

GEOLOGICAL SURVEY CIRCULAR 775



The Alaskan Mineral Resource Assessment Program:
Background Information to Accompany Folio of
Geologic and Mineral Resource Maps of the
Talkeetna Quadrangle, Alaska

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**By Bruce L. Reed, Gary C. Curtin, Andrew Griscom,
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CONTENTS

	Page
Abstract-----	1
Introduction-----	1
Purpose and scope-----	1
Geography and access-----	2
Acknowledgments-----	2
Geologic investigations-----	5
Previous investigations-----	5
Recent investigations and present study-----	5
Mineral production-----	6
Description of component maps of the Talkeetna quadrangle folio-----	6
Geology-----	6
Geophysics-----	8
Interpretation of Landsat imagery-----	9
Mineral resources-----	9
Geochemistry-----	10
Surficial deposits-----	11
Land status-----	13
Bibliography-----	13

ILLUSTRATIONS

	Page
FIGURE 1. Index map of Alaska showing location of Talkeetna quadrangle-----	3
2. Map showing Talkeetna quadrangle and the Alaska Range in south-central Alaska-----	4
3. Map showing geologic terranes in the Talkeetna quadrangle, Alaska-----	7
4. Map of Talkeetna quadrangle indexing the 24 larger scale (1:63,360) quadrangles and the classification and boundaries of proposed and existing categories of land in the quadrangle-----	12

TABLE

	Page
TABLE 1. Component maps of the Talkeetna quadrangle mineral resource assessment-----	1

The Alaskan Mineral Resource Assessment Program: Background Information to Accompany Folio of Geologic and Mineral Resource Maps of the Talkeetna Quadrangle, Alaska

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ABSTRACT

The Talkeetna 1° by 3° quadrangle, which consists of about 17,155 km² in south-central Alaska, was investigated by integrated field and laboratory studies in the disciplines of geology, geochemistry, geophysics, and Landsat data interpretation for the purpose of assessing its mineral resource potential. Past mineral production has been limited to gold from the Yentna district, but the quadrangle contains potentially significant resources of tin and silver and possibly a few other commodities including chromite and copper. The results of the mineral resource assessment are given in a folio of maps which are accompanied by descriptive texts, diagrams, tables, and pertinent references. This Circular provides background information on these investigations and integrates the component maps. A bibliography cites both specific and general references to the geology and mineral deposits of the quadrangle.

INTRODUCTION

PURPOSE AND SCOPE

This Circular and a separately available folio of maps are part of a series of U.S. Geological Survey reports prepared to furnish information on the mineral resources and mineral resource potential of Alaska. This work is being done under the Alaska Mineral Resource Assessment Program (AMRAP) and is intended to provide information both for long-range national minerals policy and for State, Federal, and industry decisions concerning the future use of Alaskan lands and its resources. In addition, it is the intent of this folio of maps to increase the geologic knowledge of the region and to provide guidance for minerals exploration.

Most of the basic data for these map reports (table 1) were collected between 1974 and 1976 when

an interdisciplinary team of earth scientists carried out field and laboratory investigations necessary for a mineral resource appraisal. The reports and this Circular supply information on the geology, and land status of the quadrangle. A bibliography of geologic literature pertinent to the Talkeetna quadrangle is included.

TABLE 1.—Component maps of the Talkeetna quadrangle mineral resource assessment

U.S. Geological Survey Miscellaneous Field Studies Map	Subject
MF-870-A (Reed and Nelson, 1977)	Geology.
MF-870-B (Griscom, 1978)	Aeromagnetic map and interpretation.
MF-870-C (Steele and Albert, 1978)	Interpretation of Landsat imagery.
MF-870-D (Reed and others, 1978)	Mineral resources.
MF-870-E (Curtin and others, 1978c)	Geochemical distribution and abundance of gold and silver.
MF-870-F (Curtin and others, 1978e)	Geochemical distribution and abundance of tin, tungsten, and beryllium.
MF-870-G (Curtin and others, 1978d)	Geochemical distribution and abundance of copper, lead, zinc, and molybdenum.
MF-870-H (Curtin and others, 1978f)	Geochemical distribution and abundance of chromium and nickel.
MF-870-I (Tripp and others, 1978)	Mineralogical data for heavy-mineral concentrates.
MF-870-J (Nelson and Reed, 1978)	Surficial deposits.

The Talkeetna quadrangle covers about 17,155 km² in south-central Alaska (figs. 1 and 2) between lat 62° and 63° N. and long 150° and 153° W. Parts of three physiographic provinces are present in the quadrangle; from northwest to southeast they are the Tanana-Kuskokwim Lowland, Central Alaska Range, and Cook Inlet-Susitna Lowland (Wahrhaftig, 1965). The topography is dominated by the high, spectacularly glaciated Alaska Range which forms a northeast-trending arc of mountains in this part of Alaska (fig. 2). Mount Foraker, the third highest peak in North America, with an altitude of 5,304 m, lies in the north-central part of the quadrangle (fig. 2). North America's highest mountain, Mount McKinley, is 23 km northeast of Mount Foraker in the adjacent Mount McKinley quadrangle.

Topographic relief within the Alaska Range is high, the altitude ranging from 3,475 m to 600 m. This contrasts sharply with the essentially flat Tanana-Kuskokwim and Cook Inlet-Susitna lowlands which, within the quadrangle, have an average altitude of 550 m and 215 m respectively.

Owing to the physiographic barrier created by the Alaska Range, precipitation is relatively heavy on its southern side. In the high core of the mountains is a nearly continuous network of large alpine glaciers, which meander between the snow- and ice-covered mountains that tower above them. The largest glaciers, the Ruth, Kahiltna, Yentna, and Tokositna, are 40–72 km long and descend to altitudes of less than 300 m. The lowest few kilometers of their lengths is mantled by rock debris and, locally, by vegetation.

The Susitna River is the master drainage artery for most of the quadrangle. It flows south along the easternmost part of the quadrangle, is joined by the second largest drainage, the Chulitna River, at Talkeetna, and discharges to upper Cook Inlet about 40 km west of Anchorage. Other major rivers include the Yentna and the Kahiltna, which join south of the quadrangle and then flow into the Susitna River. North of the Alaska Range, in the northwestern part of the quadrangle, the major drainage is the Tonzona River, which flows to the northwest, and joins the Kuskokwim River east of McGrath. Most of the larger rivers in the quadrangle are nourished by alpine glaciers. In summer months they are turbid from a continuous supply of glacier-derived material.

Population in the quadrangle is sparse and centered at Talkeetna, which had a population of 182 in 1970; this, however, has undoubtedly increased over the last 8 years. Other permanent residents have built houses or places of business along the newly completed Parks Highway; they operate transportation facilities or live on homesteads. The larger guiding camps in the area are maintained by year-round caretakers. Population increases markedly during the summer months owing to an influx of tourists, mountain climbers, placer miners in the Peters Hills-Dutch Hills area, fishermen, hunters, guiding camp personnel, summer residents, nature enthusiasts, and persons involved in mineral exploration. The main guiding establishments are at Rainy Pass Lodge, at Amos Lake, and near Boulder Creek on the north side of the Alaska Range. A fly-in tourist and fishing lodge is maintained at Chelatna Lake, and fishing camps are present at numerous smaller lakes in the southeastern part of the quadrangle.

The Parks Highway, an all-weather paved road, and the Alaska Railroad follow the Susitna and Chulitna Rivers in the easternmost part of the quadrangle. A gravel road, constructed for and presently used primarily for access to the Peters Hills gold placer operations, receives moderate use during the summer months. The road is about 65 km long and extends from near Talkeetna to Cache Creek in the Peters Hills. A few short roads used in connection with mineral exploration and which require four-wheel-drive vehicles are used intermittently in the Boulder Creek area. Access to Boulder Creek is by air, where one airstrip can accommodate C-46-type aircraft. Travel to and within the quadrangle is chiefly by small fixed-wing aircraft equipped with skis, wheels, or floats. Larger drainages provide numerous gravel bars from which small aircraft can operate, and airstrips have been constructed at several gold placer operations from Fairview Mountain northeast to the Dutch and Peters Hills. Small ski-equipped aircraft can land on some glaciers in the Alaska Range and provide access for an increasing number of mountain climbers during the summer months.

ACKNOWLEDGMENTS

This folio of maps results from the participation of many earth scientists, whose many contributions are gratefully acknowledged. Many of these persons were visiting scientists and laboratory



FIGURE 1.—Index map of Alaska showing location of Talkeetna quadrangle. Places mentioned in the text of this report can be found on the individual folio maps.

