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The Potential of Agh-Ghala Geological Site and its Role in Sustainable Tourism Development

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Abstract
The Potential of the Agh-Ghala geological site in the Gorgan area with a special view on its mud volcanoes and its role in sustainable tourism development was studied. The mud volcanoes of this geo-site include Inches Borun and Gharniarigh Tappeh, which are a geological heritage with outstanding scientific, cultural, touristic, industrial, and educational values that, in this research, its therapeutic effects were proved. The mineralogical and geochemical studies carried out by XRF&XRD methods show that both mud volcanoes have no significant toxic substances; their main minerals are quartz, calcite, dolomite, halite, and clay minerals such as smectite and illite. There is a high amount of elements boron, copper, iodine, bromine, vanadium, magnesium, sodium, calcium, organic acids, aromatic hydrocarbons, and bicarbonate. So mud volcanoes have a therapeutic aspect and can be one of the essential destinations for curative geo-tourism. The geological site of Agh-ghala has wonderful geomorphology; if tourism infrastructures are provided in that area, such as suitable access roads, accommodation, welfare, security, signposts, proper supervision and management over the collection, etc. it can say that this potential Geo-site becomes a real Geo-site with aesthetic resources. The geo-site achieves its goals through conservation, education, and tourism. The goals consist of enhancing livelihoods, increasing local economic growth, and providing for environmental protection.
Keywords: MAXQDA; Sustainable development; Tourism.

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1. Introduction

Geo-site is a place with rare forms and attractive processes of geology and geomorphology with a potential of aesthetic uniqueness, scientific, cultural, touristic, and educational (Vujičić et al , 2011). which is mainly divided into two groups: those that outcrop as natural or synthetic forms of remarkable geology and geomorphology within open boundaries limitations a like mud volcano ,glacial cirques, cliffs, deserts, or volcanoes with scientific value in- situ (Brilha, 2016) and the other is Geo-tourism access centers in confined spaces like earth sciences museum ,etc. with scientific value ex-situ. Therefore, both types are essential for tourism development .The other term that is equivalent to Geo-site is the German word of Geotope (Habibi et al.,2018; Herrera-Franco et al., 2021). Also, a Geo-site is a natural structure in the form a group of rocks, minerals or fossils, stratum, ground Formation, or geological structure resulting from an event during the creation or evolution of the earth's crust that put a process or formation into existence, that needs scientific documentation and in some cases visual attraction qualities and studies about this geomorphological features very noticeable (Carcavilla et al., 2009).

2. Literature review

In geo-touristic activities, geodiversity is at the center of attention and represents the essential resource for geo-tourism. Geodiversity is a term that is considered analogous to the term biodiversity (Erikstad, 2013). According to studies done, geodiversity is "the number and variety of structures (sedimentary, tectonic, geological materials—minerals, rocks, fossils, and soils), that constitute the substratum in a region (Nieto, 2001). A more detailed definition presented that "geodiversity is the diversity coming from the nature itself (physical-geographical environment) and the social processes, such as production, settlement ,and circulation(the human being and its activities)considering human activities as part of geodiversity (Brilha, 2016) it must remember that setting the links between geodiversity, biodiversity, culture, and history can help appreciate the geodiversity as a full-value resource for tourist activities and thus as an essential resource for local and regional development (Carrión-Mero et al., 2021). Geo-sites are geological or geomorphological sites with a recognized value through an audit, assessment, and selection process, that conservation of them for scientific, educational, geo-tourism, and other uses is an essential part of the conservation of geoheritage. Geo-sites in urbanized areas rarely introduce as forms of abiotic nature conservation (Reynard and Brilha, 2018).Still few exist in town centers, with most Geo-sites found on the outskirts of cities, where there are more open spaces. Even so, urban public spaces contribute

