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Identification and classification of karst landforms based on Cvijic, Waltham, Fookes, Komatina and Herak models (Case study: Travertine springs of Badab Soort)

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Abstract

Karst landforms are mainly formed in areas with soluble carbonate bedrock by chemical dissolution of water with low acidity. Travertine is mainly young carbonate sediments that are formed in a dry environment and from the seepage of fresh water springs with hydrothermal. The travertine springs of Badab Soort in oroost region of Mazandaran province are an example of these springs which create various forms of karst by creating sediments and travertine deposits. This research is carried out with the aim of Identification and classification of karst landforms in the area of Badab Soort spring. Research tools include topographical and geological maps of Kiyasar, satellite images, DEM, ARC GIS. The model and method of identifying karst landforms are the classification methods of cvijik, Waltham, Fookes, Komatina and Herak. The study of the karst landforms of the Badab Soort spring determined that, based on the classification of cvijik, these landforms are in the transitional karst category, Based on the classification of Waltham and Fookes in the category of young karsts, based on the classification of Komatina in the category of flat or platform karsts, and based on Herak's classification, it is placed in the row of orogenic karsts.

Introduction

Karst geomorphology studies the specific morphological and hydrological features of dissolvable rocks (mostly carbonates). Karst forms are the product of climatic phenomena and elements and geological conditions in limestone areas (Zanganeh Asadi and et al., 2002).These forms are mainly formed in areas with soluble carbonate bedrock by chemical dissolution of water with low acidity(Palmer,2007). Travertine is mainly young carbonate sediments that are formed in a dry environment and from the seepage of fresh water springs with hydrothermal (Rahmani and et al., 2011). Due to the release of waters containing calcium and other iron, manganese, copper, silicon and some other elements from the earth, the conditions for the release of carbon dioxide are provided and due to the evaporation of water rich in calcium compounds, it gradually leaves calcium in the form of calcium carbonate. This composition is based on the type of impurity that they have get colors including yellow, red, beige, white, green, brown, etc. On the other hand, with the change of season and stopping, reducing and increasing the speed, the sedimentation process is done in layers and finally, over thousands of years, a travertine area is formed. Badab Soort springs is also a spring with relatively warm water and rich in solutes which has left travertine stones over time. (Saffari and et al., 2018).

Wide areas of non-glacial arid and semi-arid lands of the planet Earth are covered with karst-prone carbonate formations and approximately 20 to 25 percent of the world's population depends mostly or entirely on karst resources (Ford and William, 2007). About 20% of the world's lands are covered by karst rocks (Milanovich, 1981). Due to the high importance of these areas, karst in the world and Iran has been investigated by various researchers including: From the eighties onwards, the study of karst regions gained momentum and more researches were conducted in most regions of the world Among the most important of them, we can mention the classification of karst forms by cvijik (1925), Waltham and Fookes (2003), Komatina (1973) and Herak (1977).

In Iran, we can refer to researchers such as Eshghi and Servati in 2000, Maleki Shohani and Alaei Taleghani in 2008, Behniafar et al. in 2009, Velayati and Khanalizadeh in 2011, Khanlari and Momeni in 2012, Khoshrafter and et al in 2016, khezri and et al. in 2017, and Rezaei Arefi and colleagues in 2019 mentioned who they worked in this field.

Material and Method

In this research, in order to classify the karst forms in the area of Badab Soort spring, first, by using library studies, the required information and data have been collected. Then, using a topographic map with a scale of 1:50,000, a geological map with a scale of 1:100,000 by Kiysar and Google Earth satellite images, the study area has been defined and demarcated. Also, the types of formations and types of faults and their roles in karst forms were identified using the geological map of Kiyasar.

Finally, by using cvijic, Waltham, Fookes, Herak classification methods, the landforms were identified and classified. The classification of karst forms is done in order to study them better and it plays an important role in their separation and identification (Rezae Arefi et al., 2018). At the end, with observations and field visits, images of karst geomorphological forms were prepared and matched with the obtained results (Figure 1).

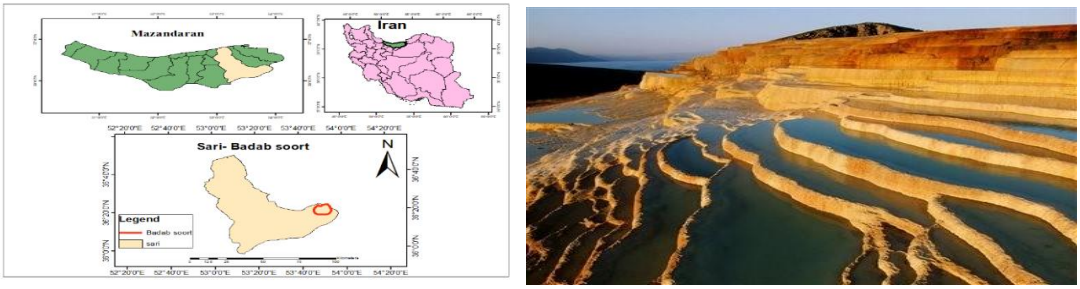

Figure 1. map of the study area

Badab Soort springs are located at 53º 51' 14" to 53º51'28" east longitude and 36º 21' 02" to 36º 21' 20" north latitude, in Sari city, Kiyasar city, Chahar Dange district, Dehistan Pushtkoh is located in the village of Soort, between the villages of Oroost and Malkhast. These springs were formed at the same time as the last folding of Alborz in Pleistocene and Pliocene (Bagheri et al, 2012).

