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ORIGINAL ARTICLE

Geological Features for Geotourism in the Western Part of Sahand Volcano, NW Iran

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Abstract The NW part of Iran is particularly rich in geological features and formations defining its geological heritage, and attracts tourists worldwide. Most of NW Iran is located in a volcanic arc zone of Cenozoic age, including the Quaternary. The subduction of the Neo-Tethys ocean floor beneath the central block of Iran during the Cenozoic resulted in the formation of this zone. This geological setting has provided NW Iran with diverse natural geological features of high significance. Some of the main geological features include the Sahand Volcano, the Urmia Lake, salt deposits, travertine deposits, springs, limestone caves, tectonic structures and Cenozoic vertebrate fossils. This exceptional geodiversity together with the rich cultural heritage provides a valuable base for geotourism and geopark development, which is needed to diversify local economy and strengthen rural development. However, for tourism to be successful and sustainable, the planning and management must be based on up-to-date knowledge and understanding of the tourism resources, as well as on a holistic overview of the many facets of the geological and cultural heritage.

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Introduction

Currently the economy of Iran is mostly dependent on petroleum. It is however proposed that by 2025 Iran may annually attract up to 20 million of the world's tourists (e.g., Mehrpress 2012). If this becomes a reality, tourism will be an important economic activity and source of income for Iran, especially in many of the rural regions. Today, however, tourism plays an insignificant role in the country's economy (Sreekumar and Parayil 2002). Hitherto, the most dominating type of tourism in Iran has been religious tourism. During the last decade, ecotourism and historical tourism has gradually been developed in some parts of the country. Iran has a great potential to develop large-scale tourism. Besides exceptional history, the country possesses significant geology and diverse landscapes, thus providing a base for a wide range of nature tourism activities.

Iran has a land area of 1,873,959 thousand km^2. Located in the Middle West and Southwest of the Asian continent, it share borders with Pakistan and Afghanistan to the east, Turkey and Iraq to the west, and Azerbaijan, Armenia, and Turkmenistan to the north. In the south, Iran reaches the Oman Sea and Persian Gulf (Fig. 1). About 55 % of the country is mountainous and the remaining 45 % is comprised of plateaus, plains, deserts, saline lands, ponds, and lakes. Two striking mountain ranges characterizes the country; Alborz to the north and Zeroes to the west. Most of Iranian deserts are located in between those mountain ranges (Fig. 1).

Due to the relatively large land size and the country's diverse climates, Iran holds very diverse landscapes, including various geographical and natural phenomena and diverse habitats. Especially ponds and lakes, brittle shear

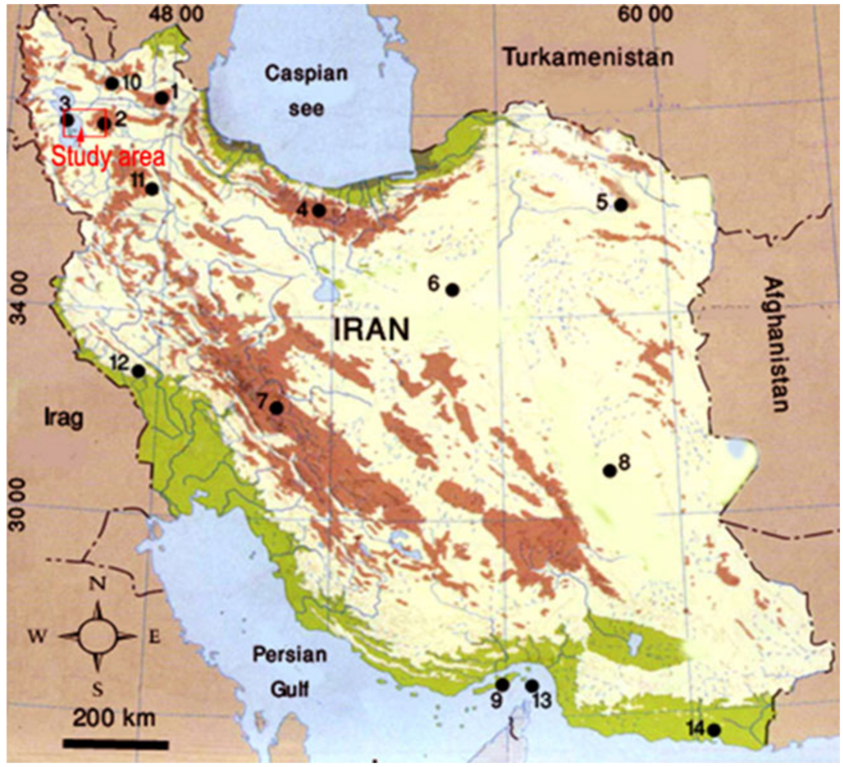

Fig. 1 Topographical map of Iran. *1* Sabalan, Ardabil, Sarein, *2* Sahand, *3* Urmia Lake, *4* Alborz, *5* Mashahad town, *6* Dashte-Kavir Desert, *7* Zagros, *8* Kavir-e-Lut, *9* Qeshm Island, *10* Arasbaran, *11* Hamadan, *12* Seimareh, *13* Hormoz Strait, *14* Chabahar

zones and thrust faults, ophiolitic complexes being remains of the Tethys ocean, sandy pyramids, rocky shores, and various mines and islands, imply great potential for geotourism development. So far, geotourism has been developed in only a few sites in Iran, such as on Qeshm Island, in Ali Sadr cave in Hamadan and Ardabil, and at the thermal springs of Sarein (cf. Fig. 1). Ghasemi Yalgouz-Agaj et al. (2010) also point out that Iran has numerous other interesting geological phenomena that would make an ideal base to further develop tourism based on the country's geological heritage. These phenomena include, e.g., the high sand hills in Kavir-e Lut (the hottest place on earth), the traces of the great landslides in Seimareh (Ilam province), and the high fresh-water lake at the summit of Sabalan Mountain. Moreover, over 300 spas can be found all over the country, including the world's second hottest—Geinarja.

