Geology and Mineral Deposits of the Chulitna-Yentna Mineral Belt, Alaska

By C. C. HAWLEY *and* ALLEN L. CLARK

GEOLOGY AND MINERAL DEPOSITS OF THE UPPER CHULITNA AND YENTNA DISTRICTS, SOUTH-CENTRAL ALASKA

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A mineral belt along the southern flank of the west-central Alaska Range is defined on the basis of epigenetic mineral deposits and anomalous concentrations of metals in stream sediments

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ABSTRACT

The Chulitna-Yentna mineral belt, which extends northeastward for 100 miles or more along the southern flank of the west-central Alaska Range, is nearly parallel to the strike of sedimentary and volcanic rock units, to the direction of elongation of intrusive bodies, and to major faults or lineaments. The Chulitna-Yentna belt is defined principally on the basis of an alinement of epigenetic mineral deposits [and] subordinately on anomalous concentrations of metals in the sediments of the streams that drain the belt. Arsenic and gold are the metals most characteristic of the entire belt; copper, tin, and other metals occur locally. The belt shares tectonic or compositional features comparable with some well-known mineral belts of the western Cordillera, including the Juneau gold belt.

INTRODUCTION

The Chulitna-Yentna mineral belt, on the southeastern flank of the west-central Alaska Range, is defined herein, principally on the basis of epigenetic mineral deposits that have a nearly linear arrangement. It is parallel to and is nearly coincident with a zone of northeastward-striking faults subparallel to the local trend of the Alaska Range and the major Chulitna Valley lineament.

This report serves as a general summary and introduction to two others—one on the northern part of the belt, or Upper Chulitna district (Hawley and Clark, 1973), and the other on the Yentna district (Clark and Hawley, 1968). The three are part of a general assessment of a larger region, the southern central Alaska Range and northern Talkeetna Mountains, undertaken in 1967 and 1968.

LOCATION

The Chulitna-Yentna mineral belt is centered about 130 miles north of Anchorage on the southeast flank of the west-central Alaska Range (fig. 1). It is a nearly linear feature 5–20 miles wide and at least 100 miles long in relatively low, but locally rugged, mountainous terrain between the main valley of the Susitna and Chulitna Rivers and the summit peaks of the Alaska Range. The southern part of the belt near Petersville is accessible by road from near Talkeetna, and the entire belt is within 6–50 miles of The Alaska Railroad.

The belt includes large parts of three districts or regions defined in other reports—Yentna, Curry, and Upper Chulitna (fig. 1). The Yentna district, defined by Capps (1913), extends approximately from a few miles south of Collinsville to the Tokositna River; the Curry district, from the Tokositna River to Eldridge Glacier (Tuck, 1934); the Upper Chulitna district, from Eldridge Glacier to near the Bull River (Hawley and Clark, 1973). Neither the Curry district (which includes the Tokosha Mountains) nor the southern part of the upper Chulitna district, both generally rugged and inaccessible, have been studied or prospected extensively.

PREVIOUS AND PRESENT INVESTIGATIONS

Although the Chulitna-Yentna mineral belt has not heretofore been recognized as a geologic entity, most of it has been studied in reconnaissance. Most investigations of the metallic resources along the belt were made before 1935. Capps was the first geologist of the U.S. Geological Survey to visit the Yentna district (Capps, 1912, 1913) and the Upper Chulitna district (Capps, 1919); he later revisited the Yentna district (Capps, 1925) and made three summaries of the geology and mineral resources on the Alaska Railroad belt (Capps, 1924, 1933, and 1940). Mertie (1919) studied the placer deposits of the Yentna district and described the occurrence of platinum, cassiterite, and other minerals

