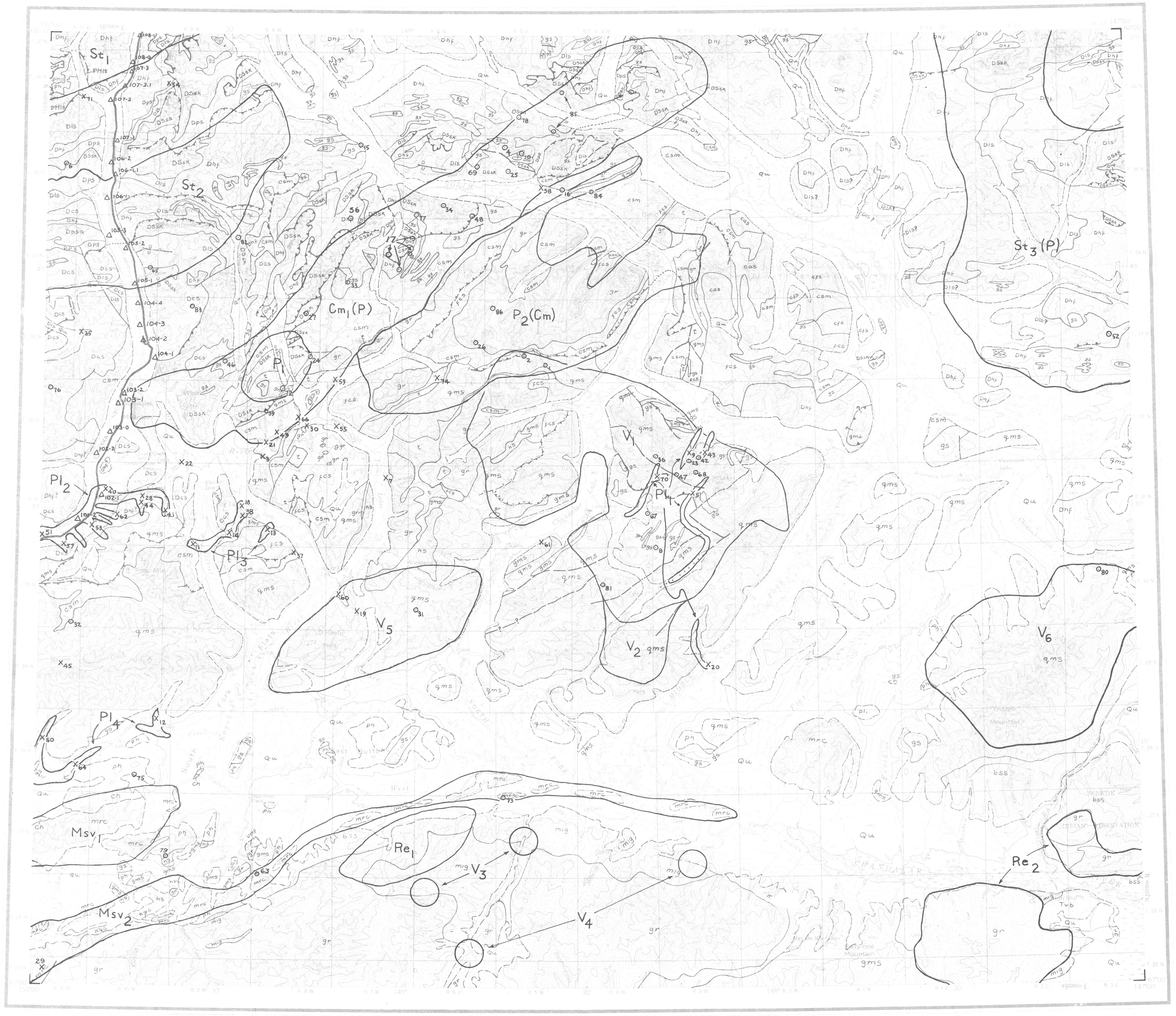
DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY



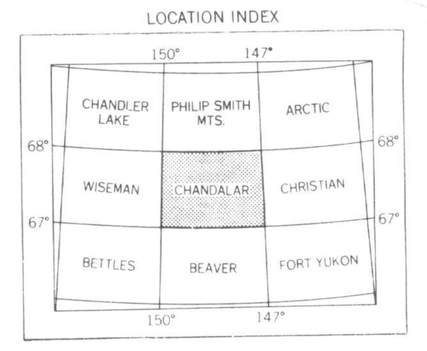
BASE FROM U.S. GEOLOGICAL SURVEY, 1956

SCALE 1:250 000

5 0 5 10 15 20 25 MILES

5 0 5 10 15 20 25 KILOMETERS

CONTOUR INTERVAL 200 FEET
DATUM IS MEAN SEA LEVEL



MINERAL RESOURCES MAP OF THE CHANDALAR QUADRANGLE, ALASKA

BY

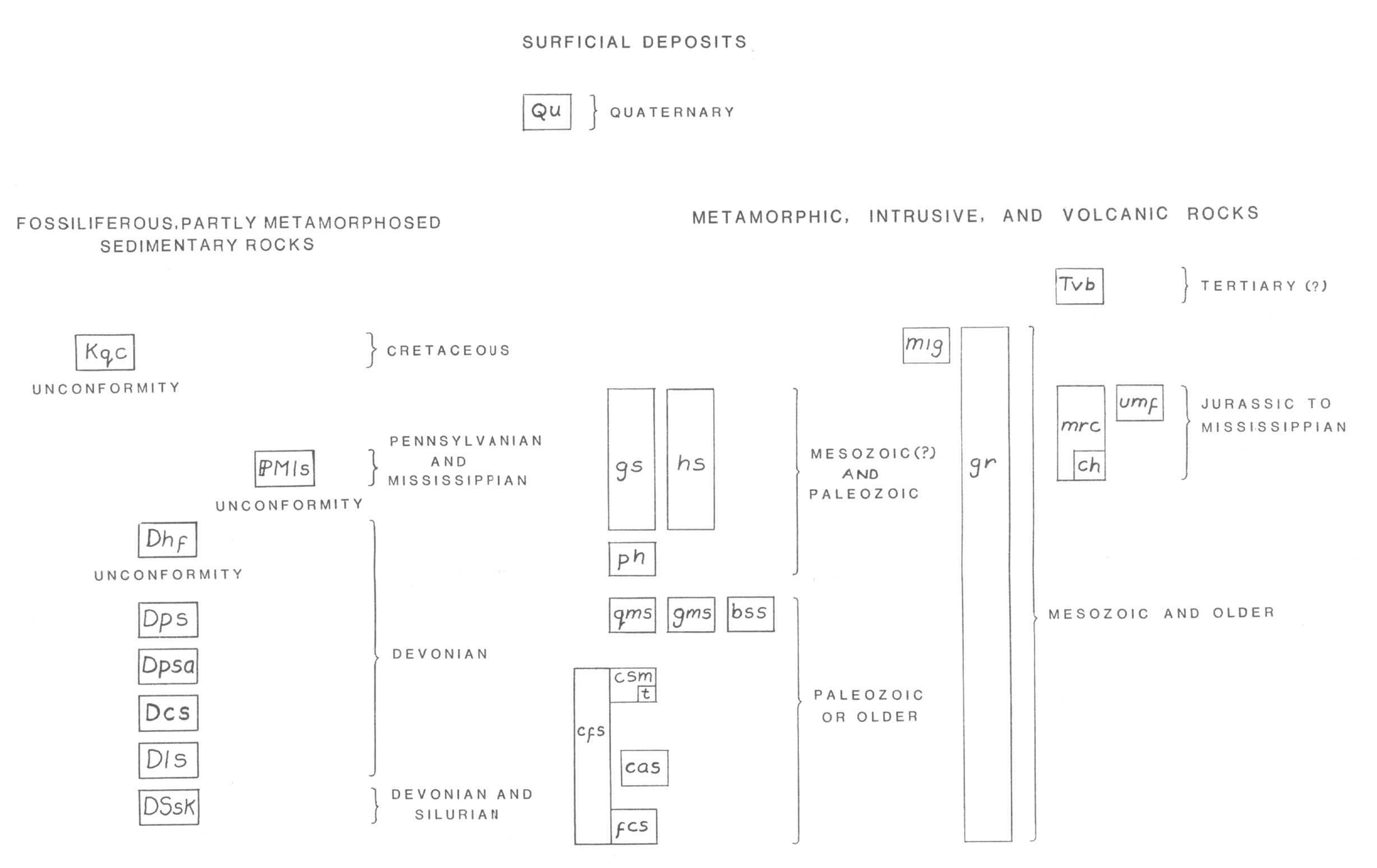
JOHN H. DE YOUNG, JR.

