UDC: 551.311.8+550.836.2

HEAT FLOW AND MUD VOLCANOES IN THE CASPIAN SEA REGION

S. Mansouri Far

Department of Regional Geology, Faculty of Geography and Geoinformatics,
Belarusian State University, Minsk, siamak_mansourifar@yahoo.com

Abstract. A number of researchers connect the manifestation of mud volcanism and diapirs with areal variability of heat flow. Most mud volcanoes in the region are known in the Republic of Azerbaijan, south-western Turkmenistan, partly – in Georgia, on the Kerch the Crimean peninsula and in waters of the Caspian, Black and Azov seas, there are such volcanoes in Iran, but they are less common. A number of geological factors stipulate development of mud volcanism in the South Caspian Sea. A thickness of sediments reaches 30 km; the upper 10 km being composed of the Pliocene-Quaternary dominantly clayey lithologies accumulated at extremely high sedimentation rates (up to 1300 m/m.y.). The Lower-Kura Depression is known by its low heat flow among the alpine region. However, in adjacent crustal blocks the abnormal heat flow approximately twice exceeds the medium value and rises to 100 mW/m^2 and slightly more within the adjoining land.

Key words: mud volcanism; diapirs; heat flow; Republic of Azerbaijan; Caspian Sea; Kura Depression.

Introduction. Mud volcanism is one of the most interesting nature phenomena encountered in many countries of the world. A number of researchers connect the influence of mud volcanism and diapirs with areal variability of heat flow. Most mud volcanoes in the region are known in the Republic of Azerbaijan [1–3], south-western Turkmenistan, partly – in Georgia, on the Kerch the Crimean peninsula and in waters of the Caspian, Black and Azov seas, there are such volcanoes also in Iran, but they are less common. It was reported that concerning the research, carried out on the volcanoes of Azerbaijan [1] show the absence of a correlation between the flow and distribution of mud volcanoes on land.

Geology. A number of geological factors stipulate development of a mud volcanism in the South Caspian Basin. Among them is the movement of the Arabian Platform northwards with a rate around 20 mm per year and producing pressure at the region of Caucasus – Black and Caspian seas. A thickness of the sedimentary cover reaches here 30 km; the upper 10 km being composed of the Pliocene-Quaternary dominantly clayey lithologies deposited at extremely high sedimentation rates (up to 1300 m/m.y.). Among special features of the basin are generally low heat flow, abnormally high formation pressure, high degree of dislocation and seismicity, etc. In the South Caspian Basin, the general region of onshore and offshore Azerbaijan is a home to over 200 mud diapirs and/or mud volcanoes (figure 1). These mud structures are associated with the production of copious oil and gas, and production wells are to be found on the flanks of many onshore mud diapirs and volcanoes. This association is no mere coincidence but is related to the dynamical development of mud diapirs and the generation, migration, and accumulation of hydrocarbons in the South Caspian Basin, as has been detailed elsewhere [4].

