

**The Path And Landing Places On The  
Road Of Imam Hussein From Mecca  
To Karbala: A Modern And Satellite-Bas  
Study A proach**

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## Abstract

The importance of the Movement of Imam Hussein from Mecca to Karbala played a great and effective role in accomplishment Imam's mission. The authors focused on the Kufi Hajj Route (Zubaydah Trail in Arabic Darb Zubaydah) as a basis for this study due to the abundance of sources through which they can learn the ancient and numerous names of the houses and stations on the route. Famous to Zubaydah Trail, it is comprised of the sites and ponds along the road. A study made to designate precisely the names of all the sites and ponds along the road. Benefiting of the modern technologies as a strong and effective tool for well managing and study we used space applications technologies and engineering such as GIS and remote sensing, telecommunications, artificial intelligence, informatics, mathematics, statistics, and so on.

A satellite or aerial image of each site and a judicial image from Google Maps for each site with the geographical coordinates were used. Putting the geographical coordinates accurately is important bias because all references do not put the coordinates and if they do, they are either incorrect or inaccurate. Furthermore, a framework for using space radar imagery for some locations provided a valuable addition to our work.

In this paper, the authors with background in space science and technologies, and telecommunications focus on and highlight effectiveness and importance of these fundamental and infrastructural technologies. Authors believe that the joint work and cooperation of the organizational and independent experts from the relevant entities and sharing knowledge and experience can lead to increment of the synergy of work for well managing and control of the event.

Authors, who are from Iraq and Iran, worked for long term in their relevant national space technology and communication organizations in both managerial and specialized levels. They share the feasible and accessible potentials and possibilities for well managing and control of the sites under study. Authors determine the steps of ideas in order of priority and importance, which inevitably involve creativity. They believe that the idea of experimenting with collaboration and remote work will certainly yield success.

### Introduction

Importance of the Movement of Imam Hussein from Mecca to Karbala played great role in accomplishing Imam's mission. The Kufi Hajj Route (Zubaydah Trail) has taken as a basis for a study that because of the abundance of sources through which they can learn the ancient and numerous names of the houses and stations on the route. Famous to Zubaydah Trail, it is comprised of the sites and ponds along the road. Benefiting of the modern technologies as a strong and effective tool for well managing and study space applications technologies and engineering such as GIS and remote sensing, telecommunications, artificial intelligence, informatics, mathematics, statistics, and so on, are used in this study. Nevertheless, the main weight of the work in this study goes to radar and thermal satellite and airborne imagery which importance is discussed in section 5.

## The ancient caravan old route from Mecca to Iraq

Since ancient times, caravans have traveled overland between the Hijaz and neighboring regions. One of the pre-Islamic routes was the ancient caravan route from Mecca to Iraq, known as the Hira Road.

Al-Hirah, the capital of the Lakhmids, was located near the site of Kufa. This was a major caravan route in ancient times, connecting the Hijaz region with Mesopotamia. Journeys departed through the Najd Plateau, passing stations with wells and ponds. They made their way through the rugged terrain of the Great Nafud Desert, using ancient wells and oases as the basis for their route. They also passed through the Al-Jawf region through depressions and valleys (Sultan Naji 1978). This road was used by Muslims at the beginning of the Islamic era for cultural and military purposes. The Islamic army, led by Sa'd ibn Abi Waqqas, took this route, stopping at some areas with water sources before reaching the rivers of Iraq. These included the areas of Al-Zarud, Al-Tha'labiyah, Sharaf, Al-Udhaib, and Al-Qadisiyah (Muhammad Al-Saidi 2018).

Because of the Hajj rituals established by Islam, Islamic states paid special attention to the ancient roads, including the Mecca-Hira Road. After the founding of the city of Kufa in the Islamic era, the road was called the Kufi Hajj Road. During the Abbasid era, great attention was paid to this road, and modern ponds, springs, traffic lights, forts, and even palaces were built.

It is worth noting that a large portion of the Al-Hirah Road falls within the newer Zubaydah Trail, established during the Abbasid Caliphate. Zubaydah Trail was used as part of the original Al-Jawf-Hail Road. Stations in the Faydh, Al-Tha'labiyah, and Wadi Al-Rummah regions were also part of Zubaydah Trail (Al-Rashed 2001). Thus, parts of the old Al-Hirah Road coincide with the Kufa Hajj Road and with modern trade routes in Saudi Arabia and Iraq.

## Land pilgrimage route from Kufa to Meka (Zubaydah Trail)

The Kufa Hajj Route is one of the most important historical routes used by Muslim pilgrims to travel from Kufa in Iraq to Mecca in the Hejaz. Its history dates back to the pre-Islamic era. However, its importance increased with the advent of Islam and it flourished beginning with the era of the Rightly Guided Caliphate and the Umayyad period, reaching its peak during the era of the first Abbasid Caliphate.

Zubaida bint Ja'far, the wife of Caliph Harun al-Rashid, constructed numerous ponds and wells to provide water for pilgrims, Umrah performers, and travelers. Pilgrims from eastern Iraq also used this route, gathering in the Iraqi city of Kufa. From there, they crossed the desert road to enter the Arabian Peninsula as the Iraqi Hajj Caravan, until they reached Mecca (Anthea Crane 2023), (Al-Rashid, S. A. 1977).

This road is approximately 1,400 kilometers long and crosses most of the lands of Najaf Governorate in Iraq, then the lands of Saudi Arabia in the governorates of Rafha, Hail and Qassim, reaching Mecca.

Its use became increasingly regular and convenient, as water centers and grazing areas located along the route became major stations. It now contained numerous stations and houses that were used as rest stops and water supply points for caravans. The road is connected by numerous main stations (each called a "manzil"), in addition to substations (called "muta'asha" for resting and eating), with ponds, pools, and wells scattered along the sides of the road. There are 27 stations from Kufa to Mecca, with Mecca being the 28th and five of the stations are located in Iraq (Al-Rashid, S. A. 1977) (The Desert Team, July 4, 2022).

Those are (Kufa, Al-Qadisiyah, Al-Mughitha, Al-Qura'a, Waqisa, Aqaba). The remaining houses are located in the Kingdom of Saudi Arabia and they are (Al-Alqae, Zubalah, Al-Shuqooq (Al-Shihiyat), Bitan (Aleashar), Althaelabia (albidae), Alkhazimat Zarud, Al'ajfar, Fid, Tawz, Samira, Alhajir, Maedin Alqurashi (now Aalnaqrat), Alnaqrat (now Aljafniat), Mughithat Almawan (Alsaqaea'), Alrabidha, Alsalila, Aleumq, Almaedin, 'Afeih, Almusalah, Alghamra, Dhat Earq, Albustan) and then Makkah Al-Mukarramah. The coordinates of these houses are shown in the Table 1 (Appendix 1).

The distance between one house and another is not fixed because the location of the houses at that time was chosen based on the daily path of the caravans and the availability of water along the way. The average distance between one house and another ranged between 40 and 50 km. As for the dinners, the number of houses, their names and coordinates are shown in Table 1 (Appendix 1). A look at the various stations and facilities along the route reveals that this historic project was characterized by high-level planning in water management and meticulous construction management, reflecting a spirit of teamwork.

The remaining landmarks, including ponds, wells, water springs, rest stops, and other sites, are among the most important physical heritage sites. Their restoration could contribute to preserving the archaeological and human values that can be transformed into tourist sites that enhance historical tourism in the region.

