

Recent eruptions of mud volcanoes in Azerbaijan (geologic-geochemical aspect)

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The South Caspian basin (SCB) and especially its west flank which covers the territory of Azerbaijan is a unique and classical region of mud volcanism in the Earth. The SCB is a region of a large downwarping with a thick sedimentary series – more than 25 km. Within the west flank of the basin the tectonic structure and orientation of local structures throughout the territory demonstrate the existence of differences in the folding in certain areas of the region. Different orientation of the folds, difference in the spatial location of the structures and their complication by mud volcanoes are due to peculiarities of the deep structure of the region.

Amount and diversity of mud volcanoes and intensity of eruptions makes the territory of the East Azerbaijan unique in the world. More than 300 different kinds of mud volcanoes are located there – this is nearly a half of the whole mud volcanoes existing in the Earth. They are active, extinct, buried, underwater, island and oil mud volcanoes. Most of them are characterized by intensive gas activity. Every year we witness the reawakening of the volcanoes and 3 to 5 and sometimes more paroxysms of their eruptions are recorded. Lockbatan and Keireki mud volcanoes in the Absheron peninsula and Shikhzagirli mud volcano in Gobustan erupt more frequently. Activation of volcanic activity in the XX-th century was observed in 1926, 1970 and in 1986 – more than 6 eruptions and in 1988 nine eruptions were recorded.

The beginning of the new millennium is marked by unusual activation of mud-volcanic activity in Azerbaijan. Only in 2001 there was fixed a record number of on-shore and off-shore eruptions of 15 mud volcanoes and especially in the South Gobustan. Many of them ejected to the earth surface a great amount of mud-volcanic breccia. Thus, Durandag mud volcano ejected nearly 700 thousand m³ of breccia which covered an area of 30 ha. According to the new catalogue of eruptions from 1810-2001 there were fixed 294 eruptions of 80 volcanoes in Azerbaijan. Analysis of the eruptions demonstrated some typical features of the process on the whole and for certain regions of mud volcanism throughout Azerbaijan as well (Aliyev, Guliyev, Belov, 2002).

Every new eruption is a new information, the so-called “message” about processes in the earth interior. Long-term investigations of mud volcanism in the SCB (especially of ejecta) allowed to solve some genetic problems and to determine regularities of the spatial location of mud volcanoes and reasons of their manifestation. They are as follows:

1. There was determined a linkage of mud volcanism with the processes in Cenozoic superpositioned molassic troughs. There was proved a linkage of the formation and mechanism of manifestation of mud volcanoes with the Paleogene-Miocene complexes of deposits. Participation of Mesozoic deposits in the process is denied. The mud-volcanic breccia is represented by a whole Cenozoic section with the dominating role of terrigenous-carbonaceous rocks of the Paleogene-Miocene (80%). The Jurassic and the Lower Cretaceous rocks are absent in the breccia whereas single fragments of mainly Upper Cretaceous rocks are associated with mud volcanoes located in the areas of molassic formations overlapped by Cretaceous deposits, i.e. the Cretaceous fragments of rocks determined in the mud volcanic breccia are of an allochthonous origin (Aliyev, 1999).

1. In the light of new data there have been considered tectonic peculiarities of location and manifestation of mud volcanoes. There have been determined new fault structures and microblocks located between them especially in the Shamakhy-Gobustan region (Boyanatin and Towragai) which are characterized by a different morphology and character of mud-volcanic activity. There were determined regularities of spread of mud volcanoes along the submeridional regional structures and sublatitudinal anticlinal zones as well as the role of oil-gas producing Paleogene-Miocene rocks in the mechanism of mud volcanoes manifestations (Aliyev, Bairamov, 2000).

1. Comparative analysis of mud volcanoes manifestation on-shore and off-shore demonstrated main differences and similarities of marine and continental mud volcanoes according to the following features: 1 - manifestation range; 2 – activity of mud volcanoes; 3 - morphology; 4 - material composition of ejecta; 5 - chemical composition of fluids of ejecta.

Number of continental mud volcanoes in the SCB is 220. Among them 190 mud volcanoes exist on-shore of the East Azerbaijan. In the South Caspian by aeromagnetic and seismoacoustic profiling and by morphometric and geochemical methods there were determined more than 170 underwater mud volcanoes (methods proposed in the 80-s). In the Baku archipelago there were determined 8 island volcanoes. There exists no special difference in morphology of continental and marine mud volcanoes.

