



The Role of Dashli Borun Geological Site in Local Economy and Sustainable Development

Parvaneh Rezaei-Rouzbahani

Department of Sustainable Tourism Development
Creative Economy Research Center, West Tehran Branch, Islamic Azad University

&
Department of Urban planning,
West Tehran Branch, Islamic Azad University
Tehran, Iran
Dr.roozbahani@gmail.com

Roya Tashayoei

Department of Earth Science Encyclopedia
Geological Survey & Mineral Explorations of Iran (GSI)
Tehran, Iran
Tashayoei_Roya@yahoo.com

Abstract—In this research ,the role of Dashli Borun geological site in the Gonbad-e Kavus area with a special view on it s mud volcano and its importance in local economic and sustainable tourism development was studied.The mud volcano of this geo-site includes Inche Borun,which is 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 Inche Borun mud volcano has no significant toxic substances; it s main minerals are dolomite, calcite, quartz and clay minerals such as smectite, kaolinite and illite.there is a high amount of elements calcium,magnesium, aluminium,sodium,iodine,copper, bromine,potassium,organic acids,bicarbonate and aromatic hydrocarbons.so the mud volcano has a therapeutic aspect and can be one of the essential destinations for curative geo-tourism.

The geological site of Dashli Borun with having geo - potential and unique geomorphologic phenomenon (Inche Borun mud volcano) that has curative potential ,besides another potential ;if tourism infrastructures provided in that area ,such as suitable access roads, accommodation, welfare, security, signposts, proper supervision and efficient management, training of local individuals ,etc.,can become a real geo-site with aesthetic resources.

It also achieves its goals through conservation, education ,and tourism. the goals consist of generation a range of economic benefits for local people (local economic development), enhancing livelihoods, income generation, creating jobs ,infrastructure improvement ,and removing deprivation.

Keywords- Dashli Borun, geological site, local economy, Sustainable development



1. Introduction

The 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 [13].

In this research, for the first time, the geo-site of Dashli Borun in northwest Gonbad-e Kavus city, with a special view on its mud volcano and its role in sustainable tourism development and in attracting maximum tourists and local economic development was studied. so after library studies, several field studies were made in northwest of Gonbad-e Kavus and observation performed at Inche Borun mud volcano during May, 2022.

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 volcano and placed in sterilized containers. These samples were analyzed by XRF and XRD methods. Mud and water separated by settling, filtered, and analyzed at Binaloud lab. and the appearance characteristics of mud and water in the field were noted.

2. Geologic setting of Dashli Borun region

The Dashli Borun area place in $54^{\circ} 49' E$ and $37^{\circ} 38' N$ at the northwest of Gonbad-e Kavus city, Golestan province. (Figure 1). this region contains a attractive geomorphological phenomenon as name Inche Borun mud volcano which locate in Tertiary – Quaternary sequences in the studied area. this sequences includes Cheleken, Aghchagyl and Apsheron Formations and alluvial deposit that mainly consist of limestone, marl, clay, silt, gravel, sand and mollusca fossils.

considering that the mud volcanoes in the world are of two types, hot and cold. so that hot mud volcanoes are associated with igneous volcanoes, and the temperature of the extruded water and mud varies from 70° to $90^{\circ}C$, much higher than the ambient temperature [11] and cold mud volcanoes are sedimentary-tectonic in origin and are formed by the subduction of oceanic crust of the under deposits continental. this mud volcanoes 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 [14]. Based on studies done, the Inche Borun mud volcano is cold and sedimentary-tectonic type.

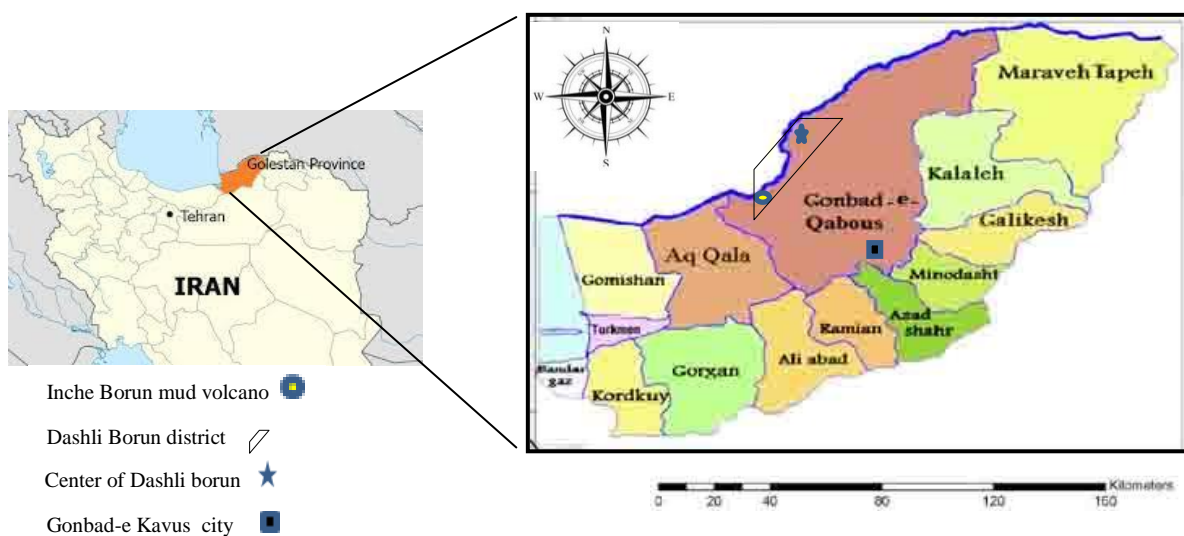


Figure 1. position of Dashli Borun region and Inche Borun mud volcano on the northwest of the Gonbad-e Kavus



2.1. Geology and geomorphology of 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 in Dashli Borun district ,about 42 kilometers northwest of Gonbad-e Kavus, in the vicinity of a lake named the same and on the plain and salty lands.(Figure 1)

on the base of morphological characteristic ,this mud volcano is in the form of a mud pool and its crater is 20 meters in diameter morphologically,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.(Figure 2).Water is containing sodium chloride ,and aromatic petroleum substances comes out of this volcano.the mud consists of clay particles and silt in light gray color ,and among materials forming this mud volcano can refer to sands, silt, and types of clay, rubble, clasts, abundant water, and hydrocarbon gases.



