A new view to the spatial distribution of the Paleogene lithostratigraphic units in the offshore part of the Dolna Kamchiya basin based on seismic profile’s interpretation

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Introduction

The offshore part of the Dolna Kamchiya basin has been investigated for oil and gas since the beginning of the 60s of the 20th century and thus it is the longest studied petroleum area in Bulgaria. On the base of geophysical and borehole data (the offshore drilling was done in the interval 1984–1993), outlining the deep geologic structure of the basin, the geological investigations have been focused on litho- and biostratigraphy (Juranov, 1991), seismostratigraphy (Georgiev et al., 2004; Dimitrov, Georgiev, 2011), sequence stratigraphy (Dimitrov, 2007), lithofacies analyses and palaeogeography (Dimitrov, Georgiev, 2005; Dimitrov, 2008), and sedimentology (Stefanov, 2018). Thus, a large amount of data and geologic interpretations has been collected.

The Dolna Kamchiya basin (DKB), also known as Dolna Kamchiya depression (DKD – Bokov et al., 1987) or Dolna Kamchiya sub-basin (Georgiev, 2012), comprises a small onshore area in the central Bulgarian Black Sea coast and extends offshore to the southeast into the Western Black Sea basin (Figs 1, 2). A brief review on the geological setting was published by Dimitrov and Georgiev (2005), and Stefanov (2018).
The present article aims to elucidate the spatial distribution and relationships of the Paleogene lithostratigraphic units in the offshore part of the Dolna Kamchiya basin on the base of lithostratigraphic interpretation of seismic profiles and borehole sections. The interpretation of seismic profiles for lithostratigraphic purposes was successfully applied (Valchev, Dimitrov, 2018) to the Paleogene in the onshore part of the basin.

### Studied material

Six selected seismic profiles (Figs 2, 4–6) were lithostratigraphically interpreted on the base of correlation to five borehole lithologic logs (Figs 2, 3), that were reinterpreted here. The primary lithologic data were collected from the geological reports kept in the National Geological Fund and they concern the following boreholes: LA-3 (Staples, Pierpoint,
LA-1 (Pettit, Pierpoint, 1994f), R-1 Samotino Sea (Jelev et al., 1989f), R-1 Samotino East (Bogatskaya et al., 1986f), and LA-2 (Staples, 1994f). For additional correlation an onshore seismic profile, located along the sea coastline, was used (Fig. 7).

Lithostratigraphic units

The lithostratigraphic reinterpretation of the studied borehole lithological logs allowed identifying of five

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formal units (Fig. 3): the Byala Formation (Paleocene), the Dvoynitsa Formation with the Armera and Gebesh Members (Lower–Middle Eocene), the Dolni Chiflik Member of the Avren Formation (Middle–Upper Eocene), and the Ruslar Formation (Oligocene). A brief description of their lithology, age, spatial distribution, and relationships is given below.

The Byala Formation

The rocks of this unit were described as “whitish limy marls” (Zlatarski, 1907), “Byala clayey marls” (Bontchev, 1926), “limestone-marl formation” (Juranov, 1984). It was formalized by Juranov (1991; see also Juranov, 1993a). In the offshore part of the Dolna Kamchiya basin the unit is represented by dark gray solid marls, established in two borehole sections – LA-1 and R-1 Samotino Sea (Fig. 3b, c). In the first one, it overlies the Upper Cretaceous base as the boundary is an unconformity and the thickness is 65 m. In the second section the lower boundary was not penetrated and thus it could be assumed that the thickness is more than 106 m. The upper boundary is a sharp lithologic contact with the Dvoynitsa Formation (represented by the Gebehs Member in LA-1 and by the Armera Member in R-1 Samotino Sea). In the southernmost boreholes R-1 Samotino East and LA-2 (Fig. 3d, e) the pre-Paleogene base was not penetrated and therefore this boundary was not studied. The Byala Formation was identified in all seismic profiles (Figs 4–6) underlyings the Gebehs or Armera Member of the Dvoynitsa Formation and showing almost constant thickness. In the northern part of B92-16 seismic profile (Fig. 4) there is probably a lateral transition between the Byala Formation and the Komarevo Formation (Thanetian). The planktonic foraminiferal data obtained from R-1 Samotino Sea borehole (Juranov, 1991) determined Paleocene age for the formation.

