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Geology and Assessment of Undiscovered Oil and Gas Resources of the Long Strait Basin Province, 2008

Chapter AA of
The 2008 Circum-Arctic Resource Appraisal

Professional Paper 1824

U.S. Department of the Interior
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COVER

Eocene strata along the north side of Van Keulenfjorden, Svalbard, include basin-floor fan, marine slope, and deltaic to fluvial depositional facies. The age and facies of these strata are similar to Tertiary strata beneath the continental shelves of Arctic Eurasia, thus providing an analog for evaluating elements of those petroleum systems. Relief from sea level to top of upper bluff is approximately 1,500 feet. Photograph by David Houseknecht.

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Chapter AA

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Abstract

The Long Strait Basin is both a stand alone petroleum province and an assessment unit (AU) that lies offshore in the East Siberian Sea north of Chukotka and south of Wrangel Island. This basin is known only on the basis of gravity data and a single proprietary seismic line. In the absence of more specific data, its position and regional setting suggest that it may have petroleum geologic characteristics similar to the nearby Hope Basin.

Because the geology and petroleum potential of the Long Strait Basin are so poorly known, only a single AU was defined for this study area. An overall probability of ~0.08 (8 percent) of at least one petroleum accumulation larger than 50 million barrels of oil equivalent was determined on the basis of estimated probabilities of the occurrence of petroleum source, adequate reservoir, trap and seal, and favorable timing. Because this probability falls below the 10 percent probability cutoff used in the U.S. Geological Survey's Circum-Arctic Resource Appraisal, no quantitative assessment of sizes and numbers of petroleum accumulations was conducted for this AU.

Introduction

The Long Strait Basin is one of six basins situated on or adjacent to the continental shelf of the East Siberian and western Chukchi Seas (fig. 1). The basin is oval shaped, 100 by 300 km, somewhat more than 4 km deep, and covers an area of ~21,000 km^2 south of Wrangel Island and just west of the Hope Basin (fig. 2). For the purposes of this assessment, the Long Strait Basin is designated as both a separate province and an assessment unit (AU).

