COVER  Eocene strata along the north side of Van Keulenfjorden, Svalbard, include basinfloor 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.
Geology and Assessment of Undiscovered Oil and Gas Resources of the Vilkitskii Basin Province, 2008

By Kenneth J. Bird, David W. Houseknecht, and Janet K. Pitman

Chapter Z of
The 2008 Circum-Arctic Resource Appraisal
Edited by T.E. Moore and D.L. Gautier

Professional Paper 1824

U.S. Department of the Interior
U.S. Geological Survey
The 2008 Circum-Arctic Resource Appraisal

Chapter

A. Introduction to the 2008 Circum-Arctic Resource Appraisal (CARA) Professional Paper
   By Donald L. Gautier and Thomas E. Moore

B. Methodology for Assessment of Undiscovered Oil and Gas Resources for the 2008 Circum-Arctic Resource Appraisal
   By Ronald R. Charpentier

C. Geology and Assessment of Undiscovered Oil and Gas Resources of the Chukchi Borderland Province, 2008
   By Kenneth J. Bird and David W. Houseknecht

D. Geology and Undiscovered Oil and Gas Resources of the Hope Basin Province, 2008
   By Kenneth J. Bird, David W. Houseknecht, and Janet K. Pitman

E. Geology and Assessment of Undiscovered Oil and Gas Resources of the Arctic Alaska Petroleum Province, 2008
   By David W. Houseknecht, Kenneth J. Bird, and Christopher P. Garrity

F. Geology and Assessment of Undiscovered Oil and Gas Resources of the Central Alaska Province, 2008
   By Kenneth J. Bird and Richard G. Stanley

G. Geology and Assessment of Undiscovered Oil and Gas Resources of the Northwest Canada Interior Basins Province, Arctic Canada, 2008
   By Marilyn E. Tennyson and Janet K. Pitman

H. Geology and Assessment of Undiscovered Oil and Gas Resources of the Franklinian Shelf Province, Arctic Canada and North Greenland, 2008
   By Marilyn E. Tennyson and Janet K. Pitman

I. Geology and Assessment of Undiscovered Oil and Gas Resources of the Sverdrup Basin Province, Arctic Canada, 2008
   By Marilyn E. Tennyson and Janet K. Pitman

J. Geology and Assessment of Undiscovered Oil and Gas Resources of the West Greenland-East Canada Province, 2008
   By Christopher J. Schenk

K. Geology and Assessment of Undiscovered Oil and Gas Resources of the East Greenland Rift Basins Province, 2008
   By Donald L. Gautier
L. Geology and Assessment of Undiscovered Oil and Gas Resources of the Jan Mayen Microcontinent Province, 2008
   By Thomas E. Moore and Janet K. Pitman

M. Geology and Assessment of Undiscovered Oil and Gas Resources of the Mezen’ Basin Province, 2008
   By Timothy R. Klett and Janet K. Pitman

N. Geology and Assessment of Undiscovered Oil and Gas Resources of the Timan-Pechora Basin Province, Russia, 2008
   By Christopher J. Schenk

O. Geology and Assessment of Undiscovered Oil and Gas Resources of the East Barents Basins Province and the Novaya Zemlya Basins and Admiralty Arch Province, 2008
   By Timothy R. Klett

P. Geology and Assessment of Undiscovered Oil and Gas Resources of the North Kara Basins and Platforms Province, 2008
   By Timothy R. Klett and J.K. Pitman

Q. Geology and Assessment of Undiscovered Oil and Gas Resources of the Northern West Siberian Mesozoic Composite Total Petroleum System of the West Siberian Basin Province, Russia, 2008
   By Christopher J. Schenk

R. Geology and Assessment of Undiscovered Oil and Gas Resources of the Yenisey-Khatanga Basin Province, 2008
   By Timothy R. Klett and Janet K. Pitman

S. Geology and Assessment of Undiscovered Oil and Gas Resources of the Northwest Laptev Sea Shelf Province, 2008
   By Timothy R. Klett and Janet K. Pitman