The Dvoynitsa Formation

The unit was introduced as formal one by Juranov and Pimpirev (1989) in the coastal region of the Eastern Balkanides. Later on, Vangelov and Sinoyovsky (2011) formalized three members of the Dvoynitsa Formation (the Armera, Gebesh and Goritsa Members), and Valchev et al. (2018) elucidated the internal structure of this unit in the onshore part of the Dolna Kamchiya basin by 3D lithological modelling recognizing all the three members. The Gebehs and Armera Members were established in all five offshore borehole sections, while the Goritsa Member was not recorded. The Armera Member comprises thick-bedded sandstones with interbeds of thick-bedded conglomerates. The Gebesh Member is composed of thin-bedded alternation of sandstones, marls, siltstones and shales. In LA-3 borehole only the Armera Member is represented and it overlies the Lower Cretaceous base, as the boundary is an unconformity (Fig. 3a). The lower boundary with the Byala Formation was discussed above. The two members show great varieties of their thickness, as they do not demonstrate an exact stratigraphic position in the Dvoynitsa Formation volume. The Gebehs Member was recorded at two or three levels in four borehole logs (Fig. 3b–c) and its presence was identified in all seismic profiles. The thinnest (100 m) it is in R-1 Samotino Sea borehole (Fig. 3c) and the thickest (over 2000 m) – in LA-2 borehole (Fig. 3e). The Armera Member occurs usually at one (Fig. 3a, d, e) or two levels (Fig. 3b, c). Its thickness varies between 54 m in LA-2 borehole (Fig. 3e) and 902 m in R-1 Samotino Sea borehole (Fig. 3e). The total thickness of the formation is from 395 (Fig. 3a) to over 2000 m (Fig. 3e). The lithostratigraphic interpretation of the seismic profiles (Figs 4–6) shows clearly the complex and variable stratigraphic and lateral relationships of the two units and the variety of their thickness. The chronostratigraphic range of the Dvoynitsa Formation was determined as Lower–Middle Eocene on the base of rare planktonic foraminiferal remains (Juranov, 1991).

The Dolni Chiflik Member of the Avren Formation

It was known as “Dolen Ciflik Seria” (Pollak, 1933), “marl-sandy complex” (Efremochkin et al., 1974f; Vavilova et al., 1978f), “Dolni Chiflik Formation” (Cheshitev et al., 1994; Kânchev, 1995), and formalized as the Dolni Chiflik Member by Juranov (1993b). Generally, the unit comprises alternation of sandy marls and clayey sandstones, as it is possible two distinct levels to be recognized. The lower one is composed predominantly of clayey sandstones and siltstones alternating with thin-bedded shales and marls. The upper level is represented mainly by sandy marls alternating with siltstones, sandstones and shales. The thickness of the lower level varies from 653 (Fig. 3e) to 789 m.
Fig. 4. Lithostratigraphic interpretation of seismic profiles SP7866 and B92-16

Figs 4–7: Geologic-geophysical sections to double-time depth (TWT, s). Abbreviations: By, Byala Fm.; Kom, Komarevo Fm.; Gb, Gebesh Mb.; A, Armera Mb.; DCh, Dolni Chiflik Mb.; Ru, Ruslar Fm.; B+D+Al, Beloslav, Dikilitash and Aladan Fms; N, Neogene cover

Фиг. 4. Литотратиграфска интерпретация на сеизмични профили SP7866 и B92-16

Фиг. 4–7: Геолого-геофизични разрези по двойно време дълбочина (TWT, s). Съкращения: Бу – Беленска свита; Ком – Комаревска свита; Гб – Гебешки член; А – Армерски член; ДЧ – Долночифлишки член; Ру – Русларска свита; В+Д+Ал – Белославска, Дикилита и Аладънска свита; N – неогенска покривка
(Fig. 3b), while the upper one is from 180 (Fig. 3e) to 500 m (Fig. 3b) thick. It should be noted that the core intervals of R-1 Samotino Sea borehole are very scarce and this fact did not allowed us to recognize the two levels. The total thickness of the unit is from 836 (Fig. 3e) to 1289 m (Fig. 3b). The chronostratigraphic range of the Dolni Chiflik Member was determined on the base of planktonic foraminiferal data (Juranov, 1991) as Middle–Upper Eocene.

