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IDENTIFICATION AND GEOMORPHOLOGICAL ANALYSIS OF KOTRAL CAVES, SARDASHT, NORTH WEST OF IRAN

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ABSTRACT
Kotral caves are the natural caves in Sardasht and Piranshahr area. These caves are located in the direction of the bottom line of a high valley in Ghandil Mountain and have two separate parts. The upstream cave is actually a blind valley with a river that led to the formation of the cave. The downstream cave is located in the thalweg line of the valley and has an icy tongue. The distance between these two caves is less than one hundred meters. The above caves are located in the northwest of Sardasht, at a distance of 30 km from Mirabad city. The purpose of this study is to identify and analyze the geomorphological characteristics of Kotral caves. In this research, documentary method along with field studies, mapping and cartography, sampling and laboratory methods have been used to collect and analyze the relevant data. In addition, various soft wares have been used in the analysis part of the research. The characteristics and morphology of the Kotral caves were also scientifically interpreted and the pollution sources of running water in both surface and underground of was investigated and the parameters and chemical elements of the water and ice samples were analyzed. After examining the concentration of chemical elements, the results of the samples were compared with the standard table of global drinking water health. Through laboratory analysis of the samples, it was found that the amount of arsenic and lead in the measuring stations is high and the water is not drinkable. However, the concentration of other elements in the collected samples, compared to the world standard table of drinking water, has shown the normal limit in the two seasons of the year.

KEYWORDS: Kotral caves, Geomorphology, Water pollution, Natural hazards, Sardasht.

1. INTRODUCTION

In the past times of human beings, caves have served as a secure shelter for humans. Shanadar in Iraqi Kurdistan is a historical cave that appears to be a primitive residential area belongs to the Neanderthal age (Gillison, 1996). Caves classification was first performed by Bogli (1980) and White (1988). Gillison (1996) classified the caves based on geology, geomorphology, hydrology, biology, archeology, culture, and geography into six major groups.

The detection of natural and anthropogenic underground cavities such as caves is of vital importance in land-use planning and engineering projects (Martinez-Lopez et al., 2013). The exploration of underground caves attracts many visitors as tourists around the world which, in turn, can enhance the quality of micro-economy for local people (Ólafsdóttir and Tverijonaite, 2018). Caves are important elements of geo heritage of an area and they should therefore be included in any inventory of geo sites regions (Ríos-Reyes et al., 2018; Valente et al., 2020). Geomorphological method was used to delineate a cave and its soluble geological structures in limestone formation at Ghandil Mountain, Northwest of Iran. The geological formation of the investigated area generally consists of limestone and marble. There are several caves in the study area, the most common of which are soluble caves. These caves are formed by dissolving rocks adjacent to fractures, faults, and rock layers. The elements of dissolution caves in this area are: running water and rain and snow water, carbon dioxide in the air, soluble limestone and marble stones, faults. Due to the presence of the above elements, the research area has several large and small caves.

The climate in this area is Cold Mountain. Based on Koppen's climatic classification the climate of the area is Mediterranean to mountain climate (Khezri, 2006).

Geomorphological and geochemical studies on other caves around Kotral caves have been performed by researchers (Khezri, 2013).

2. MATERIALS AND METHODS

2-1. Study Area

The study area is located in North West of Iran in the counties of Sardasht and Piranshahr in the province of West Azerbaijan. The closest

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urban point to the study area is the small city of Mirabad (Figure 1).

Due to the existence of large limestone and marble geological rocks and annual precipitations over 1200 mm at the study area (Ghandil Mountain), Karstification is very active and there are a large variety of karst features at surface and underground such as caves. Kotral caves are located at the bottom line of Kotral valley in the basin of Badinawa. The caves are accessible via the Sardasht–Piranshahr road.

