Employment of multiple GPR surveys in urban area, as part of the ERC Rome Transformed project.

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GI5.4 **EGU_14265**

Ground Penetrating Radar and other geophysical techniques: Applications and Advancements

Co-organized by EMRP2/SSP1

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- Project Aim
- Site location
- Geophysical Surveys – GPR surveys with different frequencies
  S. Giovanni in Laterano and S. Giovanni Paolo II square
  S. Croce in Gerusalemme
- Results
- Preliminary remarks

(https://research.ncl.ac.uk/rometrans/)

Rome Transformed has received founding from the European Research Council ERC under H2020 EU.1.1. Grant Agreement n. 835271.

Project partners

The Rome Transformed Project is developed between:

- the New Castle University (UK) – PI Prof. Ian Haynes
- the Florence University (Florence, Italy) – Prof. P. Liverani and Prof. M. Azzari
- the British School at Rome, BSR – Dott. S. Kay
- the Institute of Heritage Sciences, ISPC CNR – Dott. S. Piro

Project background and aims:

Important research and technical issues are related to the prospection in urban area to locate subsurface cavities and/or archaeological remains and to produce hazard mapping. In many cases, cavities, such as subsidence features, voids and collapses represent disruptions to the geometry of an originally near-horizontal layered system. Geophysical techniques can be employed to identify the feature geometries by contrasts in the physical properties, but can be strongly conditioned by cultural features that interfere with instrument measurements (utilities, structures, surficial debris). The most promising non-destructive geophysical prospection method for use in urban area is GPR (ground penetrating radar).

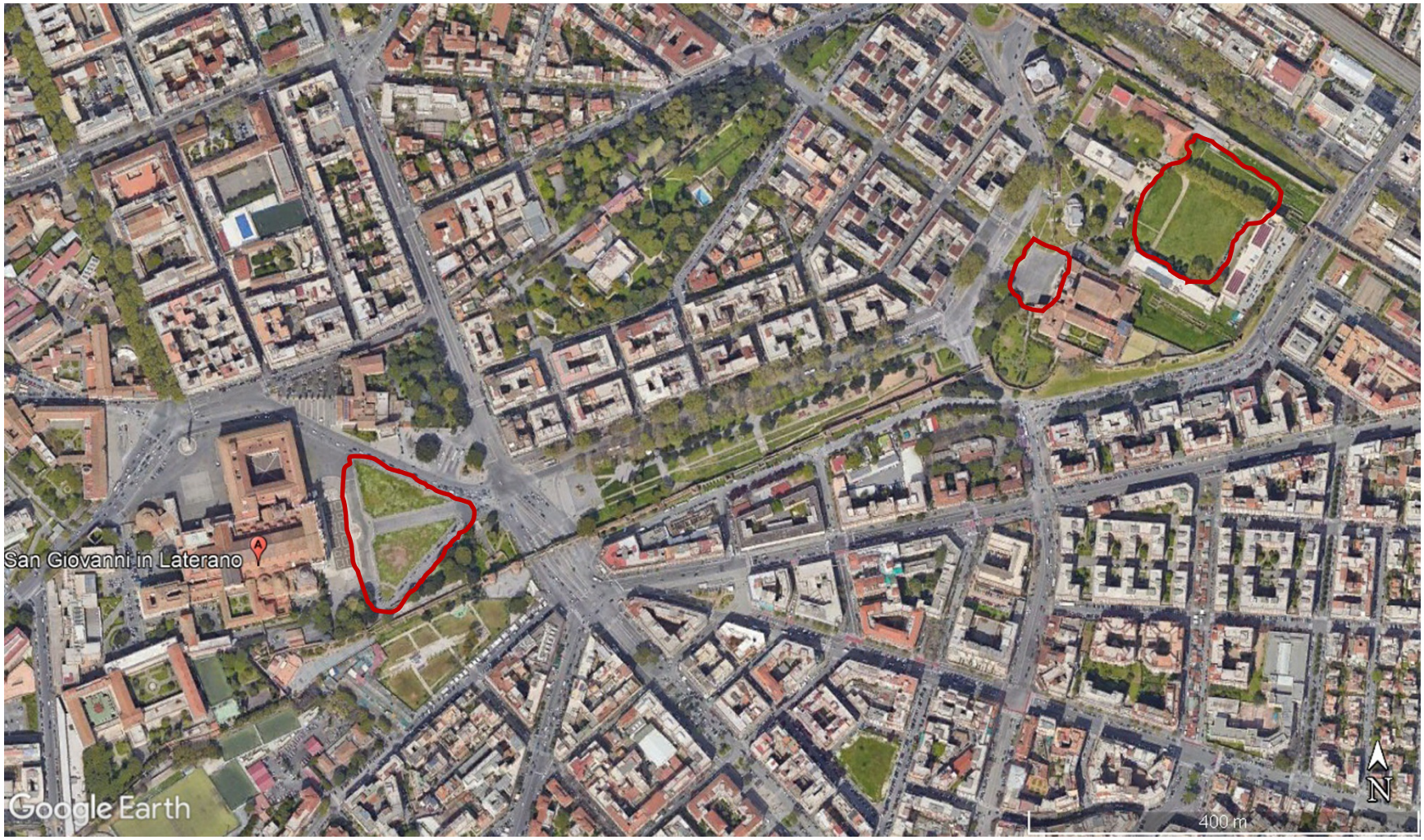
The **Rome Transformed Project** aims to enhance the knowledge of Rome place in cultural change across the Mediterranean world by mapping political, military and religious changes to the Eastern Caelian from the first to eighth centuries AD, as it developed from a marginal area of elite Roman houses at the end of the Republic to being the site of the archbasilica of Rome, Saint John Lateran.

