GASEOUS REGIME OF THE BLACK SEA

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Abstract. Spatial distribution of gas shows in the Black Sea, their relation to deep faults and mud volcanoes testifies to deep inorganic origin of gas in this region. Search for oil and gas in the Black Sea should be concentrated in the first place on the structures complicated with mud volcanoes. The zones where gas emissions were found belong to very prospective areas. Accumulations of gas hydrates are developed in bottom sediments where the depth of seawater exceeds 550- 600 m.

Key words: gaseous regime, methane, gas hydrate, Black Sea, Ukraine

Oil and gas bearing of the Black Sea and the Sea of Azov is still studied insufficiently. Exploratory drilling on the Black Sea continental shelf on the Golitsinska structure has been started in 1971, and the first wildcat in the Sea of Azov was spuded in 1975 in the Pivnichno-Kerchenska area. Exploratory drilling yielded very good results. Commercial gas was struck in both the Golitsinska and the Pivnichno-Kerchenska structures. Now 10 gas and gas-condensate fields are discovered in this region (Figs.1, 2) (in Shpak, 1986).

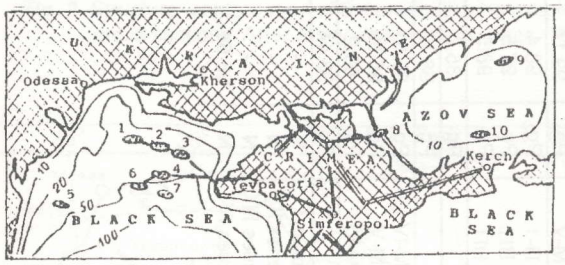


Fig. 1 Gas fields in the Black and Azov Seas area

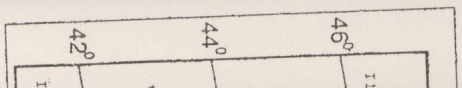
In the Ukrainian part of the Black Sea all fields are situated in the north- western part of the shelf. Depth of waters where drilling was carried out makes up from 30 m up to 90 m. The fields are confined to anticline structures. On the whole the fields are gaseous, and seldom gas-condensate. Condensate was discovered on the Colitsynske, Shmidtivske and Stormove fields. On the Shmidtovske field gas consists of methane and its homologues with a small admixture of carbon dioxide (not more than **5,5%).** Hydrogen sulphide is not present here. Pay beds occur in the depth of 480 m in the Golitsynska structure and – up to the depth of 3200 m on the Shmidtovska area. The fields are multistratal with exception of the Krymske field where only one pool was encountered. Reservoirs are sandstones and argillites in the Maikop formation. Terrigenous carbonate reservoirs are productive on the Arkhangelske and Odeske fields and are confined to the Lower Sarmatian-Tortonian (the Arkhangelska area) and to the Upper Eocene (the Odeska area) (Table 1). The Golitsynske, Shtormove, Arkhangelske and Strilkove fields are exploited at present.

Development of oil and gas industry in Ukraine was suspended in the late sixties. At that time the Soviet Union pursued a course of developing of nuclear industry. Mass media carried out a wide campaign against oil and gas industry stating that world oil recourses would be exhausted within 20-50 years. So, to avoid an energetic crisis the only possible way was construction a wide network of nuclear power stations. Financing of geological exploration for oil and gas in Ukraine was sharply reduced. In result output of oil and gas disastrously dropped. To prevent a breakdown of oil/gas industry Ukrainian geologists began exploration drilling in the Black Sea. The great Golitsynske gas field discovered by only one wildcat in the Black Sea testifies that Ukrainian geologists have detected the richest oil-bearing province that is more profitable than the North and the Caspian Seas. Ukraine is able to regain its reputation of the oil state what, however, has been contradicting interests of Russia. In order to stop development of oil industry in Ukraine in 1978 the Soviet government transferred the jurisdiction over the Black Sea from the Ukrainian geological survey to the Ministry of Gas Industry of the USSR (Gasprom, Moscow). Gasprom carried out only limited exploration for oil and gas in the Black Sea concentrating prospecting works on the Western Siberia where giant gas fields were discovered. In result oil/gas industry of Ukraine was finally destroyed. Output of oil and gas diminished to its minimum level.

