

Potentials of Iran's Geotourism and Structure of Mud Volcanoes

Abdollah Yazdi

Department of Geology, Kahnooj Branch, Islamic Azad University, Kahnooj, Iran

Received: June 10 2013

Accepted: July 10 2013

ABSTRACT

Geotourism is one of the new branches of tourism industry which recently has been highly regarded, and studies the introduction and utilization of the surface geological features in the line with tourism development. In this regard, Iran is a country which has been very apt and has countless attractions and amazing geological diversity and it can attract many tourists and scientific tourists. In the meantime, mud volcanoes as an interesting and surprising geomorphological phenomenon can play an important role to geo-tourism development. Mud volcanoes are mainly focused in the continents of Asia, Europe and America and approximately 70% of them are located in Asia and around the Caspian Sea. Most mud volcanoes are located in the coastal province of Sistan & Baluchistan and Golestan, the most important of which are: pirlgel, naftelije, borborook, ain and napag. The purpose of this paper is to describe the structure, characteristics, examples of the introduction of mud volcanoes in Iran, and providing guidelines for the development of geo-tourism potential of mud volcanoes. Hence it has been pointed to important instances of mud volcanoes such as: Understand the tectonic situation of the region (faults and subduction), evaluating hydrocarbon gas and oil reservoirs associated with mud volcano, minerals with mud, application in pottery, mud therapy and etc. Also in the line with geo-tourism development of volcanic mud areas, some guidelines are suggested such as: Further studies, development of access road, to create mud therapy centers, Panels help installation, presentation and advertising, to establish residential centers marketplaces, pools of water and mud for amusement and games around mud volcanoes.

KEYWORDS: Geotourism, Mud volcano in Iran, Mud Therapy, Hydrocarbon gases

1. INTRODUCTION

Iran has both a rich culture and outstanding places, and its diverse cultural and natural features have ranked Iran among the world's first ten best tourist destinations (F. Frangilli, World Tourism Organization Secretary General, 2004). Furthermore, Iran's archaeological, cultural, natural, and geological attractions further help the development of geo-tourism (Amri Kazemi, 2009).

Iran is located in the Middle East- Southeast Asia- and for years its geological features have been studied by many researchers from around the world; it has also been called the "geologists' heaven" (Bayati Khatibi et al., 2010). Iran has diverse climates and diverse geographical features, including high mountain peaks, vast expanses of desert, long rivers, and permanent glaciers. Iran's special climate and tectonic conditions have created varied geological and geomorphological forms in different areas statewide (Yazdi, 2012). Mud volcanoes are from among Iran's noteworthy geo-tourism attractions. Mud volcanoes appear in various geological environments: On the active continental margins, inactive continental Shelf and open seas. As a whole, these scenic geomorphological terrains have been concentrated in two areas of Iran, i.e. in the southeastern margin of Caspian Sea in Golestan province and in Iran's southeastern coasts in Sistan and Baluchistan province. Having delineated mud volcanoes' structure through introducing Iran's mud volcanoes and presenting its geo-tourism potentials, this text aims at better introducing of these potentials in the national and international arena and their effects on the regional and national sustainable development.

2. Importance and status of geotourism in developing countries and regions

Tourism development process is generally indicative of the strategies, approaches and policies of different countries as regards the subject of tourism. This process must be based on sustainable, continuous and executable methods both nationally and regionally and be effective as a part of the country's overall economic and social policy and also be complementary to it (Heydari, 2008). As geo-tourism is regarded as one of the types of tourism being specially concentrated on the perspectives of geological and geomorphological attributes (Dowling et al., 2010), to develop geo-tourism, for the first stage we need a concentrated identification of the country's geology and geomorphology. That's because Iran is one of the few countries enjoying a wide variety of geo-tourism attractions requiring suitable interpretation for tourists. That's why Dowling and Newsome (2006) regard the offering of interpretation regarding geo-tourism attributes of a region as the main solution for developing tourism. Geo-tourism development can as whole lead to the sustainable development and utilization of the benefits of this industry from among which one can allude to: influencing economic boom and currency revenues, preventing geo-sites' margin dwellers from migrating to big cities, raising culture and education levels, preventing geological attractions from being demolished, creating jobs for geography and geoscience researchers, developing geosciences, renovating culture of geosites' margin locals through monetary motivations etc.

