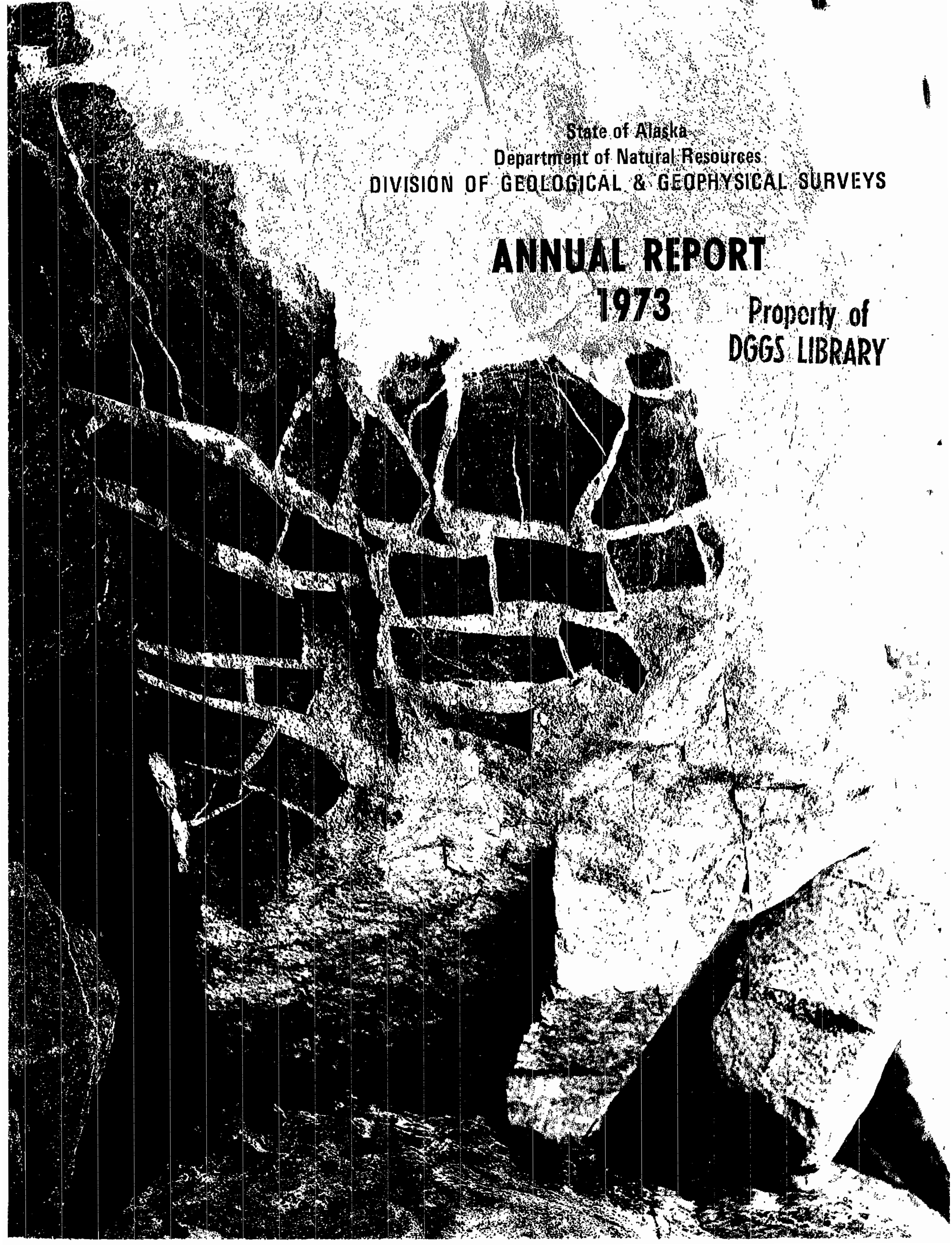
State of Alaska
Department of Natural Resources
DIVISION OF GEOLOGICAL & GEOPHYSICAL SURVEYS

ANNUAL REPORT 1973



ANNUAL REPORT
1973

STATE OF ALASKA - DEPARTMENT OF NATURAL RESOURCES

DIVISION OF
GEOLOGICAL AND GEOPHYSICAL SURVEYS

William A. Egan, Governor
Charles F. Herbert, Commissioner, Dept. Natural Resources
Donald C. Hartman, State Geologist

P.O. Box 80007
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Cover photo — Example of mag~~ne~~matic stoping of quartz diorite into a quartz monzonite, Talkeetna Mountains, Alaska — by M. W. Henning. Other photos by T. K. Bundtzen, G. R. Eakins, R. E. Garland, L. F. Larson, G. H. Pessel, T. E. Smith.

STATE OF ALASKA

WILLIAM A. EGAN, GOVERNOR

DEPARTMENT OF NATURAL RESOURCES

Division of Geological and Geophysical Surveys

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March 13, 1974

The Honorable Charles F. Herbert
Commissioner
Department of Natural Resources
Pouch M
Juneau, Alaska 99801

Dear Commissioner Herbert:

I am pleased to submit this report of the Division of Geological and Geophysical Surveys' activities during 1973.

Alaska's mineral production in 1973 was valued at $294 million, with $261 million attributable to oil and gas and $33 million to other minerals.

Division field mapping programs were carried out in the Western Brooks Range, Talkeetna Mountains, and the Alaska Peninsula. A total of some 3,000 square miles were mapped during the year.

The airborne magnetometer surveying program, begun in 1971, was continued in 1973, with 15,317 square miles of additional mapping obtained in the north-central Alaska Range.

Most of the Division staff contributed heavily to land classification projects and mineral evaluations connected with the Joint Federal-State Land Use Planning Commission and with numerous legislative requests.

The Division will continue to advance the geological knowledge of Alaska in every way possible, so as to contribute to the wisest and best use of Alaska's natural resources.

Respectfully submitted,

Donald C Hartman

Donald C. Hartman
State Geologist

WILLIAM A. EGAN

Governor, State of Alaska

CHARLES F. HERBERT

Commissioner, Dept. of
Natural Resources

DONALD C. HARTMAN

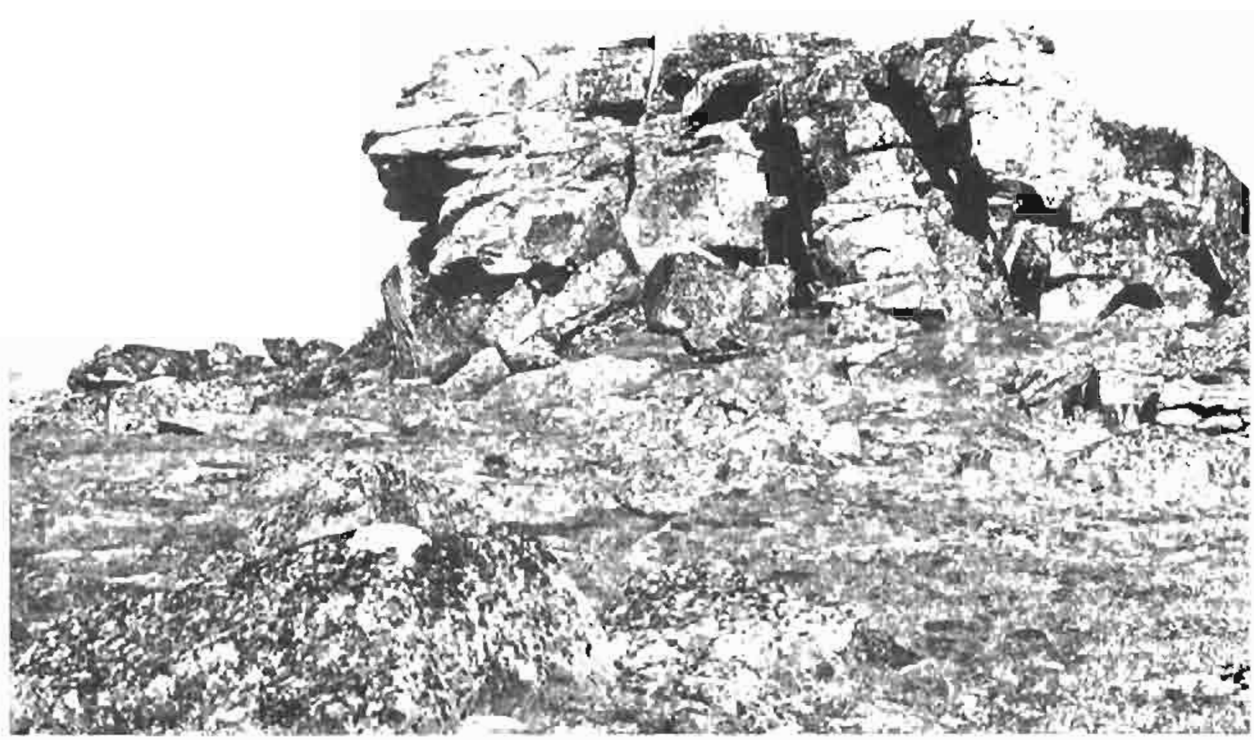
State Geologist

CONTENTS

PAGE

ILLUSTRATIONS

PAGE



Granitic outlier on altiplanation terrace, Alphabet Hills, central Alaska.

FIGURE 1. Duties of the DGGS

INTRODUCTION

The Alaska Division of Geological and Geophysical Surveys (DGGS) maintains offices with scientific and technical personnel in Anchorage and Fairbanks. Offices of Mining Information Specialists are located in Anchorage, Fairbanks, Ketchikan, and Juneau. Formerly named the Division of Geological Survey, the new division was formed on July 1, 1972 by legislative enactment.

DUTIES OF THE DIVISION

The DGGS is charged with conducting "geological and geophysical surveys to determine the potential of Alaska lands for production of metals, minerals, and fuels; the location and supplies of ground waters and construction materials; the potential geologic hazards to buildings, roads, bridges, and other installations and structures; and shall conduct such other surveys and investigations as shall advance knowledge of the geology of Alaska" (fig. 1). In accordance with this charter, geologic and geophysical mapping, economic geology studies, and geochemical sampling are carried out during the summer field season. The maps and reports resulting from these activities are one of the principal products of the DGGS.

Property examinations and technical assistance are available to Alaskan miners and prospectors. The DGGS laboratory at Fairbanks provides mineral analyses and identifications as well as studies of rocks and minerals. Files of all known Alaskan mining claims and claim holders since 1953 are maintained at Mining Information Offices (p. 2).

ORGANIZATION

The DGGS is organized in five sections: Office of the State Geologist, Mining Geology, Conservation, Mineral Analysis and Research, and Energy Resources. The changing role in response to State needs, plus the difficulties of procuring, maintaining, and transporting personnel and equipment, require personnel to be both flexible and competent.

PERSONNEL CHANGES

On April 5, 1973, Governor William A. Egan announced the appointment of Donald C. Hartman as State Geologist. Other Anchorage personnel changes include the addition of Patrick L. Dobey, Chief Petroleum Geologist; Robert M. Klein, Stratigrapher; Mitchell W. Henning and Kristina M. O'Connor, Geological Assistants; and Celia I. Heath, Clerk-Typist.

New personnel in Fairbanks are L. Frank Larson, Publications Specialist; Roberta A. Mann, Clerk-Typist; Carole H. Stevenson, Clerk-Typist; and Jean T. Purcell and Marcia A. Trainor, Laboratory Assistants.

PERSONNEL

STATE GEOLOGIST

Donald C. Hartman

ADMINISTRATIVE SERVICES

Nola J. Bragg, Secretary
Olga A. (Sue) Austin, Clerk-Typist
Celia I. Heath, Clerk-Typist (temp)
Roberta A. Mann, Clerk-Typist
Carole H. Stevenson, Clerk-Typist (temp)

MINING INFORMATION SPECIALISTS

Mildred E. Brown, Clerk
Agnes M. Burge, Clerk
Ulrika O. McBride, Clerk
Geraldine M. Zartman, Clerk

PUBLICATIONS

L. Frank Larson, Editor

CONSERVATION AND REGULATION

Cleland N. Conwell, Mining Engineer

GEOLOGIC INVESTIGATIONS

MINERAL RESOURCES

Thomas E. Smith, Chief Mining Geologist
Gilbert R. Eakins, Mining Geologist
Robert E. Garland, Mining Geologist
Gordon Herreid, Mining Geologist

SUMMER GEOLOGICAL ASSISTANTS

Thomas K. Bundtzen
Kerwin Krause
William S. Roberts
John M. Zdepski

ENERGY RESOURCES

Patrick L. Dobey, Chief Petroleum Geologist
Mitchell W. Henning, Geological Assistant
Robert M. Klein, Stratigrapher
William M. Lyle, Petroleum Geologist
Don L. McGee, Petroleum Geologist
Kristina M. O'Connor, Geological Assistant
Garnett H. Pessel, Petroleum Geologist
Charlotte M. Renaud, Cartographer

LABORATORY SERVICES

Thomas C. Mowatt, Supervisor
William W. McClintock, Mineral Lab Technician
Jean T. Purcell, Lab Assistant (temp)
Donald R. Stein, Assayer
Marcia A. Trainor, Lab Assistant (temp)
Thomas C. Trible, Geochemical Analyst
Namok C. Veach, Assayer Chemist

PERSONAL SERVICE CONTRACTS AND UNIVERSITY AFFILIATES

John R. Carden, Geologist
Robert B. Forbes, Geologist
Daniel B. Hawkins, Geologist
James H. Stout, Geologist
Marla C. Trible, Geophysicist
Donald M. Triplehorn, Geologist
Donald L. Turner, Geologist

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P.O. Box 80007
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Anchorage office
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Anchorage, AK 99501

Ketchikan office
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Ketchikan, AK 99901

Juneau office
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Juneau, AK 99801

MINING INFORMATION SPECIALISTS

The DGGS mining information specialists were kept busy in 1973. Together they processed 5,920 claim notices and 1,170 affidavits and mineral documents in addition to answering countless requests from visitors and correspondents around the globe. Clockwise from top left are Mildred E. Brown, Fairbanks; Ulrika O. McBride, Anchorage; Agnes M. Burge, Juneau; and Geraldine M. Zartman, Ketchikan.

T. K. Bundtzen collecting geochemical samples near Deadman Lake, central Alask

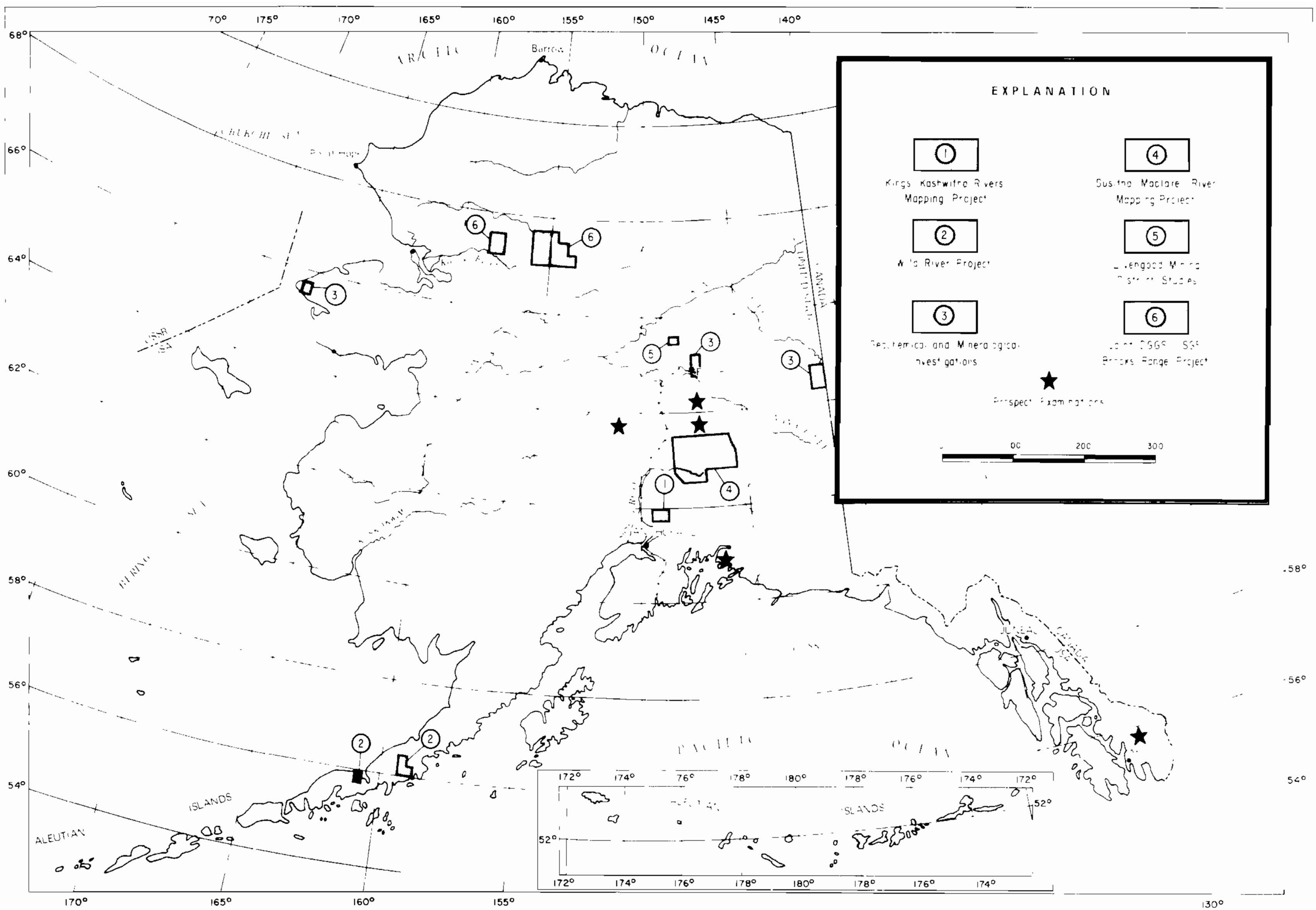


FIGURE 2. Field studies by DGGS personnel, 1973

GEOLOGICAL AND GEOPHYSICAL PROGRAMS

REGIONAL GEOLOGY OF THE SUSITNA-MACLAREN RIVER AREA

Geologic investigations during the 1973 and previous field seasons have resulted in detailed and reconnaissance geologic maps covering nearly 5000 square miles along the south flank of the central Alaska Range and the north end of the Talkeetna Mountains (fig. 2). This year's program, carried out by T.E. Smith and T.K. Bundtzen using full-time helicopter support, was concentrated in the west and southwest part of the terrane shown in figure 3. This makes the sixth and final year of continuing efforts by Smith to provide geologic and resource information on this area, which is critical to the understanding of Alaskan tectonics. Simultaneous studies in the Amphitheater Mountains, aimed at completing the mapping of this vast area, were undertaken this summer by J.H. Stout while under contract to the State of Alaska (p. 30). Much of the area has been geochemically appraised by comprehensive stream-sediment programs.

Highlights of the 1973 work include the recognition that the north end of the Talkeetna Mountains batholith is really a high-grade complex consisting of metamorphic rocks and at least two ages of composite plutons. The oldest rocks are intensely metamorphosed amphibolites (Pza), possibly representing a fragment of ancient oceanic crust. The amphibolites are in apparent unconformable contact with an extensive terrane of slightly metamorphosed silicic lavas (Pzv) with subordinate slates and carbonates. The lavas form a belt extending from the Talkeetna Mountains to the Richardson Highway and, on the basis of corals collected by Csejtey [1] near Watana Lake, are thought to be Upper Paleozoic in age. Several new fossil localities were found in these rocks, some yielding shelly fauna that have not yet been identified.

Another discovery of the recent field season was that folded basalt and andesite(?) flows of the Amphitheater Group (TRa) include many pillow horizons and seem to be in thrust contact with the schistose volcanics (Pzv) discussed above. Rocks of the Amphitheater Group are thermally metamorphosed in the pumpellyite-prehnite facies, whereas the older silicic lava series seem to be mainly lower greenschist facies. Near Watana Lake, pillow lavas of the Amphitheater Group overlie, with apparent conformity, rocks of the Pzv unit. Thus the contact between Upper Paleozoic and Triassic lava suites appears depositional in some places and tectonic in others---a situation not unlike that described in other parts of the western Cordillera. Regional comparisons of lithology, age, and chemistry imply the Amphitheatre Group is correlative with the Nikolai greenstone of the McCarthy region, the Triassic lavas of southeastern Alaska, and the Karmutsen Group of British Columbia. The present geographic spread of these rocks may well be partly due to large-scale crustal displacements such as those envisioned for Paleozoic rocks of southeastern Alaska.[2]

The Amphitheater Group is everywhere in tectonic contact with pelitic sediments and metasediments to the north (Js), which form the parent rocks of the Maclaren metamorphic belt. Isolated occurrences of conglomerate, interpreted as a basal unit, are present along the boundary fault, which extends eastward into the Broxson Gulch Thrust fault system. Fossils collected from one of the conglomerate exposures are Upper Jurassic in age, and thus it appears probable that sediments and metamorphites of the Maclaren terrane may be a central-Alaska equivalent of the Gravina-Nutzotin belt, an Upper Mesozoic sedimentary and volcanic sequence widely exposed in southern and southeastern Alaska.[3]

In the drainage of Watana Creek, a previously unreported sequence of Tertiary coal-bearing sediments was found that appears to cap the boundary fault; these are now under study by W.M. Lyle of the DGGS (circled locality A of fig. 3; see p. 19).

The Maclaren metamorphic belt preserves evidence of intense metamorphic and igneous processes existing in Cretaceous time. Well-defined mineral zones spanning the range from pumpellyite-prehnite to kyanite-sillimanite assemblages are mappable on the flanks of the belt. As shown in figure 3 the Maclaren terrane is sharply truncated at the Denali Fault. The search for a counterpart on the opposite side has resulted in the discovery of an equivalent terrane at Kluane Lake (Y.T.), implying a 250-mile dextral offset along

1 Csejtey, Béla Jr., 1973, Paleozoic island arc in Talkeetna Mountains in United States Geological Survey Alaska Program, 1973 [abs]: U.S. Geol. Survey Circ. 683, p. 45.

2. Jones, D.L., Irwin, W.P., and Ovenshine, A.T., 1972, Southeastern Alaska- a displaced continental fragment: U.S. Geol. Survey Prof. Paper 800-B, p. B211-B217.

3. Berg, H.C., Jones, D.L., and Richter, D.H., 1972, Gravina-Nutzotin belt - tectonic significance of an Upper Mesozoic sedimentary and volcanic sequence in southern and southeastern Alaska: U.S. Geol. Survey Prof. Paper 800-D., p. D1-D24.

