



STUDIES RELATED TO AMRAP The U.S. Geological Survey is required by the Alaska National Interest Lands Conservation Act (ANILCA, Public Law 96-487, 1980) to survey Federal Lands to determine their mineral resource potential. Results from the Alaska Mineral Resource Assessment Program (AMRAP) must be made available to the public and be submitted to the President and the Congress. This report presents the results of a geochemical study of streamsediment samples collected from the southern part of the Chandler Lake quadrangle, Alaska.

INTRODUCTION The Chandler Lake quadrangle is located in the central part of the Brooks Range and Arctic foothills provinces of northern Alaska (fig. 1). A geochemical investigation of the Chandler Lake quadrangle has been under way since 1981 as part of the Alaska Mineral Resource Assessment Program. The purpose of the survey was to define geochemical variations within the quadrangle and locate areas favorable for mineralization. Unconsolidated stream sediments, nonmagnetic heavy-mineral concentrates derived from the stream sediments, and rock samples were used for the study. This report presents an interpretation of geochemical data from stream-sediment samples collected from the southern part of the Chandler Lake quadrangle. It is one of a series of three reports that graphically present selected geochemical data in map format. Other reports in the series include an interpretation of geochemical and mineralogical data from nonmagnetic heavy-mineral concentrate samples collected from the southern part of the Chandler Lake quadrangle (Kelley and others, 1993b), and of stream- and lake-sediment data collected from the northern part of the Chandler Lake quadrangle as part of the National Uranium Resource Evaluation (NURE) program (Kelley and

Sutley, 1993). A comprehensive report on the mineral resource assessment

of the quadrangle is also currently underway (S.E. Church and others, written

GENERALIZED GEOLOGY The southern boundary of the Chandler Lake quadrangle, which lies south of the Brooks Range continental divide, is within the Brooks Range Province of Wahrhaftig (1965) (fig. 1). The northern and southern foothills areas of the Arctic Foothills Province comprise the northern two-thirds of the

communication, 1992).

Map A shows the generalized geology of the Chandler Lake quadrangle (Kelley, 1990). The southern part of the quadrangle is comprised of unmetamorphosed to weakly metamorphosed sedimentary rocks that are folded and thrust-faulted (Brosgé and others, 1979). The Upper Devonian Hunt Fork Shale, as described by Brosgé and others (1979), includes two members: the wacke member consists of gray-green wacke interbedded with shale, siltstone, and sandstone, and the shale member consists of dark-gray and olive shale interbedded with brown-weathering calcareous siltstone and fine-grained sandstone. Both members represent deposition in a marine environment (Brosgé and others, 1979). Marine strata of the Hunt Fork Shale are overlain by the marine Noatak Sandstone, which in turn is overlain by a nonmarine sequence

belonging to the Upper Devonian and Lower Mississippian(?) Kanayut Conglomerate (Nilsen and Moore, 1984). The Kanayut Conglomerate is as thick as 2,600 m and extends across the Brooks Range for more than 800 km from east to west (Nilsen and Moore, 1984). The Kanayut Conglomerate contains a coarse middle part of interbedded conglomerate and sandstone, and

upper and lower parts consisting of sandstone, siltstone, and shale. conglomerate contains clasts of chert, quartz, quartzite, and argillite (Brosgé and others, 1979; Nilsen and others, 1981). Sedimentary features in the

Kanayut Conglomerate indicate that deposition occurred in a deltaic environment with chert-rich source areas to the north and northeast (Nilsen and others, 1981). The Hunt Fork Shale-Kanayut Conglomerate sequence represents a southward- or southwestward-prograding deltaic complex; the coarse deltaplain deposits of the Kanayut grade downward into the marine sandstone of the Noatak Sandstone, the wacke member of the Hunt Fork Shale, and the prodelta shales of the lower part of the Hunt Fork Shale (Nilsen and Moore 1984). The Kanayut Conglomerate, therefore, forms the fluvial part of the delta that prograded to the southwest during the Late Devonian and retreated during the Late Devonian and Early Mississippian(?) (Nilsen and others, Overlying the Kanayut Conglomerate are fossiliferous marine strata

of the Lower Mississippian Kayak Shale that consist of shale, siltstone, and shaly sandstone interbedded with argillaceous and ferruginous limestone (Brosgé and others, 1979). The Mississippian Lisburne Group (Patton and Tailleur, 1964) overlies the Kayak Shale and consists primarily of medium- to light-gray limestone and dolomite with dark-gray phosphatic limestone, shaly limestone, chert, and shale. The Permian Siksikpuk Formation disconformably overlies Lisburne Group carbonate rocks. The Siksikpuk Formation has been subdivided into four lithostratigraphic subunits (Siok, 1985); the subunits consist of a lower gray to greenish-gray pyritic siltstone, greenish-gray to maroon mottled mudstone and siltstone, greenish-gray silicified mudstone or chert, and an upper gray shaly horizon. The lowermost units weather orange and yellow because of alteration of pyrite to jarosite (Siok, 1985). The greenish-gray to

