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3D reconstructions using GPR data at the Mont Beuvray

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Abstract

This short case study had the aim to show a possible use of 3D visualization of ground penetrating radar (GPR) results. GPR's main advantage over magnetometry is the presence of data related to the depth of the structures under the soil. This feature could be easily exploited using CAD applications and the results provide a great help for the evaluation of the GPR results.

Introduction

The cooperation between the Institute of Archaeological Sciences of Eötvös Loránd University and the Centre archéologique européen du Mont Beuvray started in 1988 on the research of the ancient site of Bibracte. The oppidum of Bibracte – once the capital of the Celtic tribe of *Aedui* – occupies the top of Mont Beuvray, which is situated in the heart of France *(Fig. 1)*. The excavations were carried out under the leadership of Miklós Szabó in the central zone of the *oppidum*, at the so called „Pâture du Couvent" *(Fig. 1–2)*. The results of this long time research project have been published in numerous articles, of which the main road of the *oppidum*,[1] a Late Augustean *domus*[2] and the earliest known Roman provincial *basilica* should be mentioned.[3]

In frame of this cooperation we were invited for testing our geophysical survey methods on Mont Beuvray, between the 22nd and 27th of April, 2013.[4] Two different methods, magnetometry and ground penetrating radar were used. The results will be fully published in a forthcoming report,[5] the aim of the present paper is to present the visualization of GPR data in CAD applications.

1 Szabó 1996.
2 Timár et al. 2005.
3 Szabó et al. 2007, with further references.
4 The research was funded by the Hungarian Scientific Fund (OTKA K 78 303) and the Balaton-project (2013). We would like to thank the support of the National Heritage Protection Centre, Hungarian National Museum.
5 Czajlik et al. 2013.