3. Mud volcano Definition

Mud volcano has been used in many scientific articles and dictionaries offering similar definitions. In a definition, mud volcano has been defined as a conical hole from whose crater, mud and gas discharge, being seen in volcanic areas (Ashuri, 1985). It is also referred to the swift emission or throw of loose and watery mud accompanied with gas, creating a cone mud as a result of the repeated activity on the surface (Jafari, 2007). Mud volcanoes are also known as geological structures with varied morphological forms that are the products of a natural process, being originated in deep sedimentary sequence.

4. Morphological form

Mud volcanoes are geological structures formed as a result of the infiltration of clay materials to the earth surface or sea foam. Sufficient water and gas are combined, making clay materials half-liquid and also pushing them up through the fractures of the crust for the outflow of muddy mass to the surface. The outflowed materials produce some terrains that vary a lot with regard to their form and size (Dimitrov, 2002). From among the factors influential in the form of mud volcanoes, one can refer to: pressure rate of the outflowed materials and muds, eruption pressure and movement speed of the mud, activities frequency, structure, density of the mud, temperature, mud volume, narrowness or wideness of the mud volcano passage etc. Morphology of mud volcanoes also depends on the special weight of outflowing materials or mud and their eruption or jump sequence (Negareh, 2004). It should be noted that mud volcanoes, especially those of Iran can be active or inactive. Those which are active seem to be more watery in high raining seasons and produce thicker mud accompanied with explosion.

5. Structure, composition and main constituents of mud volcanoes

During most of their life cycle, mud volcanoes have a mild appearance and develop by mass, gradual and progressive output flows from half-liquid materials called diapiric breccia (some researchers use the term "diapiric mélange") (Dimitrov, 2002 and Barber et al., 1986). Diapiric melange usually exits from a main cone called "central canal" or "feed canal". Near the surface, the feed canal can be divided into some lateral passages. The feed canal is called the main crater having different forms such as concave-flat, flat, dome-wide and a hole with fallen margins. This form is created as a result of the outflow of large amount of materials with gas in the exploding eruption, making it collapse and create a hole. Craters related to the lateral passages are called satellite, parasite or secondary craters (Fig. 1). These craters are sometimes collapsed, filled with water and form small lakes. These clayish, gassy and boiling layers are called Salses. Some many secondary craters called Gryphons might be seen around the craters and on many parts of the mud volcanoes. Although observations show that gas emission is quite prevalent in subsea mud volcanoes, most of the gas emitted around the sea bed sediments are trapped as gas hydrate (Milkov, 2000; Foucher, 1999 and Ginsburg et al., 1999) or encircled in the surface reservoirs. As excessive pressure is applied on them, they erupt and form some cavities under the sea bed. The outflowing diapiric breccia pours out in the form of wide flows of alluvial fan or tongue shape, with a width of some hundred meters and length of few kilometers in relatively thin plates from the crater. This process forms mud volcanoes (Dimitrov, 2002). From among materials forming diapirs, one can refer to sands, silt, and types of clay, in some cases rubble, clasts, abundant water, hydrocarbon gases and their derivatives, carbonic anhydride, anhydride sulfide and sometimes some elements such as Gallium, vanadium and Rubidium. Color of the mud exiting from mud volcanoes can range from grey, yellow, reddish khaki, dark grey etc. based on the minerals and accompanying elements.

6. Forms and size of mud volcanoes

Although many of mud volcanoes have forms similar to conical mountain or hills, they can have various forms. As a result, they can be named based on the form and size such as "mud cones", "mud lumps", "outcrop or cratered mounds", "mud diapers", "mud pies" etc. Some of them have regular conical form, yet they have some other forms named sharp cones, flat and plateau cones, dome or mushroom-like shapes, depressions or calderas. Anyhow most of them are composite having some craters with different shapes. Relative height of mud volcanoes range from 300-400 meters and can also exceed 500 meters. From an upside angle, they are seen in an isometric form and a bit stretched with some craters 500 meters in diameter and with an overall size of 3-4 kilometers (Dimitrov, 2002). Some of the mud volcanoes are spaced very close to each other, forming a common body and the flows of mud volcano Breccia can cover areas of 100 km² or more, as they do in northern Irian Java, New Guinea (Williams et al., 1984) and the submarine Gelendzhik mud plateau in the crest of the Mediterranean Ridge (Limonov et al., 1996).