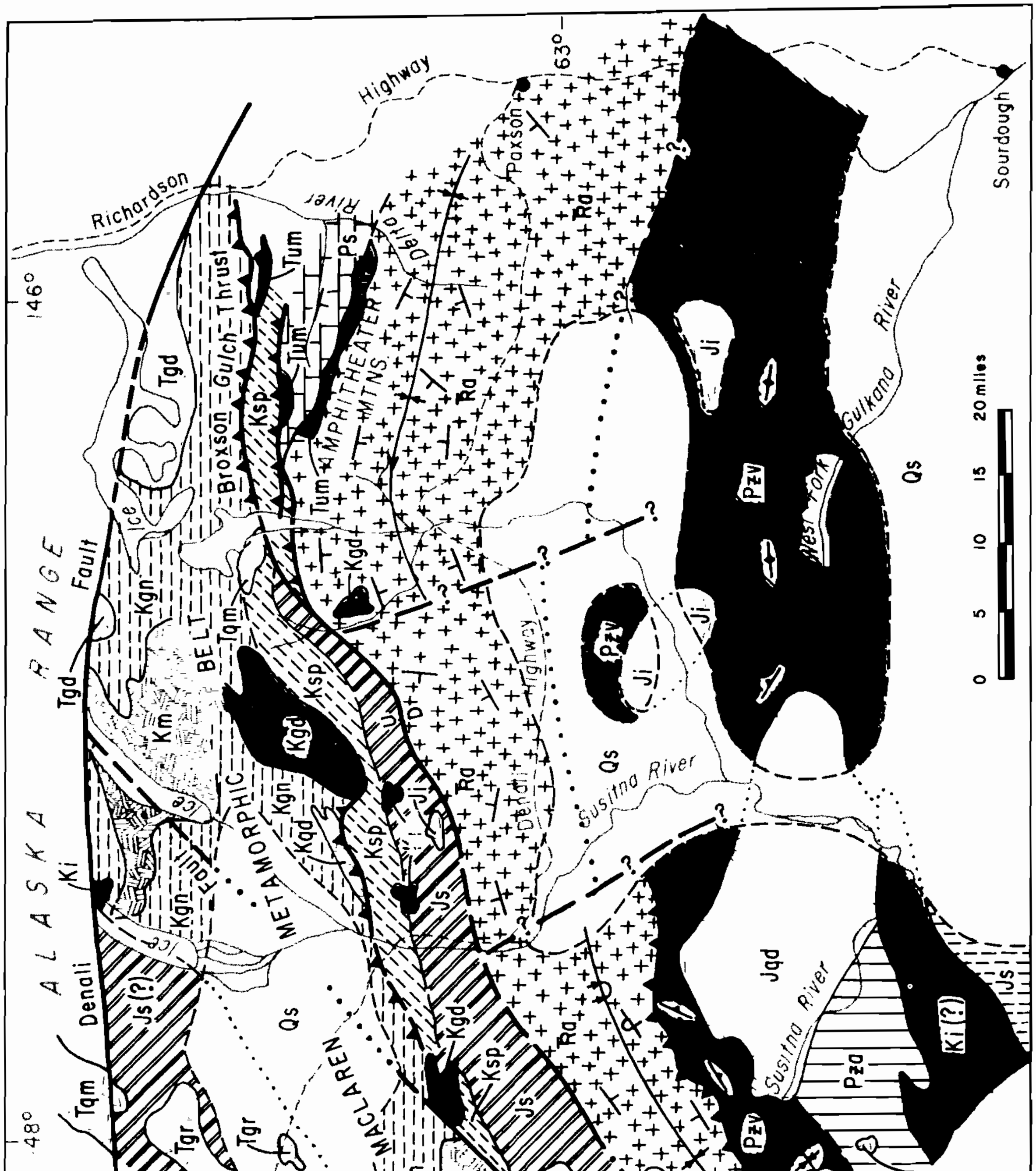
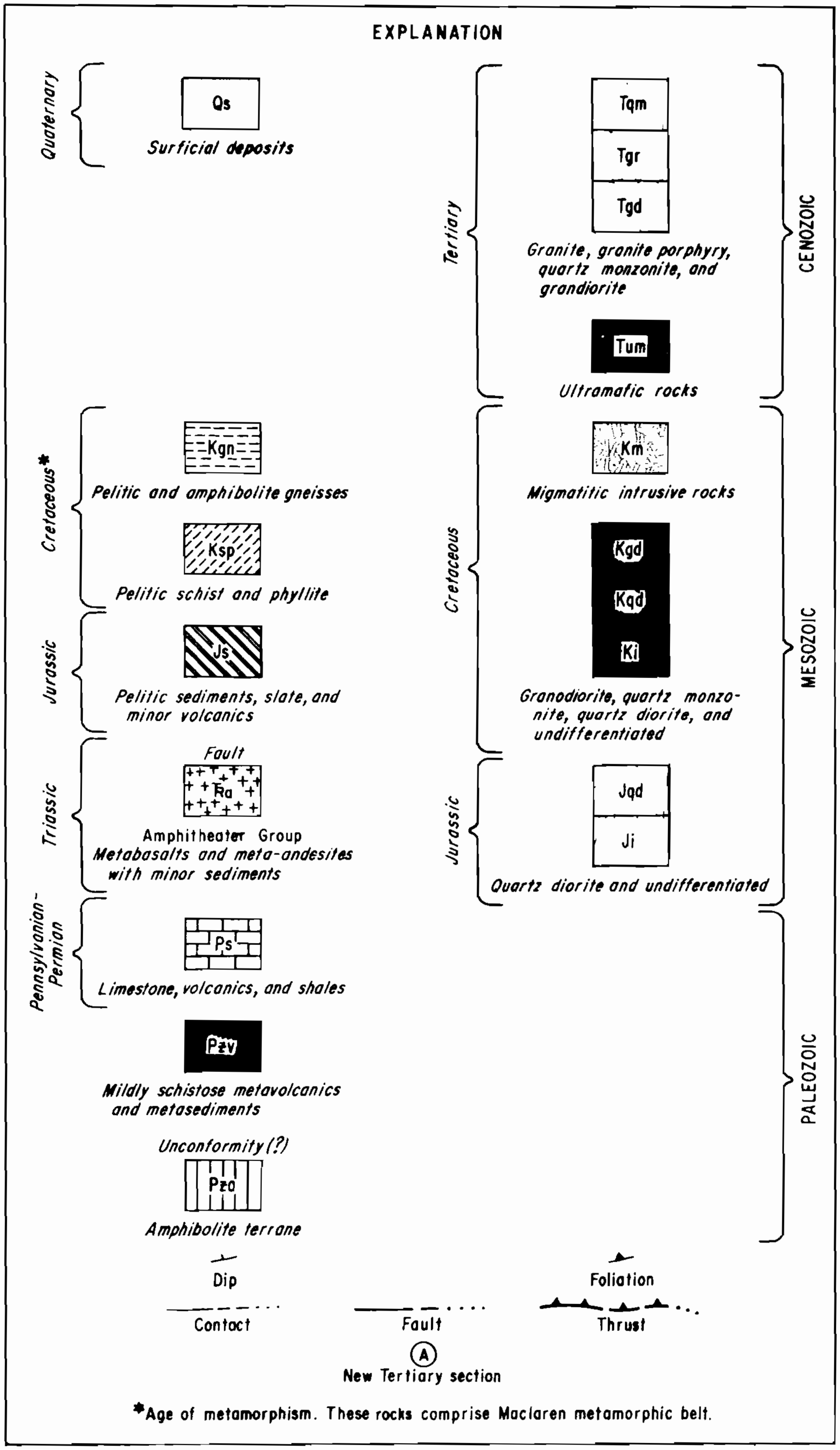


Figure 3. Generalized geology of the Susitna-Maclaren River region


EXPLANATION
Quaternary
Qs
Surficial deposits
Tertiary
Tqm
Tgr
Tgd
Granite, granite porphyry, quartz monzonite, and grandiorite
Tum
Ultramafic rocks
CENOZOIC
Cretaceous*
Kgn
Pelitic and amphibolite gneisses
Ksp
Pelitic schist and phyllite
Jurassic
Js
Pelitic sediments, slate, and minor volcanics
Cretaceous
Km
Migmatitic intrusive rocks
Kgd
Kqd
Ki
Granodiorite, quartz monzonite, quartz diorite, and undifferentiated
MESOZOIC
Triassic
Fault
Ra
Amphitheater Group
Metabasalts and meta-andesites with minor sediments
Jurassic
Jqd
Ji
Quartz diorite and undifferentiated
Pennsylvanian-Permian
Ps
Limestone, volcanics, and shales
Pzv
Mildly schistose metavolcanics and metasediments
Unconformity (?)
Pza
Amphibolite terrane
PALEOZOIC
Dip
Foliation
Contact
Fault
Thrust
A
New Tertiary section
*Age of metamorphism. These rocks comprise Maclaren metamorphic belt.

T.E. Smith mapping pillow lavas of Amphitheater Group near Watana Lake

the Denali system since Cretaceous time.[4-7] The Kluane plutonic-metamorphic complex is coextensive with the Coast Range Batholith and its marginal belts; thus the Maclaren metamorphic belt of central Alaska may be considered a displaced extension of the Coast Range complex. Definition of the Maclaren belt during the past several years through mapping programs supported by the State of Alaska has provided the key geologic element in solving the problem of lateral displacement along the Denali system. A reconstruction of displaced terranes promises to aid in the correlation of mineral belts and other geologic features across the fault.

4. Forbes, R.B., Turner, D.L., Stout, J.H., and Smith, T.E., 1973, Cenozoic offset along the Denali Fault, Alaska [abs]: EOS Am. Geophys. Union Trans., v. 54, no. 4, p. 495.

5. Turner, D.L., Smith, T.E., and Forbes, R.B., in press, Geochronology of offset along the Denali Fault system in Alaska [abs]: Geol. Soc. America Abs. with Programs, Cordilleran Section 1974.

6. Smith, T.E., and Turner, D.L., in press, Maclaren metamorphic belt of central Alaska [abs]: Geol. Soc. America Abs. with Programs, Cordilleran Section 1974.

7. Forbes, R.B., Smith, T.E., and Turner, D.L., in press, Comparative petrology and structure of the Maclaren, Ruby Range, and Coast Range belts: implications for offset along the Denali Fault system [abs]: Geol. Soc. America Abs. with Programs, Cordilleran Section 1974.

BROOKS RANGE PROJECT

The Brooks Range Project, now in its third year, is a continuing program of geologic mapping, stream-sediment sampling for geochemical analysis, and investigation of mineral occurrences in the Survey Pass and Ambler River quadrangles, in the southern part of the Brooks Range. In 1973, the project was a joint effort by the USGS and DGGS. Personnel included I.L. Tailleur and W.P. Brosge of the USGS and G.H. Pessel and R.E. Garland of the DGGS. Other personnel were T.C. Mowatt of the DGGS, who worked with the field party for several weeks in the Walker Lake area, conducting special studies of the granitic rocks and helping with the geologic mapping; R.B. Forbes of the Geophysical Institute of the University of Alaska, who spent a week with the field party in the Walker Lake area, helping with the geologic mapping; and J.M. Zdepski, a DGGS geological field assistant.

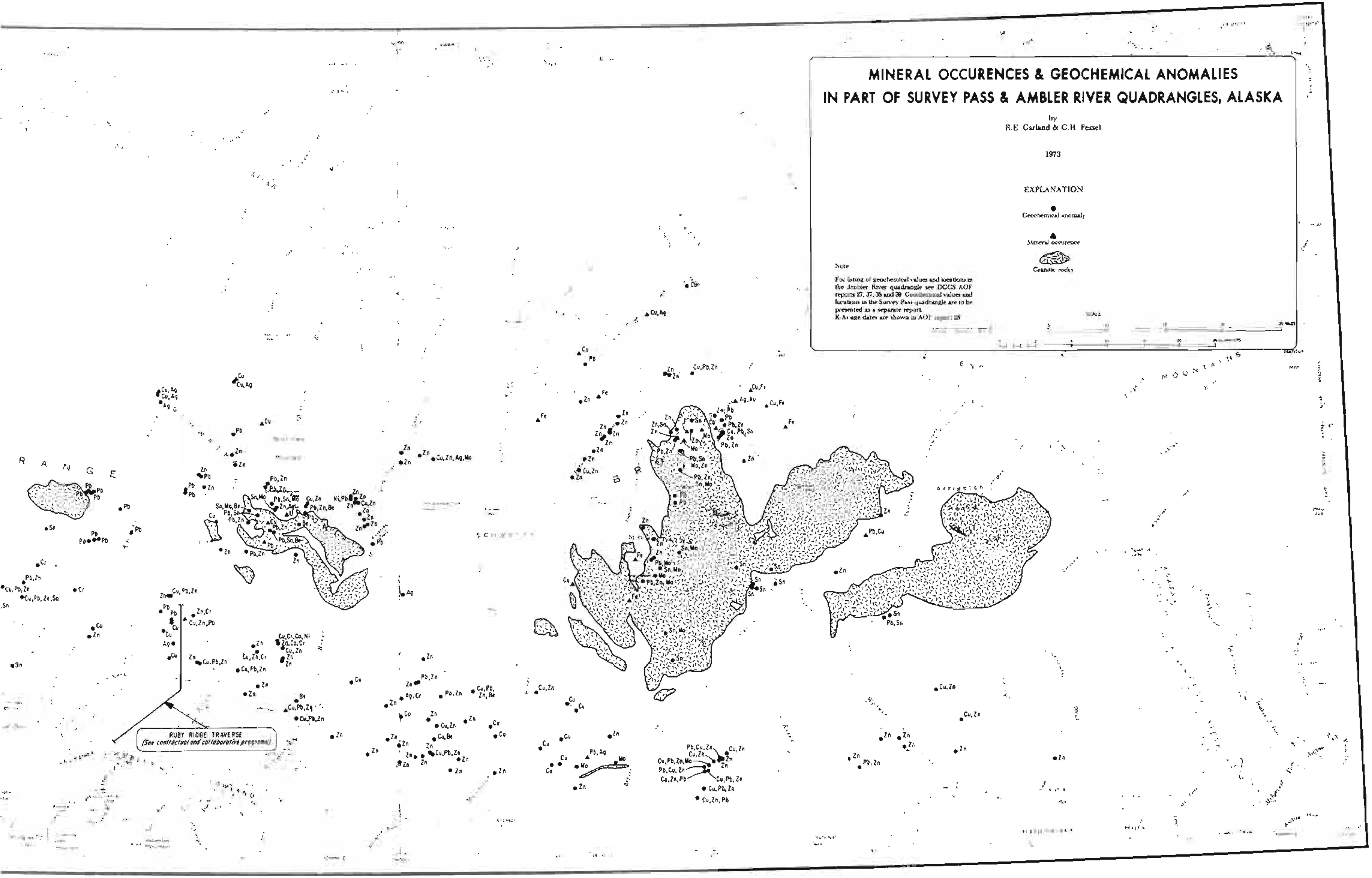
The primary purpose of the project was bedrock geologic mapping, and approximately 2,700 square miles of the Brooks Range were mapped at a scale of 1:63,360 (1 inch=1 mile). The area covered included the western two-thirds of the Survey Pass quadrangle and the central part of the Ambler River quadrangle (pl. 1). Stream-sediment samples were collected in part of the Ambler River quadrangle to extend the reconnaissance network in the area.

The cooperative nature of the program enabled the surveys to combine their unpublished data into a joint product. This cooperation allowed differences in interpretation to be resolved and ensured that the mapping units were essentially compatible with units used in the Brooks Range by the USGS in previous publications. The mapping program was designed to extend the previously open-filed mapping of the USGS in the eastern part of the Survey Pass quadrangle,[8] and to incorporate and extend mapping by the DGGS in the southeastern Ambler River quadrangle.[9] DGGS geologic mapping in 1971 in the western part of the Survey Pass quadrangle, under the direction of C.E. Fritts, had not been published because of his accidental death in 1972. His mapping was incorporated into the results of the 1973 program.

Field investigations began on May 30th, from a camp at Walker Lake. The field party spent 6 weeks at this location, mapping in the Survey Pass quadrangle. The placement of a fuel cache on a lake near the Noatak River, to extend the useful range of the helicopter, made mapping possible in the northwestern part of the Survey Pass quadrangle from the base camp at Walker Lake. On July 15th, the camp was moved to the village of Ambler, and mapping in the central part of the

8. Brosgé, W.P., and Reiser, H.N., 1971, Preliminary bedrock geologic map, Wiseman and eastern Survey Pass quadrangles, Alaska: U.S. Geol. Survey open-file rept. 479.

9. Pessel, G.H., Garland, R.E., Tailleur, I.L., and Eakins, G.R., 1973, Preliminary geologic map of the southeastern Ambler River and part of the Survey Pass quadrangles, Alaska: Alaska Div. Geol. and Geophys. Surveys open-file rept. 28.


MINERAL OCCURENCES & GEOCHEMICAL ANOMALIES
IN PART OF SURVEY PASS & AMBLER RIVER QUADRANGLES, ALASKA
by
R.E. Garland & C.H. Pessel
1973
EXPLANATION
Geochemical anomaly
Mineral occurence
Granitic rocks
Note
For listing of geochemical values and locations in the Ambler River quadrangle see DGGS AOF reports 27, 37, 35 and 39. Geochemical values and locations in the Survey Pass quadrangle are to be presented as a separate report.
K-Ar age dates are shown in AOF report 25
SCALE
RUBY RIDGE TRAVERSE
(See contractual and collaborative programs)
R A N G E
B R O
S C H W A T K A
M O U N T A I N S


ROOKS
Zn
Cu
Pb,Zn
Cu,Zn
Cu,Pb,Zn

Ambler River quadrangle was conducted from that base of operations for 3 weeks.

During operations at the village of Ambler, the field party supplied helicopter transportation and logistical support for a special study of rocks on the south flank of the Brooks Range by personnel from the University of Alaska, including R.B. Forbes, D.L. Turner W.G. Gilbert, and J.R Carden (p. 34).

The project used an FH-1100 helicopter furnished on bid contract by Merric, Inc. of Fairbanks. Bettles Aviation, a division of Merric, provided most of the charter fixed wing support for the support for the Walker Lake operations. Fairbanks Air Service, Kobuk Air Service, Ambler Air Service, and Maxon Air Service were also used on charter for some of the logistical support of the project.

GENERAL GEOLOGY

The geology of this part of the Brooks Range consists of a series of structural and stratigraphic belts trending roughly northwest-southeast. The southernmost belt, along the south flank of the range is a sequence of metasediments and metavolcanic rocks and is of economic importance because it contains large deposits of copper, lead, zinc, and silver. These rocks have undergone regional metamorphism, and generally can be categorized as belonging in the greenschist facies. The major rock types are quartz-mica schist and chloritic schist. Other less abundant but more varied types of metamorphic rocks in this belt include greenstones, glaucophane-bearing schists, and porphyroblastic schists. There are also a few thin interlayers of carbonate rocks, including marbles and dolomites. The sequence is intruded by a few thin tabulate bodies of granite. Thermal metamorphism, apparently related to the granite intrusions, is evidenced by the occurrence of biotite-garnet hornfels zones.

North of the metamorphic belt, bedrock consists of a sequence of metaclastic rocks and massive carbonates. The carbonates are mostly marbles and are probably equivalent to the Skajit Limestone of Devonian age. However, no identifiable fossils have been found in these rocks, and their age is not firmly established. Massive carbonate rocks continue northward in a zone over 50 miles wide and fossil evidence[10] in several locations on the north side of the granite intrusives indicates that some of the carbonate rocks are equivalent to the Lisburne group of Mississippian age. Structure in most of the carbonate terrane is characterized by thrust faulting. The faulting is highly complex, and extreme imbrication is apparent in much of the area. The thrust-fault zones are marked by breccias and veining in many locations. Mineralization is common in some of the thrust fault zones. Superposed folding, including probable nappes, increases the complexity of the structural relations.

The northern carbonate and metaclastic sequence is intruded by a series of granite plutons in the central part of the range. Many of the plutons are porphyritic, with large phenocrysts of K-feldspar. Most of the smaller plutons, located in the western part of the area, are foliated, and the biotite is typically altered to chlorite. The interior parts of the large plutons, near Mt. Igikpak and the Arrigetch Peaks, are generally very coarse-grained and massive. The contact zones around the granite plutons are complex, and compositional variations are common. Migmatitic contact zones are typical, as are inclusions of country rock in the granite near the contact zones. Hornfelsed rocks in the contact zones are variable in character and composition,

R.E. Garland examines isoclinal folding in calc-schist unit, upper Kogoluktuk River area, Brooks Range

10 Unpublished data, U.S. Geol. Survey

and include biotite-garnet hornfels, gneissic rocks and skarns. The granite was apparently highly mobile during the intrusive phase, and multiple sill-like bodies of aplite are common locally around the borders of the plutons. The granites are apparently syntectonic in origin. Radiometric dating indicates Late Cretaceous ages of 99 m.y.[9] for the Shishakshinovik pluton and 90 m.y.[11] for the Mt. Igikpak pluton. However, the age determinations were made with biotite samples, which may have been "reset" by a Late Cretaceous thermal event. The granite intrusions apparently postdate the major thrust faulting.

ECONOMIC GEOLOGY

The area of the Brooks Range under study includes some of the most important mineral deposits in the state, and large parts of the area have an extremely high mineral-resource potential. Investigations of the mineralization have been directed at understanding the relationship of the mineralization to the regional geology. The geochemical sampling program has been successful in showing apparent trends and local areas of mineralization. The tabulation of this data should serve as a guide to both exploration and the mineral-resource potential of the area.

Much of this part of the Brooks Range is under consideration by the Federal government for possible withdrawal into land classifications that would restrict or prohibit mining. A knowledge of the mineral resources in this area will probably play an important role in the ultimate land-classification decision.

The major known deposits of minerals in this part of the Brooks Range are in the southernmost belt of metamorphic rocks. The ore deposits are massive sulphides, and are stratiform. The deposits have some of the characteristics of volcanogenic deposits, and are considered as such by some mining geologists. The evidence is not conclusive, and more work will be necessary to resolve the problem. Economic minerals include bornite, chalcopyrite, sphalerite, and galena. Petrographic studies of these rocks and assays of some of the rocks from the ore zones are now in process. The ore zones appear to be located in a particular association of rocks within the metamorphic belt. The mineralized rocks are generally not well exposed because leaching has been extensive. Gossans and stained zones are generally all that can be found at the surface. For this reason, the extent and grade of the ore zones are impossible to accurately determine without core drilling and other elaborate prospecting techniques. The geologic mapping indicates that the ore zones are probably up to several hundred feet thick in the major known prospects, and the lateral extent may be as much as several miles.

