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FINDING THE WALL FOUNDATIONS OF KONYA ALAADDIN HILL 2ND KILIÇARSLAN PALACE BY USING THE GEORADAR (GPR) METHOD. A REVİEW

Alaaddin Hill, which is located in the city center of Konya, Turkey-Konya Province, has been exposed to intense construction and traffic; It forms the historical core of Konya. Alaaddin Hill is a mound that yields finds from the Bronze Age (450–2000 BC). Tepe is the inner castle settlement of the Anatolian Seljuk State and is one of the important natural and archaeological sites located in the center of Konya City today. The mound contains all the settlement levels from the Bronze Age to the end of the Ottoman Period. As a result of the archaeological excavations carried out in 1941, important findings were revealed in the mound. Alaaddin Hill Natural and Archaeological Site, Alaaddin Mosque-i, II Kılıçarslan Tomb and II Kılıçarslan Mansion symbolize the inner castle of Medieval Konya.

The 2nd Kılıçarslan Mansion archaeological excavation was carried out with the support of Konya Metropolitan Municipality. As a result of the archaeological excavations on the mound on which the mansion sits, the wall extending in the east-west direction and surrounding the palace ruins was revealed to the west of the mansion.

Archeogeophysical studies were carried out in order to fully reveal the wall surrounding the palace ruins, on the east of the 2nd Kılıçarslan Palace on Alaaddin Hill, the state of the western façade of the mansion, the continuation of the inner wall ruins passing in front of the mansion, to the east, and to clarify the integrity of the mansion and the Seljuk palace. Archeogeophysical studies were carried out in order to clarify the integrity of the mansion and the Seljuk palace. With the interpretation of the georadar (GPR) method used in archaeogeophysical studies, the anomalies of the inner city wall remains, which give regular geometric forms, were visualized in two and three dimensions.

Keywords: Konya, Alaaddin Hill, 2nd Kılıçarslan Palace, Archeogeophysics, GPR.

Introduction

Konya is located in the south of the Central Anatolia Region, between 36°41' and 39°16' north latitudes and 31°14' and 34°26' east longitudes (Figure 1). Most of the provincial lands are on the high plains of Central Anatolia. The area of the province, which has the largest surface area in Türkiye (excluding lakes), is 38.873 km^2 and its average height from sea level is 1.016 m.

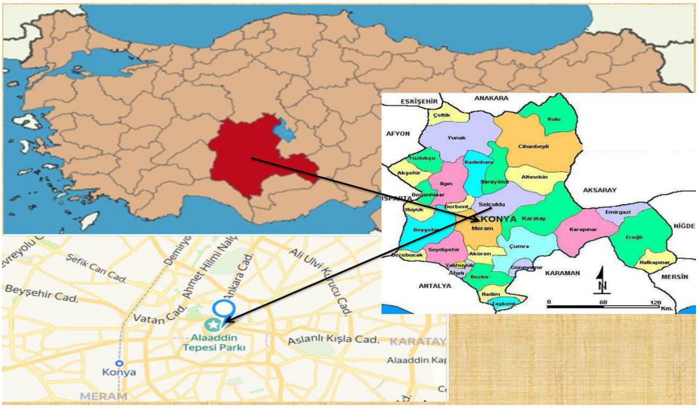

Figure 1 – Location Map of Alaaddin Hill, Selcuk District, Konya Province

There are Haymana Plateau in the north of the province, Cihanbeyli Plateau and Salt Lake in the northeast, Beyşehir Lake and Akşehir Lake in the west, Sultan Mountains in the south, volcanic mountains formed along a fault line in front of the inner slopes of the Taurus arc between the south of Karaman province, and the Obruk plateau in the east.

Plains and plateaus cover a very large area within the provincial borders. The elevations are generally gathered in the south of the province. Plains are separated from each other by plateaus. Plateaus are not deeply divided by streams. In the northern part of the province, there are Bozdağlar extending in the east–west direction and hills in places. The highest of these hills is Karadağ Tepe (1919 m). There are passes between these hills. The mountain ranges in the west of the province extend from north to south. Sultan Mountains (2169), Aladağlar (2339), Loras (2040), Eşenler (1951) are located in the northernmost part of the province. The southern part of the province is bordered by the Taurus Mountains, where Geyik (3130), Bolkar (3134), Aydos Mountains (3240) are located. There are also volcanic mountains such as Karacadağ (2025), Erenler Mountain (2319) and Takkeli Mountain (1400) in the province. Most of Konya's forests and water resources are located on the elevations here. In the areas where the limestone–

containing elevations are located in the south of the province, natural wonders such as Çamlık and Tınaztepe caves have been formed.

There are important mining areas within the provincial borders of Konya. Aluminum (bauxite) (Seydişehir), magnesite (Meram, Yunak), coal (Ilgın, Beyşehir and Seydişehir), clay (Beyşehir, Selçuklu and Ilgın); cement raw materials (clay, calcite, gypsum, trass, limestone and dolomite); There are lead–zinc (Hadim (Kızılgeriş) and Bozkır (Küçüksu)), barite (Bozkır) mines and significant underground water reserves. In Konya and its surrounding Çumra, Ereğli, Cihanbeyli, Akşehir, Yunak plains, there is ground water between 20–100 meters and in some places this water becomes artesian.

The Obruk and Cihanbeyli Plateaus of the province consist of wide plains with an average elevation of 1000 m. On the Obruk Plateau, there are Sinkhole (collapse of underground limestone melting cavities) such as the Kızören pothole, which are approximately 300 m in diameter and 145 m deep, which are karstic shapes developed on limestone layers. In addition, lakes were formed by the filling of water in these sinkholes. In the north of the province, there is the Cihanbeyli Plateau, which consists of limestone units and has a wavy surface that is less fragmented by rivers.

