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A review of Mud volcanoes situation in Caspian seaboard and new methods of their identification by remote sensing techniques

Babak Kheradmand *[1]

[1]Senior expert of geology at Iranian Gas Engineering & Development Company (I.G.E.D.C.), Tehran, Iran

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Abstract

The main issues presented in this paper, considering the future plans of the oil and gas industries in the region, include the status of the distribution of Mud volcanoes in the Caspian region as well as the presentation of the total framework of new ways of identifying and analyzing them based on remote sensing techniques using experiences in other neighboring countries of the Caspian Sea. These structures are associated with hydrocarbon deposits, subduction tectonic zones, and orogeny belts, and in very rare cases are associated with mud volcanoes. Fortunately, most mud volcanoes are found on the seabed and their effects are far less.

1. Introduction

Mud volcanoes are important morphological features that are often in the form of clay cones and from a height of 2 meters to a maximum of 500 meters around them and with a base diameter of 20 meters to a maximum of 3500 meters. It is possible that their central part is made of sand and the outer part is made of mud. These mud volcanoes are hilly and circular in shape and have a main opening and several smaller side openings. The main opening is usually located in the middle of the mud volcano and is bowl-shaped or blade-shaped and the side openings are not fixed and permanent. Sometimes mud volcanoes have no eruptions and some are not permanent and are active periodically and pulsating springs and, in this respect, they are similar to volcanoes which are much smaller than them. Mud volcanoes are found both on land and in the oceans (Kheradmand, 2013).

2. Caspian coastal mud volcanoes in Iran

"Gomishan", "Qarniaraq Tappeh" and "Naftlijeh" mud volcanoes in Golestan province of Iran are among the most beautiful natural phenomena in the form of small volcanic cones made of mud or sand, the dimensions of which vary from a few centimeters to several meters, and it seems that the central parts they are made of sand and their outer part is made of mud. In these golf courses, mud and sand materials are injected from below into the gap and with water. The rapid release of flowing, watery muds, accompanied by bubbles and noise, causes the formation of cones, and in the center of these cones, there is a crater-like hole for material to exit, which creates a gap in the ground and injects material from below. They are formed with water and gas.

Studies show that these cones occur in earthquake-prone areas and along some faults, and the rapid settling of materials and subsequent outflow of water from the particle bed causes the formation of mud volcanoes on the surface of sediments.

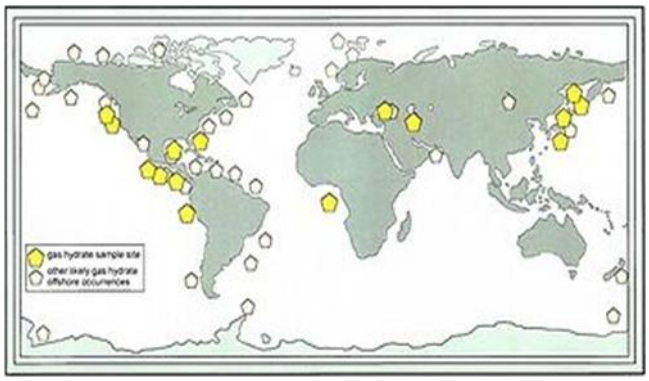

Figure 1. Map showing the distribution of mud volcanoes in the world (Wikipedia).

* **Corresponding Author**

*(kheradmand_babak@yahoo.com) ORCID ID 0000-0002-7213-6287

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Some believe that mud volcanoes have a tectonic origin and the subduction action and pressures caused by tectonic movements are the reason for their occurrence and some believe that mud volcanoes are formed in volcanic areas.

"Qarniaraq Tappeh" mud volcano in the east of Gomishan, "Naftalijeh" in the northeast of Gomishan and "Incheh" next to Incheh Borun wetland are famous mud volcanoes in Golestan province and all of them are active with gas, water containing sodium chloride and aromatic petroleum products.

Naftlijeh mud volcano in the northeast of Gomishan is associated with petroleum products and has created a hill in the middle of a flat plain of mud paste, oil that comes out of its mouth and has a high gas activity.