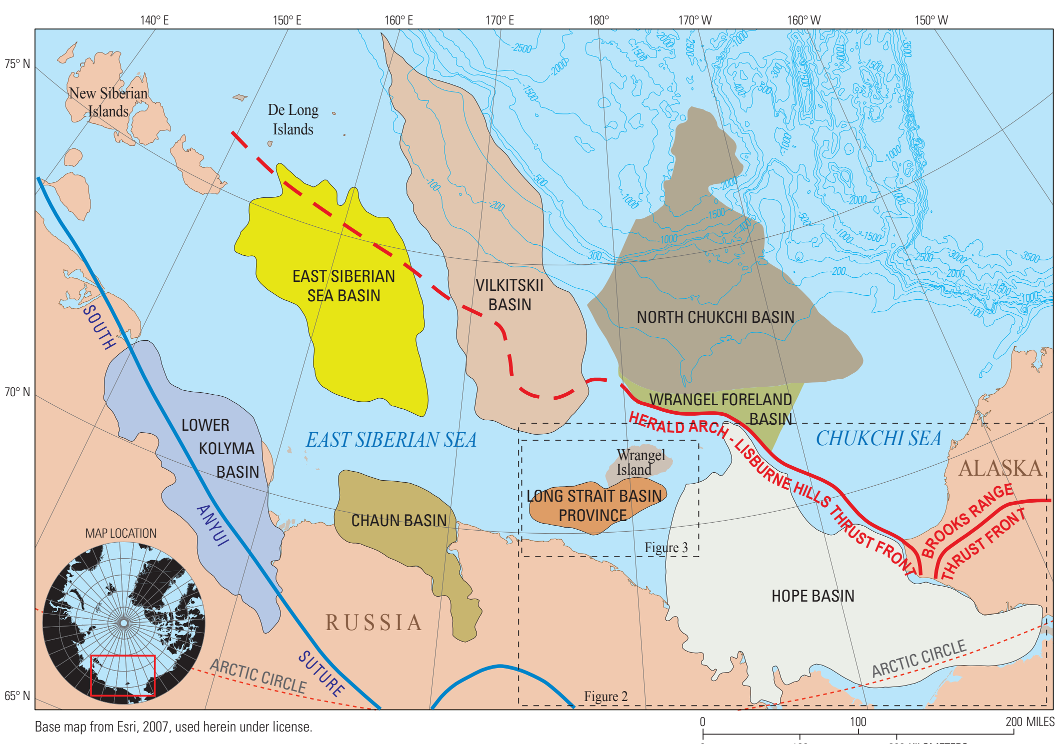

Figure 1. Map showing the Long Strait Basin in relation to other sedimentary basins of the East Siberian and Chukchi Seas that lie within and adjacent to the Brooks Range-Chukotka orogen, defined by area between the Brooks Range-Herald Arch-Lisburne Hills thrust front and the South Anyui Suture.

Geologic Setting and Stratigraphy

The Long Strait Basin is a successor or intermontane basin that formed on the Brooks Range–Chukotka orogenic belt of the Arctic Alaska-Chukotka microplate. The orogenic belt is northward vergent, extending from the South Anyui Suture on the south to the Brooks Range-Herald Arch-Lisburne Hills thrust front on the north (fig. 1). The South Anyui Suture formed during the latest Jurassic and Early Cretaceous (Neocomian) (Sokolov and others, 2002), whereas the north thrust boundary may be as old as Aptian and as young as early Paleogene (~60 Ma) (Moore and others, 2002). The orogenic belt, particularly the area of the Hope Basin and, possibly, the Long Strait Basin and beyond, is postulated to have been a Cretaceous highland that contributed the enormous volume of clastic debris that fills the North Slope foreland and the North Chukchi Basins (Molenaar, 1985; Grantz and others, 1990; Lothamer, 1994). Some interpretations of Cretaceous deposits in the Hope and Long Strait Basins are at odds with this idea (for example, Shipilov, 1989; Warren and others, 1995); thus, the origin of the Long Strait Basin is uncertain. The suggested basin-forming mechanisms of the nearby Hope Basin (strike-slip faulting, orogenic collapse, or escape tectonics) may also apply to the Long Strait Basin (Tolson, 1987; Worrall, 1991; Klemperer and others, 2002; Elswick and Toro, 2003; Scholl and Stevenson, 1989).

The position, shape, and thickness (>4 km) of sedimentary fill in the Long Strait Basin are based primarily on gravity data (fig. 3*B*) (Mazarovich and Sokolov, 2003) and supported by a single proprietary seismic line (Kos'ko and Kim, 2006). If the basin history is similar to that of the Hope Basin, the stratigraphic section may consist of a lower sequence of Paleogene volcaniclastic nonmarine sandstone and conglomerate with tuffs

Base map from Esri, 2007, used herein under license.

Figure 2. Map of the Hope and Long Strait Basins (adapted from Grantz and others, 2009). Blue contours show depth to acoustic basement (in kilometers). Points A and B are exploratory wells in easternmost part of the Hope Basin (Cape Espenberg and Nimiuk Point, respectively). Green line with diamonds marks trend of Kotzebue Arch. Dotted red line shows possible extension of Kobuk Fault. Red lines, solid or dashed, are faults; tick marks indicate downthrown side of normal fault; sawteeth indicate upper plate of thrust fault.

