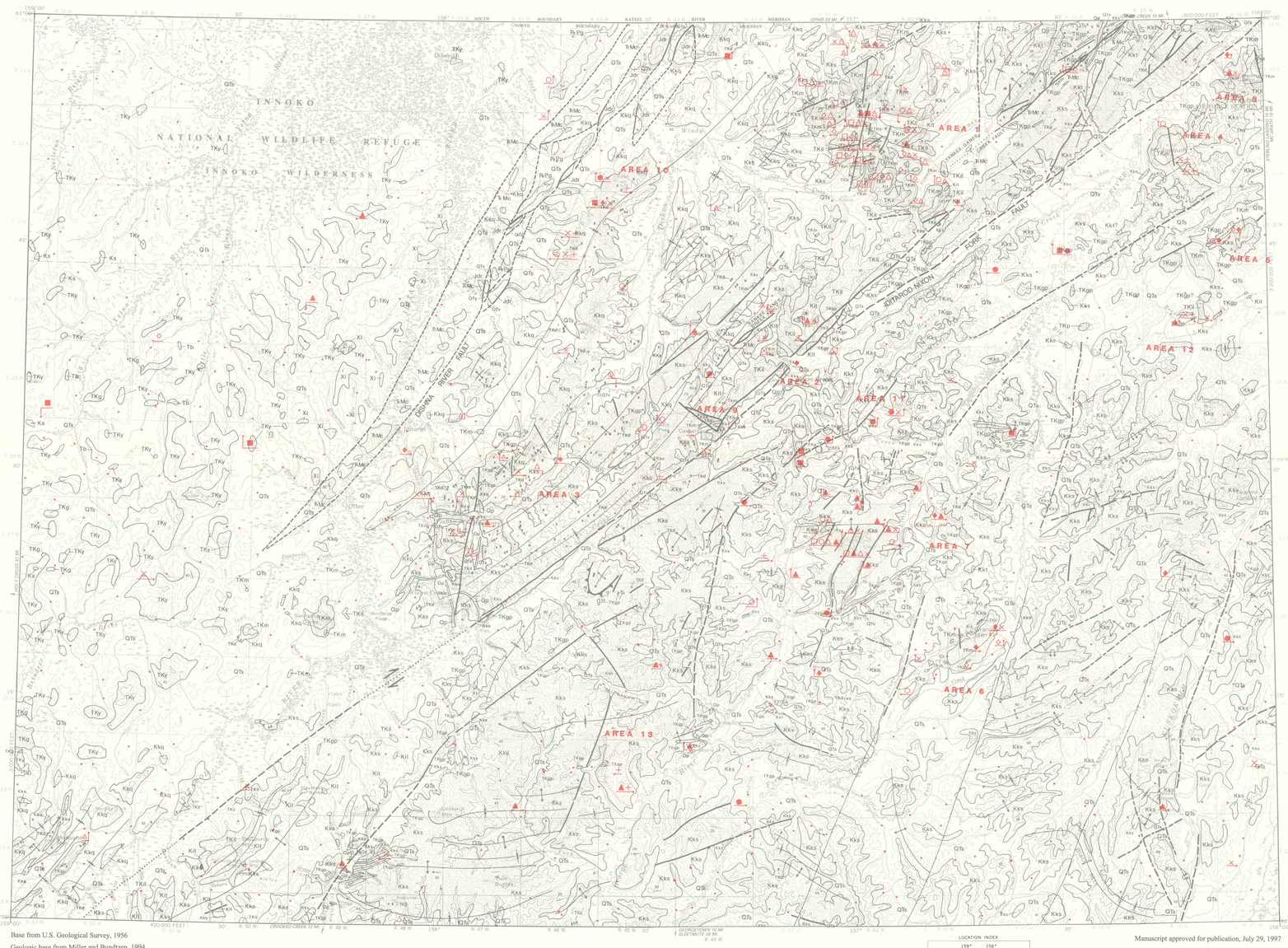
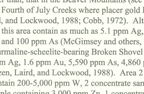


Base from U.S. Geological Survey, 1956
Geologic base from Miller and Bundtzen, 1994



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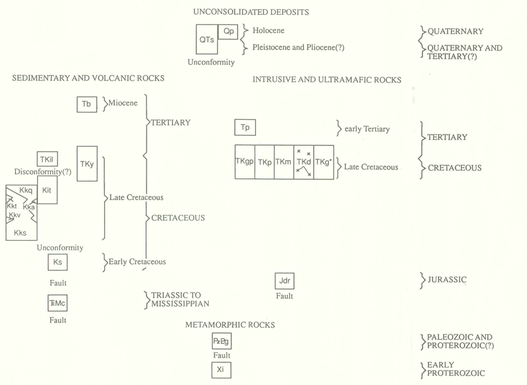
CORRELATION OF MAP UNITS

(*See Description of Map Units for specific unit age assignment.)