Having its own oil and gas industry in decay

Table 1 – Gas and Gas-Condensate Fields of the Black Sea and the Sea of Azov

No.	Name of Gas Field	Depth of Seawater M	Year of Discovery	Depth Range m	Productive Horizons		Composition Of Gas (% volumetrical)						Ultimate Recoverable Gas (bilion m3)
					Index	Age	CH_4	C_2H_6	C_3H_{10}	C_4H_{10}	C_{5+} Higher	CO_2	
1.	Golitsynske	30	1974	480-545	M-III	Pg_3	99.73	0.08	-	-	-	0.190	15.317
				555-570	M-IV	Pg_3	99.19	0.1	-	-	-	0.184	
				590-635	M-V	Pg_3	99.28	0.173	0.001	-	0.03	0.101	
				2130-2550	П-IX	Pg_1	91.42	4.54	1.54	-	-	0.810	
2.	Pivdenno-Golitsynske	30	1981	570-993		Pg_3	96.71	0.11	0.05	-	-	0.200	3.46
				650-690		Pg_3	98.69	0.12	0.04	-	-	0.180	
3.	Shmidtovske	30	1979	650-715	M-III	Pg_3						0.1-0.5	15.988
				690-780	M-IV	Pg_3						0.1-0.5	
				700-780	M-V	Pg_3						0.1-0.5	
				2710-3150	П-IX	Pg_1	90.03	5.0	1.28	0.7	0.33	1.980	
				2910-3200	K_2	K_2	86.26	4.78	1.70	0.685	0.283	5.500	
4.	Arkhangelske	50	1987	610-630	Series 1		98.9	Tr.	0.005	Tr.	-	0.226	19.163
				805-845	M-III	Pg_3	98.9	0.271	0.060	0.006	-	0.081	
				850-930	M-V	Pg_3	99.14	0.249	0.049	0.008	-	0.069	
5.	Odeske	30-40	1988	625-780	П-1	Pg_2	98.4	0.290	0.015	0.002	Tr.	0.343	9.299
				1405-1670	ВП	Pg_1	97.5	1.03	0.149	0.033	Tr.	-	
				1570-1670	НП	Pg_1	98.5	0.333	0.008	Tr.	Tr.	0.376	
6.	Shtormove	80-90	1983	1810-2000		Pg_1	85.7	6.49	2.90	0.88	1.24	0.310	16.443
7.	Krymske	70-80	1982	860-886		Pg_3	98.13	0.17	0.059	0.002	-	0.11	0.617
8.	Strilkove	9	1963	434-443	M-IV	Pg_3	96.51	-	-	-	-	0.17	4.081
				475-500	M-V	Pg_3	96.55	0.04	0.02	-	-	0.1	
				530-550	M-VI	Pg_3	98.2	0.03	-	-	-	0.29	
9.	Morske	13	1977	630-690		Pg_3	98.44	0.11	-	-	-	0.29	3.70
10.	Pivnichno-Kerchenske	11	1976		Series I	N	-	-	-	-	-	-	5.179
					Series II	N	-	-	-	-	-	-	
					Series III	N	-	-	-	-	-	-	
				1150-1370	Series IV	N	95.54	2.02	0.83	0.18	-	0.55	



