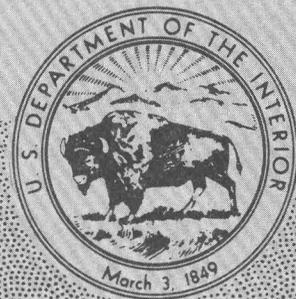


U.S. GEOLOGICAL SURVEY CIRCULAR 928



The Alaskan Mineral Resources  
Assessment Program: Guide to  
Information Contained in the Folio of  
Geologic and Mineral-Resource Maps  
of the Medfra Quadrangle, Alaska



# The Alaskan Mineral Resources Assessment Program: Guide to Information Contained in the Folio of Geologic and Mineral–Resource Maps of the Medfra Quadrangle, Alaska

By W. W. Patton, Jr., E. J. Moll, and H. D. King

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Table 1.--Component maps of the Medfra quadrangle mineral-resource assessment

U.S. Geological Survey Open-File Report	Subject
80-811-A (Patton and others, 1980).....	Preliminary geologic map.
B (Schwab and others, 1981).....	Mineral-occurrence map.
C (Moll and others, 1981).....	Chemistry, mineralogy, and K-Ar ages of igneous and metamorphic rocks.
D (Le Compte, 1981).....	Interpretation of Landsat imagery.
E (Patton and others, 1982).....	Aeromagnetic interpretation.
F (King and others, 1980).....	Final results and statistical summary of analyses of geochemical samples.
G (Patton and Moll, 1983).....	Mineral-resource assessment.
H (King and others, 1983a).....	Distribution and abundance of gold and silver in stream-sediment, heavy- mineral-concentrate, and moss samples.
I (King and others, 1983e).....	Distribution and abundance of copper, lead, and zinc in stream-sediment, heavy- mineral-concentrate, and moss samples.
J (King and others, 1983d).....	Distribution and abundance of molybdenum, tin, and tungsten in stream-sediment, heavy- mineral-concentrate, and moss samples.
K (King and others, 1983b).....	Distribution and abundance of arsenic and bismuth in stream-sediment, heavy- mineral-concentrate, and moss samples.
L (King and others, 1983c).....	Distribution and abundance of antimony and mercury in stream-sediment and heavy- mineral-concentrate samples,
M (King and Tripp, 1983).....	Multi-element maps showing the distribution and relative amounts of selected elements in four geochemical sampling media.

# **The Alaska Mineral Resource Assessment Program: Guide to Information Contained in the Folio of Geologic and Mineral-Resource Maps of the Medfra Quadrangle, Alaska**

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## **Abstract**

The Medfra quadrangle in west-central Alaska was investigated by a multidisciplinary team of geoscientists to assess its mineral resources. This Circular is intended to serve as a guide to a folio of 13 separate Open-File Reports covering various aspects of these investigations, including geology, bedrock and stream-sediment geochemistry, potassium-argon dating, Landsat imagery, mineral occurrences, aeromagnetic interpretation, and mineral-resource assessment. This Circular presents a complete reference list of these reports and a summary of the important results of each of the investigations.

## **INTRODUCTION**

### **Purpose and Scope**

This Circular and the 13 Open-File Reports (OF) listed in table 1 were prepared under the Alaska Mineral Resource Assessment Program (AMRAP) as part of a series of U.S. Geological Survey reports on the mineral resources of Alaska. The purpose of these reports was to provide information for formulating a sound long-range national minerals policy for Federal, State, and local land-use planning.

The 13 Open-File Reports (table 1) generated by the Medfra quadrangle AMRAP investigations include: A geologic map; a mineral-occurrence map; a report on the bedrock chemistry, mineralogy, and potassium-argon dating; a Landsat-imagery-interpretation map; an aeromagnetic-interpretation map; a mineral-resource-assessment report; and seven reports devoted to the results of geochemical sampling of stream sediment, heavy-mineral concentrates, and mosses.

### **Geography and Access**

The Medfra quadrangle, which covers an area of about 16,500 km<sup>2</sup>, is in west-central Alaska between lat 63° and 64° N. and long 153° and 156° W. (fig. 1). The quadrangle includes parts of two physiographic provinces (Wahrhaftig, 1965): (1) The Kuskokwim Mountains province, occupying the northwest two-thirds of the quadrangle; and (2) the Tanana-Kuskokwim Lowlands province, occupying the southeast third. The Kuskokwim Mountains province

consists of northeast-trending ridges, 300 to 700 m in elevation, surmounted locally by several small groups of mountains with rugged glaciated tops, reaching elevations as high as 1,350 m. Valley bottoms and mountain slopes are densely vegetated, and bedrock exposures are generally confined to ridgetops above 600 m. In the Tanana-Kuskokwim Lowlands province, an outwash fan from the Alaska Range slopes gently northwestward from the southeast corner of the quadrangle to merge with a lake-dotted alluvial plain along the Kuskokwim River. The lowlands are broken by several isolated clusters of hills, including the East Fork Hills, the Slow Fork Hills, the Telida Mountains, and Munsatli Ridge. Stabilized sand-dune fields are scattered across the eastern and central parts of the lowlands.

Much of the quadrangle is inaccessible except by helicopter. Small river barges can ascend the Kuskokwim River as far as Medfra and Nikolai during high water. Airstrips suitable for landing bush planes are located at the settlements of Medfra, Nikolai, and Telida, and at the Nixon Fork and Colorado Creek mines. McGrath, situated on the Kuskokwim River 50 km southwest of Medfra, is the transportation center for the area and is served by scheduled airlines from Anchorage and Fairbanks.