Numerous claims have been filed in this mineral belt by both Bear Creek Mining Company and Sunshine Mining Company. Proven reserves have been estimated at more than $2 billion,[12] and may be substantially greater.

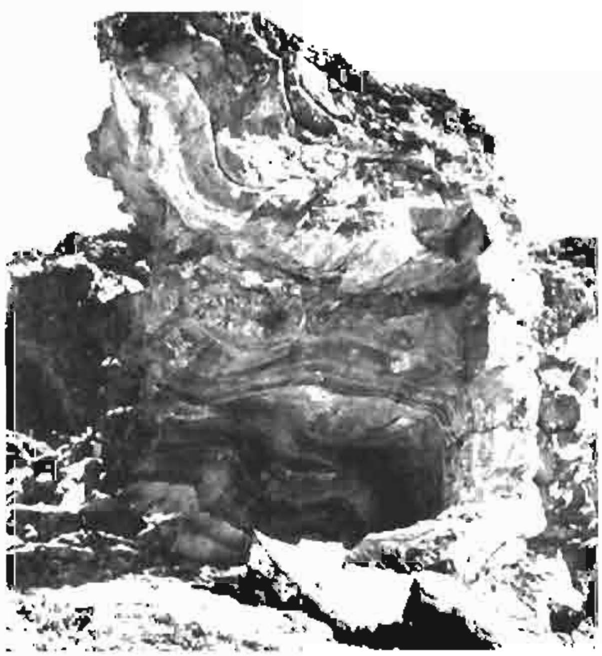
There is also mineralization in the central part of the range. Geochemical anomalies and mineral occurrences suggest the possibility of mineral deposits near the granitic rocks. The thrust-fault zones are also mineralized locally. Indications of mineralization include copper, lead, zinc, silver, tin, molybdenum, beryllium, gold, cobalt, chromium, uranium and fluorite. Serious prospecting using modern techniques has not been done in most of this part of the Brooks Range, and the true potential of the central part of the range is not really known. However, it may have a potential comparable to the metallogenic belt along the south flank of the range.

During the 1973 field season, geochemical sampling was conducted mainly in the central part of the Ambler River quadrangle. The sampling was done to extend the reconnaissance network of geochemical sampling to the limits of the geologic mapping. The geochemical anomalies and mineral occurrences are summarized in plate 1. The map also shows the trend of geochemical anomalies along the zone of known mineral deposits in the metallogenic belt in the southern part of the Brooks Range. Geochemical anomalies and mineral occurrences to the north appear to be clustered around the granitic intrusions.

9. Ibid.

11. Unpublished data, Alaska Div. Geol. and Geophys. Surveys.

12. Hawley, C.C., 1973, Mineral belts in Alaska, unpublished address to the Alaska Geological Society.



Deformation in orange-weathering carbonate unit, west of Mt. Igikpak, Brooks Range

SPECIAL PROJECTS

As a part of the Brooks Range Project, the DGGS participated in a study of the Ambler River by the Bureau of Outdoor Recreation of the U.S. Department of Interior to determine its suitability for inclusion into the Wild and Scenic Rivers System. A representative of the DGGS joined an exploratory trip down the river as part of the study. A number of rock samples and geochemical samples of stream sediments were collected to help determine the mineral-resource potential of the Ambler River drainage. This data and pertinent data from previous geologic mapping and geochemical sampling were compiled in a report for the Bureau of Outdoor Recreation.[13]

CRYSTALLOGRAPHIC STUDIES

Crystallographic studies of feldspars from various rocks of interest to the collaborative DGGS-USGS project in the Brooks Range were carried out by T.C. Mowatt and N.C. Veach. Preliminary results indicate that detailed characterization of the feldspar phases would be useful in various aspects of the Brooks Range work, particularly with respect to stratigraphy, petrology, and mineralogy, and ore genesis and localization. Efforts to date have been concentrated on the plutonic belt. Further work will be done on rocks from other geologic settings within the region.

LIVENGOOD MINING DISTRICT

The Livengood district is located about 60 airline miles or 83 miles by the Elliott Highway northwest of Fairbanks. Field work done during the summer of 1973 by G.R. Eakins, assisted by W.S. Roberts, covered the approximate area of figures 4 and 5.

A total of 150 stream-sediment and soil samples and 500 rock samples were collected to aid in interpreting the general geology and mineral occurrences. The samples were analyzed for copper, lead and zinc by W.W. McClintock of the DGGS. Some samples were analyzed for silver and gold. Sample locations and anomalous sites are indicated on figures 4 and 5. A tabulation of analytical data for these samples is now available as Open File Report AOF-42.

Bulldozer cuts and roads on the ridge south of Livengood Creek were mapped on a scale of 1 inch to 50 feet. Numerous gravity and radioactivity measurements were taken in the vicinity of Livengood as an aid in mapping the structure and intrusives, particularly in covered areas. Commonly, gold recovered in the placer operations has differing characteristics from stream to stream. T.C. Trible of the DGGS laboratory is developing a method for measuring trace elements within the gold in an attempt to determine the source of the various placer deposits (p. 37). Future work on the samples will include emission spectrographic analysis, thin-section examination, and K-Ar age dating of selected intrusive rocks.

The Livengood mining district is in the northwest portion of the Yukon-Tanana upland, a region of highly deformed metamorphic rocks of Precambrian, Paleozoic, and Mesozoic age. Structural trends are generally northeast-trending, although some units have been overturned and overthrust to the north. Metamorphism ranges from greenschist to amphibolite facies. Numerous dikes and plutons intrude the metamorphic country rock. Physiographically, it is a region of low rounded ridges and occasional broad valleys. Only the few mountains above 4000 feet have been glaciated.

The district lies within a narrow belt, designated the Livengood trend,[14] that includes alpine-type ultramafic rocks and serpentinite. It extends about 120 miles northeast from Manley Hot Springs. It may be significant as well that the mineral deposits at Livengood are situated on the axis of the postulated Alaska orocline[15] and within an area of major faulting near the junction of the Kaltag fault and the Tintina Trench, located north of Livengood. The ridge between Livengood Creek and the Tolovana River is believed to be the source for nearly all of the gold in the district and is geologically the most complex part of the terrane.

Gold was discovered on Livengood Creek near the mouth of Ruth Creek in 1914 by Jay Livengood and Nathaniel R. Hudson. A stampede immediately followed. It was soon evident that the main pay streak was on a buried bench along the northern side of Livengood Creek and the creek placers were relatively small deposits. About 380,000 ounces of placer gold is estimated to have been produced. Most of the town is now in ruins, but small-scale sluicing operations are still conducted intermittently.

Nevertheless, current mining and other activity indicate that Livengood may soon enjoy a substantial comeback. Standard Mines, Ltd., of Ontario, Canada, plans to spend over $4 million during the next 4 years to develop a placer operation on a 2,000-acre tract on the bench along Livengood Creek. The firm hopes to have two dredges operating. A copper-molybdenum prospect discovered in 1972 by Earth Resources, south of the confluence of Livengood Creek and the Tolovana River near Shorty Creek has been drilled at several locations. Both the Alyeska pipeline road and the proposed pipeline route will pass near Livengood, and extensive improvements are scheduled for the Elliott Highway. A 1,000-man construction camp is to be erected just west of Livengood. When pipeline construction begins, the Elliott Highway will be one of the busiest roads in the state.

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13. Pessel, G.H. and Garland, R.E., 1973, Preliminary geologic and mineral evaluation of the Ambler River drainage, Alaska: Alaska Div. Geol. and Geophys. Surveys open-file rept. 27.

14. Foster, Robert L., 1967, Tectonic inclusions from serpentinite, east-central Alaska: U.S. Geol. Survey Prof. Paper 575-D, p. D120-122

15. Lathram, Ernest H., 1972 Nimbus IV view of the major structural features of Alaska: Science, March 1972, vol. 175, no. 4029, fig. 3, p. 1425-1426

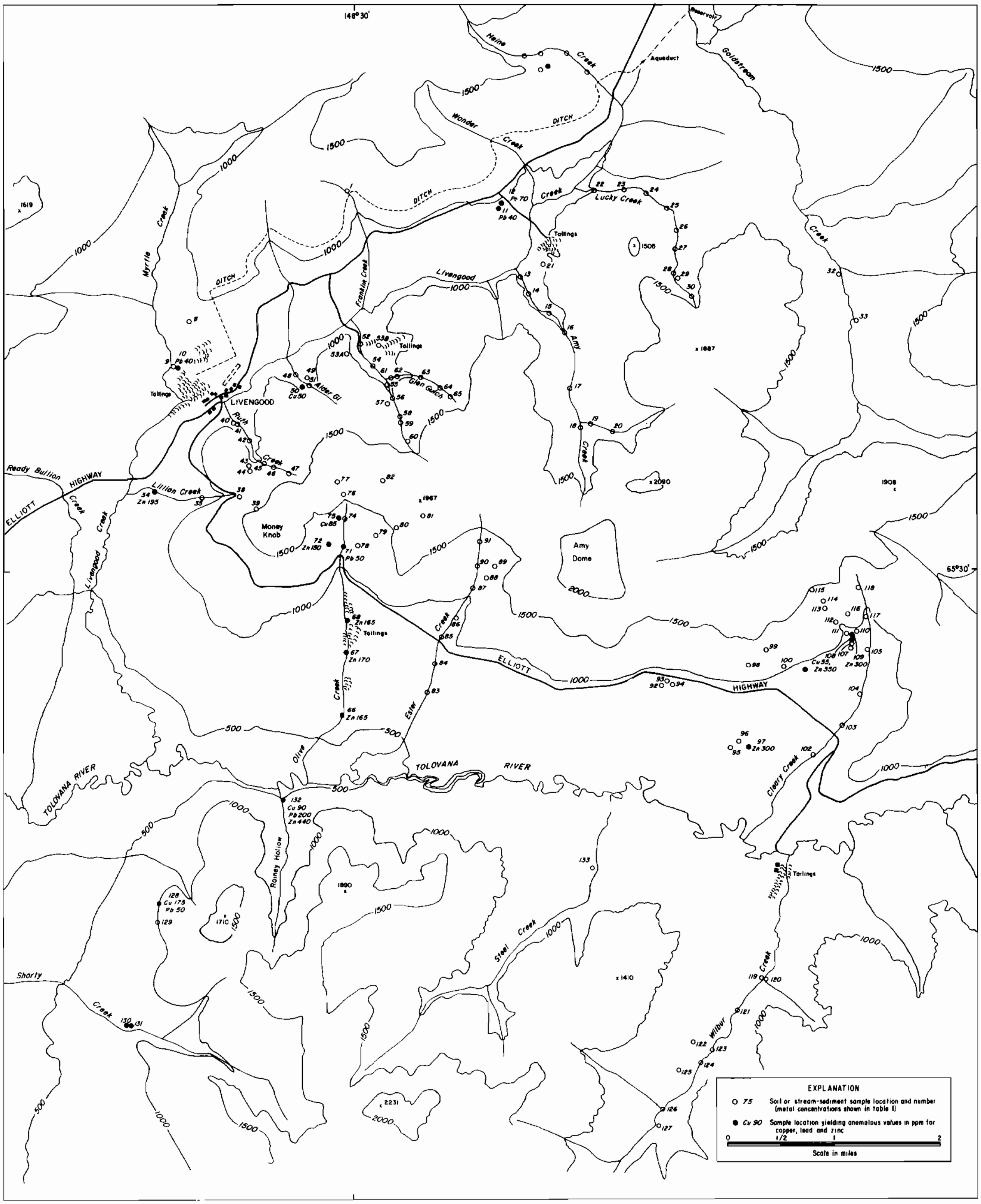


Figure 4. Soil and stream-sediment samples, Livengood area

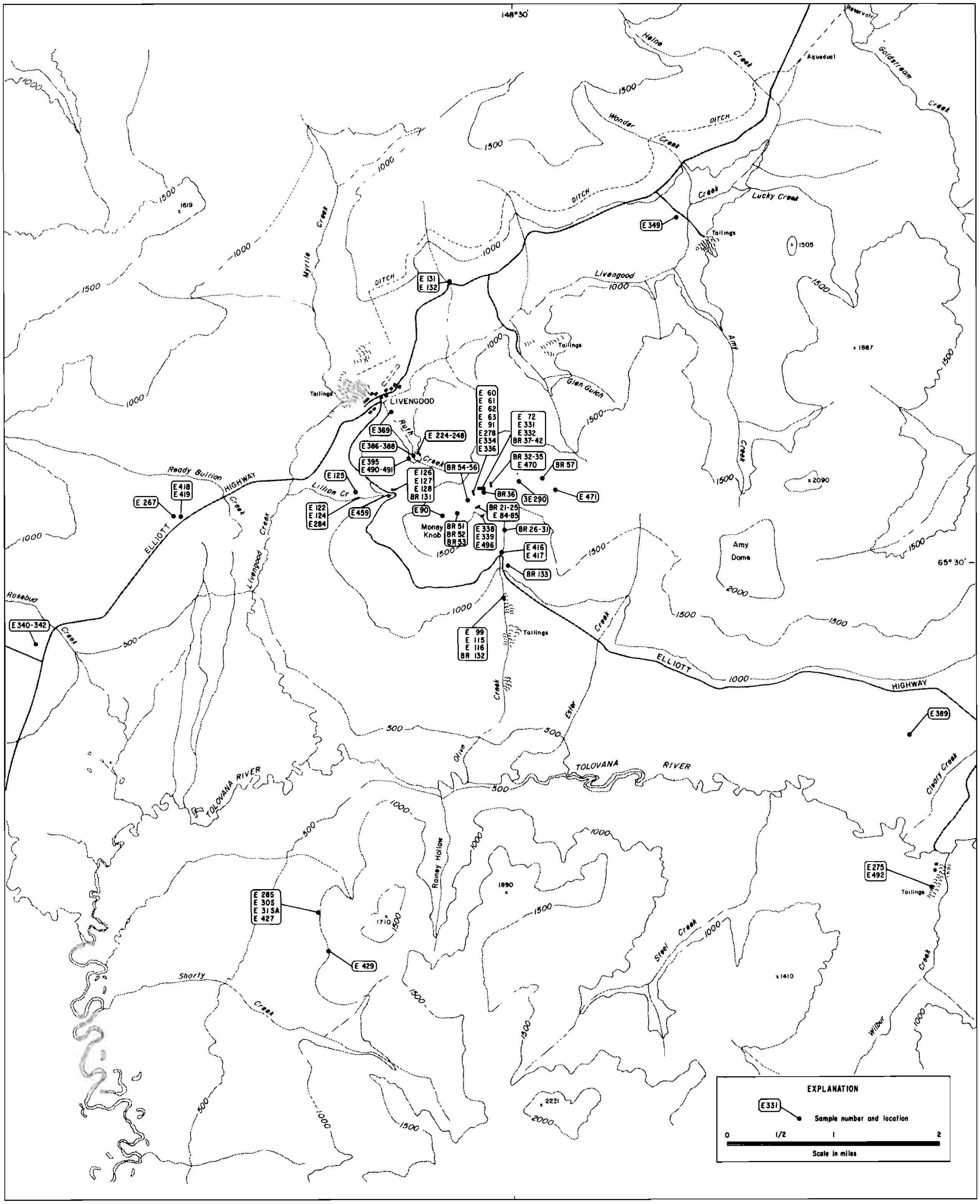


FIGURE 5. Channel and grab-sample locations, Livengood area

The growth of the Livengood mining district has depended entirely on placer gold, but the variety of minerals that have been found within the area in minor or trace amounts is striking. Elements that have been found in amounts sufficient to have caused significant expenditures of time and money include mercury, antimony, nickel, and copper. In addition, high concentrations of chromium, arsenic, silver, boron, bismuth, cobalt, lead, zinc, tin, tungsten, uranium(?), platinum, and palladium have been reported.[16-23] Despite this knowledge, there has been almost no exploration for lode deposits deeper than the shallow cuts made by bulldozers, and much remains to be learned about the district.

Most of the lode prospects and anomalies are centered around the intermediate intrusives on the western part of the ridge south of Livengood, especially in the Ruth, Lillian, and Olive Creek drainages. Scattered mineralization has been detected both east and west of this locality. The source of the gold is scattered quartz veinlets, dikes, and possibly silica-carbonate rocks. Mercury occurs in decomposed monzonitic dikes and stocks. Nickel, chromium, and traces of platinum and palladium are associated with the serpentinite.

The minerals and their relations to the intrusives suggest that mineralization occurred at shallow depths and late in the geologic history of the area. Further study of the minerals, their origins, and ages is planned to aid in interpreting the economic geology and possibly to guide future exploration. High values of copper, lead, and zinc, in some samples collected by the DGGS suggests certain areas may warrant exploratory work. These include Cleary Creek, the fault zone near the beginning of the trans-Alaska pipeline road, the area south of the Tolovana River between Rainey Hollow and Shorty Creek, and a trench on upper Olive Creek.

ALASKA PENINSULA PROJECT

A project to evaluate the energy and mineral potential of the Alaska Peninsula was begun in 1973 by W.M. Lyle, party chief, and P.L. Dobey.

16 Chapman, Robert M., and Weber, Florence R., 1972, Geochemical analyses of bedrock and stream-sediment samples from the Livengood quadrangle, Alaska: U.S. Geol Survey open-file report.

17 Foster Robert L 1968a, Potential for lode deposits in the Livengood gold placer district, east-central Alaska: U.S. Geol Survey Circ. 590.

18. ——— 1968b, Descriptions of the Ruth Creek, Lillian Creek, Griffin, Old Smokey Sunshine No. 2 and Olive Creek lode prospects, Livengood district, Alaska U.S. Geol Survey open-file report

19. ———, 1969, Nickeliferous serpentinite near Beaver Creek, east-central Alaska, *in* Some shorter mineral investigations in Alaska: U S Geol Survey Circ 615, p. 2-4

20. Joesting, Henry R., 1942, Strategic mineral occurrences in Interior Alaska: Territory of Alaska, Dept. of Mines Pamphlet no 1.

21. Saunders, Robert H 1954, Report on the examination of the Daniell prospect, Ruth Creek, Livengood quadrangle, Alaska: Alaska Territorial Dept. of Mines property examination 49-12.

22. ——— 1955, Report on the Griffin nickel prospect, Livengood quadrangle: Alaska Territorial Dept. of Mines property examination 49-13.

23 ——— 1967 Mineral occurrences in the Yukon-Tanana region, Alaska: Alaska Division of Mines and Minerals, p. 18-19

The geological and geochemical exploration party established its first camp at Mine Harbor in Herendeen Bay on June 11 and completed the summer's work 6 weeks later at Aniakchak Bay (fig. 6).

Approximately 10 days were spent at each of four project areas: Herendeen Bay, Bear Lake, Black Lake–Warner Bay, and the Aniakchak region. A 12-foot rubber raft was used for transportation (and was subsequently damaged on the Aniakchak River trip). Camp moves were by amphibious aircraft. Some helicopter support was given by USGS party chief T.P. Miller at Bear Lake, and a Cessna-180 float plane was used for reconnaissance at Warner Bay.

The results of the Aniakchak River study were released as DGGS Open File Report AOF-26, July 1973. Exploration results from the field projects at Herendeen Bay, Bear Lake, and Black Lake–Warner Bay areas will be available as an open-file report in 1974.

HERENDEEN BAY

Key Jurassic and Cretaceous outcrops were sampled in 100-foot increments at many locations around the bay. The Jurassic Naknek Formation is a hard, dense, tight sandstone and siltstone unit. The Jurassic-Cretaceous Staniukovich Formation is dense, tight, petroliferous sandstone about 600 feet thick, with local pods (200-300 feet thick) of boulder and pebble conglomerate in this area. This formation is predominantly a marine unit and is commonly fossiliferous.

The Cretaceous Chignik Formation crops out at many locations in the area, but a complete section of the formation was not found. The Chignik Formation is a nonmarine coal-bearing sandstone and claystone that is locally conglomeratic. One outcrop had a total of 20 feet of bright coal, with the thickest seam measuring 9 feet.

A Tertiary sandstone, claystone, and coaly unit was sampled on the west side of Herendeen Bay. The unit is soft and friable and is similar to the nonmarine Kenai Formation of the Cook Inlet. Sands within this unit are potential petroleum reservoirs in the subsurface, especially if a marginal marine facies exists. Geochemical samples were collected from streams throughout the area.

BEAR LAKE

D.L. Johnson's hunting camp on Bear Lake was used for the base of exploration on this part of the project. The USGS geothermal field party helicopter transported the DGGS geologists to areas near Bear Lake where the Miocene Bear Lake Formation could be studied. Over 3,000 feet of the Bear Lake Formation was measured, and samples were taken at 100-foot intervals. This section is an alternating sequence of sandstones and claystones, locally coaly and conglomeratic. Fossils were

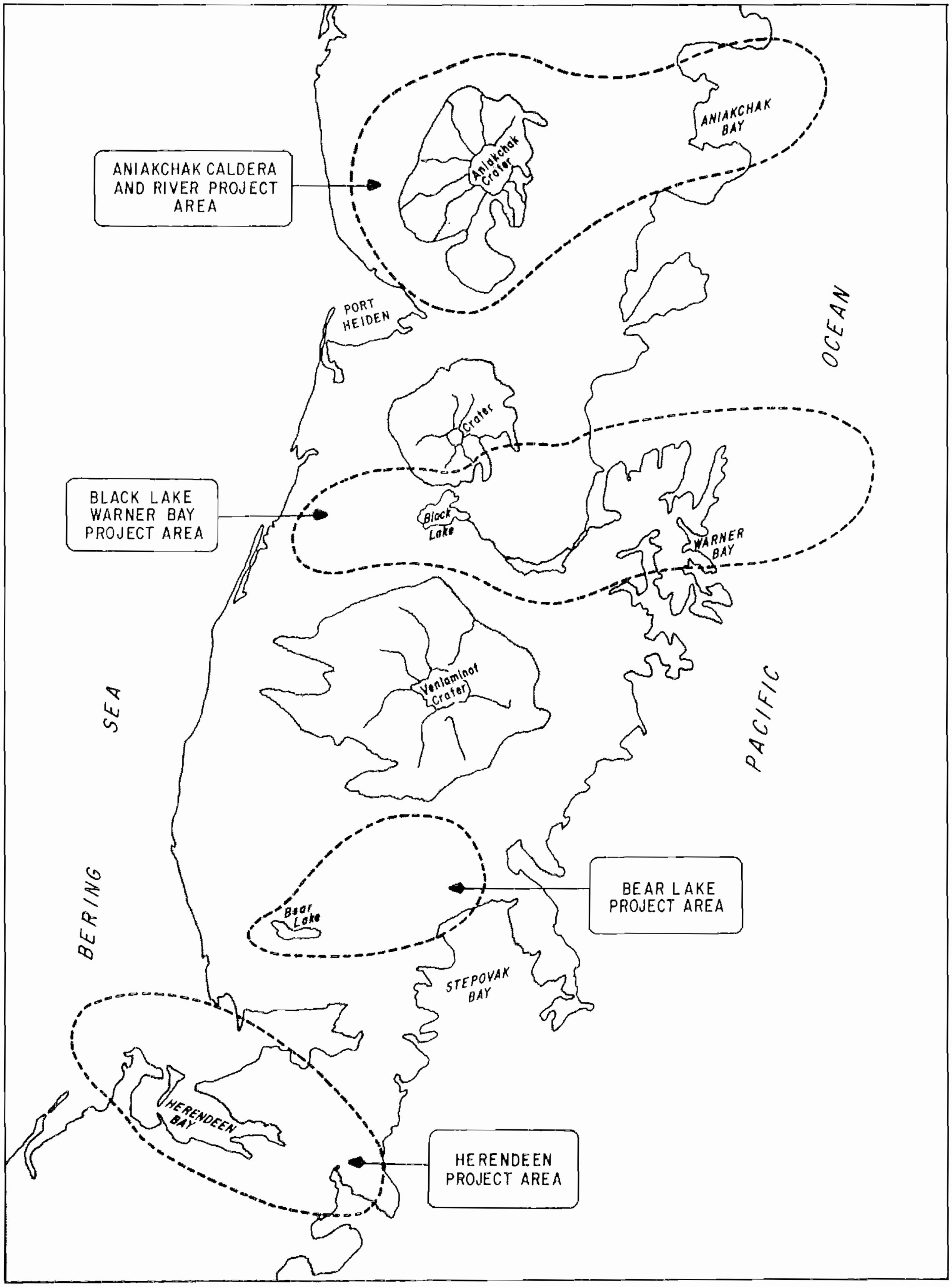


FIGURE 6 Location of 1973 Alaska Peninsula field projects

sampled for age determinations and identification. Geochemical samples were also taken from stream sediments.