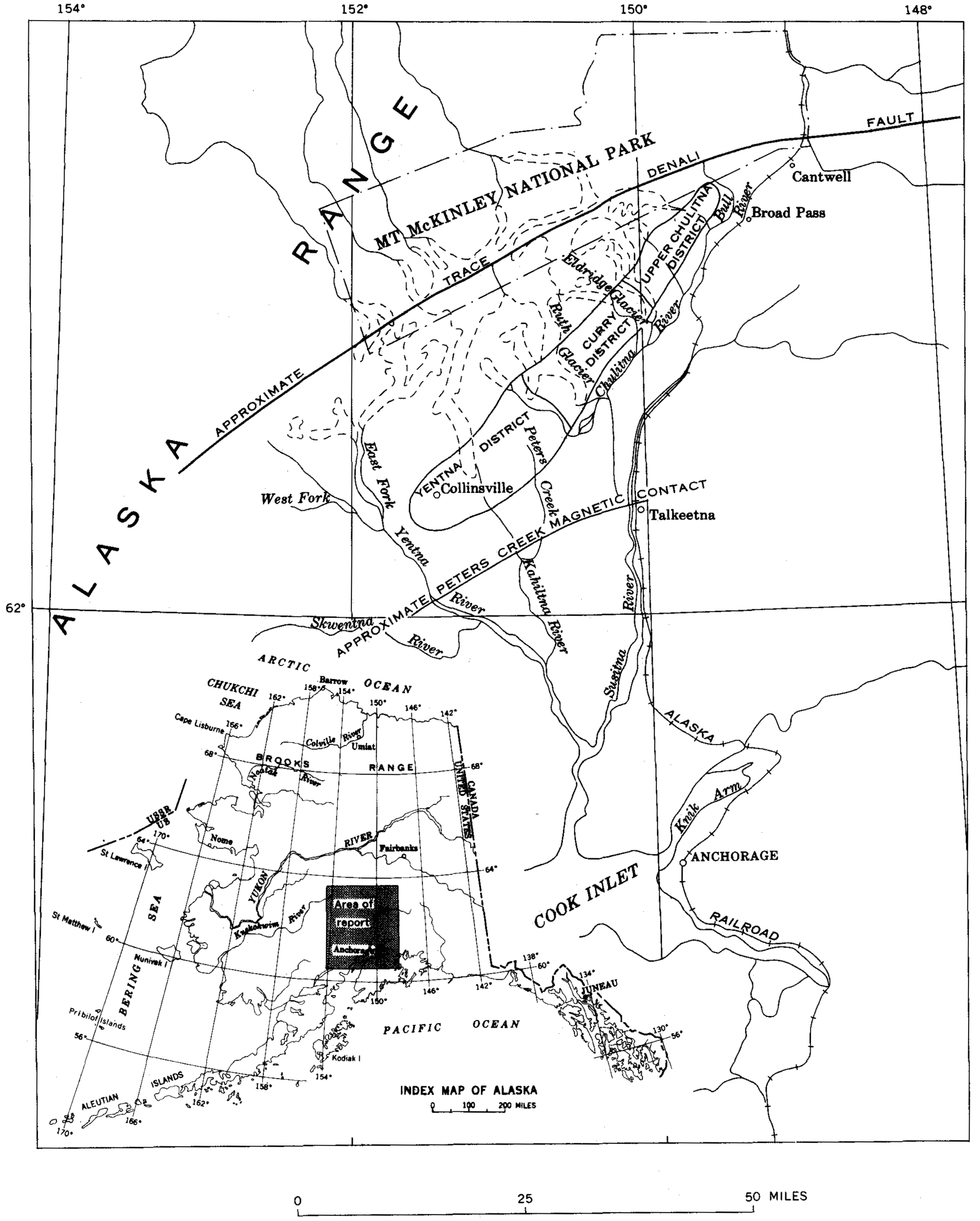

FIGURE 1.—Index map showing location of the Chulitna-Yentna mineral belt.

in the placer concentrates. The Upper Chulitna district was reexamined and mapped in 1931 by Ross (1933); Ralph Tuck followed developments near the Alaska Railroad belt for several years and made a reconnaissance of most of the Curry district (Tuck, 1934).

Except for studies of radioactivity in placer deposits of the Yentna district (Robinson and others, 1955), the Geological Survey's investigations of metallic resources along the belt began in 1967 and continued in 1968. Reports on these investigations by the authors and associates are listed in "References cited."

Our investigation was mainly reconnaissance except for detailed mapping of small areas near mineralized rocks. The approximate detail of investigations in the part of the area north of Eldridge Glacier averaged about 1:63,360; investigations in the Yentna district corresponded to about 1:125,000 scale coverage, and those in the central part or Curry district to about 1:250,000. Samples of stream sediments have not been collected in parts of the Curry district, but the coverage elsewhere corresponds to the mapping scales (Hawley and others, 1969; Clark and Hawley, 1968).

GEOLOGIC SETTING

The Chulitna-Yentna mineral belt is defined principally on the basis of epigenetic metallic deposits. Secondary criteria that authenticate the belt are placer deposits derived from lodes within the belt and anomalous concentrations of metals in stream sediments. Localities of all known lodes and placer deposits of the belt are plotted on a generalized geologic map (pl. 1). Stream-sediment samples that contain anomalous concentrations of metals are shown if they are in drainages away from known deposits, as they could indicate the existence of undiscovered bodies of mineralized rock.

The mineral belt has an average trend of about N. 45° E. and extends from a few miles south of Collinsville (fig. 1) to near the Bull River. Possible northeast and southwest extensions of the belt are masked by widespread surficial deposits, but an alinement of placer gold occurrences that projects toward lode occurrences near the Skwentna River (Spurr, 1900) suggests that the belt may continue about 35 miles farther southwest. To the north, the belt makes an acute angle with the Denali fault; to the south, it makes and acute angle with, and possibly joins, the major structural break marked by the Peters Creek magnetic contact of the Mount Susitna magnetic anomaly group (Grantz and others, 1963).

The epigenetic metallic deposits along the belt are of approximately the same age and are primarily veins or combined vein-disseminated deposits. They have a distinctive trace-element suite of metals that includes arsenic, gold, copper, tin, antimony, and bismuth.

