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Research Article

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Posted Date: May 2nd, 2026

DOI: https://doi.org/10.21203/rs.3.rs-9203955/v1

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The Collisional Origin of Umm Chaimin Depression in Western Iraq: A Synthesis of Geological and Geomorphological Evidence

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Abstract

Umm Chaimin region is located in southwestern Iraq and is characterized by a semi-circular geological depression about 95 km southwest of the city of Rutba. This study aims to investigate the geological features and geomorphological characteristics of the depression to understand its geological history and the impact of natural processes on it. The study examines the surface geological formations through geological maps and field observations. The methodology includes examining thin sections of rocks using optical and electron microscopy to assess their mineral composition. A geomorphological analysis of the crater is conducted using contour and slope maps to determine the topography and geometric dimensions. A drainage pattern map was used to represent the distribution of the water flow in the study area. The geological survey shows that the geological formations in the study area belongs to the Eocene and the Quaternary sediments, proves the impact of modern natural processes such as runoff. The depth of the crater's depression which is up to 30 meters and its semi-circular shape reinforces the hypothesis that the crater is formed by a relatively recent meteorite impact. The sample rocks taken from the depression also supports the hypnosis because they predominantly contain quartz, with Prehnite. This is an indication of a low thermal metamorphism caused by a meteorite impact. The sediment deposition within the crater indicates the influence of climatic phenomena such as rainfall and runoff in on the region's post-impact development. Water drainage patterns reveal radial drainage surrounding and within the crater's center, therefore reflecting the effect of the impact-induced topography on water routing. The results show that the meteorite impact was of moderate strength, resulting in crater formation without causing substantial thermal and pressure alterations in the region. Finally, Umm Chaimin crater is the largest in the Middle East, and the research emphasizes the importance of the region as a geological landmark that deserves further investigation, conservation and attention.

Keywords: Umm Chaimin , Meteorite impact , geological formations , drainage patterns.

Introduction

Meteorites are an extraordinary cosmic phenomenon that significantly molded the history and geological evolution of Earth. This rocky mesteloidal body from the outer space falls at an incredible speed towards Earth under the influence of gravitational forces and reaches with direct contact to the surface of the planet, forming distinct geological lesions (Bass et al., 2006). Although rare, their impact can be both catastrophic and spectacular, directly shaping the Earth's surface and sometimes leading to massive environmental and climatic changes (Jones, 2010).

Impact craters are valuable records of meteorite fall on the Earth, creating big scars on its surface. The most obvious is the Chicxulub Crater in Mexico believed to have caused a mass extinction of dinosaurs about 65 million years ago (Alvarez et al., 1980).

This phenomenon would not be understood without the use of cutting-edge techniques such as satellite imagery, geochemical analysis, radiometric dating and modeling that simulates

across a variety of scales how the collision affected Angel de la Guarda. Such tools have allowed scientists to unlock the violent physical and geological conditions of these impacts, how they moulded the global crust of our planet and affected life on Earth and its climate (March et al., 2019).

With its importance in geological features of the area an increasing interest was claimed in studies on impact craters of the Middle East region. In addition, the dry climate has helped protect these craters for millennia.

Named as one of the most important meteorite craters in the Middle East, Wabar Crater is immediately sealed to expats. Located deep in the Rub' al-Khali desert of Saudi Arabia, the crater field contains 3 to 5 separate craters, which span from 11 meters wide up to an expansive 116m. These craters are thought to have resulted from the same IIIAB iron meteorite, now called the Wabar meteorite, on account of fragments that survived both impact and subsequent weathering. The blanket sand that was mainly derived from quartz-rich dune sand (minor feldspar, calcite , accessory phyllosilicates) and the target lithology (Hörz et al., 1989; Hamann et al., 2013; Gnos et al., 2013).

Some sites in Iran that display these patterns suggest hallmarks of meteorite impact. Sahand and Dasht-e-Kavir are among the most important of these sites. These studies involved analysing rocks that have been affected by the pressure and heat generated by the impact, as well as measuring levels of trace elements such as nickel and iridium, both are proxies for meteoric activity (Rasoulian, 2015)

Some preliminary exploration in Jordan has shown the circular forms of what could be ancient meteorite craters out in the Jordanian Desert. Finally, these studies used aerial photographs and satellite data to identify these ancient circular marks suggesting that further field investigations and geophysical investigations are needed for validation of their source (Al-Zawahra, 2018).

In the Middle East, satellite imagery and effort of inference from spectroscopy have helped discover sites as remains of the impact structures. One of these sites is the Umm Chaimin crater, forming an elliptical depression in the Western Anbar Desert in Iraq. The region has harsh desert climatic conditions and distinctive geological structure, which is why it must have been an object of study as well.

Previous research has tried to elucidate its genesis and nature, assessing whether it might have formed from a meteorite impact or tectonic or volcanic processes. To obtain both quantitative and relatively accurate scientific results, researchers have primarily analyzed surface as well as geomorphological features utilizing data from amongst the geological, geophysical, remote sensing, and geographic information systems (GIS). Hence the origin of Umm Chaimin depression in a debatable issue as to whether it initiated during this orogeny. Researchers like Marriam and Holwerda (1957) suggested that the depression resulted from a meteorite impact, while other studies, such as Mitchell (1958), Al-Naqib (1967), and Aldin, et.al. (1970), suggested that the depression might be of volcanic origin or the result of erosional processes rather than volcanic activity. On the other hand, Hagopian (1979), Jassim (1980) and Al-Hashimi (1982) suggested that the depression resulted from a gas explosion. In a recent study, Sissakian and Abdul-Jabbar (2008) suggested that Umm Chaimin depression originates from karstic melting processes. The researchers examined 18 variables in comparing the current depression characteristics to the four natural depression types, and results showed that most of the variables were well representative except karst-origin depressions. Several years later, another study dubbed as Umm Chaimin depression is an elliptical geomorphological feature about 5.73 km² located in the Iraqi Western Desert south-west of Rutba town with depth ranges between 28–38 meters. The area surrounding the depression is relatively flat, with an elevation ranging from 850 to 860 meters above sea level, making it invisible from long distances

(Sissakian et al., 2020). Previous studies made it clear that impact craters, both in Iraq and the Middle East, are an intriguing topic that deserves further study and analysis.

This study aims to investigate both the geomorphology and mineralogy of this phenomenon (Umm Chaimin) and also considering new data related to impact craters, in order to obtain a complete/clear description of one aspect on the surface features located at western part of Iraq.

Location of the Research Area

The research area is located in the far west of Iraq, precisely southwest of the city of Rutba within the Western Anbar Plateau Desert. The area extends between 39°24'26’ longitude - 39°26'6’ E and latitude 32°34'26’ - 32°35'53’ N. The research area is 92.246 kilometers southwest of Rutba. To the north, it is bordered by the international highway leading to the Trebil border crossing, and to the west and southwest by the Hashemite Kingdom of Jordan and the Kingdom of Saudi Arabia. To the east and north-east, it is bordered by the city of Rutba (Mushref, Z.J, 2022). (Fig. 1).

