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Konstantin A. Kleschev[1] (1) VNIGNI, Moscow, Russia

The Karkinit Basin of the Black Sea - Northwestern Part of the Tethyan Region (geodynamic development, mud volcanism and gas exhalations)

Kinematics of plate movements of the Black Sea region-Caucasus is determined by convergence of the Arabian and Eurasian plates with the velocity of about 30 mm/year [3, 4]. The area of the maximum compression including the Great and Lesser Caucasus and East Anatolia is located just opposite edge of the Arabian plate. In this area, considerable horizontal decrease of the Earth's crust is expressed in the form of reversed faults and nappes in the Great Caucasus and Transcaucasia areas and in the form of side extrusion of blocks in the East Anatolia and northwestern Iran. So, the East Anatolian subplate is extruded to the west from the zone of maximum compression while the other blocks move to the east in the direction of the South Caspian Basin [5].

It was suggested [2] that the eastern part of the Black Sea forms a block or subplate moving to the northeast. This conclusion is important for estimation of seismic and connected geological hazard in the studied region. It was established that deformations and seismicity are mainly confined to the edges of the East Black Sea subplate while in its inner part the level of seismic activity is considerably lower.

In the West Black Sea Basin, seismicity is confined to the front of Balkanid-Pontid while the northern and northwestern passive margins are slightly static or aseismic that demonstrates the calm current tectonic regime. The West Black Sea Basin includes about 50 thousand km^2 of shelf located mainly within the Ukraine water area. The sea depth over the majority of shelf comprises lesser than 100 m. The Odessa Bay is confirmed province of gas bursts with the one exploited deposit and six deposits in the stage of preparation to the exploitation or development. The total surveyed resources of gas comprises 1.5 trillion m^3.

Gas bursts take place within the continental slope of the West Basin. The basin filled by Cenozoic sediments more than 14 km thick is located south of the slope. Judging from results of deep seismic profiling, they are overlay the basaltic basement, and only in the foot of the continental slope Mesozoic (Cretaceous?) deposits are distinguished.

Cenozoic cross-section includes carbonate deposits of the Pliocene-Eocene (2-3 km), the layer of clay with rare interbaddings of sandstone and aleurolite assigned as the Oligocene-Late Miocene (Maikop series 2-4 km), carbonate-terrigenous layers of the Middle-Upper Miocene and Pliocene different in composition (2.5-4.0 km), as well as thick terrigenous deposits of the Danube River delta (the Anthropogen). The lower part of the Maikop deposits is considered as potentially oil-bearing with the content of organic carbon up to 8 kg/tone.

Within the continental slope having fault structure, pinching out of the lower horizons and thinning of the upper horizons of Cenozoic layer take place. Minimum thickness of Cenozoic deposits reaches within the Kalamitsk Rise extending parallel with the brow of the continental slope. The Karkinit Basin is located north of the rise (Fig. 1). It is filled by a tick layer of Cretaceous-Cenozoic deposits. Formation of the basin began by formation of Albian and Aptian-Albian rift system filled by clayey-sandy synrift deposits with thickness up to 1-2 km. In the Cretaceous-Paleogene, the wide basin was formed as a result of post-rift subsidence. It was filled by sediments with thickness up to 4 km.

In the end of the Eocene, the basin underwent slight inversion accompanied by formation of reversed faults, probably, along the plains of previous normal faults. Reversed faults and conjugate anticlines are developed on the

