USING OF NON-DESTRUCTIVE UNDERGROUND GEOPHYSICAL TESTING FOR BUILDING HISTORICAL RESEARCH

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Abstract: *In this paper verification and completion of building-historical research using georadar SIR is discussed. The aim was to find invisible underground structures by non destructive technology; as a case study the parish church in Prague 9 - Dolní Počernice was chosen.*

1. INTRODUCTION

At the beginning it is necessary to briefly mention a nondestructive method for surface exploration, which is essentially a result of scientific and organizational work of PhDr. Dobroslav Líbal and his associates in the mid of the 20th century. PhDr. Líbal (we commemorate a 100 years´ anniversary from his birth this year) concentrated in the research center of the then State Institute for historical towns and objects reconstructions a number of important architectural as well as art historians, who in the cooperation with other experts and Institute specialists laid new foundations for the Czechoslovak conservation school in the area of building monuments and their urban complexes. Our then care of monuments, especially by this broader "urban" view, placed the forefront of contemporary European conservation theory and practice.

Exploratory work started right at the beginning of the existence of the Institute and crystallized in a comprehensive methodology that is essentially used until today.

These surface surveys were conducted on several levels - for wider territorial units, historic settlements´ cores and finally for individual objects and their closer units. The last mentioned level, later signified as a standard building-historical survey was and still is the most widespread form of SHP. The content of a standard SHP passport is a text part, which includes extensive archival search with a list of studied materials, architectural analysis and building description, constructions of a building history, architectural and historical object evaluation, a list and a summary of architectural and historical monument details as well as defects and finally recommendations for future treatment and functional use. The graphic part of work is represented by a stylistic analysis of the object constructions of all floor plans and their evaluation. Finally, copies of key archive documents are included – e.g. maps, plans, archive iconographies, archive and present photographs. Gradually deepening surface architectural and historical surveys do not affect constructions nor building operation. They became so an integral part of regeneration processes. They contribute to their architecturally, technically and economically successful results and immediately face the danger, to which historical objects, files and all the historic settlements are threatened by ignorance of their development, architectural nature and absolute or relative art value.

2. MODERN NON-DESTRUCTIVE RADAR METHOD

Ground penetrating radar (GPR) uses the same basic principles as conventional radars, which detect objects in the sky, on the earth's surface or in the sea. Georadars are used to determine the location of

underground facilities for radio waves´ transmission and reception. It is therefore an active device. The most important georadar part is its antenna. Georadar antennas´ frequencies have a range from 50 to 2 000 MHz (low-frequency antennas are significantly more robust than high-frequency antennas). The higher frequency provides a better vertical substrate resolution but a low penetration whereas lower frequency provides a better penetration and thus also a deeper range, but at the expense of vertical resolution. For these research measurements using the GPR system SIR-3000 from the American GSSI (Geophysical Survey Systems, Inc.) company was used. This is currently the latest georadar model from that leading company in the area of geophysical exploration.

3. CASE STUDY: THE PARISH CHURCH OF THE OUR LADY ASSUMPTION IN PRAGUE 9 - DOLNÍ POČERNICE

Figure 1:The parish church of the Our Lady Assumption in Prague 9 - Dolní Počernice

The parish church of the Our Lady Assumption in Prague 9 - Dolní Počernice is located at the eastern edge of the core of an ancient village that grew on a distance road near the ford of the Rokytka River. The church immediately adjoins a then feudal seat of the village owner - an old castle. The church is an oriented building with an elongated rectangular nave and with a rectangular chancel. To the northern side of the nave a high prism tower with a pyramidal roof is attached. The older facade after the Neo Romanesque transformation and last modifications was deprived of a number of stucco elements. Modern noble oratory adjoins the church end. The chancel is by a slightly compressed vault overlapped; the nave lies under three cross-fields arched from in-wall half pillars and cornered half pillars.

The surface building-historical survey confirmed (unlike a recently installed information board) that in the masonry an almost complete Romanesque ownership church remained preserved. That was a part of the adjacent curia of an early feudal nobleman, built sometimes at the end of 12th century or at the turn of the next century. It can not be excluded that the church is the work of the same workshop, which built an Episcopal church in nearby Kyje. A similar character and sandstone blocks´ building material, from which the church of the Assumption was built, could indicate this (as found under partly sink plaster and in the attic of the nave). Building material for both sites was probably brought from the same quarry at the edge of the Chvalská terrace. Only east little window remained visible

from the details of the Romanesque appearance of the church. Romanesque sanctuary, however, was shorter than the present church. Sometime in the 14th century, the first time when we start to learn about the existence of that building from written sources, the church nave was extended to the west, and subsequently there was another bell tower built, at the corners reinforced by sandstone blocks. The only preserved element from that period (or from younger one) is a late Gothic saddle portal into the space under the tower.

The subsequent Renaissance period influenced the appearance of the church interior by inserting cross vaults on the added half pillars. The following period that the surface building-historical survey closely followed, did not spill the historical nature very much, neither did the last radical modification of the outer building shell in the Neo Romanesque style in 1887.