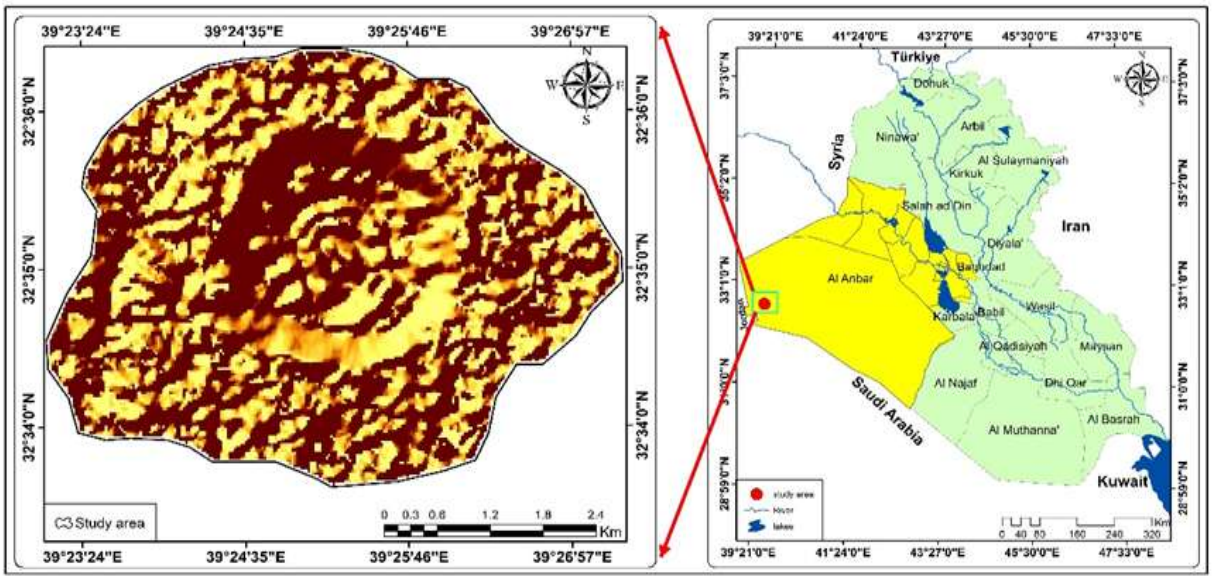


Fig.1 The location of the study area. Source: The Republic of Iraq, Ministry of Water Resources, Directorate of Public Survey, Map of Iraq and Administrative Anbar, Rutba, 2023, scale (1000000:1)

Research Methodology

1. Geological and Geomorphological Data Collection:

Umm Chaimin crater area in the western Anbar Plateau desert was visited in 2024, where a field survey was conducted to document the geomorphological features of the depression, determine the geographical dimensions of the depression using global positioning systems (GPS), in addition to collecting rock samples from the depression and the adjacent areas for laboratory analysis.

2. Laboratory Analysis

- Rock and mineral analysis: Geological examinations of rock samples taken from the crater were conducted, using optical and Scanning Electron Microscopy (SEM) to analyze the structure of minerals and identify morphological changes caused by pressure or temperature.
- Analysis using aerial and satellite imagery: Satellite imagery and geographic information systems (GIS) data were used to determine the circular characteristics of the depression.
- Comparative analysis: Available crater data were compared with similar crater data in other regions such as the meteorite crater in the Mahout States, Oman.

3. Software Tools: Includes geographic information systems (GIS) software to analyze topographic data and determine the circular features of the crater.

4. Data Sources: Primary sources include field data, aerial images, rock samples and sediments. Secondary sources include previous studies and scientific references on the Umm Chaimin crater and other impact craters. In addition to satellite databases such as Landsat and Sentinel.

5. Implementation Steps:

• The first stage: field data collection and analysis of aerial images. The second stage: conducting laboratory analyzes. Third stage: Data analysis using software and statistical tools. Fourth stage: Comparing the results with previous studies and interpreting the origin of the crater formation.

Results

1. Field Visit

The field visit to the research area is an essential part of applied geological studies, as it aims to collect field data necessary to support and enrich scientific research. These data are a priority for scientific studies to ensure the accuracy of the results obtained by collecting samples thoughtfully from different locations around the crater (Fig. 2).

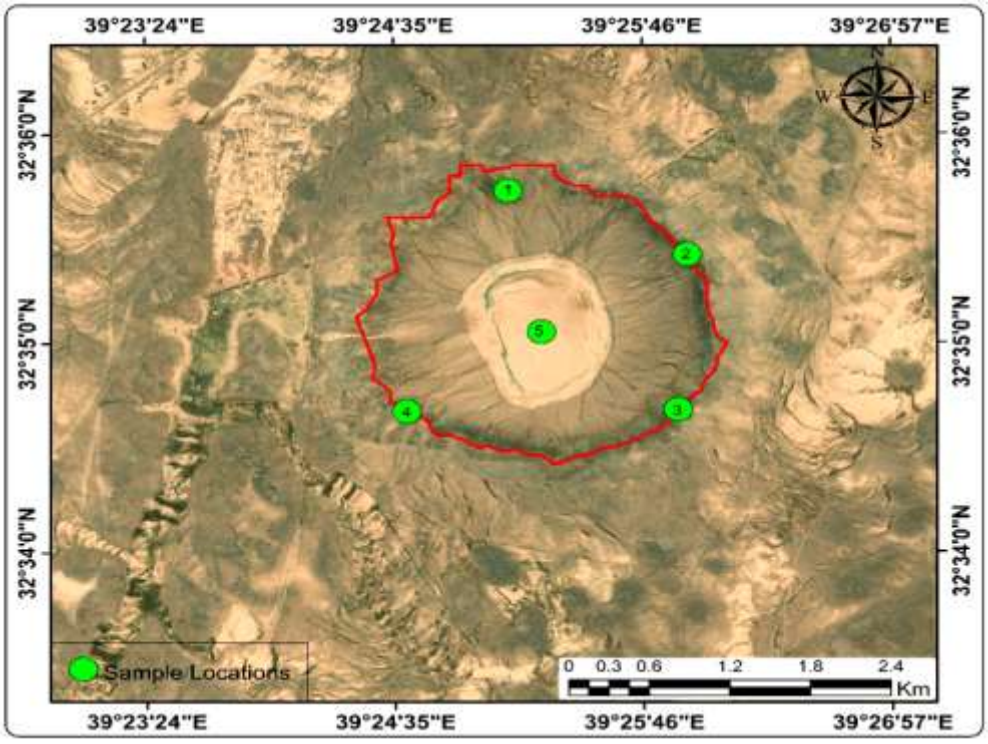


Fig. 2 Map of the locations of samples taken from the research area. Source: Based on Landsat.9 satellite imagery at 12x12 resolution using Arc map v10.8 software output.

Field visits provide a unique opportunity to understand closely the geological environment within which the crater is located, contributing to the accuracy of the geological samples used in the research. The importance of these visits comes from the reliance on advanced scientific techniques for data collection, such as highly professional sampling and the use of geographic information systems (GIS) in the representation of geological sites. Reaserchers also used GPS unit onacertin field and performed an extensive, integrated spatial evaluation of the samples. Similarly, Digital Elevation Models (DEM), satellite images and topographic maps are utilized to suggest the most affected lead of inside accessible cover from the crater. These methods describe the character but also provide an incomplete picture of the

region's natural environment and the distribution of crater-related geologic phenomena. To pinpoint the depth where the radiolarians lived, researchers used instruments such as shovels, geological hammers and bags in fieldwork. The bags also had adhesive labels applied to them so as to have proper documentation/naming of the sample. These samples were preserved under good conditions until they arrived at laboratories, where they were analyzed with the aim of reaching at an accurate and systematic understanding of the region's characteristics. (Fig. 3).



Fig. 3 The field work stage and rock sample collection. Source: Field visit to the study area in March 2024.

Location of the Research Area

2. The Geology of the Research Area

The geology of the research area is one of the main elements that contributes to the understanding of the origin of Umm Chaimin crater. Rock units are the actual field for examining the tectonic and structural reality of the region, which is an important pillar on which research depends. The exposed rocks around Umm Chaimin depression date back to the Ratga Formation (Eocene), which is equivalent to the Dammam Formation. It consists of well-bedded limestone and dolomitic-limestone, with intermittent strata of Marl and Chert. The thickness of the Ratga Formation in the area is estimated at 40 meters (Hagopian, 1979).

The research area is characterized by rock strata with a low slope ranging between (3-5) degrees to the south and southeast (Al-Mubarak, 1983). (Al-Kazemi et al., 1996) mentioned that the area is located within the stable shelf and the rock strata are almost horizontal with a slight regional inclination ranging from 2 to 4 degrees. The research area also comprises the Hauran Structure which is a host block about 300 km east-northeast – west-southwest extending approximately along the Hauran Valley (Al-Mubarak, 1983).

