



DESCRIPTION OF MAP UNITS
SURFICIAL DEPOSITS AND SEDIMENTARY ROCKS

Qs Surficial deposits (Holocene and Pleistocene) -- Unconsolidated to poorly consolidated alluvial, colluvial, glacial, marine, lacustrine, and eolian deposits. Locally includes extensive redeposited pumice and

Qls Landslide deposits (Holocene and Pleistocene) -- Nonsorted, nonstratified coarse angular rubble forming lobate masses

Ts Sedimentary rocks (Tertiary) -- Poorly to moderately well indurated, fluvial sandstone, siltstone, and conglomerate; larger clasts consist of both plutonic and volcanic rocks of local derivation

Hemlock Conglomerate (Oligocene) -- Poorly indurated fluvial conglomerate,

pale brown tuffaceous sandstone, siltstone, shale, coal, and tuff.

Age is late Oligocene

To Copper Lake Formation (Tertiary) -- Massive, well indurated, polymictic conglomerate, sandstone, and siltstone. Age is early Tertiary

Kk Kaguyak Formation (Late Cretaceous) -- Upper part consists of interbedded siltstone and graded greywacke sandstone that represent the upper and middle regimes of a submarine fan. Lower part consists of thinly bedded siltstone and some thin limestone beds and includes abundant

Kp Pedmar Formation (Early Cretaceous)--Thick-bedded grey sandstone and minor amounts of siltstone and shale that contain ammonites of Albian age

ammonites, pelecypods, and limestone concretions

Kh Herendeen Formation (Early Cretaceous) -- Calcareous sandstone and siltstone, thinly bedded, light- to dark-olive grey

Ks Staniukovich Formation (Early Cretaceous) -- Siltstone, shale, and thinly bedded fine grained foldspathic and laumontitic brown sandstone

Naknek Formation (Late Jurassic) -- Main sedimentary rock-unit of the map area, consisting of sandstone, conglomerate, siltstone, and dark shale. Divided into five members (not mapped here), from oldest to youngest: massive conglomerate and thinly bedded sandstone member; thick-bedded to massive sandstone member; thinly bedded, dark grey siltstone member with limestone concretions; thinly bedded sandstone and siltstone member; massive conglomerate member. Clasts in both the

Jt Talkeetna Formation (Early Jurassic) -- Lava flows, breccias, and lahars locally interbedded with volcaniclastic sandstone, conglomerate, and shale. Includes sills of uncertain ages. Metamorphosed to non-schitose epidote-albite-calcite assemblages suggestive of lower

oldest and youngest conglomerate members are dominantly metamorphic,

volcanic, and sedimentary rocks with subordinate plutonic rocks

non-schistose epidote-albite-calcite assemblages suggestive of lower greenschist facies

Kamishak Formation (Late Triassic)--Slightly to moderately recrystallized, non-fossiliferous limestone

Younger deposits and rocks of Aleutian volcanic arc

Qap Pyroclastic-flow deposits (Holocene) -- Poorly sorted, variably indurated deposits of ash, vitrophyric blocks, and (or) pumiceous lapilli. Comprises the 1912 ash flow of Katmai (Novarupta) and the Holocene block-and-ash flows of Kaguyak caldera

Qad Domes (Holocene) -- Domes of dacitic or rhyolitic composition

VOLCANIC DEPOSITS AND ROCKS

Qac Younger central-vent deposits and rocks (Holocene and Pleistocene)—Lava flows, tuffs, and breccias dominantly of andesitic composition but locally including lava flows of low-silica dacitic composition, airfall deposits of andesitic to rhyolitic composition on Baked Mountain and Broken Mountain, and scoria cones of basaltic composition

QTap Pyroclastic-flow deposits (Pleistocene and late Tertiary) -- Poorly

sorted, variably indurated deposits of ash, vitrophyric blocks, and/or

pumiceous lapilli. Primary compositions are uncertain owing to

QTac Older central-vent deposits and rocks (Pleistocene and late
Tertiary)--Lava flows, breccias, and domes of andesitic and dacitic
composition. Locally moderate to extensive alteration associated with
fossil fumaroles (e.g., bleaching to light red or yellow shades)

Tav Older volcanic rocks of Aleutian volcanic arc (late Tertiary)--Breccias,
lava flows, sills, and local pyroclastic and epiclastic tuffs of late

fossil fumaroles (e.g., bleaching to light red or yellow shades)