maroon siltstone and mudstone locally contain barite lenses and nodules. The lithostratigraphic sequence of the Siksikpuk Formation is consistent throughout the Killik River quadrangle to the west and throughout the western part of the Chandler Lake quadrangle (C. G. Mull, written commun., 1987). However, in the eastern part of the Chandler Lake quadrangle, the unit consists mostly of shale and lacks a consistent chert Overlying the Siksikpuk Formation is the Lower Triassic to Middle Jurassic Otuk Formation, which consists of dark-gray and greenish-gray marine shale, dark-gray to black chert, and impure limestone interbedded with dark-gray and black shale (Mull and others, 1982). The chert beds typically weather brown or green. As with the Siksikpuk Formation, the Otul Formation becomes less cherty in the eastern part of the quadrangle; the unit

here is more characteristic of the Triassic Shublik Formation, which consists of primarily shale and impure limestone (Patton and Tailleur, 1964). The Otuk is distinguished from the underlying Siksikpuk Formation by the color and weathering characteristics of the chert and shale (Mull and others, 1982). The Hunt Fork Shale, Noatak Sandstone, Kanayut Conglomerate Kayak Shale, Lisburne Group, and Siksikpuk and Otuk Formations, which form the mountains and the mountain front, comprise the Endicott Mountains allochthon, the structurally lowest allochthon in the central Brooks Range (Mull, 1982). North of the Endicott Mountains front is the southern foothills belt, which consists of primarily Mississippian to Lower Cretaceous rocks referred to by Kelley (1990) as the Arctic Foothills assemblage (map A). The assemblage consists of Lower Cretaceous coquinoid limestone, undivided

Upper Jurassic and Cretaceous strata, Jurassic mafic igneous rocks, Permian and Triassic chert, rocks of the Nuka Formation (Mississippian and Pennsylvanian?), marble, and melange.

Most of the Arctic Foothills assemblage probably is structurally repeated, complexly deformed, and tectonically disrupted (Kelley, 1990). The complexly deformed rocks are overlain by gently folded shale, graywacke, and conglomerate of the Lower Cretaceous Fortress Mountain Formation (restricted). The west-central part of the quadrangle is underlain by a thick sequence of nonresistant and tightly folded marine shale, mudstone, siltstone, and thin-bedded sandstone of the Lower Cretaceous Torok Formation (Detterman and others, 1963). The northern foothills area contains gently deformed sedimentary rocks of the Nanushuk Group (Detterman and others, 1963; Huffman, 1989), which consists of the Lower Cretaceous Tuktu and Grandstand Formations,

the Lower and Upper Cretaceous Chandler Formation, and the Upper Cretaceous Ninuluk Formation. These sedimentary rocks represent a deltaic complex composed of interbedded conglomerate, sandstone, and shale, which were derived from the Brooks Range and prograded northward and eastward into the Colville trough (Mull, 1982). This clastic wedge is folded into a series of long, linear, east-west-trending anticlines and synclines. Overlying the Nanushuk Group in the northern Chandler Lake quadrangle are relatively small exposures of Upper Cretaceous sedimentary rocks preserved in the axes of regional synclines. These rocks consist of marine shale, siltstone, sandstone, bentonite, and tuff of the Upper Cretaceous Seabee and Schrader Bluff Formations separated by the thin nonmarine sandstone and conglomerate of the Prince Creek Formation (Detterman and

Map A shows the localities of stream-sediment samples collected from the southern part of the Chandler Lake quadrangle. A total of 330 stream-sediment samples were collected and analyzed. Minus-30-mesh stream-sediment samples were collected in the southwestern part of the quadrangle (Barton and others, 1982) to be consistent with geochemical surveys conducted in the Killik River and Howard Pass quadrangles to the west, which included collection of minus-30-mesh stream-sediment samples (Theobald and others, 1978). Minus-80-mesh stream-sediment samples were collected in the southeast part of the quadrangle to be consistent with minus-80-mesh stream-sediment samples collected from the Wiseman quadrangle to the south (Cathrall and others, 1987). Sample sites were selected on first- and second-order drainages shown on 1:63,360-scale topographic maps, or on 1:250,000-scale topographic maps in areas where the larger scale maps were nonexistent. Where possible several grab samples were collected along 7.5 m of active alluvium and composited into a single sample. Each bulk sample was passed through a 2.0 mm (10-mesh) screen to remove coarse material. The stream-sediment

samples were air-dried, then sieved using either 30-mesh or 80-mesh stainless

steel sieves. The minus-30-mesh and minus-80-mesh fractions were pulverized

to approximately minus-150 mesh. A 10-mg sample was analyzed for 31

elements using a direct-current arc emission spectrographic method (Grimes

and Marranzino, 1968). The semiquantitative spectrographic results are

reported as one of six steps per order of magnitude (1, 0.7, 0.5, 0.3, 0.2, 0.1)

of the concentration ranges. The precision of the analytical method is

and multiples of these numbers) and the values are the approximate midpoints

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). The stream-sediment samples were also analyzed by atomic absorption spectrography for Au, As, Cd, Sb, and Zn. A complete listing of the stream-sediment geochemical data collected from the Chandler Lake quadrangle is given in Barton and others (1982) and