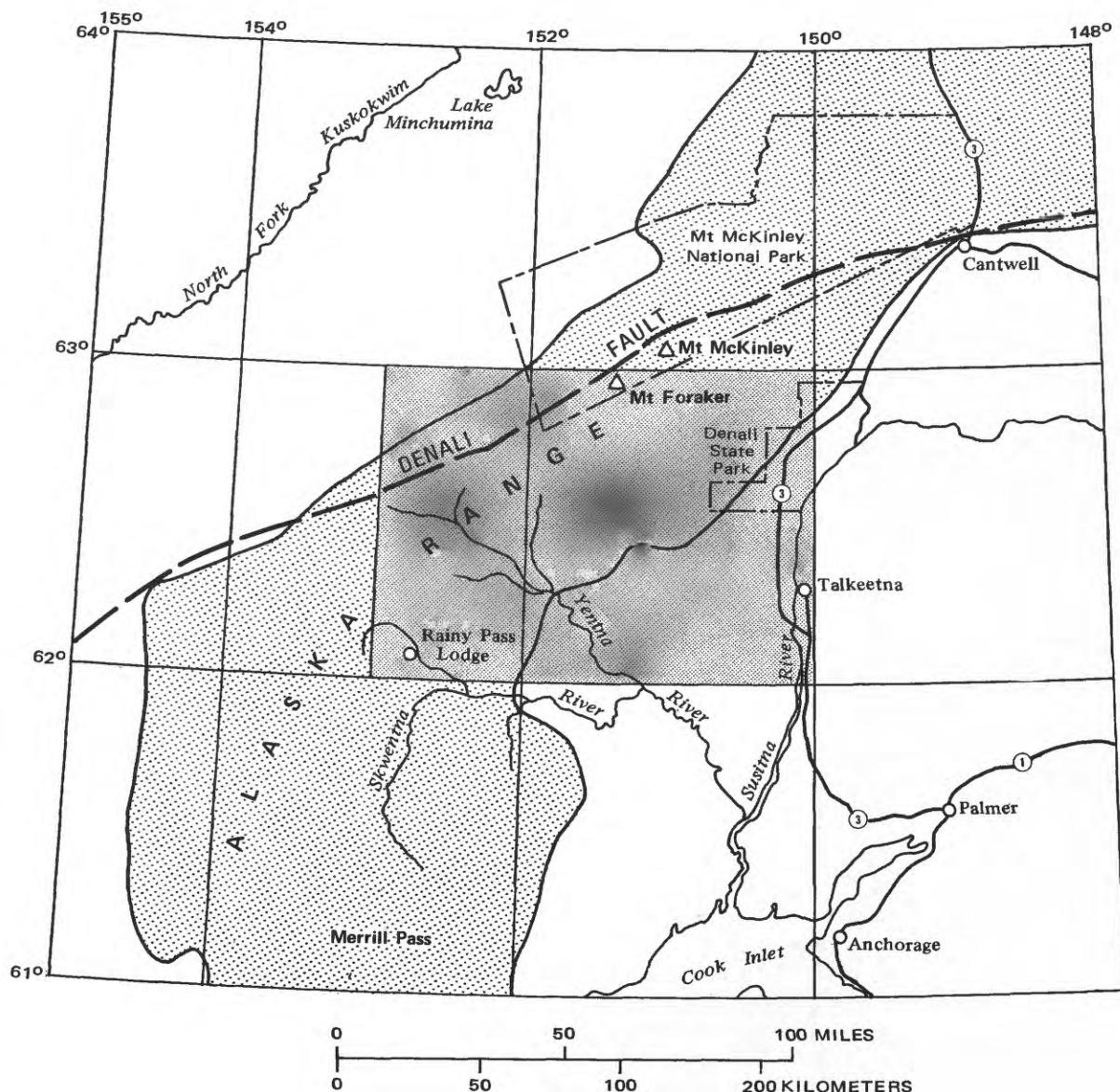


FIGURE 2.—Map showing Talkeetna quadrangle (shaded) and the Alaska Range (dotted) in south-central Alaska, (1) Glenn Highway; (3) Parks Highway.

specialists who have been cited for their work on the specific maps in the folio. It does, however, seem appropriate to mention specifically a few colleagues who made noteworthy contributions. These include geologists R. L. Detterman, J. C. Ratté, and D. H. Richter, whose exceptional field-mapping capabilities provided a better understanding of the complex geology and stratigraphy in the areas of Shellabarger Pass and north of the Denali fault, and D. L. Jones, whose expertise in regional tectonics and paleontology was a prime factor in the interpretation of the complex geologic terranes in the quadrangle. Tribute is also due to several

paleontologists without whose interest and effort the knowledge of the stratigraphic sequence of the many geologic terranes would be woefully short. Among those who made significant contributions are A. K. Armstrong, Claire Carter, J. T. Dutro, Jr., Anita Harris, W. A. Oliver, Jr., N. J. Silberling, and J. A. Wolfe. M. A. Lanphere, whose understanding of granite tectonics and willingness to provide data on the age of the many plutonic rocks in the quadrangle, provided the factual information on periods of granitic emplacement for this part of Alaska.

The cooperation of, and subsequent discussions

with, geologists engaged in oil and mineral exploration, is gratefully acknowledged; particularly helpful were H. E. Mann, C. A. Arbens, Tak Matsumoto, and C. C. Hawley. Special thanks are also due to J. J. McDougall, who, over a period of years, has provided samples and information relative to the geology and minerals exploration in the region. The geologic investigations in this remote area were especially facilitated by the cooperation and assistance of several local people. David and Angie Purkey provided logistic assistance, geologic knowledge of the area, and drill-hole information on tin-silver prospects. Mike Branham, Ann Budzynski, and Forest Charlton also were helpful in many ways.

The able and cheerful field and laboratory assistance of D. B. Clemens and D. K. Cohen is much appreciated. H. C. Berg, manager of AMRAP, coordinated various parts of this project.

GEOLOGIC INVESTIGATIONS

PREVIOUS INVESTIGATIONS

The earliest geologic data from the quadrangle were recorded in 1898 by a U.S. Geological Survey exploration team under the direction of J. E. Spurr (1900). This remarkable journey included the difficult task of lining canoes up the Squentna (Skwentna) River, portaging them across the Alaska Range at Portage Creek (5 km south of the southwestern corner of the quadrangle), and then descending the Kuskokwim River to its mouth. This same year G. H. Eldridge (1900) made a reconnaissance of the Sushitna (Susitna) River.

A second monumental expedition across this part of the Alaska Range was made four years later, in 1902, when A. H. Brooks (1911a) led a survey team supported by packhorses across the Alaska Range. His route followed the Kichatna River, across Rainy Pass to the South Fork of the Kuskokwim, then northeast along the north flank of the Alaska Range to the Nenana River. Discovery of placer gold on Cache Creek in 1905 led to a series of studies by various workers of the U.S. Geological Survey. Beginning with the early work of S. R. Capps (1913), several investigations of the district have been made, and these reports are cited in the bibliography. In 1925 Capps (1927) conducted a reconnaissance survey along the north flank of the Alaska Range from the Mount McKinley Park railroad station west to the Tonzona River. This survey, in part, followed the earlier traverse by

Brooks. In a comprehensive study of the geology along the Alaska Railroad, Capps (1940) compiled a map which included part of the Alaska Range in the northeastern part of the quadrangle. All the earlier investigations mentioned above were directed toward geography, regional geology, or studies of mining districts. For the most part, little was known about the geology and mineral resources of the high rugged mountains of the Alaska Range.

RECENT INVESTIGATIONS AND PRESENT STUDY

Geologic studies in the quadrangle after World War II consisted chiefly of radioactivity investigations and were concentrated primarily in the Yentna gold-placer district. It was not until 1967, when the U.S. Geological Survey initiated the helicopter-supported heavy-metals program, that significant progress was made toward understanding the geology in this part of the Alaska Range. Hawley and Clark (1973, 1974) added considerably to knowledge of the geology and mineral deposits of the Chulitna-Yentna mineral belt, and Reed and Elliott (1968) completed a geochemical survey in the northwestern part of the quadrangle. The latter work led to the discovery of the massive sulfide deposits at Shellabarger Pass (Reed and Eberlein, 1972). While undertaking reconnaissance topical studies on the Alaska-Aleutian batholith in 1970-72, Reed and Lanphere mapped and age-dated by potassium-argon methods the larger plutonic bodies in the quadrangle. These results were published in a series of papers (Reed and Lanphere, 1972, 1973a, 1973b, 1974).

The present study began in 1974 when fieldwork was initiated under one of four Prototype Alaskan Minerals Resource Assessment Programs (PAMRAP). The Talkeetna project differed from the other PAMRAP quadrangles (Nabesna, Tanacross, McCarthy) in that only a minimum amount of geologic information was available before the start of fieldwork. In 1974, helicopter-supported fieldwork was done north of the crest of the Alaska Range. In 1975 geologic investigations were completed in the western half of the quadrangle, and a geochemical and gravity reconnaissance was initiated in the northwestern part of the quadrangle. Geologic, geochemical, and geophysical field investigations were completed for the entire quadrangle in 1976. Most of the above fieldwork was concentrated in the Alaska Range. Data on the surficial geology are chiefly from interpretation of aerial photographs.

The primary purpose of the project was to (1) produce a modern geologic map, (2) provide reliable geologic and geochemical data on the mineral deposits and mineral resources, and (3) obtain structural and stratigraphic data which will allow for a better understanding of the tectonic history of this part of Alaska. In large part, these goals have been accomplished, and their results are included in the folio of maps and in this Circular. As with any scientific investigation, the gathering of new data opens doors to other problems. Much work remains to be done, and although this work has greatly increased our knowledge of the geology and mineral resource potential of the quadrangle, it is only the start of a thorough understanding of the geologic history and complex processes that produced the various mineral deposits in the quadrangle.

MINERAL PRODUCTION

Placer gold production in the Yentna district, which includes the Peters and Cache Creek drainages and the area near Fairview Mountain, totaled about 204,000 troy ounces through 1960 (Clark and Hawley, 1968). Recorded gold production through 1975 was slightly more than 211,000 ounces, although actual production may be closer to 300,000 ounces. For example, although there were 27 operations in the Cache Creek area in 1975, there was no recorded production (R. G. Bottge, 1977, written commun.). The recent rise in the price of gold has brought many of the placer mines back into operation, and this trend of increased activity will probably continue if environmental restrictions can be met economically.

Sand and gravel deposits along the Chulitna and Susitna Rivers were utilized for the construction of the Parks Highway, and granite along the highway has locally been quarried to provide material for bridge construction and erosion control.

DESCRIPTION OF COMPONENT MAPS OF THE TALKEETNA QUADRANGLE FOLIO

GEOLOGY

(map MF-870-A)

The Talkeetna quadrangle comprises five distinctive, generally fault-bounded, geologic terranes. The northernmost terrane (terrane A, fig. 3) is truncated on the south by the McKinley segment of the Denali fault system. Sedimentary and volcanic rocks in this terrane consist, from oldest to

youngest, of (1) a multiply folded, regionally metamorphosed quartzite, quartz semischist, quartz grit, metavolcanic rocks, and minor conglomerate, limestone, and phyllite; (2) an overlying allochthonous sequence of black, sooty, carbonaceous and calcareous shale and limestone that contains numerous dikes and sills of gabbro and quartz diorite; (3) a thick unit of Jurassic(?) and Lower Cretaceous argillite, siltstone, chert, graywacke, and pillow basalt; and (4) early and middle Tertiary continental sedimentary rocks. Within the quadrangle these four units are fault bounded, and their bases are not exposed. Serpentinite is locally developed along some faults, and the terrane is cut by McKinley sequence (55 m.y. old) granite. Schistosity and metamorphic grade of the quartzite and quartz semischist unit increase to the northeast. This unit is inferred to correlate with the Birch Creek Schist of former usage in the Kantishna Hills and is considered to be early Paleozoic or possibly late Precambrian. The age of the carbonaceous shale and limestone is unknown, but the unit may be equivalent to shale containing Ordovician graptolites 65 km to the southwest. The lower Tertiary continental rocks are thought to be remnants of an extensive continental sequence deposited in this part of the Alaska Range and now preserved in fault slivers chiefly along the Denali fault zone. They are believed to be equivalent to the Cantwell Formation of Paleocene age. Middle Tertiary coal-bearing rocks are in fault contact with the other sedimentary rocks in the northwestern part of the quadrangle and probably underlie the lowlands to the north.