to the visibility and protection of the city's geodiversity in the form of Geo-sites (Zwoliński et al, 2018). Some of these Geo-sites can have national or international importance. It is exciting to know, the economic exploitation of unique geoheritage features is the basis of geo-tourism In general, and geo-tourism is a type of sustainable tourism that promotes the protection of natural areas at local and international levels. In Newsome and Dowling's words, Geo-tourism is a part of land associated with geology, geomorphology, and natural landscape resources as well as available forms on the land surface, fossil-containing layers, rocks, and minerals according to the emphasis on understanding the underlying and shaping processes of these complications (Newsome and Dowling, 2012). For the first time, Geo-tourism was introduced by Hose (1995), referring to form of tourism that facilitates learning about the geology and geomorphology of a site for tourists, promoting geo-conservation. In addition, governments seek to protect both geodiversity and geoheritage through geo-conservation strategies. Finally geo-tourism and geo-conservation initiatives promote and protect geodiversity through inventories, geoparks ,and protection policies, leading to the sustainability of geodiversity, geoheritage, and Geo-sites.(Quesada-Román, Pérez-Umaña, 2020, Cai,etal., 2021). Iran's unique tectonic and climate situation causes diverse sights of tectonic and geomorphology (that creates Geo-sites and Geoparks) in different parts of the country. If they are introduced correctly in the international era, Iran will be one of the central poles of Geo-tourism in the world. In this article, the development of sustainable tourism in the mud volcano site of the Agh-ghala area within the framework of geo-tourism is discussed.

3. Research methods

In order to study the potential of the Agh-Ghala geological site in the Gorgan area with a special view on its mud volcanoes and its role in sustainable tourism development after library studies, several field studies made in north - northwest of Agh-ghala and observation performed at two mud volcanoes, Gharniaregh Tappeh and Inche borun during April , In order to geochemical studies to find its therapeutic effects, several samples of water and mud were collected from a depths of about 10 - 20 cm from different parts of mud volcanoes and placed in sterilized containers. These samples analyzed by XRD and XRF methods. Mud and water separated by settling, filtered, and analyzed at the Geological Survey and Mineral Exploration of Iran. Moreover, the appearance characteristics of mud and water in the field were noted. The color of the curative mud exiting from volcanoes was light to dark gray. On the base of the field visits the reason

for the expansion of Gharniarigh tappeh mud volcano is the increase in the volume of water, which has destroyed the surrounding walls. The boiling of water in this volcano, along with the release of methane gas, is seen in several places, especially in its center.

4. Results

4.1 . *Geologic setting of Agh-Ghala region*

The Agh-Ghala area place in 54° 16′ E and 36° 58′ N at the north of Gorgan city . This region contains two attractive geomorphological phenomena as name Gharniaregh-Tappeh and Inche Borun mud volcano which locates in Tertiary – Quaternary sequences in the studied area (fig 1). The geomorphology and degree of erosion at Gharniaregh-Tappeh and Inche Borun suggest that Gharniaregh-Tappeh is older than Inche Borun.the morphology of mud volcanoes also depends on the particular weight of outflowing materials or mud and their eruption or jump sequence (Negaresh, 2004). The mud volcanoes in the world are of two types, hot and cold. The hot mud volcanoes are associated with igneous volcanoes, and the temperature of the extruded water and mud varies from to C, much higher than the ambient temperature (Negaresh, 2008). cold mud volcanoes are sedimentary-tectonic in origin and are entirely unconnected with the igneous activity with water and mud at the same or lower than ambient temperature.these eruptions are associated with seismic activity, fracture formation, ground deformation, and emplacement of mud breccia flows (Yazdi, 2013). Based on studies done, the mud volcanoes of Gharniaregh-Tappeh and Inche Borun are cold and sedimentary-tectonic type.