Anbar Governorate, including Umm Chaimin crater, is located within the Stable Shelf area, a relatively stable structural unit that was slightly influenced by Alpine Tectonic Orogeny during the Cretaceous and Tertiary ages. The region is undergoing a lifting process of more

than 400 meters, at a rate of more than 0.2 cm per 100 years (Sissakian and Dikran, 1998). The research area is also within the Rutba belt, which is part of the Nubian Arab Plate (Fig. 4).

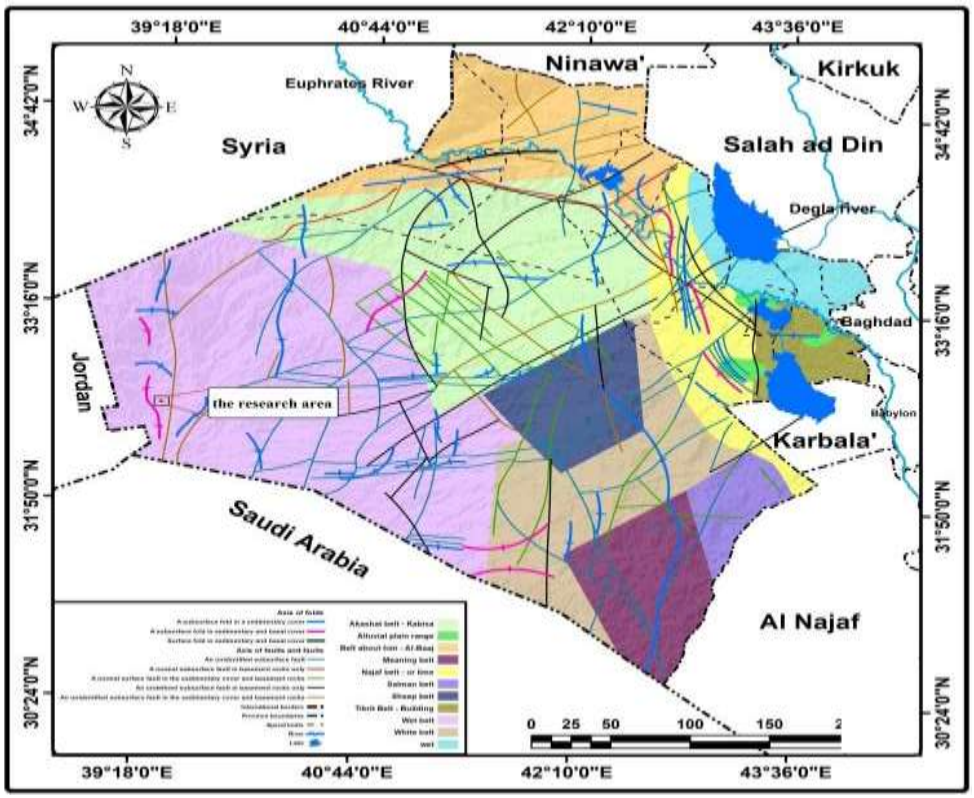


Fig. 4 Tectonic map of Anbar Governorate shows the location of Umm Chaiman crater. Source: Ministry of Industry and Minerals, Geological Survey and Mineral Investigation, Iraq Tectonic Map, 2023.

The crater does not lie directly on the axis of faults, but approaches it without passing through it. This position of the crater explains the exclusion of the possibility of its formation as a result of gaseous or volcanic activity. Accordingly, the research focused on analyzing samples taken from the research area to reach the final results.

3. Geological Formations Exposed on the Surface of the Research Area

The geological formations in the research area extend between the Tertiary (Eocene) and the Quaternary (Holocene and Pleistocene). Below is the order of these formations from oldest to newest:

- **Ratga Formation:** This formation is exposed at the rim of the crater's circumference and takes the form of a circular ring, and includes both the Swap and Damlok members from the Eocene.
- **Quaternary sediments:** These sediments are exposed in the center of the region and at the periphery of the crater, and include slope sediments, residual soil, weathering, and Wadi Al-Feel sediments.

The presence of quaternary sediments in this area is due to water leakage from the flows of Wadi Tarifawi, which belongs to the Wadi Al-Walij basin, which is responsible for transporting these sediments into the crater through an artificial corridor built after the construction of the earthen dam. Prolonged rainwater falling inside the crater contributed to the accumulation of these sediments.

It is noteworthy that despite the presence of these deposits, there are no signs of dissolving or karst formation occurring inside the crater. This indicates the stability of the water flow entering the center of Umm Chaimin depression, without any noticeable dissolution processes (Fig. 5, 6).

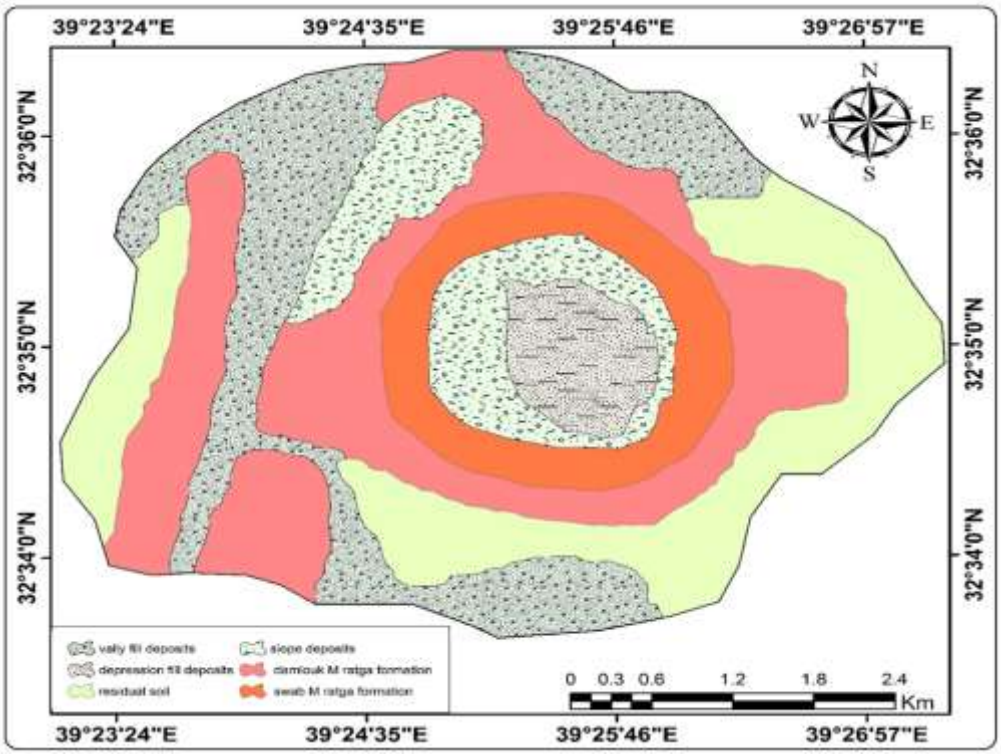


Fig. 5 Exposed geological formations on the surface and recent sediments in the research area. Source: Ministry of Industry and Minerals, General Authority for Geological Survey and Mineral Investigation, GEOLOGICAL MAP OF H4 AND WADI HORAN QUADRANGLES SHEETS NI-37-14 AND NI-37-15 at a scale of 1; 250,000