7. Mud volcanoes classification

Mud volcanoes are generally classified in two groups of cold or tectonic and warm or volcanic. Yet with regard to their initial place appearing, physical and chemical attributes, form and origin, they have some differences that the mentioned classifications cannot include all of the above-mentioned. As a result, we classify mud volcanoes in a different way.

7.1. Mud volcanoes classifications based on the location of formation

Mud volcanoes can be classified as to their location of formation into: "continental mud volcanoes" that appear on the land of sea coasts and are subject to erosion under the influence of flowing waters, wind and rain (Fasl-e-Bahar et al., 2010; Fasl-e-Bahar, 2011). "Sub-sea mud volcanoes" are mainly formed at the depth of 10 to 800 meters and are eroded by waves and sea-bed currents (Fasl-e-Bahar et al., 2008; Fasl-e-Bahar, 2011) and "island mud volcanoes" that gradually form islands in the shallow depths of seas, as a result of high volume of outflowing materials (Negareh, 2006). It seems

the formation origin of Iran's mud volcanoes, in the northern coasts of Oman Sea, has been the movement of Oman's ocean plate below Iran's continental plate.

7.2. Classifying mud volcanoes based on geological environments and origin

Geological distribution of mud volcanoes is strictly controlled by geological environments in which they are formed. In this regard, the origination of mud volcanoes is controlled by the following items:

- New tectonic activities, especially compressional.
- Sedimentary or tectonic load caused by swift sedimentation, connectivity and overthrust.
- Active and continuous production of hydrocarbon.
- Presence of deep, soft, plastic, fine-grained and thick sediments in sedimentary sequence (Negaresh, 2004; Negaresh, 2006; Dimitrov, 2002).

8. The manner of mud volcanoes formation and accompanying gases

As fine-grained sediments withdraw, they get pressurized. In this stage, microorganisms and organic materials in the sediments are disintegrated and turn into hydrocarbon gases. Concurrent with the placement of gases into ground waters and after getting mixed with soft sediments, the mass of sediments start moving. The softened mass gets influenced by the fluidity force and the change of thermodynamics conditions. Finally gases present in the dilute mud ascend to the top of diapirs, helping the mud to come to the surface (Deville, 2003). From among the most important gases ascending from mud volcanoes that sometimes go into flame, one can refer to CH₄ that constitutes 85 to 89 percents of the overall gas volume. With a maximum of 10 percents, CO₂ is ranked second and other gases such as H₂S · N₂ · C₅H₁₂ · C₄H₁₀ · C₃H₈ and C₂H₆ are found at very small volumes. Quantitative assessments of the gases released from mud volcanoes show that they are one of the most important natural sources of atmosphere methane and annually produce about 10.3 to 12.6 Tg of methane gas (Dimitrov, 2002) (Fig. 2).

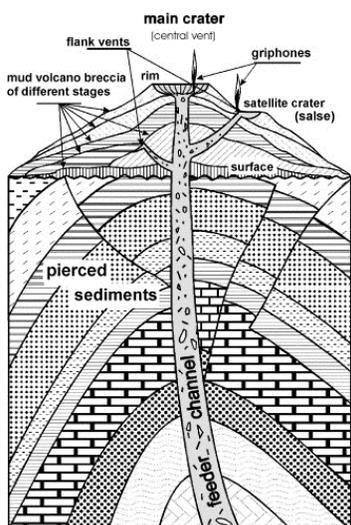


Figure 1. Basic structure and main elements of a conical mud volcano.

