Prospecting the Italian Agora in Delos Island

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Magnetic, resistivity and ground penetrating radar prospection surveys were carried out inside the Roman Agora of the ancient settlement of Delos (Fig. 1).

Magnetic and soil resistance data were processed through the use of high pass filters, directional derivatives and compression of the dynamic range of the original measurements. A high correlation between the magnetic and resistivity maps suggested a few candidate targets.

In GPR survey, CMP measurements suggested that the velocity of propagation of the acoustical waves in the area of study approached the value of 0.062m/nsec. Parallel transects were scanned through the use of 450MHz and 225MHz antennas providing information about the vertical stratigraphy of the site. Various processing procedures, such as time-slicing, 3D visualization and animation techniques were used for enhancing the resulting image. The extraction of 3D extent information was achieved through a synthetic volumetric modeling, visualized through the calculation of isosurfaces that represent the intensity of reflection of the EM wavelets.

A number of candidate targets have been suggested, one of which may coincide to the location of an older back-filled excavation trench. Other targets may represent the remnants of architectural monuments within the Agora.

Keywords: Geophysical prospection, magnetics, resistivity, GPR, Delos, Greece.

Proposed for a poster presentation

Fig. 1. The ancient settlement of Delos (above) and the Italian Agora (below).

Methodology

Prospection techniques included the use of magnetic techniques, soil resistivity and ground penetrating radar (Fig. 2).

Magnetic techniques were used for covering the whole extent of the Italian Agora (approximately an area of 3.292 m^2). A Geoscan fluxgate gradiometer was used for the specific purpose with a 50cm sampling interval.

A 1m electrode separation (Twin probe configuration) and 1m sampling were employed in the soil resistance techniques, which covered a smaller portion of the Agora at the SW section of it (an area of 1.380 m^2).

Finally, an EKKO 1000 ground penetrating radar scanned 37 lines, 31 of which were arranged in a StoN direction at the SW corner of the Agora, with a 1m separation between them. The rest transects were laid at a WtoE direction. More than 500m were investigated with GPR techniques. Most transects were covered with both 450 and 225MHz antennas. Processing included the application of high pass filtering, wow effect removal, gain control filtering, trace to trace averaging, compression of the dynamic range of measurements and time slicing techniques.

Fig. 2. Details of the geophysical survey at the Italian Agora, Delos island. Magnetics (above), Soil Resistivity (middle), Ground Penetrating Radar (below).

Results

Magnetic prospection techniques showed a number of anomalies (Fig. 3a), some of which were correlated to the surface features, such as open wells, concentration of building materials, etc. Anomaly M1 (Fig. 3d) was created by the existence of a metallic base. Anomaly M5 was correlated to a well, while anomalies M6 and M9 were created by concentrations of building fragments originating from the rooms surrounding the Italian Agora. Similarly, anomalies M2, M3, M4, M7 and M8 suggested the presence of small wells or metallic fragments. Directional derivatives and compression of the dynamic range of the original measurements were employed for emphasizing the subtle magnetic anomalies (M11 and M12) (Fig. 4).

The most promising features were indicated at the western section of the map. Anomalies M15 and M13 were registered by all techniques (magnetic, resistivity and GPR). The first anomaly (M15: x=5-10E, y=25-30N) exhibits a more or less geometric outline and it is possible to originate by a small architectural structure. The lack of a regular geometric shape suggests that the second anomaly (M13: x=5-8E, y=12-18N) may originate by the disturbance of the subsurface soil matrix. It is possible that the specific region coincides to the location of an older test excavation trench.

The above anomalies were verified through soil resistance techniques. In the west section of the surveyed region, there are a few high resistance anomalies, which seem to communicate with a linear diagonal anomaly (Fig. 3b & Fig. 5). A weaker soil resistance anomaly is also evident in the central southern section of the Agora.

In order to provide further evidence of the above anomalies, a number of parallel lines were scanned using the ground penetrating radar in both StoN and WtoE directions. Initial measurements of common mid-point (CMP) were carried out with the 450MHz antenna to estimate the transmission velocity of the electromagnetic waves through the subsurface. An estimate of 0.062m/nsec was calculated based on the above technique (Fig. 6).