Tav Older volcanic rocks of Aleutian volcanic arc (late Tertiary)--Breccias, lava flows, sills, and local pyroclastic and epiclastic tuffs of late Tertiary volcanic field located southeast of the Aleutian Range crest and extending from the Katmai River to Kukak Bay. Dominantly of andesitic and dacitic composition. Propylitic alteration is extensive and argillic or potassic alteration is locally intensive, such as near contacts with hypabyssal intrusive rocks of unit Ti

Volcanic rocks of Meshik volcanic arc (early Tertiary)--Divided into:

Tmb Basaltic lava--Plugs, dikes, and flows of basaltic composition that intrude or overlie rocks of unit Tma

Tma Andesitic and dacitic lava flows and breccia--Unit also includes local domes or tuffs of rhyolitic(?) composition, now altered to quartz and sericite or kaolinite

JURASSIC

Lower Jurassic

Lower Jurassic

Lower Jurassic

TRIASSIC,

TRIASSIC,

TRIASSIC,

TRIASSIC,

TRIASSIC,

AND PERMIAN

METAMORPHIC ROCKS

JPk

Kakhonak Complex (Jurassic, Triassic, and Permian?)--Locally foliated or banded quartzite, schist, amphibolite, and garnet-bearing gneiss indicative of amphibolite-facies metamorphism. Protoliths presumably consisted of Talkeetna Formation (Jt), Kamishak Formation (Jk),

Cottonwood Bay Greenstone (Tc), and unnamed Permian(?) sandstone and argillite

Cottonwood Bay Greenstone (Late Triassic)--Basalt flows now metamorphosed to epidote-albite-actinolite assemblages suggestive of greenschist facies; also locally includes chert and fine- to medium-grained diabase

greenschist facies; also locally includes chert and fine- to medium-grained diabase

INTRUSIVE ROCKS

Dikes (Tertiary) -- Dikes from 1 m to 20 m wide that occur southeast of the Bruin Bay fault, that is, in rocks no older than the Naknek

the Bruin Bay fault, that is, in rocks no older than the Naknek Formation (Jn). Many are in rocks as young as the Hemlock Conglomerate (Th), however, suggesting that most are middle to late Tertiary in age

Hypabyssal intrusive rocks of Aleutian volcanic arc (late Tertiary)--Sill-like or cross-cutting subvolcanic intrusive bodies generally less than 10 sq km in outcrop area, as well as larger plutonic bodies such as those beneath Fourpeaked volcano or along the Aleutian Range crest east of Serpent Tongue Glacier. Fine-grained, porphyritic to equigranular rocks that consist dominantly of

Tiu Hypabyssal intrusive rocks, undivided (Tertiary)—Intrusive bodies ranging from small plugs and sills to plutons exposed over as much as 30 sq km. Rocks are fine—to medium-grained, commonly porphyritic, and consist chiefly of quartz diorite or tonalite

Tgd Granodiorite (Tertiary)--Medium-grained equigranular to marginally porphyritic rocks that are low in modal quartz; unit includes samples that are classified as quartz monzodiorites
 Tqd Quartz diorite (Tertiary)--Medium-grained equigranular rocks in which abundance of modal quartz ranges widely, rocks of the unit include tonalite and monzonite

Tgb Gabbro and diorite (Tertiary)--Medium-grained rocks having gabbroic or diabasic textures
 Jgr Granite (Jurassic)--Medium-grained equigranular or fine-grained porphyritic rocks
 Jgd Granodiorite (Jurassic)--Medium-grained equigranular or fine-grained

porphyritic rocks. Also includes isolated outcrops of tonalite and quartz diorite

Jqd Quartz diorite and tonalite (Jurassic)—Medium—grained equigranular rocks

Jgb Diorite and gabbro (Jurassic)—Dark, diabasic—and gabbroic—textured

rocks

GEOLOGIC MAP SYMBOLS

Contact-Dashed where inferred or approximately located

Fault--Dashed where inferred or approximately located, dotted where concealed; queried where uncertain.
U=upthrown side, D=downthrown side

Thrust or reverse fault--Sawteeth on upper plate; bar with number indicates dip of fault plane