The Chulitna-Yentna mineral belt is subparallel to both structural and lithologic trends along the south flank of the west-central Alaska Range; as shown in detail, it transects progessively younger rocks southward. Sedimentary and volcanic rocks underlie most of the belt, but a major batholith cuts across its central part, and small masses of hypabyssal rocks cut both its northern and southern extremities.

STRATIGRAPHY

Sedimentary and volcanic rocks of the mineral belt range in age from Paleozoic to Tertiary but are predominantly Mesozoic. They can be diveded by lithology and age into three main groups (pl. 1). The oldest group, exposed mainly north of Eldridge Glacier on the southeast side of the belt, consists of nonfossiliferous siliceous argillite, graywacke, and shaly or slaty argillite. Unconformably overlying this group are lithologically varied mafic volcanic rocks, red beds, limestones, and calcareous argillites of Permian and Triassic age. The red beds consist of a sequence of hematitic sandstone, siltstone, conglomerate, and breccia. Clasts in the coarser grained units are chiefly quartz, red chert, and argillite, and mafic and intermediate volcanic rocks; locally, the matrix of the conglomerate breccia is tuffaceous; this, together with the presence of anomalous concentrations of chromium and nickel in the unit, suggests general mafic volcanism near the time of sedimentation. Fossiliferous limestones and pillow lavas are intercalated throughout the Permian and Triassic section and are diagnostic of at least local marine conditions. Conformably overlying the Permian and Triassic group is a group of generally noncalcareous dark argillite, graywacke, and conglomerate of Jurassic(?), Cretaceous, and possibly Paleocene age.

The pre-Permian rocks have undergone low-grade metamorphism, as indicated by the presence of chlorite and secondary biotite. Permian through Paleocene (?) rocks are essentially unmetamorphosed except in the Curry district, where rocks equivalent at least of pre-Permian, Permian, and Triassic rocks of the Upper Chulitna district have been moderately to highly metamorphosed. Specifically, equivalents of red strata are purple to green phyllite; mafic volcanic rocks are green schist; limy units are calcareous schist with intercalated marble; and argillaceous units are dark phyllite to andalusite schist in the Curry district.

Coal-bearing and locally auriferous detrital sedimentary rocks of Oligocene and Miocene age locally overlie, with marked angular unconformity, rocks of Paleozoic, Mesozoic, and possibly Paleocene age. Coal-bearing rocks occur near Costello Creek, lower Coal Creek, and Ruth Glacier, and in the Yentna district as shown by Barnes (1966); they are, however, younger than hypogene mineral deposits of the belt, and in figure 2 are combined with locally extensive glacial and fluviatile deposits of Quaternary age.

IGNEOUS ROCKS

Igneous rocks of the belt range in composition from ultramafic through diorite and quartz diorite to granite. Except for the batholith of the Curry district, the intrusive rocks form stocks, plugs, and dikes, many of which are too small to show at 1:500,000 (the scale of fig. Z).

Ultramafic rocks, largely converted to serpentinite, and associated gabbro and basalt are abundant north of Eldridge Glacier and scarce to the south. They generally form masses that are elongate parallel to the northeast structural grain and the mineral belt. Two small serpentinite bodies were reported by Ralph Tuck (unpub. data, 1932) south of Eldridge Glacier, and the existence of ultramafic or mafic rocks elsewhere along the southern part of the mineral belt is suspected because chromite and some platinum are found in placer concentrates.

Quartz diorite and diorite, generally porphyritic, occur in the part of the belt north of Eldridge Glacier. They form dikes that strike mostly northeastward and stocks of mappable size, particularly near the West Fork of the Chulitna River. Quartz monzonite or granite forms dikes and small stocks at several localities along the belt and in the batholith that transects the belt. The rocks of the batholith are mainly medium- to coarse-grained biotite granite or quartz monzonite; rocks in the smaller plutons are mainly fine to medium grained and light colored, and locally contain muscovite and tourmaline as characteristic accessory minerals.

Small syngenetic deposits of chromite are found in the ultramafic rocks, and many epigenetic metal deposits of the belt show a close spatial relation to the rocks of intermediate to granitic composition. Rich gold-arsenopyrite veins of the Yentna district are in ladder and strike veins in felsic dikes, and the Golden Zone and several other deposits of the Upper Chulitna district are in quartz diorite, diorite, or quartz (granitic) porphyry host rocks. Granitic rocks of the belt locally have detectable amounts of tin, about 10 ppm (parts per million) or more, and a tin-bearing greisen in upper Ohio Creek is in a muscovite-tourmaline-albite granite.

Both the epigenetic metallic deposits and most of the igneous rocks were emplaced after folding and faulting of the Permian, Mesozoic, and Paleocene(?) rocks but before deposition of coal-bearing rock of Oligocene and Miocene age.

