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Features of the sedimentary cover of the oil and gas basin of Côte d'Ivoire

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Abstract

This article presents the results of a huge number of available scientific papers and publications of the results of exploration work for oil and gas in the sedimentary cover of the Ivory Coast basin.

The degree of exploration of the basin has been revealed with a brief clarification of the types and stages of prospecting and exploration work aimed at determining the geological structure of the basin, the structural features of the rocks and the hydrodynamic state of the continental part of the basin. The geochemical indicators of oil and gas source rocks are presented, based on the geochemical exploration work carried out.

The results of these studies were used to assess the quality and generation capacity of the oil and gas source rock.

Based on these data, it can be concluded that the Albian, Cenomanian and Turonian oil and gas source rocks are mature enough for the formation and generation of liquid and gaseous hydrocarbons. It is also noticeable that some layers have fairly good indicators, despite the fact that they are immature within the study zones.

The characteristics of reservoir rocks are shown and a description of the types of traps present in the basin is made. The main processes caused by both formation and development are described.

This article will help to briefly clarify all existing data on exploration of the sedimentary cover of the Ivory Coast basin for a more detailed understanding.

Keywords: sedimentary basin, oil and gas source rocks, reservoir rocks, traps, geological reserves, traps, deposit, prospecting and exploration work, fluid seals, tectonics, organic matter, organic carbon content.

The study of the sedimentary basin in the Ivory Coast (Côte d'Ivoire) took place in several stages, namely in 4 stages, which began at the end of the 19th century and continue to this day (Fig. 1).

As a result of these studies, all available outcrops along the coast of the Republic of Côte d'Ivoire were studied. These works consisted of field exploration (field rock surveys, coastal seismic surveys) and shallow surface drilling to study the geological section of the Cretaceous deposits and search for hydrocarbons.

These results allowed us to compile not only a generalized section of the coastal part of the country, but also an idea of the structural features of the rocks of West Africa.

In the process of increasing the level of exploration and studying the sedimentary basin in the Gulf of Guinea, numerous seismic (2D and 3D seismic exploration) and drilling operations were carried out, on the basis of which an idea of the geological structure and tectonic structure was obtained.

The regime, structural features and oil and gas potential of the marine part of the sedimentary basin of Côte d'Ivoire were obtained (Fig. 2).

Current exploration work is aimed at studying the characteristics and potential of the deep-water part of the basin.

Due to the poor study of this part of the basin, its potential was predicted in a similar way to the deep-water part of the basin located within the administrative boundaries of the Republic of Ghana, which is currently more studied and quite promising [3].

In 2015, based on the results of exploration work on approximately 35% of the basin area, hydrocarbon reserves were estimated at 40,920 thousand tons of oil and 510 billion m³ of gas [5].

Today, the results are completely different from the reserves obtained in 2015, but cannot be published in this paper due to the lack of an official publication by the