### **Mineral Production and Exploration**

Mineral production in the Medfra quadrangle has been limited to gold lode and placer deposits within the Nixon Fork district in the south-central part of the quadrangle, and to a gold placer deposit on Colorado Creek in the Innoko district at the west edge of the quadrangle. Gold was discovered in placers within the Nixon Fork district in 1917 and in lode deposits the following year (Jasper, 1961). Between 1919 and 1949, 1,250 to 1,900 kg (40,000-60,000 troy oz) of gold was produced from lode deposits, and 300 kg (10,000 troy oz) from placer deposits (Eberlein and others, 1977). Most mining in the district was carried out before 1933. Reed and Miller (1971) reported some limited activity in 1960, and Bundtzen and others (1982) reported that about 90 t (100 tons) of high-grade ore was mined from the lode deposits of the Nixon Fork mine in 1981 by the Mespelt and Almasy Mining Co. The placer mine on Colorado Creek, operated by the Rosandar Co., is located partly in the Medfra quadrangle and partly in the adjoining Ophir quadrangle. Mining commenced in this area in 1913

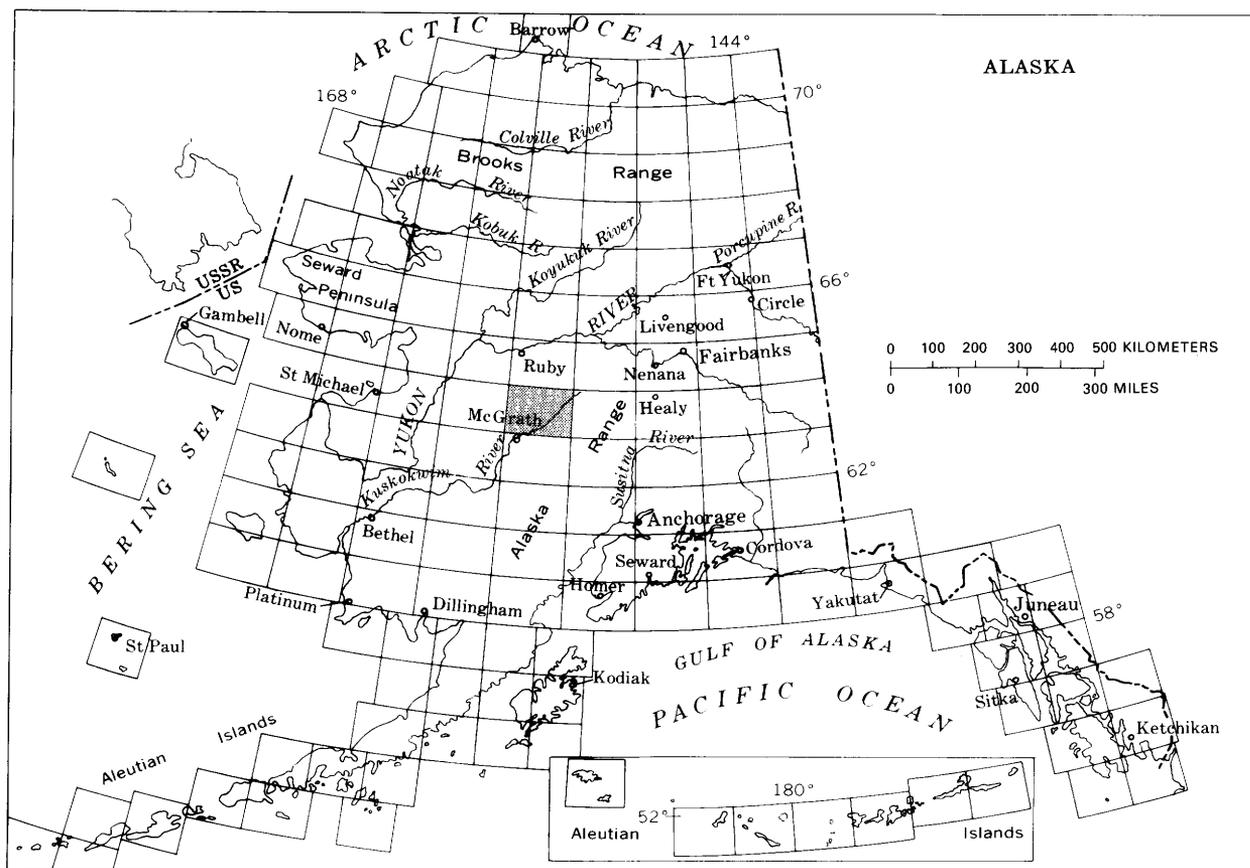


Figure 1.--Location of the Medfra quadrangle (shaded) in west-central Alaska.

and has continued intermittently to the present. Before 1940, the mining was carried out as a nonfloat hydraulic operation, but recently mining has been chiefly by bulldozer (Eberlein and others, 1977). No estimates of total gold production are available.

Exploration since 1973 has been concentrated primarily in the belt of early Paleozoic carbonate rocks that trends diagonally across the central and eastern parts of the quadrangle. There has also been some exploration activity in the Mystery Mountains in the center of the quadrangle, and some staking has been reported (Alaska Division of Geological and Geophysical Surveys, 1982) recently in the southwestern part of the quadrangle. Exploration results on all these activities are still at a proprietary stage.

#### Acknowledgments

Compilation of the Medfra AMRAP reports would not have been possible without the contributions of many colleagues in the U.S. Geological Survey. We especially acknowledge the field mapping by J. T. Dutro, Jr., R. M. Chapman, and M. L. Silberman, and the field assistance of M. L. Throckmorton, C. L.