Qarniaraq in the local language, where the abdomen is split; With a diameter of about 600 meters, it is considered to be the largest mud volcano in Golestan province, from which salt deposits, methane gas and traces of petroleum products are extracted, and the locals believe in its healing properties.

Incheh mud volcano is also located next to Incheh Borun wetland, which in recent years, the issuance of licenses for exploitation wells along the wetland, has disabled this mud volcano (Mirkazemian, 2009).

3. Mud volcanoes of the Republic of Azerbaijan

The mud volcanoes of the Republic of Azerbaijan are spectacular symbols of the hidden oil and gas resources deep in the land in the Caspian Sea. Gas leakage occurs when subsoil is saturated with methane gas and seeks to find a passage to the surface.

A famous example of gas leakage is in Yanardaq (Mountain of Fire) on the Absheron Peninsula. People often go there to watch the flames dance and enjoy watching this fascinating phenomenon that never goes out, and it is interesting for them to understand how this fire lasts forever and burns from the ground and is a tool. It is for worship.

The people of Azerbaijan link the emergence of Zoroastrianism in Azerbaijan about 2000 years ago with this geological phenomenon. According to them, the name of the country "Azerbaijan" is also derived from the Persian word "Azar" meaning "fire". This ritual has been the most important pre-Islamic historical ritual in this region.

The final annual volume of gas emitted by all mud volcanoes in the Republic of Azerbaijan is estimated at about 20 million cubic meters per year. In 1964, the Turaghayi mud volcano ignited flames that burned for several years and released 500 million cubic meters of gas (Scholte, 2011).

The mud volcanoes of the Republic of Azerbaijan, usually outside the population centers, occur suddenly and in a short time. For this reason, it is not possible to observe them from the beginning to the end. With the exception of the "Lokbatan" mud volcano, which was studied by the Faculty of Science of the Azerbaijan Institute of Geology and its eruption lasted more than 20 hours. Lokbatan is the name of an area 15 km south of Baku where camels have drowned in the past due to mud.

Mud volcanoes of the Republic of Azerbaijan vary in size and shape, but most of the mud volcanoes of this country have small cones or small mud outlets. These small cones are interesting and even have a beautiful view and cold mud, water and gas are coming out. Therapeutic properties (iodine, bromine, calcium, magnesium, organic acids and aromatic hydrocarbons) have been reported in these muds. This mud solution has no significant toxic substance (Scholte, 2011).

4. New methods of identifying and analyzing mud volcanoes

Geological researchers from the Republic of Azerbaijan have recently succeeded in using new methods to find mud volcanoes, and with these methods, they have identified buried mud- volcanoes in the southwest of the Absheron Peninsula.

These mud volcanoes were studied for 40 years at the Geological Survey of this country; but there were some doubts about this part of the science. There was no complete theory of the formation and mechanism of mud volcanoes, and no significant information was provided about buried mud volcanoes.

These researchers use a combination of wavelengths of images taken from the region with ASTER, InSAR, TM7 systems as well as Hyperion method and spectrometric analysis method; they have identified mud volcanoes and have even succeeded in determining the percentage of mineral compounds in each of them.

As it has been determined, more than 90% of the oil and gas deposits of the Republic of Azerbaijan have mud volcanic structures; thus, newly discovered mud volcanoes can testify to the oil and gas content of these areas (Figures 2 to 6) (Scholte, 2003).

Absorption wavelength (um)	Mineral Group
2.165	Low pH / acid environments
2.205	Al-OH bearing minerals
2.260	Jarosite
2.327	Carbonates and Mg-OH bearing minerals

Figure 2. Demonstrates the relationship between the accumulation of minerals in mud volcanoes and the wavelength in the ASTER imaging method (Scholte, 2003).

