UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

Mineralogical and geochemical maps showing the distribution of selected minerals and elements found in the minus-80-mesh stream-sediment and related minus-30-mesh heavy-mineral-concentrate samples from the Circle Quadrangle, Alaska

By

Richard B. Tripp, William D. Crim, James D. Hoffman,

Richard M. O'Leary, and Donald A. Risoli

Open-File Report 83-170 F *

This report is preliminary and has not been reviewed for conformity with U.S. Geological Survey editorial standards and stratigraphic nomenclature. Any use of trade names is for descriptive purposes only and does not imply endorsement by the USGS.

1986

* This report includes Open-File Reports 83-170G and H. All three reports have previously been referenced as individual reports.

CONTENTS

ILLUSTRATIONS

STUDIES RELATED TO AMRAP

The U.S. Geological Survey is required by the Alaskan National Interests Lands Conservation Act (Public Law 96-487, 1980) to survey certain Federal lands to determine their mineral values, if any. Results from the Alaskan Mineral Resource Assessment Program (AMRAP) must be made available to the public and be submitted to the President and the Congress. This report presents analytical results and some interpretation of a mineralogical and geochemical survey of the Circle quadrangle, Alaska.

INTRODUCTION

A reconnaissance mineralogical and geochemical survey using stream sediments was made in the Circle quadrangle during 1979 and 1980 to aid in the evaluation of its mineral potential.

The Circle quadrangle comprises about 6,090 mi^2 (15,800 km^2) in east-central Alaska, and lies about 47 mi (75 km) northeast of Fairbanks. Access within the Circle quadrangle to the sample sites was provided by helicopter with the exception of a few sites that were accessible by vehicle from the Steese Highway.

The geology of the Circle quadrangle is divided into three general areas: the largest is a complexly deformed, regionally metamorphosed terrane of mostly quartzitic and pelitic rocks south of the northwesterly trending Tintina fault zone; the second is the area north of the Tintina fault zone which consists mostly of folded Proterozoic(?) and (or) Paleozoic sedimentary rocks which are slightly metamorphosed. These sedimentary rocks are in probable thrust contact with mafic igneous rocks and associated chert of late Paleozoic and early Mesozoic age. Minor clastic deposits of probable Tertiary age occur in topographically low areas north of the southern margin of the Tintina fault zone. The third area consists of the northwestern part of the quadrangle and is comprised of folded and slightly metamorphosed Precambrian(?) and (or) Paleozoic sedimentary rocks, Mesozoic clastic rocks, and tuffs and tuffaceous sedimentary rocks of Paleozoic and (or) Mesozoic age.

The area south of the Tintina fault zone and the northwestern part of the quadrangle are intruded by granitic plutons which post-date regional metamorphism and associated deformation. The intrusions are composite and dominantly consist of peraluminous biotite granite. All three parts of the quadrangle have minor mafic and ultramafic rocks. The ultramafic rocks are mostly in fault contact with adjacent rocks. The individual formations and terranes have been described in more detail by Churkin and others (1982) and Foster and others (1983).

The topography south of the Tintina fault zone is mostly low to moderate mountainous relief with the average relief of 2,000 ft (610 m) and a maximum elevation of 5,286 ft (1,612 m, Mt. Prindle). North of the Tintina fault zone, the relief is predominantly lowland marshes with "islands" of low relief mountains up to maximum elevation of 3,728 ft (1,127 m, VABM craz, in the Crazy Mountains.

METHODS OF STUDY

Sample Media

Two sample types were collected, a stream-sediment sample from 875 sites and a panned, heavy-mineral-concentrate sample of stream sediment from 860 corresponding sites. The samples were collected primarily from active first-order (unbranched) and second-order (below the junction of two first-order) streams as determined from topographic maps (scale 1:63,360). The streams drain areas that range from approximately 4 to 13 km^2. This sampling survey was designed to relate geochemical anomalies to a specific drainage basin for targeting mineralized areas.