Connor, and J. L. Bentz. Throckmorton and C. E. Schwab helped with office compilation of the field data and with petrographic studies. Potassium-argon dating and strontium-isotope studies of the igneous and metamorphic rocks were carried out by M. L. Silberman. Our investigations of the magnetics of the quadrangle were guided by J. W. Cady, and the mineral-assessment map was prepared with the advice of B. L. Reed, D. A. Singer, M. L. Silberman, and S. E. Church. Fossil collections were identified by J. T. Dutro, Jr., D. L. Jones, J. E. Repetski, A. G. Harris, J. M. Berdan, W. A. Oliver, R. J. Ross, Jr., E. L. Yochelson, D. H. Rohr, C. Carter, A. K. Armstrong, B. K. Holdsworth, B. R. Wardlaw, E. A. Pessagno, Jr., J. W. Miller, N. J. Silberling, R. H. Tschudy, J. P. Bradbury, and R. M. Kosanke. B. L. Mamet of the Universite de Montreal, Quebec, Canada, kindly examined foraminifer collections from the Carboniferous limestone.

T. K. Bundtzen and W. G. Gilbert of the Alaska Division of Geological and Geophysical Surveys generously shared with us their field and laboratory data from the adjoining Ophir and McGrath quadrangles.

The hospitality and assistance of Jack and Nadine Smith of Medfra contributed greatly to the success of our field operations. John Stone of Medfra, Theodore Almasy of the Nixon Fork mine, and Ron Rosander of the Colorado Creek mine provided valuable information on the local geology.

## GEOLOGIC STUDIES

### Previous Investigations

The first geologic mapping and mineral-resource investigations in the Medfra quadrangle were carried out by Eakin (1916, 1918) in the northeastern part of the quadrangle, and by Mertie and Harrington (1916, 1924) in the west third of the quadrangle. Eakin was the first to describe the early Paleozoic carbonate rocks of the northern Kuskokwim Mountains and to illustrate their relation to the underlying metamorphic complex. The central part of the quadrangle was first studied by Brown (1926), who in a short but highly significant report provided much new stratigraphic data on the Paleozoic and Mesozoic section in the northern Kuskokwim Mountains. The surficial deposits of the Kuskokwim and lower Nixon Fork valleys were mapped and described by Fernald (1960) as part of a general study of the geomorphology of the upper Kuskokwim region.

The gold lode deposits in the Nixon Fork district were first reported by Martin (1922) and later by Brown (1926). Mertie (1936) briefly visited both the Nixon Fork district and the placer mine on Colorado Creek at the east edge of the Innoko district. White and Stevens (1953) reconnoitered the Nixon Fork district for radioactive-mineral deposits, and, later, geochemical studies of the district were carried out by Herreid (1966) and by Reed and Miller (1971). An aeromagnetic survey of the district was made by Anderson and others (1970) in connection with Reed and Miller's study.

### Recent Investigations

Recent investigations of the Medfra quadrangle started in 1975 as a helicopter-supported field study of the Paleozoic and Mesozoic strata in the northern Kuskokwim Mountains. Efforts during 1975 and 1976 focused primarily on stratigraphic studies of the Nixon Fork area, the results of which were published in a series of short reports (Patton, 1976, 1977; Patton and others, 1977; Patton and Dutro, 1979; Dutro and Patton, 1981). In 1977, these investigations were broadened in scope to include 1:250,000-scale geologic mapping of the entire Medfra quadrangle. In 1977, fieldwork was concentrated primarily in the western part of the quadrangle, where a new and different Paleozoic and Mesozoic sequence, the Innoko terrane, was recognized (Patton, 1978). Also during 1977, a ground magnetic survey was done on a small newly discovered magnetite body in the upper Sulukna River drainage (Throckmorton and Patton, 1978).

In 1978, the Medfra investigations were incorporated into AMRAP. Field and laboratory work during 1978 and 1979 were devoted mainly to collection and analysis of bedrock and stream-sediment samples, and to detailed mapping and sampling of prospective mineralized areas. A total of 41 samples from igneous and metamorphic rocks were dated by potassium-argon methods (Silberman and others, 1979a, b; Moll and others, 1981), and representative samples of all the igneous-rock units were examined in thin section and analyzed for major-

element chemistry (Moll and others, 1981). Stream-sediment, pan-concentrate, and moss samples were collected at 517 sites and analyzed by semi-quantitative spectrographic methods for 31 elements and by atomic-absorption methods for gold, mercury, and zinc (King and others, 1980). An aeromagnetic survey of the Medfra quadrangle was flown in 1978, and an aeromagnetic map was subsequently released (U.S. Geological Survey, 1979). In 1979, 10 separate ground magnetic traverses were conducted, using a hand-held magnetometer and susceptibility meter to provide additional details on specific aeromagnetic anomalies and to determine the magnetic characteristics of the various geologic-map units (Patton and others, 1982). That same year, a helicopter reconnaissance survey for radioactive minerals in plutonic and volcanic rocks resulted in the discovery of uranium- and thorium-rich volcanic rocks in the Sisichu Creek area (Miller and others, 1980). Finally, in 1979, Plumley and others (1981) made a paleomagnetic study of the early Paleozoic carbonate rocks and the Late Cretaceous and early Tertiary volcanic rocks.

## DESCRIPTION OF COMPONENT MAPS AND REPORTS OF THE MEDFRA QUADRANGLE FOLIO

### Geology (OF 80-811-A)

The pre-middle Cretaceous rocks of the Medfra quadrangle are divided into three different terranes, here called the Nixon Fork, the Minchumina, and the Innoko (fig. 2). Each terrane forms a separate and stratigraphically distinct fault-bounded belt which can be traced northeasterly across the quadrangle. In the west-central and southwestern parts of the quadrangle, the Nixon Fork and Innoko terranes are overlapped by middle and Late Cretaceous sedimentary rocks that make up the north end of the Kuskokwim basin. Late Cretaceous and early Tertiary volcanic and intrusive rocks locally overlie and intrude all three pre-middle Cretaceous terranes and the middle and Late Cretaceous rocks of the Kuskokwim basin.