These plateaus and plains, which are covered with rich steppes in Konya Province, have attracted the attention of many civilizations for centuries in terms of livestock and agriculture. Konya and Ereğli plains are the largest plains of the region. Konya province was established at the western end of these plains. Çumra, Karapınar (recently, Sinkhole occur frequently), Altınekin, Sarayönü, Kadınhanı, Ilgın, Akşehir, Beyşehir, Seydişehir, Doğanhisar, Yukarı Sakarya, Yunak and Akgöl plains are also important plains within the borders of the province.

Within the borders of the province, there are mostly seasonal and flood regime streams fed by snow and rain waters. Due to the large areas of the province and the closed basin, the streams disappear in the swamps on the plains. Since the precipitation regime in Konya is irregular, the regime of these rivers is also irregular. In Konya, the water collection basins of the rivers flow in different directions. Among these, Gökpınar Stream reaching the Upper Sakarya River and the Black Sea, Hadim Stream, which is the northern branch of Göksu River, and the creeks and streams around the upper basin of the Manavgat River are open basins and carry their waters to the Mediterranean.

The streams originating from the heights around Salt Lake, Çavuşçu Lake, Beyşehir Lake, Akgöl on the Ereğli Plain, and Hotamış Swamp flow into these areas in the form of a closed basin. In the center of the closed basin in the south of the region, lakes do not form in Konya and Ereğli plains due to drought, and the streams that take their source from the elevations here disappear in the plain. The largest and most important stream in Konya is Çarşamba Water. It takes its source from the elevations in Bozkır district. It combines with the foot of Beyşehir Lake and forms the Çumra Plain irrigation network. The Apa Dam, which was built on Çarşamba Water, was established both to prevent floods and to irrigate a part of the Konya Plain. There are many natural lakes and swamps within the borders of Konya province. Some of them have brackish and salty waters, and some of them have fresh waters. These lakes also differ from each other in terms of formation.

Salt Lake, where some of Turkey's salt needs are obtained; Beyşehir Lake, which is an important bird breeding, shelter, feeding and accommodation center in our country; Suğla and Ilgın (Çavuşçu) Lakes, which are important for aquaculture and irrigation; Ereğli Akgöl, which has more than 200 bird species living in its reeds; mostly swampy Yunak Akgol; These lakes form important lakes and wetlands within the borders of the province.

In addition, in the karstic fields of Konya province, very small lakes were formed when the sinkholes, which are karstic shapes, were filled with water. These are: Kızören pothole, Tımraş sinkhole, Obruk lake, Çıralı lake and Meyil lake. While some of the obruk lakes are used for irrigation purposes, some of the obruk lakes are also of touristic value. Lakes have also been formed by volcanic events. Circular bowls were formed around the volcanic cones by the effect of volcanism. Small maar lakes were formed by the filling of these bowls with water. These are Acıgöl Maar and Meke Lake. There are magnesium sulfate solutions in these crater lakes located within the borders of Karapınar district. That's why the water is so bitter. It does not live in it. Due to the features arising from the formation, the volcanic material around Lake Meke has been largely destroyed for briquette construction and similar purposes. Meke Lake has been declared as «1st Degree Natural Protected Area».

In the province of Konya, there is rich groundwater between 20 and 100 m depth in the Çumra, Ereğli, Cihanbeyli, Akşehir, Yunak plains. In some areas, this water becomes artesian. In addition, thousands of ordinary wells (caissons) have been dug. Many boreholes have also been drilled, mainly for agricultural purposes. The water–bearing formations around Konya are mostly Paleozoic marbles, Mesozoic and Neogene limestones and alluviums.

The city of Konya was founded on a Quaternary aged flat alluvial surface. In the east of Erenler Mountains, bedrocks are exposed. These rocks consist of various types of lithology from Paleozoic to Cenozoic (Eocene) (Figure 2). During the Neogene period, andesite and basalt flows were formed along weak fault lines due to active volcanism. Quaternary units consist of alluvial and alluvial fans. These units were formed by erosion from the Taurus Mountains bordering the Konya closed basin from the south and Erenler Mountain from the west [1].

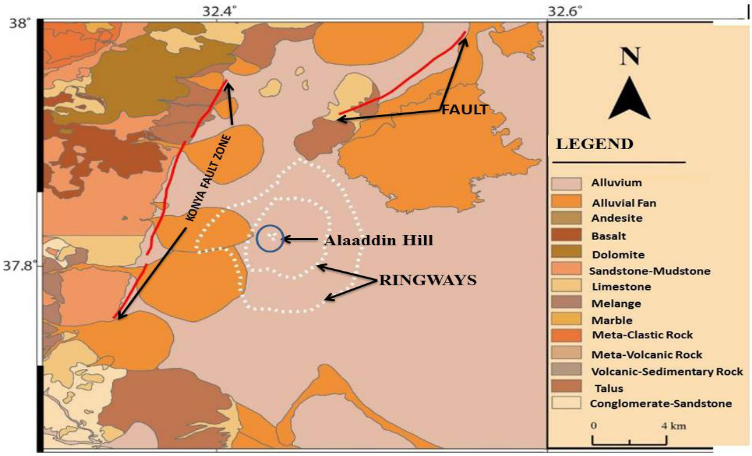

Figure 2 – Geological map of Konya and its surroundings. The location of Alaaddin Hill and its surroundings Alaaddin Hill and its ring roads (white dashed lines) and active faults (red lines) are shown on the map [2]

There are two active faults close to Alaaddin Hill [2]. The NE–SW trending Konya fault, located in front of the slopes about 6 km west of the city, separates the basement rocks from the Quaternary alluvium. The other NE–SW trending fault is approximately 5 km to the north in the alluvial plain. Both faults are normal faults and no significant tectonic activity has been observed in the region except for some small strike–slip and normal faulting [3,4]. The magnitudes of the earthquakes in the last 30 years in the study area are mostly below 4 and are scattered (Figure 3). The earthquakes with a magnitude of 4.7 and 4.9 that occurred on September 10–11, 2009 are the largest earthquakes recorded in the region in the last 30 years. Focal mechanism solutions show that earthquakes occur at shallow depths (~5 km) on a normal fault dipping southwest (Figure 3). The epicenter locations and depths

