U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

MISCELLANEOUS FIELD STUDIES MAP
MF-2428
Pamphlet accompanies map

Maps Showing Sedimentary Basins, Surface Thermal Maturity, and Indications of Petroleum in the Central Alaska Province

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EXPLANATORY NOTES

These maps and the accompanying pamphlet describe sedimentary basins, surface thermal maturity, and reported occurrences of petroleum in natural seeps, rock outcrops, and wells in central Alaska. This publication was prepared for use in U.S. Geological Survey assessments of undiscovered oil and gas resources and supersedes an earlier compilation by Troutman and Stanley (2002).

Seeps of oil and gas are among the most useful indicators of the existence of buried accumulations of petroleum. However, not all reports of oil and gas seeps are reliable. In many cases, people have mistaken iron stains, mineral salts (including iron oxide scums), coal tar, and living organic material for oil seeps (Miller and others, 1959; Martin, 1923). Some of the reported seeps may have been spills, practical jokes, or misrepresentations. Also, it is important to note that many oil and gas seeps are ephemeral, and a seep that was observed and reported years ago may be inactive today.

Wells in the Central Alaska Province have been drilled for a variety of reasons and include more than a dozen petroleum exploration wells (fig. 1), several stratigraphic tests, and numerous water wells and seismic shot holes. At least one well was drilled for undisclosed military purposes. The quality and reliability of geologic information is generally better for petroleum exploration wells and stratigraphic tests than for other types of wells. Contamination of samples, particularly from seismic shot holes, is a source of concern and risk (D.M. Hite, written commun., 2003).

The primary source of information on oil and gas seeps and on wells drilled prior to 1959 is the report of Miller and others (1959). Additional data and interpretations were acquired from (1) published literature; (2) public records available at the Alaska Oil and Gas Conservation Commission, the Alaska Geologic Materials Center, and the Minerals Management Service; and (3) unpublished documents provided by private companies and individuals.

Sedimentary basins and selected geologic features of regional importance (Map *A*) were taken from the map of Kirschner (1988) with minor modifications in some areas. Some of the sedimentary basins may actually be thicker than shown, on the basis of unpublished geophysical information obtained by the oil industry. The thickness of sedimentary strata in the Yukon Flats basin, for example, may be 4.5 km or more (Hite and Nakayama, 1980, p. 524; Kirschner, 1994, p. 483). Similarly, the thickness of sedimentary strata in parts of the Nenana basin is more than 3.7 km (Paris, 2001) and may be as great as 6 km (Grether and Morgan, 1988).

Patterns of surface thermal maturity (Map *B*) were taken from the map of Johnsson and Howell (1996), which was produced from nearly 10,000 determinations of vitrinite reflectance and conodont alteration index (Johnsson and others, 1992, 1993, 1999).

Faults on maps *A* and *B* were taken from Kirschner (1988) to facilitate comparison of the two maps. However, some of the faults shown by Kirschner (1988) were depicted differently by Johnsson and Howell (1996). These differences are noticeable on map *B* as an imperfect registration of faults with thermal maturity unit contacts in certain areas, most notably the Brooks and Alaska Ranges, the Kandik area, and parts of the Yukon-Tanana upland and southern Alaska.

Ninety-five localities are depicted on maps *A* and *B* and described in table 1 (see pamphlet). Most of the localities are within the boundary of the Central Alaska Province as defined by the 1995 National Assessment of United States Oil and Gas Resources (U.S. Geological Survey, 1995, p. 3). However, the maps also include two localities (Map Nos. 74 and 75) that occur north of the Central Alaska Province boundary near Yukon Flats basin, and a submarine gas seep and several exploratory wells (Map Nos. 12-20) located west of the Central Alaska Province boundary in the offshore Norton basin. Also shown on the maps are some of the oil and gas fields in the Cook Inlet region. Not displayed on these maps, but described by Miller and others (1959) and other published reports, are numerous hydrocarbon seeps and wells in southern and northern Alaska and adjacent parts of Canada.

The 95 localities depicted on maps *A* and *B* include 3 wells with oil shows (appearances of liquid hydrocarbons), 18 wells with gas shows (appearances of gaseous hydrocarbons), and 9 wells with no shows of oil or gas. Outcrops of oil shale and (or) oil-bearing rocks have been reported from 15 localities. The 95 localities also include 31 accounts of oil seeps and 19 accounts of gas seeps; of these, investigations by the U.S. Geological Survey and others have confirmed the existence of 5 gas seeps and concluded that reports of 18 oil seeps and 2 gas seeps are doubtful or disproved. No confirmed oil seeps are known from the Central Alaska Province, but at least 25 reports of oil and gas seeps have not been fully investigated and require additional study.