### Pre-Late Cretaceous Rocks

#### Nixon Fork terrane

The Nixon Fork terrane trends northeasterly across the center of the quadrangle and forms the higher elevations of the northern Kuskokwim Mountains. Its stratigraphic sequence is characterized by a thick section of early Paleozoic platform carbonate rocks underlain by a metamorphic complex of Precambrian and earliest(?) Paleozoic age. Thin quartz-carbonate terrigenous sedimentary deposits of Permian, Triassic, and Early Cretaceous age rest unconformably on the metamorphic complex, but their relation to the platform carbonate rocks is obscured by faulting.

The platform carbonate rocks have an aggregate thickness of more than 5,000 m and range in age from Early Ordovician to Late Devonian. Depositional environments range from mainly

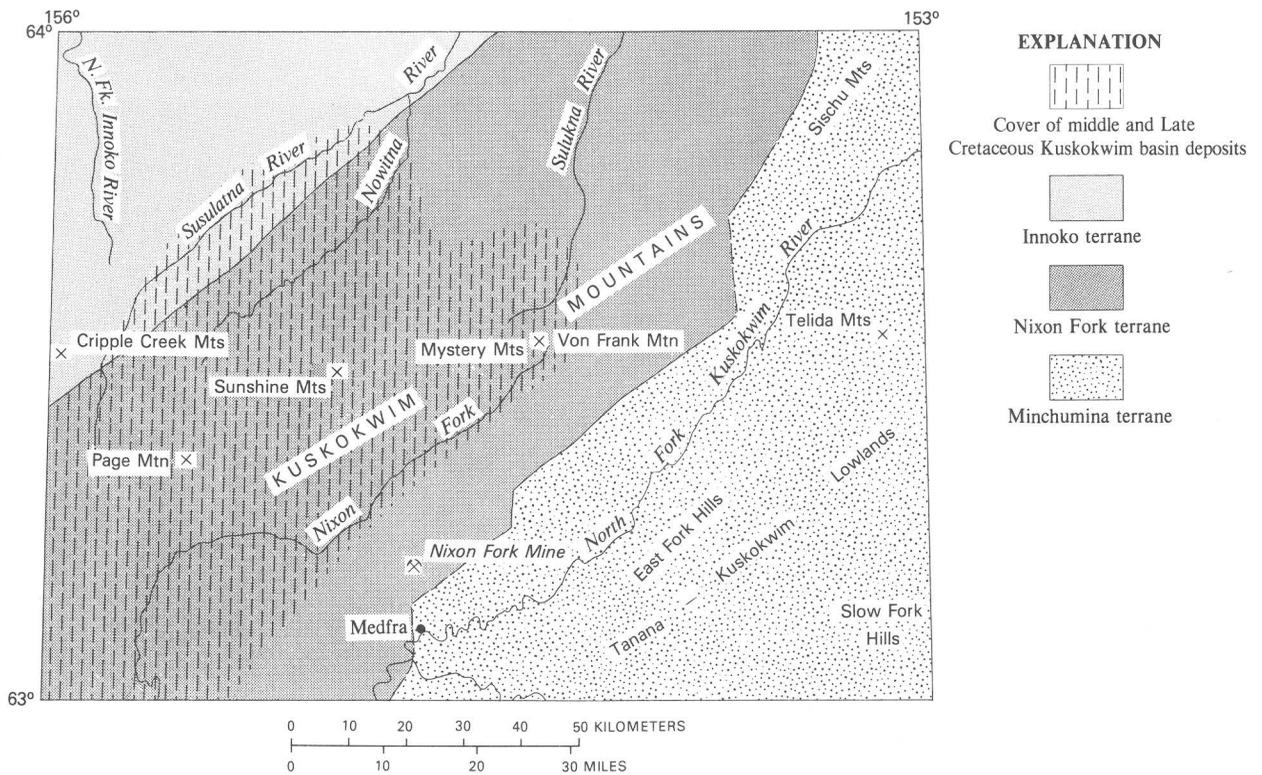


Figure 2.--Distribution of pre-middle Cretaceous geologic terranes in the Medfra quadrangle. Terrane boundaries are faults, dashed in areas of poor control.

supratidal, characterized by laminated silty limestone in Lower Ordovician beds, to shallow marine, distinguished by a complex array of shallow-water carbonate facies that include reefoid bodies in the Upper Ordovician and Middle Devonian beds. Dark platy limestone and shale containing mid-Silurian graptolites indicate that deeper water paleoenvironments prevailed between Late Ordovician and Late Silurian time.

The metamorphic complex, composed of greenschist-facies pelitic schist, calc schist, and metavolcanic rocks, unconformably underlies and locally is faulted against the platform carbonate rocks in the north-central and northeastern parts of the quadrangle. Stratigraphic relations and K-Ar data suggest that these metamorphic rocks are Precambrian and possibly earliest Paleozoic in age (Patton and Dutro, 1979; Silberman and others, 1979b).

About 500 m of Permian, Triassic, and Early Cretaceous (Valanginian to Aptian) quartz-carbonate terrigenous sedimentary rocks and spiculite beds are exposed beneath the middle and Late Cretaceous deposits of the Kuskokwim basin and locally rest unconformably on the metamorphic complex. The relation of these terrigenous rocks to the platform carbonate rocks is obscured by faulting. However, the debris which composes them clearly was derived, in large part, from erosion of the platform carbonate rocks.

#### Innoko terrane

The Innoko terrane, which occupies the northwest corner of the quadrangle (fig. 2), appears to be faulted against the Nixon Fork terrane along a conspicuous topographic lineament that parallels the Susulatna River valley. The oldest stratigraphic unit is composed of radiolarian chert and subordinate limestone turbidites of Mississippian and Pennsylvanian age. This unit is succeeded by a unit of cherty tuff, crystal and lithic tuff, and volcanic breccia of Triassic and Early Jurassic(?) age which, in turn, is overlain by an earliest Cretaceous (Neocomian) unit of volcanic graywacke and conglomerate. These three units are thought to compose a tectonic package of island-arc and oceanic rocks which has been thrust-faulted across a metamorphic complex from the northwest (Patton and Moll, 1982). The metamorphic complex is exposed only at two isolated localities in creekbeds along the west margin of the Medfra quadrangle but is widely exposed in the adjoining Ophir quadrangle (Chapman and others, 1982). It is uncertain whether these metamorphic rocks are part of the same metamorphic complex that underlies the Nixon Fork terrane.