STRUCTURE

The northeasterly trend of the belt is established by the parallelism of lithologic units, the fold axes, and the major high-angle faults and lineaments, these features are probably the main control of the mineral belt. Only a few of the numerous faults and lineaments appear to persist through long distances parallel to the strike of the belt. These structures include (1) the upper Chulitna fault, (2) the West District fault, (3) the Peters Hills lineament, and (4) the Pass Creek fault and Dutch Creek lineament (pl. 1).

UPPER CHULITNA FAULT

The Upper Chulitna fault is a complex structure that can be traced from near Hidden Creek south of Eldridge Glacier to the Costello Creek coal basin, where it is buried by Oligocene sedimentary rocks. The fault is poorly exposed between Hidden Creek and Eldridge Glacier. However, a definite lineament striking N. 40° E. can be projected through prominent saddles and broken zones and, in small tributaries to Swift Creek, through a zone of limonitic spring deposits. North of Eldridge Glacier, the fault consists of two or more subparallel strands or branches. At least one strand of the fault contains elongate masses of serpentinite or gabbro and basalt from the glacier to Long Creek, and small bodies of serpentinite or gabbro are on a branch of the fault north of the West Fork of the Chulitna River. North from a point near Copeland Creek, one prominent strand of the fault splits into two branches: the west branch trends northward into the Blind Creek fault (pl. 1; Ross, 1933); the east branch crosses the West Fork of the Chulitna near Lookout Mountain and can be traced northeastward to the Costello Creek coal basin, where it is buried by Oligocene rocks.

WEST DISTRICT FAULT

Another major fault on the northern part of the belt can be traced from Eldridge Glacier nearly to the West Fork of the Chulitna River; this structure is 1½ to 3 miles northwest of the Upper Chulitna fault zone. Near Partin Creek the fault separates basalt and limestone from red beds; northward it crosses into the dark argillite-graywacke series. Most mineral occurrences of the Canyon Creek–Partin Creek area (Nos. 10–13) lie west of the fault (pl. 1).

PETERS HILLS LINEAMENT

The northwest edge of the Peters Hills forms a nearly straight line trending N. 42° E. that coincides with a fault postulated by Capps (1913, fig. 6) to control the observed distribution of Tertiary sedimentary rocks in the basin between the Peters and Dutch Hills. Most of the productive placers of the Cache Creek basin are confined to the area northwest of the fault.

PASS CREEK FAULT AND DUTCH CREEK LINEAMENT

The Pass Creek fault (Barnes, 1966, pl. 1), near the northwest edge of the Collinsville part of the Yentna district, projects toward the prominent Dutch Creek lineament. This lineament forms the northwest edge of the Dutch Hills along the valleys of Dutch and Bear Creeks.

RELATION OF MINERAL BELT TO MAJOR FAULT STRUCTURES

The relation of the mineral belt to structures like the Upper Chulitna fault is significant. Relationships such as this have been demonstrated elsewhere by Tweto and Sims (1963), Roberts (1966), and Jerome and Cook (1967). The Upper Chulitna fault is a deep crustal structure, as implied by its length and shown by its control of igneous bodies, particularly the mafic and ultramafic ones. North of Eldridge Glacier, serpentinite, basalt, and gabbro are well exposed in linear bodies in and near the Upper Chulitna fault (pl. 2). These bodies contain local concentrations of chromium minerals and local epigenetic deposits of copper, gold, and other metals. They are therefore of direct economic importance to the belt as well as of geologic importance as depth indicators.

Other features that may be deep structures are the poorly exposed Pass Creek fault and its projection, the Dutch Creek lineament. Serpentinite and mafic rocks are sparsely exposed south of Eldridge Glacier, but occurrences of chromite and platinum in placer deposits and anomalous concentrations of chromium in stream sediments suggest their presence below the extensive surficial deposits. The distribution of chromium in stream sediments (pl. 2) in the southern part of the belt is consistent with derivation from primary deposits in and near the Pass Creek fault–Dutch Creek lineament.

MINERAL DEPOSITS

Mineral deposits and occurrences in the Chulitna-Yentna mineral belt include a few small syngenetic deposits of chromite and rocks with anomalous concentrations of nickel in ultramafic hosts, numerous epigenetic bodies containing arsenic, gold, copper, tin and other metals, and placer deposits of gold. The epigenetic deposits that are the principal basis for definition of the belt include metallized rocks in veins, lodes, shear zones, disseminated deposits, and one deposit in a breccia pipe.

The deposits, like those of many mineral belts, appear to be in clusters along the trend of the belt; part of the clustered appearance may reflect lack of data and limited prospecting. One main group of deposits (Nos. 1–9, pl. 1) is in a linear zone about 10 miles long, at the northern part of the belt. This zone extends from south of Long Creek to north of the West Fork of the Chulitna River and includes the Golden Zone deposit. Another cluster is in upper Ohio Creek (Nos. 10–12, pl. 1). Occurrences southwest of Nos. 10–11 and anomalous concentrations of metals in streams heading into the interlayered limestone and basalt unit (pl. 1) suggest that deposits may be scattered through at least an 11-mile-long zone from Eldridge Glacier to upper Ohio Creek that coincides with the interlayered rock unit.

