

Figure 2. Map of southwestern Alaska showing the distribution of major mineral occurrences on the Alaska Peninsula and the area north of the Katmai study area. Sources of data are: Unalaska quadrangle, Berg and Cobb (1967) and Hollister (1978); Port Moller and Steppok Bay quadrangles, Wilson and others (1988); Chignik and Seward Island quadrangles, Cox and others (1981); Bristol Bay, Ugashik, and western Afognak quadrangles, Church, Determan, and Wilson (1989); Naknek, Mount Katmai, and western Afognak quadrangles, Church and others (in press) and this report; Iliamna quadrangle, Determan and Reed, (1980) and Phil St. George (written commun., 1991); Lake Clark quadrangle, Nelson and others (1985) and Warfield and Rutledge (1951), and the Johnson River deposit, Steefel (1987).

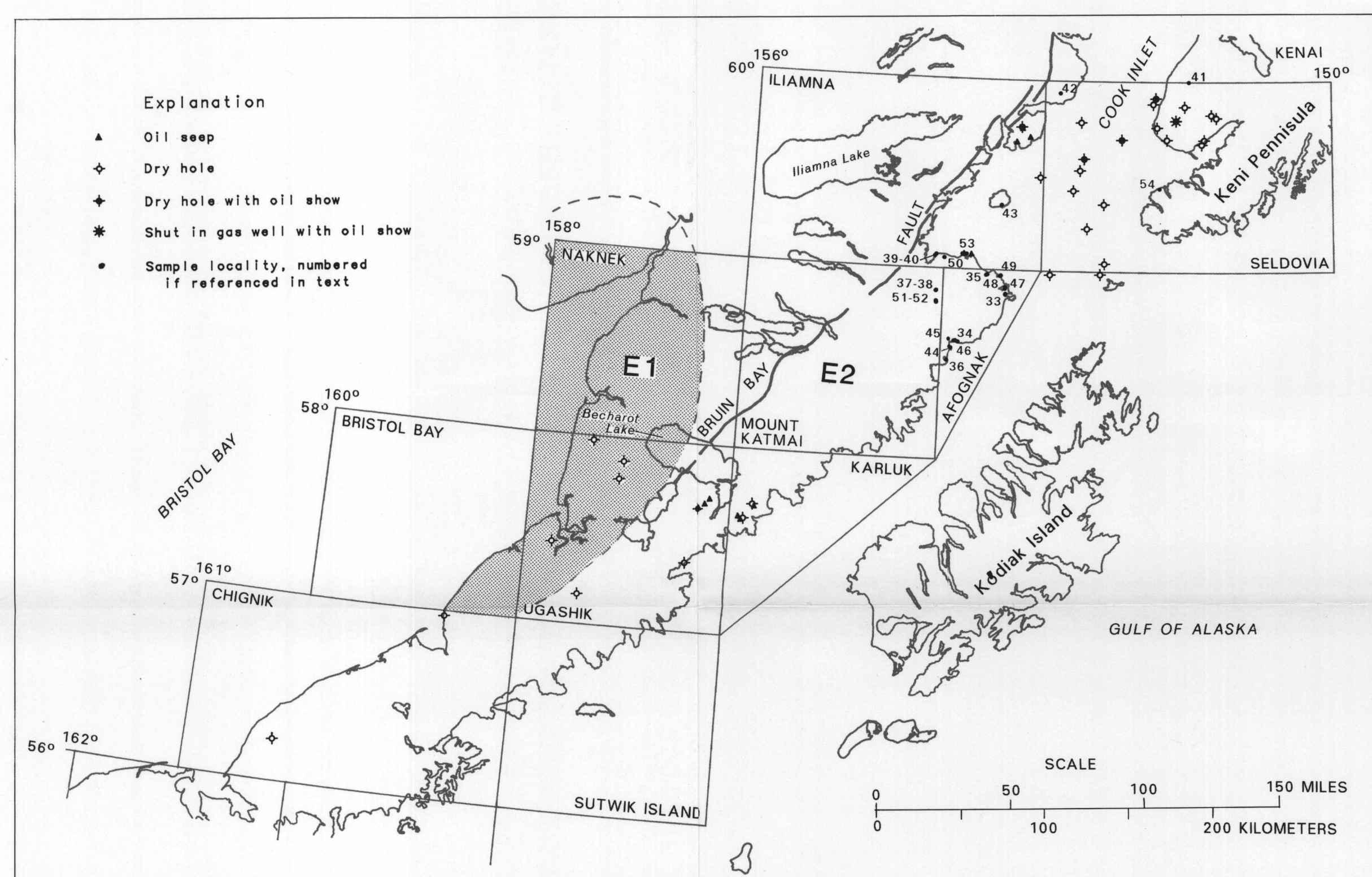


Figure 3. Map of Cook Inlet and part of the Alaska Peninsula showing the localities of oil seeps and dry holes in the Chignik and Seward Island quadrangles (Cox and others, 1981); Bristol Bay, Ugashik, and western Afognak quadrangles (Church and others, 1989); Iliamna quadrangle (Determan and Hartsock, 1966; Determan and Reed, 1980); Kenai quadrangle and the Cook Inlet basin (Magoon and others, 1976). No oil seeps were found during our field investigations in the Katmai study area and no oil test wells have been drilled therein. Two energy tracts, E1 and E2 defined in the mineral and energy resource assessment of the Bristol Bay, Ugashik, and western Afognak quadrangles (Church, Determan, and Wilson, 1989), have been extended into the Naknek, Mount Katmai and western Afognak quadrangles for this energy assessment. Localities of samples for which thermal maturity, vitrinite reflectance, porosity, and permeability data are reported in tables 5 and 6, are also shown.

Table 3. Geologic and geochemical attributes of mineralized tracts and subtracts in the Mount Katmai, eastern Naknek, and western Afognak quadrangles, Alaska

[Abbreviations used: qtz, quartz; py, pyrite; cpy, chalcopyrite; mly, molybdenite; spl, sphalerite; gn, galena; asp, arsenopyrite; bar, barite; sch, scheelite; wulf, wolfeite; clin, cinnabar; disse, disseminated-mineral grains in sample; m-grd, medium grain size; e, early; m, middle; l, late; M, million years. Elements or minerals that occur less commonly in a geochemical or mineralogical suite are enclosed in parentheses; --, indicates no data]