#### Minchumina terrane

The Minchumina terrane is sparsely exposed in a few isolated groups of hills in the Tanana-Kuskokwim

lowlands in the southeastern part of the quadrangle (fig. 2). It appears to be faulted against the Nixon Fork terrane in the hills bordering the lowlands on the northwest side of the North Fork of the Kuskokwim River. The East Fork Hills and the hills that border the lowlands on the northwest are composed chiefly of Ordovician to Devonian slightly schistose shaly limestone and chert, which are interpreted to be a deep-water facies of the early Paleozoic platform carbonate rocks of the Nixon Fork terrane. At the top of this sequence, the deep-water beds grade upward into shallow-water limestone and dolomite, an association suggesting a seaward progradation of the carbonate platform during Devonian time. The Telida Mountains are composed of an assemblage of quartzite, quartz grit, quartz-feldspar grit, and argillite which tentatively is assigned a Precambrian and early Paleozoic age on the basis of correlation with similar assemblages to the northeast in the Kantishna River and Livengood quadrangles (Chapman and others, 1971; Chapman and others, 1975). The source area and depositional environment of these coarse clastic rocks are uncertain. The Slow Fork Hills, in the southeast corner of the quadrangle, consist of sheared grit, quartzite, quartz-mica schist, and phyllite which are interpreted to be a metamorphic equivalent of the quartzite and grit beds of the Telida Mountains.

#### Middle and Late Cretaceous Rocks

##### Kuskokwim basin

The middle and Late Cretaceous rocks of the Kuskokwim basin form a broad southwest-plunging syncline which unconformably overlies the Innoko and Nixon Fork terranes in the southwestern and west-central parts of the quadrangle (fig. 2). Contacts with the underlying rocks are complicated in many places by high-angle faults. The stratigraphic section comprising the basin, which has an aggregate thickness of 3,000 to 4,000 m, is composed of shallow-marine and fluvial sandstone, shale, and conglomerate. The largely marine lower part of the section locally contains early Late Cretaceous (Cenomanian) fossils, but the base may be as old as late Early Cretaceous (Albian). The largely nonmarine upper part of the section cannot be dated more closely than Late Cretaceous.

##### Late Cretaceous and Early Tertiary Rocks

Calc-alkalic volcanic, hypabyssal, and plutonic rocks of Late Cretaceous and early Tertiary (71-59 m.y.) age overlie and intrude the pre-middle Cretaceous rocks of the Nixon Fork, Innoko, and Minchumina terranes and the middle and Late Cretaceous sedimentary rocks of the Kuskokwim basin. These igneous rocks consist of: (1) A large volcanic field composed of more than 500 m of felsic flows, domes, and tuffs in the Sischu Mountains in the northeastern part of the quadrangle; (2) a large volcanic field, more than 1,000 m thick, of chiefly intermediate flows in the Nowitna River area in the

northwestern part of the quadrangle; (3) felsic and intermediate sills, dikes, flows, and plugs in the upper Nixon Fork-Sulukna River area in the central part of the quadrangle; (4) granite and monzonite stocks scattered in a broad east-west-trending belt across the center of the quadrangle; and (5) several circular volcanic-plutonic complexes of intermediate flows and stocks in the southwestern part of the quadrangle.

#### Structure

The bedrock in the Medfra quadrangle has a general northeast-trending regional grain except in the vicinity of the Mystery Mountains in the central part of the quadrangle, where it is locally deflected to the northwest. All the pre-latest Cretaceous (that is, older than 71 m.y.) bedrock units are strongly deformed and locally display isoclinal folding and overturned beds. The latest Cretaceous and early Tertiary volcanic units are much less deformed and are characterized by gentle dips and broad open folds.

The Iditarod-Nixon Fork fault can be traced from the Medfra quadrangle southwesterly across west-central and southwestern Alaska for more than 400 km (Beikman, 1980). It is regarded as a probable strike-slip fault with possibly as much as 110 km of right-lateral displacement (Grantz, 1966). In the southwestern part of the Medfra quadrangle, the fault marks the boundary between the Kuskokwim basin and the platform carbonate rocks of the Nixon Fork terrane. The fault appears to die out along the valley of the upper Nixon Fork, and at this point major strike-slip movement may have been taken up by parallel faults that continue to the northeast along the valley of the North Fork of the Kuskokwim River.

#### Mineral Occurrence Map (OF 80-811-B)

The report by Schwab and others (1981) consists of a 1:250,000-scale map and tables providing information on the known mineral occurrences of the Medfra quadrangle. The term "mineral occurrence" is used here in the broad sense to include lode and placer mines and prospects as well as unclaimed occurrences, regardless of economic significance. Their map shows the locations of mines, prospects, mineralized-bedrock samples, and geochemical anomalies in bedrock samples; the accompanying tables describe the mines and prospects, as well as selected geochemical data for the bedrock samples.

Table 1 of Schwab and others (1981) lists 35 previously reported mines and prospects, all but four of which are gold placer or lode deposits. Among these mines and prospects, significant gold production has been recorded only from the Nixon Fork district in the south-central part of the quadrangle. A gold placer on Colorado Creek along the west margin of the quadrangle is being mined at present, but production figures are not available.

