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Research Article

Archaeo-geophysical Investigations in Ahlat Seljuk Square Cemetery, Bitlis, Eastern Anatolia Türkiye

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Abstract

Geophysical methods are frequently used in archaeological sites to obtain significant priori information. These methods assist archaeological excavation strategies by indicating the anomaly zones that may be associated with buried remains. Archaeo-geophysical methods are based on measuring the physical parameter contrast (e.g. magnetic susceptibility, dielectric constant, resistivity, density) between the buried archaeological remains and the covering environment. In this study, magnetic and ground penetrating radar methods were applied to contribute to excavation planning. The study area is a historical cemetery and has been used as an interment area for about 1000 years. Considering the information obtained from the previous excavations, the research depth was initially planned not to exceed 3 meters in general, but information up to 10 meters was obtained. We aimed at determining possible graves in the area outside the walls of Square Cemetery in Ahlat (Bitlis) district. After performing some data-processing steps to the raw data obtained, magnetic and ground penetrating radar anomaly maps were produced. Based on the distinguishable geophysical traces most promising locations were determined and suggested for archaeological excavations.

Keywords: Ahlat, Seljuk Cemetery, Archaeo-geophysics, Magnetic, Ground Penetrating Radar

Introduction

Ahlat district has a population of approximately 42,000 and is one of the three districts of Bitlis province that has coast to Lake Van. The district, which covers an area of approximately 1044 km², differs in terms of topographic features. Nemrut and Süphan Mountains are located in the close vicinity of the district (Figure 1). Archaeological investigations carried out around Lake Van revealed that the history of the region goes back to Protohistoric periods (Kafesoğlu, 1949; Özfırat, 1988; Yiğitpaşa and Can, 2012).

How the harsh climatic conditions of the Eastern Anatolia region affected the development process of ancient societies is not known exactly. Many mounds were abandoned after the Early Bronze Age, especially in the Lake Van Basin. While there is some thought that there were permanent settlements in the Iron Age until the establishment of the Urartian Kingdom, some studies reported no traces of their existence (Özfirat, 1988; Köroğlu and Konyar, 2005). In recent years, underwater surveys carried out around Lake Van have revealed a large number of structural remains (Işıklı et al., 2019; Gündüz, 2020). Additionally, some other studies showed that severe earthquakes, as well as climatic conditions, are highly effective on Lake Van and its surrounding settlements (Işık et al., 2012; Ertekin et al., 2021; Işık and Harircihan, 2022). It is known that Ahlat was under the rule of Urartu, Med, Persian, Roman, Byzantine, Mervani, Seljuk, Karakoyunlu, Akkoyunlu, Safavid, and Ottoman at different periods of history (Özfırat, 1988; Kılıç, 1999, Köroğlu and Konyar, 2005; Çilingiroğlu, 2007; Yiğitpaşa and Can, 2012; Top, 2013). Many artifacts from these civilizations that have survived until today have remained as cultural heritage. Ahlat stone, which has been used in the construction works of various cultures in the district and its surroundings, is of volcanic origin and is geologically called ignimbrite. Additionally, it has been used extensively in the constructions of Seljuk tombstones and cupolas. There are different opinions about the origin of the name Ahlat. However, the most well-known is that the name was derived from Lat, a Urartian king. The city was conquered by the commander named Iyaz bin Ganem from the Armenians in 641 during the reign of Caliph Omar and became a part of the Islamic countries. The city is known as Kubbet-ül İslam and has an importance especially in the medieval Islamic world. Both Turks and Iranians adopted the name Ahlat for the city, which is still used today. In addition, Malazgirt and Ahlat are known as the entrance gate of the Turks to Anatolia. This historical settlement has hosted many states and dynasties from the Urartians to the Ottomans. There are six cemeteries covering large areas in Ahlat. In the Square Cemetery, which is the largest and most important Seljuk cemetery in Ahlat, there are about a thousand tombstones of various types dating from the beginning of the XII century to the XVI century (Figure 2). There are also tumulus-style tombs, seven of which are called "akit" (Karamağaralı, 1992). Archaeological studies continue intensively in the Old Ahlat City Castle and the Seljuk Square Cemetery.