### **The most important features of this road are:**

- The presence of wells, ponds, basins, and rest stops along the route before its development by the Abbasids.
- Rest stops, water collection ponds, and various wells and water channels were established according to the possible terrain along parts of the road.

- Stones were paved on both sides of the road to facilitate navigation in the desert. (Fig. 3.1.)
- The road featured signposts (called “mile,” “mushrif,” and “barid”) and beacons to indicate distance and geographical location (The Desert Team, July 4, 2022).
- Villages and residential centers arose around it due to the constant movement along it.
- Between one house and the next, there was a “muta’asha” (a place for rest and eating).

The presence of some inhabited stations, which were originally small villages or towns that helped pilgrims purchase supplies.

In this study, we will follow this historic route, house by house, from Kufa, Iraq, to Mecca, relying on historical sources that describe significant details of this route. The geographic coordinates of each stop and archaeological landmark will be documented using space technology and geographic information systems for both sections of the route (Iraqi and Saudi), along with available satellite images for each region (The Desert Team, August 19, 2003), (The Desert Team, Tag Archives: Kufi Hajj Trail July 23, 2022 )

We will start with what was documented in the book of Judge Waki’, which was widely relied upon by explorers and researchers. The following is a table of stations (homes) and night rest areas (dinners).(Table1 in Appendix 1)

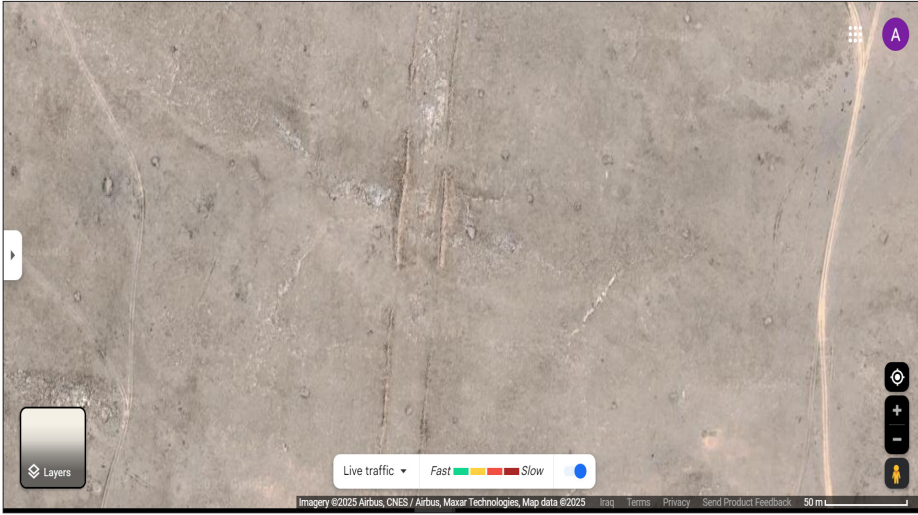


Fig.3.1: Satellite image taken from Google Maps showing the shape of Zubaydah Trail, where stone paving is noticeable on both sides of the road. Despite the passage of time, it can be seen clearly from the satellite images and coordinates (30.279349, 43.633829).

### 1. Standards: Used to Measure Distances on Zubaydah Trail.

The road signs on Zubaydah Trail are among the most prominent archaeological evidence, reflecting the meticulous organization and great care taken to facilitate the journeys of travelers between Kufa and Mecca. Engineers on Zubaydah Trail used precise units of measurement to determine distances and guide travelers (Fig. 3.2). The unit used was the mile, which is equivalent to approximately 2 km in the Arab standard. Milestones, (Fig. 3.3), were placed along the road to mark the distances between stations. Another unit of measurement was the Albirid, which equaled 12 miles (approximately 24 kilometers). Albirid markers were constructed of stone, often square in shape, (Fig. 3.5), and marked the Albirid number and the remaining distance to the next Albirid. Another guidance unit was Al-mushraf, which was built halfway between two Albirids, i.e., every 6 miles (approximately 12 kilometers) (The Desert Team Trail (1) July 4, 2022). Almushraf was also constructed of stone and was often circular in shape, (Fig. 3.4) and taller than the Albirid, making it easier to see from a distance.

These signs demonstrate the extent of progress in urban planning and engineering in the early Islamic era. The Book of the Road states that the distance from Baghdad to Mecca is seven hundred and fifty-eight miles, which is close to the distance that can be measured with modern surveying tools.

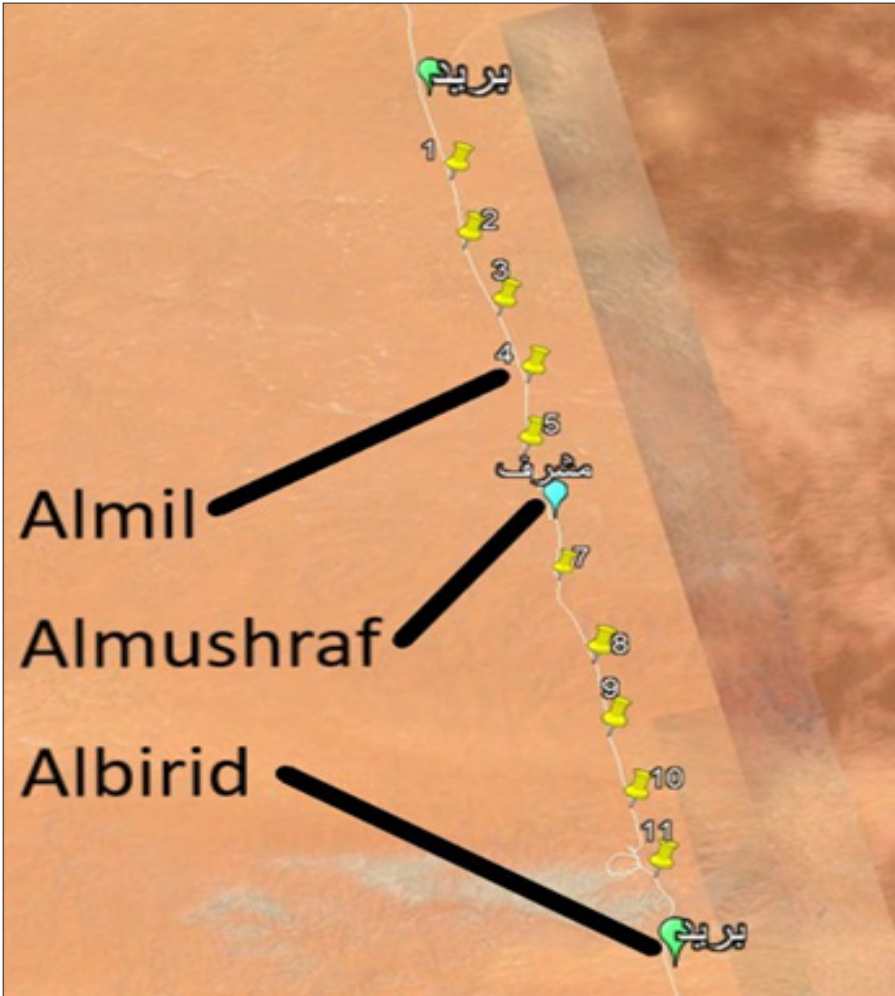


Fig.3.2:Satellite image indicating the units of measurement used on Zubaydah Trail, which are Arabic mile (Almil), Almushraf and Albirid (The Desert Team Trail (1) July 4,2022)



Fig.3.3: A photograph of the stone structure of the mile in Zubaydah Trail (The Desert Team Trail (1) July 4,2022)



Fig :3.4 .Photographs of the construction of the Almushraf in Zubaydah Trail) the one on the left( consisting of an old cylindrical brick building) the one on the right (of Almushraf built in the form of a stone cylindrical structure) The Desert Team Trail 1) July.(2022 ,4)



Fig. 3.5: Photograph of the square stone columnar building of Albirid in Zubaydah Trail (The Desert Team Trail (1) July 4, 2022).