| Attributes  | Tract 1A  |  | Tract 2B   | Tract 3B  | Tract 4A  |  | Tract 4B   | Tract 4C  |   |
|---|---|--|--|---|---|--|--|---|---|
|   | Oakley Peak-Kulik Kopper (sic) area   | Kulik Lake Gold vein                                   | Buttress Range area                                | Ikaqulik Creek area   | Kulak Bay-Katmai River area                             | Katmai Lakes-Hagebarger Pass-Dakavak Lake area                         | Kukak Bay area   | Hinayak River area  | Fourpeaked Mountain area  |
| Geologic Environment  | m-grd Jurassic quartzite; moderately porphyritic Tertiary plutons                             | Felsic dike  | Small porphyritic tonalitic stock                  | Porphyritic stocks, sills, and dikes                        | Dikes, sills, and hypabyssal plutons                    | Sheeted qtz veins and porphyritic dikes                                | Tonalitic hypabyssal plutons, sills, and dikes                         | Small plugs, dikes, and sills; small tonalitic to granitoid plutons | Multiple phase, some porphyritic tonalitic to granitoid plutons |
| Age of igneous event  | M. Tertiary (26.0-27.0 Ma)  | M. Tertiary(?)   | Tertiary   | Tertiary  | latest Tertiary to early Quaternary (0.5-2.5 Ma)        | Tertiary(?)  | Tertiary(?)  | Tertiary(?)   | M. to l. Tertiary (5 to 28 Ma)                                  |
| Country rock  | Roof pendants of Iliamna Fm.; Jurassic plutons  | Jurassic granodiorite                                  | Mesozoic sedimentary rocks                         | Hornfels zones in Mesozoic sedimentary rocks                | Sandstone and siltstone of the Naknek Fm.               | Mesozoic sedimentary rocks; Tertiary volcanic and plutonic rocks       | Mesozoic sedimentary rocks and Tertiary sedimentary and volcanic rocks | Rocks of Naknek Fm.; volcanic rocks of Aleutian arc                 | Mesozoic and Tertiary sedimentary rocks                         |
| Pyritic envelope (color anomaly)  | Yes   | None   | Weak   | Locally conspicuous   | Yes   | Yes  | Yes  | Locally developed   | Locally developed   |
| Dike swarms   | No  | No   | Dikes present                                      | Dikes present   | Yes   | Yes  | Yes  | No  | No  |
| Tensional fracturing  | Uncertain   | Uncertain  | Yes  | Yes   | Yes   | Yes  | Yes  | Yes   | Yes   |
| Intrusive breccias  | No  | No   | Yes  | No  | No  | No   | No   | Breccia dike  | No  |
| Type of alteration  | Propylitic(?) quartzite in plutonic rock  | Phylitic   | Propylitic to potassic                             | Pervasive propylitic alteration in hornfels zones           | Propylitic and phylitic                                 | Propylitic and argillic  | Propylitic, argillic, phylitic, and potassic                           | Deuteric alteration in plutons; hornfels zones                      | Small propylitic zones along dikes                              |
| Prospects, claims, and occurrences  | Kulik Kopper (6); Oakley Peak (2); unnamed (8); Kani (9); Cottonwood Creek (25); and Nix (24) | Kulik Lake Gold (5)                                    | Windy Creek (2) and Herot Creek Copper (3)         | Ikaqulik Creek (4)  | Kejulik (1)   | Sulaka Creek (15); Sakavak Bay (16); Amalik Harbor (17)                | Hagebarger Pass (13); Sakavak Lake (14)                                | Kukak Bay (12)  | Mt. Douglas Group (10) and Big River (11)                       |
| Observed form of mineralization   | Disse py in vuggy qtz veins; disse py in rocks  | Disse py in banded qtz veins                           | Qtz veins grading into cpy and mly stockworks      | Qtz veins   | Disse py in highly banded rock                          | Py in banded qtz veins and breccias                                    | Disse py in plutonic rocks; disseminated minerals in qtz veins         | Qtz veins; gold-bearing qtz veins along a gneiss fracture           | Qtz veins radial to stocks; py along fractures                  |
