GEOLOGY AND GEOCHEMISTRY OF CERTAIN LANDS WITHIN THE PROPOSED LAKE CLARK NATIONAL PARK

RESOURCE ASSOCIATES OF ALASKA, INC.

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L I S T   O F   A P P E N D I C I E S

SAMPLE AND ANALYTICAL LOG
OF CERTAIN LANDS WITHIN THE PROPOSED
LAKE CLARK NATIONAL PARK

Bound Separately

APPENDIX 1 Data Collected in 1973 Field Season.
(Samples lettered "C" on the Plates)

APPENDIX 2a & 2b Data Collected in the 1974 field season by the Reconnaissance Crew.
(Samples lettered "A" on the Plates)

APPENDIX 3 Data Collected in the 1974 field season by the Mapping Crew.
(Samples lettered "A" on the Plates)

APPENDIX 4 Data Collected in the 1975 field season.
(Samples lettered "D" on the Plates)

SUMMARY AND RECOMMENDATIONS

This document and the contained tables (30), plates (55) and appendicies (approx. 1000p.) set forth the data base, results, findings, conclusions and recommendations on "Mineral Studies of Certain Alaska Native Claims Settlement Act (ANCSA) 17 (d) (2) Lands in Alaska-Lake Clark National Park". This data is being made available to the United States Bureau of Mines by Resource Associates of Alaska as per contract (RFD) J0166108 which provides for RAA to turn over such data in kind as it had available on lands outlined generally by Figure 1 and specifically by Plates 1-3. This data was previously collected on behalf of RAA and other clients over the three year period of 1973-1975. Permission to make public such data is hereby acknowledged.

This study involved a geological and geochemical survey and reconnaissance of nearly 4500 square miles of interest lands. Approximately 57 man months of field work by professional geologists utilizing full time helicopter support were required to complete this task. Approximately 6000 geochemical samples were collected and analyzed for copper, silver, molybdenum, lead and zinc plus miscellaneous elements for well over 30,000 elemental determinations.

This investigation has resulted in the discovery of four prospects and 30 anomalous areas of interest primarily for copper, molybdenum, lead, and/or zinc which were previously unknown (Plate 2). These deposits are individually described herein and supplemented by numerous diagrams and maps. Literally dozens of other outcroppings of various metals as well as additional stream geochemical anomalies in several geologic environments are recorded in the sample and analytical logs included here as Appendicies 1-5.

A section by section rating of relative mineral potential is depicted on Plate 3 as a major summary and conclusion of this investigation. This rating is based on total geological and geochemical data available and viewed in the light of how respective lands and contained mineral occurrences compare to geological environments and deposits that have produced ore deposits elsewhere. These ratings are of necessity subjective but are valid in relation to each other. Diamond core drilling is the only way to ultimately determine grade and tonnage of contained mineralization.

Lands recommended for inclusion in the national park system are presented as Plate 4. This system would incorporate some of the most scenic glacial and volcanic terraine of Alaska into the park system yet allow for multiple use those lands which are known to contain deposits of strategic minerals of potential national importance. For example, the area on both sides of Lake Clark and the 10-12 mile wide belt extending northward from Lake Clark to Telaquana Pass is known to contain numerous occurrences of copper, lead, and zinc as massive volcanogenic deposits, and copper-molybdenum as porphyry type deposits. In addition to the previously known Kasna Creek Copper Deposit, this study has delineated two other prospects and 21 other anomalous areas of importance in the Lake Clark Quadrangle (Figure 2 and Plate 2).

Two prospects and seven anomalous areas of significant copper, molybdenum, lead, and/or zinc mineralization were discovered in the Lime Hills region west and northwest of Chakachamna Lake which attest to the high porphyry or stockwork potential of these lands. The Talkeetna Formation in the Lower West Cook Inlet was found to be highly prospective for volcanogenic network deposits of lead and zinc.

Recommended parklands then would be those covering the core of the Alaska-Aleutian Range Batholith which is thought to be some of the most scenic yet least mineralized lands in the area of interest. Much of the batholith proper remains unstudied so even the classification of these lands into single use categories is dangerous.

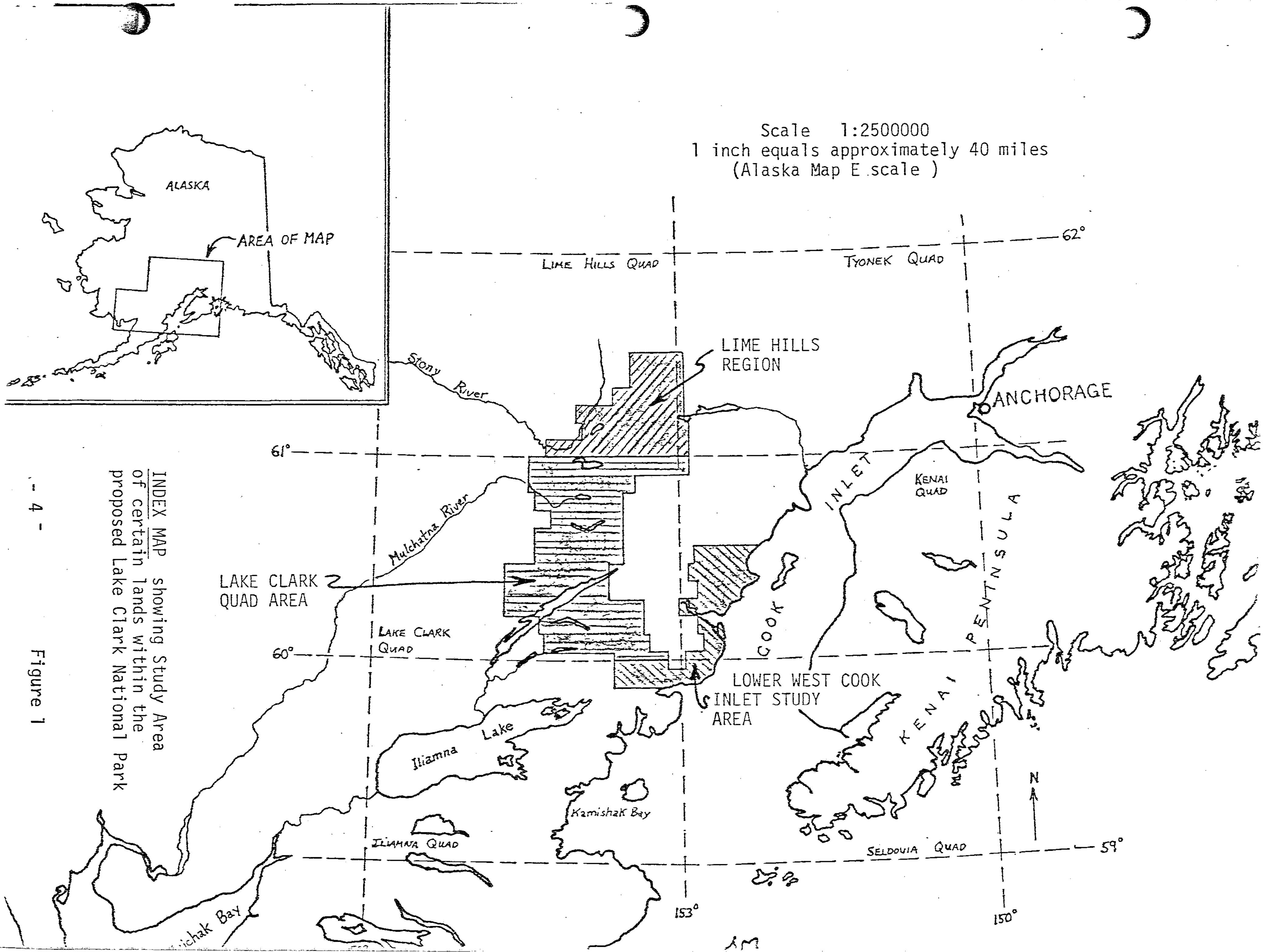
Certification is given here that no inventions have resulted from or as a consequence of this contract as required by the "Patents and Inventions Article" of the General Provisions.

PURPOSE AND SCOPE

This document and supporting data fullfills the United States Department of Interior Bureau of Mines contract (Number J0166108) to Resource Associates of Alaska to provide data on "Mineral Studies of Certain Alaska Native Claims Settlement Act (ANCSA) 17 (d) (2) Lands in Alaska-Lake Clark National Park". In brief the Secretary of Interior withdrew approximately 2.6 million acres of land for possible addition to the National Wildlife Refuge System. These withdrawals were made as a part of the Alaska Native Claims Settlement Act of December 18, 1971. Under the Act the Department of Interior had two years to make recommendations to Congress for disposal or classification of these lands and Congress has an additional five years to study and decide upon the ultimate disposition of these lands. It is in the national interest to ensure that any potential strategic and other minerals are identified prior to inclusion of land within a wilderness or other single use classification. Identification of valuable mineral resources will also enable Congress to make wise multiple use decisions in areas known to have mineral deposits.

Therefore in regard to these matters the U.S. Bureau of Mines requested proposals in middle 1976 to provide information and data on the proposed Lake Clark National Park lands which could (1) satisfy a Congressional directive to appraise "mineral potential" of areas proposed for withdrawal under the Alaska Native Claims Settlement Act", (2) "provide input into ongoing Alaska transportation corridor studies", and (3) compile mineral supply information for inclusion in the Bureau of Mines Minerals Availability System.

A contract (RFP)(J0166108) was awarded to Resource Associates to provide information and data that RAA had already developed over a three year period from 1973-1975 on most of the lands of interest (Figure 1) on behalf of itself and clients whose permission to make public such data is hereby acknowledged. Resource Associates is herewith fullfilling obligations to provide such data to the U.S. Bureau of Mines as set forth in the RAA Technical Proposal dated April 15, 1976 and the earlier cost agreement dated March 16, 1976 which were incorporated and made a part of contract Number J0166108. Since Resource Associates had already performed the work and is simply making it available in kind, the net result to the U.S. Bureau of Mines is acquisition of the data for a fraction of the cost and time which would otherwise be required.



INDEX MAP showing Study Area
of certain lands within the
proposed Lake Clark National Park

Figure 1

PROSPECTS AND ANOMALIES within
certain lands of the proposed
Lake Clark National Park

Scale 1:1000000

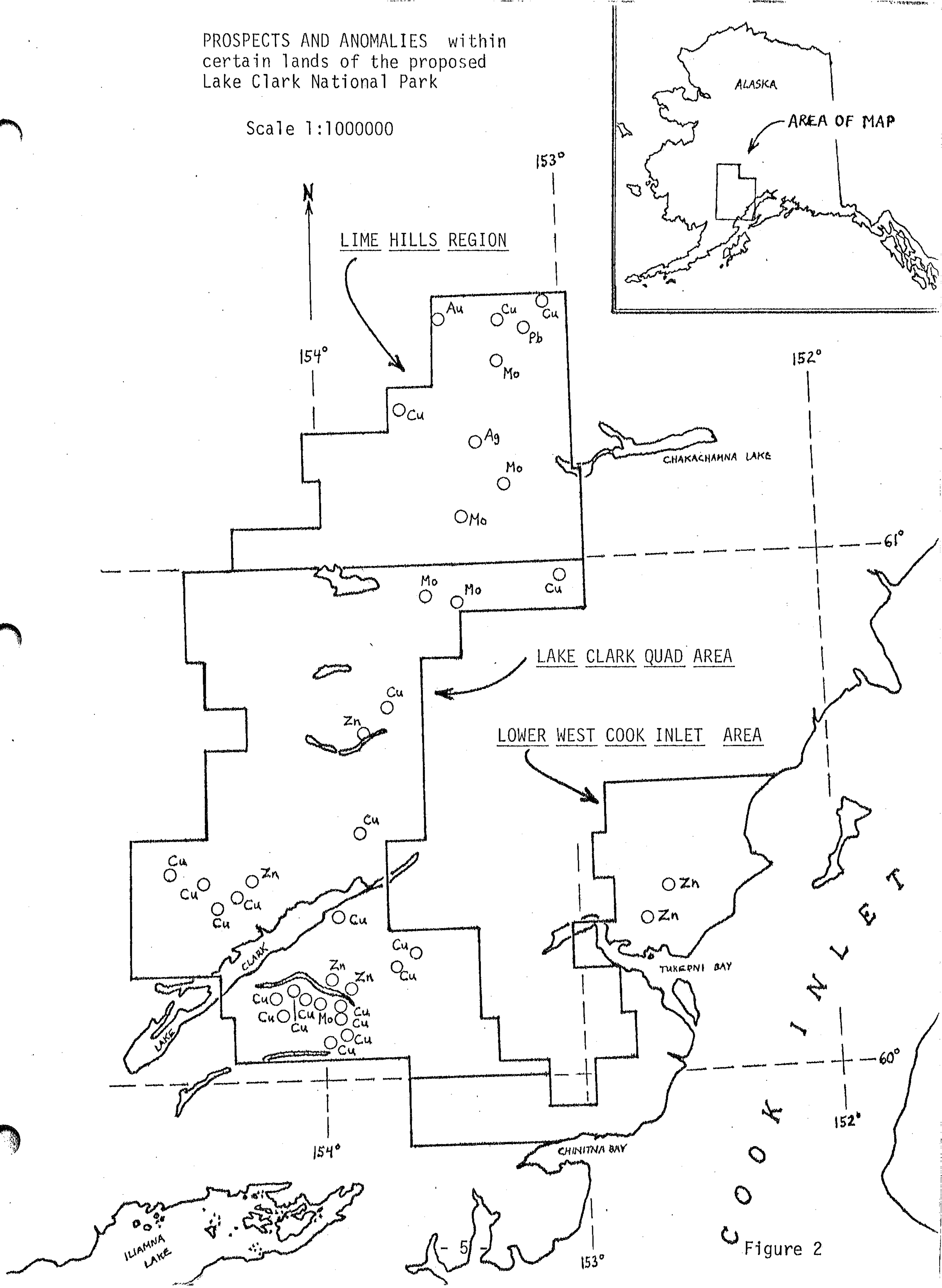


Figure 2

EXPLORATION PROCEDURE

The following discussion is intended to convey to the reader the fundamental exploration work plan and techniques that have been employed during the three-year evaluation of the herein described lands.

Target Analysis

Working hypotheses and concepts of ore genesis have guided the overall exploration philosophy and procedures on the reconnaissance program. Ideas have continually changed in view of the new data. For example, early efforts were directed almost exclusively toward porphyry copper and metasomatic deposits, and it was not until the second season and after collection of preliminary data that the full importance of volcanogenic sulfide deposits in the Lower West Cook Inlet and Lake Clark areas became apparent.

The methods of operation and the techniques used in a particular area depended to some extent upon the following factors: (1) location and accessibility, (2) topography and overall size of the area, (3) local and seasonal climatic conditions, (4) nature and type of ore deposits expected, and (5) time and money available.

Some of the techniques or "tools" that were used by Resource Associates geologists were lithology, structure, mineralogical relationships, known mineral occurrences, geochemistry, geomorphology, aerial photography, topographic maps and space imagery. Professional personnel proficient in several of these fields were assigned to the project.

An extensive literature search was one of the first tasks undertaken, as a large amount of knowledge and insight into particular areas could be gained in a short time. This expense was minimal compared to the hours of helicopter time that might have been otherwise wasted. The data was synthesized so that target areas having the best potential could be delineated.

Geological maps of the areas of interest were reviewed from numerous Federal and State bulletins as well as private sources where available. Most of the geologic maps available on Alaska are preliminary and cover relatively small areas. However, these preliminary geologic maps served as a basic tool and guide for mineral exploration in the early investigation to determine areas of favorable lithology and structure. Every bit of geological information is important, as some lithologic units and their chemical components are important as source rocks for mineralization and others are important as host rocks. Favorable rock types in conjunction with major faults, folds, unconformities and other structures are good possibilities for the occurrence of an ore deposit. Structures such as faults and stockwork fracturing are the plumbing system for hydrothermal ore deposits. Syngenetic and volcanogenic deposits are related to regional structures such as folds, unconformities and certain stratigraphic horizons.

Mining claims, mineral occurrences and geochemical anomalies in the areas of interest were studied and served in a general way to depict areas and zones of mineral potential. Another important source of information was aerial photographs and Earth Resources Technology Satellite imagery. These were very useful for structural interpretations as well as delineating general geologic units, particularly after some ground examination. All of the above information was utilized in order to direct the work and prospect specific areas and mineral zones that have the best geologic potential for the occurrence of an ore deposit.

During the winter months, office operations in Anchorage were devoted to data reduction, analysis and interpretation of field data. Findings of exploration and discoveries were compiled, studied, and data transferred to useful geochemical and geological maps. Interpretations and evaluations were used to guide future work to areas that warranted it. Regional geological and geochemical maps were prepared for each geologic province. Air photos and satellite imagery were re-examined within the context of new knowledge and field data. Selected samples were sometimes rerun for additional elements in light of supporting data from adjacent areas or geologic associations. Thin-sections for petrographic analysis under the microscope were prepared for significant prospects to study alteration and mineral assemblages. The binocular microscope was used to study physical features of hand specimens from mineralized areas. All of this data was utilized and incorporated into working hypotheses and exploration procedures for the following seasons.

What about polished sections?

Crews and Methods of Work

Are there photomicrographs and/or can we get/take some?

The standard helicopter-supported field crew consisted of a project geologist, four to seven professional field geologists, a pilot, a mechanic and a cook. One crew was utilized for a preliminary survey of the area of interest in 1973. In 1974 two crews were required as one crew did mapping and sampling of prospects and anomalies while the other continued the regional reconnaissance. In 1975 one crew was utilized to do follow-up and prospect evaluations. The field crews were supported by the RAA laboratory and staff in Fairbanks and Anchorage. Principals of RAA were involved in the conception and direction of work in all phases.

Limited aerial reconnaissance from a fixed wing aircraft was necessary at the beginning of each season to determine elevation of retreating snow and possibilities for campsites and gas caches. Later in the season aerial observation for color anomalies resulting from oxidation and weathering of sulfides proved to be very worthwhile in organizing and deploying ground examinations.

Field operations were designed to work out of tent camps for an effective helicopter radius of 30 to 40 miles. Fly camps consisting of the bare essentials were utilized to cover certain areas without the great expense of moving the entire base camp and to cut down on flying time.

General reconnaissance work consisted of each geologist traversing down stream drainages, making notes of the geology and mineralization, breaking a lot of float and collecting sediment samples of tributary streams for metal analysis. Each person was equipped with a topographic map, a compass, an FM radio and the tools of exploration, such as hand lens and soil auger. The radio, in addition to providing a measure of safety, was essential for the effective utilization of the helicopter and personnel.

The subtle nature and great variation between different ore deposits requires the exploration geologist to be competent and perceptive. Many, if not most, ore deposits are concealed by vegetation, products of weathering or several hundred to several thousand feet of overburden. Some mines have a history of having been walked over for years or even drilled by several companies before commercial mineralization was discovered. Therefore, careful observations and recording of notes on areas of veining, fracturing, alteration, mineralization and other factors were emphasized.

Logistic Support

Logistical support for the exploration program was tailored to the particular area and methods of work. During the 1973 field season, a two-passenger Bell 47G3B1 helicopter was engaged on a contract basis. During the 1974 season, a four-passenger Jet Ranger chopper was used by the reconnaissance crew to cover large areas, whereas a two-passenger B-1 was used by the mapping crew for more local detailed work. A two-place G-4 was used early in the 1975 season and was later replaced by a 4-place Hughes 500.

Fixed-wing service was supplied from time to time by several operators depending on the proximity to the work area, nature of work, and availability, capability and safety record of the operator. In 1973 the charter operators were Spernak Airways, Alyeska Air Service and Sea Airmotive in Anchorage; Kachemak Air Service in Homer; Woods Air Service in Palmer. During 1974 and 1975 Woods Air Service supplied a Beaver which could haul four barrels of fuel and was interchanged from floats to wheels to skis as the job required. Fuel was staged in the inaccessible areas in the early spring by wheeled ski aircraft.

Expeditors in the Anchorage and Fairbanks offices handled procurement, shipping and receiving of supplies and samples, and radio and telephone communications.

Areas of Coverage

Regional reconnaissance and mineral evaluation of interest to this project was conducted over a three year period (1973-1975) on lands totaling nearly 4500 square miles. The areas involved are generally outlined by the index map (Figure 1) and are specifically shown by the one inch to four mile geologic map (Plate 1). These lands include the Lower West Cook Inlet from Chinitna Bay approximately 50 miles northeast to Mount Redoubt and much of the Lake Clark and Lime Hills Quadrangles; from Tazimina Lake northward across Lake Clark through the Twin Lakes-Telaquana Lake country on up into the Merrill Pass-Chilligan River area, an estimated distance of over 150 miles. These areas include all or part of the following 30 minute quadrangles: Lake Clark A2, A3, A4, B2, B3, B4, and B5, C2, C3, C4, D1, D2, D3, and D4; Tyonek A8, and B8; Lime Hills A1, A2, A3, B1, and B2; Seldovia D8; Iliamna D1 and D2; Kenai A7, A8, B7, B8 and C7. Sample locations for these quadrangles are presented as Plates 5a-i, 6a-g, 9a-g, 12a-c, and 13a-e.

