

Subsurface investigations at Kausambi, Allahabad (Dist) using Ground Penetrating Radar

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Abstract: Kausambi, a historic town dating back to 600 BC, presently located at about 52 km to the west-south-west of Allahabad at the northern bank of River Yamuna in Allahabad district. The excavation work was taken up by Archaeological Survey of India (ASI) in 1937-38 and later by Allahabad University in 1949 revealed the remains of a large brick monastery (Ghoshitaram) and Asokan Pillar, with in the fortified area, near the eastern gate, dating back to first century A.D. Reflecting the historical importance of Buddhist culture. Geophysical investigations were carried out using Ground Penetrating Radar (GPR) at Kausambi to provide high probable details of buried remains and also to reduce trial excavation practices using GSSI SIR 3000 model using 200 MHz antenna. The 3D profiles collected from the compound of Asokan Pillar revealed the traces of width 1.0-1.25 m and of length 15m which could be suggestive of the remnants of the foundations of habitats. Two grids collected from the compound of Ghoshitaram, revealed reflections of square box shape patterns (5m x 5m) with its intersections to the corner which could be suggestive of remnants of the chambers of the monastery which have their continuity towards the entrance of the compound.

Key Words: kausambi, GPR, ghoshitaram, asokan pillar, georadar

1 INTRODUCTION

Kausambi (25°20'41.55''N, 81°22'58.50''E) which was a historic town dating back to 600 AD presently located at about 52 km to the west-south-west of Allahabad and was located at the northern bank of Yamuna in Allahabad district (Fig. 1). The excavation work was first done by Archaeological Survey of India (ASI) in 1937-38 and then the work was taken up by Allahabad University in 1949. The excavation revealed the remains of a large brick monastery, with in the fortified area, near the eastern gate, which dates back to first century A.D. The excavations have also thrown light on the age and character of the massive fortifications which enclose the ancient ruins and the connected habitations. The major monuments identified at Kausambi are Asokan pillar and Ghoshitaram. The main purpose of survey is to determine the buried structures by selecting the random locations within the fortified area. Two sites were identified to carry out detailed survey within the compound of existing monuments, Ghoshitharam monastery and Asokan pillar sites. After spotting few areas for survey, in total five grids were collected where three grids from Asokan pillar site and two grids from Ghoshitaram site. The total number of profiles collected and their respective locations are stated in Table-1.

Table 1: Table showing the location of sites and dimensions of grids collected at respective sites.

S No	Site	Grid	Dimension	Location
1	Asokan pillar	Grid-A	8 m x 8 m	(25°20'42.87"N, 81°23'13.05"E)
		Grid-B	20 m x 20 m	
		Grid-C	8 m x 8 m	
2	Ghoshitaram	Grid-D	15 m x 15 m	(25°20'24.57"N, 81°23'28.12"E)
		Grid-E	8 m x 8 m	

Table 2: Table showing the acquisition and processing parameters of grids collected at respective sites.

Acquisition Parameters	
<i>Parameter</i>	<i>3D</i>
Sample	512
Format	16
Range	120
Low Pass Filter	600
High Pass Filter	50
Stacking	9
Dielectric constant	7
Processing Parameters	
Time-zero Correction	7.85
Low pass filter	755
High pass filter	133
Horizontal scans	5

1.1 Ground Penetrating Radar (GPR)

Ground Penetrating Radar is a geophysical tool used for mapping of the buried structures typically in the range of 1 to 1000 MHz frequency (Davis and Annan, 1989; Neal, 2004). It is a non-destructive tool which acquires information by sending electromagnetic waves (radio waves) into the ground. GPR provides the 3D pseudo image of subsurface and provides depth estimates of subsurface features. The electromagnetic wave is induced by the change in acceleration of the currents of antenna. Both linear and angular acceleration of antenna produces the radiation that travels into the ground. These electromagnetic waves move with velocity that determined by the permittivity of material (Davis and Annan, 1989; Anderson et al., 2003). The transmitted wave is received by the antenna after being met with any obstruction that can be seen in the form of anomaly in the radar reflections. Archaeological investigations are carried out for identifying graves, tunnels, underground channels, buried sites, antiquities etc (Vaughan, 1986; Imai et al., 1987; Bevan, 1991; Mellett, 1992; Unterberger, 1992; Sternberg and McGill, 1995).