Preparation of the Sample Media

The stream-sediment samples and the attendant heavy-mineral-concentrate samples were obtained at each site by wet-sieving active alluvium through a stainless-steel screen with a mesh opening of 2 mm into a 14-inch steel gold pan. A small portion of the minus-2-mm material was saved for the stream-sediment sample and the remainder was panned to remove most of the quartz, feldspar, organic material, and clay-sized material. In the laboratory, the stream-sediment samples were air dried, then sieved using an 80-mesh (0.17-mm) stainless steel sieve. The minus-80-mesh fraction was then pulverized to at least minus-100-mesh and analyzed. The panned concentrate was air dried and sieved through a 30-mesh (0.12-mm) sieve. The minus-30-mesh fraction was further separated using bromoform to remove the remaining light minerals of a specific gravity less than 2.85. A nonmagnetic fraction of each sample was obtained using a Frantz Isodynamic Separator with a coil setting equivalent to 0.7 ampere and track settings equivalent to 5° forward slope and 10° side tilt. Relatively nonmagnetic fractions free of the dilutent minerals, magnetic iron oxides, garnet, amphibole, pyroxene, epidote, and other high-iron/low-magnesium silicates were obtained by this procedure. This magnetic separation reduces the interference from variations in composition of non-ore-related minerals permitting easier spectrographic detection of ore-related elements and facilitating visual identification of mineral grains.

Sample Analysis

Atomic-absorption spectroscopy (Ward and others, 1969) was used to determine gold and zinc and ultraviolet fluorometry (modification of Centanni and others, 1956) was used to determine uranium in the stream-sediment samples.

The stream sediment and the nonmagentic heavy-mineral-concentrate fraction were also analyzed for 31 elements using a semiquantitative, direct-current arc emission spectrographic method (Grimes and Marranzino, 1968). Spectrographic results were obtained by visual comparison of spectra derived from the sample against spectra obtained from standards made from pure oxides and carbonates. Standard concentrations are geometrically spaced over any given order of magnitude of concentration as follows: 100, 50, 20, 10, and so forth. Samples whose concentrations are estimated to fall between those values are assigned values of 70, 30, 15, and so forth. The precision of the analytical method is approximately plus or minus one reporting interval at the 83 percent confidence level and plus or minus two reporting intervals at the 96 percent confidence level (Motooka and Grimes, 1976). Values determined for all the elements plotted on the maps are given in parts per million (micrograms/gram). The spectrographic and chemical results are available in open-file report 86-204 (O'Leary and others, 1986).

The nonmagnetic heavy-mineral fraction was also scanned visually using a binocular microscope and shortwave ultraviolet light to identify ore and ore-related minerals. In most cases, the mineral grains could be identified from their physical properties, but x-ray diffraction was used to confirm some mineral species. This visual examination is an important supplement to the spectrographic analyses because the particulate nature of this sample medium poses problems for both the sample preparer and the analyst. A 5-milligram split of finely pulverized sample is used for spectrographic analysis, consequently, malleable minerals such as gold, silver, and copper may be poorly represented in the spectrographic sample. Another benefit of the visual examination is identifying artifacts such as bullet and solder fragments, wire, or other man-made contaminants. It is useful to be aware of these contaminants as they can give inflated values of the ore-related elements in the spectrographic results.

Mineral and geochemical results

This section of the report describes and delineates eight tracts of land which may contain mineral occurrences based on the mineralogy and chemistry of the stream sediments and their relationships to the stream basin geology. These tract areas are coincident with tracts described in Menzie and others (1983) and are shown in this report on a series of ten maps (scale 1:250,000) that includes mineralogical and chemical data, general geology, and topography.

Tract 1

Geochemical anomalies for beryllium, tin, tungsten, uranium, thorium, lanthanum, bismuth, molybdenum, silver, lead, and zinc were found in the stream-sediment samples collected within and adjacent to the Tertiary-Cretaceous peraluminous granite and the Paleozoic and (or) Precambrian grit and quartzite (Pzp Cgq) sequence in the Lime Peak (Rocky Mountain) area. An area of this tract has been explored and drilled for tin (Menzie and others, 1983).

Cassiterite and scheelite found in the heavy-mineral-concentrate samples show a strong distribution in this tract (pl. 1, map 1; pl. 2, map 4). In addition, the combined suite of minerals found in 22 samples include allanite, cyrtolite, fluorite, galena, monazite, sphalerite, tourmaline, and uranothorite.

Analyses of 22 heavy-mineral-concentrate samples show anomalous values for the elements Sn, W, Mo, Be, Bi, Cu, Pb, Zn, and Ba (pl. 3, maps 1,2; pl. 4, map 3).

Tract 2

Geochemical anomalies for tin, tungsten, beryllium, thorium, arsenic, bismuth, and copper were found in the sediment samples collected from streams draining the Tertiary-Cretaceous peraluminous granites and related tin vein/greisen areas (TKg) and the hornfelsed quartzitic schists (Pzp Cq) in the Mount Prindle area. Parts of this tract have been explored and staked (Menzie and others, 1983).