Anticlinal axis--Showing direction of plunge; dashed where approximately located; dotted where concealed; queried where existence uncertain

Area of hornfels

Synclinal axis--Showing direction of plunge;
dashed where approximately located;
dotted where concealed; queried where
existence uncertain

Measured strike and dip of beds

Approximate strike and dip of beds

 Strike and dip of foliation
 Horizontal bedding

 Dike

Quaternary volcanic vent

Area of alteration

The U.S. Geological Survey is required, by the Alaskan National Interests Lands Conservation Act (ANILCA, Public Law 96-487, 1980), to survey certain Federal lands to determine their mineral values, if any. 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 regional geochemical survey of the Mount Katmai quadrangle, and parts of the Afognak and Naknek quadrangles, Alaska.

INTRODUCTION

During the summers of 1983-85, we conducted a reconnaissance geochemical and mineralogical survey of the Mount Katmai quadrangle and parts of the Afognak, Naknek, and Iliamna quadrangles, Alaska. The study area comprises

approximately 10,000 mi2 (26,000 km2) in the northern part of the Alaska Peninsula. The villages of Naknek and King Salmon lie west of the study area. The study area encompasses all of the Katmai National Park and Preserve, as well as a part of the McNeil State Game Preserve. The topographic relief in the study area is 7.090 ft (2.170 m), with maximum altitude at the summit of Snowy Mountain. The terrain in the central and eastern parts of the Katmai study area is rugged and mountainous and contains youthful stream drainages in previously glaciated valleys. The Valley of Ten Thousand Smokes, formed by infilling of ash flows from the Mount Katmai eruption of 1912 (Fenner, 1920), has been deeply incised and was not sampled. The western part of the Katmai study area is a low tundra plain covered by a deep mantle of glacial, lacustrine, and eolian deposits. There are no outcrops of bedrock exposed. Large glacial lakes preserved in the area were formed behind terminal moraines after the retreat of the glaciers (Keller Sampling was confined largely to the alpine and foothills terrain in the eastern and central parts of the Katmai study area. Two different media were sampled: (1) stream sediments, and (2) nonmagnetic heavy-mineral concentrates panned from the stream sediments. The minus-80-mesh stream-sediment medium reflects changes in bedrock geology and geochemistry, and also reveals areas of extensive exposed mineralization, whereas the nonmagnetic heavy-mineral-concentrate medium will concentrate the ore-related minerals present and may be useful in delineating areas of poorly exposed This report, one of a series of reports that graphically present selected geochemical and mineralogical data in map format, presents the geochemical results from emission spectrographic analysis of minus-80-mesh stream sediments; MF-2021-B (Church and Motooka, 1989) presents the results from inductively coupled plasma analysis of leachable metals from the minus-80-mesh stream sediments; MF-2021-C (Church and Arbogast, 1989) presents geochemical data from emission spectrographic analysis of nonmagnetic heavy-mineral-concentrate samples; and MF-2021-D (Church and Bennett, 1989) presents mineralogical data from binocular microscopic examination of nonmagnetic heavy-mineral concentrate samples. An interpretive report, which delineates selected areas of mineralization within the study area and

Geologic mapping of the Mount Katmai region includes early reconnaissance work by Keller and Reiser (1959) and preliminary results of the AMRAP study (Riehle and others, 1987). Stratigraphic relations of sedimentary units throughout the entire Alaska Peninsula are consistent with recent revisions (R.L. Detterman written commun., 1989). The Katmai study area includes part of the Alaska Peninsula magmatic arc. Jurassic volcanic rocks (Jt), which are intruded by coeval or slightly younger Jurassic plutons (Jgr, Jgd, Jqd, and Jgb) as well as by Cretaceous and Tertiary plutons (Tgd, Tqd, and Tgb), comprise the Alaska-Aleutian Ranges batholith that extends from the southern margin of the study area north to the vicinity of Mount Denali (formerly, Mount McKinley) (Reed and Lanphere, 1969; 1973). None of the Cretaceous intrusive rocks found elsewhere in the batholith have been identified despite 38 radiometric age determinations on rocks from the study area (M.A. Lanphere and F.H. Wilson, written commun., 1988). Roof pendants are a heterogeneous assemblage of schist, gneiss, quartzite, greenstone, and amphibolite (JPk), the protoliths of which include Jurassic volcanic rocks (Jt), Triassic basalt flows and limestone (R c and R k), and possibly older sedimentary and (or) volcanic rocks. Extrusive rocks (Tmb, Tma) of middle Tertiary age (F.H. Wilson, written commun., 1987) are part of the Meshik volcanic arc, which extends from the southern Alaska Peninsula north to the Katmai region and perhaps into the liamna quadrangle (Wilson, 1985). Tertiary plutons of the Alaska-Aleutian Ranges batholith may, in the Iliamna quadrangle, be the deep-seated equivalents of the Meshik volcanic rocks. Centers of Miocene volcanism (Tav), located immediately seaward of the currently active Quaternary vents (Qap, Qad, and Qac), document the onset of the modern Aleutian arc. Volcanic rocks (QTap, QTac) that are located near and are more deeply eroded than Quaternary volcanic rocks, may be intermediate in age between the older and younger parts of the arc. Shallow intrusions of late Tertiary (Ti) and Tertiary (Tiu) age

