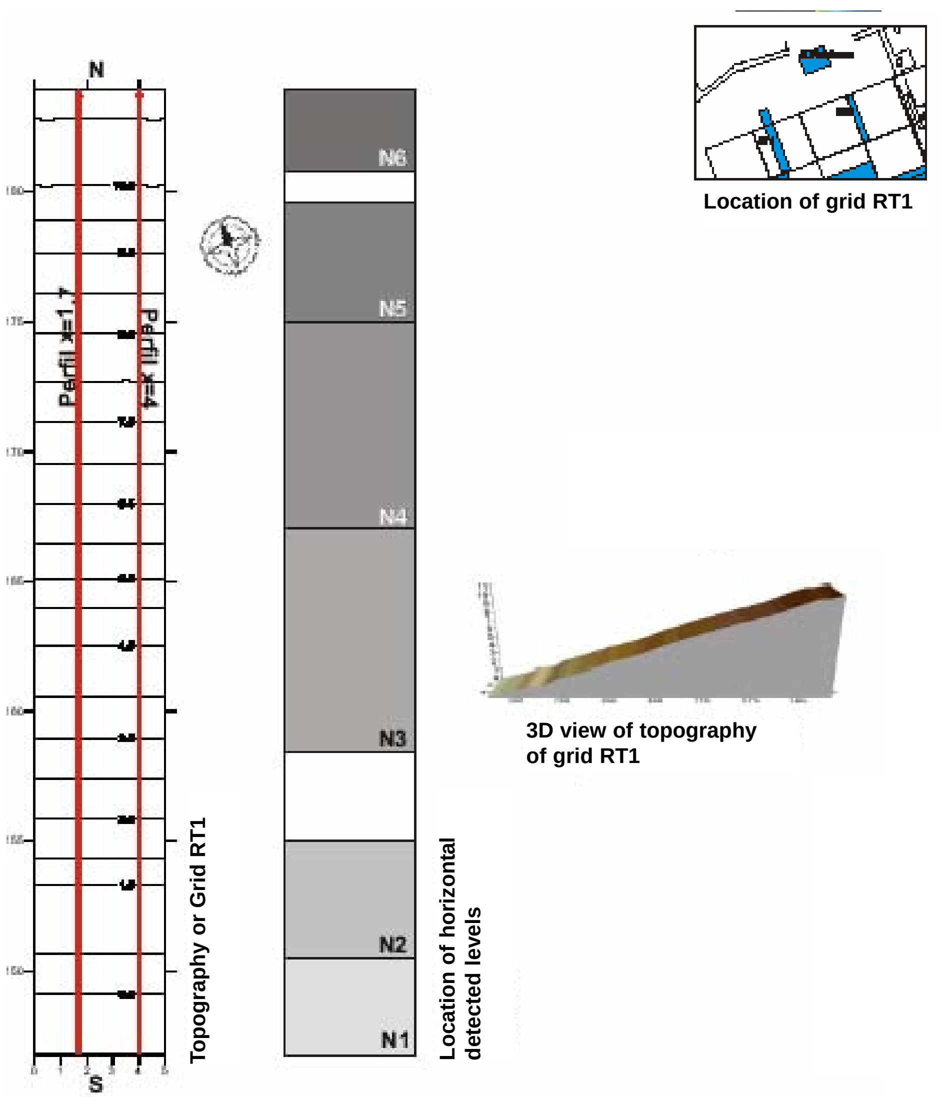


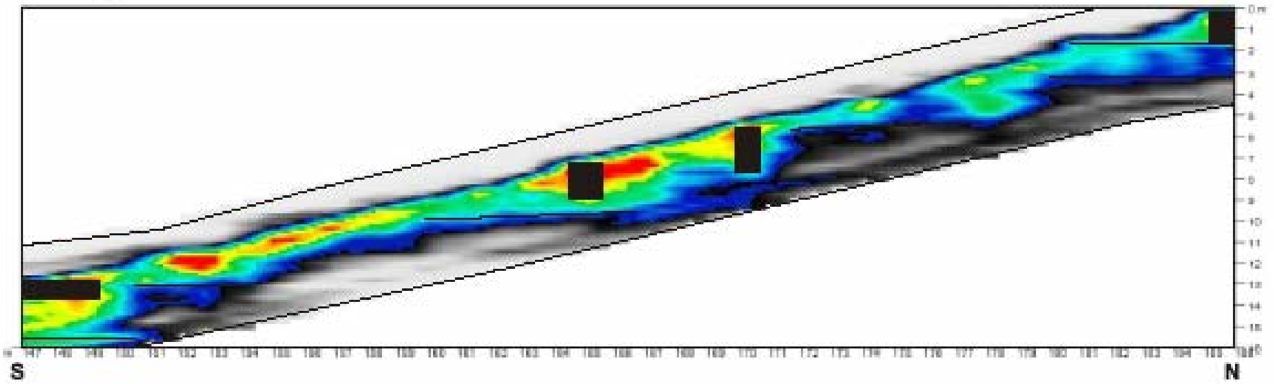
Fig. 8b: . profile of grids RT1 and RT2.

Grid RT1

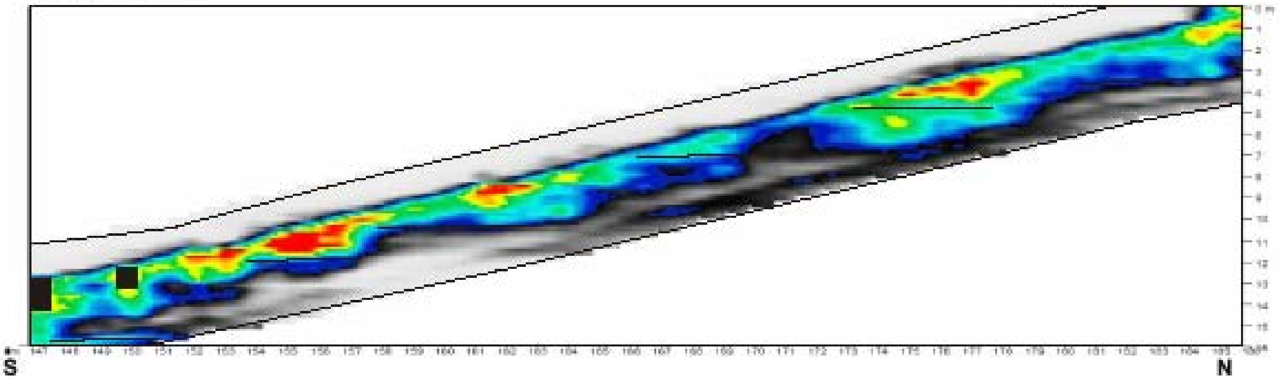
RT1 is located on the slope that runs north-northwest from the explored area, similarly to grid RD. It covers an area of 5x39m. Thanks to GPR-Slice software, topographical corrections were made and the georadar antenna's angle of incidence could be corrected, giving a set of vertical cross-sections analysed in the corresponding graphic. Heights are expressed in relative terms with respect to the highest point of the explored area. The diagram of detected structures shows evidence of numerous horizontal levels on the slope lying beneath the surface sedimentation making up the current visible topography. Although the available information does not support the claim that the structures come from the same construction period, they do clearly appear to be manmade.



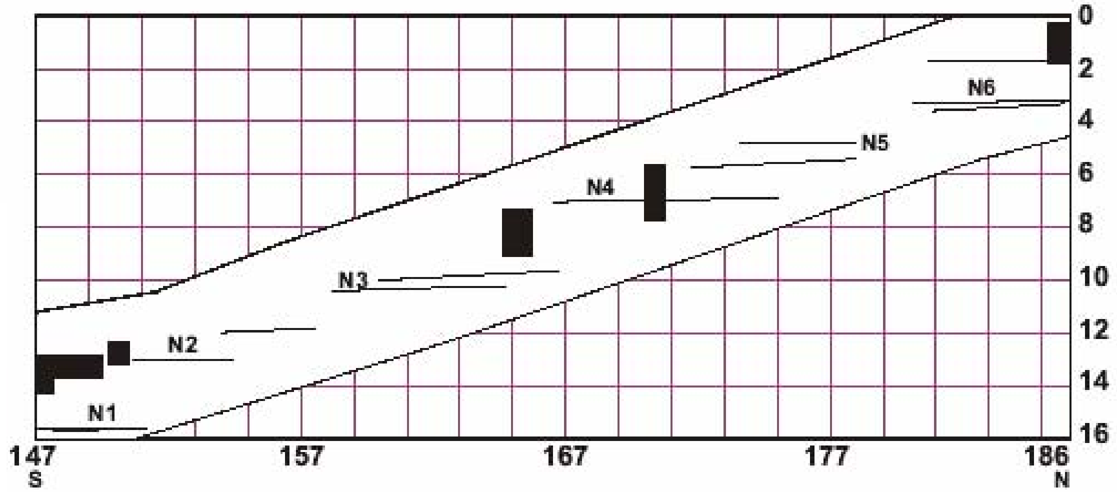
Section y x=1.7m



Section y x=4m

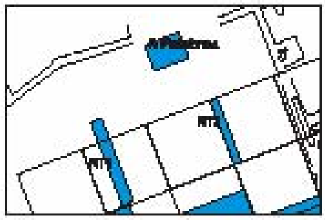


Layout of detected structures



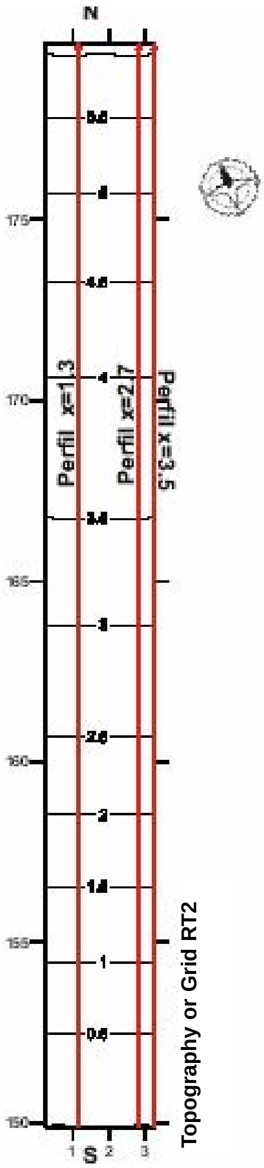
Grid RT2

RT2 lies on the slope parallel to the enclosure's eastern wall and covers an area of 3.5x30m (see graphic). The results from the set of topographically corrected profiles show evidence of a distribution of terraces similar to those detected in grid RT1. As the readings for RT2 are more diffuse, however, it is not possible to delineate horizontal levels. This may be because of the area's higher stratigraphic potential and its abundance of other objects, which could be the remains of buildings.

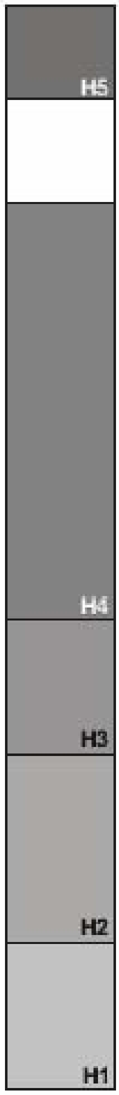


Location of grid RT1

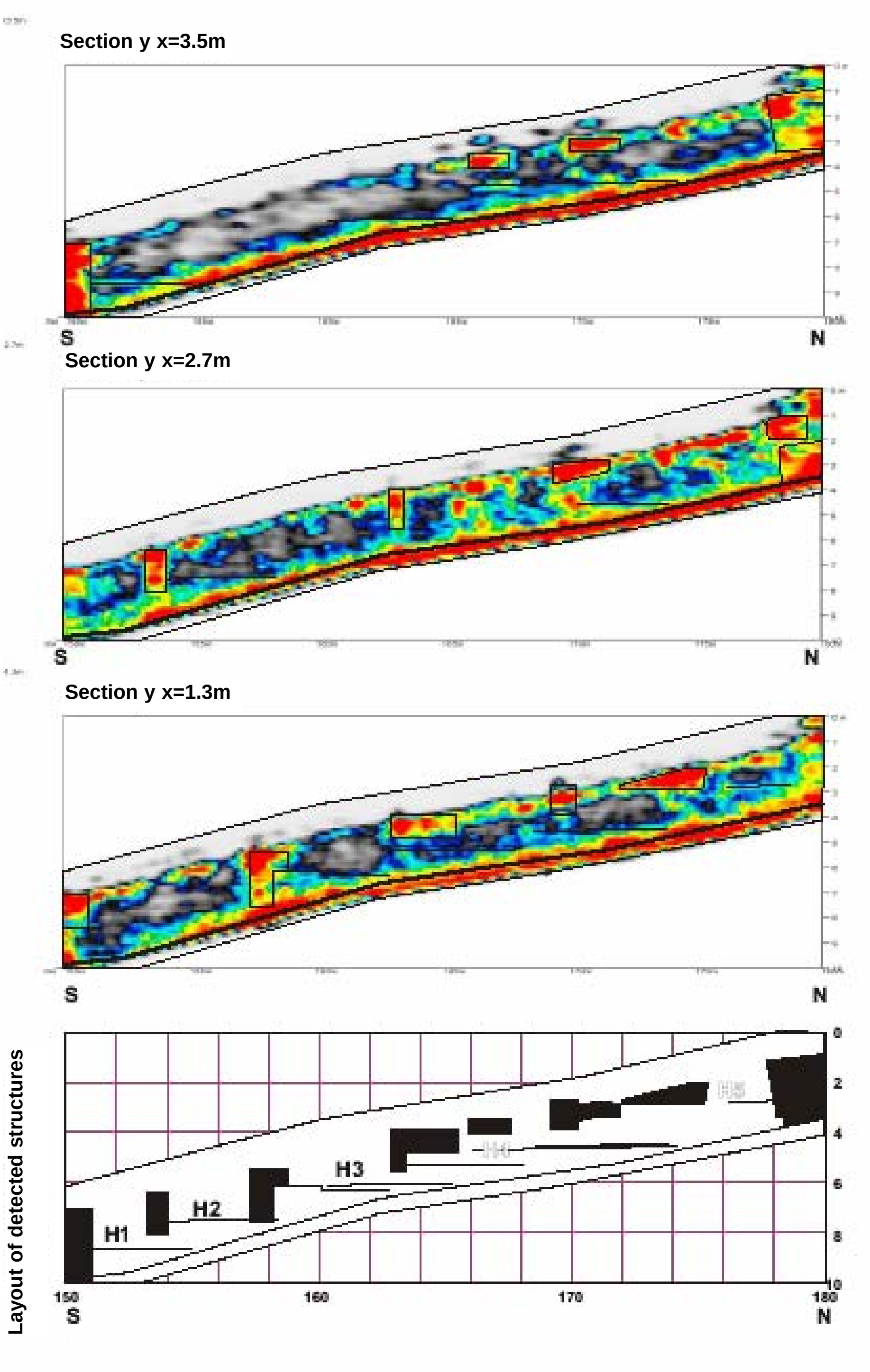
3D view of topography of grid RT2



Topography or Grid RT2



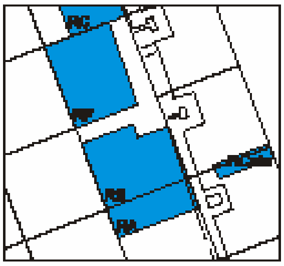
Location of horizontal detected levels


Section y x=3.5m
S
N
Section y x=2.7m
S
N
Section y x=1.3m
S
N
Layout of detected structures
H1
H2
H3
H4
H5
0
2
4
6
8
10
150
160
170
180
S
N

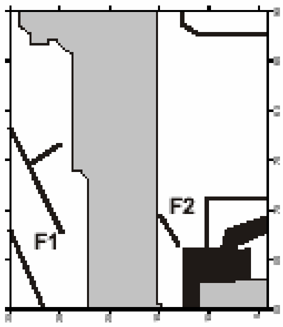
Results from southern grids

Grid RF

Grid RF runs parallel to the line of fortifications near tower 5, immediately to the south of grid RC. Because of the remains of surface earth movements caused by military use here, the area of the grid is split into two sections measuring 9x30m and 15x30m, which have been treated together. It should be noted that the eastern edge of the grid is 4m farther west than the other grids parallel to the wall. This is due to a strip being excavated[4] near the wall (see graphic). Graphic 8 shows the sequence of the first 15 plans or horizontal slices obtained from process B. The sections of sediment measure roughly 25cm in thickness. The most representative sections appear to be 1, 4 and 7. The resulting sequence reveals two large groups of structures located between slices 1 and 4 (0-0.6m) and below 0.6m (from slice 5). Structures F1 and F2 have been defined in the eastern and western section of grid RF. F1 corresponds to a group of linear structures, possibly walls, running diagonally to the line of the fortifications at a depth of 0-0.6m below the surface. F2 specifies a group of structures detected in the eastern part of the grid, at 0-0.9m of depth. Group F2 has an orientation similar to the fortifications and it is necessary yet to determine their relationships to the excavated ruins between the edge of the grid and the wall. Structure F3 (slices 3-5, 0.27-0.79m) lies in a direction similar to group F1, but at a slightly lower height, and it is discontinuous with the central part. Slices 7 and 8 (0.8-1.2m) show evidence of a new level of constructions arranged differently from the higher level structures, F1 and F2. Designated F4 and F5, they do, however, help to establish a direct connection between the structures detected in the eastern and western parts of the grid. Running diagonally, they may be walls relating to a series of spaces along a central axis. In this respect, we again define a sequence of structures similar to those in grid RC, with a first level corresponding to the last occupations and a lower level arranged differently, featuring a higher vertical potential starting with the layers nearer to 0.8-1.2m below the surface.

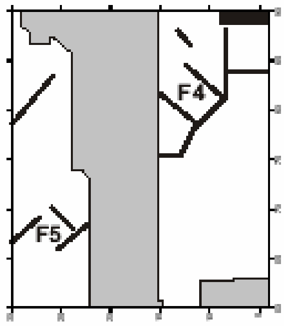


Location of grid RT1



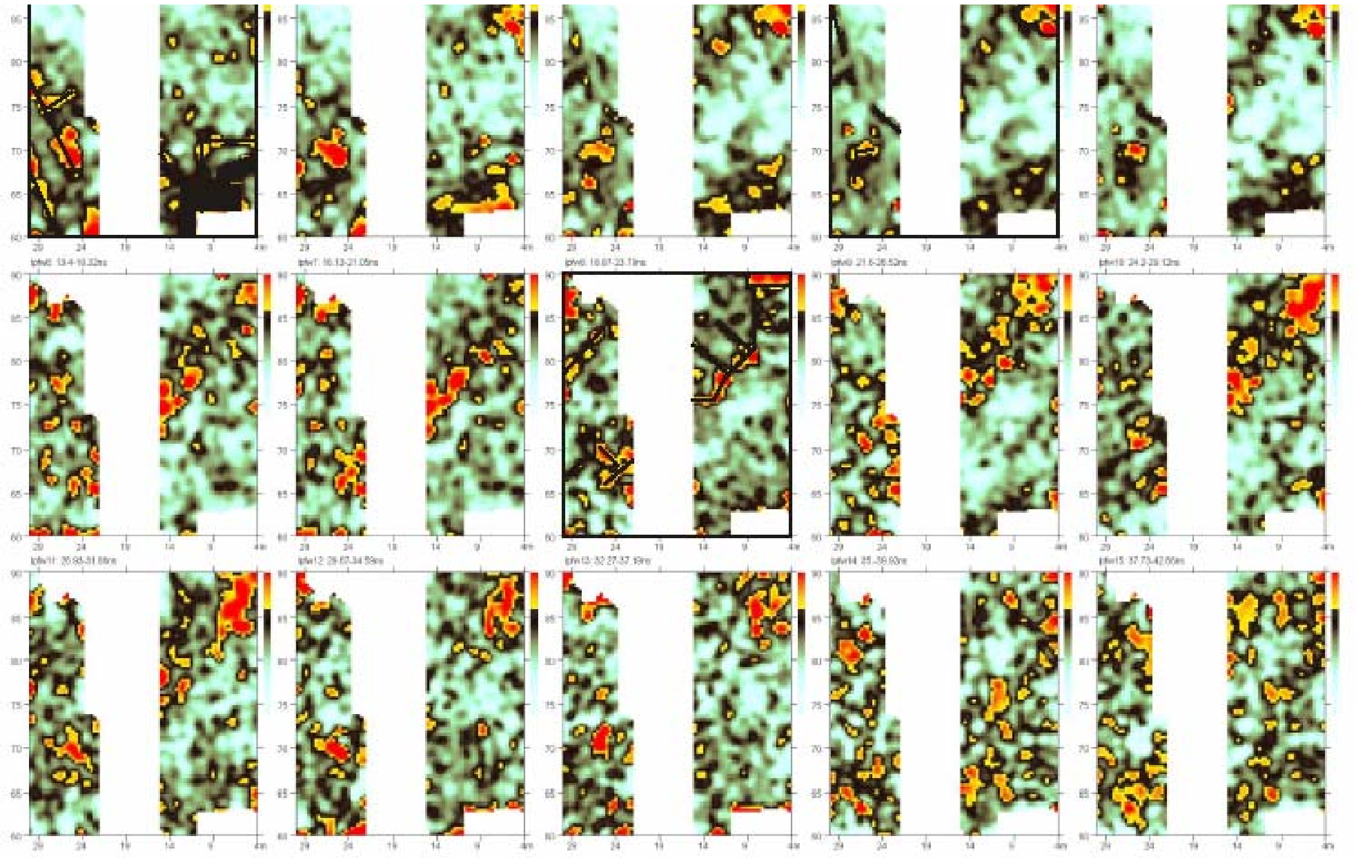
Layout of detected structures
Slice 1 (0-0.25m)

Layout of detected structures
Slice 4 (0.4-0.65m)



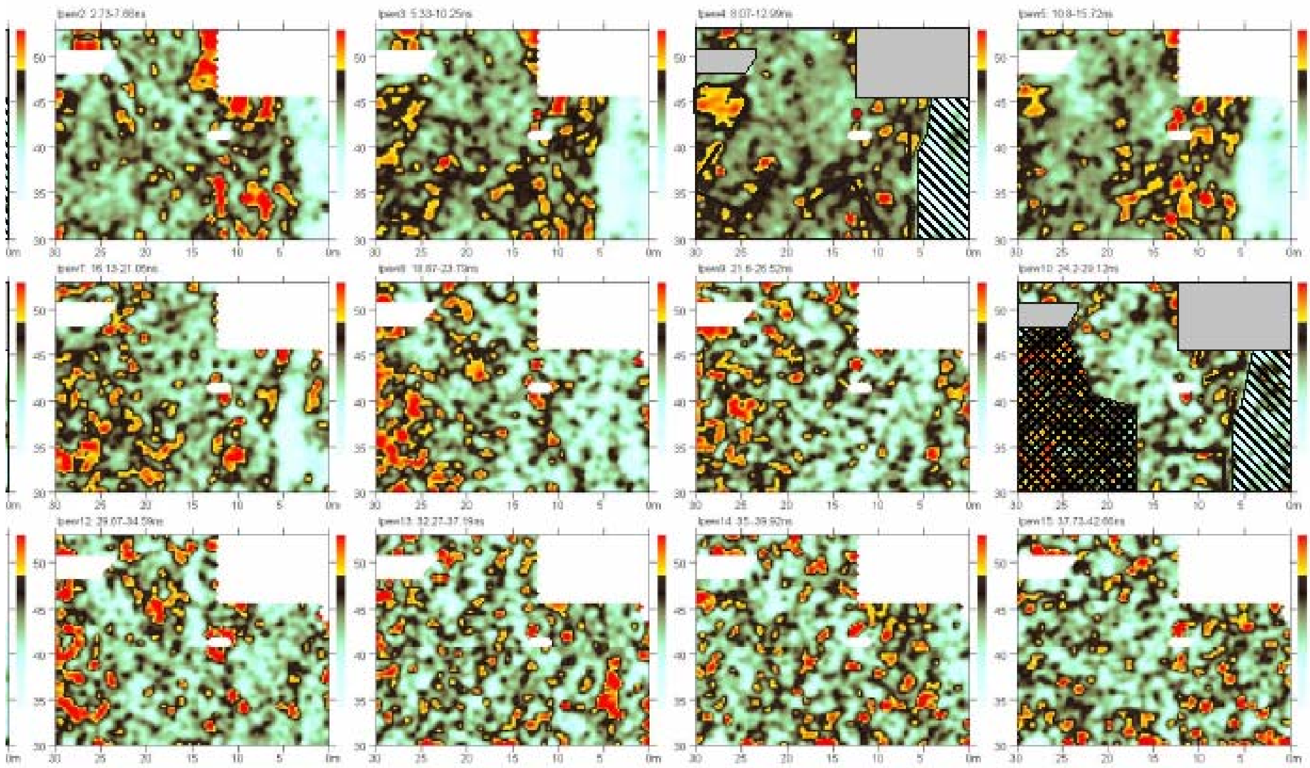
Layout of detected structures
Slice 8 (0.9-1.2m)

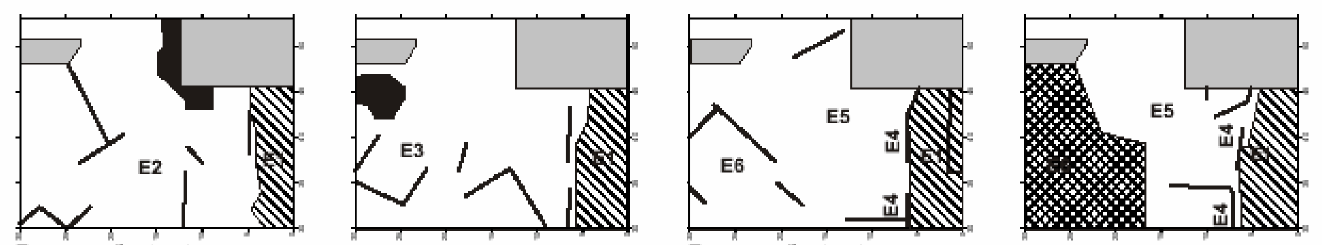
4.- Leriche, P., Pidaev, Ch. Bilan de Campagne 2004



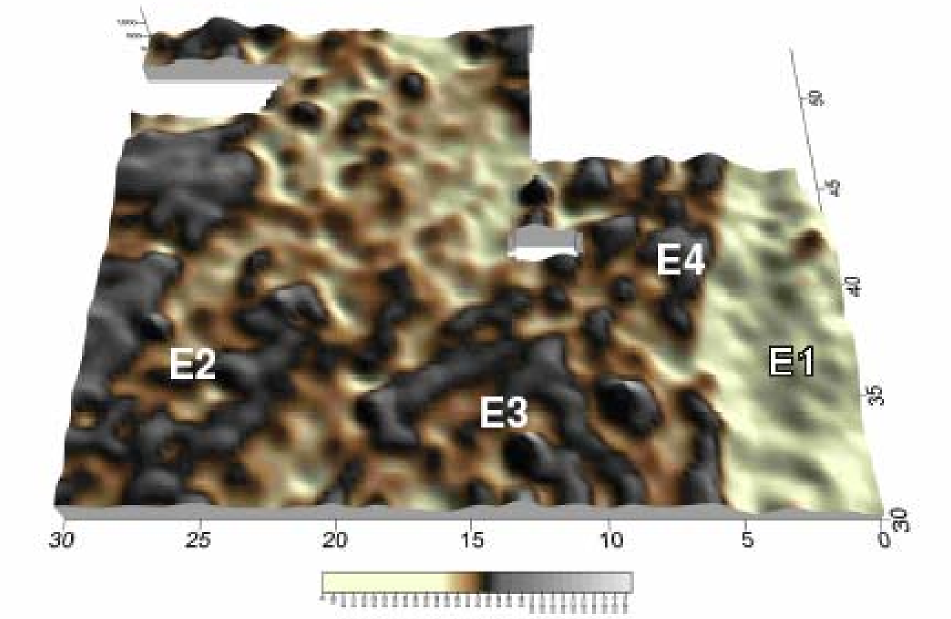
Grid RE

Grid RE is adjacent to grid RF lying to the south and abutting the wall at tower 6. As the graphic shows, a sequence of 15 plans has been generated from 0 to 2.13m below the surface. As in grid RC, a low-lying strip (E1) is clearly visible to slice 8 (0.95-1.19m), corresponding to the gap created by the military access road running inside the wall and currently silted over by surface sediments. This find helps to support the southerly continuation of the road and the counter-wall E4 bounding it to the west (E1-E4 or C2 in grid RC).