## 2 Investigation from space of selected locations from the Iraqi section of Zubaydah Trail

### Al-Mughitha House) Al-Manzil(

Satellite images revealed the remains of houses and ruins of a large village. Al-Mughitha is one of the historic stations on Zubaydah Trail and was an important stopping point on this route (The Desert Team Trail (1) July 4, 2022). Fig. 3.6 contains a Google Maps image and the station coordinates were determined from the image, which are (31.355556, 44.134722). There was a well between Wadi al-Siba' and al-Mughitha in the middle, called Bir al-Nas. This well is located approximately halfway between Wadi al-Siba' and al-Mughitha. Bir al-Nas is located 12 km, its coordinate (31.427000, 44.167615), from Wadi al-Siba' which located at coordinate (31.537776, 44.229994). After leaving al-Mughitha Station, heading south, and 13 km from it, we reach a beautiful round Zubaydah pond called Birkat Hamad located at coordinate (31.251247, 44.083773), see Fig. 3.7

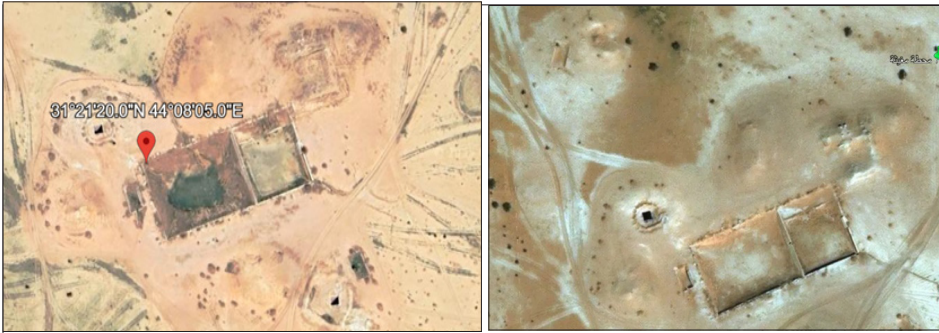


Fig.3.6.A satellite image of Al-Mughitha station) on right side ,( taken from the reference) The Desert Team Trail (1) July (2022 ,4 and compared with a satellite image ) in left side ( taken from Google Maps .The station's coordinates were determined as indicated ,which are.(44.134722 ,31.355556)



Fig. 3.7: A satellite image for Hamad water pool (at right side), taken from the reference and compared with a satellite image (at left side) taken from Google Maps. The pool coordinates were determined as indicated, which are (31.251247, 44.083773)

### Dinner Place ( Muta'asha):Al-Qubaybat:

After walking 24 km from Waqisa towards the south in a flat area, we reach a sub-site, which is Al-Muta'asha, called Al-Qubaibat (The Desert Team Trail (2) July 23, 2022). It seems that the reason for the name is the location of the site between beautiful domed hills, as we see in the satellite image. The site contains two scattered buildings, and we did not see the well, and it is most likely buried. The first palace is between Al-Qubaibat, while the second is about one kilometer away. (Fig.3.8.).

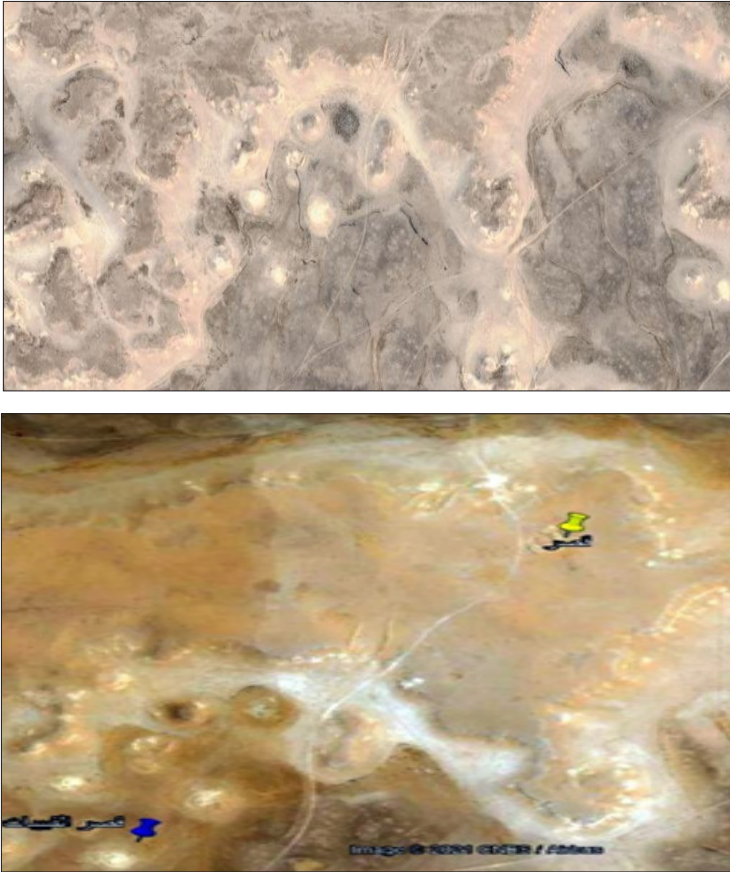


Fig. 3.8.: Satellite image of the Qubaibat site taken from the reference (The Desert Team, Trail (2) July 23, 2022 ) on the left side. The image shows the presence of domed hills. The site also contains two separate buildings: the first is a palace located between Qubaibat, and the second is approximately one kilometer away. The image on the right was taken from Google Maps and the coordinates taken are (30.369102, 43.658916).

### 3. Investigation from space of selected locations from the Saudi Arabia section of Zubaydah Trail

#### Al Amia Pool (Blind Pool) :

After crossing the Iraqi border, we first reach the Dhafiri pond, and its coordinates are (29.988029, 43.614663). Dhafiri pond is located 3 km south of the border and 11 km north of the blind pond. Fig. 3.9 illustrate a satellite image of Dhafiri pond.

After Dhafiri pond, the road heads to the Al Amia pond (see Fig. 3.10). The coordination of this pond is (29.883244, 43.620346) and the land there is stony, barren, gray, with no grass or trees. It is a square pond with a side length of 28.4 m, with cylindrical supports at the corners and semi-cylindrical supports in the walls. The entrance to the pond is south, 85 cm wide, and sloping. The pond has a breakwater that forces the torrent towards the pond.

There are remains of a square building with a side of 17 m, with 5 rooms, one of which is a prayer hall, and some other dilapidated buildings (The Desert Team, Zubaidah Trail January 14, 2010 ). Al Amia Pool is a substation between Al Aqaba station and Al Qaa house. It seems that the accumulation of sand in and around it has prevented it from receiving floods in recent years.