GEOCHEMICAL SAMPLING AND INTERPRETATION

Stream sediment geochemistry in conjunction with geologic mapping was one of the most useful tools for mineral reconnaissance as these large areas of land had to be looked at in a short time. The effective utilization and interpretation of the data required considerable knowledge and experience because of the complex interplay of numerous and often elusive factors. The main principle is that an area of mineralized rock will be mechanically and chemically weathered, producing particles and elemental ions which are transported downstream, resulting in a dispersion pattern or target area.

Some of the factors that influence the amount of an element in a stream sediment sample area are: (1) the grade and size of the mineralized outcrops, (2) the nature of the mineral (sulfide, oxide, etc.), (3) the composition of the host rock, (4) the occurrence of the mineral in the rock (fracture filling or disseminations), (5) weathering environment (physical or chemical), (6) distance from source area, (7) amount of dilution by other tributaries draining unmineralized rock, (8) volume of water flow (summer or winter), and (9) local environmental and chemical conditions. Many of these factors operate to limit severely the chances of detecting a mineral deposit more than a mile upstream from the sample collection point.

Extreme care was taken to get a valid and representative sample. Fine grained detritus was taken from several places in the active portions of the stream channel. Caution was used to avoid an excess amount of organic matter in the sample. A system of labeling and categorizing samples was devised by RAA to avoid mix-ups and transposition errors that result from dealing with large numbers of samples. Special sample data cards were used, so that many of the above factors are quickly noted by the collector; data was recorded in triplicate for each sample.

Samples were sent via returning supply planes to the RAA laboratory in Fairbanks, where they were analyzed as standard procedure for copper, silver, molybdenum, lead and zinc. Additional elements such as chromium, nickel, gold and platinum were run when warranted by the local geological environment. Standard industry techniques of drying, crushing, sieving and digestion were utilized by the laboratory. The elements were analyzed by industry standard atomic absorption techniques with the latest instrumentation available. By having the lab as part of the internal organization, it was possible to get sample results on interesting areas in a matter of hours via radio code. Normally the sample results were returned by mail.

One of the most difficult problems in interpreting results of stream sediment samples was determining significant anomalies. By way of definition, an anomalous sample is one that has a higher than "normal" concentration of an element, with "normal" representing background conditions in a general area interpreted in light of statistics and general knowledge of local conditions. Because of the many factors and variables involved, truly anomalous values are indicated only through orientation survey confined to areas of known geologic and mineralogic environments. Because this is impractical for a reconnaissance program of this nature, a statistical approach in conjunction with past experience was used to determine significant anomalies.

Histograms were therefore prepared to show the frequency distribution of copper, silver, molybdenum lead and zinc in sediment samples from major geological environments encountered within the project area. The histogram is a graphical representation of the number of samples that fall into particular ranges of values for various elements. It was used to determine the threshold value for a certain population of samples. Threshold represents the upper limit of background for each element in a particular area and a particular geologic environment.

It is important, then to realize that an anomalous value in one area may not be significant in another area, and vice versa. Additionally, there is no direct proportion between the numerical value or size of an anomaly and the importance or significance of an anomaly, because of the numerous variables involved. Most anomalous results are attributable to variations in local background conditions resulting from changes in lithology or weakly mineralized areas rather than commercial deposits.

In order to determine significant anomalies or anomalous areas which are presented in latter sections, the following procedure was followed: (1) determine anomalous breaking points for respective elements by utilizing histograms of sample populations in various geological provinces, (2) compose a series of overlays for each quadrangle showing anomalous values for individual elements in selected colors representing ranges in numerical value, (3) contour or outline exceptional or promising areas having relatively consistent anomalous values, (4) compare areas of interest and their geological setting, and (5) select promising target areas based on anomalous mineralization in favorable geologic setting.

Although most anomalies do not represent ore bodies, mining literature reveals documented cases of large and valuable ore deposits that have been found as a result of following up single anomalous stream sediment samples whose numerical value may have been only slightly above background, e.g. Arctic Camp in the Brooks Range. Oddly enough, some of the best prospects and anomalies in the project area were found by following up a single sample.

It should be noted that it is rare to investigate an anomalous stream sample and find an exposed ore body of commercial tonnage and grade. Processes of nature and the level of erosion have not generally been that cooperative. Usually it takes a great deal of work, imagination and money to determine that one has an ore deposit that will make a profit under the specific set of circumstances, e.g. tonnage, grade, market price, location, etc. If one traces an anomaly or anomalies and finds an occurrence of mineralization in a geologic environment that has produced ore bodies elsewhere and therefore merits further work, the occurrence is usually referred to as a prospect. Prospects maps presented herewith indicate all samples taken in the general vicinity. This enable comparisons between areas of interest in relation to areas not sampled or areas having negative results.

In order to evaluate the significance of the prospect, it is necessary to determine the relationships of mineralization and alteration to lithology and structure. This was accomplished by detailed mapping and sampling. In so far as possible, soil and rock samples were generally taken on lines spaced at 100 to 200-foot intervals. Grade and tonnage must ultimately be determined by drilling, but this last step is expensive. Hence the preliminary work is a prerequisite to determine drilling merit.

The total of samples taken in the area of interest during the three-year program is estimated at 6000 samples which were run for a minimum of five elements per sample, for a total in excess of 30,000 elemental determinations. As previously mentioned, approximately 4500 square miles were examined under this program, which gives a general sample density of one-two per square mile. This by the way, is more than the generally accepted industry standard of one sample per square mile for reconnaissance programs of this nature. The actual sample density in areas of favorable geology is, of course, much greater than elsewhere. The overall sample density would be higher if the glacial and lowland areas were excluded from the total acreage (Figure 1 and Plate 1).

LAKE CLARK QUADRANGLE

Lands of interest to this project that were studied in the Lake Clark Quadrangle include the general area of Kontrashibuna Lake-Tazimina Lake and thence northwest across Lake Clark into the Kijik River-Fishtrap Lake country and thence northward to the Twin Lakes-Telaquana Lake area. This includes all or parts of Lake Clark A2, A3, A4, B3, B4, B5, C2, C3, C4, D2, and D3. Regional mapping and sampling were conducted in fair detail in this area during the 1974 field season by two helicopter supported crews with a total of 11 geologists. Follow-up work and detailed mapping and sampling was conducted by a helicopter supported crew of six geologists during the 1975 season. The Pass Copper-Silver Prospect and the Tazimina Copper Prospect were mapped in some detail, as reported in the following pages. Base camps were established during respective parts of the study at Kontrashibuna Lake, Lachbuna Lake, Fishtrap Lake, and Two Lakes. Fly camps were necessary to work some of the more remote areas. As per company policy nothing was left behind. Fuel barrels, etc. were transported back to Anchorage, even where additional cost was necessary.

Geology

Public geological data for the Lake Clark area is minimal and very generalized in scope, as much of it was put together by an excellent effort by the U.S. Geological Survey from horseback in early days (Smith, 1917). The State Survey has examined and published prospect reports on the Bonanza Hills gold placer and known mineral occurrences around Lake Clark itself. Geochemical Report 20, by Gilbert Eakins (1970), was used for background data. Reed and Lanphere (1972) have radiometrically dated several of the intrusive rocks. At any rate, early reports differentiated only broadly between intrusives, volcanics and sediments, and little attempt was made to categorize or relate mineral potential to a particular geologic setting. The present study has been directed along these lines in order to evaluate the mineral potential of these lands, and the results are presented herein.

The Lake Clark area has undergone several periods of sedimentation, volcanism and intrusion, with much of this activity occurring during orogenic periods in the Lower Jurassic and Lower Tertiary times. The northeast trending Castle Mountain Fault system, which has produced the trough occupied by Lake Clark itself, is the most impressive structural feature in the area. Other subparallel north to northeast trending faults are present over the entire area. These are generally widely spaced and may be separated by several miles. They often separate major lithologic and time stratigraphic units. The northwest cross fracture system, by contrast, is more closely spaced, particularly west of Lake Clark, and is a later feature superimposed across the north to northeast trend of lithologic belts and breaks them up and offsets them. Major lithologic belts or groups and their respective mineral potentials are discussed below in order of decreasing age. (Plate 1).

How do you know

Lake Clark Schists

The Lake Clark schist is an informal name given herein to a group of primarily schistose rocks common as tectonic belts in the eastern half of the withdrawal. These schists are believed to be the oldest rocks in the area, with an age of Middle to Late Paleozoic, and to represent submarine sedimentation and volcanism. The actual proportion of sediments to volcanics and the type of deposition varies from one area to another, depending on proximity to ancient shorelines and volcanic centers.

The volcanics are generally basic in composition, being largely basalts and andesites which have been metamorphosed to chlorite and quartz-chlorite schists. Local areas of slightly more felsic volcanics in this sequence, such as dacites (quartz-muscovite-feldspar schists) are prime targets for massive sulfide mineralization. Ultramafic rocks, particularly gabbros (in part converted to actinolite schists) are also common in this group.

Sediments in the Lake Clark schists are represented by quartz-biotite schists, slates and argillites with some interbedded marble and chert. Sediments are generally fine grained silts, but considerable graywacke and even local areas of coarser detritus are present.

The schists between Portage Creek and Tlikakila River are about 60% sedimentary and 40% volcanic in origin. This area is characterized by chlorite and quartz-chlorite schists, which probably represent mafic volcaniclastics, and by slates, argillite and some interbedded marbles and cherts. Ultramafic bodies, such as pyroxenite and metagabbro, up to 2000 feet long are also common. This area has excellent potential for massive sulfide deposits.

The Portage Creek schists extend south and slightly west beneath Lake Clark, where they are apparently displaced by the Castle Mountain Fault. Ivahoe (1962) estimates a right lateral displacement of approximately eight miles on this regional fault. It therefore seems probable that the Tanalian Mountain-Copper Mountain schist belt on the east shore of Lake Clark is a continuation of these units.

The Tanalian Mountain schists are characterized by low rank greenschists, metasediments, quartzite and also metaconglomerate black slate and interbedded mafic and felsic metavolcanics. Scattered calc schist pods and marble have also been noted. Micaceous granulite was observed at one location near the eastern margin of this belt. Occasional float boulders of pyritized gabbro have also been noted in streams draining the area, but no such outcrops were mapped. No significant chert deposits were noted in this unit south of Lake Clark.

The Tazimina schist belt is about two miles wide and eight miles long, extending from the Tazimina River on the south to Ospook Creek on the north. This belt flanks the Aleutian granodiorite-diorite batholith. Rocks in this belt are typically biotite-quartz schist with variable amounts of chlorite, pyrite and pyrrhotite Schistosity trends generally northeasterly, parallel to the regional trend and to the batholith margin. Some exposures appear to be metamorphosed diorite, but most suggest argillite and metasiltstone as parent material. Gradations of metadiorite from clearly schistose structure to a migmatitic complex of granite-granodiorite are common. However, the fact that some of the younger granites are also gneissic in texture suggests that some of the gneissic structure is caused by structural alignment along faults.

The Kijik schist belt, exposed a few miles west of Kijik Lake, consists of predominantly quartz-biotite (±garnet) schists with some gneisses and metagabbros. The belt is bounded by faults separating the schists from younger volcanics. These schists are presumed to be of largely sedimentary origin, as interbedded volcanics are rare. This is attributed to a greater distance of deposition from ancient volcanic centers. Minor marble was noted.

Mineral potential for the Lake Clark schist belts is considered excellent for those areas representing near shore volcanism and sedimentation, such as the Portage Creek belt and the Tazimina belt. The Tazimina Prospect, discussed in the prospect section of this report, probably represents syngenetic copper mineralization remobilized by later intrusives.

Kontrashibuna Volcanic and Sedimentary Belt

The Kontrashibuna volcanic and sedimentary belt, of Lower Jurassic(?) age, crops out over much of the eastern third of the Lake Clark Withdrawal and is roughly centered on Kontrashibuna Lake. Rocks in this unit are predominantly andesitic flows, breccias, tuffs and agglomerates with some basalt and dacitic fractions. Many of the gabbros in this general area may represent source rocks to some of the volcanics. Interbedded with the volcanics are sandstone, conglomerate, limestone and minor chert. In areas of structural and geologic complexity, such as north of Gladiator Basin and at the Kasna Creek copper deposit, it is difficult to distinguish the rocks of this Kontrashibuna volcanic and sedimentary belt from similar rocks of the Lake Clark schist belt (Plates 1 and 2).

This distinction is important at Kasna Creek, of course, in efforts to find similar mineralized rocks. The limestone host rock at Kasna Creek can be projected along its northerly trend to outcrops of similar rock at Copper Mountain which are adjacent to rocks of the Lake Clark schist belt. The limestone may indeed be part of the older unit, which could be faulted against the Kontrashibuna sequence at Kasna Creek. There are, however, at least some narrow sections of limestone and conglomerate interbedded with the Kontrashibuna volcanics on the ridge two and a half miles north of Upper Tazimina Lake and four miles southwest of Kasna Creek.

An east-west ground magnetometer survey was conducted two miles north of Kasna Creek in the vegetated area north of Kontrashibuna Lake in an effort to detect possible magnetite mineralization along strike of the limestone horizon. Results suggest the favorable horizon is present but do not confirm any significant amount of mineralization. South of Kasna Creek the limestone has been digested or displaced by granite and granodiorite intrusives.

No chalcopyrite-specularite-magnetite mineralization similar to the Kasna Creek was located during the investigation. However, the Kontrashibuna volcanic and sedimentary belt is host to many of the anomalies discussed in the next section of this report. Strong geochemistry is present in a two to three-mile wide belt extending from Takoka Creek northeast through Kasna Creek across Kontrashibuna Lake and Gladiator Basin, pinching out in the batholith near the head of South Currant Creek. A branch of this geochemically high belt extends south from Gladiator Basin across the east end of Kontrashibuna Lake nearly to the Tazimina River.

Koksetna Formation

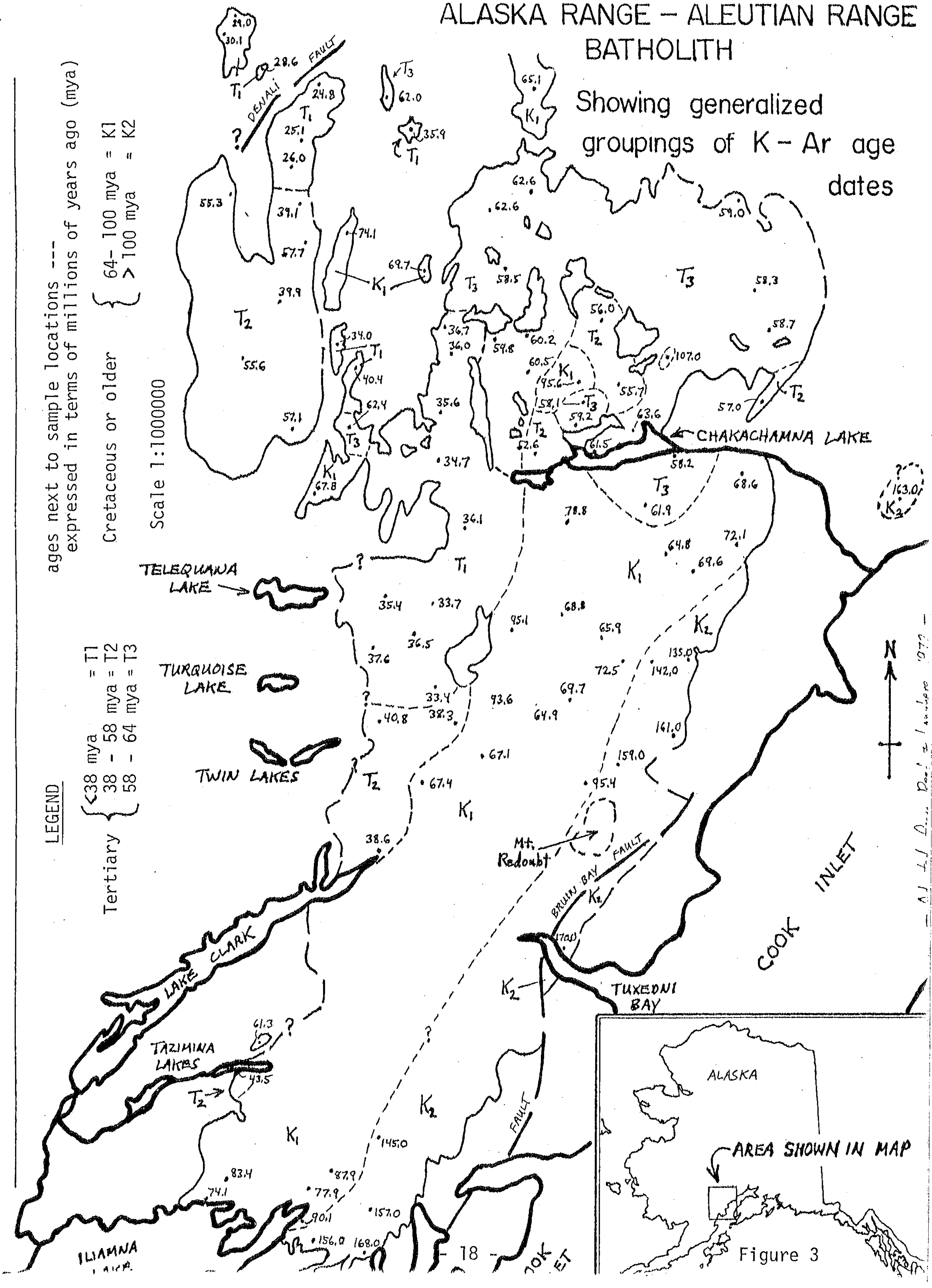
The Koksetna formation refers to the thick section of generally poorly bedded graywackes, siltstones and shales exposed within the Koksetna River area in the western part of the map area (Plate 1). These rocks are almost barren of fossils but are probably Early Jurassic to Late Cretaceous in age. Interbedded volcanics are minimal. The great lateral continuity and detrital characteristics of these sediments suggest offshore deposition over a large area. In fact, siltstones in the Two Lakes area and even those as far north as the Styx River are probably correlatives. These rocks, in addition to the older units, have also been subjected to northeast fault zones as well as the northwest cross fracture system. The Koksetna sedimentary units do not appear to be very prospective for syngenetic mineralization, although metals have been later introduced by intrusives.

Aleutian Range Batholith and Associated Intrusives

The Aleutian Range Batholith proper forms the northeastern-southwest axis of glacial mountains in the easter part of this area. The batholith has been found to consist of predominantly intermediate intrusives as diorites and monzonites but also has some granitic and even gabbroic phases. The more felsic fractions and probably younger phases are particularly common as satellite stocks intruded as far northwest as the Fishtrap Lake area.

Potassium-argon dating of the batholithic rocks by Reed and Lanphere (1972) has identified the following age groups: Jurassic (180 to 155 million years ago), Late Cretaceous-Early Tertiary (84 to 50 million years ago),and mid-Tertiary (40 to 34 million years ago). Figure 3 is a reorganization of Reed's data which clearly depicts successive stages of the batholith decreasing in age from east to west and from south to north. Batholithic rocks then in the eastern Lake Clark area are largely Cretaceous or older(greater than 100 m.y. in the eastern part of the batholith and 64 to 100 m.y. in the western part). It is not possible, of course, to distinguish these categories in the field except for general relationships such as older regionally and structurally metamorphosed rocks. For example, Left Fork West Glacier Creek and Brooks Creek show strong northeast trending gneissic and schistose structures related to faulting and metamorphism. Some of the younger stocks, such as in the Fishtrap Lake area, are intruded along or at structural intersections. Textures of various phases range from coarse grained equigranular to medium grained porphyritic.

The batholith core east of Kontrashibuna Lake was found to be lacking in mineral potential so not much time was spent there except to check local color anomalies and favorable structural areas. Nearby intrusives in the Kontrashibuna Lake area however, have given rise to several anomalies discussed in the next section. Most of the mineralization examined, however, can be attributed to local and widely spaced fracture fillings along structural zones. West of Lake Clark the only sizable intrusive with related mineralization is the granite occurring just west of the Kijik River (see anomaly report). No major porphyry copper deposits were located in spite of numerous occurrences of copper, silver, lead, zinc and molybdenum. Still the potential for such deposits is considered good on the basis



ALASKA RANGE – ALEUTIAN RANGE BATHOLITH
Showing generalized groupings of K – Ar age dates
LEGEND
Tertiary <38 mya = T1
38 - 58 mya = T2
58 - 64 mya = T3
Cretaceous or older 64-100 mya = K1
> 100 mya = K2
ages next to sample locations --- expressed in terms of millions of years ago (mya)
Scale 1:1000000
DENALI FAULT
CHAKACHAMNA LAKE
TELEQUANA LAKE
TURQUOISE LAKE
TWIN LAKES
LAKE CLARK
TAZIMINA LAKES
ILIAMNA
Mt. Redoubt
BRUIN BAY FAULT
FAULT
TUXEDNI BAY
COOK INLET
N
ALASKA
AREA SHOWN IN MAP

Figure 3

of numerous occurrences and the favorable geologic environment.