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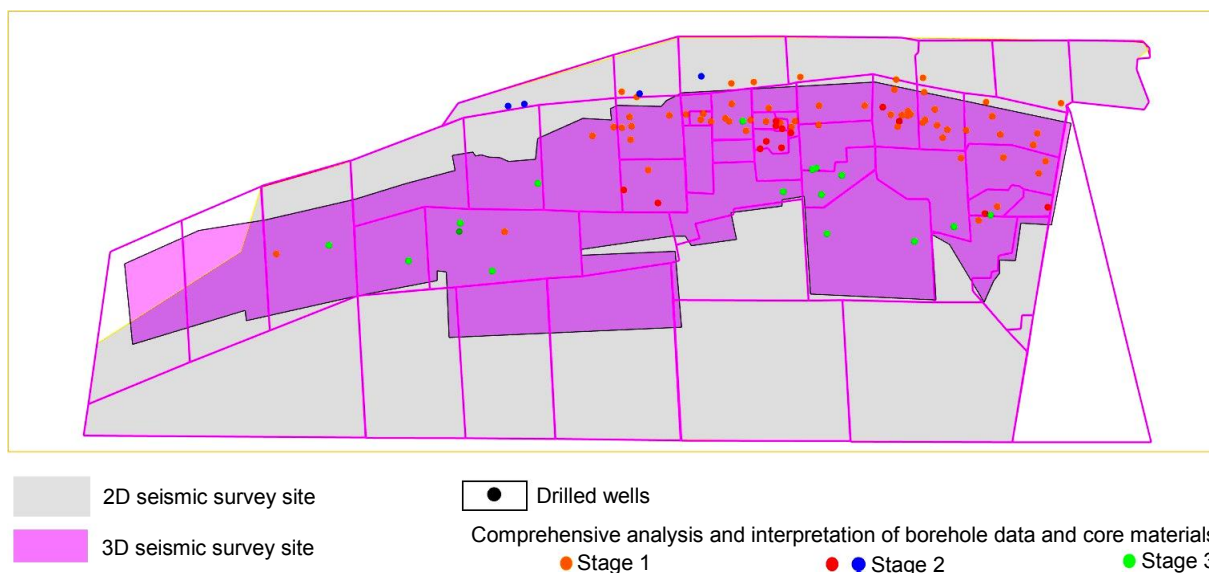


Figure 1. The degree of exploration of the sedimentary basin of the Ivory Coast [1]
Рисунок 1. Степень разведанности и изученности осадочного бассейна Берега Слоновой Кости [1]

authorities of the Republic of Côte d’Ivoire. Despite this, known and existing data on the main objects of study of the basin can be used to assess the potential of the basin (Fig. 4) [6].

The main deposits discovered in the waters of the Ivory Coast are embedded in almost all the exposed horizons of the lower and upper sections of the Mesozoic system. Discoveries in the most ancient horizons to date have been made only in the Albian deposits. The sedimentary basin on the coast of Côte d’Ivoire is currently considered poorly studied. The exposed Albian horizons are composed mainly of limestones, sandy-clayey and shales, which are oil and gas source rocks and reservoir rocks. These rocks are mainly accumulated in linear structures and are divided into blocks throughout the basin [8].

Source Rocks of the Ivory Coast Sedimentary Basin. Albian shales and limestones are source rocks by all characteristics. Middle and Upper Albian shales are mature enough to generate liquid and gaseous hydrocarbons. In addition, they are the main sources of hydrocarbon supply for the Albian and younger reservoir rocks. It is believed that Middle Albian shales are the main sources of gas generation in the basin. They consist of kerogens of marine and continental origin (kerogen types II and III) [14].

The potential of Upper Albian source rocks (shales) increases from the base of the horizon to its roof, where carbonate source rocks (limestones) occur in the upper part of the horizon and consist exclusively of kerogen type II of marine origin. The potential of carbonate source rocks is significantly higher than that of shales. The main properties of oil and gas source rocks are presented in table 1.

Reservoir Rocks of the Ivory Coast Sedimentary Basin. Reservoir rocks associated with the Albian horizons were formed mainly in continental and transitional zones (Lower Albian sandstones) and in marine settings (Upper Albian sandstones). The initial and primary hydrocarbon production volumes in the basin were obtained during

the development of terrigenous reservoirs of the Albian horizon. The terrigenous Albian sediments of marine origin have good filtration and capacity properties (porosity varies from 12–30%, permeability from 6 to 2010 D) and consist mainly of turbidites. As a result of vertical tectonic movements, positive and negative structures were formed, crumpled into folds, which were subsequently subjected to erosion. This created good conditions for the development of traps under the erosion surface [2].

It should be noted that the reserves presented in this article do not apply to all currently existing fields in the basin. This is due to the fact that all discoveries made after 2015 were not used for calculations, since they were not officially published in the reports of the Ministry of Natural Resources of the Republic of Côte d’Ivoire, but were published by foreign companies operating in the waters of the republic. Almost all licensed areas of the basin are involved in the study of the sedimentary basin (Fig. 1, 3). The conducted exploration work allows us to study new territories in more detail and assess the potential of these areas of the basin. Based on the results of these works, in the licensed area SI-205 (see fig. 3), located in the central part of the basin.