In this part of the Alaska Range, the McKinley segment of the Denali fault system has undergone right-lateral displacement of about 38 km in the last 38 m.y. Furthermore, the straight north-facing scarp along this part of the range indicates that as much as 3 km of south-side-up vertical component of movement may have occurred since middle Tertiary time. Before this investigation, it was thought that the Denali fault system in this part of the Alaska Range separated the central Alaska Range into a northern sedimentary terrane of middle Paleozoic and older age and a southern sedimentary terrane chiefly of Mesozoic age. It is now known that the terrane adjacent to and south of the Denali fault in the quadrangle (terrane B, fig. 3) consists of a middle and upper Paleozoic (Devonian to Pennsylvanian) allochthonous sequence composed of marine flyschoid sedimentary rocks which in-

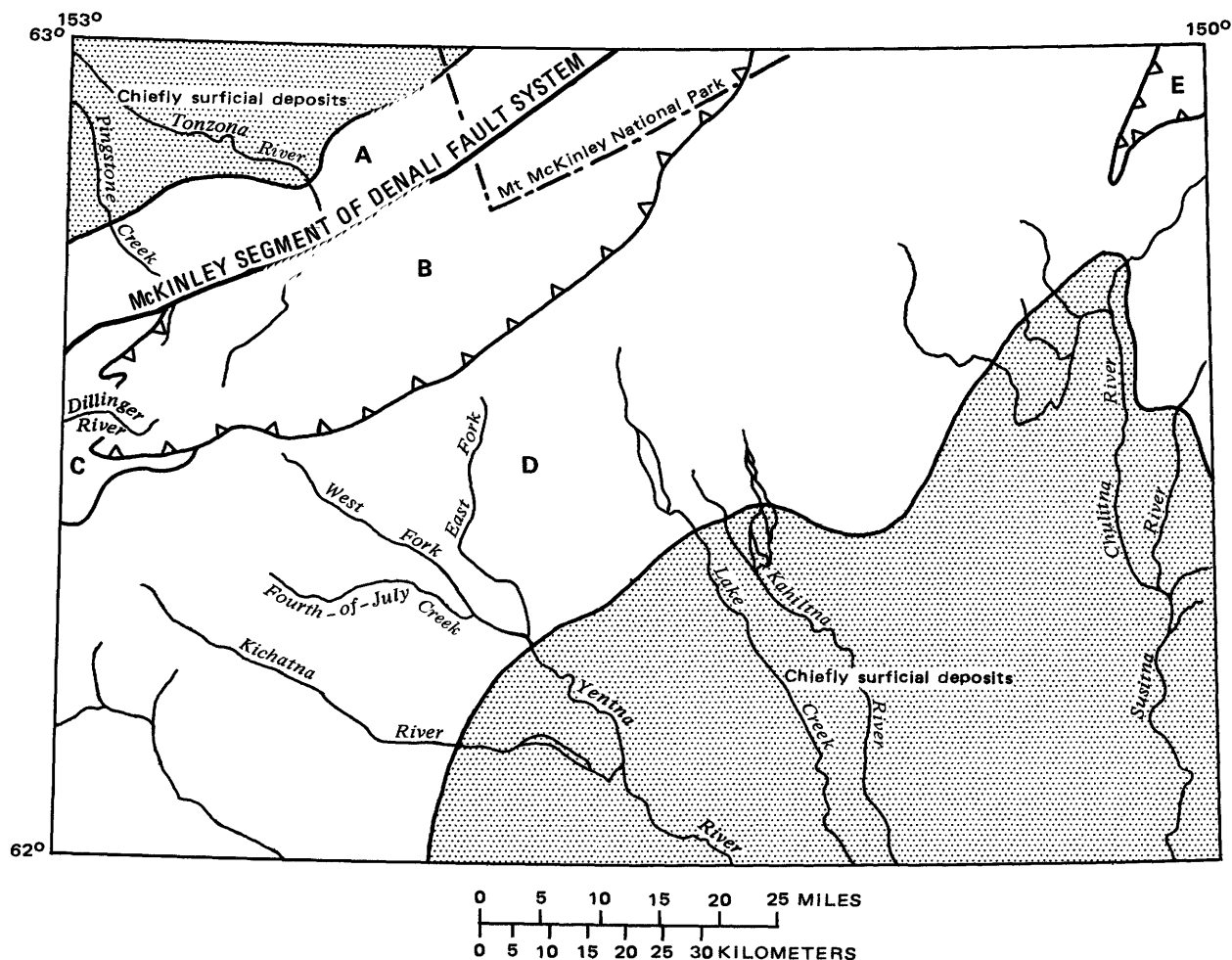


FIGURE 3.—Geologic terranes in the Talkeetna quadrangle, Alaska. A, sedimentary, metamorphic, and volcanic rocks that range in age from early Paleozoic through middle Tertiary; B, middle and late Paleozoic trench, slope, and terrestrial assemblages; C, lower Paleozoic sedimentary rocks of the Dillinger River; D, Jurassic and Cretaceous lithic graywacke, phyllite, and shale; E, Chulitna sequence of late Paleozoic, Triassic, and early Jurassic age.

clude (1) trench assemblages (and possibly intraoceanic arc deposits) characterized by terrigenous turbidites, cherty pelagites, and pillow basalt (all of which underwent complex undersea sliding and later multiple thrusting and folding); (2) slope and shelf assemblages which include chert, shale, reefoid limestone, and, locally, terrestrial conglomerate and redbeds. A third part of the sequence is a thick, locally terrestrial conglomerate and sandstone assemblage. This assemblage is typified by the Middle Pennsylvanian conglomerate of Mount Dall, a limestone-chert conglomerate, sandstone, and siltstone unit at least 1,500 m thick that is gradational downward into the flyschoid sedimentary rocks. These three dissimilar depositional sequences, which largely form disrupted nappes, are nearly everywhere juxtaposed by

thrust faults on all scales. Structural features generally show a westerly vergence. Terrane B is thrust over, and allochthonous with respect to, terrane C (fig. 3), intruded by dunite and associated ultramafic rocks along its southern margin, and cut by a sequence of Upper Cretaceous and lower Tertiary plutons of varying compositions and by the middle Tertiary Foraker pluton. A 65-m.y.-old stock which cuts the southern fault boundary of the terrane gives a minimum age for this terrane's emplacement. A maximum age is suggested by Early Cretaceous fossils in terrane D.

The oldest terrane (terrane C) south of Denali fault is composed of sedimentary rocks of the Dillinger River area. These rocks are multiply folded, at least 3,000 m thick, and continue to the west at least as far as the South Fork of the Kuskokwim

River (McGrath quadrangle). They contain abundant carbonate rocks and consist chiefly of well-bedded lime mudstone and shale, interbedded sandstone, shale and limestone, and deep-water lime mudstone. The base of the unit is not exposed. Rare graptolites, pelecypods, and conodonts from different horizons are of Middle and Late Silurian age, and Ordovician graptolites are present in rocks tentatively assigned to this terrane.

The southern terrane (*D*, fig. 3), composed of a thick sequence of lithic graywacke, phyllite, and shale of Jurassic and Cretaceous age, is in fault contact with terrane *B*. It overlies the sedimentary rocks of the Dillinger River (terrane *C*) with angular unconformity, although this contact, in most places, has subsequently been faulted. Along the southern foothills of the Alaska Range, terrane *D* is unconformably overlain by fluvial sedimentary rocks correlative with estuarine and nonmarine clastic sedimentary Tertiary formations assigned to the Kenai Group (Calderwood and Fackler, 1972) in the Cook Inlet basin. Tertiary volcanic rocks locally overlie terrane *D* in the southwest part of the quadrangle.

The informal term "Chulitna sequence" (terrane *E*, fig. 3) refers to an allochthonous sequence of upper Paleozoic limestone, tuff, and argillite, Lower and Upper Triassic limestone, basalt, and volcanic redbeds, and Upper Triassic and Lower Jurassic marine sandstone and argillite that crops out on the south flank of the Alaska Range along the Chulitna valley northeast of the Talkeetna quadrangle (Jones and others, 1976; Hawley and Clark, 1974; Clark and others, 1972). In the Chulitna area these rocks include a dismembered ophiolite (oceanic crust) sequence of Late Devonian age which has not been observed in the Talkeetna quadrangle. Within the Talkeetna quadrangle the Chulitna sequence consists of Upper Triassic limestone and basalt, Upper Triassic volcanoclastic and clastic sedimentary rocks, and Upper Triassic(?) and Lower Jurassic massive to well-bedded siliceous argillite, chert, and minor pillow basalt. These rocks structurally overlie Jurassic(?) and Cretaceous graywacke, shale, and phyllite (terrane *D*) and are locally cut by granitic rocks of early Tertiary age.

Plutonic rocks of various compositions were emplaced in Late Cretaceous to early Tertiary (55 to 67 m.y.) and in middle Tertiary (38 m.y.) time (Reed and Lanphere, 1973b). The larger and better exposed plutons of biotite or biotite and muscovite granite belong to the McKinley sequence (55 m.y.).

South of the Denali fault, these plutonic rocks intrude Jurassic and Cretaceous sedimentary rocks and are not present in terrane *B*. A series of nine relatively small plutonic bodies forms a 65-km-long curvilinear belt in the southwestern part of the quadrangle. The average composition of these plutons is quartz monzonite, but the larger, well-exposed plutons are composite in nature and appear to range in composition from peridotite to granite. Two potassium-argon age dates indicate that this composite belt of rocks was emplaced about 65 m.y. ago (Reed and Lanphere, 1973b). Also present in the western part of the quadrangle, but lying southeast of the composite plutons, are scattered small granodiorite bodies referred to as the Kichatna plutons. A single potassium-argon age on biotite from one of these plutons is 67 m.y. (Reed and Lanphere, 1973b). The youngest plutonic event in the quadrangle occurred about 38 m.y. ago and is represented by the Foraker pluton. This granodiorite pluton has mineralogy and chemistry nearly identical to the McGonagall pluton in the Mount McKinley quadrangle, and both plutons are considered to be parts of a single igneous mass that has undergone about 38 km of right-lateral displacement along the McKinley segment of the Denali fault system.