To attract more tourists to Iran, it is of vital importance to develop more diverse tourism products. Geotourism can play a key role in such development by utilizing the country's valuable and vast geological features and natural phenomena. Some of Iran's most interesting geological features are located in the NW part of the country. These include two of the largest and most recent Iranian volcanoes (i.e., Sahand and Sabalan) and the world's second largest salt lake (i.e., Lake Urmia; Figs. 1 and 2). This paper aims to assess the potential for geotourism development in NW Iran by reviewing the geosites inventories in this region.

Geotourism and Geopark

Concepts and Definitions

Geotourism and geopark are among the youngest concepts within tourism. Both concepts have however grown fast during the past decade and become relatively well known. One of the most recent definitions is from Newsome and Dowling (2010, p. 3) defining geotourism as a form of natural area tourism that specifically focuses on landscape and geology. It promotes tourism to geosites and the conservation of geodiversity and understanding of Earth sciences through appreciation and learning. This is achieved through independent visits to geological features, use of geo-trails and viewpoints, guided tours, geo-activities, and patronage of geosite visitor centers. According to Dowling (2009, 2011), geotourism can occur in a range of environments, from natural and wild to built and planned. Such tourism is simply based on geoheritage conservation through appropriate sustainability measures. Dowling stresses that the key aspect of geotourism is that it involves all of the wider aspects of tourism activity such as transport, access, accommodation, services, planning, and management. Thus, geotourism is a positive contributor both for rural development as well as increasing the tourism sector in general. Geotourism is however most importantly a sustainable tourism activity and has as such contributed more economically than other tourism to local people (Dowling and Newsome 2006).

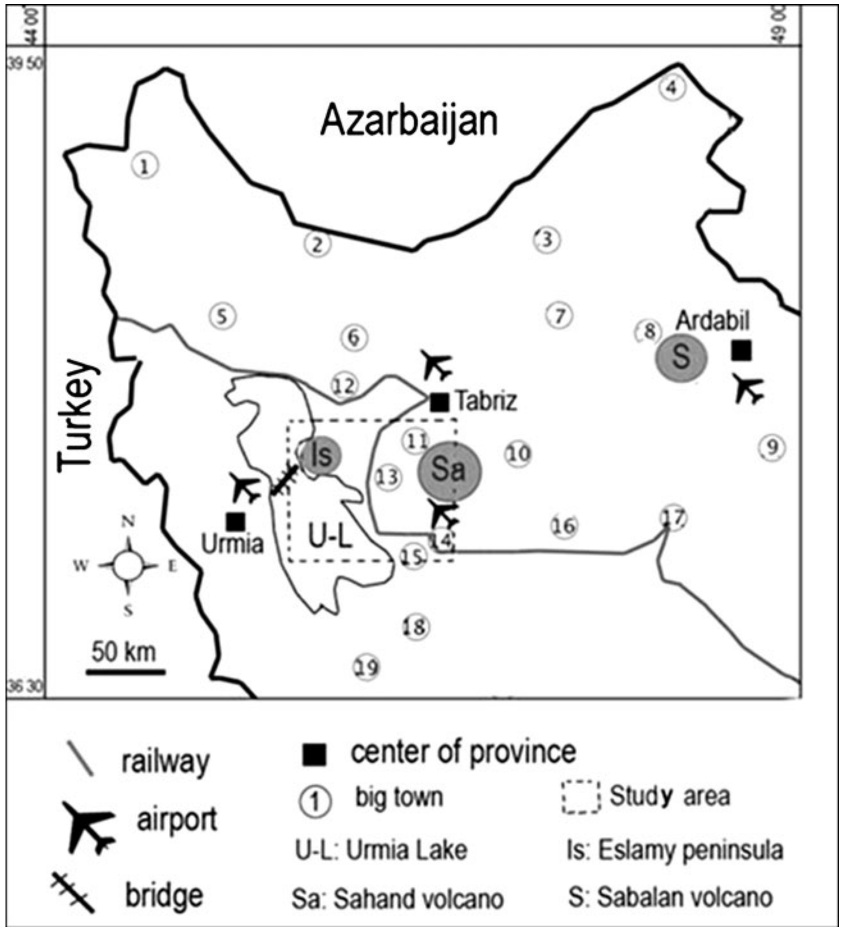

Fig. 2 Location of study area in NW Iran. Study area situated between Urmia Lake and Sahand Volcano and has access to the arirport and railway. *1* Mako, *2* Jolfa, *3* Kalebar, *4* Pars Abad, *5* Khoy, *6* Marand, *7* Ahar, *8* Meshkinshahr, *9* Khalkal, *10* Bostan Abad, *11* Osku, *12* Shabestar, *13* Azarshahr, *14* Maraghe, *15* Bonab, *16* Hashtrod, *17* Meyane, *18* Meyandoab, *19* Mahabad

Geopark is a territory with a particular geological heritage of international significance, but also with archaeological, ecological, economical, historical, and cultural significance. In a geopark, all these sites should be linked in a sustainable territorial development strategy (e.g., Mckeever et al. (2010; Cimermanova 2010). Thus, the promotion of sustainable development is a major task in the geopark ideology. According to Mckeever et al. (2010), a geopark must have clearly defined boundaries and a sufficient area to allow for true territorial economic development, primarily through tourism. Geological sites must further be of international importance in terms of their scientific quality, rarity, aesthetic appeal, and educational value. A geopark achieves its goal through a three-pronged approach, viz. conservation, education, and tourism. By conservation, a geopark seeks to conserve significant geological features, and explore and demonstrate methods for excellence in conservation. Through education a geopark organizes activities and provides logistic support to communicate geo-scientific knowledge and environmental concepts to the public through various modes. Finally, geopark stimulates economic activity and sustainable development through geotourism and most importantly encourages participation of the locals in creation of enterprises and cottage industries involved in geotourism and geo-products as well as tourism management and planning. The Global Geoparks Network (GGN) is an international, non-governmental, nonprofit, and voluntary network under the auspices of UNESCO, operating since 2004. Its mission is to influence, encourage, and assist local societies worldwide to conserve the integrity and diversity of abiotic and biotic nature, also to ensure sustainable use of natural resources as well as to support economic and cultural development of local communities. The GGN seeks to enhance the value of territories set under geopark and at the same time creating employment and promoting regional and local economic development (Global Geoparks Network 2012).