No commercial petroleum production has been obtained from central Alaska, in contrast to the prolific deposits of oil and gas that have been found and commercially developed in northern Alaska and the Cook Inlet region. Nevertheless, likely or confirmed indications of petroleum in central Alaska include (1) gas in exploratory wells, seismic shot holes, and a water well in the Kotzebue basin and vicinity (Map Nos. 2-6); (2) oil and gas in seeps and wells in and near Norton Sound (Map Nos. 11-20); (3) gas in numerous seeps on the Yukon Delta (Map Nos. 25, 33, 35-37); (4) weak indications of gas in an exploratory well in the Bethel basin (Map No. 52); (5) small quantities of liquid and solid hydrocarbon associated with mercury ore in the Kuskokwim Mountains about 90 km southeast of Aniak (Map No. 61); (6) small amounts of gas in wells that penetrated Tertiary coal-bearing strata in the Nenana basin (Map Nos. 63, 64); (7) gas in water wells and test holes in the Fairbanks area (Map No. 72); (8) tasmanite, a form of oil shale, in Paleozoic to Mesozoic rocks in the uplands north of the Yukon Flats basin (Map Nos. 74 and 76); (9) gas, presumed by many to be methane, in Miocene coal-bearing strata in a U.S. Geological Survey core hole at Fort Yukon in the Yukon Flats basin (Map No. 77); (10) oil shale and numerous occurrences of bitumen in Precambrian to Mesozoic rocks in the Kandik area, southeast of the Yukon Flats basin (Map Nos. 84-93); and (11) gas in Quaternary deposits in shallow wells in the Northway lowlands (Map Nos. 94, 95).

Certain areas and localities warrant further discussion. For example, reports of oil and gas seeps on the Yukon Delta were investigated by Foley and Enos (1997), who found and sampled several gas accumulations that are thought to have been created by intermittent gas seeps beneath lake ice (Map Nos. 25, 33, 35-37; figs. 2, 3 in pamphlet). Molecular and isotopic analyses indicate that the gas consists mainly of methane that was produced by microbial processes (Foley and Enos, 1997). A microbial origin for the gas is consistent with the geologic setting of the seeps. Surface geologic mapping shows that much of the Yukon Delta is underlain by Quaternary floodplain deposits whose thickness is unknown but may be several hundred feet (Hoare and Condon, 1966, 1971). The Quaternary strata, in turn, are underlain by Quaternary and Tertiary basaltic volcanic rocks, Tertiary sedimentary strata, Cretaceous sandstone and mudstone, and Lower Cretaceous to Jurassic andesitic volcanic and volcaniclastic rocks (Hoare and Condon, 1966, 1971; Patton and others, 1994). Tertiary sedimentary strata do not crop out on the Yukon Delta, but seismic reflection surveys obtained by the oil industry suggest that the combined thickness of Quaternary and Tertiary strata in the subsurface may be as much as 2,100 m and that these strata are thermally immature with respect to the oil window (C.H. Selman, consulting geophysicist, written commun. to C.G. Mull, 1996; C.G. Mull, oral and written communs., 2000). The Cretaceous and older rocks are structurally complex (Hoare and Condon, 1966, 1971) and, in nearby outcrops, are thermally overmature with respect to the oil window (Johnsson and others, 1999). No exploratory oil or gas wells have been drilled on the Yukon Delta.

No confirmed oil or gas seeps are known from the Innoko, Bethel, Holitna, or Minchumina basins. In the Bethel basin, weak indications of gas were reported from the Pan American Petroleum Corp. Napatuk Creek Well No. 1 (Map No. 52), but no indications of oil or gas were reported from three stratigraphic test holes that were drilled nearby and generally to the east of the Napatuk Creek well (Map Nos. 53-55). No exploratory oil or gas wells have been drilled in the Innoko, Holitna, or Minchumina basins.

Small amounts of liquid and solid hydrocarbon are associated with cinnabar at the Mountain Top mercury deposit (Map No. 61). The co-occurrence of petroleum and cinnabar has also been noted in mercury deposits in California, Texas, Peru, Europe, and eastern Asia (Peabody, 1993). Geochemical analyses and modeling suggest that petroleum and mercury in the California deposits are derived from local sedimentary rocks by heating associated with hydrothermal activity (Peabody and Einaudi, 1992). The Mountain Top mercury deposits and associated hydrocarbons may have formed in similar fashion but have not been studied in detail.