BLACK LAKE—WARNER BAY

Geologic reconnaissance and geochemical sampling were done in the drainages to Black Lake, Chignik Lake, and Warner Bay. High winds and storms slowed exploration in this area, and planned objectives were not accomplished.

ANIAKCHAK CALDERA AND RIVER

On July 11, camp was moved by amphibious aircraft from Black Lake to Surprise Lake, inside the Aniakchak volcano caldera, and the two DGGS geologists became members of the Wild and Scenic River field inspection team. The purpose of the inspection was to determine the suitability of the caldera and river for classification under the Wild and Scenic River system. Scenic, recreational, biological, and mineral studies were conducted during the trip by members of the team. A professional photographer representing the John Muir Society attempted to film the trip but was seriously handicapped by the immersion of his cameras in water, loss of film, and the development of pneumonia by his assistant.[24]

P.L. Dobey & W.M. Lyle preparing to leave Aniakchak crater

Equipment consisted of four 12-foot rubber rafts, paddles, and tents. Two days were spent in the caldera making a geologic reconnaissance, and the running of the river by raft began on July 13. Paddles were broken and rafts were holed during the trip (one raft flooded and escaped, but was later caught downstream). Three more days were needed to reach the mouth of the river. Daily progress averaged 5 miles.

Rocks sampled in the caldera and along the river were volcanic rocks and sandstones, conglomerates, and mudstones of Jurassic and Tertiary age. Geochemical sampling was conducted in the caldera and along the Aniakchak River. Forty-one samples were taken at approximate 1-mile intervals and at stream intersections. Of these, three were lost when a raft overturned.

The petroleum and mineral potential of the Aniakchak caldera and River appears limited on the basis of the field inspection. However, the unique character of the river (which originates in a volcanic caldera), the beauty of its valley and surroundings, and the excitement and danger of traversing it by raft combine to form a waterway that is truly a "wild and scenic river."

PRELIMINARY GEOLOGY OF THE KINGS-KASHWITNA RIVERS AREA

Field work in the Talkeetna Mountains during 1973 was part of a continuing program of geologic mapping and geochemical sampling between the headwaters of the Kashwitna River and Kings River, Anchorage D-5 and D-6 quadrangles (fig. 7). The project was initiated by D.L. McGee in 1972 and resumed on July 26, 1973 by McGee and M.W. Henning. P.L. Dobey worked with the field party for 1 week in August. The field assistant was K. Krause. The project during 1973 was conducted from tent camps. Camp moves were made with an FH-1100 helicopter under contract from Anchorage Helicopters.

GENERAL GEOLOGY

The plutonic rocks mapped in the Talkeetna Mountains in 1973 consist of four basic magmatic units. The predominant rock type west of Granite Creek and the headwaters of the Kashwitna River is a medium-grained, light-gray quartz diorite. Aplite and pegmatite dikes are common, and generally parallel the most prevalent joint system, striking about S40°E. Gneissic texture is well developed along the Kashwitna River, mostly in the finer-grained quartz diorite.

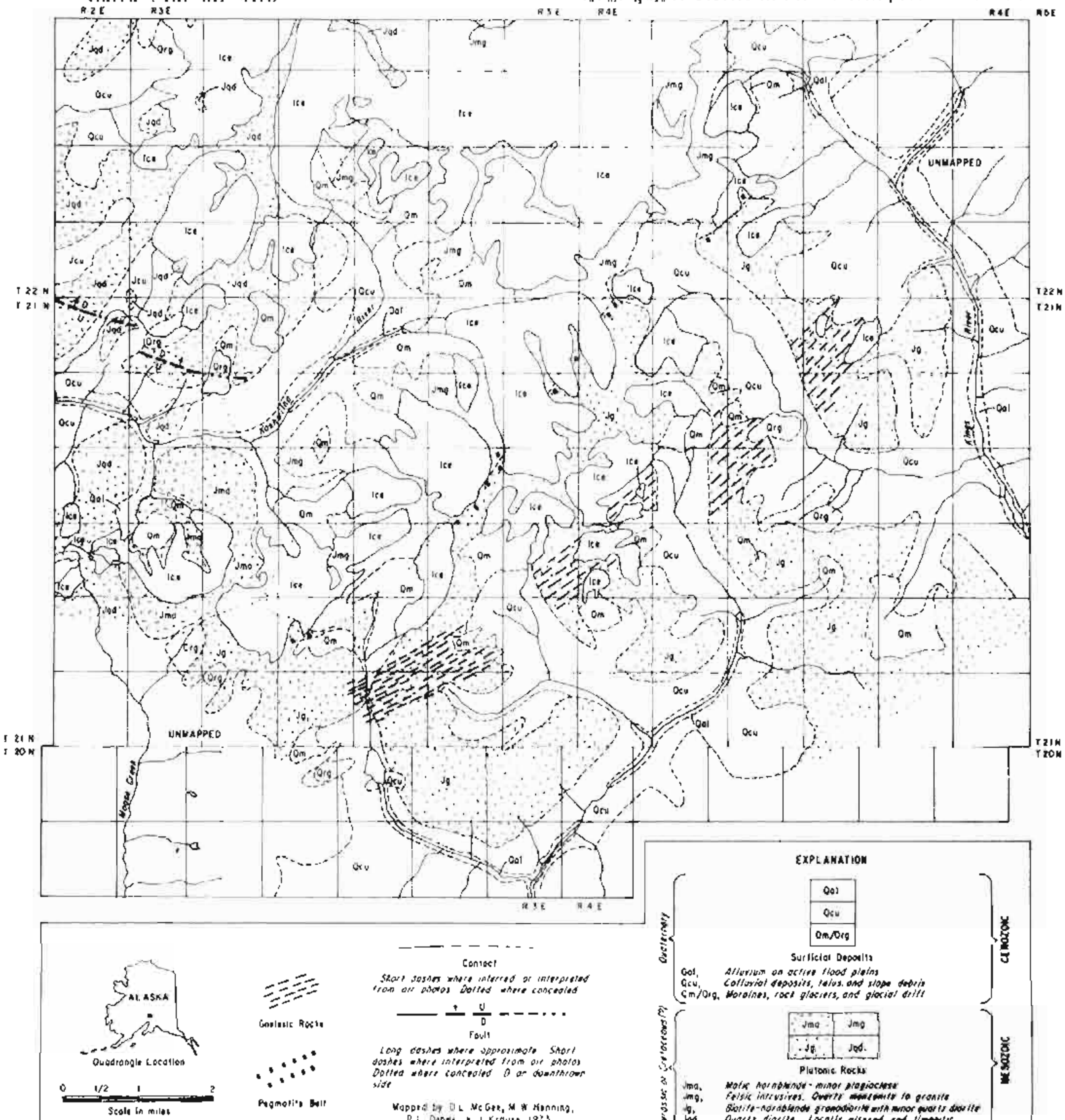
North of the headwaters of Moose Creek, an area of approximately 6 square miles is underlain by rocks composed predominantly of hornblende with some plagioclase feldspar. The high magnetic anomaly associated with this rock is due to a magnetite content of about 5 percent.

There is a northeast-trending belt of felsic rocks between the headwaters of the Kashwitna River and the west fork of Kings River. This belt extends northeast from the headwaters of the west fork of Granite Creek for an unknown distance. Rocks within this belt range in composition from quartz

24 Sincere appreciation is expressed to Shell Oil Company and its geologic party chief, William Folsko. The Shell helicopter, after being signaled by emergency flares on the morning of July 20, off-loaded its geologic party and flew [illegible] ill assistant photographer to Naknek for medical treatment.

monzonite to granite, and locally may be classified as alaskite. These rocks contain minor mafic minerals and very small amounts of magnetite, as reflected in the low magnetic anomaly associated with the belt.

East of the central quartz monzonite-granite belt, the predominant rock type is granodiorite. Magnetic susceptibilities of the granodiorite are relatively high and similar to the values obtained from quartz diorite in the western part of the area.



ECONOMIC GEOLOGY

Sparse mineralization, predominantly in the form of chalcopyrite and pyrite, occurs in thin quartz veins associated almost entirely with the quartz diorites and granodiorites. Hornblende-rich float containing disseminated chalcopyrite was found on the flood plain of the Kashwitna River, and appears to come from the mafic body at the head of Moose Creek. A belt of simple pegmatites, predominantly plagioclase feldspar, potash feldspar, quartz, and muscovite mica, intrudes the granite-granodiorite contact zone. The exposed pegmatites are barren of mineralization.

A geologic map is being prepared at a scale of 1 inch to 1 mile. This map, the results of the geochemical sampling program, and a brief summary of the susceptibility studies will be released as a DGGS open-file report.

AEROMAGNETIC FIELD PROJECT

For the past 3 years, the DGGS has conducted aeromagnetic surveys in various areas of the state (fig. 8). The purpose of this program is to encourage additional planned development of Alaska's natural resources and to add to the basic geologic knowledge of the state.

The 1973 program extended the coverage flown in 1972 to include all of the Big Delta and Fairbanks 1:250,000 quadrangles. Also flown were the areas not completed in 1972 in the Mt. Hayes and Healy quadrangles.

The 1973 contract was awarded to Lockwood, Kessler, and Bartlett (LKB), who has been low bidder for 3 consecutive years. The survey covered 15,317 square miles and consisted of flying 20,402 line miles of continuously recorded magnetic data. LKB's bid totaled $92,287, or $6.02 per square mile and $4.52 per line mile.

The survey was flown using a Cessna-310 and a Cessna-206 (fig. 9). Flight lines were spaced 3/4 mile apart with tie lines approximately every 15 miles. The lines were flown at an altitude of 1,000 feet above ground level. Magnetic data was collected with a fluxgate magnetometer towed behind the plane and was continuously recorded in the aircraft. Altitude and position were also monitored throughout the survey. Further technical details may be obtained by contacting the DGGS Anchorage office.

The final magnetic contours are printed in red over USGS topographic quadrangle maps (1 inch to 1 mile) at a contour interval of 10 gammas. An example of the output is shown in figure 10. In addition to the maps, the contractor furnished the DGGS with digital magnetic tapes of the survey data. The data is digitized by gridding the hand-contoured 1-inch to 1-mile maps on 3/8-mile centers. Interpolated magnetic intensities at each center are then key-punched and recorded on magnetic tape.

Maps completed on the 1973 aeromagnetic survey program were:

Big Delta quadrangle	A-1 thru A-6 B-1 thru B-6 C-1 thru C-6 D-1 thru D-6
Fairbanks quadrangle	A-5, A-6 B-1 thru B-6 C-1 thru C-6 D-1 thru D-6
Healy quadrangle	B-1 C-1, C-2
Mt. Hayes quadrangle	A-1, A-2 B-1 thru B-6 C-5, C-6 D-1 thru D-6

The 1-inch to 1-mile maps from the 1971, 1972, and 1973 surveys are available to the public at $1.05 per sheet. Orders or inquiries may be addressed to the DGGS Fairbanks office (address on p. 5).

Figure 9. LKB's Cessna 206 used in aeromagnetic-survey program.

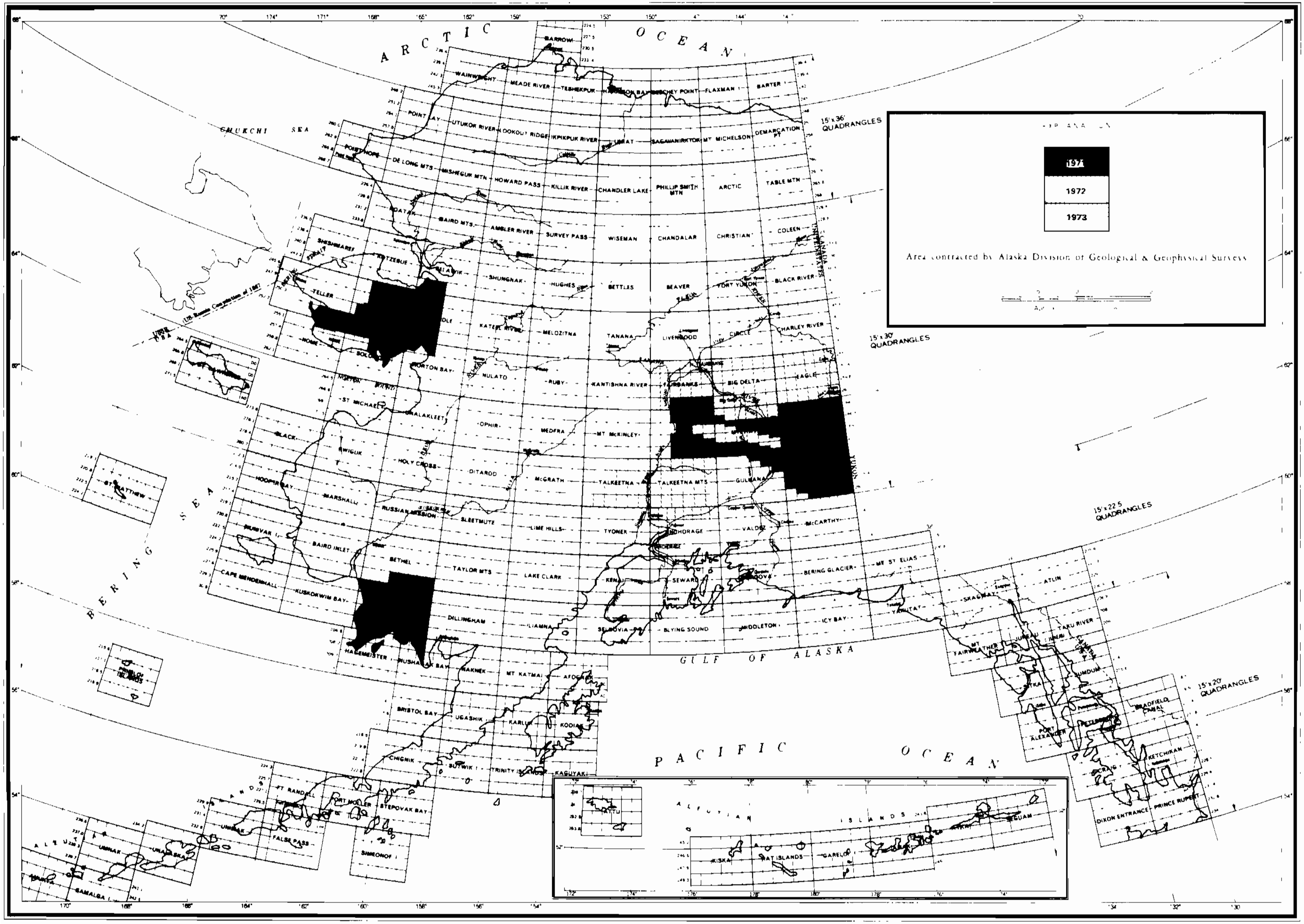


FIGURE 8. Aeromagnetic-survey areas flown by State of Alaska

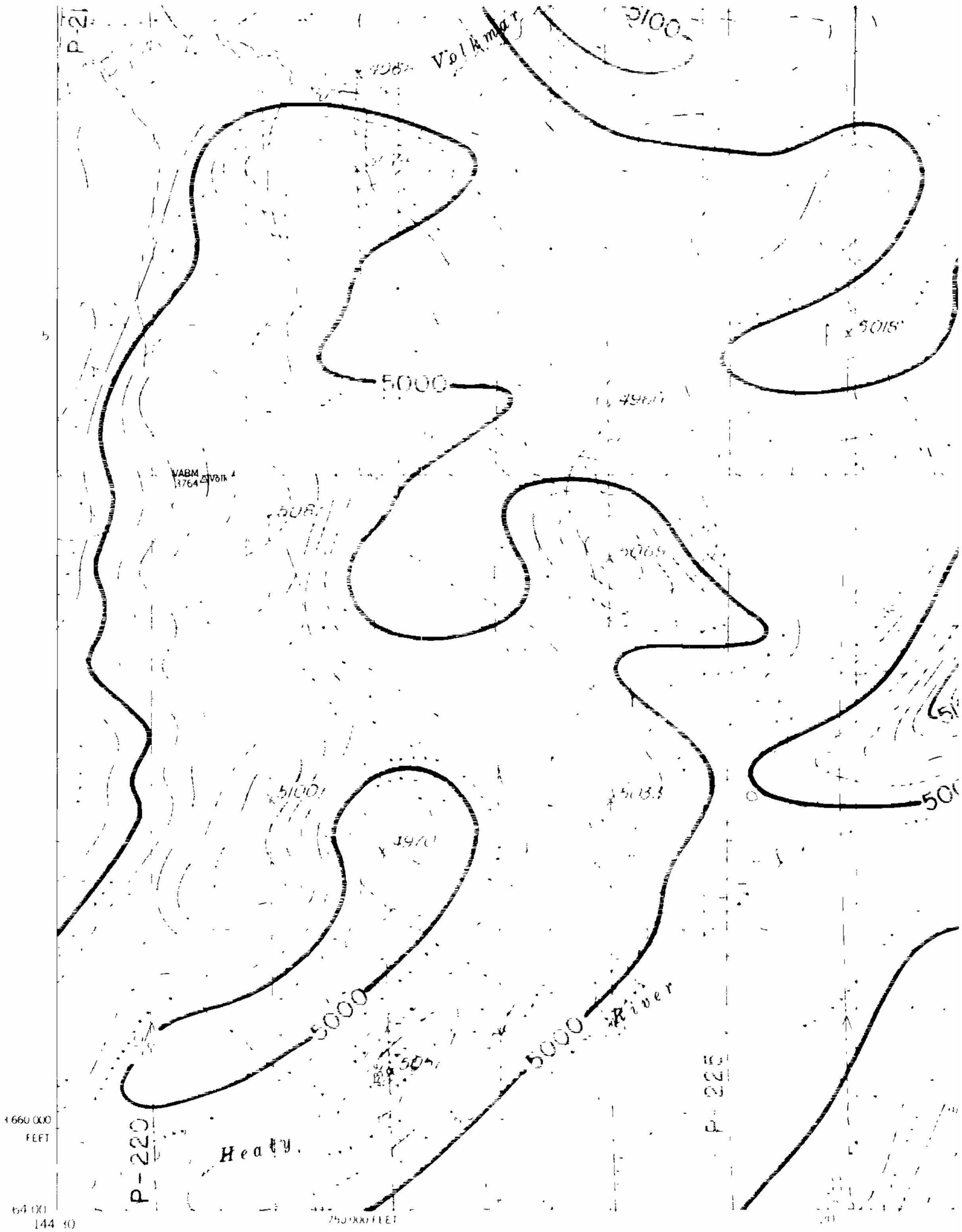


FIGURE 10 Example of final output, aeromagnetic map

NEWLY DISCOVERED TERTIARY SEDIMENTARY BASIN NEAR DENALI

A previously unreported occurrence of Tertiary sedimentary rocks was mapped by T.E. Smith while conducting geological mapping in the Talkeetna Mountains D-3 quadrangle. (See circled locality A of figure 3.) These nonmarine sediments occupy a topographic depression over an area of 3 to 4 square miles, about 30 miles southwest of Susitna Lodge, near the Denali Highway. The rocks are exposed in at least six separate localities, along the course of Watana Creek, 3 to 7 miles northeast of its confluence with the Susitna River. The outcrop sections were examined, measured, and sampled by W.M. Lyle.

The total section exposed is more than 480 feet thick, and is composed mainly of conglomerate, sandstone, and claystone, with subordinate amounts of burned clay and a few coal beds. The exposures have dips that range from nearly flat to about 35 degrees. The thickest continuous measured section had southerly dips to 15 to 17 degrees. Although the variable dips and dip direction may indicate faulting, no faults were apparent in the measured sequences. A few feet of less indurated rocks, probably Pleistocene in age, unconformably overlie these rocks in two exposures. The Tertiary beds range in thickness from a few inches to about 30 feet. The conglomerates and sandstones are lenticular and discontinuous, and

W. M. Lyle examining newly discovered Tertiary sediments in Watana Creek drainage

are gray to gray-green, whereas the claystones and siltstones are more continuous and even-bedded, and light gray to dark gray. The coal beds are thin, with seams ranging from 3 inches to 4 feet. The coals are brown and black, woody, and have little potential commercial value. The rocks appear to be dominantly stream-channel deposits with minor flood-plain and swamp deposits. A small collection of fossil leaves and wood was gathered from one locality and will be submitted to the USGS for identification. The exposures resemble the early Tertiary Chickaloon Formation of the Matanuska Valley.

FAIRBANKS DISTRICT STUDIES

Petrologic-geochemical studies in the Fairbanks district by T.C. Mowatt were continued, and an area of possible interest with respect to molybdenum mineralization was recognized. This occurrence is the first of its kind to be noted in this district, and is one of substantial magnitude. A report is in preparation.