Potential for Geotourism Development in Iran

Geotourism was first introduced in Iran in 2000 by Nabavi (2000). Nabavi's introduction was followed by several papers and symposiums focusing on geotourism and geoparks. The first geopark in Iran, Qeshm Island Geopark, was a member of the Global Geoparks Network (GGN) between 2006 and 2012 (Qeshm Global Geopark 2012). Qeshm Island is the first geopark in the Middle East and is still the only one in the area. Qeshm Island is an impressive island located in the Persian Gulf in the Hormoz Strait (cf. Fig. 1). A total of 8,000 tourists visited Qeshm geopark during the Norouz holidays (lasting from the 18th of March to the 3rd of April) in 2011 (Iran Cultural Heritage, Handcrafts and Tourism Organization 2011). In 2009, Amrikazemi wrote the first book focusing on geotourism potentials in Iran where he points out the most famous geological features in Iran (Amrikazemi 2009).

Today, the geological survey of Iran in cooperation with the Iranian Tourism Organization and the Iranian Department of Environment are working together in order to create more geoparks in the country (Amrikazemi 2009). Areas like Sabalan, Arasbaran (the area located between the towns of Jolfa and Kalebar is characterized by very impressive and dynamic natural and cultural features), and Sahand in NW Iran, and the Kaver-e-Lut in Central Iran and Charbahar in SE Iran are pointed out as the most important areas in Iran for establishing a new geopark (cf. Fig.1).

Geological Setting

The NW part of Iran belongs to the Iranian plateau that is a tectonically active region within the Alpine–Himalayan orogenic belt. It contains a number of continental fragments that have been welded together along a suture zone of oceanic character. The subduction of the Neo-Tethys ocean floor beneath Iran subsequently sutured Iran to Arabia and the following continental convergence influenced the geological evolution of Iran. Based on structural trends the Iranian plateau can be divided into six segments (Fig. 3): Zagros Orogenic Belt, Metamorphic zone of Sanandaj-Sirjan, Urmia-Dokhtar magmatic arc (UDMA), Central Iran, Alborz, and Eastern Iran. The largest part of NW Iran is located within the UDMA volcanic zone (cf. Fig. 3) which is characterized by rocks of Cenozoic age, including the Quaternary. Rocks of this zone have mainly calc-alkaline and adakitic composition (Omrani et al. 2008). The subduction of the Neo-Tethys ocean floor beneath the central block of Iran during the Cenozoic resulted in the formation of this volcanic zone. The subduction of the Neo-Tethys ocean floor beneath the central block of Iran started during the Mesozoic and ended in the Miocene. The Zagros thrust marks the subduction zone. The Mesozoic magmatic rocks in the Sanandaj-Sirjan metamorphic zone are mainly calc-alkaline, but the youngest volcanic rocks of the UDMA are adakitic in composition (Omrani et al. 2008). The Tabriz Fault, which formed during the Paleozoic, is located to the north.

The study area (i.e., western part of Sahand Volcano) is located south of the Tabriz Fault within the northern part of the Urmia-Dokhtar magmatic arc zone. The oldest rocks are Cambrian in age and occur as small patches, such as the Lalun, Mila, Ruteh, and Nesen Paleozoic formations formed by sandstone, limestone, dolomite, and quartz-arenite. Most of the contacts between the Paleozoic rocks are faulted. The Mesozoic rocks are mainly limestones in composition with intercalations of sandstones (Fig. 4). The Cenozoic rocks belong to the Sahand assemblage and the Eslamy Peninsular formation. The Sahand Volcano is a strato-volcano consisting of pyroclastics, tuffs, and lavas. The Sahand Volcano has 18 domes and has an areal extent of about 2,800 km^2. Moinvazery (2001) identified three distinct types of magma that erupted during three different periods: (a) calc-alkaline basaltic andesite and andesitic magma at 12–9 Ma, mostly occurring in the Germozegol of Azarshar; (b) calc-alkaline dacitic magma at 10–5 Ma, occurring as tuff or ignimbrite and occasionally as andesite in all parts of Sahand; and (c) alkaline andesitic and dacitic magma of Quaternary age occurring in the south of Azarshahr. Figure 5 shows two different lithological sections through the Sahand sequence in the Kandovan and Jaragil valleys. The Eslamy peninsula formation is a complex strato-volcano with a collapsed center, which is elevated due to later intrusions of subvolcanic masses with trachytic to syenitic composition. The composite cone consists of a sequence of leucite tephrite, tephrite, leucite basanite, basanite, and related pyroclastic rocks. Magmatic activities in the Eslamy peninsula began with potassic alkaline to ultrapotassic and basic, silica-under saturated shoshonitic intrusions, and were followed by intrusions of lamprophyric dykes and ended with acidic magmatism forming trachytic, microsyenitic, syenitic, and phonolitic domes. Shoshonitic and ultrapotassic magmatic rocks have a Pliocene (8–6.5 Ma) age (Moinvazery 2001; Moradian 2007). Hajalilou et al. (2009) suggested that these rocks formed in a post-collision magmatic arc setting. Quaternary rocks are divided into four groups: (a) volcanic rocks of Sahand, (b) travertine, (c) salt deposits around Urmia Lake, and (d) alluviums.

Geotourism Inventories in the Western Part of Sahand Volcano

Several studies related to tourism have been carried out in various parts of Sahand Volcano area. However, studies related to geotourism were first carried out by Amrikazemi (2004) and Gaderzadeh et al. (2007) in Azarshahr area. Amrikazemi (2009) suggested that the Sahand Mountain has high potential for geotourism development. Since most of the geotourism attractions are located on the western part of the Sahand Mountain, including the Urmia Lake, the authors of this paper believe that the western part of the Sahand Volcano has a higher potential to be established as a geopark than the eastern part. In addition, most of the basic tourism infrastructures are available there. Some of the geotourism attractions in this area are described below.