Different non-destructive geophysical methods are frequently used to detect, classify, and record various archaeological remains. These structures and remains may produce some measurable geophysical anomalies on the ground surface, which can be recorded easily with high precision geophysical instruments. Therefore, buried foundations, walls, roads, statues, columns, tombs, metallic objects, etc. can be determined quickly by geophysical methods. Classical archaeological exploration methods such as trenching and drilling are time consuming and costly. Moreover, these methods may be destructive for the buried remains in some cases. Geophysical data modelling and image processing techniques, which have developed depending on technological advances, can make significant contributions to archaeological studies. Geophysical outputs are important in terms of guiding the archaeological excavation and revealing a detailed study plan for a particular area. Such advantages play an active role in reducing the cost and time of excavation. Therefore, similar to the examples in the world, the use of geophysical methods in archaeological sites has become widespread in our country.

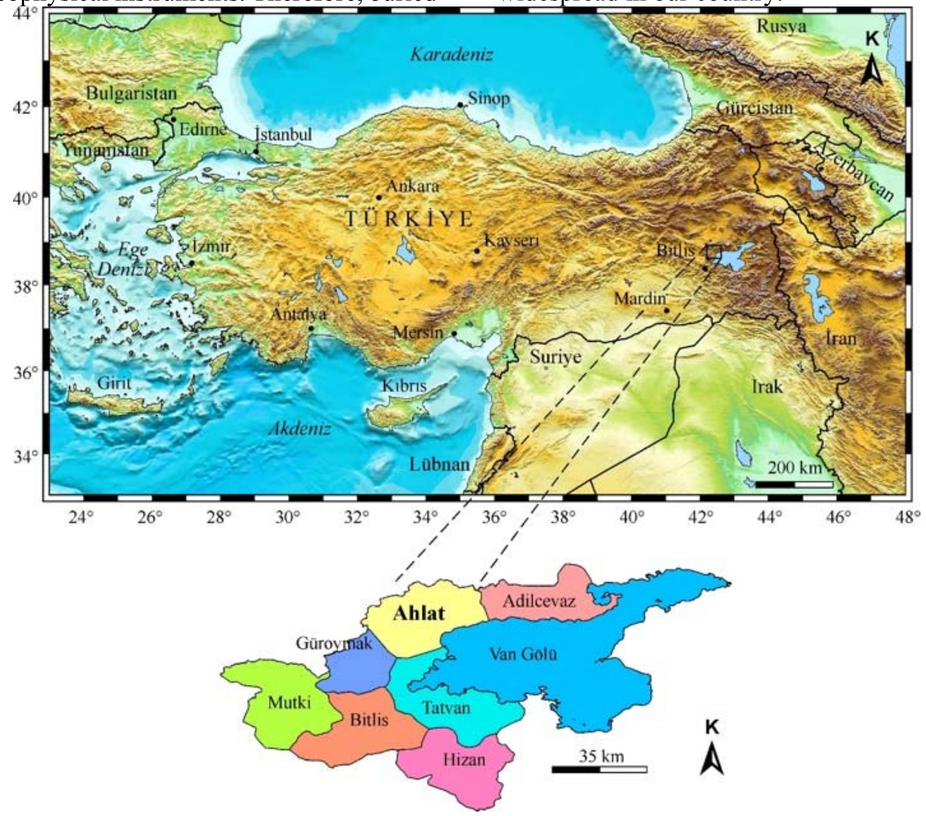

Fig. 1. Location map of Ahlat district (modified from Ekinci et al., 2020).

Türkiye has a very rich history and its archaeological potential is very high. Therefore, numerous successful archeogeophysical studies have been carried out in different parts of the country, such as Çanakkale Assos (Kaya et al., 2004), Isparta Harmanören (Büyüksaraç et al., 2006), Afyon Dedemezarı (Arısoy et al., 2007; Büyüksaraç et al., 2008), Sivas Divriği (Büyüksaraç et al., 2011), Çanakkale Parion (Ekinci and Kaya, 2007; Ekinci et al., 2012), Izmir Mt. Olympos (Büyüksaraç et al., 2013), Afyon Amorium (Kaya et al., 2007, Ekinci et al., 2014), Isparta Yalvaç (Balkaya et al., 2018), Isparta Kılıç (Yılmaz et al., 2019) and Gaziantep Doliche (Balkaya et al., 2021). In the last decade, some archaeo-geophysical investigations have been performed to detect martyr burial areas and buried war materials (Büyüksaraç et al., 2014a, b; Ekinci et al., 2022; Koşaroğlu et al., 2022). Grave research has an important place in archaeology. Cemeteries in historical settlements reflect not only the past, but also the current culture of that settlement area. Information obtained from grave gifts, tomb designs, signs, symbols, and materials provide important clues about past life. Additionally, detection of these type of burials is important for the next excavation stages and to have information about the general settlement of the city. Hence, in this work high-resolution archaeo-geophysical studies were carried out to detect the boundaries of the Seljuk Square Cemetery in Ahlat. We aimed at contributing to the excavation planning in the restricted area. Total field magnetic and ground penetrating radar measurements were carried out in the determined areas and the findings were compared with each other and also with the existing archaeological knowledge obtained from the excavations.