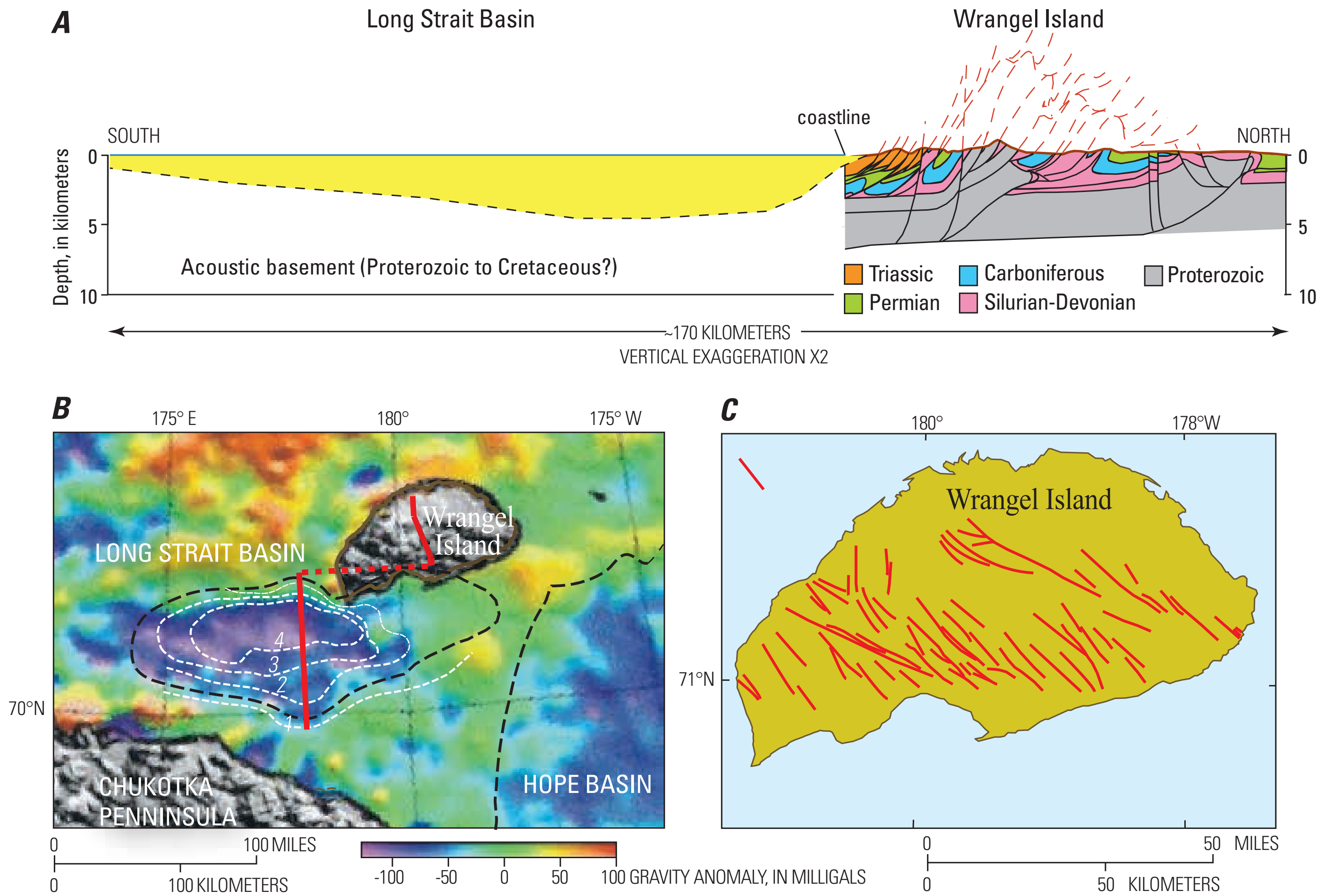

Figure 3. Structural cross section and maps of the Long Strait Basin and Wrangel Island. *A*, Basin profile, showing depth to acoustic basement (in kilometers) along heavy red line in *B*, combined with Wrangel Island section from Kos'ko and others (1993). *B*, Cross section (red line), outline of the Long Strait Basin and northwest part of Hope Basin (dashed black line), and structure contours on acoustic basement (white dashed lines; from Grantz and others, 2009) in relation to free-air-gravity-anomaly map (modified from Mazarovich and Sokolov, 2003). *C*, Map of Wrangel Island, showing normal faults (red lines) that postdate thrust faulting and display right-lateral offset (adapted from Kos'ko and others, 1993, fig. 9).

and basalt flows, overlain by Neogene nonmarine and possible marine sandstone, mudstone, and coal (Haimila and others, 1990). Projection of a structural cross section through Wrangel Island (fig. 3*A*) suggests that Triassic turbidites and mudstones lie immediately and unconformably beneath at least the eastern part of the basin. These Triassic rocks compose the youngest exposed member involved in a northward-vergent fold-and-thrust belt on Wrangel Island that also includes Paleozoic and Neoproterozoic rocks—an exposure of the Brooks Range–Chukotka orogenic belt (Kos'ko and others, 1993).