The Ruslar Formation

It was introduced as “Ruslar sandstones” by Zlatarski (1927) and formalized by Aladjova-Chriščeva (1991). In the offshore part of the Dolna Kamchiya basin the unit comprises predominantly claystones with thin-bedded interbeds of sandstones, siltstones and rare limestones. The last, as well as the sandstones, occur mainly at the lower levels of the formation. Its thickness varies from 126 (Fig. 3e) to 500 m (Fig. 3d). The boundary with the Dolni Chiflik member is a sharp lithologic contact. In the entire area of its distribution the Ruslar Formation is covered with Neogene sediments. Fossil remains have not been established, therefore the age of the unit was determined as Oligocene on the base of its stratigraphic position.

Discussion

The data, obtained from the studied borehole sections and seismic profiles, allowed us to outline the
Fig. 6. Lithostratigraphic interpretation of seismic profiles BGK92-71 and SP79124

Фиг. 6. Литотратиграфска интерпретация на сензмични профили BGK92-71 и SP79124
spatial distribution of the five established Paleogene lithostratigraphic units. Thus, we could claim that the Byala Formation is distributed in the entire southern board of the basin, showing almost constant thickness. It is covered with the Armera or Gebesh Member of the Dvoynitsa Formation in the entire area of its distribution. The last one was also recorded in the southern board of the basin, as it is difficult to outline exactly the northern boundary of its distribution. The unit demonstrates complex internal structure with varied thickness. The complicated tectonic structure of the southernmost area (Fig. 4 – profile SP7866, Fig. 5 – profile BGK92-22, Fig. 6 – profile SP79124) does not allow calculation of the exact thickness, but we could assume that it is over 2000 m. Variation of the stratigraphic position and the thickness of the Armera and Gebesh Members confirms the data, obtained from the onshore boreholes and seismic profiles (see Fig. 7), and reveals the Dvoynitsa Formation as the most complex Paleogene lithostratigraphic unit in the Dolna Kamchiya basin.

The data, concerning the Dolni Chiflik Member of the Avren Formation, proved its broad spatial distribution in the basin, but we could not mark the lateral transition to the typical Avren Formation in the northern board of the Dolna Kamchiya basin. The member covers the Armera or Gebesh Members of the Dvoynitsa Formation as the boundary is unconformity. The thickness shows considerable variations, as it is maximal in the central area of the southern board of the basin.

Compared to the onshore sections, the Ruslar Formation shows similar lithologic features and variations of the thickness. It is maximal in the central offshore areas.

The uneven distribution of the borehole sections and seismic profiles, especially in the northern board of the offshore Dolna Kamchiya basin, is an obstacle for a more precise outlining of the spatial relationships with the Paleogene lithostratigraphic units recorded from the northernmost areas of the basin, and the probable lateral transitions to the Komarevo, Beloslav, Dikilitash, Aladan and Avren Formations, established in the onshore sections.

**Conclusions**

The lithostratigraphic interpretation of the seismic profiles by correlation to the reinterpreted offshore borehole logs, gave us an opportunity to clarify the spatial distribution and relationships (stratigraphic and lateral) of the Paleogene lithostratigraphic units and to add new data of their lithology and thickness. This fact is a reliable base for further investigation of the deep geological structure of the offshore part of the Dolna Kamchiya basin including 3D lithostratigraphic, chronistratigraphic and lithological modeling, as well as more precise palaeogeographic reconstructions.

**References**


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