The modern landscape of the region is chiefly a product of glaciation and glacier-related processes. Surficial deposits that cover the lowlands in the northwest and southeast parts of the quadrangle are described in map MF-870-J.

GEOPHYSICS

(map MF-870-B)

The aeromagnetic map (sheet 1) of the Talkeetna quadrangle was made in 1973 and released by the State of Alaska as an open-file map (Alaska Div. Geol. Geophys. Surveys, 1973). The variations in the magnetic field on maps such as this provide valuable information concerning the lateral and vertical extent of rock units containing various percentages of magnetic minerals, usually magnetite. Aeromagnetic maps thus are a most useful support for a geologic mapping program as well as for mineral resource assessment. An interpretive map (sheet 2) identifies various rock units in the Talkeetna quadrangle that possess characteristic magnetic anomalies and enables the interpreter to extrapolate geologic information from known areas into covered or inaccessible regions. In particular this aeromagnetic map makes it possible to locate the contact-metamorphosed rocks bordering many

plutons, some of which are concealed. In addition the map indicates two possible belts of ultramafic and volcanic rocks.

INTERPRETATION OF LANDSAT IMAGERY

(map MF-870-C)

Interpretations of Landsat data were made on (1) a black-and-white Landsat mosaic (band 7) of the State of Alaska compiled by the U.S. Department of Agriculture and (2) computer-enhanced black-and-white and color Landsat imagery processed by the U.S. Geological Survey in Flagstaff, Ariz. Landsat scenes selected for computer enhancement are: 1428-20554, taken September 24, 1973; 1734-20485, taken July 27, 1974; and 1772-20580, taken September 3, 1974.

The black-and-white computer-enhanced product is a horizontal first derivative image. Color computer-enhanced Landsat products include a linearly "stretched" standard false-color image, two sinusoidally "stretched" false-color images, and a simulated natural color image.

As a geologic mapping tool, Landsat imagery is probably most effective for reconnaissance studies, contributing remotely sensed information about geomorphology, structural features, and variations in spectral response of surficial materials, which can be used to plan and direct geologic mapping and geochemical sampling. However, in the Talkeetna quadrangle, where reconnaissance geologic mapping and geochemical sampling were completed before the Landsat study, the Landsat interpretation augmented geological and geophysical observations by: (1) identifying the possible extensions of mapped faults; (2) providing additional evidence for the presence and location of possible faults not clearly evident on the ground or on aerial photographs; (3) identifying numerous lineaments that have been previously unnoticed; (4) analyzing joint and fracture patterns on a quadrangle-wide basis; (5) identifying circular features; and (6) identifying arcuate features.

Many of the methods used to apply Landsat imagery to mineral resource assessment in the Talkeetna quadrangle are relatively new and their potential to solve geologic problems has yet to be fully explored. The various computer enhancement techniques used to generate Landsat imagery for this study are in the development stage. In addition, a large number of lineaments and circular features observed on this imagery do not correspond to geologically known or geophysically in-

ferred features and may indicate poorly understood, or perhaps unknown, tectonic processes. The role of these phenomena and their relation to mineralization in the Talkeetna quadrangle are rather vague at present, but with further study their full implications may be understood.

MINERAL RESOURCES

(map MF-870-D)

The potentially favorable mineral resource areas of the Talkeetna quadrangle and the locations and brief descriptions of the known prospects, mineral and coal occurrences, and active and inactive placer mines are shown on the minerals resources map (Reed and others, 1978).

Eighty-nine mineral deposits and principal occurrences are categorized into active or inactive prospects, noteworthy occurrences, and active or inactive mines. Of these 89 locations, 14 are occurrences of coal, 33 are placer gold deposits or prospects, and the rest are lode mineral deposits or occurrences. The mineral deposits are classified by type and by economic commodities. A supplementary table on the map sheet gives brief descriptions of all the mineral deposits and, if available, references for additional information.

In addition to the locations of known mineral occurrences, the mineral resources map outlines favorable areas for mineral resources. This assessment is based on the known deposits, the presence of geologic conditions favorable for undiscovered deposits of similar type, and the interpretation of the geochemical, geophysical, and Landsat information given in the folio of maps. Tables list and briefly describe the criteria that led to the selection and boundaries of each favorable mineral resource area on the map. An accompanying text discusses the principal mineral commodities and presents information on their geologic setting, mineralogy, controls, grade, and genesis of the deposits.

The known and potential mineral resources of the quadrangle include gold, silver, tin, chrome, copper, molybdenum, nickel, coal, and possibly a few other commodities, including beryllium, tungsten, and natural gas. Gold has been the principal mineral product of the quadrangle. It occurs primarily in placer deposits in the Yentna district (Peters and Cache Creeks and Fairview Mountain area). Although additional detailed studies, including geochemical and drilling data, are required, areas are delineated as potentially favorable for

placer or lode gold resources. Among these are areas between the East and West Forks of the Yentna River, Kichatna River drainage, and upper Sunflower Creek.

Tin metallization is known to be closely associated with the biotite and muscovite granite of the McKinley sequence. A cassiterite-sulfide stockwork deposit in metasedimentary rocks above a granite cusp at Boulder Creek has high concentrations of tin; elsewhere within and adjacent to the quadrangle, granite of the McKinley sequence contains fluoritized or tourmalinized greisen zones. Pan-concentrate samples from several areas adjacent to or within the granite contain abundant cassiterite. The nonmagnetic fractions of these concentrates commonly contain in excess of 1,000 ppm tin. This, in itself, suggests a terrane favorable for tin metallization. Although detailed work has not been done in most of the areas delineated for tin deposits and there is no guarantee that workable tin lodes will be found in or near these areas, the possibility exists that tin associated with the granite is a significant resource.

Podiform chromite was discovered in alpine-type ultramafic rocks exposed along the Yentna and Lacuna Glaciers. The chromite is of metallurgical grade and occurs in discontinuous sills and irregular bodies of dunite which crop out for a distance of about 25 km. Chromite occurs as disseminations, streaks, and lenses, as disrupted and irregular pods up to 20 m in maximum dimension, and as lenses up to 2 m thick. None of the dunite bodies was investigated in detail, and although the observed chromite occurrences are relatively small, additional exploration for minable deposits is warranted.

The Foraker pluton contains many alteration zones. Some of these have associated geochemical anomalies, and altered cobbles of granodiorite found in glacial moraines have fractures healed with molybdenite, pyrite, and chalcopyrite. Molybdenite-bearing quartz veins are also associated with the pluton. Taken collectively, the above evidence suggests that the Foraker pluton is potentially favorable for molybdenum and copper deposits of the porphyry or stockwork type.

Numerous lode occurrences of copper suggest that it may be a significant resource in the quadrangle. It occurs in a variety of deposit types—volcanogenic, contact-metamorphic, and possibly as stockwork and porphyry deposits. The volcanogenic and contact-metamorphic deposits ap-

pear to be the most promising because of possible precious-metal content and base-metal grade. Although the indicated tonnage of the known copper-bearing massive sulfide deposits at Shelabarger Pass (Reed and Eberlein, 1972) is only on the order of 50,000 tons, the probability of additional massive sulfide bodies occurring in this assemblage of eugeosynclinal rocks is considered very high.

Estimated resources of known coal occurrences in the quadrangle are about 87 million tons. Owing to lack of road transportation, use of coal has been restricted to local consumption. The economic potential of coal within the quadrangle depends on its proximity to urban population centers or electric generators; it is currently low. Future use of the coal as an energy source must, however, be considered economically significant.

Two gravity lows in the upper part of the Cook Inlet basin probably represent thick sequences of Tertiary sedimentary rocks which crop out along the margin of the basin have adequate petroleum reservoir-quality rocks. The potential for oil accumulation in these basins is, however, considered minimal, although there might be accumulations of dry gas.

GEOCHEMISTRY

(maps MF-870-E-I)

Geochemical studies were made in the Talkeetna quadrangle to identify areas of anomalous concentrations of metallic elements. The data delineate areas of known mineral occurrences and additional areas possibly containing undiscovered potentially economic mineral resources.

During the summers of 1975 and 1976, sediment samples were collected at 835 sites in streams whose drainage areas range from approximately 7 to 13 km². Glacial debris was sampled at 108 sites on glaciers within basins with drainage areas similar to those of the streams. The minus-80-mesh fraction of these samples was analyzed for 30 elements by a semiquantitative emission spectrographic method (Grimes and Marranzino, 1968) and for copper, lead, zinc, and gold by atomic absorption (Ward and others, 1969). Heavy-mineral concentrates of stream sediment were made for 812 of the stream sites. The nonmagnetic fraction of these samples was also analyzed for 30 elements by the spectrographic method. In addition, bulk fractions (with only the magnetite removed) of 387 heavy-mineral concentrate samples from the south flank of

the Alaska Range were similarly analyzed for 30 elements and for gold. These results and analytical data from earlier reports (Clark and Hawley, 1968; Reed and Elliott, 1970) were used in compiling the geochemical maps in this folio. Other analytical data for stream sediments, glacial debris, and heavy-mineral concentrates are available in open-file reports (O'Leary and others, 1978; Curtin and others, 1978a).

The distribution and abundance of gold, silver, tin, beryllium, tungsten, copper, lead, zinc, molybdenum, chromium, and nickel in heavy-mineral concentrates, stream sediments, and glacial debris are described in this folio. Geochemical plots of these and a number of other elements are also available in open-file reports (Curtin and others, 1978b).

These geochemical data show that some of the areas of known mineral occurrences are well defined by the distribution of anomalous amounts of metals in heavy-mineral concentrates. In this quadrangle, pan concentrates have proved to be a better reconnaissance tool than stream sediment or glacial debris samples. Mechanical weathering is the primary destructive process in the central Alaska Range; relatively fresh fragments of sulfide minerals and other ore minerals are released from zones of mineralized bedrock and deposited in the nearby streams along with comparatively light minerals such as quartz and feldspar. The dilution effect of the light minerals — which can compose the bulk of the stream sediment — may mask the presence of ore-related minerals. The effect of dilution is eliminated by preparing heavy-mineral concentrate samples free of light minerals.