1978

EXPLANATION

GEOLOGY GENERALIZED AND REVISED FROM BROSGE AND REISER, 1964, AND CHIPP, 1970

CORRELATION OF MAP UNITS


SURFICIAL DEPOSITS
Qu
QUATERNARY
FOSSILIFEROUS, PARTLY METAMORPHOSED SEDIMENTARY ROCKS
Kqc
CRETACEOUS
UNCONFORMITY
PMls
PENNSYLVANIAN AND MISSISSIPPIAN
UNCONFORMITY
Dhf
UNCONFORMITY
Dps
Dpsa
Dcs
Dls
DSsk
DEVONIAN
DEVONIAN AND SILURIAN
METAMORPHIC, INTRUSIVE, AND VOLCANIC ROCKS
Tvb
TERTIARY (?)
mig
gs
hs
ph
MESOZOIC(?) AND PALEOZOIC
gr
mrc
ch
umf
JURASSIC TO MISSISSIPPIAN
qms
gms
bss
csm
t
cfs
cas
fcs
PALEOZOIC OR OLDER
MESOZOIC AND OLDER

DESCRIPTION OF MAP UNITS

This map is generalized from Brosgé and Reiser (1964). Many of these map units are combinations of units shown separately on the older map. The Devonian and Devonian(?) age that was assigned to the metamorphic rocks by Brosgé and Reiser (1964) is herein revised to early Paleozoic or older.

SURFICIAL DEPOSITS

- **Qu** Unconsolidated sedimentary deposits (Quaternary)

FOSSILIFEROUS PARTLY METAMORPHOSED SEDIMENTARY ROCKS

- **Kqc** Quartz pebble conglomerate (Cretaceous)
- **PMls** Lisburne Group (Pennsylvanian and Mississippian) and Kayak Shale (Mississippian)--Limestone, dolomite, shale and conglomerate
- **Dhf** Hunt Fork Shale (Upper Devonian)--Slate and phyllite
- **Dps** Purple and green slate and phyllite (Devonian)
- **Dpsa** Purple and green andesitic volcanic sheared conglomerate (Devonian)
- **Dcs** Chloritic siltstone and grit (Devonian)--Schistose; in part graywacke
- **Dls** Limestone and siltstone (Upper Devonian)--Schistose; includes some green slate locally
- **DSsk** Skajit Limestone (Upper and Middle Devonian, Upper Silurian)--Limestone, dolomite, and marble

METAMORPHIC, INTRUSIVE AND VOLCANIC ROCKS

- **Tvb** Vesicular olivine basalt flows (Tertiary?)
- **mig** Migmatite--Intercalated mica schist and granite; granite with mafic inclusions
- **gr** Granitic rocks--K/Ar dates of biotite are 101 m.y. and 125 m.y. (Brosgé and Reiser, 1964); of hornblende, 486 m.y. (M. L. Silberman and D. L. Turner, written commun., 1977)
- **mrc, ch** Mafic rocks and chert--Pillow basalt, andesite, minor chert; diorite; diabase and gabbro. Chert (ch) differentiated where abundant
- **umf** Ultramafic rocks
- **gs** Greenstone and greenschist--Includes pillowed flows in Hunt Fork Shale (Dhf) in northeast part of the quadrangle
- **hs** Hornblende schist--Mostly hornfels facies
- **ph** Phyllite and schistose wacke
- **qms** Quartz muscovite schist
- **gms** Garnet mica schist--Mostly hornfels facies
- **bss** Biotite staurolite schist--Hornfels facies
- **csm, t** Calcareous schist, marble and tactite (t) locally
- **cfs** Undifferentiated calcareous schist (csm) and feldspathic chloritic schist (fcs)
- **fcs** Feldspathic chloritic schist--Includes metadiorite sills and pyritic quartzite
- **cas** Chloritized amphibole schist--Local remnant glaucophane