A third cluster of deposits is in the main part of the Yentna district, near the Dutch Hills. The productive deposits here have been placer gold deposits with byproduct platinum and locally abundant cassiterite. Because these deposits are secondary, the validity of a hypogene mineral belt crossing the district is dependent on the existence of lode deposits of gold, tin, and other metals within the belt. Both Capps (1913) and Mertie (1919) proposed that the source of much of the placer gold was near, and Mertie (1919, p. 257–260, p. 261–262) stated specifically that gold and cassiterite in Poorman, Willow, Long, and Canyon Creeks were largely derived from visibly mineralized rocks of their drainage areas. Prospecting done since the visits of Mertie and Capps has resulted in the discovery of additional lode sources. Small but very rich veins are now known in Nugget and Bird Creeks and on the ridge between them (Nos. 16–18, pl. 1). In addition, auriferous quartz-conglomerate-braccia zones of the Yentna district that were described as placer deposits by Mertie (1919, p. 249–251, 252) and Capps (1925, p. 55–56) are now regarded as hypogene deposits that locally have been reworked into conglomerates (Clark and Hawley, 1968).

Although a source of cassiterite has not been identified, anomalous concentrations of tin are found in some veins and igneous rocks of the Yentna district. Another placer mineral of the district, scheelite, has been found with free gold and arsenopyrite in veins near Bird Creek.

No lode occurrences have been found in the cluster of placer deposits near Collinsville. Older bedrock is in fault contact with Tertiary rocks in the vicinity of Pass Creek (pl. 1), and the pattern of gold distribution suggests that the lode sources could be in or near the Pass Creek fault structure. However, the placer deposits may have been formed by reworking of Tertiary sedimentary rocks that contain small amounts of gold.

Very few deposits or occurrences are known in the part of the belt between Ruth and Eldridge Glaciers (pl. 1), but this area has not been extensively prospected. Stream-sediment samples that were collected in the area near the Upper Chulitna fault between Eldridge Glacier and the Hidden River contained anomalous concentrations of metals in several samples; these concentrations suggest that more metallic deposits exist than were previously reported.

A possible southward projection of the belt (not shown on pl. 1) between Collinsville and the Skwentna River is largely covered by Quaternary deposits. Though there is only one known outcrop of lode minerals (Freeman, 1963, p. 29–30), gold occurs in shallow placer deposits along the Nakoshna, Kichatna, and Skwentna Rivers (Capps, 1913, p. 70–71; Spurr, 1900, p. 260–261) very near the projected strike of the belt. South of the Skwentna where Mesozoic rocks are again exposed, slightly auriferous pyrite, chalcopyrite, and galena veins were reported by Spurr (1900, p. 110–112, 259–263). The data, though inconclusive, are consistent with a projection of the mineral belt southwestward for approximately 35 miles.

MINERALOGY AND METAL CONTENT

Individual deposits of the belt are generally characterized by a few dominant minerals and metals, but the complete suite is a complex one. The principal minerals are arsenopyrite, pyrite, pyrrhotite, and chalcopyrite; the minor minerals include common metallic minerals such as galena, bismuthinite, cassiterite, scheelite, and stibnite. The minor minerals, as shown in table 1, are known from only a few occurrences, but assays show that their metals are widely dispersed along the belt.

TABLE 1.—*Ore minerals of the Chulitna-Yentna mineral belt*

[A, major mineral of several deposits; M, moderate abundance in several deposits; Sp, sparse, may be locally abundant; O, only one occurrence known; W, widespread; Y, Yentna only; Ch, Chulitna only; X, present]

	Abundance	Distribution	Placer	Lode
Native elements:				
Gold	M	W	X	X
Copper	Sp	Y	X	....
Platinum[1]	Sp	Y	X	....
Sulfides and sulfosalts:				
Arsenopyrite	A	W	X	X
Pyrite	A	W	X	X
Pyrrhotite	M	Ch	....	X
Chalcopyrite	M	Ch	....	X
Sphalerite	M	Ch	....	X
Galena	M	Ch	....	X
Do	Sp	Y	X	....
Stibnite	Sp	Ch	....	X
Do	O	Y	X	....
Molybdenite	O	Ch	....	X
Bismuthinite	O	Ch	X	....
Argentite	O	Ch	....	X
Chalcocite	O	Ch	....	X
Tennantite(?)	O	Ch	....	X
Oxides:				
Magnetite	M	Y	X	....
Ilmenite	M	Y	X	....
Do	Sp	Ch	....	X
Chromite	M	Y	X	....
Do	O	Ch	....	X
Cassiterite	M	Y	X	....
Do	Sp	Ch	....	X
Wodginite (Ta, Nb, Sn, Fe, Mn) O_2	O	Ch	....	X
Rutile(?)	Sp	Y	X	....
Uranothorianite	Sp	Y	X	....
Tungstates:				
Scheelite	Sp	Y	X	X
Phosphates:				
Monazite	M	Y	X	....