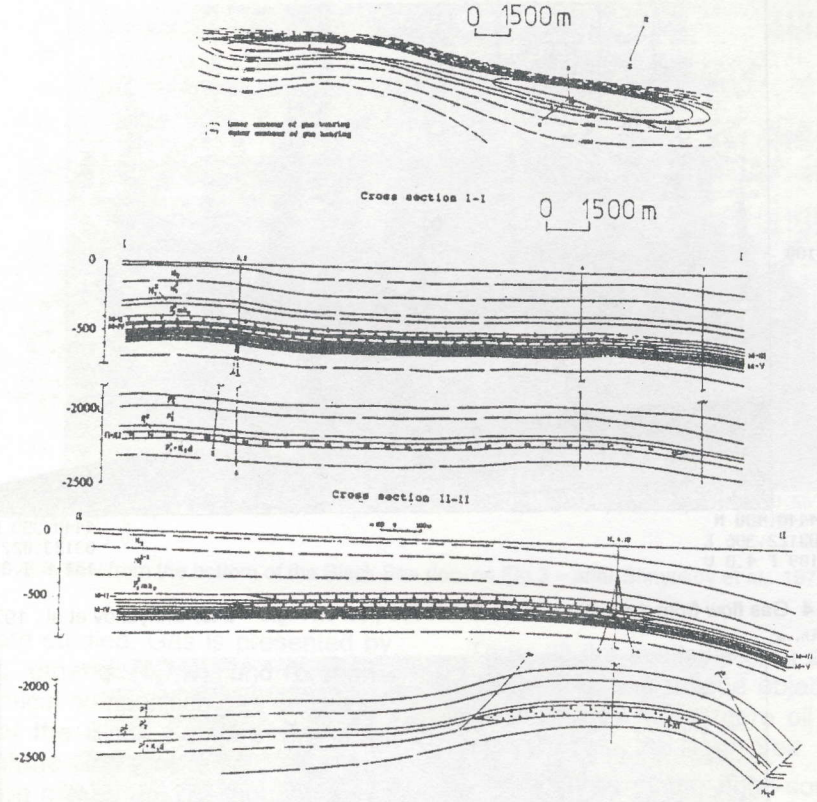


Fig. 2 Structure contour map of the productive horizon N-XI (Lower Paleocene-Golitsynske gas condensate field) and two cross sections. After A.Dargachova & M. Bass, 1977.

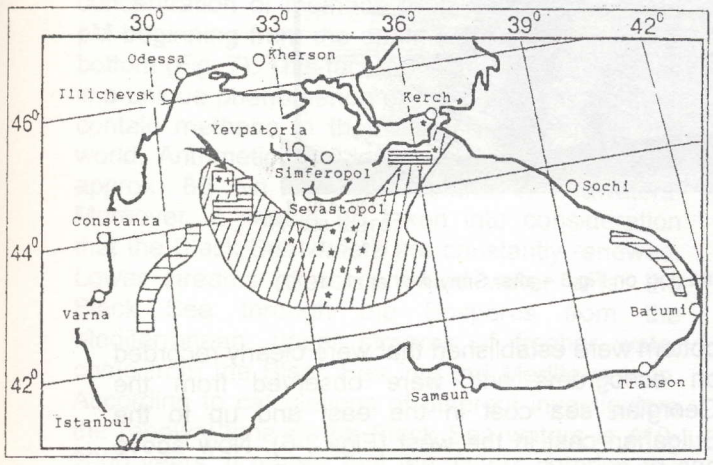


Fig. 3 Distribution of mud volcanoes and gas flows in the Black Sea

Ukraine was forced to accept domination of nuclear power engineering in its economy imposed by the Soviet government. In seventies nuclear power stations were constructed all over the country. In the shortest terms the Chornobylska, Zaporiska, South-Ukrainian, Rivnynska and Khmelnytska nuclear power stations were put into operation. The Chyhyrynska and Krymska nuclear power stations were on the final stage of their construction. After the Chernobyl disaster construction of the Chyhyrynska and Krymska nuclear power stations was stopped, and they were re-equipped for another purposes. A question about closing of the Chernobyl nuclear power station was raised.

Geochemical investigations of pollution zone caused by explosion of the Chernobylsky nuclear reactor showed that among the products thrown out by the destroyed reactor content of plutonium was high, and all the territory of Ukraine was badly contaminated with this radio-active element. Plutonium pollution considerably worsens the ecological situation in Ukraine, as plutonium itself and its combinations are highly toxic and the period of their decay is approx. 24,5 thousands years. So, in fact it means that the territory of Ukraine is contaminated with these radionuclei for ever.

