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Introducing tourist land attractions of Aghajari Formation in Genaveh, South Dezful Basin, Iran

Mohsen Liaghat[a*], Mohammad Reza Nourainezhad[a], Mohammad Hossein Adabi[a]

[a] Department of Sedimentary Basin and Petroleum, Faculty of Earth Sciences, Shahid Beheshti University, Iran

ABSTRACT

Iran is one of the five countries in the world with the highest climatic diversity, in the word, in which the existing tourist and natural attractions have a high potential for the development of non-oil revenues. Accordingly, the southern regions of Iran with prominent features in formations belong to different geological periods. Differences in sedimentological features of these formations, especially differences in lithology, have led to the formation of extraordinary geomorphological features that are of great importance in attracting tourism. In these areas, especially the Zagros sedimentary basin, which has expanded with a northwest-southeast trend, various geomorphological structures that are important in the growth of the tourism industry are abundant and pristine and unknown. Genaveh port city of Bushehr province in Zagros basin located in Dezful basin with various Neogene formations and sediments (especially Aghajari Formation) and Quaternary, has special topographic and morphological structures such as mountain ranges, hot springs, sea, etc. There is a high potential of tourist attractions that have remained unknown until now. Most of the studied geomorphological features are located in Aghajari detrital deposits (molasses) that the placement of resistant (sandstone) and unstable sequences (marl and siltstone) leads to the formation of special geomorphological structures in this region. This study examines and introduces the pristine, unknown and natural geotourism landscapes of this region. These diverse geological features, along with rich cultural heritage, have provided the basis for tourism development and the creation of geoparks, which in turn are effective in the development of regional economy and rural areas.

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*corresponding author.
E-mail address:
Liaghat.mohsen@yahoo.com
(M. Liaghat)

1. Introduction

At present, Iran's main economy is based on the sale of petroleum products and according to the Fourth Development Plan until 2025, it will attract more than 20 million global tourists annually (Mehrpress 2012). If this happens, the tourism industry will be an important economic activity in Iran and will be an important source of income for the country, especially in rural and deprived areas. According to the statistics provided, Iran has an area of 1873959 thousand square kilometers, which is located in the west of Asia, neighboring Afghanistan and Pakistan in the east, Turkmenistan, Armenia and Azerbaijan in the north, Turkey and Iraq in the west. It is also bordered by the Caspian Sea to the north and the Persian Gulf and the Sea of Oman to the south (Figure A1). Today, the tourism industry has played an important role in the economies of countries (Yazdi et al., 2013), which is the most important type of tourism industry, especially in Iran, religious and holy places. In recent years, economic tourism has gradually developed in some areas of Iran, including Qeshm Island, Ali Sadr Cave in Hamedan (Mehdipour Ghazi et al., 2012), and Sarein hot springs, Lut Desert, signs of large landslides in Seymareh, a large freshwater lake at the top of Mount Sabalan (Sadry, 2009).

In addition to the exceptional ancient history of Iran, its location in terms of geological features and diversity of geological landscapes provides a wide range of natural tourism activities (Mehdipour Ghazi et al., 2012). According to published statistics, Iran consists of 55% mountains and 45% sea and non-mountainous areas (plateaus, deserts, saline lands, playa and lakes) (Amrikazemi, 2009). The prominent features of this country are two important orogenic belts that include the east-west Alborz mountain range and the high mountains of Zagros with northwest-southeast trend (Figure 1A). With a climate of 4 seasons and climatic diversity with different sedimentary characteristics, this country includes different geographical and natural phenomena with different habitats. Since the tourist attractions of the land can play a key role in the development of more tourist attraction, so in this study to present the potential for the development of tourist land in the Dezful Embayment of Iran (Figure 1A) and in the city of Genaveh briefly and has been introduced and reviewed on geosites.

2. Material and Methods

This study is based on descriptive method and field observations. Introducing this area as a pristine area in terms of tourist land. The study area is located in Dezful Embayment and the port city of Genaveh, which is accessible via the Bushehr-Genaveh road. This study is based on surveys and field studies of Aghajari Formation in areas with suitable stratigraphic outcrops and outcrops.

