GEOLOGICAL SURVEY CIRCULAR 758

The Alaskan Mineral Resource Assessment Program:

Guide to Information Contained in the Folio of Geologic and Mineral Resource Maps of the Chandalar Quadrangle, Alaska

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ABSTRACT

The Chandalar quadrangle in east-central Alaska was investigated by a multidisciplinary research group to assess the mineral resource potential of the quadrangle. This circular serves as a guide to and integrates with a folio of 10 miscellaneous field study (MF) maps and 2 open-file (OF) reports (table 1) concerned with the geology, geophysics, geochemistry, Landsat imagery, and mineral resources of the area.

Revisions to the previously published Chandalar quadrangle geologic map, a new radiometric age determination, and a bibliography are also included.

INTRODUCTION

PURPOSE AND SCOPE

This circular and the related but separately available folio of maps and open-file reports of the Chandalar quadrangle, Alaska, are one of a series of similar publications resulting from the Alaskan Mineral Resource Assessment Program (AMRAP). Their purpose is to provide the basis for a sound long-range national minerals policy and also to aid in Federal, State and industry decisions in planning exploration and development of Alaskan resources.

The Chandalar quadrangle was selected for early study under AMRAP because of impending land selection decisions, the area's potential as the possible eastern extension of the southwestern Brooks Range copper belt (Hawley, 1976), its known gold mineralization, and because the area has recently been made more accessible by completion of the Alyeska Haul Road.

The present report integrates geologic data and mapping collected prior to AMRAP (July 1975), and the recent data acquired during the AMRAP-sponsored investigation.

GEOGRAPHY AND ACCESS

The Chandalar quadrangle is located in east-central Alaska between lat 67° and 68° N. and long 147° and 150° W. (fig. 1) and comprises approximately 14,200 km². The area includes five sections of two major physiographic provinces, the Arctic Mountains province, and the Northern Plateaus province (Wahrhaftig, 1965).

The rugged glaciated highlands of the eastern Brooks Range and Porcupine Plateau sections occupy the northern two-thirds of the quadrangle (fig. 2). The rounded uplands of the Kokrine-Hodzana Highlands make up the southern part of the quadrangle except for a small area of the Yukon Flats section in the extreme southeast.

A prominent topographic low, the Kobuk Trench, which is probably a fault-controlled feature (Payne, 1955; Grantz, 1966), separates these northern and southern physiographic sections. Most of the Kobuk Trench coincides with the Ambler-Chandalar Ridge and Lowland physiographic section of Wahrhaftig, but he included the easternmost part of the trench along the main Chandalar valley in the Porcupine Plateau (fig. 2).

Drainage within the quadrangle is divided between two major tributaries of the Yukon River; the Chandalar River drains the quadrangle to the east and the Koyukuk River to the west. The valleys of the main drainages have been glaciated and have broad flat floors covered by alluvium and glacial deposits.

TABLE 1.—*Component maps of the Chandalar quadrangle mineral resource assessment program*

Report	Subject
U.S. Geol. Survey Misc. Geol. Inv. Map I–375 (Brosgé and Reiser, 1964)	Reconnaissance geology.
U.S. Geol. Survey Misc. Field Studies (MF) Maps:	
MF–878– A (Hamilton, 1978)	Surficial geology.
B (DeYoung, 1978)	Mineral resources.
C (Cady, 1978)	Aeromagnetic contours and interpretation.
D (Marsh and others, 1978)	Geochemical distribution and abundance of copper, molybdenum, and lead.
E (Marsh and others, 1978)	Geochemical distribution and abundance of zinc.
F (Marsh and others, 1979)	Geochemical distribution and abundance of nickel, cobalt, lanthanum, and yttrium.
G (Marsh and others, 1978)	Geochemical distribution and abundance of barium, arsenic, boron, and vanadium.
H (Marsh and others, 1979)	Geochemical distribution and abundance of antimony and niobium.
I (Marsh and Wiltse, 1979)	Composite geochemical map.
J (Albert, LeCompte, and Steele, 1978).	Landsat image and interpretations.
U.S. Geol. Survey Open-File Report OF–76–492 (O'Leary and others, 1976)	Geochemical analyses and statistical data for stream sediment samples.
U.S. Geol. Survey Open-File Report OF–77–543 (Detra and others, 1977)	Geochemical analyses and statistical data for heavy mineral concentrations and organic samples.

The Alyeska haul road is the only usable road into the quadrangle. It crosses into the Chandalar quadrangle at about the midpoint of the western boundary and follows the valley of the Middle Fork of the Koyukuk River and the Dietrich River to the northern boundary (fig. 3). The haul road extends to Prudhoe Bay to the north and to Livengood to the south, where it joins the public highway. Airstrips at Chandalar Lake and at the Dietrich Alyeska campsite (fig. 3) as well as the several larger lakes in the quadrangle afford access by multi-engine fixed wing aircraft. Winter trails and the now abandoned Beaver-Caro Road served in the past to meet the freighting needs of the gold miners.

MINERAL PRODUCTION AND EXPLORATION

With the exception of recent quarrying of road-building materials, the only mineral production from the Chandalar quadrangle consists of gold and byproduct silver from lode and placer deposits in the area east of Chandalar Lake and from placer deposits along tributaries of the Koyukuk River at the western edge of the quadrangle. References to these deposits are included in a summary of published reports on mineral occurrences in the quadrangle (Cobb, 1976). Gold placers were discovered in the Koyukuk region about 1885 and in the Chandalar Lake area in 1905 (Chipp, 1970, p. 3–5). Placer mining was done by hand methods until the 1940's; after then, mechanical methods were used on some deposits. Gold production from the deposits in the Koyukuk-Chandalar district (which extends west into the Wiseman, Survey Pass, and Hughes quadrangles) has been estimated at 12 million g (380,000 troy oz) by Berg, Eberlein, and MacKevett (1964, p. 106). Gold production from placer deposits in the Chandalar Lake area has been estimated at 1.2 million g (40,000 troy oz) of which 400,000 g (14,000 troy oz) were recovered from Big Creek, primarily from mechanized operations since 1950 (Heiner and Wolff, 1968, p. 14). About one gram of silver was produced for every 7 grams of gold from placer deposits of the Chandalar district. Myrtle Creek

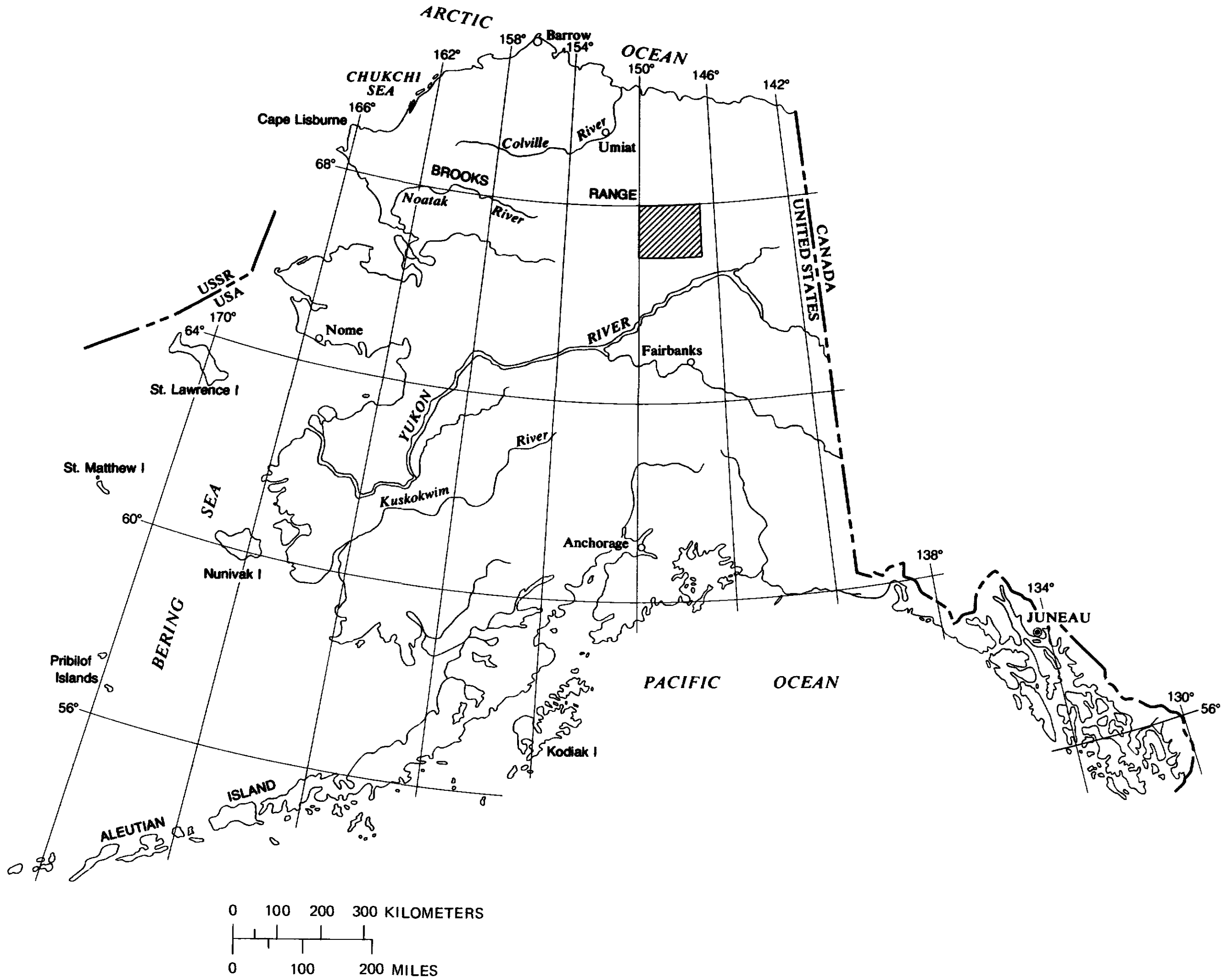


FIGURE 1.—Index map of Alaska showing location of Chandalar quadrangle (pattern).

has been one of the biggest gold producers in the Koyukuk mining district (Mulligan, 1974, p. 6). Some small placer operations are currently active.

Gold-quartz vein deposits in the Chandalar Lake area were identified in the early 1900's and some gold-silver ore was produced from underground workings at the Mikado, Little Squaw, and Summit mines. Since 1960, about 30,000 g (1,000 troy oz) of gold and about 6,000 g (200 troy oz) of silver have been reported produced from the Mikado mine.