A grid of 30x30m at the SW section of the Agora was scanned along 31 parallel transects (StoN direction), 1m apart. Radar signals were amplified through the application of high pass filters. The first break point of each transect was calculated and it was used for shifting the traces of each traverse to the corresponding timezero datum. Further processing included the removal of background noise, migration and envelope filtering. After processing, all transects were combined to create vertical time (or depth) slices. Initially, automatic time slicing techniques were applied for the whole range of the reflection time (0-74nsec) producing 10 slices of ~7.3nsec width. This type of processing produced some indication for the existence of potential targets lying within the layer of 7,4-14,7nsec.

Following the application of Dewow and DC_shift filters, 2nsec time slices were produced for the layer 0-20nsec (Fig. 7). Slices between 8-16nsec produced significant signals related to the presence of subsurface targets. The same process was repeated after processing of all transects with spatial high pass filters and rectification of the amplitudes. Time slices suggested that the cultural layer corresponds at times 6-20nsec, namely 0.4-1.2m below the current surface.

Time slices were also imported to a 3D modelling software to produce horizontal sections of the stratigraphy and a 3D model of the subsurface, aiming at a volumetric representation of the relics. A variable opacity has been used for the better visualization of the volumetric model representing the extension of the reflection anomalies (Fig. 8).

Finally, the diagrammatic representation of the GPR anomalies for times 12-14nsec was overlaid on the corresponding interpretation maps resulted by the magnetic and resistivity techniques (Fig. 3c). A high degree of correlation is suggested by all three prospection methods, increasing the credibility of the suggested anomalies.

Final Remarks

The simultaneous use of magnetic, soil resistivity and ground penetrating techniques was crucial in the interpretation of data. The geophysical maps located a number of features, some of which may be related to architectural relics existing within the open space of the Italian Agora. Excavations at the specific locations are planned by Ecole Frannaise d' Athenes for the summer of 2002.