[1]Mertie (1919) described two varieties of platinum metals in the Yentna placers; one a dark-gray or bronze type in flaky grains of <1 mm size; the other a bright silver type in more crystalline grains.

DISTRIBUTION AND OCCURRENCE OF GOLD, ARSENIC, COPPER, TIN, AND SOME OTHER METALS

Arsenic and gold appear to characterize nearly the entire belt, as shown by their abundance and pattern of distribution in lode deposits, placer deposits, and stream sediments. Copper is particularly characteristic of the part of the belt north of Eldridge Glacier, tin of the part of the belt north of Ohio Creek and of the main Yentna district.

Gold.—Gold is widely distributed along the Chulitna-Yentna belt in lode deposits, in stream sediments and is abundant in placer deposits of the Yentna district (pl. 2). Lode deposits or occurrences in the Upper Chulitna district, described by Ross (1933), and Capps (1919), and Hawley and Clark, (1973), include the Golden Zone and nearby prospects and the Partin Creek occurrence. Gold-bearing lodes in the Yentna district, which have not been as well described, include small and locally very rich deposits associated with felsic dikes and apparently low-grade deposits in major shear and altered zones. The highest grade deposits recognized are at the Bird Creek prospect, the Colby and nearby prospects, and a mineralized dike swarm in Nugget Creek. Assays exceeding 1 ounce of gold per ton have been obtained from all three areas, and selected quartz-arsenopyrite vein material from one of the Colby prospects assayed about 200 ounces of gold per ton. Two gold-bearing veins from the Curry district (pl. 2) and rich gold-bearing float from Whistler Creek have been reported by Tuck (1934).

Placer deposits of gold are abundant in the Yentna district and have been prospected in Shotgun and Bryn Mawr Creeks in the Upper Chulitna district. In the Yentna district, most of the streams draining the south flank of the Dutch Hills have auriferous deposits, as do the tributaries of Twin and Mills Creeks near Collinsville (pl. 2). Placer gold is locally present on the north flank of the Dutch Hills, and there is one important mine southeast of the Peters Hills. Gold in stream-sediment samples along the east flank of the northern Peters Hills suggests that other deposits might be developed north of the Peters Creek placer deposit.

The abundance of gold in the belt is pointed up by the frequency of its occurrence in stream-sediment samples as compared with its general absence in areas east and west of the belt. Gold was found in concentrations of 0.02 ppm or more in 21 percent of approximately 160 stream-sediment samples of the Upper Chulitna district; it was found in 17 percent of about 130 samples from the main part of the Yentna district, and in 50 percent of 8 stream-sediment samples from the Curry district part. In the Yentna district in particular, these amounts are known to be minimal, because gold placer areas were avoided in sampling. In contrast, gold was found in only 7 percent of 157 samples from the northern Talkeetna Mountains east of the Chulitna valley, and in only 1.5 percent of about 1,100 samples from the Southern Alaska Range about 80–100 miles west-southwest of the Yentna district (Reed and Elliott, 1968; Elliott and Reed, 1968).

Although the median gold content of the stream-sediment samples from the belt cannot be calculated or read directly, it can be estimated statistically or graphically (Shoemaker and others, 1959). Projections on a frequency distribution diagram (Hawley and Clark, 1973) suggest that the median concentration of gold in streams from the Upper Chulitna part of the belt would probably lie within the range of 0.001 to 0.005 ppm. Such concentrations are characteristic of streams draining weakly mineralized regions according to Fischer and Fisher (1968, p. 2, table 2). An unmineralized area investigated by the same authors had an approximate gold content of 0.000X–0.0000X ppm and an auriferous area of 0.006–0.3 ppm, the latter range is very similar to concentrations found near known deposits in the Chulitna-Yentna belt.

These comparisons were not made quantitatively. Concentrations of gold in streams of the Chulitna-Yentna belt were estimated from atomic absorption analysis of stream sediment samples, whereas Fischer and Fisher (1968) calculated gold concentration in stream sediments from analyzed preconcentrated samples. The estimates, however, are believed to be qualitatively significant, especially when used with other evidence of the enrichment of gold in the belt.

Arsenic.—Arsenic, mainly in arsenopyrite, is present in most lode deposits of the belt and locally is the most abundant metal. In was detected in approximately 18 percent of the stream-sediment samples of the Chulitna district, although its detection limit is about 200 times its crustal abundance. Although detected in only about 3 percent of stream-sediment samples of the Yentna district, arsenopyrite was found in placer concentrates from many creeks (Robinson and others, 1955; Mertie, 1919) and in the small lode deposits of the district, as shown on plate 2. Plate 2 also shows the location of some arsenopyrite lode deposits where gold is not abundant or where there is no assay information on gold.

