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Chapter 14

Interior basins of Alaska

Charles E. Kirschner
P.O. Box 154, Union, Washington 98592

INTRODUCTION

Interior Alaska has historically been considered the onshore geographic area of Alaska between the Brooks Range and the Seward Peninsula on the north and west respectively, and the Alaska Range on the south (Fig. 1). It is an area of more than 600,000 km^2 that covers the central one-third of Alaska and has been variously referred to as the "intermontane plateaus" (Wahrhaftig, this volume) and the "central plateaus" (Raisz, 1948). The Yukon River, the largest river in Alaska, approximately bisects the province. The topography of the region is generally subdued. Broad alluviated lowland areas are underlain by Cenozoic nonmarine sedimentary rocks. Extensive areas in the western and southwestern parts of the province are characterized by ridge and valley topography cut in complexly deformed Jurassic and Cretaceous flysch rocks. The Brooks Range and the Alaska Range were extensively glaciated during the Pleistocene; however, only a few very small glaciers were present in the higher mountains of the interior province. Muskeg and tundra at the lower elevations, willow and alder brush in the stream valleys, and spruce and birch forests up to the tree line, at about 750 to 900 m elevation, form a thick cover of vegetation so that bedrock exposures are generally limited to ridge tops above the tree line and river-cut bank exposures.

REGIONAL FRAMEWORK

In onshore interior Alaska there are three types of basins: Cenozoic nonmarine basins; Mesozoic, mildly to complexly deformed flysch basins; and the Kandik basin, a hinterland segment of the Cordilleran fold and thrust belt (Fig. 2; Table 1). The structural and stratigraphic development of the interior basins will be discussed in the context of their petroleum potential. Only seven exploratory wells have been drilled in all of these basins: two in Paleozoic rocks of the Kandik basin, two shallow wells in Cenozoic nonmarine rocks of the Nenana basin, one each in Mesozoic flysch rocks of the Kandik and the Yukon-Koyukuk belts, and one in the Bethel basin that penetrated Mesozoic flysch beneath a thin Cenozoic section. Many of these basins also contain coal deposits that are described in more detail by Wahrhaftig and others (this volume).

Some common characteristics of the Cenozoic basins are: (1) The sedimentary fill is less dense than the pre-Tertiary rocks so the basins form distinct gravity lows. (2) The fill is mainly nonmarine fluvial and coal-bearing sedimentary rocks deposited in cyclic fining-upward sequences. (3) A pattern of three cycles of Tertiary sedimentation appears to be characteristic, an early cycle of Paleocene to early Eocene age, a middle cycle of late Eocene to late Miocene age, and a late cycle of late Miocene and Pliocene age. (4) The depocenter for each younger cycle is commonly displaced from the preceding cycle as a result of deformation and uplift that produces a local to regional unconformity between the cycles; therefore, it cannot be predicted that early-cycle rocks will necessarily be present at depth beneath mid-cycle or late-cycle rocks. (5) Structure is commonly extensional, but folding related to thrust faulting, high-angle reverse faulting, or transpression by dextral faulting is also recognized. This style of structural development of "pull-apart" basins or "rhomb grabens and horsts," along major strike-slip fault systems, has been aptly described by Aydin and Nur (1982), Chinnery (1965), Wilcox and others (1973), and many others.

Mesozoic basins, characterized as flysch belts and flysch terranes, cover extensive areas of western and southwestern interior Alaska, are also present in the Alaska Range south of the Denali fault zone, and arc around the Gulf of Alaska from Bristol Bay on the southwest to southeastern Alaska (Fig. 3). Small, fault-bounded flysch terranes are present in central and east-central interior Alaska and may represent dismembered segments of formerly larger co-extensive basins. The common characteristic of the flysch belts of interior and southern Alaska is that they represent volcano-plutonic arc-related basin deposits. They will be discussed briefly in the context of their structural and stratigraphic development and petroleum potential.

The area generally referred to as the Kandik basin in east-central Alaska is a small hinterland segment of the Cordilleran fold and thrust belt. The Paleozoic to early Mesozoic stratigraphic sequence in the Kandik basin includes organic shales and platform carbonate and clastic rocks, but its petroleum potential appears to be very low due to strong structural deformation.

A conspicuous element of interior Alaska is the suite of relatively small, northeast-trending dextral strike-slip faults on the west limb of the Alaska "orocline," and the major southeast-

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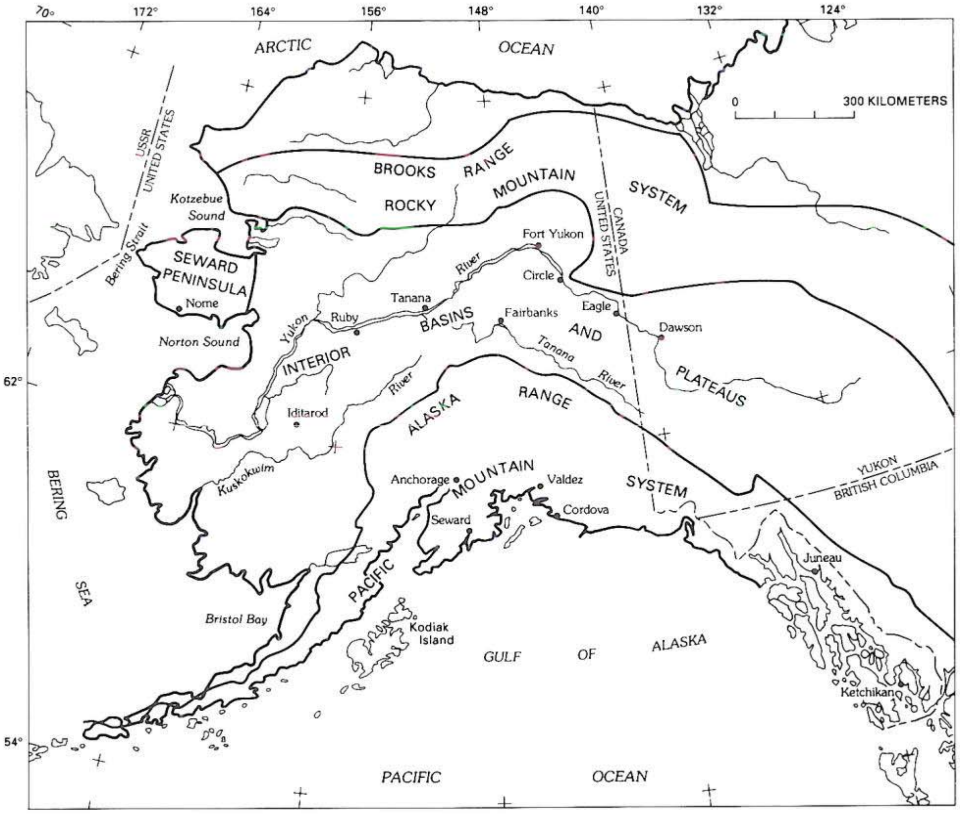


Figure 1. Map showing major North American physiographic divisions in Alaska.

trending dextral rift zones of the Tintina and Denali faults on the east limb of the Alaska "orocline" (Fig. 3; Grantz, 1966).

The northeast-trending faults in the suite are each about 400 to 500 km in length and have dextral offsets in the range of 100 km (e.g., Patton and Hoare, 1968). These faults are confined to the west limb of the Alaska "orocline" and thus are probably related to its development. The major Tintina and Denali fault zones, by comparison, are 1,500 to more than 2,500 km in length, with dextral offsets in the range of hundreds of kilometers (e.g., Gabrielse, 1985). Both the Denali and Tintina fault zones appear to end at the apex of the Alaska "orocline" in highly complex imbricate thrust systems or collision zones that must have accommodated much of the strike-slip motion on these major fault systems. The Denali fault terminates in the Alaska Range suture zone (Jones and others, 1963). The Tintina fault terminates in a similar suture zone referred to as the Beaver Creek suture (Churkin and others, 1982; Figs. 3 and 10).

Another conspicuous element of north-central interior Alaska and the southern Brooks Range, which probably indicates structural deformation on a major scale, consists of ophiolite assemblage terranes (Fig. 3; Patton and others, 1977). Around the northeastern margin of the Yukon-Koyukuk-Kobuk (YKK) flysch basin, the ophiolite assemblages are slab-like bodies that dip beneath the flysch basin. They are interpreted to represent the oceanic floor of the basin and the root zone of obducted allochthonous sheets that once extended as much as 300 km over continental crust.

Lithotectonic (tectonostratigraphic) terranes referred to in this chapter are described by Silberling and others (this volume).

TERTIARY BASINS

Bethel basin

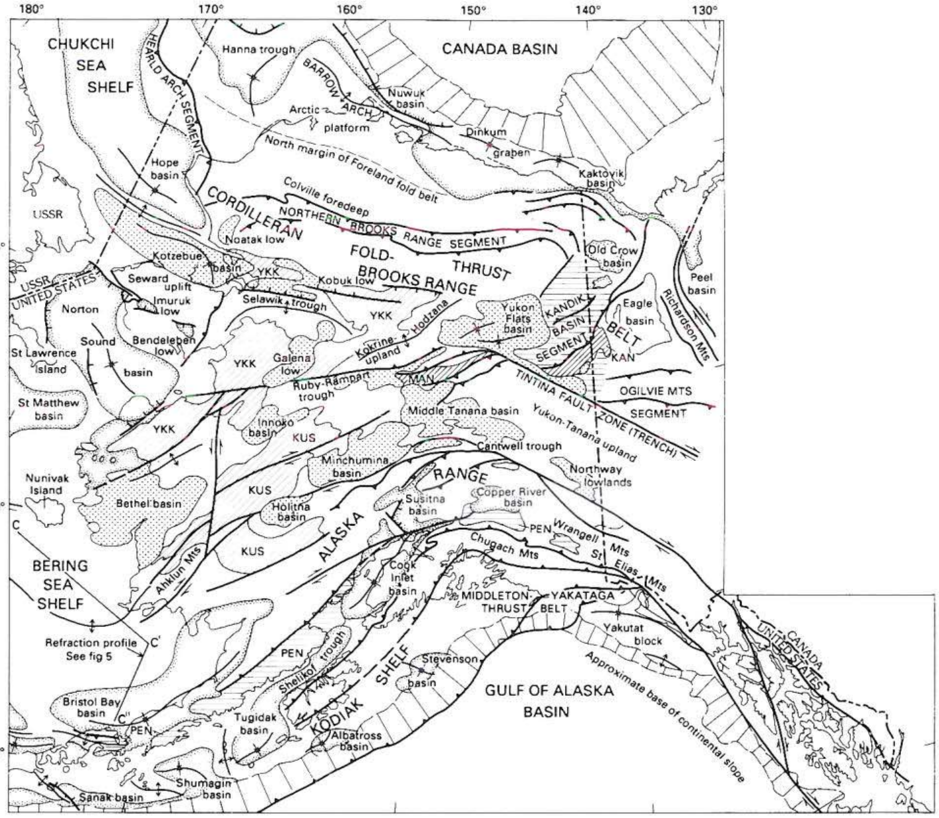
Introduction. The Bethel basin is a large lowland area bordered on the south and west by the Bering Sea, and on the north by metamorphic and sedimentary rock uplands north of the Yukon River and east of the Kuskowim River. The area thus defined includes about 50,000 km^2. It is a lake-dotted marshy plain rising 30 to 90 m above sea level. The marshy ground is underlain by patchy permafrost and is about 30 percent lake surface. Numerous basalt flows and cinder cones are present in the west-central area of the plain (Fig. 4). The basin has seen a very low level of petroleum industry interest due to evidence of a thin Tertiary section and poor source and reservoir potential in the Cretaceous and older(?) sedimentary rocks. One deep exploratory well has been drilled in the basin: the Pan American, Napatuk Creek No. 1, with a total depth of 4,541 m (14,890 ft).

TABLE 1— *Cenozoic basins of interior and southern Alaska*

[Note: Well symbols follow usage in AGI data sheets (Dietrich and others, 1982). COST, Continental offshore stratigraphic test]

BASIN	MAXIMUM SQ KM	PERCENT >1 KM FILL	PERCENT >3 KM FILL	GRAVITY LOW MG	STRUCTURAL STYLE		EXPLORATORY WELL DATA, COMMENTS
BENDELEBEN	600	*40G	0	20	Graben or half-graben	--	Probable Cenozoic fill.
BETHEL	50,000	0	0	10	Lowlands	⌖	One exploratory well. Thin Cenozoic fill over Cretaceous flysch. No shows.
BRISTOL BAY	70,000	90	35	40	Half-graben Tertiary folding	✹	Oil and gas shows in exploratory wells. One COST well offshore.
COOK INLET	28,000	65	50	100+	Half-graben Tertiary folding	● ☼	Over 200 exploratory wells. Several producing oil and gas fields. Oil seeps.
COPPER RIVER	4,500	<1	0	30	Lowlands	✹	Several exploratory wells. Only minor oil and gas shows in Cretaceous flysch. Thin tertiary fill.
GALENA	9,000	<1G	0	40	Lowlands half-graben	--	Lowland area with thin fill except for half-graben(?) low along Kaltag fault zone.
HOLITNA	5,000	1G	0	40	Gaben or half-graben trough	--	Lowland area with thin fill except for graben trough(?) along Farewell fault zone.
IMURUK	600	2G	0	20	Half-graben?	--	Probable Cenozoic fill.
INNOKO	6,000	1G	0	20	Half-graben or graben trough?	--	Probable Cenozoic fill localized by undefined dextral fault zone?
KOBUK	2,000	3G	0	20	Half-graben or graben trough?	--	Probable Upper Cretaceous and Cenozoic fill.
KOTZEBUE	40,000	30	<10	30	Half-graben	⌖	Two exploratory wells, no shows. Nonmarine Tertiary section immature.
MINCHUMINA	20,000	15G	0	30	Graben and half-graben complex	--	Large shallow basin with local small graben(?) and half-graben(?) basins.
MIDDLE TANANA	22,000	20G	<1	50	Half-graben	⌖	Large shallow basin. One small deep low. Two wells, no shows. Reported oil seeps unconfirmed.
NOATAK	1,600	15G	<1	50	Graben?	--	Probable Cenozoic fill.
NORTHWAY	3,000	0G	0	0	Lowlands	☼	Thin Pleistocene fill. Shallow wells encountered marsh gas trapped by permafrost.
NORTON SOUND	50,000	60	10	30	Extensional graben complex	✹	Two COST wells and six industry wells, oil and gas shows. Commercial production not established.
RUBY-RAMPART	6,000	25G	0	20	Half-graben trough	--	Trough along trend Kaltag fault zone. Upper Cretaceous and Cenozoic fill.
SELAWIK	2,300	>50G	0	30	Graben trough	--	Long narrow deep trough with Cenozoic fill.
SUSITNA	10,000	25	10	40	Graben and half-graben complex	⌖	Two exploratory dry holes. Up to four km Cenozoic fill.
TINTINA	2,500	<50G	<10	40	Graben trough	--	Trough along trend of Tintina fault zone. Thick Upper Cretaceous and Cenozoic fill.
YUKON FLATS	22,000	>25G	<1	40	Half-graben or graben complex?	--	Probable Cenozoic fill.