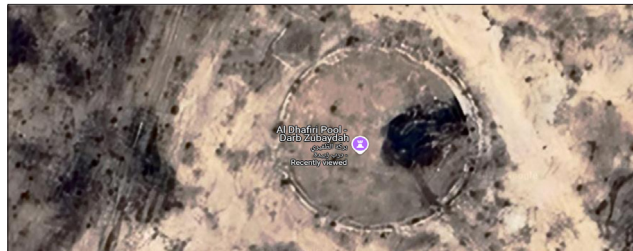


Fig. 3.9: Satellite image Al Dhafiri Pool taken from Google Maps and its coordinates are (29.988099, 43.614633)



Fig.3.10: Satellite image Al Amia Pool taken from Google Maps and its coordinates are (29.883244, 43.620346)

### The Sixth House Al-Qaa :

This station is major and has a large area ,but because its land is sandy, the sand has contributed to obscuring many of its features. Its most important features are two adjacent ponds, one to the north and the other to the south, with a distance of 7 m between them. (See Fig. 3.11) The northern one is 50 by 46 covered with sand, and the southern one is 50 by 51. They have been covered with gypsum from the inside with a wall to divert the water.

The ruins of a village are located about 200 m west of the two ponds on a dirt plateau, and it seems to consist of scattered units. It contains a large construction may be palace of the usual style in Zubaydah Trail, with a side of 60 m. A row of shops (stores) and internal rooms are also existed. In the northern part we find a row of 16 rooms and a castle and Al-Qaa Mosque and some scattered buildings (The Desert Team January 14, 2010).



Fig.3.11: Satellite image of the Al-Qaa station taken from Google Maps and its coordinates are (29.760367, 43.629985)

There is a pond located 15 km south of Al-Qaa station called Al-Haitham Pond (Al-Thalima). (See Fig. 3.12) It is a wonderful pond, and its beauty is increased by its circular shape and its diameter of 32 m. It has two strong walls, the inner one is 160 cm wide and the outer one is 80 cm wide, and the stairs are 6.5 m wide. This pond is distinguished by the beauty of its engineering and the way the water reaches it. There is a beautiful drain with a precise entrance and an exit in the form of a tunnel.

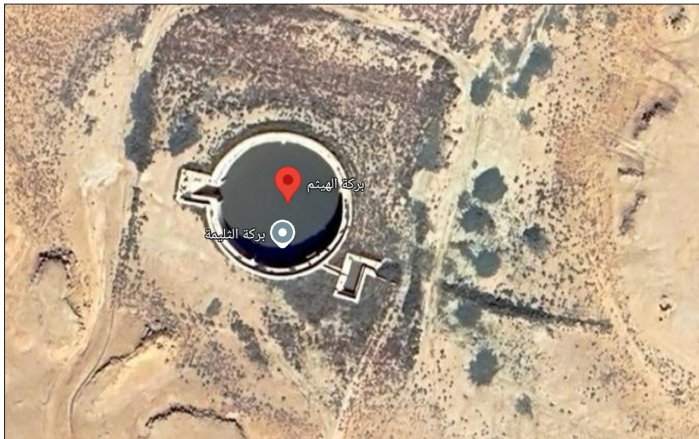


Fig. 3.12: Satellite image of Al-Haitham Lake (Al- Thalima ), taken from Google Maps. Its coordinates are (29.624914, 43.612772)

Using remote sensing techniques, it is possible to identify and record the archaeological landmarks and heritage sites of Zubaydah Trail, thus enabling high-resolution mapping using geographic information systems (GIS). One such work, which relied on these techniques, produced the result shown in Fig. 3.13 for the route of Zubaydah Trail in its Iraqi section, from Kufa to the Iraqi-Saudi border (Anthea Crane, 2023). The areas identified on this map were identified using satellite images from Google Earth, then compared with Bing aerial photographs and information available from earlier sources, such as the archaeological survey conducted by Al-Rashed (1977) and others (Anthea Crane, 2023) (Al-Rashid, S. A. 1977), which allows for comparison of site descriptions with more recent satellite images. Furthermore, distance measurements, descriptions and labels of wells and reservoirs, and photographs taken of site views facilitate the production of new maps.



Fig. 3.13: shows the path of Zubaydah Trail in the Iraqi section and the stations of this trail on Google Earth image (Anthea Crane 2023).

The map that published the Hajj and Umrah Atlas also gave a description of the stations and locations of the route. The map shows Zubaydah Trail, which extends from Kufa in Iraq to Mecca, passing through northern and central Saudi Arabia and passing through five regions: the northern Borders, Hail, Qassim, Medina, and Mecca. (Fig. 3.14)

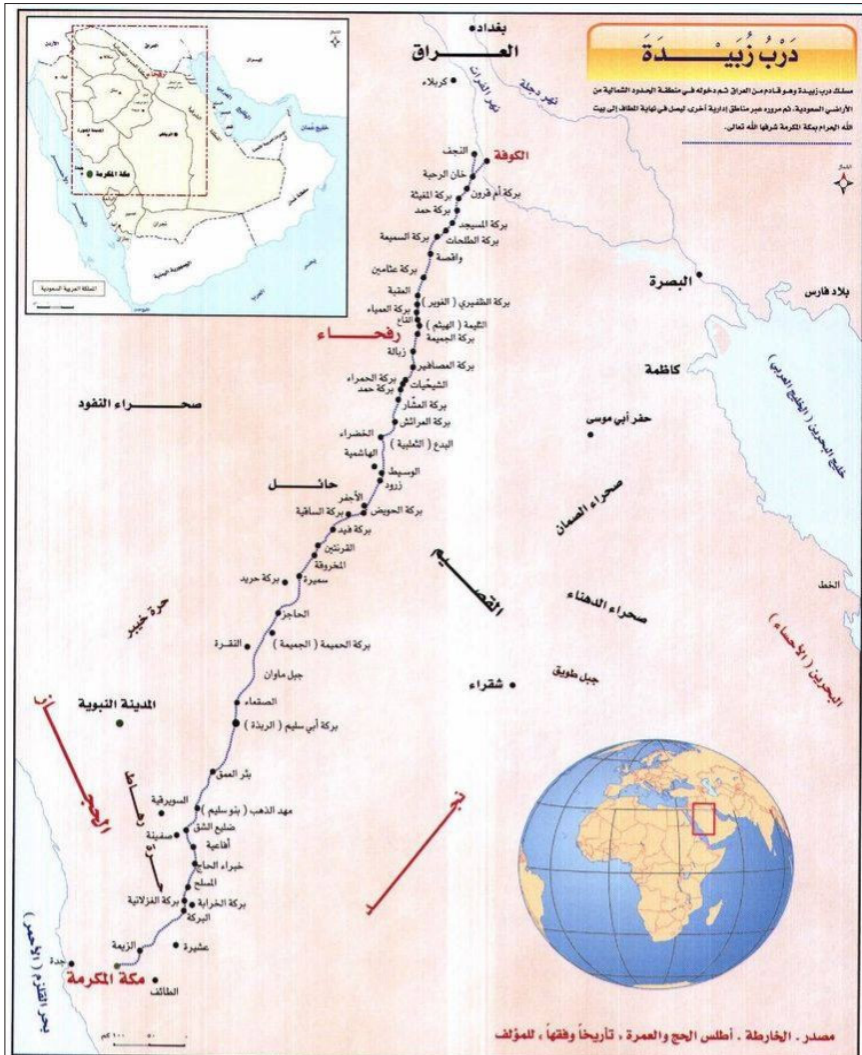


Fig. 3.14: Map of the Hajj Zubaydah Trail, showing the various service stations from Kufa to Mecca. (From the Atlas of Hajj and Umrah, by Sami ibn Abdullah al-Maghluth) (Fareeq E. W. 2021) (Sami ibn Abdullah al-Maghlouth 2010)

A geographical map of Zubaydah Trail quarter in Saudi Arabia was also produced. This map is very important because of the precise locations and details it contains. It was prepared by the United States Geological Survey and the Arabian American Oil Company under the joint sponsorship of the Government of the Kingdom of Saudi Arabia and the United States Department of State ( U.S. Geological Survey 1960).