Former feudal seat, adjacent to the western gable of the church with a tower, was indisputably related to the church. Surface building-historical survey captured in the castle wing at the church a layout of a massive fortress´ tower construction from High Middle Ages, followed by a rectangular palace, along to which a narrow neck ran to the north, ending in the castle front garden by a younger brick up part. A cellar beneath the palace corner seems obviously to Renaissance. From here a shorter flooded corridor runs out to the church ending at the outer face of the castle building.

Radar survey conducted to supplement information on the changes of the church building tried to find the original location of the origin western Romanesque gable wall first of all and then to verify the existence of the foundations of the reasonably foreseeable western grandstand. The used method also verified its own capabilities and limits. For example measurements could be done in the longitudinal strip of 170 cm width only between the rows of benches, then measurement in front of the chancel, where wooden floor is laid on the pavement, was not feasible either. It was also necessary to assume that in the area of the village, where no stone building material is available, stone building material from disparate parts of the foundations could be used for the church nave extension in the 14th century.

4. FILD WORK

For measurements in the church of the Assumption a plan of the object was given, on which two locations with the expected occurrences of objects of interest were plotted. The first of them contained the position of an original Romanesque west gable wall and pillars of the noble tribune; the second the locator grave. The locator was the person responsible for a village or a town establishing. His duty was to find people willing to settle in a new settlement, to represent and organize all activities associated with the settlements´ establishment. As an altar stands at the presumed tomb location, and radar measurements on accessible locations did not show any anomalies in the subsoil, other measurements were not executed.

Measurements of the original gable wall as well as pillars of the noble tribune were also possible on a limited, however for the survey sufficient, space only. The area was defined by 1.5 meters wide aisle between the prayer benches, which practically occupy the whole part of the main nave. In this area a network profile of the 1.5 x 9.6 meters was measured out (i.e. essentially the length from the front door to the elevated presbytery) with the help of strings and a tape measure. On the profiles there is a clearly drawn hyperbola at a depth of 0, 6 meters below the surface and at a 5 meters distance from the baseline. Because of the fine flattened hyperbole top it might concern the searching wall. The location of the found object corresponds with the presumed wall location, namely in two-thirds of the existing building. The fact, that the object display is in first two profiles at a distance of 5.8 meters from the start and at a distance of 0.8 meters closer in the remaining profiles, speaks for that these could be remains of the searched wall and not a pipeline. Should this be a pipeline, the building shape was in one line. The object on the first measured profile could be so one of the pillars.

After the filtrations and hyperbola tails removal by "migration" function the exact object depth was gained at 0.5 m. In the case of the searched wall there are more founded object points apparent and their depth range varies in each profile. From the depths, to which these points are distinct, the depth of the object along its course can be estimated.

5. GPR SURVEY'S RESULTS AND CONCLUSIONS

Wooden floor on the pavement in front of the chancel did not allow to capture the expected burial pits. Measurements made in front of the present western church gable tried to capture the palace corridor continuation toward the church tower under the palace part of the old castle. According to one of the considerate options there could be an escape church tower connector after the demise of the refuge feature of the High Middle Ages stronghold tower. According to the results gained from the radiometric survey the corridor did not continue further beneath the church tower but apparently runs into the church garden. Irregular destructions captured at the castle entrance opposite the church enter gable failed to be identified more precisely. Maybe these are the remnants of the sink lavatories, serving visitors of the later church noble tribune after by imprints substantiated arched bridge from the castle to the church (lavatories remained preserved in the castle attic).

The last measurement was made even on the pavement in front of the castle front garden and did not capture the castle neck continuation further towards the north by a non-destructive method. It wrote off so a local romantic legend about the existence of "a secret underground passage."
Radiometric measurements made in the nave captured a part of foundation walls of the western church gable and east from it probably a south pillar foundation, apparently a triple arched arcade beneath the defunct noble tribune…

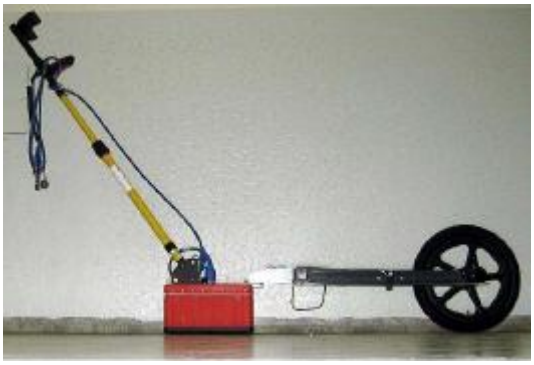

Figure 2: GPR with 400MHz antena

6. AREA SUMMARY RESULTS

Based on the mentioned findings I am inclined to that the found object really represents the remnants of the western gable wall of the original church. The wall course is displayed in 3D view, namely in the cut at a depth of 0, 50 meters. Orthogonal cut projection of the same depth was set in a church plan based on by a tape measure measured connection lengths.