The aim of the GPR surveys, employed in the present project, are to identify Roman and high-medieval age remains which could enhance understanding of the ancient topography and the urban evolution of the studied area.

Geophysical method

GPR systems SIR 3000 and SIR 4000 equiped with 400 MHz, 300/800 MHz and 70 MHz antenna

Location of the investigated area



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Newcastle University | Università degli Studi Firenze | B S R British School at Rome | Consiglio Nazionale delle Ricerche | ISPC Istituto di Scienze del Patrimonio Culturale | Rome Transformed

Location of the investigated area

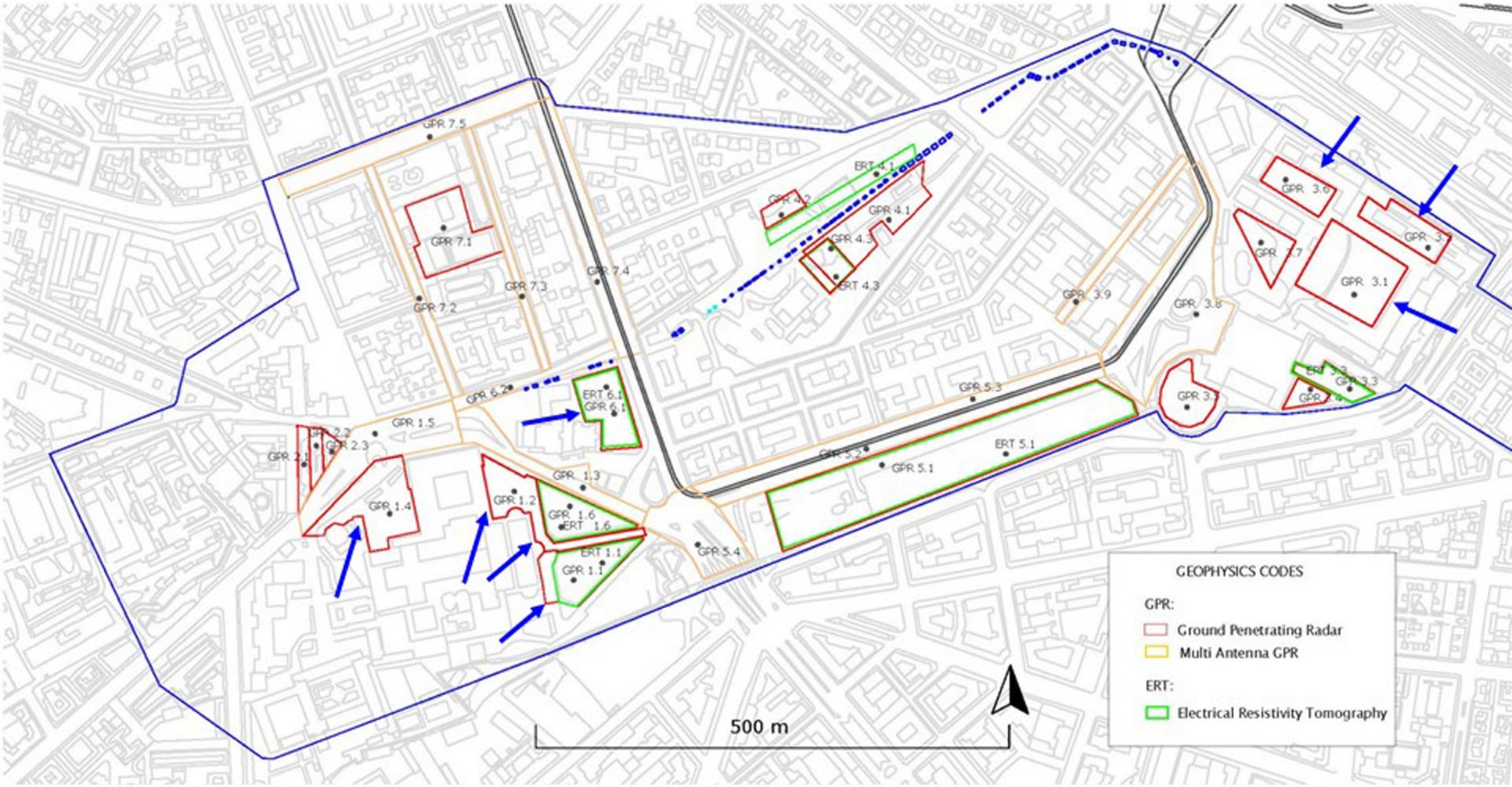

Fig. 1 - GPR surveys Area GPR 1.1, 1.2, 1.4, 1.6, 3.1, 3.2, 3.6 and 6.1

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Employed instruments

In the complex site considered in the Rome Transformed Project, a series of GPR surveys employing different frequencies were carried out. For the field measurements two different GPR SIR3000 and SIR4000 Systems (GSSI), the first equipped with a 400 MHz antenna with constant off-set and the 70 MHz monostatic antenna, the second equipped with digital dual frequency antenna with 300/800 MHz were used. The 400 MHz antenna was as a compromise between depth penetration to about 2÷3 meter and resolution of features on the order of 0.15 – 0.20 m in order to define the archaeological features of interest. The 70 MHz antenna was employed to investigate at a depth penetration more than 2÷3 m and with a resolution more than 0.30 m. The 300/800 MHz antenna was employed to investigate simultaneously two different depth ranges, 0-3 and 0-5 m, with different resolution.