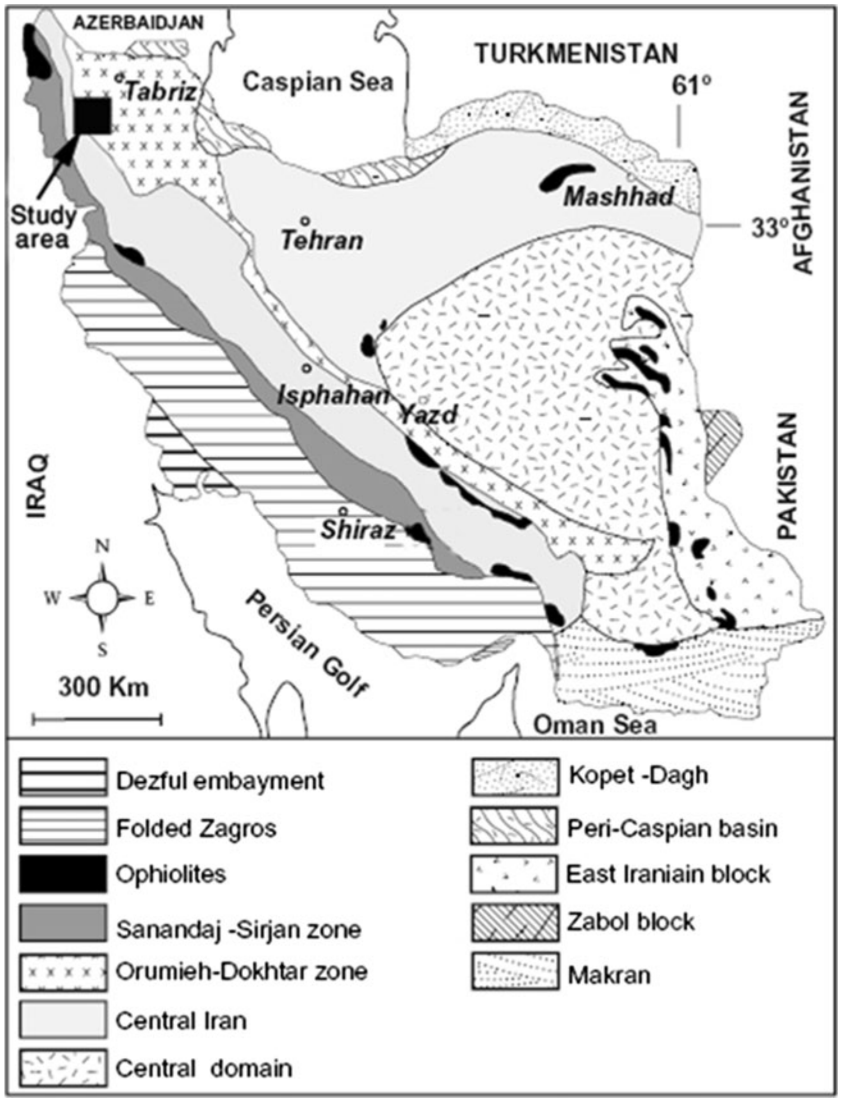

Fig. 3 Simplified geological map of Iran (Aghanabati 1998). Study area situated in NW of Urmia-Dokhtar magmatic arc (UDMA) that generated due to subduction of Neo-Tethys ocean floor beaneath the central block of Iran

Sahand Volcano

The Sahand Mountain is known as a massive and important dormant volcano in Iran (N 46° 43′ to 46° 25′–E 37° 45′ to 37° 75′). The Sahand Volcano comprises many different geological features, such as various lithostratigraphic sections, cones developed in tuff as a result of erosive processes, crag, canyons and rivers, waterfalls and tafoni (Fig. 6). Some of the lithological sequences that occur around the Sahand Volcano are nationally important for the study of strato-volcanos. Alternation of ignimbrite and agglomerate (with andesite and dacite components) is prevalent. In the Jaragil Village, intercalations of different lava flows are well exposed. Sometimes, like in Kandovan village, the tuff erosion has originated cone-shaped landforms that were excavated by local inhabitants to be used as dwellings. Differences in lithology and their resistance to erosion caused the formation of steep slopes and canyons. Near Jaragel, Almalo Dash, and Hargalan villages, the difference in altitudes between the top and bottom of these valleys may reach 25 m. About 500 years ago the inhabitants of Jaragel village dug out the inner parts of these precipices and made canals and windows for hunting, as well as for protection of their village from ambush. Today, the locals keep their history alive by telling stories about historical and sacred places (towers) of Jaragel village (IRNA 2012).

Waterfalls also develop in some areas. The final eruption of the Sahand Volcano during the Quaternary formed volcanic domes. Different examples of tafoni occur within the andesites outcrops showing forms such as concave, semi-spherical, flower-petal-shaped, crescent moon-shaped, and oval-shaped. Some of these tafoni have developed further into small caves. These caves, many of which can store hundreds of animals, have historically been used as mountain pasture by the local people. Moreover, in the Sahand Mountain area, there is a potential to develop diverse nature sports tourism such as hiking, camping, mountain biking, and parachuting from slopes. Due to the present variety of