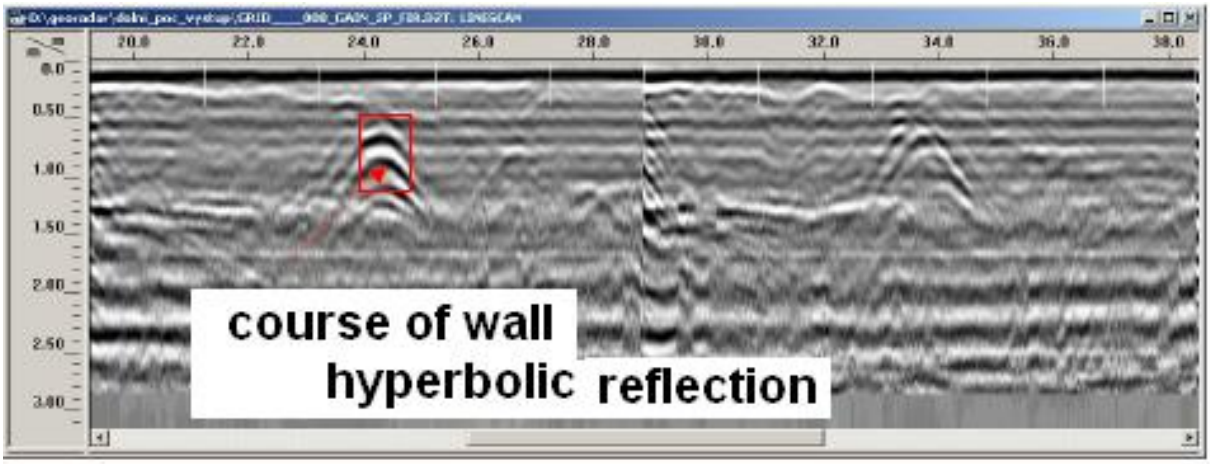

Figure 3: Hyperbolic reflection from the expected course of wall

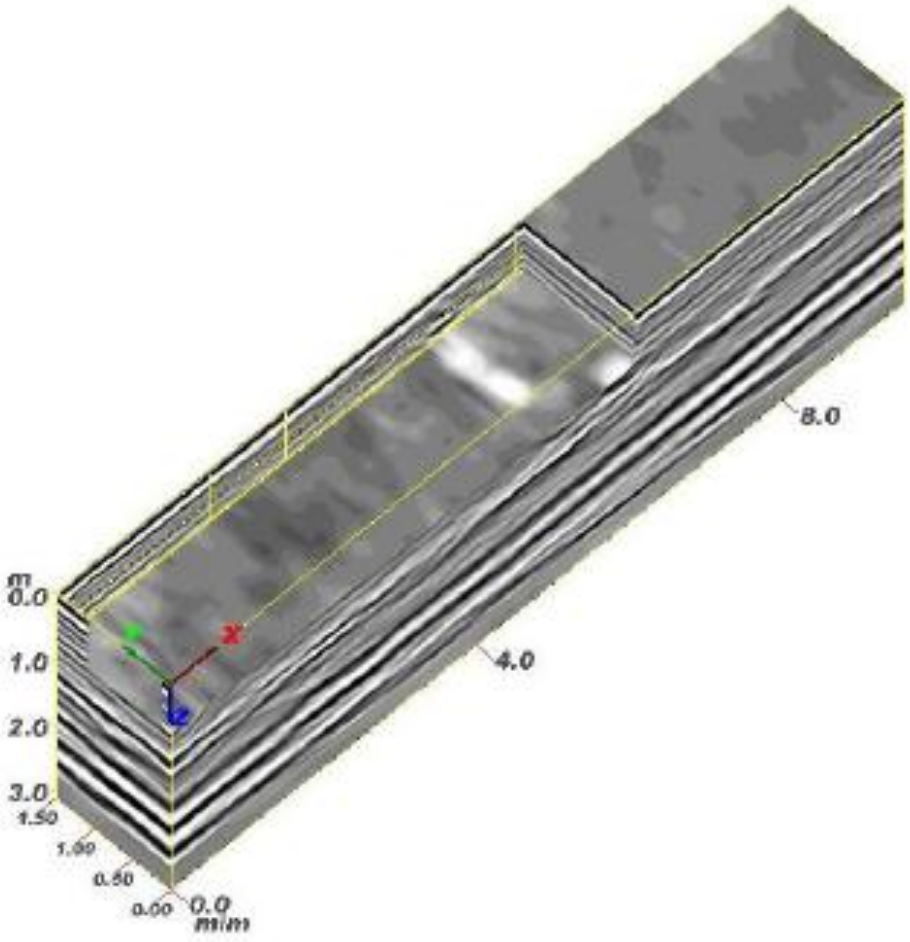

Figure 4: Wall course at the depth of 0.80 meters – a distinctive white stripe. Measurement June 2009