*G indicates thickness of fill based on gravity data



EXPLANATION

Cenozoic basins discussed in this report that contain mainly Tertiary nonmarine strata

Mesozoic basins

Belts of flysch and molasse strata, mainly of volcanogenic origin

YKK **Yukon-Koyuk-Kobuk basin**

KUS **Kuskokwim basin**

Belts of argillite and arenite, mainly of continental origin

KAN **Kandik River terrane**

MAN **Manley terrane**

PEN **Peninsular terrane**

Kandik basin—A segment of the Cordilleran fold and thrust belt

Contact—Approximately located

Fault—Sense of throw unknown. Dashed where speculative

Strike-slip fault—Arrows show relative movement. Dashed where speculative.

Thrust fault—Sawteeth on upper plate. Dashed where speculative

Normal fault—Hachures on downthrown side. Dashed where speculative

Trend of major uplift or anticlinoria

Trend of major downwarp or synclinoria

Figure 2. Map showing major basins, terranes, and structural features of Alaska.

Stratigraphy. Basement rock terranes north of the basin consist of Precambrian schist, gneiss, and migmatite of the Ruby terrane, and an Early Cretaceous volcaniclastic andesitic arc assemblage, the Koyukuk terrane (Jones and others, 1987; Silberling and others, this volume). Southeast of Bethel in the Ahklun Mountains, a similar Jurassic volcanic and volcaniclastic andesitic arc assemblage is widely exposed. North of Cape Newenham, smaller disparate terranes include an early Mesozoic to Paleozoic oceanic assemblage in a tectonic melange, ultramafic rocks of the Goodnews terrane, and Precambrian gneiss and phyllite of the Kilbuck terrane.

Cretaceous flysch and molasse of the Yukon-Koyukuk-Kobuk (YKK) basin are extensively exposed north of the Bethel lowlands (Hoare and Condon, 1966). Similar rocks of the Kuskokwim (KUS) basin are exposed east and northeast of the lowlands (Hoare and Coonrad, 1959; Decker, 1984). The flysch basins characteristically contain very thick marine and nonmarine graywacke and siltstone sequences derived largely from andesitic arc provenance terranes, and deposited in both fore-arc and back-arc settings. The rocks have been strongly deformed, altered, and locally metamorphosed. Hoare and Condon (1966) and Hoare and others (1964) have described extensive calcareous and laumontite diagenesis in the YKK sequence. Regional structural trends, supported in part by gravity, magnetic, and seismic data, suggest that similar flysch sequences underlie a thin Tertiary cover in parts of the Bethel basin and may extend southwesterly beneath the offshore waters of Kuskokwim Bay and the Bering Sea shelf. The Pan American Napatuk Creek No. 1 well penetrated about 3,900 m of sedimentary rocks at least in part coeval and lithologically similar to the flysch sequences (Fig. 5).

Tertiary sedimentary rocks in the Bethel basin are known only from the Napatuk Creek well, which penetrated 440 m of Miocene and Pliocene diatomaceous clay deposited in a nearshore marine environment. A shallow gravity low surrounds the Napatuk Creek well location (Fig. 4; Barnes, 1977). Similar lows are present northeast and southwest of the well, and indicate that Tertiary fill in the basin probably does not greatly exceed 610 m and may be less over most of the basin. Refraction data in Kuskokwim Bay indicate less than 1 m of low velocity (1.9 km/s) rocks that probably represent Cenozoic cover over Cretaceous flysch (Fig. 6).

Structure. Regional structural trends are southwesterly in the uplands around the basin, and gravity and magnetic data indicate that this trend is present beneath most of the Bethel basin. However, structural trends are westerly to northwesterly at Cape Romanzof, Cape Vancouver, and Cape Newenham, suggesting an oroclinal(?) flexure with an axial trace trending NNW. Structure in the Cretaceous flysch of the YKK and KUS basins is extremely complex, with sharp, commonly faulted anticlines and isoclinal folds. Northeast- and northwest-trending fault sets cut both the Cretaceous flysch and older basement rocks. Extensional rift basins, which are the locus of late Tertiary and Quaternary basalt flows, are associated with some of the larger fault systems, as for example, the Hagemeister-Togiak-Tikchik system (Hoare and Coonrad, 1978). Seismic maps on the Shell and Pan American development contracts define simple southwest-trending anticline-syncline pairs in shallow Tertiary rocks, but report incoherent deeper data. It is presumed that the incoherent data reflect complex structure in Cretaceous flysch, similar to that in outcrop.

Petroleum potential. Thermal maturity and visual kerogen analysis of the Napatuk Creek well indicate that the Tertiary rocks are immature, the Cretaceous (Campanian to Turonian) rocks are mature, and the Cretaceous(?) and older(?) rocks below 1,555 m (5,100 ft) are overmature. All samples are dominated by cellulosic gas-type kerogens. Analysis of outcrop samples from localities around the basin are similar to the Napatuk Creek well data and additionally indicate low organic carbon content and very low porosities and permeabilities (Lyle and others, 1982). These data suggest the potential for dry gas generation in the Late Cretaceous flysch, but complex structure would appear to preclude significant volumes of accumulation.

Kotzebue basin and Selawik trough

Introduction. The Kotzebue basin in northwestern Alaska covers an area of more than 20,000 km^2 beneath Kotzebue Sound, the northern lowland margin of the Seward Peninsula, and the Kobuk River delta east of Kotzebue (Fig. 7). A shallow arm of the basin extends westerly south of the Kotzebue arch beneath the southern Chukchi Sea, beyond the map area shown in Figure 7. If this area were included, the total area of the basin would approximately double (Fig. 2). The basin is a Cenozoic graben or half-graben downwarped across the metamorphic terranes of the southern Brooks Range and the northern Seward Peninsula. Associated gravity lows are the Selawik trough and the Kugarak-Kobuk low east of the basin, and the Noatak low north of the basin.

Stratigraphy. Basement rocks of the basin are probably Paleozoic to Precambrian schist and carbonate rocks like those exposed in the Brooks Range and on the Seward Peninsula. Similar rocks were drilled beneath the Tertiary fill of the basin in both of the Chevron wells. East of the basin, Upper Cretaceous conglomerate with carbonaceous shale, coal, and tuffaceous strata, and Lower Cretaceous flysch are exposed along the Kobuk River and in the Waring Mountains uplift.

The composite Cenozoic section in the basin appears to include three cycles of deposition; age control is not precise, however, and the stratigraphic correlations shown in Figure 9, which are based on a combination of lithology, palynology, and vitrinite reflectance data, are tentative. The early(?) Tertiary cycle is represented by 915 m of Eocene volcanic and volcaniclastic rocks in the Cape Espenberg well. The middle Tertiary cycle is represented by about 1,200 m of Pliocene to Oligocene conglomeratic sandstone, carbonaceous shale, and coal. The late Tertiary cycle is represented by about 600 m of Pliocene(?) and Pleistocene marine sandstone and shale in the Nimiuk Point well. The late Tertiary cycle is clearly represented on segment A-B of

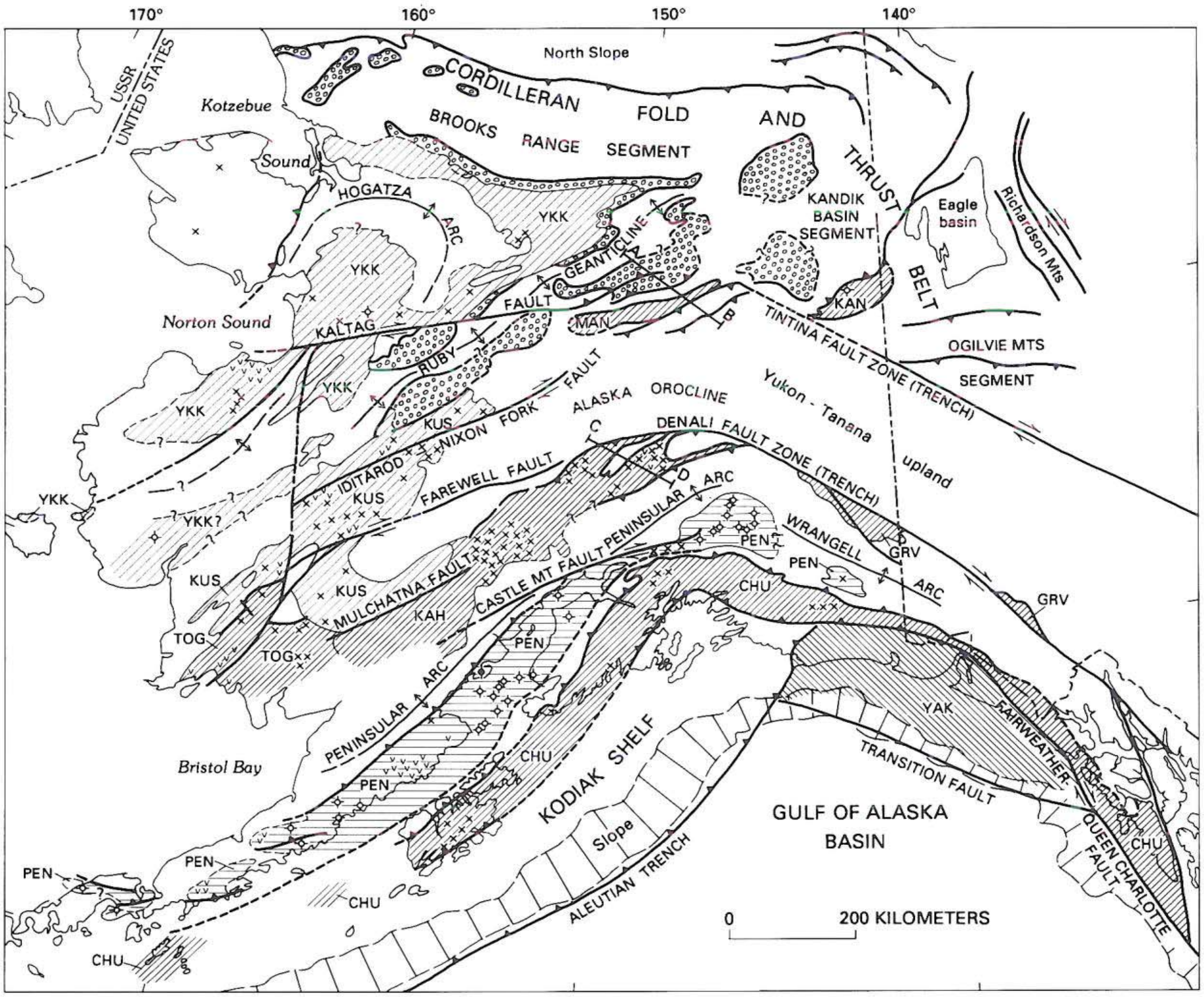


Figure 3. Map showing Mesozoic basins, terranes, and structural features of interior and southern Alaska.

the seismic line (Fig. 8) by faint, essentially horizontal reflectors to a maximum depth of about 1 sec. The middle Tertiary cycle is represented by strong distinctive reflectors from 1 to 2+ sec, which show gentle folding, minor faulting, and irregularity in continuity probably related to the nonmarine deltaic nature of the strata.

The western end of the Selawik trough is shown in segment B-C (Fig. 8), which defines a rift-graben complex with a little more than 2 sec or about 2,700 m of Cenozoic fill. Barnes and Tailleur (1970) have modeled the 50-milligal Noatak gravity low and interpret about 3 km of less dense fill. Ellersieck and others (1979) report an Upper Cretaceous or Tertiary outcrop on the Noatak River at the location of the gravity low. Patton (1973) reports small deposits of coal-bearing strata containing early Tertiary pollen at Elephant Point and on the Mangoak River near the south margin of the Selawik trough.

Structure. The broad structural pattern of the Kotzebue basin is a complex Tertiary extensional half-graben. The Selawik trough is a graben complex whose linearity, as defined by gravity, suggests a rift-graben. The en echelon Kobuk low is probably a similar feature. The Kobuk fault zone (Patton, 1973) trends easterly about 320 km along the south margin of the Brooks Range, from the Kobuk gravity low. Throughout its length the fault zone localizes Late Cretaceous nonmarine trough deposits. Comparison of Precambrian–Lower Paleozoic structural trends in the southern Brooks Range and the Seward Peninsula suggests a component of dextral offset. The Kotzebue basin appears to represent extension at the trailing edge of the north block, analogous to the Norton Sound basin at the trailing edge of the north block on the dextral Kaltag fault (Fig. 2; Fischer and others, 1982).