Fig. 2. Some views of Ahlat Seljuk tombs.

Material and Method

The works were carried out in the Ahlat Square Cemetery which occupies a very large area. This cemetery is also known as the largest Islamic cemetery in the historical period in Anatolia (Avşar and Güleç, 2019). Since there is a very dense tombstone and a certain burial on the surface in the walled part of the cemetery, geophysical studies were carried out in very narrow areas in these parts. On the other hand, detailed surveys were carried out in larger areas on the parts that have no signs on the surface outside the walls.

Magnetic Method

The purpose of magnetic survey is to investigate the subsurface structure using the observed magnetic responses. In general, the magnetic susceptibility of rocks is highly variable, depending on the type of rock and its environment. Generally magmatic rocks produce highest magnetic anomalies. However, it is often not possible to definitively determine the cause of any anomaly from magnetic information alone. The magnetic method measures the Earth's magnetic field intensity. Typically, the total field magnetic and/or vertical magnetic gradient are measured. Measurements of the horizontal or vertical components or their gradients can be also made by suitable equipment. Apart from Earth's magnetic field, magnetic anomalies are caused by induced or remanent magnetization of the rocks. The shape, dimensions, and amplitude of an magnetic anomaly depend on the extent, geometry, size, depth, thickness, etc., of the causative sources and also geographic location.

In archaeological sites, magnetic surveys are carried out to detect buried archaeological remains. The success of magnetic research depends on the magnetic contrast between the source structure of interest and the surrounding environment (Ekinci and Kaya, 2006). The most important magnetic properties for archaeological studies are magnetization and magnetic susceptibility (Smekalova et al., 2008).

In the magnetic survey carried out in Ahlat Square Cemetery, the total component of the Earth's magnetic field was measured. A magnetometer with a sensor sensitivity of 0.01 nT was used. Measurements were carried out with 1 m profile spacing, taking every 0.5-meter measurement on each profile. During the application of the method, the sensor was held in the north-south direction, and measurements was taken along this direction. The collected data were gridded and then mapped. In order to remove the effects of the inclination and declination angles, the reduction to the pole technique was applied. Then, the analytical signal technique was applied on the pole reduced anomalies to increase the amplitude of causative sources and to sharpen the responses of their edges. The measurements were performed in two parts, the outer area and the inner area of the cemetery. Wide and uninterrupted scanning was carried out in the outer area of the cemetery, since there were no signs on the surface. However, due to the existing graves in the inner area of the cemetery, measurements were made only between the graves.

Ground Penetration Radar Method

Ground penetration radar, which has a wide range of applications, is used to reveal information such as location and depth of buried remains in archaeological sites. Most surveys for archaeological applications are conducted using standard data collection and processing procedures. The depth of penetration depends on the ground conditions, the wetness and humidity of the ground, and the frequency of the signal. A low-frequency antenna provides deeper penetration, while a high-frequency antenna collects more detailed high-resolution information at shallow depths (Conyers, 2014). The transmitter provides high-frequency sinusoidal electromagnetic signals that penetrate the ground. Reflected waves are detected by the receiver and stored in the device used (Yılmaz and Soycan, 2022). Data processing steps includes various procedures such as static correction, gain function, background removal, average subtraction, DC shift subtraction, and migration. Generally, the dielectric property differences between the archaeological remains and surrounding environment provide observable anomalies. Archaeological remains made of steel or metal are easily detectable but can be difficult to detect if the archaeological remains are made of a material with dielectric properties close to those of soil. After the data processing steps, some depth slices and volumetric images are generated to interpret the anomalies obtained.