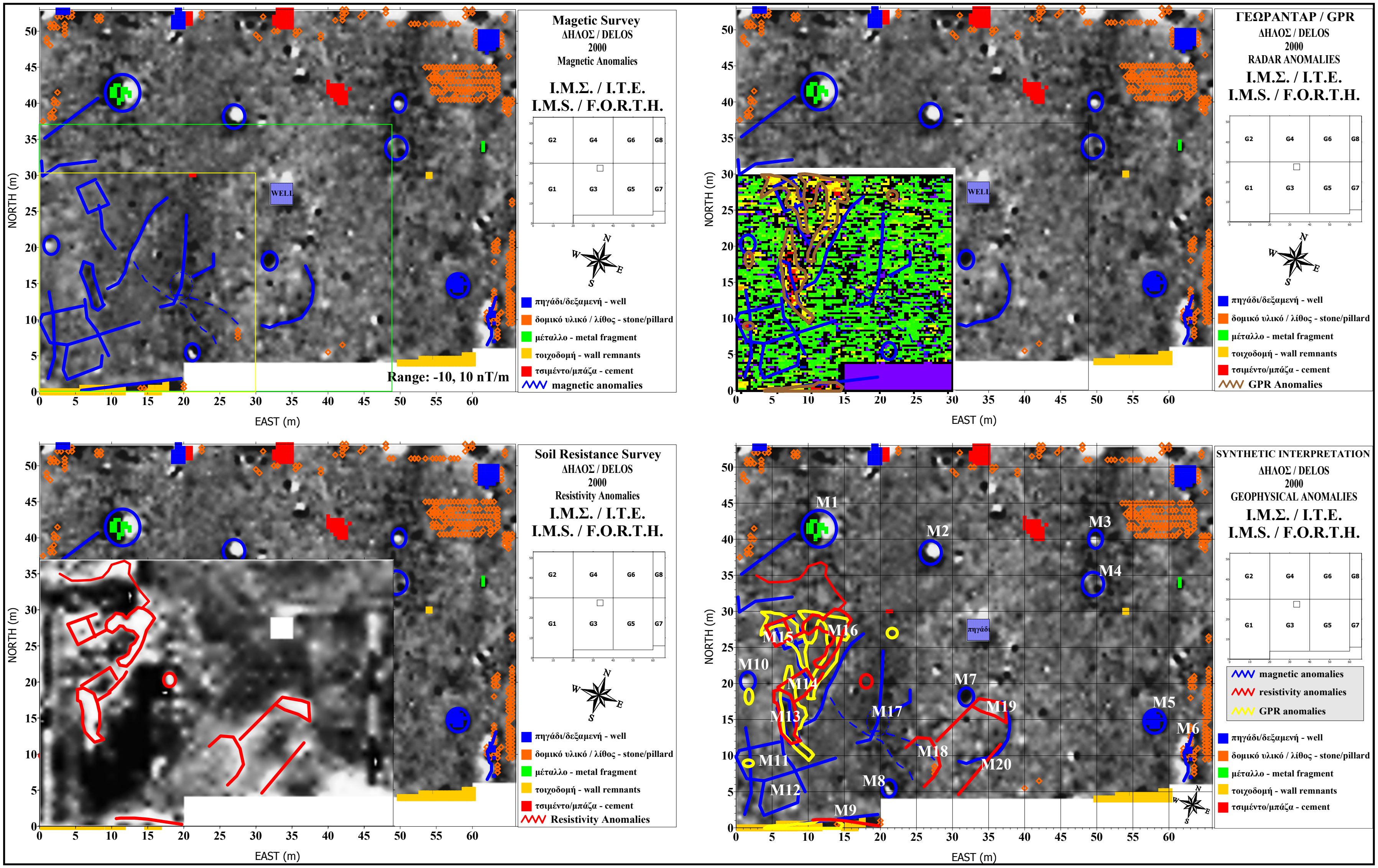

Fig. 3. Results of the magnetic survey (upper left / 3a), results of the resistivity survey (lower left / 3b), results of the GPR survey (upper right / 3c) and synthetic diagrammatic interpretation of the geophysical maps (lower right / 3d)).