1.2 Data Acquisition, Processing & Interpretation

GSSI SIR 3000 model GPR setup has been used to conduct the survey around Kausambi using 200 MHz antenna. The setup consists of antenna which acts as both transmitter and receiver of radio waves, odometer that specifies the distance travelled by the antenna depending upon the revolutions of wheel and cable of length 30 m connecting the antenna and control unit. The 3D mode has been used for collection to obtain the detailed view of feature present beneath. All the grids were collected using the parameters specified in Table 2. Later the acquired data is processed using RADAN 6.5 software using the processing parameters given in Table 2. Both acquisition and processing parameters specified helps in acquiring better results.



Fig.1a) Google image of archaeological site known as Kausambi located in Allahabad district. Inset figure shows the map of India with marked location of Kausambi b) Google image of Asokan Pillar located at Kausambi. C) Google imagery of large brick monastery known as Ghoshitaram located at Kausambi.

1.2.1 Asokan Pillar Site

Asokan pillar site (25°20'42.87''N, 81°23'13.05''E) is situated to the west of fortification wall (Fig.1& 2a). Three grids were collected at the same stretch to know the presence of structures where the previous excavation revealed the residential house remnants on the opposite side. To get better sub-surface information of the structure, three grids were marked for data collection.

Grid-A(25°20'43.36''N, 81°23'12.38''E; 25°20'43.43''N, 81°23'12.11''E; 25°20'43.18''N, 81°23'12.02''E; 25°20'43.11''N, 81°23'12.29''E) was located to the east of Asokan Pillar with dimension of 8m x 8m (Fig. 2a). There are two patterns of reflections obtained from the Grid-2 (Fig.2A-i). The two patterns are continuous to the depth of 6 m approximately (Fig. 2A-ii). The pattern-I form a large stretch of reflections which has two intersections with in the length of 4 – 5 m. The thickness of reflections of pattern-I are approximately of 1 m. The reflections of pattern-II resemble the stretch of pattern-I but has only one intersection. The intersections and the stretch of reflections may suggest the probable traces of wall features. As the reflections are clearly visible from the depth of 3 m approximately suggesting the traces could be the remnants of foundations of habitats resided in the past.

Grid-B was located to the east of Asokan pillar which is situated at an elevated area from the site of pillar (Fig.2a). The area is slightly covered in vegetation. The coordinates of four corners of the Grid-A are (25°20'42.47''N, 81°23'12.15''E; 25°20'42.63''N, 81°23'11.45''E; 25°20'42.01''N, 81°23'11.25''E; 25°20'41.84''N, 81°23'11.94''E) with dimensions 20 m x 20 m. Three patterns of reflections were observed from Grid-A by undertaking GPR investigations. The reflections of pattern-I shows the enclosing of traces at four ends having different thickness. The reflections of pattern-II and pattern-III are connected at the intersection of pattern-II occurring at 10 m on X-axis.