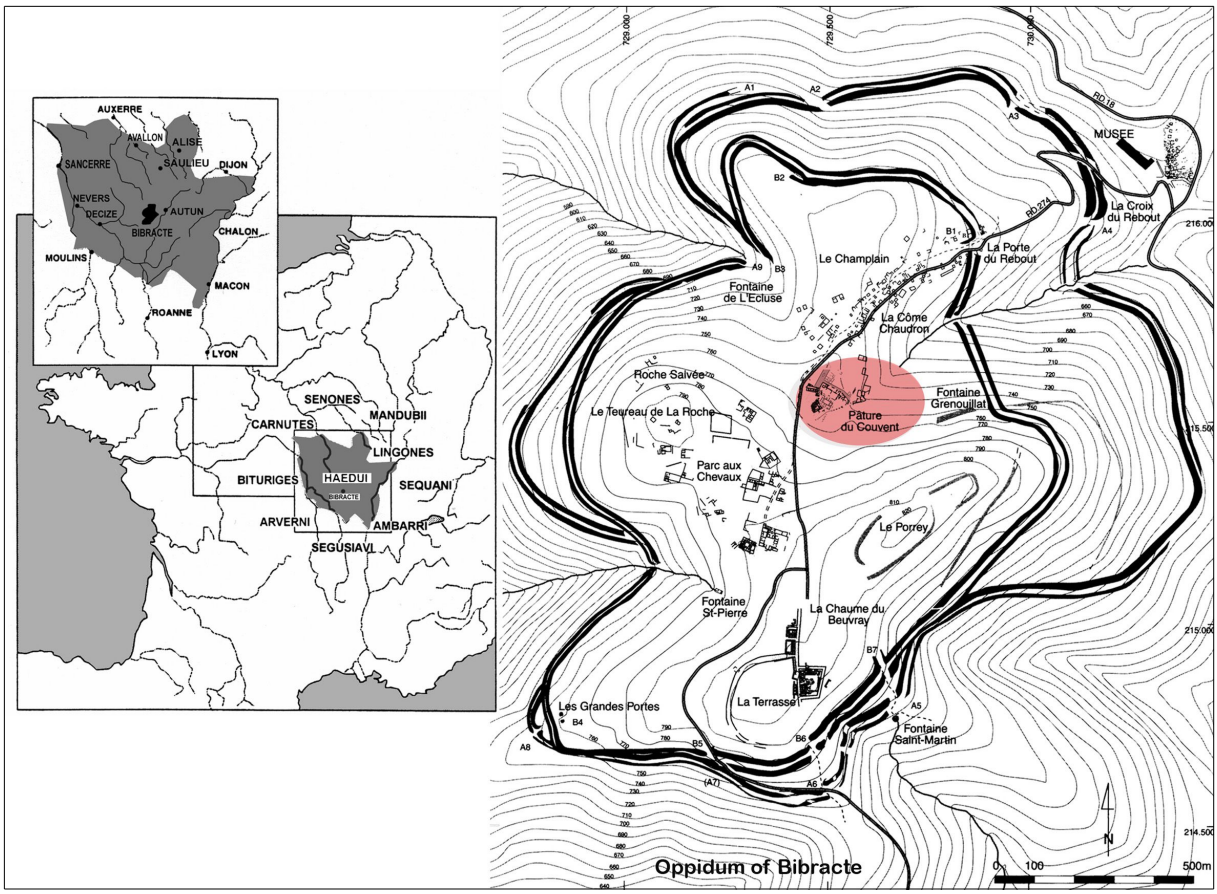

Fig. 1. Mont Beuvray, France. Location of the excavations of Eötvös Loránd University in the zone of the insula „Îlot des Grandes Forges, Pâture du Couvent".

Earlier geophysical surveys in the zone of the „Pâture du Couvent"

The site of „Pâture du Couvent" is rather complex by archaeological means. Its main *insula* in the center of the *oppidum* (referred as „Îlot des Grandes Forges") is covered by remains of several archaeological periods ranging from pre-Roman times to the Late Middle Ages, when a monastery was built and destroyed during the French Wars of Religion. The northern part of the *insula* had been partially excavated by Joseph Déchelette in the late 19th century, but excavations continued only about 100 years later by a number of international teams. The Hungarian team worked in the central part of the *insula*, while the team of the University of Leipzig excavated its northwestern corner.

According to the informations published, the first geophysical survey was carried out in 1986, on an area of approximately 1 ha using the resistivy measurement in Wenner electrode array.[6] Another resistivity measurement was done in 1994 by the Univerity of Ljubljana.[7] That research revealed the location of some walls and masonry constructions; in the zone denominated as „H" by the Slovenian researchers,[8] the team of the Eötvös Loránd University excavated the southeastern corner of the building later identified as a *domus*.[9]

6 Ducomet – Hesse 1996, 180–185.
7 Music 1994, 215, figs. 8, 11, 12.
8 Music 1994, fig. 12.
9 Szabó 1994, 85, walls [2609] and [2613]

Fig. 2. Overview of the "Pâture du Couvent".

For GPR (Ground Penetrating Radar) survey we used the following instruments:

- SIR-2000 radar and data recorder
- GSSI/Radarteam 150/300/900 MHz antennae
- grid array: 0.04 m along the lines, 0.5 m between the lines

The post processing of the GPR-data included the following processes:

- measuring gain compensation
- spherical divergence correction
- attenuation and absorption correction
- bandpass filter
- direction dependent filter
- migration

Results

Surveys in the zone of the „Pâture du Couvent" were carried out in two areas: at the southwest corner of the *insula* called „Îlot des Grandes Forges" and at the eastern side of the same *insula*, on the unexcavated field between two excavated parts.

The rendered images of the test area no. 1 *(Fig. 3–4)* indicate the position of the southwestern corner of the *insula* „Îlot des Grandes Forges" which is defined by the traces of massive masonry constructions. Unfortunately, other structures in the image are impossible to identify without any doubt, but we assume that the intensive marks in the western part of the surveyed area refer to large demolition layers consisting of stones.

In the composite images rendered from sections taken in different depths in the zone of the basilical complex (test-areas no. 2–3) traces of wall remains belonging to more than one building periods are visible. The most significant traces are located next to the walls excavated in 2005. The long excavation trench[10] comprised walls from a post-basilical phase (walls [9309] and [9243]) and both radar surveys revealed their continuation in the area southeast to the *domus* (*Fig. 3–4*; test-areas no. 2–3).