Recent exploration activity (as of 1977) is evidenced by a considerable amount of claim staking since 1969, especially in the Big Spruce Creek-North Fork Chandalar River area (1969–1975), in the Geroe Creek area (1975–1977), and along the North Fork of the East Fork of the Chandalar River (1976–1977). Exploration targets include porphyry copper and molybdenum deposits and contact metamorphic copper deposits.

Over 4 million cubic meters of sand, gravel, fill, and other road building materials have been quarried along the Koyukuk and Dietrich Rivers for use in the construction of the trans-Alaska pipeline and the pipeline road.

ACKNOWLEDGMENTS

The authors express their appreciation of the work of the scientists who pioneered topographic and geologic mapping of the Chandalar quadrangle (Schrader, 1900 and 1904; Maddren, 1913; Mertie, 1925); their work is incorporated in the present map and reports. Thanks are due to the Alyeska Pipeline Service Company and its per-

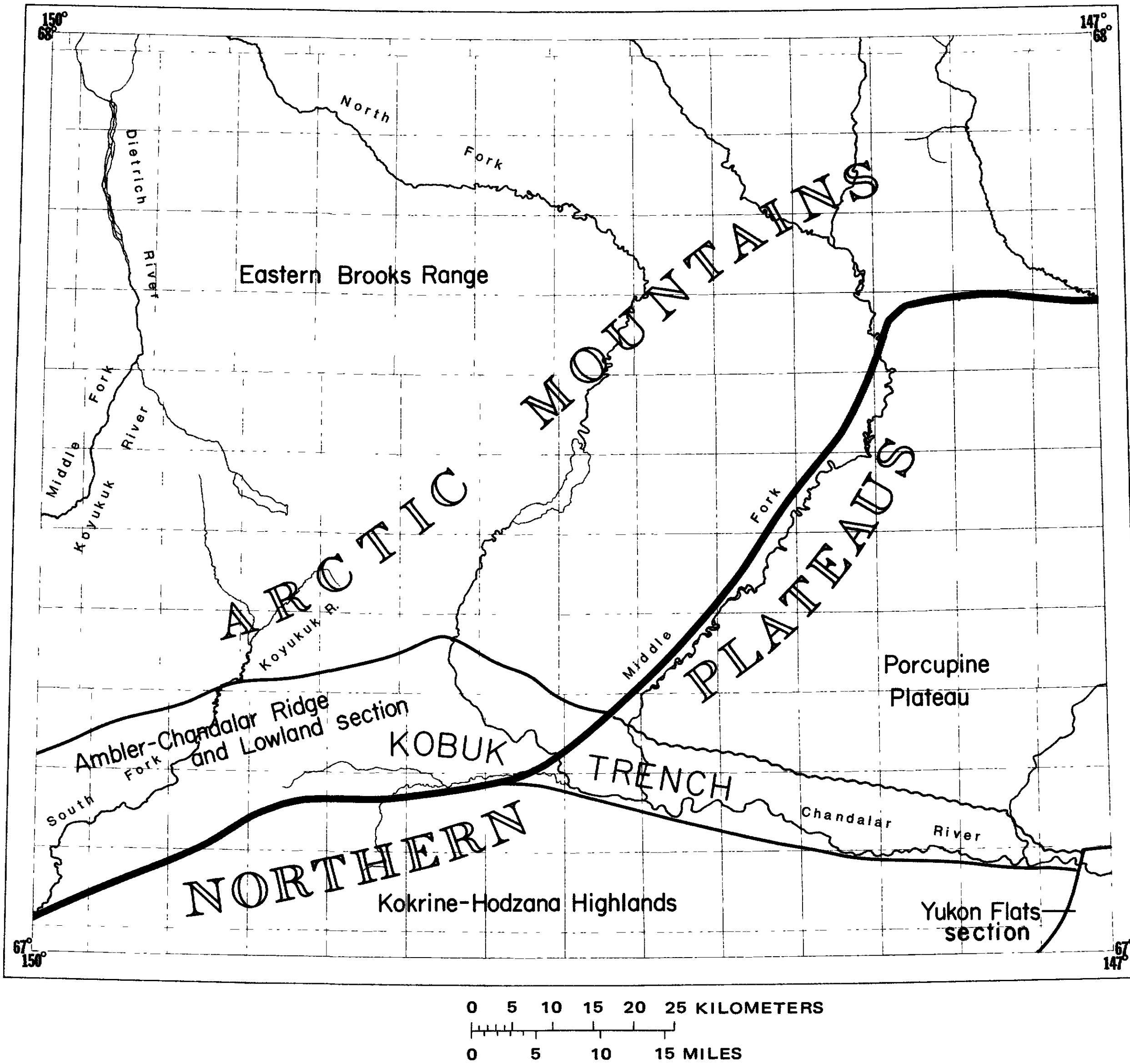


FIGURE 2.—Physiographic divisions of the Chandalar quadrangle.

sonnel for permitting refueling at construction campsites along the pipeline route, thus greatly improving the efficiency of our helicopter operations, and to local Alaskans whose helpful cooperation ranged from providing housing to providing details of local geological information. In particular, special thanks are due the late Wayne (Red) Adney—prospector, guide, and homesteader of Chandalar Lake; Eskil Anderson and the late Frank Birch of Chandalar Mining and Milling Company; John Graham of Placid Oil Company, and Russell Babcock of Bear Creek Mining Company.

We are indebted to many people within the Geological Survey, especially to Betty McIntire, who coped so ably with our logistic and supply problems, and Henry C. Berg, coordinator of AMRAP, who assisted throughout the project.

GEOLOGICAL INVESTIGATIONS

PREVIOUS GEOLOGICAL INVESTIGATIONS

Geological investigations in the Chandalar quadrangle began in 1899 when F. C. Schrader and T. G. Gerdine, topographer, made the first geologic and topographic map of the Koyukuk and

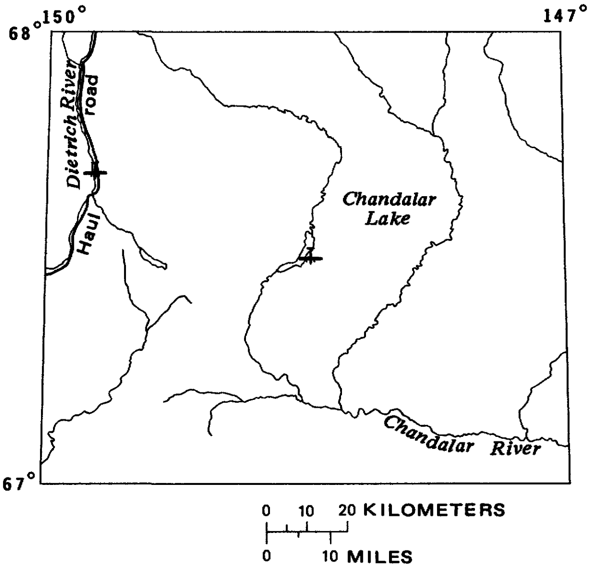


FIGURE 3.—Index map showing Alyeska haul road and large airfields.

Chandalar area (Schrader, 1900, 1904). In 1903, S. J. Marsh prospected along the eastern part of the quadrangle while traversing the Brooks Range. He provided a brief written report with a rough map to the U.S. Geological Survey. A. G. Maddren in 1909 made a detailed study of the gold placer occurrences of the Koyukuk and nearby parts of the Chandalar drainage (Maddren, 1913). J. B. Mertie (1925) refined and extended the mapping of the Chandalar mining district to essentially coincide with the present 3° quadrangle. Reports on gold occurrences, prospects, mining developments, and related geology have been made over the intervening years, at first by personnel of the Alaska Territory Department of Mines (Thompson, 1925; Reed, 1927, 1929, 1930, 1938; Stanford, 1934), and after Alaska statehood by Saunders (1963) and Chipp (1970) of the Alaskan Department of Natural Resources, Division of Mines and Geology. Chipp's detailed study of the geology and geochemistry relating to the gold mineralization in the Chandalar mining district refined the stratigraphy and structural interpretation of the regional mapping.

RECENT STUDIES

The present study incorporates field and laboratory work started in 1959 and carried out intermittently to 1977. Helicopter-supported reconnaissance geologic mapping that started in August of 1959 and concluded in the 1960 field season resulted in publication of a 1:250,000-scale geologic map of the Chandalar quadrangle (Brosgé and Reiser, 1964). In response to a national heavy metals investigation program in 1967, limited geochemical sampling and geologic mapping were carried out over an area which included part of the Chandalar quadrangle. Results of this work were published as U.S. Geological Survey Professional Paper (Brosgé and Reiser, 1972).

In 1972 and 1973 aeromagnetic surveys of the western and eastern halves of the Chandalar quadrangle were flown under contract for the Geological Survey by Aeroservice and geoMetrics, and the aeromagnetic maps subsequently were released as separate sheets (U.S. Geol. Survey, 1973, 1974). Regional gravity data were collected primarily during the summers of 1964 and 1972 as part of the effort to prepare the State gravity map (Barnes, 1977). The geology of a few small areas in the northern part of the quadrangle was remapped in 1974, 1975 and 1976 in the course of work in adjacent quadrangles (Dutro and others, 1976; Brosgé and others, 1977). In 1975 a helicopter-supported field program directed by S. P. Marsh completed systematic geochemical reconnaissance sampling of the entire Chandalar quadrangle. Slightly more than 2,100 samples consisting of stream sediments, soil, heavy concentrates, vegetation, and rock were collected and analyzed. The analytical data have been placed on open file (O'Leary and others, 1976; Detra and others, 1977). At the same time, detailed mapping and investigation of three of the mineral prospects was completed by M. A. Wiltse, who was affiliated with the Alaska Division of Geological and Geophysical Surveys, and samples were collected for K/Ar age determinations.