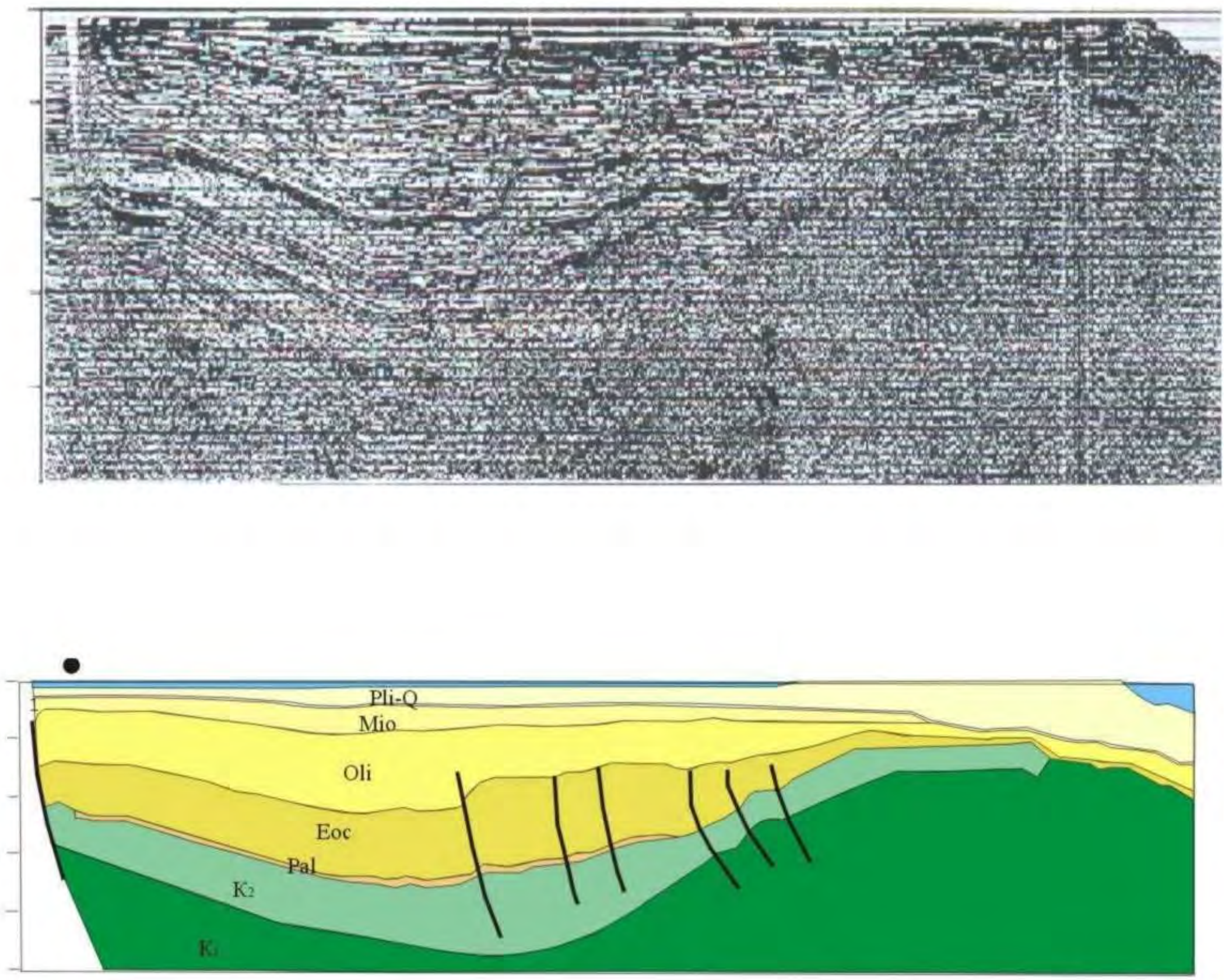

Fig. 1. Multichannel seismic profile across the Karkinit basin and Kalamit uplift (a) and geological interpretation (b). Reversed faults are seen on the northern slope of the uplift.

both slopes of the Kalamitsk Rise, likely, underwent uplift during the period of compression. Some reversed faults were active in the later periods as well up to the Pliocene.

The Karkinitsk Basin includes several gas deposits with total explored recourses of 1.5 trillion m^3. Reservoirs are confined to coarse-grained sandstone of the Aptian, Pliocene, and Oligocene overlaid by marl of the Upper Cretaceous and Eocene and clay of the Oligocene. The main type of traps is anticlines formed during the Late Eocene and later phases of compression.