Distribution of cassiterite and scheelite found in the concentrate samples suggests that numerous tin vein and greisen occurrences may be found in this tract (pl. 1, map 1; pl. 2, map 4). Other minerals observed within and adjacent to this tract were gold, arsenopyrite, chalcopyrite, galena, sphalerite, fluorite, tourmaline, thorite, monazite, and allanite.

Analyses of 35 heavy-mineral-concentrate samples show anomalous values for the elements Sn, W, Be, Bi, Th, Ag, As, Cu, Ni, and Pb (pl. 3, maps 1,2; pl. 4, map 3). In addition, analyses of 36 minus-80-mesh stream-sediment samples show anomalous values for the elements Sn, W, Be, Ag, Th, La, U, and Ba.

Tract 3

Geochemical anomalies for tin, tungsten, molybdenum, gold, silver, arsenic, lead, bismuth, copper, nickel, antimony, and thorium were found in the stream-sediment samples collected within and adjacent to the Tertiary-Cretaceous felsic igneous rocks (TKf) and the Paleozoic and (or) Precambrian quartzitic schist (Pzp Cq) sequence in the Table Mountain area. Areas of this tract have been staked (Menzie and others, 1983).

A broad distribution of cassiterite and scheelite in the heavy-mineral concentrates indicates numerous tin vein/greisen and tungsten skarn occurrences within the tract (pl. 1, map 1; pl. 2, map 4). Other minerals observed in the concentrates were gold, arsenopyrite, galena, chalcopyrite, powellite, monazite, and allanite.

Analyses of 30 heavy-mineral-concentrate samples gave anomalous values for the elements Au, Sn, W, Mo, As, Sb, Pb, Bi, Cu, Ni, Co, and Th (pl. 3, maps 1,2; pl. 4, map 3). In addition, analyses of 30 minus-80-mesh stream-sediment samples show anomalous values for the elements Au, Ag, W, Mo, Cu, Ni, and Co (pl. 5, maps 1,2; pl. 6, map 3).

Tract 4

A spectacular mineralogical and geochemical trend showing gold, arsenic, antimony, lead, tin, and tungsten anomalies was found in the stream-sediment samples collected within and adjacent to the Tertiary-Cretaceous granites (TKg) and the Paleozoic and (or) Precambrian quartzitic schist (PzpCq) sequence in the Circle mining district. This tract contains many placer claims and most of the streams in the tract have been mined for gold (Menzie and others, 1983). Our stream-sediment survey indicated that much gold remains in the district in the minus-10-mesh size range. The abundance and distribution of cassiterite and scheelite within the tract also suggests that these minerals could be recoverable by-products of placering (pl. 1, maps 1,2; pl. 2, map 4). Other minerals of interest found in the concentrates include arsenopyrite, chalcopyrite, galena, and sphalerite (pl. 2, map 3). Trace amounts of fluorite, allanite, monazite, and stibnite showed sporadic distribution throughout the tract.

Analyses of 92 heavy-mineral-concentrate samples show anomalous values for the elements Ag, As, Au, Be, Bi, Mo, Pb, Sb, Sn, Th, W, Cu, and Zn (pl. 3, maps 1,2). Analytical data on 96 minus-80-mesh stream-sediment samples show a broad distribution of anomalous values for the elements Ag, Au, Cu, Pb, and Sn along with a lesser distribution of Be, La, Th, U, W, Zn, and Ni.

The gold anomalies are probably derived from several rock types: breccia pipes, small quartz-sulfide veins and associated felsic dikes cutting the quartzite and quartzitic schists, and disseminated sulfide zones within the quartzitic schist (PzpCq). In 1979, the senior author found a broad zone (about 250-ft wide) within the country rock containing several sulfide-bearing and intensely altered felsic dikes (?). These dikes are on the Steese Highway above Miller House at SW1/4, NE1/4, NE1/4 sec. 15, T. 8 N., R. 12 E.) The dikes contain up to 20% arsenopyrite by volume with crystals up to one inch imbedded in a chloritized and highly silicified matrix. Atomic absorption analysis of a bulk run rock sample gave 10 ppm Au. A small galena-quartz vein was also found in the area, the galena altering to cerussite and mimetite. Spectrographic analysis of the galena gave G5000 ppm tin and bismuth. Gold bearing arsenopyrite-pyrite zones within the quartzitic schist occur in the Miller Creek stream bed in SE1/4, SW1/4, NE1/4 sec. 15, T. 8 N., R. 12 E., and in a road cut on Discovery Gulch in SW1/4, NW1/4, NW1/4, sec. 6, T. 7 N., R. 14 E.