| Level of exposure of mineralized rocks                                      | Moderate  | Shallow  | Moderate   | Shallow to moderate   | Shallow   | Moderate   | Shallow  | Moderate  | Moderate  |
| Org-related minerals observed in rocks                                      | py  | py   | py, cpy, and mly                                   | py, cpy, mly, spl, and chrysocolla                          | py  | Jordisite and py   | py   | py  | py, cpy, asp, spl, mly, and stibnite; aethioph. and stibnite    |
| Possible mineral deposit models   | Polymetallic vein (22c) and porphyry Cu (17)  | Polymetallic vein (22c)                                | Porphyry Cu-Mo (21a) and polymetallic vein (22c)   | Polymetallic vein (22c) and porphyry Cu (17)                | Polymetallic vein (22c) and porphyry Cu (17)            | Epithermal gold (25b), polymetallic vein (22c), and a porphyry Cu (17) | Polymetallic vein (22c) and porphyry Cu (17)                           | Polymetallic vein (22c)   | Polymetallic vein (22c) and porphyry Cu (17)                    |
| Geochemical Expression  | Cu, Mo, Pb, Zn, and B (Ag and Zn)   | Cu, Mo, Pb, Zn, and B (Ag, As, Sb, Sn, Bi, and Cd)     | Cu, Mo, Pb, Zn, and B (As, Bi, and Cd)             | Pb, Zn, Cu, Co, and Ag (Mo, Ag, Bi, and Cd)                 | Cu, Mo, Pb, Zn, Ag, Cd, and Ba                          | Co and Zn (Pb, B, Cu, Sn, and As)                                      | Co, Zn, and Mo (B and As)  | Co, Zn, and B (Mo, Pb, Ag, Ba, Sn, Cd, and Cu)                      | Pb, Zn, and Ag (Mo, Cu, and B)                                  |
| Anomalous elemental concentrations in stream sediments                      | Cu, Mo, Ag, Pb, Zn, and Bi (W, Cd, As, Au, and Ba)  | Bi   | Cu, Mo, Ag, Pb, Zn, and Bi (W, Cd, As, Au, and Ba) | Cu, Mo, Co, Ag, Pb, B, and Ba (Zn, Bi, Au, and Ag)          | Ba, Zn, and B (Cu, Pb, Ag, and Co)                      | Cu, Mo, Pb, Sn, and Bi (Ba and Cd)                                     | Mo, Co, Pb, Ba, Cd, and Cu (Zn, Ag, and Au)                            | Ba, B, Cu, and As (Zn, Sn, Cd, and Bi)                              | Cu, Mo, Ag, B, Pb, Zn, and As (Co and Au)                       |
| Anomalous elemental concentrations in nonmagmatic heavy-mineral concentrate | bar, sch, and cpy (wulf and gn)   | py, gn, spl, and cpy (asp, wulf, sch, and gold)        | py, gn, spl, and cpy (asp, wulf, sch, and gold)    | py, spl, gn, and cpy (asp, wulf, sch, and gold)             | py, bar, and spl (cpy and wulf)                         | wulf and clin (py, cpy, and gn)  | py and cpy (spl, asp, bar, and wulf)                                   | py, cpy, asp, spl, and bar (gn and wulf)                            | py, cpy, spl, and asp (gn, bar, sch, wulf, and gold)            |
| Anomalous elemental concentrations in rocks                                 | Mn, Zn, As, Sb, Cu, and Ag (Co, Mo, Pb, Cd, Bi, Au, and Hg)                                   | Au, Cu, Bi, Ag, Co, and Mo (Pb, Mn, Zn, W, Sb, and Sn) | Pb, Zn, Mn, Mo, Cu, and Ag (Cd, Co, and Sn)        | Cu, Ag, Pb, Mn, As, Mo, Zn, Au, and Cd (Sb, Bi, Co, and Sn) | Cu, Mo, Zn, Cd, Co, and Mn (Pb, Sn, As, Sb, Au, and Hg) | Zn, Sb, As, Mo, Pb, Cd, and Co (Cu, Au, Mn, and Hg)                    | Mo, Au, Ag, As, and Cu (Bi, Sb, and Hg)                                | Zn, Ag, Mo, Pb, Ni, Hg, Cu, As, Sb, Cd, Bi, Hg, and Au              | Diverse base- and precious-metal suite; varies by site          |