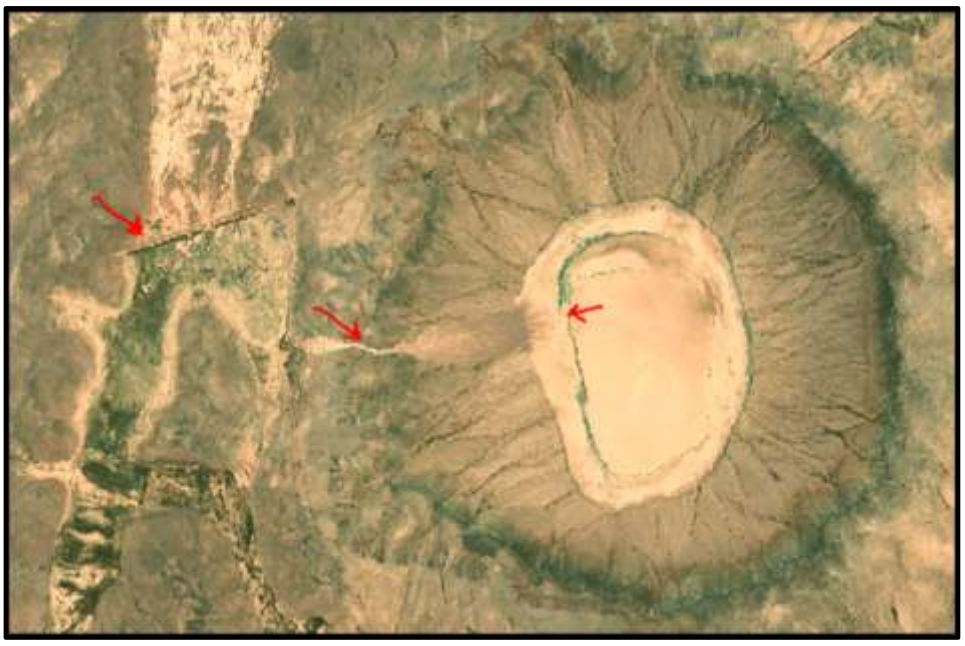


Fig. 6 shows the artificial waterway channel at the center of Umm Chaimin crater and the earthen dam. Source: Based on Landsat.9 satellite imagery at 12x12 resolution using Arc Map v10.8 output.

4. Geomorphology of the Region

- **Contour Lines:** The topography of the research area is characterized by a rocky desert with some hills and valleys that form seasonal streams. The topography generally slopes towards the northeast. The eastern half of the region is characterized by rougher terrain. Based on the contour map (Fig. 7), Umm Chaimin crater is located at an altitude of 850 meters above

sea level at the highest point, while the lowest point is recorded at 820 meters above sea level, indicating a crater depth of up to 30 meters.

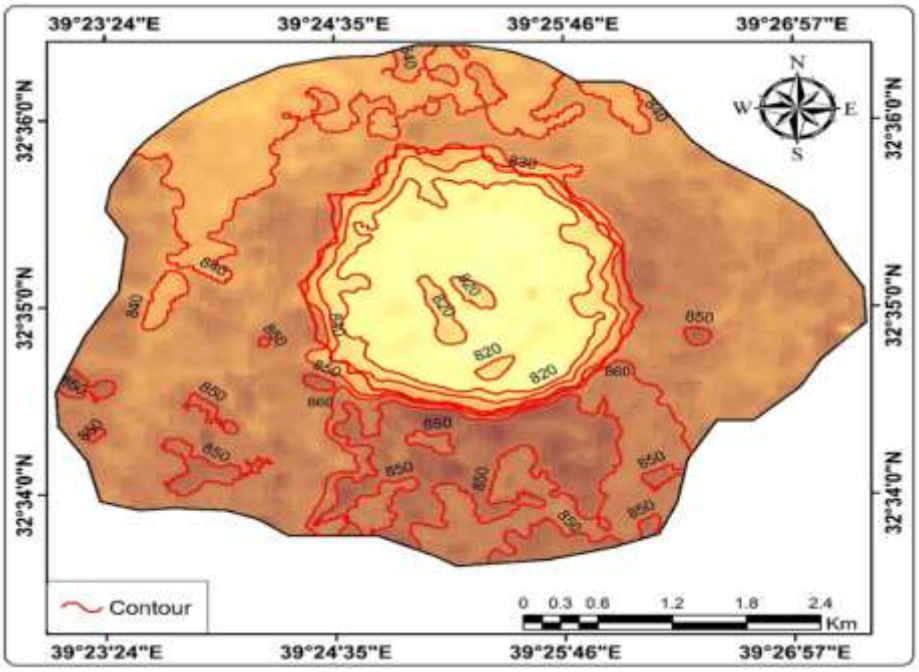


Fig. 7 The contour map of Umm Chaimin crater. Source: Based on DEM (Digital Elevation Model) with a resolution of (12×12) m and Arc map v 10.8 output.

- **Comparative Study of Geometric Dimensions:** Umm Chaimin crater and the meteorite crater discovered in the Mahout states in Oman share the same geometric properties like the circular shape with some differences in detail. Umm Chaimin crater (Iraq) (Fig.8)

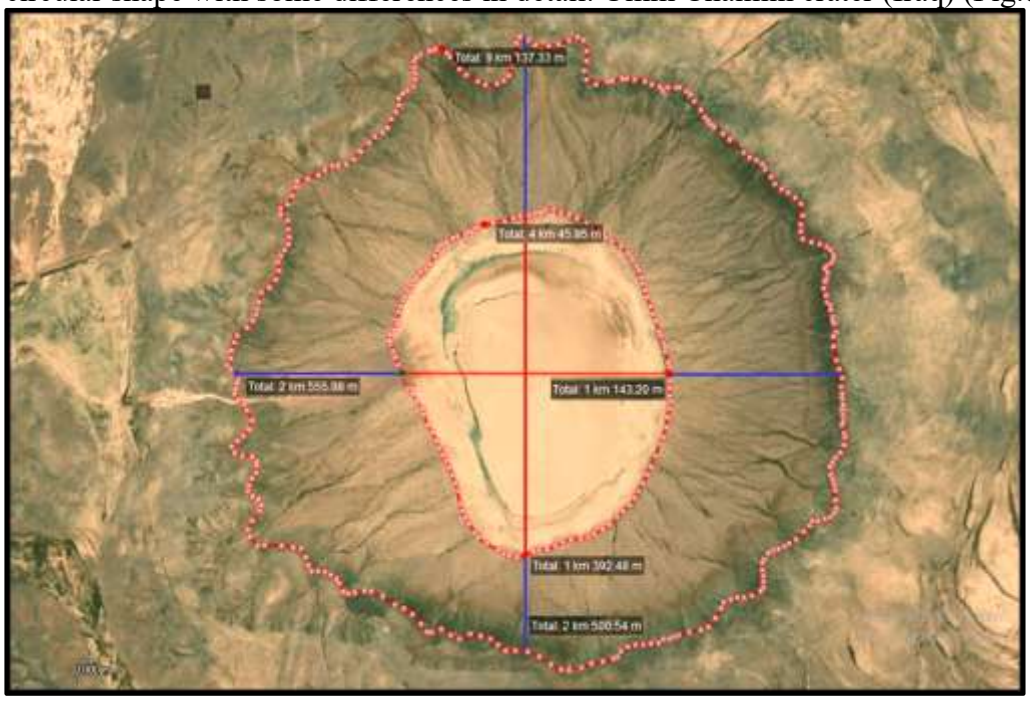


Fig 8 The geometric dimensions of Umm Chaimin crater. Source: Based on Landsat.9 satellite imagery at 12x12 resolution using Arc map v10.8 software output.

Umm Chaimin Crater displays a semi-circular morphology with a subtly zigzagged rim. Its outer perimeter spans 9.137 km, while the sediment-filled inner basin measures 4.45 km. The outer diameters are 2.500 km (N-S) and 2.555 km (E-W), contrasting with inner

diameters of 1.392 km (N-S) and 1.143 km (E-W). Mahout Crater (Oman, Fig. 9) lies in a geologically complex zone, exhibiting features suggestive of impact or volcanic origins, necessitating further investigation to clarify its formation processes.



Fig. 9 The meteorite crater discovered in the Mahout States in Oman.

