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FIRST BULGARIAN GAS HYDRATES: ASSESSMENT FROM PROBABLE BSRS

This article is a first attempt of gas hydrate study from probable bottom simulating reflectors (BSRs) for the Bulgarian part of the Black Sea. Eleven probable areas of GHs are found. The volumes of GH and methane in them are determined.The new results show the possibility of wide distribution of gas hydrates (GHs) in the area. Additionally the work introduces new challenging tasks concerning global warming impact on GHs and the role of main faults in forecasting oil and gas potential in the shelf areas.

Introduction. The world resources of methane in gas hydrates exceed as much as twice the total resources of traditional fossil fuels – coal, oil, gas and peat [4]. They can solve not only the energy problem of mankind for centuries but also are capable catastrophically to change the global climate. The present-day great interest in gas hydrates resulted in intensive studies of their reservoirs, development technologies of methane extraction from them and special studies of their influence on the climate.

Method. There are many specific features on marine seismic records which are related to the existence of GH in sediments. The most informative among them are BSRs, which mark the thermobaric base of the gas stability zone (BGHSZ) [5]. The reversed polarity of BSRs relative to the sea floor reflection boundary resulted from a jump of acoustic impedance due to low velocity in free gas-bearing layers beneath BGHSZ. The normal polarity is also registered [9]. The free gas existence has confirmed by drilling [3, 7, 11]. Small horizontal gradients of temperature control the geometry of reflections which follow that of sea floor. These reflections are clearly observed on records from the continental slope, where they intersect pinching out lithological-stratigraphic boundaries.

Approach – weak and strong sides. The most appropriate first step after model estimation is a visible determination of BSRs on archives seismic records. The presented results are from transverse to the coast line seismic profiles of Halliburton G.S. from 1992.

Weak points of the BSR approach are:

- BSRs don't contain information on the concentration of GHs in sediments – they are caused primarily by gas;
- The strongest BSRs don't occur in reservoirs of quality sands but in shales;
- For BSRs identification geometry of sedimentary strata cant be not parallel to the seafloor boundary;
- Not every GHs deposit shows BSR (free gas existence below a gas hydrate saturated zone (GHSZ) is not compulsory). BSR can be a false positive indicator of abundant hydrate, and its absence a false negative indicator.

• BSRs are not only associated with GHs. A transition of opal-A to opal-CT can create a normal-polarity diagenesis related to BSRs [1, 2]. Detailed 3D seismic interpretation including BSRs interpretation, velocity analysis and geological information should be necessary for the evaluation of methane hydrates.

Strong points of the BSR approach are:

• BSRs define the phase boundary hydrate-free gas;
• BSRs allows us to validate assumptions on geothermal gradient and gas composition.

The approach of this work was to look for crossing reflections, starting from the upper part of continental slope and continue in direction to the abyssal, where the reflections became parallel, if there are continuous invisible boundaries. Visual identification of probable BSRs, their coordinates and thicknesses of layers with GHs on seismic records were determined with the Landmark's ProMAX software. Parameters registered are shot point numbers (SPNs), two way travel times (TWTT, ms), all characteristic points of BSRs and the upper boundary of GH spreading which are needed for a shape description with straight lines, and UTM WGS84 coordinates of the above points. Second (deeper) BSRs were also determined. Velocities from [6] were used to determine 3 average velocities and to calculate depths in meters from TWTT in ms. These velocities are 1500 m/s for water, 1800 m/s — for gas hydrate saturated layers and 1625 m/s — for sediments between the seafloor and layers with gas hydrates.

Results. According to the author's model, the average thickness of the GHSZ is 300 m and it appears at water depths 500–900 m in the Bulgarian