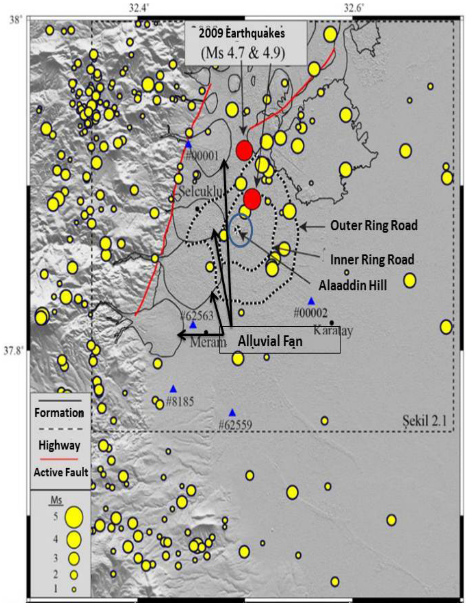

Figure 3 – Seismic activity (AFAD) observed in the Konya region between 1990–2021. Alluvial fans and other lithologies (limited by black lines), active faults (red line), Alaaddin Hill and its ring roads (white dashed lines) and water wells (blue triangles) can be seen around the Alaaddin Hill [1]

And focal mechanisms of the shocks indicate that they occurred on the east–southeast dipping Konya fault (Figure 4) [1].

In the city center of Konya, surface deformations have developed due to excessive underground water withdrawal, which causes ground settlements. Surface deformations in Konya city center were determined using satellite images with the InSAR method [1,5]. Deformations in the Konya city area and settlements reaching 6 cm per year, approximately 500 m west of the Konya central train station, were calculated [5,6]. It has been determined that there is a high agreement between GPS, groundwater and InSAR measurement results and that the surface deformations are caused by groundwater withdrawal [6].

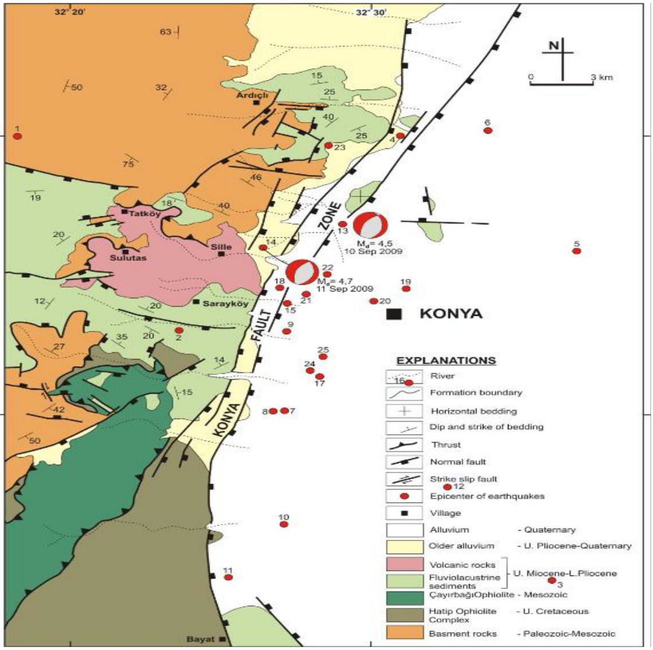

Figure 4 – The focal mechanisms (from INGV) and aftershocks (numbered red circles) distributions of the 10–11 September 2009 Konya earthquakes drawn on the geological map are shown [5,6]

One of the important stops of the Silk Road, which passes through Anatolia, is in Konya. Konya is in a strategic location due to its proximity to the Silk Road and the Mediterranean. The city of Konya is on the skirts of Alaaddin Hill, whose altitude reaches 1080 meters. The 2nd Kılıçarslan Palace is on Alaaddin Hill in the Selcuklu District (central district) of the city.

Materials and methods

2.1 Alaaddin Hill and 2nd Kilicarslan mansion

Alaaddin Hill; It is a mound that yields finds from the Bronze Age (4500–2000 BC). Tepe is the inner castle settlement of the Anatolian Seljuk State and is one of the important natural and archaeological sites located in the center of Konya City today. The mound contains all the settlement levels from the Bronze Age to the end of the Ottoman Period (Figure 5).

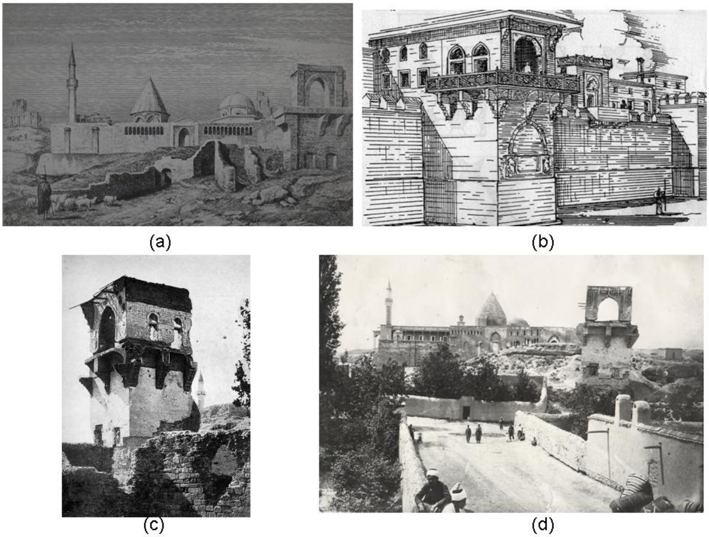

Figure 5 – Konya Province Central District Alaaddin Hill.
a) Konya Alaaddin Mosque, Alaaddin Mansion and Its Surroundings Engraving, b) Konya 2nd Kılıç Aslan Mansion Restitution, c) Konya 2nd Kılıç Aslan Mansion, d) 2nd Kılıç Aslan Mansion in Konya, Alaaddin Mosque and Its Surroundings, Late 19th Century [7–10]

As a result of the soundings made in 1941, important findings were revealed in the mound. Alaaddin Mosque, 2nd Kılıçarslan Tomb and 2nd Kılıçarslan Mansion on Alaaddin Hill, which is a Natural and Archaeological Site, symbolize the inner castle of medieval Konya.