Mahout crater is one of the rare scientific sites for studying the effects of land impacts, with an estimated diameter of about 1 km, and with age of up to 60 million years, making it one of the largest impact craters in the Middle East. Studies at the crater site have shown clear signs of melting and recrystallization of rock fragments, indicating that sandstone was exposed to high temperatures by the impact. Comparing the geometry of both craters reveal their similarly circular shape, with different dimensions and physical properties resulting from geological processes. Umm Chaimin crater is larger and has wider detail, while the crater in Mahout is smaller but holds important scientific evidence for studying the effects of impacts on rocks.

- **Slope:** Analyzing the slope map of Umm Chaimin crater indicates that the slopes range from 0-0.6 degrees to 3-5 degrees, showing that the area does not have steep slopes except for the edge surrounding the crater which takes the form of a semicircle starting from the northeast and ending in the southwest, where the slope reaches 3-5 degrees. Most of the area around the crater is slowly inclined towards a hidden slope (Fig.10 and Table.1).

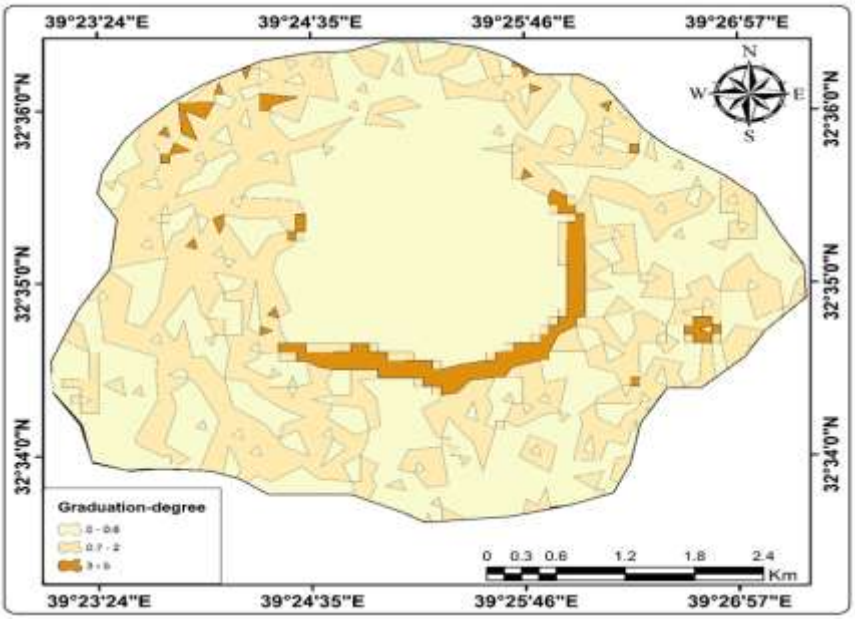


Fig. 10 Slope map of Umm Chaimin crater. Source: Based on DEM (Digital Elevation Model) with a resolution of (12×12) m and Arc map v 10.8 output.

Table 1. The slope angle value and Umm Chaimin crater Area.

No.	Slope angle (degree)	Area (m2)
1	0 - 0.6	16.10
2	0.7 – 2	11.49
3	3 – 5	1.02

Source: Based on Digital Elevation Model (DEM) and regression map (10).

- **Drainage patterns in the area**

The data of water network and the number of watercourses associated with each order were represented depending on the map (Fig. 11). In the first order, there are 83 waterways, followed by the second place with 28 waterways, while the third order contains 5 streams. The fourth order represents the mainstream. The Strahler classification was used to divide water orders based on the network complexity (Table 2).

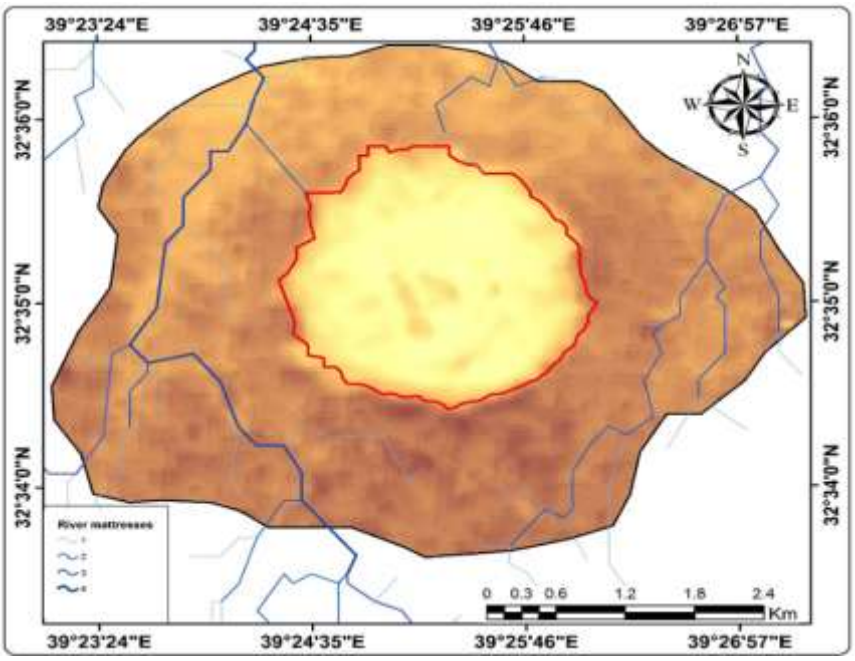


Fig.11 Map of the water network surrounding Umm Chaimin crater. Source: Based on DEM (Digital Elevation Model) with a resolution of (12×12) m and Arc map v 10.8 output.

Table 2. shows the number of watercourses and the search area size.

Order.	No.	Area (m^2)
1	83	51.4
2	28	37.1
3	5	19.3
4	1	10.1

Source: Based on the DEM digital elevation model and the water network map (11).

- **Tree Drainage Pattern:** This pattern is clearly shown by the random branches of the orders in the map (Fig. 11). This pattern resembles tree branches, where orders branch uniformly and eventually gather with the main valley. This pattern appears in areas with homogeneous rocks within the terrain surrounding Umm Chaimin crater.
- **Radial discharge pattern:** This pattern appears in the area around Umm Chaimin crater, where small streams indicate water flowing away from the central point of the crater, causing the runoff water to flow out.
- **Central drainage pattern:** This pattern is located inside Umm Chaimin crater, where small water flows start from the upper edges of the crater circumference and water flows towards the center. These small internal runoffs transport the falling rainwater to the center of the crater with each rain shower.

5. Description and analysis of rock thin sections (Thin Sections) of Umm Chaimin area.

❖ **First rock slide (A1) (Fig. 12):**

Description: The sample contains a large number of fossils, with quartz density that dominates most of the mineral composition. The sample is characterized by a low thermal metamorphism in the rocks, indicating that they have not been subjected to high temperatures and pressure.

Analysis: Based on the abundance of quartz and fossils, this sample can be described as meta-sandstone. The quartz accumulated in the rock structure appears almost uniformly, indicating a limited thermal metamorphism in the region.