The fourth area surveyed by GPR lays to the south from the *domus*. Its radar results indicate traces of a large structure, presumably of a building complex, with an orientation that differs from the known structures of the *insula* (*Fig. 3*; test-area no. 4). When compared with the results of the excavations in 1995 there (sondage 2/2005),[11] it is highly likely that one of the short walls excavated there (wall [022]) is part of the large structure. One has to remark, that some other masonry structures are visible on the deeper layers of the radar image, the orientation of which corresponds to the aquaeduct identified earlier.

3D visualization

We also made a 3D visualization hoping that it would help us to understand the nature of the structures shown in the radar image layers. The test-areas no. 2 and 3 proved to be very complex and the connection between the marks shown in the GPR images and the excavated structures seems to be difficult to establish due to the multiple construction phases and the lack of precise depth data. Therefore, we focused on the corner of the *insula* (test-area no. 1) and the zone of the aquaeduct (test-area no. 4) because the structures indicated by the GPR imagery seem to be far easier to understand. *Fig. 5.* shows the visualization of these two test-areas with the reconstructed structures. As we mentioned above, structure A in the test-area no. 1 seems to be a junction of two walls in a position which could be interpreted as the remains of the *insula*'s western corner. The 3D visualization implies short standing wall sections.

Structure B in the test-area no. 4 appears to be a part of a relatively large rectangular building. This structure is not aligned with the known ancient buildings, thus it belongs to a different archaeological period. Unfortunately, at this moment the GPR data can not be translated directly to absolute depth measurements. *Fig. 6.* shows the relationship of the surveyed, known and reconstructed structures. Structure B seems to be overlapping nearly all of the other structures that reflected the radar waves, but none of those other structures

10 See Szabó 2005 for further details.
11 Guillaumet 1995.

have connections to the excavated walls. One can assume that this part of the test-area no. 4 was destroyed extensively and the wall remains were extracted.

Through this short case study we would like to show how such 3D visualizations could help the understanding of the GPR results. When the excavated structures are properly modelled in 3D, there is a possibility to compare them with the reconstruction derived from a GPR survey.

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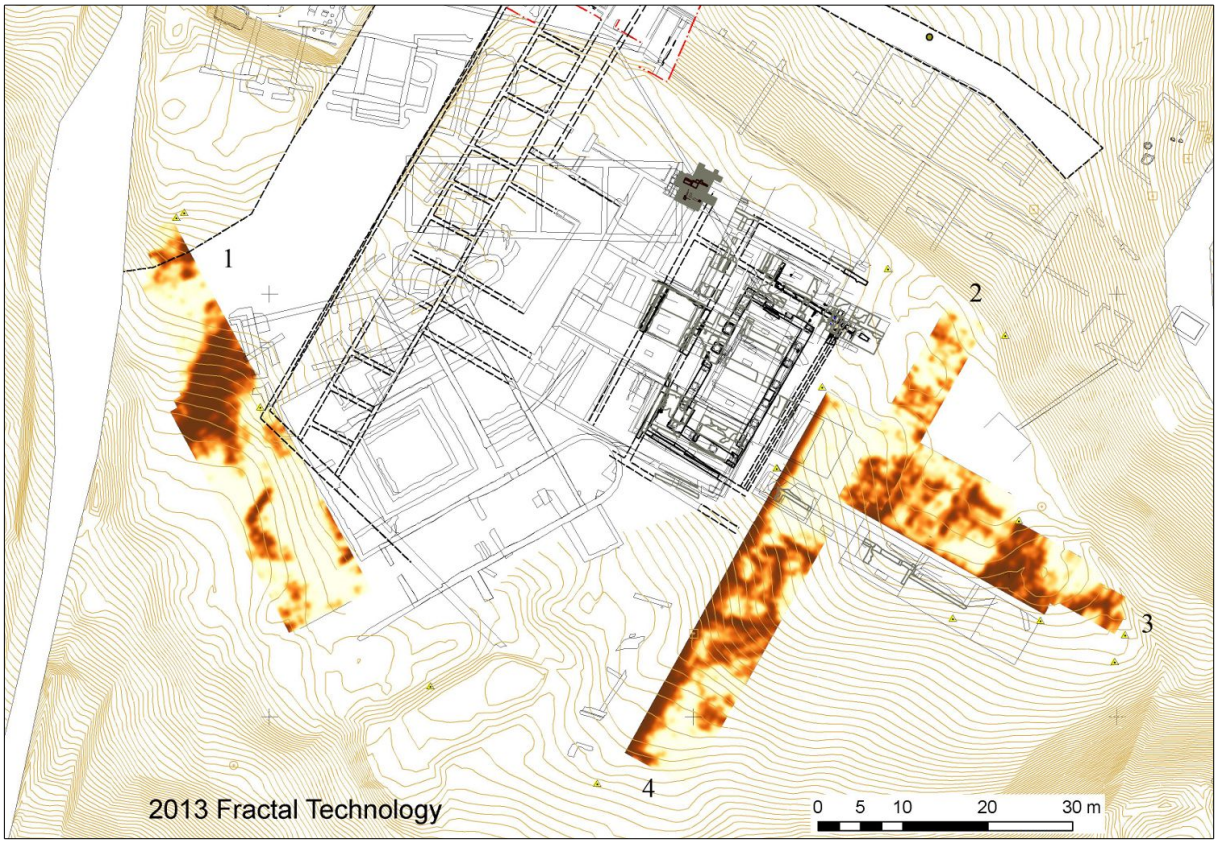