Tables 2 and 3 of Schwab and others (1981) present descriptive and geochemical data for 92 separate occurrences of sulfides and other indicators of mineralization which were observed during geologic

mapping and geochemical sampling of the bedrock units in the quadrangle between 1975 and 1979. The most abundant minerals found were tourmaline, pyrite, and iron-oxide minerals. Tourmaline is abundant in the Mystery and Telida Mountains, where it is associated with felsic subvolcanic and intrusive rocks. A small deposit of magnetite was discovered in a skarn zone near White Mountain Creek (map nos. 60-62), and galena-bearing quartz veins were found at the head of the Susulatna River (map no. 50). A gossan in carbonate rocks on upper Soda Creek yielded a strong zinc geochemical anomaly (map no. 111).

Table 4 of Schwab and others (1981) lists and describes 49 samples of bedrock which contain anomalous geochemical values but have no visible mineralization. Anomalous values were arbitrarily established partly on the basis of statistical analysis of background geochemical data obtained for each bedrock map unit and partly from the data of Parker (1967, p. D13-D14) on the abundances of elements in the Earth's crust. Of particular interest are the above-background amounts of Be, Sn, Y, Pb, Hg, U, Zn, and Mo (map Nos. 168-173) in strongly radioactive uranium- and thorium-rich rhyolitic rocks in the Sischu Creek area in the northeast corner of the quadrangle (Miller and others, 1980).

#### **Chemistry, Mineralogy, and K-Ar Ages of Igneous and Metamorphic Rocks (OF 80-811-C)**

The report by Moll and others (1981) discusses the results of chemical analyses and K-Ar age determinations for igneous and metamorphic rocks of the Medfra quadrangle. Most of the volcanic and plutonic rocks in the quadrangle are latest Cretaceous and earliest Tertiary in age. Small bodies of gabbro and diabase in the eastern and northwestern parts of the quadrangle are of uncertain but probable older age. The metamorphic rocks, which are widely exposed in the Nixon Fork terrane in the north-central part of the quadrangle and in the Slow Fork Hills in the Minchumina terrane, are of Precambrian and early Paleozoic age.

The latest Cretaceous and earliest Tertiary igneous-rock suite consists of volcanic, hypabyssal, and plutonic rocks ranging in composition from mafic to felsic. They are divided into six map units: (1) Chiefly andesite lava flows of the Nowitna River area; (2) intermediate volcanoplutonic complexes in the southwestern part of the quadrangle; (3) granite stocks; (4) monzonite stocks; (5) felsic and intermediate sills, dikes, flows, and plugs of the Nixon Fork-upper Sulukna River area; and (6) felsic flows and domes of the Sischu Mountains. The chemical data show that the entire igneous-rock suite is calc-alkalic and characterized by high  $K_2O$  contents.  $K_2O$  content is 2 to 4 weight percent at 58 weight percent  $SiO_2$  and about 4 to 6 weight percent at 72 to 75 weight percent  $SiO_2$ . Analyzed samples contain from 53 to 75 weight percent  $SiO_2$  and are classified as basaltic andesite, trachyandesite (high-K andesite), dacite, and rhyolite. A total of 30 K-Ar ages for these rocks give ages ranging from 59 to 71 m.y. Concordant mineral-pair ages from several samples indicate that this

igneous episode is well documented by the K-Ar data. The overlapping ages and calc-alkaline chemistry of the plutonic, hypabyssal, and volcanic rocks suggest that the hypabyssal and plutonic rocks represent subsurface magmas related to the same magmatic episode that produced the volcanic rocks.

Few data are available for the small gabbro bodies that occur in the eastern and northwestern parts of the quadrangle. Stratigraphic evidence indicates a possible age range of from Devonian to Cretaceous, and four K-Ar determinations give ages ranging from 85 to 267 m.y. Ages of 267 and 176 m.y. were obtained on a low- $TiO_2$  tholeiitic gabbro, 98 m.y. on an olivine tholeiitic gabbro, and 85 m.y. on a calc-alkalic gabbro. This range in ages may be due to partial resetting by postcrystallization thermal events or may represent several ages of mafic intrusive activity.

Greenschist-facies metamorphic rocks, including pelitic schist, calc schist, and felsic metavolcanic rocks, crop out in a broad area of the Nixon Fork terrane in the north-central part of the quadrangle. Stratigraphic evidence suggests that they are pre-Ordovician in age (Patton and Dutro, 1979). Four K-Ar ages on micas in these rocks in the Medfra quadrangle range from 274 to 514 m.y. To the north, in adjoining parts of the Ruby quadrangle, nine additional K-Ar ages on micas and amphiboles yielded ages ranging from 254 to 921 m.y. (Silberman and others, 1979b). The fact that several of these ages are older than 500 m.y. seems to support the pre-Ordovician age suggested by stratigraphic evidence.

In the Minchumina terrane, a greenschist-facies metamorphic assemblage of sheared grit, quartzite, and quartz-mica schist composes the Slow Fork Hills in the southeastern part of the quadrangle. This assemblage is interpreted to be the metamorphic equivalent of a quartzite, grit, and argillite unit in the Telida Mountains and on the basis of this correlation has been assigned a Precambrian or early Paleozoic age. However, three K-Ar ages obtained from this assemblage yielded ambiguous results. Muscovite from two samples of metagrit gave ages of 108 and 176 m.y., and amphibole from metagabbro intruding metagrit and quartzite gave an age of 421 m.y.

