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Preliminary Unevaluated Subsurface Stratigraphic Study (1976) of the lower Cook Inlet area, Alaska

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Abstract

This study was completed in March 1976 to provide basic geologic data for presale evaluation of the lower Cook Inlet Outer Continental Shelf (OCS) lease sale held in October 1977. At that time the report and maps were not intended for publication. However, because additional Federal and State lease sales are planned for the lower Cook Inlet area in 1981, the release of this data may be of interest to the public.

The purpose of this study is to construct a basic network of stratigraphic data for the Kenai Group rocks where well data already exist and to project these data and any trends that may be recognized into the OCS area. Fourteen maps are included which delineate the regional thickness, sandstone porosity, and sandstone/shale ratios of the five formations of the Tertiary Kenai Group rocks. An additional map shows the regional structure of the Hemlock Formation. These data indicate that the younger Sterling and Beluga Formations are either absent or very shallow offshore in lower Cook Inlet. The Tyonek, Hemlock, and West Foreland Formations appear to offer the best potential for petroleum production. However, the Tertiary section thins rapidly to the south and may be too shallow for economic petroleum production over a large portion of the lower Cook Inlet offshore area.

Introduction

This report is based on interpretation of well log data publicly available from the lower Cook Inlet area in 1976. Some published surficial geologic mapping was also incorporated. No attempt has been made to update the report or the illustrations with new data from additional wells drilled since 1976, because data from some of those wells is still considered proprietary. This study will be revised to incorporate additional well data when the confidentiality period has lapsed.

Methods

Well logs, well histories, and directional surveys were purchased from Petroleum Publications, Inc., in Anchorage. No proprietary data was used in this report.

Correlation:--The Kenai Group is a nonmarine sedimentary sequence, and correlation is based primarily on electric log character. Previous work on correlation has been published by the Alaska Geological Society, and the recognizable E-log character of the five Kenai Group Formations has been established (Plate 1). Correlation of wells used in this report is summarized in the Well Data Chart, lower Cook Inlet area (Plate 2).

The wells used in this study included all wells available south of the Kenai Gas Field and selected wells north of the Kenai Gas Field. All wells were correlated and subsea depths of all formation tops were calculated.

Pre-Tertiary rocks are penetrated in many of the wells. According to published data, primarily by the Alaska Geological Society which draws heavily on industry expertise, the pre-Tertiary is identified as Jurassic volcanics, Jurassic sedimentary rocks, Cretaceous sedimentary rocks, and undifferentiated Mesozoic metamorphic rocks. Picked paleontological slides from a number of wells are available for public inspection at the Alaska State Division of Oil & Gas Office in Anchorage. Ronald F. Turner, Paleontologist with the U.S. Geological Survey in Anchorage, has worked the available slides in the area. His conclusions have been used to determine the ages of Mesozoic rocks penetrated by some wells.

Isopach Maps:--Regional thickness maps for each unit were constructed uncorrected for dip because dipmeter data were not publicly available. Where the mapped unit was not penetrated by one of the wells used in this study, that well is labeled "N/A." Where wells only partially penetrated the mapped unit, two methods were employed:

1. The probable thickness of the unit was estimated by correlation with nearby wells, and such wells are labeled "Est." (Estimated thickness).

2. In those cases where no reliable estimate of thickness could be made, the actual footage penetrated is listed and preceded by a "greater than" symbol, i.e., the thickness of the unit at that location is some unknown amount greater than the actual footage penetrated.

Sandstone Count:--Sandstone counting can be subdivided as follows:

1. Gross sandstone was counted and recorded on the work logs, but gross sandstone values were not mapped. These values were determined primarily from the Spontaneous Potential (SP) logs and corroborated by mud log data where necessary. Without close SP control, the gamma-ray log is considered unreliable for sandstone counting. No measured stratigraphic sections are included.

2. Net reservoir sandstone is defined as sandstone exhibiting greater than 10 percent porosity as determined from a sonic log.