T. Geology and Assessment of Undiscovered Oil and Gas Resources of the Lena-Anabar Basin Province, 2008
   By Timothy R. Klett and Janet K. Pitman

U. Geology and Assessment of Undiscovered Oil and Gas Resources of the Tunguska Basin Province, 2008
   By Craig J. Wandrey and Timothy R. Klett

V. Geology and Assessment of Undiscovered Oil and Gas Resources of the Lena-Vilyui Basin Province, 2008
   By Timothy R. Klett and Janet K. Pitman

W. Geology and Assessment of Undiscovered Oil and Gas Resources of the Laptev Sea Shelf Province, 2008
   By Timothy R. Klett and Janet K. Pitman
X. Geology and Assessment of Undiscovered Oil and Gas Resources of the Zyryanka Basin Province, 2008  
   By Timothy R. Klett and Janet K. Pitman

Y. Geology and Assessment of Undiscovered Oil and Gas Resources of the East Siberian Sea Basin Province, 2008  
   By Kenneth J. Bird, David W. Houseknecht, and Janet K. Pitman

Z. Geology and Assessment of Undiscovered Oil and Gas Resources of the Vilkitskii Basin Province, 2008  
   By Kenneth J. Bird, David W. Houseknecht, and Janet K. Pitman

AA. Geology and Assessment of Undiscovered Oil and Gas Resources of the Long Strait Basin Province, 2008  
   By Kenneth J. Bird, David W. Houseknecht, and Janet K. Pitman

BB. Geology and Assessment of Undiscovered Oil and Gas Resources of the Amerasia Basin Petroleum Province, 2008  
   By David W. Houseknecht, Kenneth J. Bird, and Christopher P. Garrity

CC. Geology and Assessment of Undiscovered Oil and Gas Resources of the Lomonosov-Makarov Province, 2008  
   By Thomas E. Moore, Kenneth J. Bird, and Janet K. Pitman

DD. Geology and Assessment of Undiscovered Oil and Gas Resources of the Eurasia Basin Province, 2008  
   By Thomas E. Moore and Janet K. Pitman
Contents

Abstract ...........................................................................................................................................................1
Introduction .....................................................................................................................................................1
Geologic Setting and Stratigraphy ..........................................................1
Petroleum Systems ........................................................................................................................................6
Vilkitskii Basin Assessment Unit .................................................................6
Results .............................................................................................................................................................9
Acknowledgments .......................................................................................................................................9
References Cited ........................................................................................................................................10

Appendix

[Available for download at https://doi.org/10.3133/pp1824Z]

1. Input Data for the Vilkitskii Basin Assessment Unit

Figures

1. Map showing Vilkitskii Basin in relation to other sedimentary basins of the East Siberian and Chukchi Seas .................................................................................................................................2
2. Map of the Vilkitskii Basin and nearby geologic features .................................................................4
3. Interpreted geometry and ages in millions of years before present (Ma) of unconformity-bounded sedimentary and volcanic packages overlying acoustic basement (from Sekretov, 2001) interpreted from seismic profiles that trend northeasterly from the De Long Massif across the northwesternmost Vilkitskii Basin and into the Podvodnikov Prograded Margin ........................................................................5
4. A segment of proprietary seismic profile in southern Vilkitskii Basin east of the Herald Arch-Lisburne Hills thrust front (fig. 2) showing the easternmost of three diapiric structures .................................................................................................................................6
5. A segment of proprietary seismic profile in southern Vilkitskii Basin approximately 40 kilometers west of the Herald Arch-Lisburne Hills thrust front (fig. 2) showing faulting, reflective character, and possible gas indications ..............................................................................7
6. Burial history analysis of pseudowell located in the southern part of the Vilkitskii Basin, just east of the Herald Arch-Lisburne Hills thrust front .................................................................8

Tables

1. Assessment results for the Vilkitskii Basin Province (conventional undiscovered resources) .................................................................................................................................9
Chapter Z

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

By Kenneth J. Bird, David W. Houseknecht, and Janet K. Pitman

Abstract

The Vilkitskii Basin is a separate petroleum province that lies beneath the continental shelf of the East Siberian Sea east of the New Siberian Islands and northwest of Wrangel Island. It is a basin known only on the basis of gravity data and three seismic profiles. A small, southern part of the basin overlies the Brooks Range–Chukotka late Mesozoic-early Paleogene orogenic belt, but most of the basin lies north of that belt. Its regional setting suggests that it may have similarities to other post-orogenic (successor) basins on the East Siberian Shelf as well as to foreland, rift-sag, and passive margin basins lying north of the orogenic belt such as the North Slope, North Chukchi and Podvodnikov Basins.