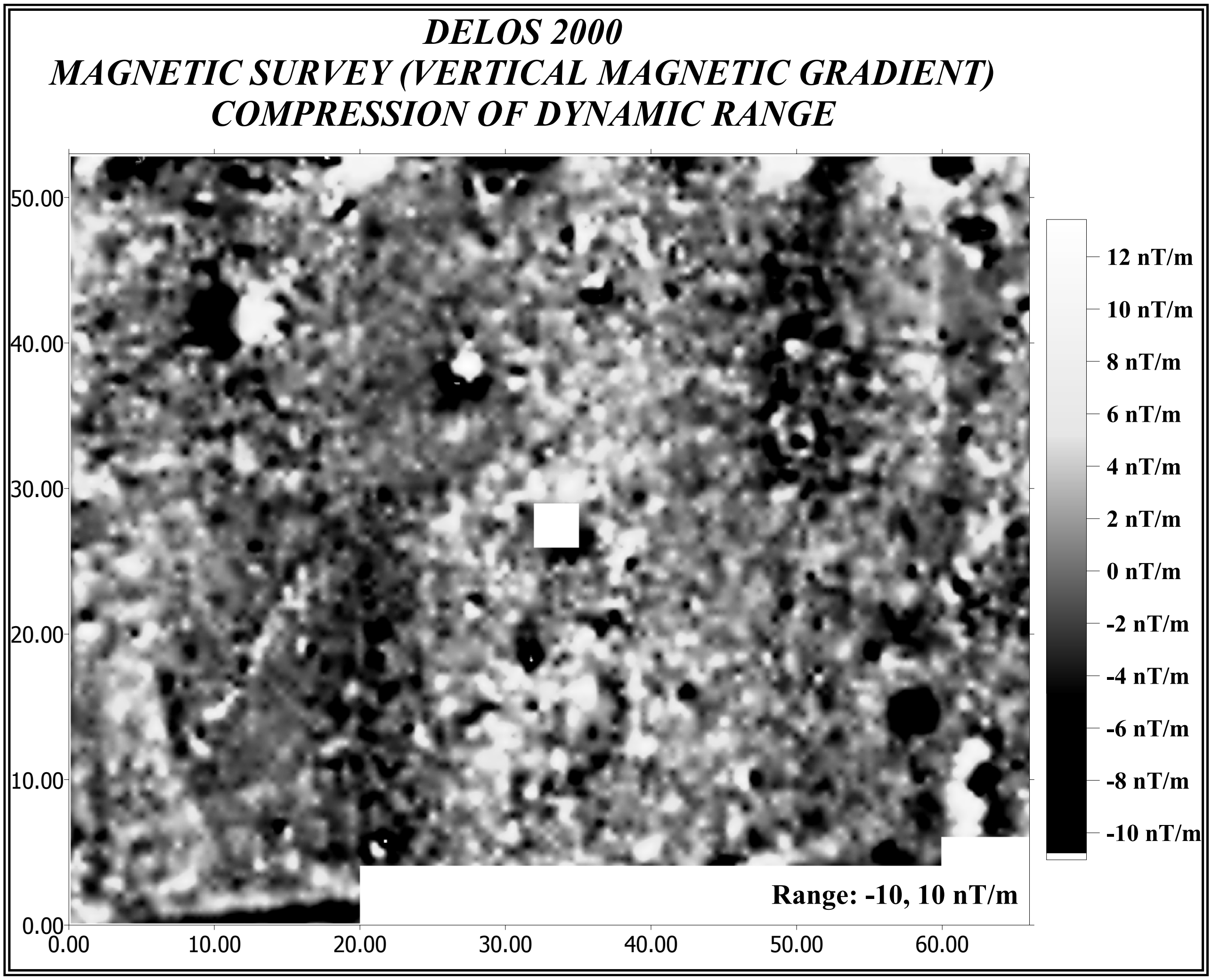

Fig. 4. Magnetic measurements. Enhancement of the weak magnetic anomalies through the compression of the dynamic range of the original measurements.