Layout of detected structures Slice 1 (0-0.25m) | Layout of detected structures Slice 4 (0.4-0.65m) | Layout of detected structures Slice 6 (0.7-0.95m) | Layout of detected structures Slice 10 (1.2-1.5m)



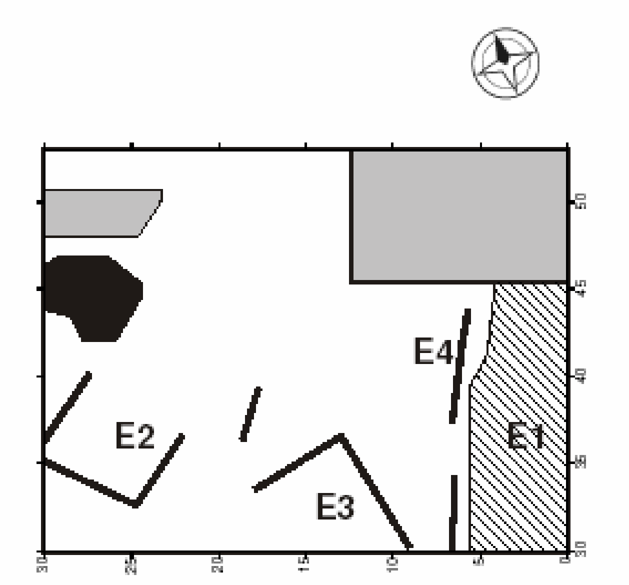
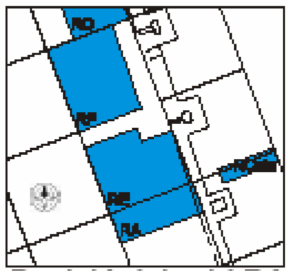


Fig. 9: The top figure offers a pseudo-3D view of grid RE at slice 4 (0.4-0.65m below the surface) showing the structures located there. Below, a diagram provides a map of the structures.

Figure 9 gives a pseudo-3D image of the structures detected at slice 4 (0.4-0.65m below the surface), suggesting that earlier rooms may lie under the vertical structures of E2 and E3. At slice 6 (0.65-0.9m below the surface), structure E6 can be defined beneath E2 and E3, and at slice 10 (1.25-1.5m below the surface) there is an area of high-amplitude response below the entire perimeter, which could be associated with a circulation floor or pavement. Beneath slice 10, the response corresponds to the natural soil of the Tchinguiz Tepe site. Therefore, grid RE is marked by two large groups of structures, one group associated with the wall, which reflect its orientation, and a second group farther to the west, which presents a superimposition changing from the surface to the deepest level of exploration.

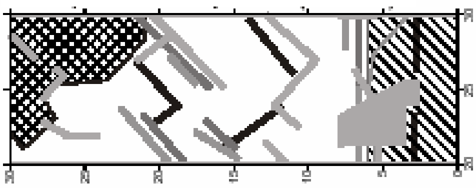
Grid RA

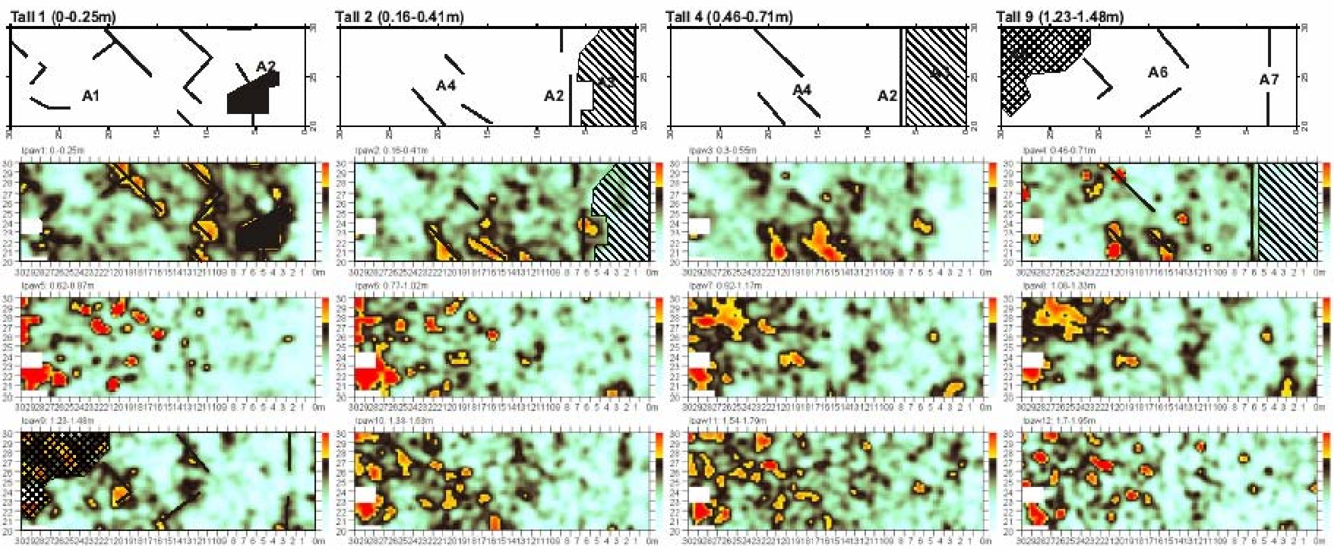
Grid RA was the first to be surveyed. It measures 10x30m and lies adjacent to grid RE. The results obtained do not offer clear information below 1.5m (slice 8). This is because of the poor quality of the gathered data, owing to external electromagnetic interferences. Nevertheless, grid RA is similar to grids RC and RE in showing detected structures that could be divided according to their orientation relative to the wall, either lying parallel along the wall or at an angle to it. Slices 1 and 2 (0-0.41m) offer evidence of A1 and A4, comprising the axes of the oblique structures, and A2 and A3, which are associated with the access road and the inner wall bounding it. Slice 8 (1.23-1.48m below the surface) shows a high-amplitude area designated A5, which we also associate with potential levels of circulation or pavement. In the same layers, a new anomaly, A7, appears. It is coherent with the orientation of A2 but lies displaced roughly 2.5m to the east, leading us to interpret it as a new structure related to the fortifications.



Location of grid RA

Superimposition of layouts (0-1.48)





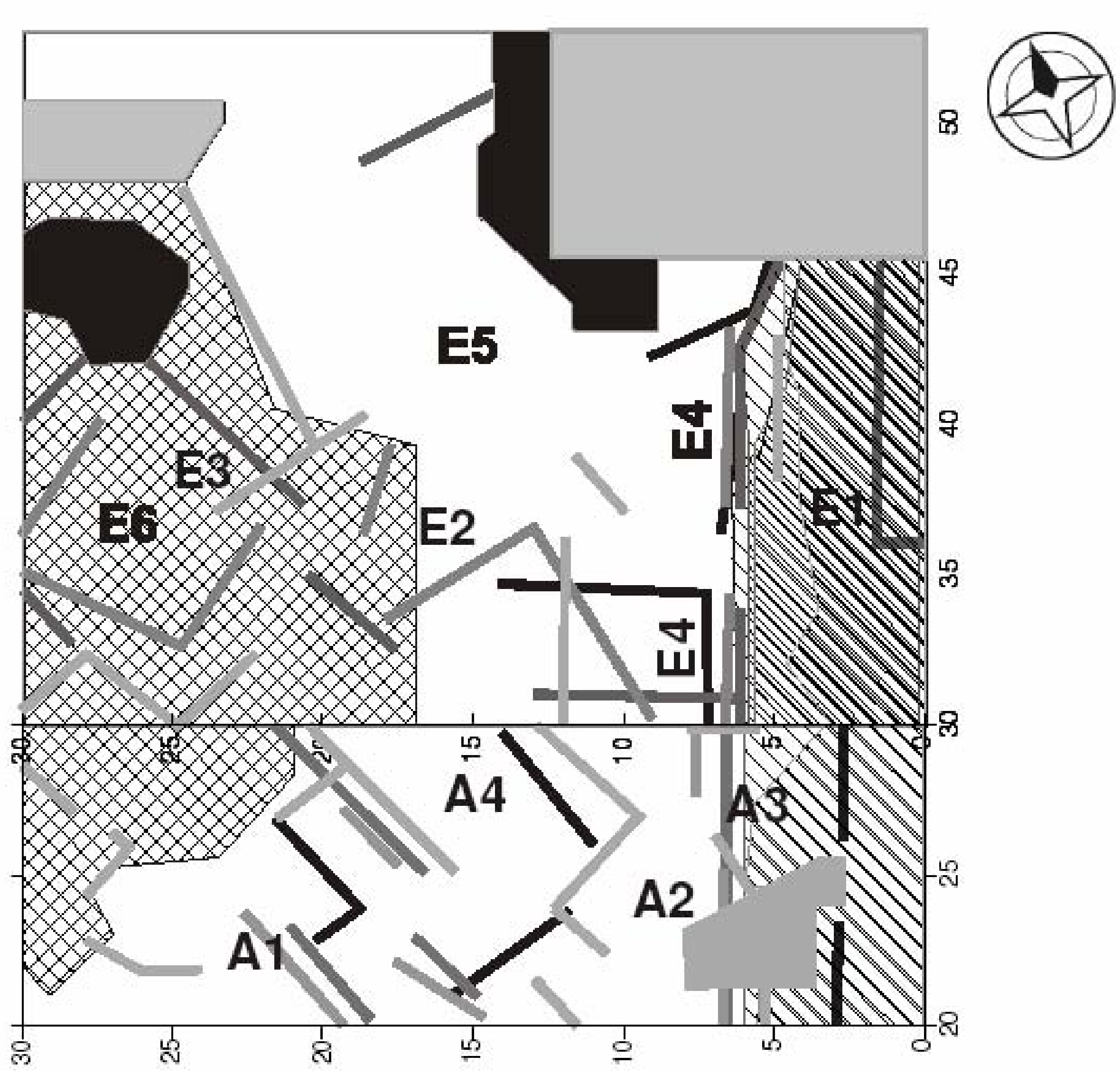
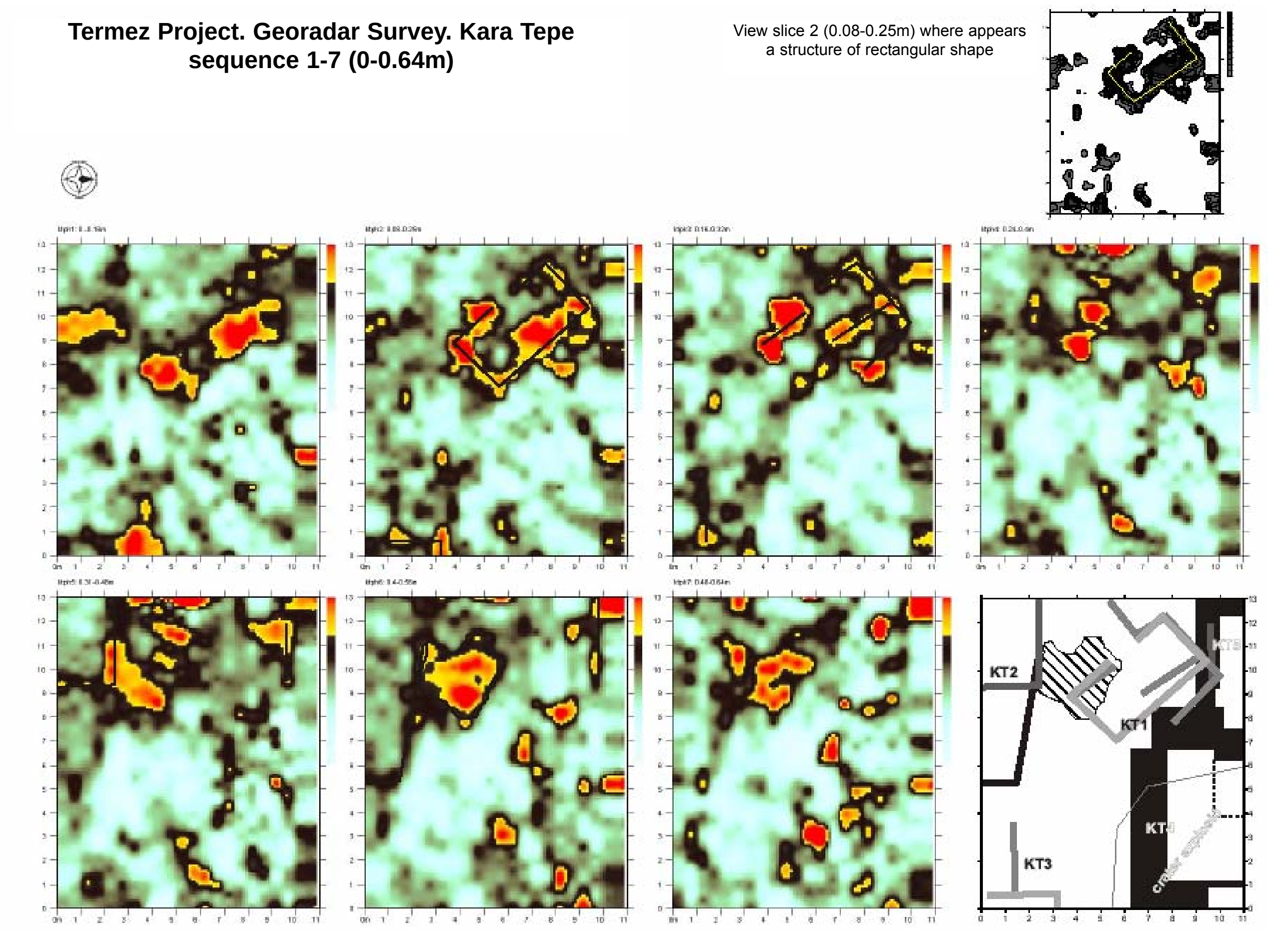


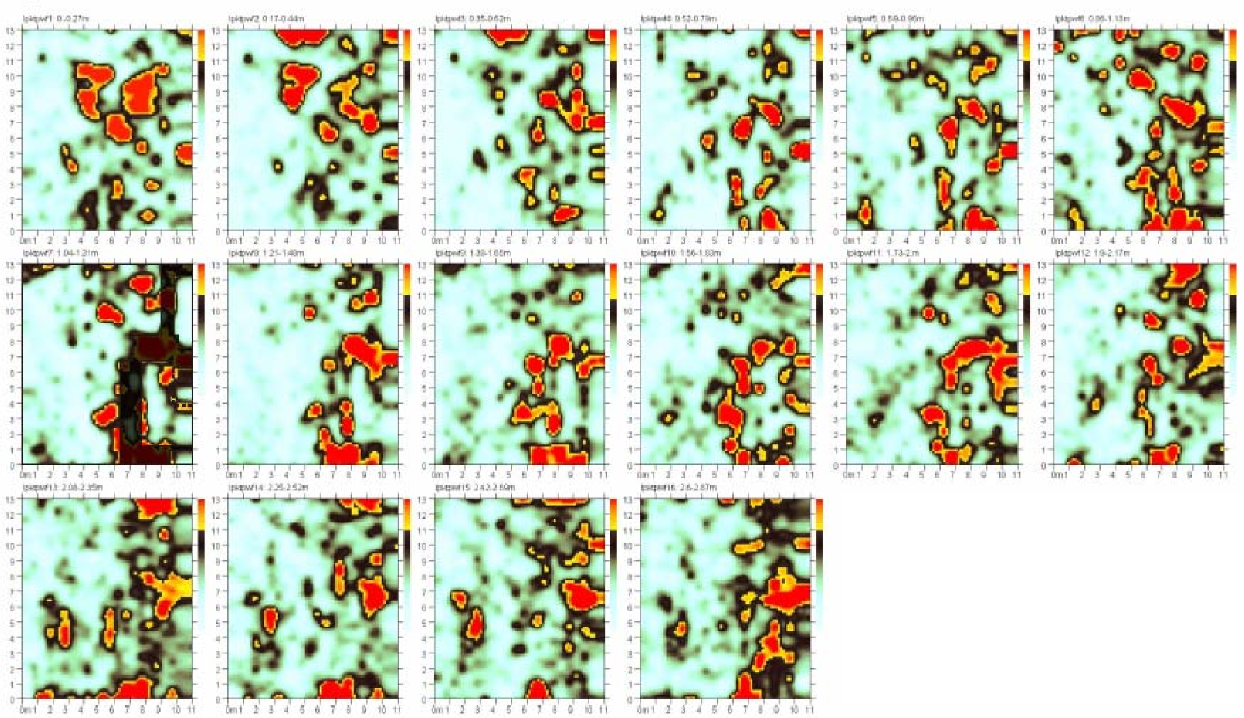
Fig. 10: Superimposition of diagrams showing structures detected in grids RE (above) and RA (below) from 0 to 1.5m below the surface. The elements are depicted in shades of grey (shallow) to black (deep). The striped areas of low amplitude depict the military access road and the secondary wall running along the inside of the outer wall. The cross-hatched areas depict high-amplitude areas caused by levels of occupation or pavements.

Kara Tepe grid

To find corroborating evidence, a small survey of 11x13m was conducted in the northern area of the military base in Kara Tepe, a few metres from the Buddhist monastery under excavation. The aim of the survey was to locate the position of a room related to the possible stupa located in the vicinity. Although the surveyed area presented a slope running in an easterly direction, the far NW edge of the grid showed evidence of a conical depression caused by the explosion of a mortar shell. As a result of this occurrence and the phenomena of compression and combustion that it entailed, the most clearly apparent structures lay outside its perimeter.

The results obtained appear in the images as a set of horizontal plans. The first image is derived from a process used to depict the first 65cm of sediment, taking slices of 16cm in width to identify the most superficial structures. The next image shows an alternative process in which the plans show thicker sediment (0.27m) and are, therefore, more schematic (i.e. data-gathering process B). Specifically, three structures could be identified. Firstly, we identified a rectangular structure measuring roughly 5x3m (KT1), of very limited height (0.08-0.4m). Structure KT3, which forms two angles with the eastern edge of the explored area, is located at similar depths. Below this level (0.24-0.64m), the evidence indicates a new linear structure, which we have designated KT2. It runs across the grid from east to west. Near KT2, there is a high-amplitude area of greater height and its shape has not yet been identified clearly, although it reaches layers nearer to 0.8m below the surface. Below these layers, numerous linear structures are detected. They are associated with a building under excavation, which is situated immediately to the north, but the definition is less sharp (see figure 11).





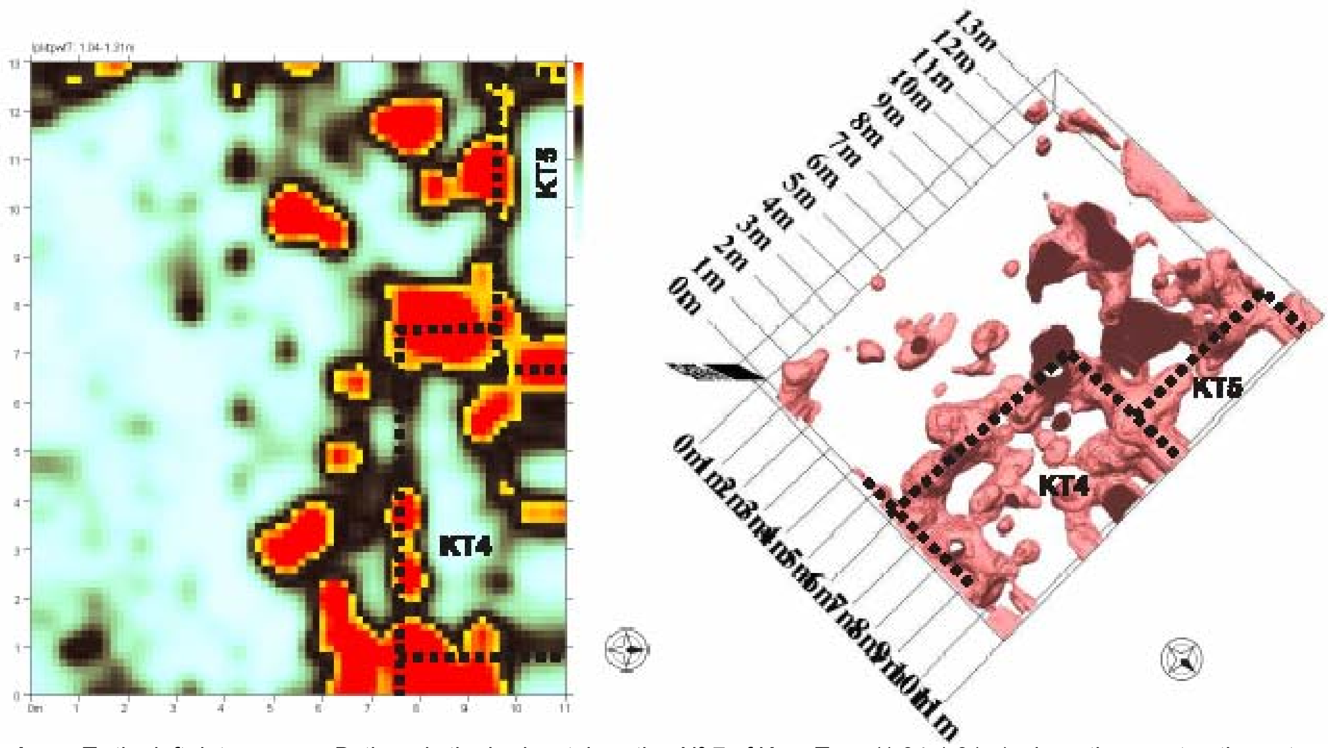


Fig 11: To the left data process B, there is the horizontal section Nº 7 of Kara Tepe (1.04-1.31m) where the constructions structures KT4 and KT5 can be distinguished in the building under excavation in the North. To the right there is the 3D representation *of the elements KT4 and KT5 from the North-East.*

Conclusions

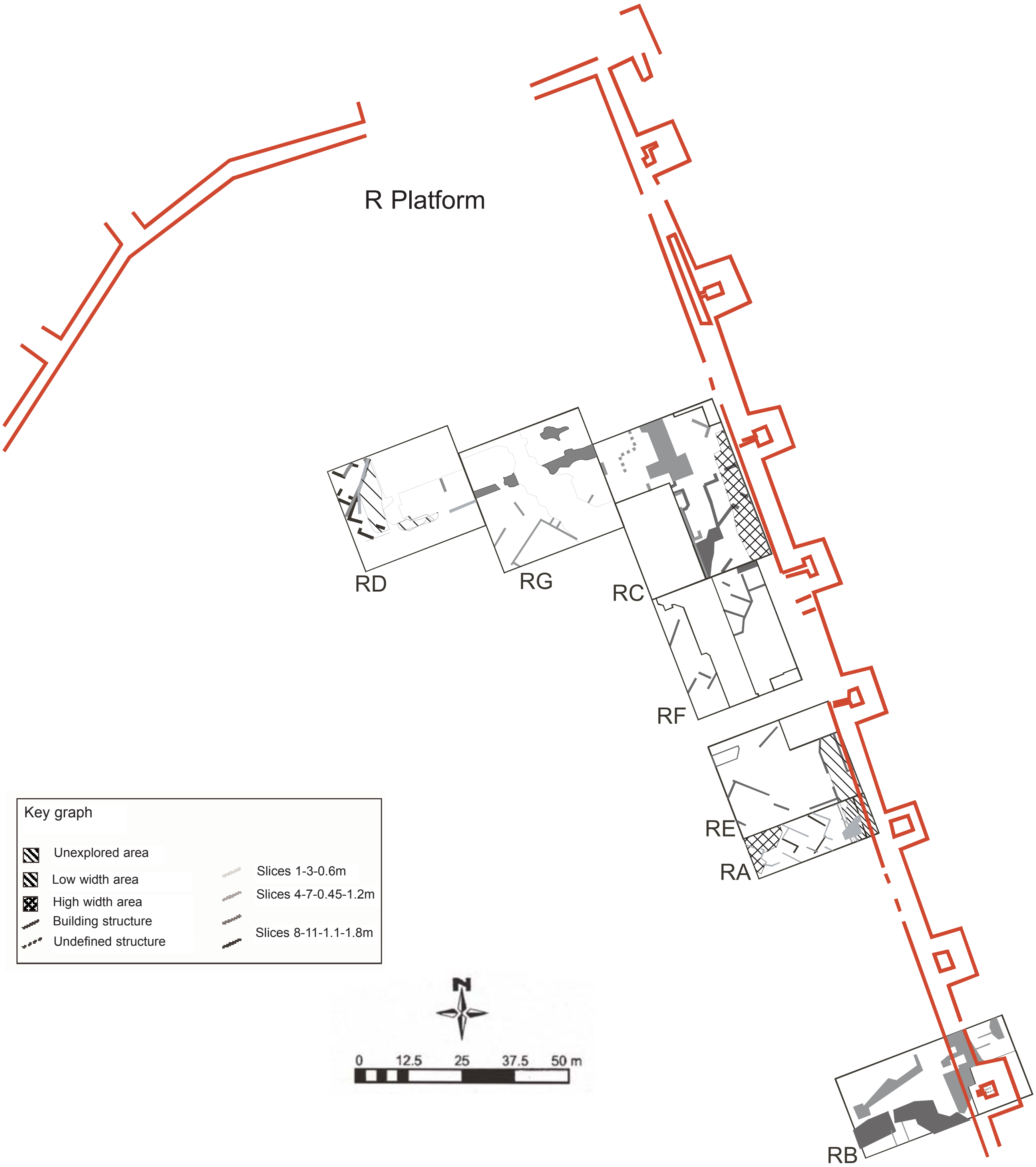
As indicated in the introduction, beyond the purely descriptive aim of the geophysical survey carried out in the 2006 season at Termez, the greatest challenge facing the team was to evaluate the viability of the methods and instruments used under the specific conditions present at the Tchinguiz Tepe site.