STATISTICAL SUMMARY

stream-sediment samples were treated as independent data sets because the

The geochemical data for minus-30-mesh and minus-80-mesh

68° SURVEY PASS WISEMAN CHANDALAR 153° 150°

Sutley and others (1984).

variation in concentration of most elements was different between the two sample media. We have included univariate statistics of both geochemical data sets in table 1. The elements Bi, Sn, Th, and W were not detected in any of the samples and were not included. The lower limits of determination for these elements are 10, 10, 100, and 50 ppm, respectively. In addition, gold was not detected in any of the samples, either by emission spectrographic analysis (lower limit = 10 ppm) or by atomic absorption spectrometry (lower limit = 0.05 ppm). Qualified values are those that are not detected (N), below the lower limit of determination (L), and those above the upper limit of determination (G). The detection ratio (DR) is the number of samples with unqualified values (determinant values) divided by the total number of samples analyzed. For instance, a detection ratio of 1.0 indicates that all samples yielded unqualified values for a particular element. Conversely, a detection ratio of 0.10 indicates that only 10 percent of the samples yielded unqualified values of a given element. Prior to calculation of the geometric mean and deviation, values qualified with "N" were set equal to one-quarter the lower limit of determination; those qualified with "L" were set equal to one-half the lower limit of determination; those with "G" were set equal to twice the upper limit of determination. Only elements with a detection ratio of 0.3 or higher were used in the calculations. After log-transformation of the data, histograms were constructed for the relatively uncensored elements. Geochemical anomalies were interpreted from the study of the histograms. If the distribution is approximately normal, the high background-possible anomaly boundary is commonly defined as the mean plus two standard deviations (Rose and others, 1979). If the distribution is bimodal or unclear, arbitrary boundaries are selected based on geologic and geochemical criteria. Where rock geochemical data are available to establish the average or background values in a particular drainage basin (or basins), the boundary for the stream-sediment data is chosen so that it is close to those values. In general, we used a combination of the above criteria in determining the boundaries between background and anomaly.

DISCUSSION OF GEOCHEMICAL DATA Because stream-sediment samples represent all rock types that exist in the drainage basin upstream from the sample site, it is important to determine the average abundance of elements in each lithologic unit. Table 2 lists the average abundance of trace elements in shale and limestone (modified from Levinson, 1974). Data for rock samples collected from specific locations in the southern Chandler Lake quadrangle collected during this study are given in table 3. The distribution of samples that contain high concentrations of Ag, As, Ba, Cd, Co, Cr, Cu, Mo, Mn, Ni, Pb, and Zn are shown on maps B through D. Element concentrations in minus-30-mesh stream-sediment

samples are plotted as square symbols and those in minus-80-mesh streamsediment samples are plotted as circles. Four general areas are defined by high concentrations of one or more of these elements: (A) the western part of the quadrangle along the rangefront and east to the area between Cobblestone and May Creeks (T. 12 S., R. 7 E. to R. 8 E.), (B) the Oolah Mountain (T. 15 S. to T. 16 S., R. 8 E. to R. 9 E.) and the Grizzly Creek area (T. 16 S., R. 5 E. to R. 6 E.), (C) the Three River Mountain and Inukpasugruk Creek area (T. 16 S., R. 2 E.), and (D) Ekokpuk Creek in the

southwestern part of the quadrangle (T. 16 S., R. 2 W. to R. 4 W.). Area A contains primarily Mississippian to Lower Cretaceous rocks of the Arctic Foothills assemblage (Kelley, 1990), which consists of limestone, chert, mafic igneous rocks, and melange. Many of the basins also drain the mountainous areas comprised of Lisburne Group carbonate rocks, and shale, siltstone, and chert of the Siksikpuk, Shublik, and Otuk Formations. Stream-sediment samples collected from area A contain high concentrations of Ba (1,000 ppm to >5,000 ppm), Mo (5-10 ppm), and Mn (1,000-5,000 ppm) (map B). Anomalous concentrations of Cd (1.7 ppm to 8 ppm) and Zn (160 ppm to 380 ppm) also characterize many of the samples collected from area A (map C). The high Ba, Cd, Mo, Mn, and Zn concentrations in the stream-sediment samples from area A are higher than the average concentrations in either limestone or shale (table 2). With the exception of one sample that was collected along the western border of the quadrangle containing 300 ppm Cu (T. 12 S., R. 4 W.), Cu and Pb concentrations in the sediment samples collected from area A probably reflect average concentrations of these elements in shale (map C) Concentrations of Cu in stream-sediment samples are mostly less than 50 ppm and those of Pb are less than or equal to 30 ppm. The average Cu and Pb concentrations in shale are 20 ppm and 50 ppm, respectively (table 2). Silver concentrations (0.5 ppm to 1.0 ppm) in samples collected from area A may also be interpreted as the result of high background concentrations in shale and limestone. However, three minus-30-mesh sediment samples collected from the western part of area A contain >1 ppm Ag, which may indicate the presence of mineralized rocks. Nonmagnetic heavy-mineral-concentrate samples that were collected