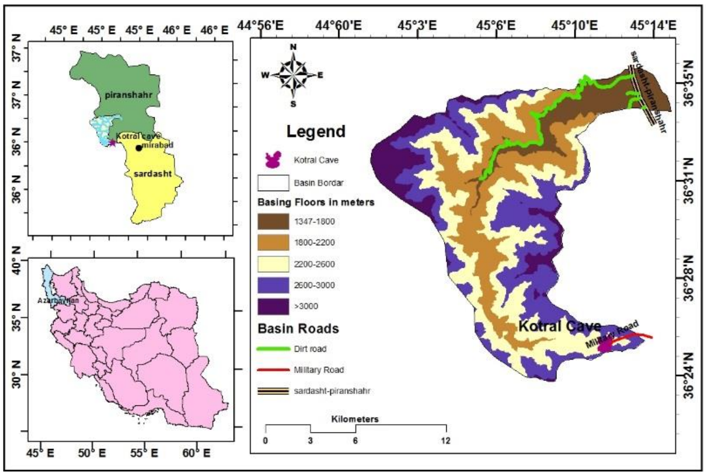

Fig. (1): Geographical position of Kotral caves in Sardasht and Piranshahr counties, West Azerbaijan province, Iran

After studying topographic and geological maps and conducting field studies, it was determined that the entrances of the caves are the end of a large cave (Fig. 2). The location of the Hydro-cave and without water cave on topographic and geologic maps were marked. The team, including ten members, entered the caves to evaluate the primitive morphology features. Then, geologic studies were performed. During field studies one other cave and a sinkhole were explored.

3. Geology and geomorphological features of the study area

The geological map shows faults which cross each other near the caves. A major fault with northwest – southeast azimuth situated at the east of the study area. The present caves are situated in the thalweg line of the Badinawa valley. The outcropped rocks around the Badinawa valley and near the present caves are limestone and metamorphic rocks and their ages are Cretaceous (Fig. 2).


Fig. (2): Entrances of Kotral Caves, Right: (Cave with running water), Left: (Glacier tongue cave)

It seems the limestone and other stones and formations in Kotral river basin has been seriously affected by faults that are a small part of main Zagros trust fault named as Piranshahr fault. The profile plan of the caves are shown in Figures. There are also many other faults in the northwest of the study area. The geological map of the study area is shown in Figure 3.

The accessible length of the first cave is about 160 m and the second cave has 80 meters length. The walls and roof of the caves have not been covered with typical calcite crystals. Field observation shows that the present caves are in the limestone and marble stones and its creation are due to the action of water on the limestone and marble formation i.e. Karstification. The entrance of the Hydro-cave has 5 meters in diameter and entrance of the without water cave has 10 meters in diameter.

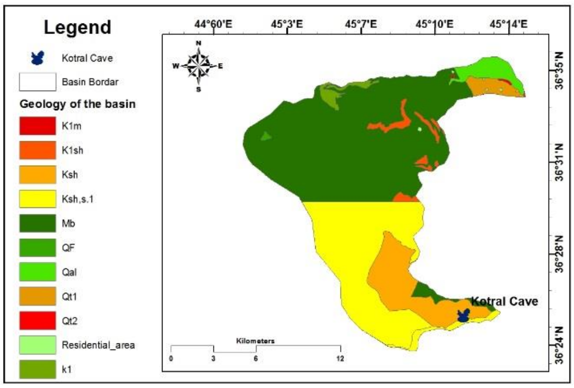

Fig. (3): Geologic map of the Kotral river basin

The study area consists mountains of the Zab River basin in northwestern Iran, which mostly covers its western slope. (Khezri, 2000). In fact, the scope of this research includes the western slopes of the Zab valley in Sardasht and Piranshahr (Badinawa) (Fig. 4).