Results

The total field magnetic anomalies, pole reduced anomalies and its analytical signal responses are illustrated in Figures 3-5, respectively. Some depth slices were produced for ground penetrating radar anomalies. Thus, amplitude variations against depth levels can be traced (Figures 6-8). It was observed that the wire fences in the west of the area produced undesirable deceptive effects and therefore magnetic measurements were continued by moving away from the fences. Affected parts were removed from the anomaly grids. The location of a magnetic high is marked on the maps. The high amplitudes are more evident in the analytic signal anomaly map which was generated by using the directional derivatives. Similar high amplitude anomalies are also observed in the study area. At the location where the magnetic high was determined, the ground penetrating radar technique also produces some evident anomalies (Figure 6). Considering that this observed anomaly loses its effect below 1.5 m depth, it can be concluded that it is not of geological origin. In addition, the shallow depth at which it was detected strengthens the possibility that it is a man-made structure. In the magnetic anomaly maps (Figure 4), a high amplitude anomaly is clearly observed in the south-west of Area-2 and it can be distinguished from other high amplitude anomalies due to its geometry. In addition, this anomaly is in the same direction with the anomaly in Area-1. Considering the area that it covers it is thought to indicate a burial tomb chamber. This anomaly is also evident in radar images. Especially in the depth slices shown in Figure 7, this anomaly is observed at a depth of 1.5 meters, and shows the highest amplitude at 2.5 m. Below this depth, the anomaly begins to weaken. Although not presented here, an anomaly cannot be observed at a depth of 3 m. Again, in terms of the area that it covers, it is thought that this anomaly is most likely indicates a burial tomb chamber rather than a single grave. In the maps presented in Figure 5, a high amplitude partially linear anomaly of approximately 60 m-long in southeast-northwest direction is determined in the central part of the area. This anomaly may be the magnetic signal of a wall remain. However, there is no finding at the ground radar depth slices (Figure 8) that can support this idea. Nevertheless, a trial archaeological excavation should be carried out.