Two notable geochemical features within the quadrangle are (1) the tin, beryllium, and tungsten anomalies in nonmagnetic heavy-mineral concentrates collected within and adjacent to granitic plutons of the McKinley sequence (Curtin and others, 1978e) and (2) anomalous gold and silver values in heavy-mineral concentrates, stream sediment, and glacial debris which are, with few exceptions, from Jurassic and Cretaceous marine sediments and associated intrusive bodies on the south flank of the Alaska Range (Curtin and others, 1978c). The anomalous tin, beryllium, and tungsten values may be derived from small greisen zones in granitic rocks similar to an occurrence described by Reed and others (1978, No. 42, table 1). Plots of anomalous gold and silver values form clusters where granitic plutons of the McKinley sequence and

granodiorite and quartz diorite plutons intrude the Jurassic and Cretaceous rocks and probably reflect mineralization associated with the intrusions.

Known and possible occurrences of other base metals are outlined by anomalous copper, lead, zinc, and molybdenum values in heavy-mineral concentrates and in stream sediment and glacial debris.

SURFICIAL DEPOSITS

(map MF-870-J)

Surficial deposits of late Pleistocene and Holocene age cover about 65 percent of the Talkeetna quadrangle. The deposits are primarily the result of glaciation and have subsequently been modified by alluvial, glaciofluvial, lacustrine, and mass-wasting processes. The glacial and glacial-related deposits are most extensive south of the Alaska Range because precipitation is heavier in this area. In contrast, the region north of the Alaska Range was much drier, and glacial deposits extend only short distances beyond the mountain front. Within the Alaska Range there remain numerous glaciers, although unconsolidated mass wasting and glacial deposits occur locally.

Subdued lateral(?) and ground moraines of pre-Illinoian age on the north side of the Alaska Range and glacial erratics on top of the Yenlo Hills south of the range represent the oldest surficial deposits in the quadrangle. These deposits are correlative with the Mount Susitna Glaciation in the Cook Inlet area.

Glacial deposits of Illinoian age are represented by drift of the Eklutna Glaciation. These deposits are greatly modified and include lateral and ground moraines that are largely covered by younger deposits on the south side of the Alaska Range. End and lateral moraines and knob-and-kettle topography of Eklutna age on the north side of the Alaska Range are moderately well preserved. Karlstrom (1960) estimated that this glaciation reached its maximum extent 90,000–110,000 years ago.

Drift of the Knik Glaciation, of early Wisconsin age, is exposed only in the northwestern part of the quadrangle. These deposits correlate with the Farewell I glacial deposits in the upper Kuskokwim region (Karlstrom and others, 1964). On the south side of the Alaska Range, the deposits of the Knik Glaciation were very extensive but are now covered by the deposits of the younger Naptowne Glaciation.

Most of the surficial materials, as well as much of

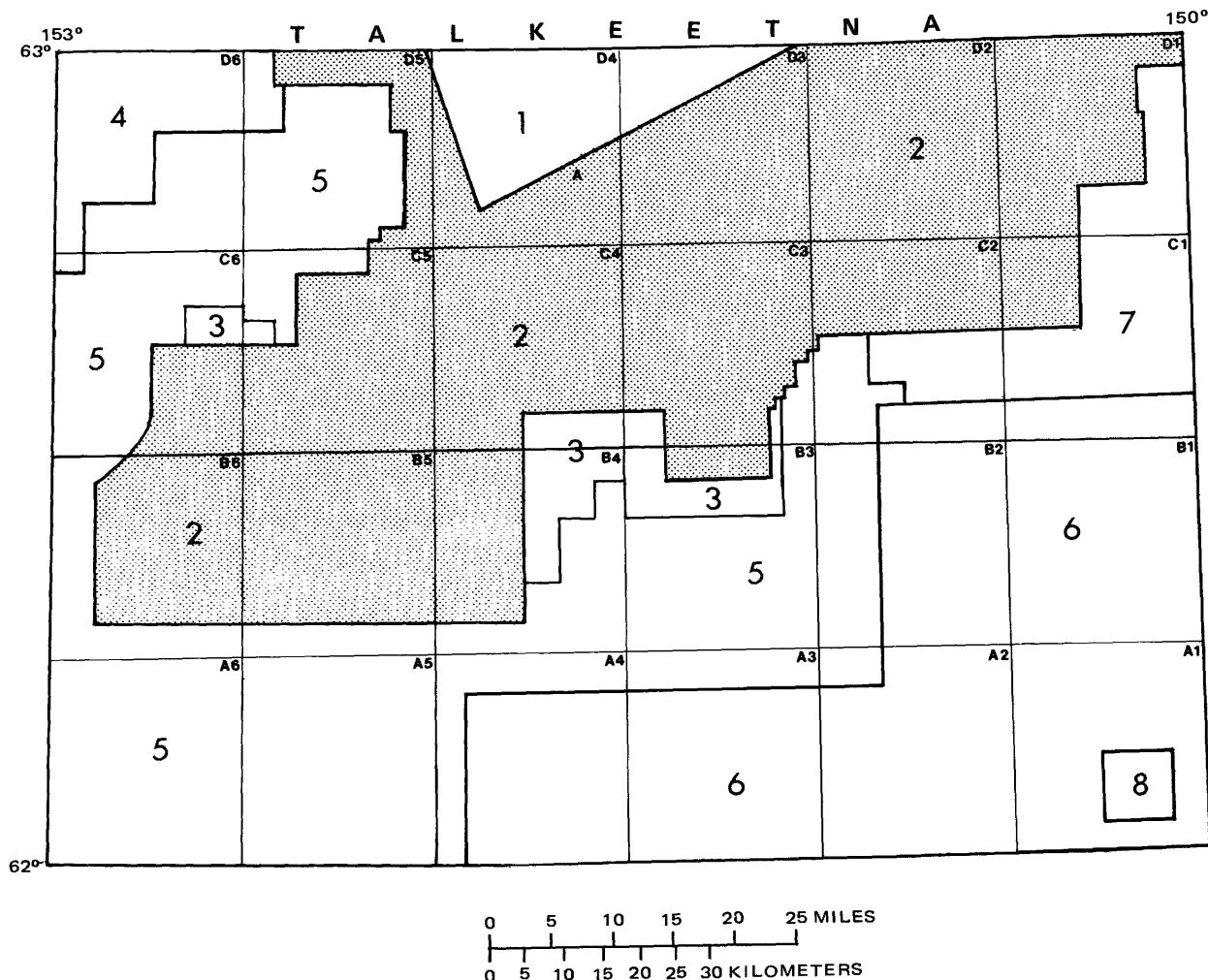


FIGURE 4.—Map of Talkeetna quadrangle indexing the 24 larger scale (1:63,360) quadrangles and showing boundaries and classifications of various reserved (U.S. Bur. Land Management, unpub. data, 1974). 1, Mount McKinley National Park; 2, D-2 lands, withdrawal for possible inclusion in the national park system; 3, Areas of ecological concern; 4, Regional deficiency withdrawal; 5, State selections, pending; 6, State selections, patented; 7, Denali State Park; 8, Withdrawal for native villages, eligibility for land selection not finally determined.

the present topography of the quadrangle, resulted from four advances of the late Wisconsin Naptowne Glaciation. During early Naptowne time large valley glaciers filled the present-day valleys of the Yentna, Kahiltna, Tokositna, Chulitna, and Susitna Rivers and coalesced in the lowland areas, forming a broad glacial front extending 40 km into the northeastern half of the Tyonek quadrangle.

Fluviolacustrine deposits of glacial origin occur primarily in the Cache Creek basin. The formation of these deposits is significant to the development of the placer gold deposits found in this area. During the late Miocene and Pliocene, placer gold was locally concentrated in lower clastic beds of the Kenai Group. During early Wisconsin time, glaciers

covered most of the Dutch and Peters Hills, and partly scoured the Cache Creek basin. In the early part of the late Wisconsin (early Naptowne Glaciation), a large glacier occupied the Kahiltna valley, and valley glaciers in the Dutch and Peters Hills again scoured and partially filled the valley of Cache Creek, although they apparently did not coalesce with the Kahiltna Glacier. After the retreat of these valley glaciers, the morainal debris was modified by meltwater both from the valley glaciers and the high-standing Kahiltna Glacier. During this fluvial episode, gold derived from the underlying Cretaceous and Tertiary formations was reworked and deposited in the basal part of the early Naptowne outwash deposit. The Kahiltna

Glacier dammed the Cache Creek valley and changed the dominantly fluvial environment to a lacustrine environment. During the lacustrine episode, a sequence of glacially derived bluish-gray mud accumulated in small ponds and lakes on top of the fluvial deposits.

The two advances of the Alaskan Glaciation, of Holocene age, have been correlated with the Tustumena and Tunnel advances recognized by Karlstrom (1957) on the Kenai Peninsula. These deposits were formed by alpine-valley glaciers occurring at higher altitudes in the Alaska Range. End moraines of the Tustumena Stade extend an average of 1.6 km from present-day ice fronts, and end moraines from the younger Tunnel Stade extend, on the average, about 0.8 km. The existing glaciers in the quadrangle are all recessional remnants of the Alaskan Glaciation.

LAND STATUS

The land status map (fig. 4) shows the classifications and boundaries of proposed and existing categories of land in the Talkeetna quadrangle. The map was compiled from a smaller scale map prepared by the Bureau of Land Management in 1974. Although subsequent changes have occurred primarily because of land selections included under terms of the Alaska Native Claims Settlement Act of 1971, the map is useful as a general guide until new maps are prepared.

BIBLIOGRAPHY

[The asterisks (*) denote references cited in this Circular and the folio of maps. References without asterisks are general, regional, or topical in scope but contain material relevant to the Talkeetna quadrangle.]