GEOLOGY OF THE CHANDALAR QUADRANGLE

The Chandalar quadrangle is underlain predominantly by low-grade metasedimentary rocks of Devonian and older age (fig. 4). The metamorphic facies represented in the Chandalar quadrangle are the greenschist facies and glaucophane schist facies of Turner and Verhoogen (1960) and the prehnite-pumpelleyite and hornblende hornfels facies as described by Hyndman (1972). Granitic rocks of several ages underlie about 15 percent of the quadrangle. Numerous small bodies of mafic greenschist, greenstone, and slightly al-

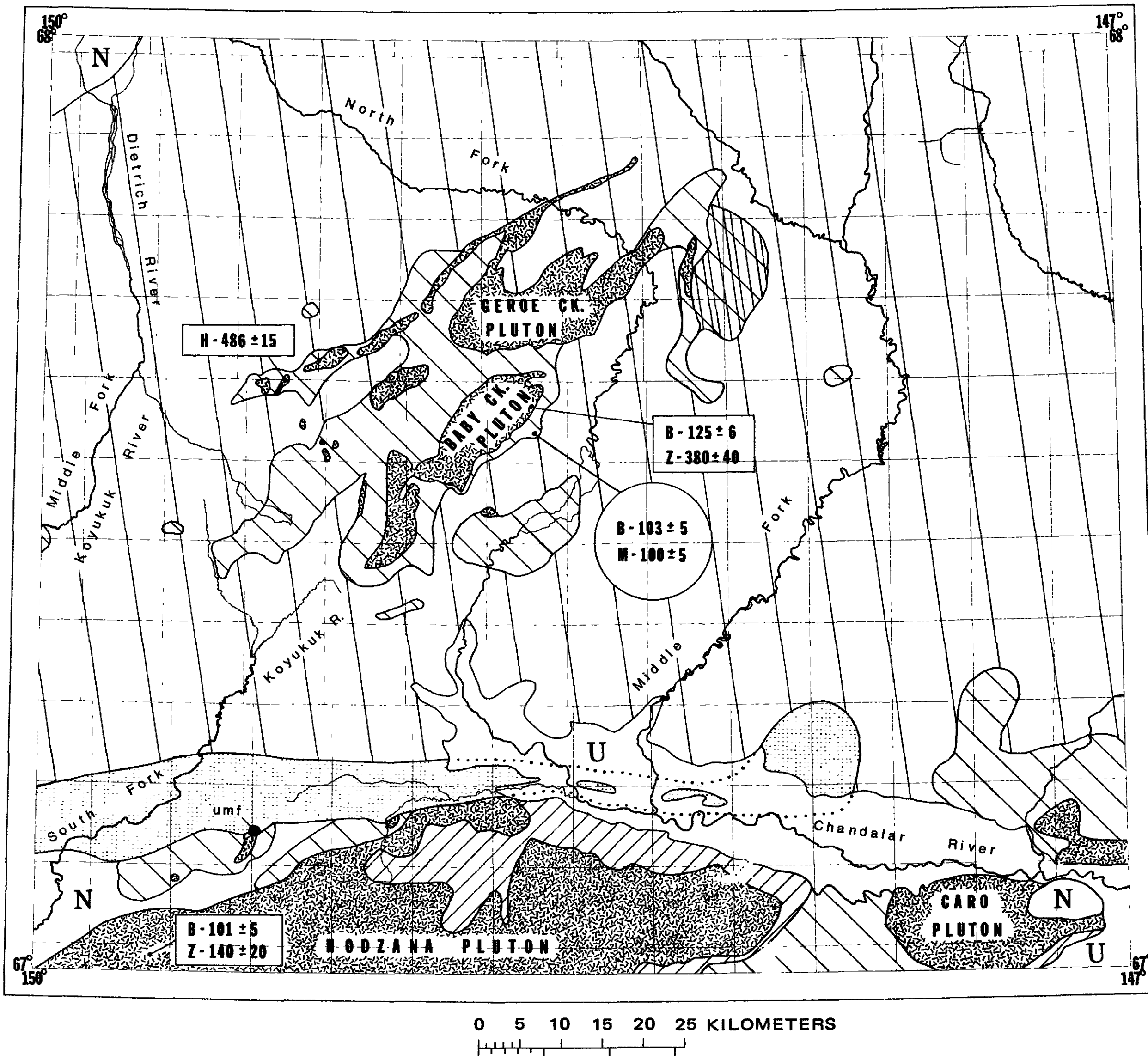


FIGURE 4.—Metamorphic facies and K-Ar ages of rocks in the Chandalar quadrangle.

tered mafic volcanic rocks, as well as one small ultramafic body, occur in the quadrangle. Folding and faulting are complex; several thrust faults have been mapped, but the full extent of the thrusting is not known. Within the quadrangle the physiographic divisions correspond with three geologically distinct terranes.

The southern part of the quadrangle, coinciding with the Kokrine-Hodzana Highlands is mostly underlain by granodiorite, quartz monzonite, granite, and gneissic granite of Cretaceous age. Migmatite and thermally altered schist border these intrusives in discontinuous outcrop.

The Kobuk Trench, flanking the north side of the Kokrine-Hodzana Highlands, is for the most part a wide flat valley covered by surficial deposits. Slightly metamorphosed sedimentary rocks form subdued outcrops in small areas, but probably represent the major rock type underlying the lowland. The dominant outcrops are an ophiolitic assemblage of mafic volcanic rocks including pillow basalt, chert, some greenstone, and one ultramafic body. A narrow band of buried volcanic rocks aligned with the mafic outcrops is also indicated by the aeromagnetic studies. Both the sedimentary and volcanic rocks are metamorphosed to the

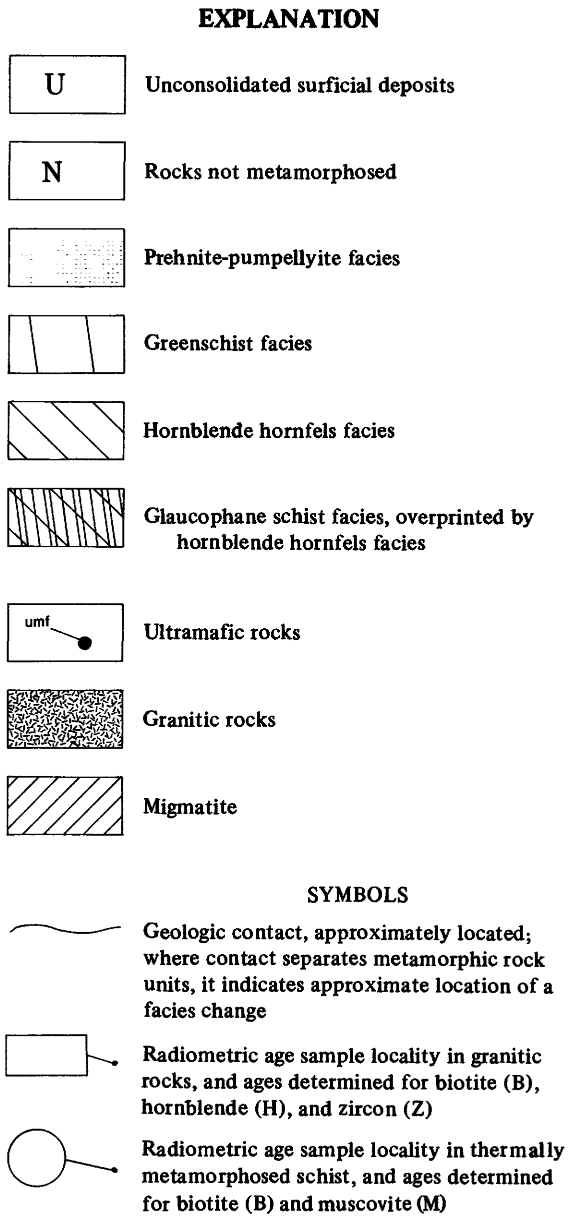


FIGURE 4.—Continued.

prehnite-pumpellyite facies. The age of the metasedimentary rocks is uncertain, possibly Devonian; the volcanic rocks are probably not older than Mississippian or younger than Jurassic. The youngest rocks in the quadrangle are in the trench. Cretaceous polymictic conglomerates with interbedded graywackes occur near the southwest corner and basalt flows of probable Tertiary age near the southeastern corner of the quadrangle.

The mountainous terrane of the northern three-fourths of the quadrangle comprising the eastern Brooks Range and Porcupine Plateau physiographic sections is underlain by schist, phyllite, slate, limestone, marble, greenstone, and granitic intrusives. Generally the metasedimentary rocks belong to the low-grade greenschist facies, but somewhat higher grade metamorphosed rocks occur in T. 34 N., R. 2 W., where relict glaucophane in chloritized amphibole schist indicates a retrograded former glaucophane schist facies. The extent that the greenschist may have replaced former glaucophane schist facies elsewhere in the quadrangle is unknown (U.S. Geol. Survey, 1975). Contact aureoles of hornblende hornfels facies occur around the granitic intrusives. Biotite-garnet schist and tactite are the typical contact rocks of the northern plutons, whereas andalusite-staurolite-biotite schists are associated with the southeastern granitic body. Unmetamorphosed sedimentary rocks, consisting mostly of Mississippian limestone, shale, and conglomerate are exposed beneath Devonian rocks in a structural window in the northwest corner of the quadrangle.

Complex folding and thrust faulting are evident in the mountains north of the Kobuk Trench. The plate of Devonian rocks thrust over the Mississippian rocks has a minimum displacement of 18.5 km. A thrust plate of similar minimum displacement but involving pre-Mississippian schist is mapped in the vicinity of Chandalar Lake and is in turn overlain by another thrust plate containing calcareous schist and the northernmost granitic pluton. The Kobuk Trench itself may mark a major linear fault zone (Grantz, 1966); the volcanic rocks and chert within the trench have been interpreted to be oceanic rocks that have been obducted onto the continental crust represented by the Brooks Range (Patton and others, 1977).

POTASSIUM-ARGON AGES

Isotopic age determinations made prior to AMRAP on micas and zircons from one southern and one northern granitic pluton (Brosgé and Reiser, 1964) are shown on figure 4. The micas from both plutons and the zircon from the southern pluton gave compatible ages, indicating a Middle Jurassic to middle-Cretaceous age. The zircon from the northern pluton, however, indicated a Late Devonian minimum age.

Recent K/Ar determinations for hornblende in a granodiorite collected at Big Spruce Creek indicate an Ordovician or older age (D.L. Turner and

M. L. Silberman, written commun., 1977). This new age determination makes uncertain the previously inferred Devonian age of the sequence of calcareous and quartz-muscovite schists apparently intruded by the granodiorite.