Successful exploration work made it possible to discover the Paon field in the SI-103 license block. According to SI-103 data, a continuation of the oil system was established, caused by the formation of the Yubiley field, which is currently the largest field [10].

The data obtained made it possible to discover not only the Paon field in the Turonian horizons by analogy with Yubiley, but also new directions for geological exploration for oil and gas.

The reservoirs were formed in the Gazel monoclinical structure. This territory is quite heavily eroded. The Cenomanian strata pinch out and lie with angular unconformity. Interpretation of seismic data made it possible to confirm the presence of gas and condensate [11].

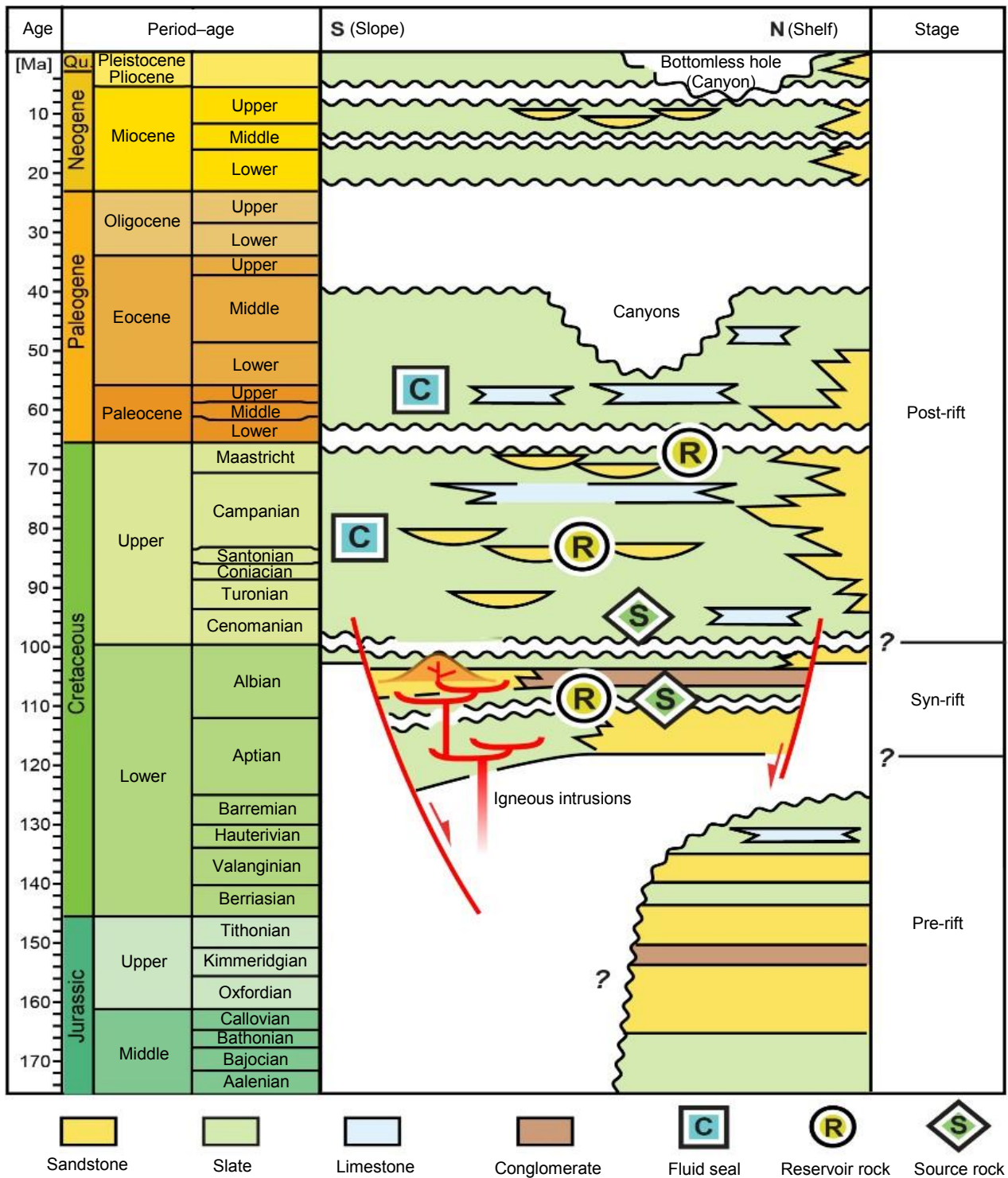


Figure 2. Tectonic and stratigraphic scheme of the sedimentary basin of the Ivory Coast [2]
 Рисунок 2. Тектоно-стратиграфическая схема осадочного бассейна Берега Слоновой Кости [2]

Key findings

A review of the vast amount of existing scientific papers and publications on the results of geological exploration for oil and gas in the sedimentary basin of Côte d’Ivoire has allowed us to understand and establish the following points:

Albian, Cenomanian and Turonian source rocks are mature enough to form and generate hydrocarbons, which is not the case with Campanian and Cenomanian source rocks. They

are not mature enough to form hydrocarbons. However, despite this, the possibility of the existence of the necessary conditions for the maturation and generation of hydrocarbons in the deeper part of the basin cannot be ruled out [12];

High tectonic activity of this region due to the rifting process allowed the formation of an excellent structure for the accumulation of hydrocarbons and the formation of promising traps at all horizons [13];