The abundance of arsenic in the belt, like gold, is best shown by a comparison with nearby regions. The southern Alaska Range area investigated by Reed and Elliott (1968; Elliott and Reed, 1968) is well mineralized and is characterized by high median concentrations of zinc, lead, and silver in stream sediments draining the area. Arsenic, however, was detected in only one of more than 500 samples that were collected in 1967 and analyzed in the same way as samples from the Chulitna-Yentna belt. In the northern Talkeetna Mountains, arsenic was detected in less than 1 percent of a group of 157 samples that were also analyzed by the same method.

Copper.—Copper minerals are found in many lode deposits in the northern part of the belt, native copper in placer concentrates in the southern part. And copper is present in anomalous amounts in stream sediments, particularly in the part of the belt north of the Hidden River. The median concentration of copper in stream-sediment samples from the Upper Chulitna district is approximately 70 ppm. This concentration is about twice the median of a group of 40 samples of unmineralized bedrock from the district and is higher than concentrations in most common rock types except basalt (Turekian and Wedepohl, 1961).

The map of copper distribution (pl. 2) shows two groups of lode occurrences; those where copper locally exceeds more than 5,000 ppm (0.5 percent) and those where it locally exceeds 1,000 ppm.

Tin.—Tin, a diagnostic element of the mineral belt, though not found as widely as gold or as abundantly as arsenic, copper, and zinc, occurs in greisen at one place on Ohio Creek, in arsenopyrite-bearing veins at Canyon Creek and Long Creek, and in much greater than normal abundance in several other deposits such as the Golden Zone and some granitic rocks of the belt. Cassiterite, a common and locally major constituent of the Yentna placers, may be very close to its primary source. This conclusion is suggested by the sharp crystalline outlines of the cassiterite grains found in concentrates from Poorman and Canyon Creeks (Mertie, 1919). Data on tin are summarized on plate 2 in three main categories: lode deposits; placer deposits, including stream-sediment anomalies; and intrusive rocks. As the tin content of most granite is only about 3 ppm or less (Turekian and Wedepohl, 1961), concentrations exceeding 15 ppm are considered to be anomalous. Rattigan (1963), Varsukov and Pavlenko (1956), and Sainsbury (1964) have pointed out that granites with associated tin deposits generally contain approximately 15 ppm or more tin. Tin is shown on plate 2 as a major element in lode deposits if its concentration exceeds 1,000 ppm, as a minor element if its concentration locally exceeds 500 ppm, and as detected if it locally exceeds 50 ppm.

Other metals.—Deposits of the belt are commonly enriched in antimony, bismuth, and silver, and locally in other metals, including cadmium, lead, tungsten, and zinc. Analyses of arsenic-rich veins of the Upper Chulitna district (Hawley and Clark, 1973, table 4) show that antimony, bismuth, and silver are ubiquitous components of such veins, and that antimony and bismuth are locally abundant enough to form discrete minerals. These same elements and tin are found, but generally in much lower concentration, in some disseminated deposits of the Upper Chulitna district (Hawley and Clark, 1973, table 5). Data on vein composition are much scarcer for in the Yentna district, but both antimony and bismuth are found in the arsenopyrite-quartz veins at the Rocky Cummins and Bird Creek prospects, along with gold, tin, and tungsten.

COMPARISON WITH SOME OTHER MINERAL BELTS

The Chulitna-Yentna mineral belt is similar to some well-known mineral belts in linearity and length, general relation to faults and igneous intrusives, tectonic position relative to the western Cordillera, and metal content.

Belts like the Front Range mineral belt (Colorado), the Idaho-Montana porphyry belt, and the Battle Mountain–Eureka belt (Jerome and Cook, 1967) are, like the Chulitna-Yentna belt, strongly linear and approximately 100 miles or more long. These belts contain clusters of igneous rocks, clusters of ore deposits, and intervening sparsely mineralized areas; they are localized essentially by fault structures that apparently extend deep into the crust.

The Chulitna-Yentna belt compares with two other well-known mineral belts — the Juneau gold belt (Spencer, 1906) and the Mother Lode belt (Knopf, 1929)—by its tectonic position on the flank of a mountain system. All the belts are on the ocean flank of a mountain system; the Chulitna-Yentna belt, in the Cordilleran Mountain system, is on the flank facing the Pacific Ocean. These belts have similar associations of igneous rocks, although serpentinite is apparently lacking in the Juneau gold belt. Rock types common to all three belts are gabbro, diorite, quartz diorite, and sodic granite or other late sodic differentiates. The metal suites are similar but do not correspond exactly. For example, arsenopyrite is the main metallic mineral of the Chulitna-Yentna belt, secondary after pyrite in the Mother Lode, and an important local constituent in the Juneau gold belt ores.