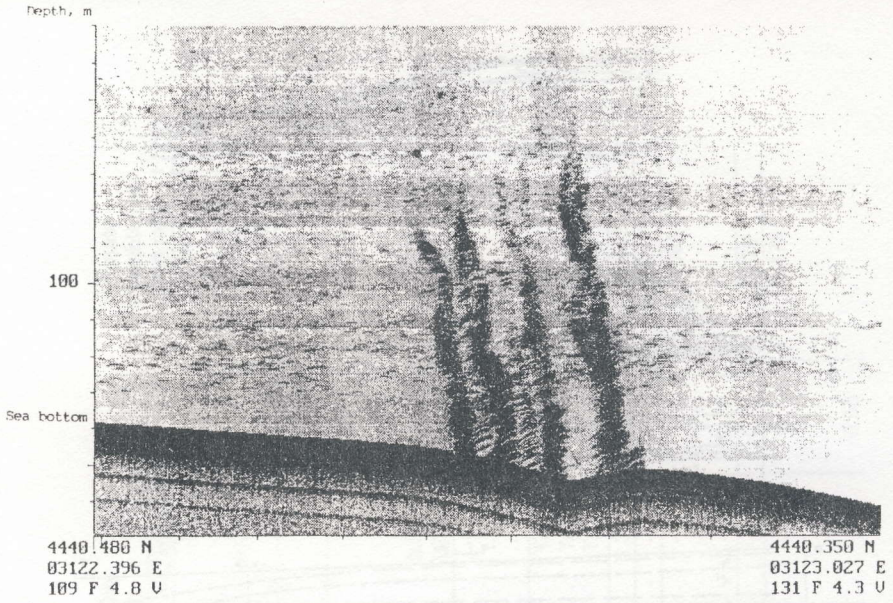


Fig. 4 Gas flow from the bottom of the Black Sea (loc. on Fig.3 – after Shnyukov et al.. 1977)

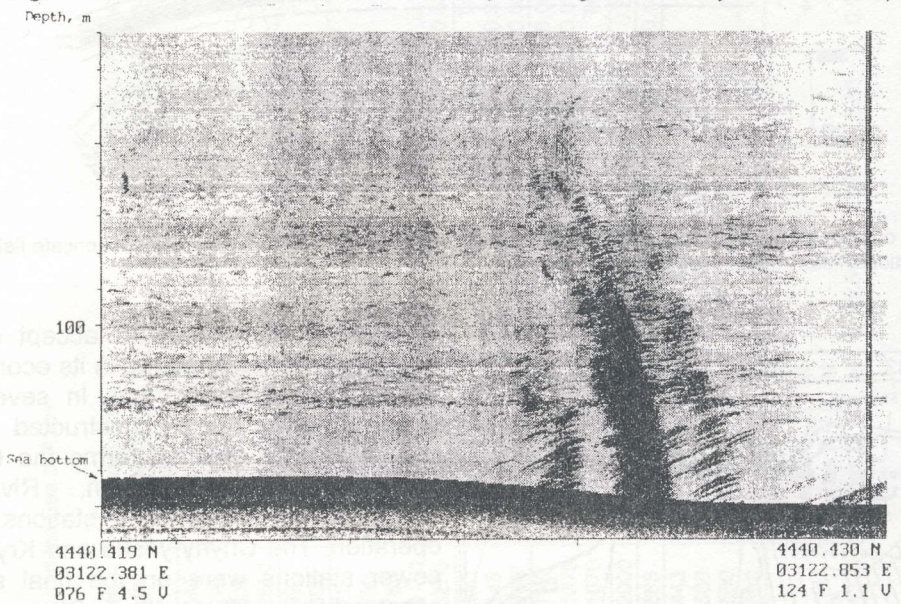


Fig. 5 Gas flow from the bottom of the Black Sea (loc. on Fig.3 – after Shnyukov et al.. 1977)

Plutonium is obtained by irradiation of uranium with neutrons in nuclear reactors. It is material for nuclear explosion and it is used for production of atomic bombs and nuclear warheads. Presence of great quantity of plutonium among the products thrown out by the destroyed Chornobylsky reactor testifies that the Chornobylska nuclear station produced plutonium side by side with electricity. Thus nuclear stations served not only for solution of energetic problems of Ukraine, but in the first place - for military purposes of the USSR.