GEOLOGICAL AND GEOPHYSICAL ASSISTANCE PROJECTS

LEGISLATIVE

SPECULATIVE PETROLEUM RESERVE ESTIMATES OF ALASKA

In response to a query by Senator Ted Stevens' office in April, the geologists of the Anchorage office conducted a study resulting in the calculating of speculative petroleum reserves for the continental shelf surrounding Alaska. This data was transmitted through Commissioner Herbert's office to Washington for use by Senator Stevens. The study has been expanded to include some of the land areas of Alaska, and will continue to be expanded and updated as more data becomes available.

HOUSE BILL 2295 - DINGELL BILL

A map was compiled by W.M. Lyle at the request of Commissioner Herbert for Senator Stevens showing the area that would be withdrawn by House Bill 2295 (Dingell Bill.) This bill was defeated, but had it passed, it would have removed from exploration nearly all the known onshore potentially oil-rich basins except Cook Inlet. Most of the offshore Gulf of Alaska would also have been removed from exploration.

EVALUATION OF D-2 LAND

An interpretation of the DGGS aeromagnetic data and available geochemical information indicated zones within the D-2 land withdrawal areas that appear prospective for the occurrence of metallic mineral deposits. There is a high density of aeromagnetic and geochemical anomalies in these zones, and it was recommended that these areas not be considered for inclusion in one of the four systems. This report is available as DGGS Open File Report AOF-21.

GEOLOGIC STUDY, NUNIVAK WILDLIFE REFUGE

A geologic and mineral evaluation of the Nunivak National Wildlife Refuge was undertaken in 1973 by P.L. Dobey. The refuge has been proposed for wilderness status. The study, released as DGGS Open File Report AOF-20, indicated on the basis of existing information that the wildlife refuge has a low mineral and energy potential. However, the absence of needed amounts of basic geological data was also noted, and additional geologic and geophysical investigations were recommended before the area be considered for inclusion in the National Wilderness System.

CRITICAL-HABITAT REVIEW, ARCTIC NORTH SLOPE

A critical-habitat proposal from the Department of Fish and Game was reviewed in March with respect to energy and mineral potential. The proposed critical-habitat units are in the offshore vicinity of Prudhoe Bay. Based on the analysis of existing data, four of the areas have very high potential for possible oil and gas production. It was recommended that in these four units, classification as critical habitats should include continuances for leasing and development of petroleum resources. This review was conducted by P.L. Dobey of the DGGS and T.R. Marshall of the Division of Oil and Gas.

FUELS REPORT

A request was received on June 14 from Senator Stevens for comments on a national fuel policy. This request was answered by D.L. McGee and P.L. Dobey, who emphasized that a critical fuel shortage would develop and that encouragement through tax relief should be given to the exploration of oil shale and coal. It was also suggested that price controls for petroleum products be relaxed to encourage the development of other energy sources.

LAND USE PLANNING COMMISSION

The joint Federal-State Land Use Planning Commission for Alaska was created by Act of Congress in the Alaska Native Claims Settlement Act of December 18, 1971 and by Act of the State Legislature of the State of Alaska, July 6, 1972. A Resource Planning Team was formed originally under the sponsorship of the Bureau of Land Management and the State of Alaska for a resource inventory of the lands of Alaska north of the Porcupine, Yukon, and Kuskokwim Rivers. On the formation of the Federal-State Land Use Planning Commission, this group became the Resource Planning Team of the Commission and its role was expanded to cover the entire State. D.L. McGee, on loan from the DGGS to the Resource Planning Team from January through June 1973, had the primary responsibility of compiling all data on known leasable minerals for the State.

DGGS reviewed the recommendations by the Federal-State Land Use Planning Commission of Alaska on October 5. Recommendations for each D-2 area were made separately. Findings and recommendations were either concurred with or were documented by statements explaining the reasons why the State could not agree. In some cases, new data were available from field work that had been completed after the resource studies were completed. It is the State's belief that resource development can proceed under orderly controls without permanently harming the environment.

The DGGS staff also prepared oil and gas resource inventory reports on all of the known onshore and offshore basins in Alaska for the joint commission. These subregions included Norton Sound, Kotzebue Sound, Lower Yukon, Upper Yukon, Central Yukon, Koyukuk, Tanana, Upper Yukon--Canada, Kuskokwim Bay, Bristol Bay, Aleutian Kodiak--Shelikof, Cook Inlet, Gulf of Alaska, and the Southeast.

The evaluation included a geological description of the basins within the subregion, prospects within the basins, production and related statistics, exploration activity, actual and potential reserves, market trends, and future development.

BUREAU OF OUTDOOR RECREATION

GEOLOGIC EVALUATION OF WILD AND SCENIC RIVERS

The Wild and Scenic River (WSR) teams began a study of 31 priority Alaskan rivers in 1972. The river teams were made up of a leader and from three to seven men from interested agencies. After the field study, the team leader wrote a field report describing the river's suitability for inclusion into the national system of Wild and Scenic Rivers and outlining, as far as known, the resources involved (including foreseeable potential uses of land and water that would be enhanced or curtailed if the area were included).

Once a river is declared a Wild and Scenic River, any activity must be conducted in accord with the provision of the WSR Act. The Secretary of the

Interior is responsible for providing safeguards against pollution or impairment of the scenery.

The field reports were reviewed and evaluated by DGGS personnel. The resultant review was especially directed toward a realistic appraisal of the mineral and resource portions of the report. The following Wild and Scenic River reports were reviewed:

Alagnak River	Fortymile River
Alatna River	Ivishak River
Ambler River[25]	Killik River
American Creek	Nowitna River[25]
Andreafsky River	Porcupine River
Aniakchak River[25]	Salmon River
Bremner River[25]	Squirrel River
Charley River	Tinayguk River
Chitina River[25]	Unalakleet River

MISCELLANEOUS ASSISTANCE PROJECTS

LOWER COOK INLET CORE-HOLE PROJECT

The Lower Cook Inlet coring program, operated by Exploration Services for a group of 11 participating oil companies, was carried out during July, August, and September. The primary purpose of this program was to obtain cores in the ocean floor at locations specified by the participating companies and approved by both the USGS and the State. The ***M.V. Heron*** was used for drilling and coring and the ***La Ciencia*** was used as a standby and supply vessel. The results of this program, although confidential, may encourage additional oil exploration on or near State acreage in the Lower Cook Inlet. Geophysical data was examined on each proposed location by DGGS geologists to ensure safety.

DEPARTMENT OF HIGHWAYS GEOLOGICAL ASSISTANCE

The Department of Highways was provided with a metallic-minerals map of the Seward Peninsula for proposed planning of the Kobuk Highway. The DGGS also provided the Highway Department with a set of maps and reports covering the status of both Federal and State mineral supplies.

In Fairbanks, the Department of Highways requested information on the geology and mineral potential of three areas: Snowshoe Pass to Tolovana River on the Elliott Highway, Canyon Creek and Shaw Creek on the Richardson Highway, and the proposed Upper Chena River Park area. G.R. Eakins investigated the three vicinities.

On the Elliott Highway reconnaissance, no mineral deposits or prospects were found along the proposed reconstruction and Eakins suggested there be no changes made to the proposed route. He noted that the improved road would benefit mining and mineral exploration in the Livengood area (page 9), immediately north of the project end. Also, gravel pits for fill and roadbed construction were found to be easily accessible.

On the Richardson Highway mineral evaluation, geochemical stream-sediment sampling showed anomalous values of lead, copper, and zinc, indicating that further exploration is warranted. Some mineral exploration would probably continue, regardless of future Highway Department actions; also, small-scale mining operations remain a distinct possibility.

The proposed Upper Chena River Park lies within the Yukon-Tanana Upland. There is little information available on this district, and Eakins stated that both the well-known thoroughness of early prospectors and the ready accessibility of the area probably negates any significant near-surface mineral deposits. Sand, gravel, and granite may be the most important resources in the area.

PIPELINE TASK FORCE

W.M. Lyle and D.C. Hartman have been working with a task force composed of Bureau of Land Management; USGS; U.S. Office of Pipeline Safety; U.S. Coast Guard; State of Alaska Divisions of Oil and Gas, Geological and Geophysical Surveys, and Lands; and State of Alaska Departments of Highways and Fish and Game. This group is responsible for reviewing the pipeline plans and regulations and for making specific recommendations for improvements where applicable. The group is currently reviewing the south 180 miles of the pipeline and the right of way between Valdez and the Paxson area. This project will continue until the plans for the entire 789 miles of pipeline have been reviewed.

SEMINARS

D.L. McGee attended a Remote-Sensing Course on the use of ERTS imagery in Alaska, sponsored by the joint Federal-State Land Use Planning Commission for Alaska and the University of Alaska. The course, held January 15-16, 1973, emphasized the use of satellite photos in applications related to geology, vegetation, oceanography, and land resources. Notes from this course are on file in the DGGS Anchorage office. Other DGGS personnel attended selected lectures of the ERTS course.

A program was started in 1973 to train DGGS staff members in the use of various geophysical instruments. The purpose of the program is to develop a total-exploration concept, whereby field parties may use a wide range of field equipment to obtain comprehensive geological and geophysical interpretations. As a result of this program, DGGS personnel have initiated a number of projects, including gravity profiles in the Brooks Range, magnetic susceptibility measurements in the Talkeetna Mountains, and a proposed radiometric sampling program in the Yukon-Kandik Basin area.

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25. Reports in which DGGS personnel either were directly involved as members of the WSR team or wrote supporting reports

I. L. Tailleur, USGS, mapping near Ambler River with Super Cub support.

COOPERATIVE PROGRAMS

The DGGS and the USGS have three cooperative projects financed by State-Federal funds on a matching basis.

COOK INLET STRATIGRAPHIC STUDY

The objective of this project is a detailed study of the stratigraphy and petroleum potential of Cook Inlet basin to aid in the evaluation of unexplored lands and to stimulate exploration of the area. The study, under the direction of J.C. Maher, is in the third year of a probable 4 or 5-year effort.

Products of this project to date are:

1) Geological literature on the Cook Inlet basin and vicinity, Alaska, by J.C. Maher, and W M. Trollman, 1969.

2) Geological literature on the Gulf and southeastern coastal regions of Alaska, by J.C. Maher, 1971.

3) Correlation of subsurface Tertiary rocks, Cook Inlet, Alaska, by R.D. Carter and W.L. Adkison, July 1972, USGS open-file report.

4) Geological literature on the Alaska Peninsula and adjacent areas, by J.S. Kelley and J.M. Denman, July 1972.

During the 1973 field season, W.L. Adkison, J.S. Kelley, and E.R. Landis completed stratigraphic studies of the Tertiary outcrops on the southern part of the Kenai Peninsula from Clam Gulch to Fox River and commenced studies in the Tertiary beds near Capps Glacier, on the west side of Cook Inlet.

GRAVITY MAP OF ALASKA

The DGGS and the USGS will acquire all data necessary to complete a gravity map of Alaska at scales of 1:1,000,000 and 1:2,500,000. Some 25,000 gravity observations have already been made, and the essential field work was completed in 1973. Under the direction of D.F. Barnes of USGS, project leader, final map compilation is now in progress.

COMPOSITE GEOLOGY OF ALASKA

In 1972, a cooperative contract was made to produce a manuscript and maps for a proposed one-volume summary of the geology of Alaska.

For many years Alaskan geologists have desired a summary of the geologic knowledge of Alaska in a single source book. This information is now contained in hundreds of separate bulletins, books, periodicals, maps, and so forth, many of which are out of print. The advantage of having all this knowledge in one source with appropriate revised maps, all reflecting the latest geologic interpretations, is obvious.

The vast size and corresponding logistics in Alaska have made the acquisition of geologic data a slow and costly process. Prior to this time, a scarcity of geologic information in substantial portions of Alaska rendered such a project impractical. Increased exploration activity and the use of helicopters and sophisticated airborne techniques by Federal, State, and industry geologists have resulted in the addition of a large body of geological knowledge of Alaska. With the belief that this is the most opportune time for this undertaking, the DGGS and the USGS Branch of Alaska Geology have initiated a joint project to produce a synthesis of the geology of Alaska. A manuscript is scheduled for completion in 3 to 4 years. Maps produced as part of the project will be released without delay to the public as they are completed; they will be included in the final product to make a complete package.

D. L. Turner making K-Ar age determinations of Alaskan rocks at mass spectrometer.

CONTRACTUAL AND COLLABORATIVE PROGRAMS

GEOCHRONOLOGY IN ALASKA-1973

The newly initiated geochronology program of the Geochronology Laboratory at the Geophysical Institute, University of Alaska, has continued to produce significant results toward the understanding of Alaskan tectonics, basement-rock chronology and mineralization. The four joint programs described below have been carried out during the past year using DGGS logistic support. (DGGS participation in the laboratory work for these programs included the employment of a part-time minerals technician, and funds for thin sectioning and expendable laboratory supplies.)

A SOLUTION TO THE DENALI FAULT OFFSET PROBLEM

An informal working group of DGGS and University of Alaska geologists was formed in 1970 to work out a solution to the problem of offset along the Denali Fault, one of Alaska's largest structural breaks and a key element in Alaska's tectonic history. It was hoped that such a solution would provide an invaluable aid in the search for mineral belts and other linear features that might have originally extended across the fault and were subsequently offset.

A working hypothesis was formed when R.B. Forbes and T.E. Smith became aware of striking petrologic and structural similarities between metamorphic terranes that they had defined and studied in their respective field areas in the Coast range metamorphic belt near Juneau[26] and the Maclaren metamorphic belt in the central Alaska Range.[27] Forbes suggested that the Maclaren belt could be a segment of the Coast Range metamorphic belt that had been offset by right-lateral displacement along the Denali Fault. Since that time, Smith's continued mapping of the Maclaren belt (p. 3) has provided the basic framework for a key geologic element in the eventual proposed solution of fault offset.

D.L. Turner joined the working group in the fall of 1970 to apply the technique of K-Ar dating to the problem. A study of published geologic mapping in Alaska and the Yukon Territory indicated the possibility of two alternative offsets that appeared to be geologically reasonable: a Maclaren belt–Haines offset, and a Maclaren belt–Kluane Lake (Y.T.) offset.

In 1972, Forbes and Turner completed two geological traverses across the western Ruby Range igneous and metamorphic complex near Kluane Lake to further explore the possibility of the Kluane offset. Twenty-four K-Ar mineral dates have since been determined for Kluane samples and 50 have been determined from the Maclaren belt and related rocks. Based on petrologic, structural,

Age-dating sample being collected in Susitna lowlands by T.E. Smith

26. Forbes, R.B., and Engels, J.C., 1970, $^{40}K/^{40}Ar$ age relations of the Coast Range Batholith and related rocks of the Juneau Icefield area: Bull. Geol. Soc. Amer. v. 81, p. 579-584.
27. Smith, T.E., 1970, Inverted metamorphic zonation in the northern Clearwater Mountains, Alaska [abs]: in Geol. Survey Res. 1970: U.S. Geol. Survey Prof. Paper 700-A, p. A47-A48.

and geochronologic correlation of the Kluane and Maclaren terranes, a 400-km (250-mile) right-lateral Denali fault offset is implied since early Cretaceous time[4-7] (fig. 11).

K-Ar mineral dates from the Maclaren metamorphic belt reflect a complex thermal history. Amphibole ages (87-64 m.y.) with younger, coexisting biotites indicate that waning thermal events persisted into the earliest Tertiary. The oldest amphibole ages (70-87 m.y.) are located in the northern part of the belt, west of a pronounced 180-km lineament---recently named the Susitna fault (fig. 3). They appear to record an earlier setting of the K-Ar clock in a crustal level structurally higher than the rest of the belt. The Maclaren belt is 150 km long and extends from the Talkeetna Mountains into the Alaska Range, where it is truncated sharply by the Denali Fault.

Dates from quartz monzonite, migmatitic gneiss, and pelitic schist sampled along the south flank of the Kluane plutonic-metamorphic complex indi-

4 Ibid
5 Ibid
6 Ibid
7 Ibid.

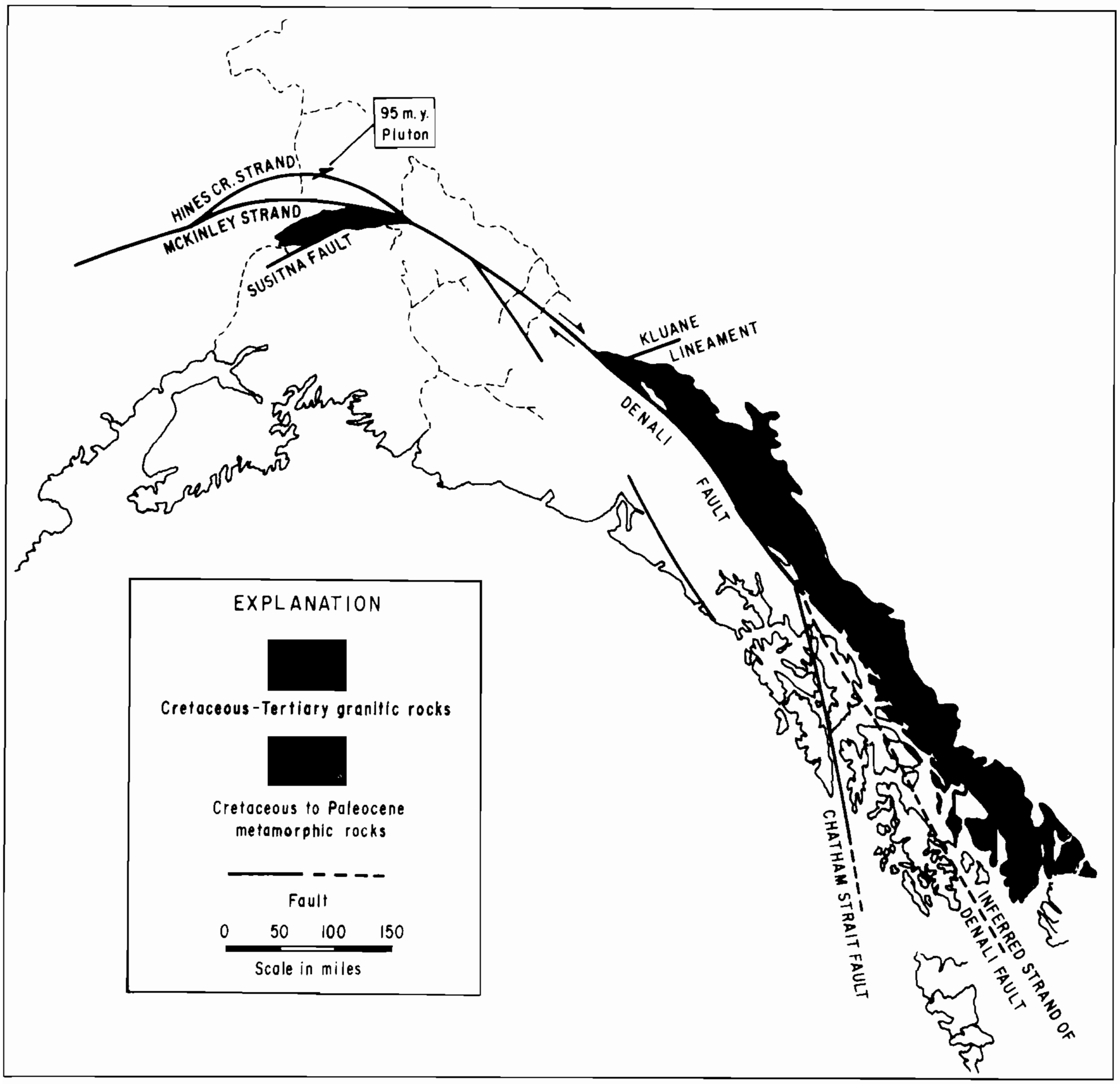


FIGURE 11. Metamorphic belts and pre-Denali Fault lineaments that are offset along the Denali Fault System

cate resetting to the time of emplacement of the Ruby Range Batholith---about 57 m.y. On the north flank of the complex, a prominent lineament visible on ERTS imagery separates igneous and metamorphic rocks yielding 57 m.y. K-Ar ages from metamorphic rocks of Mid-Cretaceous K-Ar ages. It appears that this lineament was originally contiguous with the Susitna fault and that the Susitna fault has been subsequently offset 400 km to the northwest along the Denali Fault. Comparable radiometric age differences exist across both lineaments; their correlation implies a right lateral offset of 400 km since early Cretaceous time and corroborates the previously reported 400-km offset based on correlation of the Maclaren and Kluane terranes.

The Kluane plutonic-metamorphic complex is contiguous with the Coast Range Batholith and its west and east marginal metamorphic belts. The tectonic model proposed here suggests that an unmapped strand of the Denali Fault system forms the eastern boundary of the ancient Alexander Terrane, and extends from Haines through Clarence Strait and presumably farther to the southeast (fig. 11).

Turner and Smith plan to open-file a report on the geochronology and regional geology of the Maclaren belt in the spring of 1974.

K-Ar DATING PINPOINTS CESSATION OF MOVEMENT ALONG HINES CREEK STRAND OF DENALI FAULT SYSTEM

Joint K-Ar dating and geologic mapping by Turner, Smith, and Clyde Wahrhaftig (USGS) have enabled a date to be placed on the cessation of movement along the Hines Creek strand of the Denali Fault system. An elongate quartz-monzonite pluton over 15 miles long and 3 miles wide cuts this strand in the vicinity of the west fork of the Little Delta River (fig. 11). The pluton is well-exposed and field relationships show clearly that the pluton postdates all movement along the strand. Dating samples were collected from the pluton during the summer of 1972 with a DGGS-contracted helicopter. Six K-Ar dates on biotite-hornblende pairs from three separate rock samples date the pluton at 95 m.y. (mid-Cretaceous). This work shows conclusively that there has been no significant motion along the Hines Creek Strand, as it is presently mapped in this area, in the last 95 million years---a finding that is in accord with the previously discussed conclusions concerning offset along the McKinley Strand of the Denali Fault system and with seismic evidence showing the McKinley Strand to be the presently active strand of the system.

GEOCHRONOLOGY OF SOUTHWESTERN BROOKS RANGE METAMORPHIC ROCKS

D.L. Turner has determined 12 K-Ar mineral ages from crystalline schists in this belt (Table 1). Sodic amphiboles from blueschist assemblages have produced startlingly old apparent ages ranging from 1.3 to 2.6 b.y. Micas (paragonite) from these same assemblages have produced ages of 213 to 234 m.y. Actinolite from a greenschist on the ridge east of the Kogoluktuk River was dated at 288 m.y.

The $^{40}K/^{40}Ar$ isochron technique has been applied to the discordant mineral age data. This type of isochron is constructed by plotting apparent radiogenic $^{40}K/^{40}Ar$ for a suite of samples on cartesian coordinates. Ideally, for coeval samples, the isochron is a straight line, with the argon axis intercept at the initial ^{40}Ar content of the mineral at the time the K-Ar clock was set and the slope is a function of geologic age. When this technique is applied to the data in Table 1, the plots define two isochrons representing significantly different ages (fig. 12).