<sup>1</sup>Chronology from Sheu and Langner (in press).  
<sup>2</sup>Data on mineral occurrences and claims summarized in tables 1 and 2. Numbers in parentheses are shown on the map and in tables 1 and 2.  
<sup>3</sup>Data from Church, Bailey, and Kiehl (1989); Church and Motooka (1989).

<sup>4</sup>Data from Church and Arbogast (1989).  
<sup>5</sup>Data from Church and Bennett (1989).  
<sup>6</sup>Data from Kiehl and others (1989); Church and others (in press).

Table 4. Metallic mineral resource summary of the Mount Katmai, Naknek, and western Afognak quadrangles, Alaska

| Mineral resource tract | Geologic summary  | Area has potential for the following mineral-deposit types <sup>1</sup>                            | Mineral occurrences of the following mineral-deposit types <sup>1</sup> |
|------------------------|---|--|---|
| 1                      | Middle Tertiary plutons intrude Jurassic intrusive rocks and Mesozoic and older volcanic, metamorphic, and marine sedimentary rocks | Porphyry copper (17)   | Polymetallic vein (22c)<br>Placer gold (39a)                            |
| 2A                     | Tertiary plutons intrude Mesozoic marine sedimentary rocks  | Polymetallic vein (22c)  | Porphyry Cu-Mo (21a)  |
| 2B                     | Tertiary plutons intrude Mesozoic marine sedimentary rocks  | Porphyry copper (17)<br>Placer gold (39a)  | Polymetallic vein (22c)   |
| 3                      | Late Tertiary to early Quaternary volcanic plugs intrude Mesozoic marine sedimentary rocks and Tertiary lava flows                  | Polymetallic vein (22c)<br>Porphyry copper (17)  | Porphyry copper (17)  |
| 4A                     | Tertiary dikes, sills, and plutons intrude Mesozoic marine and Tertiary fluvial sedimentary rocks and Tertiary lava flows           | Epithermal vein (25b)<br>Porphyry copper (17)<br>Porphyry molybdenum(?) (21b)<br>Placer gold (39a) | Polymetallic vein (22c)<br>Epithermal Mo-Ag-Au vein (21b?)              |
| 4B                     | Tertiary dikes intrude marine sedimentary rocks   | Polymetallic vein (22c)  |   |
| 4C                     | Middle to late Tertiary plutons intrude and deform Mesozoic marine and Tertiary fluvial sedimentary rocks                           | Porphyry copper (17)<br>Placer gold (39a)  | Polymetallic vein (22c)   |
|                        | Early to middle Tertiary volcanic rocks north of Naknek Lake  | Epithermal vein (25b)<br>Porphyry Cu-Au (20c?)   | Placer gold (39a)   |
|                        | Quaternary volcanic rocks   | Epithermal vein (25b)  |   |
|                        | Quaternary alluvium   |  | Placer gold (39a)<br>Shoreline placer titanium (39c)                    |