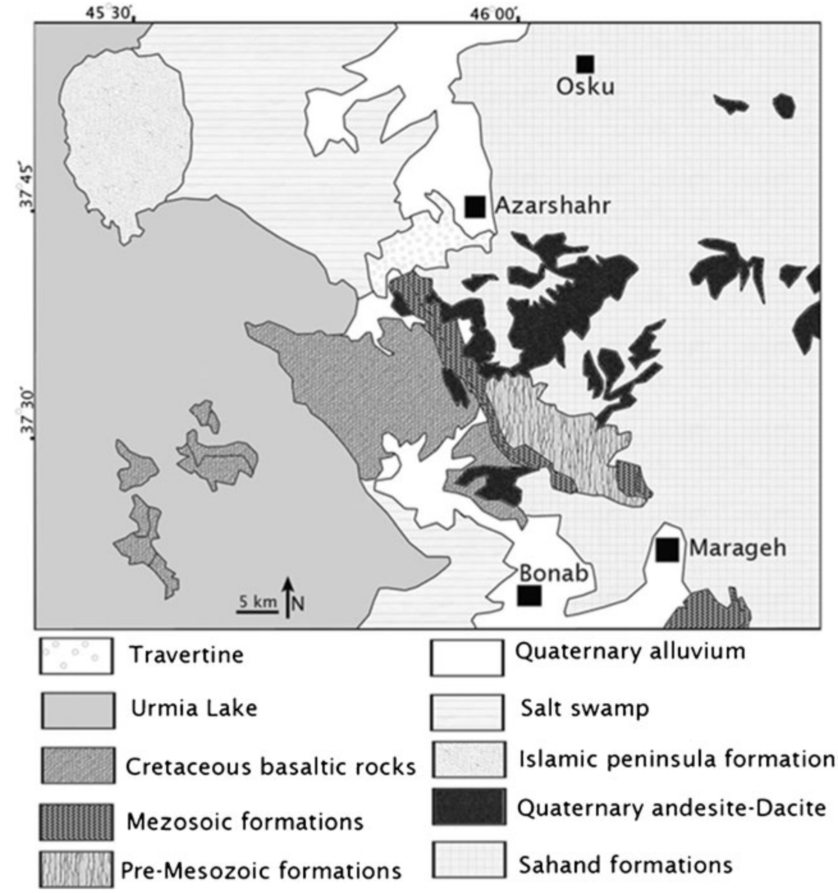

Fig. 4 Geological map of the study area (modified from Alavi et al. 1985). Most rocks of study area are composed of volcanic rocks

flora and fauna, the Sahand Mountain is known as the "Bride of mountains" in Iran (ITTO 2011). These characteristics and features of the Sahand Volcano make this volcano different from all other volcanoes in Iran.

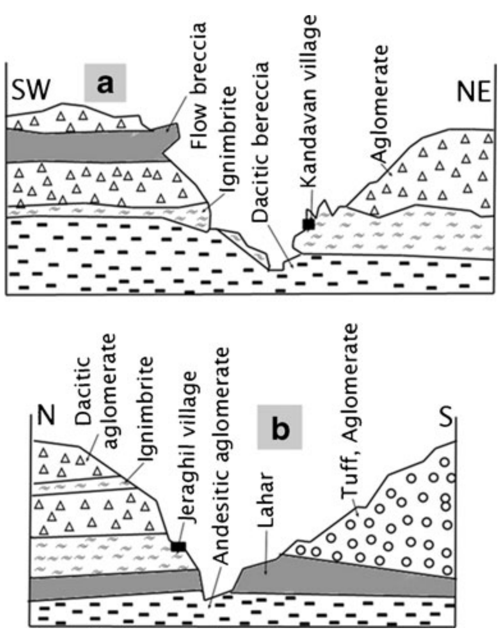

Fig. 5 Lithological section of **a** Kandovan valley and **b** Jaragil valley (Moinvaziry 2001)

Urmia Lake

Urmia Lake, located in the western part of study area, is the world's second largest salt water lake with about 5,800 km^2 area (Fig. 7; N 45° 31′ to 45° 19′–E 37° 7′ to 37° 42′). Due to the construction of a dam in a part of the lake and due to the recent drought, the volume of water has decreased and the salinity of the water has therefore increased. Beaches of the lake are covered with salt and there are wonderful assemblages of salt minerals and also mud cracks. The lake has about 120 islands and the biggest of them are Kabodan (3,175 km^2) and Ashk (2,110 km^2). The Brine shrimp Artemia (*Artemia urmiana*) is the only living organism in the lake's water. This lake is a popular place for sport and recreation in NW Iran. In addition, the water and mud from the lake are believed to have healing properties (Sadaghiani 2009). Flamingos, pelicans, spoonbills, ibises, storks, shelducks, avocets, stilts, gulls, and wild sheep are important animals of the Urmia Lake islands, but today their abundance has decreased due to the annual reduction of the lake's surface area. A project to build a highway across the lake was completed in 2008 with the opening of a 1.5-km bridge across the lake which is an

Fig. 6 Geosites of Sahand area. **a** Sequence of tuff with dacitic agglomerate in Jaragil valley. **b** Effect of erosion producing a dacitic agglomerate rock column of Jaragil valley. **c** Conical tuffs of Kandovan. **d** Precipice of Jaragil valley. **e** Quaternary volcano dam. **f** Basal tafoni in andesites. **g** Pseudotafoni in andesite fragment. **h**, **i** Nature of Sahand's valley (photos by first author)

important infrastructure for tourism. The Urmia Lake with its diverse natural heritage is ideal for geotourism development.

Springs

Springs occur in many places across the study area (Fig. 8). Most of the waters from the springs are drinkable and some of them are believed to have therapeutic and healing properties. The Kandovan spring is the most famous in the region. Numerous springs with undrinkable water occur in the travertine deposits. They show a linear distribution in the area, which indicate that they are active along a fault. It seems that the water flow output has been different over time in various parts, since there are many remains of dried spring's structures. Remains of primitive springs, rivulets and ponds are found throughout the area. There are also remains of conical travertine domes that measure 120 cm in height. The different mineral compositions of these springs have produced multi-colored travertine deposits (Ghadirzadeh et al. 2007). Amrikazemi (2004) points out that the red travertine of Azarshahr is world-renowned and points out its potential for becoming the world's first travertine park.