monostatic 70 MHz antenna


bistatic digital 300/800 MHz with constant off-set

In the selected area adjacent profiles, across the site, were collected alternatively in forward and reverse directions employing the GSSI cart systems equipped with odometer. All radar reflections within the 90 *ns* for 400 *MHz* antenna, within the 90.72 *ns* for 300 *MHz* antenna, the 54.5 *ns* for the 800 *MHz* antenna and 195 - 230 *ns* for 70 *MHz* antenna (two-way-travel) time window were recorded digitally in the field as 16 bit (or 32 bit with SIR4000) data and 512 samples per radar scan.


bistatic 400 MHz with constant off-set

Basic Radargram Signal Processing

- Post processing gain
- DC-drift removal
- Data resampling
- Background removal
- Migration

Basic image Processing

- Interpolation
- Staggering noise correction
- Transform/color application
- Time-slices
- Overlay analysis
- 3D image

S. Giovanni in Laterano square

GPR4_080 Georeferenced time-slices

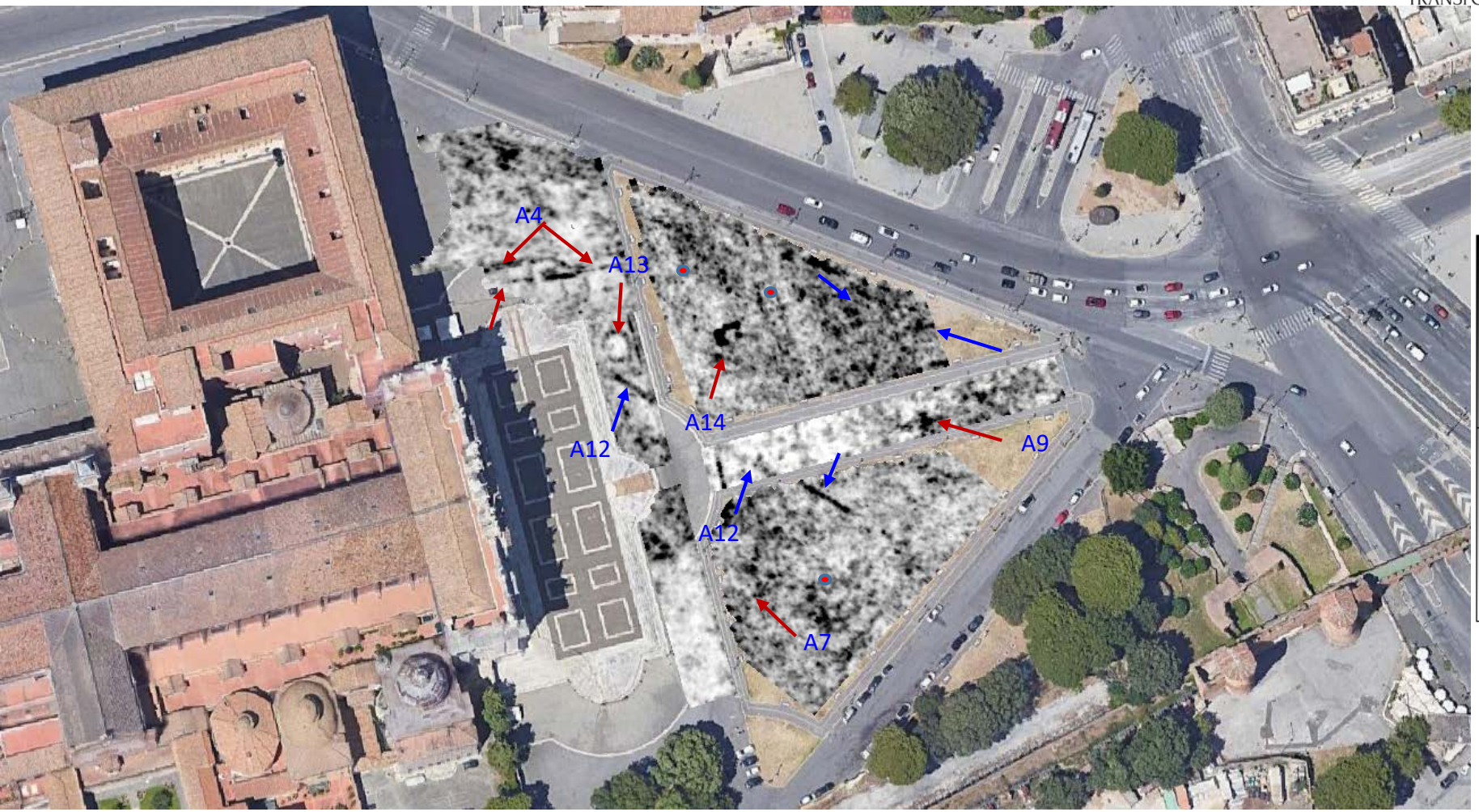
location of the bore-holes

0 m 50

At this depth, the area are characterized by many reflections due to the presence of utilities and of portion of structures.

