P36-MO

CHARACTERIZATION OF HYDROCARBON INCLUSIONS IN RESERVOIRS BY LASER MICROPYROLYSIS GC/MS (LMP-GC/MS)

Takaaki SAKAGUCHI, Susumu OKUBO, Keiko HATANO,
Hideki MATSUBAYASHI and Kunihiro TSUCHIDA

Japan Oil, Gas and Metals National Corporation, 1-2-2, Hamada, Mihama-ku, Chiba, 261-0025 Japan

Since hydrocarbon-bearing fluid inclusions in reservoir rocks retain information on hydrocarbon migration and charge history in a basin, characterizing fluid inclusions is an important key to understand petroleum systems. In terms of hydrocarbon composition, it was very difficult to analyze trapped hydrocarbon compounds in individual inclusions because extraction method of trapped hydrocarbon was not established. We developed Laser Micropyrolysis Gas Chromatograph/Mass Spectrometer (LMP-GC/MS) and applied the device to extract and analyze hydrocarbons such as biomarkers preserved in each fluid inclusion. Applying LMP-GC/MS coupled with conventional methods in a certain oil field, we recognized that several charge events existed in the field and different types of hydrocarbon were charged to the reservoir at each event.

Our LMP-GC/MS system mainly consists of following 4 units; 1) CO_2 laser system for micro-heating to extract hydrocarbons from inclusions, 2) sample chamber and absorbents for extracted hydrocarbons, 3) cryogenic focusing system to concentrate absorbed hydrocarbons for analysis, 4) GC/MS for hydrocarbon composition analysis. To avoid loss of compounds such as biomarkers with high boiling temperature in a flow line, length of the flow line was minimized in the LMP-GC/MS system. Consequently, detection limit for compounds was improved from C8 up to C40 covering typical biomarker range such as steranes and hopanes.

To make sure a mechanism of hydrocarbon extraction from inclusions, SEM observation was carried out after irradiation of inclusion by laser beam. Inclusions with open cleavages or cracks were observed, and it indicated that hydrocarbon trapped in inclusions is extracted through the cleavages and/or cracks originally formed in minerals. Since trapped hydrocarbon is vaporized and expanded by laser irradiation, it can be thought that the pressurized hydrocarbon inclusion promotes re-opening the cleavages and cracks in the host minerals. Although it was reported that unsaturated normal alkenes were formed during hydrocarbon pyrolysis, normal alkenes has not been detected by our LMP-GC/MS analytical method. It suggests that effect of thermal destruction by laser irradiation can be ignored and hence it is confirmed that LMP-GC/MS is suitable to analyze hydrocarbons essentially trapped as fluid inclusion.

To evaluate validity of fluid inclusion analysis by LMP-GC/MS for petroleum exploration, we applied our technique to carbonate reservoir samples selected from a certain oil field. In this region, although several charge events were estimated according to circumstantial evidences, composition of hydrocarbons corresponding to each event has been kept unknown. In this study, microthermometry was carried out and hydrocarbon inclusions were classified into three types with different homogeneous temperatures at around 80 degC (Type I), 120 degC (Type II) and >140 degC (Type III), respectively. Trapped hydrocarbon compositions in each types of inclusion were analyzed by LMP-GC/MS. Consistently with microthermometry, inclusions were sorted by hydrocarbon compositional profiles. C15 to C20 normal alkanes were obtained from Type I inclusions. Type II inclusions were characterized by relatively light hydrocarbons (C10-C20 normal alkanes). Inclusions with the highest homogeneous temperature (Type III) include normal alkanes ranging from C20 to C30.

Combining conventional method and LMP-GC/MS, it is interpreted that Type I inclusions trapped hydrocarbons prior to Type II inclusion formed. Hydrocarbons in Type I inclusions have relatively lower maturity compared to Type II inclusions and estimated trapping temperature of Type I inclusions was near onset of oil window. On the other hand, it is expected that the entrapment of Type II inclusions occurred at middle of oil window. Existence of these two types of inclusions reflects different timing of petroleum charge to the reservoir.

For Type III inclusions, judging from the geology in this region, obtained homogenous temperature seemed to exceed estimated paleo-temperature. Homogeneous temperature tends to become higher than formation temperature when inclusions are formed trapping two phase fluids, liquid and gas. Although further investigation is required due to poor sample condition, wide range of homogeneous temperature of Type III inclusions from 140 degC up to 320 degC suggested possibility of formation of inclusion under two phase fluid condition.