No confirmed oil or gas seeps have been reported from the Nenana or Yukon Flats basins, but—as noted above—small amounts of methane were found in two exploratory wells in the Nenana basin (Map Nos. 63, 64), and gas of unknown composition but widely presumed to be methane was noted in a shallow core hole near Fort Yukon (Map No. 77). In the uplands to the east of Yukon Flats, three exploratory wells tested Mesozoic and Paleozoic strata and found small amounts of solid bitumen but no significant shows of oil or gas (Map Nos. 81-83). As mentioned above and in other reports (for example, Laudon and others, 1966; Grether and Morgan, 1988), numerous occurrences of oil shale and bitumen have been observed in outcrops in the upland areas located both north and southeast of Yukon Flats (Map Nos. 74, 76, and 84-93).

The existence of active and (or) formerly active petroleum systems in some parts of central Alaska, most notably in certain Tertiary sedimentary basins, is suggested by the presence of confirmed occurrences of small amounts of oil and gas. However, much remains to be learned about the geology, organic geochemistry, and petroleum resource potential of these systems.

EXPLANATION

Localities analyzed for petroleum

- **Well with oil show(s)**
- **Well with gas show(s)**
- **Well with no oil or gas shows**
- **Oil seep, reported but unconfirmed**
- **Oil seep, reported but doubtful or disproved**
- **Gas seep, confirmed**
- **Gas seep, reported but unconfirmed**
- **Gas seep, reported but doubtful or disproved**
- **Outcrop of oil shale or oil-bearing rock**
- **City, town or village**
- **Mine or prospect**
- **Pipeline**
- **Boundary of Central Alaska Province**

Faults—Dashed where approximately located
- **Fault**—Throw not defined
- **Thrust fault**—Sawteeth on upper plate
- **Thrust fault**—inferred
- **Strike-slip fault**—Arrows indicate direction of relative horizontal move ment
- **Normal fault**—Bar and ball on downdropped side
- **Normal fault**—inferred

Map *A*

- **Oil field**
- **Gas field**
- **Glacier**
- **Bouguer gravity low**—in milligals. Hachured in direction of lowest gravity value
- **Bouguer gravity high**
- **Lithologic contact**

Folds—Dashed where approximately located
- **Anticlinorium**
- **Synclinorium**
- **Anticline**
- **Syncline**
- **Axial trace of complexly folded rocks (diagrammatic)**

Thickness of Cenozoic basin fill
- **Sedimentary basin isopach**—Contours in kilometers
- **Less than 1 km**—Zero line not identified on continental shelf
- **1 to 3 km**
- **3 to 5 km**
- **Greater than 5 km**

Map Units
- **Late Tertiary and Quaternary basins**—Stippled where present in outcrop
- **Lower Tertiary in remnants of older basins**—Moderately to strongly deformed. Locally metamorphosed. Stippled where present in outcrop
- **Fold belts of the Colville foredeep, Eagle basin, Alaska Peninsula, and Cook Inlet and Copper River basins**
- **Complexly deformed and locally metamorphosed flysch basins and associated nonmarine and deltaic strata of interior Alaska**
- **Pervasively deformed and metamorphosed flysch belts**
- **Volcanic rock cover**
- **Precambrian, Paleozoic, and Mesozoic rocks of Cordilleran fold and thrust belt**
- **Basement rocks**—Metamorphic and (or) igneous terranes of all ages

Map *B*

- **Thermal maturity unit contact**
- **Thermal Maturity Units**—R_o, reflectance value in oil; CAI, Conodont Color Alteration Index.
  - U — **Undermature**—R_o < 0.6, CAI < 1.0
  - M1 — **Mature I**—R_o 0.6 – 1.3, CAI 1.0 – 2.0
  - M2 — **Mature II**—R_o 1.3 – 2.0, CAI 2.0 – 3.0
  - Om — **Overmature**—R_o 2.0 – 3.6, CAI 3.0 – 4.0
  - S — **Supermature**—R_o 3.6 – 5.0, CAI 4.0 – 4.5
  - Ig-M — **Igneous–Metamorphic**—R_o > 5.0, CAI > 4.5
  - **No data**
  - Qs — **Quaternary sediments**—Unconsolidated