Fig. 1

S. Giovanni in Laterano square



GPR4_150 Georeferenced time-slices

location of the bore-holes

0 m 50

The area are characterized by many reflections due to the presence of utilities and of portion of structures.

Fig. 2

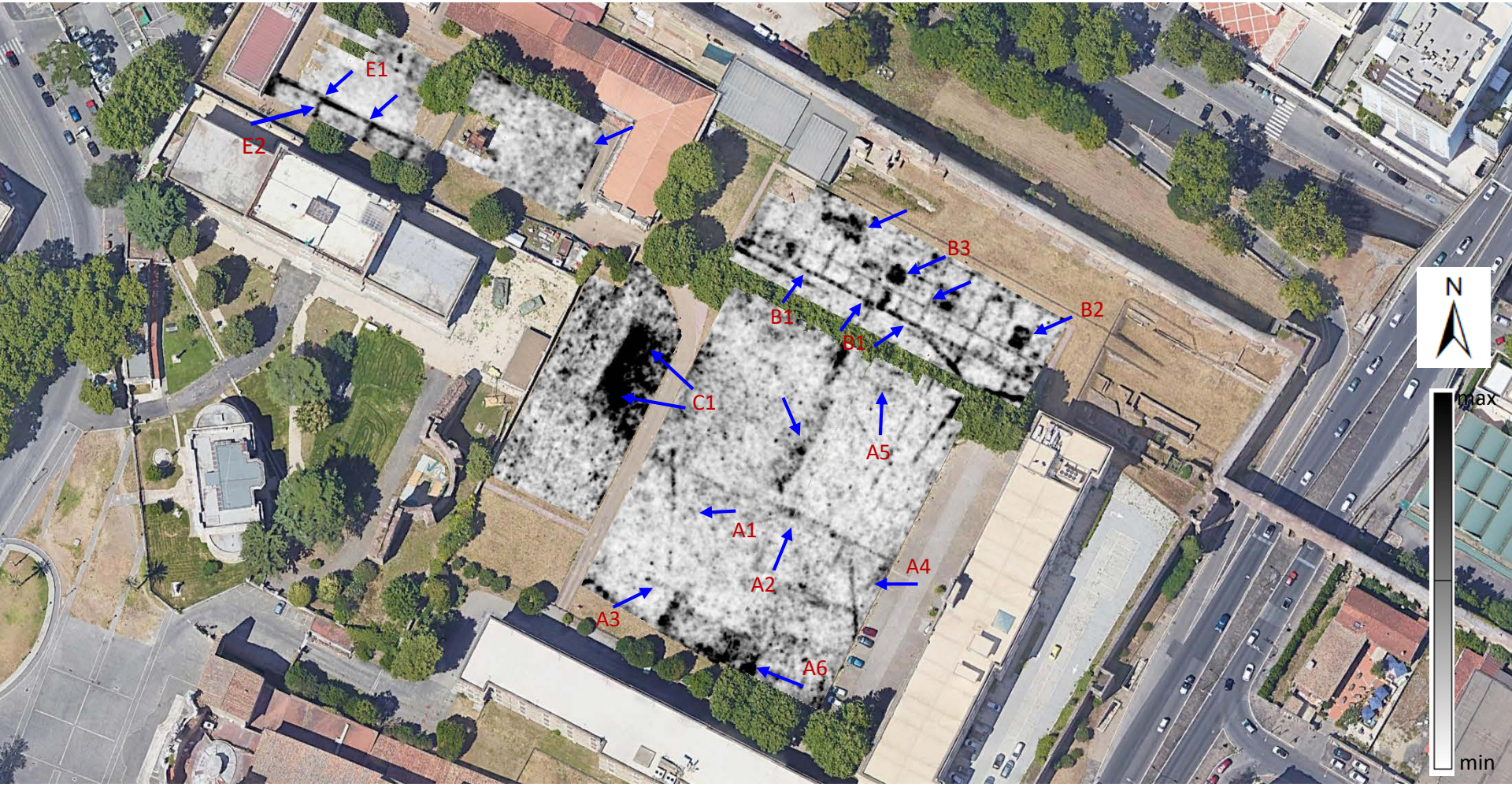
S. Giovanni in Laterano square

The size of the anomalies, indicated in **Fig.1**, are approximate: (A1) this anomaly is due to the presence of utility and it is characterized by low intensity; (A2) linear anomaly is not visible; (A3) linear anomaly is not visible; (A4) anomaly with small dimension; (A5) this anomaly is not visible. (A6) area with few anomalies without any defined geometrical shape, the surface is about 9.0 x 2.7 m; (A7) area with few anomalies; (A8) anomaly with dimension 4.8 x 2.1 m; (A9) anomaly with angular shape and dimension 14.1 x 8.6 m; (A10) anomaly due to probable utility with dimension 43.5 x 0.7 m; (A11) semicircular anomaly with dimension 21.2 x 1.1 m.