Within the land of Azerbaijan mud volcanoes are associated with structures of a different age (Paleogene, Miocene and Pliocene) and in a direction from NW to SE towards the regional subsidence there occurs a growth both of thickness and lithofacial characteristics of deposits. This fact affects the material composition of the ejecta. The marine volcanoes are linked with the Pliocene structures. The isotope composition of carbon CH_4 in the on-shore volcanoes varies from 37 to 62 %. Marine volcanoes are characterized by a light isotope composition, etc. (Aliyev, 2002).

4. Geochemical analysis of oils from mud volcanoes as compared with oils of different ages from the fields and with organic matter of oil-source deposits allowed to determine isotope-heavy and light oils and to link their source with the Paleogene and Miocene. These oils are of a naphthene-aromatic and methane composition. The isotope composition of carbon (ICC) of oils varies from 24.8% to 27.9%. Isotopically heavy oils of volcanoes are very well correlated with oils of the Pliocene and the upper Miocene deposits. Oils of mud volcanoes with a lighter ICC are better correlated with oils of the Paleogene deposits.

5. A comparative analysis of data on earthquakes and recorded eruptions of mud volcanoes in Azerbaijan for the last two centuries has been conducted as well. There was determined a spatial-time relation of earthquakes and mud volcanoes. With account of earthquake magnitude, depth of the source, energetic class and distance between the epicentre and volcano it was determined that strong earthquakes (magnitude 4-5 and more) "initiate" eruptions of mud volcanoes and especially of those located within one fault zone. For a long time they have been in a state of "peace" and accumulated energy for the paroxysm of the eruption. Earthquakes play a role of the so-called "trigger" (Aliyev, Gasanov, Bairamov et al., 2001).

Earthquakes		Mud volcanoes	
Location of the source	Date of earthquake	Name	Date of eruption
Shamakha	24.09.1848	Marazy	24.09.1848
Shamakha	28.01.1872	Marazy, Kalamadyn	28.01.1872
Shamakha	13.02.1902	Shikhzagirli	13.02.1902
South Caspian	01.10.1920	Dashly	01.10.1920
South Caspian	30.04.1927	i. Sangi-Mugan	30.04.1927
South Caspian	11.04.1932	i. Sangi-Mugan	11.04.1932
Mashtaga	08.08.1953	Bozdag-Gobu	08.08.1953
St. Nasosny	12.12.1959	Lockbatan	12.12.1959
Shamakha region v. Avakhyl	31.08.1965	Gushchu	31.08.1965
Shamakha	17.09.1967	Bozdag-Gyuzdek	17.09.1967
Shamakha-Maraza	21.11.1970	Cheildag	21.11.1970
Middle Caspian	27.09.2000	Kechaldag	27.09.2000

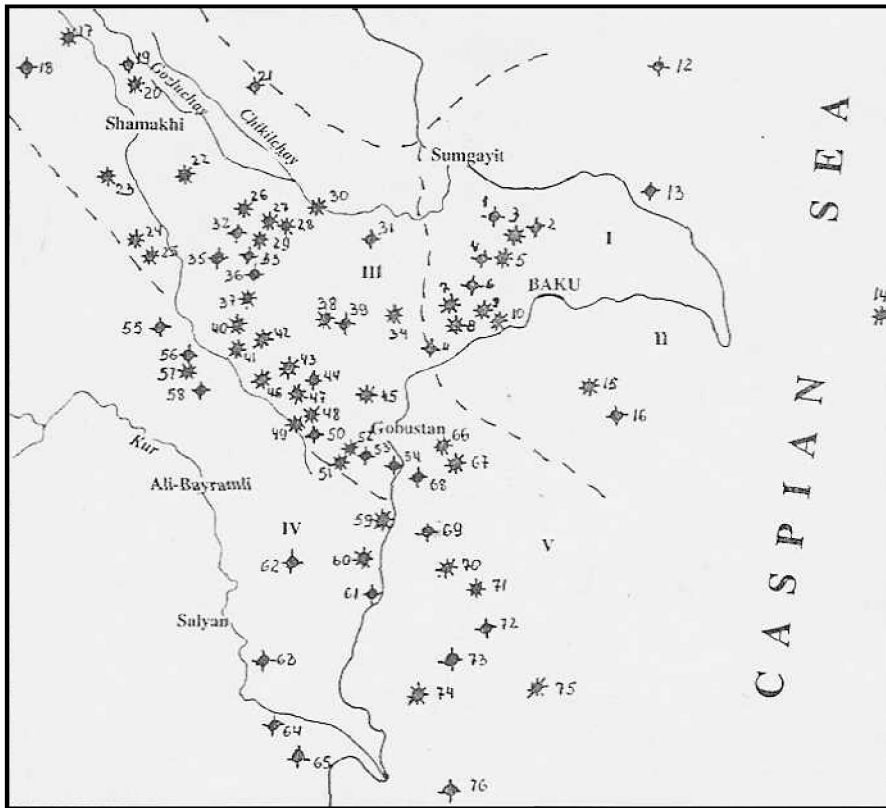
As a result of monitoring it was determined that during the preparation of the seismic events in the volcanoes characterized by gryphon-salse activity there occur abnormal changes of the ejected fluids as a result of their activation before earthquake. Amount of helium and carbon dioxide grows in the gases and amount of boron and sulphates grows in mud-volcanic waters.