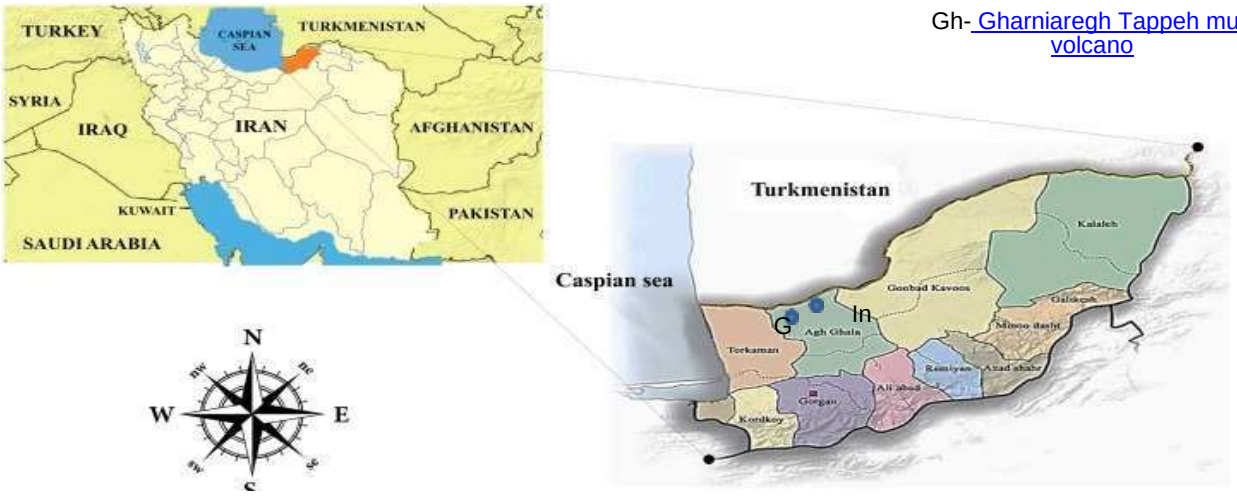

Fig 1 . Distribution of mud volcanoes in the Agh-

4.1.1 . Gharniaregh Tappeh mud volcano

The geographical location of Gharniaregh Tappeh recorded using a GPS is 54° 23′ 50′′ E and 37° 0′ 03′′ N this mud volcano locate kilometers northwest of Agh-Ghala (Fig. 1). it is externally 700 meters in diameter and has a cavity roughly to meters deep . There is a conical hill at the center of this hole, and another desolated hole at its top. There are two internal craters filled with water in between. Around the mud volcano, many grooves created by erosion, which exhibit tracks alternating layers of salt, clay, and silt, sedimentary structures such as mud cracks are visible. This mud volcano, in the rainy season's looks like a lake. in the hot seasons, evaporated water and white salt place on the ground.

Fig 2. The images of Gharniaregh Tappeh mud

4.1.2 . Inche Borun mud volcano

The geographical location of Inche Borun mud volcano recorded using a GPS is 54° 31′ E and 37° 12′ N. this mud volcano is located 26 kilometers north of Agh-Ghala(Fig) in the vicinity of a lake named the same and on the plain and salty lands. Its crater is 20 meters in diameter morphologically; this mud volcano is in the form of a mud pool. Its depth is 10 meters, and the total area is 750 square meters. This mud volcano is 8 to 10 meters above the level of Inche Lake. The mud of this mud volcano is very loose, and on its surface, due to the release of methane gas, boiling can be seen in several places. The smell of methane gas and other hydrocarbon compounds strongly felt in the area. Around the crater, mud cracks are visible. Water containing sodium chloride and aromatic petroleum substances comes out of this volcano. The mud consists of clay particles and silt in light gray color.

Fig 3 . Images of Inche Borun mud volcano

4.2 . Geology and geomorphology of gharniaregh-tappeh and inche borun mud volcanoes

Generally, mud volcanoes on the base on morphological characteristic divided as the following features: mud cone, mud pool, and mud lobe. On the base of studies done , morphology of mud volcanoes on the Gorgan plain(Agh-ghala area) is mud pool .Among materials forming mud volcanoes, one can refer to sands, silt, and types of clay, in some cases rubble, clasts, abundant water, and hydrocarbon gases. The color of the mud exiting from Gharniaregh-Tappeh and inche borun volcanoes is gray. The Inche Borun mud volcano is more active than Gharniaregh–Tappeh, while the latter is saltier than the former, indicating its proximity to salt domes.