Caves

The Kabotar (Hampoil) cave of Maraghe, located in a limestone formation, is the most famous cave within the study area (N37° 32′–E 46° 30′). Picturesque stalagmites and

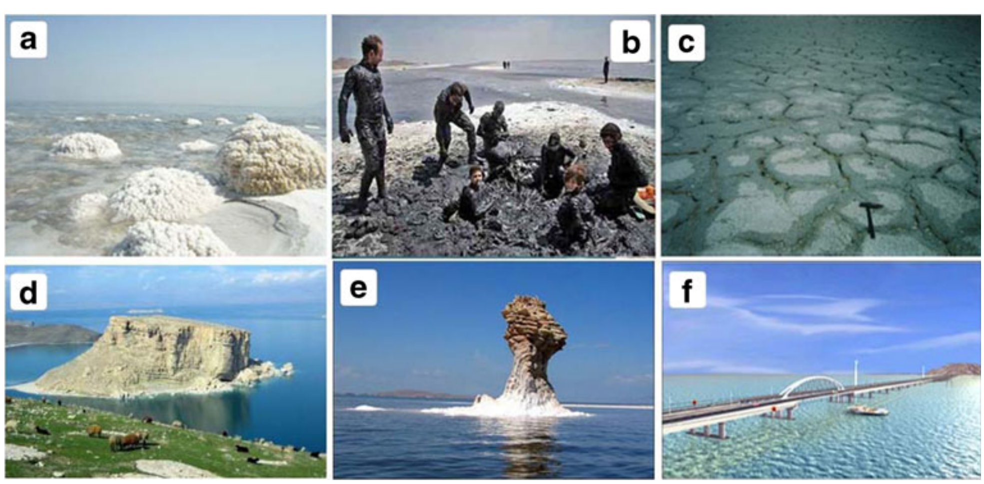

Fig. 7 Geosites around Urmia Lake. **a** Salt assemblage along the coast. **b** Mud therapy (along the coast). **c** Mud cracks along the coast. **d**, **e** Small islands. **f** Bridge of Urmia Lake (photos: **a** by first author, **b** by Outdoor Persia (2010), **c** by first author, **d** by Animal Rights Watch (2011), **e** by Iran Deserts (2008), **f** by Iranian Artemia Research Centre (2011))

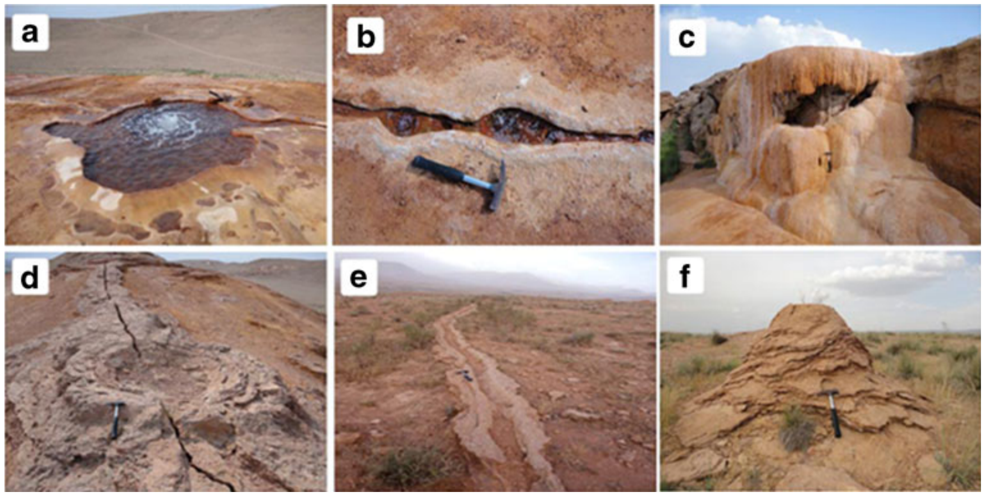

Fig. 8 Travertine geosites. **a**, **b** Spring. **c** Structure formed near an active spring. **d** Remains of a pond in an inactive spring. **e** Remains of a rivulet of an inactive spring. **f** Conical dome of travertine (photos by first author)

stalactites are found inside the cave. Another—hidden—cave located in Azarshahr has been found based on geophysical, geological, and drilling studies (in E 45° 53′–N 37° 39′ and E 45° 53′–N 37° 39′ points) by Ghadirzadeh et al. (2007). They estimated the volume of the cave to about 560,000,000 m^3. Rain and snow waters, when percolated through the Sahand volcanic units, become acidic and dissolve the limestone, especially along vertical fault lines that reach the surface of the earth. This process explains how the Kabotar cave was formed and why the travertine in the area is spread out along a line (Ghadirzadeh et al. 2007). The relationship between the travertine, the volcanic units, the caves, and the springs can be an important attraction for geotourists who want to increase their knowledge about geological processes. Figure 9 shows some of the features associated with the caves in this region.

Fault and Fold Structures

The study area has been subjected to intense tectonic activity as it is registered by intense faulting and folding affecting Paleozoic and Mesozoic rocks. Folds are commonly found in limestone rocks. A main fault (about 1 km in length and 2–80 cm wide) split the Gezel-dageh travertine dome formation (Fig. 9d). The crustal deformation has played an important role in the development of the Urmia Lake, the Sahand Volcano, caves and springs, and the fold and fault structures can be important features for geotourists who want to know about the tectonic evolution of this region.

Eslamy Peninsula

Magmatic features, such as dykes and xenoliths, are common in the whole region, whereas volcanic necks occur less frequently. Volcanic necks are furthermore rarer in Iran. One of the impressive volcanic necks, and some other magmatic features such as dykes and mantle xenoliths, occurs in the Eslamy Peninsula, east of Urmia Lake. This neck is a cone-shaped landform standing 25 m tall in the NE part of the peninsula (Fig. 9e). The center of this peninsula is situated at N 35° 50′ and E 45° 30′. In this peninsula, there are also erosion structures as the ones documented in Fig. 9f.