After the independence of Ukraine was declared the Black Sea became a region where Ukrainian geologists carried out intensive prospecting. In result of these regional investigations powerful gas blowouts from the sea bottom were established that were clearly recorded on echograms and were observed from the Georgian sea cost in the east and up to the Bulgarian cost in the west (Figs.3-6). Now above 300 torches of gas emission are discovered in the Black Sea that may be divided into four isolated areas. These gas shows are constantly manifested as powerful gas streams that are displayed sometimes on the sea surface, and the sea "is boiling" here and there. They are confined both to mud volcanoes and to faults in the earth crust (Shnyukov et al., 1997, Shnyukov, Sozansky, 1995). Detailed investigations of methane emissions from the Black Sea bottom were carried out in the mouth zone of the Supsa River on the coast of Georgia. Owing to the above investigations chemical composition and

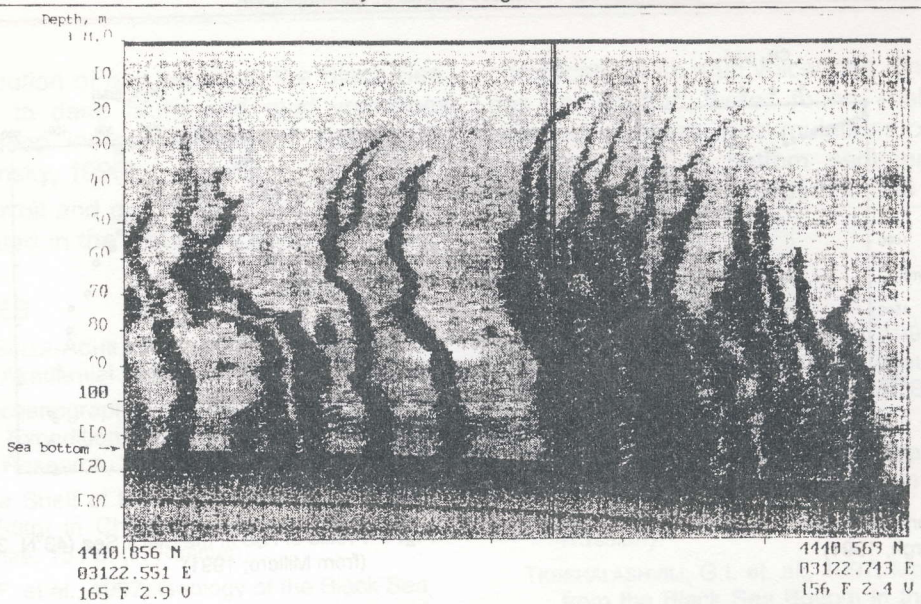


Fig. 6 Gas flow from the bottom of the Black Sea (loc. on Fig.3 – after Shnyukov et al.. 1977)

production rate were studied. Gas is presented by methane **(94,7%),** ethane **(4,7%)** and propane **(0,6%).** By its chemical composition gas emissions from the bottom of the Black Sea are similar to gas- condensate of the Golitsynske field. The total rate of gas emission makes up 172 thousands m^3 from the studied area of 16 km^2 (Tkeshalashvili et al., 1997). Gas shows constantly discharge into seawater and saturate it with methane. The oceanographic expedition of the R/V "Knor" carried out in the Black Sea in 1988 established that concentration of methane in its waters was of 11 pM beginning from the depth 550-600 m up to the bottom (Fig. 7). This fact proves that the Black Sea is a unique phenomenon of our planet, as no seas contain methane in their water elsewhere in the world. Arithmetic calculations show that there are approx. 80 bln. m^3 of methane in seawaters. Moreover, it should be taken into consideration that the Black Sea waters are constantly renewed. Lower streams of concentrated water enter the Black Sea through the Bosporus from the Mediterranean; upper streams of fresher water come from the Black Sea into the Mediterranean. According to calculations of different investigators the renewal time of the Black Sea waters is 410-2000 years. It means that the waters entering the Black Sea from the Mediterranean and those from the rivers Dnieper, Danube etc. are constantly saturated with methane owing to powerful gas flows discovered recently by Ukrainian scientists. The expedition of the R/V "Glomar Challenger" which carried out deep water drilling in the Black Sea confirmed that its bottom sediments contain huge resources of gas. Members of the expedition noted that core samples extracted from sea floor sediments were charged with gas, and sometimes they were blown out from core barrels.