4.3. Composition and main elements of sludge and waters out of mud volcanoes

On the based on studied done, Outflow materials from the mud volcanoes, including oil-saturated terrigenous and carbonate rocks, clay, silt and large amounts of methane and carbon dioxide. The most common gas, other than methane, is usually carbon dioxide. Nitrogen and hydrogen sulfide may be present in significant concentrations, but most often, they are trace gases. The mineral composition of the two mud volcanoes is different from each other. the mineralogical analysis, X-ray powder diffraction (XRD) on bulk samples and <20 and <2 μm fractions, has been undertaken to identify the constituent minerals of the sediments. Based on the results of the bulk mineralogical and its variability, a group of samples selected to determine clay mineralogy. Suspensions of < 20and <2 μm fractions were separated by centrifuge. Oriented aggregates of <20 and < 2 μm sizes over glass slides were analyzed through XRD on airdried, glycolate, and heated samples (Moore & Reynolds, 1997 ; Martín-Puertas, et al., 2007). The clay

mineralogy of the < 20 and < 2 μm fractions of all the samples characterized by illite, chlorite, kaolinite, and smectite. Based on XRD mineralogy of samples, the most abundant clay mineral at inche borun mud volcano, is smectite and illite and at Gharniarigh Tappeh mud volcano is kaolinite, chlorite, smectite ,and illite. Also, the most abundant carbonate in both mud volcanoes is calcite and dolomite(Table 1)based on XRF analysis of samples, the major element composition of the mud volcanoes has been measured(all values in Ppm)(Table 2). The base of studies done, the mud solution has no significant toxic substances and the mud ،has found to contain quantities of curative properties (iodine, bromine, calcium, magnesium, organic acids, and aromatic hydrocarbons). As it has recommended as a curative agent.

Table 1. XRD mineralogy of samples from inche borun and Ghaniarigh Tappeh mud volcano

Mud volcano	Minor Mineral	Major Mineral
Ghaniarigh Tappeh	Muscovite, Albite , feldspars, hurnbland	، illite ، dolomite ،calcite ,quartz chlorite, kaolinite, smectite, halite,
inche borun	Muscovite, Albite , Gypsum, chlorite, feldspars, halite	, illite , dolomite ،calcite smectite,

Table 2. Geochemical results from inche borun and Ghaniarigh Tappeh mud volcano (by XRF method- ppm)

Mudvolcano	Li	B	Na	Mg	Al	K	Ca	Cr	Fe	Mn	Ni	Cu	Zn	As	Sr	Cd	Ba	Pb	U	Cl	Br	NO3	SO4
Gharniaigh	57	-	26100	15200	30025	18000	110200	28	36000	557	62	139	109	1	825	0.8	117	23	-	12381	0.18	0.08	-
Inche borun	29		23800	15500	48500	16000	97400	32	20400	508	55	23	60	2	985	1.1	189	17	1	38280	0.16	0.02	11.2

4.4. Importance of Geo-sites in sustainable tourism development

Local entrepreneurship has seen as a way to improve local economic development (Newbery et al., 2017). local entrepreneurs usually develop their businesses close to their residences, at least at the early stage of their entrepreneurial process (Bosma et al., 2009).with regard to local economic development, Geo-sites have been developed as innovative efforts to preserve the national and geological heritage and serve as local economic and cultural protection (Doniz- Paez et al., 2011; Farsani et al., 2012). Accordingly, Geo-sites have considered one of the best forms of sustainable tourism that will provide jobs and production of goods and services related