Fig.2 shows the anomalies located at the estimated depth of 1.50 m, individuated in the area 1.1, 1.2, 1.6. At this depth, the area are characterized by many reflections due to the presence of portion of structures. The size of the anomalies, indicated below, are approximate: (A1), (A2) and (A3) are not visible; (A4) traces of linear anomalies (possible walls) with the same dimension. (A12) utility with the dimension 106.5 x 1.4 m; (A13) circular anomaly with diameter 7.30 and size 1.1 m; (A14) anomaly with L shape and dimension (7.8 x 1.4 m) + (5.1 x 2.2 m).

Georeferenced time-slices

S. Croce in Gerusalemme



S. Croce Aree GPR 3.1, 3.2, 3.6 – July-October 2020
Results of GPR 300 MHz surveys.
Estimated depth: 1.3 m

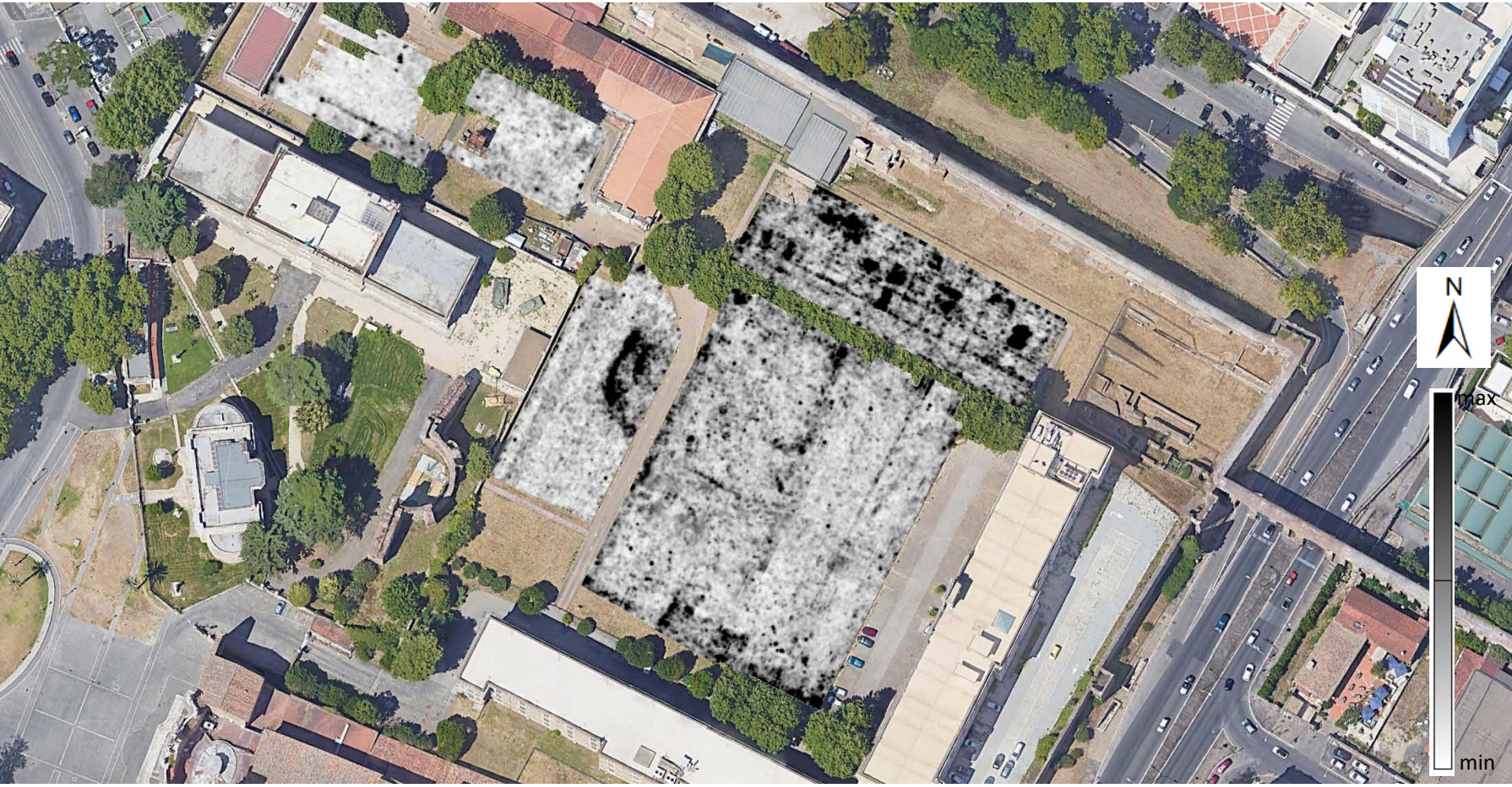
0 m 50

This area is characterized by the presence of many linear and perpendicular anomalies with the different dimensions.