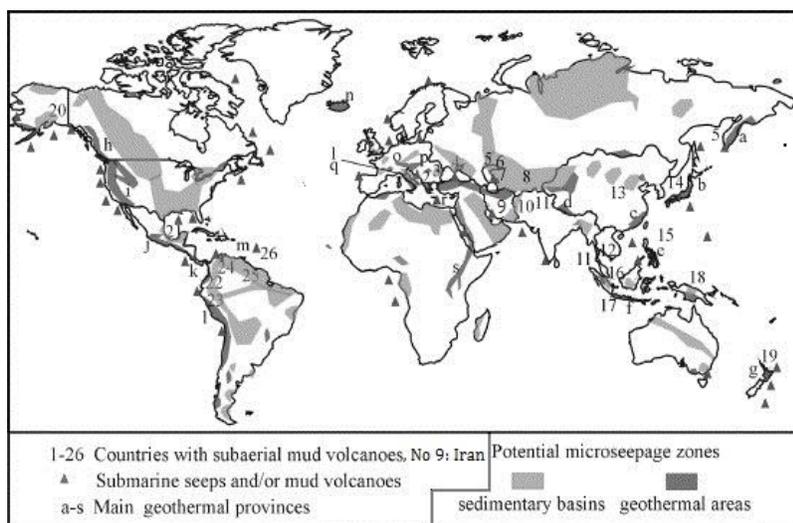


Figure 2. Geographical distribution of potential geologic methane emission sites. Mud volcanoes.

9. Geographical distribution of the world's mud volcanoes

Data presented on geographical distribution of the world's mud volcanoes show that there are 1800 of them existing globally (Dimitrov, 2002). They are mainly located in Asia, Europe and America. Researches done on the coasts and seabed of The Caspian Sea by some geologists from Azerbaijan and other coastal countries of that Sea show that near 70 percents of these mud volcanoes are situated in Asia, in the vicinity of the Caspian Sea. These mud volcanoes are usually seen in the volcanic and tectonic areas with quick sedimentation rate (Castaldini, 2008).

10. Case study (Iranian mud volcanoes)

Iran's mud volcanoes dispersion is mainly limited to the southeastern margin of the Caspian Sea in Turkman Sahra steppes and to the southeast of Iran in Oman Sea coasts, between Minab and Guatr Port that is formed from various diapirs as well as active, half-active and inactive mud volcanoes to be fully explained in the next parts (Fig. 3 & 4).

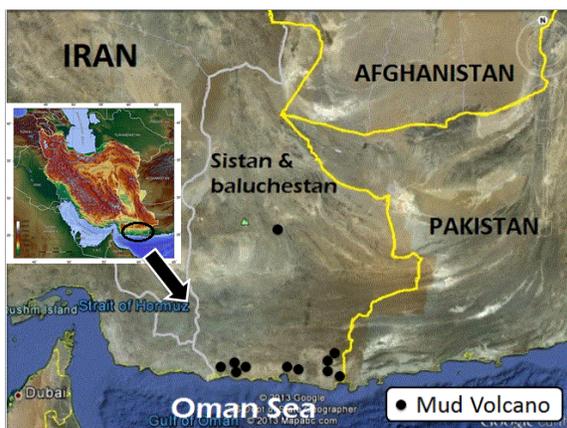


Figure 3. Position of volcanoes located on southeast of Iran (on Oman Sea Coasts) as shown by satellite images.

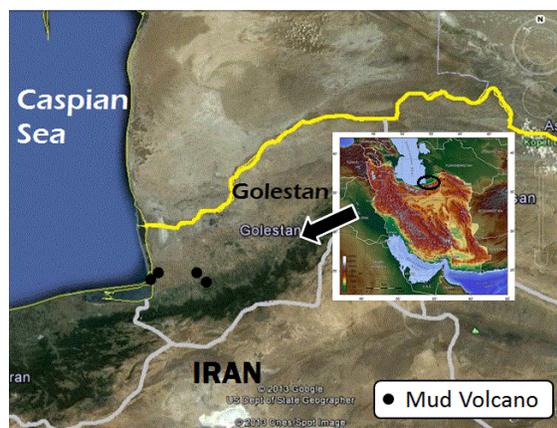


Figure 4. Position of Caspian Sea mud volcanoes on Iran coasts as shown by satellite images.

10.1. Mud volcanoes dispersion in the southeast margin of the Caspian Sea

Mud volcanoes dispersion in the southeast margin of the Caspian Sea is between eastern longitudes of 54 to 55 degrees and northern latitudes of 37 to 38 degrees, in Golestan province. There are some factors influencing the region's diapirs formation, some of which having turned into mud volcanoes. These factors include quick reflow of the margin of Caspian Sea's sediments, effects of the faults of the region and the subduction of the sea bed under the continental crust (Khosro tehrani, 1998).

10.1.1. Gharniaregh Tappeh Mud Volcano:

This mud volcano is located 18 kilometers southwest of Agh-Ghala. It is externally 700 meters in diameter and has a cavity inside roughly 5 to 10 meters deep. There is a conical hill at the center of this hole and there is also another desolated hole at its top. There are actually two internal craters filled with water in between. There are some salty sediments, methane and traces of oil materials getting out of it. It can be regarded as the largest Golestan mud volcano.