<sup>1</sup>Descriptive references for mineral deposit models (from Cox and Singer, 1986): 17--Cox (1986a); 20c--Cox (1986c); 21a--Cox (1986b); 21b--Theodore (1986); 22c--Cox (1986d); 25b--Mosier and others (1986); 39a--Veend (1986); 39c--Force (1986).

Table 5. Source-rock and maturity data from Mount Katmai and western Afognak quadrangles, Alaska

[\*, vitrinite reflectance equivalent for visual kerogen thermal alteration index (VAI); TOC, total organic carbon; wt, weight percent; %Ro, percent vitrinite reflectance; Av., average; --, not determined. Sample localities are in fig. 3]

| No. | Latitude   | Longitude   | Unit                   | Age | Samples total | TOC (wt %) | %Ro  | Av. |
|-----|------------|-------------|------------------------|-----|---------------|------------|------|-----|
| 33  | 58°51'50"N | 153°21'15"W | Copper Lake Fm. Tert.  | 2   | --            | 0.7        | 4.0* |     |
| 34  | 58°36'45"N | 153°51'20"W | Kaguyak Fm. L. Cret.   | 40  | 0.1-0.8       | 0.5        | 3.0* |     |
| 35  | 58°57'55"N | 153°33'00"W | Kaguyak Fm. L. Cret.   | 1   | --            | 0.5        | 2.0* |     |
| 36  | 58°34'30"N | 153°53'00"W | Kaguyak Fm. L. Cret.   | 5   | 0.2-0.4       | 0.3        | 0.7* |     |
| 37  | 58°52'35"N | 154°03'45"W | Herendeen Fm. E. Cret. | 6   | 0.2-0.7       | 0.3        | 0.4  |     |
| 38  | 58°52'25"N | 154°04'00"W | Herendeen Fm. E. Cret. | 3   | 0.1-0.3       | 0.2        | 0.4* |     |
| 39  | 59°03'30"N | 154°05'15"W | Naknek Fm. L. Jur.     | 2   | --            | --         | 0.4  |     |
| 40  | 59°04'00"N | 154°04'30"W | Naknek Fm. L. Jur.     | 1   | --            | 0.2        | 0.4* |     |

Table 6. Porosity and permeability data from selected samples from the Mount Katmai and western Afognak quadrangles, and from the lower Cook Inlet area, Alaska

[Analyses by Chemical and Geological Laboratories of Alaska, Inc. Data from Magoon, Adkinson, Clinek, and others, 1976, p. 50. Sample localities are in fig. 3]

