

Entropy Approach to Naphthide Systems

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Abstract

It is shown that along with other geoinformation methods, one can also use the value of the Chenon entropy to assess the maturity of oil fields. It was found that in the series of naphthides natural gas → gas condensate → associated gas → oil, entropy increases, while geocological syntropy decreases. It is curious that for natural gas $H = 0.41$, which indicates a high degree of freedom of the gas phase, while for oil the entropy and syntropy are approximately equal, which indicates that when oil is formed in a trap mainly from the mantle of a high-energy liquid, the structural formation organization is in equilibrium.

Keywords: Naphthides; Natural gas; Oil; Entropy; Shannon index

Introduction

Naphthides are in separate places of the Earth in gas, liquid, semi-solid and solid states or in the form of their mixture. Of greatest industrial importance are liquid naphthides called oil, or literally crude oil. Oil - complex heterogeneous colloid-dispersed systems. is formed in the interior of the Earth from deep mantle fluids and is a renewable resource. Oil is a mutual solution of the closest homologues and other compounds in each other. More than a thousand of individual organic substances were found in the composition of oil, containing: carbon, hydrogen, oxygen, nitrogen, sulfur, and more than 60 elements [1].

Gaseous naphthides are natural gas, gas condensate and associated gas [1]. Natural gas or fossil gas is a natural mixture of hydrocarbon gas, consisting mainly of methane, but usually containing various amounts of other low molecular weight alkanes, and sometimes a small percentage of carbon dioxide, nitrogen, hydrogen sulfide or helium. Natural-gas condensate, also called natural gas liquids, is a low-density mixture of hydrocarbon liquids that are present as gaseous components in the raw natural gas produced from many natural gas fields. The natural gas condensate is also called condensate, or gas condensate, or sometimes natural gasoline because it contains hydrocarbons within the gasoline boiling range. Associated petroleum gas is a natural hydrocarbon gas dissolved in oil or located in "caps" of oil and gas condensate fields. In contrast to natural gas, associated petroleum gas contains in addition to methane and ethane a large proportion of propane, butane and vapor of heavier hydrocarbons. Many associated gases, depending on the field, also contain non-hydrocarbon components: hydrogen sulfide and mercaptans, carbon dioxide, nitrogen, helium and argon.

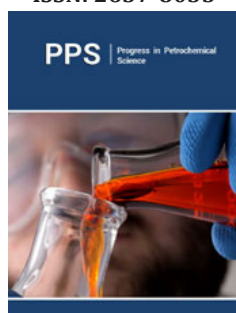
Naphthides are unstable open geodynamic systems, which under the influence of anthropogenic, deep, surface, cosmic processes can self-organize in the direction of chaos, the measure of which is entropy or the direction of order. In open systems, which include naphthides, processes can proceed with both an increase and a decrease in entropy.

The system interacts with the outside world as a whole. An open system can exchange energy, material and, which is not less important, information with environment. The system consumes information from the environment and provides information to environment for act and interact with environment. Shannon CE [2] was the first who related concepts of entropy and information. He has suggested that entropy is the amount of information attributable to one basic message source, generating statistically independent reports. Get any amount of information entropy is equal to the lost. Information entropy for independent random event x with N possible states is calculated by the following equation:

$$H = - \sum_{i=1}^N p_i \log_2 p_i$$

where P_i is the probability of frequency of occurrence of an event.

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For the first time, in 1955, Arthur RM [3] used the general Shannon entropy equation for estimating the degree of structuring of biocenoses, in which p_i was replaced by $p_i = n_i / N$; (where n_i is the total number of individuals of the species i , N is the total number of individuals in the entire biocenosis). R. Margalef postulated a theoretical concept according to which diversity corresponds to entropy when randomly choosing species from the community [4]. As a result of these works, the Shannon H Index, sometimes called the Shannon Diversity Information Index, has gained widespread acceptance.

Using the Shannon index, a comprehensive assessment of the quality of surface waters was carried out [5] and a structural analysis of the condition of Covid-19 was made [6].

The purpose of this work is to evaluate the state of naphthid systems using the chemical component composition of naphthid systems with Shannon index.

Result and Discussion

Table 1: Chemical composition (vol.%) and values of I and H for gas.

Composition	Natural Gas		Natural Gas Gas Condensate		Associated Oil Gas	
	n	$n \log_2 n$	n	$n \log_2 n$	n	$n \log_2 n$
CH ₄	94	615.8	74.8	465.36	38.8	204.66
C ₂ H ₆	3	4.75	7.7	22.66	19.1	81.23
C ₃ H ₈	0	0	3.9	7.65	17.8	73.89
C ₄ H ₁₀	0	0	1.8	1.52	8	24
C ₅ H ₁₂	0	0	6.4	17.13	6.8	18.79
N ₂	2	2	4.3	9.04	8	24
CO ₂	1	0	1.1	0.15	1.5	0.88
N	100		100		100	
$\sum n \log_2 n$	622.55		523.51		428	
I	6.23		5.24		4.28	
H	0.41		1.4		2.36	

In accordance with the purpose of the work and the formulation of the problem, the Shannon index of natural gas, associated petroleum gas, gas condensate fields, and oil fractions were calculated. Table 1 show the corresponding Shannon index calculations.

It is curious that for natural gas $H = 0.41$, which indicates a high degree of freedom of the gas phase. For oil, the Shannon entropy ($H = 3.33$) and syntropy ($I = 3.31$) are approximately equal. This indicates that the structural organization of the oil is in equilibrium. Thus, it turns out that in the series of naphthides, natural gas → gas condensate → associated gas → oil, entropy increases, and geoeological syntropy decreases. Along with other geoinformation methods and technologies, it is possible to recommend using the Shannon index to assess the maturity of oil fields.

Procedure for Determining

To determine the values of the Shannon index the following computational algorithm is used [7]:

Determines the percentage of each component-n.

Estimates the total percentage of components $(N) - N = \sum n$.

Computes $\log_2 N$, $n \log_2 n$ and $\sum n \log_2 n$.

Determines geoeological evolving syntropy (I) and entropy (H):

$$I = \sum n \log_2 n / N \text{ and } H = \log_2 N - I.$$

The values of H and I indicate what and to what extent prevails in the structure of the system: chaos or order. So, if $H < I$, then order prevails in the structure of the system, otherwise, when $H = I$ - the organization of the system is equilibrium.

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