in the eastern part of area A from the same sites as the geochemically anomalous stream-sediment samples contain abundant barite and pyrite, with or without trace amounts of galena and (or) sphalerite (Kelley and others, 1993b). Although nonmagnetic heavy-mineral-concentrate data are not available for the western part of area A, we interpret many of the high concentrations of metals in the stream-sediment samples to indicate the presence of barite and sulfide minerals in that area as well. There are several possible sources for the barite and pyrite. Throughout the Brooks Range, barite is commonly present in the Permian Siksikpuk Formation (Mull and others, 1987), and in the Howard Pass quadrangle west of the Chandler Lake quadrangle it is also present as localized concentrations in carbonate rocks and chert of Mississippian age (J.S. Kelley, written commun., 1992). Within the Chandler Lake quadrangle, the only reported barite occurrences are nodules, veins, and clots of euhedral barite within the Siksikpuk Formation (Siok, 1985). The deposition of this barite probably occurred when Ba-rich basinal fluids, possibly associated with oil generation in the underlying Lisburne Group, migrated up-section through the Siksikpuk Formation and precipitated barite in red siltstone when the Ba-

rich fluids encountered interstitial sea water and oxidizing conditions (Siok, Pyrite is present in several lithologic units. Large euhedral pyrite crystals and disseminated framboids of pyrite are present in the lowermost subunit of the Siksikpuk Formation (Siok, 1985). In addition, the Otuk Formation includes black pyritic shale (Bodnar, 1984). Disseminated pyrite was also observed in fine- to medium-grained sandstone of the Kanayut Conglomerate at Thibodeaux Mountain (Duttweiler, 1986). Geochemical analyses of these rocks are reported in table 3 (sample numbers

AKD400-AKD402). Minus-80-mesh stream-sediment samples collected from the eastern part of area B near Oolah Mountain (T. 15 S., R. 9 E.) contain 150-300 ppm Cr, 50-100 ppm Cu, 70 ppm Ni, 50-70 ppm Pb, and less than 140 ppm Zr (maps B-D). Unmineralized shale and siltstone samples from the Oolah Mountain area contain 500 ppm Ba, 100 ppm Co, 100 ppm Cr, 50-70 ppm Cu, 50-70 ppm Ni, 20 ppm Pb, and 120-180 ppm Zn (samples CL773R2 and CL773R3, table 3). These data suggest that the concentrations of these elements in the stream-sediment samples are due primarily to high background concentrations in the shale and siltstone of this area. However, sphalerite, galena, pyrite, arsenopyrite, chalcopyrite, and barite observed in nonmagnetic heavy-mineral-concentrate samples collected from the Oolah Mountain area (Kelley and others, 1993b) suggest that sulfide minerals are locally abundant and are probably responsible for the higher concentrations of Cu, Ni, and Pb in the sediment samples. Additional field evaluation of the geochemical anomalies on the

northeast side of Oolah Mountain revealed numerous quartz-calcite veins hosted by the shale member of the Hunt Fork Shale and a sandy unit of the Kanayut Conglomerate. The veins do not seem to be localized in shear zones or systematically related to any major structural features. Pyrite (mostly oxidized) and minor chalcopyrite were the only sulfide minerals observed in the veins. However, because of the presence of sphalerite, galena, and arsenopyrite in heavy-mineral-concentrate samples collected from this area, we infer that sparse occurrences of sulfide minerals in addition to pyrite and chalcopyrite may be present in the veins. Minus-80-mesh stream-sediment samples collected in the western part of area B at the headwaters of Grizzly Creek and west to Kenunga Creek (T. 16 S., R. 6 E. to T. 16 S., R. 5 E.) contain 150-200 ppm Cr, 50 ppm Cu, and 160-200 ppm Zn. Sulfide minerals, particularly pale-yellow sphalerite and pyrite, are widely distributed in heavy-mineral-concentrate samples (Kelley and others, 1993b). Samples of unmineralized sandstone and conglomerate of the Kanayut Conglomerate collected from these areas contain 70-100 ppm Ba, 15-20 ppm Co, 15-100 ppm Cr, 15-20 ppm Pb, and 35-150 ppm Zn (sample numbers CL731, AKD450, AKD455, AKD457, AKD458, and AKD460; table 3). Disseminated pyrite is present in the strata of either the lower part of the Kanayut(?) Conglomerate or the Naotak(?) Sandstone; oxidation of the pyrite resulted in discontinuous red-weathering layers. Several samples containing disseminated sulfide minerals were crushed, sieved, and panned to obtain heavy-mineralconcentrate samples from the bulk rocks; pyrite and traces of arsenopyrite were the only sulfides observed. In addition to the sulfides disseminated in sandstone and conglomerate, small polymetallic quartz-calcite veins in siltstone and shale have been observed at the headwaters of Grizzly Creek (Duttweiler, 1986). The veins are similar to those at Oolah Mountain, except that trace

amounts of sphalerite and galena are present (in addition to pyrite) in a gangue of quartz, calcite, and siderite. The vein samples contain as much as 200 ppm Zn, but concentrations of the other base metals are low (table 3). The discontinuity of the veins in area B and the presence of sparse disseminations of pyrite within the lower part of the Kanayut Conglomerate leads us to speculate that the veins and sulfide occurrences are a result of diagenesis or dewatering of the Hunt Fork Shale. The thick and porous strata of the overlying Kanayut Conglomerate are excellent host rocks for upward-migrating fluids derived from compaction of the Hunt Fork Shale.