The 2nd Kılıçarslan Mansion Rescue Excavation was carried out with the support of Konya Metropolitan Municipality. As a result of the excavation, the wall surrounding the ruins of the Palace on which the mansion sits, extending in the east–west direction, was revealed to the west of the mansion.

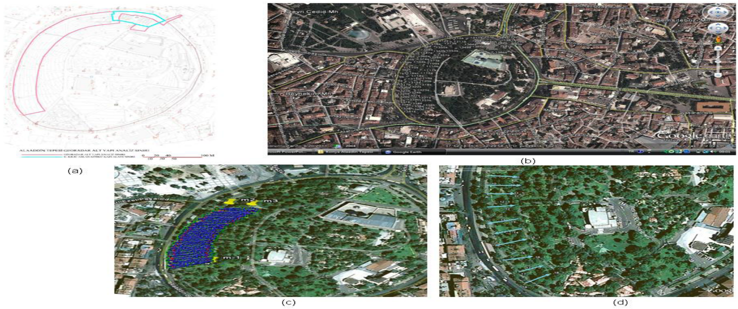

Figure 6 – Konya Province Central District Alaaddin Hill
a) Alaaddin Hill geophysical measurement Boundary (Konya Metropolitan Municipality Department of Reconstruction and Urbanization), b) Alaaddin Hill GPR measurement profiles locations Map (Google Earth) (Google Earth)

2.2 Georadar (GPR) method

Extraordinary advances in electronic engineering over the past three decades have transformed what was once a laborious and expensive task to measure the speed of light into an extremely inexpensive, easy and sensitive form. Time measurements with millisecond (10–3 sec) precision in the 1970s decreased to microseconds (10–6 sec) in the 1980s and to nanoseconds (10–9 sec) in the 1990s. Parallel to these developments in electronics, the ability to measure the travel times of electromagnetic waves, which move at a speed close to the speed of light underground, in the order of nanoseconds, has made significant contributions to shallow geophysical imaging methods. The ground radar is a tangible result of these developments mentioned above.

In general terms, it consists of a ground radar, transmitting antenna, receiving antenna and recorder. The transmitting antenna is designed to generate an electromagnetic signal with an electric field vector in the horizontal direction (TE: Transverse Electricity) with a duration of a few nanoseconds. The receiving antenna, on the other hand, is positioned in the same direction to detect the electromagnetic signal returning from underground depths. If there is an interface underground consisting of rocks with different dielectric properties on both sides, the electromagnetic wave will be reflected and transmitted at this interface. The reflection and transmission principles of electromagnetic waves are given below.

In case of using very high frequencies, Maxwell's equations are arranged

$$\nabla \cdot \boldsymbol{e} = -\mu \frac{\partial \boldsymbol{h}}{\partial t}$$

and

$$\nabla \cdot \boldsymbol{h} = \epsilon \frac{\partial \boldsymbol{e}}{\partial t}$$

is found. If the wave equations are

$$\nabla^2 \boldsymbol{h} = \mu \, \epsilon \left(\frac{\partial^2 \boldsymbol{h}}{\partial t^2} \right)$$

and

$$\nabla^2 \boldsymbol{e} = \mu\epsilon \left(\frac{\partial e^2}{\partial t^2} \right)$$

given as. The solutions of these equations

$$E = E_0 e^{-i(wt-kz)}$$

and

$$H = H_0 e^{-i(wt-kz)}$$

is given with. E_o and H_o are the initial values for the plane wave. It should be remembered here that $k_2 = \mu_0 \epsilon \ w_2$. If $\varepsilon = 8.854 \cdot 10^{-12}$ Farad/M is taken in free space, the relative permitivity is defined by $\frac{\varepsilon}{\varepsilon_0}$. The relative permeability affects the propagation of the EM wave at μ, but the $\frac{\mu}{\mu_0}$ ratio is close to the unit value ($\mu_0 = 4\pi \cdot 10^{-7}$ in free space).

The Z impedance value, using the E and H values obtained from the solution of the wave equations,

$$Z = \frac{E_x}{H_y} = \frac{\mu_0 w}{k}$$

obtained. Z value in free space

$$Z_O = \frac{\mu_0}{\epsilon_0} = 120\pi = 377 \text{ ohm}$$

is found. In the ground, definition becomes difficult due to conductivity. Hence the complex permitivity definition is made,

$$\varepsilon' = \varepsilon + i\frac{\sigma}{w}$$

loss tangent

$$\tan\delta = \frac{\sigma}{w\varepsilon}$$

The magnitude of the loss tangent indicates the height of the damping. In conductive media, the impedance relation is

$$Z_0 = \frac{\mu_0 e^{\frac{i\delta}{2}}}{\left(\epsilon^2 + \frac{\sigma^2}{w^2}\right)^{\frac{1}{4}}},$$

is given with. Impedance relation is not used much in practice. Other variables necessary to understand the method are briefly described below.