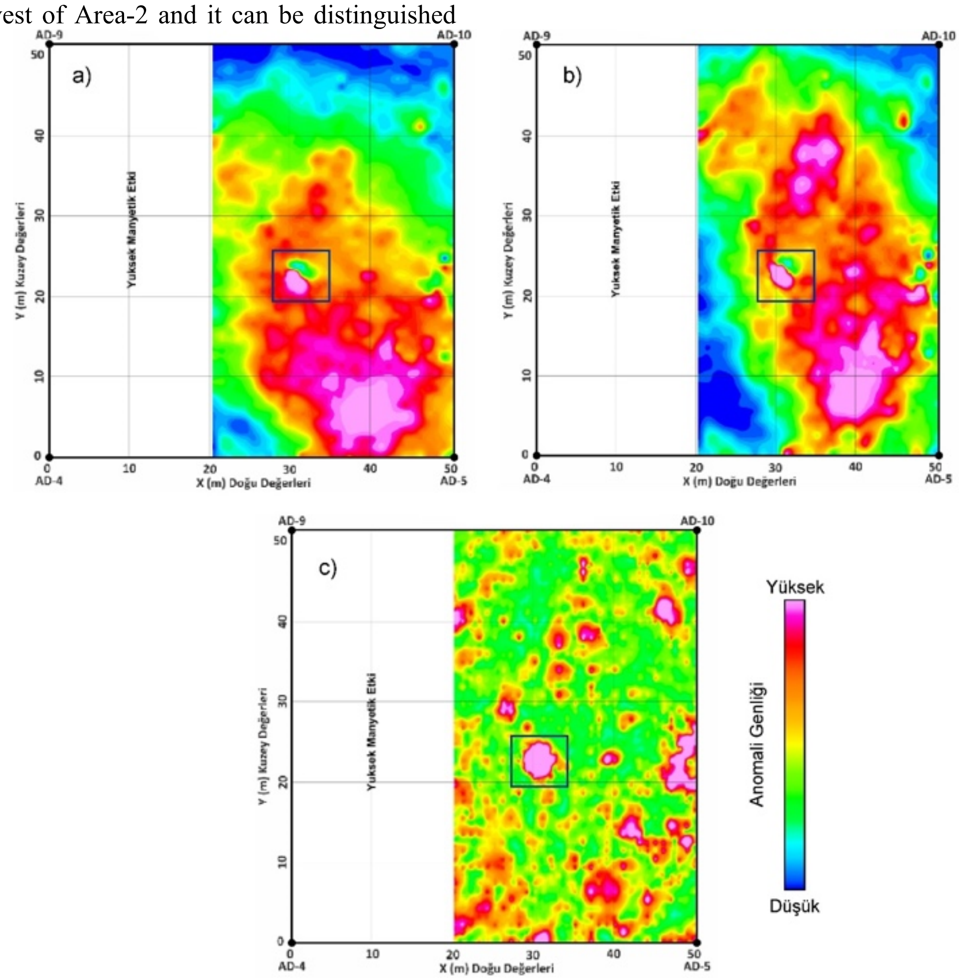

Fig. 3. Area-1. (a) magnetic anomaly map, (b) reduced to pole anomaly map, (c) analytical signal anomaly map.

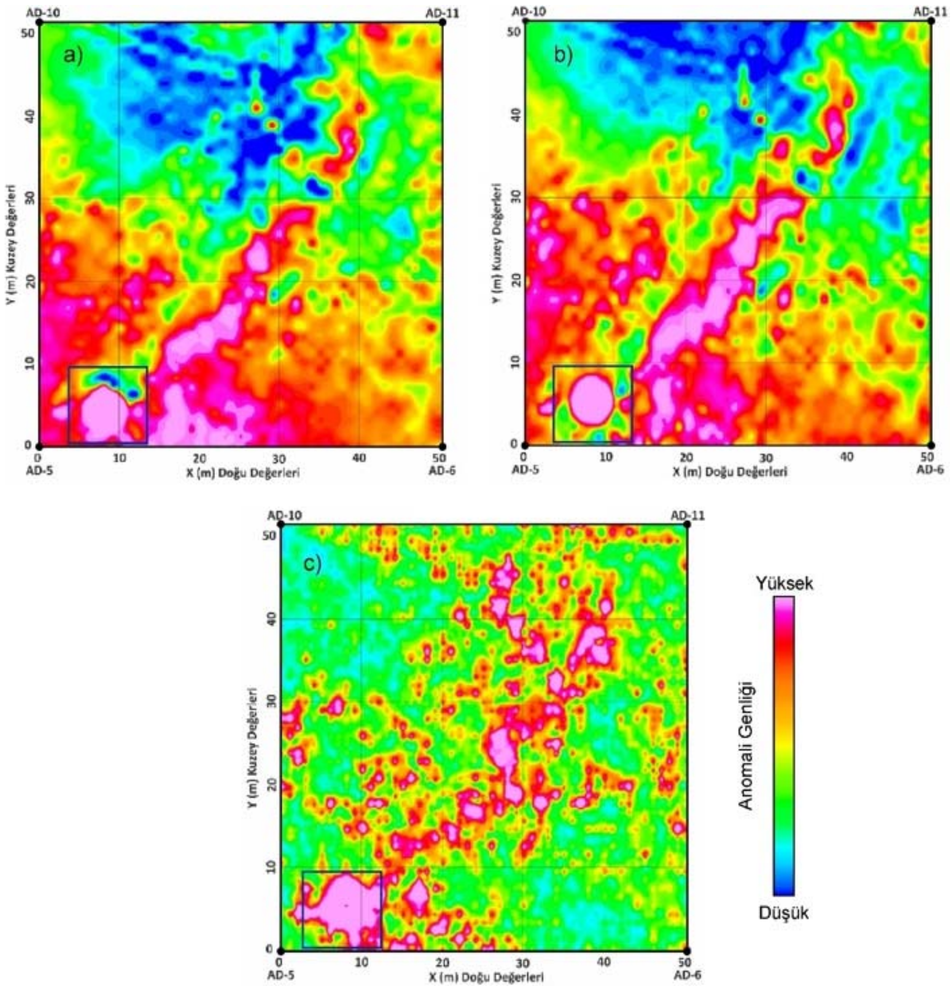

Fig. 4. Area-2. (a) magnetic anomaly map, (b) reduced to pole anomaly map, (c) analytical signal anomaly map.

