Utilization of Exploration Criteria in the Solution of Geochemical Problems of Oil and Gas Exploration

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Modern methods of geochemical exploration for oil and gas deposits are based on the concept of the movement of hydrocarbons (primarily in a gaseous state) from a pool into overlying strata. The distribution of hydrocarbons in rock forming the upper part of sections in productive areas will yield the information needed for effective prediction of the presence of pools, even though they may be located at great depth. Combined geophysical and geochemical methods and apparatus should be applied to exploratory investigation of geochemical processes in rocks above pools, the covering complex (пerekryvayushchi kompleks: PK).*

Various criteria of geochemical exploration for oil and gas are reviewed with reference to significant physicochemical parameters, mineralogical features, stabilities of solid, liquid and gaseous phases, and thermodynamic equilibria.

A variety of physicochemical processes develops along the boundaries of gas-rock, gas-water and water-rock phases as hydrocarbons migrate from a pool into the overlying strata, whose sorption capacity is conditioned by their textures, mineral composition, and other properties. On the scale of geologic time these processes can lead to substantial changes in the parameters of a normal geochemical field. Following are some examples.

1. Processes of adsorption are exothermic. Adsorption of upward migrating hydrocarbons by overlying rocks must therefore be accompanied by liberation of heat, resulting in heat disturbances above productive structures. The frequently observed analogous spatial distribution of geothermal anomalies and oil and gas pools is considered due to these processes.

2. Adsorption of one component is generally accompanied by loss of equivalent quantities of other components by ionic exchange. This process may be responsible not only for dispersion, sorption, and solution of hydrocarbons above oil pools but also for the formation of anomalous ionic bodies which accumulate in or are removed from rocks during the processes of sorption of the hydrocarbons.

3. Processes of chemical sorption of hydrocarbons lead to the formation of authigenic minerals. In the presence of sulfate sulfur, they lead to the genesis of sulfides (mainly iron sulfides), forming areas of disseminated sulfate mineralization above pools. In the presence of carbon dioxide in rocks of the PK (supergene zone), carbonates of calcium and iron (calcite, siderite) are formed. These minerals cause reduction of magnetic susceptibility, a density increase and, in the presence of abundant authigenic minerals such as siderite and pyrite, an increase in electrical conductivity. The development of secondary carbonate mineralization processes is accompanied by increased reduction of bituminoids and an increase in the abundance of nonferrous and light components (light-colored rocks). Both the composition of the sorbents (rocks of the PK) and their physical properties such as porosity, permeability, and heat conductivity are altered.

4. Vertical migration of hydrocarbons from pools aids processes of reduction of chemically active compounds in rocks of the overlying complex. Alkaline-acid parameters (pH) and oxidation-reduction potentials (Eh) of the rocks exhibit striking lateral changes. Specific secondary associations are formed by the migrating chemical elements. Concentration is controlled by the geochemical character of the rocks of the PK, and the specific associations of typomorphic chemical elements (compounds) formed differ from those found within the pools.

5. The adsorption capacity of rocks depends on their mineral composition, their capacity for dispersing infiltrating material, and the nature of the gas being adsorbed. Optimum adsorbing conditions obtain in rocks containing disseminated organic matter. Hydrocarbons migrating from pools and later sorption of disseminated organic matter exert an influence on chemical composition, isotopic relationships, and other features. The isotopic composition of the carbon of disseminated organic matter above a pool would be heavier than that in analogous rocks above “barren” structures.

Over a long period of geologic time, local geochemical characteristics are developed in the sedimentary section above pools, which differ from those of sections in unproductive areas. These local characteristics, represented by differences in the distribution of components of solid, liquid and gas phases, in the association of chemical elements and authigenic minerals and in other features, serve as parameters in theoretical and experimental geochemical investigations and form the basis of modern exploration criteria. Problems of prediction of the occurrence of oil and gas are essentially a problem of classification: the classification of