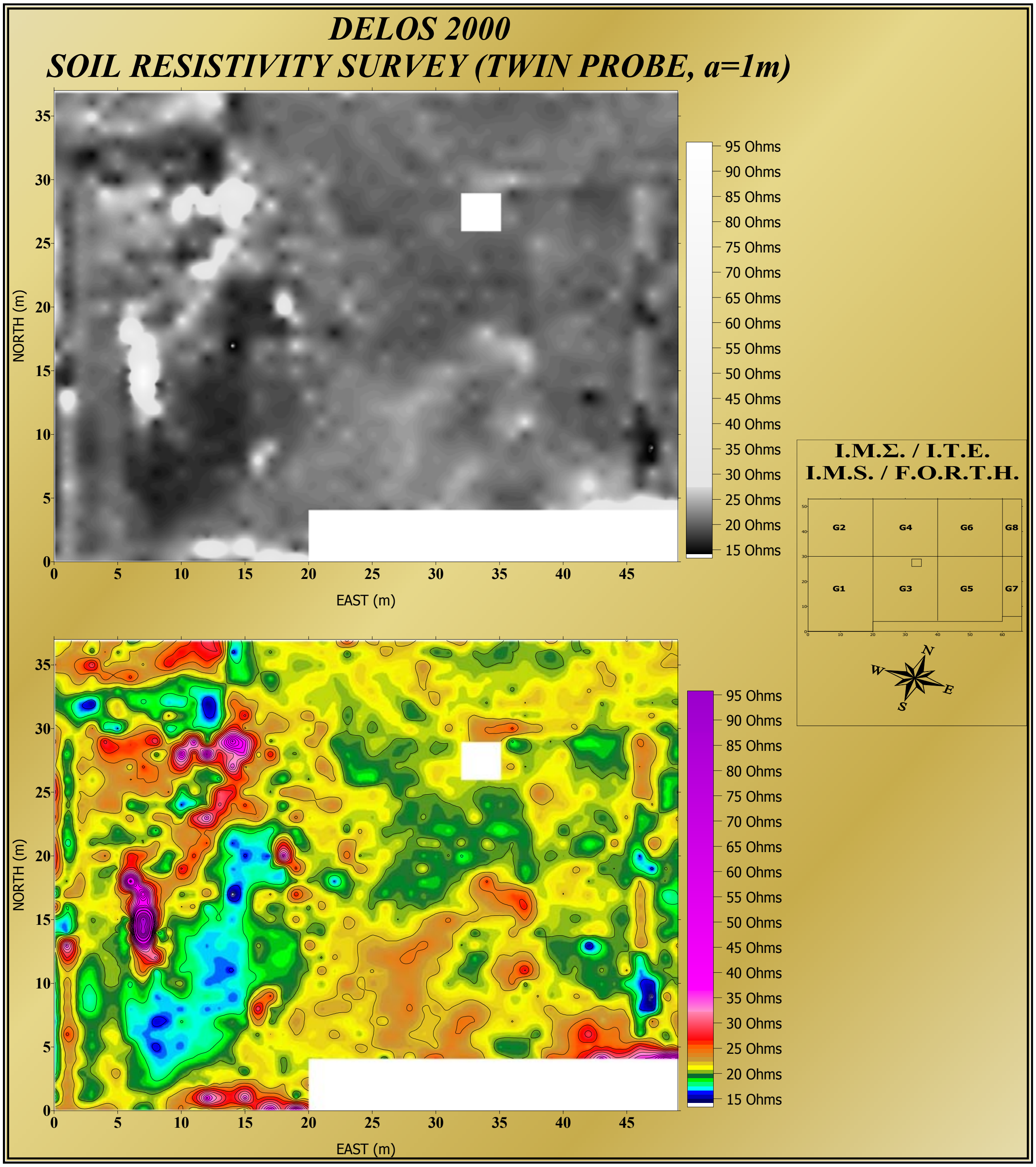

Fig. 5. A number of potential subsurface targets at the west section of the surveyed region are indicated by the map of the soil resistivity.

