SANDSTONE PETROLOGY, DIAGENESIS AND RESERVOIR QUALITY, LOWER CRETACEOUS KUPARUK RIVER FORMATION KUPARUK RIVER FIELD, NORTH SLOPE, ALASKA*

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ABSTRACT

The Kuparuk River Formation consists of upper and lower members separated by an intraformational unconformity. Marine sandstone in each is distinct in terms of depositional environments, sandbody geometry, texture, composition, diagenesis, and reservoir quality.

Sandstone in the upper member is very fine to very coarse grained sublitharenite to lithic arenite with an average Q-F-L of 75-1-24. Glauconite constitutes 10-50 percent of framework grains. Chert, muscovite, heavy minerals and mudstone, limestone, siderite, and metasedimentary rock fragments are less abundant. The diagenetic sequence is: aragonite or high-Mg calcite-collophane-pyrite-siderite-ankerite-calcite-(dissolution of carbonate cements and glauconite)-quartz-kaolinite-illite/smectite-pyrite.

Sandstone in the lower member is very-fine to fine-grained quartz arenite to subarkose with an average Q-F-L of 92-5-3. Mudstone fragments, chert, muscovite, heavy minerals and glauconite are less abundant. The diagenetic sequence is: pyrite-siderite-ankerite-calcite-(dissolution of ankerite and feldspar)-quartz-kaolinite-illite/smectite-pyrite.

Early diagenesis in upper and lower member sandstones is different, whereas burial diagenesis is similar. Early siderite cemented sandstones in the upper member, but did not significantly affect sandstones in the lower member. Subsequent changes in pore fluid chemistry during burial resulted in precipitation of the cement sequence siderite-ankerite-calcite in both upper and lower member sandstones. Stable isotope trends in carbonate cements parallel those of cement texture and composition.

Upper member porosity (mostly secondary) and permeability average 23 percent (%) and 130 millidarcies (md) with upper limits of 28-33 percent and 500-1500 md. Reservoir quality is heterogeneous and controlled by grain size, distribution of primary and secondary porosity, and fractures. Both horizontal and vertical permeability are similar except where fractures enhance horizontal permeability.

Lower member porosity (mostly primary) and permeability average 23 % and 100 md, with upper limits of 28-30 % and 400-500 md. Reservoir quality is homogeneous. Ankerite locally eliminates porosity, and shale beds and laminations reduce vertical permeability.

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The Arctic Slope province, an area of about 125,000 square miles, includes three major geomorphic provinces: the Brooks Range, the Arctic Foothills, and the Arctic Coastal Plain. About 100,000 square miles of this area or all but the southern part of the Brooks Range may be considered potentially petroliferous.

In 1923, 37,000 square miles of northern Alaska was set aside by Presidential order as Naval Petroleum Reserve No. 4. Between 1944 and 1953 the Navy undertook an extensive exploration program of the lands within and adjoining the Reserve. This program included extensive surface geologic mapping of the Arctic Foothills and Brooks Range, geophysical surveys mainly in the Coastal Plain, and the drilling of 36 test wells and 44 core tests chiefly within the Reserve. The results (Reed, 1958) of this work include the discovery of—

(1) a medium-size oil field at Umiat with an estimated reserve of 70 million barrels;
(2) a small oil field at Simpson with perhaps 12 million barrels reserve;
(3) a prospective oil field at Fish Creek;
(4) a medium-size gas field at Gubik with possibly as much as 300 billion cubic feet of reserve;
(5) a small gas field at Barrow with 5 to 7 billion cubic feet of reserve; and
(6) prospective gas fields at Meade and Square Lake.

Details of the Navy's exploration have been published in Geological Survey Professional Papers 301 to 305 and are summarized in Bulletin 1094 and Oil and Gas Investigations Map OM 126.

The oil industry has been engaged in further exploration and development in northern Alaska since 1958 when the lands adjoining the Reserve were opened for public leasing. Several companies have been carrying out extensive surface mapping and geophysical programs. Although results of this work have not been released, the area east of the Reserve will probably be tested by drilling within the next few years.

A thousand or more feet of Paleozoic clastic sediments were penetrated in the Topagoruk Test Well No. 1 about 60 miles south and east of Point Barrow (Collins, 1958b). The sediments are chiefly fine sandstone, siltstone, claystone and conglomerate cemented by silica. The gently dipping upper part of the sequence, Permian strata and red beds below of unknown age, rest with angular unconformity on Devonian(?) strata that dip 35° to 60°

The sediments beneath the coastal plain are virtually flat-lying and the known oil and gas fields appear to occur in stratigraphic rather than structural traps. It is expected that future exploration will be directed toward locating overlaps and pinchouts particularly around basement highs where favorable sandstones similar to those in the Jurassic strata at Barrow may occur.

East of the Colville River.—No wells have been drilled in the coastal plain east of the Colville River. Available information on this area comes largely from surface mapping in the foothills to the south, from the few scattered exposures of bedrock in the White Hills, and along the north-flowing streams that cross the coastal plain. Based upon the scanty data available the petroleum possibilities of this area appear highly attractive for the following reasons:

(1) Studies in the foothills suggest that Cretaceous strata thin eastward to the extent that pre-Cretaceous rocks may be within drillable depths at least along the southern edge of the coastal plain.
(2) More than 7,000 feet of marine and nonmarine Tertiary beds have been measured on Carter Creek in the extreme eastern part of the coastal plain and 2,000 feet of nonmarine Tertiary have been measured in the White Hills.
(3) Facies studies of the Triassic and Permian strata in the foothills suggest that these rocks, which are mainly shales and cherts in outcrop, may contain relatively clean sandstones beneath the coastal plain.

Patton, W. W., Jr., 1964, in Mineral and water resources of Alaska: 88th Congress, 2d Session, U.S. Government Printing Office, p. 63, 66.

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