GEOLOGIC SYMBOLS

CONTACT--Dashed where approximate; dotted where concealed

NORMAL FAULT--Dashed where inferred, queried where doubtful; dotted where concealed; U, upthrown side; D, downthrown side

THRUST FAULT--Queried where doubtful; dotted where concealed. Sawteeth on upper plate

SYMBOLS FOR DEPOSIT AND MATERIAL SITE LOCATIONS AND FAVORABLE MINERAL RESOURCE AREAS

- ⊙ 1 — Lode mineral deposit. Includes mines, prospects, and mineral occurrences; number corresponds to number in table 1 describing the mineral deposits of the Chandalar quadrangle. Symbol is placed near center of deposit and, in places, is used to locate a number of deposits or a group of claims.
- × 3 — Placer mineral deposit. Principally gold placers; number corresponds to number in table 1 describing the mineral deposits of the Chandalar quadrangle. Symbol is placed near center of placer deposit.
- △ 101-2 — Material site. Includes sand and gravel pits and rock quarries along the pipeline route; number corresponds to number in table 2 describing the material sites along the trans-Alaska oil pipeline in the Chandalar quadrangle.
- Favorable area for occurrence of mineral deposits. Type(s) of deposits designated by letter symbols. Criteria used to define areas are listed in table 3 for each area.
- Cm, (Cm) — Contact metamorphic, skarn, and tactite deposits. Symbol in parenthesis indicates possible occurrence in an area principally selected for another type of deposit.
- Msv — Massive sulfide base metal deposits in volcanic rocks.
- P, (P) — Porphyry copper and (or) porphyry molybdenum deposits. Symbol in parenthesis indicates possible occurrence in an area principally selected for another type of deposit.
- Pl — Placer deposits.
- Re — Rare-earth deposits.
- St — Stratabound sulfide deposits in shale and (or) carbonate rocks.
- V — Vein or fissure deposits.

FOLIO OF THE CHANDALAR QUADRANGLE ALASKA
MISCELLANEOUS FIELD STUDIES
MAP MF-878-B

JOHN H. DE YOUNG, JR. - MINERAL RESOURCES MAP
SHEET 1 OF 2

DISCUSSION

Areas favorable for the occurrence of seven types of mineral deposits are delineated on the mineral resources map. Known deposits and occurrences are shown on the map and described in table 1. Material sites along the trans-Alaska oil pipeline are also shown on the map and are described in table 2. The delineation of favorable areas for the occurrence of mineral deposits is based on information about known occurrences as well as geologic, geochemical, geophysical, and earth satellite information presented in the other components of the folio of the Chandalar quadrangle. The criteria used to select each of the favorable areas are listed in table 3.

Harris, Freyman, and Barry (1970, p. 12) describe four types of analysis used for regional mineral resource evaluations. They are (1) subjective and qualitative evaluation of the favorability of geologic setting based on geologic field studies, (2) statistical inference using spatial models of mineral density ignoring geologic factors, (3) multivariate statistical inference based upon quantified relations between mineral wealth and geoscience information, and (4) geologists' opinions stated in terms of subjective probabilities. The mineral resource assessment of the Chandalar quadrangle combines two of these categories of analysis. The delineation of favorable areas is accomplished by the first type of analysis. Next, the fourth type of analysis is used to produce subjective estimates of the number of deposits of a specific type that might occur in the quadrangle. Finally, information about the grades and tonnages of known deposits of the type under consideration (occurring in the Chandalar quadrangle or elswhere) is used to derive quantitative estimates of the resources of a given mineral commodity.