DESCRIPTION OF COMPONENT MAPS OF THE CHANDALAR QUADRANGLE FOLIO

GEOLOGY (MAP I-375)

The multicolored geologic map of the Chandalar quadrangle at 1:250,000 scale (Brosgé and Reiser, 1964) is based on the reconnaissance mapping done in 1959 and 1960. In the course of the 1975 and 1976 AMRAP studies some additional mapping was done, but not enough to warrant publication of a revised geologic map. Detailed maps of three copper prospects in the quadrangle are included in the folio (Marsh and Wiltse, 1979). Other new information obtained since 1960 by the U.S. Geological Survey and the Alaska Division of Geological and Geophysical Surveys has been combined with the previous mapping in the compilation of a generalized geologic map which is used as the base for the maps in the Chandalar AMRAP folio. Revised parts of the generalized geologic map that incorporate this new information are outlined on figure 5, and they are reproduced in this circular as

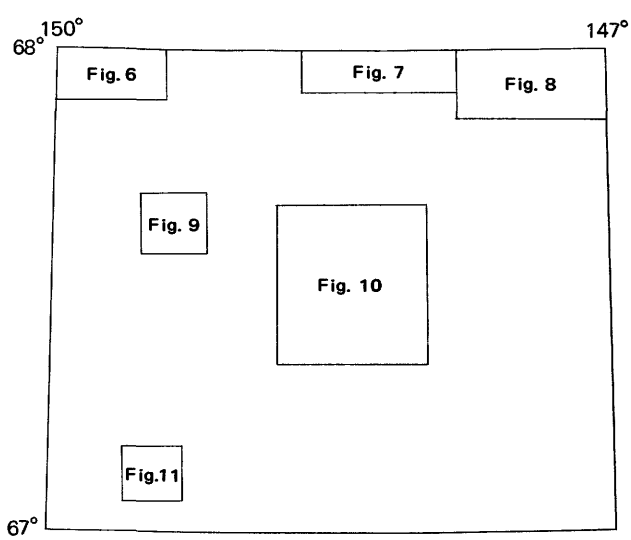


FIGURE 5.—Localities where the geologic map of the Chandalar quadrangle (Brosgé and Reiser, 1964) has been revised in the compilation of the generalized geologic map for the AMRAP folio.

figures 6 to 11, with the revised contacts, faults, or map unit symbols shown by full black lines. The revised correlation and description of the generalized map units is shown as figure 12. The more significant revisions of the mapping, stratigraphic nomenclature, and age assignments are described below.

REVISIONS OF MAP I-375

MAPPING

Most of the slate and phyllite exposed beneath the Lisburne Group in the northwest corner of the quadrangle (fig. 6) was originally mapped as the Devonian Hunt Fork Shale and as Mississippian Kayak Shale. The rocks in this small area have since been recognized as part of a phyllite unit of probable Cambrian or Ordovician age that crops out extensively farther west (Dutro and others, 1976). Because of their small area they are here included in the undifferentiated Paleozoic and Mesozoic(?) phyllite unit. Some mafic sills and a pillow basalt flow in the northcentral and northeast parts of the quadrangle that were not recognized in the original mapping have been added to the present map (figs. 7 and 8). In addition, the contacts of the Hunt Fork Shale and of the Skajit Limestone have been revised at several places along the northern edge of the quadrangle (figs. 6, 7, and 8). At Big Spruce Creek in the west-central part of the quadrangle a sill of hornblende granodiorite has been added to the map within an area previously mapped as tactite (fig. 9). This sill is shown in more detail on the map of the Venus prospect by M. A. Wiltse (Marsh and Wiltse, 1979). In the central part of the quadrangle (fig. 10) the areas of tactite north of Squaw Lake and of greenstone and greenschist south of Squaw Lake are smaller than originally shown. The flat thrust faults that dip beneath the Chandalar gold mining area from the north and from the south have been relocated to conform to the detailed mapping by Chipp (1970), and a few high-angle faults have been added.

In the southwest part of the quadrangle (fig. 11) a small body of serpentinite that was previously mapped as volcanic rocks has been separately mapped as ultramafic.

NOMENCLATURE

Quartz pebble conglomerate (Cretaceous).—The name "Bergman group" used on map I-375 has

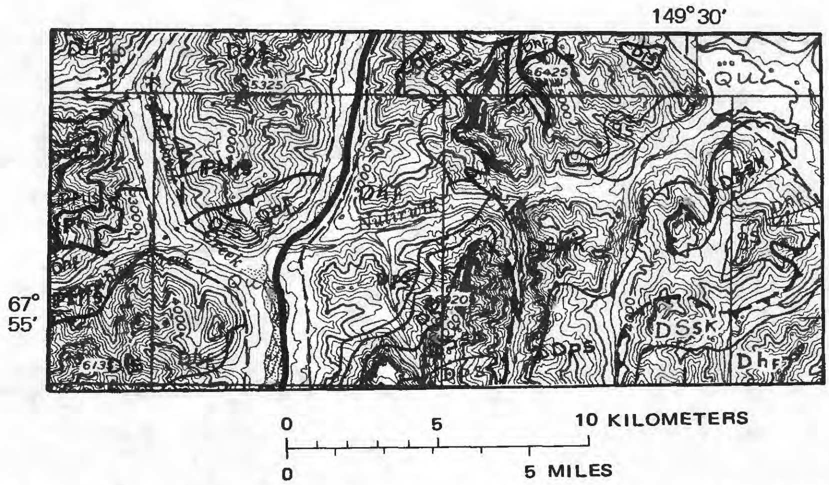


FIGURE 6.—Revisions of the northwest part of the geologic map of Chandalar quadrangle (Brosgé and Reiser, 1964).

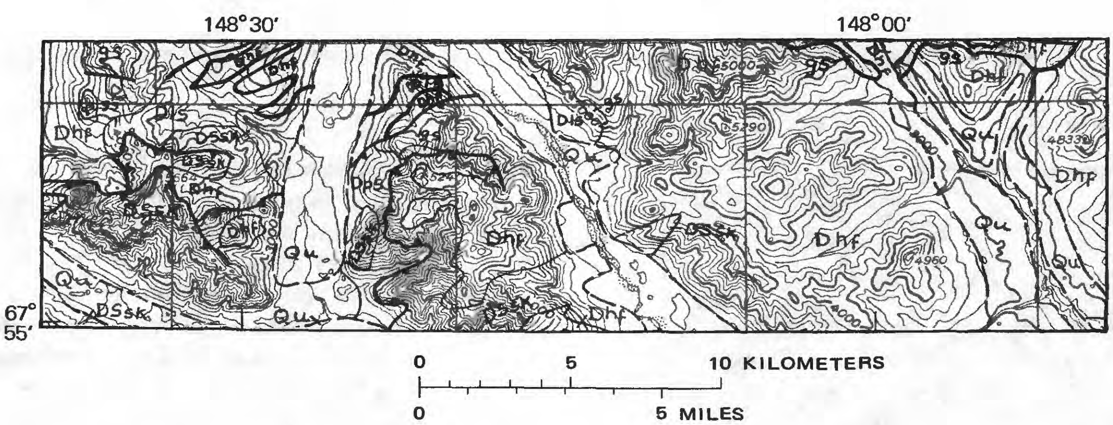


FIGURE 7.—Revisions of north-central part of geologic map of Chandalar quadrangle (Brosgé and Reiser, 1964).

been abandoned (Patton, 1973) and has been replaced by informal descriptive terms for these rocks in the adjacent Wiseman and Bettles quadrangles (Patton and Miller, 1973).

Hunt Fork Shale (*Upper Devonian*).—The Hunt Fork Shale has been mapped continuously from its type area in the Killik River quadrangle (Chapman and others, 1964) to the Chandalar quadrangle. The term "slate and sandstone" used on map I–375 has therefore been replaced by the name Hunt Fork Shale on the generalized map. As outlined, the lower part of the Hunt Fork Shale as generalized includes some thin interbedded reefs that were previously mapped as "Skajit Limestone." It also includes some brown-weathering shale that occurs locally below the horizon of these reefs and that has now been recognized in the adjacent Philip Smith Mountains quadrangle as the upper part of a newly recognized unnamed Upper Devonian formation that is in part coeval with the Hunt Fork (Brosgé and others, 1977; Dutro and others, 1977). The basal conglomerate of the "slate and sandstone" unit that was differentiated in a few places on map I–375 may also be equivalent to the upper part of this new formation. The rocks equivalent to the lower part of the new formation are mapped separately as the purple and green slate and phyllite unit and the limestone and siltstone unit which underlie the Hunt Fork.

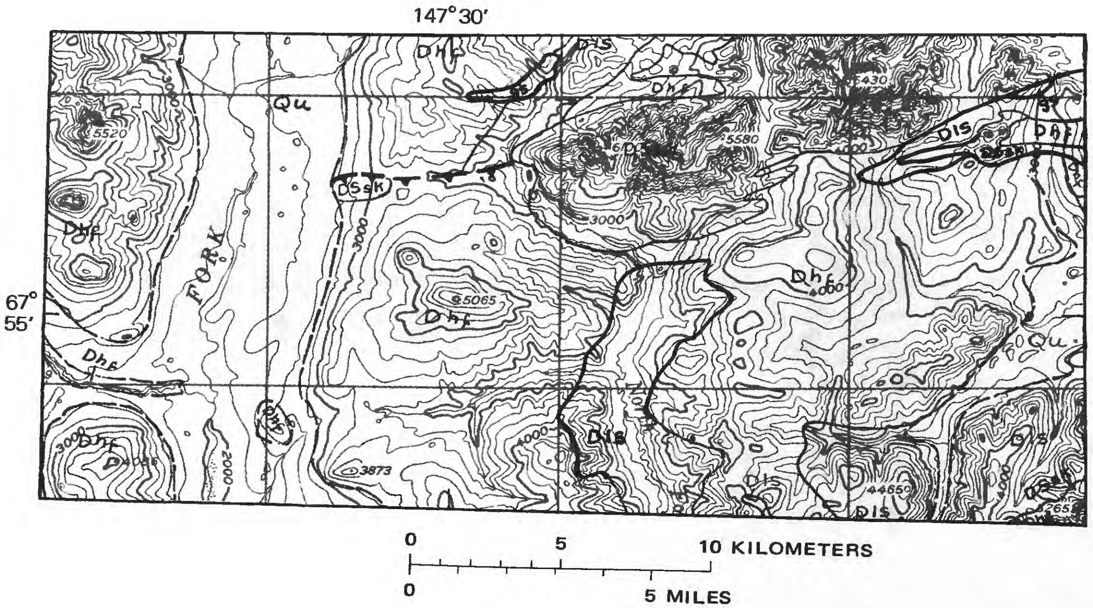


FIGURE 8.—Revisions of northeast part of geologic map of Chandalar quadrangle (Brosgé and Reiser, 1964).