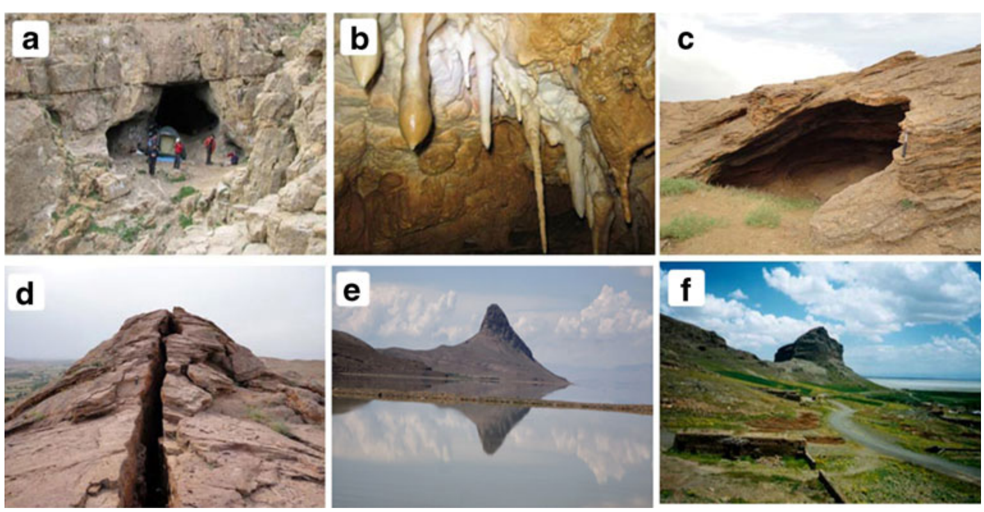

Fig. 9 **a** View of Kabotar cave. **b** Stalactites of inner Kabotar cave. **c** Dissolution pit in travertine. **d** Vertical fracture in travertine dome. **e** Volcano neck in the Eslamy peninsula. **f** Cylinder-shaped limestone erosion (photos: **a**, **b** by Mihan Blog (2010); **c**, **e**, **f** by first author)

Fossils

Mesozoic fossils such as ammonites, belemnites, and orbitolina are commonly found in the limestone formations. Vertebrate fossils occur in the Maraghe area, in marls, sandstones, and tuffs with an age of 12.5–7.5 Ma (Pur Abrishami et al. 2008). Some of the fossils belong to species related to fishes, elephants, horses, monkeys, deer, and rhinoceros (Fig. 10). Research results show that these animals lived in a fluvial environment and have died after an eruption of the Sahand Volcano and a consequential changing of the environmental conditions (Pur Abrishami et al. 2008). The diversity and abundance of fossils in the Maraghe area (N 37° 20′ to 37° 77′–E 46° 23′ to 46° 30′) has made Maraghe a very important location for paleontologists. Studies of these vertebrate fossils are likely to be an important link in understanding the area's paleo-ecology and likewise the complete history of animals and humans in the area.

Mines

The region has rich deposits of minerals and natural resources. The most important mines extract silica sand, gravel, travertine, limestone, marble, bauxite, and salts. Even though most of the mines are more than 30 years old, they are still contributing to the economy of the region. The present diversity of minerals and mining activities in this region can be an attraction for geotourists who want to know more about mineral formation and the mining industry.

Discussion and Conclusions

Geotourism is rapidly being recognized as an exciting new direction for tourism regarding geological and geomorphological attractions and destinations. Nekouie-Sadry (2009) points out that the geodiversity in the Iranian landscapes recognized through scientific knowledge about the Earth's history and geological processes provide an immense scope within the context of potential geosites. Compared to other types of tourism, Dowling and Newsome (2006) stresses that geotourism is different, i.e., geotourism depends on scientific, educational, and historical values, international significance, cultural, social structure, biodiversity, and appearance. Thus, it is likely that the types of tourist who visits geosites are also different. Hence, geotourism is concerned with sustaining or enhancing a destination's geographic character (e.g., Wartiti et al. 2008).

Based on the geologically diverse attractions of Iran, geotourism is likely to be a successful candidate in tourism development. However, since geotourism utilize geological features as its main attraction, it is extremely important to protect them by having a comprehensive management plan. This is in line with Wartiti et al. (2008) concluding that geological heritage sites has to be properly managed to generate employment and new economic activities, especially in regions in need of new or additional sources of income. Most of the geological features described in this paper are valuable and interesting to Iran, and as such, have a high heritage value. The Sahand Volcano and Urmia Lake also have a high potential to attract a lot of tourists (e.g., Amrikazemi 2009). The diverse vertebrate fossils furthermore add to the natural attractions of the region, but fossil sites and tourism, however, usually generates problems. If no proper management exists, fossils are put at risk due to the increasing number of visitors, which over time might lead to destruction of the geosites. This supports the conclusion of Ghasemi Yalgouz-Agaj et al. (2010) that Iran with its vast and unique natural environment has potential to become the world's ideal natural tourist destination. However, despite the numerous attractions, tourism is not well-developed in Iran. Recent wars and political conflicts in Middle East together with baseless propaganda against Iran are likely to add considerably to that fact. This is