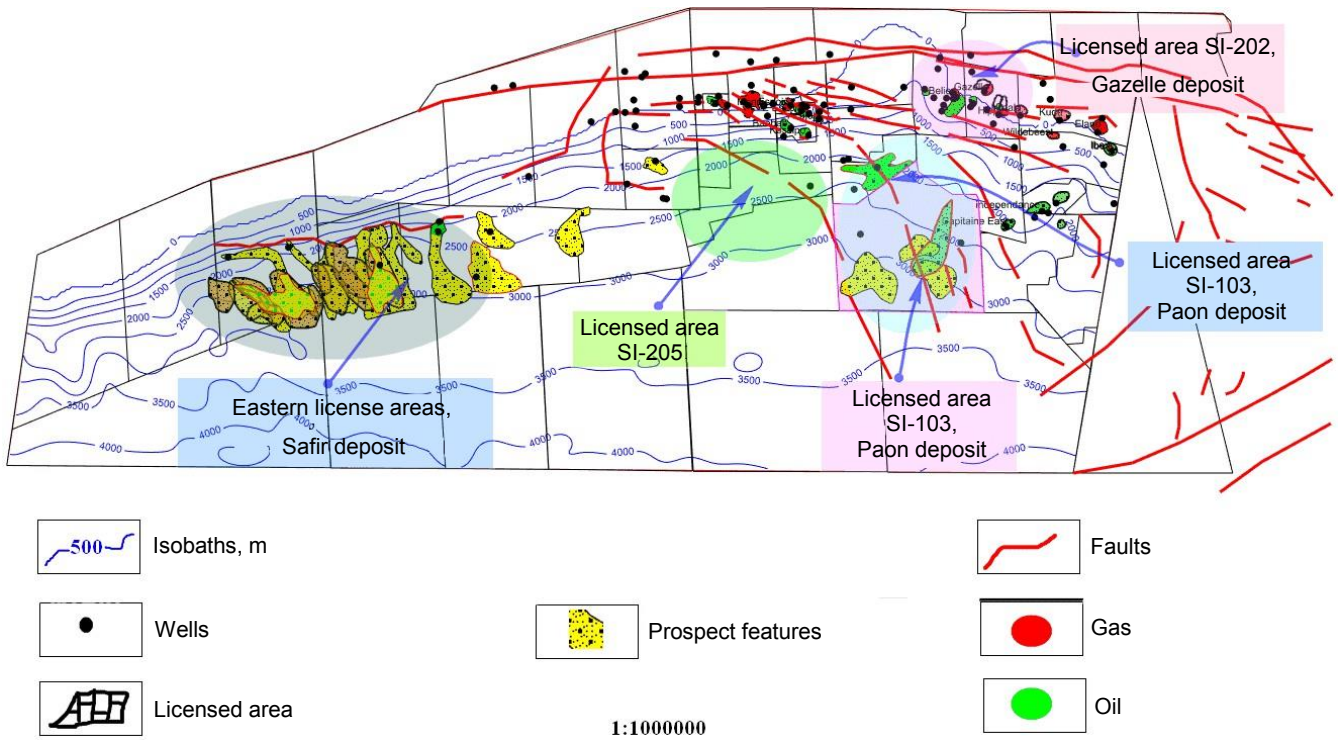


Figure 3. Main deposits and prospective licensed areas of the Ivory Coast sedimentary basin [4]

Рисунок 3. Основные месторождения и перспективные лицензионные участки осадочного бассейна Берега Слоновой Кости [4]