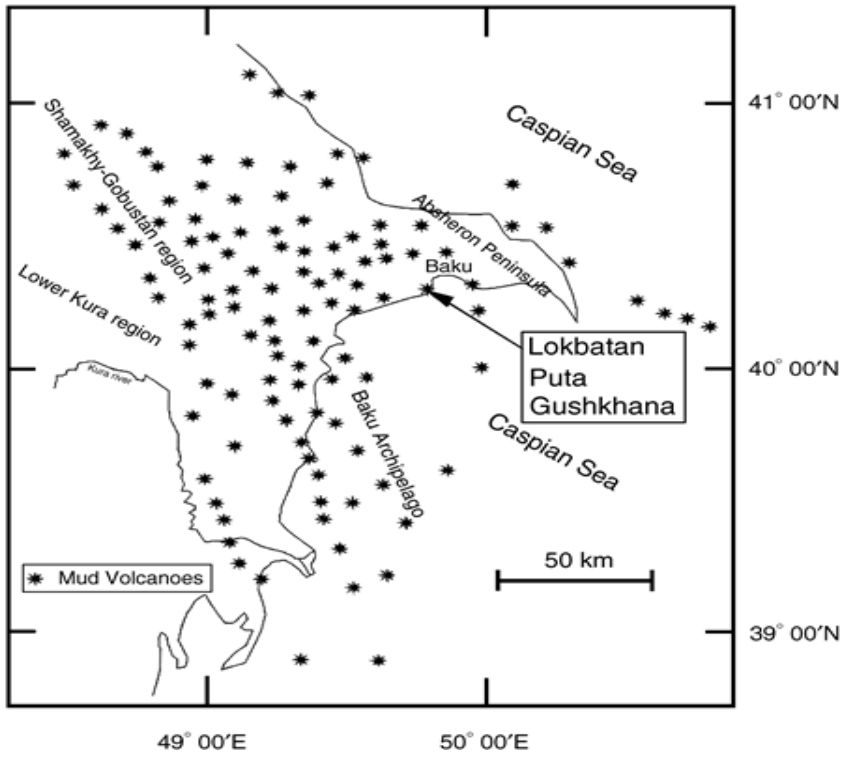

Figure 1 – Scheme of mud volcanoes location [3, 17].

Geothermal Research. Locally, individual mud volcanoes are distinguished by high values of heat flow density [1, 4]. At the same time, in the regions of development of mud volcanism, their regional values were lower than the average continental values [5]. The lower Kura Depression is distinguished in general by low heat flows among similar regions.

Temperature measures of mud volcanoes in Azerbaijan were first mentioned, in 1904–1905 [6]. It was defined that the water temperature of mud volcanoes could be compared with the average annual temperature on these localities [7, 8]. More detailed geothermal research on mud volcanoes was developed during exploration of oil and gas fields. It can be explained, mud volcanoes fill the majority of oil-gas structures. In result different anomalies of their field were defined including the reduction of geothermal gradient by the depth, and in area of mud volcanism development [9–13].

We have compared the distribution of mud volcanoes in the Caspian region, including altogether volcanoes on land, also dozens of volcanoes in waters of the Caspian Sea, southwestern Turkmenistan, figure 2. At first glance it looks like no unambiguous correlation was revealed either. Nevertheless, among the total number of volcanoes shown in the map (231) around (80) fall inside the isoline of 40 mW/m^2, (68) volcanoes are inside of the isoline of 50 mW/m^2 and (123) are within area with higher heat flow. Therefore, it can be concluded that with the increase of heat flow in the region, the density of mud volcanoes is significantly reduced.