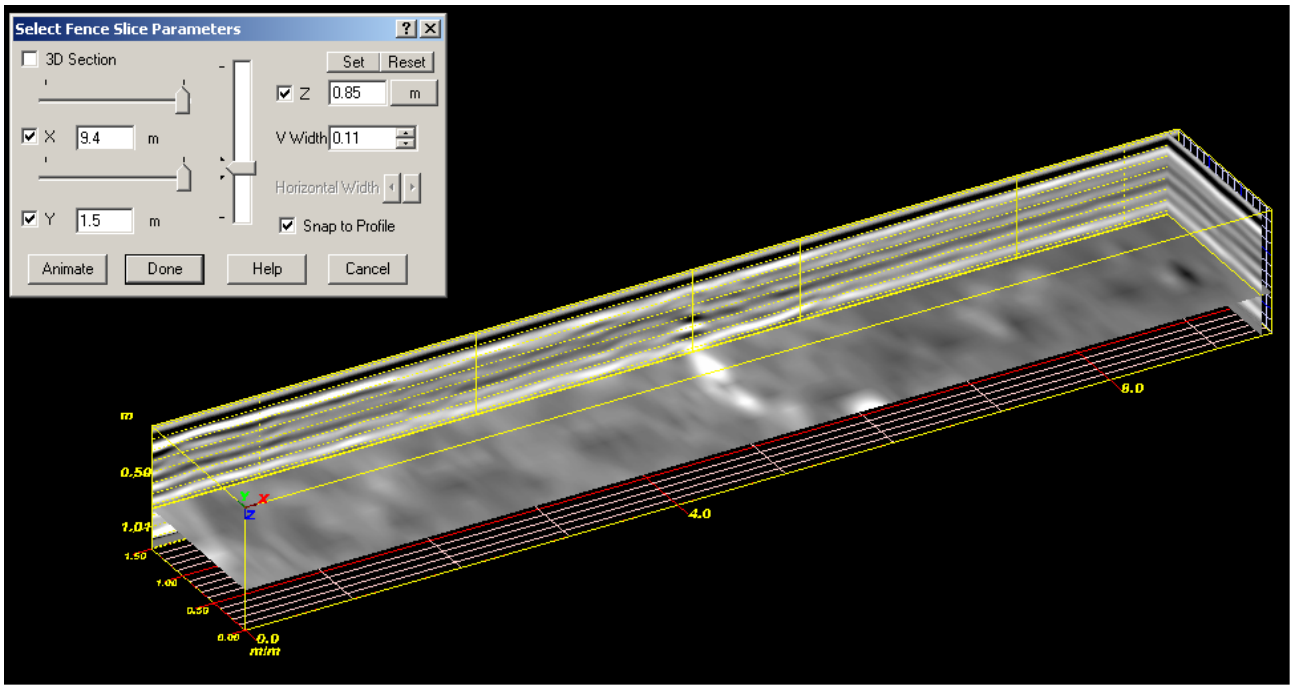

Figure 5: Wall course at the depth of 0.85 meters – a distinctive white stripe. Measurement July 2011

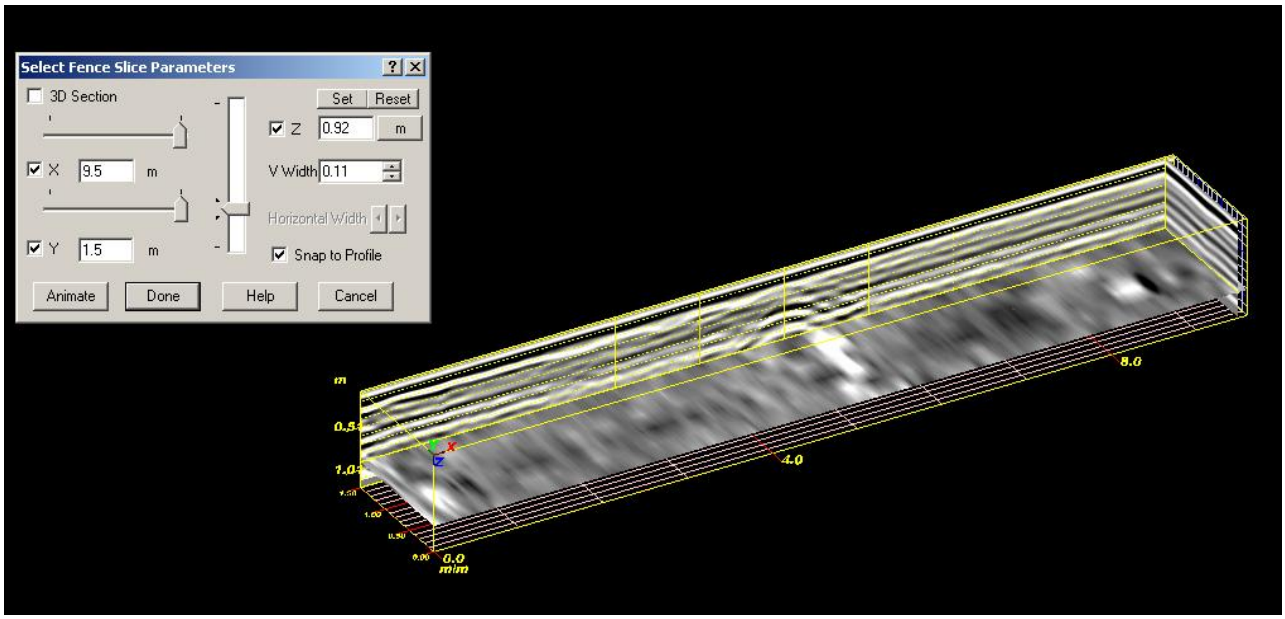

Figure 6: Wall course at the depth of 0.92 meters – a distinctive white stripe. Measurement July 2011