3. Results and discussion

3.1. Potential of tourism development in Iran

Tourism land was first introduced in 2000 by Nabavi (2000) in Iran, which was later continued by various researchers in the form of research and conferences focusing on tourism land and geopark. For example, Qeshm Island should be introduced as the first geopark in Iran and Middle East, which is a member of Global Geopark network in 2006 to 2012 (Qeshm Global Geopark 2012). Today, the country's geological organization is working with tourism organization and environment organization to create geoparks in the country (Amirkazemi, 2009). In Iran, different areas have geopark potential. Based on the studies of other researchers, various geoparks have been introduced and described, including the geoparks of Lut desert, Damavand, Sabalan, Makran, Sahand, Kalat, Kuhdasht, Ashtaran Kooh, Mako, Hormoz, etc. In the southern regions of Iran, especially in the Zagros sedimentary basin, a great variety of formations with different lithologies provide favorable conditions for creating a geopark and attracting tourists, and among these, the study area of Genaveh in Bushehr province has the potential for creating a geopark.

3.2. Geological features

The folded belt of Zagros has expanded by about 1800 km as a result of the collision between the Arabian plate and the Iranian plate between Iraq and Iran (Stöcklin, 1974; Berberian and King 1981) (Figure 1A). In southwestern Iran, Zagros Folded Belt is divided into a structural and stratigraphic zone from southwest to northeast, including Foreland, Simple Folded Zone, and imbricate zone (Falcon, 1974; Sepehr and Cosgrove, 2004;). The Dezful Embayment has developed as a structural embayment in front of a simple folded zone and its subsidence is related to the Fordeep expansion in Zagros Fold-Thrust Belt (ZFTB) (Vatandoust and Saein, 2018). Balaroud and Kazerun faults are located on the west and east sides of the basin, respectively (Sepehr and Cosgrove, 2005; Abdollahie Fard et al., 2006). In this sedimentary basin, Cenozoic deposits including Pabdeh, Asmari, Gachsaran, Mishan, Aghajari and Bakhtiari formations (Figure 1B). Upper Miocene-Pliocene Molasses sediments of the Aghajari Formation, which is due to the last orogenic phase in Zagros basin, are about 3000 meters thick (Motiei 1994). The sediments of this formation are mainly composed of sandstone, marl and siltstone and are spread throughout the folded Zagros. Based on field studies, various morphological features have been studied. In this article, field surveys and study of the structural features of these formation were carried out in Genaveh. A variety of geological structures were identified for the development of geoparks and geotourism, which are briefly introduced below.