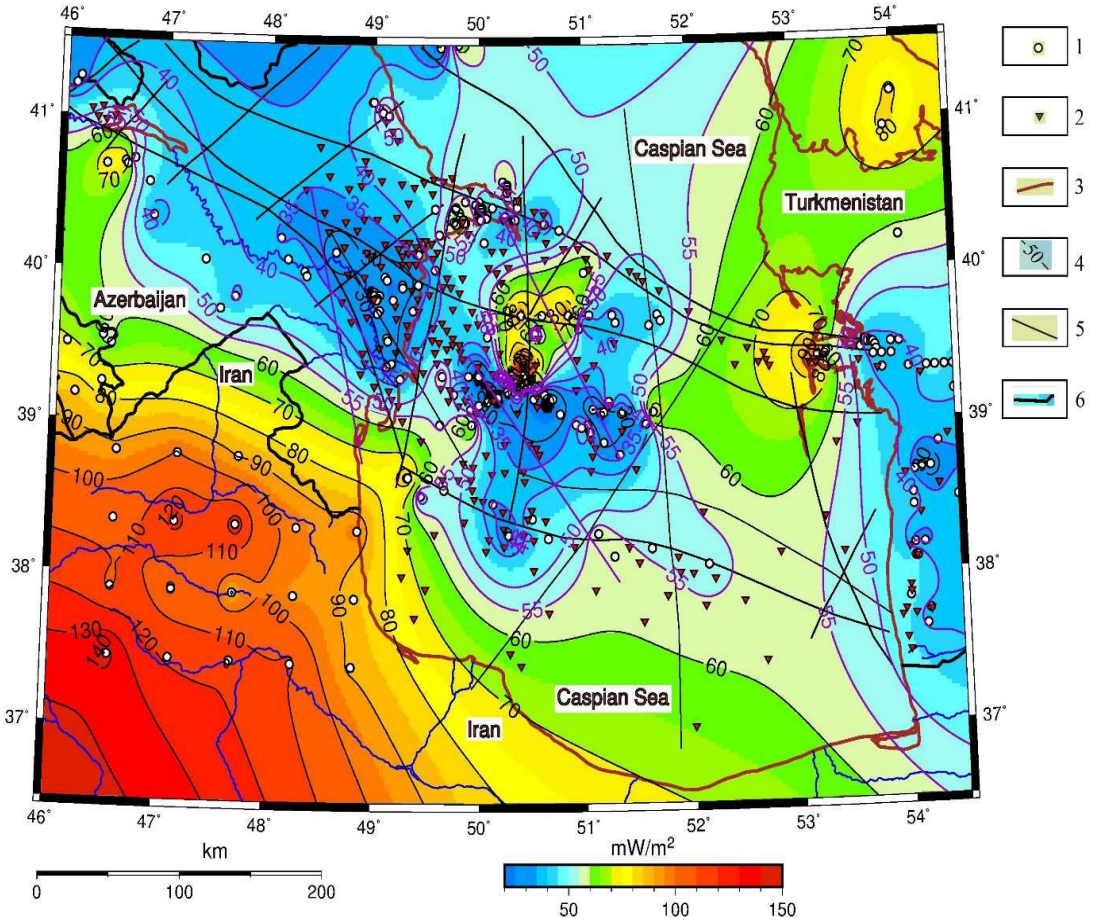

Figure 2 – Scheme of correlation of the mud volcanoes distribution and heat flow in the Republic of Azerbaijan, southwestern Turkmenistan and the South Caspian basin. Legend: 1 – points for determining the heat flow, 2 – known mud volcanoes, 3 – shoreline of the Caspian Sea, 4 – isolines of heat flow density, 5 – major faults, 6 – country borders.

It turned out, that sometimes mud volcanoes are known by high values of heat flow density (figure 3), at the same time in adjacent districts of mud volcanism regional values of heat flow occurred below average continental ones [9; 13–15]. Meanwhile, the Lower-Kura Depression is known by its lowest heat flows among the region. In the local area separate structures affected by high temperatures and heat flow densities were observed near mud volcanoes (figure 3). At flanks of the Lokbatan they are 48–55 mW/m^2. However, in some cases the abnormal heat flow exceeds the medium value within the structure approximately twice and increases up to 90–100 mW/m^2 for some of mud volcanoes.

Conclusions. We conclude that the main regularities of the heat flow within the region are: **1.** its average values (40–60 mW/m^2) within structures with a Precambrian basement, in our case – the Caspian Basin, parts of the Turan plate, folded structures of the Balkhan-Kopetdag within Turkmenistan, deep-water areas of the Caspian Sea; **2.** alternation of low (40–50 mW/m^2) and high heat flow stripe anomalies reaching up to 100–120 mW/m^2 within the Greater Caucasus; **3.** the presence of a submeridional strip of increased flow in the adjoining land of Iran and up to 100 (single value – more than 200) mW/m^2 within the Caspian Sea.

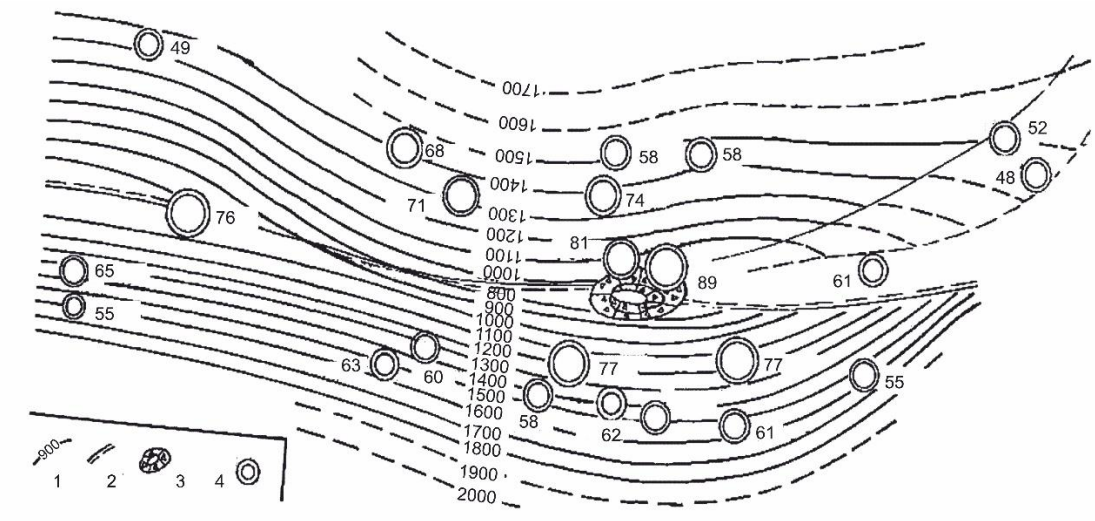

Figure 3 – Heat flow distribution of the Lokbatan mud volcano area (modified) 1 – contour line along the suite NKP roof; 2 – tectonic dislocations; 3 – Lokbatan mud volcano; 4 – values of heat flow density in wells, mW/m^2 [16]