Contact--Approximately located

Fault--Approximately located. Dashed where inferred; dotted where concealed; queried where uncertain. Arrows indicate relative movement

Thrust fault--Approximately located; queried where uncertain. Sawteeth on upper plate

Lineament--Air photo interpretation; queried where uncertain

Folds--Showing trace of axial surface and direction of plunge, where known

F_1 anticline

F_1 syncline

F_1 overturned anticline

F_1 overturned syncline

F_2 fold--See accompanying pamphlet

Strike and dip of beds or flows--Ball indicates top known

Inclined

Overturned

Strike and dip of inclined foliation

DESCRIPTION OF MAP UNITS

(Geology is shown in gray on the map)

UNCONSOLIDATED DEPOSITS

Qp **Placer mine tailings (Holocene)**—Symmetrical to irregular piles of artificially water worked, sorted gravel and in situ slab rock derived from bedrock. Fine silt and sand fractions partially removed during placer mining process. Tailings in most drainages range from 1 to 4 m thick

QTs **Surficial deposits (Holocene to Pliocene?)**—Unconsolidated fluvial, terrace, colluvial, glacial, and eolian deposits usually covered by vegetation. Surficial deposits generally range from 3 to 20 m thick and exhibit at least some degree of permafrost, depending on slope orientation and composition. Glacial deposits occur mainly in the Beaver Mountains and nearby highlands. Age of unit is primarily Pleistocene and Holocene; some Pliocene deposits may also be present locally

SEDIMENTARY AND VOLCANIC ROCKS

Tb **Basaltic andesite (Miocene)**—Scattered exposures of very fine grained to aphanitic, dark- to medium-gray, locally vesicular, augite basaltic andesite in west-central part of study area. Unit is undeformed and unaltered except for local devitrification

TKy **Volcanic rocks of Yetna River area (early Tertiary and Late Cretaceous)**—Chiefly subaerial lava flows of andesite, dacite, rhyolite, and minor basalt and subordinate welded to nonwelded rhyolitic to andesitic ash-flow tuffs. Outcrops and rubble found mainly in stream bluffs and occasionally on rounded hill tops as tors; columnar-jointed andesite is present near VABM Reindeer (T. 28 N., R. 50 W.). Unit thickness roughly estimated at 500 m

Iditarod Volcanics (early Tertiary and Late Cretaceous)—Dominantly subaerial volcanic rocks consisting of a heterogeneous basal unit (tuff, altered flows, and volcaniclastic rocks) overlain by mafic and intermediate lava flows. Iditarod Volcanics are 500–600 m thick and overlie sedimentary rocks of Kuskokwim Group. In this area, divided into:

TKd **Andesitic to basaltic subaerial lava flows and mafic volcanic breccia (early Tertiary and Late Cretaceous)**—Subaerial, locally columnar jointed, aphanitic to porphyritic, olivine-clinopyroxene basaltic andesite, clinopyroxene andesite, and minor dacite; volcanic breccia locally interfingers with flow rocks. Unit is generally resistant forming prominent blocky outcrops and tors near ridgetops. Unit is roughly 150 to 250 m thick and contact with underlying unit **Kd** may be disconformable

Kit **Tuff, volcanic breccia, altered andesitic to dacitic flows, and volcaniclastic sandstone (Late Cretaceous)**—Heterogeneous assemblage characterized by tuff (lithic, crystal, and water-laid) and altered intermediate lava flows; locally includes volcanic breccia, volcaniclastic sandstone, and lahar deposits. Total unit thickness estimated to be around 350 m. Unit may be correlative with unit **Kka**

Kuskokwim Group (Late Cretaceous; Campanian to Cenomanian)—In map area, the Kuskokwim Group consists predominantly of sedimentary rocks but also has minor, interbedded volcanic tuff and flow rocks primarily in upper part of section. The sedimentary rocks represent turbidite fan, foreslope, shallow-marine, and shelf facies deposited into a Late Cretaceous basin. The Kuskokwim Group is estimated to average 2,200 m in thickness northeast of the Iditarod-Nixon Fork Fault, but may be as much as 5,000 m thick southwest of the fault. In this area, divided into:

Kkq **Quartzose sandstone and siltstone (Late Cretaceous; Campanian to Turonian?)**—Quartzose sublithic sandstone, conglomerate, siltstone, and siliceous shale representing shallow-marine and locally non-marine facies. Unit is estimated to be 600 m thick. Unit and basal part interfingers with deeper water facies rocks of unit **Kks**. Lower age limit of unit is speculated to be Turonian based on interfingering with unit **Kks**. Upper age limit at least as young as Campanian but not younger than Paleocene.

Kks **Sandstone, siltstone, shale, and conglomerate (Late Cretaceous; Campanian? to Cenomanian)**—Thick assemblage of fine- to coarse-grained lithic sandstone, micaceous siltstone, shale, and minor chert-pebble conglomerate that forms the major part of the Kuskokwim Group in the map area. Structures and compositions indicate that unit **Kks** was primarily deposited by turbidity currents. Total thickness of unit is poorly known but may be as much as 5,000 m. Upper age limit is not clearly defined but must be older than the youngest part of unit **Kkq**, which generally overlies unit **Kks**

Kkt **Volcanic tuff and agglomerate (Late Cretaceous)**—Heterogeneous assemblage of tuff, agglomerate, cherty tuff, and locally minor sandstone that crops out in isolated areas. Lithologically and petrographically identical to unit **Kit**; the two units are distinguished only by their associated rocks. Unit **Kkt** is apparently interbedded with sedimentary rocks (**Kks**) of Kuskokwim Group, whereas unit **Kit** is spatially associated with massive flow rocks of unit **TKil** but could either overlie, or locally interfinger with, the Kuskokwim Group. Unit assigned a Late Cretaceous age based on apparent interbedded relation with unit **Kks**