Fig.3

Georeferenced time-slices

S. Croce in Gerusalemme



S. Croce Aree GPR 3.1, 3.2, 3.6 – July-October 2020
Results of GPR 300 MHz surveys.
Estimated depth: 1.9 m

0 m 50

At this depth we observe an enhancement of the dimensions for B4: 2.3 x 5.9 m and B5: 5.0 x 2.0 m.

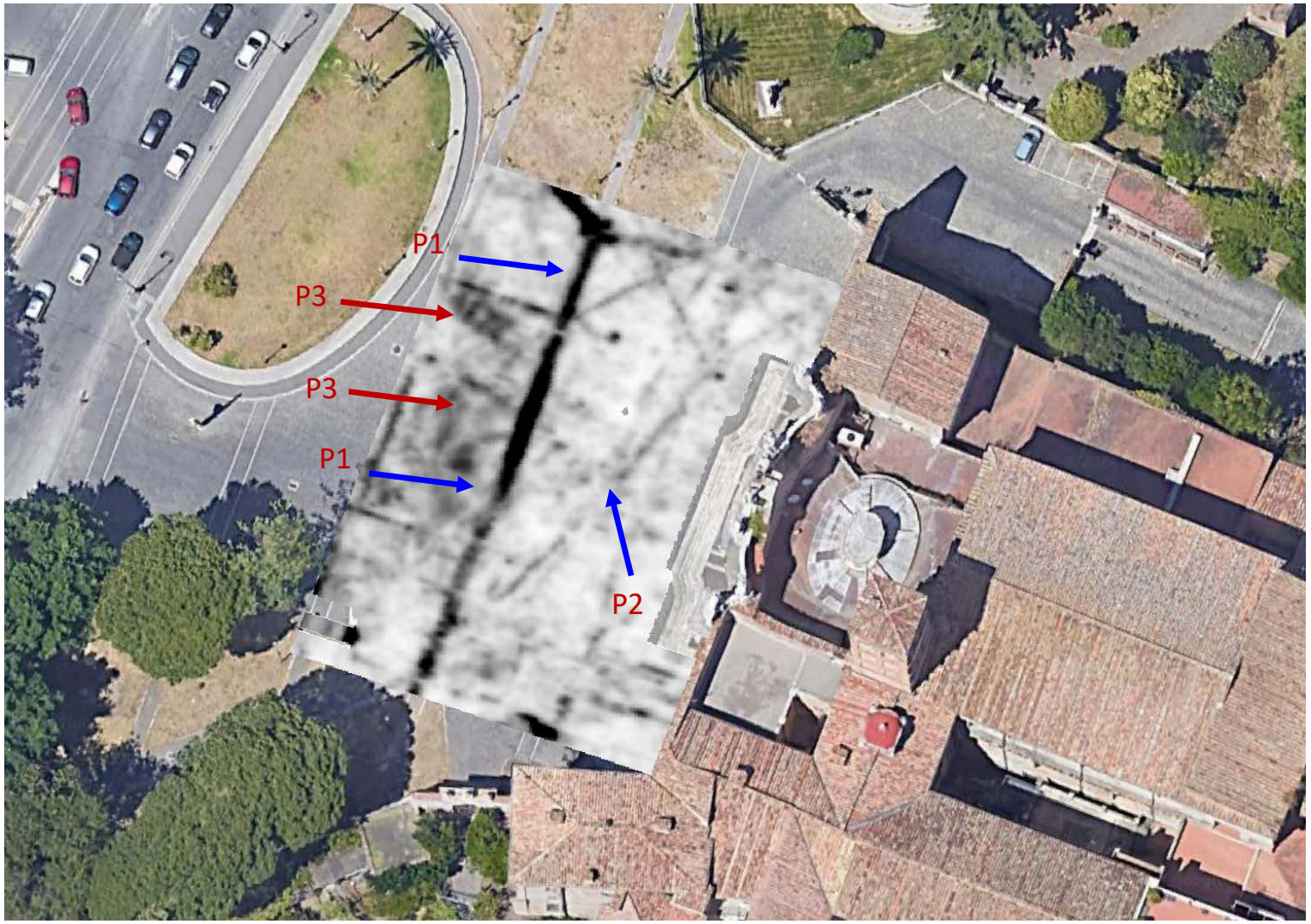
Fig.4

S. Croce in Gerusalemme garden

Fig.3 shows the anomalies located at the estimated depth of 1.30 m, individuated in the area GPR 3.1.
At this depth, the area is characterized by many reflections due to portion of possible structures.
A1: 2 circular anomalies with size 1.3 m and diameter 6.0 m; A2: linear anomaly with dimension 1.2 m x 41.0 m. A3: anomaly with dimension 1.4 x 48.5 m; A4: anomaly with dimension 3.1 x 23.4 m; A5: anomaly with dimension 1.4 x 5.0 m (3 segments of perpendicular utilities ?).
In the sector C, we observe a big High reflected surface with dimension of 109 square meters.
In the sector B, the area is characterized by the presence of many linear and perpendicular anomalies with the following dimensions: B1: 1.2 x 78 m, and 1.2 x 19.8 m (the shorter); B2: 3.7 x 6.4 m and B3: 3.2 x 2.2 m.
In sector D, we do not observe any clear anomalies, but a diffused small reflections.
In sector E we observe two kinds of linear and perpendicular anomalies with dimensions, E1: 0.9 x 12.0 m and E2: 0.7 x 4.3 m.