The defensive perimeter of Tchinguiz Tepe reflects a construction system based on adobe or sun-dried bricks, except in areas located in the SE sector, where magnetic surveying or inspection of the terrain has uncovered a group of structures built later of baked brick. Geomagnetic surveying has already uncovered that the contrast between the magnetic reading of adobe structures and in-fill is too low to support a description of the subsurface remains. Basically, the magnetic system has performed very effectively in defining anomalies related to combustion and the presence of ferrous metals, but the results do not stand up to comparison with the results obtained with the survey technique based on georadar data and the application of time-slicing. The results of georadar exploration presented here, however, are the fruit of months of work and experimentation with a software programme which is highly specialised in generating images of built structures to provide useful information to season leaders. The experience gained from these months of work has served to define a process routine that makes it possible to obtain reliable results. In addition, it has served to define new scientific objectives for the mission of geophysical research.

Less is more

After having analysed the characteristics of the collected data, the problems associated with the location of the site in a military area (see graphic) and the electromagnetic interferences arising from military activities[5], data processing turned to comparing the different numerical filters that would eliminate certain kinds of information in the original data (electromagnetic noise, geometrical errors, phase corrections, etc.).

5.- Radio communication systems, satellite transmissions, air traffic control assistance (VOR) associated with the Termez airport or the countermeasures taken by transport planes.



Termez Project. 2006 Season. Georadar Survey. Tchinguiz Tepe. Diagram of structures detected

The set of surveys revealed a phenomenon that is well-known and widely documented in the literature on the subject[6], involving the risk entailed in the use of filters. While the filters eliminate a large part of the undesirable information in radargrams, they can also remove important data. As a result, filters were ultimately rejected. Once it was clarified that applying the filters most commonly used in archaeological geophysics (e.g., migration and background removal) did not improve the results or actually wor-

6.- Clark 1989

sened them, the strategy shifted to examining other factors, which are also critical in creating horizontal maps with georadar data, such as questions of shape and volume and of visualisation. Firstly, it is necessary to define the density of useful data per surface unit and the approximate thickness of each horizontal slice. If each slice represents too great a thickness of sediment, the wealth of information can lead to misleading results. On the other hand, too small a thickness can give an equally false image, because it can magnify the signal of unimportant archaeological structures in the overall stratigraphy. Once the parameter had been set at slices of 0.25m (5 nanoseconds at a speed of 0.1m/ns) and the overlap was set at roughly 12cm, the issue of visualisation was addressed. While the archaeological geophysics clearly depend on these parameters, i.e. to depict the volume and shape of objects conventionally, the most significant find of the project at this point lay in better defining an effective process.

Generating maps of subsurface structures from a geophysical survey is nothing more than expres-

Termez Project. Georadar Survey. Tchinguiz Tepe
Grid RC. Slices 1-15 (0-2.1)

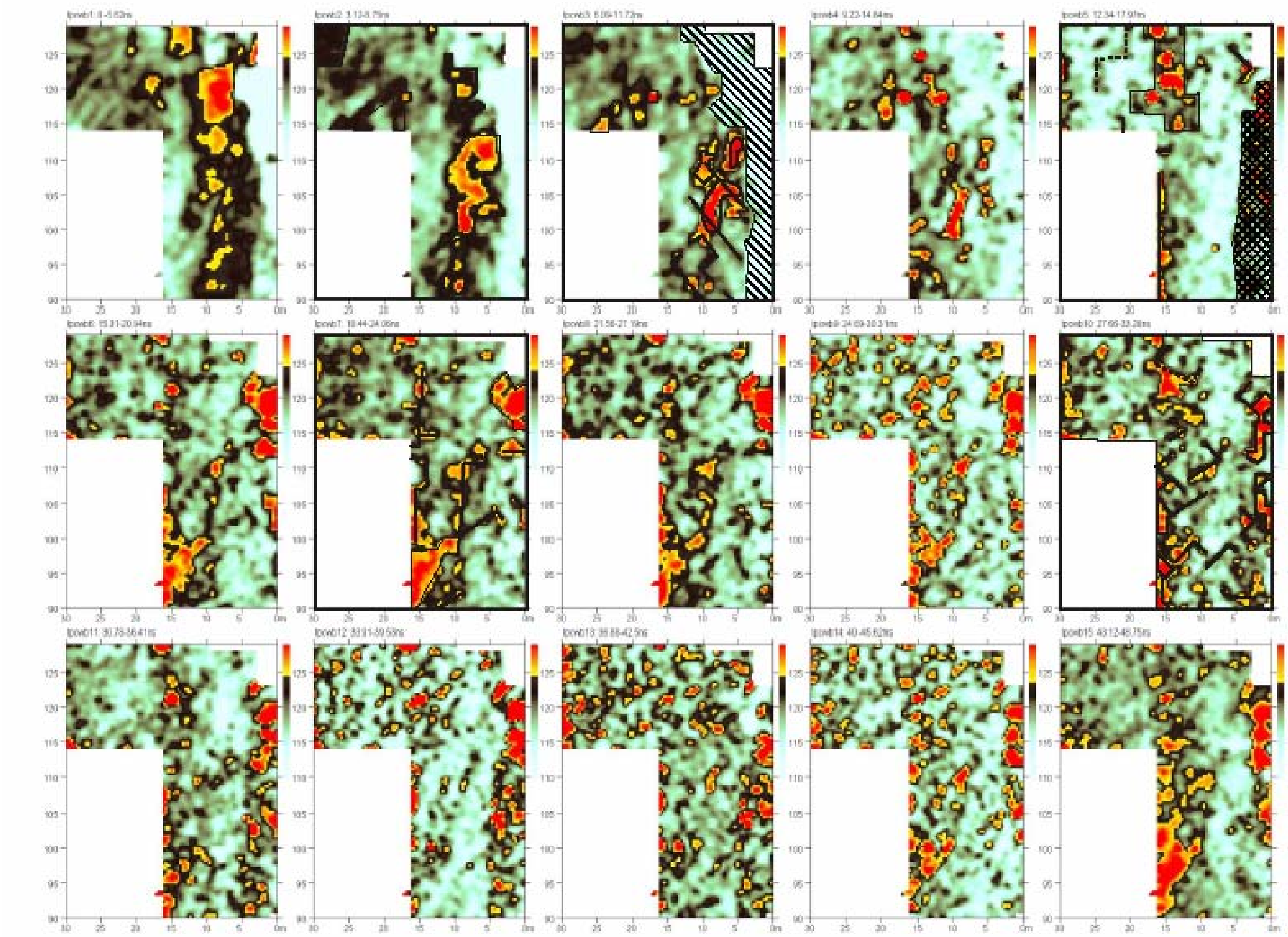
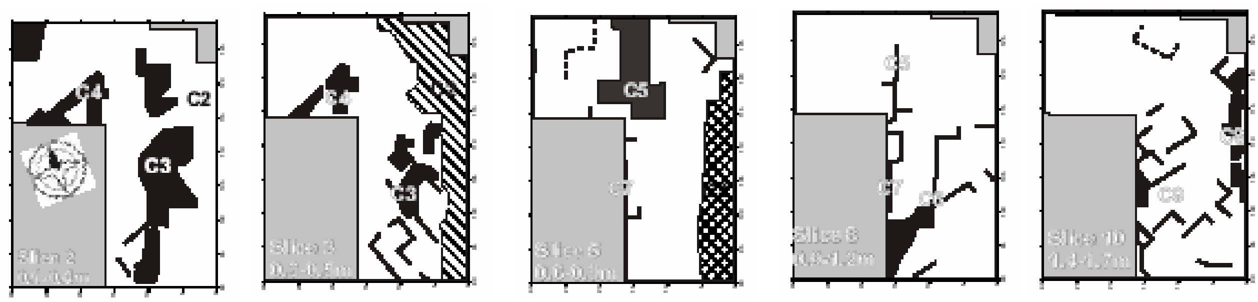
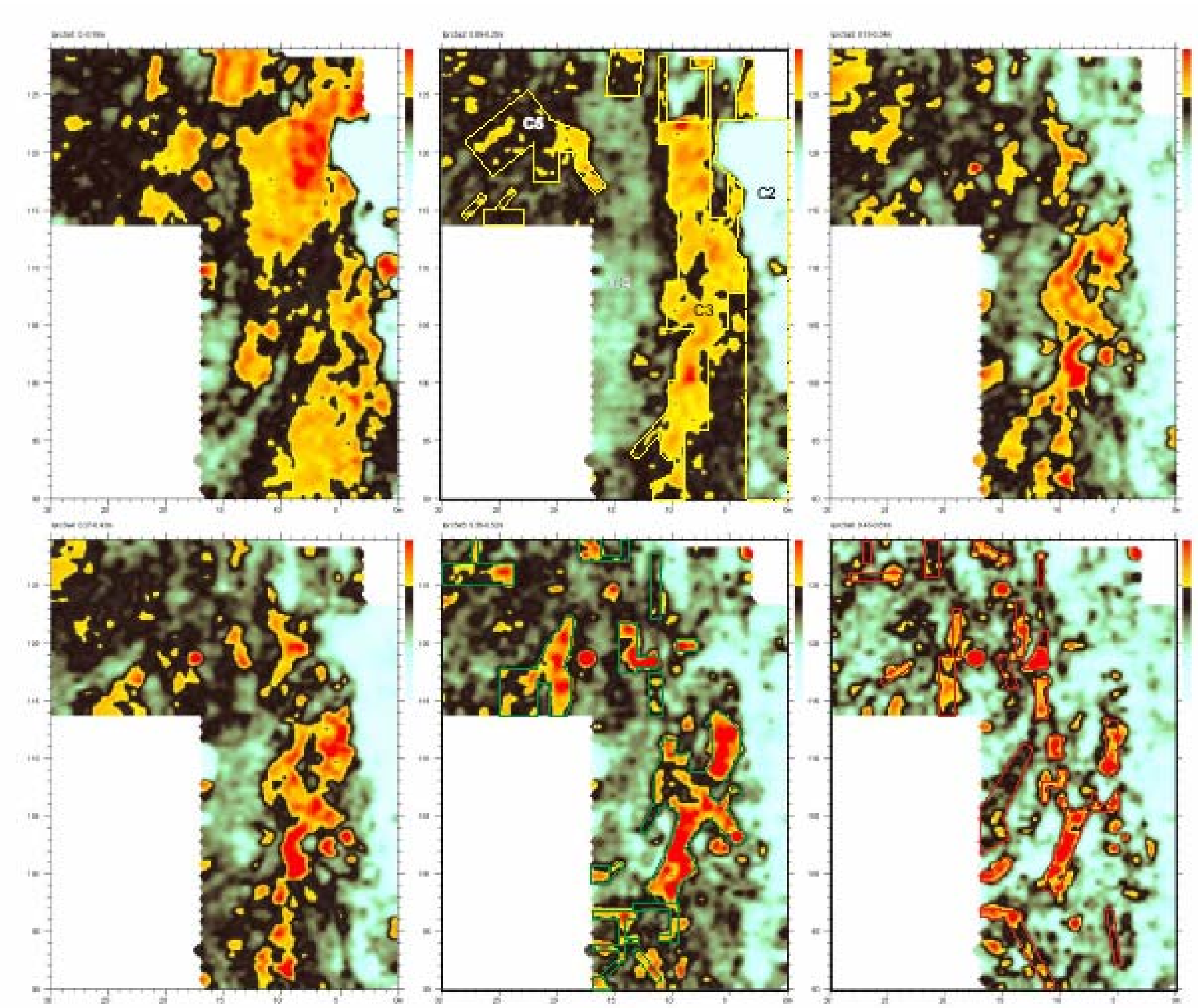


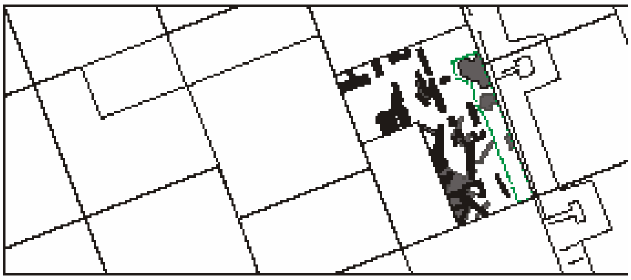
Diagram of structures detected



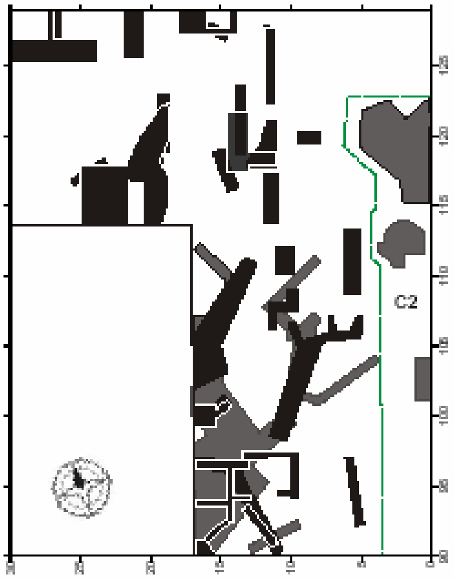
sing in graphic form the changes in properties that are produced there. An excess of information, however, can often give rise to what are called artifacts. That is, the excess of variables in terrains exhibiting low contrast between the geology and the remains of human activity can give evidence of false anomalies because of the redundancy in the mathematical processes involved in creating maps of this sort. This is consequence of the general trend in archaeological geophysics to seek increasing detail in the description of structures. The data processing conducted at Tchinguiz Tepe, however, has been notable in minimising artifacts. Accepting the need to gather maximum data at each location, the process of creating horizontal slices has nevertheless shown that more information is obtained and the information is clearer if a large pixel size is used (0.25m), as in data-gathering process B. Other processes offering more detailed visualisations (pixels of 0.125 or 0.15m in size) also pose a greater number of doubts for interpretation (compare corresponding graphics).

Termez Project. Georadar Survey. Tchinguiz Tepe
Grid RC. Slices 1-6 (0-0,6)





Location of grid RC



Layout of detected structures

In conclusion, when the environmental and built setting is hostile and of low contrast, the most fruitful data-processing option is to sacrifice detail in the interests of greater reliability. Although the images are more schematic in nature, they will also be less subject to adverse artifacts generated by the mathematical processes being applied. The variations caused by small subsurface objects will be highly localised as well.

In the preceding pages, the structures described have mostly been located in layers calculated at between 0 and 1.5m below the surface. As noted earlier, data quality has been adversely affected by external interferences. Even so, the results obtained in a number of grids have been consistent with the structures delineated in the reports of excavations carried out in 2004 and 2005. Although the task of archaeological verification and analysis of the structures remains to be done, three essential aspects identified in the georadar survey should be highlighted.

1 Levels. In light of the results, three basic levels have been detected. They are related to the successive occupations of Tchinguiz Tepe. An initial level, which concerns modern and contemporary activities (e.g., trenches for manoeuvres and baked brick structures), can be detected at the surface and descends through the first 40cm of depth. A second level, which is formed by the structures related to the defensive perimeter and the system comprising the inner military access road and secondary wall, is detected in all points explored adjacent to the wall between 0.4 and 0.9m in depth. Lastly, a third level, associated with the built structures oriented at angles divergent from the defensive perimeter, are located in layers between 1 and 1.5m below the surface.

2. Orientation. One matter that has remained unknown since the data processing began is why the orientations of the structures detected near the defensive perimeter are different from the orientations of the structures farther to the west. The data resulting from the survey reinforces the notion that there are indeed systems with divergent orientations between the interior walls and the defensive system, particularly between the second and third levels. There is, therefore, a further need to study the stratigraphic and chronological relationships between the two sectors and levels[7].

7.- Temple building in the centre of the enclosure, clearly bearing the same orientation as the defensive perimeter, although located at some distance from it.

3. Topography. The general topographical map of Tchinguiz Tepe provides evidence that is still unclear on the extent of occupation, the building programme pursued within the enclosure and, particularly, the reason for some of the elevations to the north. The results obtained from surveys of RT1 and RT2, which are located against the talus slopes north of the enclosure, have shown structural elements related to slope construction. It could be highly useful, therefore, to clarify the transformations made to the geological base, and employing a larger survey grid over the same slope would help to increase the descriptive precision of any archaeological remains that may be there.

Obviously, these three aspects are of great archaeological importance in the study of Tchinguiz Tepe. It should also be kept in mind, however, that future excavations or surveys could greatly expand on the usefulness of the data obtained in the 2006 season and any methodological aspects derived from it.

Final reflections on the results of the 2006 season

The geophysical research was limited to two main purposes. Although the main aim of the survey was to describe cultural remains using non-destructive methods, the great scientific and methodological challenge of the two seasons has been to find a specific protocol or methodology that could obtain reliable images of structures built in adobe or uncooked bricks, and do so in environmental conditions of extremely low humidity.

In other words, the aim was to take the empirical experience gained from field work, analysis of the results and comparison of the results with excavation results and then devise a non-destructive survey methodology that would better enable us to describe archaeological sites of these characteristics, extremely common from the Middle East to Central Asia.

During the 2006 season, the survey was carried out over parts of the Tchinguiz Tepe and Kara Tepe sites, using magnetic gradiometry (FM-256) and georadar (GSSI SIR-3000) with a 400MHz antenna. Given the subtlety of the physico-chemical changes between the sediments and built structures, it was necessary to try using different systems that, theoretically, could provide results. Their efficacy then had to be verified in practice.

Analysing the data from the first season revealed that magnetic gradiometry was entirely ineffective in providing useful results for the description of urban areas or large elements. The data obtained with georadar, however, have been much more useful in describing the Tchinguiz Tepe site. Although there were a number of severe interferences experienced because of the activities of the nearby military base and airstrip, most of the data could be processed through GPR-Slice v.5 software, generating images that map the various layers of the detected anomalies. The data-filtering process provided one of the keys for the direction of the 2007 season: in numerous instances of data processing, it was seen that the radar captured only a very subtle variation in amplitude and frequency between a wall and wind-borne in-fill. The resulting visualisations showed very low levels of contrast, which hindered interpretation. Another factor that was verified was that the survey density used in 2006 (50x2.5cm) limited interpolation to roughly 12cm per pixel, at which point the structures began to appear more confused and complex, becoming statistical artifacts. On the other hand, a more schematic interpretation resulting from the use of larger pixels (25-30cm) required less interpolation and was more beneficial in the identification of structures. A similar process was used in addressing the numerical resolution of the readings (i.e., the disparity between the maximum and minimum values of detectable amplitude), because it could be seen that the original 16-bit data presented a dynamic range that was too broad for a graphic of only 256 colours. Converting the original data to 8 bits gave acceptable results in some of the grids, enabling clear identification of the military access road inside the wall and a number of rooms.

Consequently, if the most suitable process for surveying adobe structures was related to spatial resolution and frequency, a plan was needed for a new survey applying the modifications emerging from the data obtained in the previous season. As a result, GSSI SIR-3000 equipment was used with a 270MHz antenna. For readings, the numerical resolution was set at 8 bits, the frequency was set at 40sc/m (2.5cm), and the radargrams were taken 0.4m apart. The survey covered a total of 9 grids of varying sizes.

Archaeological follow-up planned

The results of the georadar survey done during field work at Tchinguiz Tepe in the September 2006 season were the subject of intense work in the ensuing months, and they have recently been made public. They led us to reconsider the next steps in our geophysical surveying plans. As a result, the archaeological activity focused on three areas, all three of which logically have been surveyed using georadar. The main objective was to compare the geophysical results with earlier archaeological records in order to verify whether there was any occupation, presumably of ancient Kushan origin although affected by later activities in the Sassanian period. As noted earlier, the survey focused on three geographical points, two of which lie in areas near or over the wall and the third of which is located in an area connecting the lower part of Tchinguiz Tepe with the higher, apparently monumental, space near the northeast edge of the wall. In terms of the geophysical survey, the three points offered clear indications of complex structures that were hard to delineate. Only subsequent archaeological work would be able to provide such clarity. In this respect, two main objectives were established for our subsequent season of geophysical surveying using georadar. The first was to survey the three points again, but with a new antenna over smaller grids, in order to expand on the geophysical information from the previous season and compare the two sets of geophysical information with the archaeological information gathered subsequently. The second objective was to extend the geophysical survey using radar to spaces as yet unsurveyed, basically in the southwest sector. Surveying there would be affected largely by the state of the site's surface, which has been heavily disturbed by military training activities in the contemporary period.

The final outcomes of this research need to investigate the relationship between the real data and the data obtained by sensors, then propose with a survey strategy aimed at obtaining the maximum output from the geophysical surveying of arid environments and adobe structures.

Looking at the results from the survey carried out on the Tchinguiz Tepe slope running up to the upper platform (RT1 and RT2), it was felt advisable to conduct a further survey that would focus on an area nearly coinciding with the RT2 platform. It was decided, however, to survey over a greater area at higher amplitude, connecting the lower survey areas (RL and RC) with the platform.

Geophysical Survey at Tchinguiz Tepe in the 2007 season (Termez, Uzbekistan)

Roger Sala, Maria Lafuente and Josep M. Gurt

Research context

Within the context of the Catalan archaeological mission in Uzbekistan since 2006, geophysical surveys have been carried out to describe the archaeological remains at the Tchinguiz Tepe site. The work has also included other less substantial interventions at the Kara Tepe and Zurmala sites. The geophysical research covers two principal vectors. Although the main aim of the survey is to describe the cultural remains using non-destructive method, the great scientific and methodological challenge of the two seasons has been to develop a specific protocol or methodology able to obtain reliable images of structures built of adobe or uncooked bricks, in environmental conditions notable for their extremely low levels of humidity. In other words, the aim was to build on the empirical experience gained during field work, the analysis of results and their comparison with excavation results in order to devise a non-destructive survey methodology that would better enable us to describe any archaeological sites of these characteristics, which are extremely common from the Middle East to Central Asia.

In the 2006 season, surveying was carried out over portions of the Tchinguiz Tepe and Kara Tepe sites, using magnetic gradiometry (FM-256) and georadar (GSSI SIR-3000) with a 400MHz antenna. Given the subtlety of the physico-chemical changes present between the sediments and built structures, it was necessary to try using different systems that, theoretically, could deliver results. Their efficacy then had to be verified in practice. Analysing the data from the first season revealed that magnetic gradiometry was entirely ineffective in providing useful results for the description of urban areas or large elements. Surveying a pottery kiln at the nearby site of Kara Tepe did, nonetheless, give optimal results in determining the location and identification of the objective. The data obtained with georadar, however, have been much more useful in describing the Tchinguiz Tepe site. Although some episodes of severe interference were experienced because of the activities of the nearby military base and airstrip, most of the data could be processed through GPR-Slice v.5 software, generating images that map various layers of the detected anomalies. The data-filtering process provided one of the keys for the direction of the 2007 season. In numerous instances of data processing, it was seen that the radar captured only a very subtle variation in amplitude and frequency between a wall and wind-borne in-fill. The resulting visualisations showed very low levels of contrast, which hindered interpretation. Another factor that was verified was that the survey density used in 2006 (50x2.5cm) limited interpolation to roughly 12cm per pixel, at which point the structures began to appear more confused and complex, becoming statistical artifacts. On the other hand, a more schematic interpretation resulting from the use of larger pixels (25-30cm) required less interpolation and was more beneficial in the identification of structures. A similar process occurred with the numerical resolution of the readings (i.e., the disparity between the maximum and minimum values of detectable amplitude). It was verified that the original 16-bit data presented a dynamic range that was too broad to be represented in a graphic of only 256 colours. Converting the original data to 8bits gave acceptable results in some of the grids, enabling clear identification of the military access road inside the wall and a number of rooms.

Season objectives

Consequently, if the most suitable process for surveying adobe structures was related to spatial resolution and frequency, a plan needed to be formulated for a new survey applying the modifications emerging from the data obtained in the previous season. In this case, GSSI SIR-3000 equipment was used with a 270MHz antenna. For readings, the numerical resolution was set at 8bits, the frequency was set at 40 sc/m (2.5cm), and the radargrams were taken 0.4m apart. The survey covered a total of 9 grids of varying sizes. In two of the locations, excavations would be conducted to compare the results with the results obtained from the georadar survey. The aim was to use the information obtained from the process to validate or correct the survey results, using a detailed description of the archaeology to clarify the outcome. The final result of the research would need to investigate the relationship between the real data and the data obtained by sensors, then come up with a survey strategy that would be able to obtain the maximum output from the geophysical surveying of arid environments and adobe structures.

Survey strategy

In accordance with the conclusions reached from the 2006 season data, survey locations were chosen and modifications made to the data-collection parameters. As shown in figure 1, the seven survey grids chosen lay within the walled perimeter of Tchinguiz Tepe. Of the seven grids, three (grids CRH, O-P and C) covered georadar survey areas from the 2006 season, involving a 400MHz antenna. Archaeological excavations were conducted in the three grids to verify the results and validate the effectiveness of the changes introduced in the survey and data-processing strategies.

The results obtained in 2006 clearly showed the vulnerability of survey systems to external interferences when anomalies present low contrast. Another problem related to the antenna's frequency became apparent when the data were processed using a background filter. While the filter removed most of the noise, it also reduced the differences between detected structures and the sediment to very subtle values. As a result, any variation in the antenna's contact with the ground or any large metallic element on the surface led to anomalies that were dozens of times greater than some of the subsurface structures. Consequently, the maps or horizontal plans posed many contrast problems, because the elements of interest for surveying gave very low, fragmented values. The strategy chosen to rectify the issue involved using a very low frequency antenna (GSSI 5103 model with 270MHz). The aim of the strategy was to obtain a much less erratic response, since medium and low frequency antennas give a longer wavelength or, what amounts to the same thing, they are much less disturbed by small subsurface objects and generate more schematic images. In addition, the antenna that was used has a higher penetration power and lower sensitivity to high-frequency interferences of the sort encountered in the 2006 season.

The adjustments made to the reading parameters of the georadar system focused on three aspects:

a. Modifying reading densities. The results of georadar surveying in 2006 revealed that the reading density on each axis is of paramount importance to obtaining comprehensible results. As has already been shown, the geological and built materials of the walled enclosure are limited to loess sedi-ments, the remains of buildings and their disintegration, and the geological rock base (sandstone). The considerable similarity in the responses obtained by georadar from these materials narrows the diffe-rences between loess and the built structures to a very small part of the signal. In other words, the threshold of values that distinguishes a structure from the loess covering it is very subtle. Obviously, in this context, the gap between readings is crucial to ascertaining a correct representation. Figure 1 diagrammatically represents the change in resolution due to changing the spatial reading parameters from 0.5m to 0.4m of separation between radargrams (keeping a final resolution of 0.2m constant in the y-direction) when defining an imagined structure that has been fully captured. In wide-area georadar surveys, it is common to work in grids employing reading densities marked by a disparity between one axis (i.e., in the direction of the radargram system's sweep) and the other axis (i.e., the gap between radargrams). This is not an obstacle to obtaining good results if the contrast is high between the structures being described and any irrelevant ones. If the resolution is increased along the x-axis (i.e., the gap between radargrams), the possibility is diminished that numerical artifacts will be generated when interpolating the results, because the disparity among the data contained on each axis is reduced.