Kka **Altered andesitic flows, tuffs, and sills(?) (Late Cretaceous; Campanian)**—Unit crops out in the Mosquito Mountain area (southwestern part of the quadrangle) and consists of 1- to 5-m-thick layers of intermediate igneous rocks apparently interbedded with unit **Kkq**. The flows and tuffs are andesitic in composition and have 15–30 percent phenocrysts of plagioclase, oxidized amphibole, clinopyroxene, magnetite, and local biotite in a groundmass of felted plagioclase laths, opaque oxides, and accessory apatite. Tuffs characterized by broken crystals and abundant andesite lithic fragments

Kkv **Volcanic flow(s) and tuff (Late Cretaceous)**—Hornblende-clinopyroxene andesitic volcanic flow(s) and chlorite-, calcite-altered tuff. Unit poorly exposed and found only in one area (T. 27 N., R. 42 W.); estimated to be no more than 20 m thick. Assigned a Late Cretaceous age based on apparent interbedded relation with unit **Kks**

Ks **Sandstone and siltstone (Early Cretaceous)**—Medium-grained to very fine grained sandstone, tuffaceous sandstone, and siltstone exposed only as colluvial chips in western part of map area

TRMc **Chert, volcanic rocks, metasandstone, and limestone (Triassic to Mississippian)**—Radiolarian chert (partly to wholly recrystallized), clinopyroxene basalt to basaltic andesite, lithic tuff, water-laid tuff, metasiltstone, and minor fossiliferous shallow-water limestone. Unit primarily exposed along the Dishna River Fault Zone in the north-central part of the map area; however, six small occurrences, interpreted as fault slivers, are scattered throughout the northeastern part of the quadrangle. Prehnite-pumpellyite facies metamorphism is indicated by presence of secondary prehnite, chlorite, clinozoisite, and pumpellyite in the volcanic rocks. Unit is correlative with the Innoko terrane of Jones and others (1987) and Patton and others (1989b)

INTRUSIVE AND ULTRAMAFIC ROCKS

Tp **Porphyritic granodiorite plug (early Tertiary)**—Unit consists of one exposure in T. 28 N., R. 46 W. Small granodiorite body containing abundant phenocrysts of hornblende and albitic plagioclase in finer-grained, phaneritic groundmass

TKgp **Hypabyssal granite porphyry dikes, sills, and plugs (early Tertiary and Late Cretaceous)**—Porphyritic to fine-grained phaneritic dikes, sills, and plugs of granitic composition. Phenocrysts of biotite + quartz + plagioclase + sanidine + white mica ± trace garnet compose as much as 5 percent of most dikes and 20 percent of most plugs; sericitic alteration common in groundmass. Biotite generally composes less than 5 percent of the samples, so rocks could be classified as alaskite

TKp **Pilotaxitic dacite-andesite plugs (early Tertiary and Late Cretaceous)**—Three small bodies of subvolcanic dacite to andesite are exposed in the east-central part of the quadrangle. Unit is moderately resistant and morphology of exposures suggests they are hypabyssal intrusive bodies rather than volcanic flows, but they have a distinctive pilotaxitic (flow-oriented) texture to the fine-grained groundmass

TKm **Monzonite, quartz monzonite, syenite, granodiorite, granite, and minor lamprophyre (early Tertiary and Late Cretaceous)**—Small stocks and plutons of fine- to coarse-grained, phaneritic to hypidiomorphic, clinopyroxene-biotite ± olivine monzonite, hornblende-clinopyroxene-biotite quartz monzonite, biotite syenite, biotite-hornblende granodiorite, biotite granite, and rare lamprophyric rocks. Composite intrusive rocks are in part overlain by, and in part intrude coeval volcanic rocks (Iditarod Volcanics)

TKd **Altered intermediate to mafic dikes (early Tertiary and Late Cretaceous)**—Porphyritic biotite-clinopyroxene-plagioclase ± olivine dikes, which are partly to extensively altered to chlorite-calcite-silica assemblages. Original compositions were probably intermediate to mafic. Dikes generally are less than 1 m thick, discontinuous, and usually cannot be traced for more than 10 m. Presence of dike is indicated by "x" on the map for visual emphasis, but extent of actual exposures is exaggerated

TKg **Alkali granite (early Tertiary and Cretaceous)**—Poorly exposed, medium-grained, granophyric alkali granite found as discontinuous rubble cropping out under heavily vegetated cover in the western part of the map area. All rocks of the unit are light colored (color index <7 percent), but the mafic minerals vary locally. In the southwestern part of the quadrangle (T. 24 N., R. 53 W. and T. 25 N., R. 52 W.) mafic minerals consist of alkali amphibole, pyroxene, and biotite, but exposures farther north have biotite (chloritized) only