### **The movement of Imam Hussein caravan and its route from Mecca to Karbala**

Historical references indicate that the blessed journey of Imam Hussein’s (peace be upon him) procession took 24 days, starting from Mecca and arriving in Karbala. It traveled in the Hijaz for 16 days and in Iraq for 8 days. The procession departed on the eighth of Dhu al-Hijjah in the year 60 AH and continued until the second of Muharram in the year 61 AH. The total number of houses that Imam Hussein (peace be upon him) passed during this period—from his departure from Mecca until his arrival in the holy land of Karbala (al-Taf)—was thirty-eight, including the first house (Mecca) and the last (al-Taf). He (peace be upon him) spent the night in twenty-four of these houses. The distance covered by this blessed procession was approximately 1,403 kilometers (Sheikh Saleh Al , Karbasi 2004).

Although Imam Hussein’s journey from Mecca to Iraq is considered a significant historical event, we note the presence of more than one sequence of stations and stops documented along this journey. This was due to several historical and geographical reasons (The Holy Shrine of Imam Hussein 08/04/2017 ). One of these reasons is the discrepancy in historical accounts in ancient references, which describe from similar, if not completely identical, routes. This is due to each historian’s reliance on oral accounts from different eyewitnesses and the varying details in describing stations.

The names of some sites have changed over time, or been known by multiple names. Some ancient villages have disappeared, or the routes have been altered. Due to the circumstances of the journey at that time required the Imam to choose villages and sites with large settlements and abundant water. Also to avoid enemies, the Imam deviated from his route several times, taking alternate routes through the desert and stopping at unfamiliar stations. Differences in the geographic location of some sites are described, and water pools and springs are mentioned in the narratives

Here, we will cite the sequence of points in various sources for accuracy and to make them available to researchers for scientific investigation and verification. The following lists the names of the houses that Imam Hussein (peace be upon him) passed on his way to Karbala (Labib Baydoun 1987), and the geographical coordinates of the houses where he stopped or spent the night. We also mention the distance between each of these houses, which are:

The route of the Imam's caravan's movement from Mecca to Karbala was determined in the Encyclopedia of Imam Hussein, peace be upon him, in the Book, Sunnah and History, Part 3 (Mahmoud Tabatabai 1969 ), as the stations that this caravan passed through are according to the following sequence: ( مكة (Mecca), Al-Tan'eem (التنعيم), Al-Safah (صفاح), Bustan Ibn Amir (بستان ابن عامر), Dhat 'Iraq (ذات عرق), Ghamrah (الغمره), Al-Maslah (المسلاح), Al-Ufay'iyah (الافيعية), Ma'din Bani Sulaym (معدن بني سليم), Al-Umq (العمق), Al-Sililiyah (السليلة), Al-Rabadhah (الربذة), Mughithat al-Mawan (مغيثة), Al-Naqrah (النقرة), Al-Hajir (الحاجر), Samira (سميراء), Twz (توز),

Fayd (فيد), Al-Ajfur (الاجفر), Al-Khuzaymiyah (الخرزيمية) , Zarud (زرود), Al-Thaḡlabiyyah (الثعلبية), Al-Batḡan (البطان), Al-Shaḡuq (شقوق), Zubalah (زباله), Al-Qaḡ (القاع), Al-ḡAqabah (العقبة), Waqisah (واقصة), Sharaf (شراف), Dhu Husum (ذو حسم), Al-Baydah (البيضة), ḡUdhayb al- Hijanat (عذيب الهجانات), Al-Ruhaymah (الرهيمة), Qasr Bani Muqatil (قصر بني مقاتل), Al-Taff (الطف) then Karbala (كربلاء)

The investigative study conducted by the eminent scholar Sheikh Muhammad Sadiq al-Karbasi was informative, and his concluding opinion on the stations of Imam Hussein's path was explained in his book (History of the Shrines of Hussein, His Family, and His Supporters (Part 5)). (Sheikh Muhammad Sadiq Al-Karbasi 2018 ). He gave the names and distances between the stations and stations according to the sequence of the journey from Mecca to Karbala. Table 2 (Appendix 2) shows the sequence of stations that the caravan of Imam Al-Hussein passed through. A map of Imam Hussein's journey from Mecca to Karbala is also provided, with a scale of 1 mm  $\approx$  11 km (Fig. 4.1). This helps those interested in understanding the subject and helps in determining locations using modern optical instruments.