Fig. 3. Pâture du Couvent. Composite ground-penetrating radar results, constant time slice 38 ns.

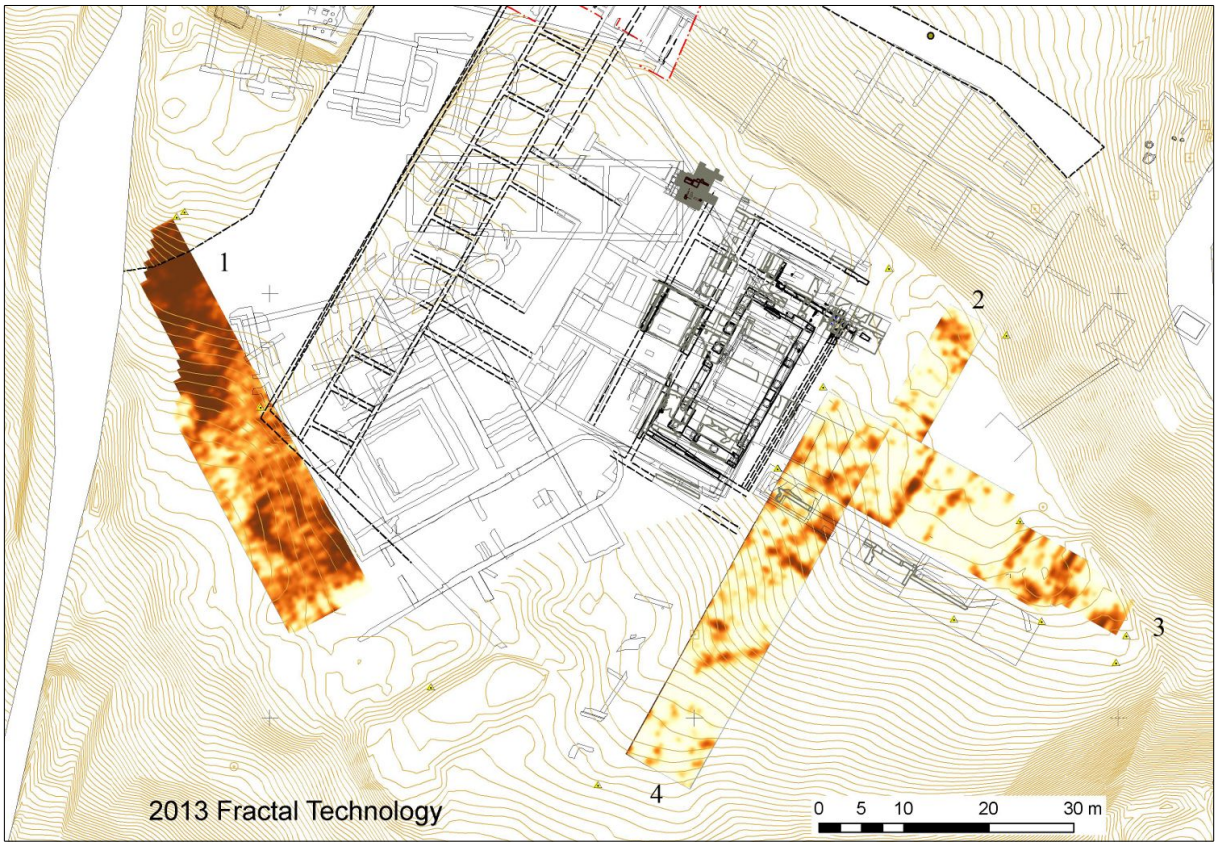

Fig. 4. Pâture du Couvent. Composite ground-penetrating radar results, constant time slice 58 ns.