Petroleum potential. No pre-Tertiary source rocks can be predicted for the basin, and so the only known generative rocks

EXPLANATION

Mildly to moderately deformed rocks of the Peninsular terrane, locally petroliferous, common laumontite grade diagenesis

Moderately to complexly and isoclinally folded and faulted rocks. Pervasive laumontite and local higher grade metamorphism

- YKK **Yukon-Koyukuk-Kobuk basin**
- KUS **Kuskowim basin**

Pervasively deformed and structurally disrupted rocks; laumontite to amphibolite grade metamorphism

- CHU **Chugach terrane**
- GRV **Gravina-Nutzotin belt**
- KAH **Kahiltna terrane**
- TOG **Togiak terrane**
- KAN **Kandik River terrane**
- MAN **Manley terrane**
- YAK **Yakutat terrane**

Andesitic or basaltic rocks of all ages

Intrusive rocks of all ages

Ophiolite assemblage rocks

Contact—Approximately located. Dashed where speculative

Fault—Sense of throw not defined. Dashed where speculative

Strike-slip fault—Arrows show relative movement. Dashed where speculative

Thrust fault—Sawteeth on upper plate. Dashed where speculative

Normal fault—Hachures on downthrown side. Dashed where speculative

Trend of (volcanic-plutonic) arc and/or geanticline

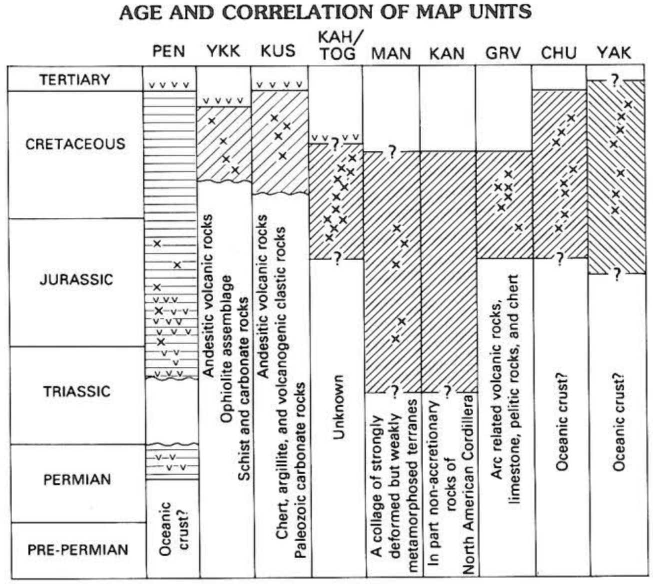
Abandoned exploratory well

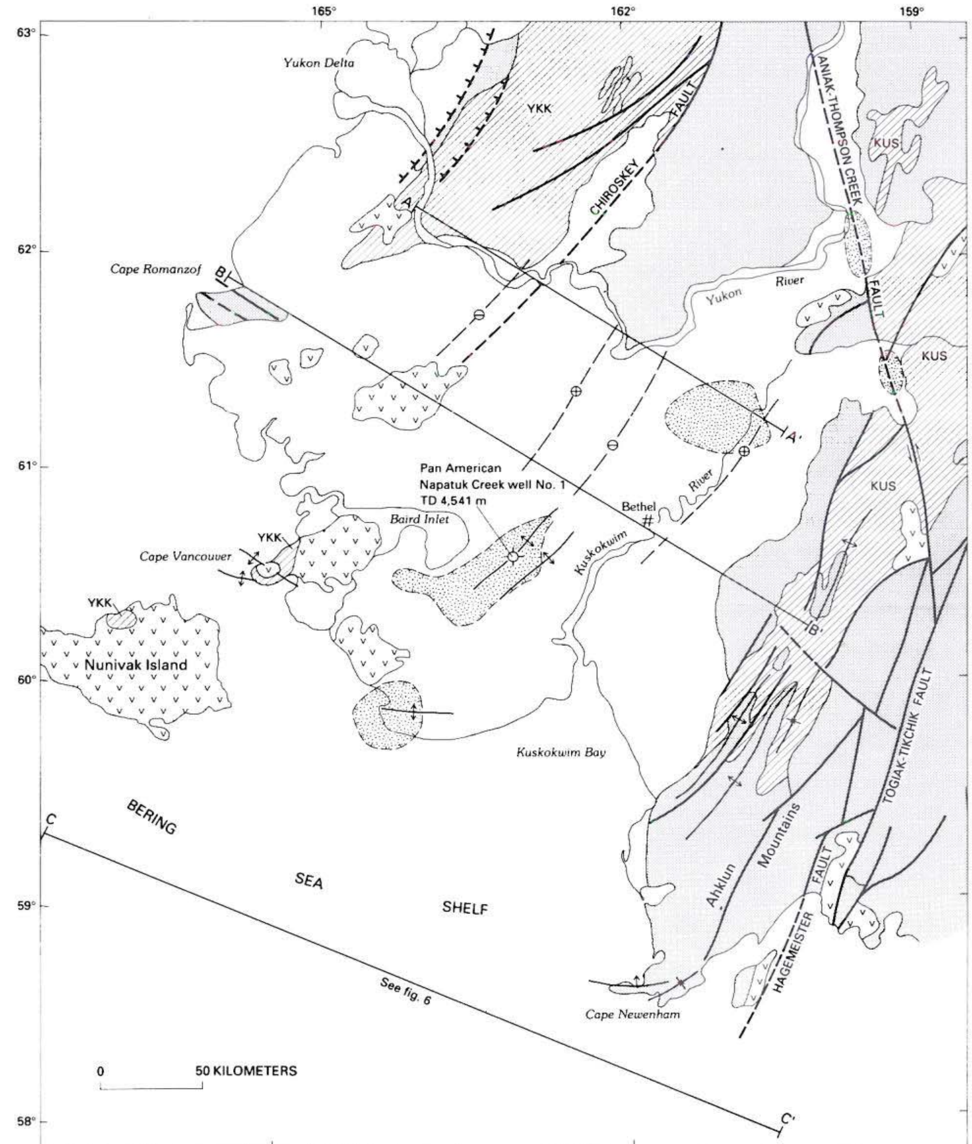
Abandoned exploratory well that produced a small volume of high, 50°API, oil

A B **Beaver creek suture zone**

C D **Central Alaska Range megasuture zone**

AGE AND CORRELATION OF MAP UNITS





EXPLANATION

- Quaternary deposits
- Quaternary and Tertiary volcanic rocks
- Cretaceous flysch and molasse strata of the Yukon-Koyukuk-Kobuk (YKK) basin, and the Kuskokwim (KUS) basin
- Lower Cretaceous and older basement rocks
- Shallow gravity low that probably represents about 600+m of Cenozoic (mainly Tertiary) sedimentary strata
- Contact—Approximately located
- Fault—Sense of throw not defined. Dashed where speculative
- Strike-slip fault—Arrows show relative movement. Dashed where speculative
- Normal fault—Hachures on downthrown side. Dashed where speculative
- Anticline
- Syncline
- Structural trend
- Positive magnetic trend
- Negative magnetic trend
- A A' / C C' Magnetic profile lines (see figure 6)
- B B' Refraction profile line (see figure 6)

Figure 4. Generalized geologic map of Bethel basin showing gravity lows and locations of refraction and magnetic profiles.

would have to be the Tertiary basin fill and coal-bearing strata of Miocene to Oligocene age. Vitrinite reflectance data (Fig. 9) indicate that the Tertiary rocks are immature, and so the most likely potential in the Kotzebue basin is for dry gas.

Middle Tanana basin, Ruby-Rampart trough, Cantwell trough, and Northway lowlands

Introduction. The Middle Tanana basin of central Alaska is an alluvial and swampy lowland area of about 22,000 km^2 north of the central Alaska Range and south and west of the city of Fairbanks and the Yukon-Tanana upland (Fig. 10). The basin is drained by the Tanana River, which collects a large outflow of glacial meltwater from rivers flowing north out of the Alaska Range.

The eastern part of the basin between Nenana and Big Delta is believed to have a thin Cenozoic section on the basis of the local outcrop of basement monadnocks and of a shallow magnetic signature (Andreason and others, 1964). North of Nenana, the Minto gravity low in excess of 50 milligals suggests about 3 km of late Cenozoic fill. At the south margin of the basin near Healy, about 700 m of the Usibelli Group (in Nenana coal field) and as much as 1,200 m of the overlying Nenana Gravel are present in outcrop. The Ruby-Rampart trough northwest of the basin and the Cantwell trough south of the basin contain significant thicknesses of early Tertiary rocks.

The Northway lowlands on the Tanana River is a lowland area of about 3,000 km^2 near the Canada-Alaska international boundary, referred to by Miller and others (1959) as the upper Tanana basin (Fig. 10). Methane trapped by permafrost was encountered in a well drilled for water at a depth of about 60 m. A second well drilled by Alaska Propane Co., Inc. about 5 km northwest of the first well also encountered gas at about the same depth.

Stratigraphy. Basement pre-Tertiary rocks north and south of the Middle Tanana basin are thoroughly metamorphosed rocks of the Yukon-Tanana terrane. The Union Nenana No. 1 well bottomed in schist that is probably part of this terrane. Northwest

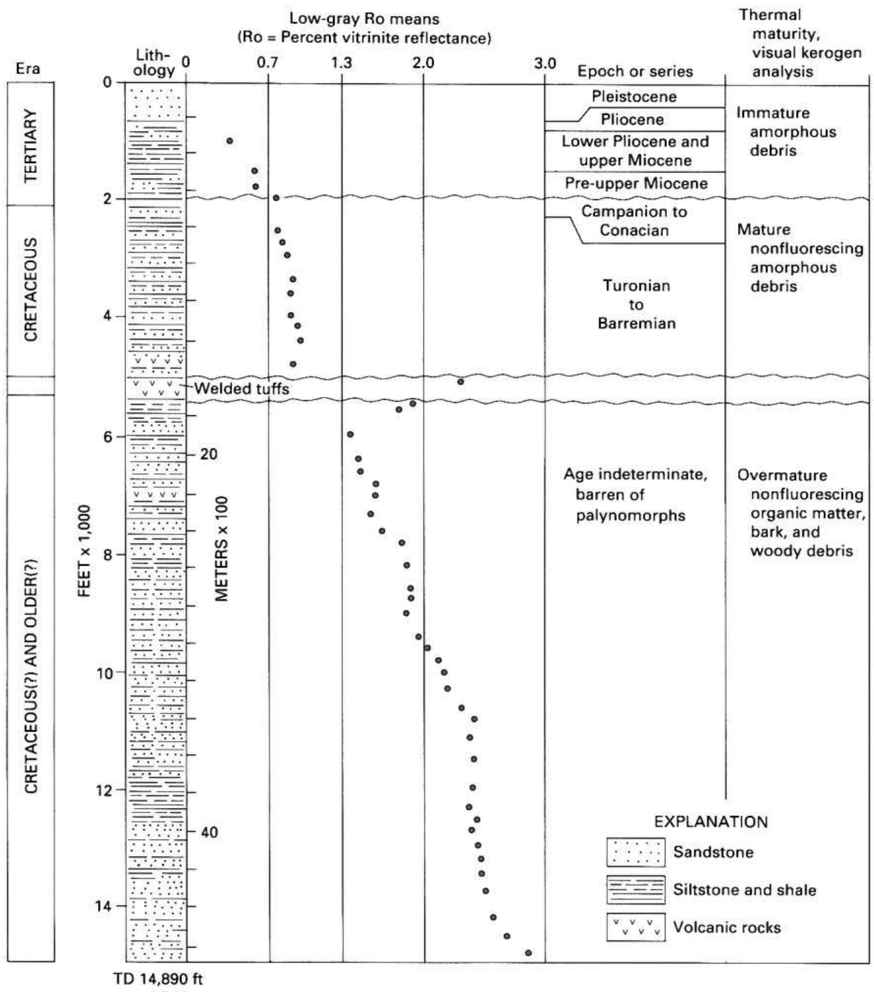


Figure 5. Lithologic log, stratigraphic column, and vitrinite reflectance of Pan American–Napatuk Creek No. 1 well, located southwest of Bethel (Fig. 4, this chapter).