Figure 12a is an isochron plot of paragonite data from blueschist samples A-1, A-2 and A-3, and the actinolite from greenschist sample 72 F10 aRGII. The actinolite and the paragonite from blueschists A-2 and A-3 define an isochron with a slope that gives an age of 213 m.y. The paragonite from blueschist A-1 does not plot on this isochron, and this mineral and coexisting glaucophane from the same sample do not plot on their respective isochrons; the reason is not clear. Figure 12a indicates that each of these rocks (A-2, A-3, 72 F10 aRGII) experienced a metamorphic event that culminated in early Triassic time. This isochron intersects the Ar axis near the origin, indicating that the isochron age has not been significantly affected by inherited argon.

Figure 12b shows an isochron plot of sodic amphiboles from blueschist A-1, A-2, A-3 , and C-2. The data from A-2, A-3, and C-2 appear to define an isochron that gives an age of 1.29 b.y. and also suggests that the amphiboles are coeval and were not reset by the early Triassic metamorphic event that crystallized or reset the coexisting paragonite. The glaucophane from blueschist A-1 plots above the isochron in harmony with the discordant plot of coexisting paragonite from the same sample.

The very old apparent ages of the sodic amphiboles, coupled with their very low potassium content, might suggest that the old ages are erroneous because of inherited argon. However, the intersection of the isochron near the origin of the argon axis argues against the presence of significant amounts of inherited argon. If the Precambrian ages were due to inherited argon, the apparent ages should vary inversely with the potassium content, because age is a function of the ratio $^{40}Ar/^{40}K$. However, such an inverse relationship is not present in the data, and similar ages are obtained from mineral samples ranging in K_2O content from 0.015 to 0.044.

It is possible that the much older apparent age of 2.6 b.y. for glaucophane A-1 may be related to inherited argon, as this particular amphibole has the lowest K_2O content of any sodic amphibole yet analyzed in this study (0.012). Analytical error does not appear to be the cause of the anom-

TABLE 1. *K-Ar dates from southwestern Brooks Range*

Sample	Rock Type	Mineral Dated	Age + 1σ (m.y.)
72F10aRGII (72161)	actinolite schist	actinolite	289.1 ± 46.2
72F10aRGII (72159) replicate	actinolite schist	actinolite	287.1 ± 45.9 $\bar{x}$ = 288.1 ± 46.1
A-1 (72146)	glaucophane-paragonite schist	paragonite	234.4 ± 7.0
A-2 (72162)	jadeite-glaucophane-paragonite schist	paragonite	213.4 ± 6.4
A-3 (72163)	jadeite-glaucophane-paragonite schist	paragonite	216.8 ± 6.5
A-1 (72093)	glaucophane-paragonite schist	glaucophane	2571 ± 77
A-1 (72156) replicate	glaucophane-paragonite schist	glaucophane	2549 ± 76
A-1 (72158) replicate	glaucophane-paragonite schist	glaucophane	2547 ± 76 $\bar{x}$ = 2556 ± 77
A-2 (72127)	jadeite-glaucophane-paragonite schist	glaucophane	1270 ± 38
A-3 (72129)	jadeite-glaucophane-paragonite schist	glaucophane	1429 ± 43
C-2 (72125)	garnet-glaucophane-carbonate schist	glaucophane	1333 ± 40
72B2II (73011)	biotite-muscovite-quartz-carbonate schist	biotite	96.4 ± 29

Constants used in age calculations:

$$\lambda_{\varepsilon} = 0.585 \times 10^{-10}/\text{yr} \qquad \lambda_{\beta} = 4.72 \times 10^{-10}/\text{yr}$$

$$^{40}K/K_{total} = 1.19 \times 10^{-4}\ \text{mole/mole}$$

alously old age, as six potassium and three argon determinations have been completed on this sample, and the replicate analyses agree within the standard deviation of analytical precision.

PLUTONIC ROCKS

Turner and Carden have recently obtained a K-Ar biotite age of 96 m.y. (Table 1) from a mica schist within the contact zone bordering the Shishakshinovik Pluton. This date agrees within analytical uncertainty with a muscovite K-Ar date from the pluton.[28]

28. Unpublished data, USGS.

TECTONIC AND PETROLOGIC PROBLEMS

A possible Precambrian blueschist facies metamorphic event is troublesome, as Paleozoic (probably Devonian) fossils were recovered from a marble in the blueschists facies terrane by G.R. Eakins, and the metavolcanics in the southern part of the belt are believed to be equivalent to similar units to the east, which contain Devonian fossils in intercalated sedimentary beds.

According to the apparent stratigraphic evidence, the blueschist facies metamorphic event that developed the incipient glaucophane in the

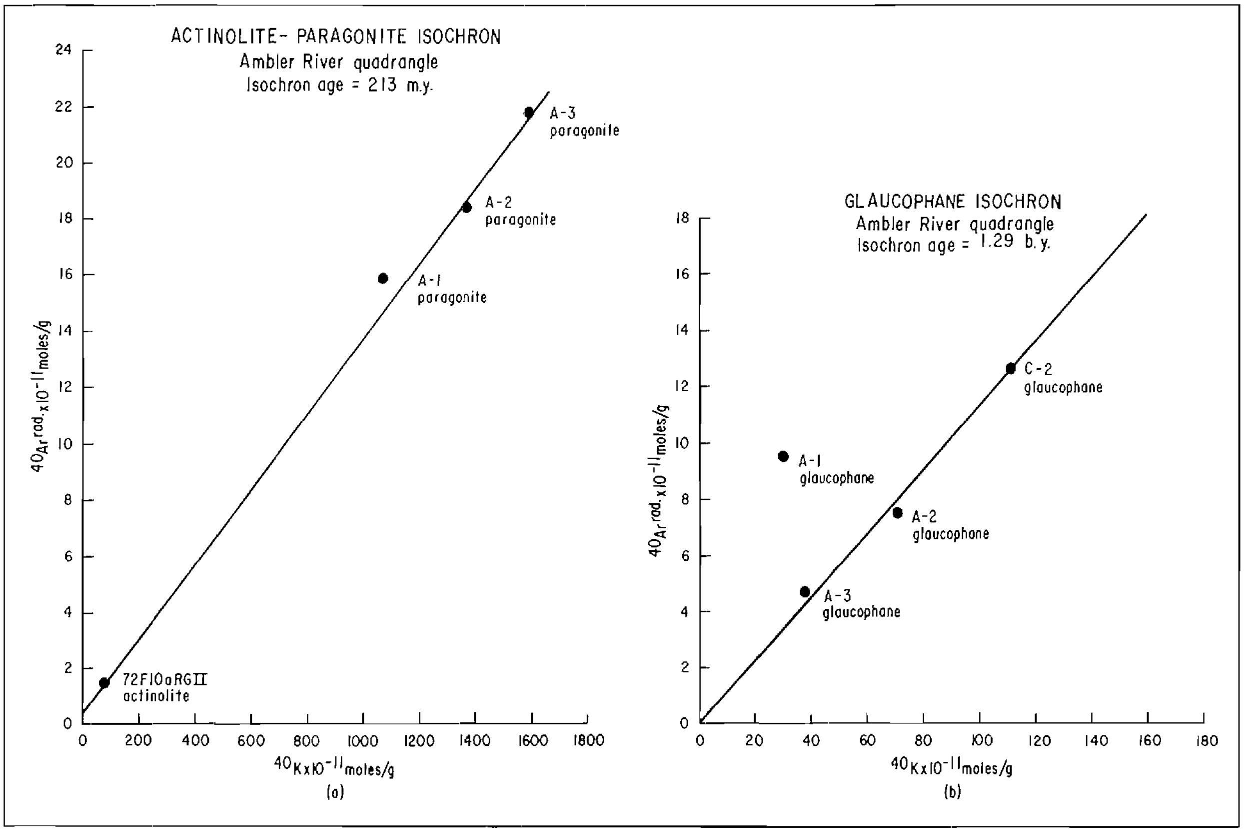


Figure 12. $^{40}K/^{40}Ar$ mineral isochron diagrams

metabasalts should be of post-Devonian age. The paragonite actinolite isochron age of 213 m.y. is compatible with this evidence, but the Precambrian glaucophane ages will require the investigation of alternate hypotheses, including the following possibilities:

1) The polymetamorphic blueschist occurrences are older tectonic imbrications in a younger metamorphic terrane.

2) The Devonian fossil-bearing marble has been tectonically emplaced in an older polymetamorphic terrane.

3) The metavolcanics in the southern part of the belt are actually Precambrian, and not of Devonian age.

4) The Baird Mountains metamorphic terrane includes two blueschist facies metamorphic events: a Precambrian event that recrystallized the coarse-grained blueschists with polymetamorphic fabrics and a post-Devonian episode that retrograded the Precambrian blueschists and induced incipient blueschist facies metamorphism in the volcanics located along the south margin of the Precambrian belt.

5) The K-Ar isochron age determination from the glaucophanes is erroneous because of inherited argon increasing in proportion to potassium content, or some other unrecognized source of error.

There is also a difference of opinion concerning the age of the volcanics and associated sedimentary interbeds on the south margin of the belt. Although there is general agreement that these rocks are equivalent to the "Angayucham Volcanics," in the Hughes quadrangle, the age of this sequence is disputed. Fritts[29] recovered Devonian fossils from intercalated sedimentary beds that appeared to be conformable with volcanic units in the sequence. However, Patton and others[30] correlate the Angayucham Volcanics with similar rocks of Jurassic age in the eastern Brooks Range. If they are correct, the Devonian sedimentary units have been faulted or infolded into the sequence (or both), but field evidence and outcrop relations do not appear to support this contention. The 213-m.y. isochron is acceptable as the age of the culminating

29. Unpublished data, Alaska Div. Geol. and Geophys. Surveys.
30. Patton, W., Miller, T., and Tailleur, I., 1968, Regional geologic map of the *Shungnak and southern part of the Ambler River quadrangles*: U.S. Geol. Survey Map I-554.

metamorphic event in the metamorphic terrane south of the Walker Lake Fault---a finding that argues against the possible presence of recrystallized Jurassic parent rocks within the metamorphic belt.

GEOCHRONOLOGY OF PRINCE OF WALES ISLAND, SOUTHEASTERN ALASKA

Field mapping during 1970-1972 in the Craig A-2 quadrangle by Gordon Herreid, assisted by J.G. Pray and T.K. Bundtzen, has disclosed many of the geological details of this well-mineralized region. D.L. Turner spent several days in the field in 1972, collecting samples for K-Ar dating.

Schist and interlayered marble on southern Prince of Wales island have long been considered to be the oldest rocks in the area and have been named the Wales Group. These rocks consist of interbedded keratophyre tuff, volcanic mudstone, mixtures of the two, and other rocks that have undergone low-grade metamorphism and deformation that included at least two periods of folding. Near Eek Inlet, Wales Group greenschist grades into the overlying volcanic mudstone of the Descon Formation by a gradual lessening of: (1) penetrative deformation caused by the two foldings and, (2) the percentage of keratophyre tuff beds. Eberlein[31] believes, on the basis of faunal evidence, that the Descon in this area is probably of Middle or Upper Ordovician age. This would imply that the Wales should be considered pre-Middle Ordovician(?) in age.

On Klakas Inlet, probable Descon Formation rocks consist of conglomeratic graywacke and argillite, overlain by thinly laminated mudstone, overlain by metabasalt. The whole section is several thousand feet thick, right side up, and dips moderately to the southwest. The section is unconformably overlain by dark mudstone, graywacke, arkose, and andesitic breccia dated in its lower portion as Early Devonian by Churkin and others.[32] Granitoid rocks, intrusive into the metabasalt at Max Cove, have shed large boulders into the conglomerate at the base of the Lower Devonian rocks. Similar granitoids at Kendrick Bay, 12 miles to the east, have been dated as Ordovician (about 440 m.y.) by the K-Ar method. It seems likely that the intrusive rocks at Max Cove are Late Ordovician and the metabasalt is pre-Late Ordovician.

The intrusives around Max Cove range from albite granite to albite-hornblende diorite, typically with altered plagioclase. Samples collected for K-Ar dating in 1972 will yield minimum ages due to mineral alteration. One mile west of Max Cove, the Lower Devonian mudstone is cut by Mesozoic(?) diorite plutons. A scattering of Mesozoic(?) plutons extends northwest toward Copper Mountain. These intrude both Devonian and older rocks.

31. Donald Eberlein, personal communication, 1972.

32. Churkin, Michael, Jr.; Jaeger, Herman; and Eberlein, G.C., 1970, Lower Devonian graptolites from southeastern Alaska: Lethaia, v. 3, no. 2, p. 183-202.

Laboratory dating work on samples collected by Turner (fig. 13) is now being completed and several preliminary results can be reported.

The hornblende granodiorite pluton at Mt. Jumbo, which intrudes Wales greenschists near the head of Hetta Inlet, has been dated at 101.6 m.y. Actinolite from hornfelsed greenschist within the contact aureole of the pluton gives an age of 141 m.y., indicating nearly complete thermal resetting by the pluton. This pluton cuts a thrust fault with marble and black slate of indeterminate age being thrust over Wales greenschist. Our radiometric age for the pluton establishes a minimum age for this thrust.

A small hornblende diorite intrusive body cutting a thrust fault that juxtaposes Devonian mudstones and Wales greenschist northwest of the head of Klakas Inlet was dated at 102±10 m.y. (mean of two hornblende determinations); this dates the thrusting as previous to this time.

An attempt was made to date the greenschist facies metamorphism of the Wales Group and lower Descon Formation by selecting samples containing amphiboles of sufficient size for mineral separation. Petrographic study has shown that all of these samples contain broken and rotated relict crystals of hornblende in a matrix of chlorite, albite, and tremolite. The hornblendes show incipient overgrowths of tremolite. Relatively pure concentrates of each amphibole from two lower Descon greenschists near Sukkwan Strait were dated separately to determine if the two amphiboles were of significantly different ages. The initial dating results show the tremolite apparent ages to be affected by inherited argon---that is, argon that was present in the system when the minerals crystallized and was occluded within them, thus artifically increasing their measured apparent ages.

The hornblendes (the first-generation amphiboles in the rock fabric) were less affected by inherited argon because they contained greater amounts of potassium and therefore produced larger quantities of radiogenic argon than did the tremolites.

The preliminary radiometric data now available suggest that Wales and lower Descon greenschists were metamorphosed at least 400 million years ago. Several additional age analyses are now being completed and will be included as part of a report on the geology and geochronology of the Craig A-2 quadrangle to be completed in 1974 by Herreid and Turner.

AMPHITHEATER MOUNTAINS AND VICINITY

Detailed field mapping by J.H. Stout, University of Minnesota, and three assistants during the 1973 field season resulted in a geologic compilation at a scale of 1 inch to 1 mile of portions of the Mt.

Denali Fault, looking toward Cantwell, Mt. Hayes B-3 quadrangle

Hayes A-4, A-5, B-4 and B-5 quadrangles. A total of 365 stream-sediment samples were collected over an area of approximately 350 square miles.

A major breakthrough in the understanding of the regional stratigraphy and structure came with the recognition that the entirety of the Amphitheater Mountains from Paxson to the Maclaren River consists of a simple, open syncline (fig. 3). The structure is referred informally as the Amphitheater syncline. Its axial trace extends for nearly 50 miles in a N70°W direction; its plunge is approximately 15 degrees to the west.

The youngest layered rocks in the Amphitheater Mountains are found in the core of the syncline. They comprise 6,000 feet of interlayered vesicular and nonvesicular basalt flows. Underlying pillow basalts and pillow andesites crop out on both limbs of the fold and serve to define its symmetry on a regional scale. These rocks contain interbedded siliceous tuffs, flow breccias, and assorted volcaniclastic sediments that locally include shaly horizons containing *Halobia*(?) fragments. These are suggestive of a mid-Late Triassic age as reported elsewhere in the Amphitheater Group.[33,34]

Beneath the Late Triassic section is a very thick sequence of massive gray to greenish-gray basalt. These rocks are well exposed on Paxson Mountain and have been correlated by Rose[35] with the Nikolai Greenstone in the southern Copper River Basin. These rocks overlie with apparent conformity a very fossiliferous Permian sequence of interbedded limestone, shale, and thin vesicular basalt. Approximately 15,000 feet of this section is exposed in the vicinity of Rainy and Eureka Creeks. The lower part bears a Lower Permian fauna.[36]

The oldest sedimentary rocks recognized to date south of the Denali Fault are the lower Pennsylvanian sandstones, siltstones, and silty limestones described by Rowett[37] near Rainbow Mountain on the east side of the Delta River. The same rocks are found west of the Delta River, where they are truncated by the Broxson Gulch low-angle fault system, placing regionally metamorphosed pelitic sediments of the Jurassic and Cretaceous(?) Maclaren belt over the older, essentially unmetamorphosed rocks described above.

On the south limb of the Amphitheater syncline, the Permian and Pennsylvanian sections are completely missing. In their equivalent stratigraphic position, apparently regionally metamorphosed amphibolite facies rocks are found instead. These may correlate with amphibolite facies terrane near Meiers on the Richardson Highway. Their contact with the pre-Late Triassic basalts on Paxson Mountain is thought to be a major fault.

Mapping in the Mt. Hayes B-4 and B-5 quadrangles along the southern flank of the Alaska

33. Smith, T.E. and Turner, D.L., 1973, Geochronology of the Maclaren metamorphic belt, south-central Alaska, a progress report: Isochron/West, No. 7, p. 21-25.

34. Smith, T.E. and Lanphere, M.A., 1972, Age of the sedimentation, plutonism and regional metamorphism in the Clearwater Mountains region, central Alaska: Isochron/West, No. 2, p. 17-20.

35. Rose, A.W., 1965, Geology and mineralization of the Midas mine and Sulphide Gulch areas near Valdez, Alaska: Alaska Div. Mines and Minerals Geol. Rept. 15.

36. Petocz, R.G., 1970, Biostratigraphy and Lower Permian *Fusulinidae* of the upper Delta River area, east-central Alaska Range: Geol. Soc. America Spec. Paper 130.

37. Rowett, C.L., 1969, Upper Paleozoic stratigraphy and corals from the east-central Alaska Range, Alaska: Arctic Inst. North America Tech. Paper 23.

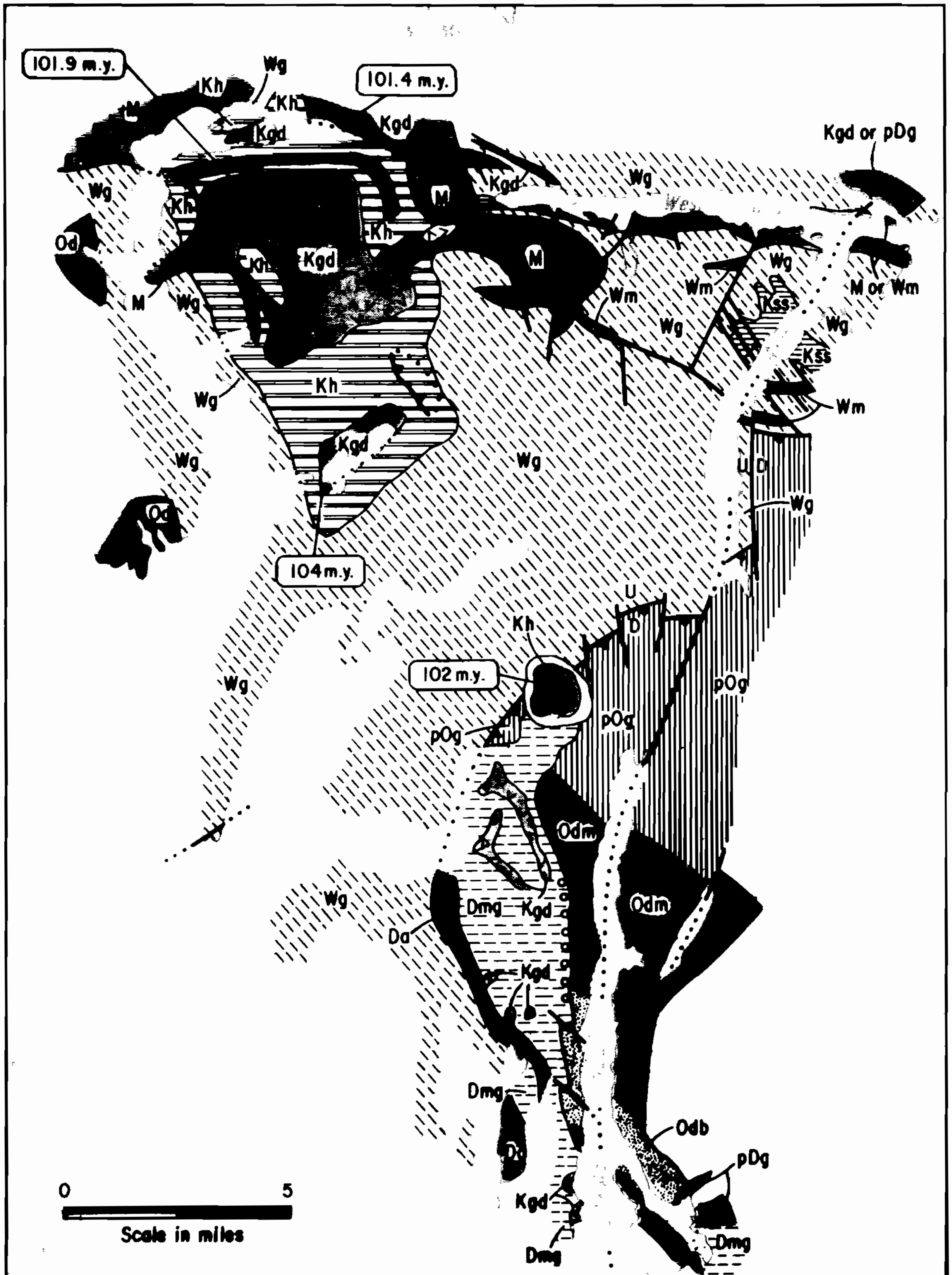
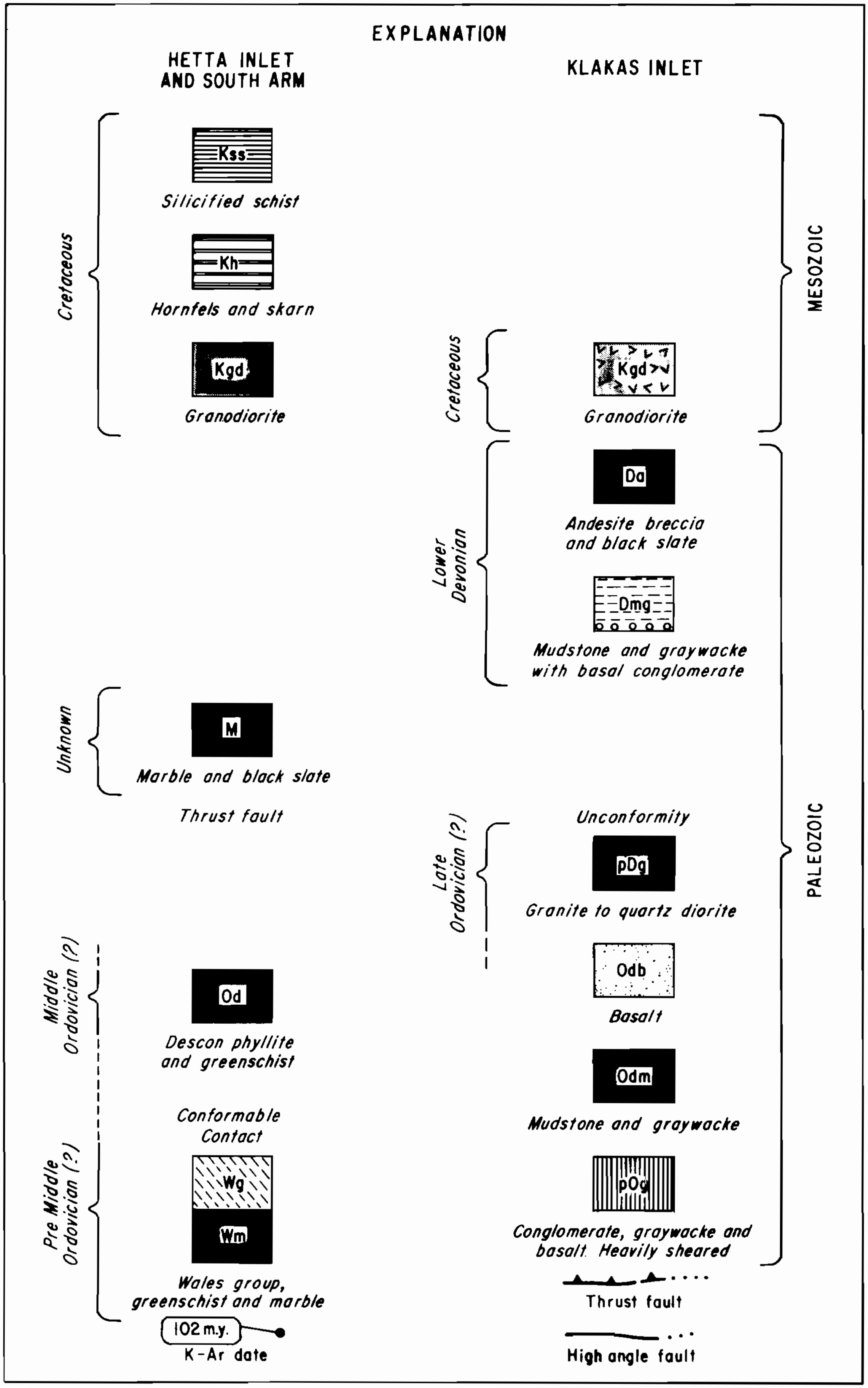


