CORRELATION OF SUBSURFACE TERTIARY ROCKS COOK INLET BASIN, ALASKA

by

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Introduction

Significant oil reserves were discovered in Cook Inlet basin at Swanson River in 1957. Since then many wells have been drilled and these have provided new information that makes it possible to describe the stratigraphic framework of the basin. This report presents preliminary results of a subsurface study of the petroleum geology of the Cook Inlet basin in southern Alaska.

The work was done under a cooperative agreement between the U.S. Geological Survey and the Division of Geological and Geophysical Surveys, Department of Natural Resources of the State of Alaska. The assistance of W. C. Fackler, State Geologist, T. R. Marshall, Jr., Chief Petroleum Geologist, and G. H. Pessel, geologist, of the Division of Oil and Gas is gratefully acknowledged. The Forest Oil Company of Denver, Colorado, aided the study by supplying the electric log of their Sunrise Lake well prior to its public release under State regulations.

The Cook Inlet basin in southern Alaska is a narrow elongate trough filled with Mesozoic, Tertiary, and Quaternary sedimentary rocks. It extends northeastward from the Shelikof Straits opposite Kodiak Island to the Matanuska Valley northeast of Anchorage and includes an approximate area of 14,000 square miles (Kelley, 1963, p. 278). This report is concerned with the central part of the basin. In this area each side of the basin is flanked by northeast-trending mountain ranges.

Since the discovery of oil at Swanson River in 1957, many wells have been drilled, and about 18 additional oil and gas fields have been discovered. Despite this, relatively little information on the subsurface geology of this important petroleum province has been published. Some of the recent information includes stratigraphic correlation sections across the basin published by the Alaska Geological Society in 1969, and the stratigraphic nomenclature for the thick Tertiary rocks in the basin set up by Calderwood and Fackler in 1972.

This report is primarily an electric-log correlation study, although commercial sample logs were used to supplement the interpretations. Section AB (pl. 1) is a southwest-to-northeast section generally parallel to the axis of the basin, and section CD (pl. 2) is a west-to-east section normal to the axis. The distribution of wells with electric logs in the Cook Inlet basin is such that both strike and dip sections can be made. For a few wells, gamma-ray curves were recorded instead of self-potential curves, however the use of gamma-ray curves does not affect the interpretation appreciably.

Correlations based on specific electric-log characteristics between wells spaced so far apart as those shown on sections AB and CD (pls. 1 and 2) are difficult, but thick sequences of particular lithologies are recognizable in overall aspect and can be correlated. The Beluga Formation in the Union Kasilof No. 1 well (well 8, pl. 1) exhibits such distinctive electric-log characteristics as compared with the formations above and below it. The Hemlock Conglomerate also appears as a distinctive unit in nearly all wells. Fortunately, the

distinctive formations, such as the Beluga and Hemlock, alternate with strata that have less distinctive electric-log characteristics.

In conjunction with the electric-log study, well cuttings and cores from the Standard Oil Company of California Deep Creek Unit No. 1 well were examined and described by Adkison (oral commun., 1972). Palynomorphs from 56 samples from the Deep Creek well were studied and age assignments made by K. B. Newman. Because the Tertiary rocks in the Cook Inlet basin are predominantly nonmarine and lack diagnostic marine fossils, spores and pollen are the only available criteria for age assignments. Six samples from the Deep Creek well were barren; preservation and abundance of fossils in the remaining 50 samples ranged from poor to excellent but averaged poor to fair (Newman, written commun., 1972). Diagnostic fossils are listed at the appropriate depths beside the Deep Creek electric log (well 5) on plate 1.

Stratigraphic sequence

Mesozoic rocks considered to be "basement" in the central Cook Inlet area were reached in six wells on section AB (pl. 1) and in five wells on section CD (pl. 2). The ages and lithology of the Mesozoic rocks encountered differ so widely that correlations are more dependent upon samples than consistent electric-log characteristics. For example, the Halbouty Alaska Fritz Creek No. 1 well (well 1, pl. 1) drilled several hundred feet of mica schist of Cretaceous (?)-Triassic (?) age below the Tertiary rocks (oral commun., G. H. Pessel, 1972), and the Standard Anchor Point No. 1 well (well 3, pl. 1) drilled several thousand feet

of Cretaceous shale, conglomerate, claystone, siltstone, and sandstone.

Tertiary rocks in the central part of the Cook Inlet basin have been assigned to the Kenai Formation for many years. Recently Calderwood and Fackler (1972, p. 741) formally raised the Kenai to group rank and divided the group into five formations. As thus subdivided, the Kenai Group consists, in upward order, of the West Foreland Formation, Hemlock Conglomerate, Tyonek Formation, Beluga Formation, and Sterling Formation. Calderwood and Fackler (1972, p. 741-753) established subsurface type sections for each formation and described the lithology and electric-log characteristics. Three of these type sections are present in wells used in the present report. The subdivisions of Calderwood and Fackler are used in this report, and the identification of the formations is based largely on their lithologic descriptions.