Jdr **Dishna River mafic and ultramafic rocks (Jurassic)**—Assemblage of poorly exposed mafic and ultramafic rocks in north-central part of quadrangle. Mafic and ultramafic rocks are probably ophiolitic in origin but now occur as isolated, fault-bounded blocks that lie along the Dishna River Fault Zone. Mafic rocks include two-pyroxene gabbronorite, clinopyroxene ± hornblende gabbro, hornblende gabbro, and diabase. Ultramafic rocks include harzburgite, minor dunite, and rare pyroxenite, all partially to completely serpentinized. Unit assigned a Jurassic age based on correlation with lithologically similar mafic and ultramafic complexes that lie north of the map area (the Tozitna-Innoko belt described by Patton and others, 1989a)

METAMORPHIC ROCKS

PzPg **Greenschist, pelitic schist, and metagranite (Paleozoic and Proterozoic?)**—Generally poorly exposed, mixed assemblage of greenschist facies metamorphic rocks including mafic metaigneous rocks, subordinate metasedimentary rocks (pelitic schist, phyllite, calcareous schist, and quartzite), and minor granitic orthogneiss. Mafic schists commonly exhibit secondary mineral assemblages of epidote-chlorite-hornblende/actinolite-albitic plagioclase-quartz ± biotite ± sphene, indicative of middle greenschist facies, but assemblages characteristic of lower and upper greenschist facies also occur. Unit is correlative with rocks of the Ruby terrane as outlined by Jones and others (1987) and Patton and others (1989b), and is therefore assigned the same age. Unit assigned a Proterozoic(?) and Paleozoic age based on correlation with rocks of the Ruby terrane

Xi **Idono Complex (Early Proterozoic)**—Foliated metaplutonic rocks, lesser amphibolite, and minor metasedimentary rocks. Outcrop exposure is limited to a dozen localities; float-riven rubble is sparse but widespread. The compositionally diverse metaplutonic rocks consist primarily of biotite ± muscovite granitic orthogneiss but also include orthogneisses of tonalite, granodiorite, quartz diorite, and quartz monzonite, minor metagabbro, and rare hornblendite. Texturally, metaplutonic rocks range from slightly foliated varieties to blastomylonitic augen gneiss. Amphibolite varies little in composition and consists of moderately foliated to well-foliated epidote-biotite-hornblende-intermediate plagioclase ± garnet ± sphene. The well-foliated, semipelitic metasedimentary rocks include muscovite-biotite-feldspar-quartz ± garnet ± epidote schists. Metamorphic grade of the Idono Complex is amphibolite facies

STUDIES RELATED TO AMRAP

The U.S. Geological Survey (USGS) is required by the Alaska National Interests Lands Conservation Act (Public Law 96-487, 1980) to survey certain federal lands to determine their mineral potential. Results from the Alaska Mineral Resource Assessment Program (AMRAP) must be made available to the public and be submitted to the President and Congress.

This is one of a series of maps that present geological and geochemical results from the mineral resource assessment study of the Iditarod quadrangle, Alaska. This report shows the distribution of anomalous concentrations of Cu, Pb, Zn, Sn, and W determined from the geochemical analysis of stream-sediment and nonmagnetic heavy-mineral-concentrate samples as well as the estimated abundance of scheelite in the nonmagnetic heavy-mineral-concentrate samples collected from the quadrangle. Other reports in this series on the Iditarod quadrangle include a geologic map (Miller and Bundtzen, 1994), a mineral resource assessment of the quadrangle (Miller and others, in press), a Hg-Sb-As anomaly map (Gray, Folger, and Hageman, 1997), and a Au-Ag anomaly map (Gray, Motooka, and O'Leary, 1997). The geologic map from Miller and Bundtzen (1994) is used as a base map for interpretations in this study.

INTRODUCTION

During the summers of 1984-86, a reconnaissance geochemical survey was conducted in the Iditarod 1° X 3° quadrangle, Alaska. The quadrangle is bounded by latitudes 62°N and 63°N and by longitudes 156°W and 159°W. The study area is about 6,700 mi^2 (17,350 km^2) in southwestern Alaska and it includes the Beaver Mountains and part of the Kuskokwim Mountains (see map). Part of the Innoko National Wildlife Refuge is in the northwestern corner of the quadrangle. Few roads exist in the quadrangle and access to much of the study area is limited to travel by aircraft or by foot on various trails. Boat access is possible on some larger rivers.

The terrain is dominated by low rolling hills and broad, sediment-filled lowlands. This terrain is best exemplified by the Kuskokwim Mountains in the central part of the quadrangle. Rugged topography characterizes the Beaver Mountains and a few other mountain peaks scattered throughout the quadrangle. The maximum elevation in the quadrangle is 4,055 ft (1,236 m) in the northern Beaver Mountains. Much of the western part of the quadrangle is low and swampy, particularly in the Yetna and Iditarod River basins where the minimum elevation is about 100 ft (30 m). Most of the quadrangle is covered with vegetation that ranges from northern latitude forest to subarctic tundra.

GENERAL GEOLOGY

The map shows the geology of the quadrangle as described by Miller and Bundtzen (1994). The following descriptions are summarized from their work, but additional details of the geology of the quadrangle are given in Miller and Bundtzen (1994). Bedrock of the Iditarod quadrangle can be broadly subdivided into (1) displaced slices of pre-Cretaceous rocks that are found in narrow fault bounded belts, and (2) overlap assemblages of Cretaceous and younger sedimentary, volcanic, and plutonic rocks that constitute about 95 percent of the bedrock in the quadrangle (Miller and Bundtzen, 1994). The overlap assemblages have experienced at least two periods of open to isoclinal folding that includes a well-expressed generally northeast-trending earlier event and a poorly expressed north-trending later event. The Iditarod-Nixon Fork Fault is a major northeast-trending strike-slip fault that bisects the quadrangle. The Dishna River Fault bounds the northwestern part of the quadrangle and defines the southeast side of the northeast-trending belt of pre-Cretaceous rocks (Miller and Bundtzen, 1994).