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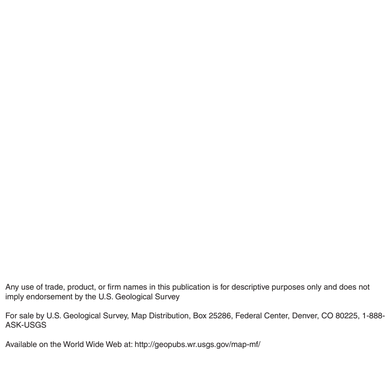
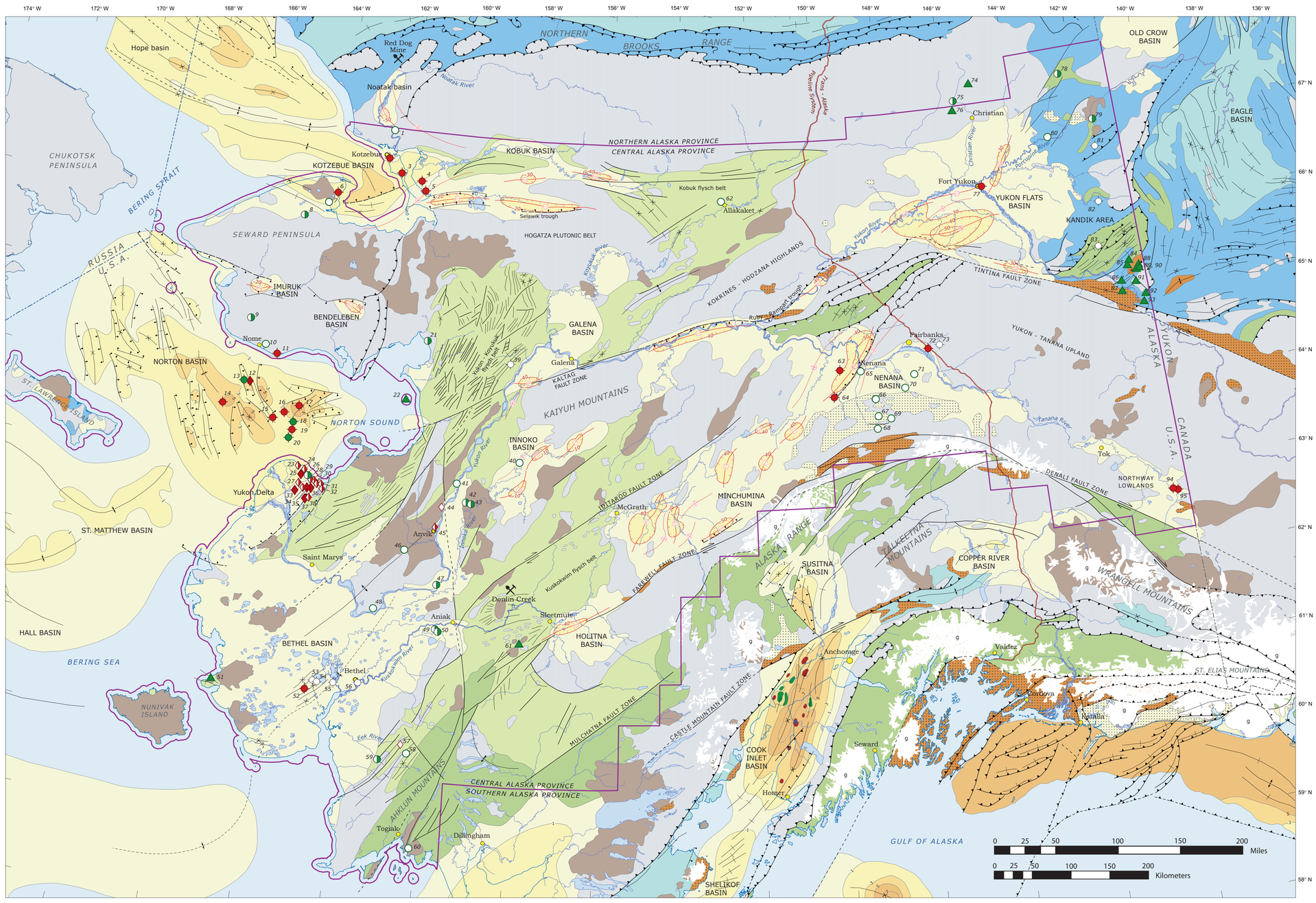
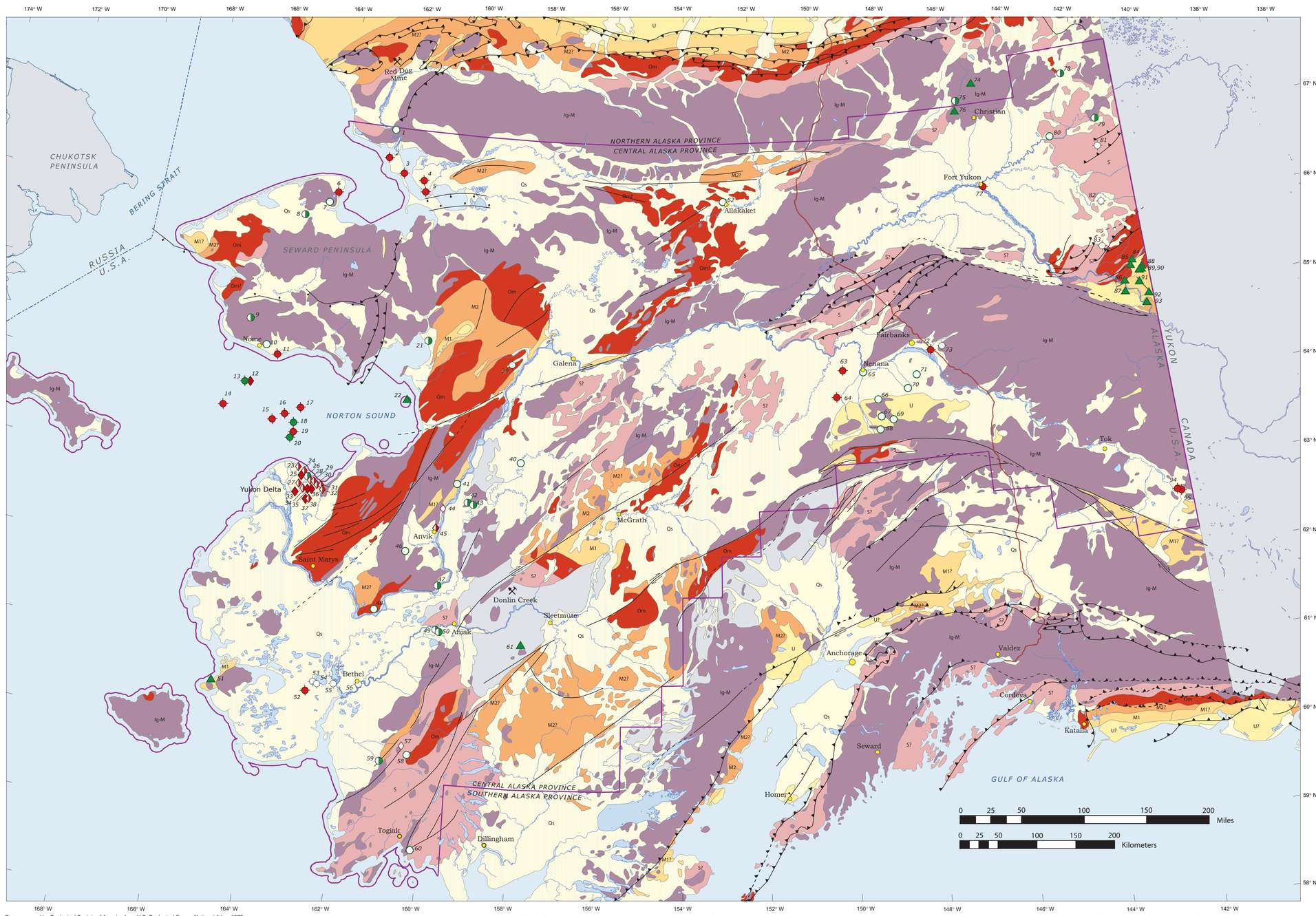


Figure 1. Photograph showing drilling operations at the Louisiana Land and Exploration Company Doyon Ltd. Well No. 2 (Map No. 82), about 300 km northeast of Fairbanks, Alaska. Photograph by Bruce Clardy, 1977.



A. Sedimentary basins and selected geologic features of regional importance.

Geology compiled and modified by S.M. Troutman and R.G. Stanley from Kirschner (1988). Indications of petroleum compiled by R.G. Stanley and S.M. Troutman from Miller and others (1959), from other sources described in text, and from field work by R.G. Stanley and others, 1984-1991 and 2002



B. Patterns of surface thermal maturity.

Base prepared by Geological Society of America from U.S. Geological Survey National Atlas, 1970
Clark Albers projection (maps A and B)

Faults compiled and modified by S.M. Troutman and R.G. Stanley from Kirschner (1988). Thermal maturity compiled and modified by S.M. Troutman and R.G. Stanley from Johnsson and Howell (1996). Indications of petroleum compiled by R.G. Stanley and S.M. Troutman from Miller and others (1959), from other sources described in text, and from field work by R.G. Stanley and others, 1984-1991 and 2002

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