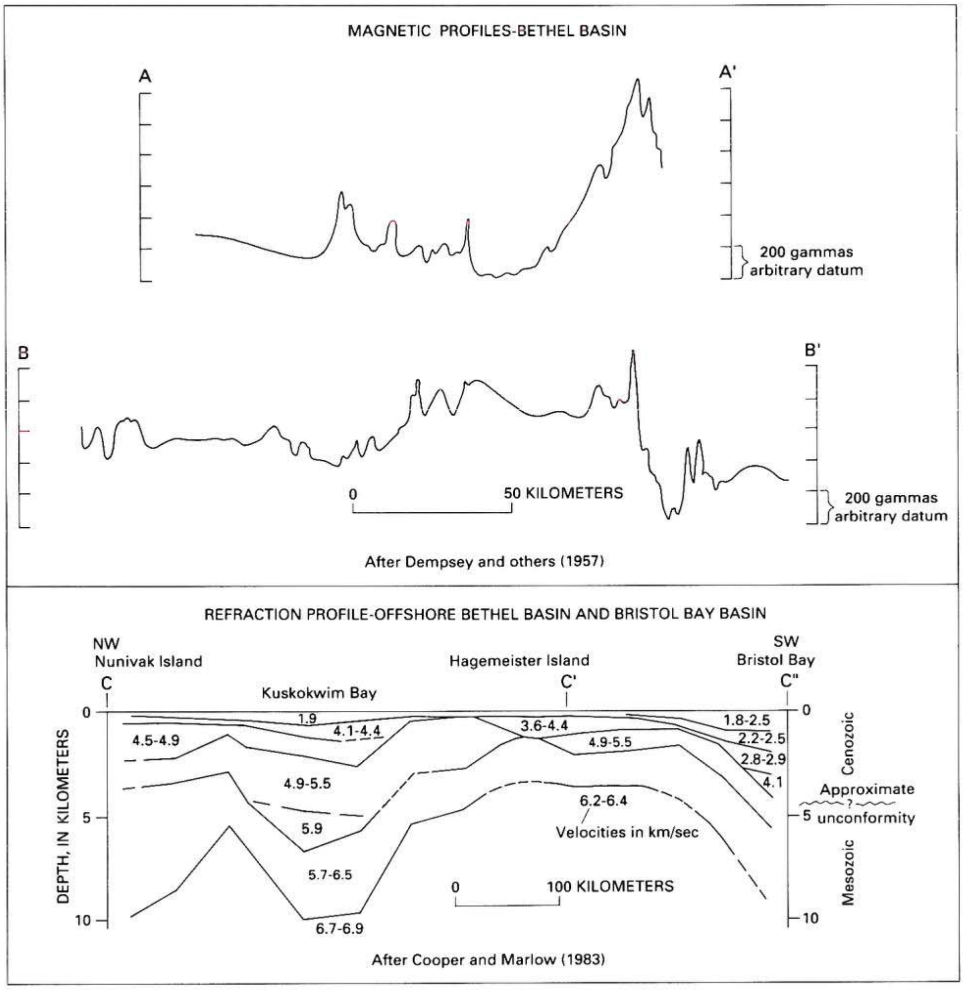


Figure 6. Magnetic (A–A′ and B–B′) and seismic refraction (C–C′–C″) profiles of Bethel and Bristol Bay basins (see Figs. 2 and 4).

of the basin, a collage of disparate Mesozoic and Paleozoic terranes, referred to by Churkin and others (1982) as the Beaver Creek suture zone, crops out in the Livengood and Tanana Quadrangles.

Nonmarine sedimentary fill in the Middle Tanana basin and adjacent areas represents three cycles of Tertiary sedimentation (Fig. 11). The early cycle is represented by outcrops in the Ruby-Rampart trough and the Cantwell trough. The mid-Tertiary cycle is represented by the Usibelli (coal-bearing) Group of the Healy coal basin and the coal-bearing section in the Union Nenana No. 1 well. The late Tertiary cycle is represented by the Nenana Gravel. The depositional cycles are punctuated by orogenic episodes in late Eocene and late Miocene time. Following each orogenic episode the depocenter for the succeeding cycle of deposition shifted, so it cannot be predicted that the deepest part of the Middle Tanana basin will contain early-cycle sedimentary deposits, and it is likely the coal-bearing beds of the Nenana coal field and the Union Nenana No. 1 well were deposited in separate basins (Wahrhaftig and others, this volume).

Early-cycle rocks of the Cantwell Formation average 600 to 1,500 m but are locally as much as 3,000 m in thickness. The formation consists of nonmarine, coal-bearing, clastic and volcanic rocks in the upper part of the formation (Wolfe and Wahrhaftig, 1970). The volcanic rocks have been designated the Teklanika Formation (Gilbert and others, 1976). The formation is complexly folded and is well indurated. Approximately equivalent-age rocks (early cycle) along the Yukon River in the Ruby-Rampart trough consist of about 900 to 1,500 m of conglomeratic sandstone, shale, and coal in thick, fluvial, fining-upward sequences (Page, 1959). Early Tertiary volcanic and volcaniclastic rocks are also recognized in the Ruby-Rampart trough (Chapman and others, 1971, 1982).

Mid-Tertiary cycle rocks of the Usibelli Group near Healy are subdivided into five formations (Fig. 11; Wahrhaftig and

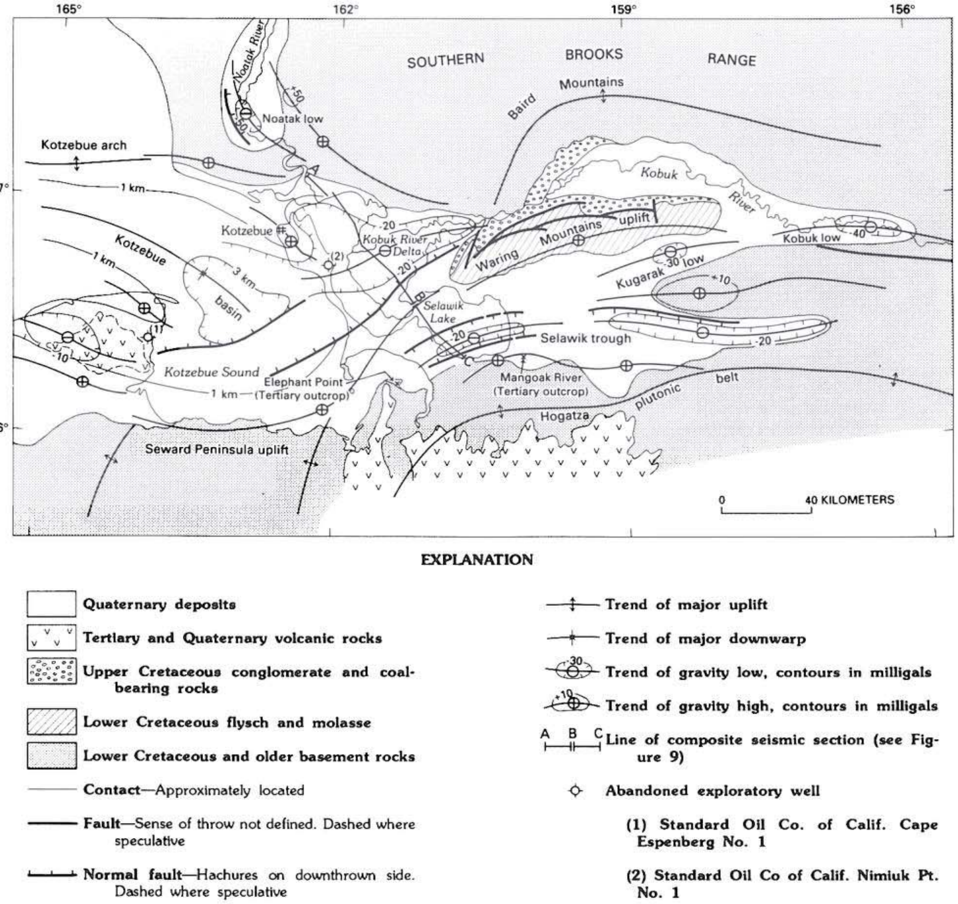


Figure 7. Generalized geologic map of Kotzebue basin, Selawik trough, and adjacent areas showing gravity trends and isopachs of Cenozoic basin fill at 1 and 3 km thickness.

others, 1969, this volume). The group is about 700 m thick and consists primarily of interbedded conglomeratic sandstone, shale, and coal in thick, fluvial, fining-upward sequences. Coal rank ranges from lignite to sub-bituminous B. Two formations, the Sanctuary Formation in the lower part of the group and the Grubstake Formation at the top of the group, are lacustrine shales that total about 60 m in thickness. Paleocurrent data indicate that a northerly provenance terrane, probably the Yukon-Tanana uplands, supplied sediment to the coal-bearing group in the Healy area during the Miocene (Wahrhaftig and others, 1969).

Late Tertiary-cycle rocks are represented by the Nenana Gravel, which is as much as 640 m thick in outcrop along the north front of the Alaska Range and at least 450 m thick in the Union, Nenana No. 1 well. The formation consists primarily of thick conglomerate and conglomeratic sandstone beds with minor lenticular interbeds of shale and lignite. The rocks were derived from the rising Alaska Range and deposited in large alluvial fans along the north flank of the range, and are regionally unconformable on the underlying coal-bearing group.

Structure. The structure of the Minto gravity low north of Nenana may be an extensional half-graben or graben complex (Fig. 12). Structure to the south in the coal-bearing group of the Healy area is a series of northeast- to east-trending folds and minor normal faults of latest Miocene and Pliocene age. Structure in the early Tertiary rocks in the Cantwell trough and the Ruby-Rampart trough is complex and reflects a period of strong folding and volcanism of Eocene age. The early Tertiary basins are strongly deformed and eroded to a fraction of their former depositional extent.

Petroleum potential. Miller and others (1959, p. 84–86) report an oil seep on Totatlanika Creek and provide an analysis of oil from an oily sand and gravel sample from that locality. An oil seep near the mouth of the Nenana River and oil-saturated tundra on the Wood River have also been reported but never confirmed. The most likely source rocks for oil or gas are coal beds and lacustrine shales. Coal rank ranges from lignite to sub-bituminous B in the Healy coal fields, so that methane is the most likely hydrocarbon product that the coals could generate. The

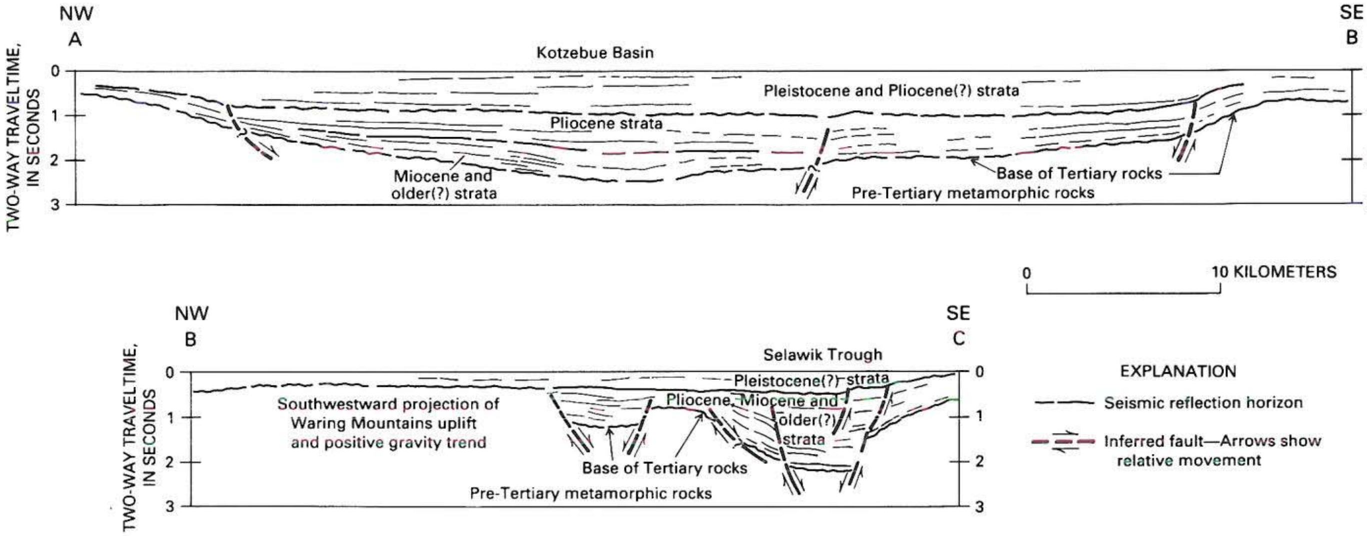


Figure 8. Interpretation of regional composite seismic line A–B–C (line location shown on Fig. 7) across eastern Kotzebue basin and western Selawik trough.

lacustrine beds in outcrop are relatively thin and have rather low (as much as about 2 percent) organic carbon content, but could be thicker and have a higher organic carbon content in the unexplored subsurface. An optimistic evaluation is that gas reserves of economic importance for local consumption could be present.

Minchumina, Holitna, and Innoko basins

Introduction. The Minchumina basin is a large Cenozoic basin of about 21,000 km^2 northwest of the central Alaska Range and Mt. McKinley, and southeast of the Kuskokwim Mountains (Fig. 13). It merges with the middle Tanana basin on the northeast and the Holitna basin on the southwest. The Holitna basin is a small Cenozoic basin of about 5,000 km^2 astride the Farewell fault zone (Fig. 14). The Minchumina basin has topographic and geologic similarities to the Nenana basin, having local basement metamorphic rock monadnocks and local sharp gravity lows that suggest a few kilometers of Cenozoic fill in small extensional basins. The most conspicuous feature of the Holitna basin is a long, narrow gravity trough localized along the trend of the Farewell fault zone, which suggests a rift-graben with a few kilometers of Cenozoic fill. Small outcrops of middle(?) and late Tertiary nonmarine coal-bearing strata are present locally along the Farewell fault zone, on trend with the Holitna basin. The Innoko basin is a lowland area of about 6,000 km^2 in the Kuskokwim Mountains, 150 km west of the Minchumina basin (Fig. 2). It localizes an elongate gravity low having about 20 milligals of relief that could represent as much as 2 km of Cenozoic fill. Surrounding terranes are metamorphic and volcanic rocks (Chapman and others, 1985).

