2012 International Conference on Environmental, Biomedical and Biotechnology
IPCBEE vol.41 (2012) © (2012) IACSIT Press, Singapore

Investigation of the Relationship Between Tectonics and Karstification

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Abstract. Akhlamad basin is one of the Kashafroud sub-basins in northeast of Iran. In this area, Mozduran formation has formed a lot of Karstic features like Karrens, Karstic valleys, caves and springs. Introducing the Karstic forms and investigation of the relationship between tectonics and Karstification, were the aims of this project. The results of the present study could be used in water management and maintaining of karst aquifer systems. In this project, for finding the relationship between tectonics and Karstification, fractures orientations were studied in 5 stations and for each station rose diagram of fractures and faults orientations were plotted. The result of analysis of diagrams shows that in most cases, orientations of faults and fractures are the same and since these fractures are the origins of many Karstic features, tectonics has an important role in the genesis of Karstic features in this area.

Keywords: Karst, Tectonics, Joints, Akhlamad.

1. Introduction

Karst is a special topography that develops as a result of the dissolving action of water on soluble bedrock (usually limestone), which produces a landscape characterized by fluted and pitted rock surfaces, sinkholes, sinking streams, springs, subsurface drainage systems, and caves. The unique features and three-dimensional nature of karst landscapes result from a complex interplay between geology, climate, topography, hydrology, and biological factors over long time scales (BC ministry of forests, 2003:2). Karst covers approximately 12% of the earth's land surface and Karst aquifers are important water resources in many parts of the world. Across the world, sedimentary karstic formations constitute aquifers with important water reserves. It is estimated that 25% of the global population is supplied largely or entirely by groundwater from karst aquifers (Ford and Williams, 2007; Jaquet et al., 2004). Therefore identification and evaluation of karstic features and investigation of karstification situations have an important role in preparing water and maintaining of these resources for future needs.

There are a lot of studies about karst features in the world and in fact man was intrigued with karst, particularly cave development, long before the word karst came into use (Lamoreaux and Lamoreaux, 1998). In study location (Akhlamad basin) Asadi (2000) studied the karst geomorphology and provided a model for evaluating of karstic features and estimation of erosion in similar karstic areas and about the relationship between karst and tectonics, Ahmadipour in hydrological investigating of Aleshtar basin in west of Iran showed that ground water flow is affected by tectonic structures and all of karstic springs in the area are located in cross location of lineaments (Ahmadipour, 1998)

2. Study Area

Akhlamad basin is located in northern slope of Binaloud Mountains. The geographical coordinates are beween 36° 30' 41" to 36° 39' 53" N and 58° 29' 27" to 59° 2' 28" E. Akhlamad river that originated from high altitude of Binaloud Mountains, drains a basin with the area of 132 square kilometres and joins to

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Kashafroud. Concerning the structural and topographical properties of different regions of these mountains, more than of 69 different basins are created in its northern slopes and akhlamad basin is one of the most important of them (figure 1).

Geological formations in this basin belong to Mesozoic Era and investigations in micro fossils have shown that limestones of Akhlamad were deposited during upper Jurassic (Lessani, 1997).

Carbonate rocks entitled upper Jurassic (JL) or Mozduran formation_consist of limestone, dolomite, Marl and evaporative depositions_is the most important rock unit and has wide distribution in the basin. This formation has caused different karstic features and has an important role in storage and direction of water, so most of large springs of the region are originated from this formation. Chamanbid formation that includes clay limestone, carbonate shale, and fine grain black marl limestones and marl, is usually seen in north-western of Akhlamd village and thickness of carbonate layers is about 8 meters. These formations are located on the Palaeozoic depositions and act as blocking layers for underground water.

Tectonics_ late Cimmerian movements_ led to renewal of old faults activities. There is a dominant fault system in Akhlamad basin (with a trend, N35E) that has formed many joints and fractures parallel to layers. The effects of this system are summarized as follow: creation of slip surface of fault, existence of numerous joints and fractures in the basin, change in direction of carbonate layers in formations, sigmoidal fractures filled with silica and calcite, and degradation of Mozduran formation layers.