to the uniqueness of the Geo-sites (Bentivenga et al., 2019).Indeed, Geo-sites have been able to generate novel ideas for business development for local people, such as geo-tours, geo- products, geo-museums, geo-sports, geo-restaurant, geo-bakeries, hotels and health centers (Farsani et al., 2011).This geo-site can attract many domestic and international tourists and is chosen as one of Iran s best ecotourism spots in the line with sustainable tourism. Current research on local entrepreneurship is mainly conducted in developed countries like the USA (Newbery & Bosworth, 2014), Malaysia (Dahalan et al., 2015) ,and Finland (Kibler, 2013). There are also a number of research on sustainable community-based tourism in Ghana (Atanga,), South Africa (Strydom et al., 2018), Romania (Vijulie et al., 2018), Indonesia (Aswita et al., 2018), as well as the roles of Geo-sites and geoparks in local development (Dowling & Newsome, 2018; Farsani et al., 2012). However, there is still a research gap on entrepreneurship development in areas. Universal commission of environment and development was held in 2009 at the conference “Our Common Future” and defined sustainable development as a development that meets the needs of the current generation with no harm to the need of the next generations. Sustainable development is a new era that pays attention to politic, culture, economy ,and business simultaneously and stresses on the economic, commercial, and industrial boom. (Bahram Zade, 2003). Sustainable development is one of the essential requirements that have a main role in tourism programming. According to a Declaration of WTO, this growing industry has gained the third rank in international trade (Yavari, 2011). therefore, countries that have various geomorphological and ecological effects and do the necessary affairs for a universal record of their potential Geo-sites and Geoparks in the universal heritage list of Geoparks can be more successful in the attraction of tourists as well as economic returns.

5. Discussion and Conclusion

The geological site of Agh-ghala with exciting and unique geomorphologic phenomena (mud volcanoes), besides industrial, cultural, social, economic, historical, and anthropological potentials have curative potential. Geochemical studies showed there are no toxic substances in mud volcano and contain a high amount of elements boron, copper, iodine, bromine, vanadium, magnesium, sodium, calcium, and bicarbonate, and their correct and principled use compensates for the lack of these elements in the body, so this mud volcano has therapeutic effects and can be one of the essential destinations for curative geo-tourism and can attract a large number of domestic and foreign tourists and geo-tourists. Attribution of "Geo-site" or

"geopark" to each region requires such necessary infrastructures provided as efficient management, training of local individuals, tourist attraction based on the education of geological-recreational concepts, and protection of phenomena. Geo-tourism, as a credible sustainable tourism industry can have the most harmony with sustainable development and all economic, cultural, social, and environmental dimensions. This industry can offer new development and employment opportunities for local people. Also can generate a range of economic benefits for local communities, including revenue creation, job generation, diversification, and infrastructure improvement. Net benefits from tourism accrue from the balance of economic, social, and environmental interactions of tourists with a destination (Greiner, Stoeckl, & Schweigert, 2004). Any geo-tourism venture should only consider successful if local communities have some control over them and if they share equitably in the benefits emerging from geo-tourism opportunities. Iran's land has the most diverse landforms and new geology phenomena according to its climates and geology situation. The availability of these tourism natural areas, besides ancient culture and monuments, facilitates Geo-tourism development. In this regard, the introduction and creating of Geo-sites and Geoparks can be effective in adding scientific content and making tourism professional as well as the local economy and creating jobs besides preserving geology heritage and prevention of land conservation and environmental elements related to industrial societies. When a given geological site acquires a tourism value, it will find international /national significance in addition to that a geological heritage being used to promote sustainable development, it is necessary to assess the possible natural hazard processes which might threaten the safety of visitors. According to mentioned subjects , the geological site of Agh-ghala with having geo - potential ,and another potential can become a real Geo-site with aesthetic resources if tourism infrastructures provided in that area ,such as suitable access roads, accommodation and welfare, security, signposts, proper supervision and management over the collection ,etc. and within the international ,national, regional and local frameworks can one of the essential tools in development ,income generation, creating jobs and removing deprivation**.**

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