Status of Research on Exploration and Production*

Kōzo Kawai**

In Japan, scientific and technical researches on oil and natural gas geology, exploration, drilling and production are conducted by the scholars and research members of the University of Tokyo, Tohoku University, Akita University, Nagoya University, Geological Survey of Japan, Japan Petroleum Exploration Co., Ltd., Teikoku Oil Co., Ltd., Arabian Oil Co., Ltd., and others. The oil fields subjected to these researches are concentrated within the territories of Japan, but a few of them are located in the Arabian Gulf and North Sumatra.

In the field of petroleum geology and related sciences, it is a remarkable tendency that geochemical researches have been actively going on in recent years. For example, Yagishita and Abe make studies on extractable organic matter in the argillaceous rocks from the petroleum regions, including source rock of petroleum, using analytical methods such as liquid chromatography. Taguchi examines geochemical data on the organic matter in the source rock of petroleum from the point of view of sedimentology. Shimada carries out geochemical studies on the extractable organic constituents of the recent sediments for the purpose of comparing the sediments with the source rock of petroleum. Besides these, following themes are studied by the other researchers:

- Correlation of oil reservoirs by xylene content of crude oils. Geochemistry of oil field brines.
- Evolution of petroleum in the geologic age.

Of the above-mentioned studies, the results obtained by Yagishita contribute toward the exploration of petroleum to a considerable extent.

While many researches are under way regarding stratigraphy, geologic structure, micropaleontology, oil occurrence, and so forth of each oil field or a local part of a sedimentary basin, some extensive studies on geology of each petroleum region are done. Tsuchida published a comprehensive study on geology of the Central Hokkaido region. Inoue established volcanostratigraphy of the Akita petroleum province, based upon volcanism concurred with sedimentation. Takahashi published a detailed study on the evolution of the Niigata oil-producing sedimentary basin as viewed from isopachous maps. Besides these, extensive or comprehensive studies on oil geology of petroleum provinces are pushed forward by the geologists of oil companies. Investigation into oil potentiality of Cretaceous system in Japan is carried out by the Petroleum Resources Development Advisory Committee.

In addition to the studies mentioned above, there are such special investigations as follows. For the purpose of exploration of oil pools, Juge studies clay mineral assemblages of the oil-bearing formations using X-ray diffraction method. Okino carries out a systematic study on clay minerals of the sedimentary rocks from petroleum provinces, as a basic study in connection with many shale troubles encountered at drilling wells. Sasa et al. report oil-bearing Tertiary formations developing under the seabottom of the Tsugaru Straits. As an oil-geological contribution concerning overseas oil fields, there is Sekiya’s valuable study on the oil fields in North Sumatra.

In Japan, inflammable natural gas includes the natural gas similar to that commonly exploited in foreign countries, so-called suiyosei gas and coal field gas, and the latter two occupy an important position as hydrocarbon resources as well as the former, though ignored or insignificant in foreign countries. (Suiyosei gas is natural gas which has no close geological relation to petroleum or coal and which is mostly dissolved in formation water in the reservoirs.) As to the genesis of suiyosei gas, there are some papers published by Nakai, Maki and others. Nakai carries out detailed studies on the mechanism of origination and concentration processes of methane through geochemical analysis of organic decomposition products in recent sediments and gas-bearing formations, including analysis of carbon isotope ratio in these products. On the other hand, Kawai published an economic geological study on the Southern Kanto region, which is the largest

* Received December 25, 1961.
** Faculty of Engineering, the University of Tokyo.
suiyosei gas-producing region in Japan. Researches of coal field gas are made chiefly by the geologists of Geological Survey of Japan.

Among other things, special researches on microflora in oil and natural gas reservoirs are conducted by Iizuka and other microbiologists with steadily growing results.

In the next place, explanation is made for the researches of geophysical exploration, especially of seismic prospecting. While a number of academic researches on seismicity are done chiefly by the geophysicists of universities, technical researches on practices of seismic prospecting and on analysis of its data are conducted by the researchers of Geological Survey and oil companies, and many efforts are made to get a clear picture of deeper geologic structures. Field experiments are carried out chiefly concerning noise structure test, multiple geophone setting, pattern shooting, directional shooting and checking test for abnormal events, and studies on signal detection based upon auto-correlation and cross-correlation are also proceeded. Besides these, in connection with adoption of velocity logging, studies on synthetic seismogram are pushed forward. A method of solving oil field structures through analysis of filtering effect by a thin layer reflection, is tested by Tamano et al. with good success.

As to geophysical logging, some researches are made. Sato studies on a method of evaluating such pyroclastic oil reservoirs as tuff or tuffaceous sand by analyzing induction-electrical and micro-resistivity logs, since most oil reservoirs in Japan are more or less pyroclastic.

In the field of petroleum drilling engineering, several researches are published in 1961. One of them is "Capacity of Circulating Liquid to Carry Cutting" studied by Fujii. This study gets a relationship between the carrying capacity of flowing liquid and both the velocity and the viscosity of liquid. A study about the lost circulation in a depleted oil field is also published by Matsumoto et al. They find some materials are effective for preventing lost circulation.

Fluid for well completion has been discussed. For example, the invasion of mud fluid into gas-dissolved water zone is studied by Fujii et al. In this study they conclude that more mud fluid invades into a sand of higher permeability than that of lower permeability. Studies about the fracturing for oil reservoirs are published by Shibamiya. He explains about many factors that affect the efficiency of fracturing. He concludes that the over-flush of fracturing fluid into a reservoir reduces the effect of fracturing to less than 50 per cent.

Several oil wells are drilled in Japan Sea. For the purpose of understanding many problems concerning off-shore drilling, the research is carried out by Japan Petroleum Exploration Co. They have studied mainly about the effect of waves upon a drilling rig, piles and also upon production facilities.

In the field of petroleum production engineering, several researches are published in 1961. One of them is "Relation between Vapor Pressure and Capillary Pressure of the Core and its Application" studied by Saito. This study is theoretically and experimentally made on the relation between vapor pressure and capillary pressure of the core. The discussion is stated about the method of obtaining capillary pressure curves, which can be utilized for determination of irreducible water saturation of the reservoir and of displacement pressure of the caprock.

The accumulation of water in producing wells decreases the productivity of natural gas. A study about the application of foams to remove water column and the foaming ability of non-ionic surface active agents is studied by Ogino et al.

A study about two-phase flow in an oil well is carried out by Tanaka. He uses an apparent friction factor "a" instead of a friction factor in Fanning's equation. The apparent friction factor in a flow of gas-liquid mixture in a vertical pipe is expressed as follows:

\[ f = a \rho \]

where \( \rho \) = apparent density of gas-liquid mixture

\[ a \) and \( b \) = constants concerning flow rate and diameter of pipe

He finds the validity of this relationship in his experiments and also in data measured at an oil field in Japan.

Besides the aforementioned, there is a study concerning the flow of fluid in suiyo sei gas reservoirs conducted by Hirakawa.

**Literature cited**

1) Teikoku Oil Co., Ltd.
2) Tohoku University
3) Japan Petroleum Exploration Co., Ltd.
4) Akita University
5) Yokohama National University
6) Hokkaido University
7) Nagoya University
8) Geological Survey of Japan
9) Faculty of Engineering, the University of Tokyo
10) Institute of Applied Microbiology, the University of Tokyo