$$k = \alpha + i\beta = w\mu_0^{\frac{1}{2}}\varepsilon^{\frac{1}{2}}(1+\delta^2)^{\frac{1}{4}}e^{\left(\frac{iatan\delta}{2}\right)},$$

if given,

$$\alpha = w\,\mu_0^{\frac{1}{2}}\varepsilon\varepsilon^{\frac{1}{2}}\,(1+\delta^2)^{\frac{1}{4}}\,cos(\frac{1}{2}\,atan^{-1}\,\delta)$$
$$= w\,\mu_0^{\frac{1}{2}}\varepsilon\varepsilon^{\frac{1}{2}}2^{\frac{1}{2}}(1+(1+\delta^2)^{\frac{1}{2}})^{\frac{1}{2}}$$

and

$$\beta = w\,\mu_0^{\frac{1}{2}}\varepsilon\varepsilon^{\frac{1}{2}}\,(1+\delta^2)^{\frac{1}{4}}\,sin(\frac{1}{2}\,atan^{-1}\,\delta)$$
$$= w\,\mu_0^{\frac{1}{2}}\varepsilon\varepsilon^{\frac{1}{2}}2^{\frac{1}{2}}(1-(1+\delta^2)^{\frac{1}{2}})^{\frac{1}{2}}$$

is found. If the phase velocity of the plane wave is defined as the displacement ratio of the phase front,

$$wt - \alpha z = sabit$$

writable. Here, for the stability condition, z depth should increase as t increases. The rate of changes will give the velocity relation,

$$v = \frac{dz}{dt} = \frac{2\pi f}{\alpha}.$$

In any material, the wavelength of the EM field is obtained by dividing the wave velocity by the frequency,

$$\lambda = \frac{v}{f} = \frac{2\pi}{\alpha}$$

For damping factor δe

$$\delta_e = \frac{1}{\beta} w\, \mu_0^{\frac{1}{2}} \varepsilon \varepsilon^{\frac{1}{2}} 2^{\frac{1}{2}} (1 - (1 + \delta^2)^{\frac{1}{2}})^{\frac{1}{2}}$$

can be written.

Light, which is itself an electromagnetic wave, propagates in vacuum with the speed c given by the following equation [16]:

$$c = \frac{1}{\sqrt{\varepsilon_0 \mu_0}}.$$

Here $\varepsilon_0 = 8.854 \cdot 10^{-12}\, C^2\, N^{-1}\, m^{-2}$,
$\mu_0 = 4\pi \cdot 10^{-7}$ Wb A^{-1} m^{-1} and $c \approx 3 \cdot 10^8$ m/s. ε_0 is the permittivity of the cavity and μ0 is the permeability of the cavity.

If the electromagnetic wave propagates through the material, the velocity relation c is

$$w = \frac{1}{\sqrt{\varepsilon \mu}}$$

is expressed as. Here, ε is the permittivity of the substance and μ is the permeability of the substance. If the relative permittivity K of the substance is defined as the relative permeability K_m:

$$\varepsilon = K \varepsilon_0$$

$$\mu = K_m \mu_0$$

It is possible. If the relations c, ε and μ are placed in the velocity relation w:

$$w = \frac{c}{\sqrt{K_m K}}$$

obtained. For materials with weak magnetic properties, the relative permeability can be taken as Km ≈ 1. In this case, the electromagnetic wave velocity w will only be a function of the material's relative permittivity K:

$$w = \frac{c}{\sqrt{K}}$$

Electromagnetic wavelength for a given frequency f:

$$\lambda = \frac{w}{f}$$

is expressed as.

At this stage, the reflection and transmission principles of electromagnetic waves can be examined. Let λ1 be the length in the medium in which the electromagnetic wave is still moving, and λ2 be the length in the medium into which the electromagnetic wave will soon be transmitted. In this case, the reflection coefficient R is:

$$R = \frac{\lambda_2 - \lambda_1}{\lambda_2 + \lambda_1}$$

transmission coefficient T:

$$T = 1 - R$$

defined as. If the w and λ relations are placed in the R and T relations, the following relations are obtained for R and T [11,12]:

$$R = \frac{\sqrt{K_1} - \sqrt{K_2}}{\sqrt{K_1} + \sqrt{K_2}}$$

$$T = \frac{2\sqrt{K_2}}{\sqrt{K_1} + \sqrt{K_2}}$$

In the R and T relations, K1 shows the permittivity of the medium in which the electromagnetic wave is still moving, and K2 shows the permittivity of the medium into which the electromagnetic wave will be transmitted soon [13].

As stated in the w relation, the increase in K with depth in general will cause the electromagnetic wave velocity to decrease gradually and therefore the electromagnetic beam will gradually approach normal. The most widely used method in ground radar is the zero offset (source–receiver distance zero) reflection method.

The relative permittivity K is synonymous with the dielectric constant of the capacitances. The increase in the dielectric constant of a capacitance means that that capacitance can accumulate more electromagnetic energy through polarization. Neutral molecules that make up the structure of a substance become polarized under the influence of the electromagnetic wave passing over them and store electromagnetic energy in them. Immediately after this, they give back the energy in question as an electromagnetic wave. This is how electromagnetic waves travel from one molecule to another in matter. Also, electromagnetic waves can travel through space without matter.

The electromagnetic signal sent to the ground has a harmonic structure and contains an effective frequency. The value of this frequency determines the depth of penetration, the amount of absorption and the degree of scattering. When the frequency in question is less than 10 MHz, two negative situations are encountered while the depth of penetration increases: (1) the vertical resolution decreases with decreasing frequency, (2) the polarizable elements in the material at low frequencies leave their original positions instead of polarizing, causing electrical conductivity (current). The conversion of electromagnetic energy into electrical conductivity at low frequencies is the main cause of absorption. At frequencies higher than 300 MHz, polarizable elements in the material will not have the opportunity to leave their original places, so they will not be affected by the absorption caused by electrical conductivity. However, there will be an action–reaction delay problem at high frequencies, resulting in a frequency dependent decrease in the relative permittivity with increasing frequency. On the other hand, as the frequency increases, there is an improvement in the vertical resolution, this time the penetration depth decreases. High frequencies also cause the appearance of a large number of scattering hyperbolas in ground radar sections.

The antenna frequencies used in practice are 80 MHz, 100 MHz, 120 MHz, 300 MHz, 500 MHz, 750 MHz, 900 MHz, 1 GHz and 2.5 GHz. While 40 m depths can be penetrated with an 80 MHz antenna, a 40 cm wall can be examined with a 2.5 GHz antenna.