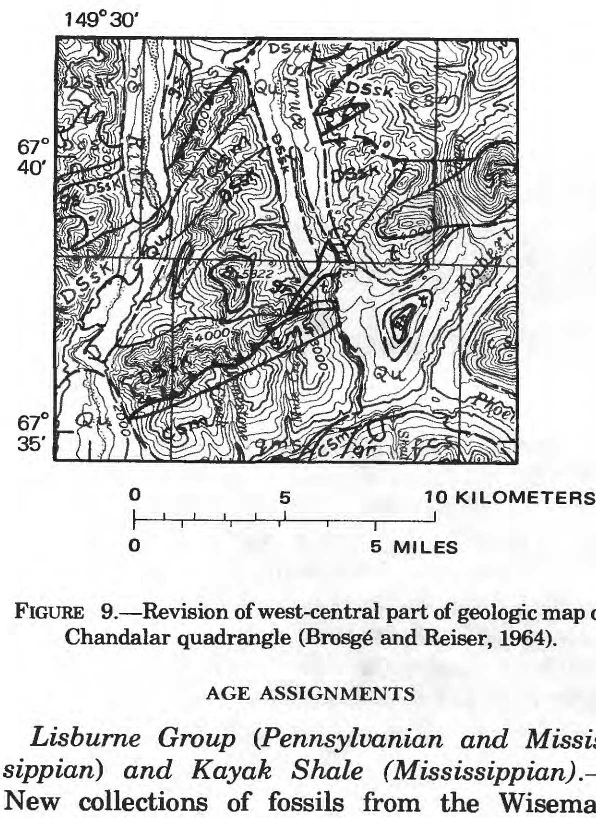


FIGURE 9.—Revision of west-central part of geologic map of Chandalar quadrangle (Brosgé and Reiser, 1964).

AGE ASSIGNMENTS

Lisburne Group (Pennsylvanian and Mississippian) and Kayak Shale (Mississippian).—New collections of fossils from the Wiseman quadrangle show that the Lisburne Group about 25 km west along strike from the Lisburne in the northwest corner of the Chandalar quadrangle includes Pennsylvanian as well as Mississippian limestone (Armstrong and others, 1976). Fieldwork in that area has also shown that the thin conglomerate at the base of the Kayak Shale is part of the Mississippian, and not the Devonian Kanayut Conglomerate as it was shown on map I–375. Therefore the Kanayut Conglomerate has been deleted from the map, and the age of the Lisburne has been revised to Pennsylvanian and Mississippian, although it is not known that beds as young as Pennsylvanian are actually preserved in the small area of Lisburne outcrop within the Chandalar quadrangle.

Skajit Limestone (Silurian to Upper Devonian).—The age of the Skajit Limestone recently has been revised to Silurian and Devonian on the basis of Silurian brachiopods found in the western Brooks Range (Oliver and others, 1975, p. 27 and fig. 12). This revision has been confirmed by the discovery of Silurian brachiopods in limestone boulders in the stream that bisects the large anticlinal exposure of the Skajit in the northeast corner of the Chandalar quadrangle (J. T. Dutro, Jr., written commun., 1977).

Granitic rocks (Mesozoic and older).—The granitic rocks were assigned a Mesozoic or late Paleozoic age on map I–375. Micas from two of the plutons gave K/Ar ages of 101 to 125 m.y. (Early

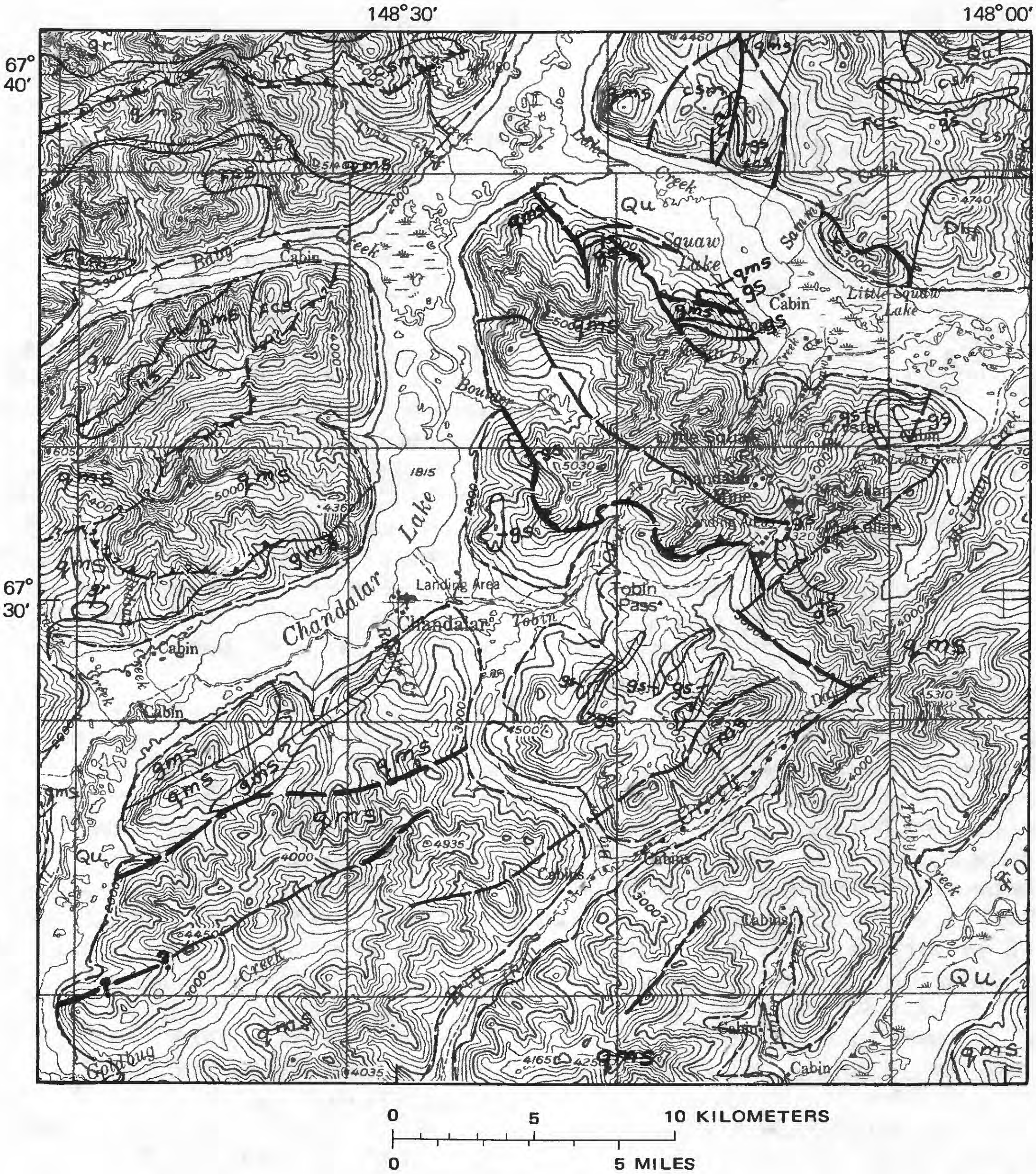


FIGURE 10.—Revisions of central part of geologic map of Chandalar quadrangle (Brosgé and Reiser, 1964).

Cretaceous), while zircons from the same localities gave a confirmatory Pb/alpha age of 140 m.y. (latest Jurassic or earliest Cretacous) for the Hodzana pluton in the southwest part of the quadrangle and a discordant Pb/alpha age of 380 m.y. (Devonian) for the Baby Creek pluton west of Chandalar Lake (see fig. 4). No mineral ages were measured for the Geroe Creek pluton.

A Cretaceous age for emplacement of the Hodzana pluton is probably correct. The analytical age of the zircons agrees fairly well with that of the biotite, and the pluton contains mafic schlieren and small roof pendants which suggests that the granite has intruded part of the adjacent Mississippian to Jurassic volcanic rocks. This pluton appears to be one of the many closely spaced Cretaceous plutons that have invaded the schist of the Kokrine-Hodzana Highlands (Patton and Miller, 1973; Brosgé and others, 1973). However, recent analyses of hornblende indicate that at

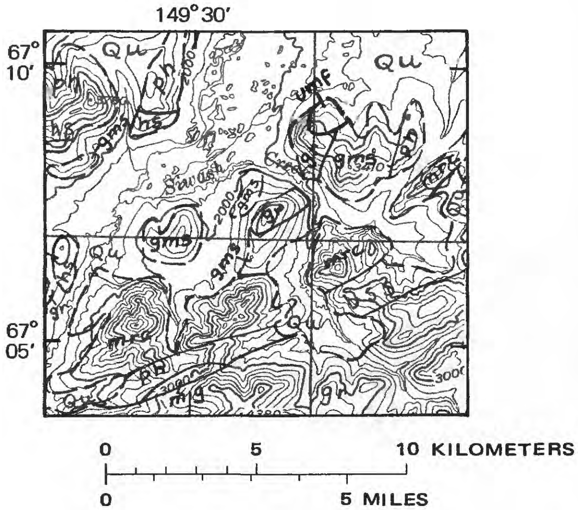


FIGURE 11.—Revision of southwest part of geologic map of Chandalar quadrangle (Brosgé and Reiser, 1964).

least some of the granitic rocks in the northern part of the quadrangle are Ordovician or older.

During his 1975 mapping of the Venus prospect on Big Spruce Creek, M. A. Wiltse sampled a small, previously unmapped sill of partly metamorphosed hornblende granodiorite porphyry similar to that in some of the larger bodies of "gneissic granitic rocks" previously mapped northeast of Big Spruce Creek and along the northern margin of the Geroe Creek pluton. Replicate samples of hornblende and of partially chloritized and sericitized hornblende from the sill on Big Spruce Creek have been analyzed by D. L. Turner and M. L. Silberman (written commun., 1977). The average K/Ar ages determined were 286 m.y. (Permian) for the partially chloritized hornblende and 486 m.y. (Ordovician) for the purer samples of hornblende. These analytical ages appear to be reliable; however, some uncertainty remains about the age of these granitic rocks because Wiltse also found two small bodies of sheared granodiorite in the Skajit Limestone at the Gayle prospect (Marsh and Wiltse 1979), where the Skajit contains brachiopods of Devonian or Silurian age. Because of this uncertainty the granitic rocks in the northern part of the quadrangle are not assigned to any specific part of the Paleozoic, and the generalized unit of all granitic rocks is shown as Mesozoic and older.