Although the basin’s petroleum potential is poorly known, extremely thick sediments, diapiric structures, and gas plumes interpreted from a seismic profile are considered favorable features for petroleum presence and imply that there may be an active petroleum system. An overall probability of about 30 percent of at least one petroleum accumulation >50 MMBOE (million barrels of oil equivalent) was determined based on estimated probabilities of the occurrence of petroleum source, adequate reservoir, trap and seal, and favorable timing. A single assessment unit (AU) was defined and assessed, resulting in mean estimates of undiscovered, technically recoverable resources that include about 100 million barrels of oil and 5,500 billion cubic feet of nonassociated gas.

Geologic Setting and Stratigraphy

Limited geologic and geophysical evidence indicates that Vilkitskii Basin is a hybrid basin. Its southern quarter, overlying the Brooks Range-Chukotka orogenic belt, is believed to be a successor or intermontane basin. The larger northern part of the basin lies inboard (southwest) from the Podvodnikov Prograded (passive) Margin and the rifted North Chukchi Basin, and adjacent to the Wrangel Foreland Basin and the high-standing volcanic plateau of De Long Massif (fig. 2). Accordingly, this part of the basin probably has some combination of passive-margin, rift-sag, and foreland-basin characteristics.

The Brooks Range-Chukotka orogenic belt, part of the Arctic Alaska-Chukotka Microplate, is bounded on the south by the South Anyui suture and on the north by western extent of the Herald Arch-Lisburne Hills–Brooks Range thrust front (fig. 1). The northern boundary of the orogenic belt may be as young as early Paleogene (~60 Ma) if timing is similar to that on the Alaskan North Slope. The orogenic belt, in particular its eastern part, is postulated to have been a Cretaceous highland (Tigara Uplift) and major contributor of the enormous volumes of clastic debris filling the North Slope foreland and North Chukchi basins (Molenaar, 1985; Grantz and others, 1990; Lothamer, 1994). The Cretaceous highland may have contributed sediment to the Vilkitskii Basin as well.

The origin of Vilkitskii Basin is uncertain but the limited observations of structural and stratigraphic features and its regional setting are generally compatible with an early episode (Jurassic-Cretaceous) of crustal extension related to opening of the Amerasia Basin coincident with the Brooks Range-Chukotka orogeny and northward sediment dispersal followed by pervasive, but poorly understood, Cenozoic extensional (strike-slip?) faulting of northwest and northeast trend that appears to affect the entire East Siberian-western Chukchi Sea region (for example, Filatova and Khain, 2007; Franke and others, 2004; Kos’ko and others, 1993; Tolson, 1987).
Figure 1. Map showing Vilkitskii Basin in relation to other sedimentary basins of the East Siberian and Chukchi Seas that lie within and adjacent to the Arctic Alaska-Chukotka orogenic belt, defined as the area between the South Anyui Suture and the Herald Arch-frontal Brooks Range thrust trend. Map and basin outlines derived from Grantz and others (2009). Bathymetric contour labels are in meters.
The most revealing, albeit limited, views of the basin are provided by the three seismic profiles shown in the map in figure 2. In the absence of information from drilling, the age of seismic reflectors is inferred from outcrop geology, Arctic region tectonics, and global eustatic sea level. The two profiles in the northwestern part of the basin cross the very narrow (<30 km wide) northern tip of the basin so it is unknown how representative they are of the whole basin. As interpreted by Sekretov (2001), these lines (fig. 3) show a northeastward-expanding sedimentary succession resting on down-faulted acoustic basement. His five “key reflectors,” which range from 10.5 Ma to 120–125 Ma indicate that the sedimentary succession is Cretaceous and Cenozoic and has volcanic rocks represented by relatively high interval velocities (4.7–4.8 km/s) in its lower (Cretaceous) parts. The sedimentary cover thickens from <1–2 km on the high-standing De Long Massif to 2–6 km in the Vilkitskii Basin and nearly 10 km in the Podvodnikov Prograded Margin. In this area, the Vilkitskii Basin seems to part of the overall Siberian passive margin.