It is important to recognize several aspects of resource assessment that are not embodied in this analysis. First, the likelihood of discovery of mineral deposits in an area is contingent upon the intensity and quality of the search efforts as well as the favorability for the occurrence of deposits. Only occurrence is considered here. Second, quantitative estimates have been made in terms of physical units rather than monetary units so that future price changes can be incorporated into the analysis by the reader. Third, areas not delineated as favorable for the occurrence of mineral deposits include areas where little information is available owing to poor bedrock exposure as well as areas where available information does not indicate mineral deposit occurrence. The acquisition of additional information throughout the quadrangle, particularly by drilling, may change the boundaries of favorable areas. Fourth, the estimates of undiscovered resources are made in terms of deposit types that are recognized to exist somewhere in the world. Speculation about hitherto unrecognized deposit types is akin to forecasting technological inventions or scientific discoveries. The potential for occurrence of Carlin-type disseminated gold deposits could not have been discussed prior to 1962 just as the availability of penicillin prior to 1929 or the effect of television on society prior to 1923 could not have been analyzed. A discussion of identified mineral resources of several commodities and of the potential for occurrence of undiscovered deposits follows.

Energy Resources

Coal.--No coal deposits are known within the Chandalar quadrangle.

Geothermal energy.--Rocks favorable for geothermal energy have not been identified in the quadrangle. The volcanic rocks either are older than 0.5 million years or are mafic.

Petroleum.--No oil or gas deposits are known in the Chandalar quadrangle. Payne (1959, p. 72) indicates that the eastern part of the Kobuk Cretaceous province extends into the southwestern corner of the Chandalar quadrangle, but this province is described as "structurally less favorable for petroleum exploration than the province to the south". Geologic conditions favorable for the occurrence of oil and gas have not been identified in the quadrangle.

Radioactive minerals.--Reports of radioactive minerals in the Chandalar quadrangle include the occurrence of uranothorianite in Big Squaw Creek (map number 9) and the observation of radioactivity at the O'Keefe placer claim (near map number 19) that is "higher than is normal in areas of mica schist" (Freeman, 1963, p. 31). Small amounts of monazite, an important source of thorium, have been reported in placer deposits in area Pl_1 (Mertie, 1925, p. 260). Uranium or thorium deposits of exploitable quality are not known in the quadrangle. No radiometric surveys had been made in the area at the time of this publication. On the basis of available geologic information, the quadrangle appears to have a low potential for occurrence of large uranium or thorium deposits.

Metal Resources

Copper.--Copper has been identified in porphyry and contact metamorphic deposits in the Chandalar quadrangle. Recently (1976) the occurrence of stratabound copper deposits has been reported (map number 52). Copper minerals have also been observed in small amounts in vein gold deposits. Massive sulfide copper deposits may also occur.

One porphyry copper deposit (Venus prospect - map number 72) has been identified in the quadrangle, and parts of a porphyry molybdenum deposit (Geroe Creek prospect - map number 26) contain disseminated copper mineralization. These deposits are associated with granite intrusions that crop out in a northeast-southwest-trending belt. Drilling at the Venus prospect has not been extensive enough to determine the boundaries of the mineralized part of the intrusive; the grade of that part sampled by drilling is estimated at 0.1 percent copper. The Geroe Creek prospect has been studied by geologic mapping and geochemical sampling but has not been drilled. On the basis of the consistency of the information used in selecting favorable areas [areas P_1, P_2(Cm), Cm_1(P), and St_3(P)] and the number and size of these areas, a subjective estimate of the number of porphyry copper deposits that occur in the quadrangle is:

(1) a 90 percent chance that there is one or more deposit,

(2) a 50 percent chance that there are three or more deposits, and

(3) a 10 percent chance that there are five or more deposits.

Most of the exploration for copper deposits in the Chandalar quadrangle has been done in recent years (the Venus claims were first staked in 1967), and further exploration has been discouraged by the absence of promising discoveries (discoveries have been characterized by inadequate tonnages of high-grade material and low grades for disseminated material) and by uncertainty regarding land-use decisions. The limited information available about the Venus porphyry copper prospect indicates that its copper content is low by comparison with deposits in the conterminous United States. The grades and tonnages of deposits expected to occur in the Chandalar quadrangle may be similar to those of porphyry copper deposits in British Columbia and Yukon Territory. Information from the frequency distribution of tonnages of 21 porphyry copper deposits in western Canada (Singer and others, 1975) and from data presented on 23 major calc-alkaline-suite porphyry deposits of the Canadian Cordillera (Drummond and Godwin, 1976) is used to estimate the ore tonnages of deposits in this quadrangle. Information available about disseminated mineralization in the Chandalar quadrangle indicates that the average grades of deposits are considerably less than those of deposits in western Canada. Whereas the median of average grades of the Canadian deposits is about 0.4 percent, the estimated median of average grades of deposits in the Chandalar quadrangle is 0.2 percent. The estimated percentages of porphyry copper deposits that will have various average grades and tonnages when completely drilled are:

Tonnage

(1) 90 percent $\geq$ 25 million metric tons,

(2) 50 percent $\geq$ 160 million metric tons, and

(3) 10 percent $\geq$ 420 million metric tons.

Grade

(1) 90 percent $\geq$ 0.1 percent copper,

(2) 50 percent $\geq$ 0.2 percent copper, and

(3) 10 percent $\geq$ 0.4 percent copper.

Skarn or tactite-type deposits of copper mineralization occur in area Cm_1(P), and favorable geologic conditions for this type of deposit exist in area P_2(Cm). Copper mineralization in observed tactite occurrences is confined to isolated bodies. At the Evelyn Lee prospect (map number 24), total copper resources of these bodies have been estimated at 1 million tons of ore with an average grade of 5 percent copper (Russell Babcock, written commun., 1977).

Other types of copper deposits that may occur in the Chandalar quadrangle are stratabound deposits, massive sulfide deposits associated with volcanic rocks, and vein-type deposits. The possible occurrence of these types of deposits is indicated by geochemical anomalies and favorable rock types. The possibility of significant amounts of copper resources from the last two types is low, but recent prospecting for stratabound deposits (map number 52) may produce information about this type of deposit in the Chandalar quadrangle--information that could be used in a revaluation of the quadrangle's copper resources.

Gold.--The discovery of placer gold at Tramway Bar, 115 km southwest of Chandalar, led to increased prospecting activity and the discovery of placer gold near Wiseman in 1901 and 1902 and in the Chandalar area in 1905 (Little Squaw Creek - map number 43) and in 1906 (Big Creek - map number 5) (Chipp, 1970, p 3-5). Areas of past prospecting and production that may be favorable for occurrence of additional placer gold are some areas draining into the Middle and South Forks of the Koyukuk River (Pl_2, Pl_3 and Pl_4) and areas of placer deposition about 10 km east of Chandalar Lake (Pl_1). Reported production from deposits in areas Pl_2, Pl_3, and Pl_4 prior to 1910 totalled about 690,000 g. Over 90 percent of this amount came from two deposits--Gold Creek (map number 28) and Myrtle Creek (map number 50). Gold production from placer deposits in the area east of Chandalar Lake (Pl_1) has been estimated at 1.2 million g, of which 400,000 g were recovered from Big Creek, primarily from mechanized operations since 1950 (Heiner and Wolff, 1968, p. 14). On the basis of records of prospecting and production, it is estimated that the remaining placer gold resources in the Chandalar quadrangle are no more than what has already been produced or about 2 to 3 million g. The most likely estimate of remaining resources may be much lower than the upper limit.

Gold-quartz vein deposits were identified in 1908 at the Little Squaw mine (map number 42), and some gold-silver ore has been produced from that mine and from the Mikado and Summit mines (map numbers 47 and 68). Proven reserves at the Little Squaw and Mikado mines are 12,800 metric tons of ore averaging 71 g/t (grams per metric ton) gold. Additional occurrences of gold resources in area V_1 may exist as extensions to known deposits (total reserves at the Mikado and Little Squaw mines were estimated to be 45,000 metric tons at about 80 g/t in 1968 by Frank Birch, mining engineer for Chandalar Gold Mining and Milling Co.) and as undiscovered deposits. Although areas V_6, V_5, and V_2 have not yielded gold production, similarities in rock type and geochemical anomalies to area V_1 indicate that they may contain gold-quartz vein deposits.