#### **Interpretation of Landsat Imagery (OF 80-811-D)**

The report by Le Compte (1981) consists of two 1:250,000-scale generalized geologic maps of the Medfra quadrangle on which are superimposed linear, circular, and arcuate features interpreted from Landsat imagery. Interpretations of the Landsat data were made on: (1) A black-and-white Landsat mosaic of Alaska, (2) false-color images, and (3) computer-enhanced simulated natural-color images. All these images were analyzed for linear, circular, and arcuate features as a possible aid in the mineral assessment of the quadrangle. Although many features were observed from the imagery, no marked spatial relations between the features and known mineral deposits are apparent. However, numerous linear, circular, and arcuate features do show good spatial correlation with known geologic features. For exam-

ple, a conspicuous lineament in the south-central part of the quadrangle corresponds closely to a segment of the Nixon Fork fault. Other lineaments in the central and northeastern parts of the quadrangle also mark important faults. Arcuate and circular features encircle the volcanoplutonic complexes at Page Mountain, Cloudy Mountain, and near bench mark Alone, and they rim the granite cores and bordering hornfels zones in the Sunshine, Cripple Creek, and Telida Mountains and at Von Frank Mountain. These concentric features may reflect circular fracture patterns resulting from doming during magma emplacement or from cauldron subsidence during magma withdrawal during Late Cretaceous and early Tertiary time. Similar circular and arcuate features were observed in the Mystery Mountains and in a small mountainous area at the head of the Nowitna River. Although no plutonic rocks are exposed in either of these two areas, the occurrence of these features and of widespread sedimentary hornfels suggests that granitic plutons may be present at shallow depths.

### **Aeromagnetic Interpretation (OF 80-811-E)**

An aeromagnetic survey of the Medfra quadrangle was flown in 1978 and subsequently compiled (U.S. Geological Survey, 1979) at a scale of 1:250,000. The survey was flown at an altitude of 300 m above the ground along northwest-southeast flightlines spaced approximately 1.6 km apart. In 1979, 10 separate ground magnetic traverses were carried out, using a hand-held magnetometer and susceptibility meter. The ground traverses were selected to provide additional details on specific aeromagnetic anomalies and to determine the magnetic characteristics of the various geologic-map units.

For descriptive purposes, the aeromagnetic map is divided into three broad terranes, each with distinctive first-order magnetic characteristics:

**Terrane I** (eastern and central parts of the quadrangle) is characterized by broad anomalies of less than 50 $\gamma$  relief which are interpreted to reflect a magnetic metamorphic basement complex of probable Precambrian age beneath a cover of weakly or nonmagnetic late Precambrian(?) and early Paleozoic sedimentary rocks. Superimposed on this pattern of broad deep-seated anomalies are several clusters of smaller steep-gradient anomalies which have their source in surface and near-surface volcanic and intrusive bodies, chiefly of Late Cretaceous and early Tertiary age but also including some older gabbro and metavolcanic bodies.

**Terrane II** (southwestern and west-central parts of the quadrangle) is characterized by a background of shallow-gradient low-intensity anomalies on which are superimposed scattered isolated steep-gradient anomalies. This area approximately corresponds to the outline of the Kuskokwim basin. The field intensity is 50 to 150 $\gamma$  lower than in terrane I and decreases to the southwest; this decrease may reflect the increasing thickness of the nonmagnetic Cretaceous sedimentary rock sequence in that direction. All the steep-gradient anomalies appear

to be caused by surface and near-surface Late Cretaceous and early Tertiary mafic and intermediate intrusive and volcanic rocks, or by hornfels zones in the Cretaceous sedimentary rock units.

**Terrane III** (northwestern and north-central parts of the quadrangle) is characterized by rugged steep-gradient anomalies with a strong northeast-trending grain in the northwestern part of the quadrangle and a northwest-trending grain in the north-central part of the quadrangle. This pattern of anomalies reflects a mixed geologic assemblage of gently deformed Late Cretaceous and early Tertiary volcanic rocks, highly deformed Mississippian to Cretaceous volcanoclastic rocks, chert, and mafic igneous rocks, and Precambrian or early Paleozoic metamorphic rocks.

### **Results and Statistical Summary of Analyses of Geochemical Samples (OF 80-811-F)**

Stream sediment, heavy-mineral concentrates, and mosses from a helicopter-supported reconnaissance in the Medfra quadrangle were sampled to provide geochemical information for the interpretation of the mineral-resource potential of the quadrangle. Geochemical data include analytical results for 513 minus-80-mesh (smaller than 0.177 mm) stream-sediment samples, 370 nonmagnetic-heavy-mineral concentrates (C3 fraction), 422 moderately magnetic heavy-mineral concentrates (C2 fraction), and 355 ash-of-aquatic-bryophytes (moss) samples. In all, 517 sites were sampled in 1978 and 1979.

Most samples were taken from channels of active streams with upstream catchment areas averaging about 9 km<sup>2</sup>. Samples were taken from first- and second-order streams wherever possible. Larger, or third-order, streams were sampled when landing sites along first- or second-order tributary streams were inaccessible. A large part of the quadrangle, particularly along valley bottoms, is densely covered by vegetation, and so accessibility of helicopter landing sites commonly determined the points along the streams at which samples were taken. Lowland areas, approximately 4,000 km<sup>2</sup>, mainly in the southern and southeastern parts of the quadrangle, were not sampled because of the thick cover of Quaternary unconsolidated deposits.

Stream-sediment and concentrate samples were analyzed semiquantitatively by an emission-spectrographic method (Grimes and Marranzino, 1968) for 31 elements, including Fe, Mg, Ca, Ti, Mn, Ag, As, Au, B, Ba, Be, Bi, Cd, Co, Cr, Cu, La, Mo, Nb, Ni, Pb, Sb, Sc, Sn, Sr, V, W, Y, Zn, Zr, and Th. Moss samples were analyzed for these same elements, except Ca, Sc, and Th, and were analyzed for Na, Ga, Ge, In, and Tl by a semiquantitative emission-spectrographic method for plant materials (Mosier, 1972; modified by Curry and others, 1975). Stream-sediment samples were also analyzed for Au, Hg, and Zn, using the atomic-absorption methods of Ward and others (1969).