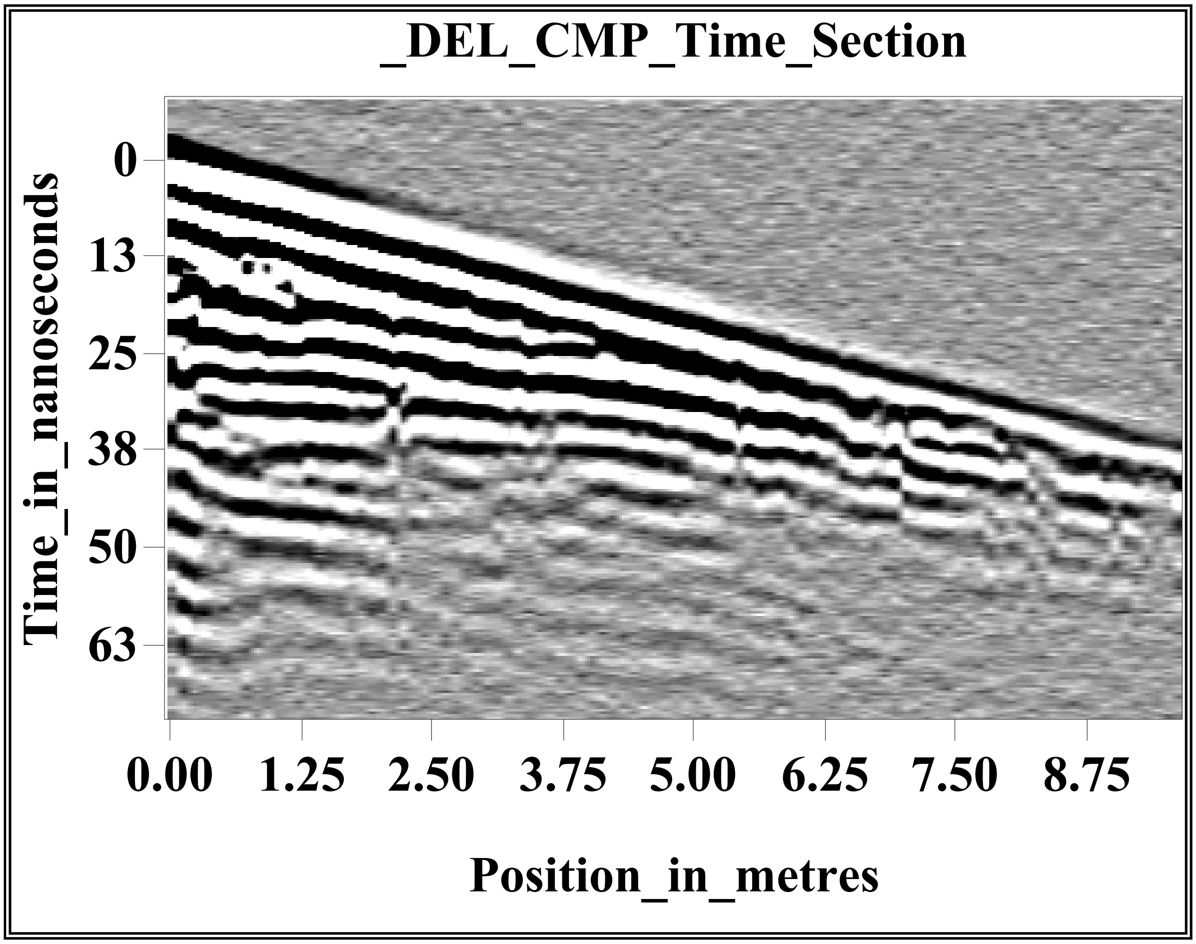

Fig. 6. Results of the common mid-point (CMP) measurements, which were carried out with the 450MHz antenna to estimate the transmission velocity of the electromagnetic waves through the subsurface.