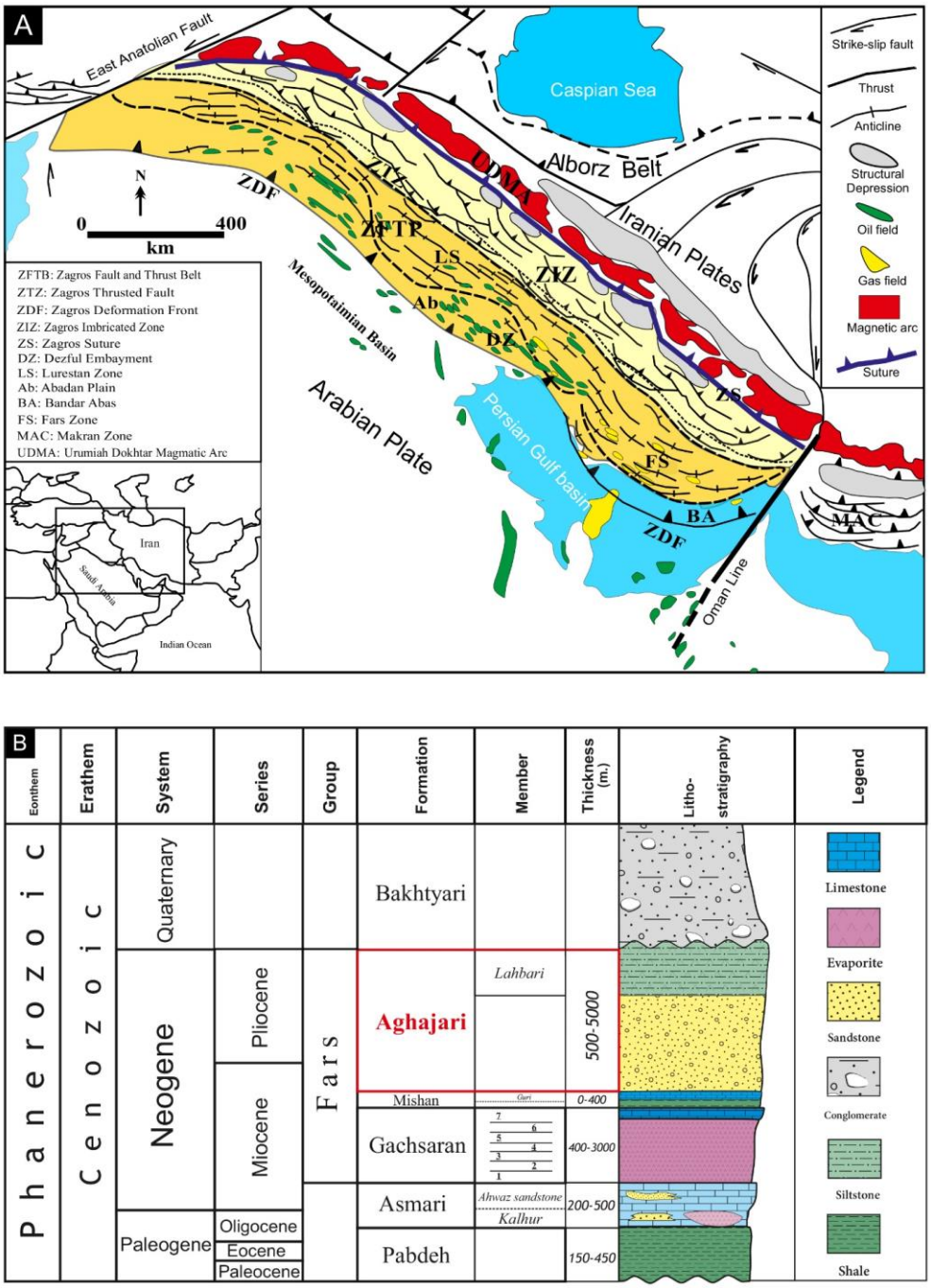

Fig. 1. A) Location of Zagros Mountains and Dezful Embayment in Iran and neighboring countries (adapted with changes from Alavi, 2004), B) Stratigraphic column of Cenozoic sediments in Dezful Embayment and location of the Aghajari Formation in it (based on Colman-Sadd studies, 1978).

3.2.1. Geological structures studied in the region

One of the most important prominent features with wide spatial distribution in the study area is fractures in resistant sandstone sediments of the Aghajari Formation (Figure 2A). Also, one of the unique and attractive landscapes in the study area is the Martian/miniature mountains with a special structure and shape, which due to the of erosion and condition of erosion and special sedimentary features, give unique shapes in the area (Figure 2B). On the other hand, the rotation of colored marl layers in the area has caused a beautiful landscape in the sediments of this area (Figure 2C). The alternation of thick layers of sandstone, marl and siltstone and the difference in the strength of these sandstone sequences have prevented the erosion of their lower marl layers, creating special structures called Kalut, which are widely used in southern regions of the study are (Figures 2D and E). Another interesting feature on the manual sample scale is the

presence of secondary gypsum colored crystals that are found secondarily between the layers of Aghajari sandstone (Figure 3A). In the sandstones of this formation in some areas, the presence of differential erosion has caused the phenomenon of karstification in these sandstones (Figure 3B). In the study area, the alternation of colored layers in anhydrite and marl sediments in the Aghajari Formation sediments has led to the creation of unique features in the area (Figure 3C).