The report by King and others (1980) consists of a text describing sampling, sample preparation, and analytical methods; tables of statistical summaries; tables of analytical data; and a map showing sample-

site locations. Further information on the distribution and abundance of key elements in the various sample media is given in the reports by King and Tripp (1983) and King and others (1983a, b, c, d, e).

### **Mineral-Resource Assessment (OF 80-811-G)**

The report by Patton and Moll (1983) describes known mineral deposits, outlines areas designated as favorable for the occurrence of undiscovered mineral deposits, and discusses the mineral-fuels potential of the quadrangle. The report includes the mineral-occurrence map and tables found in the report by Schwab and others (1981), a table summarizing criteria used in the selection of areas favorable for the occurrence of undiscovered mineral deposits, and a table listing the threshold geochemical values above which an element is considered anomalous in each of the sampling media.

The only mines and prospects in the Medfra quadrangle are gold-copper skarn deposits and gold placers within the Nixon Fork district in the central part of the quadrangle, and gold placer deposits in the Innoko district along the west edge of the quadrangle. At the time of the investigation, active mining in the quadrangle was limited to a single gold placer deposit on Colorado Creek in the Innoko district.

A total of 10 areas considered favorable for the occurrence of undiscovered mineral deposits are delineated on the map. Criteria used in their selection include: (1) Favorable rock types, structures, and alteration; (2) known mineral occurrences; (3) geochemical anomalies in bedrock, stream-sediment, heavy-mineral-concentrate, and moss samples; (4) occurrence of ore minerals in heavy-mineral concentrates; and (5) aeromagnetic data suggesting possible mineralization in the subsurface or in unexposed areas.

Boundaries of the favorable areas are drawn generally to conform to the distribution of favorable host-rock units or hornfels zones. Specific mineral-deposit types are identified or suggested for each area. These deposit types include: (1) Beryllium-fluorite-uranium vein deposits and precious-metal deposits in Late Cretaceous and early Tertiary felsic volcanic fields of the Sischu Mountains; (2) skarn deposits and carbonate-hosted sulfide deposits in early Paleozoic carbonate rocks of the Nixon Fork terrane; (3) porphyry tin deposits in felsic volcanic rocks and sedimentary hornfels in the Mystery Mountains; (4) precious-metal and skarn deposits in the granite-cored Sunshine Mountains; (5) lead-silver, tin-silver, or lead-zinc-silver vein deposits in sedimentary hornfels in a small group of unnamed hills at the head of the Susulatna River; (6) precious-metal deposits in rhyolite domes and andesite flows within a large Late Cretaceous and early Tertiary volcanic field in the northwestern part of the quadrangle; (7) precious- or base-metal deposits in a belt of sedimentary hornfels and Late Cretaceous and early Tertiary volcanic and plutonic rocks that extends from Cloudy Mountain to the Sunshine Mountains in the southwestern part of the

quadrangle; and (8) tin lode deposits within granitic rocks and associated sedimentary hornfels in the Telida Mountains.

The petroleum possibilities of the quadrangle are considered to be low because of the thermal history of the pre-Tertiary rocks. Although the lower Paleozoic platform carbonate rocks appear to have favorable source-bed characteristics, their thermal history, as revealed by the color-alteration index of conodonts (Epstein and others, 1977), suggests that hydrocarbons, if present, would be limited to dry gas. The hydrocarbon potential of the Cretaceous rocks of the Kuskokwim basin also appears to be unfavorable, owing to the widespread presence of Late Cretaceous and early Tertiary volcanic and plutonic rocks.

### **Maps and Histograms Showing the Distribution and Abundance of 12 Different Elements in Various Sampling Media (OF 80-811-H to 80-811-L)**

The five reports by King and others (1983a, b, c, d, e) summarize the results of a geochemical survey carried out in 1978 and 1979. They show the distribution and abundance of Au, Ag, Cu, Pb, Zn, Mo, Sn, W, As, Bi, Sb, and Hg in nonmagnetic and moderately magnetic heavy-mineral concentrates, minus-80-mesh stream sediment, and ash-of-aquatic-bryophytes samples.

### **Multielement Maps Showing the Distribution and Relative Amounts of Selected Elements in Four Geochemical Sampling Media (OF 80-811-M)**

The report by King and Tripp (1983) consists of four maps and histograms showing the distribution and relative amounts of Ag, As, Au, Bi, Cd, Cu, Hg, Mo, Pb, Sb, Sn, W, and Zn in four sampling media: (1) Nonmagnetic-heavy-mineral concentrates, (2) moderately magnetic heavy-mineral concentrates, (3) minus-80-mesh stream sediment, and (4) ash-of-aquatic-bryophytes samples. Several geochemically anomalous areas are indicated by the results of the survey and displayed on the maps, and 16 of the more conspicuous areas are described in the text. Eight of these areas, including anomalies related to the Nixon Fork area and the Stone mine, are in the belt of early Paleozoic rocks that extends northeasterly across the quadrangle. Other anomalous areas are in the Telida, Sischu, Mystery, and Sunshine Mountains, an area south of the Sunshine Mountains, the Ivy Creek and Cloudy Mountain area, unnamed mountains north of Page Mountain and southeast of the Cripple Creek Mountains, and an area about 16 to 32 km northeast of the Cripple Creek Mountains.

Table 1 of King and Tripp (1983) lists threshold anomalous values of Ag, As, Au, Bi, Cd, Cu, Hg, Mo, Pb, Sb, Sn, W, and Zn in four separate sample media: The minus-80-mesh fraction of stream sediment, moss, the moderately magnetic heavy-mineral fraction of

pan-concentrated stream sediment, and the nonmagnetic-heavy-mineral fraction of pan-concentrated stream sediment. Table 2 of King and Tripp lists anomalous concentrations of these elements in bedrock, stream-sediment, moss, and pan-concentrate samples from areas designated as permissive for certain types of deposits.

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