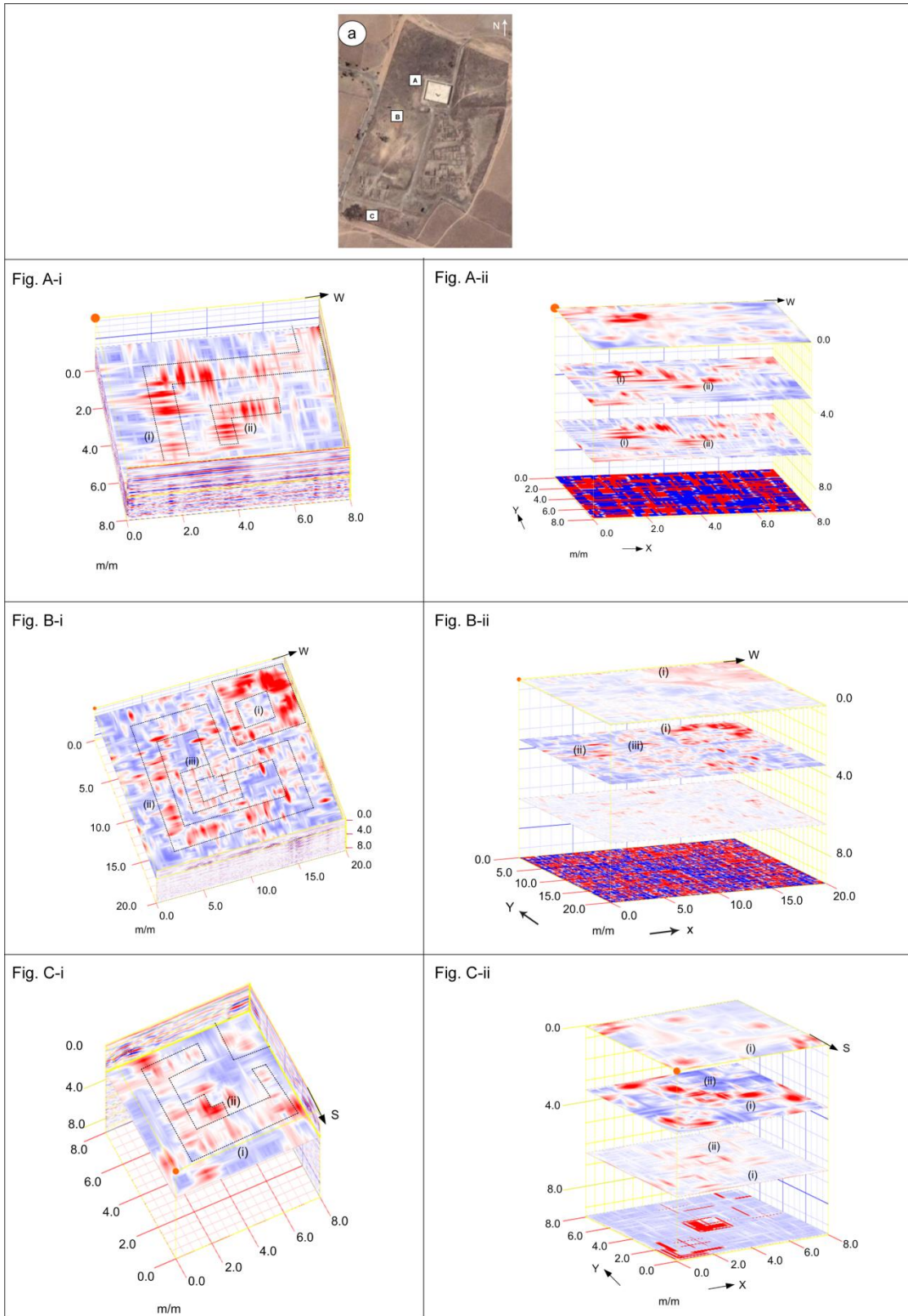


Fig.2(a) Google Imagery showing the location of Asokan Pillar located in the fortified area of Kausambi (Refer Fig.1 for location) with locations of three survey sites namely A, B & C. (A-i) 3D mode of Grid-A showing two different pattern of reflections. (A-ii) Vertical slicing of Grid-A showing the continuity of reflections at various depth slices. (B-i) 3D mode of Grid-B showing three different pattern of reflections with intersections. (B-ii) Vertical slicing of Grid-B showing the continuity of reflections at various depth slices. (C-i) 3D mode of Grid-C showing two different pattern of reflections with end intersection. (C-ii) Vertical slicing of Grid-C showing the continuity of reflections at various depth slices.