Stratigraphy. The northeastern part of the Minchumina basin is underlain by metamorphic rocks of the Yukon-Tanana

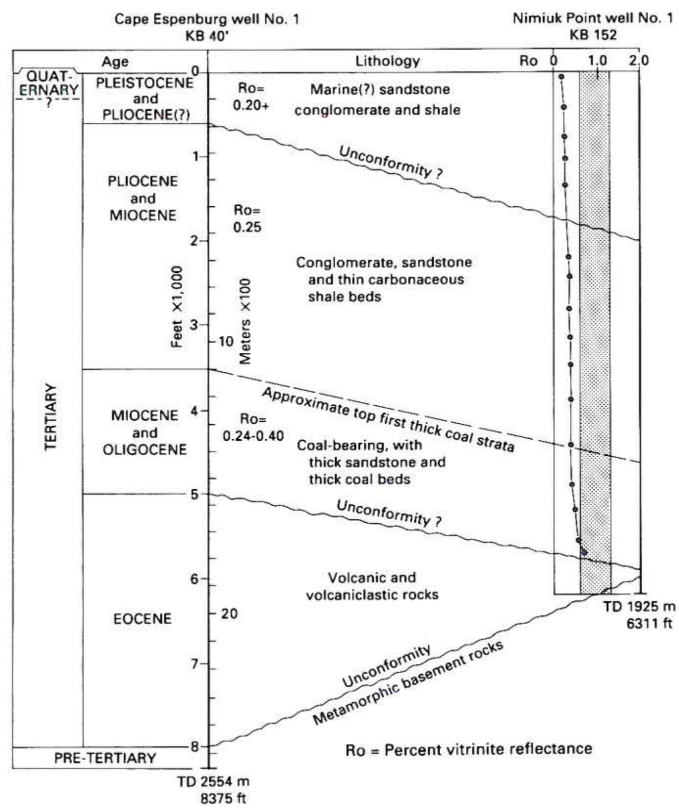
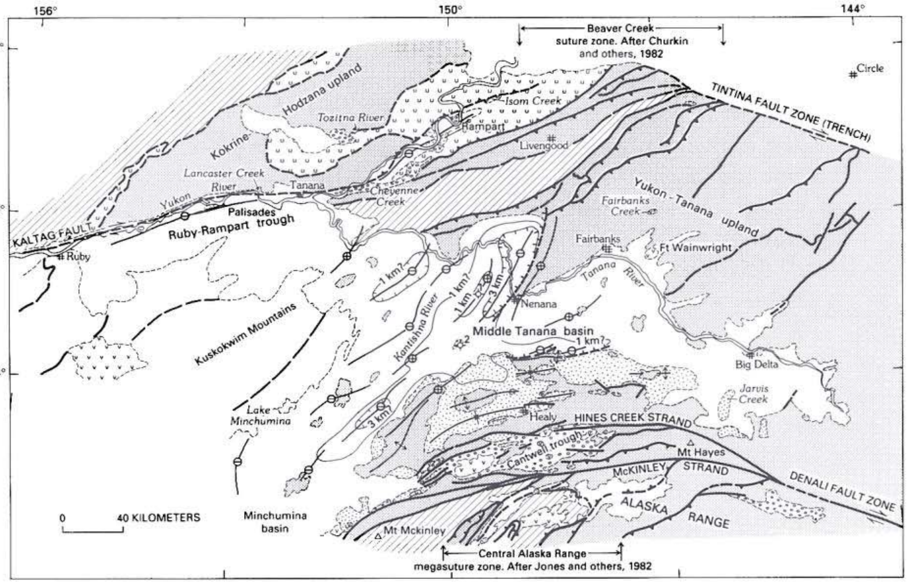


Figure 9. Well correlation section of Standard Oil Company of California Cape Espenburg No. 1 and Nimiuk Point No. 1 wells in the Kotzebue basin (Fig. 7 shows well locations).



EXPLANATION

Quaternary deposits

Upper Tertiary rocks—Upper Miocene to Upper Oligocene nonmarine coal-bearing and lacustrine strata of the Usibelli Group (Wahrhaftig, 1986) in the Healy coalfields of the Middle Tanana basin, and equivalent age nonmarine strata in the Ruby-Rampart trough, the Tintina trench, and the Yukon Flats basin

Lower Tertiary rocks—Paleocene nonmarine coal-bearing strata of the Cantwell Formation (Wolfe and Wahrhaftig, 1970) in the Cantwell trough, and nonmarine strata of early Tertiary and Late Cretaceous age in the Ruby Rampart trough and the Tintina trench (Brabb and Churkin, 1969) (See also fig. 15)

Tertiary volcanic and volcaniclastic rocks

Mesozoic rocks—Mainly Lower Cretaceous and Upper Jurassic flysch and molasse strata, mildly to strongly deformed and metamorphosed. Includes the Kandik Group of the Kandik River terrane thrust belt (Churkin and others, 1982), the Manley terrane in the Livengood area, and the Kaliltna terrane in the central Alaska Range (Jones and others, 1987)

Mesozoic and Paleozoic rocks—Jurassic to Mississippian structurally and stratigraphically complex ophiolite assemblage rocks. Angayucham terrane (Am) and Tozitna terrane of Jones and others, (1987). Tozitna terrane includes the Rampart Group of Brosge'and Reiser, (1969)

Lower Mesozoic, Paleozoic, and Late Proterozoic rocks—Metamorphosed assemblages of accretionary terranes undivided. Juxtaposed in complex suture (Churkin and others, 1982) or megasuture zones (Jones and others, 1982; see fig. 11)

Contact—Approximately located

Fault—Sense of throw not defined. Dashed where inferred

Thrust fault—Sawteeth on upper plate. Dashed where inferred

Strike-slip fault—Arrows show relative movement. Dashed where inferred

Normal fault—Hachures on downthrown side. Dashed where inferred

Anticline

Syncline

Trend of gravity high

Trend of gravity low

3 km **Isopach of Cenozoic section, in kilometers**—Hachures indicate depression

Wells in middle Tanana basin

1 **Union, Nenana No. 1**

2 **Arco, Totek Hills No. 1**

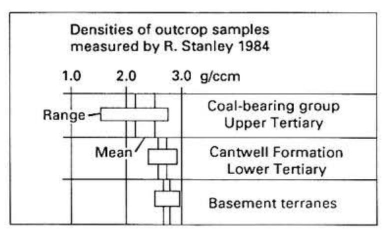


Figure 10. Generalized geologic map showing gravity and structural trends of the Middle Tanana basin, Ruby-Rampart trough, and adjacent upland terranes.

terrane that crop out in monadnocks surrounded by Quaternary alluvial deposits. Southwest of the Minchumina suture zone (Bundtzen and Gilbert, 1983), the Nixon Fork and Dillinger terranes probably underlie much of the Cenozoic fill in the basin, where several gravity lows suggest thick Tertiary fill. The Nixon Fork terrane represents a Paleozoic carbonate platform sequence, and the Dillinger terrane a basinal turbidite shale-out facies (Bundtzen and Gilbert, 1983; Churkin and others, 1984). Henning and others (1984) concluded that these rocks are overmature and have poor reservoir characteristics.

Flysch of the Cretaceous Kuskokwim Group may underlie parts of the Holitna and Minchumina basins. Generally, this flysch is strongly deformed and extensively intruded. Overall, these Cretaceous flysch rocks are unlikely to have oil source or reservoir rocks, or to provide a petroleum source for the overlying Tertiary fill.

Tertiary rocks of the Minchumina and Holitna basins appear to represent three cycles of deposition. Paleocene rocks of the Cantwell Formation are known only in the Cantwell trough northeast of the basin and represent the early cycle. Although not recognized farther southwest along the Farewell fault zone, it would not be surprising to find early-cycle rocks in the rift graben of the Holitna basin trough. A middle Tertiary cycle is represented by nonmarine deposits of conglomerate, sandstone, siltstone, and lignite (Dickey and others, 1982). The middle(?) Tertiary rocks were derived from northerly metamorphic provenance terranes and deposited by southerly flowing braided streams. The late Tertiary cycle consists of conglomerate that represents alluvial fan deposition from the rising Alaska Range on the southeast. The middle(?) and late Tertiary rocks are about 1,800 m thick along the Farewell fault zone near Farewell. Smith and others (1985) interpret as much as 4,500 m of Tertiary rocks in the Holitna basin trough, which has a maximum of about 40 milligals negative relief. Several gravity lows in the Minchumina

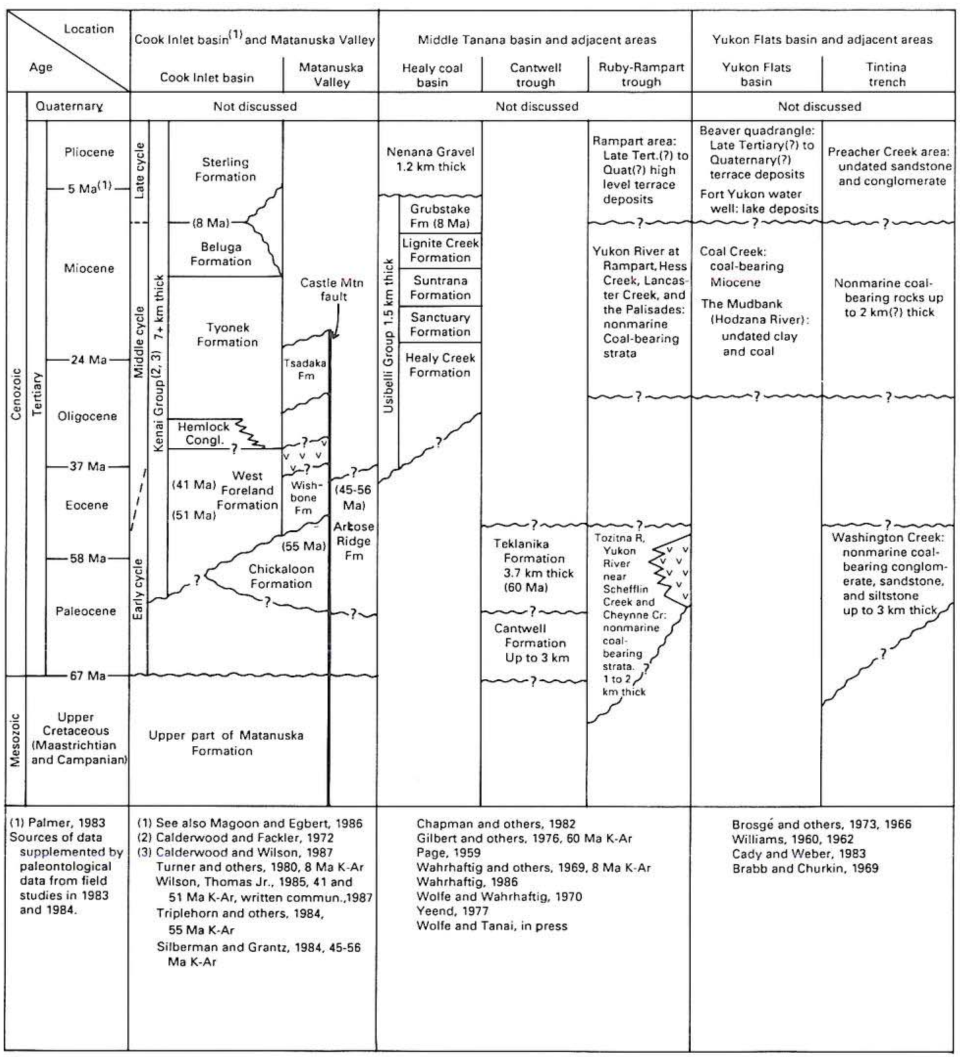


Figure 11. Correlation chart of the Tertiary and Upper Cretaceous stratigraphic units of Cook Inlet basin, Middle Tanana basin, Yukon Flats basin, and adjacent areas.

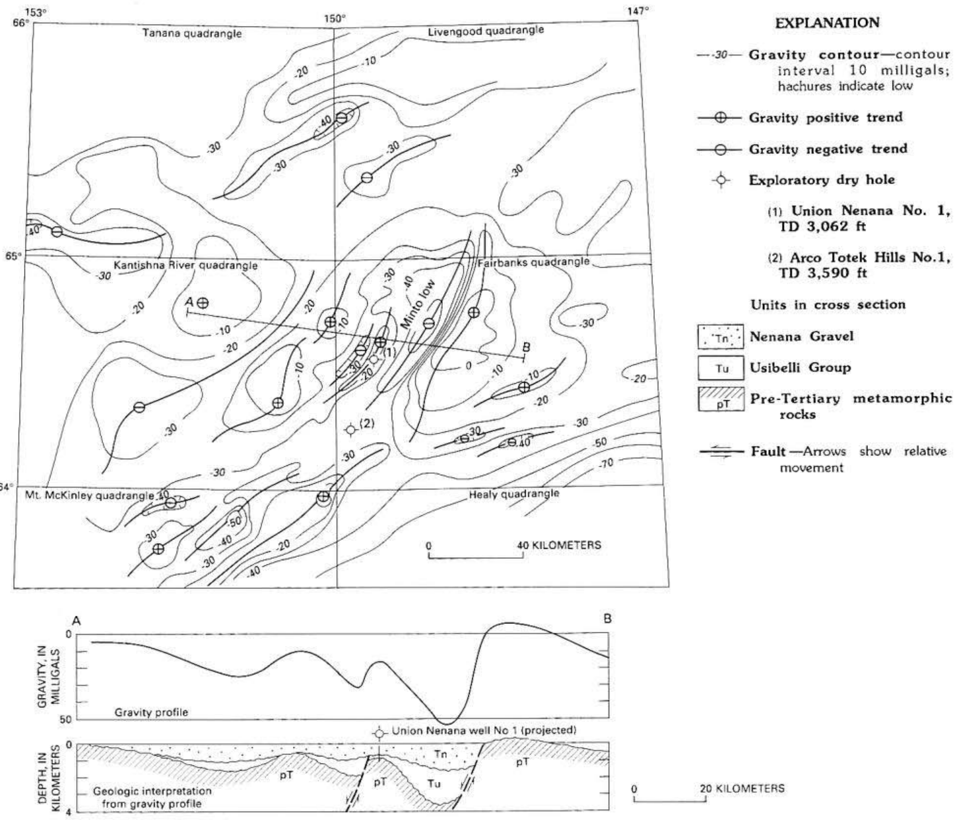


Figure 12. Gravity map of the western part of the Middle Tanana basin with gravity profile and cross-section interpretation of the Minto gravity low.

basin have 20 to 30 milligals negative relief, and so by comparison, may be expected to have 1,800 to 3,000 m of middle to late Tertiary fill.