As can be understood from the discussions above, the more resistant (less conductive) the underground is, the higher the quality of the ground radar images. Where penetration depth is important, the environment should be as dry as possible. At this wet level, there is both a significant relative permittivity contrast (R–correction) and a significant decrease in the amplitude and high frequency content of the electromagnetic signal reflected to the earth due to the sudden increase in electrical conductivity at this level. As a result, the amplitude and high frequencies decrease due to absorption as one goes deeper from the groundwater level in the ground radar sections, and the energy in the sections below the groundwater level in the section has a 'swept' appearance.

2.3 Archaeogeophysical studies on Alaaddin hill

On Alaaddin Hill, during the Archaeological Excavations of the 2nd Kılıçarslan Palace, the complete exposure of the wall surrounding the palace ruins, located to the east of the palace, The condition of the western facade of the mansion, The continuation of the inner city wall remnant passing in front of the mansion towards the east can be seen, Archeogeophysical studies were carried out in order to clarify the integrity of the mansion and the Seljuk palace (Figure 7).

A geophysical (GPR) survey was carried out to determine the fortification walls in the NW–W direction surrounding Alaaddin Hill. Before starting the geophysics studies, the study areas were gridded. The grids were made at locations determined to fit between the remnants of the overturned and scattering walls showing a linear distribution on the western slope of the hill (Figure 8).

Figure 7 – Konya Province Central District Alaaddin Hill and the remains of the city walls (upper left and right); GPR measurement around Alaaddin Hill western slope fortification remains and map of Alaaddin Hill western slope GPR measurement locations (bottom left and right) (Google Earth)

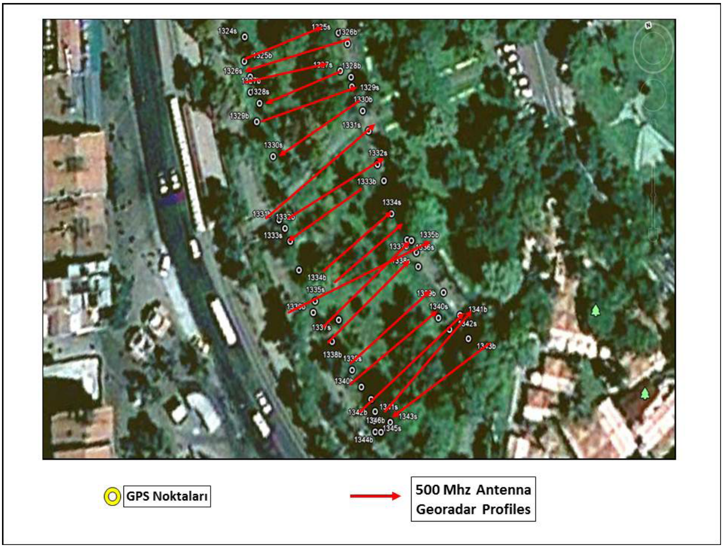

Figure 8 – Konya Province Central district Alaaddin Hill and Alaaddin Hill west slope GPR measurement locations map (Google Earth)

The ground radar (GPR) method, which is one of the Geophysical Electromagnetic Research Methods with high resolution, has been frequently used recently because it is fast and economical in archaeogeophysical researches. In the GPR method, high frequency electromagnetic waves are sent underground with a transmitting antenna. Some of this wave is reflected underground from surfaces with different dielectric properties, while the other part can penetrate deeper environments. In GPR measurements, data can be taken in continuous form with 3 cm intervals, and the lateral and vertical changes of the two (2D) and/or three (3D) dimensional examination area can be displayed along the lines determined parallel to each other.

In general terms, it consists of a ground radar, transmitting antenna, receiving antenna and recorder. The transmitting antenna is designed to generate an electromagnetic signal with an electric field vector in the horizontal direction (TE: Transverse Electricity) with a duration of a few nanoseconds. The receiving antenna, on the other hand, is positioned in the same direction to detect the electromagnetic signal returning from underground depths [11,14]. If there is an interface underground consisting of rocks with different dielectric properties on both sides, the electromagnetic wave will be reflected and transmitted at this interface.

In the study area, Zond 12e brand Jeoradar Control unit, HP laptop, transceiver antennas and battery as energy source were used. Measurements were made using a shielded 500 MHz antenna in the field. Beginnings and endings of the profile are marked in the detected areas. The start and end points of each profile were precisely determined using DGPS and mapped.

Measurements were taken using a 500 MHz antenna. Technical Specifications of the equipment used:

Zond–12e Control Unit:
Performance: Single channel.
Time Interval: user–selectable from 1 to 2000 ns in 1 ns intervals.
Transmit rate: 115 khz.
Scan interval: 56 signals/sec.
Sampling: 512.
Resolution: 16 bit.
Filter : user optional high pass filter set: 0.00; 400; 800 Hz.
Data Transfer: through Ethernet to PC.
Power: 10.5–13 V DC 0.4 A
500 MHz antenna unit, shielded, surface coupled, CE Certified:
Resolution & depth*: 0.5 x 7–10 m.
Dimensions: 72x33x12 cm.
Weight: 5.2 kg.
Power supply: 0.35 a @ 12 v dc powered from the control unit with a cable.
Transmitter output: 400 v.
Receiver sensitivity: 120 mcv.
Receiver amplific: 10 db.

In order to determine the direction of the wall in the field, measurements were tried to be taken with 1 and 2 m profile intervals. However, measurements could not be taken in places that were not suitable for measurement.

After the measurements in the field were taken by controlling, firstly, the received signals were gained with an amplitude function. After this process, repeated reflections were eliminated by background removal. Then an ombasy bandpass filter was applied to eliminate very low and very high frequencies from the data [15,16].