Highest altitude in the basin is 2550 meters and the lowest is 1280 m and mean altitude is 1996 m. Also the slope of the river channel is about 23 degrees.

3. Karstification

Investigations show that the type of karst in Akhlamad is between holokarst and merokarst. This type of karst is mainly found in layers of limestones surrounded by impermeable deposits with low solubility. Underground forms of karst are developed properly but karstic poljes are not presented.

3.1. Karstic Forms in the Basin

Karrens are minor forms of karst due to solution of rock on its surface and are typical forms of karsts that present the best indication of karstification in the basin. Types of karrens in the basin include: 1- rillenkarren that are more common in northern parts and their length is between 10 to 60 centimetres. 2- Tectonic karrens or tectonic joints and fractures that are widen by solution. Their length reaches to some meters and they are common in lime plateaus of upper basin. 3- Rain karrens in the form of pits with 1 to 3 centimetres in diameter.

Another form of karst in this area is doline. Dolins (sinkholes) are one of the most characteristic forms of kast morphology in the region and where 2 faults cross each other is the best place for karstic process especially creation of dolines. The mechanisms of doline formation involve natural processes of erosion (Freind, 2002) or gradual removal of slightly soluble bedrock (such as limestone) by percolating water, the collapse of a cave roof, or a lowering of the water table. Sinkholes are often created through the process of suffosion. Usually the long axis of dolines is parallel to faults and a series of dolines are found along them. In Akhlamad basin dolines with respect of local arrangement and distribution are divided into two groups: dispersive and collective dolines.

Karstic valleys are other forms of karst topography and are divided into 2 main groups: dry valleys and canyon valleys. Canyons are more common types and their walls are consisting of resistant and contiguous rocks with sharp slopes that usually reach to the valley floor with a knick. Cross sections of these valleys are almost fixed and no phenomena can cause irregularity in valleys except semi terracettes remained from old cave roofs (Baghban, 2004). Because of resistance and impermeability of walls, erosion agents couldn't have effective activities on them except in the valley floor. Tectonic activities have caused joint and fractured systems and water can transfer to the deeper parts of rocks through these joints. Dry valleys don't have any permanent or temporary flows. Their cross section is V shaped and in comparison with canyon valleys, since these valleys are formed in layered limestones, they have little symmetry. Solution pits are round-bottomed or tapering forms that are circular, elliptical or irregular in plan view. Diameters greater than 1 to 2 meters

are rare (Ford and Williams, 2007). They are mainly parallel to joints and joints are the origin of solution pits. In some pits, clay and deposits indicate the presence of water and deposition. Pits density depends on the altitude and lithology.

3.2. Investigation of the Relationship Between Tectonics and Karstification

The present study is the first research about the relationship between tectonics and karstification in Akhlamad basin. The role of tectonics in karstifiation is that tectonics cause empty spaces in the forms of joints and fractures and presence of water in this joints and micro faults forms the karstic features.

In order to study of the relationship between tectonics and karstification in the basin, 5 stations were selected for evaluations (figure 2). In these stations most of joints are systematic and are resulted from tectonics. In fractured fault zones in two sides of akhlamad fault, especially in western margin, there are a lot of non-systematic joints that cut the rocks in the forms of rhombus and trapezoids and therefore permeability of rocks are extremely increased which leads the penetration of large amounts of water in to the rocks and feed the hard-rock aquifer of the region.