FIGURE 13. Generalized geology of Craig A-2 quadrangle and vicinity


EXPLANATION
HETTA INLET AND SOUTH ARM
KLAKAS INLET
Cretaceous
Kss
Silicified schist
Kh
Hornfels and skarn
Kgd
Granodiorite
Unknown
M
Marble and black slate
Thrust fault
Middle Ordovician (?)
Od
Descon phyllite and greenschist
Conformable Contact
Pre Middle Ordovician (?)
Wg
Wm
Wales group, greenschist and marble
102 m.y.
K-Ar date
MESOZOIC
Cretaceous
Kgd
Granodiorite
Lower Devonian
Da
Andesite breccia and black slate
Dmg
Mudstone and graywacke with basal conglomerate
Unconformity
Late Ordovician (?)
pDg
Granite to quartz diorite
Odb
Basalt
Odm
Mudstone and graywacke
pOg
Conglomerate, graywacke and basalt. Heavily sheared
PALEOZOIC
Thrust fault
High angle fault

Range has yielded new data on the timing of the Broxson Gulch Thrust fault system and the emplacement of associated ultramafic rocks. Most, if not all of the movement on the Broxson Gulch Thrust[35] is Tertiary in age, probably post-Oligocene. Conglomerate and sandstone with well-preserved Oligocene(?) flora have near-vertical dips along low-angle, north-dipping faults and locally are structurally overlain by Pennsylvanian volcaniclastics. The deformed Tertiary rocks contain no clasts of the dunites and peridotites that are now recognized to be volumetrically important. It is thus tentatively concluded that the emplacement of ultramafic rocks was contemporaneous with the low-angle faulting, and that both events followed the deposition of Tertiary clastics.

These relationships bear directly on the age and origin of scattered mineralization in the area. Quartz veins and associated copper and nickel mineralization in the Amphitheater Mountains clearly antedates the folding of the Amphitheater Group. The occurrence of base-metal sulfide mineralization north of Eureka Creek in close association with ultramafic rocks, as well as extensive pyritization and development of limonite along major fault zones in the same area, suggest that the mineralization is Tertiary in age.

35 Ibid

RUBY RIDGE TRAVERSE, SOUTHWESTERN BROOKS RANGE

A detailed geological traverse across the schist belt in the Ambler River quadrangle was completed in August by R.B. Forbes, D.L. Turner, W.G. Gilbert, and J.R. Carden. The field party was a cooperative effort between the DGGS, the USGS, and the University of Alaska to obtain detailed petrologic, structural, and geochronological data from the schist belt that forms the south margin of the Brooks Range from Kotzebue Sound to the Chandalar district.

On the basis of earlier work by the three groups, the metamorphic belt was known to include blueschists in the Baird Mountains and Survey Pass quadrangles. The Ruby Ridge area (pl. 1; fig. 14) was traversed in the hope of solving several important problems concerning the genesis and structural evolution of the blueschists, including questions on:

1) The allochthonous vs autochthonous origin of blueschist rock units within the schist belt.
2) Structural style and setting of the belt.
3) Geochemical and petrologic explanations for the apparent Precambrian $^{40}K/^{40}Ar$ glaucophane ages and the accompanying discordant Permo-Triassic mica and actinolite ages from the belt.
4) Tectonic setting of the belt at the time of metamorphism.
5) Relationship of blueschists to stratabound copper deposits that occur in the district.
6) Tectonic significance and geometry of the "Walker Lake fault."

Figure 14 is the north-south structure section along the Ruby Ridge traverse, showing the location of the garnet isograds in metaigneous and metasedimentary rocks, the zonal distribution of chloritoid-bearing rocks, and the known occurrences of glaucophane-bearing assemblages (blueschists). The figure also contains a highly generalized illustration of the nappelike structure that appears to be the dominant deformational style along the schist belt in the Ambler River and Survey Pass quadrangles. Table 2 is a summary of metamorphic mineral assemblages from intercalated rock units in the section.

The Baird Mountains metamorphic belt is a

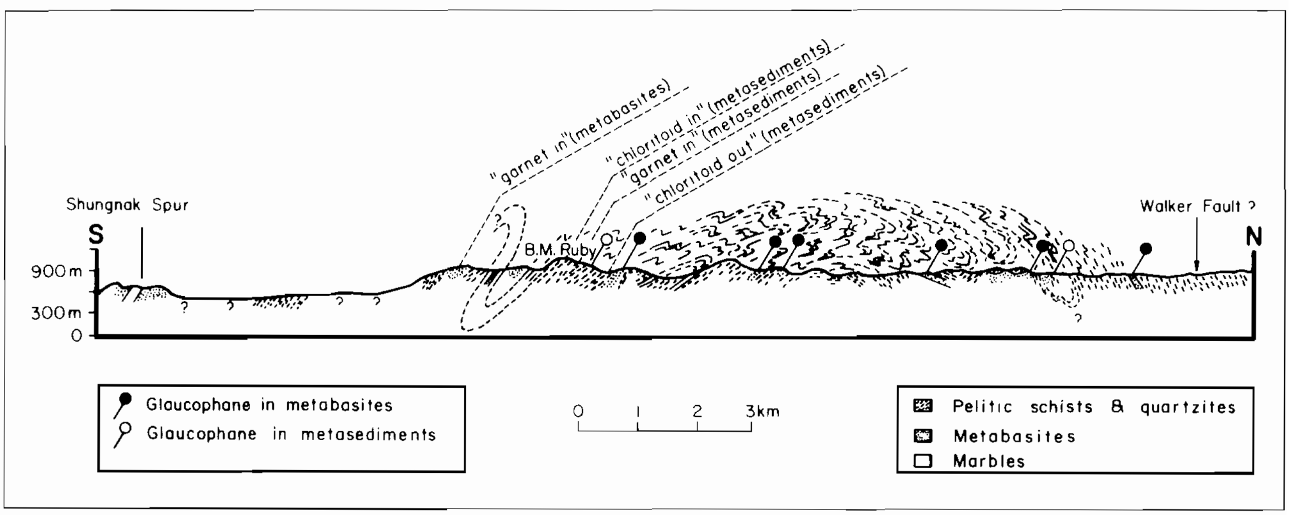


FIGURE 14. Ruby Ridge traverse, north-south structure section

TABLE 2. *Mineral assemblages from intercalated metamorphic rocks in the Ruby Ridge Section*

METABASITES

Eclogitic (retrograded) Assemblages	Blueschist Assemblages
clinopyroxene-amphibole-quartz-garnet (+calcite)	glaucophane-paragonite-quartz-albite-sphene (+jadeite) glaucophane-garnet-epidote-sphene (+ stilpnomelane, paragonite, albite)
garnet-amphibole-sphene (+relict clinopyroxene)	glaucophane-mica-garnet-sphene-epidote
	glaucophane-mica-epidote-sphene

Greenschist Assemblages
garnet-actinolite-mica-epidote
garnet-actinolite-epidote-albite
actinolite-calcite-quartz-albite
chlorite-actinolite-epidote-sphene-albite

METASEDIMENTS

Blueschist Assemblages	Glaucophane-free Assemblages
calcite-quartz-glaucophane	quartz-mica-chlorite-garnet
quartz-mica-glaucophane-albite	quartz-mica-chloritoid-chlorite
garnet-calcite-quartz-glaucophane	quartz-mica-chloritoid-garnet-chlorite
quartz-mica-chloritoid-glaucophane (+stilpnomelane)	

ORTHOGNEISSES

oligoclase-quartz-K feldspar-muscovite-biotite

progressively metamorphosed terrane containing rocks of the prehnite-pumpellyite, blueschist, and greenschist facies. Metamorphic grade appears to increase to the north, across the structural trend.

Incipient recrystallization is displayed by the rocks that crop out on the southwestern tips of ridges that form the interstream divides of the Ambler, Shungnak, and Kogoluktuk Rivers, where the section contains greenstones, metacherts, siltstones, argillites, calc-argillites, and fine-grained marbles. In this part of the succession, the greenstones contain pumpellyite, epidote, and chlorite, and the argillites display incipient sericite.

With a slight increase in metamorphic grade, the first sodic amphiboles appear as incipient patches on clinopyroxenes in the metavolcanics, along with stilpnomelane and actinolite. Intercalated argillites become phyllites (albite-muscovite-quartz), and some of the calc-phyllites contain stilpnomelane.

Progressive recrystallization is accompanied by the development of a pervasive crystallization foliation and the first appearance of garnet, and coarse-grained glaucophane or crossite in the metavolcanics. Intercalated metasediments include glaucophane or chloritoid-bearing assemblages, and garnet-bearing pelitic schists.

Biotite does not occur as a stable phase in assemblages south of the "Walker Lake Fault," with the exception of the K-feldspar porphyroblast schists, which appear to have originally been synkinematically emplaced granitic sills and dikes.

Rock units adjacent to these masses show the effects of superimposed thermal metamorphism, with the development of discordant aggregates of biotite. Sodic amphibole-bearing rocks have not been found north of the "Walker Lake fault" in this area, and conversely, biotite appears to be a stable assemblage mineral in the pelitic schists (greenschist facies). The greenschist-facies rocks continue to the north, where they disappear beneath the imbricate thrust sheets of Devonian and Mississippian carbonates.

To date, neither aragonite nor lawsonite have been identified in the Baird Mountains assemblages, but jadeite has been found in a blueschist, collected from a locality northwest of benchmark ***Ruby*** on the ridge between the Ambler and Shungnak Rivers. The jadeite occurs with coarse-grained glaucophane aggregates in a relict fabric cut by a later foliation defined by paragonite and actinolite. Other blueschist fabrics display evidence of this same retrograde metamorphic event, as characterized by the widespread development of actinolite at the expense of sodic amphibole. Aegirine-amphibole rock and retrograded eclogite have also been collected from the same ridge, south of the jadeite locality.

As shown in figure 14 and table 2, blueschists of both igneous and sedimentary parentage are found throughout the section. There is no evidence for tectonic emplacement of the blueschist units, and all units in the section appear to have experienced the same metamorphic history.

The style of folding grades from asymmetric to isoclinal-overturned and recumbent from south to north in the direction of increasing metamorphic grade. The so-called "Walker Lake fault" could not be found along this traverse, and field relations and structural data suggest that the previously mapped "Kalurivik arch" may be the arcuate axial surface of a nappelike structure, rather than a simple anticlinorium (fig. 14).

K-Ar mineral ages from the Baird Mountains metamorphic terrane indicate that the ages of both parent rocks and major metamorphic events are older than previously recognized--a discovery that will require a reevaluation of previously developed concepts for the tectonic evolution of the Brooks Range.

Geochronological, geochemical, and petrologic samples are being processed, and over 300 thin sections are being studied. A preliminary 1-inch to 1-mile geologic map and a structure section have been completed; these will be made available through open file in 1974.

ZEOLITE DEPOSITS OF UPPER MATANUSKA VALLEY

This work is a continuation of that reported in 1972.[38] The previous work established that zeolite deposits of possible economic significance were present in the upper Matanuska Valley near Sheep Mountain and the Horn Mountains. Work performed during 1973 by D.B. Hawkins was directed at mapping the mordenite deposit present on Albert Creek and prospecting for further zeolite deposits in the general vicinity. Samples collected during the summer are now being analyzed for zeolites. The results of these studies and a map of zeolite localities are being prepared for publication.

Preliminary investigations by D.H. Dinkel of the Agricultural Experiment Station, University of Alaska, using laumontized tuff as a support medium for hydroponics experiments, showed that the tuff was not particularly effective in stimulating plant growth. Prior treatment of the zeolite may be required to improve agricultural efficiency.

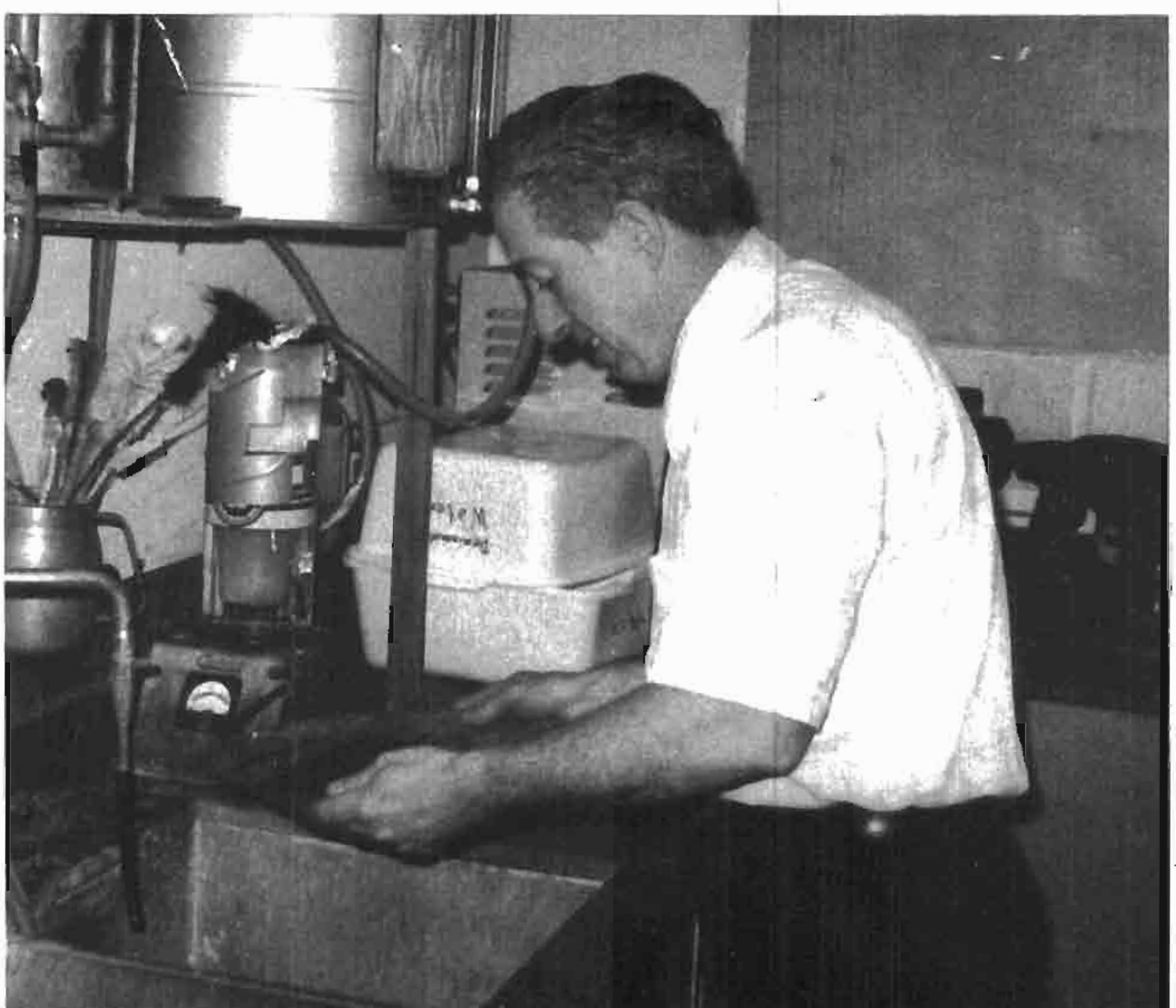
MARINE GEOLOGY

A cooperative program of research was continued with the Institute of Marine Science (IMS), University of Alaska. T.C. Mowatt, N.C. Veach, and T.C. Trible collaborated with A.S. Naidu of IMS on a mineralogic-geochemical-petrologic-sedimentologic study in northern Arctic Alaska and the adjacent offshore areas of the Arctic Ocean.

Mowatt participated with Naidu in the scientific cruise (WEBSEC-73) of the U.S. Coast Guard icebreaker ***Glacier*** in the Beaufort Sea in August 1973.

In this program, the following aspects were studied: 1) the mineralogic-geochemical-sedimentologic relationships per se. 2) the potential "scavenging" activity of the sediments, 3) the delineation of currents and transport mechanisms, and 4) the environmental "base-line" level of concentration for various chemical elements. Of paramount interest was the characterization of these parameters before the area is further developed by man so that any departures from the environmental base-line can be readily assessed. Sediments studied included those from the major drainages of the region, suspended and bottom deltaic and offshore samples, ice-bound materials, and gravel particles with associated iron-manganese coatings.

38. Hawkins, D.B., 1973, Sedimentary zeolite deposits of the upper Matanuska Valley, Alaska: Alaska Div. Geol. and Geophys. Surveys, Spec. Rept. 6.



D. R. Stein preconcentrating a sample in the Mineral Analysis Laboratory.

MINERAL ANALYSIS AND RESEARCH LABORATORY

ANALYTICAL PROGRAM - 1973

The staff of the DGGS Laboratory, located in Fairbanks, performed mineralogical, petrologic, and elemental analyses on 5,166 DGGS samples, a 58% increase over the previous year. A total of 42,938 individual elemental or mineralogical determinations were made on these samples. Also, 488 public samples were analyzed.

The varied analytical services included qualitative to quantitative elemental and mineralogical determinations, precious-metal assays and considerable advisory work for the public.

NEW EQUIPMENT

The Laboratory acquired a digital-readout Baird-Atomic Microphotometer-Comparator for use in its continuing program of 30-element semiquantitative emission spectrographic analysis of DGGS stream-sediment samples. This unit replaces the handmade instrument on loan from the USGS.

METHOD DEVELOPMENT

The Laboratory, in addition to providing routine analytical services, carried out the following development work on several projects.

1) An atomic-absorption spectrophotometry liquid-liquid extraction procedure for the determination of gold by atomic absorption using DBK/Aliquot 336. This method is more efficient than conventional techniques, and achieves greater accuracy. A total of 271 stream sediments and rocks were processed using this method.

2) Experimentation and perfection of a cold H_2O_2 leach for the determination of Cu and Ni sulfides in ultramafic rocks.

3) An ore-microsopy and powder-camera X-ray diffraction capability. This capability was established in cooperation with the Mineral Industry Research Laboratory, University of Alaska, to produce, examine, and photograph polished sections. The addition of the powder camera broadens the Laboratory's capability for mineral analyses by X-ray diffraction.

4) Analytical procedures for the standard analysis and petrographic examination of coal. This development is a result of renewed DGGS interest in Alaskan coal resources.

5) Determination of Hg in stream sediments. There is a need for additional experimentation with the analytical technique; unresolved difficulties concerning data interpretation and sample-handling procedures arose for those samples containing appreciable amounts of gold.

LIQUID-LIQUID EXTRACTION OF TIN FROM HCl/$LiBO_2$ SOLUTIONS

Several investigators [39,40] have reported the resistance of tin-containing minerals such as cassiterite to acid decomposition even when subjected to elevated temperatures and pressures. The Laboratory confirmed this suggestion and concluded that a fusion technique must be used to effect the necessary decomposition and solution of silicates containing tin minerals prior to analysis by atomic-absorption spectrophotometry.