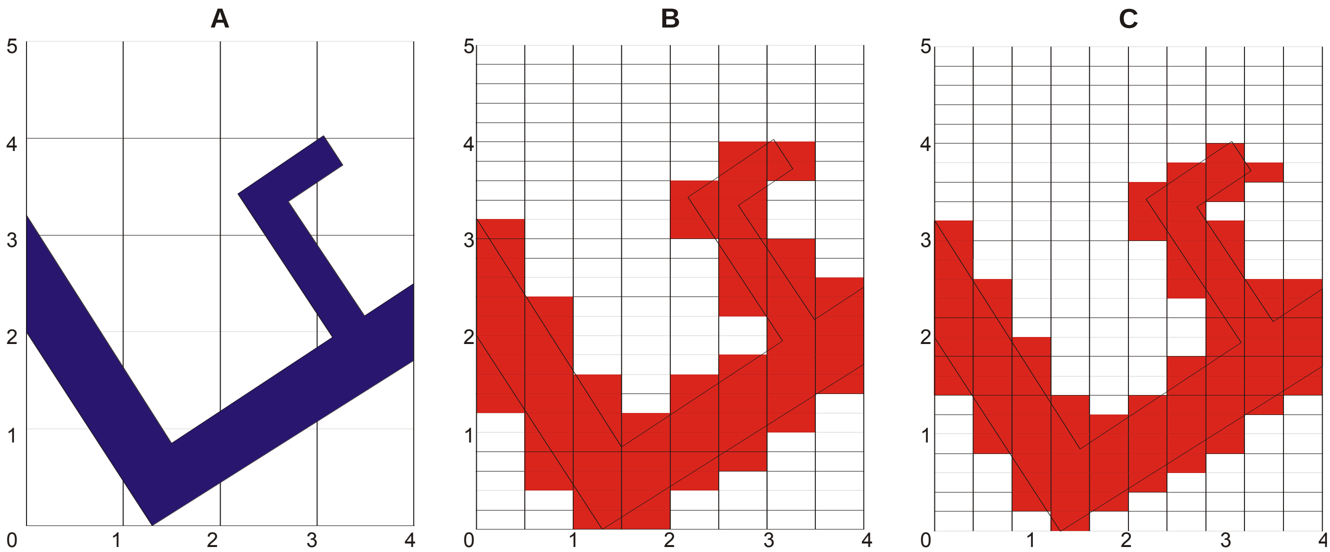
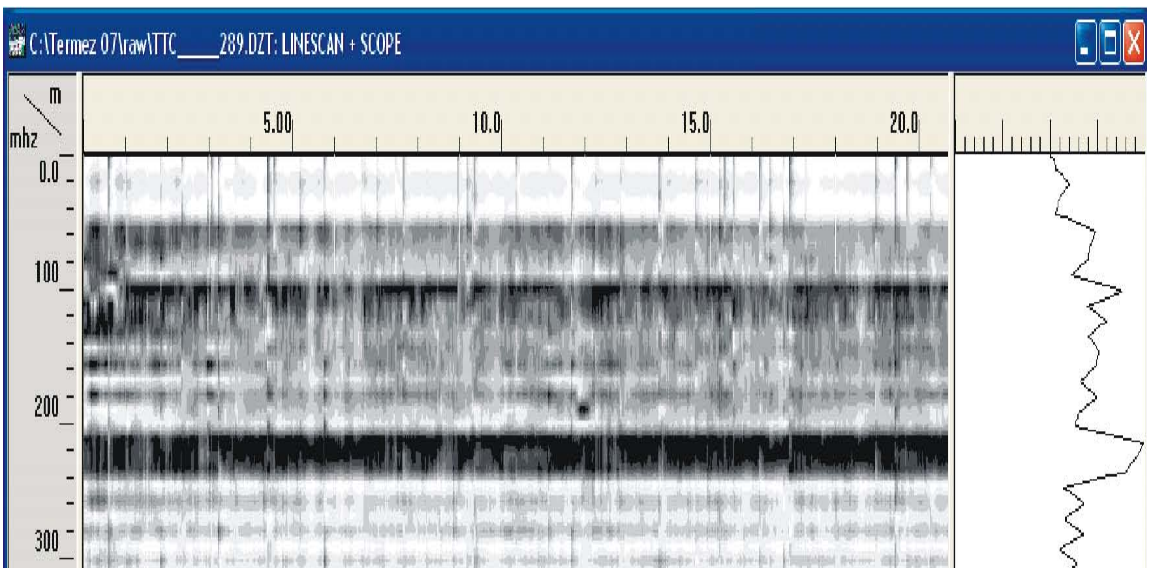


***Figure* 1.** Alias effect and spatial resolution in a survey. An imaginary grid (A) contains an ideal anomaly caused by a structure (in blue) which has geophysical properties differentiated from the sediment covering it. B represents an ideal image of the structure obtained with a final resolution of 0.5x0.2m. C shows the image with a resolution of 0.4x0.2m.

b. Data-collection parameters. The adjustments made to the georadar system for data-gathering purposes met the general criterion of changing the signal as little as possible in order to obtain results that would enable the post-processing work to be as open it could be. As a result, only high-pass filters (90MHz) and low-pass filters (700MHz) were applied to the signal recorded by georadar. As in the 2006 season, episodes of interferences were detected during field work and the effect was to invalidate some of the radargrams, especially in grid L.



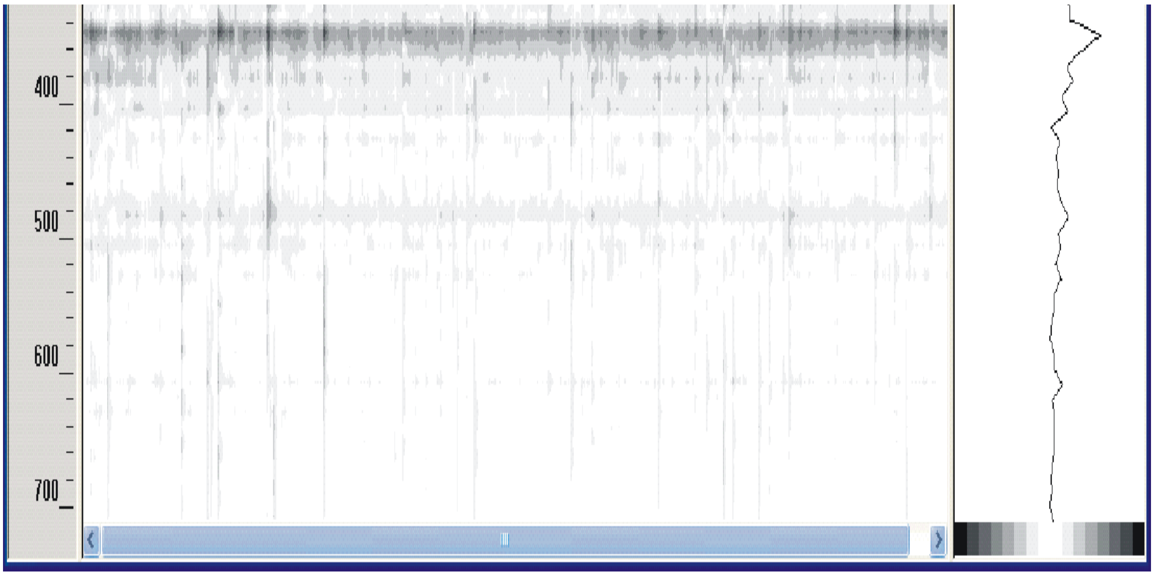


Figure 2. Frequency spectra of radargrams 289 and 306 from grid L, obtained a few minutes apart. The spectrum of radargram 289 is very erratic and broken and a strong interference appears between 220 and 250 MHz.

c. Reading distribution was maintained at 40 scans/metre (1 scan=2.5cm) and 512 samples per scan, at an exploration depth of 90 nanoseconds (see figure 3).

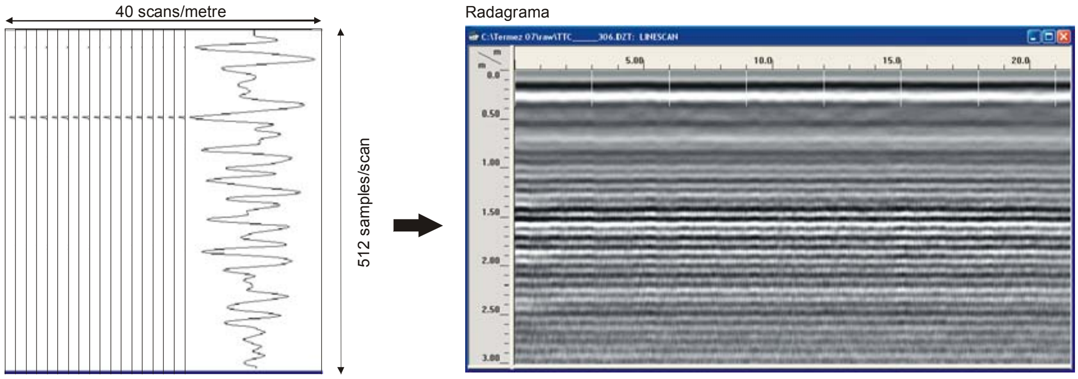


Figure 3. The radargram is an expression of the response oscillations captured by radar. The reading parameters used are indicated.

d. Lastly, owing to the confirmed necessity of maintaining the signal at maximum stability, the position of the cable joining the antenna to the central unit was kept as immobile as possible in order to minimise any noise produced by the movement of the apparatus (see figure 4).

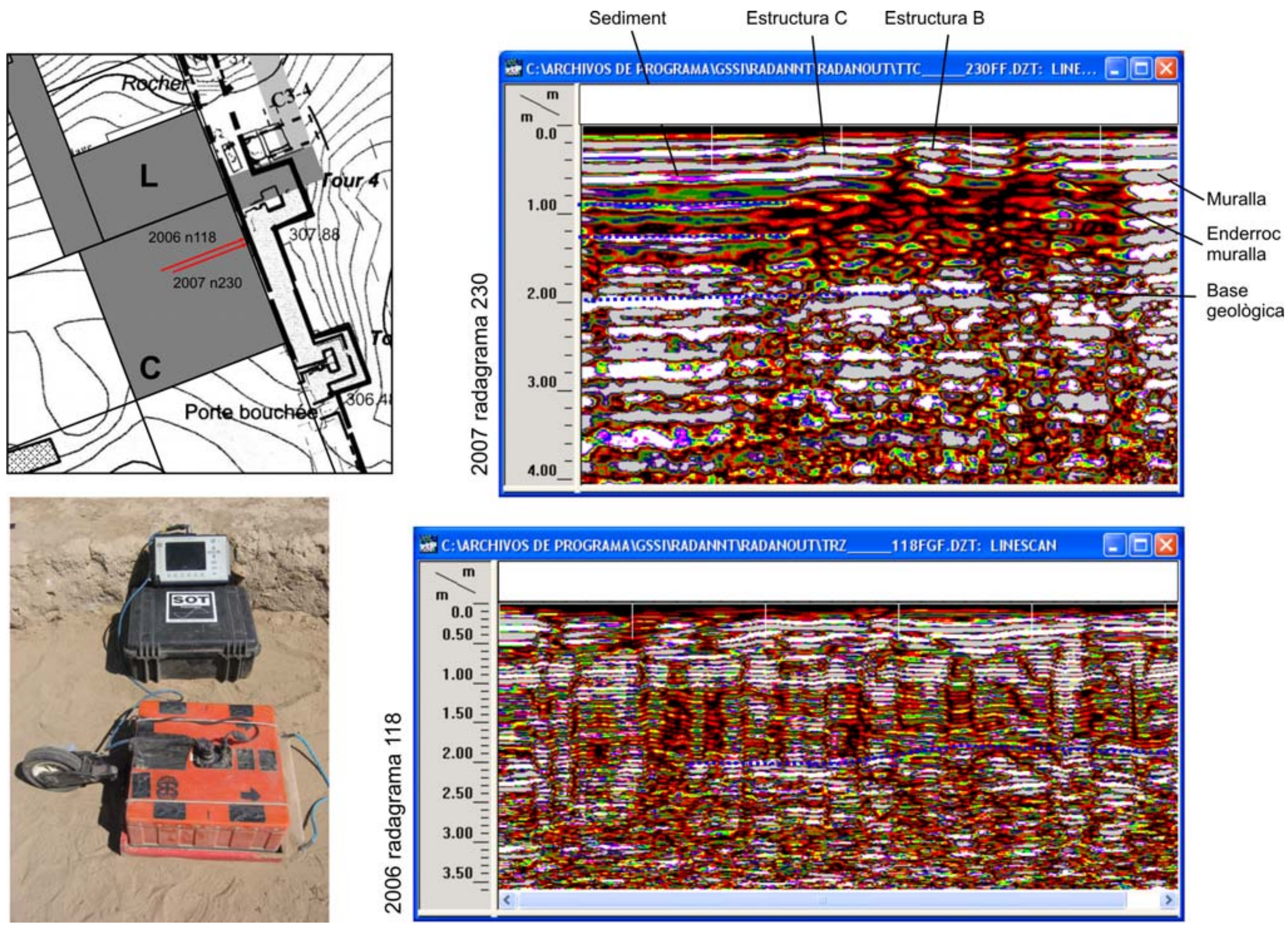


Figure 4. Differences between the data collected in the 2007 season with a 270 MHz antenna (top right) and in 2006 with the 400 MHz antenna (bottom right). The radargrams correspond to positions near grid C (top left). The lower left image is a result of the GSSI SIR-3000 system and a 270MHz antenna, with the signal cable kept still.

Signal processing and visualisation

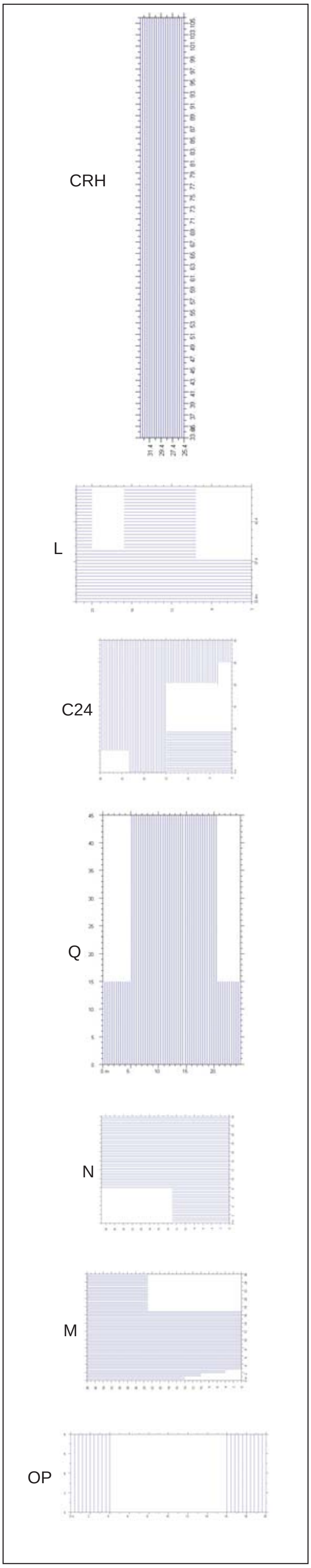
The analysis and numerical processing of the data obtained so far at the Tchinguiz Tepe site have served to establish what the data problems are. There are two aspects: the spatial relationship of the data collected and the low contrast of the subsurface elements to be described. While the description above covers the corrections applied to reading density, the use of a lower frequency antenna (270MHz) and other procedures used in the field, signal processing and visualisation are the stages at which the collected data must be transformed into subsurface maps.

The method used for visualisation and analysis of the results is the one known as time-slicing (Goodman). It is used for interpolation based on known data (radargrams), generating a volume of three-dimensional data on the explored area that can be visualised on all three axes. In this way, the entire analysis and signal-processing effort has led to the production of images mapping the detected structures with the best definition possible. Thanks to the excavations carried out by the Mission's team of archaeologists, an initial test pit was dug in grid C. It served to verify that the best results-i.e. the results that best matched the excavated structures-were the ones obtained using radargrams processed with a background filter. That has led to a refocusing on the data obtained in 2006, which have been processed again using a background filter to verify similarities and dissimilarities in the results from the excavated area of grid C.

Georadar survey results

Applying the changes mentioned above to the parameters and data-collection strategy, seven locations were explored within the site's perimeter (see graphic 1).

Diagram showing position of readings



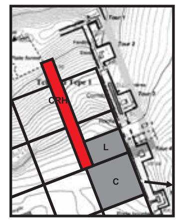
Graphic 1: Termez Project. 2007 Season. Georadar Survey at 270MHz. Explored Areas

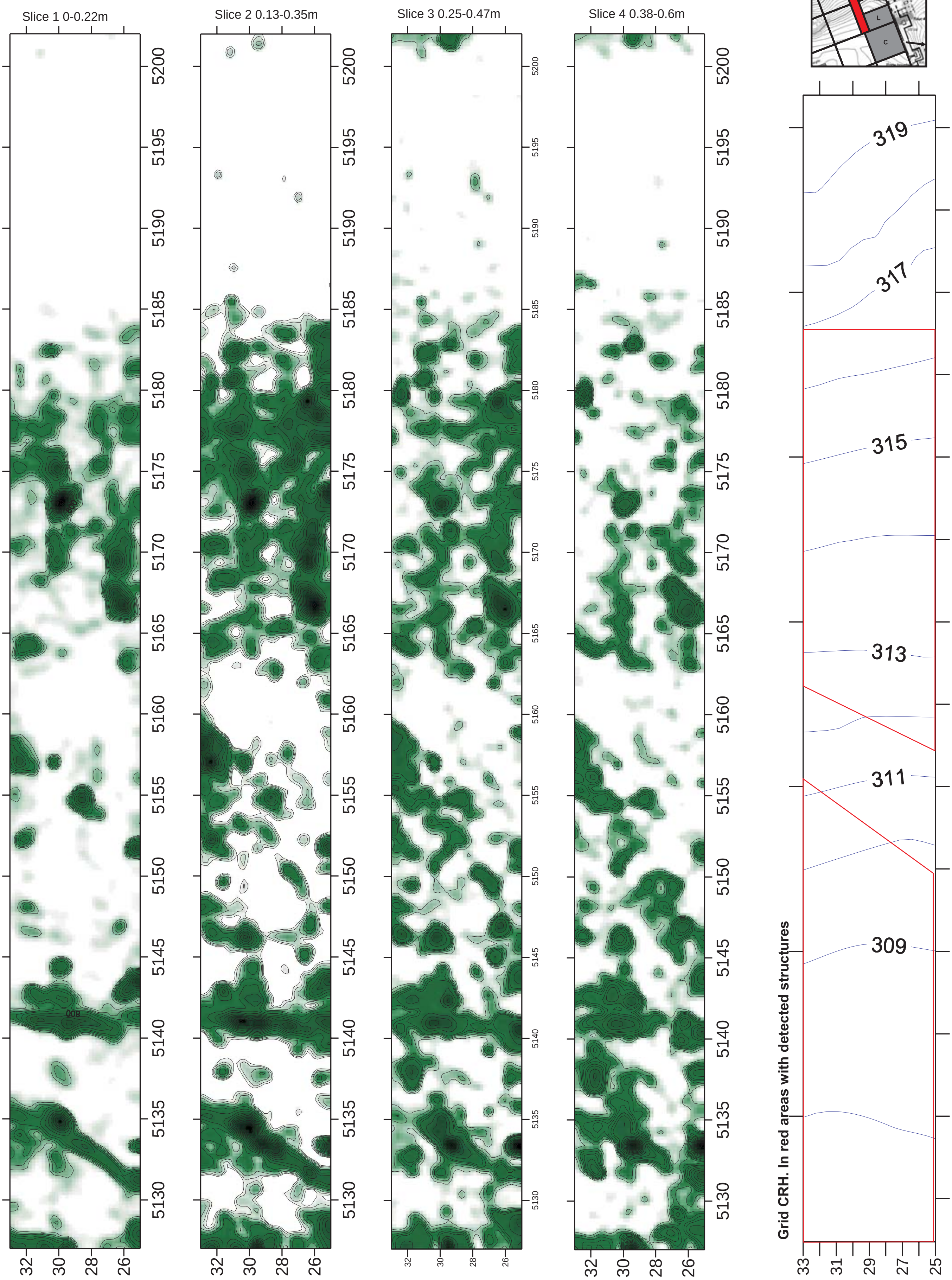
Grid CRH: This exploration area was located on the north-south slope. It covered an area measuring 8x76m and an altitude differential of 13m. The method used for signal processing and visualisation of the data corrects the data in terms of topography and direction, and it is available with the software programme GPRSlice[1] . The method can correct the geometric deformation of the results by righting any tilt of the antenna that may have occurred at the time of data collection.

The results (see graphic 2) have uncovered the presence of built remains in two level areas of the grid. Graphic 3 shows slices 2-4 of the grid, corresponding to the area that is more level, located to the south. In this area, groups of structures 1, 2 and 3 are detected. They are situated only a few centimetres below the surface and have orientations similar to the structures detected in grids C and G (2006 season). The excavated area to the north of grid CRH is shown separately in graphic 4.

1.- Goodman correction

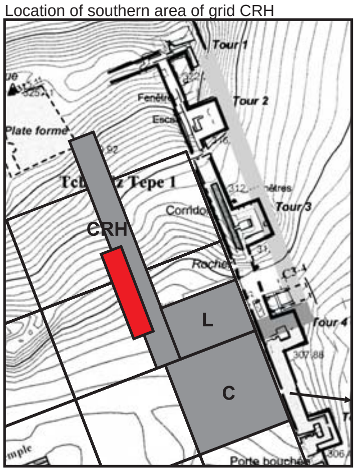
Graphic 2:
Termez Project. 2007 Season.
Georadar Survey at 270MHz.
Horizontal slices without topographical correction

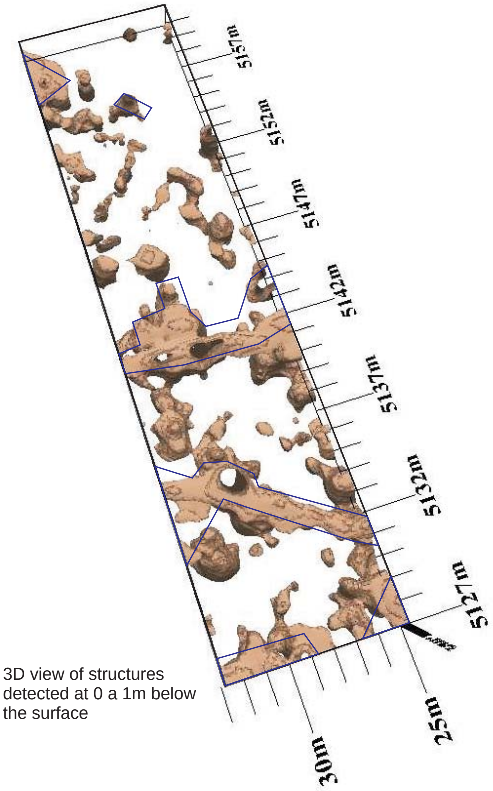




Graphic 3:
Termez Project. 2007 season.
Georadar survey at 270MHz.
Grid CRH
Detailed view of sothern area

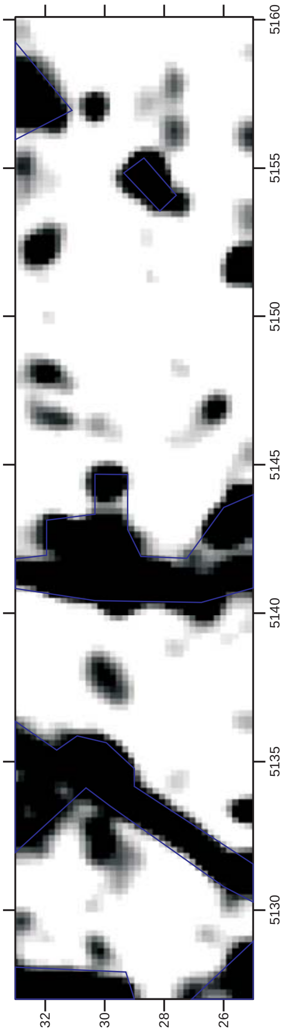
Location of southern area of grid CRH



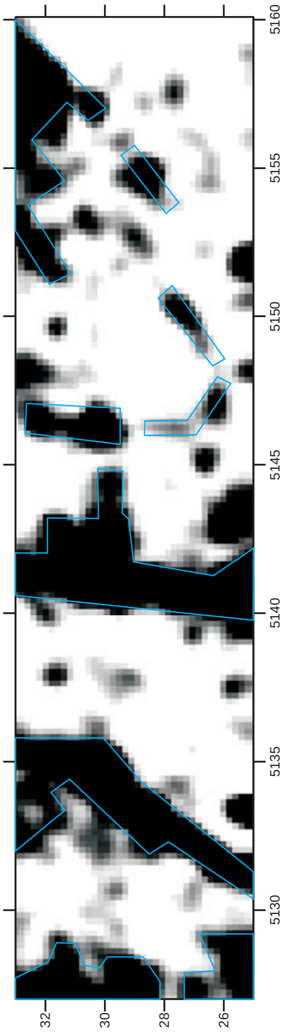


3D view of structures detected at 0 a 1m below the surface

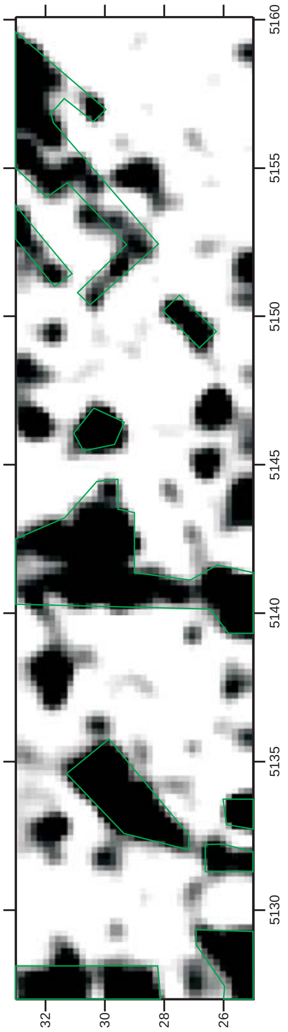
Slice 2 0.13-0.35m



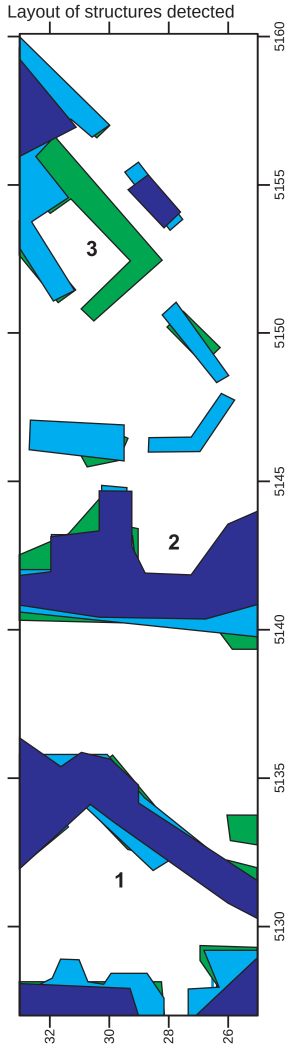
Slice 3 0.25-0.47m



Slice 4 0.38-0.6m

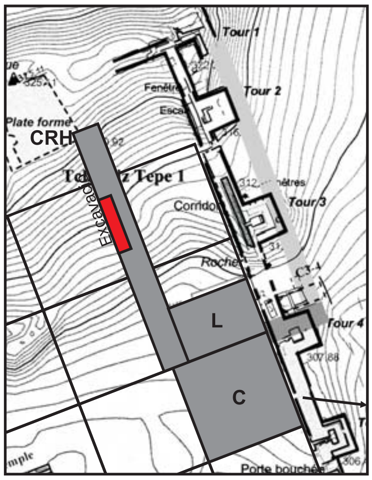


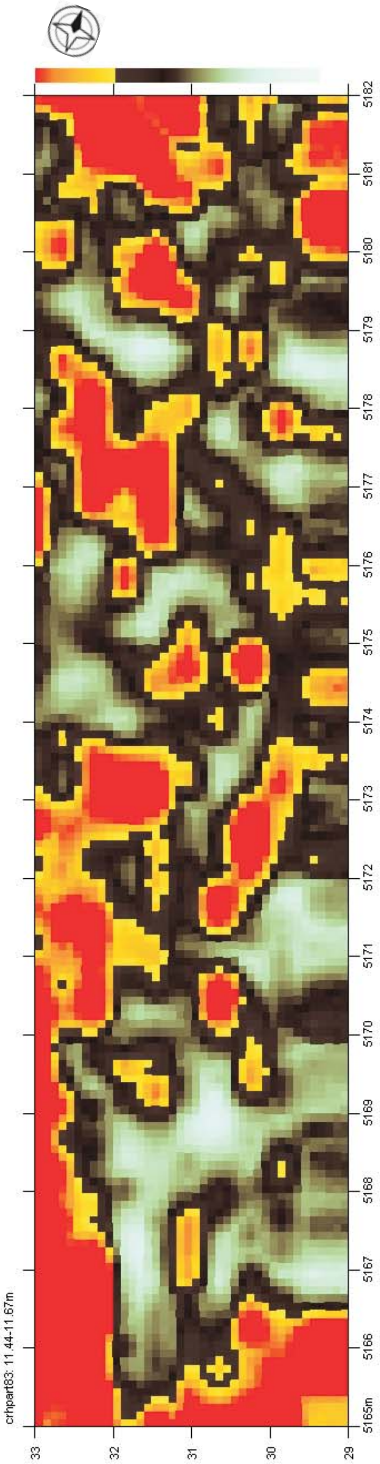
Layout of structures detected



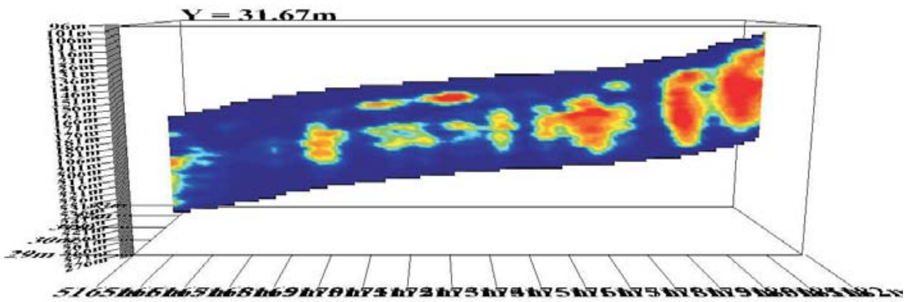
Graphic 4:
Termez Project. 2007 Season.
Georadar Survey at 270MHz.
Grid CRH
Excavation area