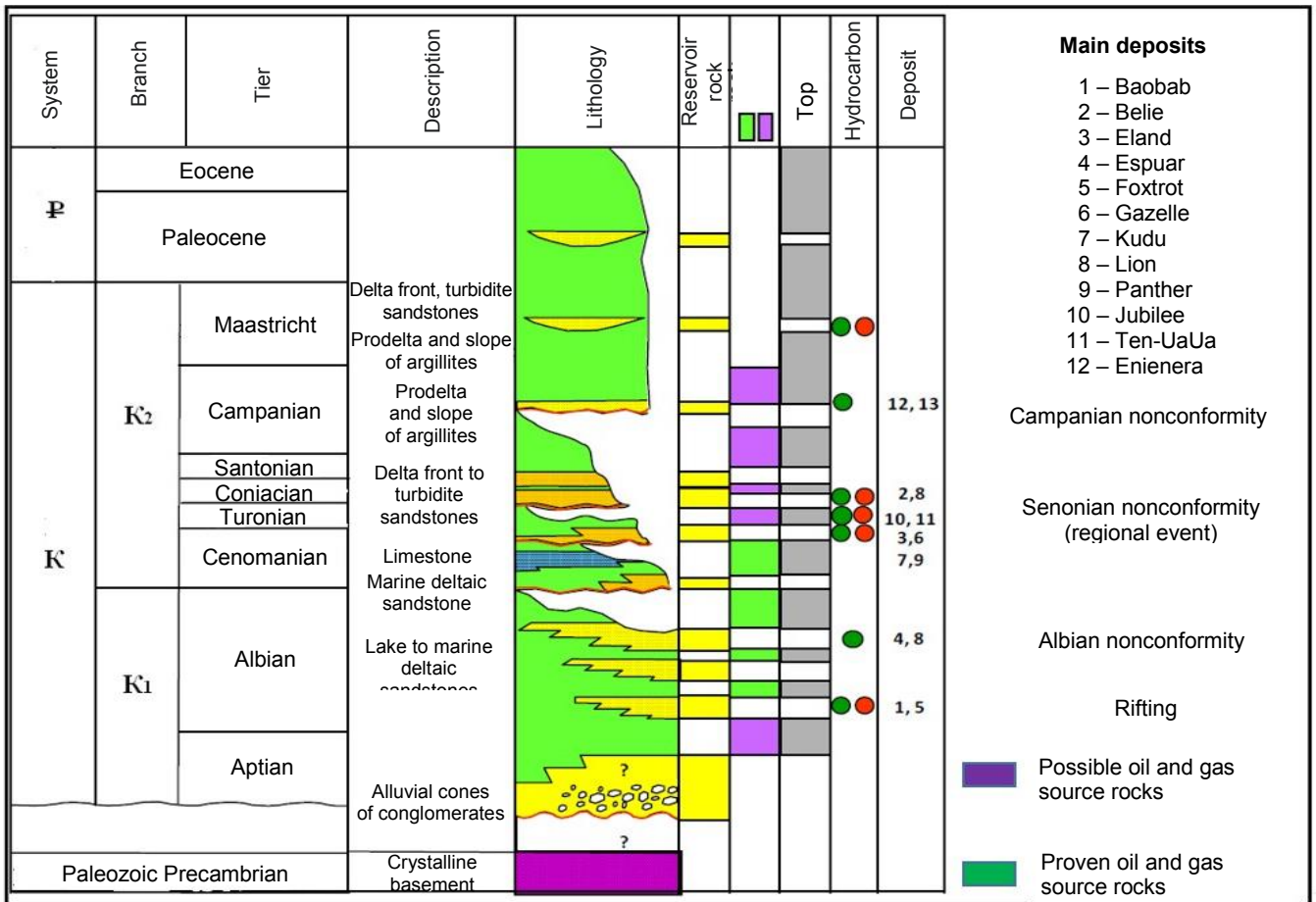


Figure 4. Lithostratigraphic scheme of the sedimentary basin of the Ivory Coast – Tano [7]

Рисунок 4. Литостратиграфическая схема осадочного бассейна Берега Слоновой Кости – Тано [7]

Table 1. Basic properties of oil and gas mother rocks [9]
Таблица 1. Основные свойства нефтегазоматеринских пород [9]

Tier	Breed	Type of kerogen	Sorg, %			S2, mgUV/g of rock		Ro, %		HI, mgUV/g CBT
			min	av.	max	min	max	min	max	
Albsky	Slate	II/III	0.50	2.2	5.00	1.90	50.0	0.49	1.29	600
	Limestone	II	0.72	6.7	15.50	2.10	34.0		0.49	
Cenomanian	Slate	II	0.19		6.50	1.80	51.0		1.30	574
Turonian	Slate				6.70		26.9			576
Senonian	Slate	II/III	0.59		4.30	1.51	32.0	0.40	0.59	
Campanian	Slate	II	1.59		4.19	1.98	35.0		0.51	
The Maastricht	Slate		0.86		3.00	1.49	16.0	0.44	0.59	

The results of the study allowed us to understand and determine the right direction for exploration work on oil and gas. The established balance reserves do not reflect the real potential, since the studied blocks, where the main discoveries were made, have not been fully studied [11].

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Особенности осадочного чехла нефтегазового бассейна Кот-д'Ивуара

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Аннотация

В настоящей статье предложены результаты проведенных поисково-разведочных работ на нефть и газ в осадочном чехле бассейна Берега Слоновой Кости.