To the south, a proprietary seismic profile spans the entire 240-km width of the basin (fig. 2). It shows relatively unfaulted acoustic basement that slopes westward from less than 2 km (<2-s two-way traveltime) at the eastern margin of the basin to more than 12 km (>6.5-s two-way traveltime) at the Herald Arch-Lisburne Hills thrust front where it is uplifted to about 3.5 km (~2.5-s two-way traveltime) across a poorly resolved reverse fault. From there, acoustic basement shallows westward to about 1 km (~1-s two-way traveltime) at the edge of the basin and is even shallower in the area between Vilkitskii and East Siberian Sea basin. The basin fill is composed of four unconformity-bounded sequences, all of which are thickest in the basin center and thin by onlap toward the basin margins. Extensional (transtensional?) faults cut all but the youngest sequence (fig. 4) in the basin.

The oldest and thickest sequence, nearly 10 km (~4-s two-way traveltime) thick, is only present northeast of the Herald Arch-Lisburne Hills thrust front. Adjacent to the thrust front this old, thick sequence displays three diapiric structures, the easternmost of which is illustrated in figure 4. The sequence is undeformed farther east and thins by sedimentary onlap and convergence to less than 1 km (0.5-s two-way traveltime) at the basin margin. The sequence is clearly older than the bounding fault, which could be as young as early Paleogene (~60 Ma) if timing is similar to that on the Alaskan North Slope. Considering this and its regional setting, the sequence is provisionally assigned a Cretaceous age (120–65 Ma) for burial history modeling but recognizing that it could include Jurassic strata as well. By analogy with the north Alaskan (Colville) foreland basin and the North Chukchi Basin, this sequence probably consists of marine and nonmarine strata. The diapirs are inferred to be shale-cored and derived from the deepest parts of the basin (fig. 4), which implies an early shale-dominated (marine) basin fill that was probably overpressured.

The beds overlying the oldest and thickest sequence consist of a thin (0.5 km, 0.25-s two-way traveltime) interval of high amplitude reflectors that overlaps the bounding fault and thickens toward the basin center. On seismic profiles in the East Siberian Sea Basin, a thin, highly reflective sequence overlying acoustic basement, as shown in figure 5, has been related to the stratigraphic succession on the New Siberian Islands. Different investigators have considered this sequence equivalent to a mid-Cretaceous (Aptian-Turonian) coal-bearing clastic and volcanic succession (Kos’ko and Trufanov, 2002) or to a younger sequence composed of Paleocene-Eocene coal-bearing clastic and shallow marine rocks (Franke and others, 2004). Given the overlap of the bounding fault and the possible early Paleogene age of the fault, this sequence has been assigned a provisional age of 65–32 Ma for burial history modeling.

The next higher sequence is as thick as 2.5 km (1.5-s two-way traveltime). Changes in stratil thickness across faults (fig. 5) and folds related to the diapirs (fig. 4) indicate deformation during deposition of this sequence. Extensional faults are truncated at an unconformity at the top of the sequence or extend just above the unconformity. These observations of deformation relative to the overlying (youngest) sequence are similar to those in the East Siberian Sea Basin, where this sequence has been interpreted as Oligocene-mid-Miocene (33–10 Ma) by Franke and others (2004); they interpret it as shallow-marine Oligocene strata that grade upward into nonmarine Miocene rocks.

The youngest sequence in the basin is virtually undeformed and is as thick as 1 km (1-s two-way traveltime). In the East Siberian Sea Basin, Franke and others (2004) interpret this sequence as late Miocene to recent shallow marine to nonmarine clastic sediments.