Anomalous concentrations of Cd (5.1-7.5 ppm), Cr (300 ppm), Ni (200 ppm), and Zn (as much as 900 ppm) are common in stream-sediment samples collected from the headwaters of Inukpasugruk Creek (T. 16 S., R. 1 E.), and from tributaries west of Three River Mountain (T. 16 S., R. 2 E.). High concentrations of Ag (0.7 ppm), Ba (>5,000 ppm), Co (50-70 ppm), Cu (50-100 ppm), Mn (>1,000 ppm), and Pb (50-200 ppm) are present in some samples with the anomalous Cd, Cr, Ni, and Zn (maps C and D). Corresponding nonmagnetic heavy-mineral-concentrate samples contain pyrite, chalcopyrite, and sphalerite (Kelley and others, 1993b). Although veins such as those at Grizzly Creek and Oolah Mountain were not observed in area C, occurrences of disseminated pyrite in strata of the Kanayut Conglomerate are widespread. As was suggested for area B, this pyrite probably formed during compaction and diagenesis of the underlying Hunt Fork Shale. The abundant pyrite may be the source of some of the anomalous concentrations of Ag, Co, Cu, and Ni in the stream-sediment samples. One sample (AKD431; table 3) of the Kanayut Conglomerate containing disseminated pyrite contains 2,000 ppm Ba, 4 ppm Cd, 100 ppm Cu, and 200 ppm Zn. Although chalcopyrite, sphalerite, and barite were not observed in this sample, the geochemical data suggest that they may be present along with the pyrite.

Many stream-sediment samples collected from tributaries of Ekokpuk Creek in area D (T. 16 S., R. 4 W.) contain relatively high concentrations of Ba (>5,000 ppm), Cd (4.9-10 ppm), Co (50-70 ppm), Cr (200-300 ppm), Cu (50-100 ppm), Mn (1,500-2,000 ppm), Pb (70-150 ppm), and Zn (as much as 900 ppm) (maps B-D). Unlike most stream-sediment samples collected in the Chandler Lake quadrangle that contain low concentrations of As and Sb (mostly less than lower detection limits of 10 ppm and 1 ppm, respectively), the stream-sediment samples collected in area D contain high concentrations of As (15-25 ppm) and Sb (1-2 ppm), in addition to the anomalous concentrations of Ba, Cd, Co, Cr, Mn, Pb, and Zn. Although there are no nonmagnetic heavy-mineral-concentrate data from area D to confirm mineralogy, the strong correlation between Cd and Zn, and the anomalous concentrations of Ba, Co, and Pb in the stream-sediment samples suggests the presence of barite and sulfide minerals. The stratigraphic sequence at Ekokpuk Creek consists of siltstone and shale of the Permian Siksikpuk Formation and Lower Mississippian Kayak

Shale, dark-gray to black chert of Mississippian age, and sandstone and conglomerate of the Upper Devonian and Lower Mississippian(?) Kanayut Conglomerate. Although not mapped as the Kuna Formation by Kelley (1990), the dark-gray to black chert facies (unit Mawc; map A) was originally mapped as the Kuna Formation of the Lisburne Group by Brosgé and others (1979). The rocks of the Kuna Formation host the Ag-Ba-Pb-Zn deposit at Red Dog Creek in the Delong Mountains (Moore and others, 1986).

Rock samples were collected across the Mississippian and Permian section at Ekokpuk Creek; results of the analyses are included in table 3 Black shale (locally pyritic) of the Kayak Shale contains 300-500 ppm Ba, 20-30 ppm Co, 150 ppm Cr, 70-100 ppm Cu, 100-150 ppm Ni, 15-30 ppm Pb and 100-130 ppm Zn (samples AKD405, AKD408, AKD410). Although not shown on table 3, As concentrations in these samples range from 10 ppm to 20 ppm. Gray to black chert contains relatively lower concentrations of all of these elements (samples AKD420-AKD422). Likewise, the Siksikpuk Formation contains relatively low concentrations of all elements except Ba, which ranges from 700 ppm to 5,000 ppm (samples AKD423-AKD428). The high concentrations of many of the metals in the stream-sedimen samples collected from area D may, in part, reflect relatively high background concentrations in shale, siltstone, and chert. However, some of the highest concentrations of Cd, Pb, and Zn may also indicate the presence of

base-metal-sulfide mineral occurrences. The As-Ba-Cd-Mn-Pb-Sb-Zn geochemical association is also prevalent in samples collected from an area located in the adjacent Killik River quadrangle that extends northwestward from area D. High As (5,000 ppm) and Sb (500 ppm) concentrations were reported in two samples that were collected from drainage basins whose source areas are located in the Chandler Lake quadrangle (Kelley and others, 1993a). In addition, Cathrall and others (1987) reported anomalous concentrations of Pb and Zn at a site located due

south of area D in the northwestern part of the Wiseman quadrangle. They observed numerous quartz veins that are locally Pb- and Zn-rich. CONCLUSIONS The geochemical data of minus-80-mesh and minus-30-mesh streamsediment samples collected from the southern part of the Chandler Lake quadrangle suggest that there are four areas that may be mineralized. The samples collected in area A are characterized by high concentrations of Ag, Ba, Cd, Mn, Mo, and Zn. These samples were collected from drainage basins underlain largely by carbonate rocks, shale, and siltstone. The anomalous concentrations of these elements may indicate the presence of bedded barite and (or) sediment-hosted Ag-Ba-Zn mineral occurrences.