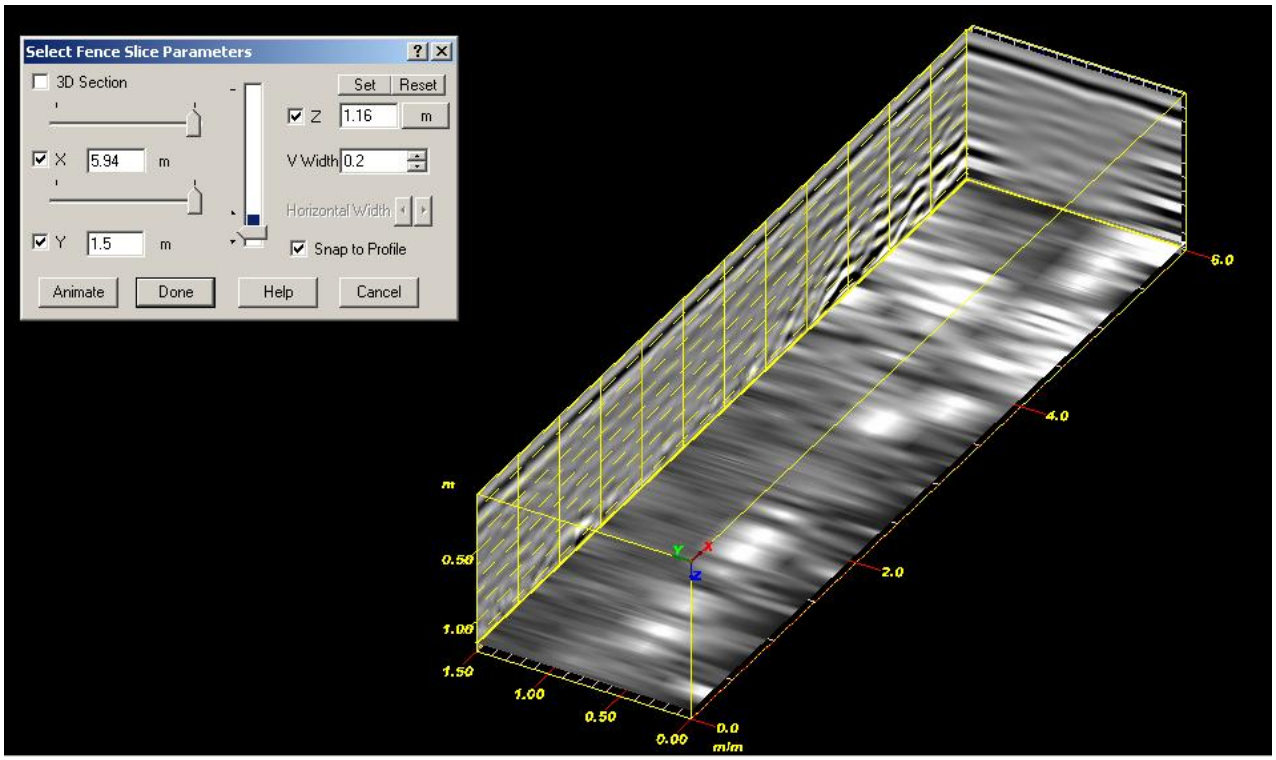

Figure 7: New strictures at the depth of 1.16 meters in from of entrance. Measurement July 2011