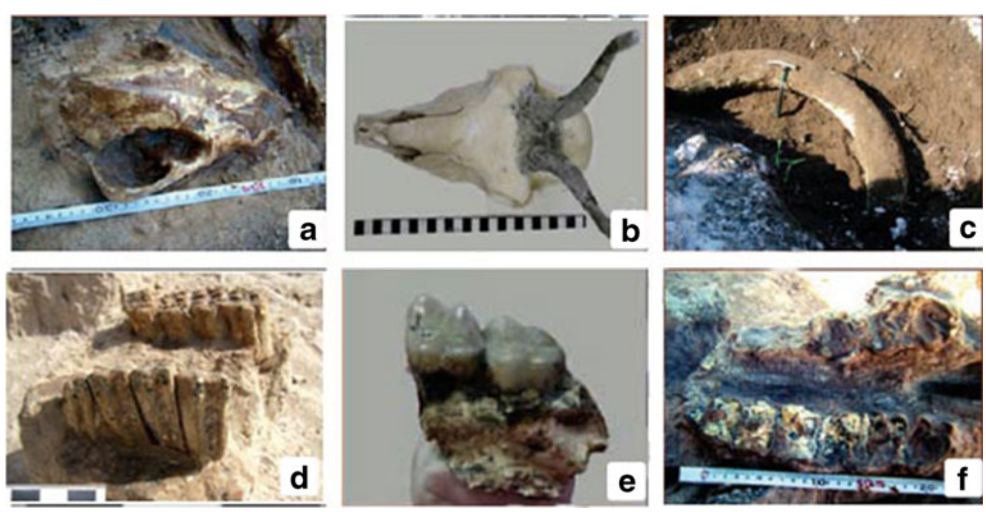

Fig. 10 Vertebrate fossils of Maraghe. **a** Cranium of carnivore. **b** Horns of Oioceros atropatnes. **c** Ivory of elephant. **d** Tooth and jaw of horse. **e** Tooth of monkey. **f** Mandible of rhinoceros (photos by Pur Abrishami et al. (2008))

supported by Morakabati (2011), who states that parts of the Middle East can be regarded as being among the least preferred tourism destinations in the world and that travellers' perception of the region as a whole has in recent years generally gone from bad to worse.

Regarding tourism development in the NW part of Iran, this paper emphasizes the region's high geoheritage value and its potential to attract tourists. In addition to the geological heritage, the region also holds many important sites and attractions that characterize Iran's historical and cultural heritage. Examples of historical features before the Islamic era include the Qadamgah cave (Fig. 11a), which currently is utilized for religious ceremonies; the cemetery and burial stones of Qadamgah, which are from the Safavid period (about 280 to 500 years old); and the Maraghe, which was the capital of Iran during the Ilkhanian era (about 850 years ago) and has numerous historical buildings such as the Rasad Khaneh, the Ilkhanian era museum, the Mehrabe, the Ghafarieh dome, and the Kabod dome. The historical and geological features meet in Iran's history mirroring many geo-historic phenomena showing the power of ancient people and their knowledge and interest in geological phenomena. The Kandovan rock village in the Oskou District is moreover an outstanding example of the region's unique geoarchaeosites in Iran (Fig. 11b). The cave settlements in Cappadocia, Turkey are similar to the ones in Kandovan (Solaripedia 2011). However, only in Kandovan there has been unbroken residence during the last 6,000 years (Mirrazavi 2011).

Still the value of most of the geological and historical heritage of NW Iran is relatively unknown, both within and outside of Iran. Protected areas are therefore few. At present, the only protected areas in NW Iran are the fossil-rich area of Maragheh and the islands of Lake Urmia. Since tourism is expected to increase in NW Iran, protection is however of vital importance for many of the geosites, as many of the area's geological features currently face the risk of destruction. This is largely due to rapid anthropogenic exploitation. For example, the stone industry of Azarshahr travertine has grown more than 70 % the past 25 years with subsequent exploitation of geo-resources (Aryanews 2011).

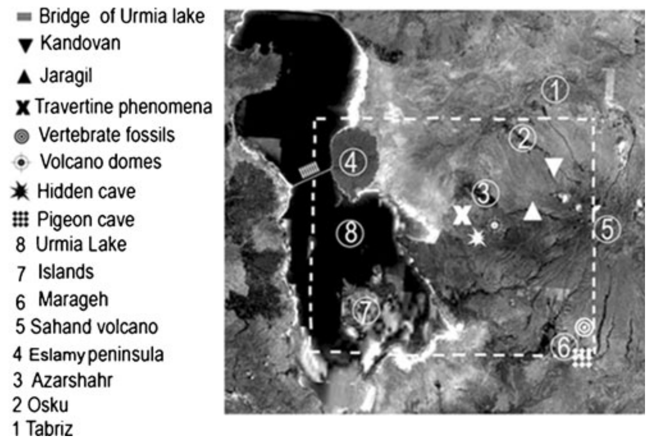

Fig. 12 Satellite image showing the location of important geological features in the study area

Presently, the most popular tourism sites in the study area are the slopes of the Sahand Volcano and the beaches of the Urmia Lake (Fig. 12). However, Kandovan attracts about 300,000 visitors annually (Iran Review 2007), emphasizing people's interest in the rocks, as is often said about Kandovan. To increase the number of visitors in the western part of Sahand Volcano, it is critical to increase tourism facilities. It is likewise critical that the increase of tourism development is carried out in a sustainable manner in order to secure long-term economic benefit from tourism in the area.

This review underpins that the western part of the Sahand area is an important area for geotourism development, and moreover, has a promising potential to become a Global Geopark. In addition to its rich geological heritage, basic

Fig. 11 **a** Inner views of Qadamgahe cave. **b** Kandovan dwellings (photos: **a** by first author, **b** by Odditycentral (2009))

tourism infrastructures are already in place. The establishment of a geopark in this area can be legally used as an effective tool to expedite geological conservation of natural features in the Sahand area. A geopark is likely to stimulate great interest among the visitors as well as among the locals to know more about geology, and hence, help in popularizing geosciences. It will also support the claim that tourism can be sustainably developed by making use of existing natural features without great investments and with minimum damage to the environment. To ensure the success of this geopark, some of the lessons learned from the implementation of Iran's first geopark, the Qeshm Geopark (Jamejam 2011), will have to be taken into account.

To develop successful and sustainable tourism in these areas, more research are however needed, such as geological and geomorphological mapping, analysis of geological and ecological vulnerability, and detailed documentation and assessment of the significant features that define the region's geological heritage. For a long-term economic benefit of tourism, a sustainable tourism management plan of the region is crucial to ensure that the geological features are conserved, protected, and utilized sustainably. It is hoped that this research will provide essential knowledge for developing geotourism policy, planning, and management in Iran as well as highlighting the potentials of NW Iran for establishing a Global Geopark.

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