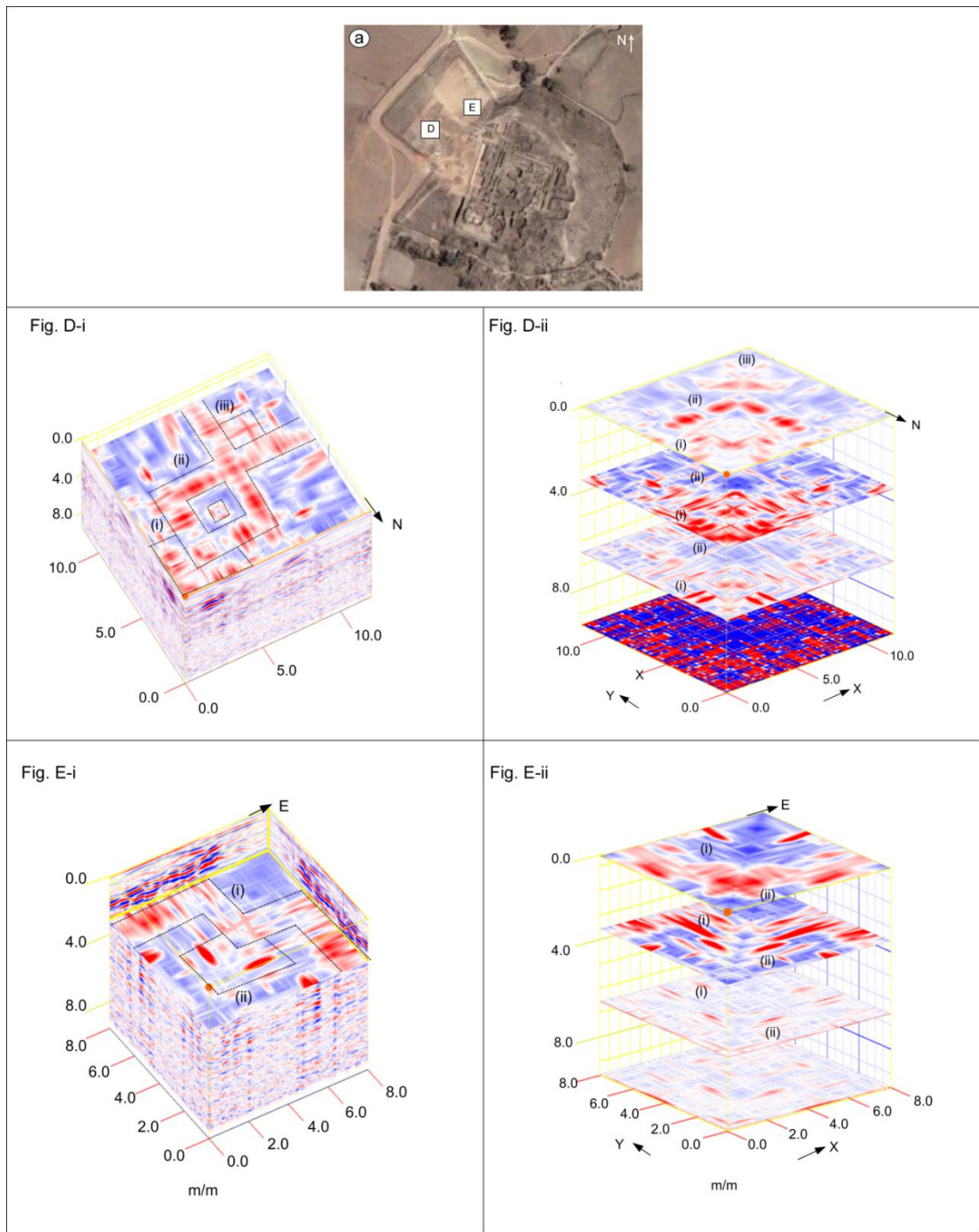


Fig.3(a) Google Imagery showing the location of Ghoshitaram monastery in the fortified area of Kausambi (Refer Fig.1 for location) indicating the locations of survey sites named as D & E. (D-i) 3D mode of Grid-D showing three different pattern of reflections intersected at the corners and extending towards south. (D-ii) Vertical slicing of Grid-D showing the continuity of reflections at various depth slices up to 8m and also showing the vanishing of reflections further deep. (B-i) 3D mode of Grid-E showing two different pattern of reflections with only one intersection. (B-ii) Vertical slicing of Grid-E showing the continuity of reflections to the depth of 7m approximately and vanishes further deep.

The pattern-II form the long stretch of reflections having length of 10 – 12m whereas pattern-I stretches to the length of 7 m and pattern –III stretches to the length of 5 m (Fig. 2B-i). The vertical slicing of profile explains the continuity of the remnants to the depth exceeding 5 m (Fig. 2B-ii). But the entire structure is

incident clearly at the depth of 4 m. All the three patterns of reflections show the long stretching having equal intersections suggesting the traces could be the remains of habitation.