Structure. Regionally, the Minchumina basin lies between the dextral Iditarod–Nixon Fork fault zone on the northwest and the dextral Farewell fault zone–Denali fault complex on the southeast. Henning and others (1984) have noted that steep gravity gradients associated with basement highs suggest large-displacement, high-angle block faulting and folding in the subsurface, possibly an extensional horst-and-graben complex having north- to northeast-trending structures imposed by dextral strain.

Petroleum potential. The areas of either the Minchumina or the Holitna basin that could have 3 km or more of nonmarine Tertiary fill are less than 1 percent of the total basin area. Although coal-bearing beds in these basins could generate gas, and fluvial sandstones are likely reservoirs, the size of any accumulation would probably be small; it is concluded that the Minchumina basin potential, at best, is limited to small gas prospects.

Yukon Flats basin and Tintina trench

Introduction. The Yukon Flats basin of east-central Alaska is an alluvial and marshy, lake-dotted lowland of more than 22,000 km^2, south of the southern Brooks Range and north of the Yukon-Tanana upland (Fig. 15). The basin is confined on the west by the Kokrine-Hodzana highlands and on the east by the Kandik thrust belt, a hinterland segment of the Cordilleran fold and thrust belt of Northwest Territories, Canada. On the basis of gravity modeling (Fig. 16), it is suspected the Yukon Flats basin may have as much as 3 km of Cenozoic fill. Hite and Nakayama (1980) report that seismic data along portions of the Yukon River indicate that the Cenozoic section locally may be as much as 4.5 km thick. The Tintina fault system and trench trends southeasterly from the southern margin of the basin and from the northern edge of the Beaver Creek suture zone (Churkin and others, 1982). The Tintina trench contains both late Tertiary and early Tertiary to late Cretaceous (Maastrichtian) nonmarine coal-bearing clastic rocks that are about 1.0 km thick in outcrop (Brabb and Churkin, 1969) and may be as thick as 3.0 km in the Circle Hot Springs gravity low (Cady and Weber, 1983).

Stratigraphy. Basement terranes north, west, and south of the Yukon Flats basin are low- to high-grade metamorphic terranes and mostly cannot be considered potential source beds for overlying Tertiary reservoir rocks. One unlikely exception is the presence of tasmanite (TA) in the Tozitna terrane (TZ) near Christian quadrangle (Fig. 15). Tasmanite is an oil shale that may yield a significantly higher volume of oil per unit volume than normal oil shales. The occurrence near Christian has been known for many years and is recorded in Mertie (1927). Apparently, the outcrops are extremely small and limited in extent; follow-up effort by geologists of the U.S. Geological Survey (Tailleur and others, 1967) and the U.S. Bureau of Mines (Donald W. Braggs and Donald P. Blasko, oral communication, 1986) have not been able to delineate additional deposits. The occurrence of the tasmanite in rocks of the Tozitna terrane is of interest because this terrane is present in outcrop around the north, west, and south margins of the basin, and it has a distinctive magnetic signature that can be correlated with the outcrop pattern and traced beneath the Tertiary fill over part of the basin (Fig. 17). Consequently, if larger occurrences of tasmanite were present in the Tozitna terrane in the subsurface, there is a remote potential for pre-Tertiary source beds in part of the basin.

The Porcupine terrane (PC) in the Kandik segment of the Cordilleran fold and thrust belt east of the basin includes Precambrian metamorphic rocks overlain by a thick, structurally and stratigraphically complex assemblage of limestone, dolomite, and shale of Cambrian to late Devonian age. Pennsylvanian and Permian rocks include shale, argillite, limestone, quartzite, and conglomerate. Two exploratory test wells have been drilled in rocks of the Porcupine terrane: the Louisiana Land and Exploration Company Doyon Nos. 2 and No. 3, which encountered Devo-

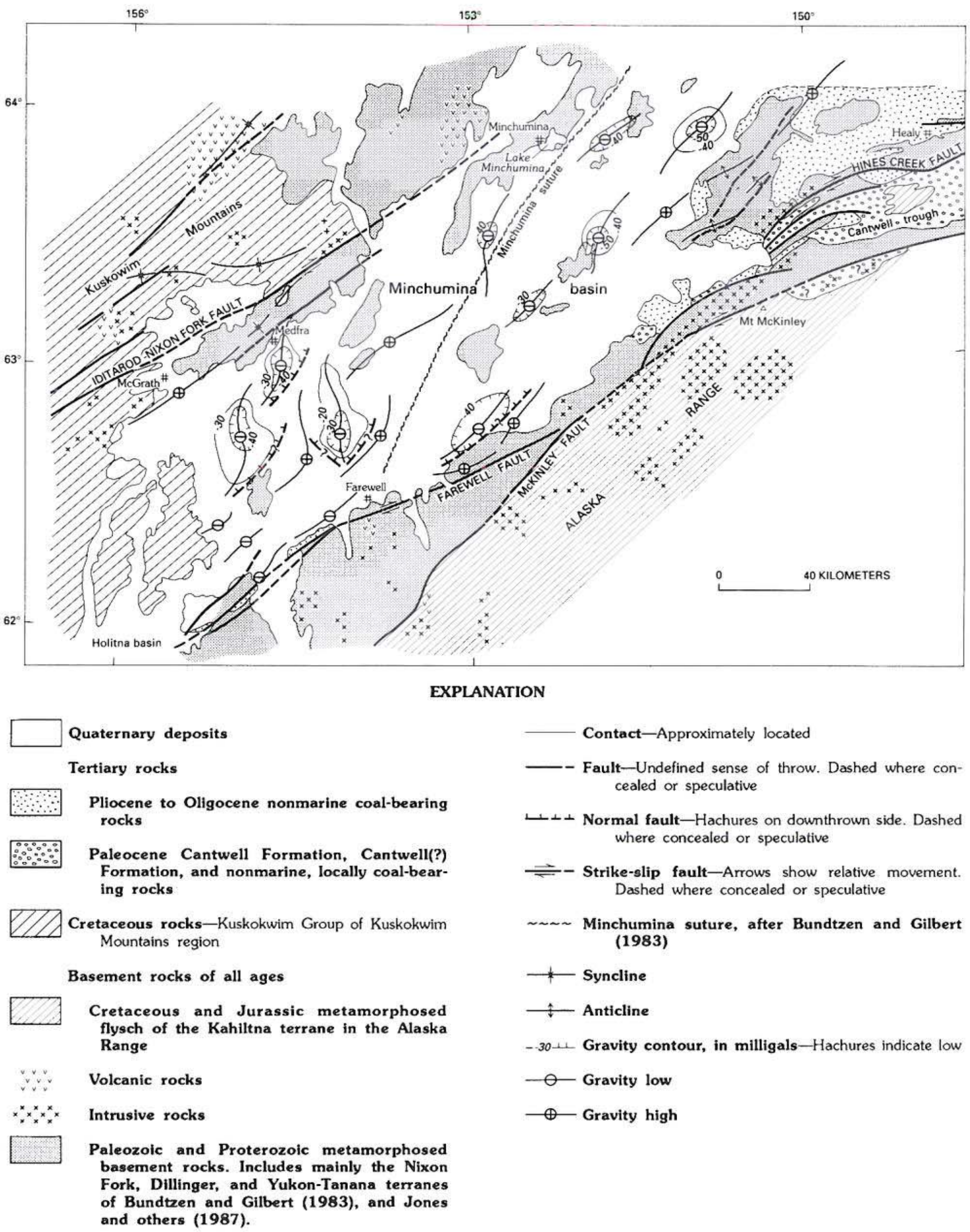


Figure 13. Generalized geologic map of Minchumina basin showing gravity and regional structural trends in adjacent upland terranes.

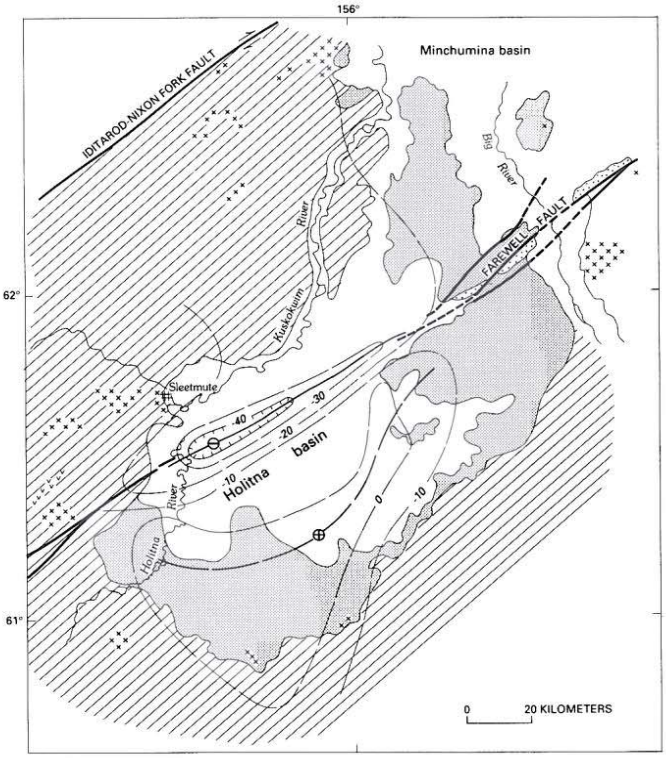
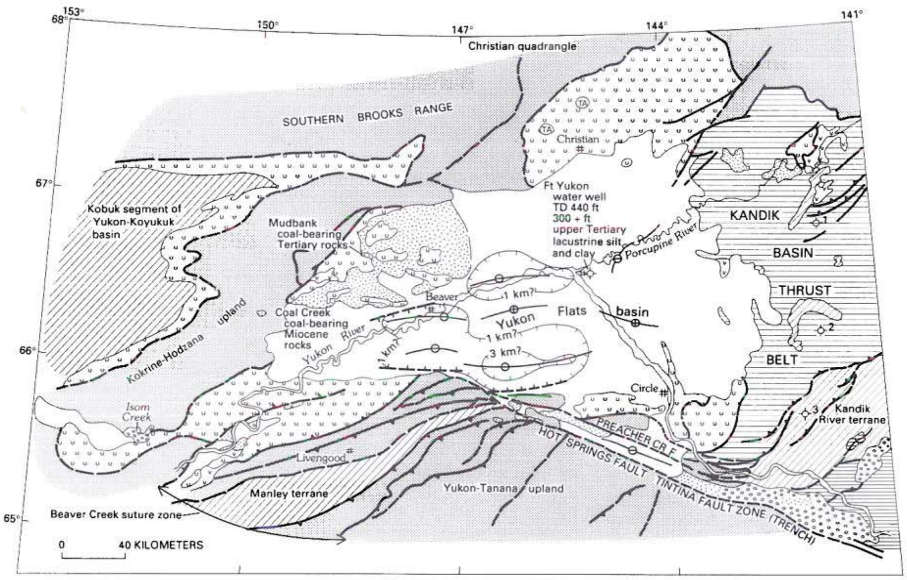


Figure 14. Generalized geologic map of Holitna basin showing gravity trends and surrounding upland terranes.

nian sandstone and shale, and Devonian, Silurian, Ordovician, and older(?) limestone and dolomite. A minor indication of dead oil is reported in the cuttings from the Doyon No. 2 well.

Nonmarine Tertiary sediments are locally present in small, widely scattered outcrops around the margin of the Yukon Flats basin, and in the Tintina trench. As in the Nenana basin, three cycles of sedimentation are suspected. An early cycle of latest Cretaceous (Maastrichtian) and early Tertiary age is represented by at least 1.0 km of conglomerate, sandstone, shale, and minor coal beds in the Tintina trench (Brabb and Churkin, 1969). These rocks are strongly folded and moderately indurated so that their average densities are comparable to densities of the Cantwell Formation (Fig. 10). A middle Tertiary cycle of Miocene age may be represented by coal-bearing beds at Coal and Mudbank Creeks in the Beaver Quadrangle, and in outcrops in the Tintina trench and in the Coleen Quadrangle northeast of Fort Yukon. The rocks consist primarily of conglomerate, sandstone, coal-bearing siltstone or shale, and lacustrine silt and clay. In the Coleen Quadrangle, lacustrine beds contain Miocene(?) clams (Brosgé and Reiser, 1969). As much as 2.0 km of section has been recognized in the Tintina trench southwest of the Preacher Creek fault. A late Tertiary cycle is probably represented by high-level sand and gravel deposits of Tertiary(?) and Quaternary(?) age in the Beaver Quadrangle (Brosgé and others, 1973) and by late Tertiary lake deposits in a water well at Fort Yukon (Williams, 1960).