2D and 3D underground modeling of the site was made by taking GPR measurements along the profiles determined in the NW–W direction surrounding Alaaddin Hill where the remains of the city walls are located. Structures showing a certain system (with the appearance of an architectural plan) have been identified in the study area. Regions with anomaly distributions showing this architectural plan feature, that the fortification wall remains are in harmony with the wall foundation remains unearthed in the previous experimental 2010 archaeological excavations, and that the linear–looking high–amplitude anomaly distribution in 2D and 3D models is in NW–W direction surrounding Alaaddin Hill. It was seen that it formed the foundations of the fortification walls. The importance of Geophysical Prospecting in archaeological sites has been demonstrated once again with this geophysical study carried out on the slope where the remains of fortifications are located in the NW–W direction surrounding Alaaddin Hill (Figure 9, 10, 11, 12).

Considering the Alâeddin Tepesi Mound and the architectural structures on it, the ruins forming the mound and the changes made today, the information obtained through geophysical studies before starting the excavation is extremely economical and guides the archaeological excavations. In order to determine the structures determined by archeogeophysical methods and their continuity and to test the GPR results, research soundings should be made in and around the site.

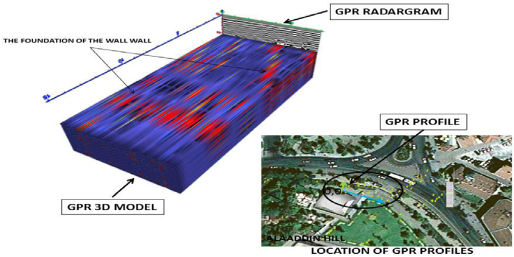

Figure 9 – 3D GPR image of the fortification foundations on Alaaddin Hill and the western slope of Alaaddin Hill in the Central district of Konya and the location map of the GPR Profiles (Google Earth)

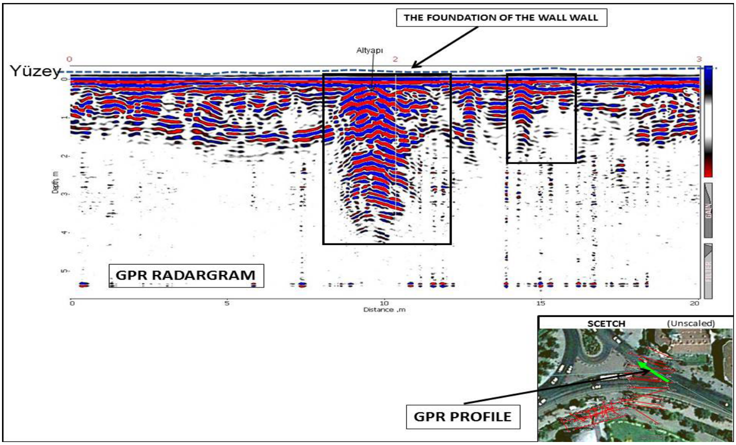

Figure 10 – GPR Radargram image of the fortification wall foundations under the road on the west side of Konya Province Central District Alaaddin Hill and Alaaddin Hill and the location map of the GPR Profile (Google Earth)

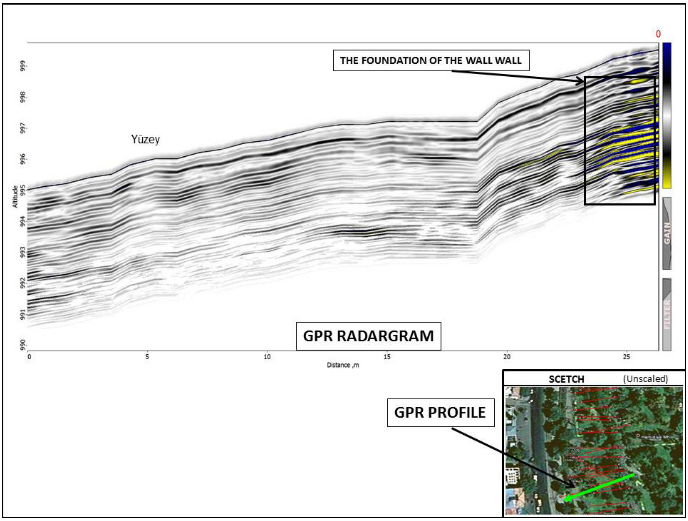

Figure – 11 GPR Radargram image of the fortification foundations of Alaaddin Hill and the western slope of Alaaddin Hill, Central district of Konya Province, and the location map of the GPR Profile of the northern part (Google Earth)

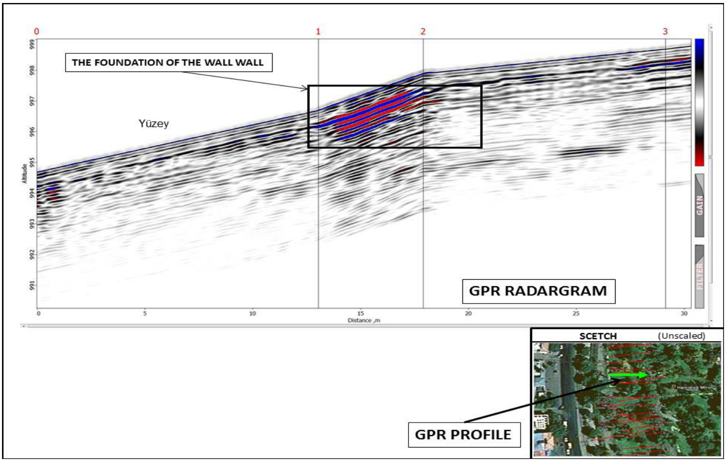

Figure 12 – GPR Radargram image of the fortification foundations of Alaaddin Hill and the western slope of Alaaddin Hill, Central district of Konya Province, and the location map of the GPR Profile of the southern part (Google Earth)

Results and discussion

It is a well–known fact that the 2nd Kılıç Aslan mansion, which was built on the Konya Alaaddin Hill Mound, is not an independent structure, and that the palace and palace annexes around it, the inner wall, were written by travelers, scientists, researchers, archaeological excavation reports and historical sources. Architectural remains strengthen the possibility that the Seljuk palace was located in the south of the mansion. We see in Matrakçı Nasuh's miniature and in the written and visual works of travelers that this palace was used for a long time, and that it preserved its importance in the Ottoman Period with additions and additions in different periods [17].