Porosity Determinations:--The sonic log is the most common porosity log available for the wells of the area, and all mapped porosity data are from these logs. Sonic porosity was correlated to known core porosities. The following parameters governing sonic porosity were established and used throughout the area:

Formation	Matrix Velocity (feet per second)	Compaction Correction
Sterling	18,000	1.4
Beluga	18,000	1.4
Tyonek	18,000	1.4
Hemlock	19,500	---
West Foreland	19,500	---
Any section shallower than 5,000 feet	18,000	---

Density log porosity was calculated and recorded on the work logs wherever it was available. As a general rule density-derived porosities average 2 to 3 porosity percent lower than sonic-derived porosities.

Permeability Determinations:--Because of a lack of available core data, no permeability data are included in this study.

Structural Mapping:--One structure map was constructed on the top Hemlock Formation (Plate 3). The map is an attempt to define present-day regional structure, but no attempt is made to define faulting or individual prospective areas.

Conclusions

Total Kenai Group thickness in the offshore lower Cook Inlet area ranged from a maximum of ± 15,000 feet in the extreme northern part of the OCS area to less than 5,000 feet in the southern OCS area (Plate 4). Two centers of deposition appear to have persisted in the lower Cook Inlet Basin during deposition of Kenai Group rocks. Thick depocenters are located under the present-day Cook Inlet and lower Kenai Peninsula. These depocenters are separated by an active structural arch along the present-day southwestern shoreline of the Kenai Peninsula. Mapping of the individual units of the Kenai Group indicates a gradual shift in depositional thickness from the west during deposition of the West Foreland, Hemlock, and Tyonek Formations to the east during deposition of the Beluga and Sterling Formations. The Kenai Group thins toward the eastern and western basin margins as the result of both stratigraphic thinning and down-to-basin faulting.

Sandstone percentages are greatest along the basin margins and along the structural feature separating the two depocenters, and least in the thicker depocenters. The best sandstone porosities are associated with the highest sandstone percentages.

The Sterling Formation, known to be gas productive in upper Cook Inlet, probably offers little potential in the lower Cook Inlet area. This formation is exposed along the southwestern shore of the Kenai Peninsula and is probably extremely shallow or absent offshore (Plate 5).

The Beluga Formation, also known to be gas productive in upper Cook Inlet, is exposed along the southern tip of the Kenai Peninsula (Plates 6, 7, and 8). It is probably shallow or absent in the southern offshore area.

The Tyonek and Hemlock Formations are known to be productive in the upper Cook Inlet area and probably offer the highest potential for Tertiary production in the lower Cook Inlet area where sufficient thickness of Tertiary section occurs. The Tyonek Formation is 6,000 to 7,000 feet thick under the southwestern Kenai Peninsula and thins further southwest under the OCS area (Plate 9). Tyonek Formation percent of net sandstone to total section is ± 20 percent (Plate 10), and sandstone porosities are 15 to 20 percent (Plate 11). No proven oil accumulation has been found in the Tyonek Formation in the lower Kenai Peninsula area, but minor gas accumulations occur at North Fork and at Falls Creek.

The Hemlock Formation is ± 300 feet thick under the southwestern Kenai Peninsula (Plate 12), but the formation probably thins to the southwest in the OCS area. Percent of net sandstone to total Hemlock thickness averages 50 percent (Plate 13), and average sandstone porosity is 15 to 20 percent (Plate 14). On the Starichkof structure in State waters just west of Anchor Point, noncommercial oil accumulation is present in the Hemlock Formation adjacent to the OCS sale area.

The West Foreland Formation has limited known oil accumulation in upper Cook Inlet and is generally considered to be "economic basement" in the Cook Inlet Basin. One West Foreland Formation sandstone penetrated by the SOCAL-operated North Fork Unit 41-35 well was oil saturated but nonproductive. Under the southwestern Kenai Peninsula, this formation is 400 feet thick (Plate 15), but may increase westward to as much as 1500 feet in the center of the basin. Percent of net sandstone to total section in the area is 10 to 20 percent (Plate 16). Average sandstone porosity is 16 percent (Plate 17).

Preliminary mapping of USGS seismic data indicates that the Tertiary section over much of the lower Cook Inlet OCS is thin and shallow, and the productive potential in these shallow areas is questionable even if reservoir rocks are present. There is no commercial production in upper Cook Inlet shallower than 3,000 feet subsea depth.