Thus, all the available data allows to state that the Black Sea is a unique object on the Earth: its continental shelf hides more oil and gas than the Persian Gulf and the North Sea.

The analysis of the echo-sounder data shows that gas blow-outs are observed at the depth from 0 up to 550-600 m in the Black Sea and there are no gas emissions from the sea bottom situating lower. However study of the gaseous regime of the Black Sea testifies that seawaters do not contain methane at the depth from 0 up to 550-600 m, but lower and up to the bottom seawaters contain hydrocarbon gas.

Such distribution of the gaseous regime in the Black Sea corresponds to the equilibrium diagram of methane hydrate: methane converts to hydrate state in water by the temperature +8° C and the pressure 55-60 atm (Berecz, Balla-Achs, 1983). Hence, methane occurs in hydrate condition both in seawater and in bottom sediments lower than 550-600 m. Existing pressure and temperature conditions in the Black Sea allow to suggest that methane and hydrogen sulphide previously regarded as dissolved in the seawater are in gas hydrateous condition (Figs.8-11).

Gas hydrates play an important role in the geologica1 history of the Earth. Unconventional giant gas accumulation in the Kivu Lake waters (a rift system in the West Africa) containing 57,3 bln. m^3 of methane not in porous rock, but in the waters of the lake at the depth from 275 m up to 425. m (bottom) became a puzzle for geologists, as gas is held in the lake without any screening. This strange gas field may be explained by hydrateous nature of methane. Gases in the Black Sea have the same nature.

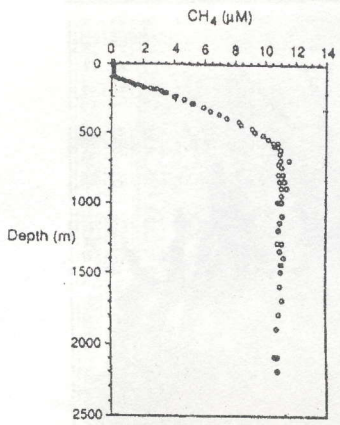


Fig. 7 Water column methane concentration profile at Sta.BKS2 (from Reeburgh, 1991)

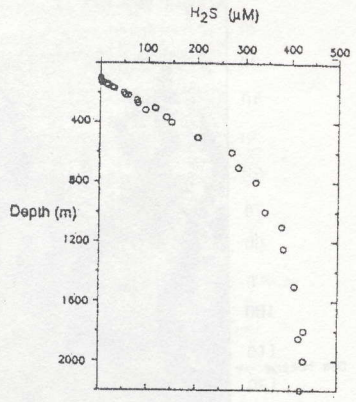


Fig. 8 Profile of H_2S in the Black Sea (43°N, 34°E – BS5-2 (from Millero, 1991)

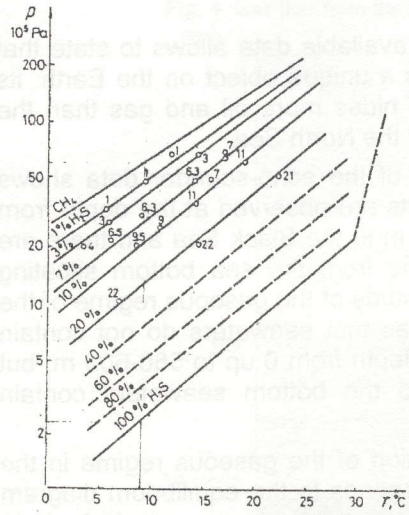


Fig. 9 Equilibrium diagram for CH_4-H_2S hydrate (from Berecz & Balla-Achs, 1983)