The reason of activation of mud volcanoes in Azerbaijan in 2001 – is the intensification of seismic activity in autumn of 2000 (strong earthquakes of November 25 and December 6 with epicentres in the NE and SW of Baku city in the sea and further seismic events occurred in the South Caspian in 2001).

The paper also deals with some theoretical provisions of the problem touching issues of the modelling of mud-volcanic process and scientific substantiation of the solution of oil and gas exploration in the region of mud volcanoes.

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
 - once	 - from 5 to 10 times
 - to 5 times	 - over 10 times
----- borders of oil-gas bearing regions	
I - Absheron peninsula; II-Absheron archipelago; III- Shemakha-Gobustan; IV- Lower Kura; V- Baku archipelago.	

Fig. 1 Intensity of mud volcanic eruptions of Azerbaijan.

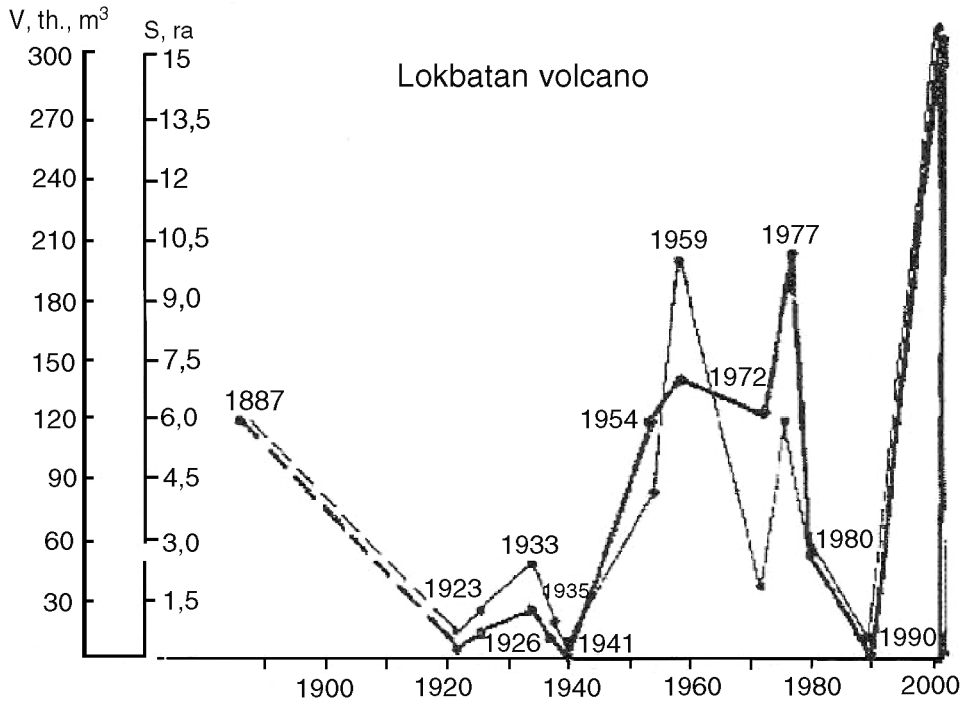


Fig. 2 Dynamics of area variation and volume of ejected volcanic breccia.