Mafic rocks and chert (Mississippian to Jurassic).—On map I–375 the unmetamorphosed volcanic rocks and chert in the southern part of the quadrangle were considered to be Late Devonian(?) in age, although a note was added just before publication that similar rocks in the adjacent Christian quadrangle are Carboniferous or younger in age. The volcanic rocks and chert of this southern belt have recently been assigned a Jurassic to Permian age (Patton and Miller, 1973) on the basis of Permian fossils found in the Wiseman quadrangle and Jurassic K/Ar dates on mafic rocks in the Christian quadrangle. The whole suite of volcanic rocks, ultramafic rocks, and chert around the Koyukuk Basin has more recently been assigned a Mississippian to Jurassic age (Patton and others, 1977), and this age has been shown for those rocks in the generalized map of the Chandalar quadrangle.

Greenstone and greenschist; hornblende schist (Mesozoic(?) and Paleozoic).—Metamorphosed mafic rocks in the central and northern parts of the quadrangle were assigned a probable Devonian age on map I–375 and were considered to be probably age equivalents to the volcanic rocks in the southern part of the quadrangle. Inasmuch as the volcanic rocks are now thought to be Mississippian to Jurassic, some of the metamorphosed mafic rocks may be as young as Jurassic. However, many of the mafic rocks in the northern part of the quadrangle are probably Devonian. Recent fieldwork has shown that part of the tabular body in the Hunt Fork Shale along the north edge of the quadrangle at longitude 148° (fig. 7) is a pillowed flow, rather than a sill and that a few more flows occur in the Devonian shale north of the quadrangle (Brosgé and others, 1977). In addition, a K/Ar age of 363±11 m.y. (Devonian) has been measured for albite from a gabbro sill that intrudes the Hunt Fork 33 km north of the Chandalar quadrangle (M. L. Silberman, written commun., 1977). The generalized unit of metamorphosed mafic rocks and the unit of thermally metamorphosed mafic rocks are therefore shown as Mesozoic(?) and Paleozoic in age.

Quartz-muscovite schist; garnet-mica schist; biotite-staurolite schist; calcareous schist and marble; feldspathic chloritic schist; chloritized amphibole schist (Paleozoic or older).—The schist units were previously assigned a Devonian age, but new radiometric dates indicate that the protolith of the schist may be early Paleozoic or Precambrian image. On map I–375 each of the schist units was correlated with a less metamorphosed Devonian unit of similar composition. The pelitic quartz-muscovite schist was correlated with the

Hunt Fork Shale, and the calcareous schist with the limestone and siltstone unit. This lithologic correlation is supported by the apparent geographical and structural continuity between each of the schist units and its presumed Devonian counterpart where these units cross the axis of the large anticlinorium that plunges northeastward from the granite near Chandalar Lake. The calcareous schist crops out on the axis of this anticlinorium on the west side of the Middle Fork of the Chandalar River, while just across the river, the slightly less metamorphosed limestone and siltstone unit crops out on the axis (fig. 13). The structural continuity of the calcareous schist with the limestone and siltstone unit at this place is evident from the continuity of a long linear magnetic anomaly that follows the strike of the calcareous schist along the anticlinorium for about 40 km and continues on eastward into the area of limestone and siltstone (Cady, 1978). The Hunt Fork Shale overlies the limestone and siltstone and also some of the calcareous schist on the axis of the anticlinorium and extends southward to the area of quartz-muscovite schist on the south flank. Since all the rocks involved have been regionally metamorphosed to greenschist facies, the geographic relations suggest that the well-foliated schist units simply grade northeastward into the less metamorphosed bedded Devonian rocks.

A post-Devonian, probably Cretaceous age for this regional metamorphism can be inferred from the metamorphism of the fossiliferous Devonian rocks, from the presence of schist clasts in the Cretaceous conglomerate, and from the Cretaceous radiometric dates of micas in the Baby Creek pluton and adjacent schist. However, recent radiometric dating by D. L. Turner of glaucophane, paragonite, and actinolite from schist in the western Brooks Range gives evidence that two other metamorphic events preceded the Cretaceous granitic intrusions—a late Precambrian blueschist event (Forbes and others, 1977) and a Triassic event that retrograded the blueschist (Alaska Division of Geological and Geophysical Surveys, 1973, p. 27–30, 34–36). The schist in the Chandalar quadrangle probably has a metamorphic history similar to the schist in the western Brooks Range because the schist belt is continuous between the two places and because the chloritized amphibole schist in the Chandalar area is at least in part retrograded glaucophane schist. This, these new radiometric data would indicate that the schist is Precambrian. A Precambrian or early Paleozoic age of the schist is also indicated by the Ordovician K/Ar age of the granodiorite that intrudes the calcareous schist on Big Spruce Creek.

The Precambrian or early Paleozoic age of the schist is not certain, however, because both of the lines of evidence based on radiometric ages seem to be in conflict with paleontologic data. The blueschist facies terrane in the western Brooks Range includes beds of marble that contain Paleozoic (probably Devonian) fossils (Alaska Division of Geological and Geophysical Surveys, 1973, p. 28). At the copper prospects of the Chandalar area small bodies of granodiorite occur in fossiliferous Devonian or Silurian limestone as well as in the calcareous schist where the dated granodiorite sample was obtained. These apparent conflicts have several possible solutions, but since they are not resolved, an indefinite age has been assigned to the schist.

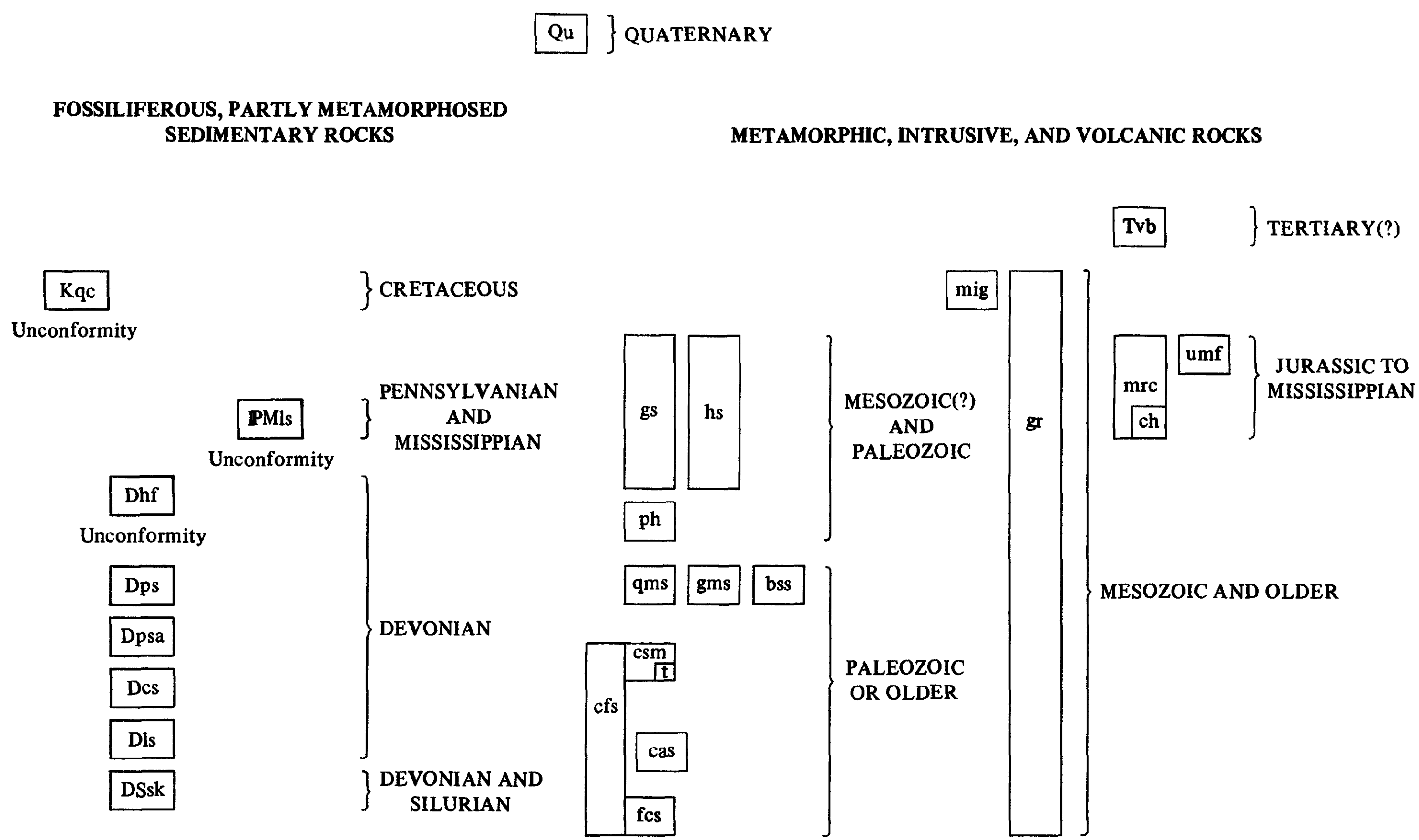
Relations between the Hunt Fork Shale and the schists can be interpreted to fit either a Precambrian or a Devonian age of the schist protolith because there is a regional unconformity beneath the Hunt Fork. The Hunt Fork contains a basal conglomerate in many places and rests unconformably (Brosgé and Dutro, 1973) on the Skajit Limestone and on several Devonian units younger than the Skajit. If the schists are Precambrian, the Hunt Fork was probably deposited unconformably upon them. On the east side of the Middle Fork of the Chandalar the basal conglomerate of the Hunt Fork rests on the moderately metamorphosed calcareous rocks of presumed Devonian age that are the lateral equivalents of the calcareous schist unit (see fig. 13). If the schist is Precambrian these less metamorphosed rocks must also be part of the Precambrian rather than part of the Devonian limestone and siltstone unit, and the basal contact of the Hunt Fork at this place is a profound unconformity rather than a minor one. The contact of the Hunt Fork with the calcareous schist and the feldspathic schist units west of the Middle Fork might also be such an unconformity, although the basal conglomerate was not found in that area. The nature of the contact between the Hunt Fork and the quartz-muscovite schist unit is uncertain in the two places where it has been mapped, partly because of poor exposures and partly because of the diffi-

EXPLANATION

Geology generalized and revised from Brosgé and Reiser (1964) and Chipp (1970)

CORRELATION OF MAP UNITS

SURFICIAL DEPOSITS



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 and 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—Include 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

U D ? 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

FIGURE 12.—Correlation and description of the map units shown on the generalized geologic map of the Chandalar quadrangle.