Mulchatna Volcanics

The Mulchatna volcanics are comprised predominantly of rhyolitic, rhyodacitic and quartz latitic flow rocks and pyroclastics. Minor latites and trachytes have been included in the formation. Notably, there are no interbedded sediments other than local tuffs near volcanic sources, which, along with locally developed columnar jointing, is indicative of subaerial origin for these volcanics. Textures show extreme variation, as welded tuffs, tuff breccias and flow banded rhyolites are all fairly common. Apart from slight chlorite and argillic alteration near vent areas, these volcanics are quite fresh, and their age is almost certainly Middle Tertiary. Nearly all the volcanics north and west of Kijik Lake fall into this group. This belt of Tertiary volcanics extends north to Twin Lakes, Two Lakes and into the upper Stoney River and Styx River areas. Tertiary volcanics of felsic composition extend easterly, where they cover part of the older, basic volcanics south of Lachbuna Lake. On the east side of Lake Clark, Tertiary volcanics occur as remnants north of the mouth of Currant Creek, on north central Copper Mountain, and northwest of Upper Tazimina Lake.

The predominantly subaerial origin of these volcanics makes them non-prospective for volcanogenic massive sulfides. In fact, the generally low geochemistry of the group helps to distinguish them from higher background volcanics of the older groups. However, small Tertiary intrusives and particularly breccia pipes were probably source areas to volcanic flows of this group and are mineralized with copper, silver, and zinc in the Koksetna-Kijik area. The Pass Prospect is considered to be a good example of this type of mineralization.

Geochemistry

The Lake Clark Quadrangle was found to be a highly mineralized province with some metallization occurring in nearly every major lithologic group. Well over three thousand samples (Plates 5a-i and 6a-g) were collected in conjunction with reconnaissance geologic mapping. These samples were analyzed for the standard copper, silver, lead and zinc (Appendicies 1-4). Molybdenum and arsenic were used extensively as guides in early stages of the exploration. Rock samples were additionally analyzed for other elements such as gold, chromium, cobalt, tin, tungsten, nickel, cadmium, selenium, mercury, barium and/or beryllium as dictated by local geologic inference and metal association.

Several areas of interest and numerous geochemical anomalies were isolated. In fact, great care had to be taken to isolate meaningful anomalous mineralization from the often high background geochemistry, particularly in areas of volcanic rocks. Geochemical maps of respective elements were prepared in conjunction with field work to overlay the geology and guide the follow-up program.

Frequency distribution plots suggest anomalous values for streams and soils in the Lake Clark area to be greater than 100 ppm copper, 3 ppm silver, 9 ppm molybdenum, 60 ppm lead, 150 ppm zinc and 40 ppm arsenic. These values serve only as a general guide, and results are obviously influenced by local geologic and topographic conditions.

Several occurrences of gold, silver, copper and molybdenum have been known in the Lake Clark area for some time. Two prospects have been drilled by Falconbridge Mining. The most important is the Kasna Creek Prospect, on the south shore of Kontrashibuna Lake, which is rumored to contain nearly three-fourths of a billion dollars worth of copper in the ground. The other is the TAK group of claims approximately two and a half miles southeast of Kasna Creek. Both of these occurrences of mineralization are located in or near the previously described Kontrashibuna volcanic and sedimentary belt.

Numerous occurrences of previously unknown mineralization, primarily of interest for copper, silver and zinc, were isolated by the present study using stream and rock geochemistry in conjunction with geologic indicators. Significant occurrences or areas of interest are individually discussed in the next section under Prospects and Anomalies.

Prospects and Anomalies

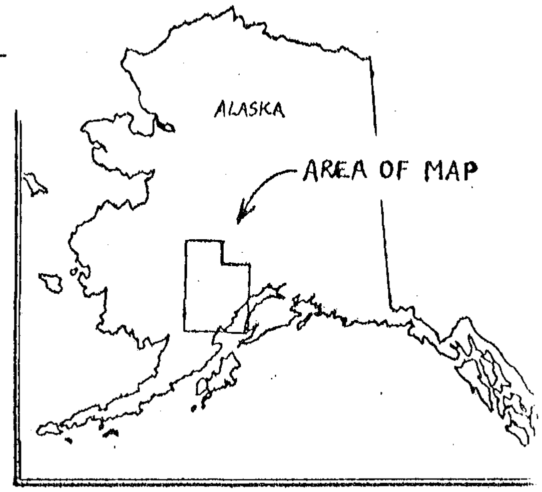
During the course of this investigation in the Lake Clark area, with substantial field work in 1974 and follow-up in 1975, twenty-three areas of interest primarily for copper, silver, and/or zinc mineralization were delineated (Figure 4 and Plate 2). Some of the better areas of mineralization discovered in this region include the Pass Copper-Silver Prospect, Tazimina Copper Prospect, Kijik Copper Anomalies, and the Gladiator Basin Copper Anomalies. These prospects are discussed in the pages that follow and the anomalies of merit are presented in Tables 1 to 23. Numerous other occurrences of mineralization were found, although generally in minor amounts. Many of these are associated with major fault zones, volcanic-sedimentary contacts, intrusive contacts and in or near the lime sedimentary rocks and intermediate volcanics. The sample description log (Appendices 1-5) makes reference to many such occurrences.

The Lake Clark area is one of the most mineralized and most promising geologic provinces in Alaska and has excellent potential for massive sulfide deposits in portions of the Lake Clark schist belts and in parts of the Kontrashibuna volcanic and sedimentary belt. Volcanogenic network deposits are likely in the Kontrashibuna series. Porphry copper potential is good in the younger intrusive stocks and plutons. Some of the Tertiary intrusives which represent volcanic feeders or "necks" are good possibilities for breccia pipe mineralization such as the Pass Copper-Silver Prospect.

Figure 4

LAKE CLARK QUADRANGLE - PROSPECTS AND ANOMALIES

10 - Telaquana River Mo anomaly
11 - Telaquana Pass Mo anomaly
12 - Neacola River South Cu anomaly
13 - Twin Lakes East Cu anomaly
14 - Twin Lakes West Zn anomaly
15 - Otter Lake Cu anomaly
16 - Pass Lake West Cu anomaly
17 - Pass Cu Prospect
18 - Kijik Lake Cu anomaly
19 - Kijik River West Cu anomaly
20 - Kijik Mountain North Zn anomaly
21 - North Currant Creek Cu anomaly
22 - South Currant Creek Cu anomaly
23 - Upper South Currant Creek Cu anomaly
24 - East Gladiator Zn anomaly
25 - West Gladiator Zn anomaly
26 - West Takoka Creek Cu anomaly
27 - Tak II Cu Prospect (not discussed)
28 - East Takoka Creek Cu anomaly
29 - Kasna Creek Cu Prospect (not discussed)
30 - Kontrashibuna Mo anomaly
31 - West Ospook Cu anomaly
32 - Upper Tazimina Cu anomaly
33 - Tazimina Cu Prospect
34 - Little Tazimina Cu anomaly



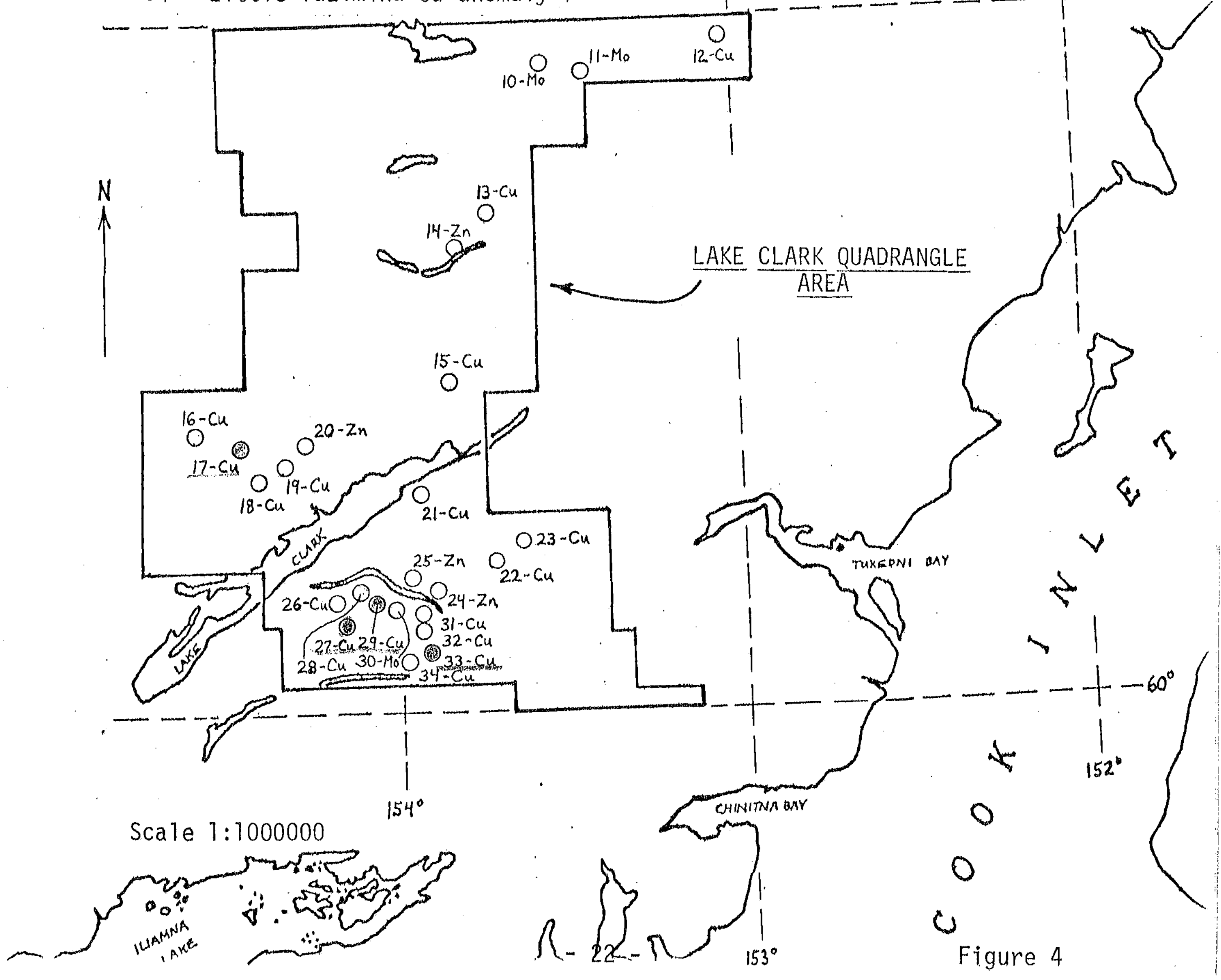


Figure 4

Pass Copper-Silver Prospect

A copper-silver anomaly related to a "breccia pipe" was discovered by regional reconnaissance in 1974. The area is located in Lake Clark B-4, seven miles northwest of Kijik Lake, and is now referred to as the Pass Prospect. The two square mile iron stained area was recognized as a potential porphyry copper deposit. On this basis plus encouraging values in copper, silver, lead and zinc, the anomaly was investigated in some detail as part of the 1975 follow-up program. Several man-days were spent mapping and sampling, which determined the area of interest to be approximately 2500 by 3000 feet (Figure 4 and Plates 7a-g).

Geology

The mineralized area is marginal to a dacite porphyry body having feldspar and/or quartz phenocrysts. The marginal facies is brecciated and mineralized on the north and west sides by copper, silver, lead and zinc. This breccia is suspected to be an explosion breccia related to a vent supplying extrusive dacite and rhyodacite breccia tuffs and flows to the surrounding area. Volcanic breccia fragments are generally less than one half to one inch in size, although some have been observed to be six to eight inches in diameter. Faulting along a north-northwest trend during or shortly after emplacement of the intrusive-volcanic center may be in part responsible for northwest trending iron stained zones. These zones are about 500 feet wide and 1500 to 2000 feet long and reflect some of the better geochemical values. Lithologic contacts are obscured by talus and rubble over most of the 100 to 2000-foot relief in the prospect area.

This volcanic-intrusive complex is suspected to be of Tertiary age because of the subaerial volcanics with no interbedded sediments. Effects of regional metamorphism are absent, and most of the rocks outside of the "vent" area are fairly fresh and unaltered. Iron staining is common in outlying areas but seldom contains any elements of economic interest.

Mineralization

Mineralization consists of stockwork fracture fillings of pyrite and/or pyrrhotite with variable amounts of associated chalcopyrite, galena and possible tetrahedrite. Weathering and oxidation have resulted in the formation of a sizable color anomaly of iron and manganese oxides with some development of a gossan material having leached cavities.

Well over one hundred rock chip samples were taken to delineate the mineralized areas. The potential "ore" zones consist of three main slab-like plates dipping steeply to the southwest with values ranging up to 3000 ppm copper, 470 ppm silver, 1500 ppm lead and 3600 ppm zinc. Average values are only one-third to one-fourth of the above. Interesting copper and zinc values are present in all three zones, whereas most of the better silver occurs in the westernmost zone, and most of the lead is in the easternmost zone (Plates 7a-e).

Alteration is largely restricted to the "vent" area on the southwest side of the dacitic intrusive. Chloritic and sericitic alteration of feldspar is moderately developed. Extensive silicification is absent.

Conclusions and Recommendations

Ore grade mineralization is not exposed at the Pass Prospect. However, this area is geologically very similar to some of the breccia pipe deposits now in production elsewhere. On this basis, higher grade mineralization might occur at shallow depths, considering outcrops of the Pass Prospect are high in the geologic section as demonstrated by the presence of adjacent volcanic flows and breccias. In other words, the occurrence has just barely been unroofed by erosion and the best mineralization would be expected somewhat lower in the breccia pipe. Further work on the Pass Prospect is warranted if the land classification permits.

Tazimina Copper Prospect

The Tazimina Copper Prospect was discovered in 1974 in the Lake Clark A-3 quadrangle, three miles northeast of Upper Tazimina Lake (Figure 4 and Plate 2). There are no mining claims or patented lands in the immediate vicinity. Detailed mapping and sampling (Plates 8a-c) were conducted in 1974 at the scale of one inch equals one hundred feet.

Geology

The area of interest is centered on a discontinuous northeast trending zone of quartz-chlorite-sericite-pyrite schists which may contain significant amounts of copper, lead and zinc. This zone of schists is part of a broad metamorpic belt flanking the west side of the Aleutian Batholith which was described earlier as the Lake Clark schist belt. The schists in the prospect area are strongly pyritic (1% to 10%) and trend N30°E to N40°E with a dip of 50 to 90 degrees east. They are bounded on the east by a porphyritic monzonite and on the north by a medium grained chloritic gneiss. In the western part of the prospect area a strongly pyritized fault(?) appears to separate the chlorite schists from schistose metasediments (siltstones and sandstones). The metasediments also trend northerly but dip in the opposite direction (45 degrees to the west) from the chlorite schists.

Several other northerly trending fault zones which parallel regional schistosity may be represented by intermittent zones 10 to 20 feet wide of strong sericite and silica alteration which in some cases is more resistant than the chloritic schists and has created waterfalls in the main creek. It is remotely possible that these zones could also result from siliceous parent material such as felsic volcanics. At any rate, tectonic forces are at least in part responsible for development of schistosity in the area of interest. Outside of the prospect area are local zones of gneissic and schistose diorite and granite adjacent to major fault zones. There is also some suggestion the schist belt in the area of interest could be a large "roof pendant" in the Aleutian Batholith. This is certainly common in the general Kontrashibuna Lake area.

Mineralization

Mineralization in the prospect area is confined to the older schistose rocks. The intrusive rocks of the batholith and related dikes are fresh and unmineralized. The Lake Clark schist is impregnated in the prospect area with 1% to 10% disseminated pyrite and local massive sulfide pods that approach 50% pyrite. Traces of chalcopyrite and native copper are disseminated as small grains with the pyrite in exposures of rocks in the main stream. One six-inch sulfide vein or bed paralleling the foliation of the schist contains 60% pyrite, 20% quartz, 10% magnetite, 5% chalcopyrite, 1% bornite and traces of native copper. Talus covers much of the southern part of the prospect area, but isolated outcrops of schist containing 1% to 3% pyrite are similar to rocks in the main stream. Numerous boulders of massive sulfides, mostly pyrite, are present in the talus between the creek and the isolated outcrops. Most of these boulders are within 100 feet of each other and vary in size from several inches to six feet. They contain approximately 0.5% copper, 0.5 ounce per ton silver, 0.5% lead and up to 3% zinc (Plates 8a-b).

The source of these sulfide boulders is debatable. Bedrock may be only a few feet under the talus, and the boulders could have originated close to their present position. A glacier may have plucked them from a source further up the valley, but there is good evidence, however, that they traveled no more than 200 to 300 feet. First, they are grouped in a small area pointing to a small source slightly uphill. Second, they are of the same composition, although richer, as the nearby massive sulfide occurrences in the schist of the main creek. Unfortunately, mapping and detailed sampling on 100-foot centers of available outcrops was overall discouraging; only one copper value was significantly anomalous. Many samples were run for arsenic, gold, tin, tungsten, beryllium, vanadium and cadmium, with negative results.

Conclusions and Recommendations

The source and origin of sulfides at the Tazimina Prospect, such as those contained in the "veins" parallel to bedding as well as the massive sulfide boulders, is somewhat debatable. Both a volcanogenic origin with a later reorganization of sulfides and a hydrothermal introduction of sulfides have been considered. There is evidence that can be cited for both thesises. However, the exclusiveness of mineralization in the schists and volcanics and not in the later intrusives suggests that mineralization was of a volcanogenic origin with later remobilization of sulfides by intrusive rocks.

In this particular prospect the schists do not contain enough economically viable mineralization to warrant further work. The massive sulfide boulders , although containing ore grade material, probably come from relatively small lenses or pods. The lack of gold or appreciable silver hurts the chances of an economic deposit in the immediate area. However, this occurrence lends much support to potential deposits in other parts of the schist belt. True!!

Table 1 Telaquana River Molybdenum Anomaly.

Type of Anomaly or Commodity of Interest:

Molybdenum.

Location by Quadrangle and Topography:

Lake Clark D-2; at the head of Telaquana River.

Approximate Size of Area of Interest:

Two to three square miles.

Number of Samples or Data Supporting Anomaly:

Three anomalous samples out of eight. One rock sample ran 3200 ppm molybdenum.

General Geologic Setting, Lithology and Structure:

The area of interest is in quartz diorite near the intersection of major northwest trending faults and a suspected northeast lineament. The diorite in this area contains several roof pendants or inclusions of schist and lesser amounts of limestone.

Nature, Occurrence and Controls of Mineralization:

Molybdenum seems to be associated with pyritized areas in both the diorite and schistose inclusions.

Alteration Products and Halo Effects:

Strong iron staining and fracturing; chlorite-epidote alteration of diorite. There is a weak zinc halo in surrounding rocks.

Classification or Type of Potential Ore Deposit:

Bulk molybdenum.

Remarks, Including Suggestions for Prospecting:

Particular attention should be directed to fault intersections and chemically reactive inclusions. A local area of quartz monzonite may be the supplier of mineralization.

Table 2 Telaquana Pass Molybdenum Anomaly.

Type of Anomaly or Commodity of Interest:

Molybdenum; similar to an occurrence four miles to the west.

Location by Quadrangle and Topography:

Lake Clark D-2; at Telaquana Pass.

Approximate Size of Area of Interest:

One and a half square miles.

Number of Samples or Data Supporting Anomaly:

Five samples consistently anomalous. One rock sample contained 2200 ppm molybdenum, and an adjacent stream contained 200 ppm molybdenum.

General Geologic Setting, Lithology and Structure:

The predominant rock type is quartz diorite with lesser amounts of quartz diorite porphyry and quartz monzonite. These rocks appear to have been intruded by a wedge of biotite granite. Mineralization occurs in the quartz diorite and seems to be exclusive of the adjacent granite. Several major faults have affected the area of interest.

Nature, Occurrence and Controls of Mineralization:

Molybdenum occurs in veinlets of quartz and veinlets of pyrite. There is some associated magnetite in the quartz-molybdenum veinlets.

Alteration Products and Halo Effects:

Large area of strong iron staining from pyrite veins and from disseminated pyrite and pyrrhotite.

Classification or Type of Potential Ore Deposit:

Stockwork type molybdenum deposit.

Remarks, Including Suggestions for Prospecting:

The area of interest is fairly well defined by geochemistry, iron staining and faults, so it would be a matter of checking grade and geological characteristics.