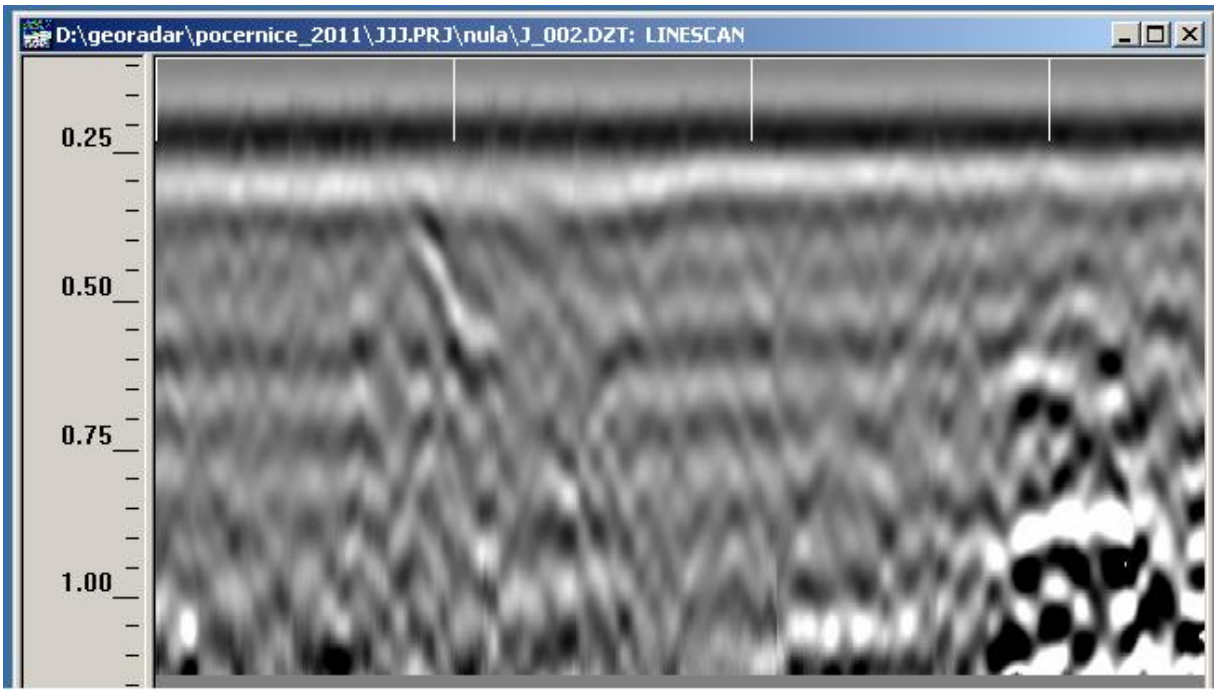

Figure 8: New strictures at the depth of cca 0.9 meters in from of entrance by the staircase of the old castle. Original radarogramm nr.2. Measurement July 2011

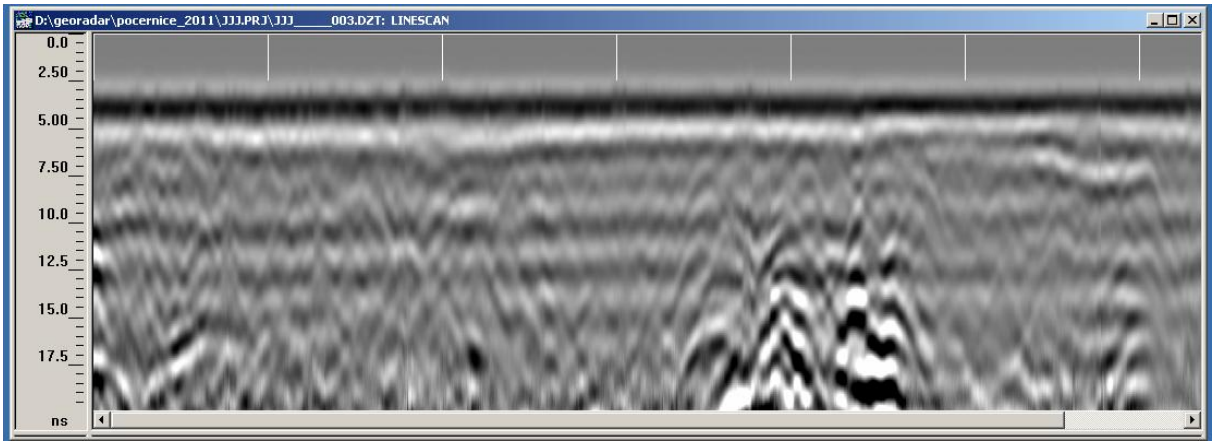

Figure 9: New strictures in from of entrance; center of the area in fromt of entrance. Original radarogramm nr.3. Measurement July 2011