The reason for the formation of these springs is that the atmospheric waters have gained a high dissolution power during penetration into the ground and heating under the influence of the intensity of geothermal heat and can dissolve many solutes in the form of solution. Now, by passing through the underlying magmatic rocks containing iron minerals and carrying dissolved calcium carbonate, after evaporation, they leave behind beautiful travertine sediments in red, yellow and orange colors (Mirktouli, 2015).

Results & Discussion

The requirement for the classification of karst forms is their identification, which is done using field methods and techniques, aerial photos, satellite images and geological maps. In identifying and classifying the karst forms of the studied area, we tried to use methods that are compatible with its geomorphology. Therefore, the karst forms of the region were identified and classified based on the classifications of cvijik (1925), Waltham and Fuchs (2003), Komatina (1973) and Harak (1977):

1. cvijic classification model: The basis of this classification is based on geomorphological and geological conditions. n this classification, karst forms are divided into three categories: complete, incomplete and transitional karst (Table 1).

Table 1. Classification of karst forms based on cvijik classification

karst type	type of stone	stone face	Karst landforms	Karst development
Complete karst (Holokarst)	High dissolution limestones	Completely rocky and without vegetation	Surface and deep karst phenomena	very high
Incomplete karst (Merokarst)	non-limestone rocks, low purity lime	Vegetation - non-limestone soils	Incomplete karst forms, lack of macrokarst	very little
Transitional karst	A combination of limestone layers	A combination of limestone and other	Underground karst,microkarst, incomplete	The expansion of underground forms, the formation of slow karens

between thin layers of formations non-limestone	formations - sparse vegetation	dolines, lack of pulleys	and the lack of expansion of pulleys

2**. Waltham and Fookes model:** The basis of that classification has been considered the maturity level and karst development rate. According to this classification, the karst forms created in carbonate rocks can range from the young stage to the full old stage or the most developed stage.

It is widely used in road construction, construction, urban development and land preparation activities and is based on the type and presence of dolines in a region.

3**. Komatina model:** The classification of Komatina is based on the main geological characteristics and most importantly, lithological and structural, topographical and hydrological characteristics. The type of karst is determined by considering the geological characteristics of the basin. In this classification, karsts are divided into the following two categories (Komatina, 1975):

A- flat karst or platform: In this type of karst, the layers are low-sloping or horizontal, and due to the spread of rocks containing marl materials and weather conditions, the process of karstization in them is less widespread.

B- Synclinal Karst: This type of karst is spread in areas with many folds and ruptures.

Large Synclines that consist of carbonate rocks are suitable areas for the dissolution and development of karst due to subsequent folds with active tectonics and favorable climate (Milanovich, 1981).

4. **Herak model:** In the classification of Herak, the influence of tectonic activities plays an important role in the classification of karsts.

Based on this, karsts are divided into two groups: inter-orogenic karsts (before orogeny) or epierogeny (including sheet or columnar, folded, basin and deep karsts) and epigenetic (including lenticular, folded, crushed karsts). and cumulative or collapsed and debris) are divided (Herak, 1977).

Badab Soort travertine spring area in Kiasar, Mazandaran of geology, most of its formations are limestone and in terms of weather conditions, its weather is semi-arid. The area of Badab Soort spring in cvjik classification considering that in terms of rock type, among the limestone layers, there are non-limestone impurity layers and other additional compounds such as iron, manganese and copper. And in terms of the face of stone and earth, it is a combination of lime with other formations and there is sparse vegetation and in terms of karst forms, they include microkarst, incomplete dolines and karns, except for transitional karst.

In the classification method of Waltham and Fookes, since the environment of the Badab Soort spring in the city of Kiasar is classified as temperate and mountainous, and this spring is located in the highlands and in terms of karst and geomorphic shapes, seams, cracks and small dolines can be seen and it lacks evolved forms of karst, it is placed in the young karst class or young stage. In the classification model of karst forms, Komatina Badab Soort spring is placed in the category of flat or platform karst.

And in the classification of Herak, which is based on the state of tectogenesis, according to the investigations of the geological map and landslide faults in the region and the earthquakes that occurred in recent years, the tectonics of the region is active and it is considered as part of karst orogeny.

Conclusion

According to the field surveys, geological and tectonic maps and the structure and lithology of the region and the identification of karst forms, based on the classification of cvijik, the karsts of this region are in the category of transitional karsts, based on the classification of Waltham and Fookes, in the category of the young karst, according to the classification of Komatina, was placed in the row of flat karsts and according to the classification of Harak, it was placed in the row of folded orogenic karsts. This classification revealed that the karst forms of the basin are often young and undeveloped, and the most important factor that accelerates them is the geological and lithological conditions.

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