Konya Palace is the oldest architectural structures of Turkish existence in Anatolia, together with the Alaaddin Mosque and the tomb of the Seljuk Sultans, in the center of the city of Konya, which became the capital city during the Seljuk period, to the north of Alaaddin Hill. Although the palace was extensively destroyed, the researches and excavations yielded very valuable tile, plaster and ceramic finds to the museums. Strengthening the existing ruins of the palace, excavating the underground parts and bringing them to light are of great importance for the promotion of Turkish History and Art, Konya.

Conclusions

Archeogeophysical georadar studies were carried out in order to determine the presence of possible palace and palace outbuildings and architectural remains of the inner castle wall within the 2nd Kılıç Aslan Mansion Excavation area. High amplitude anomalies seen in the two– and three–dimensional diagrams obtained from the GPR measurements are the anomalies that indicate the presence of architectural remains of the inner castle wall and give the architectural foundation geometry.

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GEORADAR ӘДІСІН ҚОЛДАНА ОТЫРЫП, 2-ШІ КИЛИЧАРСЛАН САРАЙЫНЫҢ КОНИЯ АЛААДДИН ТӨБЕСІНІҢ ҚАБЫРҒАЛАРЫНЫҢ ІРГЕТАСТАРЫН ТАБУ. ШОЛУ

Кония қаласының орталығында, Түрік Кония провинциясында орналасқан Алааддин төбесі қарқынды құрылыс пен жол қозғалысына ұшырады; ол Конияның Тарихи өзегін құрайды. Алааддин төбесі – қола дәуірінен (б.з. д. 4500–2000) табылған қорған. Тепе – Анадолы Селжұқ мемлекетінің ішкі құлып елді мекені және бүгінде Кония қаласының орталығында орналасқан маңызды табиғи және археологиялық орындардың бірі. Қорған қола дәуірінен Османлы кезеңінің соңына дейінгі қоныстардың барлық деңгейлерін қамтиды. 1941 жылы жүргізілген археологиялық қазба жұмыстарының нәтижесінде Қорғаннан маңызды олжалар табылды. Табиғи және *археологиялық ескерткіш Алааддин төбесі, Алааддин-і мешіті, Кылычарслан II қабірі және Кылычарслан II сарайы ортағасырлық Конияның ішкі қамалын бейнелейді.*

2–ші Кылычарслан сарайына археологиялық қазба жұмыстары елордалық Кония муниципалитетінің қолдауымен жүргізілді. Особняк тұрган қоргандагы археологиялық қазба жұмыстарының нәтижесінде зәулім үйдің батысында шыгыс-батыс багытта созылып, сарайдың қирандыларын қоршап тұрган қабырга табылды.

Археогеофизикалық зерттеулер сарайдың қирандыларын қоршап тұрган қабырганы, Алааддин төбесіндегі 2-ші Кылычарслан сарайының шыгысында, зәулім үйдің Батыс қасбетінің күйін, зәулім үйдің алдында, шыгысқа қарай өтетін ішкі қабырга қирандыларының жалгасын толық анықтау және сарай мен Селжұқ сарайының тұтастыгын нақтылау үшін жүргізілді. Зәулім үй мен Селжұқ сарайының тұтастыгын нақтылау мақсатында археогеофизикалық зерттеулер жүргізілді. Археогеофизикалық зерттеулерде қолданылатын радиолокациялық әдісті (GPR) түсіндіру арқылы дұрыс геометриялық пішіндер беретін ішкі қала қабыргасының қалдықтарының ауытқулары екі және үш өлшемде бейнеленген.

Кілтті сөздер: Кония, Алааддин төбесі, 2-ші Кылычарслан сарайы, археогеофизика, радар.

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НАХОЖДЕНИЕ ФУНДАМЕНТОВ СТЕН ХОЛМА КОНЬЯ АЛААДДИН 2-ГО ДВОРЦА КИЛИЧАРСЛАН С ИСПОЛЬЗОВАНИЕМ МЕТОДА GEORADAR (ГЕОРАДАР). ОБЗОР

Холм Алааддин, расположенный в центре города Конья, турецкая провинция Конья, подвергся интенсивному строительству и дорожному движению; он образует историческое ядро Коньи. Холм Алааддин – это курган, в котором найдены находки бронзового века (4500–2000 до н.э.). Тепе является внутренним замковым поселением Анатолийского государства сельджуков и является одним из важных природных и археологических памятников, *расположенных сегодня в центре города Конья. Курган содержит все уровни поселений от бронзового века до конца османского периода. В результате археологических раскопок, проведенных в 1941 году, в кургане были обнаружены важные находки. Природный и археологический памятник Холм Алааддин, мечеть Алааддина-і, гробница Кылычарслана II и особняк Кылычарслана II символизируют внутренний замок средневековой Коньи.*

Археологические раскопки 2-го особняка Кылычарслана были проведены при поддержке столичного муниципалитета Коньи. В результате археологических раскопок на кургане, на котором стоит особняк, к западу от особняка была обнаружена стена, простирающаяся в направлении восток-запад и окружающая руины дворца.

Археогеофизические исследования были проведены для того, чтобы полностью выявить стену, окружающую руины дворца, к востоку от 2-го дворца Кылычарслан на холме Алааддин, состояние западного фасада особняка, продолжение руин внутренней стены, проходящих перед особняком, на восток, и уточнить целостность особняка и сельджукского дворца. Были проведены археогеофизические исследования с целью уточнения целостности особняка и сельджукского дворца. С помощью интерпретации георадарного метода (GPR), используемого в археогеофизических исследованиях, аномалии остатков внутренней городской стены, которые придают правильные геометрические формы, были визуализированы в двух и трех измерениях.

Ключевые слова: конья, холм Алааддин, 2–й дворец Кылычарслан, археогеофизика, георадар.

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