Gas Exhalation and Mud Volcanism of the Black Sea Basin

Emanation of hydrocarbon gases during the eruptions accompanied by powerful explosion, bursts of gas, water, and fragments of rocks as well as by issue of breccia are typical for the first type of volcanoes. These events can be observed during Crimea earthquake in 1927. Such violent eruptions take place either at the initial burst at the moment of formation, or when output channel of gas sip captures the great pocket of gas accumulation in joint-porous rocks.

At the usual regime and relatively low gradient of porous pressure in the channel of gas sip, gas-fluid mixture moves fluently and erupts slowly on the surface. In the second case, mud-fluid volcanoes result in bursts of diluted breccia mixture without of manifestations of hydrocarbon gases. As it is known, gas bursts and mud-fluid volcanoes are confined to the geodynamically active zones of the ocean and sea floor. They are presented in the form of hydrothermal activity of the mid-oceanic ridges or gas bursts and mud volcanoes defined to the fracture zones of subducting plate overlapped by thick sedimentary cover. High-energy stress level of fluids in the deeply submerged deposits of the subduction zone provides the development of their vertical migration at a pressure exceeding the geostatical pressure. This results in formation of microjoints and diapir folds, hydrorupture of the layer, gas and mud volcanism.

The majority of vents of the gas burst and mud volcanisms are confined to the upper part of the continental slope and adjacent areas of the shelf of the northwestern sector of the Black Sea (Odessa Bay). It is the peculiar transition zone between the continental part and abyssal basin. It has clearly pronounced flexure-fault character caused by tectonic processes.

The majority of gas flares is defined to the area of transition from the inner shelf to the continental slope and its discontinuity. Flares have most often a conic form thinning progressively in the direction of the surface. However, some gas emanations located over the shelf form broad gas fields in the form of "turbidity" with rare gas cones. One of the flares has clearly pronounced "dendroid-like" gas column 100 m high with lateral branches. The heights of gas bursts vary from 10 to 250 m. In this case gas spouts do not reach the surface on almost all images, even when they are located at a minimal depth. They are dissolved at the approaching to the near-surface horizons. Individual gas bulbs crowing the gas spots are well seen on some images.

The field of individual and group flares localized within the sublatitudinal belt of the continental slope discontinuity adjoins from the east to the canyon of the Paleo-Dnieper River. Flares are confined to the clearly seen roughness of the sea floor and are grouped near the isobathes of 100 and 200 m. The field consisting of eleven scattered individual gas flares located at a depth from 200-300 m and deeper is extended in the sublatitudinal direction (Fig. 2). Alternation of narrow submarine ridges and extended canyon-like cuttings is typical for the topography of this part of the continental slope. Gas emanations are confined both to positive and to negative forms of the bottom topography.

It was discovered during the expedition on the board of R/V "Kiev" that gas vents are confined, as a rule, to the plicate and disjunctive tectonic zones. This is confirmed by results of seismic surveys. The zones of total crumpling and dividing of rocks under the fields of gas flares on obtained seismograms reach visual depth of 500 m. Total crumpling of rocks is typical for diapirism accompanied often by mud volcanism. However, the practice of researches on mud volcanoes including volcanoes located over the sea floor demonstrates various manifestations of these processes in geological structures. Prerequisites to formation of mud volcanoes and gas flares are the favorable tectonic setting and diapirism. At the same time, it is difficult to disclaim the single roots of the deep processes resulting in formation of mud volcanism and gas emanation in this area of the Black Sea. The discovery of gas emanations at a great depth and near the foot of the slope show their abyssal origination [1].

The structure of the deep Odessa (Odessa-Sinopsk) Fault is the largest submeridional structure to which the fields of active gas emanations are adjacent. This zone was named as Trans-Black Sea Deep Fault. The later studies established that this fracture zone is the fragment of Tornkwist Line or the North Sea-Arabian lineament. The systems of complexly built disjunctive, flexures, zones of pinching out of sediments and so on are found in this zone.