interprets the significance of the geochemical and mineralogical signatures of

these anomalous areas, is in preparation.

have locally metamorphosed and (or) hydrothermally altered the older Miocene volcanic rocks east of the range crest as well as the Mesozoic sedimentary rocks west of the range crest. The most extensive rock unit in the region is the Naknek Formation (Jn), a composite of Upper Jurassic shallow marine, littoral, and fluvial conglomerates, sandstones, and siltstones that document the unroofing and erosion of the Jurassic part of the batholith. Younger strata locally preserved in the study area are Cretaceous sandstone, siltstone, and calcareous sandstone (Ks, Kp, Kk, and Kh) and Tertiary conglomerate, sandstone, and siltstone, locally tuffaceous and (or) coal-bearing (Ts, Th, and Tc). The main structural feature of the study area is the Bruin Bay fault, a high-angle reverse fault 480 km in length (Detterman and Hartsock, 1966; Detterman and others, 1976) that, in the Katmai study area, juxtaposes the batholith and older rocks on the west against the Naknek Formation on the east. Other structural features include north- to northeast-trending folds and northwest-trending, high-angle minor faults, fractures, veins, and dikes; most or all of such features in the study area are probably late Tertiary in

SAMPLE COLLECTION, PREPARATION, AND ANALYSIS

We collected stream-sediment samples from active alluvium, primarily from first-order (unbranched) and second-order (below the junction of two first-order) streams, as shown on U.S. Geological Survey topographic maps (scale 1:63,360). We collected stream-sediment samples from a total of 1198 stream sites. Each sample was composited from several localities within an area that may extend as much as 100 ft (30 m) along the active stream channel. Duplicate samples were taken at approximately every 20th site. Sampling density was about 1 sample site per 5 mi $^{\prime}$ (13 km $^{\prime}$); areas covered by glacial material were not sampled. The area of the drainage basins sampled ranged from 2 mi² (5 km²) to about 10 mi² (26 km²). Each bulk sample was screened with a 10-mesh (2.0-mm) screen to remove the coarse material. After air drying in the field, the samples were sent to the laboratory for analysis. The samples were sieved to minus-80-mesh (0.177 mm) and then ground to minus-100-mesh (0.149 mm) prior to analysis. Analyses were carried out using the semiquantitative spectrographic method described by Grimes and Marranzino (1968) and Motooka and Grimes (1976). Bailey and others (1986) presented a detailed description of the geochemical sampling, sample preparation, and analytical methods utilized in the reconnaissance study. Tabulated geochemical data are also presented in that report (table 2, Duplicate samples were taken during the course of the field study at 62 sites, chosen at random, for an unbalanced analysis of variance study. Level 1 in the analysis of variance is a measure of the variance between these 62 sample localities, that is, the site variance. Level 2 is represented by the analyses of duplicate samples taken at each of these sites, that is, the sampling variance. Replicate analyses were made of these duplicate samples. These data form level 3 of the analysis of variance and are a second measure of sampling variance, and level 4 is represented by the data provided by each analyst as they both read the same films from the replicate analyses providing some measure of analytical variance. The variance components, expressed in percent, are shown in table 1. All of the data were log-normalized before