Location of grid CRH and detailed view of excavation area

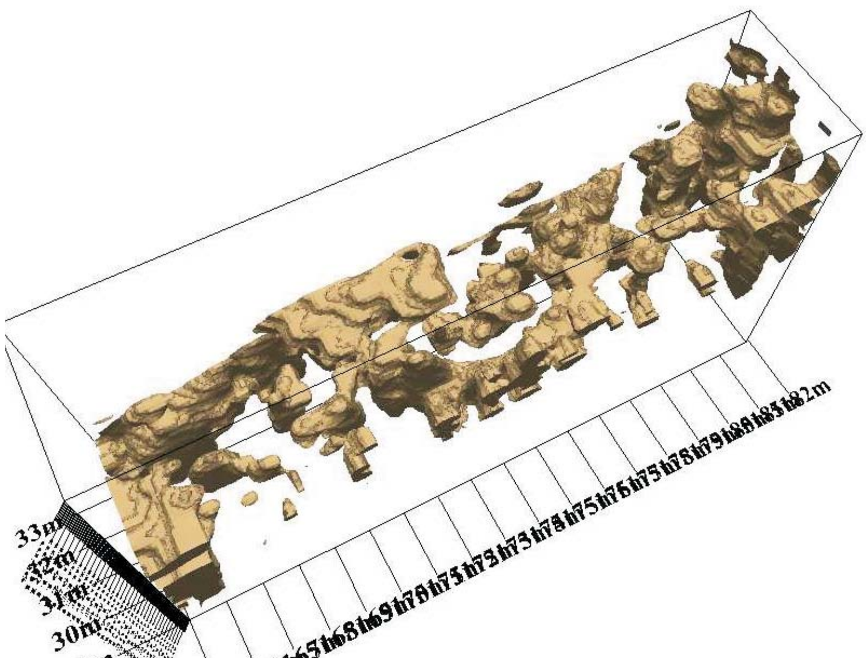




Superimposition of horizontal slices 1-59



Vertical cross-section obtained by georadar survey of excavation area. View from E

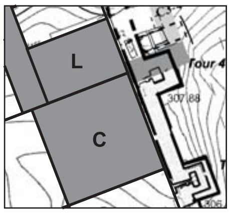


3D rendering of the georadar surveys results
of the excavation area
View from SE

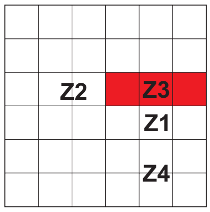
Grid C: Grid C runs parallel to the inner face of the wall between towers 4 and 5. The same location was explored in the 2006 season but work was constrained then because it had served as a dumping ground for previous excavations. As a result, it was decided to remove the detritus in the 2007 season and a test pit was dug in the central area of the grid. The grid has been divided into four parts according to the time and direction of data collection to accommodate the processing and interpretation of results. Area C3 (15x5m) corresponds to the space excavated at the foot of the wall. As in area C1, data collection was carried out in the first days of fieldwork and the surface of the area had been cleared of its surface stratum (5-10cm). Four anomalies A, B, C and D were detected that were identified as built remains. The vertical profile of the anomalies can be seen in the slices in graphic 6. Graphic 8 shows the overall processing result for areas C1 and C3, where clear continuity is apparent between the structures delineated in the excavation of C1 in the direction of C3. C2 and C4 (30x30m, irregular) are the largest areas and they have made it possible to describe a group of highly superficial anomalies, which are also identifiable as built remains, particularly in the case of structures E, F and G. Graphic 7 shows interpretations of the structures in diagram form.

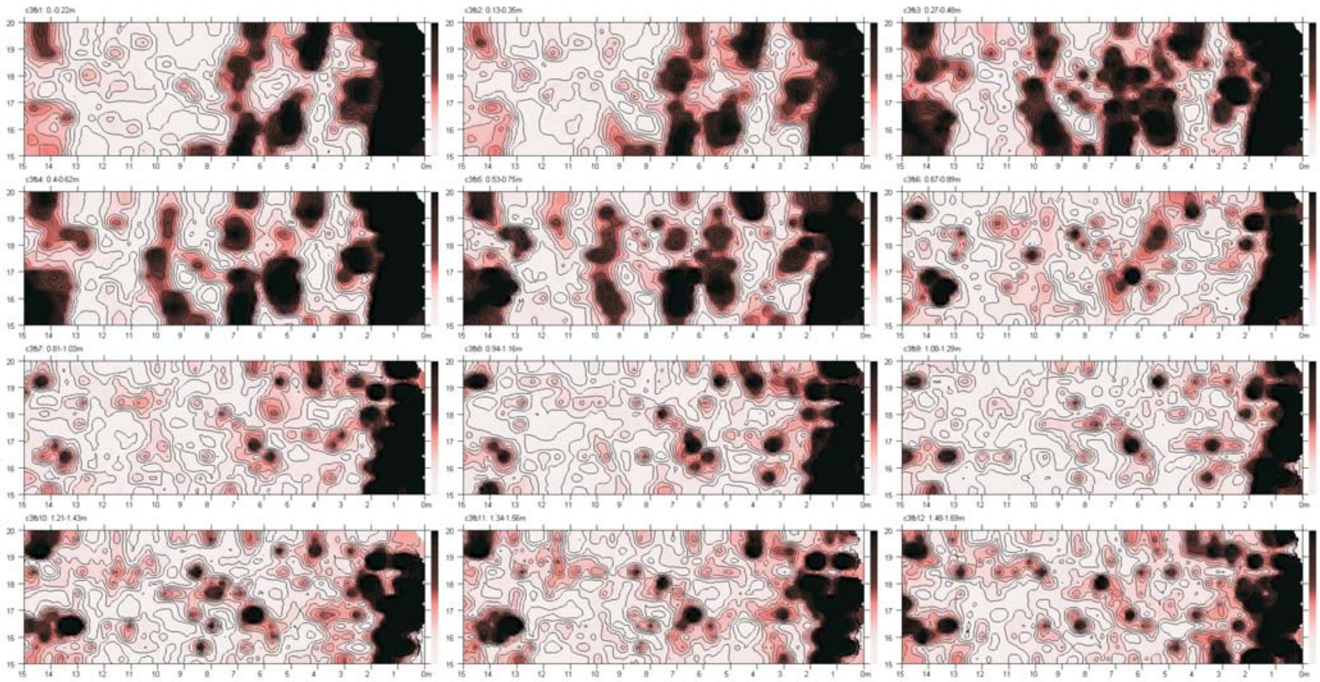
Graphic 5:
Termez project. 2007 season.
Georadar survey at 270MHz.
Grid C area 3
Excavation area

Location of grid C

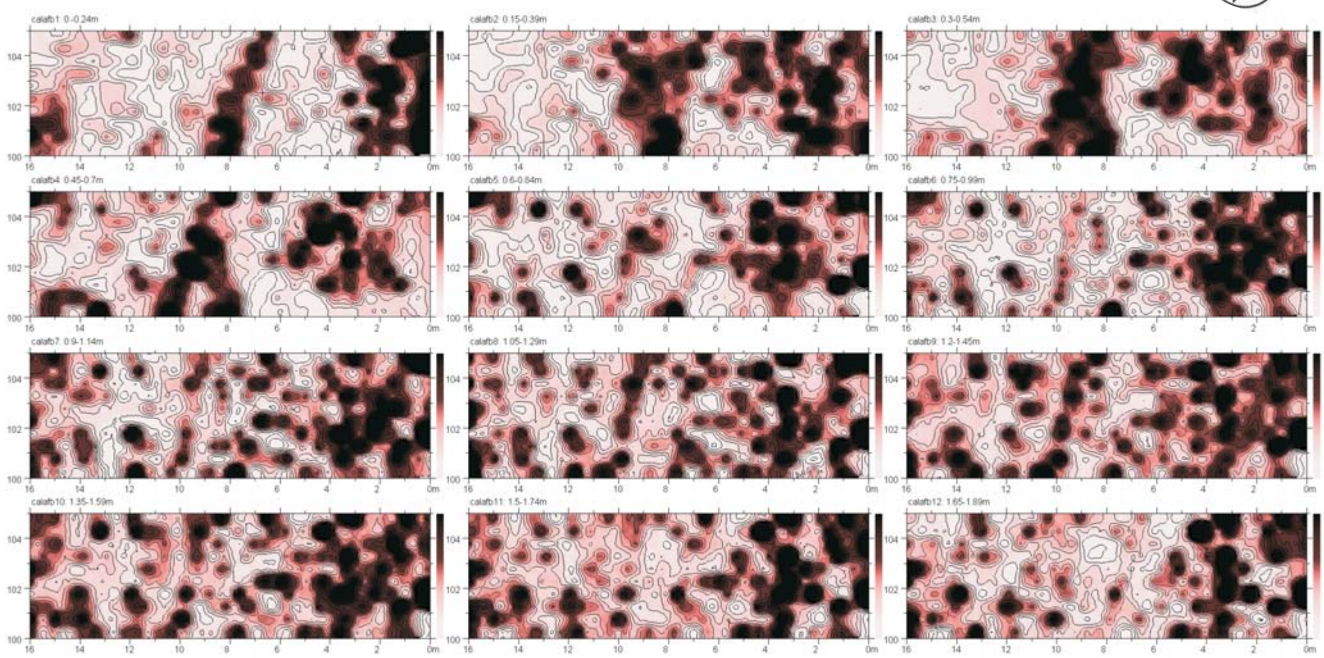


Divisions of grid C



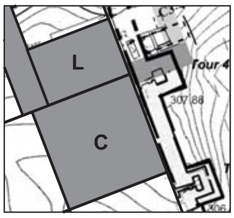


Termez project. 2007 season.
Georadar survey at 270MHz.
Grid C area 2
Excavation area
(400MHz Data from 2006 season)

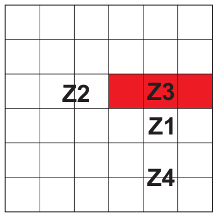


Graphic 6:
Termez project. 2007 season.
Georadar survey at 270MHz.
Grid C Area 3

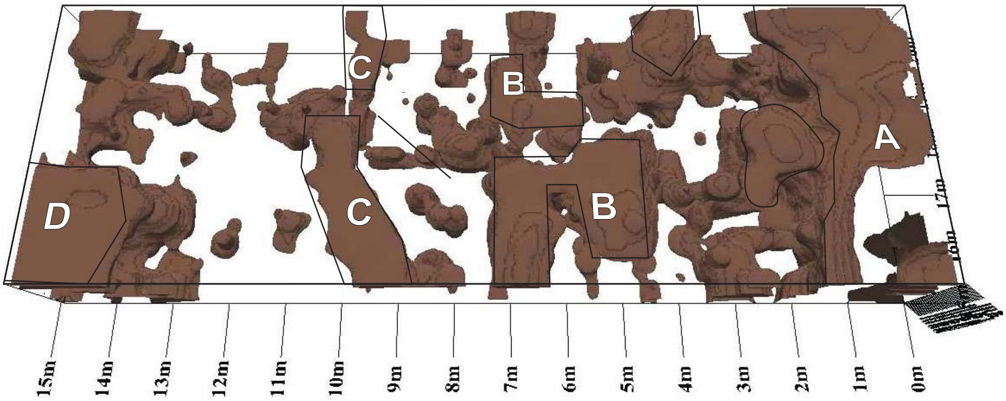
Location of grid C



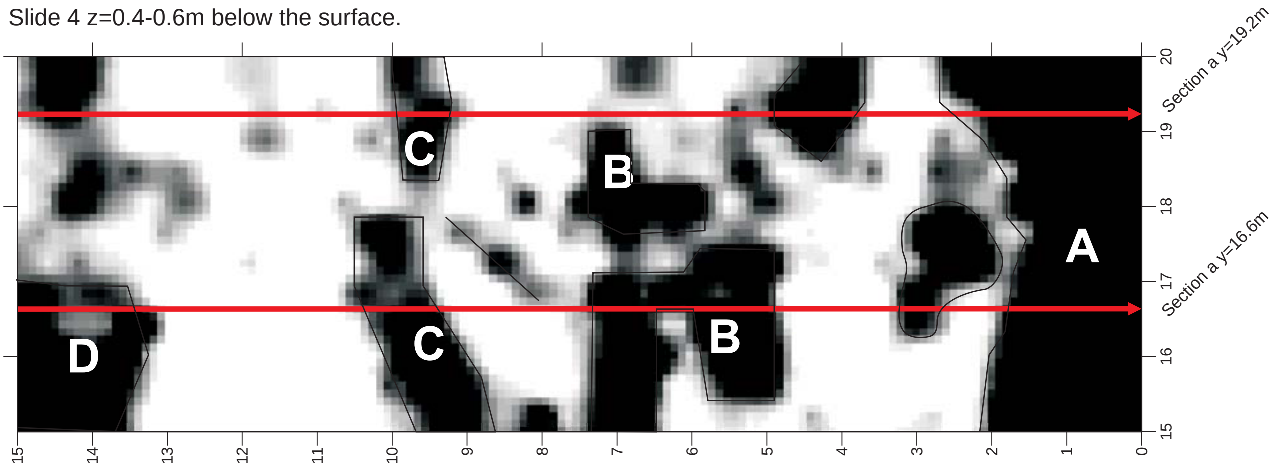
Divisions of grid C



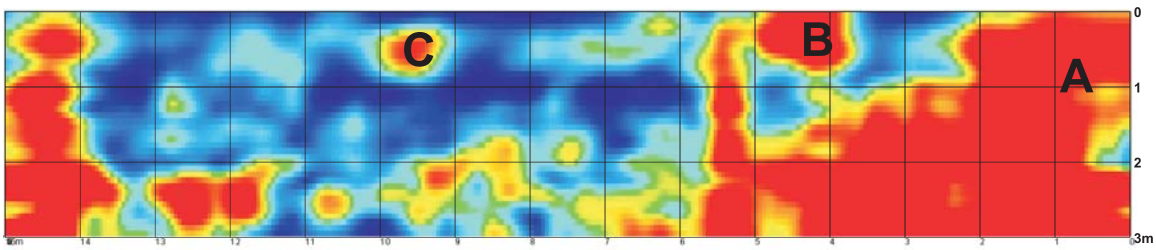
3D view of structures detected
at 0 to 1.8m below the surface.



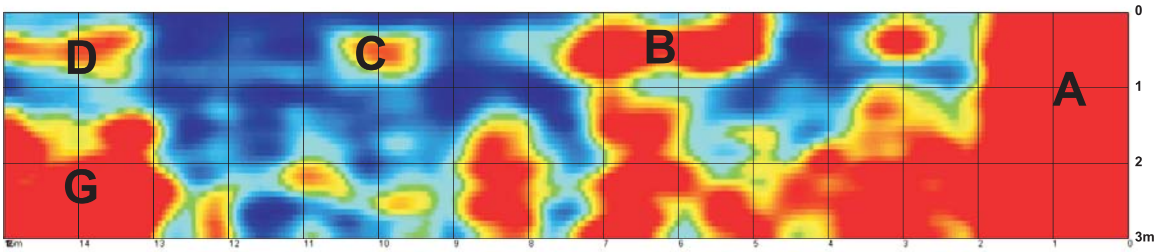
Slide 4 z=0.4-0.6m below the surface.



Section a y=19.2m

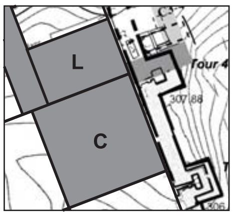


Section a y=16.6m

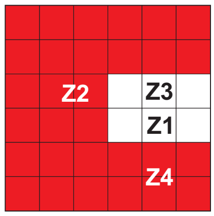


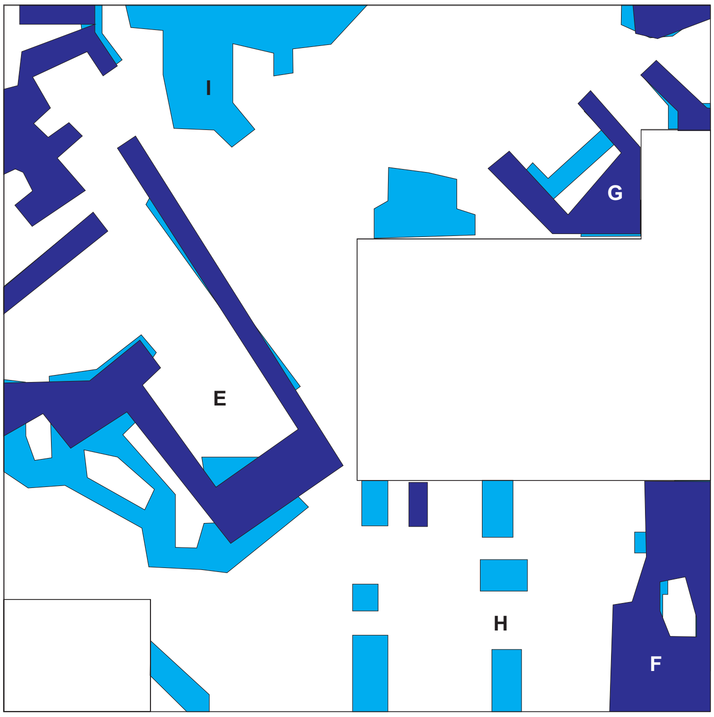
Graphic 7:
Termez Project. 2007 Season.
Georadar Survey at 270MHz.
Grid C Areas 2 and 4

Location of grid C

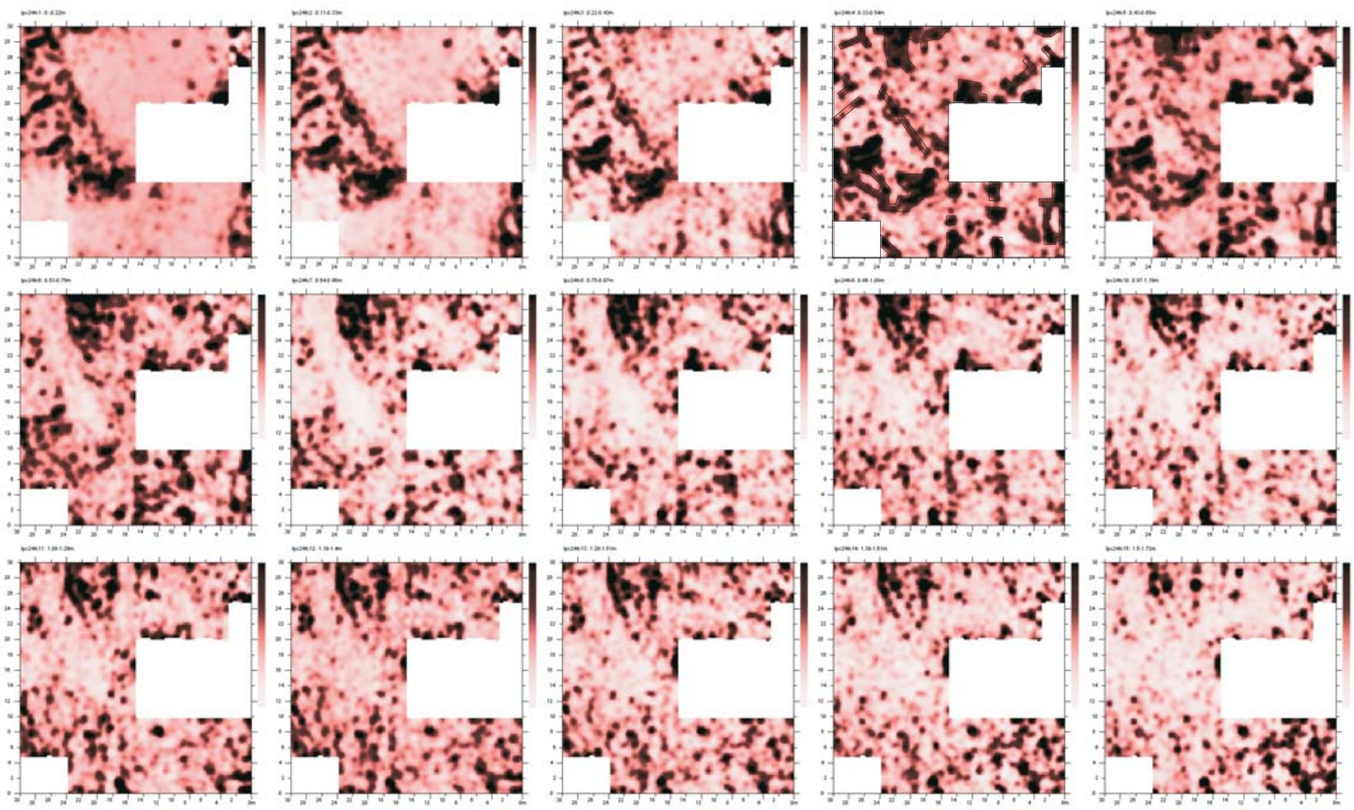


Divisions of grid C



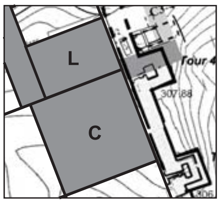


Layout of detected structures

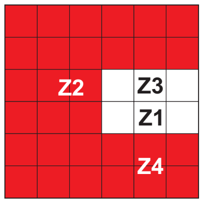


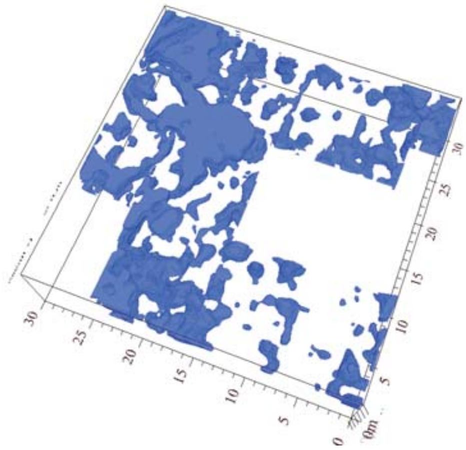
Graphic 7b:
Termez Project. 2007 Season.
Georadar Survey at 270MHz.
Grid C Areas 2 and 4