Late Cretaceous sedimentary rocks of the Kuskokwim Group (Cady and others, 1955) are a regionally extensive basin-fill sequence found throughout southwestern and west-central Alaska and are the dominant bedrock in the Iditarod quadrangle. Rocks of the Kuskokwim Group represent turbidite fan, foreslope, shallow-marine, and shelf facies deposited in a Late Cretaceous basin, but subordinate shallow-marine and fluvial strata were deposited along the basin margins (Miller and Bundtzen, 1994). Rocks of the Kuskokwim Group consist primarily of intercalated sandstone, shale, chert, and conglomerate (Kks, Kkq), but they also include interbedded volcanic tuff and flow rocks (Kka, Kkv, Kkt). Volcano-plutonic complexes intrude or overlie rocks of the Kuskokwim Group at many localities such as the Beaver Mountains, Camelback Mountain, Swinging Dome, Chicken Mountain, Granite Mountain, Mount Joaquin, Takotna Mountain, and VABM Tatalina (Miller and Bundtzen, 1994). Volcanic rocks of these complexes consist primarily of Late Cretaceous and early Tertiary andesitic to basaltic flows (Kit and TKd) that together constitute the Iditarod Volcanics (Miller and Bundtzen, 1994). The volcanic rocks are generally in fault contact with or overlie comagmatic monzonite, quartz monzonite, syenite, granodiorite, granite, and minor lamprophyric plutons (TKm). At the contacts with the plutons, volcanic and sedimentary rock hornfels are common. Other Late Cretaceous and Tertiary igneous rocks include: (1) an extensive field of felsic to mafic volcanic rocks of the Yetna River area (TKy) that covers much of the western part of the quadrangle, (2) small dikes of intermediate to mafic composition (TKd) found throughout the quadrangle, (3) granite porphyry dikes, sills, and plugs (TKgp), (4) dacite-andesite plugs (TKp), and (5) alkali granite (TKg) in the western part of the quadrangle (Miller and Bundtzen, 1994). Minor exposures of Early Cretaceous sandstone and siltstone (Ks), Miocene basaltic andesite (Tb), and a small early Tertiary granodiorite plug (Tp) are also found in the quadrangle.

Volumetrically minor pre-Cretaceous rocks are divided into four narrow, northeast-trending fault bounded units in the west-central part of the quadrangle. The two older units (Proterozoic to Paleozoic age) are metamorphosed continental rocks and the younger two units (Mississippian and Jurassic age) are oceanic in origin (Miller and Bundtzen, 1994). The oldest rocks are Early Proterozoic rocks of the Idono Complex (Xi), which is a fragment of metamorphosed continental crust that consists of amphibolite grade granitic to dioritic orthogneiss, amphibolite, and metasedimentary rocks (Miller and Bundtzen, 1994). Isotopic data indicate a protolith age of 2.06 Ga for granitic orthogneiss in the complex (Miller and others, 1991). Another belt of continental rocks consists of greenschist facies metaigneous and metasedimentary rocks of middle Paleozoic and possibly Proterozoic protolith age (PzPg). These rocks are characterized by mafic greenschist, lesser pelitic schist, phyllite, calcareous schist, quartzite, and minor granitic orthogneiss that are possibly correlative with rocks of the Ruby terrane of Jones and others (1987). Mississippian to Triassic oceanic crustal and volcanic-arc rocks (TRMc) are also found in the belt of pre-Cretaceous rocks (Miller and Bundtzen, 1994). These rocks consist of radiolarian chert, basalt to basaltic andesite, lithic tuff, metasiltstone, and minor limestone that are correlative with rocks of the Innoko terrane of Jones and others (1987). Mafic and ultramafic rocks (Jdr) of the Dishna River area are the youngest of the pre-Cretaceous rocks (Miller and Bundtzen, 1994). These rocks consist generally of greenschist facies mafic rocks and serpentinized ultramafic rocks of probably ophiolitic origin that are correlative with the Jurassic ophiolites of the Tozitna-Innoko belt of Patton and others (1989a).

MINERAL DEPOSITS

Gold and silver are the most economically significant commodities in the Iditarod quadrangle, for example, over 1,600,000 oz (49,700 kg) of gold and 240,000 oz (7,500 kg) of silver have been produced mostly from placer mines in the quadrangle (Miller and Bundtzen, 1987; Bundtzen, Cox, and Veach, 1988; Bundtzen and Miller, 1997); additional estimated gold reserves in the quadrangle exceed 4,500,000 oz (140,000 kg) (Bundtzen and Miller, 1997). The largest placer mines are those near Flat (T. 27 N., R. 47 W.), Moore Creek (T. 29 N., R. 42 W.), Donlin Creek (T. 23 N., R. 49 W.), Ganes Creek (T. 33 N., R. 38 W.), and in the George River area (about T. 26 N., R. 42 W.) (see map). Although Au and Ag are the most economically significant commodities in the Iditarod quadrangle, base-metal-sulfide-bearing vein lodes are also found in the quadrangle, such as in the Beaver Mountains (Bundtzen and Laird, 1982). Such deposits may contain significant Cu, Pb, Zn, and Sn resources. In addition, W is an important commodity in the quadrangle and it is found in vein deposits such as the Golden Horn mine (fig. 1), where abundant scheelite is found with Au. Additional discoveries of mineral deposits containing significant concentrations of Cu, Pb, Zn, Sn, or W are possible in the Iditarod quadrangle.