Table 3 Neacola River South Copper-Molybdenum Anomaly

Type of Anomaly or Commodity of Interest:

Copper and molybdenum

Location by Quadrangle and Topography:

Northeast corner of Lake Clark D-1 about six miles south of the Neacola River in T.10N., R.21W.

Approximate Size of Area of Interest:

Four square miles of immediate interest

Number of Samples and Data Supporting Anomaly:

Two rock samples taken one half mile apart and containing highly anomalous copper and molybdenum. Samples from steep slope at margin of glacier.

General Geologic Setting, Lithology and Structure:

Mineralization in this area occurs in a granite-granodiorite-diorite intrusive complex. Parent rock for the mineralization is unknown but the diorite and granodiorite are both mineralized to some extent. The general area is broken by fracture systems trending east-west and northeast-southwest. Dikes of diorite have commonly been intruded into the granite along the east-west fracture set.

Nature, Occurrence and Controls of Mineralization:

Sample B 1367 is a rock chip sample of diorite rubblecrop containing disseminate pyrite, azurite, and traces of bornite. This rock is fractured but not particularly veined. This sample contained only 38 ppm molybdenum but has 870 ppm copper. The granodiorite in this area does contain quartz veins with some pyrite-galena and pyrite-azurite as examplified by B 1366 which contains 3600 ppm molybdenum and 8800 ppm copper.

Alteration Products and Halo Effects:

Epidote alteration and veining is common in this area, particularly in the diorite. Quartz veining is also abundant and locally is near pegmatitic in character.

Classification or Type of Potential Ore Deposit:

Possible stockwork or porphyry deposit

Remarks, Including Suggestions for Prospecting:

The complexity of intrusive phases in this area is encour-

Table 3 Neacola River South Copper-Molybdenum Anomaly (cont.)

aging as is the multiple fracture systems, but the area is extremely rugged and difficult to prospect. A closer examination of talus and float may be sufficient to evaluate this occurrence. The area east of the sample locations should be examined if possible.

Table 4 Twin Lakes East Copper Anomaly

Type of Anomaly or Commodity of Interest:

Copper

Location by Quadrangle and Topography:

In NW corner of Lake Clark C-2 and SW corner of Lake Clark D-2 about 8 miles southeast of Turquoise Lake

Approximate Size of Area of Interest:

Nearly 12 square miles

Number of Samples or Data Supporting Anomaly:

Approximately 20 samples, most of which are rock samples with values of a few hundred ppm to several percent copper

General Geologic Setting, Lithology and Structure:

Mineralization in this area is hosted by the older volcanic rocks (Jurassic?) of the Kasna Creek Volcanic belt which occurs here as a fairly large remnant or inclusion in the Aleutian Batholith. This is suggested by the abundance of andesites and andesite porphyry volcanics with interbedded limestone and minor argillite and tuffaceous sediments. Small gabbro intrusive bodies similar to those in the Kontrashibuna area are likewise common here. Dikes of gabbro truncate the limestone. Younger diorite and granite of the Aleutian series disrupt and displace this volcanic series, particularly on the east side of the area of interest.

Nature, Occurrence and Controls of Mineralization:

Copper mineralization is present as chalcopyrite and bornite. The chalcopyrite is associated with pyrrhotite as disseminations and blebs in the andesites whereas the bornite is more common as disseminations in the andesite porphyry units.

Alteration Products and Halo Effects:

(Fracture fill not veining — H.T.)

Epidote and calcite are both strong alteration products in the mafic volcanics. Bull quartz veining of near stockwork intensity is locally developed near gabbroic intrusives where they have been emplaced into the limestone.

Classification or Type of Potential Ore Deposit:

Volcanogenic sulfide deposit

Table 4 (Cont.)

Remarks, Including Suggestions for Prospecting:

This is a fairly large area of weak mineralization in a favorable environment similar to that of the Kasna Creek Deposit. Efforts should be made to explore areas where the basic volcanic and intrusive rocks are in contact with the limestone. The areas of quartz veining may also be important hosts to sulfides.

Table 5 Twin Lakes West Lead-Zinc Anomaly

Type of Anomaly or Commodity of Interest:

Lead and Zinc

Location by Quadrangle and Topography:

Eastern part of Lake Clark C-3 quadrangle near east Twin Lakes

Approximate Size of Area of Interest:

Approximately 12 square miles

Number of Samples or Data Supporting Anomaly:

Twenty anomalous samples with values of 200-400 ppm zinc in rocks out of about 45 total samples

General Geologic Setting, Lithology and Structure:

The area of interest is a felsic center of rhyolite and rhyolite-dacite in a larger area of andesitic volcanics. Alteration and mineralization are related to areas of felsic volcanic breccia. Some breccias contain clasts 0.5-4 cm in diameter and may represent vent areas. Silicification and weak argillization are common near these breccia centers. Some of the porphyritic rhyodacite is thought to be intrusive and represent the plug or throat area of the volcanic center. Tuffaceous sediments such as sandstone, graywacke, and argillite are interspersed with this volcanic buildup. Some of these tuffaceous units may represent remnants of the older (Jurassic?) volcanic belt.

Nature, Occurrence and Controls of Mineralization:

Mineralization occurs as fine-grained disseminations and hairline fracture fillings of pyrite and lesser chalcopyrite, sphalerite, and galena in silicified rhyolite and rhyolite-dacite volcanics; particularly volcanic breccia. Sulfide fragments are present in some of the mineralized breccias. Areas of manganese and iron staining have at least some anomalous mineralization.

Alteration Products and Halo Effects:

Epidote and chlorite alteration of basic to intermediate volcanics are widespread. Silicification and lesser sericitization are common and locally intense in the more felsic volcanics, particularly near the

Table 5 (Cont.)

F > S, how about low T + P min

breccia centers. Minor calcite and ?hematite alteration? is present along some fractures.

Classification: ? Not good usage

Porphyry type mineralization related to a volcanic breccia deposit

Remarks:

This volcanic center is probably Tertiary in age and the occurrence of lead-zinc and lesser copper in a volcanic breccia complex here is similar to the Pass Copper Prospect. The Twin Lakes anomaly should be investigated in some detail with particular attention to areas of volcanic breccia? in conjunction with silicification and limonite staining.

Table 6 Otter Lake Copper Anomaly

Type of Anomaly or Commodity of Interest:

Copper with some zinc.

Location by Quadrangle and Topography:

NE corner of Lake Clark B3, SE corner of Lake Clark C3, and SW corner of Lake Clark C2.

Approximate Size of Area of Interest:

About 16 square miles; the belt is two miles wide and eight miles long and trends N 10-20 degrees east.

Number of Samples or Data Supporting Anomaly:

Over 30 anomalous samples with copper values of several hundred ppm in both stream and rock samples.

General Geologic Setting, Lithology and Structure:

This area is of interest for possible massive sulfide deposits related to the "Lake Clark Schist" belt described in the geology text of this section. In brief the area west and north of Otter Lake is pyritic chlorite schists with interbedded argillites, cherts and recrystallized limestone or marble. These chlorite schists represent andesitic volcanics, including breccias and lapalli tuffs The area north of Otter Lake and northeast of Portage Lake is much more felsic in composition as represented by dacitic and rhyodacitic volcanics and breccias. Gabbro dikes and a large sill have been intruded into the chlorite schist west of Otter Lake. This gabbro is moderately to strongly serpentinized.

Nature, Occurrence and Controls of Mineralization:

Copper mineralization is present as chalcopyrite which occurs as disseminations in more massive pyrite associated with chlorite schists west of Otter Lake and with felsic volcanics and breccias northeast of Portage Lake. Limestone and limestone breccia are also common host rocks for sulfides west of Otter Lake. Red to brown chert beds are also weakly anomalous in copper.

Alteration Products and Halo Effects:

Chlorite alteration of mafic volcanics and fine-grained tuffaceous sediments is strong and widespread. Serpentine ~~alteration~~ of mafic volcanics and particularly the gabbro sills is common.

Table 6 Otter Lake Copper Anomaly (continued)

Classification or Type of Potential Ore Deposit:

Volcanogenic network and/~~or~~? massive sulfide. *Hul?*

Remarks Including Suggestions for Prospecting:

The geology and geochemistry of rocks in this area are very favorable for massive sulfide deposits. The chlorite schist unit is known to contain at least small pods of massive pyrite and lesser chalcopyrite together with strong disseminations (10-20%) of pyrite. The felsic volcanics northeast of Portage Lake are more likely to contain network type deposits of copper-zinc.

Table 7 Pass Lake West Copper-Silver Anomaly.

Type of Anomaly or Commodity of Interest:

Copper-silver mineralization similar to the Pass Prospect may be suggested by a large area of anomalous zinc associated with rhyolites or granite.

Location by Quadrangle and Topography:

Lake Clark B-5; near the largest unnamed lake, west and northwest of the nearby Pass Copper-Silver Prospect.

Approximate Size of Area of Interest:

Two to three-mile wide area west of the fault trending N25E for nine miles and thence N50W for five miles on the south side of the Koksetna-Pass lineament.

Number of Samples or Data Supporting Anomaly:

Twenty-five anomalous samples along the above trends were outlined by 1974 reconnaissance. Two of these also have coincident copper and silver, and one has anomalous molybdenum. One sample has anomalous silver without coincident copper.

General Geologic Setting, Lithology and Structure:

The zinc-copper-silver anomaly occurs in granites, rhyolites and rhyodacites south and west of the above-mentioned faults. Near the southern third of the trend are three separate rhyolite pipes(?) that are of special interest, as they may have been feeders to rhyolite flows in the area. The granites show local argillization, and secondary biotite was noted at one locality.

Nature, Occurrence and Controls of Mineralization:

Mineralization and intrusion of rhyolite-granite along two faults are controlling features; other granites, rhyolites and other faults in the adjacent area outside the area of interest are not mineralized.

Alteration Products and Halo Effects:

Rhyolites are iron and manganese stained and fractured. Granites are less affected.

Classification or Type of Potential Ore Deposit:

Bulk copper-silver, if source areas can be located.

Table 7   Pass Lake West Copper-Silver Anomaly (Cont.)

Remarks, Including Suggestions for Prospecting:

One man-day of follow-up work was conducted during the 1975 field season two miles southwest of the lake, as indicated by the better stream sediment geochemistry. Weak mineralization was observed in an intrusive-volcanic "pipe-like" setting, but nothing that approaches ore grade was found.

Table 8 Kijik Lake Copper-Silver Anomaly.

Type of Anomaly or Commodity of Interest:

Copper and silver.

Location by Quadrangle and Topography:

Lake Clark B-4; three miles northwest of Kijik Lake, and two to three miles southeast along strike of fault from the Pass Prospect.

Approximate Size of Area of Interest:

The area of interest is two miles long and one-half mile wide, along strike of northwest trending fault.

Number of Samples or Data Supporting Anomaly:

Three anomalous samples out of eight. One rock sample ran 180 ppm copper, 5.8 ppm silver and 275 ppm zinc.

General Geologic Setting, Lithology and Structure:

The area of interest is along a structural zone where dacite porphyry and dacitic volcanic breccia have been mineralized by 1% to 3% pyrite and traces of chalcopyrite(?). The target would be a breccia pipe or small stock which may have served as a feeder for volcanic flow and tuffs in this area.

Nature, Occurrence and Controls of Mineralization:

Possible breccia pipe or intrusive localized by northwest-southeast fault, and mineralization spreading out along the fault.

Alteration Products and Halo Effects:

Locally, dacites are strongly silicified with secondary biotite developed and in some places weak chlorite.

Classification or Type of Potential Ore Deposit:

Possible breccia type deposit for bulk copper-silver.

Remarks, Including Suggestions for Prospecting:

Overall, this anomaly is weak and has been partially checked. Outcrops along the northwest-southeast structural trend were checked for occurrence of volcanic breccia, which proved to be unexciting. The area to the southeast toward Kijik Lake has not been sampled.

Table 9 Kijik River West Copper-Silver Anomaly.

Type of Anomaly or Commodity of Interest:

Copper and silver.

Location by Quadrangle and Topography:

Lake Clark B-4; west of the Kijik River Fault.

Approximate Size of Area of Interest:

Two to three square miles

Number of Samples or Data Supporting Anomaly:

Four anomalous samples in rhyolitic volcanics and 14 anomalous samples in granodiorite were collected in 1974.

General Geologic Setting, Lithology and Structure:

A granodiorite stock one square mile in area is cut by widely spaced one-fourth to one inch, north-south trending quartz-chalcopyrite and quartz-pyrite-arsenopyrite veins and by more widely spaced four to five-foot zones of mineralized intrusive breccia having rounded clasts of rhyolite(?). Rhyolite outcrops north and west of the granodiorite are also mineralized and should be considered as a possible source of mineralization which may have migrated into north-south fractures in granodiorite that developed parallel to the Kijik River Fault.

Nature, Occurrence and Controls of Mineralization:

Host rocks are rhyolite, intrusive breccia zones and granodiorite. Most veins were high-graded to check for gold, with negative results. Values shown on maps are therefore not representative of any sizable areas of similar grade.

Alteration Products and Halo Effects:

Granodiorite is altered adjacent to veins and breccia zones by bleaching, and more commonly quartz-sericite-greisen with locally potassic alteration. Rhyolite is strongly fractured, iron stained and locally argillized.

Classification or Type of Potential Ore Deposit:

Possible bulk copper-silver.

Table 9 Kijik River West Copper-Silver Anomaly (Cont.).

Remarks, Including Suggestions for Prospecting:

Mineralization was thought at first to be related to granodiorite. Later information suggests that the rhyolite, which is also mineralized, is later than the granodiorite stock, so more attention should be given to the rhyolites north and west of the granodiorite . The area to the north was investigated in 1975 and found to be rhyolitic and dacitic volcanics of presumed subaerial origin. These are brightly colored from iron and manganese oxide stains, but no intrusive center was found and geochemistry is discouraging.

Why? There may have been 2 periods of mineralization.
Do the mineral assemblages suggest 1 or 2?

Table 10 Kijik Mountain North Zinc Anomaly.

Type of Anomaly or Commodity of Interest:

Zinc, with minor lead and silver.

Location by Quadrangle and Topography:

Lake Clark B-4; three miles north of Kijik Mountain, at the north end of the north-south Kijik River Fault zone.

Approximate Size of Area of Interest:

Four square miles, coincident with a stream and rock anomaly, in which the literature also reports a zinc-lead-silver occurrence.

Number of Samples or Data Supporting Anomaly:

This was a strong zinc anomaly from 1974. In 1975, 13 more samples were collected, and several man-days of reconnaissance were spent on the anomaly and adjacent areas.

General Geologic Setting, Lithology and Structure:

There is strong zinc stream sediment geochemistry peripheral to the 3180-foot mountain, which is composed largely of porphyritic rhyolite, cherty rhyolite tuff breccia and mixed felsic to intermediate volcanics. The southwestern flank, where the strongest geochemistry occurs, is predominantly dacite porphyry. A small, medium grained, dark gray diorite stock intrudes the volcanic complex north of the highest peak.

The rhyolite and rhyolite tuff breccia are generally strongly fractured, leached and silicificed. Chert fragments up to 5 mm. are common. Toward the southern part of the anomaly, an orbicular texture is found in the volcanics. An intrusive center was not pinpointed in follow-up work. The rhyolite and felsic volcaniclastics appear to strike northwest and dip steeply to the southwest. The dacite porphyry is probably the uppermost unit. The north-south Kijik River Fault may branch out near this anomaly, and splinter faults may have caused fracturing in much of the iron stained volcaniclastics.

Nature, Occurrence and Controls of Mineralization:

One stream sediment sample carried up to 2000 ppm zinc. Float in this stream was primarily intermediate volcanic tuffs and tuff breccias, although exposed bedrock was dark gray dacite porphyry. Several zones of intense fracturing and iron staining which contained 1% to 3% pyrrhotite or pyrite carried 220 to 260 ppm zinc. Only three of the 13 samples collected in 1975 were slightly anomalous in lead. No samples were significantly rich in silver or gold.

High zinc values in the rock samples were generally coincident with strong fracturing, strong iron staining and weak to moderate pyrrhotite or pyrite mineralization. The best mineralization did not seem to be restricted to a particular rock type or contact. No massive sulfides were located.

Alteration Products and Halo Effects:

Most of the volcanics are strongly silicified and leached and contain only traces of chlorite. Most of the area is strongly iron stained due to small amounts of pyrite and pyrrhotite.

Classification or Type of Potential Ore Deposit:

A porphyry silver deposit is possible. The rock types are similar to those found in volcanogenic massive sulfide terrains; however, these volcanics are suspected to be subaerial in origin and Tertiary in age.

Remarks, Including Suggestions for Prospecting:

Fairly detailed prospecting did not reveal any breccia pipe type mineralization in spite of favorable geology and consistent zinc values. Economic deposits at depth are possible but would be expensive to evaluate.

Table 11 North Currant Creek Copper Anomaly

Type of Anomaly or Commodity of Interest:

Copper

Location by Quadrangle and Topography:

Lake Clark B3 on the east shore of Lake Clark about two miles northwest of Currant Creek.

Approximate Size of Area of Interest:

About six square miles

Number of Samples or Data Supporting Anomaly:

Eight highly anomalous samples with local stream sediments containing values of 360 and 1200 ppm copper.

General Geologic Setting, Lithology and Structure:

The host rocks for mineralization are a complex volcanic-intrusive series of predominantly dacite porphyry, rhyolite and lesser andesite. Volcanic breccias and tuffs are also common. These rocks are highly fractured and broken as well as being intensely silicified and recrystallized. Many samples are described as being "hornfelsic" but overall the geology suggests a volcanic neck or breccia pipe environment similar to that of the previously described Pass Copper Prospect.

Nature, Occurrence and Controls of Mineralization:

Mineralization results from disseminations and fracture fillings of pyrite and chalcopyrite in strongly iron stained volcanics. Minor sulfides are present in the adjacent hornblende diorite intrusive but only where the diorite is in contact with the volcanic complex.

Alteration Products and Halo Effects:

The general area of interest is highly iron stained from hematite and pyrite which results in a spectacular color anomaly visible for several miles. The volcanic rocks are characterized by extensive silicification and recrystallization.

Table 11 North Currant Creek Copper Anomaly (Cont.)

Classification or Type of Potential Ore Deposit:

Breccia pipe deposit in a volcanic-intrusive complex

Remarks, Including Suggestions for Prospecting:

Detailed examination of this highly significant anomaly is warranted on the basis of the similarity of the geology and type of mineralization to that of the previously described Pass Copper Prospect. The areas of brecciation and silicification as well as those containing sulfides should be sampled and mapped in detail.

Table 12 South Currant Creek Copper Anomaly

Type of Anomaly or Commodity of Interest:

Copper, with minor zinc and gold.

Location by Quadrangle and Topography:

Southwest Lake Clark B-2 and northwest Lake Clark A-2; between Currant Creek and South Currant Creek.

Approximate Size of Area of Interest:

Three to four square miles.

Number of Samples or Data Supporting Anomaly:

Two stream sediment samples, two soil samples and three rock samples.

General Geologic Setting, Lithology and Structure:

At sample locations B-1778 and B-1779 limestone with interstitial quartz, hornblende and biotite was observed in bedrock. Basalt dikes cut the limestone. Float rock in the stream beds was primarily chloritic altered limestone and diorite. One and a half to two miles further north a 30-foot wide zone containing numerous calc silicate veins cuts barren and unaltered granodiorite. Weak chlorite and potassium feldspar alteration and weak brecciation with minor iron oxides accompany this zone.

The occurrence of primary rock-forming minerals within the limestone may indicate that the diorite intrusive completely remobilized a sedimentary limestone deposit. The strong calc silicate veining in the granodiorite to the north may also be related to this intrusive episode.

Nature, Occurrence and Controls of Mineralization:

Several stream sediment samples collected from the area of limestone analyzed between 100 and 150 ppm copper. One sample contained 0.4 ppm gold. A few float boulders contained disseminated pyrite, magnetite and chalcopyrite. A stream sediment sample collected one mile east of the limestone ran 220 ppm copper. Interestingly, no limestone was noted in the float, only diorite and minor syenodiorite(?) with magnetite and epidote.

Table 12 South Currant Creek Copper Anomaly (Cont.)

Zinc was the only anomalous metal in the iron stained calc silicate zone north of the limestone. Two samples of glacial fines ran up to 500 ppm zinc. Glacial moraine material in this area was nearly 100% granite-granodiorite, with rare quartz-chalcopyrite-pyrite-malachite veins.

Alteration Products and Halo Effects:

Relatively little skarn development was observed in the limestone. The diorite and granodiorite are only locally altered to chlorite, except along calc silicate veins, where pyrite-magnetite and stronger chlorite and potassium feldspar alteration are developed.

Classification or Type of Potential Ore Deposit:

If this is a true carbonatite, rare earth elements may have been assimilated from the diorite. A porphyry copper deposit within the intrusives is a remote possibility. Bulk gold in the limestone is also a very long shot.