REFERENCES

1. Mukhtarov A. Sh., Adigezalov N.Z. Thermal regime of mud volcanoes in East Azerbaijan // Proceedings of Geology Institute, 1997. Vol. 26. P. 221–228. (in Russian)

2. Regional geology and oil and gas content of the Caspian Sea / I. F. Glumov [et al.]. M.: OOO, Nedra-Business Center, 2004. 342 p. (in Russian)

3. Yakubov A.A., Alizade A.A., Zeynalov M.M. Mud volcanoes of the Azerbaijan SSR. Atlas. Baku: Publishing house of the Academy of Sciences of the Azerbaijan SSR, 1971. 257 p. (in Russian).

4. USSR, Black Sea and Caspian Sea / Geothermal Atlas of Europe (Editor in-Chief E. Hurtig). Gotha: Hermann HaackVerlagsgessellschaft mbH. Geographish-Kartographische Anstalt, 1991. P. 132–152.

5. Lyubimova E.A., Nikitina V.N., Tomara G.A. Thermal fields of the inner and marginal seas of the USSR: State of observations and the theory of interpretation of two-dimensional inhomogeneities. M.: Nauka, 1976. 224 p. (in Russian)

6. Krasnov A.N. Materials for the learning the mud volcanoes in Eastern Transcaucasus. A paper of nature, researches society at Kharkov University. 1905. Vol. 39. Issue 2. P.31–73. (in Russian).

7. Abramovich M.V. About mud volcanoes. Papers of Baku department. Russian technical society. 1916. Issue 6. P.74–77. (in Russian)

8. Shnyukov Ye.F., Lebedev Yu.S., 1971, Mud volcanism // Mud volcanism and ore formation. Kiev : Naukova Dumka, 1971. P. 52–88. (in Russian)

9. Sukharev G.M., Taranukha, Yu.K., Vlasova, S.P. 1969, Heat flow from Azerbaijan // Soviet geology. 1969. № 8. P. 146–153. (in Russian)

10. Kurbanmuradov A.K. Geothermal and hydrochemical conditions of formation for oil and gas deposits in South-Western Turkmenia // Review Turkm. Acad. Sci. Ser. phys.-techn., chem., geological sciences. 1970. № 3. P. 61–66. (in Russian)

11. Mekhtiyev Sh.F., Mirzajanzade A.Kh., Aliyev S.A. Geothermal researches of oil and gas fields. Moscow: Nedra, 1971. 215 p. (in Russian)

12. Kutas R.I., Gordienko V.V. Thermal fields of Ukraine. Kiev: Naukova Dumka, 1971. 138 p. (in Russian).

13. Yakubov A.A., Atakishiyev I.S. Geothermal researches of oil-gas fields of Apsheron. Baku: Azerneshr, 1973. 88 p. (in Russian)

14. Kashkai M.A., Aliyev S.A. Heat flow in Kura Depression // Abyssal thermal stream in European part of USSR. Kiev: Naukova Dumka, 1974. P. 95–108. (in Russian)

15. Aliyev S.A. Geothermal fields of South-Caspian Depression and their connection with oil-and-gas content : Thesis. Doctor of geol.-min. science degree. Baku. 1988. 28 p. (in Russian)

16. Bagirov E., Lerche I. Impact of Natural Hazards in Oil and Gas Extraction: The South Caspian Basin. New York : Plenum Press. 1999. 352 p.

17. Nadirov R.S., Bagirov E., Tagiyev M., Lerche I. Flexural plate subsidence, sedimentation rates, and structural development of the super-deep South Caspian Basin // Marine and Petroleum Geology. 1997. Vol. 14. Issue 4. P. 383–400. DOI:10.1016/S0264-8172(96)00054-2.