10.1.2. Naftelijeh mud volcano:

This mud volcano is located 8 kilometers from the northeast of Gomishan, inside the plain. It is 4 meters higher than the surrounding lands, being 160 meters in diameter. Its crater is nearly 10 meters in diameter. Outflow mud of this mud volcano is flowing and gas bubbles exist in it. It is surrounded by salty water with traces of petroleum substances (Fig. 5).

10.1.3. Inche Borun mud volcano:

This mud volcano is located 25 kilometers north of Agh-Ghala, in the vicinity of a lake named the same and on the plain and salty lands. Its crater is 20 meters in diameter, its outflow mud is more running than the previous ones, being morphologically different from them (Fig. 6).

10.1.4. Gomishan mud volcano:

Recent studies done on the southeastern bed of the Caspian Sea indicate that many developing diapirs are being created in the form of mud volcanoes and that one of which has activated in 2007, 6 kilometers from Gomishan in the shallow part of the Sea (Fasle Bahar, 2010; Fasl-e-Bahar, 2011). The outflow mud is dark smelling gas and sludge with an altitude of 1 and 2 meters.

10.2. Mud volcanoes dispersion, Southeast of Iran

These mud volcanoes are located in Sistan and Baluchistan province between eastern longitudes of 58 to 61 degrees and northern latitude of 25 degrees. They are about 25 in number, yet different with regard to their dimensions and rate of activity. Some are currently active and some others are inactive. Below we refer to the most important ones:

10.2.1. Napag mud volcano:

This mud volcano is regarded as one of the most important and well-known Iranians mud volcanoes, being located 75 kilometers northwest of Chabahar. It is of 35 meters higher than the neighborhood land, with the crater diameter of 10 meters and 3 meter deep. Mud outflow happens in the 5 and 10 minute periods as it is thick, as a result this occurs with an explosion sound. The sound of bubbles bursting up is pleasurable as well. The mud thickness has gradually heightened this mud volcano and lead to this morphology (Fig. 7). Yet in the winter, the outflow mud is more running and more active (Fig. 8).



Figure 5. Naftelijeh mud volcano.



Figure 6. Inche Borun mud volcano.



Figure 7. Location of different layers of mud poured out of Napag mud volcano.

10.2.2. *Pirgel mud volcano:*

Due to its characteristics, this mud volcano is one of the most beautiful and most unique mud volcanoes in the world and has been chosen as one of Iran's national-natural attractions. Being 127 meters higher than the surrounding lands, this mud volcano is located on small hills, 1000 by 500 meters in dimensions and 50 hectares in area (Fig. 9). On the hill, there are nearly 11 cones with large and small craters, seven of which being active and the rest inactive (Fig. 10). This mud volcano has some characteristics differentiating it from other mud volcanoes. These features are as follow:

- It is the highest Iran's mud volcano, being 127 meters higher than its surrounding lands.
- Against all other mud volcanoes of Sistan and Baluchistan that are located on the coast, this one is located on the coastal plain, at the center of the province, with the direct distance of 300 kilometers from the coast.
- It is Iran's vastest mud volcano with an area of 50 hectares compared to others in the province that are 2 hectares vast at the most.
- The number of blind valleys, gullies as well as wonderful perspectives of this mud volcano is more than mud volcanoes in other provinces.
- Outflow mud of this mud volcano is creamy, while that of other ones is grayish.
- Outlet gas of this mud volcano is CO₂ while others let out methane.
- Against other mud volcanoes of this province, it doesn't have a single cone. and yet it is constituted form a crater and some cones.
- There are some springs around this mud volcano that is quite unique among other mud volcanoes.
- As it is located between the igneous bodies of Taftan and Bazman, it seems to be an active volcanic one, yet it is cold and tectonic! This is wonderful.



Figure 8. Napag mud volcano.



Figure 9. A part of small hills on which craters of Pirgel mud volcano are located.



Figure 10. Image of one of Pirgel mud volcano craters.

10.2.3. *Eastern Drabol Mud Volcano:*

Being 10 meters higher than the surrounding lands and having a circular cone 90 meters in diameter, it is located in the vicinity of a mountain with the same name, on a coastal plain and has one main crater as well as 4 side craters. Flowing muds are always boiling and once after some minutes run down to a small hole 1.5 meters in diameter through subterranean blind valleys.