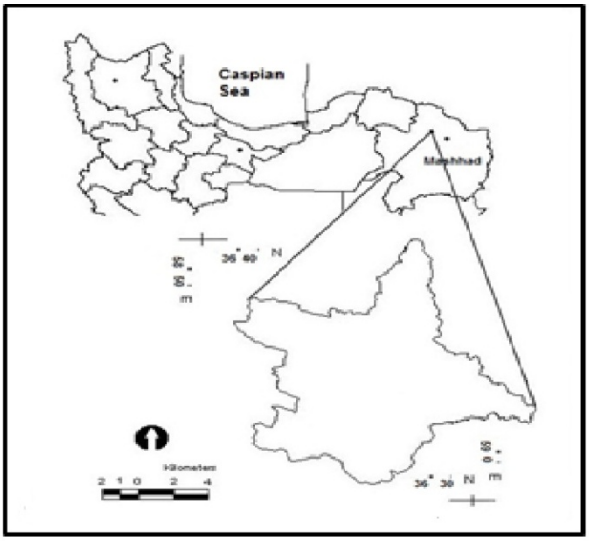

Fig.1: Location map of Akhlamad basin

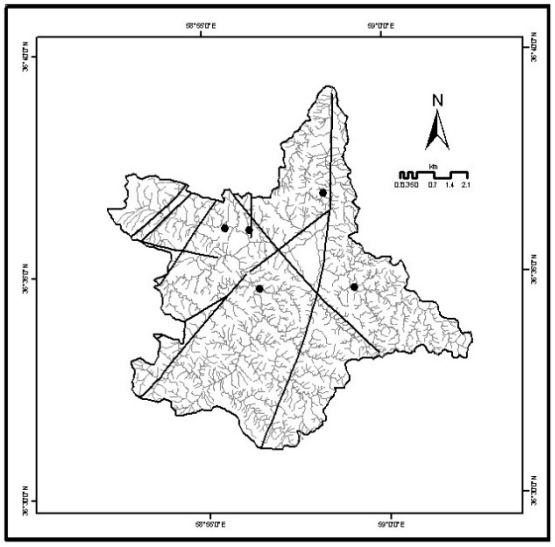

Fig.2: location of the 5 stations

- Station 1

This station is located between Ashilagh and akhlamad mountains. The coordinates of this station are 36° 37' 12" N and 58° 57' 53" E. The altitude of the location is 1380 m above sea level. In this station, azimuth of 115 joints were measured. These joints are in massive limestones of Mozduran formations. Azimuths of 2 faults around this station were measured and also the direction of main channels was compared with other data and then rose diagrams for them were plotted. Figure 3(1) shows that the dominant orientations of joints in this station are justified with fault orientations. And main channel direction is parallel to main direction of joints and akhlamad fault and this shows that the origin of this valley is akhlamad fault.

- Station 2

The coordinates of this station are 36° 35° 3° N and 58° 58' 3" E, in 1680 m above the sea level. In this station azimuths of 106 joints were measured. Orientations of near faults were determined and compared with main channels orientations. Rose diagram also prepared and as can be seen in figure 2 joints and faults are justified with a little difference, in the other words, dominant orientation of joints (0 to 20 NW) indicates that since distances from 2 faults are the same, joints are affected by both of them (figure 3 (2)).

- Station 3

This station is located between first and second fall of Akhlamad in 36° 36' 20" N and 58° 55' 35" E. 103 joints in massive limestone of Mozduran formation were evaluated and also azimuths of 2 faults near this

station were defined and rose diagrams were plotted. Results as can be seen in figure 3 show that dominant orientations of joints is justified with faults directions. Most effects are related to the larger fault and relationship between tectonics and karstification is very clear in this station and also channels are completely in the same directions as faults orientations (figure 3 (3)).

- Station 4

The position of station 4 is 36° 36' 21" N, 58° 54' 48" E, with the altitude of 1911 m above sea level. This station is located in a canyon with very steep walls. Azimuths of 115 joints in layered limestone of mozduran formation were measured. Results from rose diagram indicate that joints have different orientations but two main orientations of joints are parallel with two faults directions but main channels don't have the same orientations as faults (figure 3 (4)). The reason can be one of the followings: layered formation affects the directions or different orientations of faults complicated the joints and channels directions.

- Station 5

Station 5 is located in 36° 34' 48" N and 58° 55' 51" E. The altitude from sea level is 1804 m and 109 joints in massive limestone of Mozduran formation were evaluated. Like other stations azimuth of near faults were defined too and the rose diagrams show that dominant orientations of joints are justified with one of the faults directions (figure 3 (5)).