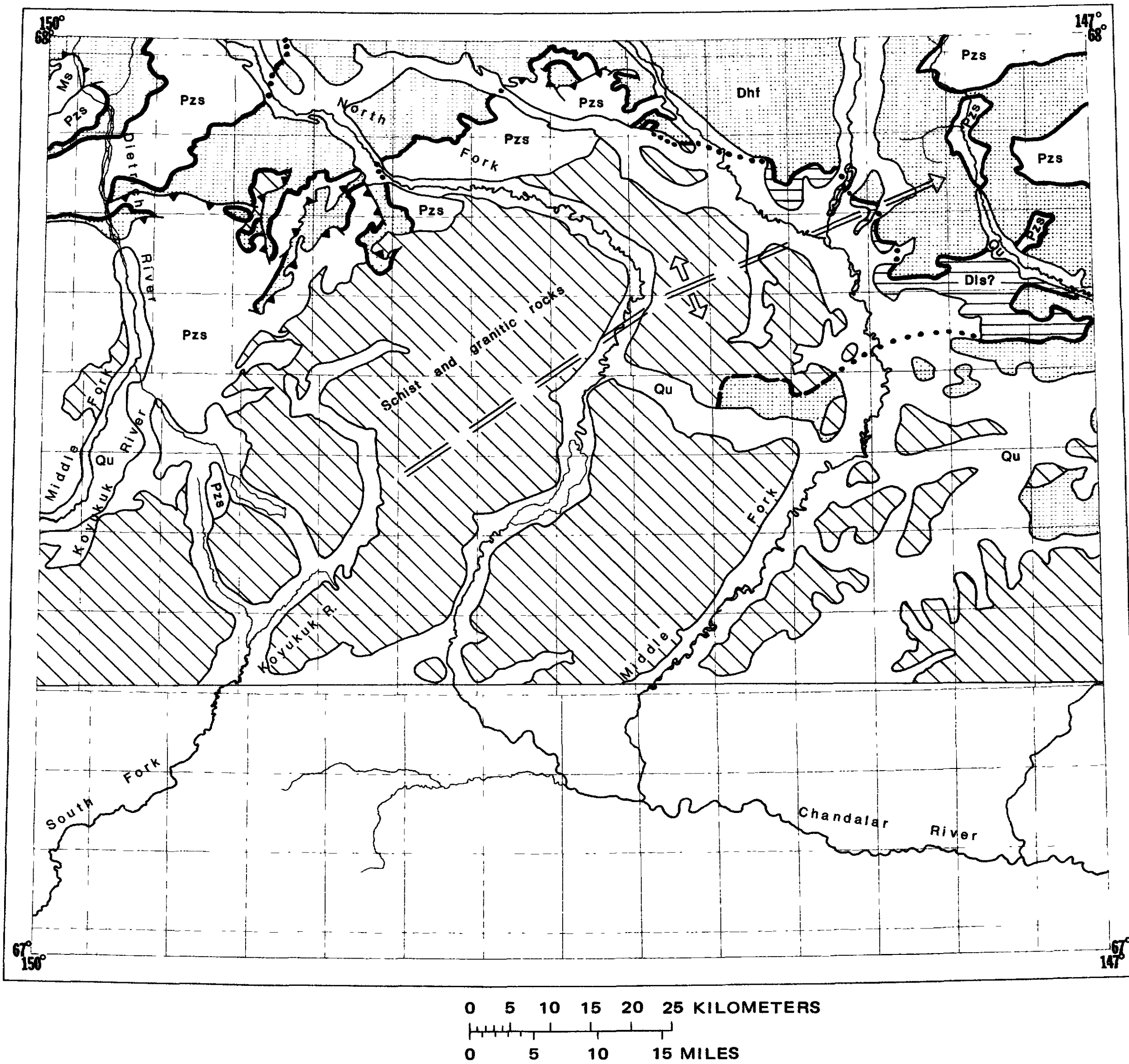


FIGURE 13.—Generalized geologic map of northern part of Chandalar quadrangle showing the possibly unconformable relation of the Upper Devonian Hunt Fork Shale to the older Paleozoic sedimentary rocks, to the schist, and to the calcareous rocks that are equivalent to part of the schist.

culty in distinguishing the more phyllitic phases of the Hunt Fork from some of the phyllitic schists.

SURFICIAL GEOLOGIC MAP (MAP MF–878–A)

Initial fieldwork along the Dietrich River and the Middle Fork of the Koyukuk River was carried out in connection with trans-Alaska pipeline activities in 1969–1971, and the entire Chandalar quadrangle subsequently was covered by ground and helicopter traverses during 1975 and 1976. Able field and office assistance was provided by Robert M. Thorson during 1975 and 1976 and by James P. McCalpin during 1976 and 1977.

The surficial geologic map of the Chandalar quadrangle is based on (1) surface observations of morphology and composition of unconsolidated deposits, (2) examination of test pits, trenches, road cuts, and other shallow excavations, (3) stratigraphic study of bluff exposures, and (4) analyses of maps and drill logs prepared by U.S. Geological Survey personnel and Alyeska consul-

EXPLANATION

Qu — Unconsolidated Quaternary deposits

Ms — Mostly Mississippian sedimentary rocks

Dhf — Hunt Fork Shale (Upper Devonian)

Pzs — Undivided Paleozoic sedimentary rocks older than the Hunt Fork Shale

Dls ? — Calcareous rocks mapped as probably the Devonian limestone and siltstone unit that occurs in unit (Pzs). These rocks are also equivalent to the calcareous schist unit in the lower part of the undivided schist and granitic rocks

Undivided schist and granitic rocks

SYMBOLS

Geologic contact, includes some faults

Contact of base of Hunt Fork Shale on older rocks. Dashed where doubtful; dotted where concealed

Thrust fault contact of Hunt Fork Shale. Sawteeth on upper plate

Axis of anticlinorium, showing direction of plunge

FIGURE 13.—Continued.

tants for the corridor occupied by the trans-Alaska pipeline (see map MF–878–B). Placement of glacial deposits within the standard central Brooks Range stratigraphic sequence was based on similarities in position, extent, and postglacial modification to Anaktuvuk, Sagavanirktok, Itkillik, and Echooka drift sheets at type localities designated by Detterman, Bowsher, and Dutro (1958) and on subsequent correlations by Williams (1962), Hamilton (1969), and Hamilton and Porter (1975). Drift nomenclature has been revised in accordance with the recommendations of Keroher and others (1966) and Hamilton and Porter (1975). The former Anaktuvuk and Sagavanirktok glacial advances and deposits are currently termed *Anaktuvuk River* and *Sagavanirktok River* to avoid conflict with previously named rock units (Keroher and others, 1966, p. 91 and 3379; Sable, 1977, p. 24–30). Itkillik and Echooka are replaced by Itkillik I, Itkillik II, and late Itkillik, which correspond to the drift sequence described and illustrated by Hamilton and Porter (1975).

Surficial geology of the Chandalar quadrangle is dominated by the effects of successive episodes of Pleistocene valley-glacier activity which deeply scoured mountain passes and valley systems and deposited vast quantities of drift and outwash at and beyond the south flank of the Brooks Range. Glacier erosion oversteepened the walls of mountain valleys, creating unstable rock faces subject to falls, slides, and flows of rock and debris and to the accumulation of talus rubble (tr) and of landslide (ls) and flow-slide (fl) deposits. Glacier retreat from massive end moraines near the south flank of the range left extensive closed basins (stippled pattern) which received thick deposits of lacustrine sediment (l), alluvium (al), fluvial and eolian sand (sa), and fan delta sediment (fd) at the mouths of tributary streams. The older glacial deposits generally are more weathered, more dissected by stream erosion, and often bear relatively thick blankets of ice-rich, frozen silt and muck. Younger deposits are less altered by postglacial processes and hence provide more suitable and readily accessible construction materials.

The oldest glacial deposits, presumably of the Anaktuvuk River Glaciation (ad), consist of highly eroded and fragmentary weathered drift patches and erratics beyond the limits of later ice advances in Funchion Valley and the main valley of the Chandalar. Outwash related to this advance forms terraces incised within older preglacial terrace gravel (Tpt). During the subsequent Sagavanirktok River Glaciation, large valley glaciers flowed south through the Brooks Range along the Chandalar and Koyukuk drainage systems (Williams, 1962) and coalesced with one or more smaller ice tongues that originated in unnamed highlands south of the range. The coalescent piedment glacier complex deposited an extensive drift sheet (sd) within the broad structural trough presently occupied by the South Fork of the Koyukuk River and the West Fork and trunk stream of the Chandalar system. Ice flowed eastward nearly to the southeast corner of the Chandalar quadrangle and westward beyond the quadrangle's western boundary. Drift deposited during the subsequent Itkillik Glaciation (id_1) defines a piedmont lobe formed by the coalescence of glaciers at the mouths of the Koyukuk's South Fork and the Chandalar's North Fork (Williams, 1962). Less extensive glaciers farther east deposited individual drift sheets within the Brooks Range and at its southern flank. Itkillik II deposits (id_2, io_2, and ik), which formed within the main forks of the Chandalar Valley and the South Fork of the Koyukuk Valley (Williams, 1962), include extensive ice-contact gravel and outwash deposits and generally lack significant cover of ice-rich or organic silt. These deposits provide particularly well drained and stable surfaces and abundant borrow materials. Late Itkillik deposits (id_3 and io_3), which generally occur in tributary valleys, consist largely of poorly sorted till, fine-grained glaciolacustrine sediments, and outwash overlying lake beds.

Holocene glaciation has been restricted to relatively high altitudes predominantly in a 25-km-wide belt centered on the Continental Divide (Hamilton, 1977), and only a few small drift bodies (nd, nd_1, and nd_2) are present in the Chandalar quadrangle. Rock glaciers are more abundant and widespread. They occur to altitudes as low as 600 m (2,000 ft) along the South Fork of the Koyukuk and at altitudes of 900 m (3,000 ft) and above along tributaries to the Chandalar's North Fork. Rock glaciers formed from talus cones and aprons along valley sides are most abundant, but many others occupy abandoned cirques at valley heads. Additional Holocene deposits include beach deposits (b) along lake shores, solifluction sheets and aprons (s) on slopes, alluvium (al) along valley centers, and fans (f) at the mouths of tributary streams. Many of these deposits are much more abundant than indicated on the map, because the scale is too small to show alluvium along smaller tributary valleys, minor beach deposits, and small or thin sheets of talus and solifluction debris.

With the exception of sediments beneath the larger rivers and lakes, all surficial deposits of the Chandalar quadrangle are perennially frozen. Permafrost lies at shallow depth (0.2 to 1 m) beneath poorly drained or well insulated surfaces such as peat and organic silt; its depth is greater and more variable (1–5 m) beneath more open-textured deposits such as sand, gravel, and rock rubble.