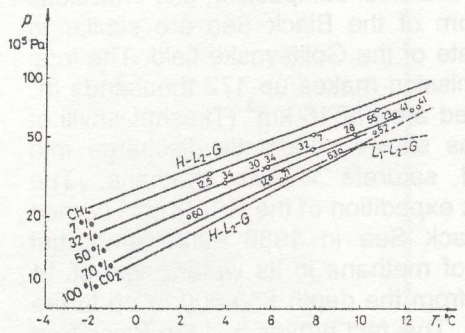


Fig. 10 Equilibrium diagram for CH_4-CO_2 hydrate (from Berecz & Balla-Achs, 1983)

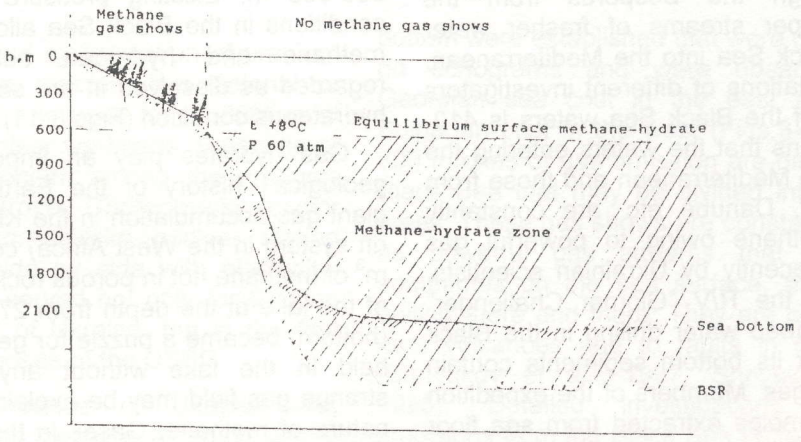


Fig. 11 Scheme of distribution of the free methane and methane hydrate in the Bleck Sea

Spatial distribution of gas shows in the Black Sea, their relation to deep faults and mud volcanoes testifies to deep inorganic origin of gas in this region (Sozansky, 1990).

Search for oil and gas in the Black Sea should be concentrated in the first place on the structures complicated with mud volcanoes. The zones where gas emissions were found belong to very prospective areas. Accumulations of gas hydrates are developed in bottom sediments where the depth of seawater exceeds 550-600 m.

REFERENCES

BERECZ, E., BALLA-ACHS, M., 1983, Gas Hydrates, Budapest: Akademiai Kiado, 343 p.

Black Sea Oceanography. Results from the 1988 Black Sea Expedition, Editor: J.W. Murray, 1991, Deep-Sea Research, 38, Suppl. Issue 2a, 1266 p.

Geology of the Shelf of the Ukrainian SSR, Oil/Gas-Bearing, Editor in Chief: P.F.Shpak, 1986, Kiev: Nauk. Dumka, 151 p. (in Russian).

SHNYUKOV, E.F. et al., 1997, Geology of the Black Sea According to the Results of Geological and Geophysical Investigations, 5 Cruise R/V "Kiev", Department of Marine Geology, National Academy of Sciences of Ukraine, 189 p. (in Russian).

SHNYUKOV, E.F., SOZANSKY, V.I., 1995, Gas Hydrates of the Black Sea Basin. Petroleum Geology and Hydrocarbon Potential of the Black Sea Area. Abstracts, Varna, 64-65.

SOZANSKY, V.I., 1990, Theory and Practice of Exploration of Oil and Gas from Position of their Abiogenic Origin, Kiev, Nauk. Dumka, 82. (in Russian).

TKESHALASHVILI, G.I. et. al., 1997, Methane Emissions from the Black Sea Bottom in the Mouth Zone of the Supsa River at the Coasts of Georgia. Geokhimia, 3, 331-335 . (in Russian).