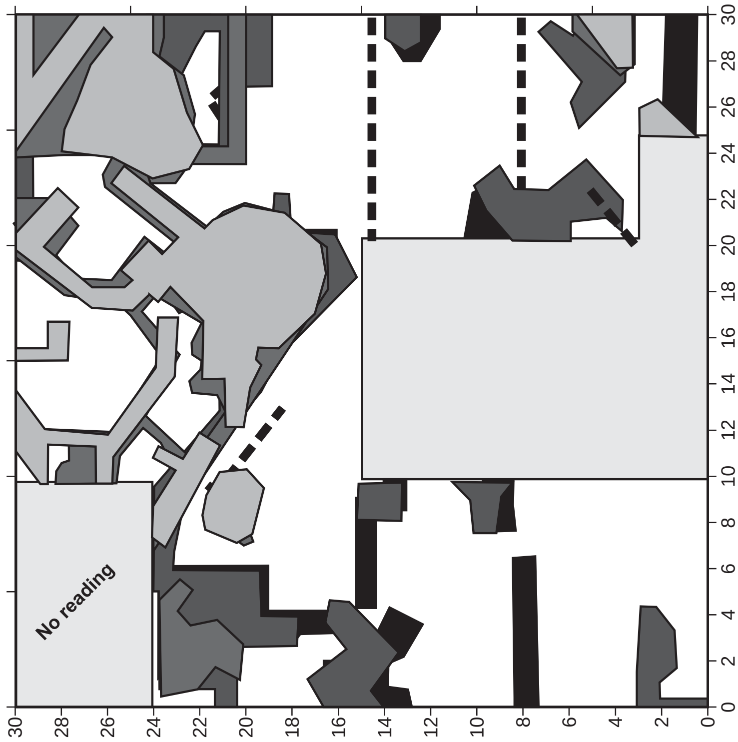
Location of grid C

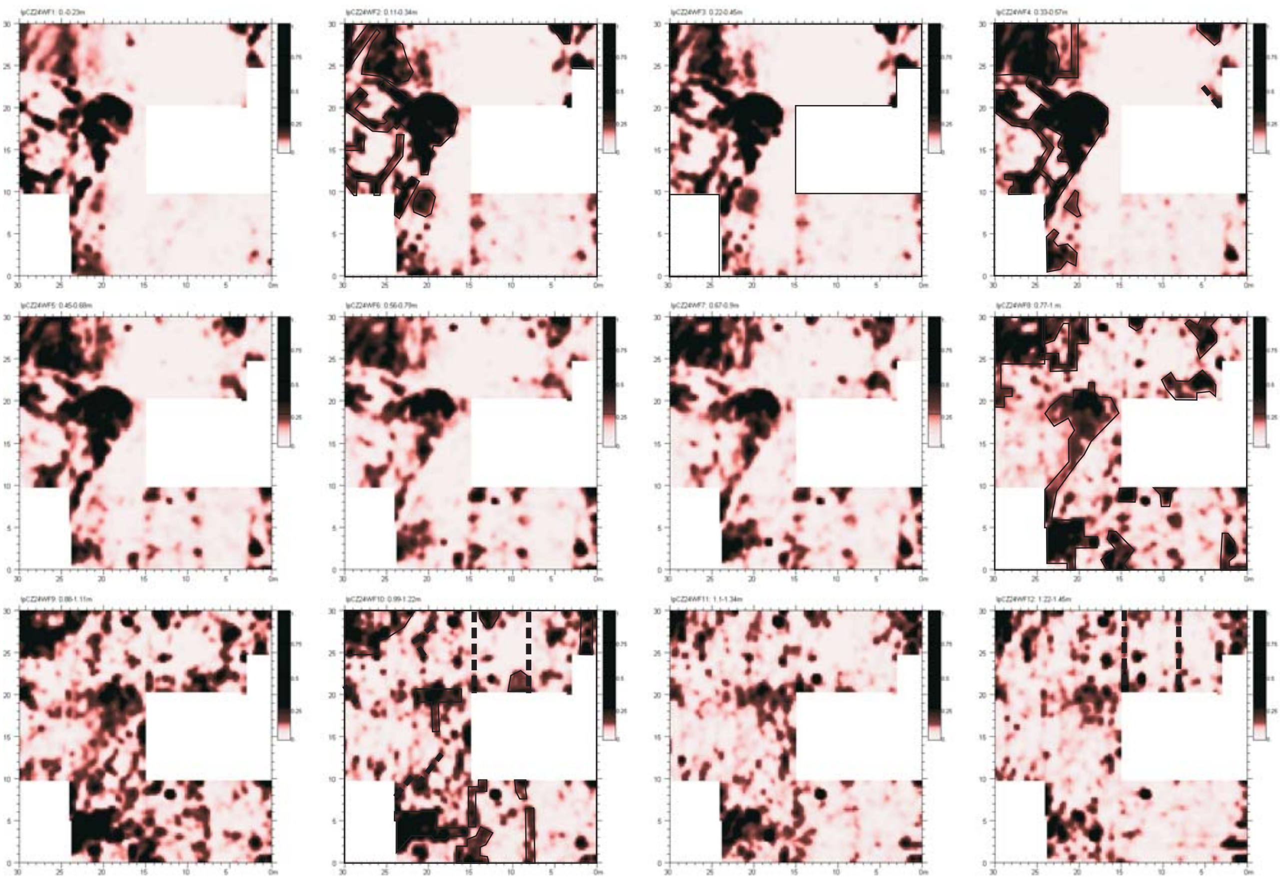


Divisions of grid C



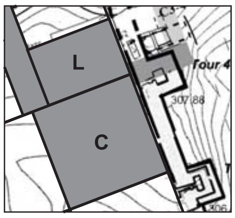




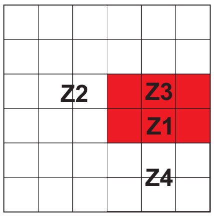


Graphic 8:
Termez Project. 2007 Season.
Georadar Survey at 270MHz.
Grid C Areas 2 and 4

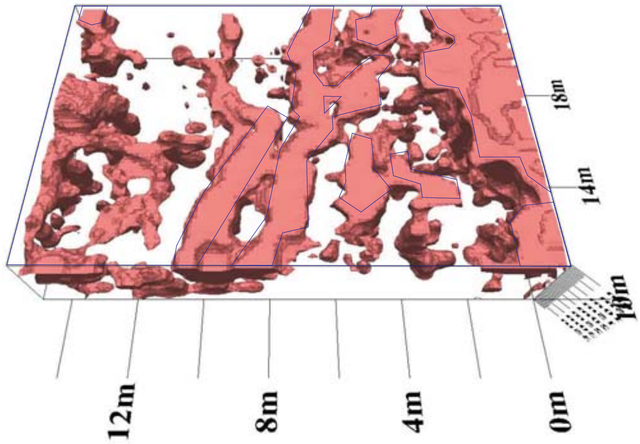
Location of grid C

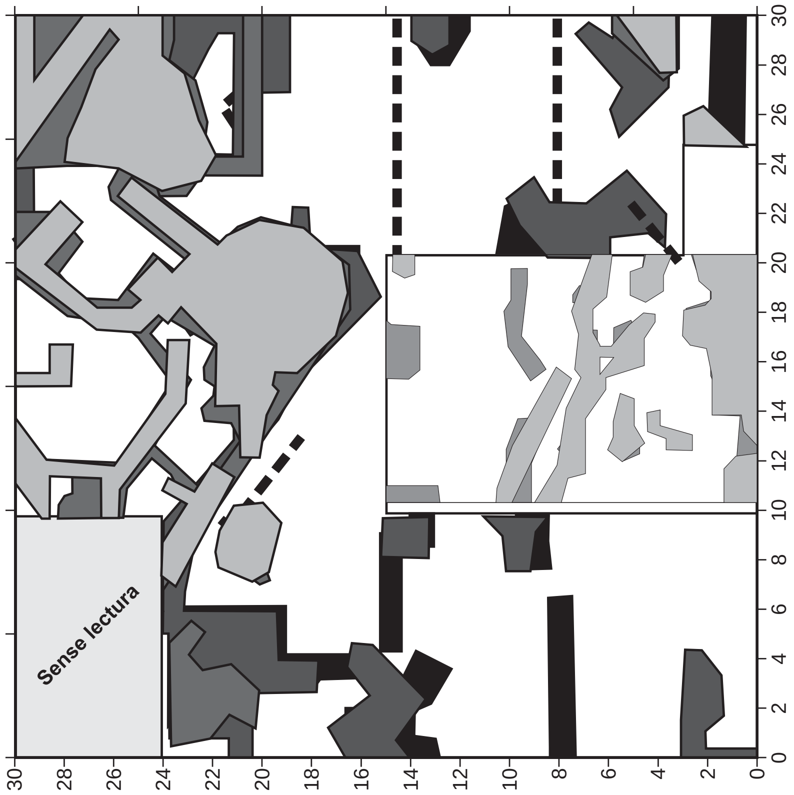


Divisions of grid C

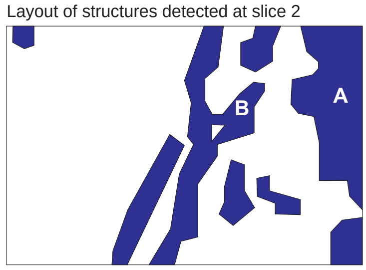


3D view of structures detected
at 0 to 1.8m below surface

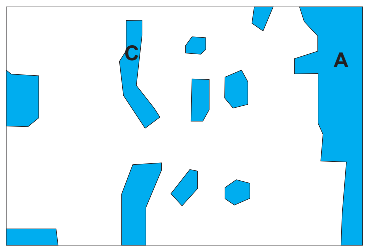


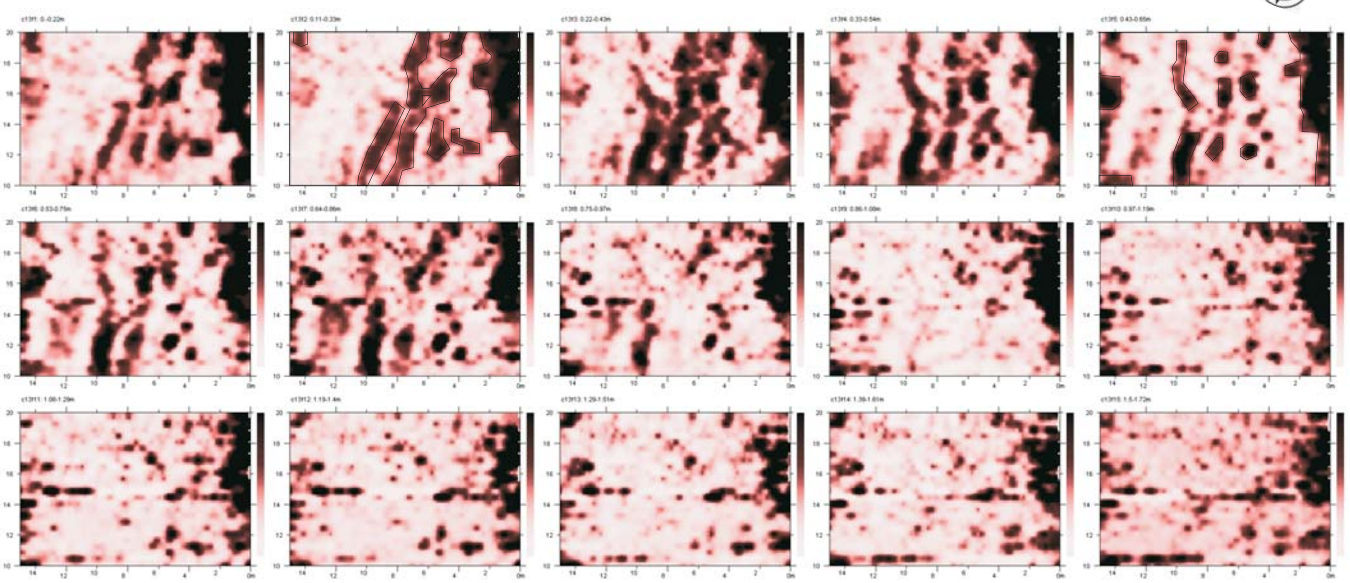


Layout of structures detected at slice 2



Layout of structures detected at slice 5

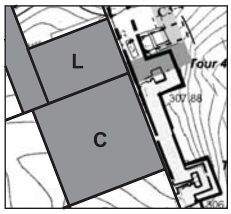




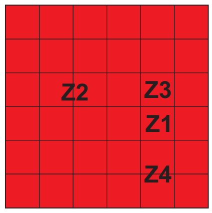
Grid L: Graphic 9 encapsulates the results from grid C. Unfortunately, the radargrams that connected grids L and C were spoilt by nearby telecommunication interferences (see figure 2). The portions free of interference, however, were of interest (see graphic 10). From the surface, structure J can be detected running parallel to the wall at approximately 1m underground. Structure J is accompanied by structures K and M, which are of minimal height and apparently lie at similar angles, while structure L corresponds to an imprecise anomaly that reaches to 0.8m of depth. In the second layer (0.5-1m deep), a new structure, N, can be detected. It runs parallel to the wall as well. In addition, structures J and L are still detected. From 1.2m in depth, a new anomaly, indicated as O, is detected. It progressively takes shape at increasing depths until the exploration limit is reached. Its position is aligned with the direction of the antenna's sweep and its depth requires the exercise of prudence in interpreting it as a built element.

Graphic 9:
Termez Project. 2007 Season.
Georadar Survey at 270MHz.
Grid C details

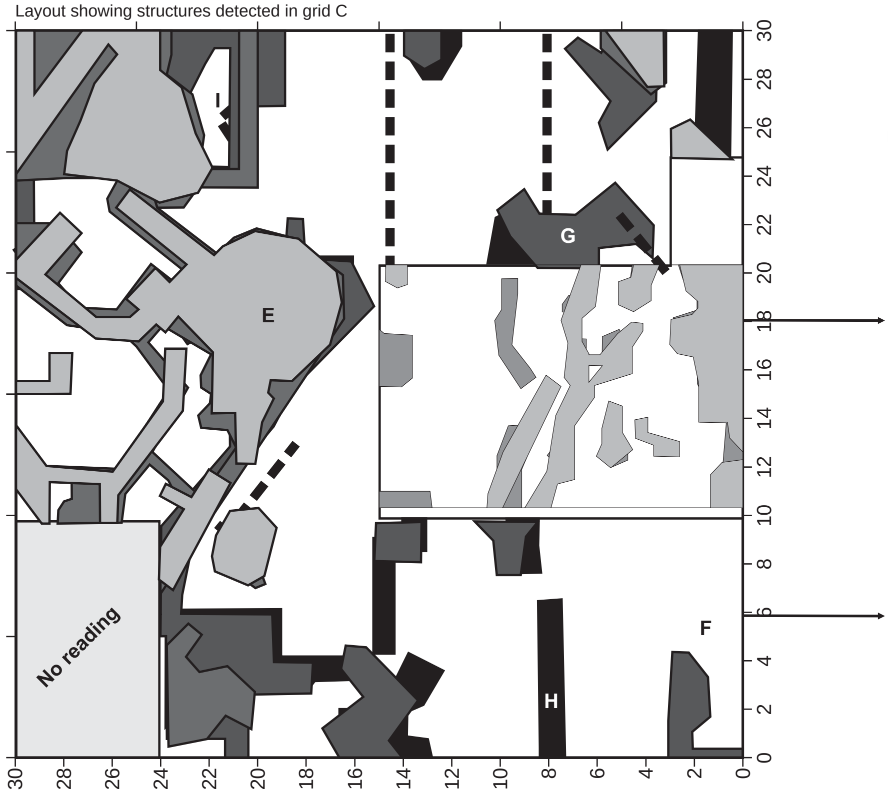
Location of grid C



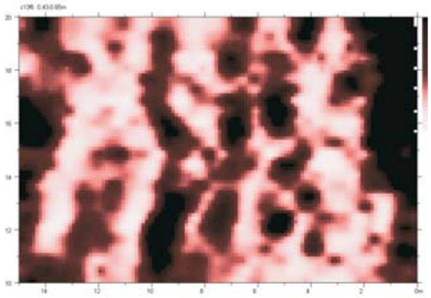
Divisions of grid C



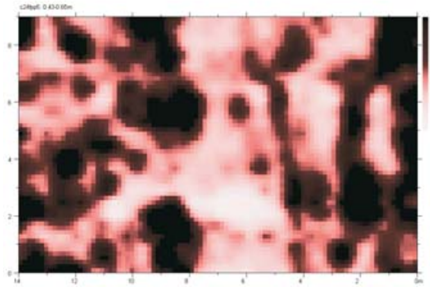
Layout showing structures detected in grid C



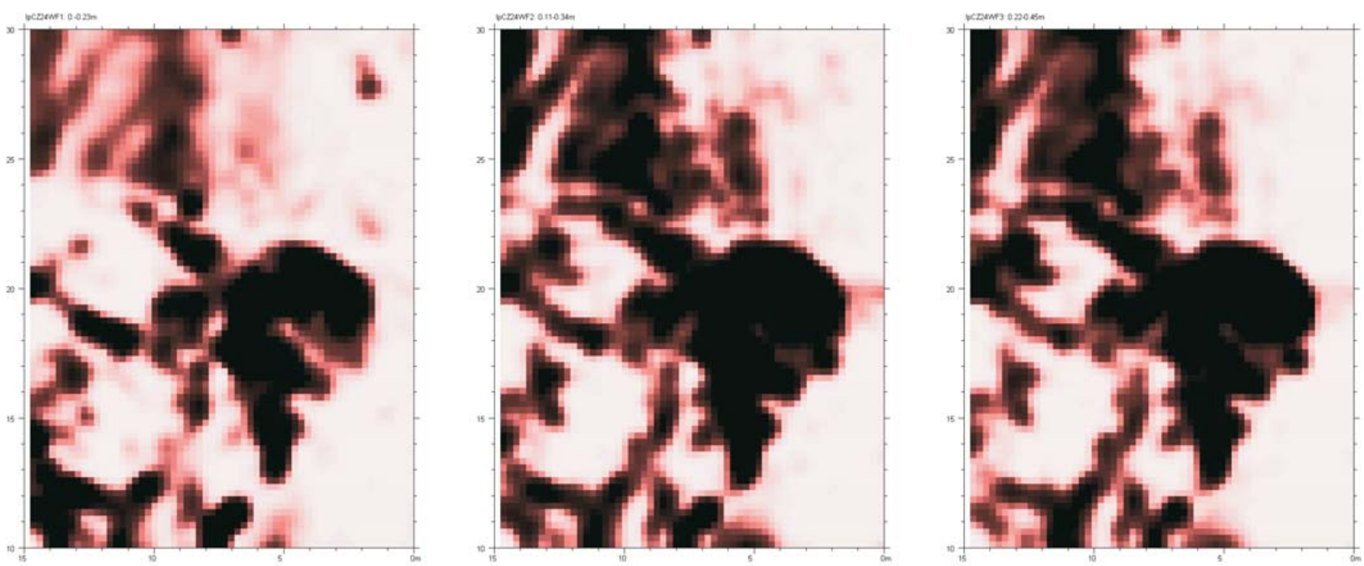
Detail of areas C1+C3 at 0.43-0.65m below surface.



Detail of area C4 a 0.43-0.65m below the surface.

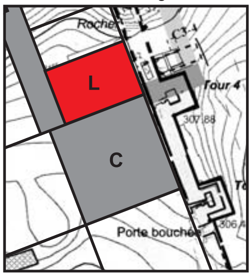


Detail of the evolution of structure E from 0 at 45cm below the surface

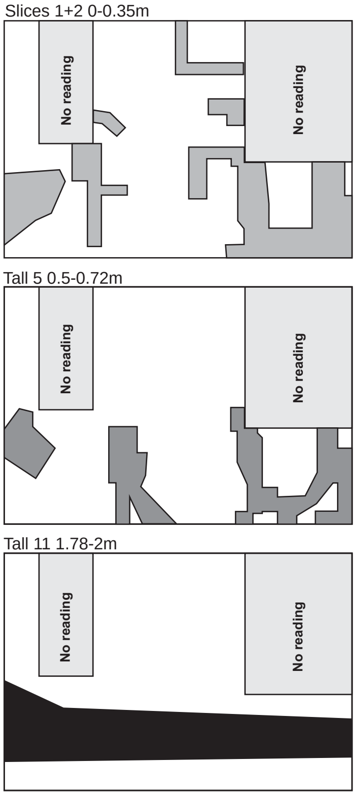


Graphic 10:
Termez Project. 2007 Season.
Georadar Survey at 270MHz.
Grid L

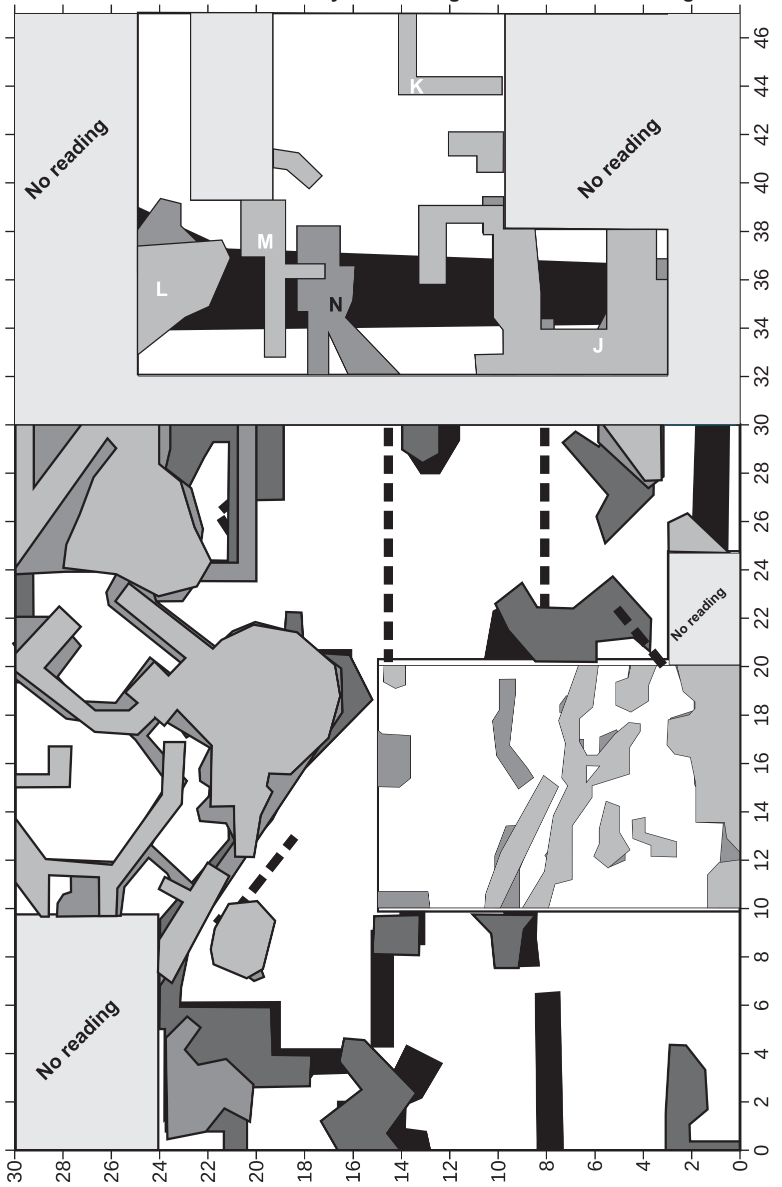
Location of grid L

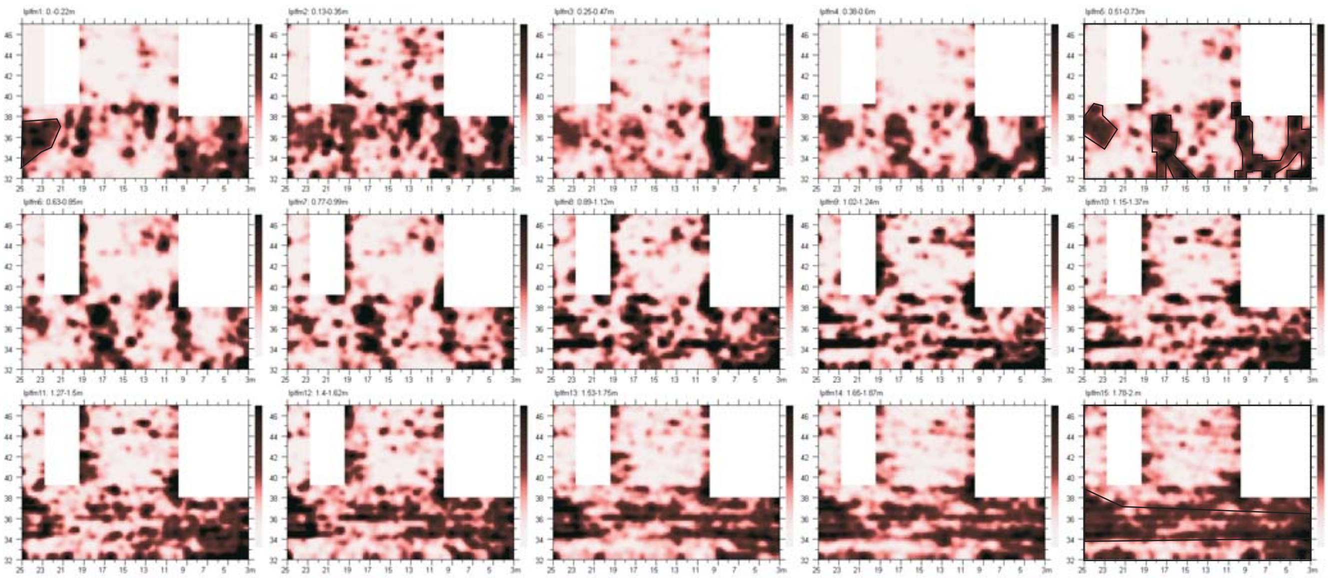


Layout of detected structures



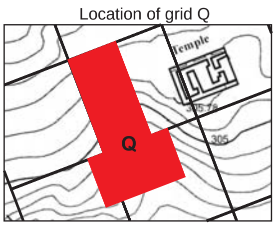
Layout showing structures detected in grids C i L