10.2.4. *Western Drabol Mud Volcano:*

It is about 10 meters high and located on a coastal plain. This mud volcano has a steep slope and is from among Iran's highest inactive mud volcanoes.

10.2.5. *Sigari Mud Volcanoes:*

It is 20 meters high located northeast of villages Kalati and Rimdan. It is about 80 meters in diameter and its secondary crater is seen at the height of 15 meters.

10.2.6. *Sisad Mud Volcano:*

Being located west of the desolated village of Sisad on a coastal plain, it is 10 meters high and 50 meters in diameter. Outflow of mud and gas happens once per some minutes accompanied with some noise and burst of bubbles. It then flows into the surrounding lands. This mud volcano has a one side craters.

10.2.7. Sande Mirsoban Mud Volcano:

Being 8 meters high, this mud volcano is located 2 kilometers south of Mirsoban village, on a coastal plain. Its crater is 3.5 meters in diameter. As a result of the existence of petroleum odor and traces as well as being inflammable, its color is attributed to hydrocarbon substances.

10.2.8. Borborak Mud Volcano:

Being located 15 kilometers southwest of Kahir village, it is composed of some large and small cones; one crater of which being active and others inactive. In Baluchi language, Borbork means gurgling. As this mud volcano's activity is accompanied with murmuring and gurgling of water, that's why it is named as such. The highest cone of this mud volcano is 25 higher than the coastal plain. Having flowed down the slope for about 400 meters, its muddy flows create some beautiful scenes. At the moment, it has 14 inactive and 1 or 2 active craters that get frequently active and inactive, attracting attentions.

10.2.9. Vashnam Mud Volcano:

Being 10 meters high, it is located on the coastal plain, 5 kilometers from Maleki Mountain. The cone's base is about 200 meters in diameter and the crater is nearly 8 meters in diameter. This mud volcano is currently inactive.

10.2.10. Ain Mud Volcano:

It is located 7 kilometers northwest of village Tran, 1.5 meters higher than the surrounding lands. The crater is 75 meters in diameter and mud flows and methane is always running from it.

10.2.11. Abad Kashi Mud Volcano:

Being 1 meter higher than the surrounding lands, it is located 12 kilometers from Kashi village. It is of a low rate of activity and its outflow substances include water, sludge and mud that are accompanied with the odors of hydrocarbon gases. Locals of this region believe this mud is of a therapeutic property. Hence after it erupts, they start bathing in it.

10.2.12. Talab Mud Volcano:

It is located between Porm and Konarak, 1.5 meters higher than the surrounding lands. The cone is 55 meters in diameter with two craters each 20 centimeters in diameter, 5 meters away from each other. It is currently inactive (Fig. 11).

10.2.13. Tang Mud Volcano:

Being 100 meters high, it is one of the largest and most notable mud volcanoes in Iran, located 400 meters from the coastal road of Tang fishing port, 100 kilometers from Chabahar. Its cone has some craters that repeatedly go active and inactive one after the other. Outflow of mud happens once per some minutes accompanied with some noise and burst of bubbles. It then flows into the surrounding lands in a way that the mud flows extend to 500 meters far away (Fig. 12). From a geo-tourism outlook, this mud volcanoes as well as Pirlgel mud volcano that have been regarded as natural-national tourism attractions have some special benefits as follow:

- Being located in the vicinity of Chabahar free zone, having some scenic places such as Hera forest, beautiful rocky and etc
- It is visible from far away as a result of the region's topographical conditions
- Easy access

10.2.14. Bolbolok Mud Volcano:

It is located around village Tang on a plain land and has 3 cones, one of which being active and the other two inactive. Once per a quarter of an hour, grey mud outflows accompanied with the sound of bubbles bursting. This mud volcano is from among other mud volcanoes of this province (Fig. 13).



Figure 11. Talab mud volcano.



Figure 12. Bubbles produced in Tang mud volcano.



Figure 13. Bolbolok mud volcano.