Remarks, Including Suggestions for Prospecting:

This anomaly does have some similarities to known carbonatite deposits, such as the Mountain Pass district in California. Unfortunately, follow-up work on the north side of the anomaly in 1975 was not encouraging. Any future work should include detailed mapping and sampling of the steep slope to the north and northeast of the limestone at B-1779 and B-1780 and of the drainage from which sample B-1774 was collected. Samples should be tested for radioactive elements and rare earths.

Table 13 Upper South Currant Creek Copper-Molybdenum Anomaly

Type of Anomaly or Commodity of Interest:

Copper and molybdenum.

Location by Quadrangle and Topography:

Lake Clark B-2; T2N, R25W, section 14; at the head of South Currant Creek, on the north side.

Approximate Size of Area of Interest:

One to one and a half square miles.

Number of Samples or Data Supporting Anomaly:

Four samples, including two anomalous stream sediments.

General Geologic Setting, Lithology and Structure:

Weak propylitic altered diorite and quartz diorite are cut by pyritized rhyolite and gabbro dikes. All are cut by pegmatite dikes. A large area, more than one square mile, is iron stained.

Nature, Occurrence and Controls of Mineralization:

One northeast trending fault with six-inch clay-quartz-pyrite gouge was not anomalous. Two stream sediment samples draining the iron stained area contained 360 ppm copper and 50 ppm molybdeum.

Alteration Products and Halo Effects:

The diorite has weak propylitic alteration and moderate but pervasive iron stain.

Classification or Type of Potential Ore Deposit:

Copper-molybdenum porphyry is a possibility.

Remarks, Including Suggestions for Prospecting:

One good traverse along the ridge may be all that is necessary to determine the merits of this anomaly. The two stream sediments are certainly anomalous for this Aleutian Range diorite, which characteristically has a low background in copper.

Table 14 East Gladiator Copper-Zinc-Lead Anomaly.

Type of Anomaly or Commodity of Interest:

Copper, zinc and lead with lesser silver; also several high molybdenum values.

Location by Quadrangle and Topography:

Lake Clark A-3; one to three miles northeast of the headwaters of Kontrashibuna Lake.

Approximate Size of Area of Interest:

Eight square miles; grading into a separately described copper-silver-zinc anomaly to the west.

Number of Samples or Data Supporting Anomaly:

Nearly 70 samples have been collected in the area, of which approximately 20 are anomalous in one or more metals.

General Geologic Setting, Lithology and Structure:

Argillite and metasiltstone appear to be the oldest rocks in the area. They are interbedded with andesite in the central portion of the area, and to the east they are in sharp and often brecciated contact with intermediate volcanics. Both the metasediments and volcanics have been intruded by a wide range of igneous rocks. The major intrusive appears to be a hornblende quartz diorite which has several slightly more felsic phases. Also present in the anomalous area are gabbro, granite and alaskite.

Barren diorite and granodiorite of the Aleutian Range Batholith bound the anomaly on the east.

Two major northeast trending faults transect the area of interest. They are at least 10 to 20 miles long. No attitude or amount of movement has been determined. Numerous cross faults are also present.

Nature, Occurrence and Controls of Mineralization:

Strong sulfide mineralization is best developed in the metasiltstone and argillite near the andesite or diorite contact. Moderate quartz veining and weak basalt or dacite dikes are common near these contacts. One to three percent pyrite or pyrrhotite in the metasediments is common, and cobbles of 40 to 50% iron sulfides have been observed. Chalcopyrite occurs as very thin fracture coatings, often without appreciable iron sulfides, or within quartz veins which cut metasiltstone or meta-graywacke. The best rock chip sample ran 0.32% copper.

Lead and zinc occur in similar ways. The highest zinc value was 0.1%, and the highest lead 0.09%. Anomalous values of silver up to 27.7 ppm and tin up to 75 ppm have also been collected.

Shear zones within granitic and mafic intrusives have localized strong sulfide mineralization. Iron staining in other wise barren granitic rock can be followed for hundreds of feet. Patches of pyrite with occasional veins of chalcopyrite or molybdenite are scattered erratically throughout. One sample of a quartz vein cutting gabbro contained nearly 0.1% lead. Eight samples within intrusive rock were anomalous in zinc, the highest being a stream sediment sample which contained 680 ppm zinc.

Unfortunately, shear-related mineralization is much too erratic and narrow to be economically significant. Quartz, sericite or clay alteration of the intrusives is much too weak to suggest major copper porphyry potential.

The entire hill south of Gladiator Basin shows a bright orange-maroon iron stain. It is very obvious from the air. The pyrite content is high, but it contains little or no copper, lead or zinc. A large rock slide of this material covers the foot of the basin, which extends the iron stained area to nearly two and a half miles.

Alteration Products and Halo Effects:

The intrusives display deuteric to weak chlorite alteration. Along shears, argillic or sericitic alteration may be developed. Volcanics may have strong epidote-chlorite associated with sulfides.

Classification or Type of Potential Ore Deposit:

Possible massive sulfide in volcanics or metasediments; some chance for low grade, large tonnage stockwork copper and/or molybdenum in volcanics or intrusives.

Remarks, Including Suggestions for Prospecting:

This is probably the largest and most pervasive polymetallic anomaly east of Lake Clark. Prospecting of the volcanics and metasediments should take priority over the intrusives. There are still several square miles that have not been examined in detail which have a moderate potential for mineralization.

Table 15 West Gladiator Copper-Silver-Zinc Anomaly.

Type of Anomaly or Commodity of Interest:

Copper, silver and zinc.

Location by Quadrangle and Topography:

Lake Clark A-3; immediately north of the west end of Kontrashibuna Lake-

Approximate Size of Area of Interest:

Six square miles.

Number of Samples or Data Supporting Anomaly:

Two soil samples and five rock chip samples.

General Geologic Setting, Lithology and Structure:

As at the East Gladiator Anomaly, greenstone and metasediments are intruded by diorite, granodiorite and granite. The intrusive contacts and the close proximity of a major northeast trending fault zone on the east side of the anomaly are the two main localizers of mineralization. Air photo interpretation indicates a large intrusive near the center of the anomaly; float on the flanks of the mountain suggests a granite rock type.

Nature, Occurrence and Controls of Mineralization:

Sample D-792 is a 15-foot chip of greenstone (metavolcanic?) which was intruded and brecciated by a strong propylitically altered granodiorite. Traces of malachite and chalcopyrite occur in fractures. This sample assayed 910 ppm copper and 4.3 ppm silver. Higher grade mineralization is localized in quartz-epidote-chalcopyrite-malachite veins which cut intrusives near the greenstone contact. An example is the high-graded sample D-782, which contained 1.0% copper, 22.0 ppm silver and 250 ppm zinc. float

On the northwest side of the anomaly, two soil samples and a rock sample were anomalous in copper, with minor lead, zinc, silver and molybdenum. Float boulders indicate that the source may be medium grained, chloritically altered diorite with quartz-chlorite-chalcopyrite-pyrite veins.

An isolated outcrop one-fourth mile north of Kontrashibuna Lake in the southwest part of the anomaly shows malachite and traces of pyrrhotite and chalcopyrite on fracture

Table 15 West Gladiator Copper-Silver-Zinc Anomaly.

surfaces and disseminated in an epidote altered andesite. A six-foot chip of the best mineralization contained 0.23% copper.

Alteration Products and Halo Effects:

There is local strong chlorite-epidote in shear zones and hornfels alteration of sediments near intrusives.

Classification or Type of Potential Ore Deposit:

The volcanics and sediments are possible hosts for massive sulfides. Fault zone mineralization by hydrothermal fluids emanating from the intrusives is remotely possible to be of economic concentrations.

Remarks, Including Suggestions for Prospecting:

Several of the anomalous samples should be followed up with more detailed investigation. Most of the area that needs work is either very rugged or heavily vegetated. There are large areas of overburden which cover potential mineralization between Kontrashibuna Lake and the mountains. Soil sampling may be a useful tool in this area.

Table 16 West Takoka Creek Copper Anomaly.

Type of Anomaly or Commodity of Interest:

Copper, with possible silver.

Location by Quadrangle and Topography:

Lake Clark A-4; T1N, R28W, sections 29 and 30; one and a half miles south of the west end of Kontrashibuna Lake, and one mile west of Takoka Creek.

Approximate Size of Area of Interest:

One and a half to two square miles.

Number of Samples or Data Supporting Anomaly:

Twenty-nine rock samples were collected in 1975 as follow-up of a 1974 silver anomaly. None of the 1975 samples were anomalous in silver, although two were strong in copper.

General Geologic Setting, Lithology and Structure:

Additional mapping and sampling in 1975 expanded the area of intermediate volcanics and revealed a sizeable unit of metasiltstone and argillite with weak quartz veins. Andesite tuff and tuff breccia is the most abundant rock type; minor basalt was noted. Most of the 1975 work was aimed at pinpointing the source of eight anomalous silver samples. A thorough investigation along the south and west sides of the hill drew only negative results. It was suspected that this area is composed of older volcanics (Jurassic?), not Tertiary volcanics. The associated metasediments lend support for this theory.

Nature, Occurrence and Controls of Mineralization:

Small patchy iron stained zones occur in all rock units. Close examination shows traces to 3% disseminated pyrite. Only traces of chalcopyrite were noted. In one iron stained and moderately fractured zone of fine grained andesite, a four-foot chip sample assayed 270 ppm copper.

Alteration Products and Halo Effects:

The andesites and tuffs locally contain strong chlorite and epidote. Specularite and/or pyrite are locally abundant.

Classification or Type of Potential Ore Deposit:

The environment is weakly favorable for stratiform massive sulfides, but the geochemistry is weak.

Table 16 West Takoka Creek Copper Anomaly (continued).

Remarks, Including Suggestions for Prospecting:

The anomalous silver values from 1974 look very suspicious; perhaps a laboratory error or a misplaced decimal point gave a false anomaly. None of the 1975 rock samples contained appreciable silver. The slight copper anomaly at the east end of the hill is real but small.

Table 17 East Takoka Creek Copper Anomaly.

Type of Anomaly or Commodity of Interest:

Copper, with trace of gold.

Location by Quadrangle and Topography:

Lake Clark A-3; the area between Takoka Creek and Kasna Creek, south of Kontrashibuna Lake.

Approximate Size of Area of Interest:

Four to five square miles.

Number of Samples or Data Supporting Anomaly:

Four rock samples and one strong stream sediment sample, with five weaker but significant stream sediment samples.

General Geologic Setting, Lithology and Structure:

Greenstone, which is probably a dark, fine grained andesite or basalt, is the primary rock type within this anomaly. There are small gabbro bodies on the east side near the north trending limestones and siltstones in Kasna Creek. Numerous shear zones from one to six feet wide cross the anomaly in a northeast direction. A belt of calc schist, greenschist and schistose metasediments bounds the anomaly on the northwest side.

Nature, Occurrence and Controls of Mineralization:

The greenstones may have a high background copper content which gives high stream sample values. Nevertheless, there are local zones of fracturing and epidote or quartz-carbonate veining containing chalcopyrite and pyrite. The best rock sample collected came from amphibole-chlorite basic volcanics on the west side of the anomaly. It contained fine grained disseminated chalcopyrite and pyrite and weak to moderate epidote veins; copper ran 530 ppm.

A soil sample in greenstone talus gave the only gold anomaly in the entire Kontrashibuna Lake area -- 0.8 ppm. The sample also ran 180 ppm copper.

This anomaly is notably lacking in lead, zinc and molybdenum.

Alteration Products and Halo Effects:

Generally strong chlorite, moderate epidote and weak quartz-carbonate throughout most of the anomaly.

Classification or Type of Potential Ore Deposit:

Possibly massive sulfide; low grade bulk gold as a long shot. One type of copper mineralization as fracture coatings and disseminations is typified by the TAK II claim group two miles to the southwest. The TAK II claims are owned by Falconbridge Mining Company.

Remarks, Including Suggestions for Prospecting:

Additional traverses to the south and in the brushy area to the north might uncover related and more significant mineralization. These or similar volcanics have a moderate potential for an ore deposit, but it will take a great deal of sampling and mapping on a detailed basis to establish the most favorable horizons or structures.

Table 18 Kontrashibuna Molybdenum Anomaly.

Type of Anomaly or Commodity of Interest:

Molybdenum, with nearby lead, zinc, copper and silver.

Location by Quadrangle and Topography:

Lake Clark A-3; two miles east of Kasna Creek.

Approximate Size of Area of Interest:

One square mile.

Number of Samples or Data Supporting Anomaly:

Four rock samples and one stream sediment sample.

General Geologic Setting, Lithology and Structure:

A 70-foot thick basalt unit is the localizer of molybdenum in quartz and simple pegmatite stringers generally less than one inch thick that emanate from an overlying(?) granite. The granite and basalt have both been sliced by a major northeast trending fault. There appears to have been considerable movement along this fault zone, which dips 60 degrees to the south. Strong gouge and mylonite have been developed. On the south side of the fault, andesite and tuffaceous sediments have been brought into contact with the granite and basalt.

Nature, Occurrence and Controls of Mineralization:

Quartz-pyrite-molybdenite veins from one-fourth to one inch thick occur in basalt with the strongest concentration near the contact with a granite. Quartz and pyrite form the core of each vein, and molybdenite occurs as coarse flakes near the wall. These quartz-pyrite-molybdenite veins can be followed into the granite, where they become deficient in molybdenum and assume more of a pegmatite character, rich in potassium feldspar.

The major northeast fault zone appeared to play a major role in mineralization, being the mechanism by which the basalt was shattered, providing channels for migration of fluids from the intrusive.

Less than one mile to the northwest, a stream sediment sample which drains this general area contained 1030 ppm zinc and 320 ppm lead. Neither molybdenum nor copper was anomalous. A minor northwest shear zone, subordinate to the major northeast fault previously mentioned, may be

Table 18 Kontrashibuna Molybdenum Anomaly (continued).

the source of this stream anomaly. A rock sample of a six to ten-inch gossan from the central part of the silicified shear zone assayed 2000 ppm lead and 8.5 ppm silver. Seventy percent of the float in the area was iron stained intermediate volcanic breccia and agglomerate.

Alteration Products and Halo Effects:

The two different shear zones contain two different types of mineralization. Whether these two areas are related in some way is impossible to tell from the meager data available.

Classification or Type of Potential Ore Deposit:

Copper-molybdenum stockwork porphyry is a possibility. Economic shear zone of base and precious metal sulfides is also possible.

Remarks, Including Suggestions for Prospecting:

The coarse nature of the molybdenum is discouraging, as most producing mines have fine-grained molybdenum in stockwork quartz and pyrite veins, fracture coatings and disseminations. It is possible that the above mineralization could represent distal features to a higher grade deposit. Not much work has been done in this area, and the stream sediment sample containing 1030 ppm zinc is worth investigating in connection with any future work in the area.

Table 19 West Ospook Copper-Lead-Molybdenum Anomaly.

Type of Anomaly or Commodity of Interest:

Copper, lead and molybdenum, with minor zinc and silver.

Location by Quadrangle and Topography:

Lake Clark A-3; immediately south of the head of Kontrashibuna Lake and two miles west of Ospook Creek.

Approximate Size of Area of Interest:

Four square miles.

Number of Samples or Data Supporting Anomaly:

Two stream sediment samples, two soil samples and two rock samples.

General Geologic Setting, Lithology and Structure:

Andesite porphyry, tuffs, agglomerates and other intermediate volcanics have been injected by at least two small intrusives. A gabbro on the north side of the anomaly is generally barren. A fine grained granodiorite or quartz diorite is mineralized near its contact with the andesite. This iron stained intrusive is also adjacent to a major northeast fault zone which can be followed from Gladiator Basin to Upper Tazimina Lake. This anomaly is one of several anomalies which lie in a one and a half mile wide belt extending from the Tazimina River to South Currant Creek.

Nature, Occurrence and Controls of Mineralization:

Sulfide mineralization is strongest along fracture zones at the contacts between granodiorite and andesite porphyry. Locally the andesite contains 2 to 4% disseminated pyrite, magnetite and traces of chalcopyrite. Several soil and stream sediment samples were anomalous in copper to 1800 ppm, molybdenum to 183 ppm and lead in rock samples to 230 ppm.

Alteration Products and Halo Effects:

Iron staining, silicification and chloritic alteration are moderately developed along the main northeast trending fault zone.

Classification or Type of Potential Ore Deposit:

Possibility for hydrothermal vein or replacement deposit in the andesite near the granodiorite or along the strongly fractured fault zones; also a weak possibility for stratiform massive sulfides within the volcanics or volcaniclastics.

Remarks, Including Suggestions for Prospecting:

More mapping and sampling, especially near the high soil samples, should be done in connection with any future work in the area. The geochemistry in and near the fault zone is erratic, and some remobilization of mineralization by later faulting is suspected.

Table 20 Upper Tazimina Copper-Zinc Anomaly.

Type of Anomaly or Commodity of Interest:

Copper, with minor zinc, silver, and lead.

Location by Quadrangle and Topography:

Lake Clark A-3; two and a half miles southwest of the head of Kontrashibuna Lake, four miles northeast of the head of Upper Tazimina Lake, on the divide between the two drainages.

Approximate Size of Area of Interest:

Less than one square mile.

Number of Samples or Data Supporting Anomaly:

One moderately strong stream sediment sample and two rock samples, one of which is questionable.

General Geologic Setting, Lithology and Structure:

Andesite porphyry breccia (less than two-inch clasts) overlies dark, siliceous, fine grained metasediments(?) which have strong epidote-quartz-magnetite-chalcopyrite veins within three feet of contact. This is a small zone within a broader belt (up to one mile) of andesite, dacite and basalt with interbedded (?) metasiltstone and metashale. Mineralization is very sparse. Large granitic and small gabbroic intrusives are close at hand.

Nature, Occurrence and Controls of Mineralization:

In at least one instance the metasediment-volcanic contact is the localizer of copper up to 1100 ppm, silver to 11.2 ppm, lead to 180 ppm and zinc to 680 ppm. Another silicified metasedimentary rock outcrop ran 1.1% copper over 50 feet. However, follow-up samples were completely negative, so the original result may have been an analytical error, or else the area of mineralization is very small.

Alteration Products and Halo Effects:

Local strong quartz-epidote alteration and strong iron staining of metasediments and gabbros.

Classification or Type of Potential Ore Deposit:

Volcanic flows appear to have drawn metals from the sedimentary rocks which were redeposited near the contacts.

Table 20 Upper Tazimina Copper-Zinc Anomaly (continued).

Remarks, Including Suggestions for Prospecting:

One stream sediment sample which drains the north side of the anomaly ran 109 ppm copper. This is slightly anomalous and should be examined briefly.

Table 21 Little Tazimina Copper-Lead Anomaly.

Type of Anomaly or Commodity of Interest:

Copper and lead, with minor zinc and silver.

Location by Quadrangle and Topography:

Lake Clark A-3; two miles northeast of the head of Upper Tazimina Lake.

Approximate Size of Area of Interest:

Less than one square mile.

Number of Samples or Data Supporting Anomaly:

Two rock samples and one soil sample.

General Geologic Setting, Lithology and Structure:

The area of interest is confined to the contact of fine to medium grained, weakly sericitized granite which is overlain by andesite or basalt breccia. Northeast trending faults have fractured the granite, and mylonite has developed.

Nature, Occurrence and Controls of Mineralization:

Sulfide mineralization is confined to the contact area between the basalt breccia and the granite. One sample across approximately one foot assayed 2% copper, 3 ounces per ton silver, 1.7% lead, 0.2% zinc and 107 ppm molybdenum. This was described as strong disseminated chalcopyrite, azurite and malachite, with strong manganese.

Alteration Products and Halo Effects:

No halo effects were noted. Weak sericitization along shear zones was observed.

Classification or Type of Potential Ore Deposit:

Contact metasomatic replacement or fissure vein filling of fracture zones by hydrothermal fluid may be developed in adjacent areas.

Remarks, Including Suggestions for Prospecting:

The best chance for deposits of significance in this area is along the contact of basalt-andesite with granite. Air photo interpretation indicates a one-fourth square mile area of volcanics bounded by granite(?) just to the south of

Table 21 Little Tazimina Copper-Lead Anomaly (continued).

this anomaly. This area should be checked, especially along the contact.

Lake Clark Quadrangle
Conclusions and Recommendations

Regional mapping and sampling were conducted in fair detail over that portion of the quadrangle south of Snipe Lake in 1974. This amounts to some 1500 square miles, from which approximately 3000 samples were collected, resulting in a sample density of about two samples per square mile. An additional 2000 or so square miles between Two Lakes and Little Lake Clark were examined briefly in late 1974. Approximately 3000 samples were collected from this region, for a sample density of a little over one per square mile. Investigations in the Lake Clark area in 1974 resulted in the discovery of the Tazimina Copper Prospect (Plates 8a-c) as well as other geochemical anomalies. Follow-up mapping and sampling in 1975 delineated the Pass Copper-Silver Prospect (Plates 7,a-g) and seventeen other areas of mineralization of interest for copper, silver and/or zinc. In addition to the two prospects, some of the better anomalies include the Kijik copper anomalies and the Gladiator basin copper anomalies (Tables 1-21).