Представлена степень изученности бассейна с кратким уточнением видов и стадий проведенных поисково-разведочных работ, направленных на определение геологического строения бассейна, структурных особенностей горных пород, гидродинамического состояния континентальной части бассейна. Представлены геохимические показатели нефтегазоматеринских пород на основе проведенных геохимических разведочных работ. Результаты данных исследований использованы для оценки качества и генерационной способности нефтегазоматеринской породы.

На основе этих данных можно сделать вывод о том, что альбские, сеноманские и туронские нефтегазоматеринские породы достаточно зрелые для формирования и генерации жидких и газообразных углеводородов. Также заметно, что некоторые слои имеют достаточно хорошие показатели, несмотря на то, что не все породы являются зрелыми в пределах изучаемых зон. Представлены характеристики коллекторских свойств пород и сделано описание типов ловушек, присутствующих в бассейне. Описаны основные процессы, обусловленные и формированием, и развитием. Данная статья поможет кратко обрисовать все существующие данные о разведке осадочного чехла бассейна Кот-д'Ивуара для его более точной характеристики.

Ключевые слова: осадочный бассейн; нефтегазоматеринские породы; породы-коллекторы; ловушки; геологические запасы; ловушки; залежь; поисково-разведочные работы; флюидоупоры; тектоника; органическое вещество; содержание органического углерода.

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