The anomalous tin and tungsten are probably derived from numerous small greisen zones within the Circle Hot Springs pluton and from intensely altered felsic dikes which cut both the granite and country rock. A vuggy felsic body (dike?) at SE1/4, SE1/4, SE1/4 sec. 9, T. 7 N., R. 15 E. was found to contain wulfenite ($PbMoO_4$) and a bulk analysis gave 100 ppm tin.

Tract 5

Geochemical anomalies for tin, tungsten, beryllium, thorium, uranium, lanthanum, silver, lead, and copper were found in the stream-sediment samples collected within and adjacent to the Tertiary-Cretaceous peraluminous granites (TKg) and the Paleozoic and (or) Precambrian quartzite and quartzitic schist (PzpCq) sequence in the Chena Hot Springs area. Placer claims have been worked within this tract (Menzie and others, 1983).

A broad distribution of cassiterite and scheelite found in the heavy-mineral concentrates is consistent with the possibility that the tract contains tin vein/greisen and tungsten skarn occurrences (pl. 1, map 2; pl. 2, map 4). Other minerals observed in the concentrate samples are tourmaline, powellite, and monazite. Analyses of 22 heavy-mineral-concentrate samples show anomalous values for the elements Sn, W, Be, Mo, Th, As, Pb, Zn, and Ba (pl. 3, maps 1,2; pl. 4, map 3). In addition, analyses of 22 minus-80-mesh stream-sediment samples show anomalous values for the elements Be, Mo, W, U, La, Ag, Pb, Cu, and Co (pl. 5, maps 1,2; pl. 6, map 3).

Tract 6

Geochemical anomalies for tungsten, tin, beryllium, bismuth, thorium, lanthanum, uranium, arsenic, zinc, lead, silver, nickel, cobalt, copper, and barium were found in the stream-sediment samples collected within and adjacent to the Tertiary-Cretaceous granite (TKg), the augen gneiss (Da), and the Paleozoic and (or) Precambrian pelitic schist (PzpCs). The tract contains several blocks of tungsten lode claims (appendix 2, Menzie and others, 1983).

A broad distribution of cassiterite and scheelite found in the heavy-mineral-concentrate samples suggests that numerous tin vein/greisen and tungsten skarn occurrences may be found in this relatively large tract (pl. 1, map 2; pl. 2, map 4). A lesser number of concentrate samples collectively contained allanite, thorite, monazite, gold, arsenopyrite, galena, and sphalerite.

Analyses of 150 heavy-mineral-concentrate samples show anomalous values for the elements Sn, W, Be, Th, Bi, Pb, Zn, As, Ni, Co, and Ba (pl. 3, maps 1,2; pl. 4, map 3). In addition, 151 minus-80-mesh stream-sediment samples were analyzed; some show anomalous values for the elements Sn, W, La, U, Th, Be, Ag, Ni, Co, Zn, Cu, and Ba (pl. 5, maps 1,2; pl. 6, map 3).

Tract 7

This tract is divided into 2 sections, the north and the south. The north tract contains a sequence of Paleozoic quartzite, meta-argillite and phyllite (Pzq). The mineral suite of 11 heavy-mineral-concentrate samples includes gold, scheelite, chalcopyrite, and sphalerite (pl. 1, map 1; pl. 2, maps 3,4). Barite also occurred in most samples. Both the stream-sediment samples and the heavy-mineral-concentrate samples collectively showed anomalous values for the elements Au, Ag, W, Co, Cu, Zn and Ba (pl. 3, map 2; pl. 4, map 3; pl. 5, map 1; pl. 6, map 3). The widespread occurrence of those anomalies suggests the possibility of shale-hosted mineral occurrences.

The south tract contains a sequence of Paleozoic phyllite and marble (Pzm) and some Paleozoic quartzite and meta-argillite (Pzq). Placer claims have been worked within this tract. The mineral suite of 25 heavy-mineral-concentrate samples includes gold, cassiterite, scheelite, arsenopyrite, galena, and sphalerite (pl. 1, maps 1,2; pl. 2, maps 3,4). Barite was also found in many of the samples. Analyses of the stream-sediment samples and the heavy-mineral-concentrate samples collectively show anomalous values for the elements Au, Ag, W, Sn, Cu, Pb, Zn, and Ba (pl. 2, map 1,2; pl. 3, map 3; pl. 5, maps 1,2; pl. 6, map 3). The assemblage of anomalous silver, lead, zinc, copper, and barium is consistent with the possibility of shale-hosted lead-zinc mineral occurrences within this tract.

