GENETIC DIAGNOSTICS OF HYDROCARBON SYSTEMS OF DIFFERENT ORIGINS

Svetlana A. Punanova, Tatiana L. Vinogradova

Institute of Oil and Gas Problems, Russian Academy of Sciences, Moscow, Russia

Introduction

The genesis of heavy oil accumulations that occur at a depth of 2 km or greater and have a high concen tration of asphaltic-resinous components and, frequently, a high sulfur content is still open to question. Hydrocarbon (HC) accumulations are represented by two genetic groups, those of early generation (immature) and hypergenetically altered (biodegraded). The oils of early generation are weakly transformed or "primary" and they have been formed in protocatagenesis or early mesocatagenesis zones. Their hydrocarbon composition contains information on the original organic matter (OM), is rich in hydrocarbon biomarkers, and is functionally related to the nature of lithofacies environments of OM burial (marine, continental) and their features (types). As a result of destruction processes, oils biodegrade and their genetic code due to the parent biomass is changed and obscured. The amount of biomarkers decreases until the complete disappearance. Genetic diagnosis of primary (unalterted) and secondary (biodegraded) naphthides occurring in similar geological environments and having close physiochemical properties and even the same chemical type is a demanding task of scientific and practical importance.

Results

In this work, we classified accumulations of oils of the primary genesis and secondary transformed oils in sedimentary basins of various geostructural types and developed geochemical criteria for their recognition. To do this, published data on the geology and geochemistry of naphthides from oil-and-gas basins (OGB) of Russia, Azerbaijan, Belarus, Georgia, Western Turkmenistan, Tajikistan, Kazakhstan, the United States, Israel, Western Canada, Brazil, Australia, Guatemala, New Zealand, Indonesia, China, Nigeria, and Venezuela were selected and analyzed (Vinogradova and Punanova, 2012a; Punanova and Vinogradova, 2016).

Comparative analysis of immature and biodegraded oils (Vinogradova and Punanova, 2012b; Vinogradova, 2013) revealed the most informative HC criteria for their distinguishing (Table 1). These criteria for fluids of chemical types A-2, B-2, and B-1 in biodegradation stages I–III are the 20S/(20S + 20R), ββ/(ββ + αα), and diasteranes/regular steranes ratios of C_{29} steranes; the 22S/(22S + 22R) ratio of H_{31} hopanes; and the Σbenzothiophenes/Σdibenzothiophenes ratio of aromatic sulfur compounds. In immature oils, values of the first four factors are low to be respectively 26–52, 31–60, 12–38, and 48–53%. They are characterized by not only the prevalence of benzothiophenes over diben zothiophenes, but also increased oleanane/H_{30}, moretane/H_{30}, and gammacerane/H_{30} ratios due to an increased concentration of the individual hydrocarbons. In the biodegraded oils, which generally preserve the features of mature oils, the values of the first four criteria are higher and there is a predominance of dibenzothiophenes over benzothiophenes. In highly biodegraded oils of the B-2 type (stages III–V) the oleanane/H_{30}, 20S/(20S + 20R), ββ/(ββ + αα), and diasteranes/regular steranes ratios are significantly higher as a result of the reduction of 20R epimer of regular steranes and H_{30} hopane.

Conclusion

Type classification of oils according to the concentration of "biogenic" trace elements (V, Ni, Fe), as we detailed in (Punanova, 2014), revealed significant differences in the course of naphthidogenesis between early generation and hypergenetically altered oils. The immature oils are depleted in TE and are characterized by low V and Ni contents (V < 10 ppm and Ni < 50 ppm) (except crude oils generated by marine OM of the Monterey formation, California) and a predominance of Ni over V (V/Ni < 1); i.e., they form provinces with nickel metallogeny. The hypergenetically altered oils and natural bitumens genetically related with them are characterized by high, close to commercially viable TE concentrations (V > 150 ppm, Ni > 50 ppm) due to the secondary enrichment in metals and by predominance of V over Ni (V/Ni > 1) and make metallogenic provinces of the vanadium type.

Table 1. *Benchmarks of immature (of various lithofacies) and biodegraded crude oils*

Parameter (HC ratio), %	Immature oils					Biodegraded oils		
	Chemical types of oils according to Al.A. Petrov							
	A-2			B-2	B-1	A-2	B-2	A-1
	1	2	3	4	5			
20S/(20S + 20R)	32–47	27–48	28–33	26–35	30–46; 48– 52	50–55	50–55	58–85; 100
20S/20R	–	–	–	40–52	10–52	–	79	100–120
ββ/(ββ + αα)	–	–	–	60	47–58	86–87	86–87	87–100
Diasteranes/regular steranes	12–34	–	–	38	–	52–54	52–54	48
22S/(22S + 22R) (H_{31})	53–60	54–56	57–59	54–58	48–55	53–55	53–55	51
Oleanane/H_{30}	5–33	–	–	15–36	38–95	5–8	8–10	46–82
Moretane/H_{30}	18–20	29	12–13	19–24	20–61	12	6–14	7–8
Gammacerane/H_{30}	–	40–44	40–110	–	–	–	13–20	8–10
ΣBenzothiophenes/ Σdibenzothiophenes	20–140	–	–	120	–	69	62	61
23,28–bisnorlupane/H_{30}	None	None	None	72–78	78–190	None	None	None

The dash in the table columns means the absence of data; lithofacies: (1) marine terrigenous–siliceous, (2) marine terrigenous carbonate, (3) lacustrine saline water, (4) shallow marine, and (5) continental.

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