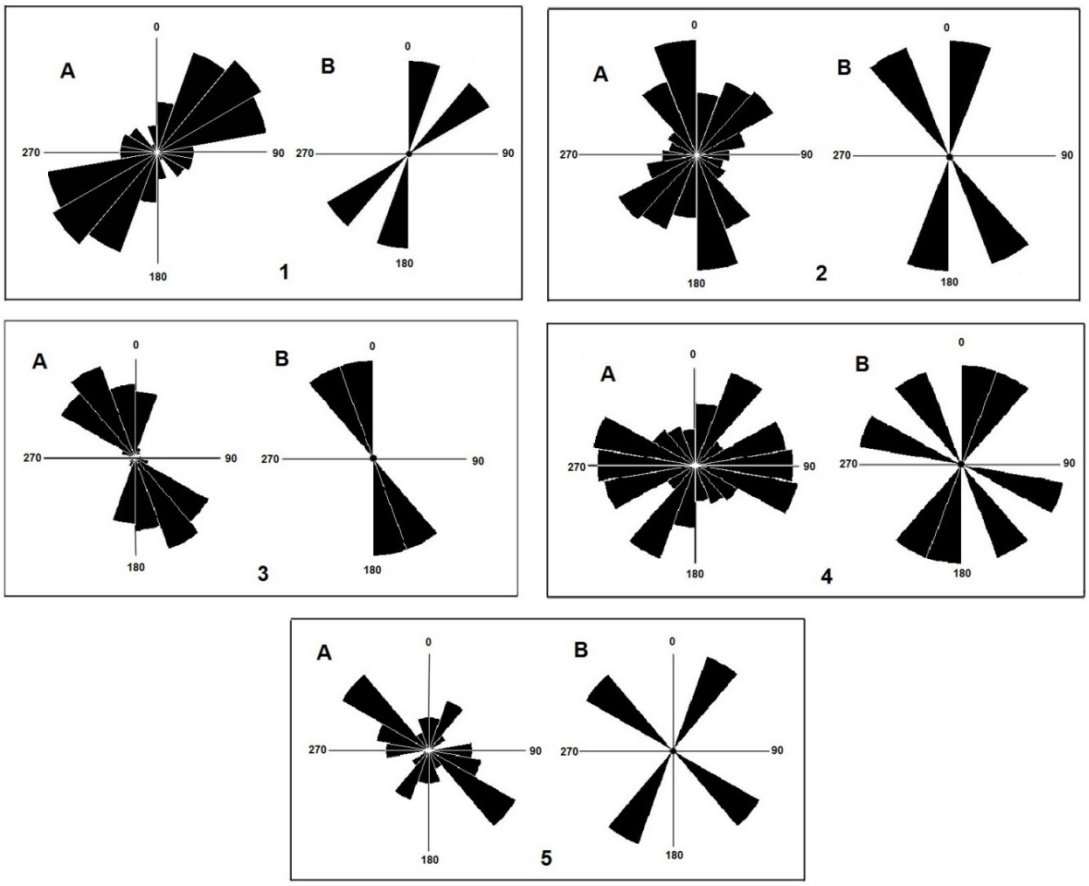

Fig. 3:

(1) - Rose diagram for joints (A) and faults (B) orientations for station 1
(2) - Rose diagram for joints (A) and faults (B) orientations for station 2
(3) -Rose diagram for joints (A) and faults (B) orientations for station 3
(4) - Rose diagram for joints (A) and faults (B) orientations for station 4
(5) - Rose diagram for joints (A) and faults (B) orientations for station 5

4. Results and Discussion

Results from 5 stations show that in 4 stations located in massive limestone, directions of joints are roughly in complete justification with angles of faults but in layered limestone this accordance is not apparent and leads to this result that in massive limestone, joints and faults orientations are more likely the same than in layered limestone.

Also investigations of relations between tectonics and karst features indicate that almost all of pits in the basin are along joint systems and formed in the middle of joints and therefore these joints are the origins of the soluble pits. Furthermore the main valleys in the area especially akhlamad Valley and other branches are following the main fault direction. These valleys are widening by karstification and during a long time they have been formed as a canyon. Subsidiary valleys especially in mass limestones are in the direction of tectonics activities and thus it could be resulted in meaningful relationship between karstification and tectonics in this area.

Since fractures and pits have an important role in penetration of snow and rain water and natural feeding of hard rock aquifer of this region, tectonics could be taken into account as one of the factors which affect the ground water supplies in karstic areas.

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