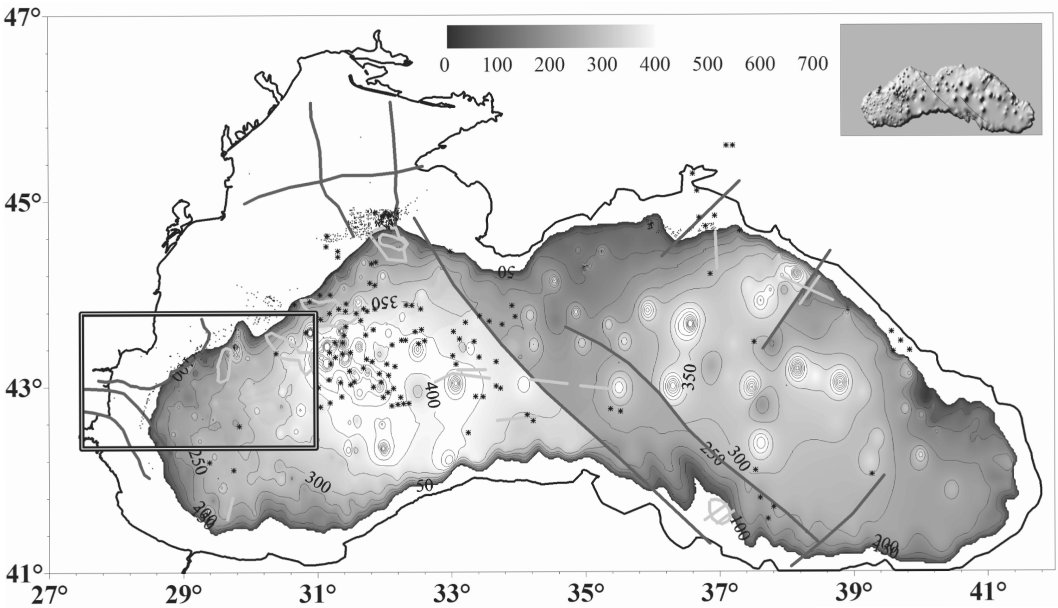

Fig. 1. Model of the Black Sea GHSZ base depth.

Light grey – registered BSRs; dark grey – faults; straight lines – seismic lines; stars – potential and studied mud volcanoes; points – gas seepages; rectangular – study area of the Bulgarian part of the Black Sea sector of the Black Sea (Fig. 1). In the Black Sea BSRs were discovered in 17 areas and 4 fields are outlined (Fig. 1). Eleven potential areas with GHs were found in the northern deep water part of the Bulgarian economical zone (EZ) (Fig. 2).

They are results of 21 groups/volumes with probable GHs determination on seismic records. Three of them are not entirely bottom sub-parallel; 9 – have one point which is out of the rest sub-parallel; 9 – are sub-parallel (maximum difference between every depth and the average depth of the group is <10% of the average). Only one area is located outside the GHSZ determined from the model. Additional study is needed to prove if the reason is a wrong interpretation, a relict GH deposit or there are GHs with "non-traditional" gaseous content (a BSR area out of the GHSZ in the Turkish EZ is assumed to present a deposit of H_2S-hydrate (Fig. 1).

The three closest to the coast extend to the South-Moesian Fault which is the Northern and Western boundary of the Kamchian Trough (paleo-Kamchia river valley). The fault is main obstacle for hydrocarbons (HC) migration. Gaseous flares, registered in expeditions of the IO-BAS (circles on Fig. 2) are situated on the boundaries of these three areas. If the gas sources are related to GHs these 3 areas can become a key target for the global warming study.

The largest area has a complex shape and a "peninsula of instability", reached the central part. Multiple BSRs are registered in 2 sub-areas. These facts suggest a high oil and gas potential of the area and complex paths and processes of HC distribution (Fig. 3). The most of relief of the probable BSR is close to the relief of the model GHSZ base, but is shifted to the shallow waters

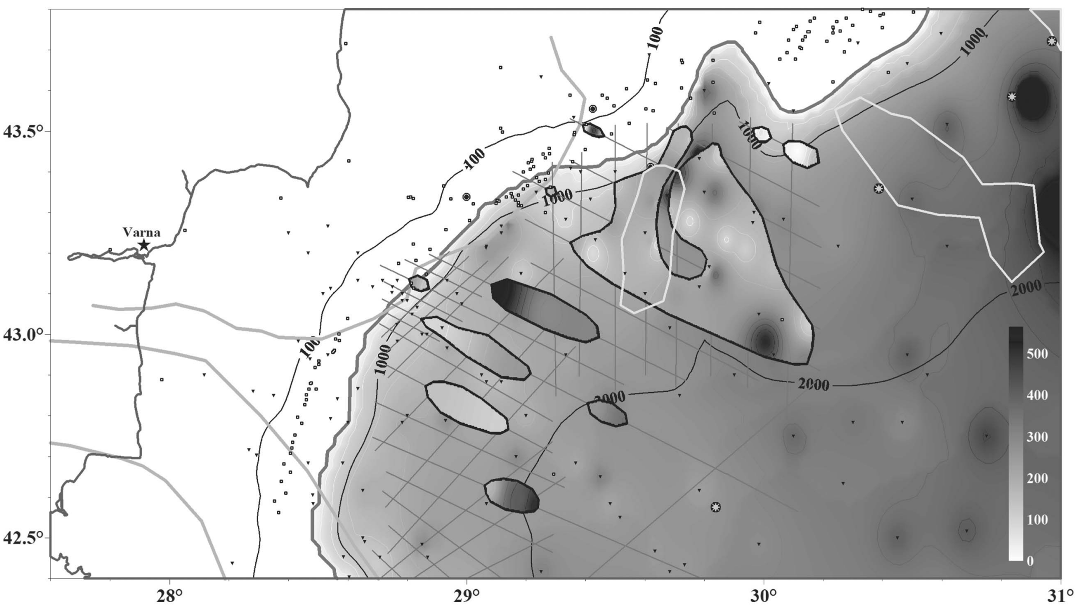

Fig. 2. Potential areas of GHs and their thicknesses on the map of model GHSZ. Light grey contours –BSRs are registered during the EC 6FP project ASSEMBLAGE.