Figure 2. Images of Inche Borun mud volcano

3.Composition and main elements of sludge and waters out of mud volcano

On the based of studied done , Outflow materials from Inche Borun mud volcano, 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 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 <20 and <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 [9] [10].

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, the most abundant carbonate , is calcite and dolomite .(Table 1).based on XRF analysis of samples,the major element composition of the mud volcano 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, copper, aluminium ,calcium, magnesium, organic acids ,and aromatic hydrocarbons) thus it has recommended as a curative agent.

Table 1. XRD mineralogy of samples from Inche Borun mud volcano

Sample No.	Minor Mineral	Major Mineral
N1	Muscovite, Albite , Gypsum, chlorite ,halite	kaolinite, smectite, illite ,calcite ,quartz , dolomite
N2	illite , halite , orthoclase ,chlorite ,Muscovite,	calcite ,quartz,,smectite, kaolinite
N3	Muscovite, Gypsum, chlorite, orthoclase , halite	calcite , dolomite , illite ,smectite,

Table 2. geochemical results from Inche Borun mud volcano (by XRF method- ppm)

No	Li	B	Na	Mg	Al	K	Ca	Cr	Fe	Mn	Ni	Cu	Zn	As	Sr	Co	Ba	Pb	U	Cl	Br	No3	SO4
N1	57	-	26100	15200	30025	18000	110200	28	36000	557	62	139	103	1	825	0.8	117	23	-	12381	0.18	0.08	-
N2	-	-	-	-	-	-	-	44	-	-	67	26	69	1	2762	-	201	18	-1	53270	-	-	-
N3	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

Table 3. water properties of Inche borun Mud volcano (all values in ppm).

Elements	No.1	No.2	No.3
I	<5	<5	<5
Cl	148	142	163
Br	29	33	39
Zn	0.004	0.004	0.007
Na	1911	1893	2198
Ca	34	35	31
Mg	133	139	117
Li	1.6	1.5	2.0
K	55	51	71
Pb	0.009	0.011	0.015
Fe	2.8	2.6	0.26



4. The importance of Dashli Borun geological site

The importance of Dashli Borun geological site in the line sustainable geotourism and local economic development is related to potential of Inche Borun mud volcano in this area.

Based on geochemical studies in this research, Inche Borun mud volcano has a therapeutic aspect and can be one of the important destinations for medical tourism. The studies showed: in this mud volcano, there is no significant toxic substances and there is a high amount of elements potassium, bromine, calcium, copper, iodine, magnesium, sodium, aluminium, organic acids, aromatic hydrocarbons, and bicarbonate, that people by using of this mud can make up for the lack of some elements such as sodium, calcium, iodine and other substances their bodies need. nowadays mud-therapy has an especial status and many physicians have realized its effectiveness, therefore this mud volcano will attract many people for treatment.

also the Inche Borun mud volcano contains applied scientific information about subduction in region, detecting the status of region's faults, and a natural exploratory estimations through which the regions' deep hydrocarbon reserves and information on oil and gas movement can be accessed freely. so, this mud volcano as a scientific educational geo-site, can attract many scientific tourists. this feature of mud volcano is in line with the definition of modern tourism (Knowledge - based tourism).

The Inche Borun mud volcano is well used in the pottery industry and enjoy especial attributes. Unlike clay, it doesn't take so long for this mud to be ready to use in pottery, it is polished better than clay, and it is stickier than clay, it is flexible, it doesn't curl, it doesn't get cracked, it has a fixed volume, endures high temperature even up to 800 degrees and it turns creamy and beautiful having been baked.

According to mentioned subjects, and attention to these points that geo-sites are considered one of the best forms of sustainable tourism, that will provide jobs and goods and services related to geo-sites [1]. and, that have 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 [4]. so geo-sites can attract many domestic and international tourists and cause local entrepreneurship as a way to improve local economic development [12].

According to the mentioned items, the geo-site of Dashli Borun as one of Iran's geo-sites that has unique geomorphological and ecological effects can be successful in the attraction of maximum tourists, economic returns and, entrepreneurship development in area and is chosen as one of Iran's best ecotourism spots in the line with sustainable tourism.

5. Discussion and Conclusion

The geological site of Dashli Borun with exciting and unique geomorphologic phenomenon (Inche Borun mud volcano), besides cultural, social, economical, historical, and anthropological potentials has curative potential. geochemical studies showed there is no toxic substances in this mud volcano and contain a high amount of elements copper, iodine, bromine, magnesium, aluminium, 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 medical tourism and can attract a large number of domestic and foreign tourists.



This geological site 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 land conservation .

considering that the 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 ,so 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 Dashli Borun 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 , efficient management, training of local individuals, and etc.

This geological site ,also within the international ,national, regional and local frameworks can offer new development and employment and also generate a range of economic benefits for local communities opportunities for local people and can be one of the essential tools in development ,income generation , infrastructure improvement ,and removing deprivation..

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