The Chulitna-Yentna belt contrasts with the Juneau gold and Mother Lode belts by being characterized by an association of rocks that are generally not metamorphosed, and by having a relatively greater abundance of metallic minerals contained in vein deposits as compared with quartz. Except for some poorly metallized quartz veins like those of the Blind Creek fault zone (Hawley and Clark, 1973, fig. 2), quartz veins are not characteristic of the Upper Chulitna district. Quartz veins are, however, abundant in parts of the Curry district (Tuck, 1934); they are believed to be abundant in the Yentna district where they are represented by the generally poorly exposed zones of crushed quartz and alteration minerals (Clark and Hawley, 1968).

The metal suite of the Chulitna-Yentna belt is strikingly similar to that of the Battle Mountain–Eureka mineral belt of Nevada (Roberts, 1966; Jerome and Cook, 1967). As shown by Wrucke, Armbrustmacher, and Hessin (1968) and by Erickson, Van Sickle, Nakagawa, McCarthy, and Leong (1966), gold deposits along the Nevada belt are characterized by arsenic, antimony, bismuth, cadmium, copper, mercury, lead, silver, tin, and tungsten. Arsenic is, perhaps, the most characteristic associate of gold (C. T. Wrucke, oral commun., 1969). These metals, with the possible exception of mercury, whose abundance is not known, are also characteristic of the Chulitna-Yentna mineral belt.

MINERAL RESOURCES AND GENERAL SUGGESTIONS FOR PROSPECTING

The value of the Chulitna-Yentna belt as a metal resource, based on geologic mapping and reconnaissance sampling, some drilling information, and past production, is at least several tens of millions of dollars. Geologically, the belt has potential for (1) vein and disseminated deposits in the belt of limestone and basalt, which contain occurrences at Partin and Canyon Creeks in the southern part of the Upper Chulitna district, (2) replacement deposits in volcanic units or limestones, (3) shear-zone deposits, and (4) breccia pipes in the northern part of the belt near the Golden Zone. Rocks favorable for replacement deposits, such as limestones and greenschists, are also present in the Curry district in the central part of the belt. Although the granite batholith that cuts across the belt in the Curry district generally is not favorable for prospecting, an enrichment of copper and molybdenum in widespread limonitic knots in the granite suggests that the metals could be enriched in certain environments such as the contact regions and cupolas. Anomalous concentrations of metals found in stream sediments collected in the Curry district between the Hidden River and Eldridge Glacier suggest that mineral deposits are more widely distributed in the central part of the belt than previously believed. In the Yentna district, the variety of placer deposits, together with the difficulty of finding bench or buried channel-type deposits in extensively alluviated terrain, suggests that undiscovered deposits exist in the area. A favorable locale for prospecting, as indicated by the gold content of stream-sediment samples, is along the northeast flank of the Peters Hills. Some of the small vein deposits of the Yentna district are locally rich enough in gold and tungsten to be exploited profitably if mined on a small scale.

The Chulitna-Yentna belt has produced gold valued at more than $7 million (at $35 per ounce) from the placer deposits of the Yentna district and more than $60,000 from lode deposits in the Upper Chulitna district. Although the highly productive Cache Creek basin of the Yentna district has been mined extensively, there are unmined bench and buried-channel deposits near Cache Creek and in lower Cache Creek. One deposit near Bird Creek has drilled reserves of more than $1 million; very likely there are other deposits whose approximate reserves are known by owners, but this information is not available. Because of the possibility of undiscovered placers along the east side of the Peters Hills and the multiple types and ages of placers, it is not unreasonable to assume that as much gold remains in the Yentna district as has been mined.

In the Upper Chulitna district, calculable resources are much greater than the known production. Fairly abundant assay data on the Golden Zone show that it is worth more than $10 million (Hawley and Clark, 1968). Ross (1933) and Thurmond (unpub. data, 1918) estimated reserves of about 10,000 tons and within the range $50,000 to about $200,000 on vein deposits of the Eagle and Ready Cash, respectively; and data from surface samples at other veins such as the East, and Little, and one vein at Partin Creek permit estimates of about the same order. Mining rocks with disseminated sulfides like those at Partin Creek and Canyon Creek along with the veins possibly is feasible and could lead to a manyfold increase in apparent estimated tonnage of the vein-type deposits.

The belt is believed to have some potential for the production of metallic commodities other than gold and silver. Tin is abundant enough in some vein deposits that it might be recovered as a byproduct; and other greisen deposits where tin is the principal commodity of value could be present in and near the Ohio Creek tin-bearing granite. Antimony, bismuth, and tungsten are locally abundant enough to be of economic interest.

The belt has some potential for deposits of chromium or nickel in and near ultramafic rocks, and the presence of ultramafic rocks in a belt with other intrusive rocks is geologically favorable for the formation of asbestos deposits in the serpentine.

Because of the relative scarcity of geologic data on the belt, the conclusions on mineral resources are speculative, but the dollar estimate given of metals as a resource is almost certainly of or below the right order of magnitude. It is uncertain how much of the metallic resource of the belt could be exploited at the present time. The authors believe that the belt is worth diligent prospecting and exploration.

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