Grid-C was located in the southern direction of Grid-A and Grid-B at the stretch (Fig. 2a). The coordinates of Grid-C are (25°20'39.41''N, 81°23'10.60''E; 25°20'39.41''N, 81°23'10.60''E; 25°20'39.34''N, 81°23'10.88''E; 25°20'39.09''N, 81°23'10.60''E) with dimensions 8 m x 8 m. This grid was located away from the Asokan Pillar and towards right side of the entrance of Asokan Pillar compound. There are two patterns of reflections obtained from the Grid-C which are continuous to the depth of 6 m approximately (Fig. 2C-i & 2C-ii). The pattern-I form a large stretch of reflections which has two intersections within the length of 2 – 4 m (Fig. 2C-i). The pattern-II reflections are connected to the pattern-I reflections at the west intersection corner. The thickness of pattern-I reflections varies from 0.5 - 1m approximately and pattern-II reflections is of 2 m. The reflections are clearly visible at the depth of 2 - 3 m approximately, continuous to the depth of 6 m and starts vanishing (Fig. 2C-ii). The long stretching reflections with end intersections also suggest that the traces could be of remnants of the residential areas of late Buddhist culture flourished.

1.2.2 Ghoshitaram Site

Ghoshitaram (25°20'24.57''N, 81°23'28.12''E), a large brick monastery, was situated to the east of fortification wall at an elevated area compared to Asokan pillar site (Fig.1). Two grids were collected opposite to each other to determine the continuity of remains of monastery.




Grid-D is located to the right of the entrance of Ghoshitaram monastery compound (Fig.3a). The coordinates of the Grid-D are (25°20'26.41''N, 81°23'27.35''E; 25°20'26.05''N, 81°23'26.58''E; 25°20'26.40''N, 81°23'26.61''E; 25°20'26.76''N, 81°23'26.98''E) with dimensions 12 m x 12 m. There are three patterns of reflections observed which are continuous to the depth of 6 m approximately (Fig. 3D-i & 3D-ii). All the three patterns were intersected and are extending towards south. The reflections of pattern-II form traces of 1m thickness which are enclosing at the start of third pattern. The thickness of reflections does not exceed 1 m (Fig. 3D-i). Hence the enclosing traces may suggest that the remnants could be of chambers used by ancient people and the intersections at the corners suggest that the traces could be of walls of other chambers which are interconnected. The clear visibility of reflections of structure starts at the top and continuous to the depth of 4 m approximately and then the reflections start to vanish (Fig. 3D-ii). This may suggest the structure to be a super structure.

Grid-E was located to the left of the entrance of Ghoshitaram compound (Fig.3a). The coordinates of Grid-5 are (25°20'25.45''N, 81°23'25.93''E; 25°20'25.67''N, 81°23'26.08''E; 25°20'25.86''N, 81°23'25.88''E; 25°20'25.64''N, 81°23'25.73''E) with dimensions 8 m x 8 m. Two patterns of reflections were obtained that are continuous to the depth of 5 m approximately (Fig. 3E-I & 3E-ii). The reflections of pattern-I forms a long stretch of reflections compared to reflections of pattern-II. Both the reflections are continuous to the depth of 5 m. The thickness of pattern-I reflections is 1 m with intersections for about 3 to 4 m whereas the thickness of reflections of pattern-II is of 2 m extending to the length of 2 m. Such variations in thickness suggest that the both patterns indicate different structures. The intersections and

linear stretch suggests the pattern-I could be remnants of wall and the equal length and thickness suggest the pattern-II to be remnants of base which is connected to the wall.

2 CONCLUSION

Three grids collected from Asokan Pillar site and two grids collected from Ghoshitaram site revealed few patterns of reflections suggesting that the traces to be the remnants of walls of habitation existing in past and chambered structures at nearby monastery. The long stretch reflections obtained from all the grids collected at Asokan Pillar site have the intersections at the ends of the traces clearly suggesting the remains of foundation walls of habitation in the Asokan pillar compound in the past. The enclosing traces obtained from the grids collected at Ghoshitaram monastery with ascending patterns suggests that the traces could be of interconnected chambered structures used by the people residing in the monastery in past.

Sir Leonard Wooley in his famous report had suggested two sites, Kau  mb  and Ahichat  as the most important sites in the Ganga valley, the excavation of which, according to him, would unravel the early history of the Indian people and help us in understanding the urbanization process in the Ganga valley in the ancient times. The archaeological significance of the ancient site of Kaushambi has been amply demonstrated by the excavations conducted by the University of Allahabad from 1949 to 1965. What is needed now is a reinvestigation using modern Geoinformatics techniques.

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