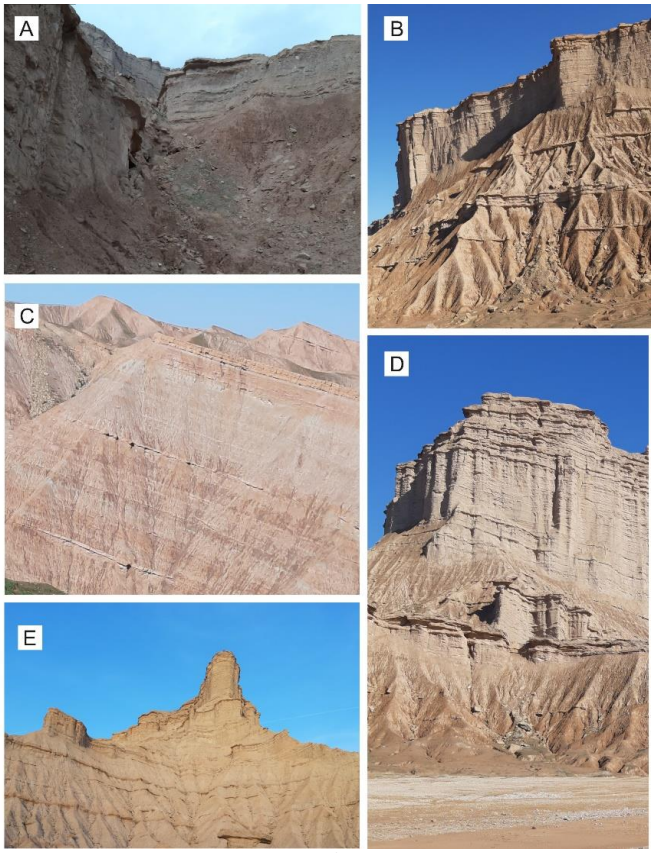

Fig. 2. Unique landscapes in marl, siltstone and sandstone sediments of the Aghajari Formation in the study area. A) Fractures and faults in sandstone sediments of the Aghajari Formation, B) Martian/miniature mountains in marl sediments of the Aghajari Formation which have dendritic grooves due to high erosion, C) Marl sediments of Aghajari Formation with alternating layers are seen due to color difference, D and E) Clout-like structures that are prominent landscapes in the area due to differences in sediment resistance (sand to marl).

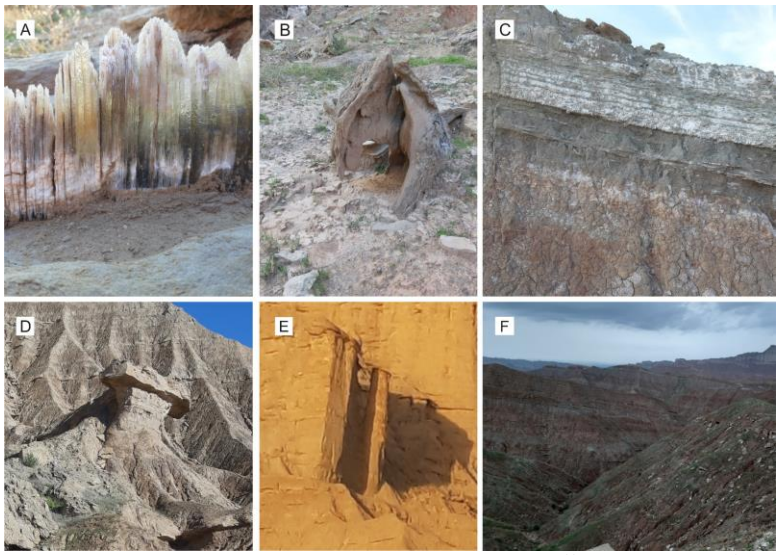

Fig. 3. A) Secondary gypsum crystals that are secondary to in Aghajari marls, B) Differential erosion of misplaced sandstones of the Aghajari Formation which is also karstic, C) Alternation of marl and colored gypsum layers. D) Fungal structures due to the placement of loose marl sediments with low strength below and resistant sandstone sediments at the top. E) The Hoodoo, which is a column with a height of approximately 13 meters in the sandstones due to the erosion of surrounding sediments. F) Extensive valleys in the marl units of the Aghajari Formation.