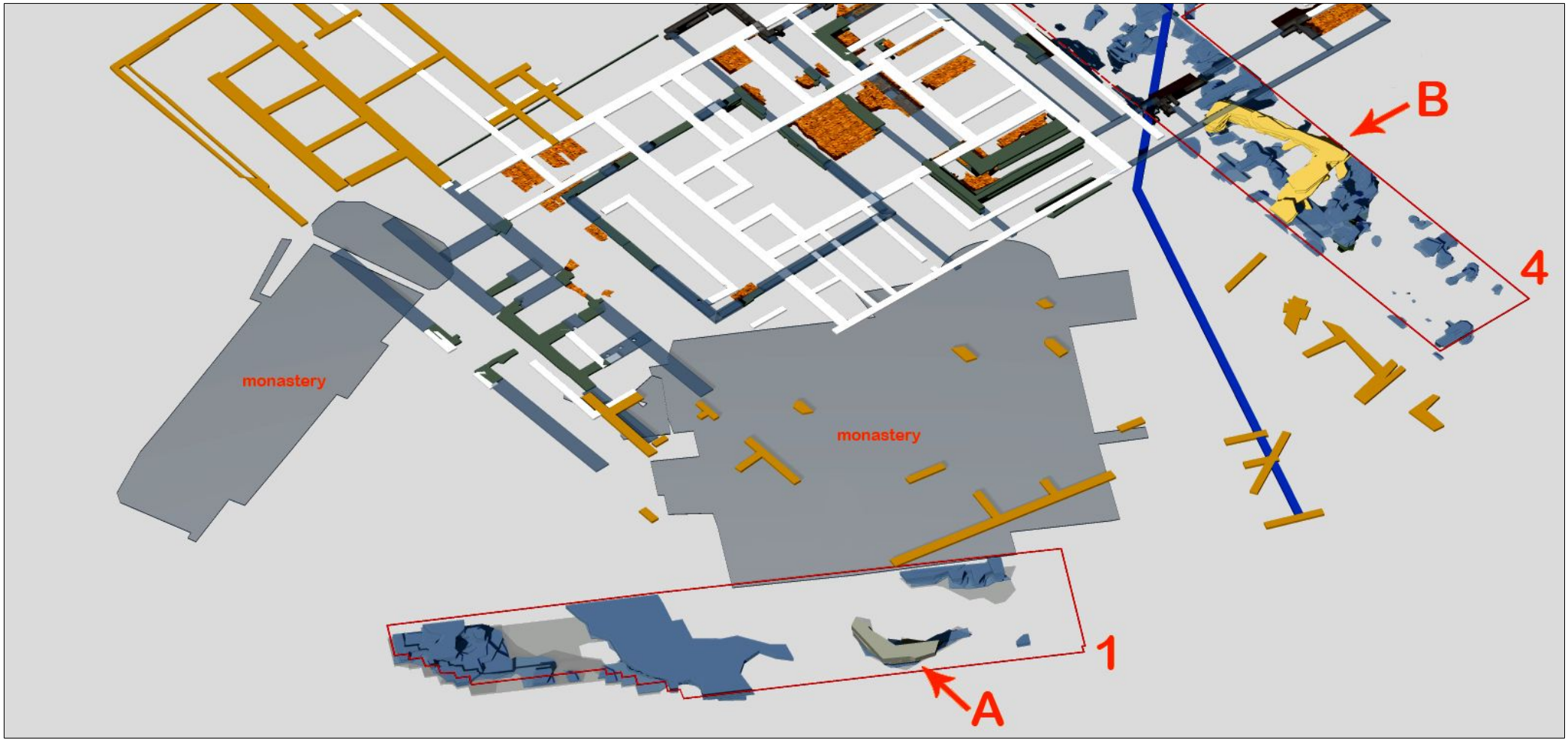

Fig. 5. 3D visualization of the GPR test-areas no. 1 and 4.