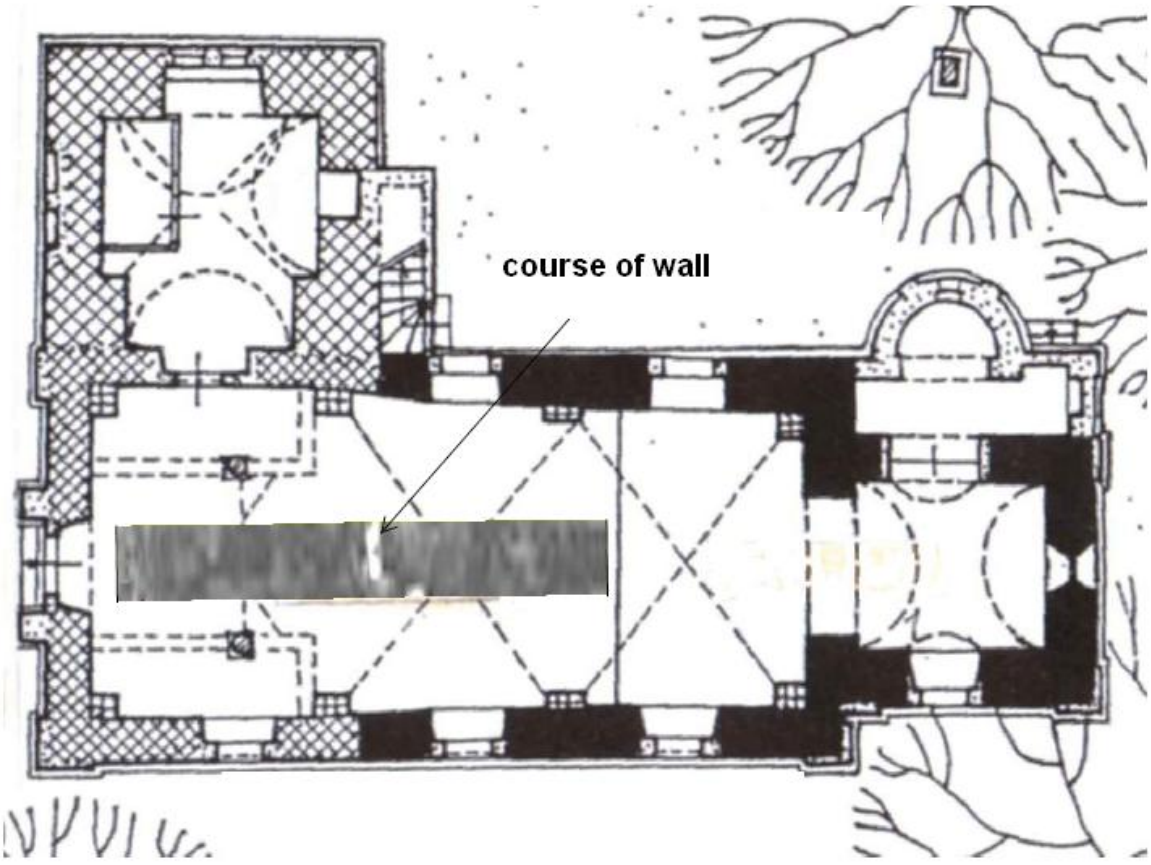

Figure 10: The plan of church with GPR measurement result

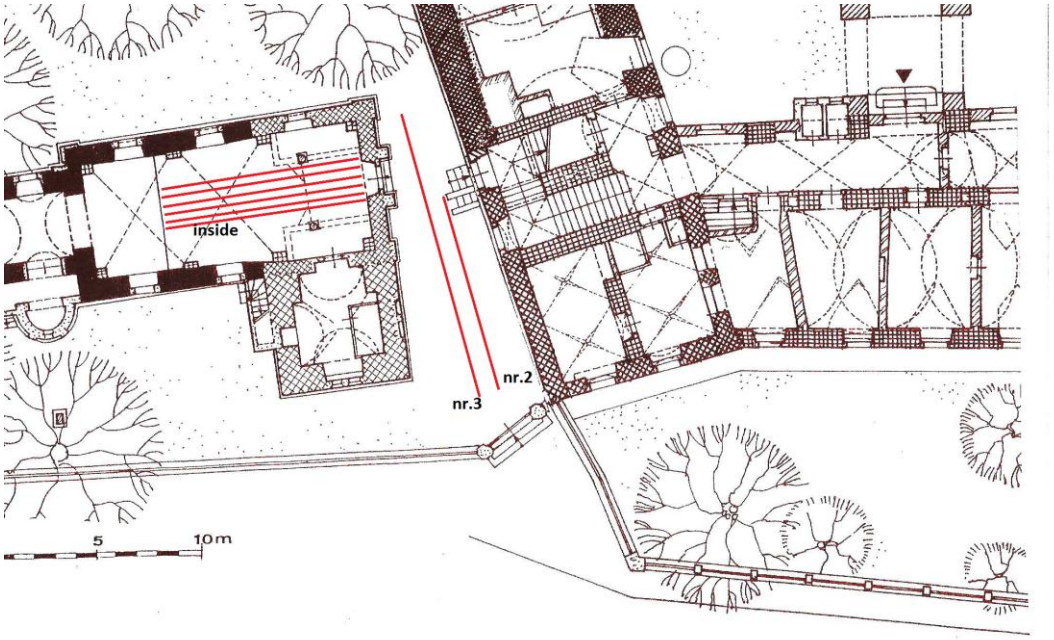

Figure 11: Ground floor plan of the church with the old castle, a black colour is Roman masonry, reticulated stage of Gothic. Other is Renaissance and younger.