running the analysis of variance program (VanTrump and Miesch, 1977). Only those elements that were at least 70 percent determinate were included in the analysis of variance study. An estimate of the distribution of the data for each element was made by visual comparison of the histograms for the suite of duplicate samples with those for the entire data set. Two elements, boron and vanadium, have distinct bimodal distributions and cobalt also has two modes. These elements have been included in the analysis of variance study for comparison. A 5 percent probability level (F) was used to test for significance. In every case, site variance was significant. That is, the geologic changes control the geochemical variation within the data set. The three elements identified as being bimodal, boron, vanadium, and cobalt, have larger percentage of variance at Level 1. Level 3, that is replicate analyses of a sample from the same site, also showed rather poor reproducibility and the percent variance in the analytical variance component column is also large. Visual inspection of the data and comparison with the error limits assigned to spectrographic data, especially as one approaches the limit of detection, indicate that the data fall within the limits of reproducibility demonstrated for the six-step semiquantative emission spectrographic method (Motooka and Grimes, 1976). The analytical variance of the elements magnesium and calcium is large, but the variance of these elements is small. The histograms for these two elements show a quite restricted range of values with most of the data lying within four spectrographic intervals. With an error ramge of plus or minus one spectrographic interval at the 83 percent confidence level, and plus or minus two spectrographic intervals at the 96 percent confidence level (Motooka and Grimes, 1976), it is not surprising that much of the error shows up in the analytical variance column for these elements. The analysis of variance data indicates that for the elements plotted on the map, the majority of the variance is between sample localities; most of the variance is a direct result of the changes in the geology across

the study area. Sampling variance and analytical variance are of lesser importance in determining the stability and resolution of this geochemical

NATIONAL GEODETIC VERTICAL DATUM OF 1929 A statistical summary of the geochemical data from 1198 stream-sediment samples is given in table 2. Because semiquantitative spectrographic data are reported in geometrically spaced classes (Grimes and Marranzino, 1968), the Chi-squared test for normality or log-normality was not used because the Chisquared test is valid only for continuously variable data. Furthermore, several of the distributions are censored by the lower limit of determination. Cohen's method of estimating the geometric mean and geometric deviation has been used to estimate these parameters for censored distributions with detection ratios greater than about 0.5 (Cohen, 1959). The skewness and kurtosis of these censored distributions were estimated after replacing qualified values with one-half of the lower determination limit of the element if qualified with an L, with one-quarter of the lower determination limit if qualified with an N, and with a value one class interval larger than the upper determination limit if qualified with a G. The skewness and kurtosis values for both the raw data and the log-transformed data were compared with the table of critical values for the 5 percent confidence limits (Bennett and Franklin, 1954, p. 95) to estimate whether a particular trace-element distribution more closely approximates a log-normal rather than a normal population. All of the data have distributions that are more nearly log-normal than arithmethic-normal. Selected percentiles of the data are also given in table 2. No data are reported for the elements bismuth, cadmium, niobium, tin, and thorium because there are no determinate The data for eight elements, selected to reflect sulfide mineralization expected in this geologic environment, are shown on the stream-sediment geochemical map. Histograms of these data are shown in figure 1. Anomalous element concentrations are shown, using a star diagram, by vectors for each element that radiate from the sample localities, shown as small circles. The vectors are subdivided into three lengths that approximate the 90th, 95th, and 98th percentile distributions of the data. Threshold values were very similar to those chosen by Goldfarb and others (1988), for the area underlain by Tertiary volcanic rocks (Tav) in the southeastern part of the Katmai study area. Three of the elements--molybdenum, silver, and zinc--are strongly censored; the rest of the selected elements show essentially a log-normal distribution that is positively skewed (fig. 1). Anomalous concentrations of gold (Au), Arsenic (As), antimony (Sb) and tungsten (W) are indicated on the map by their chemical symbols. The star diagrams not only show the presence of anomalous concentrations of these elements, but can also be used to indicate the geochemical signature of particular mineral deposits. These signatures are indicated by patterns in the individual stars representing suites of elements characteristic of particular mineral deposit types. Clusters of similar stars on the geochemical map may represent one or more deposits that have large areal exposure. Mineralization in the Katmai study area is indicated by the geochemical data from drainages surrounding the concentrations of cobalt, lead, zinc, and silver occur in the area underlain