Kenai Group

West Foreland Formation

The West Foreland Formation was completely penetrated in less than half of the wells on sections AB and CD (pls. 1 and 2). The type section, as designated by Calderwood and Fackler (1972, p. 742), is in the Pan American West Foreland No. 1 well (well 2, pl. 2). The lower boundary in the Standard Deep Creek Unit No. 1 well has been placed at 13,780 feet on the basis of lithology and palynology of the core samples, and a slight change in electric-log characteristics. The top of the formation is readily picked at the base of the Hemlock Conglomerate. Along sections AB and CD the West Foreland Formation is thickest in the Union Ninilchik No. 1 well (well 6, pl. 1), where it reaches a thickness

of 1,657 feet. It is absent from the Halbouty Alaska Fritz Creek No. 1 well (well 1, pl. 1), the Standard Swan Lake Unit 34-27 (No. 1) well (well 8, pl. 2), and the Sinclair Swan Lake Unit No. 2 well (well 9, pl. 2) on the east side of the basin, and from the Shell Kustatan River No. 1 well (well 1, pl. 2), on the west side. Apparently the West Foreland Formation has been transgressively overlapped by later sediments on the flanks.

Hemlock Conglomerate

The Hemlock Conglomerate, the primary objective of many wells in the Cook Inlet basin, is a distinctive electric-log unit in most wells on the sections. The type section of the Hemlock Conglomerate was established by Calderwood and Fackler (1972, p. 744), in the Richfield Swanson River No. 1 well shown as well 12 on section AB (pl. 1) and well 6 on section CD (pl. 2). The conglomerates and sandstones of the Hemlock generally cause sizable excursions of both the self-potential and resistivity curves of the well logs and provide a characteristic pattern that is easily recognized. The maximum thickness of the Hemlock along sections AB and CD is 1,030 feet in the Pan American Middle Ground Shoal No. 1 well (well 4, pl. 2). It thins both eastward and westward and, like the West Foreland Formation, is absent along the margins of the basin.

Tyonek Formation

The lower part of the Tyonek Formation consists mainly of fine clastics, which contrast sharply on electric logs with the conglomerates

and sandstones of the underlying Hemlock Conglomerate. The upper part of the Tyonek is made up of interbedded sandstones and rather thick coal beds underlain by several hundred feet of claystones and scattered coal beds. The maximum thickness of Tyonek along section AB and CD was drilled in the Occidental South Diamond Gulch No. 1 well (well 2, pl. 1) where 7,000 feet was penetrated. The formation is apparently absent on the flanks of the basin as indicated by abrupt thinning at the southwest end of section AB (pl. 1) and by its absence in the eastern- and western-most wells of section CD (pl. 2).

Beluga Formation

Electric-log curves of the Beluga Formation exhibit distinctive characteristics. Both the self-potential and the resistivity curves show an extraordinary number of excursions, one immediately following another, which reflect the thin intercalated beds of claystone, siltstone, and coal. The formation also includes beds of sandstone -- some near the top are fairly thick. The coal beds are generally thinner than those in the Tyonek Formation. The thickness of the Beluga Formation ranges from 3,453 feet in the Union Kasilof No. 1 well (well 8, pl. 1) on section AB to 513 feet in the Sinclair Swan Lake No. 2 well (well 9, pl. 2) on section CD.

Sterling Formation

The type section for the Sterling Formation in the Union Sterling Unit No. 23-15 well (well 10, pl. 1) is composed primarily of thick sandstones separated by thinner beds of claystone and coal. The lower

formational boundary of the Sterling is drawn at the base of the thick sandstone sequence and the top of the thinner beds of claystone, siltstone, and coal of the underlying Beluga Formation. The top of the Sterling is difficult to place on electric logs because of the similarity between the thick Sterling sandstones and the overlying thick-bedded sandy deposits of Quaternary age. An upward change in electric-log characteristics may help in determining the boundary in some wells. The Standard Anchor Point No. 1 well (well 3, pl. 1) drilled only 243 feet of the Sterling Formation; the Halbouty Alaska Bishop Creek Unit 11-11 well (well 5, pl. 2) penetrated a thickness of 4,564 feet.

Quaternary rocks

Quaternary glacial and alluvial deposits cover the Sterling Formation. The Halbouty Alaska Bishop Creek Unit 11-11 well (well 5, pl. 2) drilled near the center of the basin, drilled more than 4,000 feet of these deposits. Coal was reported in the well cuttings from this well at a depth of 1,100 feet. However a coal bed at this depth is not evident on the electric log, and the writers are uncertain as to whether a coal bed is present at this horizon.

References cited

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