On the basis of geologic mapping together with the occurrence of various prospects and anomalies, future economic potential is considered good for massive sulfide deposits in portions of the Lake Clark schist belts and in parts of the Kontrashibuna volcanic and sedimentary belt (Plate 1). The Kasna Creek Copper deposit, owned by Falconbridge, may be an example, as it is rumored to contain three-fourths of a billion dollars in-the-ground value. Volcanogenic network deposits are likely in the Kontrashibuna series. Porphyry copper potential is considered weak in the larger and older intrusive stocks and batholiths. However, the late phases of the batholith and the smaller stocks are considered to have good potential for porphyry type mineralization as demonstrated by several occurrences. Additionally, some of the Tertiary volcanic "necks" or vents are good possibility for breccia pipe deposits as indicated by the Pass Copper-Silver Prospect. Mineralization at this prospect is present over nearly a square mile area as stockwork fracture fillings of pyrite and/or pyrrhotite with variable amounts of associated chalcopyrite, galena, and possible tetrahedrite in a host of dacitic breccia related to a volcanic-intrusive complex.

Section by section ratings of relative mineral potential in the Lake Clark Quadrangle are presented as Plate 3 as the major conclusion of work in this area. Recommendations for lands to be included in the Lake Clark Park are outlined on Plate 4. It is important to note that in the national interest, high mineral potential lands on either side of Lake Clark and the 10-12 mile wide belt extending northward from Lake Clark to Telequana Pass should be classified as multiple use.

THE LIME HILLS REGION

Lands of interest in the Lime Hills region (Figure 1 and Plate 2) center around the Merrill Pass area and include drainages of the Chilligan, Neacola and upper Necons Rivers. This area is represented by all or part of the Tyonek A8, B8, and Lime Hills A1, A2, B1, and B2 quadrangles. Economic evaluations of these lands were conducted during parts of the 1973 and 1974 field seasons, with base camps at Chakachamna Lake and Two Lakes. Fly camps and fuel caches were established in the upper Chilligan, upper Nagishlamina and Crystal Creek areas. All supplies and traces of man were subsequently removed.

Outcrop exposure is excellent, as the lands are extremely rugged with very steep relief. Hundreds of active glaciers and related snowfields and crevasses make it hazardous to explore much of the area. Not much could be done with the icefields south of Chakachamna Lake, for example.

Geology

Geological pulbications and literature in the area of the Lime Hills region consist of a preliminary reconnaissance geologic map by Reed and Elliott (1970) and a report by Reed and Lanphere (1972) on age dates of plutonic rocks in the Alaska-Aleutian Range Batholith. Both of these reports were used as a general guide to aid the present study and direct efforts to favorable areas. The reconnaissance map was particularly helpful for generalities, and some of the rock unit names have been retained for association purposes.

The Lime Hills region occupies a portion of a geologically interesting area in that it lies near the northern extremity of the tremendous Aleutian Range Batholith and near the southern extremity of the huge Alaska Range Batholith. The area of interest is about 25 to 50 miles northwest of the Castle Mountain Fault and about 100 miles southeast of the Farewell-Denali Fault. These tectonic elements have operated to produce some major faults in the area of interest, in particular the northwest cross fracture system represented by the northwest-southeast trending Chilligan and Nagishlamina Rivers. The major north-south system is the Igitna River-Styx River Fault, and east-west structures are represented by the Merrill River-Another River Fault and the South Twin Glacier Fault.

During the geological and geochemical evaluation of the area of interest, results were plotted daily onto one inch to one mile scale topographic maps, using successive overlays for copper, silver, molybdenum, lead, zinc and arsenic. Air photographs were particularly helpful in this area of high relief and little vegetation for picking out major geologic units and structures and in interpreting between known data points. The geology of the Lime Hills region can be summarized here into the following generalized units in order of decreasing age:

1. Metasedimentary and metavolcanic unit
2. Diorite gneiss and quartz diorite-gabbro unit
3. Biotite diorite of the Mount Estelle Batholith
4. Granitic rocks of the Styx River Batholith
5. Quartz monzonite-granodiorite stocks
6. Tertiary volcanics and related feeder dikes and vents

These units have been mapped and categorized on the basis of field observations of mineralogical composition, texture and relative age by cross cutting or stratigraphic relationships. Absolute or true ages of these rocks can only be determined by classification of fossils, which are very rare in these rocks, or by radiometric age dating, which because of expense is not justifiable to this project.

Metasedimentary and Metavolcanic Unit

Metasedimentary and metavolcanic rocks are lumped together here for general classification, although each was mapped separately where a predominance of one or the other was obvious. At any rate, these rocks are weakly metamorphosed and represent submarine deposition in a probably miogeosynclinal environment. This is surmised on the basis of the generally fine grained, well bedded shales and siltstones with some interbedded limestone and volcanic flows of andesitic to basaltic composition. These rocks are suspected to be late Paleozoic to early Mesozoic in age and trend in general N20E to N40E. Later intrusives have, of course, rotated, tilted and otherwise disturbed the regional trend. Large blocks of metasediments and metavolcanics are left as "islands" and roof pendants in the younger batholiths. A possible stratigraphic horizon within this unit is limestone or marble beds represented by a thick section in the upper part of the Telaquana River and by isolated remnants and pods in the Neacola River area. This is probably the same limestone unit as that 20 miles south near east Twin Lakes and 55 miles south in the Lake Clark-Kontrashibuna area.

Mineralization in this metasedimentary-metavolcanic unit south of the upper Chilligan Fault is weak except in contact zones around later intrusives. For example, there is some lead, molybdenum and iron (hematite) mineralization developed in a skarn zone along the granite-marble contact three miles south of the Tusk in the Neacola River area and local fracture mineralization of magnetite, garnet and epidote along contacts of gabbro-marble in the upper Telaquana River area. Otherwise, the metasediments and even the metavolcanics south of the upper Chilligan River have a low geochemical background.

Diorite Gneiss and Quartz Diorite-Gabbro Unit

The diorite gneiss and quartz diorite-gabbro unit occupies sizable areas in the upper Neacola River-Telaquana River area and north of Kenibuna and Chakachamna Lakes. These rocks also probably underlie much of the glacier area south of Chakachamna Lake and presumably represent the northernmost portion of the Aleutian Range Batholith. Approximately half of this unit has clearly gneissic texture and structure, whereas the rest is more equigranular. Quartz biotite schists and relict volcanic units, such as those north of Chakachamna Lake, are present as local layers or zones. Gabbroic rocks comprise about 3% of the unit and may represent remobilized areas, as they are characteristically small bodies with discordant contacts. For example, gabbros intrude metasediments in the Neacola-Telaquana River area, with resultant hornfelsing of sediments near contacts and strong development of disseminated pyrrhotite. Much of the quartz diorite is also remobilized and shows discordant or intrusive contacts into the metasediments. Additional evidence of remobilization is the numerous inclusions of mafic-rich diorites in lighter colored quartz diorites. Some of these quartz diorites may actually be much younger than the diorite gneiss unit. The quartz and biotite diorites north of the Chilligan River, for example, are clearly younger than the diorite gneiss and are classed with the Mount Estelle Batholith. The rocks within the diorite gneiss-diorite unit are probably at least 70 to 100 million years old, based on potassium-argon age dates by Reed and Lanphere (1972).

Mineralization in the diorite gneiss and diorite-gabbro unit is not particularly encouraging. Several weak anomalies of lead and zinc and sometimes a trace of silver have developed along diorite and/or gabbro intrusive contacts with metasediments, particularly where these older sediments occur as pendants or inclusions. In most of these cases, however, the mineralization probably represents remobilization of elements already in the sediments, rather than considerable hydrothermal introduction, which ordinarily would have been more likely to have produced a commercial deposit. The Chilligan Prospect, described in a later section, may be an exception.

Biotite Diorite of the Mount Estelle Batholith

The biotite diorite of the Mount Estelle Batholith proper lies just north of the project area on State land and occupies much of the highlands between the Styx River and the Skwentna River. The northern part of the batholith in the Mount Estelle area is an irregular, northerly trending belt three to eight miles wide. Southward, the Mount Estelle Batholith gives way to the younger Styx River granitic batholith, next to be discussed, except that numerous apophyses of the Mount Estelle Batholith are present as far south as the upper Chilligan River as isolated stocks one to three square miles in area.

The Mount Estelle Batholith and associated stocks are medium grained equigranular rocks with local variants of biotite diorite, quartz-biotite diorite and quartz diorite. These compositional variants seem to be a result of differential pressure and cooling features from one magma, rather than any sort of multiple injection. These rocks are radiometrically dated by Reed and Lanphere as 60 to 70 million years old (1972).

This lineal north-south trend of the Mount Estelle and other rocks, together with structure and drainage patterns, suggests that zones of weakness existed in north-south directions prior to the emplacement of the Mount Estelle Batholith. During the cooling period of probably several million years, stresses changed to initiate permanent northwest-southeast structures such as the Timber Creek and Emerald Fault systems. East-west faults subsequently followed to a lesser degree. The importance of these structural features is emphasized by sulfide mineralization

Occurrences of copper, silver, lead, zinc and lesser gold are numerous in spatial and probably genetic relationship to the Mount Estelle Batholith and subsidiary stocks. Anomalous mineralization occurs in and near the diorite-siltstone contacts as well as in north-south and northwest-southeast structures that transect the diorite. Northwest structures transecting the diorites of the Mount Estelle group are particularly important mineralizers, as emphasized by occurrences at the Crystal Creek North Copper Prospect and the Chilligan Lead-Zinc Prospect (Figure 5).

Granitic Rocks of the Styx River Batholith

Medium to coarse grained granites of the Styx River Batholith occupy much of the area from the Chakachamna-Neacola River area north to the Crystal Creek-Hayes Glacier area and eastward beyond the Nagishlamina River. These rocks are amazingly similar throughout the area, with only slight variations of texture from equigranular to porphyritic. Potassium-argon age dates by Reed and Lanphere (1972) suggest these rocks are 50 to 60 million years old. Field relationships of cross-cutting features indicate that the Styx River Batholith is younger than the Mount Estelle group, as well as the diorite gneiss and, of course, the metavolcanics and metasediments.

These granitic rocks characteristically weather to pale yellow and dull orange colors. Local areas of moderate to strong pyrite develop bright orange gossans that can be seen for miles, as in the Chilligan and Styx River drainages. Local manganese staining is also common. Sulfide mineralization other than iron, however, is generally weak in these gossan areas.

Molybdenum, lead and zinc are the most common elements of merit associated with rocks of the Styx River granite group. Minor amounts of copper and silver are locally present, but these latter elements are much more characteristic of the other groups, in particular the Mount Estelle diorites.

Unfortunately, most of the molybdenum, lead and zinc occurrences in the Styx River Batholith that were found and investigated represent weak mineralization in widely spaced, tight fractures with generally minor alteration. Molybdenum in most of these occurrences is present as coarse flakes in quartz veins that follow joint sets, and this type of occurrence rarely makes a commercial deposit. Examples of such anomalies are those south of the upper Chilligan River, and south of Another River. Merits of individual anomalies are discussed in the anomaly section.

Quartz Monzonite-Granodiorite Stocks

Quartz monzonite-granodiorite stocks are present in the area of interest as generally small intrusives, as compared to the large batholiths. These intermediate stocks may be a late phase of the Styx River Batholith. These rocks occur in two predominant zones. One is about two to four miles wide and is nearly continuous from the Neacola River northwest to the Merrill Pass area and on to the Necons River. This zone of predominantly quartz monzonite contains minor anomalies of molybdenum, lead and zinc on joint surfaces. The other zone, of predominantly granodiorite intrusives, is near the upper Chilligan Fault and is represented by intermittent intrusives such as at the South Crystal Creek, and the West Chilligan Anomalies. Nearly every one of the granodiorite intrusives along this zone is mineralized to some extent with copper, silver, lead and zinc. Merits of those anomalies are discussed in the sections to follow. The age of these intrusives is questionable but is expected to be less than 50 million years, based on field evidence suggesting that they are younger than the Styx River Batholith.

Tertiary Volcanics and Related Feeder Dikes and Vents

Tertiary volcanics cover much of the upper Necons-Stoney Rivers area and northwards through the upper Chilligan into the South Fork and Styx River drainages. These volcanics are Tertiary in age and represent almost exclusively subaerial deposition as flows, tuffs and breccias. They are predominantly dacitic to rhyolitic in composition, although mafic fractions are present locally and mafic dikes are common.

There are some spectacular color anomalies developed in the volcanics, particularly near vent areas represented by lots of clastic material. These areas, however, carry little more than iron sulfide as pyrite and iron oxide as hematite. Very weak lead and zinc values are locally present.

The mineral potential for the Tertiary volcanics is very minimal from extrusive fractions such as flows, tuffs and breccias, because the subaerial origin is not conductive to mineral concentration. The intrusive feeder vents or pipes have weak to moderate potential for mineral deposits. The best example of this type of mineralization in the area of interest is the copper-molybdenum anomaly in a rhyolite intrusive east of Two Lakes (see anomaly report). The best example of this type of mineralization in the Lime Hills area is the Bowser Creek Lead-Silver Deposit documented in the literature and owned by Falconbridge Mining Company.

Geochemistry

By using stream sediment geochemistry in conjunction with geological prospecting, several mineralized areas were discovered in the Lime Hills region. The Crystal Creek Copper Prospect and the Chilligan Lead-Zinc Prospect, as well as several other anomalous areas, were found during the investigation and are described in the next section. Frequently distribution diagrams suggest anomalous values for streams and soils in the Lime Hills area to be greater than 100 ppm copper, 3 ppm silver, 8 ppm molybdenum, 80 ppm lead and 220 ppm zinc. Naturally, these values serve only as a guide and must be viewed in terms of the local geologic setting. Weak to moderate mineralization is present over much of the Lime Hills area in several geologic environments. In fact, weak mineralization over much of the country makes it difficult to distinguish significant anomalies from the stream sediment geochemical data. Sample locations are shown on one inch to one mile maps(Plates 9a-g) and the sample descriptions and corresponding analytical values are presented in the Appendicies.

Prospects and Anomalies in the Lime Hills Region

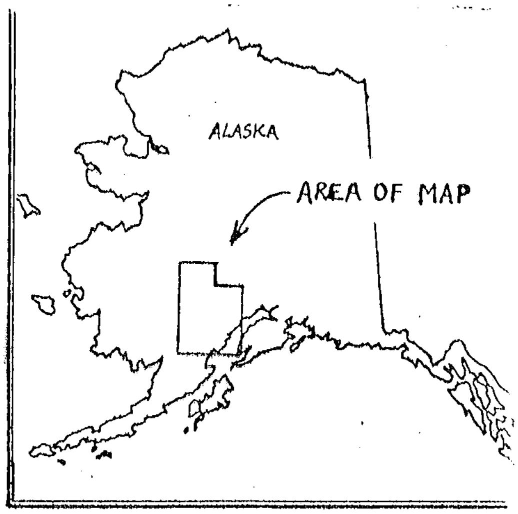
Two prospects and seven anomalous areas of mineralization have been identified in the Lime Hills region (Figure 5 and Plate 2). The Chilligan Lead-Zinc Prospect (Plates 11a-e) is just inside the northern boundary of the D-2 lands. The Crystal Creek Copper Prospect (Plates 10a-e) overlaps the boundary so that approximately the southern half is inside the D-2 lands and the northern half is on State Selected lands. These prospects and numerous other anomalies in this area are of interest primarily for base metals of copper, lead, and zinc but precious metal occurrences of gold and particularly silver are also important. Many of these anomalies, though separated by several miles, have similar geologic features that can be used as guides to further exploration. For example, nearly all of the major occurrences are located on or near north-south and northwest-southeast structures or combinations thereof.

Particular areas of interest can often be recognized by the local development of disseminated sulfides, usually pyrrhotite up to several percent, in hornfelsic sediments adjacent to intrusive contacts. Another common feature of most of the prospects is the abundance of quartz-tourmaline gangue present as either fracture fillings or sometimes intrusion breccias and "breccia dikes".

The Mount Estelle Batholith and satellite stocks of dioritic composition are probably parent to much of the copper-silver-gold-zinc mineralization in the area. The younger Styx River granitic rocks are host to many of the molybdenum anomalies. The still younger but small granodiorite stocks support several areas mineralized by copper-silver-lead-zinc. The features and merits of the various prospects and anomalies are presented in Tables 22-28 and the pages that follow.

Figure 5
LIME HILLS REGION - PROSPECTS AND ANOMALIES

1 - Crystal Creek Cu Prospect
2 - Chilligan Pb Prospect
3 - West Chilligan Cu anomaly
4 - Snowcap Mountain East Au anomaly
5 - Pass Lake Mo anomalies
6 - Necona - Stony River Cu anomaly
7 - Merrill Pass Ag anomaly
8 - Another River Mo anomalies
9 - East of Two Lakes Mo anomalies



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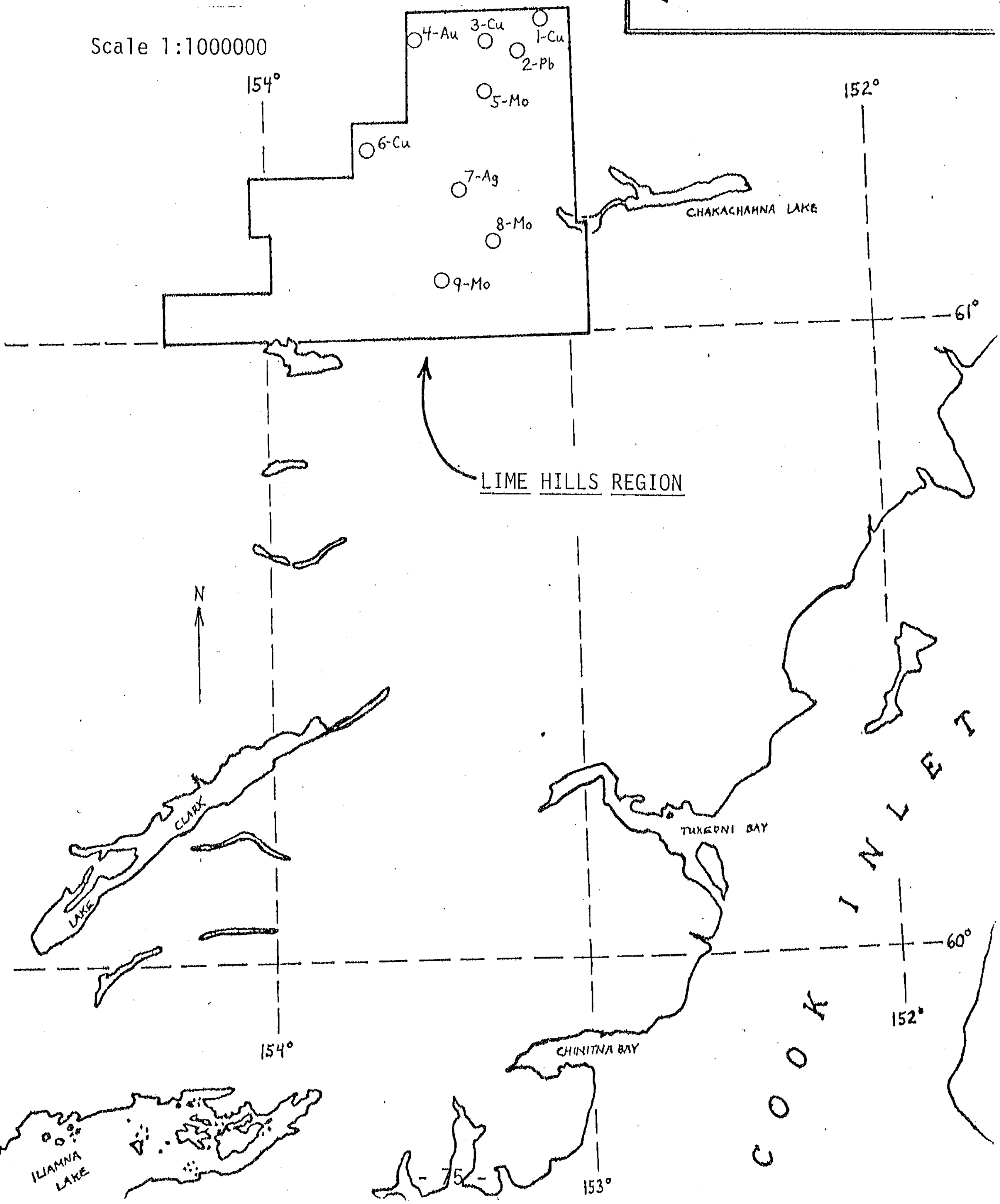


Crystal Creek Copper Prospect

Reconnaissance stream sampling in the Crystal Creek area in 1973 led to the discovery of several areas of weak to moderate copper, silver, lead and zinc mineralization. An approximate 20 square mile area was mapped and sampled in 1974 at the scale of one inch to 1000 feet (Plates 10a-e) in an effort to evaluate this prospect. Several mineralized areas and three types of mineralization were identified:

1. Chlorite-epidote-tourmaline-chalcopyrite veins and fracture coatings near the contact between the Stoney River(?) monzonite-Styx River granite contact.
2. Quartz-chalcopyrite-galena-sphalerite and quartz-molybdenum-fluorite veins within structural zones in the Styx River granite.
3. Pyrite-galena-sphalerite disseminations, pods and lenses related to limy fractions within the Cretaceous(?) siltstones.