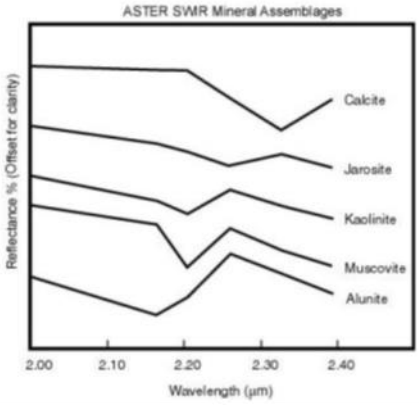

Figure 3. Representation of reflecting wavelength range of different groups of minerals in mud volcanoes in ASTER imaging method (after USGS) (Scholte, 2003).

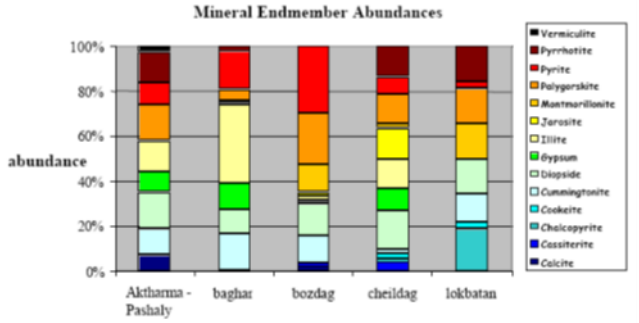

Figure 4. Indicates the percentage of abundance of different minerals in each of the mud volcanoes located in the Republic of Azerbaijan (Scholte, 2003).

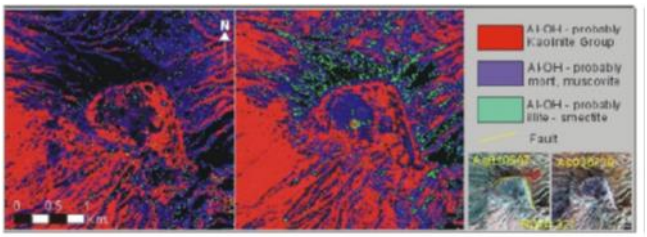

Figure 5. Mineralogy map of Aktharma-Pashaly mud volcano located in the Republic of Azerbaijan (using ASTER images method) (Scholte, 2003).

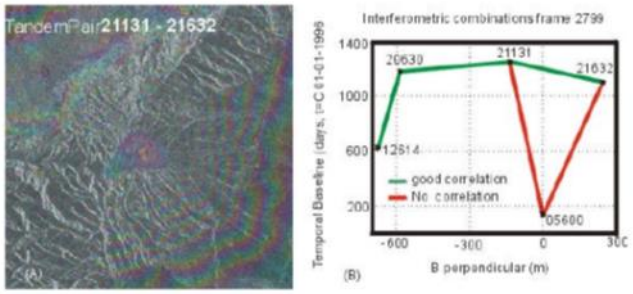

Figure 6. Matching two consecutive images of the Aktharma-Pashaly mud volcano (Figure A) using the InSAR technique (green and red lines in Figure B indicate the degrees of good matching and non-matching, respectively) (Scholte, 2003).

5. Results

- Mud volcanoes are among the natural phenomena that are caused by tectonic activities in the region and are consistent with fault structures and are morpho-neotectonic signs that indicate the activity of the area containing them from a tectonic point of view.

- These structures (mostly conical) are formed by the pressure of gases from hydrocarbon layers (oil and gas) and their reserves so that the lower clay and marl rocks are saturated and softened by groundwater or in the form of mud in have come; They are ejected, creating sometimes very large craters resembling volcanic craters (quasi-craters or craters).

- Due to the special morphological condition of these structures, construction operations, especially permanent structures (such as power plants, dams and the route of lifelines such as oil and gas pipelines and related facilities) are not recommended at all and should be avoided. From the wastage of expenses and unfortunate events, the location of these complications should be carefully determined and studied using new methods.

- Since mud volcanoes are among the obvious surface signs of the presence of rich hydrocarbon resources in the region (such as oil or sulfur springs or protrusions of bitumen and natural asphalt in the southern and southwestern parts of Iran), planning for studies comprehensive geology and geophysics are recommended to explore for oil and gas resources in such areas.

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