- *Alaska Department of Mines, 1954, Report to the Commissioner of Mines, biennium ended Dec. 31, 1954: 110 p.
- Alaska Division of Geological and Geophysical Surveys, 1972a, Aeromagnetic survey, east Alaska Range, Talkeetna, Alaska: Alaska Div. Geol. and Geophys. Surveys aeromagnetic series, 22 sheets, scale 1:63,360.
- 1972b, Aeromagnetic map, Talkeetna quadrangle, Alaska: Alaska Div. Geol. and Geophys. Surveys open-file map, scale 1:250,000.
- *—1973, Aeromagnetic survey east Alaska Range, Talkeetna quadrangle, Alaska: Alaska Div. Geol. and Geophys. Surveys open-file rept. 19, 1 sheet, scale 1:250,000.
- Alaska Geology Branch, U.S. Geological Survey, 1972, The status of mineral resource information on the major land withdrawals of the Alaska Native Claims Settlement Act of 1971: U.S. Geol. Survey open-file rept., 164 p.
- *Albert, N. R. D., 1975, Interpretation of Earth Resources Technology Satellite imagery of the Nabesna quadrangle, Alaska: U.S. Geol. Survey Misc. Field Studies Map MF-655-J, 2 sheets, scale 1:250,000.

- *Albert, N. R. D., and Steele, W. C., 1976a, Interpretation of Landsat imagery of the Tanacross quadrangle, Alaska: U.S. Geol. Survey Misc. Field Studies Map MF-767-C, 3 sheets, scale 1:250,000 [supersedes Open-File Rept. 76-850].
- *—1976b, Interpretation of Landsat imagery of the McCarthy quadrangle, Alaska: U.S. Geol. Survey Misc. Field Studies Map MF-773-N, 3 sheets, scale 1:250,000.
- *Armstrong, A. K., Reed, B. L., and Carter, C., 1977, Paleozoic sediments in the northwest part of the Talkeetna quadrangle, Alaska Range, Alaska: U.S. Geol. Survey Circ. 751-B, p. B61.
- Barnes, D. F., 1976, Bouguer gravity map of Alaska: U.S. Geol. Survey Open-File Map 76-70, scale 1:2,500,000.
- 1977, Gravity map of the eastern part of southern Alaska: U.S. Geol. Survey Open-File Rept. 77-169-C.
- *Barnes, F. F. 1966, Geology and coal resources of the Beluga-Yentna region, Alaska: U.S. Geol. Survey Bull. 1202-C, 54 p.
- *Bates, R. G., and Wedow, Helmuth, Jr., 1953, Preliminary summary review of thorium-bearing mineral occurrences in Alaska: U.S. Geol. Survey Circ. 202, 13 p.
- *Beikman, H. M., 1974a, Preliminary geologic map of the southeast quadrant of Alaska: U.S. Geol. Survey Misc. Field Studies Map MF-612, 2 sheets, scale 1:1,000,000.
- *—1974b, Preliminary geologic map of the southwest quadrant of Alaska: U.S. Geol. Survey Misc. Field Studies Map MF-611, 2 sheets, scale 1:1,000,000.
- *—1975a, Preliminary geologic map of southeastern Alaska: U.S. Geol. Survey Misc. Field Studies Map MF-673, 2 sheets, scale 1:1,000,000.
- *—1975b, Preliminary geologic map of the Alaska Peninsula and Aleutian Islands: U.S. Geol. Survey Misc. Field Studies Map MF-674, 2 sheets, scale 1:1,000,000.
- *Beikman, H. M., Holloway, C. D., and MacKevett, E. M., Jr., 1977, Generalized geologic map of the eastern part of southern Alaska: U.S. Geol. Survey Open-File Rept. 77-169-B.
- *Beikman, H.M., and Lathram, E. H., 1976, Preliminary geologic map of northern Alaska: U.S. Geol. Survey Misc. Field Studies Map MF-789, 2 sheets, scale 1:1,000,000.
- *Berg, H. C., and Cobb, E. H., 1967, Metalliferous lode deposits of Alaska: U.S. Geol. Survey Bull. 1246, 254 p.
- Bottge, R. G., 1974, Potential mineral resources in selected D-2 lands: U.S. Bur. Mines open-file rept. 9-74, 55 p.
- Brooks, A. H., 1906, The mining industry in 1905: U.S. Geol. Survey Bull. 284, p. 4-9.
- 1908, The mining industry in 1907: U.S. Geol. Survey Bull. 345, p. 30-53.
- 1910, The mining industry in 1909: U.S. Geol. Survey Bull. 442, p. 20-46.
- *—1911a, The Mount McKinley region, Alaska, with descriptions of the igneous rocks and of the Bonfield and Kantishna districts, by L. M. Prindle: U.S. Geol. Survey Prof. Paper 70, 234 p.
- *—1911b, The mining industry in 1910: U.S. Geol. Survey Bull. 480, p. 21-42.
- 1913, The mining industry in 1912: U.S. Geol. Survey Bull. 542, p. 18-51.
- 1914, The Alaskan mining industry in 1913: U.S. Geol. Survey Bull. 592, p. 45-74.
- 1915, The Alaskan mining industry in 1914: U.S. Geol. Survey Bull. 622, p. 15-68.

- 1918, The Alaskan mining industry in 1916; U.S. Geol. Survey Bull. 662, p. 11–62.
- 1919, Alaska's mineral supplies, in McCaskey, H. D., and Burchard, E. F., Our mineral supplies: U.S. Geol. Survey Bull. 666, p. 89–102.
- 1921, The future of Alaska mining: U.S. Geol. Survey Bull. 714, p. 5–57.
- 1922, The Alaskan mining industry in 1920: U.S. Geol. Survey Bull. 722, p. 7–74.
- 1923, The Alaskan mining industry in 1921: U.S. Geol. Survey Bull. 739, p. 1–50.
- 1925, Alaska's mineral resources and production, 1923: U.S. Geol. Survey Bull. 773, p. 3–52.
- Brooks, A. H., and Capps, S. R., 1924, The Alaskan mining industry in 1922: U.S. Geol. Survey Bull. 755, p. 3–56.
- Brooks, A. H., and Martin, G. C., 1921, The Alaskan mining industry in 1919: U.S. Geol. Survey Bull. 714, p. 59–95.
- Bultman, T. R., 1973, Denali fault (Hines Creek strand) near the Nenana River, Alaska: Geol. Soc. America Abs. with Programs (North-Central Sec.), v. 5, n^o. 4, p. 304.
- *Bundtzen, T. K., Smith, T. E., and Tosday, R. M., 1975, Progress report: Geology and mineral deposits of the Kantishna Hills, Alaska: Alaska Div. Geol. and Geophys. Surveys open-file rept. 98, 80 p.
- *Calderwood, K. W., and Fackler, W. C., 1972, Proposed stratigraphic nomenclature for Kenai Group, Cook Inlet basin, Alaska: Am. Assoc. Petroleum Geologists Bull., v. 56, no. 4, p. 739–754.
- Campbell, D. D., 1972, Regional faults and Ridge River gold deposits [abs.], in Program and abstracts, Symposium on faults, fractures and lineaments and related mineralization in the Canadian Cordillera, Vancouver, B. C., Feb., 1972: Geol. Assoc. Canada, Cordilleran Sec., p. 16.
- Capps, S. R., 1912, Gold placers of the Yentna district: U.S. Geol. Survey Bull. 520, p. 174–200.
- *—1913, The Yentna district, Alaska: U.S. Geol. Survey Bull. 534, 75 p.
- 1924, Geology and mineral resources of the region traversed by the Alaska Railroad: U.S. Geol. Survey Bull. 755, p. 73–150.
- *—1925, An early Tertiary placer deposit in the Yentna district: U.S. Geol. Survey Bull. 773, p. 53–61.
- *—1927, The Toklat-Tonzona River region: U.S. Geol. Survey Bull. 792, p. 73–110.
- 1933, Geology of the eastern portion of Mount McKinley National Park: U.S. Geol. Survey Bull. 836-D, p. 219–300.
- *—1940, Geology of the Alaska Railroad region: U.S. Geol. Survey Bull. 907, 201 p.
- Carnes, D. R., 1976, Active Alaskan placer operations 1975: U.S. Bur. Mines open-file rept. 98-76, 90 p.
- Churkin, Michael, Jr., 1973, Paleozoic and Precambrian rocks of Alaska and their role in its structural evolution: U.S. Geol. Survey Prof. Paper 740, 64 p.
- *Churkin, Michael, Jr., Reed, B. L., Carter, Claire, and Winkler, G., 1977, Lower Paleozoic graptolitic section from the Terra Cotta Mountains, southern Alaska Range: U.S. Geol. Survey Circ. 751-B, p. B37.
- Clark, A. H., and Cobb, E. H., 1972, Metallic mineral resources map of the Talkeetna quadrangle, Alaska: U.S. Geol. Survey Misc. Field Studies Map MF-369, scale 1:250,000.
- *Clark, A. L., Clark, S. H. B., and Hawley, C. C. 1972, Significance of upper Paleozoic oceanic crust in the Upper Chulitna district, west-central Alaska Range, in Geological Survey Research 1972: U.S. Geol. Survey Prof. Paper 800-C, p. C95–C101.
- *Clark, A. L., and Hawley, C. C., 1968, Reconnaissance geology, mineral occurrences, and geochemical anomalies of the Yentna district, Alaska: U.S. Geol. Survey open-file rept., 64 p.
- *Cobb, E. H., 1973, Placer deposits of Alaska: U.S. Geol. Survey Bull. 1374, 213 p.
- 1974, Index of metallic mineral deposits of Alaska compiled from published reports of Federal and State agencies through 1972: U.S. Geol. Survey, 590 p. Available from Natl. Tech. Inf. Service, U.S. Dept. Commerce, Springfield, Va., no. PB-233 217/AS.
- Cobb, E. H., Bacon, C. D., MacKevett, E. M., Jr., and Berg, H. C., 1977, Map showing distribution of mineral deposits (other than organic fuels and construction materials) in Alaska: U.S. Geol. Survey Open-File Rept. 77-496, scale 1:2,500,000.
- *Conwell, C. N., 1973, Granview Exploration Company tin and silver prospects, Talkeetna D-5 quadrangle, Alaska: Alaska and Div. Geol. Geophys. Surveys, Prospect Examination 75-4, 39 p.
- Coulter, H. W., Hopkins, D. M., Karlstrom, T. N. V., Péwé, T. L., Wahrhaftig, Clyde, and Williams, J. R., 1965, Extent of glaciations in Alaska: U.S. Geol. Survey Misc. Geol. Inv. Map 1-415, scale 1:2,500,000.
- *Crick, R. W., 1971, Potential petroleum reserves, Cook Inlet, Alaska, in Future petroleum provinces of the United States; Their geology and potential: Am. Assoc. Petroleum Geologist Mem. 15, v. 1, p. 109–119.
- *Curtin, G. C., Cooley, E. F., O'Leary, R. M., and McDanal, S. K., 1978a, Spectrographic and chemical analysis of bulk heavy-mineral concentrate samples from the Talkeetna quadrangle, Alaska: U.S. Geol. Survey Open-File Rept. 78-146, 26 p., 1 pl.
- *Curtin, G. C., Karlson, R. C., Day, G. W., O'Leary, R. M., and Tripp, R. B., 1978b, Geochemical maps showing distribution and abundance of selected elements in the Talkeetna quadrangle, Alaska: U.S. Geol. Survey Open-File Rept. 78-301, 15 sheets, scale 1:250,000.
- *Curtin, G. C., Karlson, R. C., O'Leary, R. M., Day, G. W., and McDanal, S. K., 1978c, Geochemical maps showing the distribution and abundance of gold and silver in the Talkeetna quadrangle, Alaska: U.S. Geol. Survey Misc. Field Studies Map MF-870-E, 2 sheets, scale 1:250,000.
- *Curtin, G. C., Karlson, R. C., O'Leary, R. M., Day, G. W., and McDougal, C. M., 1978d, Geochemical maps showing the distribution and abundance of copper, lead, zinc and molybdenum in the Talkeetna quadrangle, Alaska: U.S. Geol. Survey Misc. Field Studies Map MF-870-G, 4 sheets, scale 1:250,000.
- *Curtin, G. C., Karlson, R. C., Tripp, R. B., and Day, G. W., 1978e, Geochemical map showing the distribution and abundance of tin, tungsten and beryllium in the Talkeetna quadrangle, Alaska: U.S. Geol. Survey Bull. U.S. Geol. Survey Bull. Misc. Field Studies Map MF-870-F, 3 sheets, scale 1:250,000.
- *Curtin, G. C., Karlson, R. C., Tripp, R. B., Day, G. W., Cooley, E. F., and McDougal, C. M., 1978f, Geochemical maps showing the distribution and abundance of chromium and nickel in the Talkeetna quadrangle, Alaska: U.S. Geol. Survey Misc. Field Studies Map MF-870-H, 2 sheets, scale 1:250,000.