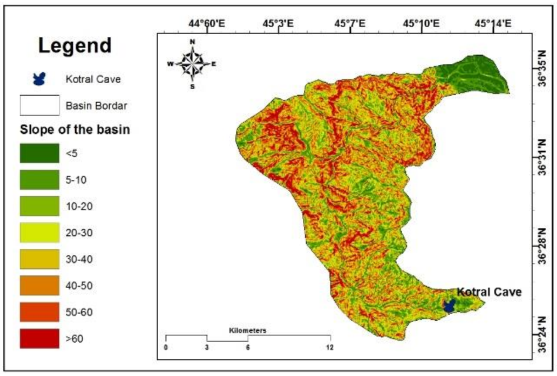

Fig. (4): The slop map of the of Kotral river basin (Badinawa river basin)

High mountains spread along western international borders of Iran and Iraq. The platform slopes join western mountains to thalweg line of the Zab River. The maximum height is 3000 meters in western mountains, while the maximum differences in height is 1653 meters. The disparities in height are stark. The length of slopes can be up to five kilometers. Slopes come in a variety of shapes and sizes. Some of the slopes are extremely lengthy and they join the ridge lines to the River of Badinawa. Many fractures in the dips can be found along the slopes (Fig. 4).

In case of tectonic aspect, the region is located in the major Zagros thrust direction in line with the active Sanandaj - Sirjan zone. This zone is quite susceptible to erosion due to its climatic conditions, geology, geomorphologic characteristics and human activities (N. G. O., 1997). Pit development is primarily caused by faults. That is why the tectonic forces have a significant impact on the morphology of the region.

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4. RESULTS

During the field studies, it was revealed that the earth's structure played an important role in changing the stones and forming karstic landforms. According to the lithological map of the area, the research area contains marble and limestone that are prone to forming karstic landforms. The most important karstic landforms are karens and sinkholes.

In the field, linear karens come in a variety of shapes and sizes, including degraded forms, parallel karens, wall-mounted karens, and checkered karens. They can be found in the around of entrances the caves.

In the second cave (waterless cave), a glacial ice tongue with a thickness of about five meters and a large volume was identified (Fig. 5).

Fig.(5): Glacial ice tongue in Kotral cave

Karstic erosion is a threat to sinkholes. The presence of vauclusien springs at the field is a strong evidence for the presence of much larger holes. Cave stones, stalactites, and stalagmites are examples of karstic landforms found in the caves. Cave stones provide indication that caverns have lime solutions. Their signs are as follows:

4.1. Stalactites

The water containing calcium bicarbonate penetrates into the roof cracks of caves (N. G. O., 2001). Sedimentation occurs as a result of this process, and repeating it produces attractive features on the cave roofs.

4.2. Stalagmites

Some stalagmites have been found on the floor of the second cave (which lacks water) in very small numbers.

4.3. Flowstones

The outcome of water reaching the steep wall of the rocks is a beautiful lime feature. This phenomenon has formed beautiful features in the without water cave (Second cave).

Some of the structural and macro karstic landforms in theses caves are passage ways, pits, halls and circular sinks (Fig.6). The characteristics and morphology of the Kotral caves were also scientifically interpreted and the pollution sources of running water in both surface and underground of was investigated and the parameters and chemical elements of the water and ice samples were analyzed.