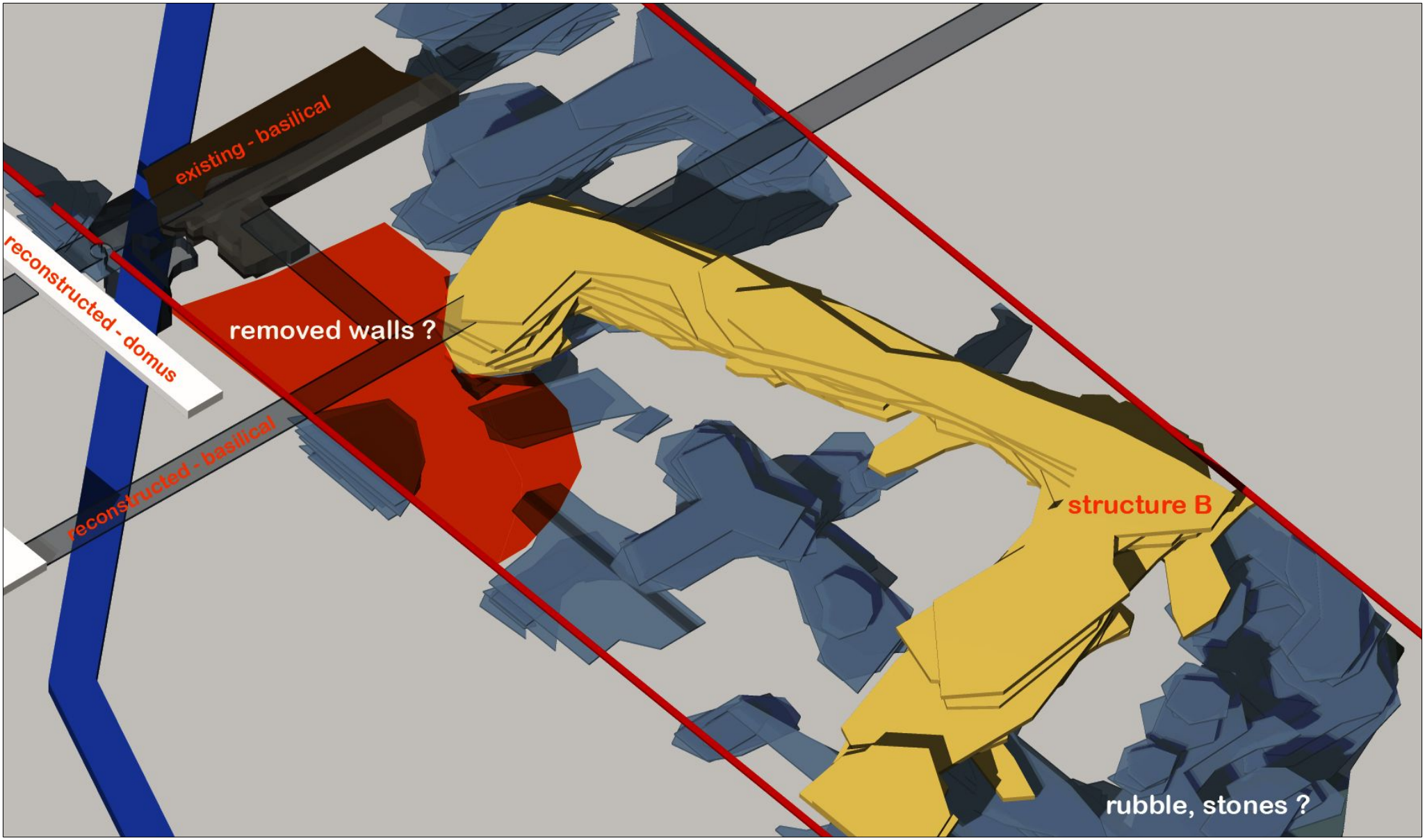

Fig. 6. Close view of GPR test-area 4, showing the connection between excavated and GPR surveyed structures.