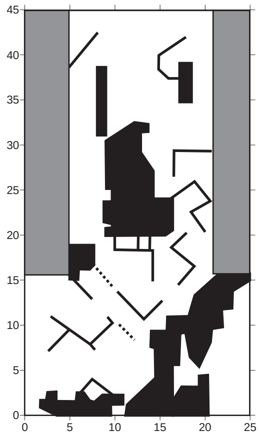


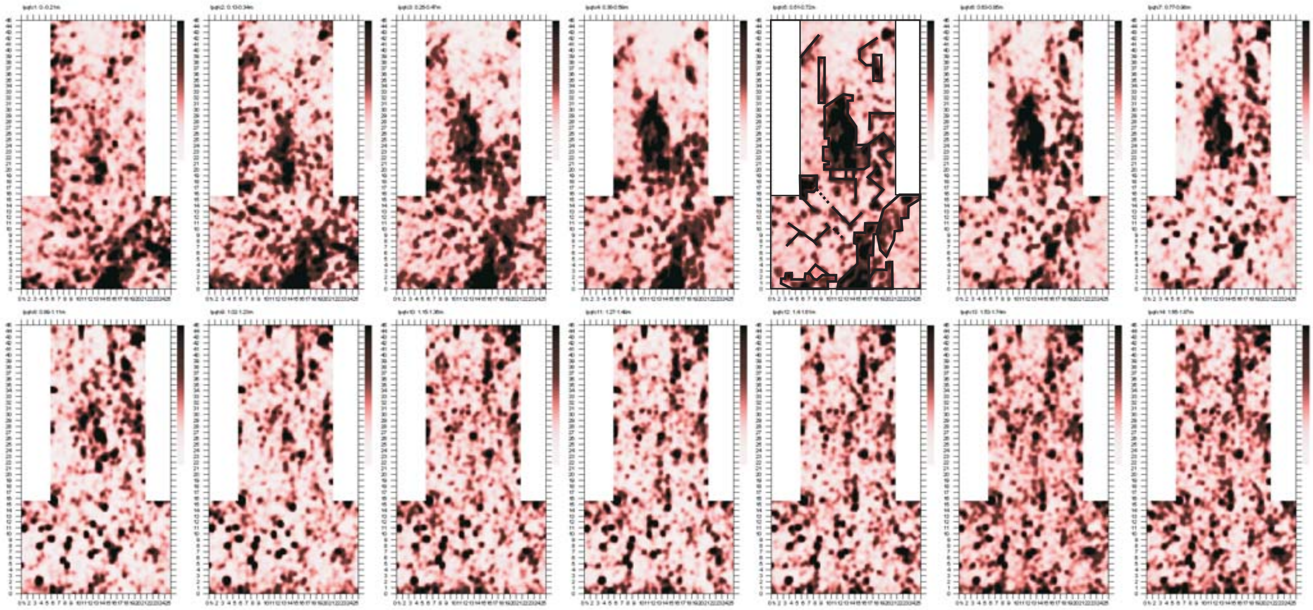


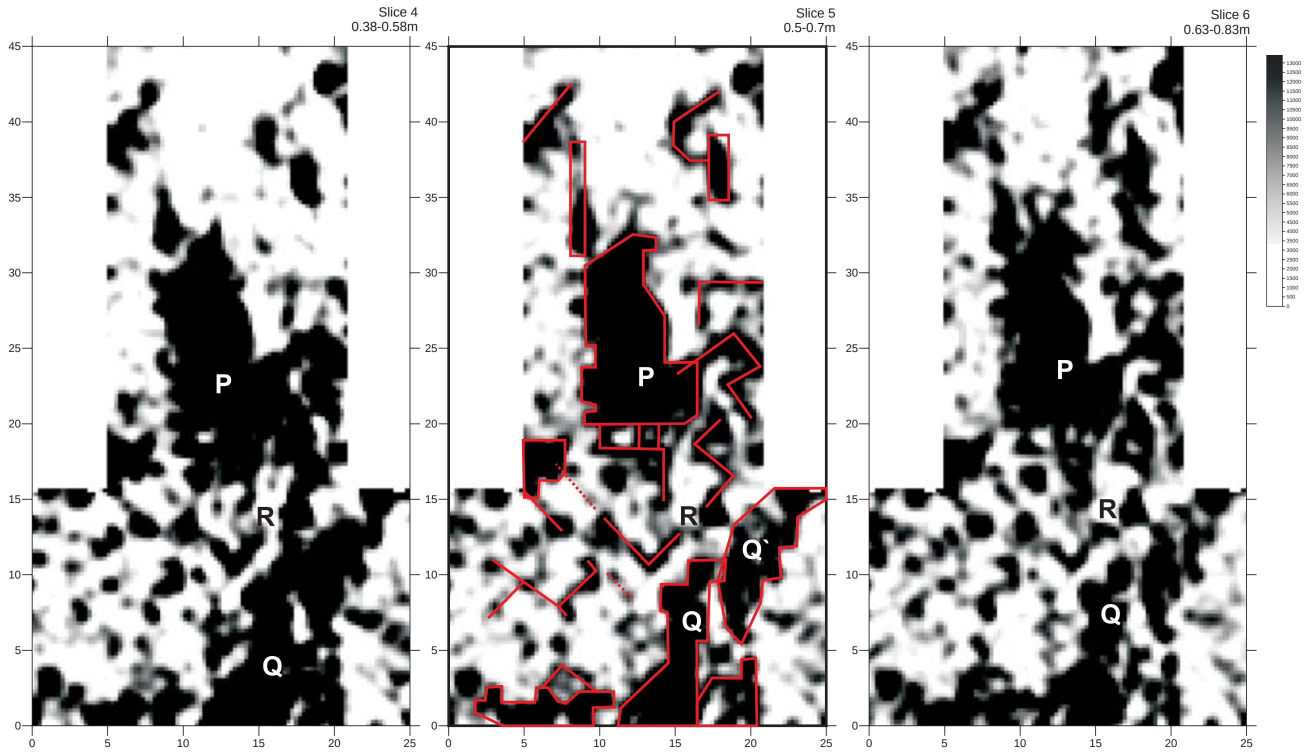
Grid Q: Grid Q runs from SE to NW, parallel to the building known as the temple and at roughly 15m distance. The results obtained in the area identify various built structures up to 1m below the surface. Obviously, however, the structures could extend farther downhill, particularly in the northern area of the grid. The sequence of horizontal slices in graphic 11 shows the first structures, P and Q, taking shape. The first two slices (up to 0.34m) also include other structures of little height and low definition. In slices 4 and 5 (0.38-0.72m below the surface), structures P and Q are clearly defined. Structure Q can be detected from the surface, in the lower right-hand corner of the grid. It takes the shape of a diffuse, high-amplitude disturbance, suggesting a N-S orientation in the first three horizontal slices (0-0.47m below the surface). In slices 4 and 5, the shape of the disturbance changes and splits into Q and Q', forming a strip running north-south. The transformation could respond to a reclaimed use of elements Q and Q' to support the elements detected in the first three slices. P appears as an irregular area measuring 7x14m. Its interior is heterogeneous and it extends to an estimated depth of 1m below the surface. The attendant response is compatible with the remains of a massive built structure connected to other minor structures in its vicinity or abutting against it (see graphic 12). Structure R, which covers a smaller area, can be detected between the positions of P and Q from slice 3 onwards (0.25-0.47m below the surface). It forms a right angle which is interrupted in the centre, dividing the space between structures P and Q. In similar layers, other linear structures appear and they could be associated with R, but it would be hazardous to venture a more precise interpretation, given the geometric complexity of the space defined by P and Q.

Graphic 11:
Termez Project. 2007 Season.
Georadar Survey at 270MHz.
Grid Q

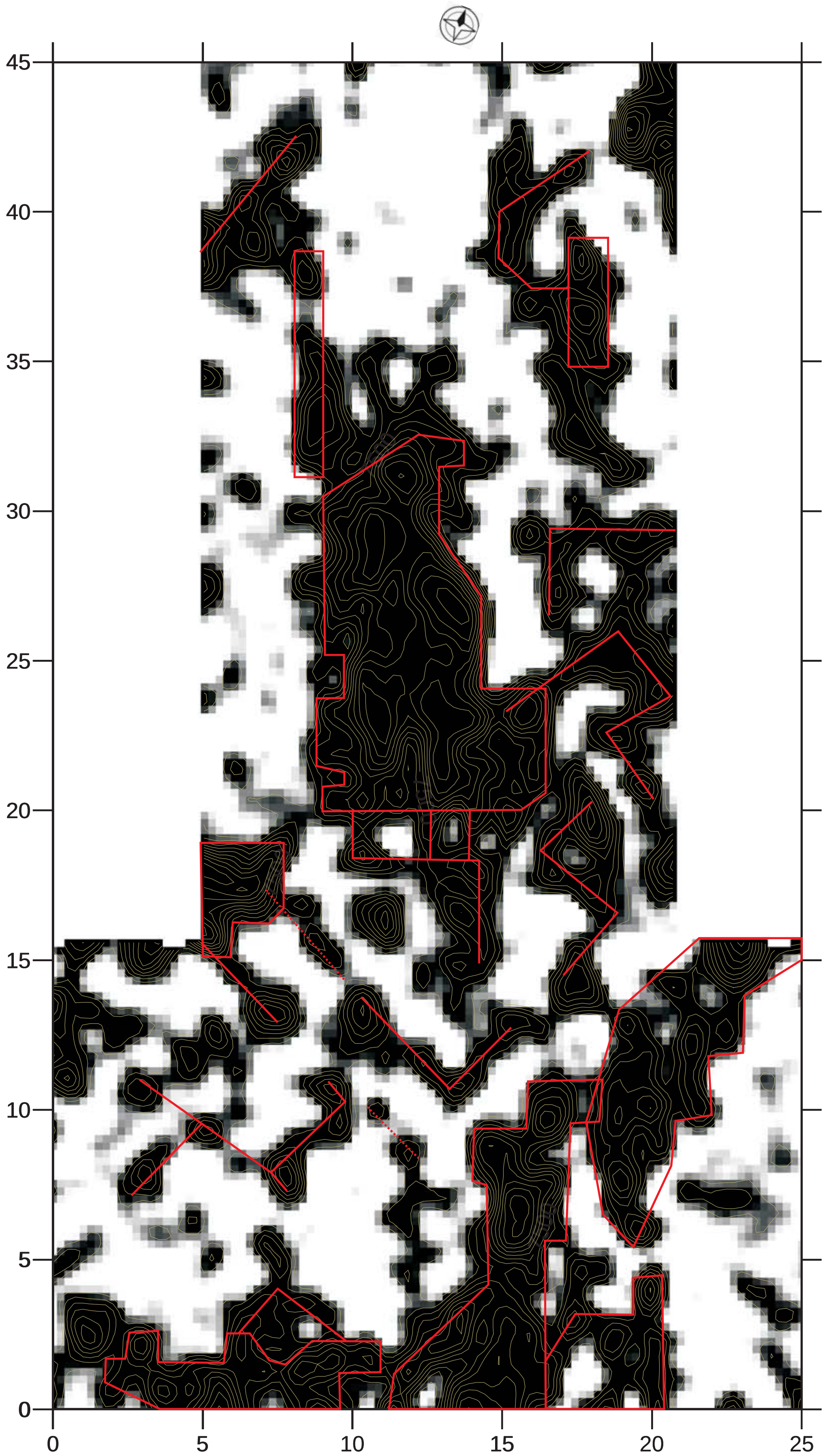








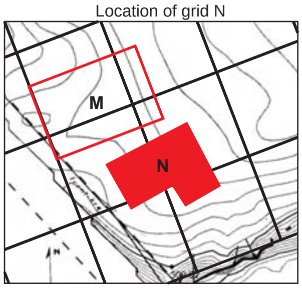
Graphic 12: Grid Q. Slice 6 at 0.63-0.8m below the surface. Image showing contour lines.

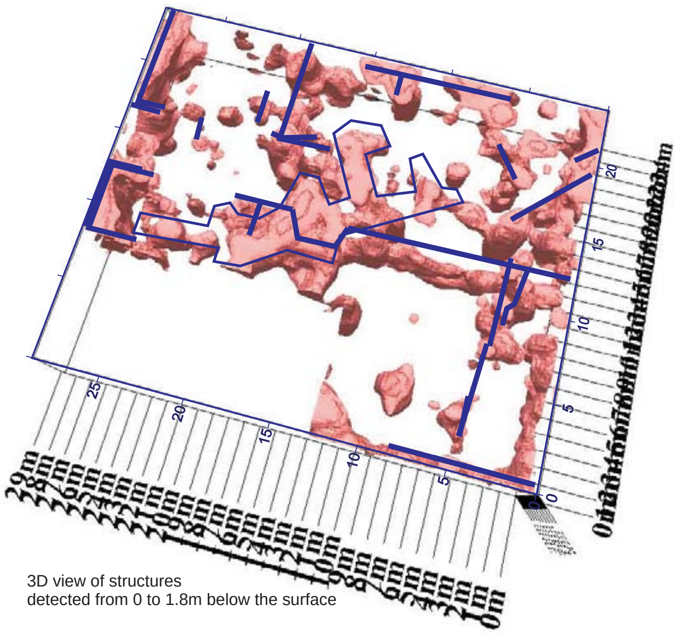


Grid N: Located at the SW edge of the exploration area, grid N measures 29x24m. Two differentiated levels have been detected and they contain structures that are apparently unconnected. Structures S and T are delineated on the first level, between 0 and 1m below the surface. Structure S has a diffuse shape, lying NE-SW. Our interpretation is that it may be the remains of a building, reaching up to 0.8m below the surface. Structure T, located at the western edge of the grid, presents a double linear structure. It appears to be divided into two blocks ending in right angles, with an interruption of approximately 4m in the middle. The division disappears between 0.8m and 1m below the surface. That enables us to interpret the structure as an external wall with an opening or doorway, with a threshold at some 0.8m below the surface. Under the first level, a second level is defined by two new structures, U and V, forming from 1m below the surface. They lie at right angles but no direct connection can be detected within the limits of the vertical exploration.

Graphic 13:
Termez Project. 2007 Season.
Georadar Survey at 270MHz.
Grid N

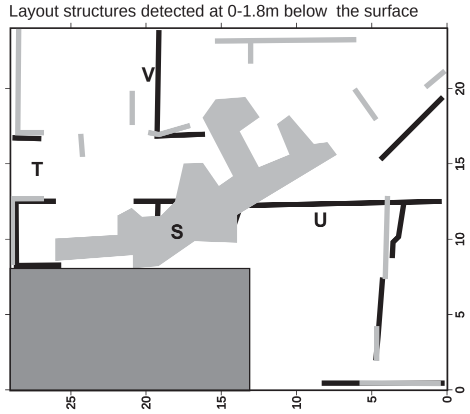
Location of grid N



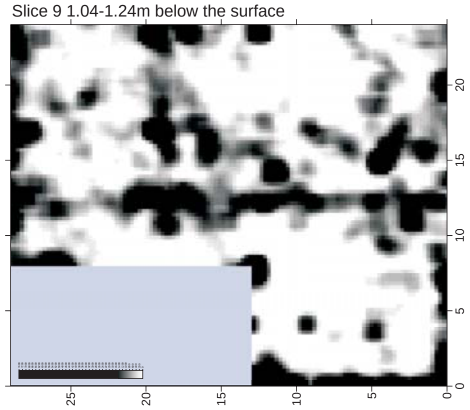


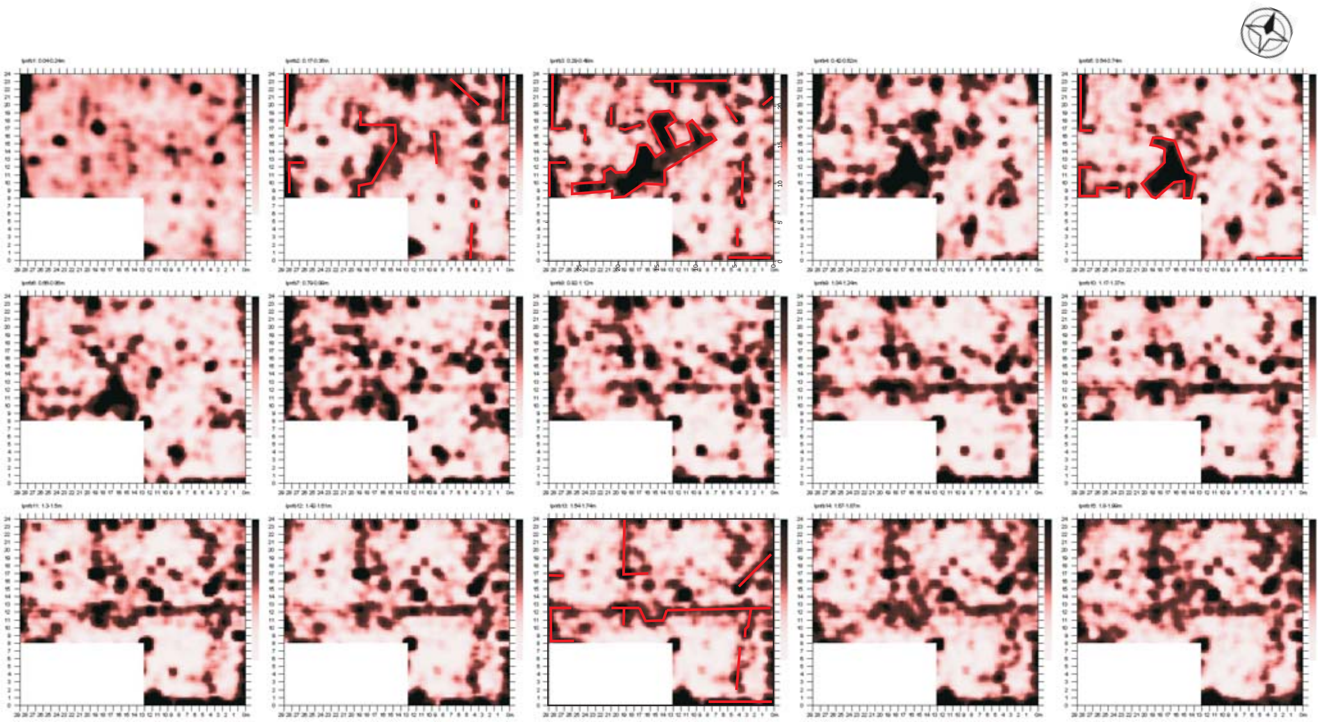
3D view of structures
detected from 0 to 1.8m below the surface

Layout structures detected at 0-1.8m below the surface



Slice 9 1.04-1.24m below the surface



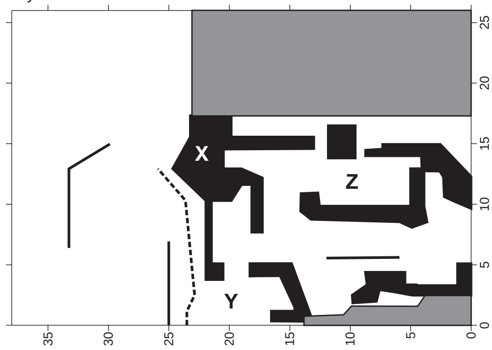


Grid M: Located roughly 8m north of grid N, grid M measures 38x26m. Graphic 14 shows the sequence of horizontal plans obtained from the area. At first glance, it can be seen that the explored area is divided into two parts, giving differentiated responses. One lies to the right and one to the left. Most of the detected structures are concentrated on the right-hand (eastern) side of the grid. The division between the two areas is clear-cut and can be interpreted as the contact between an area occupied by a building (to the right) and an exterior area (to the left), such as an courtyard, street, etc. This is apparent from the simple radargrams such as the one reproduced in figure 5, in which the main anomalies are indicated. Figure 5 also shows how the disposition of the layers on the right-hand half of the grid appear to present a stratum, possibly of sand, lying above a likely level of occupation at 1.2m below the surface, from which the remains of the detected structures rise.

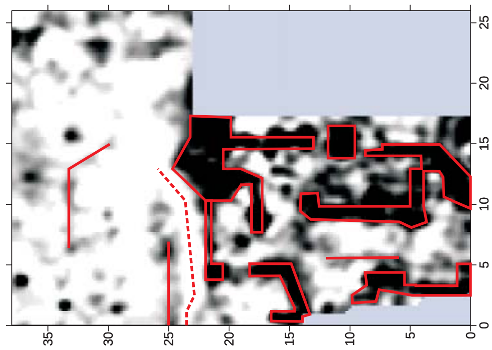
Graphic 14:
Termez Project. 2007 Season.
Georadar Survey at 270MHz.
Grid M

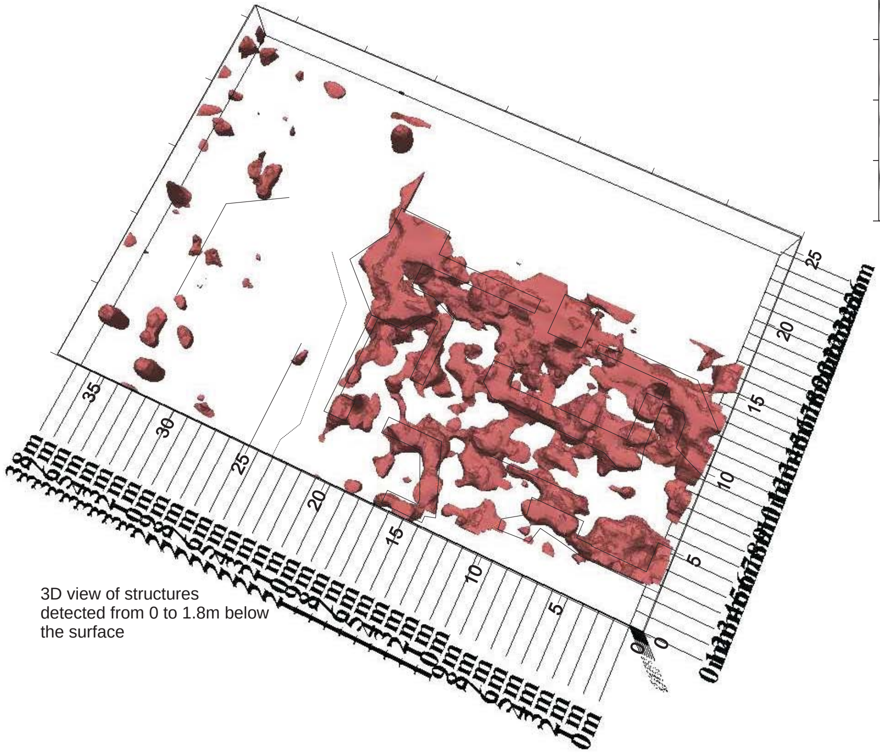
Location of grid M

Layout of structures detected at 0-1.8m below the surface

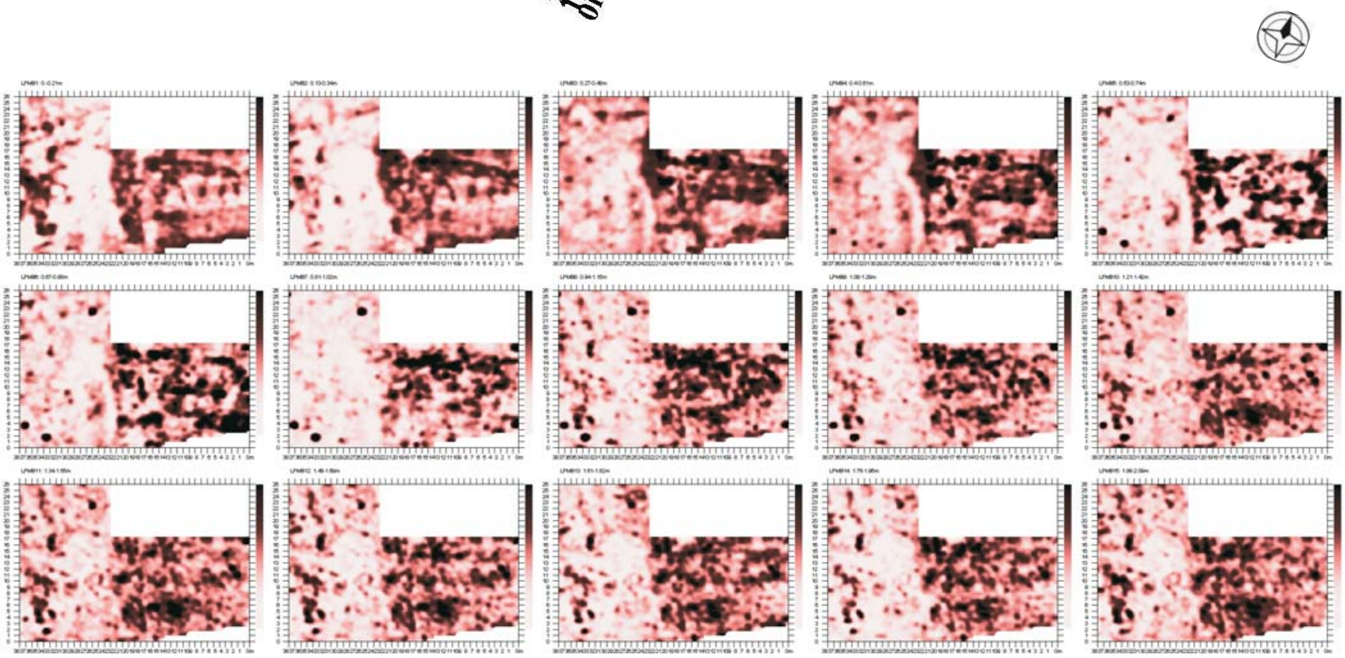


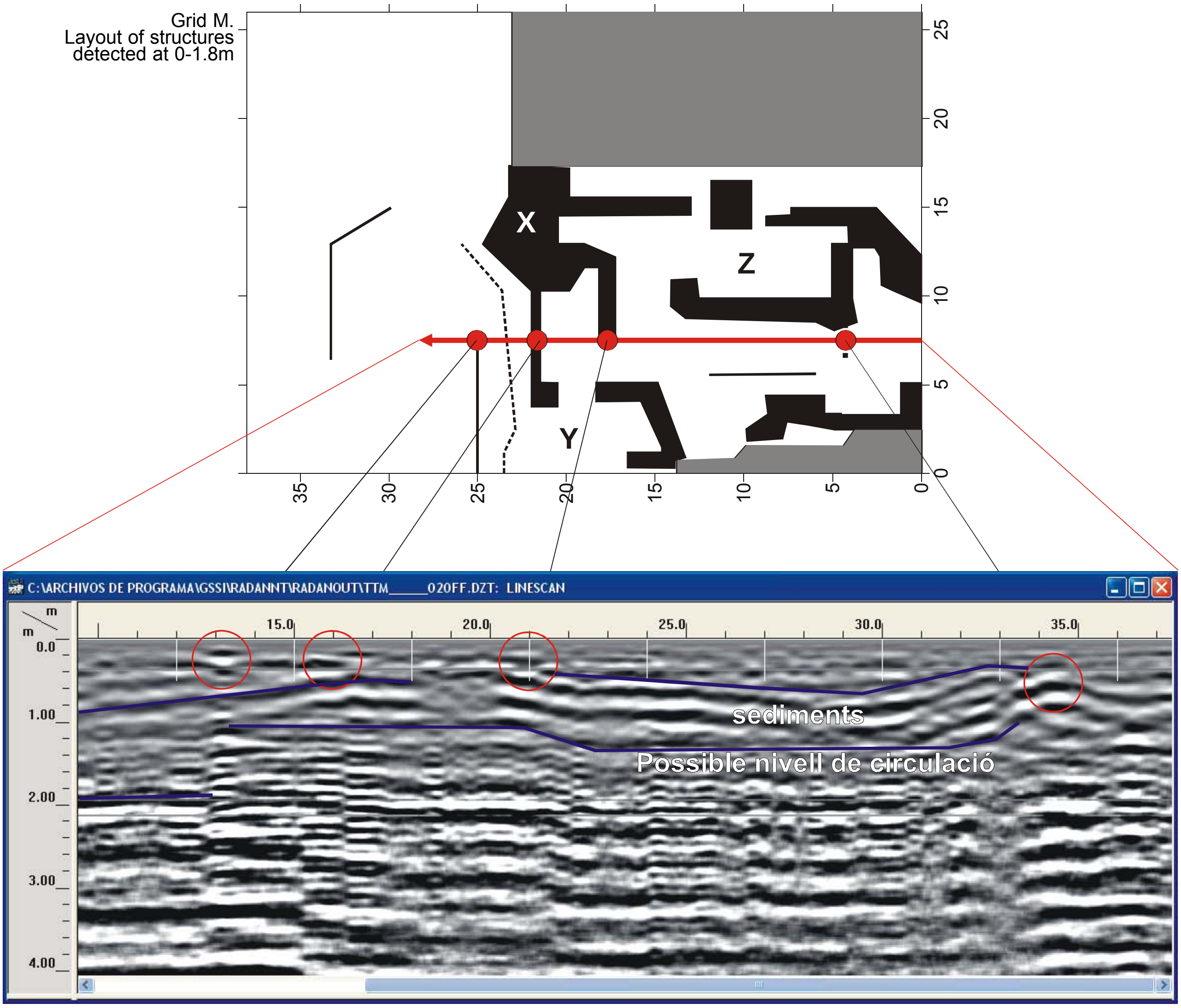
Slice 4 0.4-0.61m below the surface.