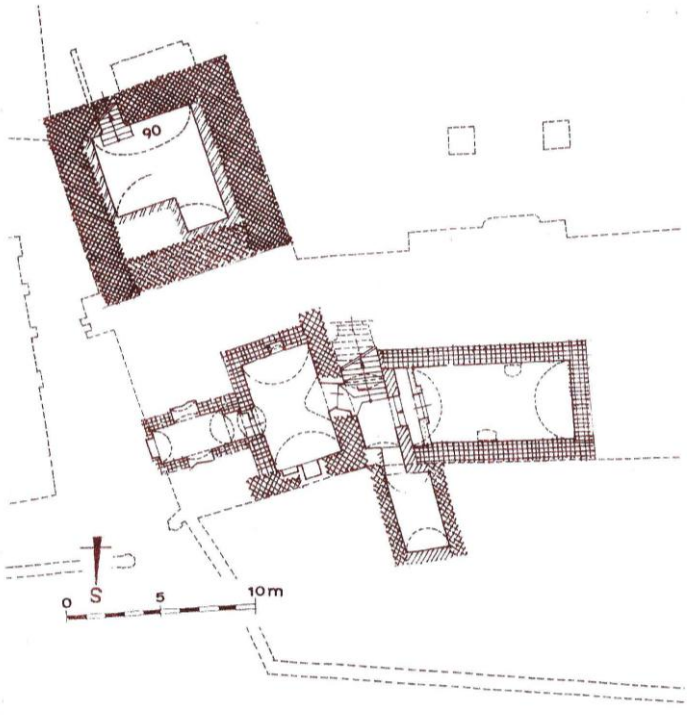

Figure 12: The old castle cellars and underground passages

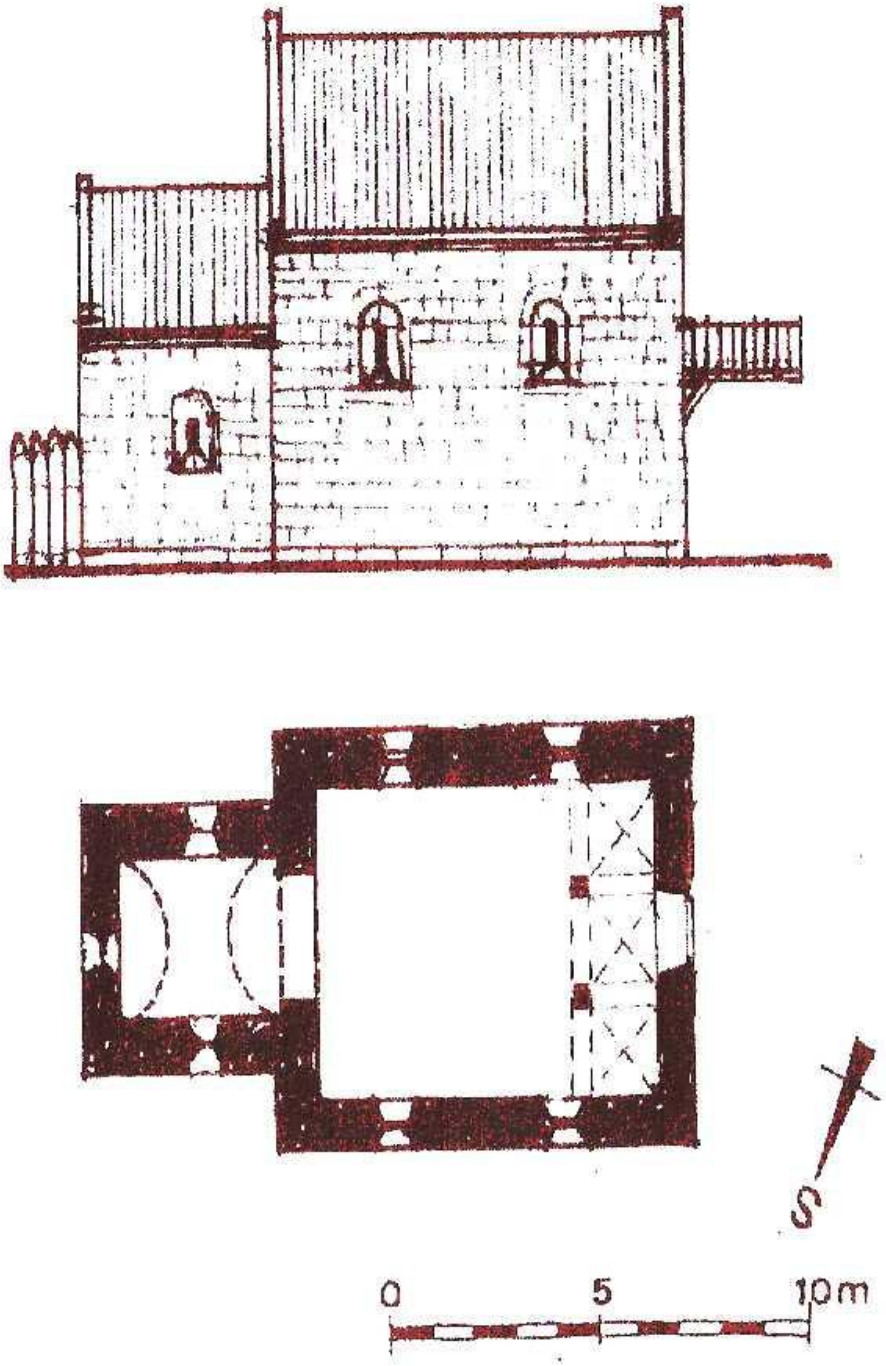

Figure 13: Reconstruction of the church, around 1200 AD

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