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Role of Fluids in Spreading Zones of Sakhalin Island and Formation of Hydrocarbons

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Ocean-floor spreading, uplift of deep-seated material to the Earth surface, and generation of new oceanic crust characterize extremely active rift zones of the World Ocean. Volcanic activity in the axial rift zones of mid-oceanic ridges is accompanied by formation of extensive hydrothermal systems, which accomplish mobilization, migration, and deposition of many chemical elements.

One among the most perspective direction in studying the ocean floor is the research of hydrothermal fields within the most active zones — rift valleys, where the processes of spreading of the ocean floor, uplift of the deep matter to the surface of the ocean floor, and creation of the new oceanic crust occur. Volcanic activity in these zones is accompanied with the formation of the hydrothermal system executing separation, transfer, and precipitation of a series of chemical elements. It is known that ore deposits with high concentration of iron, manganese, copper, nickel, cobalt are formed as a result of hydrothermal activity. It is much less known that hydrothermal activity in these zones play important but not so evident role — the formation of hydrocarbons.

Hydrothermal fluids migrating in the faults filtrate through the sedimentary cover, and form hydrocarbon and gas hydrate deposits. Transform plate boundaries are just such structures in the ocean. They represent wide zones of deep-seated faults along which realizes the plate motion. Queen Charlotte fault extending along the Western Canada coast and the western part of Aleutian Trench from the Bering Island to Kamchatka, transform fault near Sakhalin Island are examples of such plate boundaries in the Pacific Ocean. Geological situation in the Gulf of California characterized by enormous sedimentation rates is unique. Therefore, long-living deep-seated faults dissecting sufficiently old oceanic crust with a thick sedimentary cover are more prospective for a possible formation of large hydrocarbon accumulations.

Geological situations comparable with those of hydrocarbon deposits formation along transform plate boundaries may also occur at tectonic boundaries of microplates. In particular, a similar situation is observed at the western boundary of the Sea of Okhotsk plate formed by a long-living dextral fault (Fig.1). For example, a considerable dextral dislocation occurred in the focus of Neftegorsk earthquake. In general, the Sakhalin tectonic boundary zone is characterized by a rather weak shallow-focus seismic activity.

The depression extending along the western coast of Sakhalin Island represents a graben-like structure that is controlled by meridionally oriented fracture zones with transverse faults Deep-seated faults at the microplate boundaries dislocate not only the crust, but also upper mantle rocks resulting in their intense serpentinization. High heat flow values ranging from 23 to 330 mW/m2 are evidence of an intense hydrothermal activity in the deep-seated faults. Serpentinite bodies exposed on the north-eastern coast of the Sakhalin Island support this suggestion.

Density and capacity parameters of the serpentinite collectors are confirmed by seismic survey data. Recovered core samples of serpentinite contain visible bitumoid inclusions. Serpentinites of the overthrusted plate are underlain and overlain by rocks of the Nilsk complex. This considerably increases a possibility of hydrocarbons accumulation in fractured zones of the massif. North Kaigan and East Odoptinsk structures represent first-priority objects for prospecting and exploration works. Estimates of possible hydrocarbons reserves for the East Odoptinsk structure show that a large oil and gas-condensate deposit with geological hydrocarbons resources (sum of oil, gas, and condensate) about 300 million tons may be discovered here.

The authors advance and justify the idea that serpentinization plays a significant role in formation of hydrocarbon deposits.