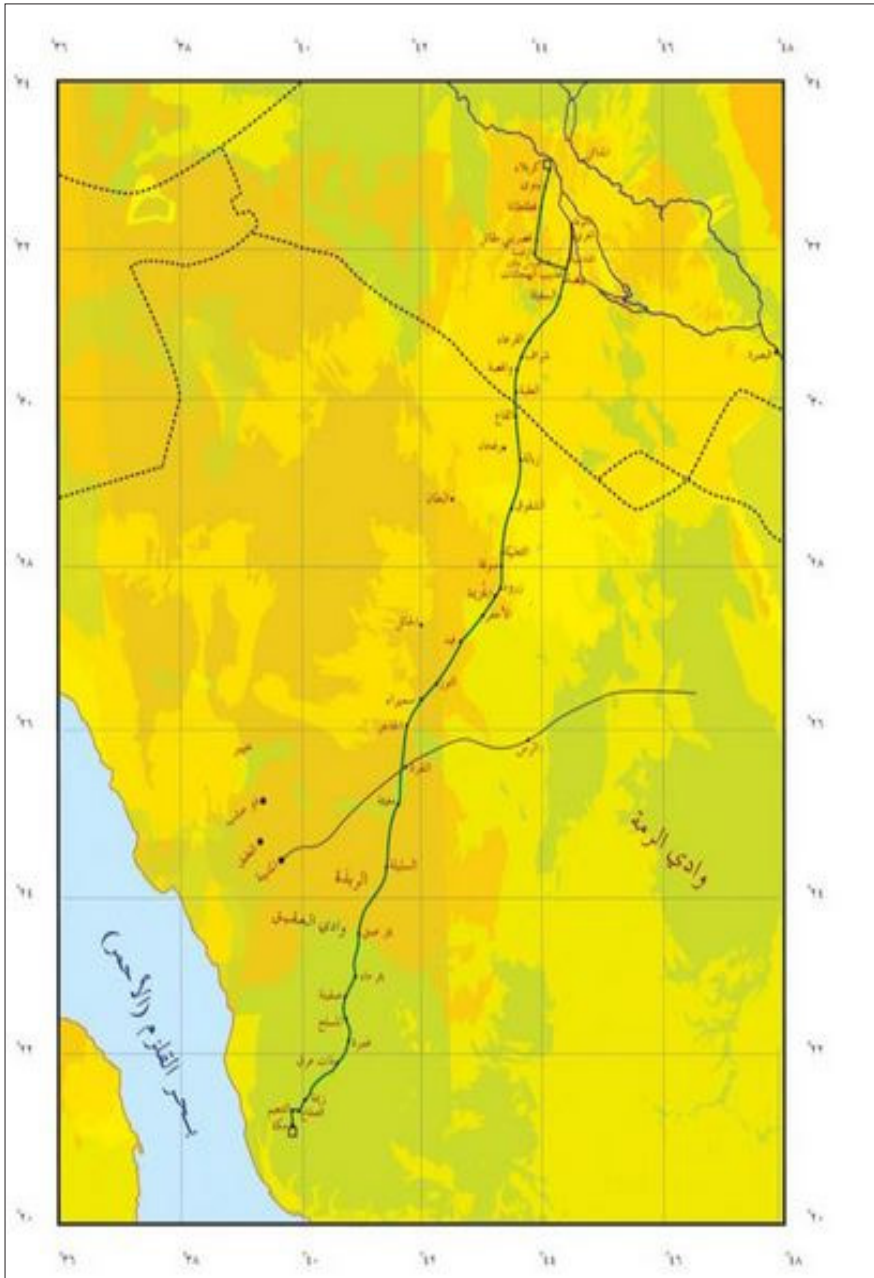


Fig. 4.1: shows a map mentioned by the researcher Sheikh Al-Karbasi about the journey of Imam Al-Hussein from Mecca to Karbala, showing the route, the stations that the Imam passed or stayed. It is on a drawing scale of 1 mm  $\approx$  11 km. (Sheikh Muhammad Sadiq Al-Karbasi 2018).

The officials of the Holy Shrine of Imam Hussein also paid attention to the route taken by the Imam, and the sequence of the houses and stations that Imam Hussein passed through was published (Sabah Al-Talqani and Maitham Al-Husseini 2022), and Fig. 4.2 shows the names and sequence of the stations. The Karbala Center also produced a map of this route that included a table of all the stations and areas that Imam Hussein passed through and the distances between those stations c, as in Fig. 4.3. This detailed map of Imam Hussein's (peace be upon him) journey from Mecca to Karbala, prepared by the Karbala Center for Studies and Research. This map represents a recent and important scientific effort to document Imam Hussein's (peace be upon him) journey geographically and historically. Geographic Information Systems (GIS) and remote sensing were used to determine the route. The map shows the stations through which Imam Hussein (peace be upon him) passed from Mecca to Karbala. This map helps researchers understand the geographical challenges faced by the caravan and serves as a primary reference for historical and archaeological studies. There are also other references that provide ancient and modern maps of this sacred path, including what is mentioned in the seventeenth chapter of the first part of the Karbala Encyclopedia (Labib Baydoun 1987).



Fig. 4.2: An illustrative Arabic panel showing the homes of Imam Hussein from Mecca to Karbala in a sequential manner, supported by the date of his arrival and departure for each home (Sabah Al-Talqani and Maitham Al-Husseini, 2022).



## Framework for using space tools for deep study on this historical road

Radar imaging has revolutionized archaeological surveys by offering a non-invasive window into the subsurface. Techniques such as ground-penetrating radar (GPR), synthetic aperture radar (SAR), and others allow researchers to detect hidden features like foundations, ditches, and former river channels without disrupting the fragile underground structures. By integrating methods like infrared aerial photography—exemplified in regions of Japan—archaeologists can visualize features as deep as 5 meters, ensuring careful planning and preservation before any excavation takes place.

Beyond mere detection, radar imaging characterizes the physical properties of the subsurface. Different materials reflect radar waves uniquely, enabling the identification of man-made structures through contrasts in dielectric properties, moisture retention levels, or carbonaceous deposits. Airborne and spaceborne SAR techniques have proven effective in mapping large areas, including arid regions like the Gobi Desert, where subtle topographical details are critical. This ability to survey extensive tracts of land quickly and precisely has dramatically reduced the time and costs associated with traditional field surveys, while also supporting advanced spatial modeling and GIS integration (Yoshito Miyatsuiq and Yasuhiro Takahashi 1996) ( Douglas C. Comer & Ronald G. Blom 2002 ).

Practical applications of these radar techniques are evident in diverse archaeological contexts. For instance, GPR surveys at the Aquileia Archaeological Park in Italy have mapped Roman construction beneath silty loam layers, while urban excavations in Lecce have distinguished between modern debris and historical deposits. Similarly, at sites like the State Museum-Reserve “Tsaritsino,” areal GPR surveys have revealed structural

details such as gazebos and pathways, guiding excavation teams efficiently. Ongoing advancements, including the integration of machine learning and additional remote-sensing tools like LiDAR, are further enhancing the depth and accuracy of archaeological investigations, ensuring that our understanding of past cultures continues to expand while preserving the integrity of the archaeological record (Derrold W. Holcomb 2001).

Thermal imagery offers a non-invasive means of detecting subtle temperature variations on and just below the surface, enabling archaeologists to uncover buried features without disturbing the site. Infrared cameras capture these thermal differences, revealing anomalies where construction materials or soils retain heat differently from their surroundings. For instance, a buried stone wall may create a distinct thermal signature compared to the adjacent sediment, especially during early mornings or late afternoons when temperature contrasts are greatest.

In archaeological prospecting, these temperature variations help pinpoint the locations of hidden structures such as foundations, roads, or ditches—insights often obscured by vegetation or undetectable by traditional visible-spectrum imaging. Advanced aerial thermography conducted by drones or UAVs can rapidly cover large and challenging areas, guiding archaeologists to promising excavation sites. Moreover, integrating thermal imagery with other data sources like multispectral imaging or LiDAR further refines site models, enabling researchers to distinguish material types, assess moisture patterns, and interpret the overall functional layout while remaining non-destructive (Ahmed Faize , Gamil Alsharahi and Mohammed Hamdaoui 2020).

Several successful thermal imaging projects underscore its value in archaeological research. For example, aerial thermography studies conducted across North America, the Mediterranean, and the Near East have effective-

ly used drone-mounted thermal cameras to reveal subtle ground anomalies that guide excavation efforts. In the realm of historic building investigation, thermal imaging has detected hidden construction modifications and sub-surface features, preserving the integrity of these structures while revealing their history. Additionally, the case study of the abandoned medieval town of Montecorvino in Italy demonstrated how UAV-based thermal surveys could map buried walls and pathways, providing critical data for efficient, targeted excavation strategies. These examples, along with emerging integrations involving modern data analytics and machine learning, highlight thermal imagery's transformative role in advancing archaeological diagnostics and landscape interpretation.

Satellite imagery has become a transformative tool in archaeology, offering a non-invasive approach to detect and monitor subtle features that remain hidden to ground-level observers. By capturing high-resolution images and employing advanced analytical techniques, researchers can remotely identify archaeological sites and monitor evolving landscapes over time. This technology not only aids in the discovery of buried structures but also addresses challenges posed by modern land-use activities, helping to preserve cultural heritage.