In the Beaver Mountains, the Cirque prospect (T. 32 N., R. 41 W.) and other similar prospects consist of quartz-tourmaline-axinite-fluorite veins and vein breccias that contain chalcopyrite, pyrite, galena, and sphalerite (Bundtzen and Laird, 1982; Bundtzen and Miller, 1997). Tetrahedrite, cassiterite, arsenopyrite, scheelite, and wolframite are also found locally in these veins (Bundtzen and Gilbert, 1983). The veins are hosted in monzonite, syenite, intermediate to mafic volcanic rocks, and associated sedimentary rock hornfels that form a large volcano-plutonic complex in the Beaver Mountains (Bundtzen and Laird, 1982). Bundtzen and Miller (1997) designate such lodes in the Beaver Mountains, as well as similar lodes near Granite Mountain (T. 26 N., R. 40 W.), Bismarck Creek (T. 27 N., R. 42 W.), and the Broken Shovel lode (fig. 1) in the Moore Creek area (T. 29 N., R. 42 W.) as plutonic-related B-enriched Ag-Sn-polymetallic deposits. Anomalous concentrations of Cu, Pb, Zn, Sn, and W, as well as Au, Ag, Hg, Sb, As, Bi, Cd, and B have been reported from mineralized vein samples collected from these polymetallic deposits (Bundtzen and Laird, 1982; Bundtzen, Laird, and Lockwood, 1988; McGimsey and others, 1988).

In the Flat area are several gold and base-metal-sulfide-bearing quartz veins. The mineralized veins are found in monzonite plutons, surrounding hornfels, or in altered intermediate to mafic dikes that are part of a volcano-plutonic complex in this area (Bundtzen and Gilbert, 1983; Bundtzen and others, 1992). These veins may contain gold, arsenopyrite, pyrite, chalcopyrite, scheelite, cinnabar, stibnite, galena, and sphalerite (Bull, 1988). Fluorite, tourmaline, and sericite gangue are found in veins and vein breccias in the area (Bull and Bundtzen, 1987). These deposits may contain anomalous concentrations of Cu, Pb, Zn, Sn, and W. The Golden Horn Au-W-Sb deposit (fig. 1) is the most significant gold lode mine in the Flat area and the quadrangle, and in addition to producing about 2,700 oz (84 kg) of Au and 2,600 oz (81 kg) of Ag, Golden Horn has produced the only known Pb (4,243 kg or 9,336 lb), Zn (297 kg or 653 lb), and minor W from the quadrangle (Kimball, 1969; Bundtzen and others, 1992). Bundtzen and Miller (1997) describe the Golden Horn deposit and similar deposits on Chicken Mountain as plutonic-hosted Cu-Au-polymetallic deposits. Other deposits of this type are possible throughout the Iditarod quadrangle.

Several epithermal Hg-Sb vein deposits are found in the Iditarod quadrangle. These Hg-Sb deposits are found primarily within sedimentary rocks of the Kuskokwim Group and rarely in felsic dikes, sills, or small stocks that intrude these sedimentary rocks (Sainsbury and MacKevett, 1965). Cinnabar and stibnite are the dominant ore minerals found in quartz-carbonate veins. Lesser amounts of realgar, orpiment, native mercury, pyrite, gold, hematite, limonite, and dickite are locally found in these deposits (Sainsbury and MacKevett, 1965; Gray and others, 1990). These deposits are a significant Hg resource and over 41,000 flasks of Hg (1 flask weighs 76 lbs or 34.5 kg) have been produced from mines in the Kuskokwim River region, although most of the Hg (about 36,000 flasks) was recovered from the Red Devil mine in the Sleetmute quadrangle (Miller and others, 1989; Gray and others, 1997). The DeCourcy Mountain mine (T. 23 N., R. 50 W.; fig. 1) is the most significant Hg mine in the Iditarod quadrangle, having produced over 1,200 flasks of Hg (Cady and others, 1955). Several Hg-Sb deposits in southwestern Alaska contain significant concentrations of Au and Ag (Hawley and others, 1969; Gray and others, 1990; Bundtzen and Miller, 1997; Gray and others, 1997); as a result, Bundtzen and Miller (1997) consider these deposits to be epithermal Au-Ag deposits. In southwestern Alaska, Hg, Sb, and As are most diagnostic when exploring for Hg-Sb vein deposits (Gray and others, 1991). Base-metal sulfides are rare in these Hg-Sb vein deposits, however, minor amounts of Cu, Pb, Zn, Sn, or W may be associated with these deposits.