Gas bursts and mud-fluid volcanoes are confined to the geodynamical active zones of the sea floor. They are presented in the form of hydrothermal activity as gas bursts, or mud volcanoes defined to the fracture zones overlapped by thick sedimentary cover. High-energy stress level of fluids in the deeply submerged deposits provides the development of their vertical migration at a pressure exceeding the geostatic pressure. It causes the formation of microjoints and diapir folds, hydrorupture of the layer, gas and mud volcanism.

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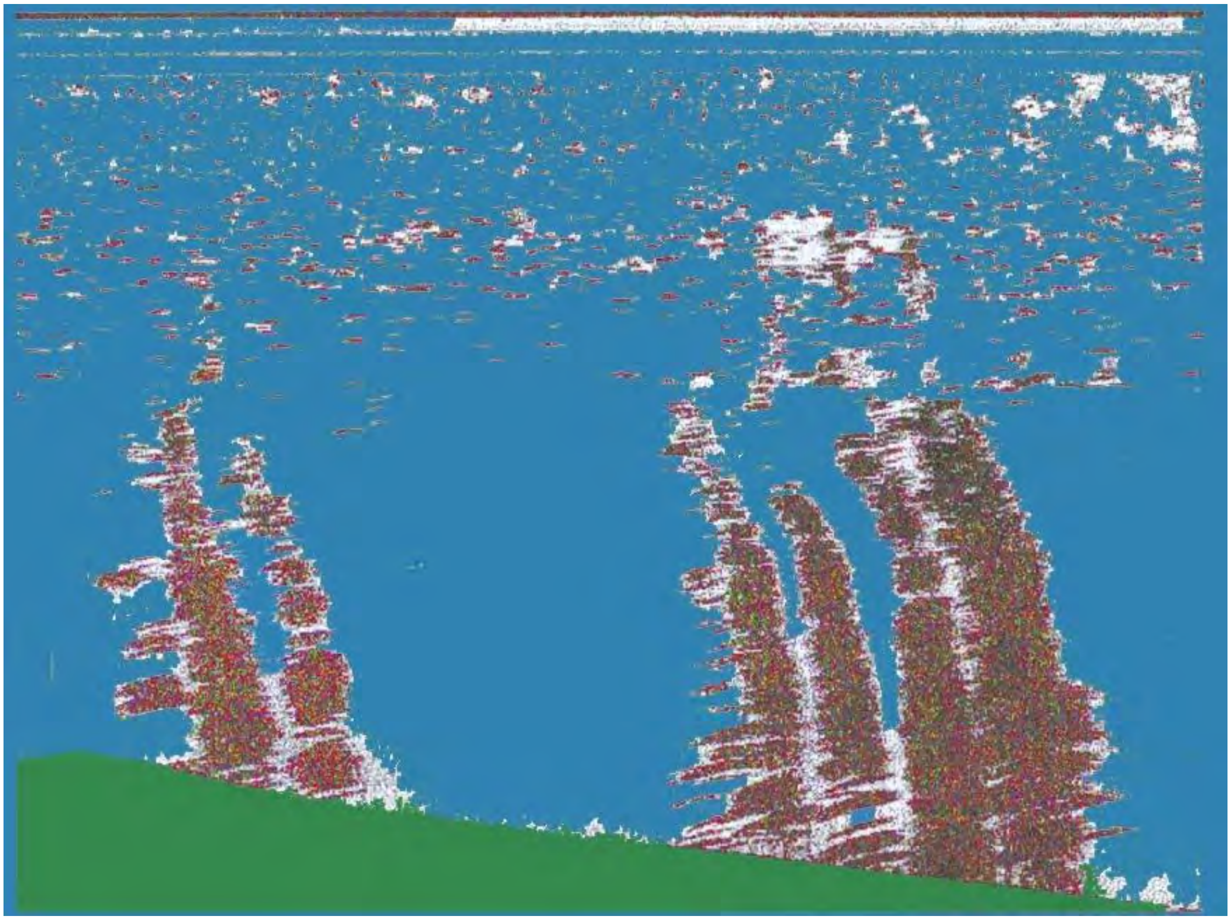

Fig. 2. Field of disseminated gas exhalations in the Karkinit basin of the north-western part of the Black Sea.

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