In North Africa, for example, a study published in 'Remote Sensing' used free Sentinel-2 imagery combined with Google Earth Engine to implement per-pixel change detection. The research focused on sites in regions such as the Aswan and Kom-Ombo areas in Egypt and the Jufra oases in Libya, achieving accuracy rates between 85% and 91% in identifying changes caused by construction, agriculture, and natural processes. Similarly, in the South Caucasus, free and low-cost aerial remote sensing techniques have proven valuable in countries like Armenia, Azerbaijan, and Georgia, enabling the identification and management of archaeological

resources while tracking historical land-use changes in areas where traditional field surveys are often limited by budget constraints (Ahmed Faize , Gamil Alsharahi and Mohammed Hamdaoui 2020).

Globally, satellite imagery is being harnessed to reveal a myriad of archaeological features and landscapes. Organizations like Satellite Imaging Corp. have demonstrated its effectiveness in detecting buried structures, creating digital elevation models to map ancient terrains, and monitoring cultural heritage sites—for instance, at Mount Ararat in Turkey. Together, these examples underscore the cost-effective, non-invasive power of satellite imagery, which not only enhances archaeological site detection but also supports long-term preservation strategies and provides deeper insights into the interplay between past human activities and the environment.

### Conclusions

The importance of integrating technology with heritage lies in the possibility of rediscovering ancient trails using modern tools and promoting heritage tourism. We see the need to design and build a specialized scientific database that links historical writings to archaeological sites, which will benefit historians, archaeologists, and researchers.

Nowadays, satellite surveys of houses, stations, and archaeological sites, as well as space tools (such as remote sensing, aerial photography, and geographic information systems), are crucial tools for reviving this heritage, contributing to the discovery of its lost features, and documenting its cultural value.

Accurate and detailed knowledge of the stations and areas of the route is useful in developing the necessary designs to revive and invest in the historical route, by developing realistic plans to invest in this historical

road. There is immense need to expand cooperation between universities, research centers, and heritage bodies in this field, both inside and outside Iraq, to undertake useful projects.

It is necessary to plan for the creation of a virtual museum that includes the main and secondary stations and landmarks of the route. At the same time, emphasis is placed on creating computer models of all buildings, ponds, and springs that mimic the original construction.

Tracing clear sections of the trail's path and accurately capturing the coordinates of these sections to create an accurate route for the main and secondary roads using geographic information systems and similar tools is highly felt.

Multispectral analysis is required, as it allows for distinguishing between different surface material, such as soil, stones, and water, thus facilitating the identification of ponds or ancient structures. Emphasis on drawing and producing interactive maps of the trail contributes to the creation of tourist itineraries. It encourages media professionals to prepare informative and cultural articles that inform decision-making and encourage decision-makers to pay attention to such heritage and cultural projects.

Given the extension of this historic road between Iraq and Saudi Arabia, it is necessary to cooperate between the two countries to establish a joint research center and conduct in-depth studies. It is also necessary to create a unified database between the Saudi and Iraqi sides for high-resolution satellite and aerial images and 3D digital maps, which are available to interested parties, graduate students, and researchers.

It is necessary to have an information database classified according to the writings of historians to facilitate the work of future researchers.

High-resolution satellite images are used to monitor the remains of the road extending across the desert, revealing patterns that may be hidden from the naked eye.

Recent space studies have revealed dozens of sites that were part of Zubaydah Trail, such as the remains of large pools and rest stops partially submerged in sand.

The importance of this approach lies in its blending of technology and heritage, enabling the rediscovery of ancient routes using modern tools. It also helps document landmarks before they disappear, contributes to promoting heritage tourism, and creates a scientific database for historians and archaeologists. Space tools have become a cornerstone for reviving Zubaydah Trail, not only as a pilgrimage route, but also as a model of an advanced civilization in urban planning and human exchange.

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## Appendix 1

Table 1: Stations (houses) and night rest areas (dinners) for Zubaydah Trail

House No. رقم المنزل	The House and coordinates المنزل و إحداثياته	Diner place and coordinates المتعشى وإحداثياته		
	The House	Coordinates	Diner place	Coordinates
1.	Kufa الكوفة	32.030000, 44.400000		
2.	Al-Qadisiyah القادسية Khan Al Rahbah خان الرحبة	31.785857, 44.367366 31.731091, 44.313900	Wadi Alsub- ae ( Alsubae Valley) وادي السباع - ام القرون	31.537776, 44.229994
3.	Al-Mughitha المغيثة	31.355557, 44.134720	Masjid Saed (Saad Mosque) مسجد سعد	31.100557, 43.707843
4.	Al-Qura'a القرعاء	30.935278, 43.906390 Birkat at Talhat بركة الطلحات	Al-Taraf الطرف	30.950248, 43.600156
5.	Waqisa واقصة	30.589142, 43.781561	Al-Qubaybat (The small Domes) القبليات	30.369102, 43.658916
6.	Aqaba العقبة	30.140368, 43.620187 Al `Aqabah	Barakat Aleamya' (Aleamya' Pond) بركة العمياء	29.883342, 43.623801 Birkat al' Amya' 29.883500, 43.620282

7.	Al- Alqae القاع	9.760405, 43.630017 Bottom Station- 29.761737, 43.630693 بركة القصري وبركة مجاورة 29.761183, 43.630486 بركة السهابية	Al-Juraisi الجريسي	29.605532, 43.603611
8.	Zubalah زُبالة	29.397341, 43.563984 بركة زبالا Zibala bond 29.263804, 43.535397 ”بركة الفيصوم” الرضم	Al-Tananir التنانير	بركة الجميماء،
9.	Al-Shuqooq (Al-Shihiyat) (الشقوق) (الشيحيات)	29.094397, 43.473515 بركة الشيحيات	Al- Alqae القاع	28.933985, 43.383454 بركة الشيحة 28.927812, 43.380656 بريد طريق زبيدة التاريخي او علم طريق
10.	Bitan (Aleashar) بطان (العشار)	28.460446, 43.315562 أبار زبيدة، برك زبيدة 28.512814, 43.353555 منطقة آثار - درب زبيدة 28.462643, 43.316357 Baqaa, Saudi Arabia 28.465550, 43.311956 Birak al `Ara`ish,	Altanahi التناهي	

11.	Althaelabia (albidae) التعلبية (البدع)	28.223644, 43.239642 (محطة التعلبية (البدع), 28.223665, 43.239647 (محطة التعلبية (البدع), 28.273483, 43.240214 ،بئر التعلبية - درب زبيدة		
12.	Alkhazimat and zarud الخرزيمة و زرود	27.827586, 43.198960 زرود، 27.827527، 43.199079 بئر زرود (الخرزيمية) وفيها 27.827529, 43.199059 - ( بئر زرود ) الخرزيمية 27.831937, 43.190837 زرود Bi'r al	Barakat khalisa بركة خالصة	
13.	Al'ajfar الأجفر	27.152875, 42.465289 ،الساقية، 27.502772 43.001035 ،بركة زبيدة بالأجفر 27.487421, 42.993525 - بركة الأجفر الجنوبية 27.531434, 43.028327 رصيف خالصة - درب زبيدة، الأجفر	Alsaaiyat , Alqarayin الساقية ، القرانن	
14.	Fid فيد	27.101913,42.523770 بركة فيد - درب زبيدة 27.020513, 42.500253 جبل أم هروج	Abar am huruj , birak alghari- bat ابار ام هروج ، برك الغريبات	