Geology

The oldest rocks in the prospect area are apparently the Late Paleozoic to Jurassic(?) sediments. These sediments are predominately fine grained siltstones and shales characterized by thin bedding, often tightly folded, and high content of silica and pyrite. Interbedded with these siltstones and shales are limestone lenses and pods and discontinuous limy beds less than six to eight inches in width. Beds as mentioned are quite irregular but in general trend eastwest, with steep dip to the north. Volcanic flows are not identifiable, if present at all, but certainly some of the more siliceous units could be tuffaceous sediments.

These sediments have been intruded by the one mile wide by three miles long northerly trending zone of monzonite. The monzonite is largely equigranular but does have some porphyritic fractions on the northerly end. Weak to moderate epidote and chlorite alteration is present over much of the monzonite, particularly near its eastern contact with the Styx River granite. The age and relationships of this monzonite to the Styx River granite is questionable, as no cross cutting features have been identified. The monzonite could be a compositional variant of the same Styx River magma, but more likely the monzonite is a separate and distinct intrusive. This is based on the fact that the two intrusives are generally separated by fault contacts, implying different age.

The Styx River granite occupies much of the prospect area and is part of the larger Styx Batholith. The granite is medium to coarse grained, locally porphyritic and characterized by a yellow limonite color and low percentage of mafic minerals. The granite weathers easily to a granular soil (grus), which facilitates mapping. Multicolored, subaerial Tertiary volcanics and tuffs cover parts of the southwest prospect area. Tertiary dikes and sills are particularly abundant in the southeast prospect area cutting the metasediments so as to constitute a "dike swarm." The volcanics are predominately andesitic, particularly the dikes, but some dacites are also present to the west of the mapped area.

All of the above units have been subjected to regional north-south and particularly northwest-southeast faulting. These faults and fracture sets are host to much of the mineralization in this area. The intersection of northwest faults with limy beds and intrusive contacts are particularly favorable areas for mineralization.

Mineralization

One of the better areas of mineralization is in sections 3, 4 and 9 (Plate 22c), where tourmaline-chalcopyrite mineralization has developed in the monzonite near its contact with the Styx granite. This was the original discovery from stream sampling in the Crystal Creek area in 1973. Brief investigations the following season indicated the tourmaline-chalcopyrite mineralization was largely restricted to a northwest fracture set in which epidote-chlorite alteration and sulfide mineralization is confined to the fracture set without much dissemination between fractures. This is best typified by outcrops on the west side of a small glacier in the eastern part of section 4 and by mineralization in and near the major northwest trending fault zone in secitons 9 and 16.

Mineralization of the "contact type" is present in outcrops on the east side of the above glacier and in the southeast corner of section 9, where limy sediments are host to disseminations and spotty replacements by chalcopyrite, quartz and minor fluorite, in addition to the fracture fillings. Samples from these outcrops reflect somewhat higher grade and the general absence of tourmaline.

Stream sediments and rock samples in sections 25 and 30 in the northeast corner of the general prospect area resulted in tracing copper-silver-lead-zinc mineralization to an east-west trending fault zone in the Styx River granite. Mineralization of the above elements totals less than one percent and is contained in quartz-clay zones in the fault and in a two to four-foot wide rhyolite dike intruded along the fault. The importance of this occurrence is that it suggests that a second period of mineralization may be related to the Styx River granite and/or whatever the source of the rhyolite dikes. Additional supporting evidence is the occurrence of 1/16 to 1/8-inch wide quartz-molybdenite-fluorite veinlets approaching weak stockwork intensity in the Styx granite in section 1.

One of the more interesting areas of mineralization is the strongly pyritic sediments in sections 11, 12, 13 and 14 in the southeast corner of the prospect area (Plate 10d), where reconnaissance sampling turned up massive sulfide cobbles containing up to 13% zinc. Several lines of chip samples were then taken, and these indicate the sphalerite-pyrite and lesser galena mineralization is predominantly in limestone or marble lenses and discontinuous beds that are a few inches to one foot thick and are generally conformable with the enclosing siliceous and pyritic (3% disseminated) siltstones. This area was studied in some detail to determine the amount of mineralization exposed and if the sulfides represent syngenetic deposition or hydrothermal replacement. Evidence to date from this occurrence and the general area suggests the mineralization is related to hydrothermal replacement of limy fractions in the metasediments, with the Styx River granite probably being the source of mineralizing fluids.

The better mineralization in outcrop is about one-half mile from the granite contact and on the basis of field relations, the granite is suspected to underlie the area of interest as a shallow instrusion. Numerous rhyolite and andesite porphyry dikes intrude the sediments and trend in a northerly direction, but these are not mineralized.

Conclusions and Recommendations

Investigations in the Crystal Creek area as a result of moderate to high stream geochemistry followed by some detailed mapping and prospecting turned up several occurrences of copper, molybdenum and zinc with lesser silver and lead. None of the occurrences, however, represent sizable amounts of ore grade material, and the potential for better deposits at shallow depth is only moderate. It is encouraging though, that St. Eugene Mining Company (Falconbridge) does hold apparently valid mining claims on the better showings of the "glacier occurrence" just outside the D-2 lands in sections 4 and 9 (Plate 10d). Their exploratory work has included at least some drilling.

The general Crystal Creek area is very intriguing, based on several occurrences of mineralization in the immediate area, the nearby Chilligan Lead-Zinc Prospect (next to be discussed) and several other anomalies just to the west. The better parts of all of these anomalies occur in the northern most row of D-2 townships north of the Chilligan River (T.15N., R.21, 21, and 23W.). These townships should be classified so as to permit further exploration.

Chilligan Lead-Zinc Prospect

Additional mapping and sampling at the scale of one inch to 1000 feet was conducted in 1974 over an approximate 20 square mile area near the pass between the Styx and Chilligan Rivers, which is referred to as the Chilligan Prospect (Plates 11a-e). Additional work was delegated to this area as a result of favorable 1973 stream geochemistry and favorable geology such as at the adjoining Crystal Copper Prospect to the northeast. The Chilligan Prospect area was classified as regional deficiency with a D-2 override in 1974. No prior discoveries are known in the area.

The mapping project identified two interesting areas of mineralization having a size of about one-half square mile each and several smaller zones of related mineralization. The areas of interest are (1) lead-zinc mineralization in section 31, and (2) silver-lead-zinc mineralization in section 23 (Plate 11a). These and other lesser areas of mineralization are found in proximity to a quartz monzonite stock and zones of major structure.

Geology

The general geology in the Chilligan Prospect area is complicated by no less than four stages of intrusive rocks and at least three different stages of faulting. The older sedimentary rocks are strongly iron stained siltstones of late Paleozoic age with up to 10% disseminated pyrite and interbedded chert layers. These rocks strike northwest at shallow dips and have been nearly obliterated by the later intrusives. Rounded and angular fragments of sediments several inches to several feet are found as breccias in most of the intrusives, particularly the Mount Estelle(?) diorite in the northern prospect area. In contrast to the Crystal Creek area, the sediments here are not limy and contain no appreciable mineralization except for sulfides of iron.

The northerly trend zone (one by four miles) of quartz monzonite-granodiorite, tentatively categorized as part of the Stoney River granodiorite(?), is host to most of the lead-zinc-silver and lesser copper mineralization in the area. This pluton intrudes the diorite on the north and is bounded on the east by the major, northerly trending Styx River Fault, which confuses the contact relations with the adjoining intrusive rocks of the Styx River granite and granite porphyry.

Smaller Tertiary(?) intrusives of both rhyolite and andesite composition have been emplaced along this major north-south fault, particularly at intersections of the northwest-southeast faults. The best area of lead-zinc mineralization (section 31) is localized in andesite and quartz monzonite at one of these intersections and just south of one of the small rhyolite intrusives.

Both the andesite and rhyolite intrusives as well as related dike swarms are strongly altered to quartz, clay, pyrite and sericite, but to date mineralization of economic interest has only been found in the andesitic fraction. Subaerial breccias, tuffs and flows of predominantly andesite with lesser dacite cap several of the intrusives in the prospect area. These volcanics contain numerous clasts of shale and chert (section 14), which is the basis for the age classification.

Mineralization

As previously mentioned, an interesting showing of lead-zinc mineralization was discovered in the northeast corner of section 31 as part of the mapping program. This mineralized area is characterized by a distinctive seal brown, iron-manganese color resulting from hematite and specular hematite combined with gray-black manganese oxide. Lead up to 1.4% and zinc up to 3.0% are contained in strongly sheared and fault gouged rocks of chloritized andesite(?) and quartz monzonite(?) in the form of fine to medium grained specularite, galena and sphalerite disseminations. This mineralization occurs at the intersection of three major faults which are conincident with intrusive contacts of quartz monzonite, andesite and rhyolite, and adjacent to granite prophyry. Resultant fault gouge and clay, together with strong chloritic and hematitic alteration, plus rotation and jumbling of fault blocks makes it extremely difficult to evaluate this prospect.

Several pits and trenches to five feet deep were hand dug into the site hill in order to penetrate the clay and gouge in an effort to "unravel" the geology and mineralization. Coarse grained, sheared pyrite with traces of chalcopyrite in chloritized andesite(?) was found in one pit. Other pits revealed weak to moderate lead and zinc (around one percent combined) in strongly altered (chlorite-hematite-clay) quartz monzonite(?) and andesite(?). Rhyolite blocks are also strongly altered as above but are apparently not mineralized. The average grade of mineralization across the 500-foot shear zone is approximately 0.25% lead and 0.5% zinc. About 500 feet to the west (downstream) the mineralization begins to horsetail or finger out, even though strong chloritization and specularite veining continue some 1500 feet overall.

Metal values in other elements such as gold, silver, copper, molybdenum and nickel are low. This is actually a fairly distinct difference from the usually high silver and copper values contained in sulfides from the general area. Perhaps this mineralization is related to a small gabbro-andesite intrusive center, instead of the usual intermediate intrusives typical of the district. An incomplete and distorted set of andesite dikes radiate from the mineralized area.

Actually, though, any one of the other three intrusives could be the mineralizer, particularly the quartz monzonite, which is mineralized here and elsewhere in the general area. For example, the other area of interest in the Chilligan Prospect is sphalerite-pyrite-chalcopyrite localized in quartz-chlorite and quartz-sericite shears and fractures trending roughly eastwest in quartz monzonite in the eastern half of section 23. Locally mineralized rubcrop and float boulders contain 4 to 10 ounces per ton silver and up to nearly 2% each of lead and zinc. However, these fracture zones based on rubble crop and float appear to average only one to two feet in width and are probably widely separated with only weak alteration between such zones. Other occurrences of mineralization of less importance in the Chilligan area are recorded on Plates 11a-d.

Conclusions and Recommendations

Mapping and sampling efforts in the Chilligan area did result in finding one area of interest for lead and zinc and another area of interest primarily for silver, as well as numerous other small showings of these elements. Mineralization in this prospect area is largely related to host rocks of quartz monzonite and major tectonic zones. The two occurrences described are approximately two and a half miles apart on opposite margins of the quartz monzonite stock. Neither ore grade mineralization nor sizable tonnage is evident from surface exposures in either deposit.

However, these occurrences together with the Crystal Creek Copper Prospect attest to the high mineral potential in the north Chilligan area, which as previously mentioned, should be classified so as to permit further exploration and evaluation.

Table 22 West Chilligan Copper-Silver-Lead Anomaly

Type of Anomaly or Commodity of Interest:

Copper, with isolated anomalies of silver, molybdenum, lead and zinc.

Location by Quadrangle and Topography:

Lime Hills B-1; in the upper reaches of the Chilligan River on the north bank, three miles west of the Chilligan Prospect.

Approximate Size of Area of Interest:

Six square miles in six separated but related anomalies.

Number of Samples or Data Supporting Anomaly:

Two to five samples per anomaly. Copper values in rocks range up to 0.1% to 1.6%.

General Geologic Setting, Lithology and Structure:

The anomalies are related to small stocks of fine grained granodiorite that has intruded and locally mineralized older quartz diorite and siltstone. Structural influence on mineralization is represented by the northwest line of anomalies and by the two north-south faults. Intermediate to basic volcanics overlie the intrusive rocks and are unmineralized.

Nature, Occurrence and Controls of Mineralization:

Mineralization is controlled by northwest-southeast fractures, north-south faults and proximity to the southwest contact of the granodiorite stock. Mineralization is largely fracture surface pyrite with traces of chalcopyrite, galena and sphalerite. Some disseminated sulfides, largely pyrite, are present locally. Molybdenum was identified as coarse flakes in quartz veins.

Table 22 West Chilligan Copper-Silver-Lead Anomaly (continued).

Alteration Products and Halo Effects:

Strong argillization and intense quartz-chlorite veining are locally present, along with north-south faults.

Classification or Type of Potential Ore Deposit:

Porphyry copper type mineralization.

Remarks, Including Suggestions for Prospecting:

The anomalies are spread along a northwest trend, which probably represents horsetailing of the northwest-southeast fault which runs down the main Chilligan River valley.

Table 23 Snowcap Mountain East Copper-Gold Anomaly.

Type of Anomaly or Commodity of Interest:

Target for gold, but the area is anomalous in copper and arsenic. Reed (1970) also found this area anomalous in gold, copper and zinc.

Location by Quadrangle and Topography:

Northeast corner of Lime Hills B-2; near the southern extent of the BEK Prospect, four miles east of Snowcap Mountain.

Approximate Size of Area of Interest:

Need to check parts of five square miles.

Number of Samples or Data Supporting Anomaly:

Approximately eight anomalous samples out of 18 in the area of biotite diorite. One sample ran 2.3 ppm gold.

General Geologic Setting, Lithology and Structure:

Traces of gold found in quartz and quartz-arsenopyrite veins appear to be related to the contact of hornblende-biotite diorite stock with argillites and black shales. Three small bodies of quartz monzonite intrude diorite in the area of interest and may be mineralogically important. Better mineralization may be related to a northeast trending offshoot or dike of diorite from the main body.

Nature, Occurrence and Controls of Mineralization:

There are traces of gold in quartz veins up to six inches wide which constitute one percent of the float. Quartz-ankerite(?) and quartz-calcite are most common, but veins also locally contain arsenopyrite, pyrite, chalcopyrite and pyrrhotite. One

Table 23 Snowcap Mountain East Copper-Gold Anomaly (continued).

Nature, Occurrence and Controls of Mineralization:

quartz-pyrite vein ran 2.3 ppm gold.

Alteration Products and Halo Effects:

Slight to moderate chloritization of diorite with locally intense iron stain; argillites locally bleached and shattered.

Classification or Type of Potential Ore Deposit:

Possible bulk gold.

Remarks, Including Suggestions for Prospecting:

The contact area between diorite and argillites should be walked if possible, paying particular attention to the density of quartz veins and possible major structures. Quartz monzonite intrusives should be sampled.

Table 24 Pass Lake Molybdenum Anomalies.

Type of Anomaly of Commodity of Interest:

Molybdenum, with some associated zinc and/or copper.

Location by Quadrangle and Topography:

Lime Hills B-1; near Pass Lake at the head of Necons River.

Approximate Size of Area of Interest:

Five square miles in five separated anomalies.

Number of Samples or Data Supporting Anomaly:

Two to three samples from each of five anomalies. Sediments contain 25 ppm or so molybdenum and rocks up to 960 ppm molybdenum.

General Geologic Setting, Lithology and Structure:

Molybdenum and sparse zinc and/or copper occur in five separated areas within a large biotite granite batholith. Local areas of quartz diorite, probably older rocks, are also weakly mineralized. The geology supports a simple intrusive of large extent rather than multiphase emplacement of several intrusives. The latter, of course, would be more likely to have developed an economic deposit.

Nature, Occurrence and Controls of Mineralization:

Local quartz veins carry molybdenum as coarse flakes, often with associated disseminated pyrrhotite.

Alteration Products and Halo Effects:

Very local quartz-sericite along fractures. Disseminated pyrrhotite in quartz veins gives weak iron stain.

Table 24 Pass Lake Molybdenum Anomalies (continued).

Classification or Type of Potential Ore Deposit:

Remote chance for molybdenum stockwork.

Remarks, Including Suggestings for Prospecting:

These anomalies are rated fairly low because coarse molybdenum rarely makes commercial grade deposits. Also, the biotite granite batholith here contains locally high background in molybdenum and probably gives rise to the above anomalies. The area just east of Pass Lake has disseminated molybdenum in biotite granite itself, but the best samples ran only 960 ppm molybdenum, and the chances for much concentration are speculative.

Table 25 Necons and Stoney Rivers Copper Anomaly.

Type of Anomaly or Commodity of Interest:

Copper and possible gold.

Location by Quadrangle and Topography:

Lime Hills B-2; between the Necons and Stoney Rivers.

Approximate Size of Area of Interest:

Two square miles.

Number of Samples or Data Supporting Anomaly:

One sample running 3700 ppm copper. The nearest samples are one-fourth mile away and one-half mile away, and these were not anomalous.

General Geologic Setting, Lithology and Structure:

Mineralization appears to be localized in meta-siltstone and purple, massive metaconglomerate adjacent to and as rood pendants in quartz diorite-monzonite pluton. There is a major N30W Fault just north of the area. North of the fault is a circular gossan area estimated at 1500 feet with 10% to 20% pyrite with strong sericite alteration. Float was not anomalous.

Nature, Occurrence and Controls of Mineralization:

Epidote, quartz and feldspar occur as blebs and vugs in siltstone and metaconglomerate with some chalcopyrite, pyrite and pyrrhotite. Calcite is common near the contact.

Alteration Products and Halo Effects:

Discoloration and iron staining of metasediments.

Table 25 Necons and Stoney Rivers Copper Anomaly (continued).

Classification or Type of Potential Ore Deposit:

Contact metasomatic deposit.

Remarks, Including Suggestions for Prospecting:

Prospect the contact area between the metasediments and diorite, and check the gossan area. There is a very remote possibility of phosphorite in the metasediments.

Table 26 Merrill Pass Silver Anomaly.

Type of Anomaly or Commodity of Interest:

Silver, with lesser values in lead and zinc.

Location by Quadrangle and Topography:

Lime Hills A-1; four miles north of Merrill Pass.

Approximate Size of Area of Interest:

Four square mile hole in data base which could contain mineralization similar to samples A-2087 and A-2088.

Number of Samples or Data Supporting Anomaly:

Four samples-- two rocks and two stream sediments.

General Geologic Setting, Lithology and Structure:

The predominant host rock is quartz diorite, which appears to be transected by small intrusive bodies of quartz monzonite and/or quartz porphyry. Later intrusives are apparently the mineralizers and are altered by quartz and sericite. One rock sample, apparently representative of mineralized quartz monzonite(?), ran three ounces per ton silver. The question is: How much mineralized rock is there to the north?

Nature, Occurrence and Controls of Mineralization:

Mineralization is disseminated and appears to be associated with quartz monzonite and in adjacent fractured quartz diorite.

Alteration Products and Halo Effects:

There is strong quartz-sericite-pyrite alteration of quartz porphyry dikes(?) and small intrusives. Altered rocks are mostly float. Slight iron stain occurs on outcrop of adjacent fractured diorite.

Table 26 Merrill Pass Silver Anomaly (continued).

Classification or Type of Potential Ore Deposit:

Possible bulk silver, but tonnage is questionable. Air photos show encouraging size to quartz porphyry to the north.

Remarks, Including Suggestions for Prospecting:

The three square mile area north of the sample site should be prospected lightly with concentration on the amount and type of occurrence of quartz monzonite and quartz porphryr. Air photos indicate a tonal anomaly in the form of three projections from glacier areas and possible mineralized quartz porphyry one-half mile wide and one mile long.

Table 27 Another River Molybdenum Anomalies.

Type of Anomaly or Commodity of Interest:

Molybdenum, with associated lead, in six anomalies trending approximately N45W.

Location by Quadrangle and Topography:

Lime Hills A-1; south of Another River from the Tusk northwest to Merrill Pass.

Approximate Size of Area of Interest:

Aggregate of seven square miles from six separated anomalies.

Number of Samples or Data Supporting Anomaly:

One to four samples for each of the six anomalies. Stream sediments run 20 to 40 ppm molybdenum.