On Wrangel Island (fig. 3*C*), geologic mapping (Kos'ko and others, 1993) shows abundant northwest-trending normal faults, most of which demonstrate right-lateral offset that postdates thrust faulting. The northwestward orientation of these normal faults is similar to that of the Hope Basin faults (fig. 2), suggesting similar ages of faulting. The widespread occurrence of normal faults on Wrangel Island also suggests that similar faults are likely present in the Long Strait Basin and that fault-block traps similar to those observed on seismic profiles in the Hope Basin may also be present.

Petroleum Systems

No petroleum systems have been identified in the Long Strait Basin. By analogy with the nearby Hope Basin, petroleum-source rocks are probably limited to the nonmarine Cenozoic basin fill and likely consist of coal and carbonaceous mudstone that have created a gas-prone petroleum system. A basin-fill and heat-flow history similar to that of the Hope Basin suggests an early elevated heat flow related to volcanic activity, with reduced heat flow after ~25 Ma. Modeling indicates an onset of petroleum generation below ~1.5 km of burial as early as 40 Ma for source rocks at the base of the sedimentary fill. With reduced heat flow, modeling indicates petroleum generation below ~2.5 km of burial (fig. 4).

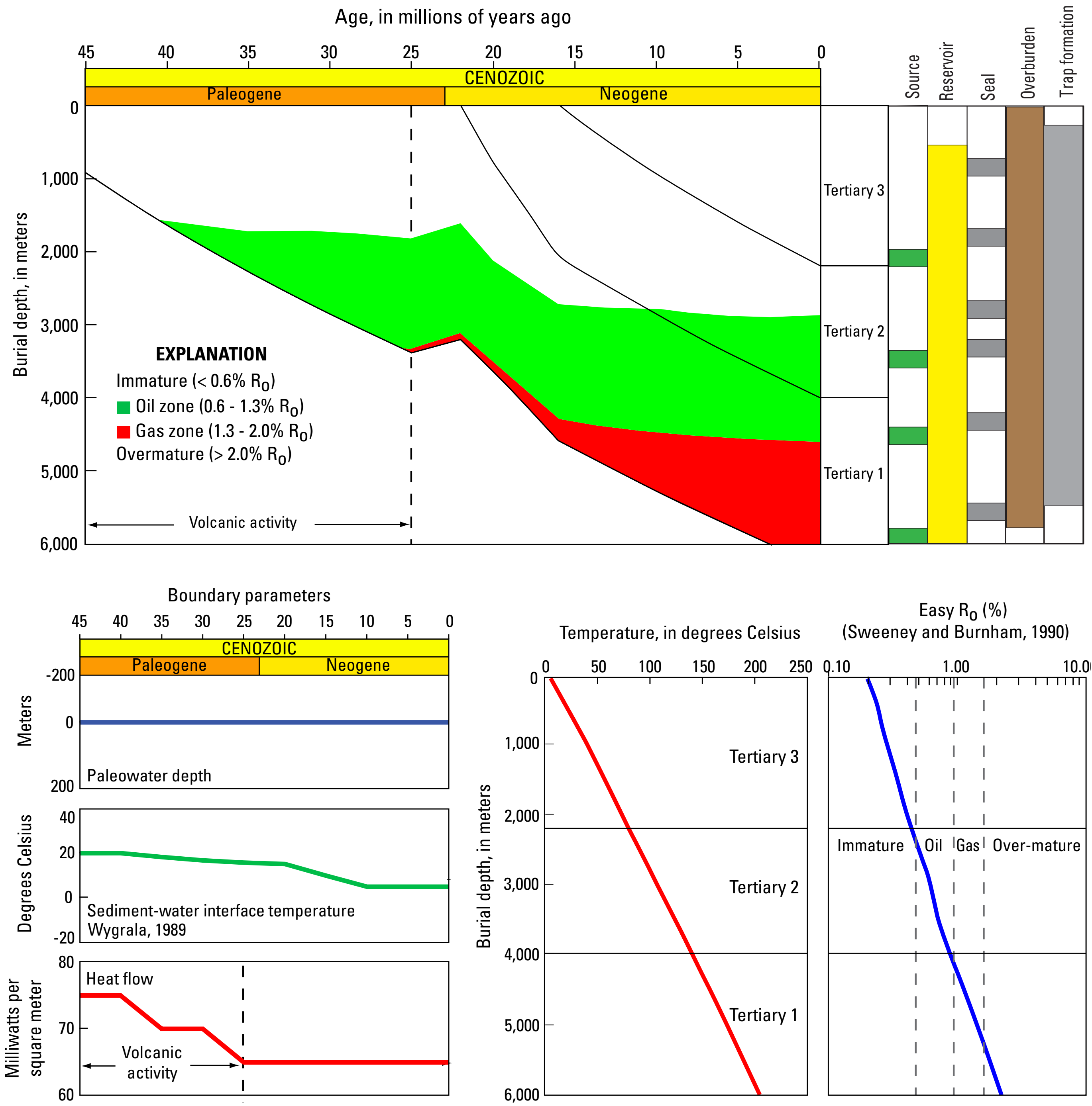

Figure 4. Burial-history diagrams from a pseudowell (fig. 2) located in the Hope Basin that may also, in the absence of any other data, apply to the Long Strait Basin. Sequences and ages used in this analysis are derived from exploratory wells in the southeastern part of the Hope Basin. Petroleum-system components (source, reservoir, seal, overburden, and trap formation) are hypothetical. Ro, vitrinite reflectance, in percent (%). Model produced with IES Petromod software, version 10.

Long Strait Assessment Unit

AU description.—The Long Strait Basin AU encompasses the entire basin, covering an area of ~21,000 km^2 (fig. 2). The basin is defined primarily on the basis of a conspicuous gravity low and a single proprietary seismic line. In the absence of more specific data, the Long Strait Basin is estimated to have geologic characteristics similar to those of the nearby Hope Basin, including (1) >4 km of Cenozoic strata unconformably overlying varyingly deformed Mesozoic and older sedimentary, igneous, and metamorphic rocks that are part of the Brooks Range-Chukotka orogenic belt; (2) Cenozoic basin fill consisting of nonmarine sandstone