Badlands are structures that are formed by severe and deep erosion in areas with loose sediments and often in semi-arid regions (Howard, 1997), and are abundant in northern regions of the study area. In this type of geological features, marl sediments alternate with siltstone deposits (Figure 3C). Different lithology and erosion of the layers in some areas of the study area have led to the formation of mushroom-shaped structures that have given a special perspective to the areas containing these features (Figure 3D). Hoodoo chimneys, which are columnar / fungal-like forms of sediments stacked on top of each other, and their characteristics have caused sediments with different characteristics to be seen in the sedimentary sequence of these structures, then, soft sediments with high erosion are located in the lower part and then hard sediments with lower erosion are located in the upper part of the sequence (Ekren, 1988). These structures are located in the access road to the area and sometimes some of them include up to 13 meters high (Figure 3 E). One of the most prominent and characteristic geomorphological features in the study area is the valleys, which are widely spread due to the marl lithology and climate of the region (Figure 3 F). Other landscapes in the Kalut / Yardang region (Turkmen equivalent) were identified based on field studies: 1- Kalut-like forms similar to the citadels of ancient Iran (Figure 4 A), as well as clout-like shapes similar to those of ancient China (Figure 4B). These geomorphological structures are observed on a large scale in the northern part of the study area. Badlands are formed as a result of deep erosion in areas including loose sediments and often in semi-arid regions (Howard, 1997), which are abundant in the northern regions of the study area. In this type of geological feature, the marl sediments alternate with siltstone deposits (Figure 4C). Due to the fact that Genaveh is located near the Persian Gulf, the beaches of this city with cross-bedding sands are among the existing attractions (Figure 5A). The role of tectonic forces in the study area can be identified by existing fractures and faults. These fractures and faults have led to the formation of springs by movement layers and sediments in areas with suitable aquifers. Due to the Presence of the Gachsaran Formation in the lower sequences due to the thermal reaction caused by the conversion of gypsum to anhydrite, sulfur springs have been developed as hot springs (Figure 5B). which if the area is introduced as a suitable place. Geotourism can be used to treat diseases in the form of hydrotherapy. The hot water flow of springs and its effect on sediments around streams has led to the formation of colored sequences in the areas where these hot springs are flowing (Figure 5C). Lithological diversity of sandstones and marls of the Aghajari Formation due to the difference in their erodibility has created a wide variety of landscapes of rocks and sediments in the study area (Figure 5D). Other prominent features in the region are the existence of dissolution features due to past karstification along with the process of dissolution and erosion of the present in the marl and sandy sediments located in the valleys or their margins, which are abundant throughout the study area. These features are visible with proper access (Figure 6A to C).

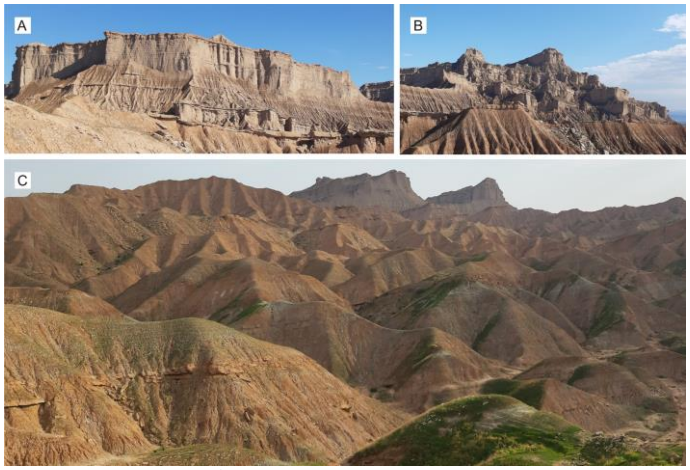

Fig. 4. A and B) Study clumps in sandstone units of the Aghajari Formation, C) Large badlands in marl colored sequences with high erodibility in the Aghajari Formation.