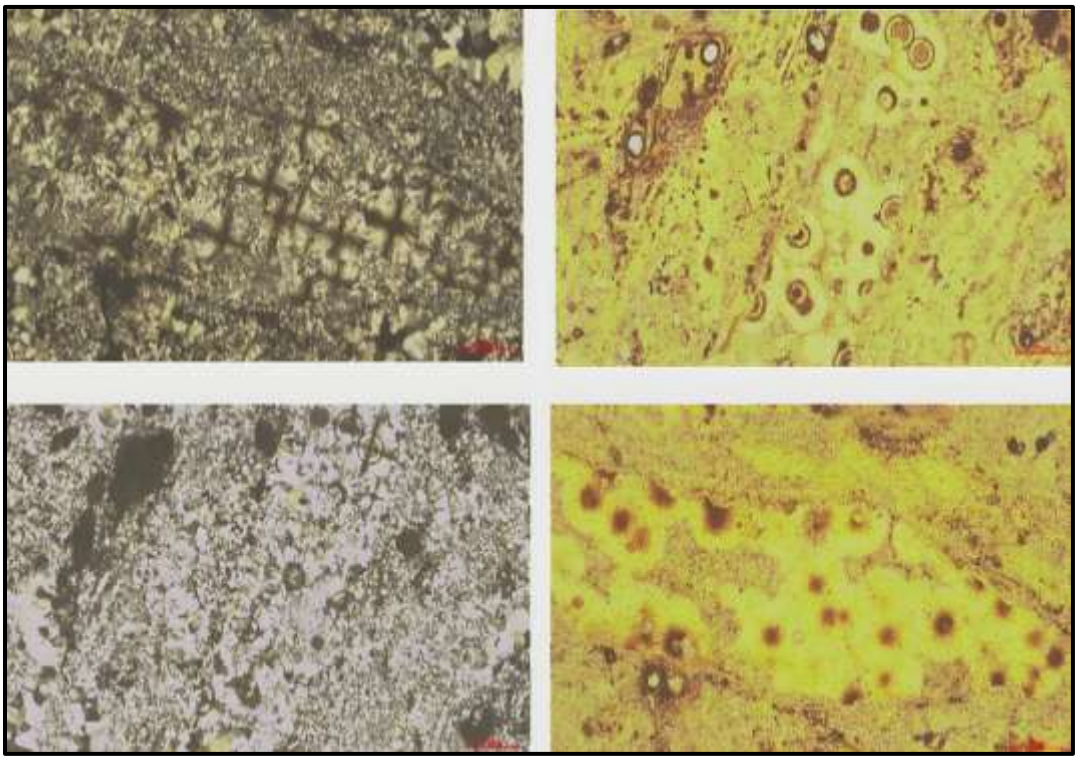


Fig.12 shows the first slide (A1). Source: done by Çukurova university lab. 2024

❖ **Second rock slide (A2), (Fig. 13):**

Description: The sample contains very few fossils, with quartz dominance. In addition, Perhnite, a metamorphic mineral that occurs at low temperatures, appears in the sample.

Analysis: The presence of Perhnite suggests that the rocks underwent low thermal metamorphism, reinforcing the theory that meteorite impact is the cause of this simple metamorphism. Prehnite, as a mineral usually formed in low thermal conditions, refers to minor impacts caused by impact. This sample can be classified as slightly meta-sandstone rocks, with minimal thermal metamorphism.

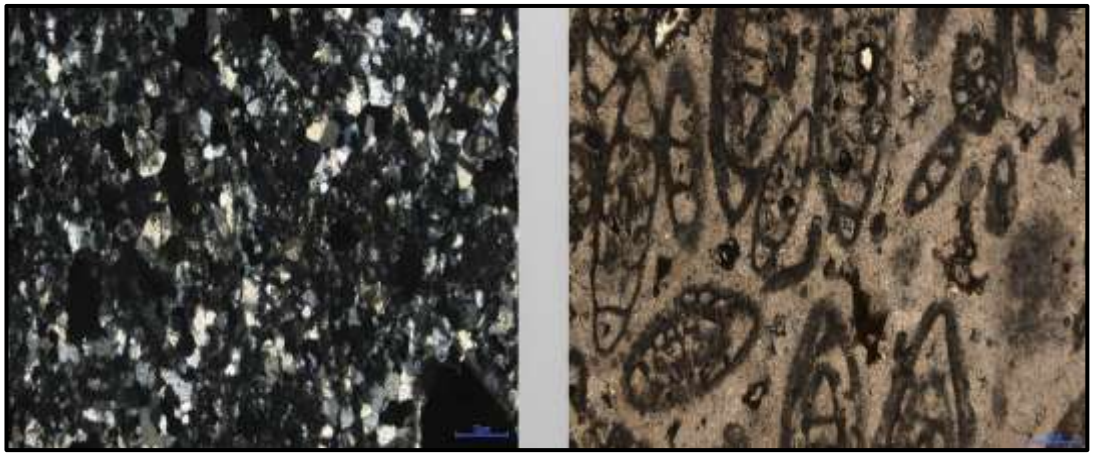


Fig. 13 shows the second rock slide (A2). Source: done by Çukurova university lab. 2024

❖ **Third rock slide (Fig. 14) (A3)**

Description: This sample contains abundant fossils, with a density of quartz. With the exception of quartz, there is no evidence of other metamorphic minerals. This suggests that the rocks were not exposed to high temperatures or strong pressure.
Analysis: Regarding mineral composition, this sample is similar to the first one on A1 slide, as it is dominated by an abundance of quartz with little thermal metamorphism. Based on these characteristics, the sample can be classified as partially meta-sandstone with very slight metamorphism, supporting the Meteorite impact theory.



Fig.14 showing the third rock slide (A3). Source: done by Çukurova university lab. 2024

6. Mineral analysis of rocks in Umm Chaimin Area

Through the metallurgical examination of rock samples taken from Umm Chaimin area using thin sections under optical and electron microscopy, the following important minerals were detected:
Quartz: One of the main minerals in the samples, indicating the presence of low-meta-sandstone sedimentary rocks. The presence of quartz with abundant fossils is indicative of marine deposits from the Lower Eocene. The spread of quartz supports the theory that rocks in Umm Chaimin area did not experience significant thermal metamorphic conditions, suggesting that the meteorite's influence was limited in terms of temperature generation or high pressure.
Prehnite: The presence of this metal reinforces the theory of low thermal metamorphism. Prehnite has physical properties such as yellow-green color, 6 and 6.5 hardness on the Mohs scale, and glass luster, indicating that the region is affected by specific thermal conditions as a result of the meteorite impact.
The presence of Prehnite, which usually forms at low temperatures and in conditions of minor geological metamorphisms, indicates that rocks in Umm Chaimin area underwent limited meteorite influences, resulting in a minor metamorphism in rock structure. This supports the theory that the meteorite impact was relatively recent, and did not cause a complete metamorphism of the surrounding rocks.

7. Silica Containing Rocks (SiO_2)

The presence of silica (SiO_2) in rocks can prove a meteorite's impact on Earth in some cases. The high temperatures and pressures resulting from meteorite impacts usually produce mineral and chemical changes in rocks. Sometimes, the impact causes the formation of silica-rich compounds, such as glass fragments, which are formed by the process of liquefaction and rapid freezing of rocks due to the enormous heat generated by the impact.
When impacting the Earth, a meteorite can lead to the melting of surrounding rocks and the formation of silica-rich glass materials such as tridymite or high-pressure quartz. These

materials are produced as a result of high temperatures that occur only in meteorite-impact environments. These phenomena include the formation of rock fragments (impact Briccias) consisting of broken and intertwined pieces of rock, often mixed with glass materials. Using spectral analysis in the near-infrared region, dark blackish colors can be observed, reflecting thermal and lithological changes. Silica-rich rocks have a higher thermal property compared to surrounding rocks, such as recent sediments and calcareous rocks in the study area. The results show turbulent mass paths that are visible in dark colors (Fig. 15), which is documented in field observations. Taken together, these phenomena indicate a meteorite impact effect on the Earth's surface, producing silica-rich components due to the heat and pressure of the impact (Fig. 16).