11. Importance of Mud Volcanoes

Mud volcanoes are from among the attracting geomorphological terrains of earth that can be used for different purposes, from among which:

- As mud flows come to the surface along joints and fractures, mud volcanoes are good clues for detecting the status of region's faults and considering the constructions in the vicinity, especially important structures such as firms and plants.
- Mud volcanoes especially in coastal zones are mostly connected with volcanoes and subduction zones. Hence presence of mud volcanoes in such areas and their continuous activities can be a sign of subduction in the region and can be used for investigating development rate of volcanic activities.
- As mud volcanoes have direct relationship with oil reserves and hydrocarbon gases, researchers regard them as natural exploratory estimations through which the regions' deep hydrocarbon reserves and information on oil and gas movement can be accessed freely.
- Based on the researches, there is a high amount of elements boron, copper, iodine, bromine, vanadium, magnesium, sodium, calcium and bicarbonate and some animals such as elephants through licking them (mud volcanoes), make up for the lack of some elements such as sodium, calcium, iodine and other substances their bodies need (Negaresh, 2006).
- As regards the presence of organic and inorganic substances in the mud and sludge of mud volcanoes, mud-therapy is nowadays of an especial status and many physicians have realized its effectiveness. Due to the existence of the mentioned elements, many patients go to these places for treatment. Even in European countries like Italy, industrial, sanitary and beauty units produce skin creams using this mud (Fasl-e-Bahar, 2011) (Fig. 14, 15 and 16).
- Mud volcanoes are 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 (Negaresh, 2006).



Figure 14. Soap produced from the mud of one of mud volcanoes.



Figure 15. Sanitary mask produced from the mud of mud volcanoes.



Figure 16. Cream produced from the mud of mud volcanoes.

12. Tourism Potentials of Mud Volcanoes

Today in different parts of the world, mud volcanoes attract many tourists through beautiful and unique scenes they exhibit. Outflow of mud and water accompanied with hydrocarbon gases that sometimes go into flames, as well as the forming of some lavas filled with mud and also the manner bubbles burst making some sounds, downturn of mud volcanoes from mud volcanoes' craters are quite wonderful. These can be noteworthy for scientific researchers and tourists. Currently those countries enjoying this natural phenomenon have earned a lot of foreign currencies through correct policies and planning. Apart from the above-mentioned attractions, therapeutic attributes of this kind of mud have notably aided tourism. From among those countries having been successful in attracting tourists to mud volcanoes, one can refer to mud volcanoes of Azerbaijan, Papiro mud volcano south of Trinidad, Berca in Romania and Castaldini in Italy (Fasl-e-Bahar, 2008).

In summary, the most important attributes and applications of mud volcanoes that can influence Geo-tourism include: form, morphology, manner of activity and mud outflow, importance in therapeutic mud, importance in forming small herbal and animal ecosystems, application in pottery and connection with oil and gas resources.

13. Ways of developing geotourism in mud volcanoes focal points

In order of developing geotourism in mud volcanoes focal points, some items should be considered as follow:

- Carrying out complementary studies on mud volcanoes and their geological environment by researchers
- Presenting media publicity nationally and internationally, developing and reconstructing access roads to important mud volcanoes such Pirgel mud volcano.
- Establishing therapeutic centers and publicizing benefits of mud volcanoes.
- Erecting guide signs of mud volcanoes attribute.
- Publicizing the culture of using natural phenomena by related organizations.
- Creating lavas filled with mud and water for entertaining activities, games, etc.
- Establishing hotels and lodging places, cultural centers etc. in the vicinity of important mud volcanoes.

14. Conclusion

Mud volcanoes are regarded as Iran's notable and wonderful geo-tourism scenes. They have many characteristics and applications that as to their varied forms, beautiful scenes of mud and hydrocarbon flows scenes, beautiful scenes of bubbles bursting and the resulted sounds, therapeutic attributes etc., can attract domestic and foreign tourists and geotourists. Yet what matters is that there have been few scientific studies done in this regard and tourism publicity has even been less. In this regard, researchers must endeavor more and take steps in introducing Iran and world's geo-tourism centers, especially mud volcanoes, through doing research and presenting articles. Also statewide, related authorities should create apt infrastructures and through doing publicity in developing national and regional geo-tourism make a lot of profits for the state.