Stibnite-rich lodes are known in the Donlin Creek area (T. 23 N., R. 49 W.), Granite Creek (T. 26 N., R. 42 W.), Julian Creek (T. 25 N., R. 44 W.), and at the Independence mine (T. 33 N., R. 38 W.) (Cady and others, 1955; Bundtzen and others, 1986; Bundtzen and Miller, 1997). The Independence mine was briefly operated in 1912 and produced about 161 oz (5 kg) of Au (Bundtzen and Miller, 1997). The lodes consist of small quartz-carbonate veins and vug fillings containing stibnite, pyrite, arsenopyrite, and local cinnabar in granite porphyry dikes, adjacent sedimentary rocks, or at contacts between the two rock types (Bundtzen and Miller, 1997). Clay and sericite gangue are local. Stibnite-rich samples from the Donlin Creek area and Granite Creek have anomalous concentrations of Au and Ag (Cady and others, 1955; Bundtzen and others, 1986; McGimsey and others, 1988; Gray and others, 1990). Bundtzen and Miller (1997) describe such deposits as granite-porphyry-hosted Au-polymetallic deposits. Although these deposits rarely contain significant concentrations of Cu, Pb, Zn, Sn, or W, they are an important deposit type in the Iditarod quadrangle and throughout the Kuskokwim River region.

In addition to scheelite-bearing vein lodes, detrital scheelite is found in heavy-mineral concentrate collected from streams draining eroded monzonite stocks near Flat (T. 27 N., R. 47 W.), Mount Joaquin (T. 32 N., R. 37 W.), Tatalina Mountain (T. 31 N., R. 36 W.), Moore Creek (T. 29 N., R. 42 W.), and in the Beaver Mountains (Bundtzen, Cox, and Veach, 1988). Gold placer deposits in the quadrangle are also known to contain detrital scheelite (Bundtzen, Cox, and Veach, 1988). Although placer scheelite is not probably only a minor W resource in the quadrangle, scheelite identification in heavy-mineral-concentrate samples may help delineate additional areas favorable for the occurrence of scheelite-bearing lode deposits.

METHODS

Stream-sediment and heavy-mineral-concentrate samples were collected from active channels of perennial first-and second-order streams. The area of most drainage basins ranged from 1 mi^2 (2.6 km^2) to about 5 mi^2 (13 km^2). The sampling density was about 1 sample locality per 9 mi^2 (23 km^2).

In this study, 1,151 stream-sediment samples were collected, sieved to minus-80-mesh, ground, and chemically analyzed. There were 799 panned-concentrate samples collected, and these samples were sieved to minus-30-mesh, separated in bromoform, and then further separated magnetically to obtain a nonmagnetic heavy-mineral-concentrate sample. The nonmagnetic heavy-mineral-concentrate samples were split, and one split was ground for semiquantitative spectrographic analysis (SQS) and the other split was saved for mineralogy identification.

All 1,151 stream-sediment samples collected in this study were chemically analyzed. The 799 heavy-mineral concentrate samples were examined using a binocular microscope for the presence of scheelite, but only 662 concentrate samples contained sufficient material for chemical analysis. The stream-sediment and heavy-mineral-concentrate samples were analyzed for multi-element suites that included Cu, Pb, Zn, Sn, and W by the SQS technique described by Grimes and Marranzino (1968). Geochemical results for stream-sediment and heavy-mineral-concentrate samples are listed in Gray, Arbogast, and Hudson (1988), and mineralogy results are given in Bennett and others (1988). Histograms for the data used in this report are shown in figure 2.

RESULTS

The geochemical data used for this study include anomalous concentrations of Cu, Pb, Zn, and Sn in stream-sediment samples and Cu, Pb, Zn, Sn, and W in nonmagnetic heavy-mineral-concentrate samples. No stream-sediment samples contained W concentrations above the lower limit of determination (50 ppm), and thus, W in stream sediment is not used in this study. The estimated abundance of scheelite in nonmagnetic heavy-mineral-concentrate samples was also used for identifying upstream mineralized areas. The nonmagnetic heavy-mineral-concentrate study revealed scheelite to be the most reliable mineral indicator of upstream Cu, Pb, Zn, Sn, or W mineralized areas. Scheelite was detected in 159 heavy-mineral-concentrate samples. However, chalcopyrite was found in only 9, galena in 18, sphalerite in 26, and cassiterite in only 38 heavy-mineral-concentrate samples, and they were not particularly useful for identifying mineralized areas. All anomalies were selected by identifying breaks in the frequency distribution of each data set, generally those above the 95th percentile. Geochemical analyses of aquatic-moss (Arbogast and others, 1991) and stream-water samples (Gray, Ryder, and others, 1988) collected in the quadrangle were generally unreliable for identifying mineralized areas (Gray and others, 1992), and thus, these data were not used in this study. A summary of the data used in this report is presented in Table 1.

On the map, 13 areas contain sample localities that have highly anomalous concentrations of Cu, Pb, Zn, Sn, or W. All of these areas are spatially associated with Late Cretaceous and Tertiary igneous rocks that intrude sedimentary rocks of the Late Cretaceous Kuskokwim Group (see map). Eight of these areas are near volcano-plutonic complexes, and 5 areas are near felsic to mafic intrusions or volcanic flows. Several other sample localities have anomalous concentrations of Cu, Pb, Zn, Sn, or W, and they are generally found as single-locality anomalies. Such single-locality anomalies are difficult to explain, but they may indicate the presence of less extensive Cu, Pb, Zn, Sn, or W deposits.