Radiocarbon dates from the central Brooks Range have been discussed by Hamilton and Porter (1975). We concluded that the Itkillik I ice advance was broadly contemporaneous with the Late Wisconsin advance of the Laurentide ice sheet, that the Itkillik II readvance probably occurred about 14,000 ^{14}C yr B.P., and that late Itkillik fluctuations may represent individual events that terminated by 10,000 yr B.P. or earlier. More recent preliminary radiocarbon dates from the Koyukuk and Chandalar Valleys suggest that initial deposition of Itkillik I drift may have occurred more than 30,000 ^{14}C yr B.P. and that this ice advance may be older than previously believed. Dating and identification of peat and wood specimens collected in the Chandalar quadrangle during 1975 and 1976 are now in progress, and results will be published when they are available. Since publication of the surficial geologic map (MF–878–A), seven radiocarbon dates have become available for the Chandalar quadrangle; dates and measured sections were published by Hamilton (1979).

MINERAL RESOURCES MAP (MAP MF–878–B)

The locations of mines, prospects, and mineral occurrences and favorable areas for the occurrence of mineral deposits are shown on the mineral resources map and described in the tables accompanying the map. In addition, the resource potential of the principal mineral commodities is discussed, and, where possible, quantitative estimates are made of resource potential. The assessments of favorable areas have been made with respoct to the possible existence of mineral deposits within an area. The probability of discovery of existing mineral deposits is contingent upon the intensity of search effort and the effectiveness of the methods used and is not considered in this evaluation. The terminology used in discussing mineral resources has been jointly adopted by the Bureau of Mines and the Geological Survey (U.S. Bur. Mines and U.S. Geol. Survey, 1976).

Mineral resource potential areas have been selected on the basis of information about known deposits, combined with geologic, geophysical, geochemical, and earth satellite data presented in other components of the Chandalar quadrangle folio. The particular criteria used to delineate each area are listed on the map sheet. In some areas, mineral deposits of the specified type(s) are known to exist. Other areas, although not known to contain mineral deposits, are considered permissible for the occurrence of some type(s) of mineral deposits because of geology and exploration history. The concept of geologic permissibility was proposed by Lasky (1947, p. 3) to consider the question of "Could ore be here?" in contrast to the concept of geologic probability—"Should ore be here?" In this report, areas are considered to be permissible for the occurrence of deposits of a specified type if they have not been explored to the extent that any undetected mineral deposits would have already been discovered, and if they contain specific indicators of the deposit type such as characteristic alteration, geochemical anomalies, or related types of mineralization, or they contain geologic units, relations, or environments similar to those of areas that are known to contain deposits of the type under consideration.

The boundaries of the mineral resource areas have been determined with the assistance of the authors of the component maps of this study with final responsibility resting on the author of the mineral resources map. The relationship between geologic environments and various types of mineral deposits as described in Brobst and Pratt (1973) was used in considering the limits of a favorable area. The report of Boyle (1974) was of valuable assistance in interpreting the relationship between geochemical information and possible deposit types. The interpretation of aeromagnetic data provided some indication of subsurface structure and plutons. Although circular and linear features interpreted from earth satellite imagery were not a primary consideration in delineating any of the areas, the coincidence of these features with mineral resource potential areas has been noted on the mineral resources map in order to provide a basis for possible future applications of this technology to mineral resource appraisal.

The possibility exists that areas designated as favorable may not contain deposits and that areas not commented upon may contain deposits. This is of particular importance in areas where bedrock exposure is poor, such as along the Middle Fork of the Chandalar River. Despite this limitation, the mineral resource assessment provides usable information for decisionmakers in government and industry.

Seven types of deposits have been described as favorable within the selected areas. Examples of four of these types have been observed: placer gold deposits, vein-type gold deposits, contact-metamorphic copper bodies, and porphyry copper or molybdenum deposits. Although strata-bound base metal deposits in sedimentary rocks, massive sulfide deposits in volcanic rocks, and rare-earth deposits associated with pegmatitic rocks have not been found, these types of deposits occur elsewhere in similar geologic environments to those of the areas in the Chandalar quadrangle and may occur in the areas designated on the mineral resources map.

AEROMAGNETIC MAP AND INTERPRETATION (MAP MF–878–C, 2 SHEETS)

The western and eastern halves of the aeromagnetic map (sheet 1) and of the Chandalar quadrangle were flown separately and were released as open-file reports by the U.S. Geological Survey in 1973 (western half) and 1974 (eastern half). Regional trends calculated from the International Geomagnetic Reference Field were removed from both maps, but a difference in datums prevented connecting the contour lines across the join. Very complex variations of the magnetic field in the Chandalar quadrangle indicate significant variations in magnetite content of rocks exposed at the surface and also buried at depth.

The interpretive map (sheet 2) identifies magnetic rock units, many of which differ in their distribution from mapped geologic formations.

Among the rock units delineated by highs on the aeromagnetic map are an anticline of contact-metamorphosed calc-mica schist; a highly complex and variable band of quartz-muscovite schist; volcanic rocks associated with the Kobuk Trench; and granitic plutons south of the Kobuk Trench. In contrast to those south of the trench, granitic rocks north of the Kobuk Trench are nonmagnetic. Magnetic mapping may help to delineate copper, molybdenum, lead, and zinc deposits associated with the magnetic calc-mica schist and nonmagnetic granite and limestone. Detailed magnetic mapping may be useful in delineating faults in the quartz-muscovite schist which may contain gold-bearing veins. Two magnetic lows may mark nonmagnetic, possibly mineralized shear zones or alteration zones in the quartz-muscovite schist.

GEOCHEMICAL MAPS (MAPS MF–878–D to I)

The distribution and abundance of selected elements as obtained from stream sediment samples are shown on a series of geochemical maps. These elements were selected on the basis of their potential economic importance, their ranges of concentrations, or on their importance as geochemical pathfinders to economic deposits. The geochemical data are plotted on a screened base map showing the generalized geology, topography, and sample localities. Values of the selected elements are shown by map symbols, and the ranges of values are indicated on accompanying histograms. Statistical data are shown along with a perspective plot of each element. The geochemical maps show the results of minus 80 mesh (177 micrometers) stream sediment samples. Panned concentrates, rock, and vegetation samples were also taken and have been used in the mineral resource evaluation. Raw geochemical data as well as an explanation of sampling, preparation, and analytical procedures of all samples are given in U.S. Geol. Survey Open-File Report OF–76–492 (O'Leary and others, 1976) and in U.S. Geol. Survey Open-File Report OF–77–543 (Detra and others, 1977). The minus 80-mesh (177 micrometers) stream sediment medium was used in this study because of the regional setting in the north-central Brooks Range. The study area is one of generally high relief with short, fast moving streams and broad glacial valleys. All samples were taken from active streams, as close to the center channel as possible. All sediments were considered to be locally derived. Care was taken, when sampling an obviously glaciated terrane, to sample above or upstream from morainal material, wherever possible. Most samples were taken in areas where bedrock was within 30 meters of the sample site. The minus 80-mesh (177 micrometers) stream sediment has proved to be the most effective medium where clastic sediments are being derived from local bedrock (Foster and others, 1976). Stream sediment samples were air dried and prepared by shaking through an 80-mesh (177 micrometers) stainless steel sieve. The minus 80-mesh (177 micrometers) fraction was saved for analysis. The samples were analyzed by a six-step, DC-arc semiquantitative spectrographic method described by Grimes and Marranzino (1968) for the analysis of geologic material. Owing to the high limits of determination for zinc (200 parts per million) by the semiquantitative spectrographic method, all samples were analyzed for zinc by atomic absorption methods described by Ward, Lakin, Canney, and Van Sickle (1969).

Because of previous work done (Chipp, 1970; Brosgé and Reiser, 1972; Mertie, 1925; Reed, 1927; Stanford, 1934; Thompson, 1925) no sampling was done in the gold district in the central part of the quadrangle, although geochemical data from previous work are included (Brosgé and Reiser, 1972).

A composite geochemical map showing major alteration zones and detailed geologic maps of selected mineral prospects are shown in a geochemical interpretation map.

INTERPRETATION OF LANDSAT IMAGERY (MF–878–J, 2 sheets)

By Nairn R. D. Albert

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, Arizona. Landsat scenes selected for computer enhancement are 1772–20565, taken September 3, 1974; 1773–21020, taken September 4, 1974; and 2208–20425, taken August 18, 1975.

The black and white computer-enhanced products include horizontal, vertical, and diagonal first derivative images. Color computer-enhanced Landsat products include linearly "stretched" standard false color, sinusoidally "stretched" false color, and simulated natural color images. Because of geometric aberrations, image 2208–20425 could not be mosaicked by computer to the other two images. Thus, all computer-enhanced products are in two sections (see MF–878–J, sheet 1). 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 Chandalar quadrangle, where reconnaissance geologic mapping and geochemical sampling were completed prior to the Landsat study, the Landsat interpretation augmented geological and geophysical observations by (1) identifying the possible extensions of numerous mapped faults; (2) providing additional evidence for the presence and location of several possible faults that were not clearly evident on the ground or on aerial photographs; (3) identifying numerous lineaments that were undetected previously; (4) analyzing joint and fracture patterns on a quadrangle-wide basis; (5) identifying numerous circular features, some of which have diameters of over 150 km; (6) identifying arcuate features; and (7) detecting several iron oxide colored areas that have escaped recognition on the ground.

Several of these observed Landsat phenomena seem to be directly related to mineral resources. One of the more notable conjectured fault extensions passes through the two known porphyry copper deposits and closely coincides with the northern limit of the gold-bearing quartz-mica schist unit. A number of lineaments show a strong correlation with known mineralization and geochemical anomalies, suggesting a strong likelihood for significant mineralization in the Your Creek-Middle Fork area. Several of the observed concentric circular and arcuate features coincide with anticlines or synclines and with areas of copper or gold mineralization. Several iron oxided colored areas were identified on Landsat imagery and may warrant further field investigation.

Many of the methods used to apply Landsat imagery to mineral resource assessment in the Chandalar quadrangle are relatively new and their potential contribution toward better understanding of the areal geology remains to be fully explored. Several of the various computer enhancement techniques used to generate the Landsat imagery in this study have not yet been reported in the literature. Additionally, because a large number of lineaments and circular features observed on this imagery do not correspond to geologically known or geophysically inferred features and seem to indicate the workings of poorly understood, or perhaps even unknown, geologic or tectonic processes, their role in mineralization is rather vague at present.

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