and conglomeratic strata that may be volcanic rich in the older, Paleogene part, with sandstone, mudstone, coal and shallow marine deposits in the younger, Neogene part; (3) pervasive northwest-trending normal faults active at various times throughout the Cenozoic era that may form fault-block traps; and (4) petroleum-source rocks of coal and carbonaceous mudstone that are dominantly gas prone and thermally mature at present below ~2.5 km of burial.

Geological analysis of AU probability.—Considering data limitations, the probability that the Long Strait Basin AU contains at least one undiscovered accumulation larger than 50 million barrels of oil equivalent (MMBOE) is considered to be ~0.08 (8 percent) (table 1).

Charge.—A charge probability of 0.2 (20 percent) was assigned for charge sufficiency in this AU. Source rocks are considered to be coal and carbonaceous mudstone of unknown quality, thickness, and stratigraphic position within the basin. Furthermore, the area in which these rocks are mature is probably limited to that part of the basin where they are buried to depths >2.5 km, similar to the maturity-depth estimate for the nearby Hope Basin.

Rocks.—A rock probability of 0.6 (60 percent) was assigned for adequacy of reservoirs, traps and seals in this AU. The best reservoirs are probably in the Neogene and upper part of the Paleogene section. Volcanic rocks and debris in the lower Paleogene section, if present, would likely result in greatly diminished reservoir quality. Fault-block traps similar to those in the Hope Basin are considered most likely, but they are of unknown size and number. Adequate mudstone and fault seals are considered a significant risk.

Timing and preservation.—With the basin estimated to currently be at maximum burial and with a probable history of continuous subsidence, a relatively favorable probability of 0.7 (70 percent) was assigned to adequacy of timing and preservation of fields larger than the minimum size within this AU.

Results

Because an overall probability of ~0.08 (8 percent) of at least one petroleum accumulation larger than 50 MMBOE was estimated, no quantitative assessment of sizes and numbers of petroleum accumulations was conducted for this AU.

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Appendix

Appendix is available online only, and may be accessed at https://doi.org/10.3133/pp1824AA

Appendix 1. Assessment input data for the Long Strait Basin Assessment Unit

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