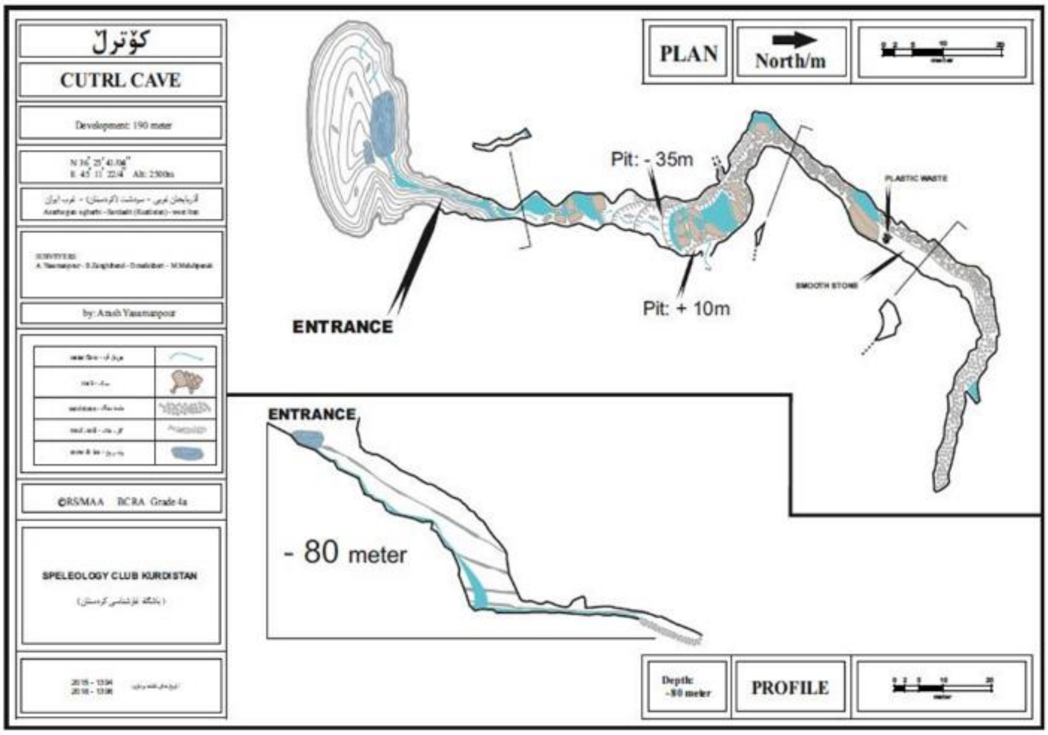

Fig.(6): The map of Hydro-cave of Kotral

After examining the concentration of chemical elements, the results of the samples were compared with the standard table of global drinking water health. Through laboratory analysis of the samples, it was found that the amount of arsenic and lead in the measuring stations is high and the water is not drinkable. However, the concentration of other elements in the collected samples, compared to the world standard table of drinking water, has shown the normal limit in the two seasons of the year (Table 1).

Table (1): Results of elements and parameters of water and snow samples of Kotral caves.

Limit Mg/L	desired limit Mg/L	Point 4	Point 3	Point 2	Point 1	Symbol	Anions and cations	Row
1500	550	6/87078	280/932	31/4344	331/787	EC	Electrical conductivity	1
1500	1000	25	115	121	124	TDS	Soluble solids	2
6/5-9	8/6-6/5	6/432	8/345	8/24	7/585	PH	PH	3
-	300	0/432	0/732	0/85	0/83	CA	Calcium	4
-	0/3	0/194	0/105	0/255	0/194	FE	Iron	5
0/01	-	0/096	0/135	0/08	0/29	AS	Arsenic	6
200	-	1/158	0/277	0/185	2/047	NA	Sodium	7
20	-	2/777	0/923	1/017	1/142	K	Potassium	8
50	30	0/111	0/208	0/208	0/448	MG	Magnesium	9
0/01	-	0/019	0/026	0/046	0/016	PB	Lead	10
400	250	0/34	0/22	0/42	0/32	CL	Chlorine	11
50	-	1/8	0/95	1/4	2/5	NO_3	Nitrate	12
400	250	7/6	12/4	12/5	10	SO_4	Sulfate	13

5. CONCLUSION

Caves are the most important karstic features, representing the powerful action of precipitation and running water over limestone and calcic geologic formations. Their occurrences could be a symptom of fresh groundwater availability in an area such that hydrologists and geologists can have hydrology plans for that area. They are also important in terms of geo-tourism since they attract many people through which micro-economy of the area can be developed.

Therefore, the exploration of caves in an area has always been an important task. This methodology of study Kotral caves was successful in cave exploration in the study area; therefore, it can be used in any area to investigate karstic caves.

Tectonic, lithology, and lime solubility are all important elements in cave development. The Kotral caves appear to have been formed by tectonic and other geological features. It indicates that some fault fissures in the mountains and valleys have generated stalactite, stalagmite, and other limestone landforms, and that penetrating water has formed stalactite, stalagmite, and other limestone landforms. In this cave the environmental stones have not been arranged firmly, they crash at every moment. Through laboratory analysis of the water samples, it was found that the amount of arsenic and lead in the measuring stations is high and the water is not drinkable.

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