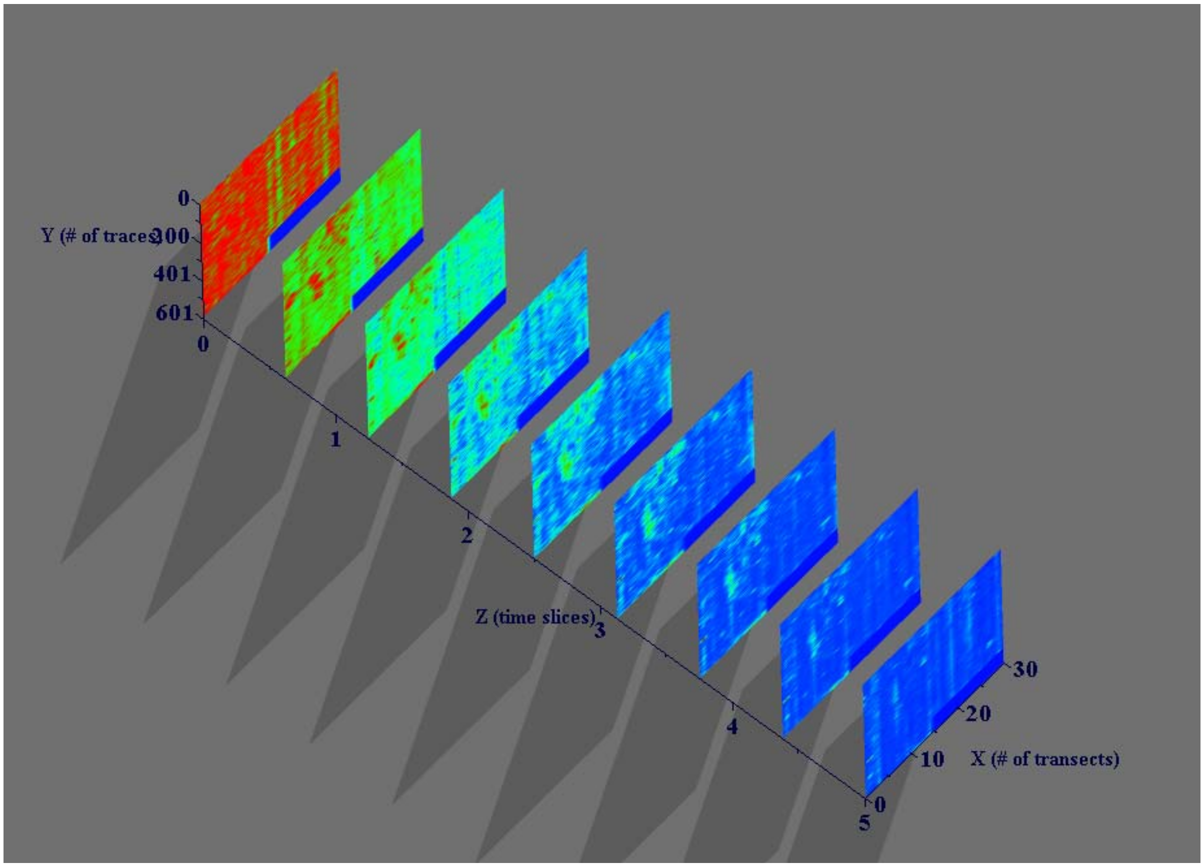

Fig. 7. Time slices for 0-20 nsec, after processing with DEWOW, DC_SHIFT, 1st_PICK, 1st_SHIFT, SPAC_HI & RECTIFY filters.

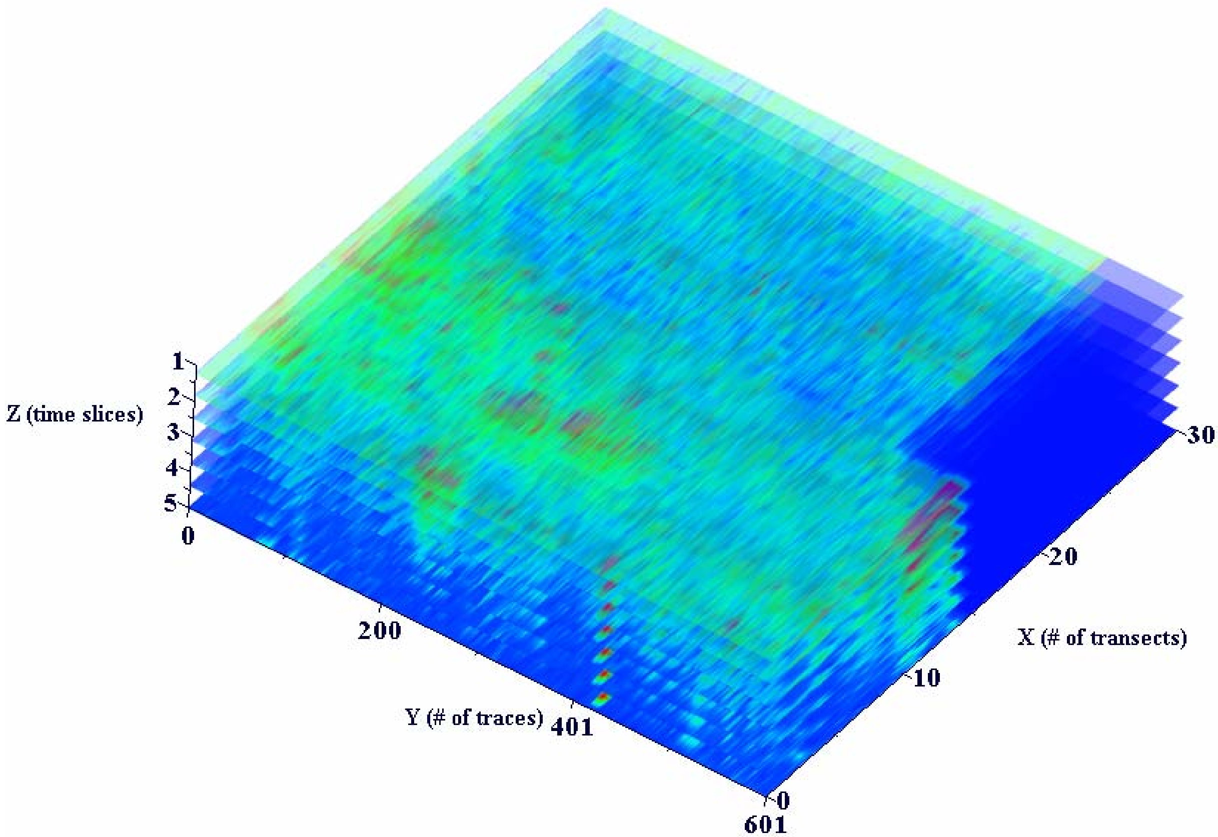

Fig. 8. Horizontal sections (time slices) of the stratigraphy with variable opacity were used for creating a 3D volumetric model representing the extension of the GPR reflection anomalies.