Fig.4 shows the anomalies located at the estimated depth of 1.90 m, individuated in the area GPR 3.1.
In the sector A, there are few short anomalies with high reflections along the limit of the investigated area.
In the sector C, it is possible to observe two semicircular anomalies with dimension, size 1.8 m at a distance, each other, of 3.4 m.
In the sector B, we observe an enhancement of the dimensions for B4: 2.3 x 5.9 m and B5: 5.0 x 2.0 m.
In the sectors D and E we observe only few linear anomalies in E area.

S. Croce in Gerusalemme square



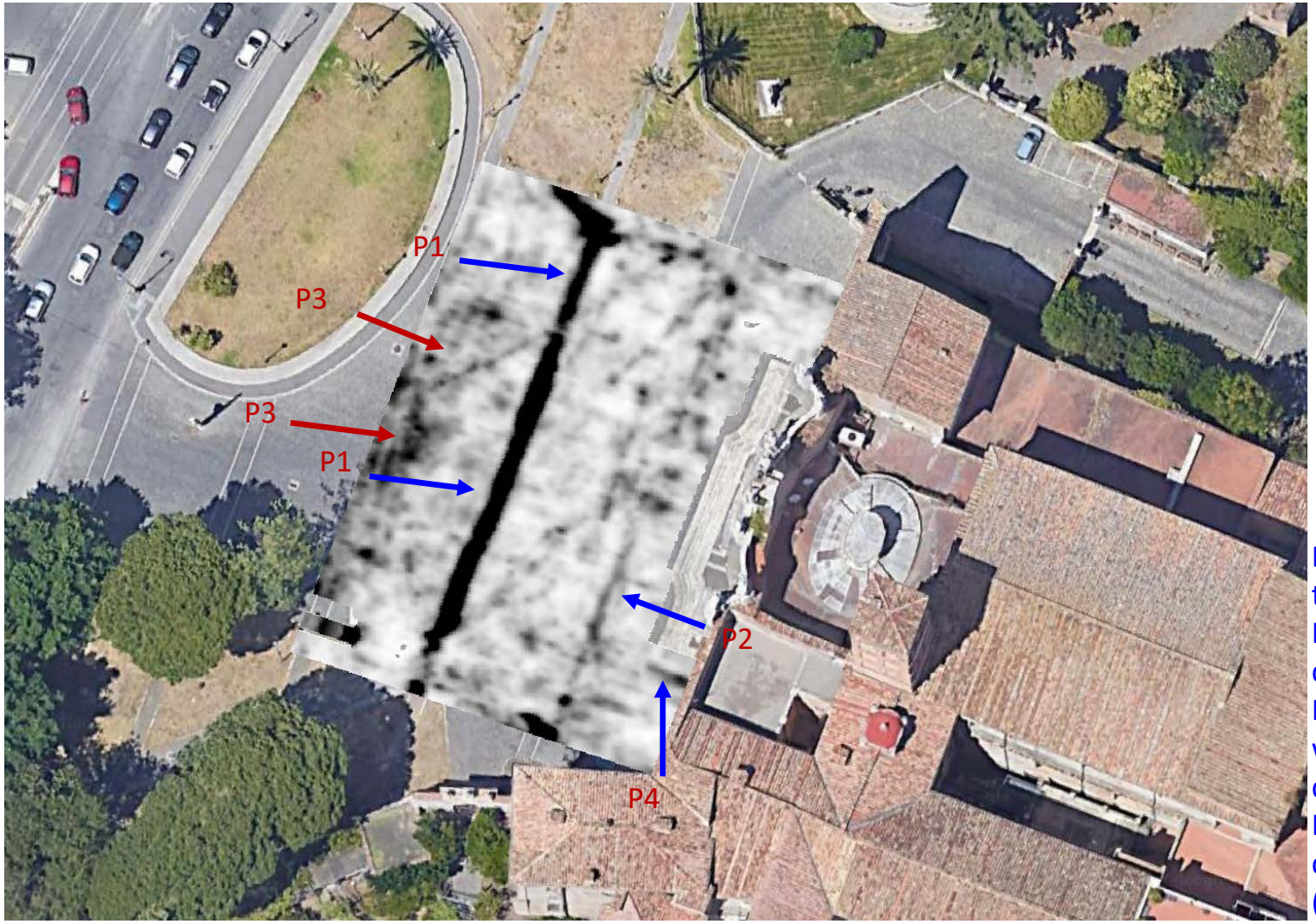
P1: main anomaly due to a utility (probably a channel hosting underground services), with dimension 2.4 x 46.8 m (visible part);
P2: utility with dimension 0.8 x 25.0 m.

Georeferenced GPR time-slice

Fig.5

S. Croce square July 2021 Results of GPR 300 MHz. Estimated depth: 0.8-1.0 m

S. Croce in Gerusalemme square



P1: main anomaly with the same size and length;
P2: an utility with dimension 0.8 x 39.7 m;
P3: a diffused anomaly, with the main with dimension 3.9 x 7.0 m.
P4: anomaly with dimension 1.0 x 4.8 m (visible part).