- *Decker, John, and Karl, Susan, 1977a, Preliminary aeromagnetic map of central Alaska: U.S. Geol. Survey Open-File Rept. 77-168-E, scale 1:1,000,000.
- *———1977b, Preliminary aeromagnetic map of eastern part of southern Alaska: U.S. Geol. Survey Open-File Rept. 77-169-E, scale 1:1,000,000.
- *———1977c, Preliminary aeromagnetic map of the Brooks Range and Arctic Slope, Alaska: U.S. Geol. Survey Open-File Rept. 77-166-E, scale 1:1,000,000.
- *———1977d, Preliminary aeromagnetic map of western part of southern Alaska: U.S. Geol. Survey Open-File Rept. 77-169-J, scale 1:1,000,000.
- *DeYoung, J. H., Jr., 1978, Mineral resources map of the Chandalar quadrangle, Alaska: U.S. Geol. Survey Misc. Field Studies Map MF-878-B, 1 sheet, scale 1:250,000 (in press).
- *Douglas, R. J. W., ed., 1970, Geology and economic minerals of Canada: Geol. Survey of Canada, 838 p.
- *Drummond, A. D., and Godwin, C. I., 1976, Hypogene mineralization; an empirical evaluation of alteration zoning, in Brown, A. S., ed., Porphyry deposits of the Canadian Cordillera: Canadian Inst. Mining and Metallurgy, Spec. Volume 15, p. 52-63.
- *Eldridge, G. H., 1900, A reconnaissance in the Sushitna basin and adjacent territory, Alaska, in 1898: U.S. Geol. Survey 20th Ann. Rept., pt. 7, p. 1-29.
- *Freeman, V. L., 1963, Examination of uranium prospects, 1956: U.S. Geol. Survey Bull. 1155, p. 29-33.
- *Gilbert, W. G., Ferrell, V. M., and Turner, D. L., 1976, The Tekalnika Formation — A new Paleocene volcanic formation in the central Alaska Range: Alaska Div. Geol. and Geophys. Surveys Geol. Rept. 47, 16 p.
- Grantz, Arthur, 1966, Strike-slip faults in Alaska: U.S. Geol. Survey open-file rept., 82 p.
- *Grimes, D. J., and Marranzino, A. P., 1968, Direct-current arc and alternating-current spark emission spectrographic field methods for the semiquantitative analysis of geologic materials: U.S. Geol. Survey Circ. 591, 6 p.
- *Griscom, Andrew, 1978, Aeromagnetic map and interpretation of the Talkeetna quadrangle, Alaska: U.S. Geol. Survey Misc. Field Studies Map MF-870-B, scale 1:250,000.
- *Hackett, S. W., 1976, Regional gravity survey of Beluga Basin and adjacent area, Cook Inlet region, Alaska: Alaska Div. Geol. and Geophys. Surveys open-file rept. AOF-100, 38 p.
- 1977, Gravity surveys of Beluga Basin and adjacent area, Cook Inlet region, south-central Alaska: Alaska Div. Geol. and Geophys. Surveys geol. Rept. 49.
- Hawley, C. C., 1973, Mineral belts and districts, prospective regions and land status in Alaska: Anchorage, C. C. Hawley and Associates, 26 p.
- Hawley, C. C., and Clark, A. L., 1968, Occurrences of gold and other metals in the upper Chulitna district, Alaska: U.S. Geol. Survey Circ. 564, 21 p.
- *———1973, Geology and mineral deposits of the Chulitna-Yentna mineral belt, Alaska: U.S. Geol. Survey Prof. Paper 758-A, 10 p.
- *———1974, Geology and mineral deposits of the Upper Chulitna district, Alaska: U.S. Geol. Survey Prof. Paper 758-B, 47 p.
- Hawley, C. C., Clark, A. L., Herdrick, M. A., and Clark, S. H. B., 1969, Results of geological and geochemical investigations in an area northwest of the Chulitna River, central Alaska Range: U.S. Geol. Survey Circ. 617, 19 p.
- Hickman, R. G., 1971, The Denali fault near Cantwell, Alaska: Univ. Wisconsin, Madison, Master's thesis, 76 p.
- Hickman, R. G., and Craddock, Campbell, 1973, Lateral offset along the Denali fault, central Alaska Range, Alaska: Geol. Soc. America Abs. with Programs (North-Central Sec.), v. 5, n° 4, p. 322.
- Joesting, H. R., 1942, Strategic mineral occurrences in interior Alaska: Alaska Dept. Mines Pamph. 1, 46 p.
- *Jones, D. L., Pessango, E. A., Jr., and Csejtey, B., Jr., 1976, Significance of upper Chulitna ophiolite for the late Mesozoic evolution of southern Alaska: Geol. Soc. America Abs. with Programs, v. 8, n° 3, p. 385-386.
- *Karlstrom, T. N. V., 1957, Tentative correlation of Alaskan glacial sequences: Science, v. 125, p. 73-74.
- *———1960, The Cook Inlet, Alaska, glacial record and Quaternary classification, in Short papers in the geological sciences 1960: U.S. Geol. Survey Prof. Paper 400-B, p. B330-332.
- *———1964, Quaternary geology of the Kenai lowland and glacial history of the Cook Inlet region, Alaska: U.S. Geol. Survey Prof. Paper 443, 69 p.
- *Karlstrom, T. N. V., and others, 1964, Surficial geology of Alaska: U.S. Geol. Survey Misc. Geol. Inv. Map 1-357, scale 1:1,584,000.
- King, P. B., 1969, Tectonic map of North America: U.S. Geol. Survey, 2 sheets, scale 1:5,000,000.
- Kirschner, C. E., and Lyon, C. A., 1973, Stratigraphic and tectonic development of the Cook Inlet petroleum province, in Proceedings of the 2d International Arctic Symposium: Am. Assoc. Petroleum Geologists Mem. 9, p. 396-407.
- Koschmann, A. H., and Bergendahl, M. H., 1968, Principal gold-producing districts of the United States: U.S. Geol. Survey Prof. Paper 610, 283 p.
- *Lathram, E. H., and Albert, N. R. D., 1976, Significance of space image linears in Alaska, in International conference on the new basement tectonics: Utah Geol. Soc. Proc., 1st, Salt Lake City, 1974, p. 11-26.
- *Lathram, E. H., and Reynolds, R. G. H., 1977, Tectonic deductions from Alaskan space imagery, in Proceedings of the first annual William T. Pecora Memorial Symposium, October 1975, Sioux Falls, South Dakota: U.S. Geol. Survey Prof. Paper 1015, p. 179-191.
- MacKevett, E. M., Jr., and Holloway, C. D., 1977, Map showing metalliferous and selected nonmetalliferous mineral deposits in the eastern part of southern Alaska: U.S. Geol. Survey Open-File Rept. 77-169-A, 99 p., scale 1:1,000,000.
- *Maloney, R. P., and Thomas, B. I., 1966, Investigation of the Purkeypile prospects, Kuskokwim River Basin, Alaska: U.S. Bur. Mines open-file rept., 12 p.
- *———1919, The Alaskan mining industry in 1917: U.S. Geol. Survey Bull. 692, p. 11-42.
- 1920, The Alaskan mining industry in 1918: U.S. Geol. Survey Bull. 712, p. 11-52.
- *Mertie, J. B., Jr., 1919, Platinum-bearing gold placers of the Kahiltna Valley: U.S. Geol. Survey Bull. 692, p. 233-264.
- 1969, Economic geology of the platinum minerals: U.S. Geol. Survey Prof. Paper 630, 120 p.
- Miller, D. J., Payne, T. G., and Gryc, George, 1959, Geology of possible petroleum provinces in Alaska, with an annotated bibliography by E. H. Cobb: U.S. Geol. Survey Bull. 1094, 131 p.
- Moffit, F. H., 1927, Mineral industry in Alaska in 1925: U.S. Geol. Survey Bull. 792, p. 1-39.