Conclusions

In this archaeo-geophysical study carried out on the outside of the walls of the Historical Seljuk Square Cemetery in the Ahlat district of Bitlis province, magnetic and ground penetrating radar methods were used to determine most promising locations for archaeological excavations. After the application of some data processing steps to the raw data sets, anomaly maps of both methods were produced. The geophysical findings were compared with both each other and the existing archaeological information obtained from the area and previous excavations. Clearly observable high amplitude anomalies were determined as a result of applying reduction to the pole and analytical signal techniques to magnetic data. Slices for increasing depth levels were produced at 0.5 m intervals for ground penetrating radar data. Some amplitude changes which support the magnetic highs were determined in these radar depth slices.

In general terms, it is concluded that the causative sources are located at different depth levels. Considering the size of the near-surface anomaly detected in Area-1, it can be interpreted as a buried tomb remains. In Area-2 the promising anomaly is evident at a depth of 1.5 m and has a thickness of about 1.5-2 m. Unlike to the anomaly detected in Area 1, this anomaly covers a wider area and therefore it can be interpreted as a grave remain. Additionally, some other anomalies in both areas were observed at different depth levels. These depths are in well agreement with the unearthed archaeological remains in the study area. In Area-3, partially linear oriented high amplitude magnetic signals may indicate a buried wall structure. However, supportive anomaly traces could not be observed in depth slices. It is suggested that the anomalies determined in the first two areas should be examined by trial excavations. According to the findings to be obtained from these excavations, a decision should be made about similar anomalies. Although no trace is seen in the depth slices for Area-3, magnetic anomalies are thought to be worth examining. This study clearly showed that in historical cemetery areas possible man-made structural remains that are not detected from the surface can be determined quickly by geophysical applications.

Conflict of Interest

No conflict of interest has been declared by the authors.

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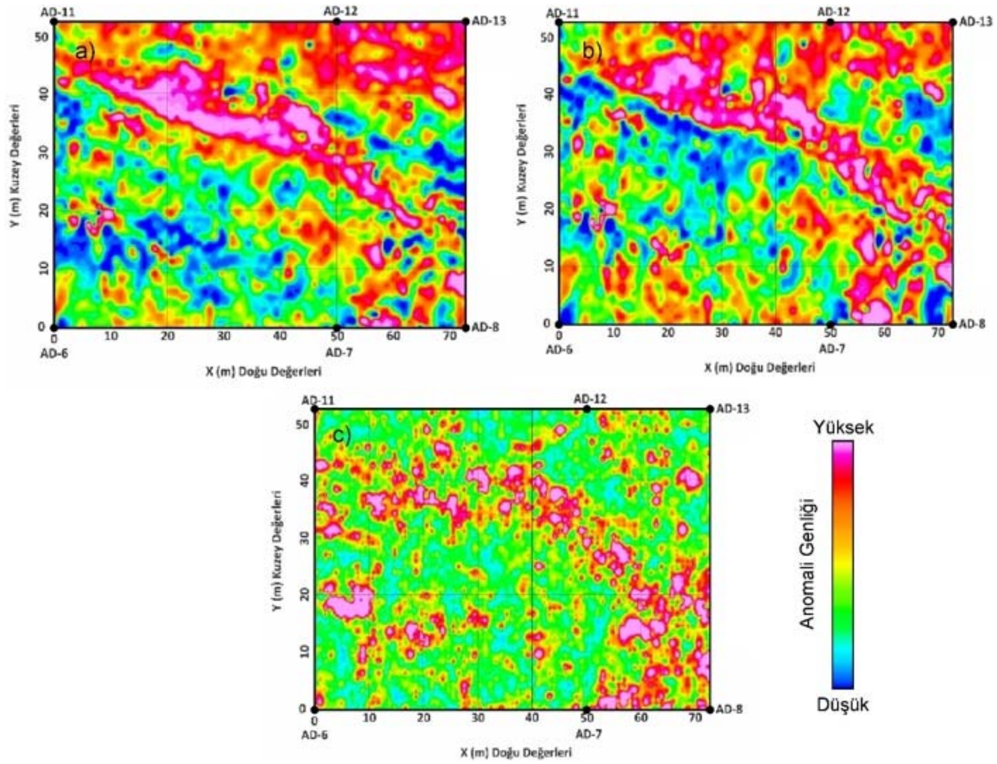

Fig. 5. Area-3. (a) magnetic anomaly map, (b) reduced to pole anomaly map, (c) analytical signal anomaly map.