Some of the areas that have anomalous concentrations of Cu, Pb, Zn, Sn, or W overlap Au-Ag anomalies (Gray, Motooka, and O'Leary, 1997) or Hg-Sb-As anomalies (Gray, Folger, and Hageman, 1997). The anomalies designated in this study are numbered to be consistent (when possible) with other USGS geochemical maps in the Iditarod series. For example, area 1 (Beaver Mountains) correlates with area 1 in Gray, Motooka, and O'Leary (1997) and area 1 in Gray, Folger, and Hageman (1997).

Area 1 surrounds the Beaver Mountains and is the largest area in the Iditarod quadrangle containing anomalous concentrations of Cu, Pb, Zn, Sn, and W (see map). The Beaver Mountains are underlain by a large volcano-plutonic complex consisting of monzodiorite to syenite intrusions, intermediate to mafic volcanic rocks, and sedimentary and volcanic rock hornfels; intermediate to mafic dikes are also found in the area (Bundtzen and Laird, 1982). Several plutonic-related B-enriched Ag-Sn-polymetallic prospects containing base-metal sulfides are known in the Beaver Mountains (Bundtzen and Laird, 1982; Bundtzen and Miller, 1997). There are numerous Cu, Pb, Zn, Sn, and W anomalies in area 1. Stream-sediment anomalies include 9 samples containing 100-200 ppm Cu, 15 samples containing 70-150 ppm Pb, 4 samples containing 300-500 ppm Zn, and 20 samples containing 10-50 ppm Sn. Heavy-mineral-concentrate samples collected in the Beaver Mountains include 1 sample containing 300 ppm Cu, 2 samples containing 300 ppm Pb, 2 samples containing greater than 2,000 ppm Sn, and 10 samples containing 200-500 ppm W. The Beaver Mountains also have anomalous concentrations of Au and Ag (Gray, Motooka, and O'Leary, 1997) and Hg, Sb, and As (Gray, Folger, and Hageman, 1997). The Cu-Pb-Zn-Sn-W anomaly shown on the map is related to base-metal-sulfide-bearing vein deposits as described by Bundtzen and Laird (1982), although it is possible that the W anomalies reflect high backgound concentrations in the hornfels underlying the Beaver Mountains. The Beaver Mountains are favorable for the presence of plutonic-related B-enriched Ag-Sn-polymetallic deposits similar to the Cirque prospect (Bundtzen and Miller, 1997); the Cu, Pb, Zn, Sn, and W anomalies in stream-sediment and heavy-mineral-concentrate samples in area 1 support this conclusion.

Areas 2-6, 8, and 9 are spatially associated with other volcano-plutonic complexes similar to, but generally smaller than, that in the Beaver Mountains (see map). Area 2 is near the headwaters of Moore, Deadwood, and Fourth of July Creeks where placer gold has been reported (Brooks, 1912; Mertie, 1936; Bundtzen, Laird, and Lockwood, 1988; Cobb, 1972). Altered volcanic rocks and silicified sedimentary rock hornfels in this area contain as much as 5.1 ppm Ag, 1.4 ppm Au, 150 ppm Cu, 200 ppm Pb, 10 ppm Hg, 32 ppm Sb, and 100 ppm As (McGimsey and others, 1988). Also in area 2 is the tetrahedrite-arsenopyrite-tourmaline-scheelite-bearing Broken Shovel vein lode where mineralized samples contain as much as 555 ppm Ag, 1.6 ppm Au, 5,590 ppm As, 4,860 ppm Cu, 1,430 ppm Pb, 2,400 ppm Sb, and 760 ppm Zn (Bundtzen, Laird, and Lockwood, 1988). Area 2 is defined by 6 heavy-mineral-concentrate samples that contain 300 and 500 ppm Pb, and 1 stream-sediment sample containing 30 ppm Sn. Parts of this area were designated as having highly anomalous concentrations of Au and Ag (Gray, Motooka, and O'Leary, 1997) and Hg, Sb, and As (Gray, Folger, and Hageman, 1997). The Pb, Zn, Sn, and W anomalies in stream-sediment and heavy-mineral-concentrate samples suggest that area 2 is favorable for the occurrence of plutonic-related B-enriched Ag-Sn-polymetallic vein deposits as discussed by Bundtzen and Miller (1997), but possibly also epithermal Hg-Sb vein deposits and Au-polymetallic deposits. The Pb-Zn-Sn-W anomaly in area 2 extends into additional watersheds west of the areas that have anomalous concentrations of Au-Ag and Hg-Sb-As.

Area 3 is roughly centered around Flat where placer gold mines and lode deposits are numerous. Quartz veins at the Golden Horn and those on Chicken Mountain contain gold, pyrite, arsenopyrite, chalcopyrite, scheelite, stibnite, and cinnabar (Bundtzen and others, 1992; Bundtzen and Miller, 1997). The lodes in this area are associated with monzonite plutons, sedimentary rock hornfels, or altered dikes. Quartz veins and vein breccias in granite porphyry and sedimentary and volcanic rock hornfels in area 3 contain