General Geologic Setting, Lithology and Structure:

The anomalies occur in a crude N45W trend near the contact of the biotite granite with the older quartz diorite batholith. Molybdenum seems to be associated with local areas of quartz monzonite which may be a marginal phase of the biotite granite batholith. Also, local areas of intrusive breccia are mineralized and contain fragments of older biotite diorite in quartz monzonite and/or granite.

Nature, Occurrence and Controls of Mineralization:

Pyrite and coarse molybdenite occur on joint surfaces and as local, fairly coarse disseminations in quartz veins.

Alteration Products and Halo Effects:

In local areas granite is altered to sericite, chlorite and/or clay. Argillic alteration predominates but even so affects only local areas.

Table 27 Another River Molybdenum Anomalies (continued).

Classification or Type of Potential Ore Deposit:

Porphyry type deposit.

Remarks, Including Suggestions for Prospecting:

Local areas in granite near glaciers south of the Tusk contain up to 2.0% lead and 1.85% zinc, but these are local areas along widely spaced fractures. Inclusions, particularly limy sediments, are also mineralized locally, but in both cases the possibilities for tonnage are not good. Consequently, the anomalies are rated low. The one anomaly near the horseshoe-shaped glacier just north of Neacola River should be checked as the best possibility.

Table 28 Two Lakes East Copper-Molybdenum Anomalies.

Type of Anomaly or Commodity of Interest:

Copper, molybdenum, zinc and trace of gold. This was a 1973 anomaly which could not be checked sufficiently during the follow-up program in 1974 because of low ceiling. The part we did get to on the southeast side was moderately encouraging.

Location by Quadrangle and Topography:

Lime Hills A-2; ten miles east of Two Lakes, and north of Tlikakila River.

Approximate Size of Area of Interest:

Seven to eight square miles in the general area, but two square miles in particular where mineralization was noted.

Number of Samples or Data Supporting Anomaly:

Eight anomalous samples out of a total of 15 samples from two localities four miles apart.

General Geologic Setting, Lithology and Structure:

The area of interest is rhyolitic volcanics apparently intruding and overlying granite and quartz diorite of the batholith. Also, roof pendants of cherts, metasiltstone and mafic volcanics are weakly mineralized on the southeast end of the anomaly by pyrite and traces of chalcopyrite. Much of the central anomaly is reported as volcanic sediments or tuffs(?) that are relatively unaltered.

Nature, Occurrence and Controls of Mineralization:

On the northwest end of the anomaly, malachite occurs in association with rhyolite as disseminated replacements. Molybdenum on the southeast end occurs as blebs in quartz veins less than two inches wide in a rhyolite plug(?).

Table 28 Two Lakes East Copper-Molybdenum Anomalies (continued).

Alteration Products and Halo Effects:

The rhyolite is cut by basaltic dikes. Alteration has not been defined. The rhyolite has strong manganese stain.

Classification or Type of Potential Ore Deposit:

Porphyry copper, with some potential for breccia pipe association.

Remarks, Including Suggestions for Prospecting:

These anomalies differ from other molybdenum occurrences in the Merrill Pass-Neacola River area by having a copper association and by having a spatial and suggested genetic relationship to rhyolite intrusives and volcanics of suspected mid-Tertiary age instead of granite-quartz diorite batholithic rocks. The north end of the anomaly is an air photo dike(?) swarm. Also, five small anomalies of molybdenum and zinc on the northeast trend should be checked.

LOWER WEST COOK INLET STUDY AREA

The Study area referred to as the Lower West Cook Inlet is the coastal land on the west side of Cook Inlet extending from Chinitna Bay on the south some 50 air miles to Mount Redoubt on the north. This 8 to 16 mile wide belt totals approximately 600 square miles and includes all or parts of Seldovia D8, Iliamna D1, D2, and Kenai A7, A8, B7, and B8 quadrangles. During the course of investigations of these areas, camps were temporarily established at the following locations from south to north: Iniskin Bay, Chinitna Bay, Johnson River, and Crescent Lake. All camp sites were left neat and clean. Most of the Lower West Cook Inlet area is either very steep and rugged or else densely vegetated by alders and other brush, so the going was tough. Additionally, efforts were continually hampered by coastal weather of rain, fog, and wind.

Geology

Previous geological investigations in the general area of interest include a one inch to four mile Preliminary Map of the Geology of the Iliamna Quadrangle by Detterman and Reed (1964), a one inch to one mile map of the Geology of the Iniskin-Tuxedni Region by Detterman and Hartsock (1966), and a generalized map by Helen Beikman at the scale of one inch to 16 miles on the Southwest Quadrant of Alaska. This geology was used to guide exploration efforts in the early stages toward geological units that might be favorable for particular types of ore deposits.

The geology of the Lower West Cook Inlet is lithologically and structurally very complex, but by the same token economically very interesting (Plate 1). All of this focuses around or rather along the Bruin Bay Fault system, which transects the entire map area northeast from Chinitna Bay through the head of Tuxedni Bay east of Crescent Lake, across the headwaters of Redoubt Creek and thence beneath cover, a distance of more than 50 miles. The fault extends out of this section of the study area both to the north and to the south for many miles.

In this section the fault forms the boundary between the intermediate intrusives of the Aleutian Range Batholith on the west and bedded Triassic and Jurassic sediments and volcanics on the east. Recent volcanics on the slopes of Mount Redoubt spill out and cover immediate parts of the batholith. Small bodies of granite, syenite, quartz monzonite and granodiorite have been intruded intermittently along the fault, e.g. near Johnson Glacier, Open Creek, Crescent River, Redoubt Creek and Katchin Creek. All of these stocks are less than one or two square miles in area except Katchin Creek, which covers about nine square miles. None of these contain very significant mineralization with the possible exception of the Johnson Glacier quartz monzonite, which is anomalous in copper, zinc, and mercury.

Economically, the most interesting rocks and the primary target of exploration efforts in this area are in the four to six-mile wide zone of volcanic flows, breccias, tuffs and sediments of the Lower Jurassic Talkeetna Formation. This zone strikes northeasterly at 45 degrees across the map area (Plate 1), is bounded on the west by the Aleutian Batholith, and is overlain to the east by sandstones, siltstones and conglomerates of the Tuxedni Group, Chinitna and Naknek Formations. In general, the entire section strikes about N30E to N50E and dips 10 to 30 degrees east. The limestones and calcareous siltstones of the Triassic Kamishak Formation which underly the volcanics of the Talkeetna Formation have been almost completely faulted out of the stratigraphic section by the Bruin Bay Fault, except for small slices near Johnson Glacier and southwest Tuxedni Bay.

Midway through the 1975 field season, important occurrences of lead-zinc and minor copper-silver were found in relationship to felsic centers in the Talkeetna Formation. While there are still many unanswered questions concerning the geology of these occurrences, the general rock associations were used as exploration tools, and efforts within the Talkeetna volcanic belt were intensified. Particular attention was given to recognition of the three members of the Talkeetna Formation with concentration on the more rhyolitic to dacitic centers.

The lower part of the Talkeetna Formation is referred to as the Marsh Creek Member and is characterized by massive, green volcanic breccia and lava flows, which are at least in part submarine, with interbedded argillite and metatuff. These units and lithologies are well exposed in the Johnson Glacier-Tuxedni Bay area.

The Portage Creek Agglomerate is the middle member of the Talkeetna Formation and is described in the literature as massive pink agglomerate and some volcanic breccia with minor andesitic flows and local metasedimentary rock. In the Tuxedni Bay-Redoubt Creek area this member is characteristically more felsic. It does have quite a bit of andesite flows, breccias, and tuffs, but also has a considerable amount of dacitic volcanics and even local areas of rhyolite, particularly around the Johnson Glacier area. Some of the dacitic fractions may or may not be intrusive. Tuffaceous sediments compose a large portion of the upper part of this unit in local areas. At any rate, this middle member correlates well with rocks found to be mineralized in several areas.

The Horn Mountain Tuff is the name given to the upper member of the Talkeetna Formation and generally consists of mottled andesitic tuff, tuffaceous sandstone and siltstone, with minor interbedded andesitic flows. However, in the Johnson River-Tuxedni Bay area this unit, as is the case with lower members, is much more felsic than elsewhere and has quite a bit of rhyolite breccia and tuff interbedded with tuffaceous siltstone and argillite.

The three members of the Talkeetna Formation are distinguishable south of Tuxedni Bay, but from there north the sequence is disrupted by the Aleutian Batholith and several faults (Plate 1). Between Tuxedni Bay and the Crescent River, the lower member has been removed by the batholith. All three members are believed present again between Crescent River and Redoubt Creek. To the north, all three members have been removed by intrusives and/or covered by later sediments. A large remnant of the lower member (?) does crop out again on the hill south of Cannery Creek and the Drift River.

Geochemistry

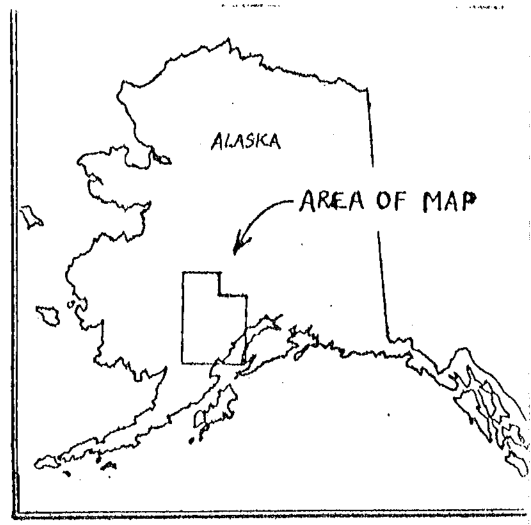
The Lower West Cook Inlet area was examined briefly during the 1974 field season to determine if the geology merited detailed geochemical sampling. While the full significance and potential of the Talkeetna Formation was not obvious at that time, it was recognized that the volcanics of this formation were similar to those that have produced massive sulfide ore bodies elsewhere, the main difference being geologic age. At any rate, the geology was recognized as favorable and more detailed work ensued in 1975, particularly in areas of felsic volcanics. This eventually led to the discovery of the Crescent River and Little Polly Creek Lead-Zinc Occurrences (Figure 6 and Tables 29-30). Because of time and bad weather restrictions during the 1975 field season, most of the work had to be priority rated to these anomalies. As a result, the rest of the Talkeetna Formation and the adjacent areas have not received the attention merited. Less than 300 geochemical samples have been taken in the project area and many of these were reconnaissance samples taken outside of the favorable zone before its recognition (Plates 12a-c and 13a-e).

Background geochemical values in this study area have been found to be low in copper, molybdenum and arsenic, and in fact the latter two were omitted from the standard run when it was found that they weren't much help. Even the lead, zinc and silver values as a rule are low in this area, which makes the anomalous areas stand out as exceptions with distinct boundaries. Sample and analytical logs are included in the Appendicies.

Prospects and Anomalies

As mentioned, the Crescent River and Little Polly Creek Lead-Zinc Occurrences are considered important discoveries as possibilities for volcanogenic network type sulfide deposits (Figure 6 and Tables 29-30). The details of the geology and relationship to felsic centers are presented herein. The recognition of geologic indicators connected with these anomalies emphasizes the need for detailed mapping and sampling of the lower to middle part of the Talkeetna Formation in this area. The covered areas between the anomalies along this favorable horizon should be prospected and locally soil sampled in some detail, as the present anomalies represent the better outcrops and not necessarily the better mineralization.

Figure 6
LOWER WEST COOK INLET STUDY AREA
PROSPECTS AND ANOMALIES



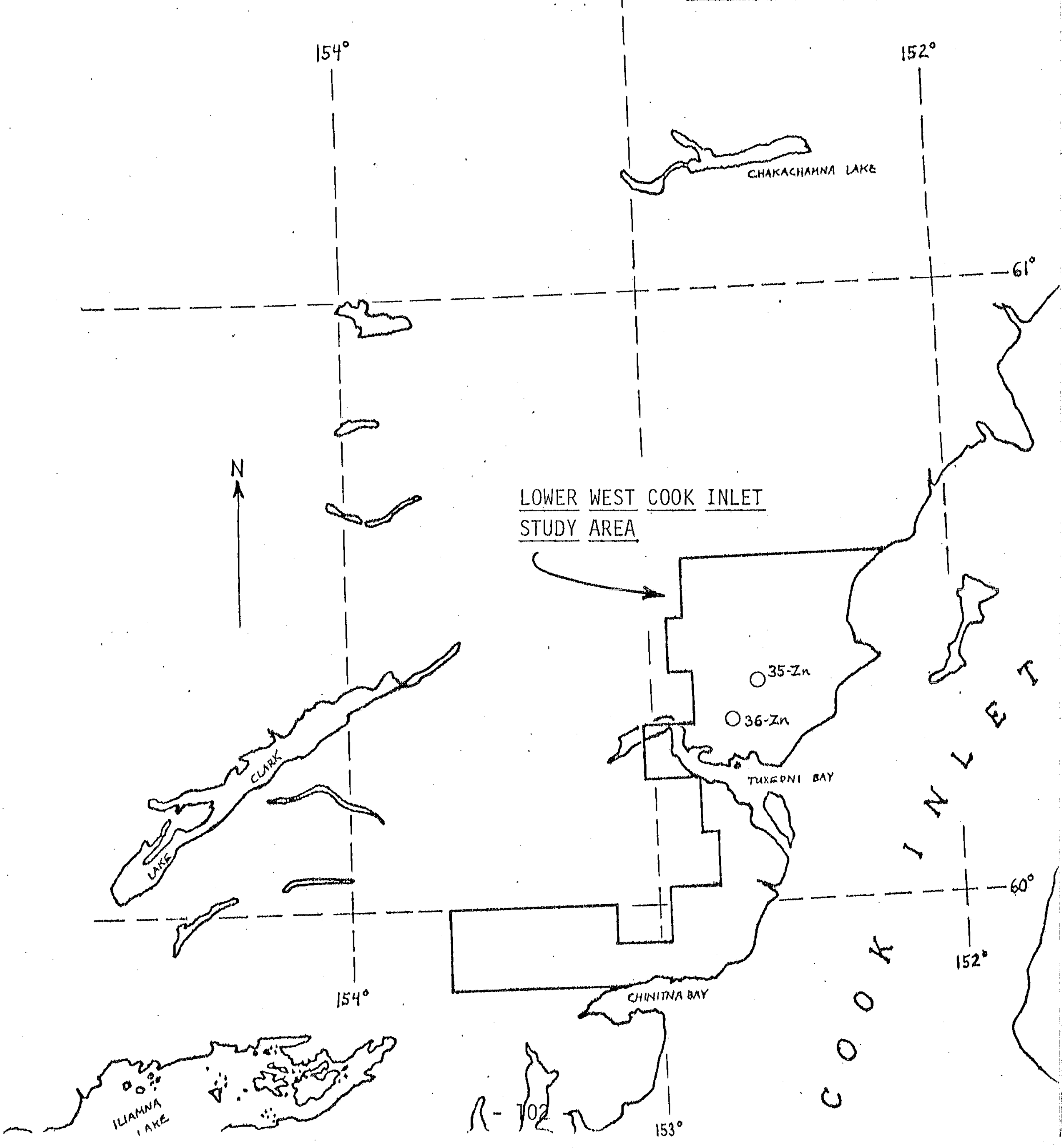


Table 29 Little Polly Creek Lead-Zinc Anomaly.

Type of Anomaly or Commodity of Interest:

Lead and zinc.

Location by Quadrangle and Topography:

Kenai B-7; halfway between Redoubt Creek and Crescent River at the headwaters of Little Polly Creek.

Approximate Size of Area of Interest:

Siz square miles; open along a N45E strike of units.

Number of Samples or Data Supporting Anomaly:

About six rock samples with values of 100 to 420 ppm lead and on the order of 250 to 300 ppm zinc, with one sample of 5400 ppm zinc.

General Geologic Setting, Lithology and Structure:

This anomaly occurs in volcanics of the Middle Member of the Talkeetna Formation and is separated from the Lower Member, which is unmineralized, by a fault and is overlain by green, fine grained tuffs of the Upper Member, which is also unmineralized. The better mineralized rocks are dacites and dacitic breccias and agglomerates with interbedded tuffaceous sediments. Andesitic volcanics, breccias and agglomerates with clasts to four inches in diameter compose much of the sequence, particularly to the southeast.

Nature, Occurrence and Controls of Mineralization:

Mineralization is strata bound and confined to the Middle Member of the Talkeetna Formation, with good possibilities for better mineralization laterally.

Alteration Products and Halo Effects:

Local areas, particularly along the fault boundary between the Middle and Lower Members, are intensely silicified with pyrite to 20% of the rock. Black chlorite is an important alteration mineral outside of the fault zone.

Classification or Type of Potential Ore Deposit:

Volcanogenic network sulfide deposit.

Table 29 Little Polly Creek Lead-Zinc Anomaly (continued)

Remarks, Including Suggestions for Prospecting:

Lead and zinc mineralization of this anomaly is weak but is strata bound, being associated with the Middle Member of the Talkeetna Formation. The association with a felsic center is certainly encouraging, and detailed prospecting should be conducted laterally along this horizon, with particular attention to small sedimentary basin environments between volcanic units.

Table 30 Crescent River Lead-Zinc Anomaly.

Type of Anomaly or Commodity of Interest:

Lead and zinc with weak silver.

Location by Quadrangle and Topography:

Kenai B-8; halfway between Crescent River and Tuxedni Bay, four to five miles northeast of Rusty Mountain.

Approximate Size of Area of Interest:

Six to eight square miles; open on both ends along a N45E strike of units.

Number of Samples or Data Supporting Anomaly:

About a dozen rock samples with values of 150 to 320 ppm zinc and 60 to 1000 ppm lead.

General Geologic Setting, Lithology and Structure:

This anomaly occurs in volcanics of the Middle Member of the Lower Jurassic Talkeetna Formation and is bounded on the west by intrusive rocks and is overlain by light green, fine grained arkosic tuffs of the Upper Talkeetna Formation. Host rocks are predominantly rhyodacite tuffs and breccias with some sparse andesitic tuff breccias. The rhyodacite breccias and tuffs contain 1 to 5% disseminated pyrite and a trace of chalcopyrite.

Nature, Occurrence and Controls of Mineralization:

This disseminated pyrite and traces of chalcopyrite are not going to make ore in themselves but may be a clue to massive sulfide deposits in a nearby horizon.

Alteration Products and Halo Effects:

Local areas of iron stain with silicification and recrystallization with up to 5% disseminated pyrite, particularly in the rhyodacite breccias.

Classification or Type of Potential Ore Deposit:

Volcanogenic network sulfide deposit.

Remarks, Including Suggestions for Prospecting:

The lead and zinc mineralization is not strong, but it is distinctly anomalous and has favorable features for volcanogenic network deposits. Detailed mapping and sampling should be conducted on the anomaly and proceed along strike with particular attention to the rhyolites and rhyolite breccias.

Lower West Cook Inlet Study Area
Conclusions and Recommendations

The Lower West Cook Inlet study area has been found to have considerable potential for base metal sulfide deposits such as copper, lead, zinc and associated precious metals such as silver and gold of volcanogenic origin. The Crescent River and Little Polly Creek Lead-Zinc Occurrences are examples of this type of volcanogenic network mineralization. The strata bound nature of these deposits in the middle to lower part of the Talkeetna Formation makes the rest of the formation prospective for other such occurrences, particularly in areas of felsic buildup. (Plates 1 and 2)

Too quick for recommendations

A quick check of the Aleutian Batholith and particularly the later intrusives did not reveal much in the way of porphyry copper potential. Iron deposits in the form of magnetite are known to occur at Tuxedni Bay. However, the outlook for sizeable tonnage is not good as these are small but high grade lenses and pods. Limestone for cement and/or lime is a possibility for commercial production in this general area since it is near tidewater. Limestones of the late Triassic Kamishak Formation provide some potential in this regard, primarily south of the present study area such as at Iliamna Bay, where analytical results indicate large quantities of suitable grade material (Detterman, 1969). Impure, poor quality coals of minor thickness are found in some of the younger bedded rocks such as the Kenai Formation, but these are considered of no economic significance. However, economic concentrations of zeolites for industrial purposes may occur in these younger bedded formations and in particular the Kenai Formation. Investigations by Madonna (Alaska Open File Report 87) indicate that a 20' thick brown siltstone bed near Clam Cove on the north shore of Chinitna Bay contains the zeolite heulandite in sufficient grade and volume to be of possible economic value.

The relative mineral potential of lands in the Lower West Cook Inlet study area is shown on Plate 3 and recommendations for land classification are outlined on Plate 4. That portion of the Lower West Cook Inlet area east of the Aleutian Batholith should be retained for multiple use. This would primarily involve the Talkeetna Formation which is prospective for volcanogenic network type sulfide deposits of copper, lead, and zinc with lesser gold and silver.

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