A critical question related to Vilkitskii Basin’s petroleum potential is the regional extent of the thick (Cretaceous) basin fill observed on the proprietary seismic profile. Using stacking velocities, a total basin fill of more than 12 km is indicated, nearly 10 km of which is estimated to be Cretaceous. In other basins of the Chukchi-East Siberian Sea region, inspection shows fair to good agreement between location of basin fill observed on seismic profiles and negative gravity anomalies, for example in Hope, Long Strait, North Chukchi, and East Siberian Sea Basin Provinces (fig. 2B). In the southern Vilkitskii Basin, however, only a very minor gravity low, covering a relatively small area of the basin, is observed where the seismic data suggest that lower gravity anomaly values would be present. Perhaps the observed Cretaceous basin is only of limited thickness or extent, or Cretaceous strata are higher density, or intra-basement density variations are causes of this discrepancy. It is also possible that negative gravity anomalies in other basins may only be indicative of low-density Cenozoic strata. In the East Siberian Sea Basin north of the Herald Arch-Lisburne Hills thrust front (fig. 2, star symbol), Drachev and others (2001) interpret the seismic profile LARGE 89001 as showing one of the deepest and oldest (Albian?) parts of the basin (>3.5-s two-way traveltime), but, like the situation in southern Vilkitskii Basin, the gravity anomaly in this area is near zero (fig. 2B).
Figure 2. Map of the Vilkitskii Basin and nearby geologic features adapted from Grantz and others (2009). A, Vilkitskii Basin (yellow) with interpreted faults (red lines), isopachs (in kilometers) on acoustic basement within the basin, reflection seismic profiles (green lines), the pseudowell used in burial history analysis, and bathymetry in meters. Star symbol, segment of Drachev and others (2001) seismic profile discussed in text. Islands in the De Long Massif area: H, Henrietta; J, Jeannette; Z, Zokhov. B, Features of map A superimposed on free-air gravity anomaly map adapted from Mazarovich and Sokolovich (2003) showing relation of basin outlines, faults and isopachs to gravity anomalies.
Figure 3. Interpreted geometry and ages in millions of years before present (Ma) of unconformity-bounded sedimentary and volcanic packages overlying acoustic basement (from Sekretov, 2001) interpreted from seismic profiles that trend northeasterly from the De Long Massif across the northwesternmost Vilkitskii Basin and into the Podvodnikov Prograded Margin. Islands in the De Long Massif area: H, Henrietta; J, Jeannette; Z, Zokhov.
Two-way traveltime, in seconds

Depth, in kilometers

Acoustic basement

estimated top of oil window

~ 10 kilometers

120 Ma

65 Ma

32 Ma

10 Ma

WEST EAST

10 Ma

32 Ma

65 Ma

120 Ma

0

-1

0

1

2

3

4

5

6

7

8

9

10

11

12

13

~ 10 kilometers

Vilkitskii Basin Assessment Unit

Assessment Unit Description.—The Vilkitskii Basin assessment unit encompasses the entire basin, about 167,000 km$^2$ (fig. 2). Knowledge of the basin is limited to information derived from gravity data, magnetic data, three reflection seismic profiles, and regional geologic relations. It appears that the basin is geologically complex and has an undetermined mix of characteristics of foreland, rift-sag, passive margin, and successor basins (figs. 3–5). Basin fill, locally greater than 12 km thick, is composed of at least 4 unconformity-bounded sequences, the ages of which are uncertain because of an absence of well penetrations (fig. 4). Regional tectonic considerations, combined with seismic interpretations in nearby areas/basins, suggest that the oldest and thickest sequence is probably marine Cretaceous and the three overlying sequences are Cenozoic. The Cenozoic sequences show seismic reflection characteristics (fig. 5) similar to those observed to the west in the East Siberian Sea Basin (see, for example, Franke and others, 2004), which suggests a similar lithologic succession and similar ages. Those sequences are inferred to be composed predominantly of coal-bearing nonmarine clastic sediments with probable shallow marine intervals from parts of the Eocene, Oligocene, Pliocene, and Pleistocene based on outcrop geology projections from the New Siberian Islands (for example, Kos’ko and Trufanov, 2002). Volcanic rocks are known in the late Early Cretaceous and Pliocene-Pleistocene parts of