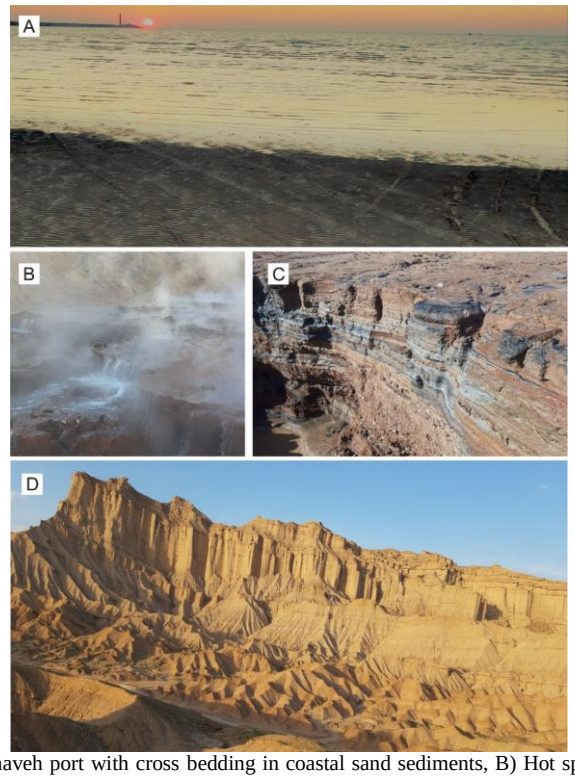

Fig. 5. A) Persian Gulf coast in Genaveh port with cross bedding in coastal sand sediments, B) Hot springs in the region which are due to gypsum to anhydrite conversion in the Gachsaran Formation and due to fracture process in the ground, C) Dark and light sequences around hot springs due to the effect of sulfur in hot springs, D) Differences in the erodibility of sandstones and marls of the Aghajari Formation causing rocks and precipices extensive structures have been formed in this formation.

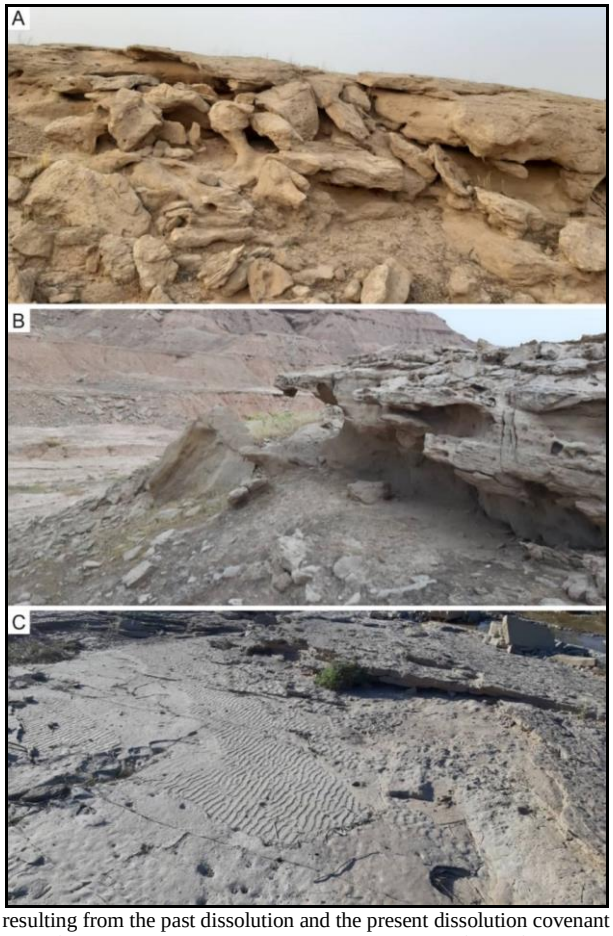

Fig. 6. (A to C) Structural features resulting from the past dissolution and the present dissolution covenant along the canals and river banks in the area. which can be seen in Figure C of the ripple marks in the sediments at the time of their formation are also present.

4. Conclusion

Land for tourism is rapidly being considered as a new and interesting way of tourism, due to its geological and geomorphological attractions. Iran, with its vast and unique natural environment, has the potential to become an ideal global tourism destination. Despite the various attractions in Iran, tourism is not well developed, which was affected by the 8-year war and the Political situation in the Middle East. One of the unknown places of tourist land in the south of Iran and in Dezful's embayment, which has remained pristine until now, is the sediments of the Aghajari Formation, which has many tourist attractions. Due to easy access and pristine landscapes, the natural attractions of the study area have a high potential to improve the living conditions of the people there, which requires proper management. The most important studied landscapes are erosion, faults, Martian mountains, gypsum crystals, differential erosion in sandstones, badlands, hoodoos, clout / yards, Persian Gulf sandy beaches and springs. The creation of a geopark in this area can legally be an effective tool to show the preservation of the geology of natural features in Genaveh. The geopark in question is important in terms of the richness of geological attractions that due to the different and diverse geological features in the study area, more research is needed, using existing natural features without large investment and minimal damage to the environment. For the successful and sustainable development of tourism in this area, geological and geomorphological surveys and ecological analyzes are important. In order to introduce this area as a geopark, the integrated management of various organizations such as the governor's office, the cultural heritage organization and the assistance of the Ministry of Roads and Urban Development are needed to exploit and better understand it. The participation of local and indigenous people in the area is also needed as a guide to introduce the attractions to tourists.

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