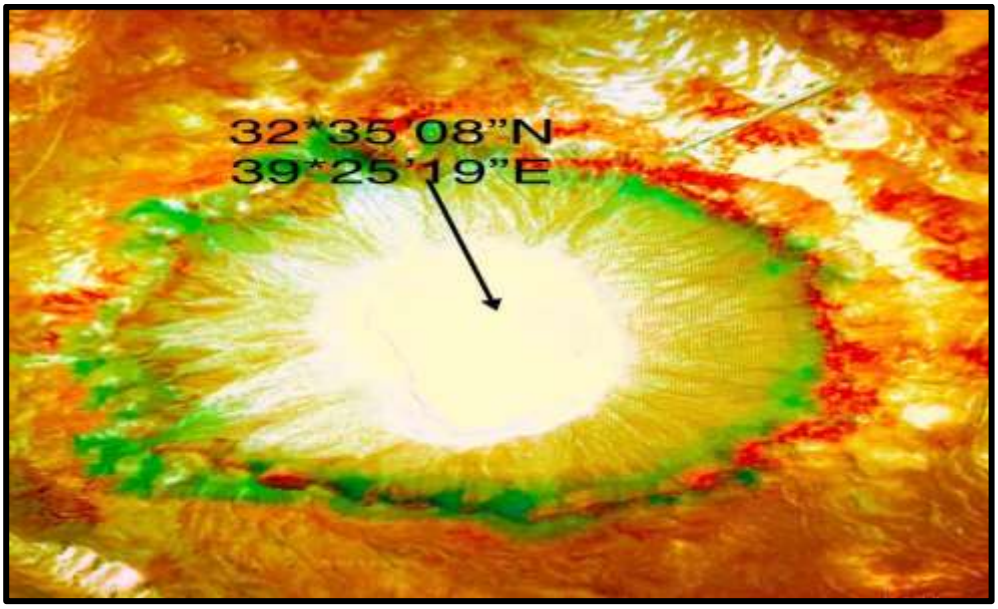


Fig. 15 The rock fragments (impact breccia s) mixed using color treatments. Source: USGS; done by elevation Pro.2024.



Fig.16 The rock fragments (impact breccias) mixed with silica (SiO_2). Source: Field visit to the study area in March 2024.

Discussion

The geological and geomorphological data of Umm Chaimin reflect precise details about the history of the region and the impact of various geological processes on it. Studies show that

geological and laboratory analysis can contribute to a deeper understanding of the crater properties and conditions of its formation. Exposed geological formations, such as the Ratga Formation and the Quaternary sediments, indicate a graded geological history that extends from Eocene formations to recent sediments.

This gradient shows the region's exposure to multiple environmental and climatic changes that have affected surface rock formations, with a clear absence of karst dissolution processes within the crater, highlighting relative geological stability that can be attributed to the dominance of sedimentation processes at the expense of erosion. Geomorphological and topographical characteristics indicate that Umm Chaimin crater represents the only characteristic geomorphological phenomenon in the western region of Iraq. The top sheet map of the study area clearly shows that this crater is unique in the area, indicating a particular local influence in this part of the area only (Figures 17 and 18).

The crater has a relative depth of about 30 meters, a clear semi-circular shape, and a surrounding terrain consisting of multiple surroundings, both internal and external. These geometric dimensions support the theory that the crater is formed by a meteorite impact. The semi-circular shape and steep slopes surrounding the crater indicate a strong effect focused mainly on the surrounding edge. Low slopes in other surrounding areas show that the impact was concentrated in the edge region. Furthermore, the presence of turbulent masses scattered around the circular edge of the crater is further evidence of a meteorite impact.

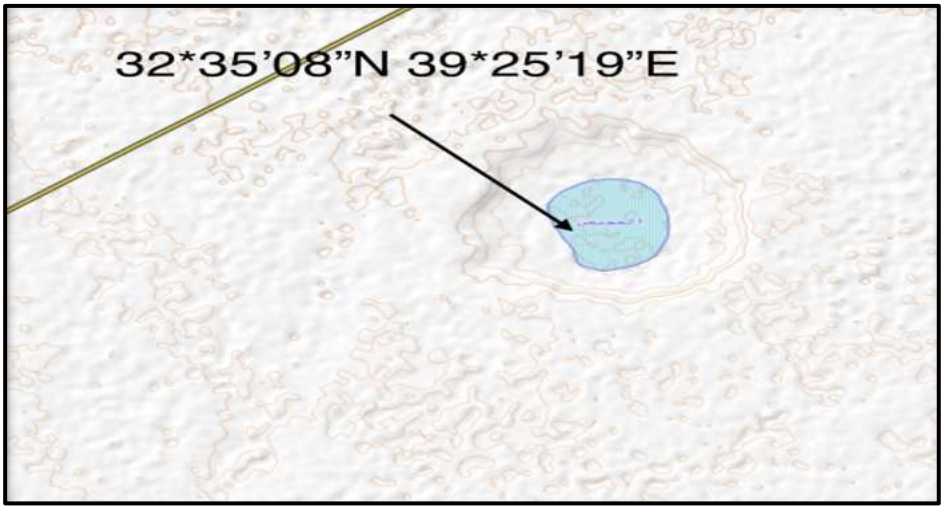


Fig. 17 The unique phenomenon of Umm Chaimin in the region. Source: USGS; done by elevation Pro.2024



Fig. 18 A topographic section of Umm Chaimin in the east-west direction. Source: USGS; done by elevation Pro.2024

Different types of water drainage patterns, such as tree, radial, and central patterns, clearly vary in the impact of geological processes on water flow. The circular pattern of water flow inside the crater reflects the direction of the water toward its center, supporting the theory that the crater was formed by an impact. Analysis of rock thin section and constituent minerals shows that the impact of meteorite collision on rocks in Umm Chaimin region was thermally limited. The presence of quartz and fossils indicates low-metamorphic sedimentary rocks, showing that the impact was not violent enough to cause a significant thermal metamorphism. The presence of Perhnite reinforces the idea that the thermal conditions resulting from the impact were low.

When compared to the meteorite crater discovered in the Mahout state in Oman, Umm Chaimin crater has a similar semi-circular shape with some differences taking the shape of minor zigzags. The outer circumference measures 9.137 km and the internal circumference measures 4.45 km, while the diameters range from 2.500-2.555 km externally to 1.143-1.392 km internally. The crater is an important scientific site for studying the land-based impact effects, with a diameter of about 1 km and an estimated age of 60 million years. Studies have shown clear signs of melting and recrystallization of rocks caused by the impact.

The impact of the meteorite that made the Umm Chamin crater was confined and short, so when it came to a small hole there were no significant thermal and pressure signs. The absence of significant thermal metamorphism, the preservation of karst terrains that were buried miles beneath the surface, and new measurements of shocked quartz are consistent with such a limited impact structure. Moreover, the distribution of sediment in the crater indicates repetitive water flows from runoff along its periphery being responsible for sediment infilling, and they received very significant contribution to crabbing rock but did not change its composition notably. Rocks with SiO2 (silicon dioxide which is the Main component of glass) will show evidence of a meteorite impact, Rock fragments are highly compressed and deformed by high temperatures and pressures create interlocking pieces of rock as well as glass formed by the impact. Some have been documented in the research area even to support such hypothesis.

By studying Umm Chaimin area, it is clear that the crater came as a result of a moderate meteorite impact. Mineral compositions such as quartz and Perhnite give evidence of low thermal and pressure impact. The crater topographic geometry also provides additional evidence of the nature of the impact and its effect on local terrain.