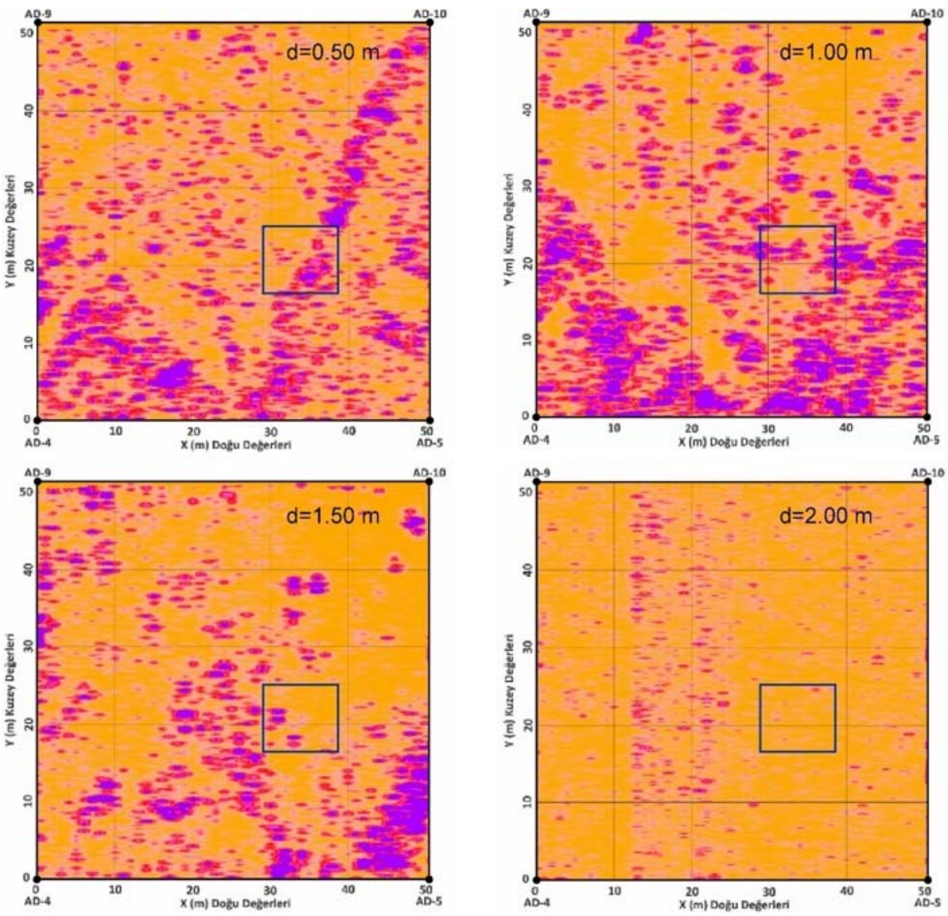

Fig. 6. Area-1. Ground penetrating radar depth slices.