Molybdenum.--The principal known occurrence of molybdenum in the Chandalar quadrangle is the disseminated molybdenite associated with the granitic pluton at the Geroe Creek prospect (map number 26). No estimates of grade and tonnage for the deposit are available. The possibility exists that other deposits of the type occur in area P_2(Cm). Published information about porphyry molybdenum deposits in western Canada provides some insight about the expected molybdenum resources (Drummond and Godwin, 1976). For the six Canadian deposits discussed, average grades range from 0.11 to 0.43 percent MoS_2, ore tonnages range from 1.4 million to 194 million metric tons, and metal tonnages range from 3000 to 163,000 metric tons of molybdenum. Isolated geochemical anomalies may indicate the occurrence of vein-type molybdenum deposits in area V_4, but the resource potential of these deposits is not significant.

Lead and zinc.--Galena and sphalerite, the common ore minerals of lead and zinc, have been observed in contact metamorphic deposits at the Bob, Gayle, and Jim-Montana claims (map numbers 10, 25, and 34). These deposits and lead and zinc stream-sediment anomalies in the northeastern part of area Cm_1(P) may be indicative of resources of these metals, but no deposits with quantified grades and tonnages have been demonstrated. Lead and zinc mineralization has also been observed in quartz veins at various localities in the quadrangle.

Favorable conditions exist in several areas [St_1, St_2, and St_3(P)] for the occurrence of stratabound deposits containing lead and(or) zinc and other resources. One possible deposit type is stratabound lead-zinc-barite deposits in Devonian black shales and related to minor mafic and rhyolitic volcanic rocks. Examples of this type of deposit occur in western Canada and have been described by Carne (1976). Some of these deposits in Yukon Territory contain as much as 3 to 9 million metric tons of ore averaging 8 to 17 percent combined lead and zinc.

Rare-earth metals.--Stream-sediment samples in areas Re_1 and Re_2 are characterized by higher values of yttrium, lanthanum, niobium, vanadium, and barium than neighboring areas. Although these "anomalies" may be simply a characteristic of the intrusive rocks in the southern part of the quadrangle, these intrusive rocks may contain pegmatite or vein-type concentrations of rare-earth minerals.

Other metals.--Silver has been a byproduct of placer and lode gold operations in the Chandalar quadrangle. Mertie (1925, p. 263) reports that, for placer operations in the Chandalar area (Pl_1), one unit of silver was produced for every 7 units of gold during the period 1906 through 1923. The ratio of gold to silver in 1971 shipments from the Mikado mine (map number 47) was about 4.5. Silver has also been reported from argentiferous galena in the northeastern part of area Cm_1(P). Silver-bearing copper ore has been reported along the East Fork of the Chandalar River (James Funchion, written commun., 1922).

Arsenic and antimony minerals are found in some of the vein gold deposits. Arsenopyrite and scorodite occur in the gold-quartz veins of the Mikado mine.

One occurrence of platinum-group minerals has been reported (map number 39), but significant deposits have not been identified.

Other Resources

Construction materials.--The Chandalar quadrangle contains numerous sources of sand, gravel, and rock suitable for construction material. Over 4 million m^3 of sand, gravel, fill, and other road-building materials has been quarried along the Koyukuk and Dietrich Rivers for use in the construction of the trans-Alaska pipeline and the pipeline road (table 2). The types of material present in glacial and fluvial deposits have been described by Hamilton (1978).

Barite.--Heavy- mineral concentrate samples in the northwestern part of the Chandalar quadrangle (including areas St_1 and St_2) contain more barium than do those from the remainder of the quadrangle. No barite deposits have been reported, but favorable rock types exist for the occurrence of stratabound barite deposits similar to those in Yukon Territory. Some examples of Yukon barite deposits are the TEA barite deposit, which contains over 68,000 metric tons of ore-grade material and the MEL-JEAN deposit, which contains 3 million metric tons of ore containing about 50 percent $BaSO_4$ and about 8 percent combined lead and zinc (Carne, 1976, p. 30 and 40).

THIS MAP IS ONE OF A SERIES
ALL BEARING THE NUMBER MF-878
BACKGROUND INFORMATION RELATING TO
THIS MAP IS PUBLISHED AS U.S.GEOLOGICAL