Abstract

Crude oil stability was investigated in the earth crust thermobaric conditions (up to 450°C and 1.5 GPa) and upper mantle thermobaric conditions (up to 1000°C and 5.5 GPa). The result of the experiments showed that crude oil could save its stability in such conditions. The crude oil deposits can be situated much deeper in the earth crust than in the organic oil and gas origin theory claims. Some possible reactions of crude oil and iron compounds in upper mantle conditions were modeled and carried out (up to 2000°C, up to 10 GPa). Iron carbides and hydrides were obtained. These substances may take part in deep carbon and hydrogen cycle.

What is petroleum?

Petroleum is a complex mixture of naturally occurring hydrocarbon compounds found in rock. Petroleum can range from solid to gas, but the term is generally used to refer to liquid crude oil (Schlumberger Oilfield Glossary).

Petroleum stability in the Earth crust

The theory of biogenic petroleum origin claims that there is a "crude oil window" – the range of depth in the Earth crust, where crude oil deposits may occur. It should be no oil deposits deeper than this “oil window” level, any gas deposits deeper conditions crude oil will be cracked. But such deep crude oil deposits were found. They are explored successfully in industrial purposes.

The main goal of the experiment was to check if what depth crude oil can keep to stability. The investigations were made in Diamond Anvil Cell (DAC). The main goal was to investigate the petroleum stability in TH conditions corresponding to the Earth crust. Crude oil showed high luminescence in Raman spectroscopy (Fig. 1), so it was possible to gain all the data on the experiments. To solve this problem, the synthetic crude oil was taken as an experiment sample (Fig 2). It was a mixture of hydrocarbons with known composition similar to gas condensate (very light oil). Under the pressure of 0.7–1.4 GPa, the substance was cooled at 300°C (30–30°C), 5 hours; P=1.4 GPa, T=280–30°C, 5 hours; P=1.4 GPa, T=150–5°C, 12 hours. The experiment result showed petroleum stability in TH conditions (Fig. 2). The Raman spectra of the sample after heating was the same as the Raman spectra before heating.

Conclusions

1. Petroleum can be stable at the Earth crust TP conditions up to 50 km depth (450°C, 1.4 GPa, at least during the experimental time). We can suggest that deep crude oil deposits may occur in the Earth crust (deeper than 10 km).

2. Iron carbide and iron hydride can be generated from crude oil and FeO and exist at upper mantle TP conditions (up to 280 km). Our results identify novel mechanisms that can lead to one of the possible carbon cycles: hydrocarbons–iron hydrides and carbides formation–hydrocarbons.

Future plans

1. To investigate the thermobaric conditions limit of hydrocarbons stability.

2. To investigate a new analysis method that can be applied for crude oil sample.

3. To investigate petroleum stability in the porous rock at thermobaric conditions corresponding to the Earth crust and upper mantle.

4. To make an experiment with iron carbide, iron hydride and water at TP conditions corresponding to the Earth crust and upper mantle.

5. To investigate the possible mechanisms of petroleum chemical reactions at TP conditions corresponding to the Earth crust and upper mantle.