3D view of structures
detected from 0 to 1.8m below
the surface



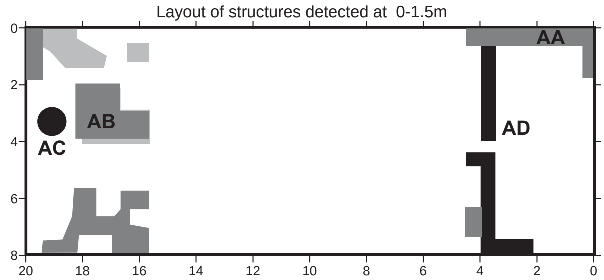


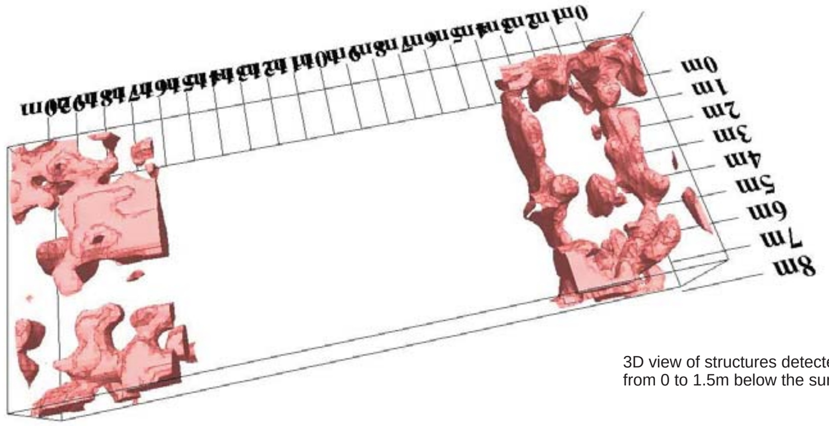
Radargram 20 expressed in depth (background filter)

Figure 5. Interpretative diagram of grid M and identification of the structures described in radargram 20 (indicated in red). The radargram shows the fluctuation between the interior and exterior levels of the building below a layer of in-fill lying at 50-70cm.

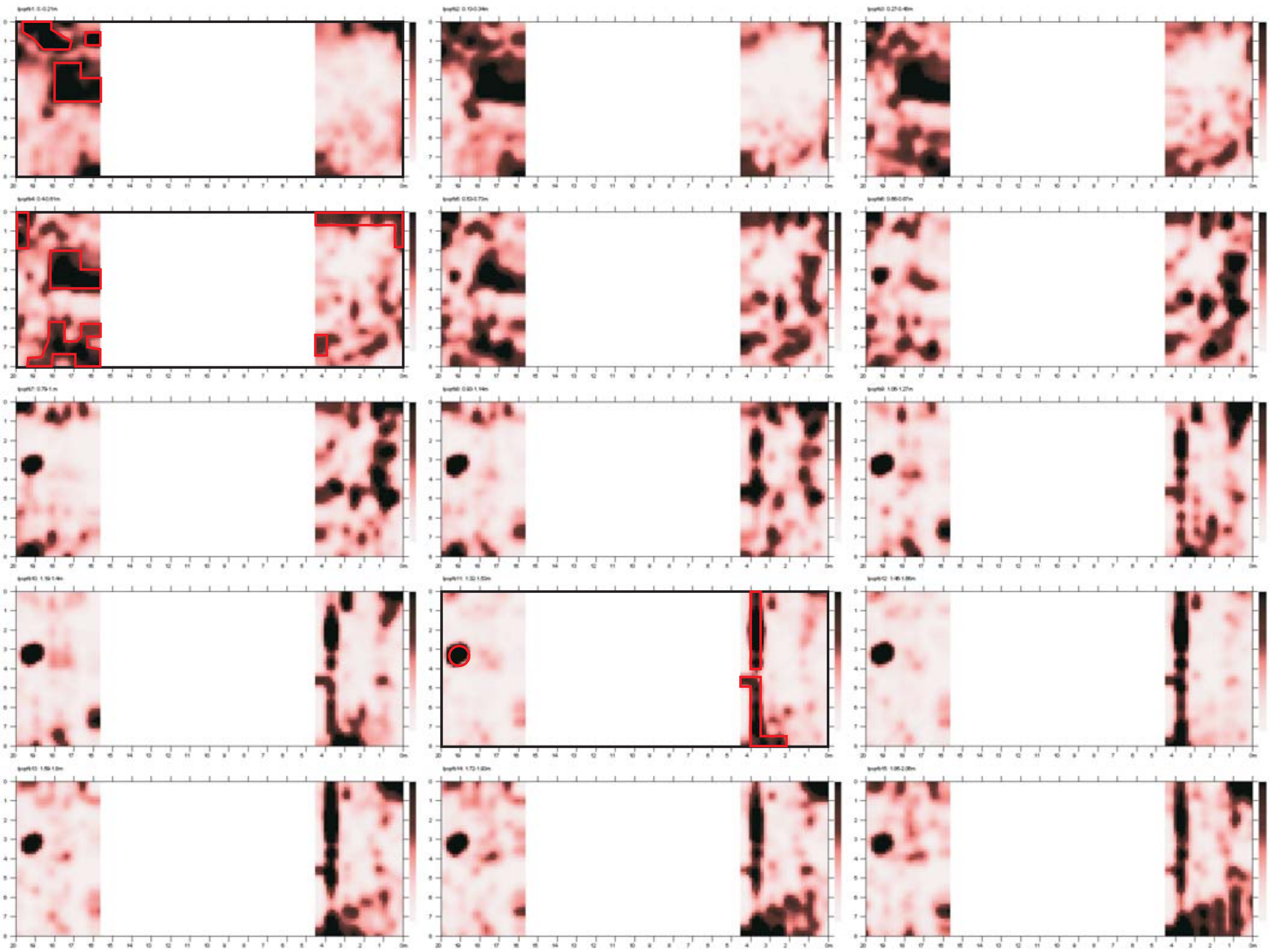
Grid OP. Located at the southern edge of the enclosure, grid OP is broken into two halves measuring 4x8m and separated by 12m. The aim of exploring grid OP was to verify the presence of a wall enclosing Tchinguiz Tepe. The results distinguish several anomalies of limited size, but no clear image appears of any wall similar to the defensive wall visible on the eastern edge of the enclosure. Nevertheless, there is evidence of anomalies, AA, AD and AB, which appear to relate to built remains. All of the anomalies are located between the surface and 1.5m of depth. Of especial interest is anomaly AC, which presents a high-contrast response and could concern the remains of a specific structure built of cooked brick or stone. Figure 6 offers one of the radargrams of the grid, capturing evidence of the differences in subsurface composition and the variable potential of the sediment.

Graphic 15:
Termez Project. 2007 Season.
Georadar Survey at 270MHz.
Grid O-P





3D view of structures detected
from 0 to 1.5m below the surface



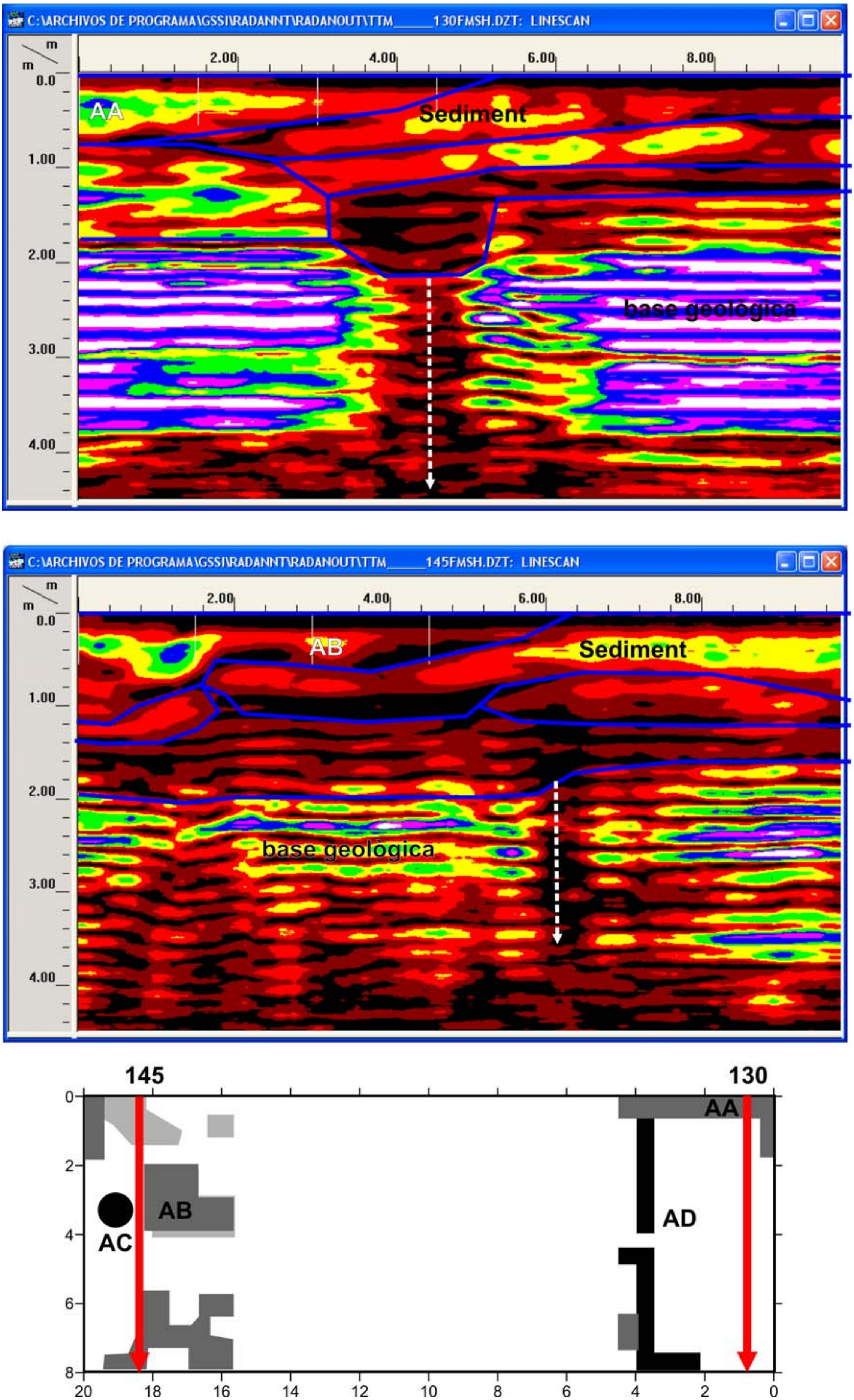


Figure 6. Radargrams 145 and 130 of grid OP (using Hilbert transform processing). The blue lines indicate the divisions between the subsurface materials. The white line indicates interruptions in the geological base.

Conclusions

Examination of the results will not be finalised until direct comparisons can be established with the information coming from the excavations. It is possible, however, to draw out various features arising from the data and their processing (see graphics 16 and 17). Firstly, applying methodological measures to improve the results has been partly successful. The quality and stability of the raw data has gone up. By contrast, however, the resolution has not risen as much as expected. As a result, the study of some simple radargrams has contributed valuable information, as in the case of grid OP or the radargrams taken parallel to the excavation of the exterior moat site (see figure 7), but their presentation in horizontal slices has been less clear.

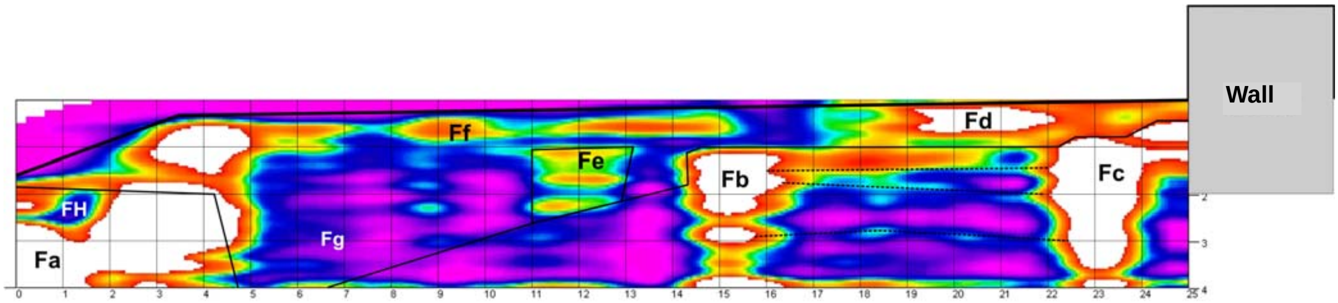
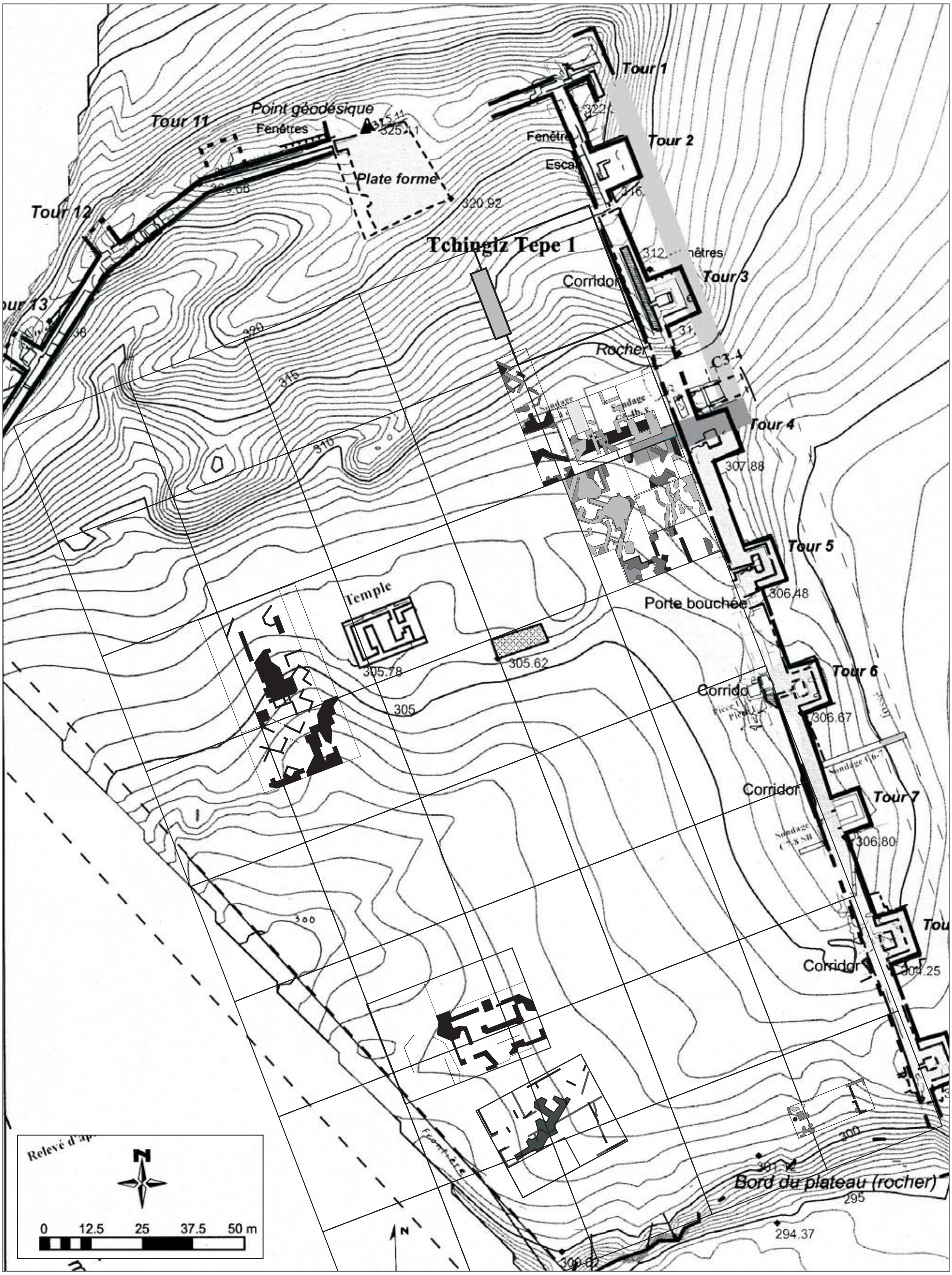


Figure 7. Pseudo-section parallel to the pit dug outside the walled perimeter where the moat site is located. As in other areas (grid C), the surface layer of sediment Ff and Fd shows high reflectivity (0.7-1m deep). The graphics show anomalies caused by built structures abutting the wall (Fc) and possible levels of circulation associated with structure Fb (1m below the surface). The geological base (Fa) shows an abrupt break where the moat site lies (Fg), but there is also an interruption (Fh) that had not been documented before, lying outside the area of the pit.

On the other hand, the grids in the western part of the enclosure have provided clear results in the horizontal slices. It has been possible to document a complex system of constructions in grid Q, as well as a division between interior and exterior spaces in grid M. Comparing the results from grids C and CRH with the excavation data could provide new criteria for the interpretation of the other explored areas, although the two grids in question have given the least clear results and the excavated remains there have been the most diffuse or difficult to interpret. Lastly, a review of the 2006 data, obtained with a 400 MHz antenna and a separation of 0.5m between profiles, has opened up a new perspective onto the small grid on the Tchinguiz Tepe platform (see graphic 18). Processing the data using a background filter and the data integration parameters from the 2007 season, a visualisation can be obtained to compare with the excavation diagram provided by the French excavation team.

The variability in the results obtained during the present season stems from a sum of factors that have already been mentioned (i.e., reading density, antenna frequency, and external interferences), but sight should not be lost of the possibility that the greater precision achieved in the western area of the enclosure may be due to the state of conservation in which the built remains under the surface are found

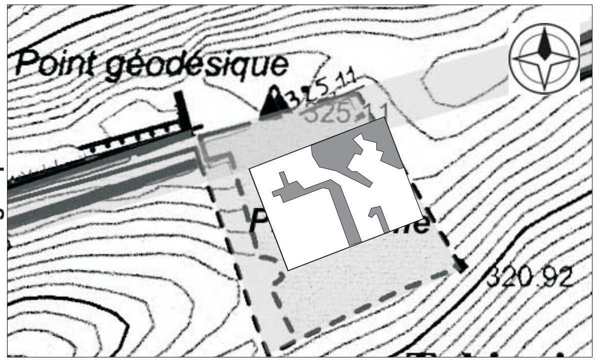
Graphic 16:
Termez project. 2007 season.
Diagram of detected structures

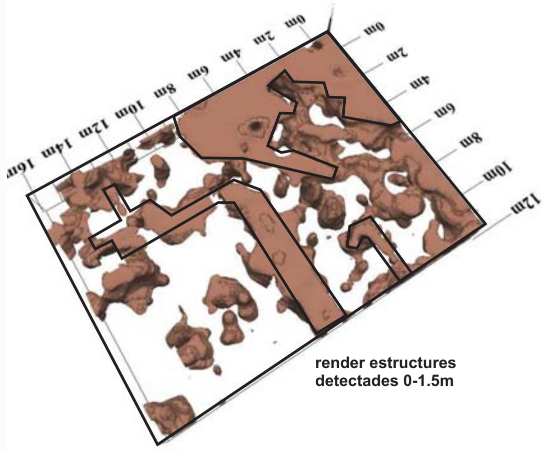


Graphic 17:
Termez project. 2007 season.
Diagram of detected structures

Gràfic 18:
Projecte Termez. Campanya 2007.
Revisió de dades 2006

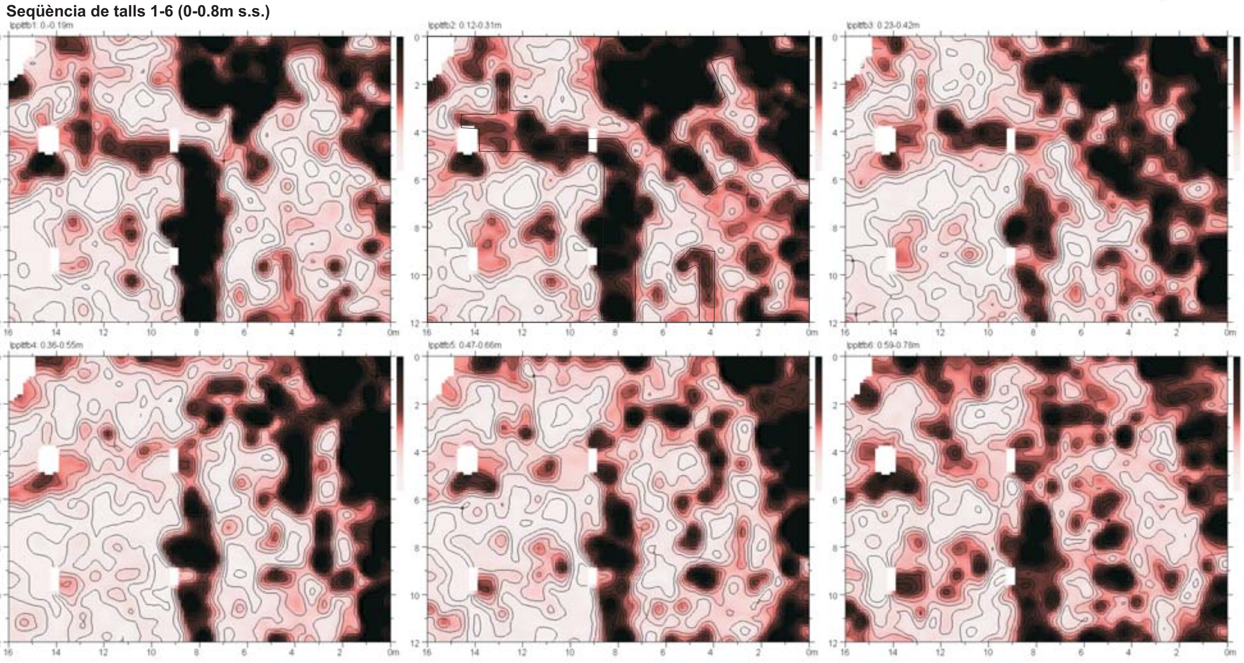
Ubicació del grid plataforma





render estructures detectades 0-1.5m

Seqüència de talls 1-6 (0-0.8m s.s.)



Geophysical Survey at Zurmala

Oriol Achón, Enrique Ariño, Diego García, Josep M Gurt and Roger Sala

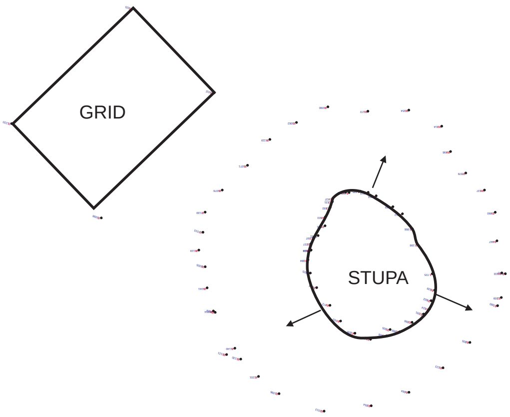
This year, geophysical surveying was planned for the area near the Zurmala Tower (stupa), located to the southwest of the ancient city, in order to take advantage of the monument's state of conservation and verify the existence of any structures associated with it. The aim was to confirm or rule out the existence of a Buddhist monastery on the site, which might be added to the known monasteries at Kara Tepe and Fayaz Tepe to the northwest. In 1964, the archaeological excavations conducted in the vicinity of ancient Termez focused on the outlying Buddhist monuments: under the aegis of the Ministry of Culture of the former Soviet Union, Kara Tepe was excavated by B. Ja. Staviskij and Zurmala by G. A. Pugachenkova. The work involved first establishing a topography of the tower in order to be able precisely to situate the space to be surveyed and later relate the georadar survey results to the tower itself. In the end, the surveyed area was a rectangular area measuring 20x15m, or 300 sq m in size.

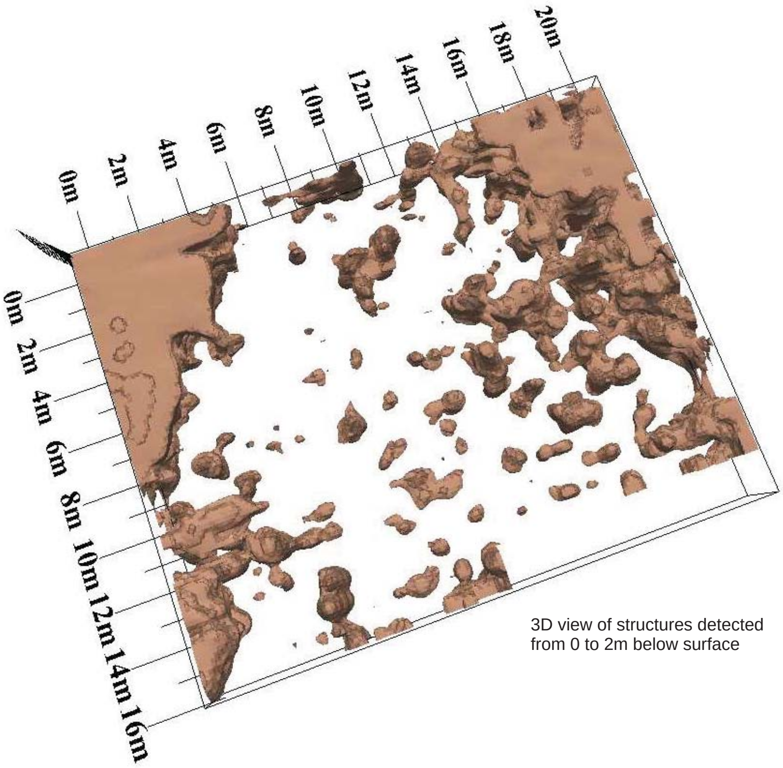
Zurmala grid. The Zurmala stupa is located only a few kilometres from the Tchinguiz Tepe site and it is the only visible remains of an ancient edification that is as yet basically unexplored, although a team of archaeologists from the former Soviet Union conducted a poorly documented intervention as noted above. A survey was planned for a small area to the NW of the visible remains in order to provide information on any possible archaeological remains related to the monument and, at the same time, to serve as a control for evaluating the extent to which the responses obtained in the Tchinguiz Tepe surveys were the result of location conditions (e.g., built materials, proximity to the river, external interferences). Applying the same research parameters, a sequence of plans was obtained and four differentiated structures were defined.

Structure Z1 is located in the upper left-hand corner of the grid and maintains a vertical potential from 0 to 1.5m below the surface. We associate the anomaly with the remains of a solid adobe structure. Structures Z2 and Z3 occupy the right-hand half of the grid. Their vertical position is similar and they define a rectangular perimeter (Z2) of roughly 2.5x5m, which abuts an amorphous anomaly (Z3), which we associate with the remains of a demolished building or other unknown structure. Structure Z4 can be detected at similar levels in the lower right-hand part of the grid. Although it is an anomaly of limited size, its orientation appears to be coherent with group Z2-Z3 and divergent from Z1.

As with the results obtained in the other locations, the definition of the structures is good in the first 1.5m below the surface. Archaeological verification of the structures, however, is needed to define their function and date them in relation to the Zurmala Tower.

Zurmala, Termez
Georadar Survey





3D view of structures detected
from 0 to 2m below surface