Conclusions

The study reached the following conclusions:

1. Umm Chaimin area contains geological formations extending from the Eocene (Ratga Formation) to the Quaternary sediments, as these formations indicate the influence of recent natural processes such as runoff and rainfall in the formation of the area.
2. The existence of rock fragments containing intertwined pieces of rock and glass reinforces the theory that the crater's formation results from a meteorite impact.
3. The low-grade meta-sandstone rocks in Umm Chaimin region, with their quartz density, and the presence of Perhnite indicate a low thermal metamorphic effect, and a moderate meteorite impact.
4. Based on the geological characteristics observed in the research area, the impact that led to the formation of Umm Chaimin crater can be classified as moderate. Evidence indicates that the size of the meteorite responsible for the impact ranged from 100 meters to a kilometer. The meteorite impact was characterized by moderate energy that caused noticeable changes in the geological formations of the area. The dimensions of Umm Chaimin crater are consistent with medium-sized meteorite craters, ranging in diameter from 1 to 10 kilometers. These characteristics support the theory that Umm Chaimin crater was the result of a meteorite impact of moderate intensity.
5. Umm Chaimin crater can be considered the largest meteorite crater in the Middle East, characterized by a relative depth of 30 meters, and a semi-circular shape with simple zigzags. Its outer circumference measures 9.137 km, while the inner circumference in which sediment collects is 4.45 km. The outer diameter in the north-south direction is 2.500 km, and the interior is 1.392 km. In the east-west direction, the outer diameter is 2.555 km and the interior is 1.143 km.
6. The semi-circular shape of the depression, the metamorphic processes that occurred to the sandy rocks, and the existence of Perhnite metamorphic mineral indicates that the meteorite impact was relatively recent and impact limited.
7. The area around the depression or crater shows slight slopes, indicating that the terrain remained stable after the formation of the crater.
8. The different types of drainage patterns, especially the central pattern inside the crater, reflect its circular shape.
9. The accumulation of sediment inside the crater indicates that subsequent processes were dominant in the formation of the post-impact area.

Recommendations

1. Guiding efforts to protect the area from any human activities that affect the natural formations of the crater, given its scientific and geological importance.
2. Classifying the crater as a distinctive natural feature that can be used in education and scientific research. Developing the region as a scientific and tourist attraction to promote awareness of geological history and natural processes.
3. Conducting additional analyses of rocks and sediments inside the crater and the adjacent area to determine the composition of the meteorite responsible for the impact and assess its influence on the area.

Supplementary Information
The online version contains supplementary material available at https://doi.org/10.6084/m9.figshare.30757766

Acknowledgements
The researchers would like to express their sincere gratitude and appreciation to the various government agencies and institutions for their cooperation and the facilities provided. Their support was instrumental in enabling the research team to access the study area and conduct the necessary fieldwork.

Author contributions: Turhan Al-Mufti: methodology, software, validation, visualization; Ameer Mohammed Khalaf: conceptualization, investigation, writing original draft; Zuhair Jaber Mushref: supervision, project administration, resources; Ahmed Ibrahim Al-Naemi: formal analysis, data curation; Abu Baker A. Najm: writing review and editing. All authors agreed with the results and conclusions.

Funding: No funding source is reported for this study.

Availability of Data and Materials
All geological, geomorphological, and field data supporting the findings of this study on the Umm Chaimin Depression are available upon reasonable request.

Declarations

Ethics approval and consent to participate
Not applicable.

Consent for Publication
Not applicable.

Competing Interests
The authors declare that they have no competing interests (financial or otherwise) that could inappropriately influence or bias the findings presented in this study.

References

Al-Din, T. S., Al-Sanawi, S. A., & Matolin, M. (1970). Umm Chaimin depression, Western Iraq: Not an astrobleme. Journal of the Geological Society of Iraq, 3(1), 73–88.

Al-Hashimi, H. A. J. (1982). Contribution to the origin of Umm Al-Chaimin depression, Western Desert, Iraq. Journal of the Geological Society of Iraq, 15(1), 35–39.

Al-Kadhimi, J. A. M., Sissakian, V. K., Fattah, A. S., & Deikran, D. B. (1996). Tectonic map of Iraq (2nd ed., scale 1: 1,000,000). GEOSURV, Baghdad, Iraq.

Al-Mubarak, M. A., & Amin, R. M. (1983). Regional geological mapping of the eastern part of the Western Desert and the western part of the Southern Desert. GEOSURV Library No. 1380.

Al-Naqib, K. M. (1967). Geology of the Arabian Peninsula. U.S. Geological Survey Professional Paper No. 560-G.

514 Alvarez, L. W., Alvarez, W., Asaro, F., & Michel, H. V. (1980). Extraterrestrial cause for the
515 Cretaceous-Tertiary extinction. Science, 208(4448), 1095–1108.

516 Al-Zawahra, M. (2018). Circular formations in the Jordanian desert: Remote sensing and field
517 study.

518 Bass, J. D., Anderson, D. L., & Wu, T. (2006). Meteorites: Geological and environmental
519 impacts.

520 Gnos, E., Hofmann, B.A., Halawani, M.A., Tarabulsi, Y., Hakeem, M., Al Shanti, M., Greber,
521 N.D., Holm, S., Alwmark, C., Greenwood, R.C. and Ramseyer, K. (2013) The Wabar
522 impact craters, Saudi Arabia, revisited. Meteoritics & Planetary Science, 48(10), pp.
523 2000–2014.

524 Hagopian, D. H. (1979). Regional geological mapping of Nahidain–Tinif area. Iraq Geological
525 Survey Library Report No. 983.

526 Hamann, C., Hecht, L., Ebert, M. and Wirth, R. (2013) Chemical projectile–target interaction
527 and liquid immiscibility in impact glass from the Wabar craters, Saudi Arabia.
528 Geochimica et Cosmochimica Acta, 121, pp.291–310.

529 Hörz, F., See, T.H., Murali, A.V. and Blanchard, D.P. (1989) Heterogeneous dissemination of
530 projectile materials in the impact melts from Wabar crater, Saudi Arabia. In Proceedings
531 of the 19th Lunar and Planetary Science Conference, pp. 697–709.

532 Jassim, S. Z. (1980). Umm Chaimin depression, Western Desert. Iraq Geological Survey
533 Library, Manuscript Report.

534 Jassim, S. Z., & Goff, J. C. (2006). Geology of Iraq. Dolin, Prague and Moravian Museum,
535 Brno.

536 Jones, A. P. (2010). Impact of meteorites on Earth's lithosphere and climate systems.

537 Marriam, R., & Holwerda, J. G. (1957). Al-Umchaimin: A crater of possible meteoritic origin
538 in Western Iraq. Geographical Journal, 123(2), 231–233.

539 Marsh, S., Taylor, L., & Gupta, S. (2019). The use of modern techniques in the study of
540 meteorite craters.

541 Mitchell, R. C. (1958). The Al-Umchaimin crater, Western Iraq. Geographical Journal, 124(4),
542 578–580.

543 Mushref, Z. J., Abd, A. H. W., Mikhlif, A. M., & Abed, S. O. (2022). A cartographic
544 representation of the characteristics of Al-Rutba district population. International
545 Journal of Design & Nature and Ecodynamics, 17(4), 621–626.

546 Mushref, Z. J., Khalaf, A. M., & Al-Ani, S. O. A. (2021). The model of digital cartographic
547 layers of different scales to calculate the ratios of cartographic generalizations: An
548 applied study to Anah city. International Journal of Sustainable Development and
549 Planning, 16(7), 1245–1252. https://doi.org/10.18280/ijsdp.160705

550 NASA. (2020). Near-Earth Object Program: Tracking and mitigating asteroid threats.

551 Rasoulian, K. (2015). Geological and geomorphological analysis of potential impact craters in
552 Iran.

553 Sayel, J.J., Khalaf, A.M., Al-Bayati, A.H.I. (2025). Spatial distribution of some soil
554 characteristics of Ramadi district, western Iraq. International Journal of Environmental
555 Impacts, Vol. 8, No. 1, pp. 103-111. https://doi.org/10.18280/ijei.080111

556 Sissakian, Varoujan K., and Mawahib F. Abdul Jabbar. (2008). Using Remote Sensing and GIS
557 Techniques in Detecting the Origin of Umm Chaimin Depression, West Iraq. Iraqi
558 Bulletin of Geology and Mining, Vol. 4, No. 2, pp. 51-72.

559 Sissakian, Varoujan K., Nadhir Al-Ansari, Nasrat Adamo, and Jan Laue. (2020). Origins and
560 Utilizations of the Main Natural Depressions in Iraq. Journal of Earth Sciences and
561 Geotechnical Engineering, Vol. 10, No. 1, pp. 15-41. ISSN: 1792-9040 (print version),
562 1792-9660 (online).

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