Structure. The Yukon Flats basin appears to represent an extensional graben complex at the northwesterly terminus of the dextral Tintina fault system. It is interpreted to be a typical pull-apart basin or rhomb-graben. Sharp topographic breaks associated with steep gravity gradients on the northwest and southeast flanks of the regional gravity low are interpreted to represent normal faults (Fig. 16). Beneath the Tertiary fill of the basin there are divergent magnetic fabrics (Fig. 17). Beneath the central and eastern parts of the basin there is a distinctive northwesterly trending magnetic fabric that may be in part Tozitna(?) terrane and in part other, unknown, terrane(s). In the Kandik thrust belt the magnetic fabric trends northeast. The magnetic fabric in the basin and in the Kandik thrust belt suggests that the Porcupine terrane of the Kandik thrust belt may not project southwesterly beneath the eastern part of the Yukon Flats basin. The magnetic trends also do not support the extension of the Kaltag fault in Canada (Norris, 1985) beneath the basin to join the Kaltag fault of west-central Alaska (Patton and Hoare, 1968), as has been proposed by numerous authors (see, for example, McWhae, 1968). In contrast, the Tintina fault system has a strong gravity and magnetic signature (Cady and Weber, 1983) that ends in the northwest corner of the Circle Quadrangle, where it appears to merge with



EXPLANATION

Quaternary deposits

Upper Tertiary rocks—Upper Miocene to Upper Oligocene nonmarine coal-bearing and lacustrine strata of the Usibelli Group (Wahrhaftig, 1986) in the Healy coalfields of the Middle Tanana basin, and equivalent age nonmarine strata in the Ruby-Rampart trough, the Tintina trench, and the Yukon Flats basin

Lower Tertiary rocks—Paleocene nonmarine coal-bearing strata of the Cantwell Formation (Wolfe and Wahrhaftig, 1970) in the Cantwell trough, and nonmarine strata of early Tertiary and Late Cretaceous age in the Ruby Rampart trough and the Tintina trench (Brabb and Churkin, 1969)(See also fig. 10)

Tertiary volcanic and volcaniclastic rocks

Mesozoic rocks—Mainly Lower Cretaceous and Upper Jurassic flysch and molasse strata, mildly to strongly deformed and metamorphosed. Includes the Kandik Group of the Kandik River terrane thrust belt (Churkin and others, 1982), the Manley terrane in the Livengood area, and the Kahiltna terrane in the central Alaska Range (Jones and others, 1987)

Mesozoic and Paleozoic rocks—Jurassic to Mississippian structurally and stratigraphically complex ophiolite assemblage rocks. Angayucham terrane (Am) and Tozitna terrane of Jones and others, (1987). Tozitna terrane includes the Rampart Group of Brosge'and Reiser, (1969)

Lower Mesozoic, Paleozoic, and Late Proterozoic rocks—Nonaccretionary continental rocks of the North American plate (Jones and others, 1987)

Lower Mesozoic, Paleozoic, and Late Proterozoic rocks—A structurally and stratigraphically complex assemblage of continental rocks considered provisionally part of the North American plate (Churkin and others, 1982), but a seperate accretionary terrane, the Porcupine terrane (Jones and others, 1987; see fig. 19)

Lower Mesozoic, Paleozoic, and Late Proterozoic rocks—Metamorphosed assemblages of accretionary terranes undivided. Juxtaposed in complex suture (Churkin and others, 1982) or megasuture zones (Jones and others, 1982; see fig. 11)

Contact—Approximately located

Fault—Sense of throw not defined. Dashed where inferred

Thrust fault—Sawteeth on upper plate. Dashed where inferred

Normal fault—Hachures on downthrown side. Dashed where inferred

Trend of gravity high

Trend of gravity low

3 km **Isopach of Cenozoic section, in kilometers**—Hachures indicate depression

Wells in Kandik basin thrust belt and Kandik River terrane

1 **Louisiana Land and Exploration Co. Doyon 1**

2 **Louisiana Land and Exploration Co. Doyon 2**

3 **Louisiana Land and Exploration Co. Doyon 3**

(TA) **Small occurence of oil rich tasmanite in the Christian quadrangle north of Yukon Flats basin**

Figure 15. Generalized geologic map of Yukon Flats basin, Kandik basin thrust belt, and adjacent areas.

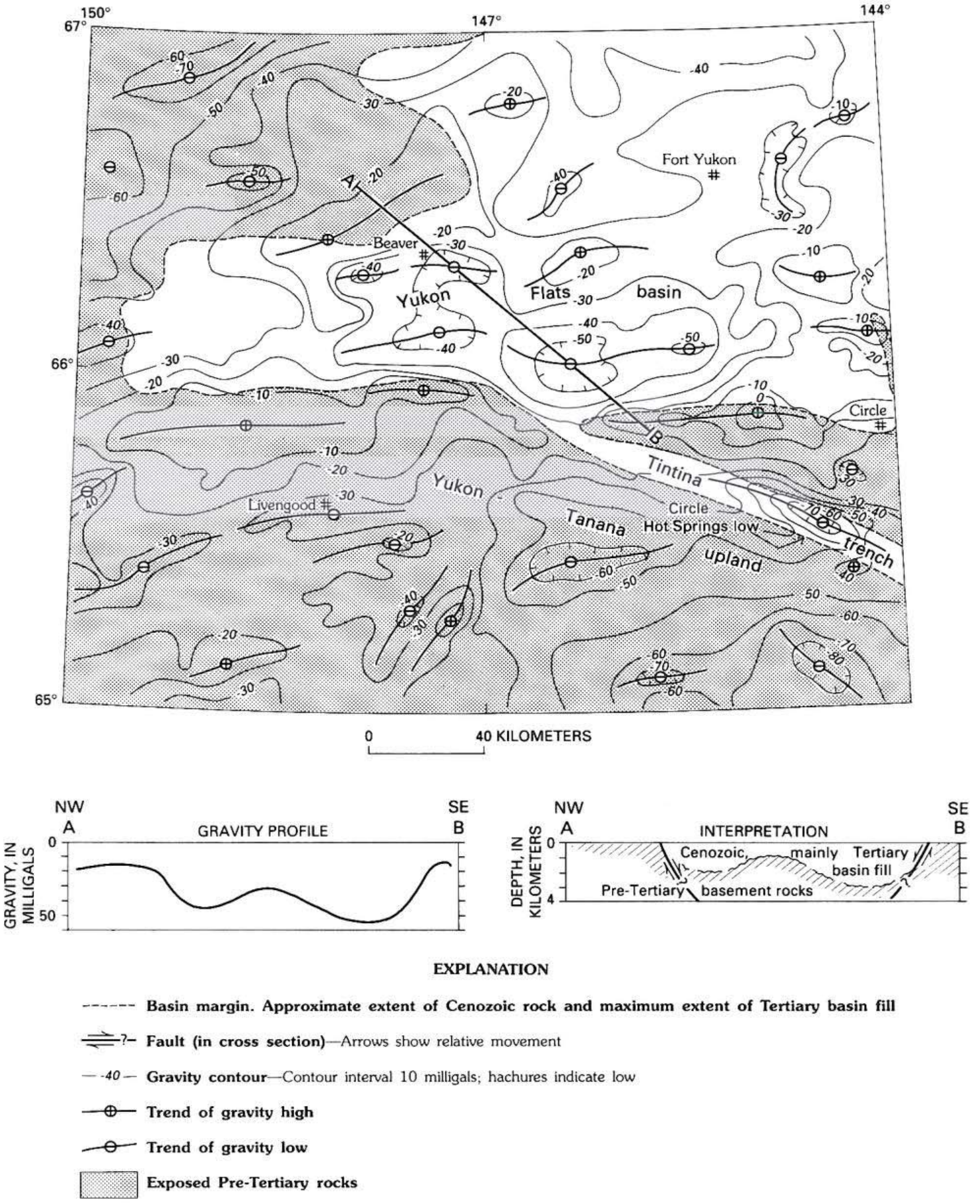


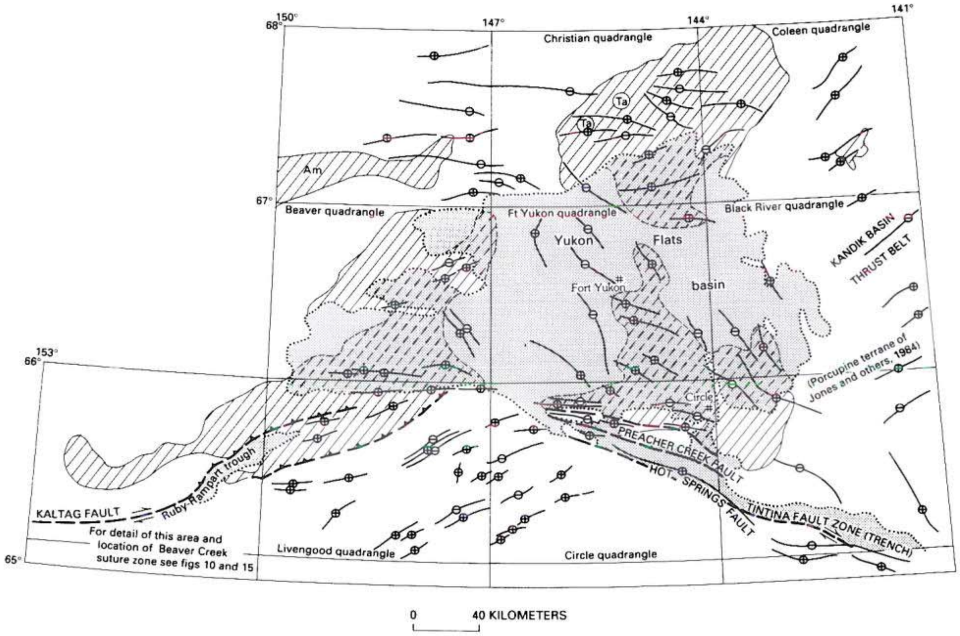
Figure 16. Gravity map of Yukon Flats basin and adjacent areas with gravity profile and interpretation of Cenozoic fill in the basin.

the Beaver Creek suture zone. These geophysical data suggest that the Beaver Creek suture zone accommodates much of the several hundred kilometers of Paleozoic to Tertiary dextral displacement on the Tintina fault.

Petroleum potential. No direct evidence for hydrocarbons has been reported in the Yukon Flats basin. The prospect for pre-Tertiary tasmanite source rocks in the Tozitna terrane appears to be extremely remote. Paleozoic and Triassic organic shales of North American plate affinity (NA) south of the Kandik flysch belt (KAN) cannot logically be projected beneath the basin, and two test wells in the Porcupine (PC) terrane east of the basin indicate that these rocks do not have significant source or reservoir characteristics. Thus, if there is petroleum potential in the basin, source beds most probably are nonmarine Tertiary lacustrine or coal beds. As in the Nenana basin, an optimistic evaluation is that gas reserves of economic importance for local consumption could be present.

MESOZOIC BASINS

The Mesozoic basins, characterized here as flysch belts, cover extensive areas of western and southwestern interior Alaska, and south-central Alaska. The sedimentary fill of these



EXPLANATION

- **Cenozoic rocks (basin fill)**
- **Angayucham (Am) and Tozitna terranes in outcrop**
- **Speculative extent of Tozitna terrane beneath Cenozoic fill in Yukon Flats basin**
- **Contact**—Approximately located, dashed where inferred
- **Fault**—Sense of throw not defined. Dashed where speculative
- **Strike-slip fault**—Arrows show relative movement. Dashed where speculative
- **Thrust fault**—Sawteeth on upper plate. Dashed where speculative
- **Approximate margin Cenozoic fill in Yukon Flats basin, Tintina trench, and Ruby-Rampart trough**
- **Positive magnetic trend**
- **Negative magnetic trend**
- (Ta) **Tasmanite occurrence in Tozitna terrane of the Christian quadrangle**

Figure 17. Map showing Angayucham and Tozitna terranes in outcrop, speculative extent of Tozitna terrane beneath Tertiary fill, trends of magnetic anomalies, and tasmanite occurrences in the Yukon Flats basin.

basins includes thick sequences of Mesozoic marine volcaniclastic graywacke and mudstone turbidites, and thick, coal-bearing paralic and marine shelf deposits in the regressive late-stage fill of the basins.

Basin fill was derived largely from volcanic-plutonic arc complexes and in part from adjacent continental metamorphic highlands. Deposition is interpreted to have been in fore-arc (mainly oceanic?) and back-arc (mainly continental?) basins synchronous with volcanism. The extent of the Mesozoic flysch basins is shown in Figure 3. In general, the data permit the interpretation that the fore-arc basins are the more strongly deformed and have no oil and gas potential, whereas the back-arc(?) basins are less deformed and may have oil and gas potential. Three exploratory wells have penetrated flysch rocks in the interior basins, one in the Kandik (KAN) basin flysch, one in the YKK flysch, and one in YKK(?) flysch in the Bethel lowlands beneath a thin Tertiary section. The Peninsular terrane (PEN) has been extensively explored without success.

Peninsular terrane (PEN)

The Peninsular terrane extends northeasterly the length of the Alaska Peninsula province and beneath the Tertiary fill of the Cook Inlet basin and the Copper River basin. It is interpreted that the basinal rocks were deposited in a back-arc setting, as tentatively proposed by Reed and others (1983), and that the pervasively deformed and metamorphosed flysch rocks of the Togiak (TOG) and Kahiltna (KAH) terranes on the northwest flank of the Peninsular arc represent partly synchronous fore-arc deposits. The stratigraphy of the Peninsular terrane includes Permian limestone; Upper Triassic petroliferous limestone, argillite, and volcanic rocks; Lower Jurassic andesitic volcanic rocks and volcaniclastic siltstone and sandstone; Middle Jurassic through Cretaceous fossiliferous clastic rocks (including Middle Jurassic organic shale), and minor bioclastic limestone and quartzite (Jones and others, 1987). Locally, oil seepages appear to be associated with faults, and oil and gas shows have been logged in exploratory tests. Structurally, the rocks are moderately to mildly deformed and faulted. They were once deeply buried, have high densities, and show the effects of diagenetic alteration, including laumontite and locally higher-grade metamorphism. About 40 exploratory tests with Cretaceous and Upper to Middle Jurassic objectives have been drilled in the Copper River and Cook Inlet basins and on the Alaska Peninsula. Only minor oil shows have been encountered in Cretaceous sandstone and Middle Jurassic fractured shale. These discouraging results may not eliminate the potential for future discoveries, but the lack of discoveries to date indicates that the resource potential is limited.