Tract 8

Geochemical anomalies for zinc, lead, copper, silver, molybdenum, beryllium, bismuth, tungsten, thorium, nickel, tin, and barium were found in the stream-sediment samples collected within the Mesozoic-Paleozoic argillite, tuff, quartzite, and conglomerate (MzPzat) sequence.

Sphalerite and chalcopyrite found in the heavy-mineral-concentrate samples show a strong distribution within the tract (pl. 2, map 3). Galena and barite are also present in some samples. The presence of cassiterite and scheelite suggests the possibility of isolated tin veins and tungsten skarn in the tract.

Analyses of 20 heavy-mineral-concentrate samples show anomalous values for the elements Pb, Cu, Zn, Ni, Bi, Mo, Be, Sn, W, Th, and Ba (pl. 3, maps 1,2; pl. 4, map 3). In addition, analyses of 20 minus-80-mesh stream-sediment samples show values for the elements Cu, Zn, Ba, Sn, Ag, Mo, Be, and La (pl. 5, map 1; pl. 6, map 3).

SUMMARY

The stream-sediment survey, particularly the panned concentrate fraction, has proven to be an effective reconnaissance tool as shown by the data. These data show areas of known mineral occurrences which are well defined by the distribution of anomalous amounts of metals in the heavy-mineral concentrates. In addition, other areas of mineralization are indicated which may contain potentially economic mineral resources. More specifically, tracts 2, 3, and 4 and areas adjacent show a distribution of gold anomalies suggesting that these tracts may contain low grade disseminated deposits in country rock, in small veins, crushed zones or saddle reefs.

Tracts 1-6 show a strong distribution of cassiterite suggesting numerous occurrences of tin veins, greisen deposits or disseminations within the Tertiary-Cretaceous granite. The cassiterite found in tract 8 may be derived from local tuffs or may be from unknown tin veins. These tracts also contain an ubiquitous distribution of scheelite suggesting numerous occurrences of skarn tungsten deposits.

The geochemical distribution of beryllium in tracts 1, 2, 4, 5, and 6 indicates the presence of the peraluminous granites with the potential of beryllium-bearing pegmatites and (or) hydrothermal veins.

Tracts 1, 2, 4, 5, and 6 show a strong distribution of uranium and thorium anomalies suggesting mineral occurrences associated with the peraluminous granites.

Shale-hosted lead-zinc occurrences are possible within tracts 7 and 8 as they show mineralogical and geochemical anomalies for these elements.

REFERENCES CITED

Centanni, F. A., Ross, A. M., and DeSesa, M. A., 1956, Fluorometric determination of uranium: Analytical Chemistry, v. 28, p. 1651.

Churkin, Michael, Jr., Foster, H. L., Chapman, R. M., and Weber, F. R., 1982, Terranes and suture zones in east-central Alaska: Journal of Geophysical Research, v. 87, no. B5, p. 3718-3730.

Foster, H. L., Laird, Jo, Keith, T. E. C., Cushing, G. W., and Menzie, W. D., 1983, Preliminary geologic map of the Circle quadrangle, Alaska: U.S. Geological Survey Open-File Report 83-170-A, 30 p.

Grimes, D. J., and Marranzino, A. P., 1968, Direct-current arc and alternating-current spark emission spectrographic field methods for the semiquantitative analysis of geologic materials: U.S. Geological Survey Circular 591, 6 p.

Menzie, W. D., Foster, H. L., Tripp, R. B., and Yeend, W. E., 1983, Mineral resource assessment of the Circle quadrangle, Alaska: U.S. Geological Survey Open-File Report 83-170-B, 57 p.

Motooka, J. M., and Grimes, D. J., 1976, Analytical precision of one-sixth order semiquantitative spectrographic analyses: U.S. Geological Survey Circular 738, 25 p.

O'Leary, Richard M., Hoffman, James D., Risoli, Donald A., and Tripp, Richard B., 1986, Analytical results and sample locality map of stream-sediment and heavy-mineral-concentrate samples from the Circle quadrangle, Alaska: U.S. Geological Survey Open-File Report 86-204, 124 p.

Ward, F. N., Nakagawa, H. M., Harms, T. F., and Van Sickle, G. H., 1969, Atomic-absorption methods useful in geochemical exploration: U.S. Geological Survey Bulletin 1289, 45 p.