Samples collected from areas B and C contain high concentrations of Cd, Co, Cu, Cr, Ni, Pb, and Zn. Pyrite is disseminated in strata of either the lower part of the Kanayut Conglomerate or the Noatak Sandstone; oxidation of the pyrite resulted in discontinuous red-weathering layers in these rocks. Although only pyrite and minor arsenopyrite have been observed in these layers, relatively high concentrations of Ba, Cd, Cu, and Zn in some of the samples suggest that other minerals, such as barite, chalcopyrite, and sphalerite, may be present. In addition to the disseminated sulfide minerals, area B is characterized by numerous discontinuous quartz-carbonate veins within the Hunt Fork Shale and sandstone of the Kanayut Conglomerate. Some of these veins contain small amounts of one or all of the following sulfide minerals: sphalerite, galena, chalcopyrite, and pyrite. The veins probably formed during compaction and diagenesis of the Hunt Fork Shale. Stream-sediment samples collected from the tributaries of Ekokpuk Creek in area D contain high concentrations of As, Ba, Cd, Mn, Pb, Sb, and Zn. The geochemistry of these samples is similar to that of samples collected from area A, except that samples from this area do not contain detectable Ag, and As concentrations are relatively high. The geochemistry of the stream-sediment samples collected from this area possibly indicates the presence of sulfide-mineral and barite occurrences similar to other shale- and chert-hosted base-metal deposits in the western Brooks Range.

Dk; conglomerate with quartz veining CL783 CL728 CL731 Dk; conglomerate with disseminated pyrite 68 05 38 k; medium-grained sandstone with pyrite Dk; conglomerate AKD445 AKD446 AKD447 AKD450 AKD451 AKD453 AKD454 AKD455 AKD457 AKD458 AKD460 Green sandstone with pyrite Green sandstone with pyrite Quartz veins; minor pyrite and sphalerite conglomerate with disseminated pyrit Medium-grained sandstone with pyrit Medium-grained sandstone with pyrite Medium-grained sandstone with pyrit 150 57 40 150 57 40 CL770 CL771 CL773R1 150 03 30 150 06 10 Dk; conglomerate with disseminated pyrit Mountain Shale-siltstone with oxidized pyrite CL773R2 CL773R3 CL773R5 CL773R6 CL773R7 Red-brown shale Silicified sandstone Dk; sandstone Shale-siltstone Quartz veining Medium-grained sandstone with pyrite Medium-grained sandstone with veins Three River Mountain, AKD431 Sandstone or conglometate with pyrite Green sandstone with pyrite Green sandstone with pyrite Dk: oxidized pyrite AKD443 Ekokpuk Creek Mk: black shale AKD410 AKD413 AKD416 Mawc: black cher AKD420 Mawc; chert, quartz vei Ps; shale/siltstone

Table 3. Concentrations of selected elements in rock samples

Thibodeaux

Mountain Area

AREA B Grizzly

Table 2. Average abundance of selected trace elements in shale and limestone (modified

per million. ---, no data]

from Levinson, 1974, p. 43) [all values in parts

Creek Area

[N, not detected: <, less than the lower limit of determination; NA, not analyzed. For locations of rock samples, see index map

150 08 00

150 24 05

150 24 05

M.S. thesis, 232 p.

303-E, 323 p.

79-1224, scale 1:200,000.

U.S. Geological Survey Open-File Report 87-12, 67 P.

Grimes, D.J., and Marranzino, A.P., 1968, Direct-current arc and

alternating-current spark emission spectrographic field methods for

the southern part of the Killik River quadrangle, Alaska:

elements in sediment samples from the northern part of the Chandler

Lake quadrangle, Alaska: U.S. Geological Survey Miscellaneous

of selected elements and mineralogy of nonmagnetic heavy-mineral-

concentrate samples from the southern part of the Chandler Lake

quadrangle: U.S. Geological Survey Miscellaneous Field Studies Map

Miscellaneous Field Studies Map MF-2225-D, scale 1:250,000.

Kelley, K.D., and Sutley, S.J., 1993, Maps showing distribution of selected

Kelley, K.D., Sutley, S.J., and Frisken, J.G., 1993b, Maps showing distribution

Field Studies Map MF-2144-D, scale 1:250,000.

MF-2144-B, scale 1:250,000.

Geological Survey Circular 978, p. 10-13.

Geological Survey Circular 998, p. 27-30.

Survey Circular 591, 6 p.

¹ zinc analyzed by atomic absorption method; analysis for all other elements are by emission spectrographic method.