15.	Tawz توز وهي نصف الطريق	26.600917, 42.184032 بركة الجفالية / الحمة / - فرفرة 26.597832, 42.185589 ”جبل الحمة” الفحيمة	Barakat Aleanaabat - arinbat, barakat alhimat – alja- falia بركة العنابة - ارينبات، بركة الحمة - الجفالية	29.761183, 43.630486
16.	Samira سميراء	26.650827, 42.234118 المذيريات	Al- Alqae	بركة السهبانية
17.	Alhajir الحاجر	26.012593, 41.835998 Al-Sulaimi, Saudi Arabia بركة البعايث / الحاجر	Qiruri, alhima قروري، الحمة منه بتفرع الى فرعين	القاع
18.	Maedin Alqurashi ( Now Aalnaqrat) الفرع الأول : معدن القرشي وهي النقرة الآن		.	
19.	Alnaqrat (Now Aljafniat) منزل الفرع الثاني: النقرة قديما وهي الجفنية الان		The two branches meet at the diner’s location	
20.	Mughithat Al- mawan (Alsaqa- ea’) مغيثة الماوان وهي الصقعاء محطة مغيثة الماوان	25.024591, 41.428366	‘Arimat - Snam أريمة سنام	23.650061, 44.750678 سنام

21.	Alrabidha ( It is 2/3 the road ) الربذة	24.631839, 41.292359 - بركة الربذة الجنوبية	Alruwtha (Al- kanas( الروثة (الكناس)	24.517635, 41.239546 حجر الكناس
22.	Alsalila السليلة بركة السليلة ،التاريخية	24.241411, 41.088804	Daba ضبة	24.050315, 41.037810 بركة الضبة
23.	Aleumq العمق	23.943822, 40.978740 ببر ، العمق 23.943351, 40.974840 ،ببر الربعانية 23.846859, 40.960349 ،مقبل زبيدة - درب زبيدة	Sharuraa شرورى	23.846957, 40.960249 Zubaydah Trail, Omaq 23.852629, 40.912163 Al Mahd, Saudi Arabia جبل صايد
24.	Almaedin المعدن	23.858710, 40.964209	Karac كراع	23.803097, 40.958053
25.		Alkabwana الكبوانة	22.825471, 40.825236 المويه 22.834371, 40.787643 المهد 22.801736, 40.797771 المهد	
26.	Almusalah المسلح خيراء الحاج	22.682792, 40.784790	Alqasr القصر بركة العموسى	22.673071, 40.784360

27.	Alghamra الغمره بركة الغمير	21.830152, 40.354527	Awtas بركة أوطاس	22.056539, 40.615327
28.	Dhat Earq Water Well (Built by Zubai- yda binte Jaffer ذات عرق	21.929324, 40.425690	Ghamar Dhi Kanda غمر ذي كنده	21.830180, 40.354541
29.	Albustan البستان		Mashash مشاش	20.313481, 40.981397
30	مكة المكرمة			

## 2 Appendix

**Table 2 :The sequence of stations that the caravan of Imam Al-Hussein passed through, according to what was achieved by Al-Karbasi [24], and the goals were extracted by the authors from Google Maps.**

S	Stations in sequence [5]	Station and coordinates from googl map	Station and what follows	distance (km)
1	مكة	Mecca 21.426022, 39.826264	.	
2	التنعيم	At-Tan'im 21.467843, 39.796459	Mecca - At-Taneem	8
3	الصفاح	As-Saffah 21.470160, 40.039296 Located between Hunayn 21.472506, 40.052063 And Mon- uments of the Sacred of Mecca 21.484424, 39.941328	At-Taneem - As-Saffah	9
4	زيمه	Zima	As-Saffah – Zimah	36

5	ذات عرق	Dhat Irq 21.929352, 40.425680	Zima - That Irq	41
6	غمرة	Ghamra 22.186395, 40.727262	That Irq – Ghamrah	36
7	المسلح	Al-Musallah 22.490208, 40.750269	Ghamrah - Al-Musallam	24
8	بئر ماء	Water Well 21.467042, 40.110964	Al-Musallam - Water Well	78
9	سليلا	Suleila 24.243668, 41.089224 Nearby are wells 24.241411, 41.088804	Water Well – Sulaylah	120
10	المغيثة	Al-Mughitha 25.024591, 41.428366	Sulaylah - Al-Mughithah	144
11	النقرة	Al-Naqra 25.591297, 41.446535	Al-Mughitha - An-Naqrah	30
12	الحاجر	Al-Hajr 25.964575, 41.921068	An-Naqrah - Al-Hajr	60
13	سميراء	Samira 26.456489, 42.096905	Al-Hajr – Samira	54
14	التوز	Al-Tawz 26.600874, 42.184112	Samira - At-Tawz	30
15	الفيد	Al-Fayd 27.120519, 42.521674	At-Tawz - Al-Fayd	66
16	الاجفر	Al-Ajfar 27.502304, 43.000814 الاجفر الجنوبية (27.482984, 42.997233)	Al-Fayd - Al-Ajfar	42
17	الخرزيمية	Al- Khuzaymiyah 27.831901, 43.190965	Al-Ajfar - Al-Khazimah	36
18	الزورد	Al-Zarud 27.827506, 43.199024	Al-Khazimah - Al-Zurud	18
19	سوقة	Souqah	Al-Zurud – Suqah	18

20	التعلبية	Al-Tha'labiyah 28.273378, 43.240336	Suqah - Al-Tha'labiyyah	30
21	الشقوق	Al-Shuqooq	Al-Tha'labiyyah - Al-Shuqooq	66
22	زباله	Zubalah 29.395870, 43.565750	Al-Shuqooq – Zubalah	66
23	القاع	Al-Qaa	Zabala - Al-Qa'a	42
24	بطن العقبة	Batn Al-'Aqaba 30.140862, 43.622406	Al-Qa'a - Batn Al-'Aqaba	48
25	واقصة	Waqisa 30.580807, 43.766707 or 30.588751, 43.781079	Batan Al-'Aqaba – Waqisas	42
26	شراف	Sharraf 30.620774, 43.751408	Waqisas – Sharaf	18
27	القرعاء	Al-Qar'aa 30.935294, 43.906414	Sharraf - Al-Qura'a	18
28	المغينة	Al-Mughitha 31.356179, 44.135918	Al-Qura'a - Al-Mughitha	66
29	ببضة	Baydah (نو حُسم) 43.716623, 30.786551	Al-Mughitha – Bayda	18
30	عذيب الهجانات	Udheeb Al-Hijanat 31.613455, 44.376484	Bayda - Udhaib Al-Hi- janat	24
31	الرُهَيْمَة	Al-Ruhaymah 32.234826, 44.098656	Udhaib Al-Hijanat - Al-Ruhaymah	30
32	قَصْرُ بَنِي مُقَاتِلَ	Qasr Bani Muqatil 32.355994, 44.011881	Al-Ruhaymah - Qasr Bani Muqatil	18
33	الْفُطْقَاتَانَه	Al-Qatqatanah 32.030901, 43.925578	Qasr Bani Muqatil - Al-Qatqatanah	42
34	نينوى	Nineveh 32.616376, 44.0326	Al-Qatqatanah – Nineveh	24
35	الطف	Al-Taf 32.616376, 44.032617	Nineveh - Al-Taf	1