- *Nelson, S. W., and Reed, B. L., 1978, Surficial deposits map of the Talkeetna quadrangle, Alaska: U.S. Geol. Survey Misc. Field Studies Map MF-870-J, 1 sheet, scale 1:250,000.
- *O'Leary, R. M., Day, G. W., Cooley, E. F., Curtin, G. C., and McDougal, C. M., 1978, Spectrographic and chemical analysis of geochemical samples from Talkeetna quadrangle, Alaska: U.S. Geol. Survey Open-File Rept. 78-143, 141 p., 1 pl. scale 1:250,000.
- Overstreet, W. C., 1967, The geologic occurrence of monazite: U.S. Geol. Survey Prof. Paper 530, 327 p.
- Page, Robert, 1972, Crustal deformation on the Denali fault, Alaska, 1942-1970: Jour. Geophys. Research, v. 77, p. 1528-1533.
- Paige, Sidney, and Knopf, Adolph, 1907, Reconnaissance in the Matanuska and Talkeetna basins, Alaska, with notes on the placers of the adjacent regions: U.S. Geol. Survey Bull. 314, p. 104-125.
- Payne, T. G., 1955, Mesozoic and Cenozoic tectonic elements of Alaska: U.S. Geol. Survey Misc. Geol. Inv. Map 1-84, 1 sheet, scale 1:5,000,000.
- Péwé, T. L., 1975, Quaternary geology of Alaska: U.S. Geol. Survey Prof. Paper 835, 145 p.
- *Reed, B. L., and Eberlein, G. D., 1972, Massive sulfide deposits near Shellabarger Pass, southern Alaska Range, Alaska: U.S. Geol. Survey Bull. 1342, 45 p.
- *Reed, B. L., and Elliott, R. L., 1968, Results of stream sediment sampling in parts of the southern Alaska Range: U.S. Geol. Survey open-file rept., 9 p.
- *———1970, Reconnaissance geologic map, analyses of bedrock and stream sediment samples, and an aeromagnetic map of parts of the southern Alaska Range, Alaska: U.S. Geol. Survey open-file rept., 145 p.
- *Reed, B. L., and Lanphere, M. A., 1972, Generalized geologic map of the Alaska-Aleutian Range batholith showing potassium-argon ages of the plutonic rocks: U.S. Geol. Survey Misc. Field Studies Map MF-372, scale 1:1,000,000.
- *———1973a, Plutonic rocks of the Alaska-Aleutian Range batholith, in Proceedings of the 2d International Arctic Symposium: Am. Assoc. Petroleum Geologists Mem. 15, p. 421-428.
- *———1973b, The Alaska-Aleutian Range batholith—Geochemistry, chemistry, and relation to circum-Pacific plutonism: Geol. Soc. America Bull., v. 84, no. 8, p. 2583-2610.
- *———1974, Offset plutons and history of movement along the McKinley segment of the Denali Fault System, Alaska: Geol. Soc. America Bull., v. 85, p. 1883-1892.
- *Reed, B. L., and Nelson, S. W., 1977, Geologic map of the Talkeetna quadrangle, Alaska: U.S. Geol. Survey Misc. Field Studies Map MF-870-A, 1 sheet, scale 1:250,000.
- *Reed, B. L., Nelson, S. W., Curtin, G. C., and Singer, D. A., 1978, Mineral resources map of the Talkeetna quadrangle, Alaska: U.S. Geol. Survey Misc. Field Studies Map MF-870-D, 1 sheet, scale 1:250,000.
- Reed, J. C., Jr., 1961, Geology of the Mount McKinley quadrangle, Alaska: U.S. Geol. Survey Bull. 1108-A, 36 p.
- *Robinson, G. D., Wedow, Helmuth, Jr., and Lyons, J. B., 1955, Radioactivity investigations in the Cache Creek area, Yentna district, Alaska, 1945: U.S. Geol. Survey Bull. 1024-A, p. 1-23.
- Scully, D. R., 1976, Hydrologic investigations related to coal resources, in Cobb, E. H., ed., The United States Geological Survey in Alaska: Accomplishments during 1975: U.S. Geol. Survey Circ. 733, p. 45.
- Smith, P. S., 1926, Mineral industry of Alaska in 1924: U.S. Geol. Survey Bull. 783, p. 1-30.
- 1929, Mineral industry of Alaska in 1926: U.S. Geol. Survey Bull. 797, p. 1-50.
- *———1930a, Mineral industry of Alaska in 1927: U.S. Geol. Survey Bull. 810, p. 1-64.
- 1930b, Mineral industry of Alaska in 1928: U.S. Geol. Survey Bull. 813, p. 1-72.
- 1932, Mineral industry of Alaska in 1929: U.S. Geol. Survey Bull. 824, p. 1-81.
- *———1933a, Mineral industry of Alaska in 1930, U.S. Geol. Survey Bull. 836, p. 1-83.
- *———1933b, Mineral industry of Alaska in 1931: U.S. Geol. Survey Bull. 844-A, p. 1-82.
- 1934a, Mineral industry of Alaska in 1932: U.S. Geol. Survey Bull. 857-A, p. 1-91.
- 1934b, Mineral industry of Alaska in 1933: U.S. Geol. Survey Bull. 864-A, p. 1-94.
- *———1936, Mineral industry of Alaska in 1934: U.S. Geol. Survey Bull. 868-A, p. 1-91.
- 1937, Mineral industry of Alaska in 1935: U.S. Geol. Survey Bull. 880-A, p. 1-95.
- *———1938, Mineral industry of Alaska in 1936: U.S. Geol. Survey Bull. 897-A, p. 1-107.
- *———1939a, Mineral industry of Alaska in 1937: U.S. Geol. Survey Bull. 910-A, p. 1-113.
- *———1939b, Mineral industry of Alaska in 1938: U.S. Geol. Survey Bull. 917-A, p. 1-113.
- 1941, Mineral industry of Alaska in 1939: U.S. Geol. Survey Bull. 926-A, p. 1-106.
- *———1942a, Occurrences of molybdenum minerals in Alaska: U.S. Geol. Survey Bull. 926-C, p. 161-210.
- 1942b, Mineral industry of Alaska in 1940: U.S. Geol. Survey Bull. 933-A, p. 1-102.
- *Smith, S. S., 1917, The mining industry in the Territory of Alaska during the calendar year 1916: U.S. Bur. Mines Bull. 153, 89 p.
- *Spurr, J. E., 1900, A reconnaissance in southwestern Alaska in 1898: U.S. Geol. Survey 20th Ann. Report., pt. 7, p. 31-264.
- St. Amand, Pierre, 1957, Geological and geophysical synthesis of the tectonics of portions of British Columbia, the Yukon Territory, and Alaska: Geol. Soc. America Bull., v. 68, p. 1343-1370.
- *Steele, W. C., 1976, Computer program designed to aid in the analysis of linear features derived from Landsat data: U.S. Geol. Survey Open-File Rept. 76-605, 39 p.
- Steele, W. C., and Albert, N. R. D., 1978, Interpretation of Landsat imagery of the Talkeetna quadrangle, Alaska: U.S. Geol. Survey Misc. Field Studies Map MF-870-C, 2 sheets, scale 1:250,000.
- Stout, J. H., Brady, J. B., Weber, F., and Page, R. A., 1973, Evidence for Quaternary movement on the McKinley strand of the Denali fault in the Delta River area, Alaska: Geol. Soc. America Bull., v. 84, p. 939-948.
- Thorne, R. L., Muir, N. M., Erickson, A. W., Thomas, B. I., Heide, H. E., and Wright, W. S., 1948, Tungsten deposits in Alaska: U.S. Bur. Mines Rept. Inv. 4174, 22 p.
- Triplehorn, D. M., 1976, Contributions to clay mineralogy and petrology, Cook Inlet basin, Alaska: Alaska Div. Geol. and Geophys. Surveys open-file rep. AOF-102, 18 p.

- *Tripp, R. B., Karlson, R. C., and Curtin, G. C., 1978, Maps showing mineralogical data for heavy-mineral concentrates in the Talkeetna quadrangle, Alaska: U.S. Geol. Survey Misc. Field Studies Map MF-870-I, 2 sheets, scale 1:250,000.
- Tuck, Ralph, 1934, The Curry district, Alaska: U.S. Geol. Survey Bull. 857-C, p. 99-140.
- Turner, D. L., Smith, T. E., and Forbes, R. B., 1974, Geochronology of offset along the Denali fault system in Alaska: Geol. Soc. America Abs. with Programs (Cordilleran Sec.), v. 6, no. 3, p. 268-269.
- Twenhofel, W. S., and Sainsbury, C. L., 1958, Fault patterns in southeastern Alaska: Geol. Soc. America Bull., v. 69, p. 1431-1442.
- *U.S. Bureau of Mines, 1973, Alaska 1:250,000 scale quadrangle map overlays showing mineral deposit locations, principal minerals, and number and type of claims: U.S. Bur. Mines open-file rept. 20-73.
- Wahrhaftig, Clyde, 1958, Quaternary geology of the Nenana River and adjacent parts of the Alaska Range: U.S. Geol. Survey Prof. Paper 293-A, 68 p.
- *———1965, Physiographic divisions of Alaska: U.S. Geol. Survey Prof. Paper 482, 52 p.
- *Wahrhaftig, Clyde, Wolfe, J. A., Leopold, E. B., and Lanphere, M. A., 1969, The coal-bearing group in the Nenana coal field, Alaska: U.S. Geol. Survey Bull. 1274-D, 28 p.
- *Ward, F. N., Nakagawa, H. M., Harms, T. F., and Van Sickle, G. H., 1969, Atomic absorption methods of analysis useful in geochemical exploration: U.S. Geol. Survey Bull. 1289, 45 p.
- Wegner, W. W., 1973, The Denali fault (Hines Creek strand) in northeastern Mt. McKinley National Park, Alaska: Geol. Soc. America Abs. with Programs (North-Central Sec.), v. 5, no. 4, p. 363.
- Wilson, F. H., and Turner, D. L., 1975, Radiometric age map of Alaska — South-central Alaska: Alaska Div. Geol. and Geophys. Surveys open-file rep. AOF-85, 12 p., 1 map.
- Wolfe, J. A., Hopkins, D. M., and Leopold, E. B., 1966, Tertiary stratigraphy and paleobotany of the Cook Inlet region, Alaska: U.S. Geol. Survey Prof. Paper 398-A, 29 p.