| No. | Locality           | Latitude   | Longitude   | Sample      | Unit             | Depth (ft) | Porosity (percent) | Permeability (millidarcies) |
|-----|--------------------|------------|-------------|-------------|------------------|------------|--------------------|-----------------------------|
| 37  | Kamishak Hills #3  | 58°52'35"N | 154°03'45"W | 0331AL-155  | Naknek Fm.       | Surface    | 10.1               | 0.21                        |
|     |                    |            |             | 0332AL-156  | Herendeen Fm.    | do         | 8.2                | 0.09                        |
|     |                    |            |             | 0333AL-157  | Herendeen Fm.    | do         | 3.2                | 0.01                        |
| 41  | Deep Creek Well #1 | 59°59'40"N | 151°29'35"W | Core        | Tyonek Fm.       | 6,103      | -6,104.4           | 17.5                        |
|     |                    |            |             | Core        | Tyonek Fm.       | 10,244     | -10,259            | 2.4                         |
|     |                    |            |             | Core        | Tyonek Fm.       | 10,264     | -10,266.3          | 16.3                        |
|     |                    |            |             | Core        | Tyonek Fm.       | 10,286     | -10,287.3          | 4.4                         |
|     |                    |            |             | Core        | Tyonek Fm.       | 11,990.4   | -11,991.6          | 8.8                         |
|     |                    |            |             | Core        | Tyonek Fm.       | 12,118.5   | -12,120.3          | 9.1                         |
|     |                    |            |             | Core        | Hemlock Cgl.     | 12,182     | -12,183.6          | 3.4                         |
|     |                    |            |             | Core        | Hemlock Cgl.     | 12,235     | -12,236.5          | 12.1                        |
|     |                    |            |             | Core        | W. Foreland Fm.  | 13,657.4   | -13,658.9          | 4.4                         |
| 42  | Hickerson Lake     | 59°55'45"N | 152°50'30"W | 1974-4 Occ. | W. Foreland Fm.  | Surface    | 9.8                | 18                          |
| 43  | Augustine Island   | 59°20'00"N | 153°25'00"W | 1974-5 Occ. | Naknek Fm.       | do         | 4.7                | 0.02                        |
| 44  | Kaguyak Point      | 58°34'50"N | 153°54'00"W | 00292A-28   | Naknek Fm.       | do         | 7.8                | 0.57                        |
| 45  | Kaguyak Bay        | 58°37'15"N | 153°54'45"W | 0048AL-32   | Herendeen Fm.    | do         | 9.4                | 0.01                        |
|     |                    |            |             | 0092ML-28   | Kaguyak Fm.      | do         | 3.1                | 0.01                        |
|     |                    |            |             | 0127ML-45   | Kaguyak Fm.      | do         | 5.3                | 0.01                        |
|     |                    |            |             | 01532AL-110 | Herendeen(?) Fm. | do         | 4.9                | 0.01                        |
|     |                    |            |             | 0213ML-71   | Copper Lake Fm.  | do         | 6.9                | 0.01                        |
|     |                    |            |             | 0213ML-71   | Copper Lake Fm.  | do         | 7.3                | 0.10                        |
|     |                    |            |             | 0223AE-45   | Copper Lake Fm.  | do         | 7.4                | 0.02                        |
| 48  | Sukoi Bay Bench    | 58°53'40"N | 153°21'30"W | 0240AE-62   | Copper Lake Fm.  | do         | 3.3                | 0.01                        |
| 49  | Sukoi Bay Mountain | 58°54'10"N | 153°21'20"W | 0306EM-105  | Copper Lake Fm.  | do         | 12.4               | 0.10                        |
|     |                    |            |             | 0308EM-107  | Copper Lake Fm.  | do         | 6.5                | 0.53                        |
| 50  | Akumavrik          | 59°03'00"N | 153°59'30"W | 0351AE-175  | Naknek Fm.       | do         | 9.3                | 0.13                        |
| 51  | Kamishak Hills #4  | 58°49'10"N | 154°03'40"W | 0346ALF-170 | Herendeen Fm.    | do         | 10.1               | 0.03                        |
|     |                    |            |             | 0350ALF-174 | Herendeen Fm.    | do         | 18.0               | 0.16                        |
|     |                    |            |             | 0351AE-175  | Herendeen Fm.    | do         | 0.9                | 0.80                        |
|     |                    |            |             | 0355AE-179  | Herendeen Fm.    | do         | 21.8               | 2.06                        |
| 52  | Kamishak Hills #5  | 58°48'45"N | 154°03'30"W | 0362AL-118  | Herendeen Fm.    | do         | 3.0                | 0.01                        |
|     |                    |            |             | 0370EL-126  | Herendeen Fm.    | do         | 8.9                | 0.06                        |
|     |                    |            |             | 0372EL-128  | Kaguyak Fm.      | do         | 10.2               | 0.21                        |
|     |                    |            |             | 0374EL-130  | Kaguyak Fm.      | do         | 8.6                | 0.15                        |
| 53  | Douglas River      | 59°04'25"N | 153°45'30"W | 0429MA-1    | Naknek Fm.       | do         | 1.5                | 0.01                        |
|     |                    |            |             | 0502M-150   | Naknek Fm.       | do         | 5.6                | 0.03                        |
| 54  | Seldovia           | 59°26'00"N | 151°47'30"W | 75JK-147    | Kamishak(?) Fm.  | do         | 0.2                | 0.01                        |