REFERENCES

1. Amri Kazemi, A., 2009, "Atlas of Geopark and Geo-tourism Resources of Iran", Institute of Geology and Mining Publication, Tehran, pp. 270-289.
2. Ashuri, A., 1985, Natural Geography Terminology, 1st ed. Tehran: Jahade Daneshgahi.
3. Barber, A.J., Tjokrosapoetro, S., Charlton, T.R., 1986. Mud volcanoes, shale diapirs, wrench faults and mélanges in accretionary complexes, eastern Indonesia. AAPG Bull. 70, 1729–1741.
4. Bayati Khatibi, M., Shahabi, H., Ghaderi Zadeh, H., 2010, "Geo-tourism, a new approach in exploiting geomorphological attractions", Geographical Quarterly 10, no. 29.
5. Castaldini, D., 2008, Maps and Multimedia tool for the environmental tourism in protected areas of the Modena Apennine (Northern Italy), geo. Journal of Tourism and Geosites, 1(1), 13-33.
6. Deville, E., Battan, A., Griboulard, R., Guer Luis, S., Herbni, j.p., Houzay, j.p., Muller, C., Prinzhofer, A., 2003, the origin and processes of mud volcanism: new insights from Trinidad, geological society, London, special publications, V. 216, pp. 475-490.
7. Dimitrov, I.L., 2002, Mud volcanoes—the most important pathway for degassing deeply buried sediments, Earth Science Reviews, 59: pp. 49-76.
8. Dowling, R.K., Newsome, D. 2006, Geo-tourism, oxford, Burlington (Elsevier Butter worth- Heinemann), pp. 1-2 , 350.
9. Dowling, R.K., Newsome, D. 2010, Geo-tourism: The tourism of geology and landscape Good fellow, Book Review, Publishers Ltd, Oxford, pp. 1, 246.
10. Fasl-e-bahar, J., 2011, mud Volcano, Arianzamin Publications, Tehran, PP. 24-109.
11. Fasl-e-Bahar, J., Fasl-e-Bahar, Sh., 2008, Mud Volcano Phenomenon and its Environmental Effects, Humans and Environment, no.6 (Iran's expert society for environment)
12. Fasl-e-Bahar, J., Purkermani, M., Fasl-e-Bahar, SH., 2010, Investigating Mud Volcanoes, South East Skirts of Caspian Sea, no. 75 (State's Geology and Mining Discoveries)
13. Footer, J.P., De Lange, G., 1999. Submersible observations of cold seeps on eastern Mediterranean mud volcanoes. J. Conf. Aster. EUG 10, 28th March–1st April, Strasbourg, France, B134.
14. Ginsburg, G.D., Milkov, A.V., Soloviev, V.A., Egorov, A.V., Cherkashev, G.A., Vogt, P.R., Crane, K., Lorenson, T.D., Khutorsky, M.D., 1999. Gas hydrates accumulation at the Haakon Mosby Mud Volcano. Geo-Mar. Lett. 19, 57– 67.
15. Heydari, R., 2008, Basics of Tourism Industry Planning (Tehran: Samt), p. 51.
16. Jafari, E., 2007, Great Cosmology Technology, 1st ed. (Tehran: Gitashenashi)
17. Khosro Tehrani, Kh. 1998, Iran's Geology (Tehran: Payame Noor University)
18. Limonov, A.F., Woodside, J., Cita, M., Ivanov, M., 1996. The Mediterranean Ridge and related mud diapirism, a background. Mar. Geol. 132, 7–19.
19. Milkov, A.V., 2000. Worldwide distribution of submarine mud volcanoes and associated gas hydrates. Mar. Geol. 167, 29– 42.
20. Negareh, H., 2004, Investigating Pirlgel Mud Volcano and its Attributes East of Bazman Volcano, Geography and Development Quarterly, no. 4, pp. 191-207.
21. Negareh, H., 2006, Investigating Some Scientific and Applied Aspects of Mud Volcanoes, Applied Geology Quarterly 2, no.20.

22. Negareh, H., 2006, Mud Volcanoes and Their Geographical Dispersion in Iran, *Geography and Development Quarterly*, no. 16.
23. Williams, P., Pigram, C., Dow, D., 1984. Melange production and L.I. Dimitrov / *Earth-Science Reviews* 59 (2002) 49-76 75 the importance of shale diapirism in accretionary terrains. *Nature* 309, 145–146.
24. Yazdi, Abdollah. 2012, A Study of Iran's Lut desert: Geomorphological and Geotourism Attractions, *Proceedings of Annual International Conference on Geological & Earth Sciences (GEOS2012)* 3-4 December, Singapore: 35-41.