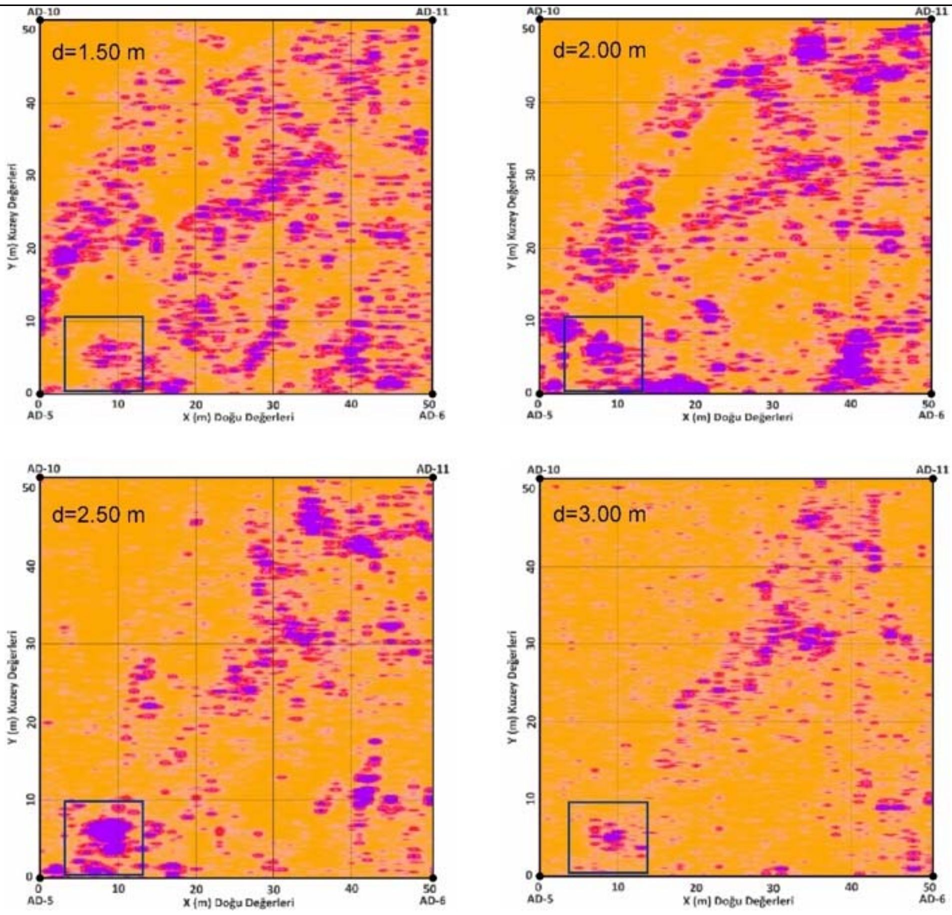

Fig.7. Area-2. Ground penetrating radar depth slices.

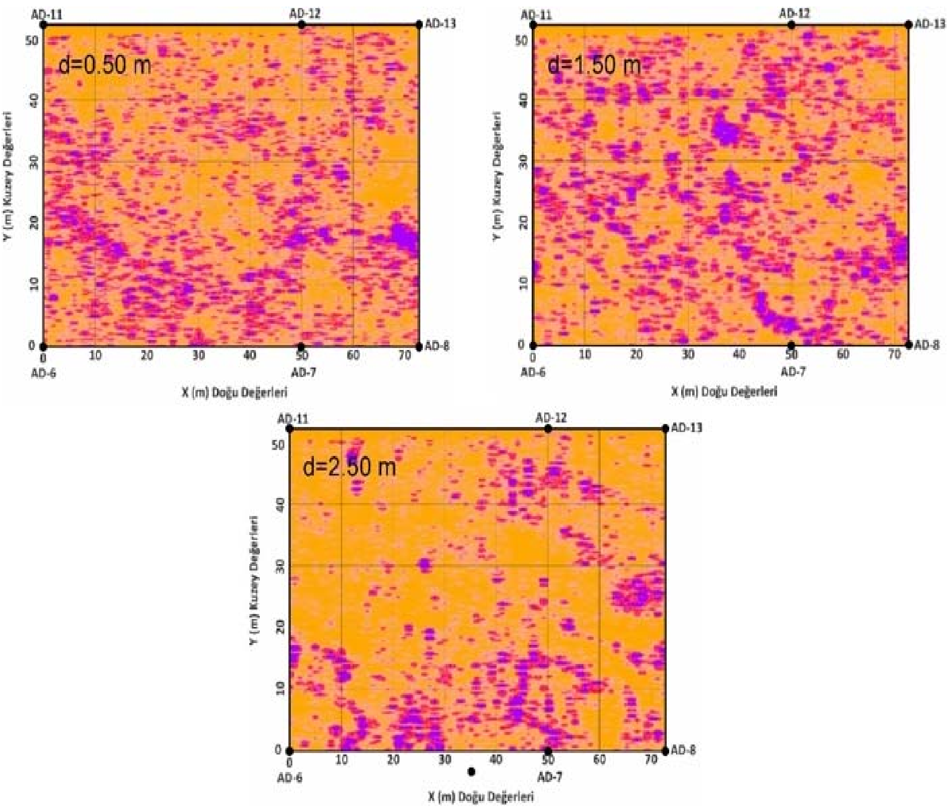

Fig. 8. Area-3. Ground penetrating radar depth slices.

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