E H H

CONTOUR INTERVAL 200 FEET

study area is indicated by the geochemical data from drainages surrounding the Cape Douglas area (Cu, Mo, Ag, Pb, Zn, B, Ni, Co, As, Sb, and Au). Anomalous concentrations of cobalt, lead, zinc, and silver occur in the area underlain by the Tertiary volcanic rocks (Tav). These anomalies grade northeastward into a more complete porphyry-copper suite (Cu, Mo, Pb, Zn, Ni, and Co) near Mount Griggs. A second cluster of porphyry-copper anomalies (Cu, Mo, Ag, Pb, Zn, and Co) indicate possible mineralization between Margot and Angle Creeks, south of Mount Katolinat. Finally, a third suite of porphyry-copper anomalies (Cu, Mo, Ag, Pb, Zn, W, and B) outline possible mineralization in the northern part of the Katmai study area. These anomalies are associated with the Tertiary intrusive rocks (Tgd, Tqd, Tgb) of the Alaska-Aleutian Range batholith.

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COPPER (PARTS PER MILLION)

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TABLE 1.--Analysis of variance table for the geochemical data from the stream-sediment samples from the Mount Katmai and parts of the Afognak and Naknek quadrangles, Alaska
[All variance components expressed in percent, concentrations reported in ppm except for Mg, Ca, Fe, and Ti, which are reported in percent] Replicate Analytical Detection Detection Range Element Ratio Variance Variance Variance Variance Limit 1.00 1.5-20.0 1.00 70-1000 1.00 1.00 300-3000 50-1500 7-200

¹Detection Ratio (DR) is the numbered of uncensored values divided by the total number of samples

Geologic Base fron Richle and others (192)

Map Area

Significant Map Area

Significant

ZINC (PARTS PER HILLION)

BORON (PARTS PER MILLION)

Flave 1. Histograms showing the distribution of values detarmined for the eligin elements show on the rise. The leight of the vectors show on

each histogram indicates the concentrations of each element plotted.

N 1 2 20 20 30 30

MOLYBDENUM (PARTS PER MILLION)

TABLE 2.--<u>Statistical summary of the geochemical data from the stream-sediment samples from the Mount Katmai and parts of the Afognak and Naknek quadrangles, Alaska Method of analysis: semiquantitative emission spectrography; values reported in ppm except for Mg, Ca, Fe, and Ti, which are reported in percent.</u> Geometric mean expressed as the log of the concentration. Leaders (--) indicate insufficient or no data) Data based on the Data based on the unqualified population qualified population Data based on the log transformed population No of Minimum Median Maximum Geometric Geometric Expected Skewness Kurtosis 1.91 1.198 1,198 1,169 2.00 1.000 2.00 2.00 15.00 >1.0 1.10 5.14 0.51 4.84 .50-2.44 1.000 10.00 1.84-14.33 10.00 -.029 -.03 -0.51 0.976 -.17 .19-1.39 1.94 4.43 1.50 1.66 1.24 700 1.000 1,198 121-918 .035 .999 .997 12.4-50.4 34.3-280 1.09 1,198 1,196 1,198 5,000 1,500 417-2.227 1.000 56.9-682 1,195 1,189 18.3-224 6.4-45.2 1,194 1,195 6.9-90.3 2.34 5.6-94.8 3.88 0.5N 200N .003 1,186 200N 200N 200N 200N 100N 100N 100N 50N 50N 50N Detection Ratio (DR) is the number of uncensored values (that is those without N, L, and G) divided by the total number of samples analyzed. N is the number of samples in which concentrations could not be detected at the lower determination limit. is the number of samples in which the element was observed, but the concentration was less than the lower determination limit. G is the number of samples in which the element was observed, but the concentration was greater than the upper determination limit.

The 95 percent expected range (Miesch, 1976) is calculated from the geometric mean (GM) and geometric deviation (GD) as follows:

 $GM/(GD^2)$ to $GMx(GD^2)$ where the limits of Cohen's method were exceeded (Cohen, 1959).

SILVER (PARTS PER MILLION)

GEOCHEMICAL MAP SHOWING THE DISTRIBUTION OF SELECTED ELEMENTS DETERMINED IN STREAM SEDIMENTS FROM THE MOUNT KATMAI AND PARTS OF THE AFOGNAK AND NAKNEK QUADRANGLES, ALASKA

LEAD (PARTS PER MILLION)