Petroleum Systems

Reflector fade-outs and velocity sags in the proprietary seismic profile in the southern part of the basin (figs. 4, 5), interpreted as gas indicators, suggest one or more petroleum systems are active in the Vilkitskii Basin. No other hydrocarbon indicators are known from the basin. Likely source rocks are Cretaceous marine shale in the deep basin and coal, carbonaceous shale, and shallow marine mudstone in the Cenozoic section. The Azolla interval, identified in the New Siberian Islands (Brinkhuis and others, 2006, table S-1), is probably present. The possibility of Paleozoic and early Mesozoic source rocks within the acoustic basement cannot be ruled out, but, if present, their original thickness, distribution, organic richness, and thermal maturity are unknown.

Burial history of a pseudowell located in the deepest known part of the basin, on the proprietary seismic profile about 30 km west of the diapir in figure 4, was modeled to estimate thermal maturity and timing of petroleum generation (fig. 6). This analysis, using a constant heat flow of 50 milliwatts per square meter (mW/m$^2$) (derived from the Popcorn well in the U.S. Chukchi Sea, 800 km to the east) and the interpreted sequence ages and depths, suggests that onset of petroleum generation would occur at about 3.6 km of burial, as early as Albian (~105 Ma). In modeled depocenters, postulated source rocks as young as Paleogene would lie within the oil window at maximum burial. If the free air gravity anomalies in the basin (fig. 2B) give reliable estimates of Cenozoic sediment thickness, then just a few relatively small areas of the basin would have mature Cenozoic strata. Thus, mature source rocks at any particular part of Vilkitskii basin are more likely to occur in the underlying Mesozoic succession, assuming it is present.
Petroleum source rocks may be marine shale, coal, carbonaceous shale, and shallow marine mudstone, and, thus, are expected to be predominantly gas prone. The Eocene *Azolla* interval, reported in the New Siberian Islands (Brinkhuis and others, 2006, table S-1), is likely present, but its organic-carbon richness, aerial extent, and burial depth are unknown. Petroleum source rocks of Paleozoic and Mesozoic age may also be present in the acoustic basement, but nothing is known of their thickness, distribution, or source characteristics. Analysis of the burial history suggests that only the part of the basin that has greater than about 3.6 km of fill is capable of petroleum generation.

**Geological Analysis of Assessment Unit Probability.**— Considering data limitations, the probability that the Vilkitskii Basin AU contains at least one undiscovered accumulation >50 MMBOE is considered to be about 29 percent (table 1).

**Charge.**—A probability of 0.6 was estimated for charge sufficiency in this AU. Cenozoic and late Mesozoic source rocks of unknown quality and thickness were considered.
Figure 6. Burial history analysis of pseudowell located in the southern part of the Vilkitskii Basin, just east of the Herald Arch-Lisburne Hills thrust front (fig. 2). Age of horizons in the pseudowell and the petroleum system components shown are speculative. Ro, vitrinite reflectance, in percent (%). PetroMod references: Wygrala (1989), Sweeney and Burnham (1990), and Integrated Exploration Systems (2008).
Table 1. Assessment results for the Vilkitskii Basin Province (conventional undiscovered resources).

[AU, assessment unit; BCF; billion cubic feet; MMB, million barrels. Results shown are fully risked estimates. For gas fields, all liquids are included under the natural gas liquids category. F95, 95-percent probability of at least the amount tabulated, and so on for F50 and F5. Fractiles are additive under the assumption of perfect positive correlation. N/A, not applicable]

<table>
<thead>
<tr>
<th>Total petroleum system and AU</th>
<th>AU probability</th>
<th>Field type</th>
<th>Oil (MMB)</th>
<th>Gas (BCF)</th>
<th>Natural gas liquids (MMB)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Oil</td>
<td>F95</td>
<td>F50</td>
<td>F5</td>
</tr>
<tr>
<td>Vilkitskii Basin AU</td>
<td>0.228</td>
<td>Oil</td>
<td>0</td>
<td>0</td>
<td>530</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Gas</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
</tbody>
</table>