Yukon-Koyukuk-Kobuk (YKK) terrane

The Yukon-Koyukuk segment of the YKK terrane includes a belt of strongly deformed and mildly to strongly metamorphosed flysch rocks trending northeasterly along the eastern margin of Norton Sound in west-central Alaska. These rocks are interpreted to represent fore-arc deposits of the Hogatza volcano-plutonic arc. The Kobuk segment of this terrane trends easterly north of the Hogatza arc and south of the Brooks Range. The Kobuk segment probably represents back-arc molasse deposits derived from both the Hogatza arc and the Brooks Range and Kokrine-Hodzana upland. Stratigraphically, the terrane comprises a Lower and Upper Cretaceous volcaniclastic sequence, including turbidite, prodelta, and deltaic coal-bearing facies (Patton, 1973; Patton and others, this volume, chapter 7). Basement rocks are andesitic volcanics of early Cretaceous metamorphic terranes. The thickness of the stratigraphic sequence is poorly constrained. Patton (1973) suggests that the deepest part of the basin may be more than 7.0 km deep on the basis of magnetic data. Structure of the Yukon-Koyukuk segment is complex. Isoclinal folding is characteristic. Locally, broad synclines are flanked by sharply folded and faulted anticlines. Structure in the Kobuk back-arc(?) segment is less complex, and a few large anticlinal structures have been defined. For this reason it has been suggested that the Kobuk segment of the province could have petroleum potential (Patton, 1978; Hite and Nakayama, 1980); however, no direct evidence of oil and gas in the form of seepage is known from the region. Speculative potential petroleum resources based on a cubic mile of sediment in this type of basin may be misleading (Hite and Nakayama, 1980). Compared with the Peninsular terrane, which has numerous oil seepages and oil and gas shows in wells, even the most favorable areas of the Yukon-Koyukuk-Kobuk province could be expected to have, at best, minor gas reserves.

Kuskokwim terrane (KUS)

The Kuskokwim terrane covers about 60,000 km^2 in southwestern Alaska. The stratigraphy of the basin is similar to that of the Yukon-Koyukuk-Kobuk basin and includes several thousand meters of Lower to Upper Cretaceous quartzose lithic conglomerate, and sandstone and siltstone turbidites. Basement rocks include early Mesozoic andesitic volcanic rocks, chert, argillite, volcanogenic clastic rocks, and Paleozoic carbonate rocks, amalgamated prior to the deposition of the Cretaceous flysch (Decker and others, this volume). Structure of the province includes both open folds and tight chevron folds. Numerous high-angle faults and large strike-slip faults segment the terrane and localize many intrusive dikes and plutons. The intrusive bodies host numerous mineral occurrences. Petroleum potential of the province is believed to be precluded by structural complexity, intrusive bodies, and mineralization.

Kandik (KAN) and Manley (MAN) terranes

The Kandik and Manley terranes incorporate thick, highly deformed flyschoid rocks of Triassic to Early Cretaceous age (Dover, this volume). The thicknesses of the stratigraphic sections are poorly constrained, but they probably include at least 3.0 to 4.5 km of strata. The stratigraphy of the two terranes is similar enough to suspect that the Manley terrane is a dismembered segment of the Kandik terrane, displaced about 170 km by the Tintina fault zone since Early Cretaceous time. Churkin and Brabb (1969) have summarized the oil potential of the Kandik terrane as negligible, owing to complex structure and low-grade metamorphism. The Manley terrane is similar and has no petroleum potential.

PALEOZOIC AND MESOZOIC BASIN

Kandik basin

Introduction. The Kandik basin of east-central Alaska, as discussed here, is confined approximately by the Porcupine River on the north, the Tintina fault system on the south, the Alaska-Canada boundary on the east, and the Yukon Flats Cenozoic basin on the west (Fig. 18). As thus defined it covers an area of more than 20,000 km^2. Along the Canadian border, elevations reach 600 to 1,200 m in relatively rugged terrain but drop away to the west to the low elevations of the Yukon Flats. The basin has long been of interest to geologists and petroleum companies because it has the most complete Paleozoic to early Mesozoic stratigraphic section in Alaska, and has organic shales and oil shows at several stratigraphic levels from the Ordovician to the Jurassic (Fig. 19).

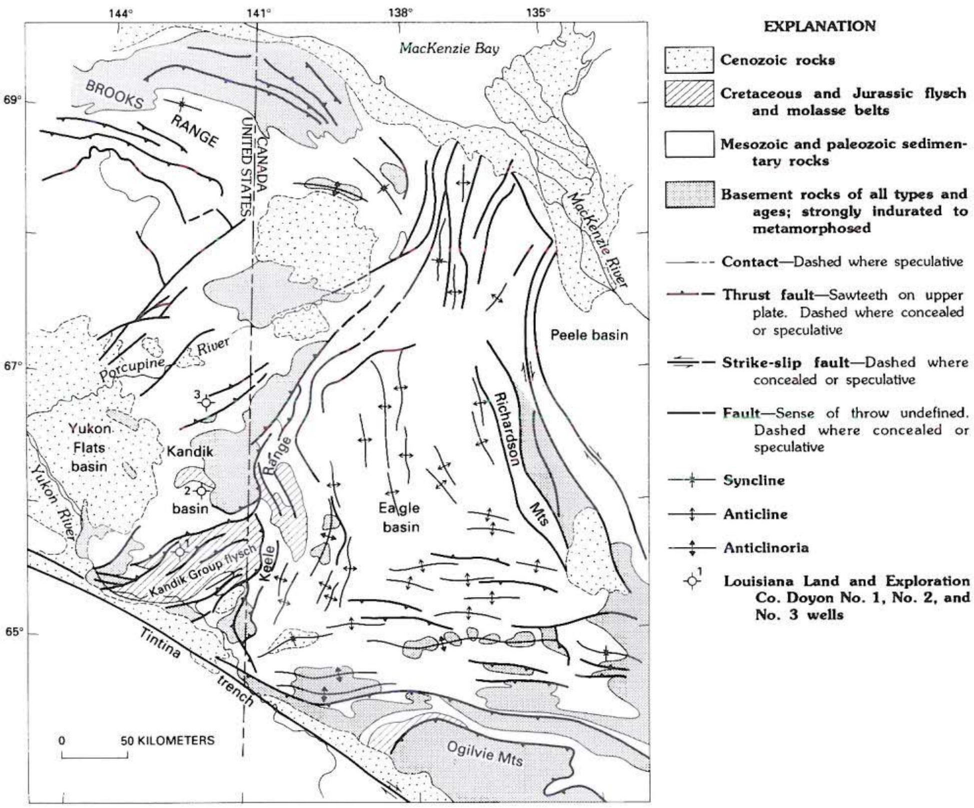


Figure 18. Generalized geologic map of the Cordilleran fold and thrust belt in northeastern Alaska and northwestern Canada, showing the Kandik basin and its geographic location to other basins and structural trends in the Cordillera.

Stratigraphy. The stratigraphic succession in the Kandik basin includes metamorphosed late Precambrian rocks, overlain by a thick Paleozoic continental-margin section deposited in shelf to open-marine environments, and a thick Jurassic-Cretaceous (Kandik Group) flysch sequence. The flysch sequence separates the Precambrian and Paleozoic sequences in Alaska into a small triangular area south of the flysch belt and a larger northern area from the flysch belt to the Porcupine River. South of the flysch belt, geologists agree that the terrane is part of the North American plate (unit NAm of Jones and others, 1987; Silberling and others, this volume; unit T of Churkin and others, 1982), but differ as to whether the rocks north of the flysch belt are different from those of NAm (Porcupine [unit PC] of Jones and others, 1987, and Silberling and others, this volume), or (provisionally) the same (Tatonduk terrane [unit T?] of Churkin and others, 1982). Rocks of the Porcupine (unit PC) or Tatonduk (unit T?) terranes are not as well known as those of NAm. The missing strata may be due to facies changes, to structural complication, or simply to inadequate data. A notable difference between the PC and T(?) terranes is the apparent absence of highly organic shales, petroliferous limestones, or oil shows from the PC terrane. The Doyon No. 2 well drilled 2,783 m of Devonian sandstone and Devonian to Cambrian(?) dolomite. A minor dead oil show was reported in dolomite in the lower part of the well. The Doyon No. 3 well drilled 4,128 m of Devonian to Ordovician dolomite and limestones. Thrust faulting is suspected, so that stratigraphic thickness of the well sections is uncertain.

The intervening Kandik unit of Jones and others (KA or K terrane) includes about 4.5 km of strongly deformed, low-grade metamorphic flysch rocks that are probably regionally unconformable or in fault contact with underlying Paleozoic rocks (Brabb and Churkin, 1969). The Doyon No. 1 well drilled 3,368 m in this terrane, probably in a thrust-repeated section. Dead oil reportedly was found in the cuttings.

Structure. Structure of the Kandik basin is complex and not mapped in detail. However, the regional structural setting of the basin, in the hinterland of the North America Cordilleran fold and thrust belt, offers some clues to its structure by analogy to other parts of the Cordillera. Dover (1985, this volume) interprets the structural framework as resembling the classical fold and thrust belt structure of the Canadian Cordillera. I agree in general with this concept and suggest an analogy to the Main Ranges or Front Ranges of the southern Canadian Cordillera as shown in Bally and others (1966, Plate 12). Reports of recent field studies (Gardner and others, 1984) tend to confirm this general analogy for at least the NAm (or T) terrane segment of the basin. Thrust

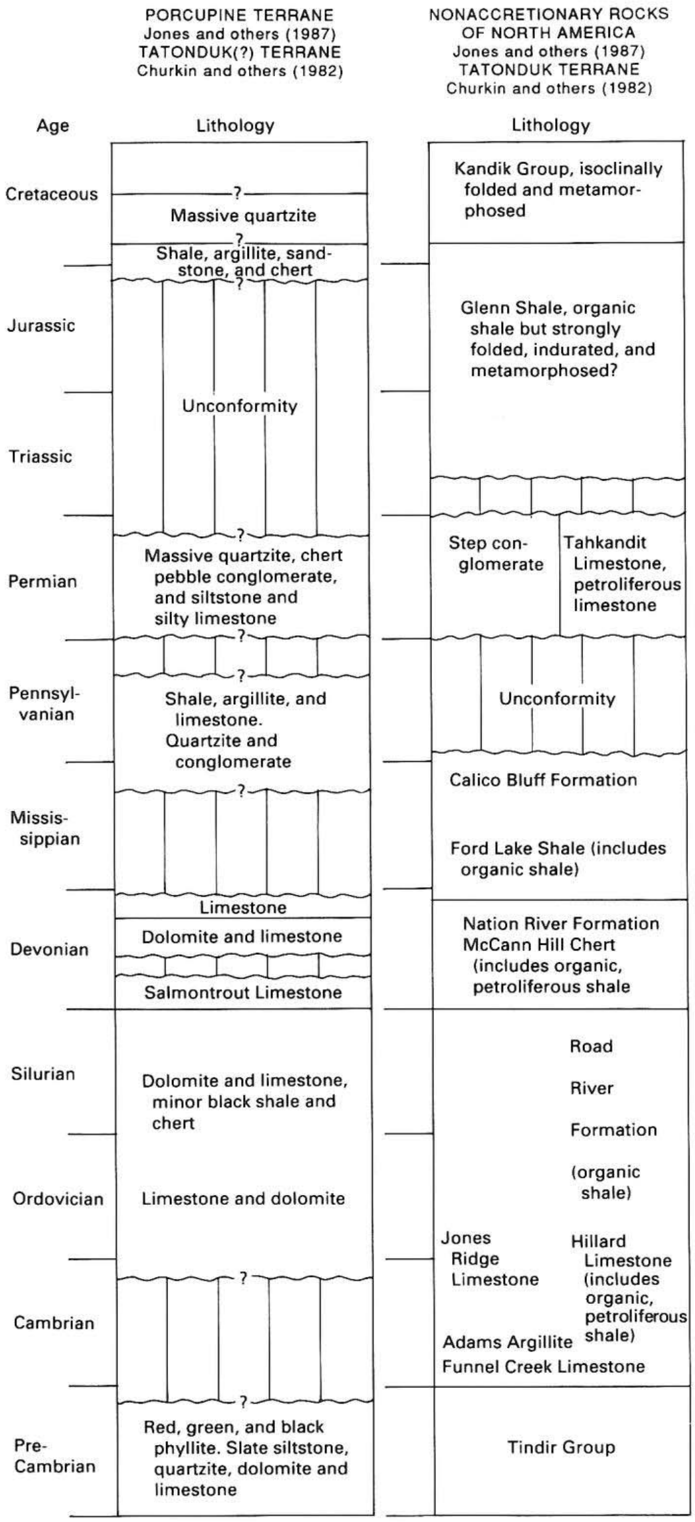


Figure 19. Stratigraphy of the Porcupine terrane compared to that of the nonaccretionary rocks of the North American plate in Kandik basin.

shortening in underlying Paleozoic rocks is apparently accommodated in the overlying Mesozoic flysch by isoclinal folding and accompanying low-grade metamorphism. Alternatively, the flysch belt could conceal a terrane boundary between the PC or (T?) terrane to the north and the NAm (or T) terrane to the south and east.

Petroleum potential. In spite of the abundant evidence for source rocks and the possible presence of reservoir rocks in the Paleozoic section, the extreme structural deformation, low-grade metamorphism, and discouraging results of three dry holes suggest little potential for significant or economic petroleum resources in the Kandik basin.

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