INDEX MAP SHOWING LOCALITIES OF ROCK SAMPLES LISTED IN TABLE 3

REFERENCES Levinson, A.A., 1974, Introduction to exploration geochemistry: Calgary, Barton, H.N., Odland, S.K., O'Leary, R.M., and Day, G.W., 1982, Alberta, Applied Publishing Ltd., 612 p. Geochemical data for the Killik River and Chandler Lake Mayfield, C.F., Curtis, S.M., Ellersieck, I.F., and Tailleur, I.L., 1979, quadrangles, Alaska: U.S. Geological Survey Open-File Report Reconnaissance geology of the Ginny Creek zinc-lead-silver and 82-1026, 52 p.

Nimiuktuk barite deposits, northwestern Brooks Range, Alaska: U.S. Bodnar, D.A., 1984, Stratigraphy, age, deposition, environments, and hydrocarbon source rock evaluation of the Otuk Formation, Geological Survey Open-File Report 79-1092, 20 p. Moore, D.W., Young, L.E., Modene, J.S., and Plahuta, J.T., 1986, Geologic north-central Brooks Range, Alaska: Fairbanks, University of Alaska, setting and genesis of the Red Dog zinc-lead-silver deposit, western Brooks Range, Alaska: Economic Geology, v. 81, p. 1696-1727. Brosgé, W.P., Reiser, H.N., Dutro, J.T., Jr., and Nilsen, T.H., 1979, Geologic Motooka, J.M., and Grimes, D.J., 1976, Analytical precision of one-sixth order map of Devonian rocks in parts of the Chandler Lake and Killik semiquantitative spectrographic analyses: U.S. Geological Survey River quadrangles, Alaska: U.S. Geological Survey Open-File Report Circular 738, 25 p. Cathrall, J.B., Dillon, J.T., Hoffman, J.D., Brosgé, W.P., and Bliss, J.D., 1987,

Mull, C.G., 1982, Tectonic evolution and structural style of the Brooks Range, Alaska: An illustrated summary, in Powers, R.B., ed., Geologic Geochemical maps and evaluation of stream-sediment geochemical studies of the Cordilleran thrust belt: Denver, Colorado, Rocky data of the Wiseman 1 x 3 degree quadrangle, Brooks Range, Alaska: Mountain Association of Geologists, v. 1, p. 1-45. Mull, C.G., Tailleur, I.L., Mayfield, C.F., Ellersieck, Inyo, and Curtis, S., 1982, Detterman, R.L., Bickel, R.S., and Gryc, G., 1963, Geology of the Chandler New Upper Paleozoic and lower Mesozoic stratigraphic units, central and western Brooks Range, Alaska: The American Association of

MISCELLANEOUS FIELD STUDIES

MAP MF-2144-C

Rock description

Fine- to medium-grained sandstone

Fine- to medium-grained sandstone

Dk; conglomerate with pyrite concretions

Dk; conglomerate with disseminated pyrit

Veins; limonite and siderite Pyrite in quartz-calcite veins

Black shale-siltstone

Ps; shale/siltstone

5,000

(map-unit symbols from map A)

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River region, Alaska: U.S. Geological Survey Professional Paper Duttweiler, K.A., 1986, Sulfide occurrences in the Itkillik River region, Petroleum Geologists Bulletin, v. 66, no. 3, p. 348-362. southeast Chandler Lake quadrangle, Brooks Range, Alaska: U.S. Mull, C.G., Crowder, R.K., Adams, K.E., Siok, J.P., Bodnar, D.A., Harris, E.E., Alexander, R.A., and Solie, D.N., 1987, Stratigraphy and structural setting of the Picnic Creek allochthon, Killik River 1987, Use of factor analysis in locating base-metal quadrangle, central Brooks Range, Alaska--A summary, in v. 2 of mineralization in the Killik River quadrangle, Alaska: U.S. Tailleur, I., and Weimer, P., eds., Alaskan North Slope: Society of Economic Paleontologists and Mineralogists, Pacific Section, p. Ellersieck, I.F., Jansons, U., Mayfield, C.F., and Tailleur, I.L., 1982, The Story Creek and Whoopee Creek lead-zinc-silver occurrences, western

Nilsen, T.H., Brosgé, W.P., Dutro, J.T., Jr., and Moore, T.E., 1981, Brooks Range, Alaska: U.S. Geological Survey Circular 844, p. Depositional model for the fluvial Upper Devonian Kanavut Conglomerate, Brooks Range, Alaska in Albert, R.D., and Hudson, Travis, eds., The United States Geological Survey in Alaska--Accomplishments during 1979: U.S. Geological Survey Circular 823-B, p. B20-21. Nilsen, T.H., and Moore, T.E., 1984, Stratigraphic nomenclature for the

the semiquantitative analysis of geologic materials: U.S. Geological Hamilton, T.D., 1979, Surficial geologic map of the Chandler Lake quadrangle, Alaska: U.S. Geological Survey Miscellaneous Field Upper Devonian and Lower Mississippian(?) Kanayut Conglomerate, Brooks Range, Alaska: U.S. Geological Survey Bulletin 1529-A, 64 Studies Map MF-1121, scale 1:250,000. Huffman, A.C., Jr., 1989, The Nanushuk Group, in C.G. Mull and K.E. Patton, W.W., Jr., and Tailleur, I.L., 1964, Geology of the Upper Killik-Itkillik region, Alaska: U.S. Geological Survey Professional Paper 303-G, p.