Cenozoic coal and shallow marine carbonaceous mudstones are likely present throughout the basin. The Eocene Azolla interval is probably present and may have source potential in the eastern and northern parts of the basin that are presumed to be distal from clastic sediment influx. Late Mesozoic (Cretaceous and possibly Jurassic) marine source rocks are likely to be present north of the Herald Arch-Lisburne Hills thrust front (fig. 2) in the extremely thick succession shown on the seismic profile (fig. 4). But in the absence of gravity or magnetic anomalies, there is no way of knowing the aerial extent and thickness of these strata beyond the observed seismic sections. The onset of thermal maturity at a depth of about 3.6 km at the pseudowell (fig. 6), indicated by burial history modeling, suggests that Cenozoic source rock strata are mature only in local depocenters whereas significant parts of the thick Cretaceous and older (?) source rocks are likely mature and overmature.

**Rocks.**—A probability of 0.8 was estimated for adequacy of reservoirs, traps and seals in this AU. Sandstone reservoirs deposited in a variety of settings appear likely to be present. Cenozoic fluvial and shallow marine sandstones and late Mesozoic turbidites and shallow marine deposits are probably present. Diapiric folds, faults, and unconformity trap geometries are observed on available seismic images. The seismic sections indicate that folding, faulting, and diapiric deformation were most active during the second-youngest sequence, provisionally dated to 33–10 Ma. The youngest seismic sequence (<10 Ma) forms an unconformable, overlapping, generally unfaulted cap on the underlying strata that is as much as 1 km thick and may constitute a sealing unit. The presence of adequate mudstone and fault seals are considered a significant risk.

**Timing and Preservation.**—With the basin currently at maximum burial and a history of relatively continuous subsidence, a favorable probability of 0.6 was assigned to adequacy of timing and preservation of accumulations greater than the minimum size of 50 MMBOE within this AU.

**Analog.**—The USGS World Analog Database (Charpentier and others, 2008) was searched for the following basin features or types: extensional structural setting, continental crustal system, rifted passive margin, rift-sag architecture, and basement-involved block fault structures or extensional grabens. This is the same analog set that was used in the Arctic Platform assessment unit (Houseknecht and others, 2012).

**Numbers of Accumulations.**—Based on the set of analogs searched, the total number of petroleum accumulations >50 MMBOE was set to minimum, median, and maximum values of 1, 15, and 70.

**Oil/Gas Mix.**—Based on the inferred kerogen types, thermal history, and common gas indications on the seismic profile, the minimum, median, and maximum values for oil/gas mix were set at 0, 0.1, and 0.3 (table 1).

**Accumulation Size Distribution.**—The median and maximum oil accumulation size was set to 70 and 4,000 MMBO, and the median and maximum gas accumulation size was estimated to be 600 and 40,000 BCFG.

**Estimated Maximum Field Size.**—Maximum accumulation sizes of 500 MMBO and 9 TCFG were selected based on the interpretation that some very large traps are probably present, but that maximum accumulation size may be constrained by limited hydrocarbon charge and possibly by seal integrity.

Ancillary properties and coproduct ratios used are world averages in analogs from the USGS World Analog Database (Charpentier and others, 2008).

### Results

Probabilistic estimates of volumes of undiscovered, technically recoverable hydrocarbons in the Vilkitkii Basin AU are summarized in table 1. These results include mean estimates of about 100 MMBO and 5,500 BCFG nonassociated gas.

### Acknowledgments

Reviews by Richard W. Saltus and Arthur Grantz have improved this report. The U.S. Department of Energy provided funding for the purchase of selected seismic data in the Vilkitkii Basin.
References Cited


Appendix. Input Data for the Vilkitskii Basin Assessment Unit

Appendix is available online only, and may be accessed at https://doi.org/10.3133/pp1824Z