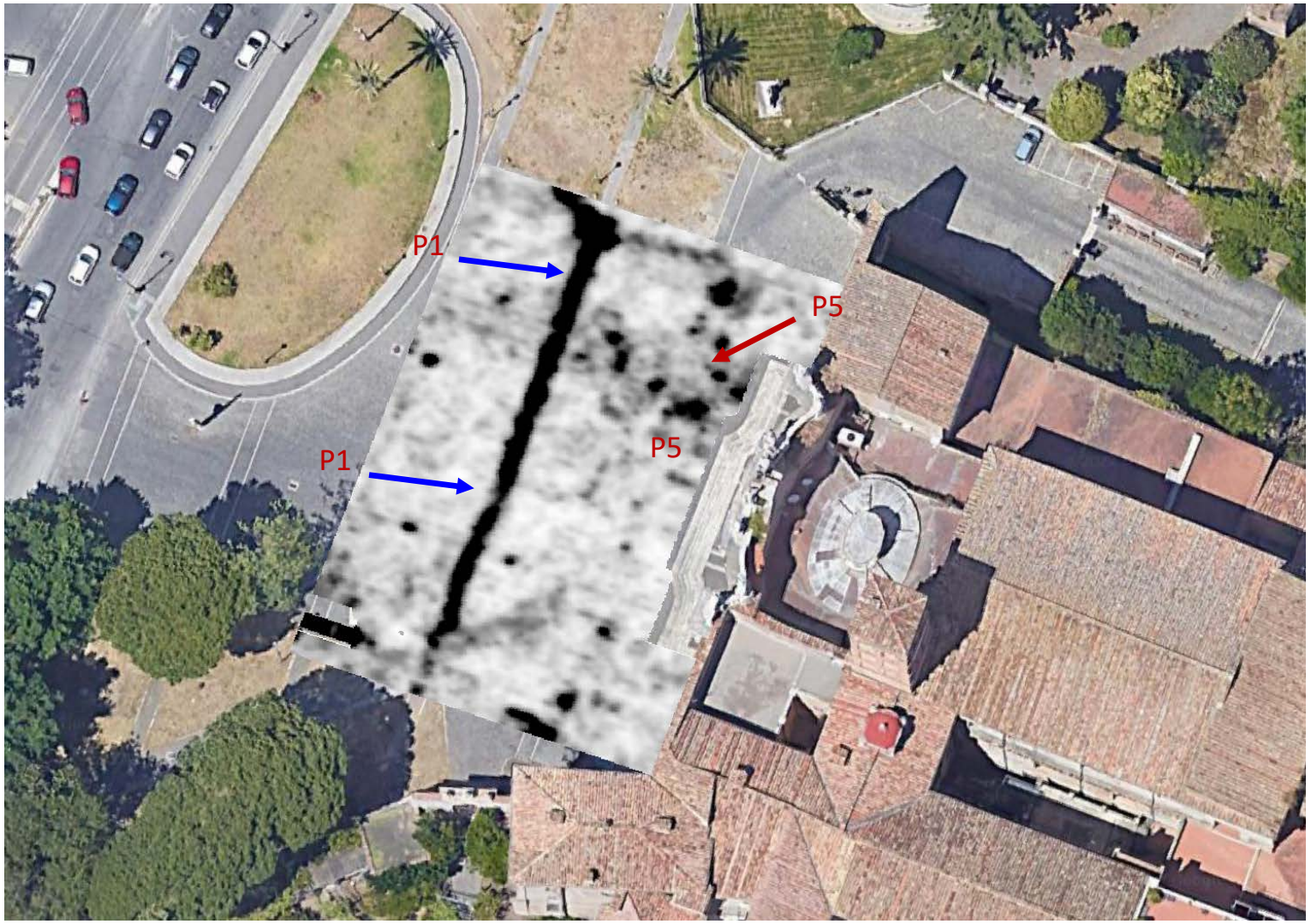
Georeferenced GPR time-slice

Fig.6

0 m 20

S. Croce square July 2021 Results of GPR 300 MHz. Estimated depth: 1.2-1.4 m

S. Croce in Gerusalemme square



In the position P5 we observe three different highest reflections with dimension 2.9 x 4.3 m, 3.3 x 3.0 m, 2.6 x 3.1 m. These anomalies are inside a surface with 61.1 square meters.

Georeferenced GPR time-slice

Fig.7

S. Croce square July 2021 Results of GPR 300 MHz. Estimated depth: 2.3-2.6 m

Preliminary remarks

The location, depth, size and vertical overlapping of the buried remains were effectively estimated from non-destructive ground remote sensing with ground penetrating radar systems, together with information on the archaeology of the sites.
Ground Penetrating Radar (GPR) survey at the selected areas produced significant and fruitful results which demonstrate that when appropriately targeted and analysed GPR can be successfully undertaken for archaeological purposes in complex urban environments.
The project is still in progress and the next step will be the joint interpretation with archaeologists.

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Soprintendenza Speciale Archeologia Belle Arti e Paesaggio di Roma;

Comune Di Roma – Sovrintendenza Capitolina ai Beni Culturali; Musei Vaticani.

Thank you for your attention