Isobaths – 100, 1000, 2000 m; light grey - faults; dark grey – GHSZ boundary; straight lines – seismic lines; 0-500 m – depths of GHSZ & BSRs; stars – potential mud volcanoes; triangles– heat flow stations; circles – gas seepages

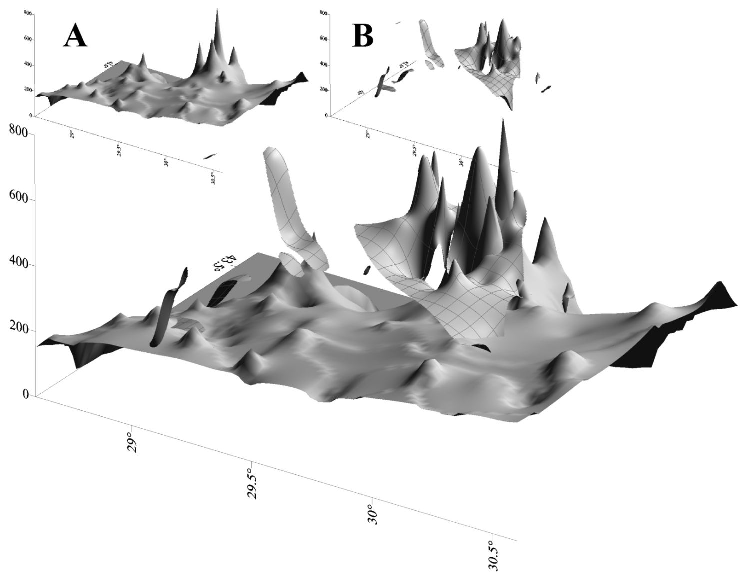

Fig. 3. Potential areas with GHs and BSRs depths on the model of the GHSZ base. A. Only GHSZ base; B. Only pBSR

and more wide. This is result from lack of geothermal station data (Fig. 2 – filled triangles).

Four areas are longer than 10 km and one reaches 60 km. The total area for which can be assumed existence of GHs is 2,600 км^2. The determined minimum, average and maximum thickness of the sediments with GHs are 8, 240 and 580 m respectively, and their total volume – 620 км^3.

The volume porosity can be assumed as 55% from deep sea drilling and the filling of the pore space with GH – 15±2% [6, 10]. Based on these assumptions, the potential reserves of GHs are ~50 км^3 and methane – 7,500 км^3 in the GHSZ.

In the Dnieper paleo-delta area under the BSR one assumes the existence of a zone with thickness of 100±5 m with free gas content of 1±0.1% [13]. In this case the total methane reserves increase to ~7,800 км^3 with an accuracy of ±25% (4±1 Gt or $4\pm1\cdot10^{-3}$ Tt Carbon). The reliability of similar assessments could be increased by special processing of digital records and additional investigations, mainly geophysical.

Conclusions. This amount exceeds by six times the assessment of Lüdmann for the paleo-Dnieper area and is 18% of the Black Sea reserves [12] or 0.04% of the world total – 10 Tt [5].

The only for the present Bulgarian small marine gas field “Galata” has reserves of 1.8 км^3. The preliminary result shows that the maximum potential reserves are equivalent to 4,300 such fields. In comparison with the world largest gas field “Qatari North Field” the potential methane reserves are 30% (45% from the area).

Let consider some additional information for comparison. Bulgarian annual consumption of Russian gas is 3 км^3 and transit gas transport is 16 км^3. The domestic market leader is “Bulgargaz” Ltd with a capacity of 7.8 км^3 (2002). The energy of 1 l benzene burning is equal to thus form 1.2 м^3 SPT methane.

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Эта статья освещает первую для Болгарии попытку изучения газогидратов (ГГ) с использованием BSR. Открыты 11 вероятных площадей с ГГ, оценен объем ГГ и содержащегося в них метана. Доказана возможность значительного распространения ГГ в болгарской части Черного моря. Результаты ценны для будущих исследований в означенных районах на перспективных глубинах. Работа привлекает внимание к вопросу исследования влияния изменения климата на ГГ Черного моря и роли глубинных разломов в формировании нефтегазоносности шельфа.

Стаття висвітлює першу для Болгарії спробу вивчення газогідратів (ГГ) з використанням BSR. Знайдено 11 вірогідних площ із ГГ, оцінено об'єм ГГ і вміщеного в них метану. Доведено можливість значного поширення ГГ у болгарській частині Чорного моря. Результати цінні для майбутніх досліджень означених площ і перспективних глибин. Робота привертає увагу до питання впливу зміни клімату на ГГ Чорного моря та ролі глибинних розломів у формуванні нафтогазоносності шельфу.