Adams, eds., Dalton Highway, Yukon River to Prudhoe Bay, Alaska; Bedrock geology of the eastern Koyukuk basin, central Brooks Range, and eastcentral Arctic Slope, Guidebook 7 Alaska: Division Rose, A.W., Hawkes, H.E., and Webb, J.S., 1979, Geochemistry in mineral of Geological and Geophysical Surveys Report no. 7, v.2, p 303-309. exploration, London, Academic Press Inc., 657 p. Kelley, J.S., 1990, Generalized geologic map of the Chandler Lake quadrangle, North Central Alaska: U.S. Geological Survey Siok, J.P., 1985, Lithostratigraphy, petrology, age, and depositional environments of the Siksikpuk Formation on the Endicott Mountains Miscellaneous Field Studies Map MF-2144-A, scale 1:250,000. Kelley, K.D., Mull, C.G., and Barton, H.N., 1993a, Geochemistry and mineralogy of nonmagnetic heavy-mineral-concentrate samples from

and Picnic Creek allochthons, north-central Brooks Range, Alaska: Fairbanks, University of Alaska, M.S. thesis, 235 p. Sutley, S.J., Duttweiler, K.A., and Hopkins, R.T., 1984, Analytical results and sample locality map of stream sediment and panned-concentrate samples from the Chandler Lake 1 x 3 degree quadrangle, Alaska U.S. Geological Survey Open-File Report 84-412, 30 p. Theobald, P.K., Barton, H.N., Billings, T.M., Frisken, J.G., Turner, R.L., and Van Trump, G., Jr., 1978, Geochemical distribution of elements in stream sediments and heavy-mineral concentrate samples in the

Survey Professional Paper 482, 52 p., 6 plates.

southern half of the National Petroleum Reserve, Alaska: U.S

Geological Survey Open-File Report 78-517, scale 1:500,000.

Wahrhaftig, Clyde, 1965, Physiographic divisions of Alaska: U.S. Geological

MAPS SHOWING GEOCHEMISTRY OF SEDIMENT SAMPLES FROM THE SOUTHERN PART OF THE CHANDLER LAKE QUADRANGLE, ALASKA

CORRELATION OF MAP UNITS

Unconformity(?)

Maw Mawc

Unconformity

LIST OF MAP UNITS

Cretaceous)

Formations, undivided

and Upper Devonian)

undivided (Upper Devonian)

undivided (Upper Devonian)

} Holocene

Upper

Lower

Upper

Devonian

EXPLANATION

Major folds --- Showing direction of plunge where known

steeper dipping limb

Thrust fault---Sawteeth on upper plate

Overturned syncline

Syncline--- Dashed where inferred position of strata that formed syncline is found in upper thrust plate and since been eroded

Strongly asymmetrical syncline---Double dip arrow indicates

Detachment surface---Approximately located. Sawteeth on upper plat

Shear zone---Melange; zone of pervasively sheared and structurally

Outcrops of shaly strata in undivided part (Dh) of Hunt Fork Shal

Fault---Type uncertain; ticks indicate hanging-wall block

Outcrops of radiolarian ribbon chert and very cherty

Tectonic block of coquinoid limestone in melange

Minus-80-mesh stream-sediment sample locality

Minus-30-mesh stream-sediment sample locality

rhytmically bedded limestone

Outcrop of basalt---Locally pillowed

Well---Drilled for oil and gas; abandoned

Cretaceous

Cretaceous

QUATERNARY

CRETACEOUS

AND

TRIASSIC

PERMIAN

MISSISSIPPIAN

DEVONIAN

ARCTIC COASTAL PLAIN PROVINCE

Chandler Lake quadrangle, Alaska

calculated because detection ratio less than .3]

Figure 1. Index map of the central and eastern Brooks Range showing location of the

Table 1. Statistical summary of minus-80-mesh and minus-30-mesh stream-sediment samples

[Concentrations in parts per million unless otherwise noted; all elements determined by emission

spectrography unless otherwise noted; DV, Number of determinant or unqualified values; N(), not detected at the lower detection limit shown in parethesis; L, less than lower detection limit; G, greater

than upper detection limit; DR, detection ratio or the number of samples with determinant values

divided by the total number of samples; GMean, geometric mean; GD, geometric deviation; --, not

Minus-80-mesh stream-sediment samples

Minus-30-mesh stream-sediment samples

Bi, Sn, Th, and W concentrations were below limit of determination in all samples (lower limits 10, 10, 100, and 20 ppm, respectively). Au concentrations were below

Calculated only for elements with detection ratio of 0.3 or greater--values with "N" were set equal to one-quarter the lower determination limit; values with "L" were set

imit of determination by both emission spectrography (10 ppm lower limit) and atomic absorption spectrometry (.05 ppm lower limit).

equal to one-half the lower determination limit; values with "G" were set equal to twice the upper determination limit.