The Laboratory used $LiBO_2$ as a suitable fluxing agent for tin minerals, generally taking the silicate melt into solution with dilute HCl. Using 0.1g to 0.5g of sample results in 50:1 to 100:1 dilution of the original tin concentration in the sample. Because igneous rocks often contain less than 10 ppm tin,[41] fusion and solution of this type of sample might have resulted in an ultimate aqueous

39. Dolezal, J., Povondra, P. and Šulcek, Z., 1968, Decomposition techniques in inorganic analysis: New York, New York, American Elsevier, 224 p.
40. Headridge, J.B., 1972, The application of hydrofluoric acid and fluorides in analytical chemistry: CRC Critical Reviews in Analytical Cemistry, p. 467.
41. Vinogradov, A.P., 1962, Average contents of chemical elements in the principal types of igneous rocks of the earth's crust: Geochemistry, no. 7, p. 641-664.

tin concentration of 0.1-0.02 ug/ml. Unfortunately, tin at this level is usually insufficient to measure precisely by conventional flame spectroscopy.[42-44]

With the argon/hydrogen-entrained air flame,[45,46] an SBW of 3.3Å, full-scale expansion with the Varian AA-4 instrument, and the less sensitive but more stable 2863Å tin resonance line, the detection limit for tin in a 1.5% $LiBO_2$, 3.5% HCl solution was found to be about 0.15 ug/ml by atomic-absorption spectrophotometry. A 1.0-ug/ml tin standard similarly prepared gave 0.202 absorbance units with the preceding instrumental parameters.

It was apparent that some preconcentrating technique was necessary prior to the atomic-absorption determination of tin in igneous rocks. Such a procedure, first suggested by Lyle and Shendikar[47] and later again investigated by them and others,[48,49] indicated that tin could be extracted at the appropriate pH from HCl solutions by using N-benyoylphenyhydroxylamine (BPHA) with chloroform. The final tin measurements were made by spectrophotometry. The Laboratory investigated this liquid-liquid extraction procedure as well as others for possible use prior to tin determination by atomic-absorption spectrophotometry.

Extracting 50 ml of a 1-ug/ml tin solution made to 0.5M HCl and 2% $LiBO_2$ with 20 ml of chloroform containing 2 ml of 1% BPHA yielded an absorbance of 0.146 when back-extracted in 5 ml of 7M HCl. This result was found using the previously given instrumental parameters, except that no scale expansion had been used. However, when extracting 10 ug of tin from a solution made 2% in $LiBO_2$ and 0.5M HCl with BPHA/$CHCl_4$, the absorbance measured only 0.0209 at full-scale expansion, an insufficient signal for precise results.

Other preconcentration procedures[44, 49-51] increase the final tin concentration to levels that could be measured by atomic-absorption spectrophotometry. However, the recent availability of electrodeless discharge lamps (EDL's),[41] which provide a spectral output 5 to 50 times higher than conventional hollow cathode devices, may eliminate the need for the extraneous (but presently necessary) preconcentration steps now required for low-level tin analysis.

Placer gold miner. (Photo by U.S. Forest Service.)

42. Smith, J.D., 1971, Spectrophotometric determination of traces of tin in rocks, sediments and soils: Anal. Chem. Acta, v. 57, p. 371.

43. Browner, R.F., Dagnall, R.M., and West, T.S., 1970, The determination of tin by atomic fluorescence spectroscopy, with an electrically modulated electrodeless discharge tube as source: Anal. Chim. Acta, v. 46, p. 207.

44. Huffman, C. and Bartel, A.J., 1964, Ion-exchange separation of tin from silicate rocks: U.S. Geol. Survey Prof. Paper 501-D, p. D131-D133.

45. Hubáška, E., and Miksovský, M., 1972, Interferences on tin in the argon-hydrogen and nitrogen-hydrogen diffusion flames: Atomic Absorption Newsletter, v. 11, no. 3, p. 57.

46. Juliano, P.O., and Harrison, W.W., 1970, Atomic absorption interferences of tin: Anal. Chem., v. 42, no. 1, p. 84.

47. Lyle, S.J., and Shendrikar, A.D., 1965, A separation scheme for gallium, indium, thallium, germanium, tin and lead by solvent extraction with N-Benzoyl-N-Phenylhydroxylamine: Anal. Chim. Acta, v. 32, no. 6, p. 575-582.

48. Lyle, S.J., and Shendrikar, A.D., 1966, Some aspects of N-Benzoylphenylhydroxylamine and cupferron reactions with tin, antimony and other selected elements: Anal. Chim. Acta, v. 36, p. 286-297.

49. Jordanov, N., Mareva, S., and Koeva, M., 1972, Selective separation of tin (IV) by solvent extraction with N-Benzoyl-N-Phenylhydroxylamine: Anal. Chim. Acta, v. 59, p. 75-80.

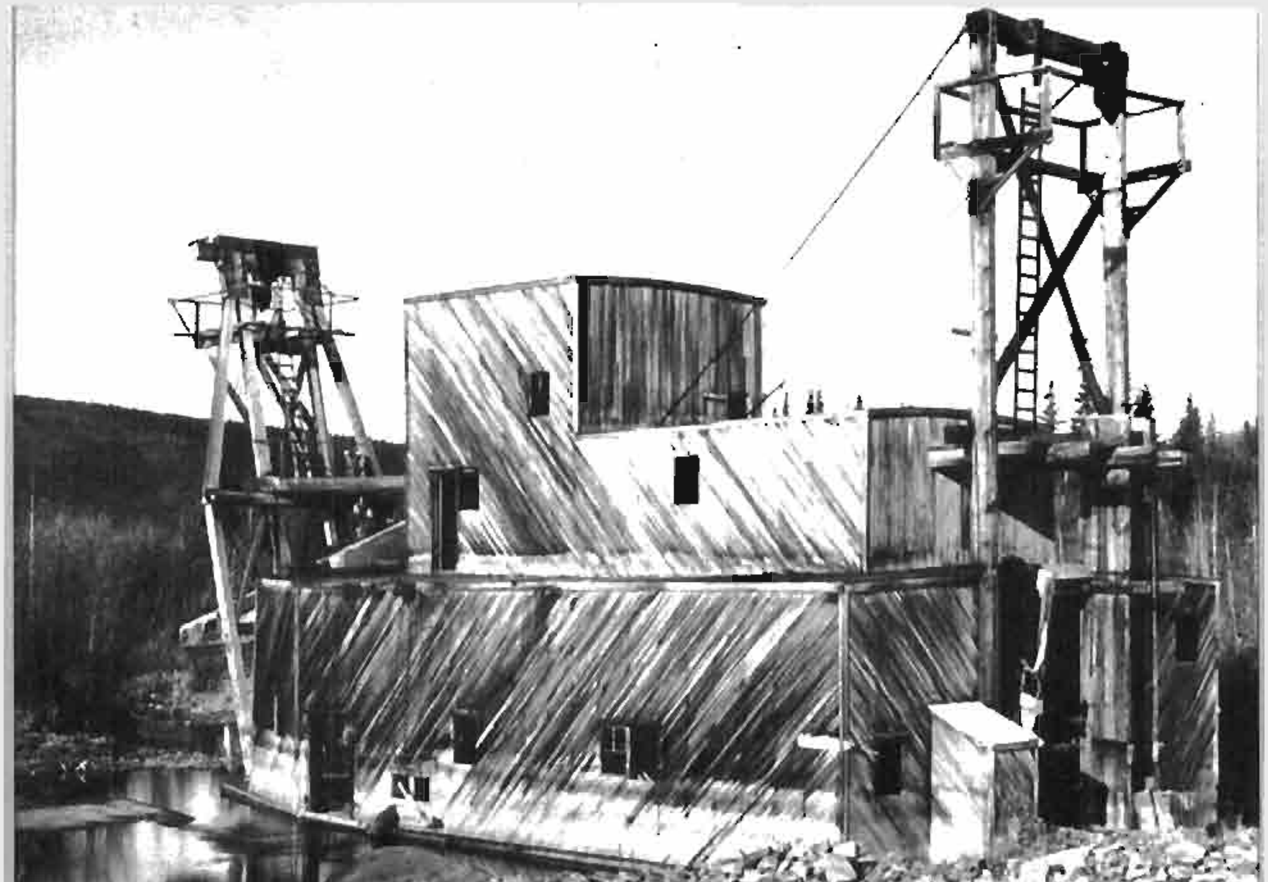
44. Ibid.

50. Newman, E.J., and Jones, P.D., 1966, Separation and determination of small amounts of tin: Analyst, v. 91, p. 406-410.

51. Onishi, H. and Sandell, E.B., 1956, Colorimetric determination of trace of tin with dithiol: Anal. Chim. Acta, v. 14, p. 153-161.

52. Smith, J.D., 1970, The spectrophotometric determination of microgram amounts of tin with phenylfluorone: Analyst, v. 95, p. 347-350.

43. Ibid.



Historic gold dredge (c. 1910), Walker Fork of Fortymile River.

CONSERVATION AND REGULATIONS

FUNCTIONS

The Conservation section is supervised by C.N. Conwell, Mining Engineer. One function of the section is to conduct geological studies on potential economic mineral targets.

The Kantishna region, north of Mt. McKinley National Park, was visited to evaluate its potential, and a mineral preparation study was made of its high grade lead-zinc-gold-silver ore.

Prospect examinations are made on request for clients unable to afford a private consultant. In the summer months, prospect examinations were made on a potential porphyry copper deposit in the Healy D-1 quadrangle, a potential massive sulphide deposit in the Fairbanks A-1 quadrangle, and an offshore gold placer deposit near Ketchikan.

The Conservation section is also charged with administering the regulatory provisions of Alaska Mine Safety Code for coal, metal, and nonmetallic mining. (Twelve coal-mine safety inspections and seven metal-mine inspections were completed in 1973.) In addition, safety precautions on all underground construction activities are inspected. The capability to detect toxic and explosive gases, to measure air flow, and to detect working areas with oxygen deficiencies is maintained to ensure proper health standards in mining and in underground construction.

Specific commodities that occur in the State's inventory of natural resources were studied---including coal fields from Palmer to Healy. Another study on tin is currently in progress to determine both the availability of the metal in the state and the chance for increased production. Alaska is the only state that produces tin other than as a by-product from other mining.

In a continuing effort to conserve and stimulate resource development in Alaska, the Conservation section has prepared and published review articles in national mining journals.

Labor affidavits from the Division of Lands on offshore prospecting permits and coal prospecting permits are inspected to determine if the requirements of the law have been met. The use of those lands with a mineral potential or subject to mineral leasing is reviewed. All State lands near potentially economic coal deposits are reviewed to determine if the land should be reserved for mining or if a conflict of interest would arise if the land were otherwise used. All lease-mineral mining programs are reviewed---particularly coal mining---to ensure that adequate provisions are made for conservation of the natural resource and that the land will be returned to a condition that is in harmony with the natural environment. An example of successful reclamation is the Healy area, where in 1973 approximately 600 acres of disturbed coal lands were seeded with grass. The grass has dramatically improved the habitat for wild game in the mining area, particularly for the sheep that winter there. Another example is the Hogatza River gold placer area, where UV Industries reported reclaiming 32 acres of dredged-over tailings land.

The Conservation Section assists the Compliance and Industrial Hygiene section of the Department of Labor in such functions as destruction of old explosives and detection of explosive gases and mercury vapor. The DGGS gas-detection capability is available on request.

EXPLORATION

Hard-mineral investigations took place at about the same pace as in 1972. The major oil companies continued to dominate exploration in the lesser known areas of the state, and the major mining companies concentrated on the known potential mining areas. Physical exploration was limited mainly to diamond drilling, with very little drifting or shaft sinking to explore new ore bodies. As in 1972, the primary effort was directed toward deposits containing copper, nickel, coal, and iron in quantities large enough for surface mining.

The increase in the price of gold revived the interest of individual prospectors, who were active in all parts of the state. However, exploration was adversely affected by the uncertainties in land status and requirements of various environmental protection agencies. The number of new mining claims filed in 1973 was 5,920, compared to 6,581 in 1972. The number of affidavits of labor was 1,170 for 1973, versus 1,089 for 1972. The active claims in the state increased from 23,726 in 1972 to 26,580 in 1973.

The DGGS Fairbanks office maintains a list of Alaskan companies and prospectors considered to be active in 1973. This list is available as Information Circular 7 and may be obtained on request.

The total expenditure for hard minerals in Alaska in 1973 is estimated at $6.5 million, the same as for 1972 (fig. 15). In addition, about $400,000 was expended on coal exploration. A regional breakdown of exploration expenditures is given below.

ARCTIC ALASKA

Approximately $500,000 was expended on mineral exploration in Arctic Alaska. Bear Creek Mining continued its effort to increase reserves by diamond drilling on its copper properties near Arctic Camp, in the Kobuk area. Placid Oil, Cities Service, Humble Oil, and Sunshine Mining continued reconnaissance exploration throughout the Arctic region. Little Squaw Mining reactivated its camp near Chandalar and initiated a geochemical exploration program along the known gold veins in this historic area.

WESTERN ALASKA

The estimated expenditure on mineral exploration in Western Alaska was $2 million, slightly less tnan in 1972. Of this, the major portion was expended by Lost River Mining in diamond drilling of the fluorite-tin deposit at Lost River, approximately 90 miles northwest of Nome. During the summer months, an additional 10,000 feet of drilling was completed to test other known zones in the immediate vicinity of Lost River and to increase the ore reserves. A 100-ton bulk sample was shipped for additional metallurgical testing. A revised feasibility report will be completed in the spring of 1974.

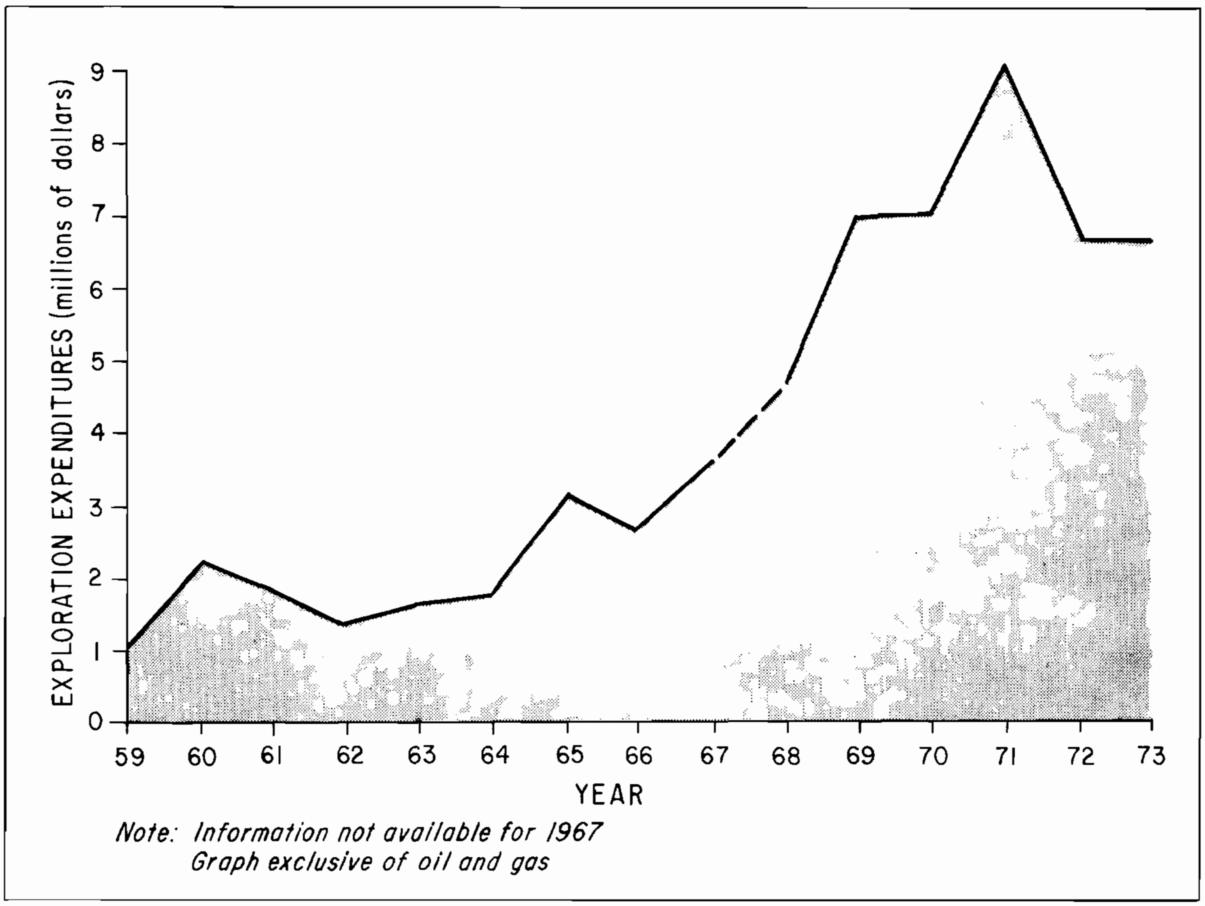


FIGURE 15. Estimated exploration expenditures in Alaska

Rhinehart Berg continued exploration at the old Independence property on the Kugruk River. Exploration consisted of drifting along a limestone-schist contact. The objective was a complex lead-zinc-silver ore. Berg also increased exploration for placer gold in the old Candle area and started excavation and refloating his No. 14 dredge. He expects to drill a thaw pattern, by which it would be possible to reactivate the dredge and start dredging gold in the summer of 1974.

Other activities continued, including some not aimed at gold exploration.. In the Nome area, American Smelting and Refining (ASARCO), in a contract with the Institute of Marine Science of the University of Alaska, initiated a program to determine environmental effects of offshore undersea gold-placer mining. Also, UV Industries initiated an experimental program with a rotary drill with tricone bits to drill a thaw pattern immediately ahead of the No. 6 dredge, just beyond the Nome airport on the submarine-beach placer ground. In addition to the rotary drill, a new churn drill was shipped into the area to be used in exploring and extending the known reserves. UV Industries reportedly has a reserve of more than a million ounces of gold in the Nome placer deposits.

Placid Oil conducted a reconnaissance program in the central Seward Peninsula. Other activity included offshore exploration for platinum deposits in the Goodnews Bay area.

INTERIOR ALASKA

Expenditures for exploration in Interior Alaska were estimated at about $200,000, up from those of 1972. The activities were generally well-scattered throughout the Interior, with some concentration around known deposits. The main expenditure was $200,000 for improving the camp and initiating a drilling program on an attractive tin prospect known as Purkey's prospect, in the Talkeetna D-5 quadrangle. B.J. Blair completed 2,700 feet of diamond drilling on the old Liberty Bell property near Ferry. Inspiration Consolidated Copper completed a drilling program on coal beds in the Marguerite Creek area of Healy. Rio Algom–Rio Tinto conducted a reconnaissance in parts of the Nabesna. Gulkana, Mount Hayes, and Tanacross quadrangles, and about 4,000 feet of drilling was reportedly completed in the Slana area. American Exploration was again in the Fortymile area. Resource Associates drilled 2,000 feet in an area northeast of Tok.

Considerable interest was shown in exploration completed on the antimony prospect near My Creek, northwest of the old mining area of Chicken. Other companies reportedly maintaining exploration field parties in the Interior were Humble Oil, Chevron Oil, Cypress Mining, and Newmont Mining.

SOUTH-CENTRAL ALASKA

J.L. Wilson, an agent for Geneva-Pacific, continued an active exploration program in the McCarthy area---the lone exception to the prevalent diamond drilling. Geneva-Pacific drove a drift for 330 feet along a vein of chalcocite ore. Inexco again entered the McCarthy area, completing approximately 6,000 feet of diamond drilling on geophysical anomalies.

Exploration was completed on gold properties in an area immediately southwest of Chitina. Ranchers Development completed exploration for copper and placer gold along Slate Creek, a tributary of the Chistochina River.

There was considerable activity on placer gold prospects in the Valdez Creek area, east of Cantwell. Cities Service was again active in the Talkeetna Mountains, and Homestake Mining based a party at Valdez and examined old copper prospects that had been active between 1900 and 1914. Homestake also carried out a regional appraisal of the state, presumably in anticipation of future programs.

SOUTHWESTERN ALASKA

There was no known exploration for hard minerals in Southwestern Alaska in 1973. However, Cities Service, Humble Oil, American Oil, Texaco and Standard Oil of California all maintained active helicopter-supported geological field crews in the area of Cold Bay. This work was regarded primarily as exploration for oil, but effort may have been directed toward the hard minerals.

SOUTHEASTERN ALASKA

Southeastern Alaska continued to host the most important exploration activities in the state, and Ketchikan was the center. There were several diamond-drilling projects within a 100-mile radius of town, the main areas of interest being on the mainland near Texas Creek and Prince of Wales Island. Phelps Dodge reportedly continued its prospecting and drilling on Coronation Island, west of Prince of Wales. Alaska Metals, Ltd., continued to drill their Red Rock silver claims on Admiralty Island. El Paso Natural Gas maintained an office with geological staff and geochemical laboratory in Ketchikan, their major effort of exploration was directed towards a porphyry copper. American Oil completed a geochemical survey of parts of Gravina Island.

The major drilling program in Southeastern Alaska was one undertaken by the Inspiration Development Company of Inspiration, Arizona to further delineate and improve ore reserves of the nickel deposit on Yakobi Island. Other active groups in the area were Inlet Oil, Alaska Petroleum & Mining, U.S. Borax, Humble Oil, Newmont Mining, Utah International, and Resource Associates.

The iron deposit at Klukwan continued to attract interest. Dresser Industries, a newcomer to the state, showed interest in locating a new barite deposit.

MINERAL PRODUCTION

Value of total mineral production in Alaska is estimated at $294 million, compared to a revised estimate of $286 million in 1972. The revised estimate is based on statistics compiled by the U.S. Bureau of Mines. Crude oil and natural gas from the Kenai Peninsula and offshore Cook Inlet field once more were the leading commodities, accounting for $261 million, or 89%, of the total mineral production. Other mineral commodities in order of value were: sand and gravel, coal, stone barite, gold and silver, platinum-group metals, antimony, mercury, gemstones, and tin.

Alaska's 1973 mineral production, excluding oil and gas, was estimated at $33 million. This is a decline of 28% over the adjusted figure of $46 million in 1972 (fig. 16). The principal decrease was in the undistributed section, which included uranium, gemstones, mercury, platinum-group metals, and tin. Part of the decline can be attributed to two factors: a) there was no uranium mined in 1973, and b) the 1972 figure represented some uranium mined in 1971.

Statistics shown in table 3 were prepared under cooperative agreement between DGGS and the U.S. Bureau of Mines for the collection of mineral data. Production of the major commodities since 1950 is listed in table 4. The fiscal amount of Alaska mineral production is listed in table 5. The production figures for 1972 are revised on the basis of information collected by the U.S. Bureau of Mines, and are the best estimate of production for the year; the coal and barite figures are DGGS estimates.

Annual production in Alaska (excluding oil and gas) from 1900 through 1972 is illustrated in figure 16. Plate 2 indicates the approximate location of mineral deposits that were in production at least part of the year and deposits where there was an active exploration program. There undoubtedly were prospectors and miners active in other areas, and the figure should be considered at a minimum. Sand, gravel, and stone deposits were omitted.

PRECIOUS METALS

GOLD

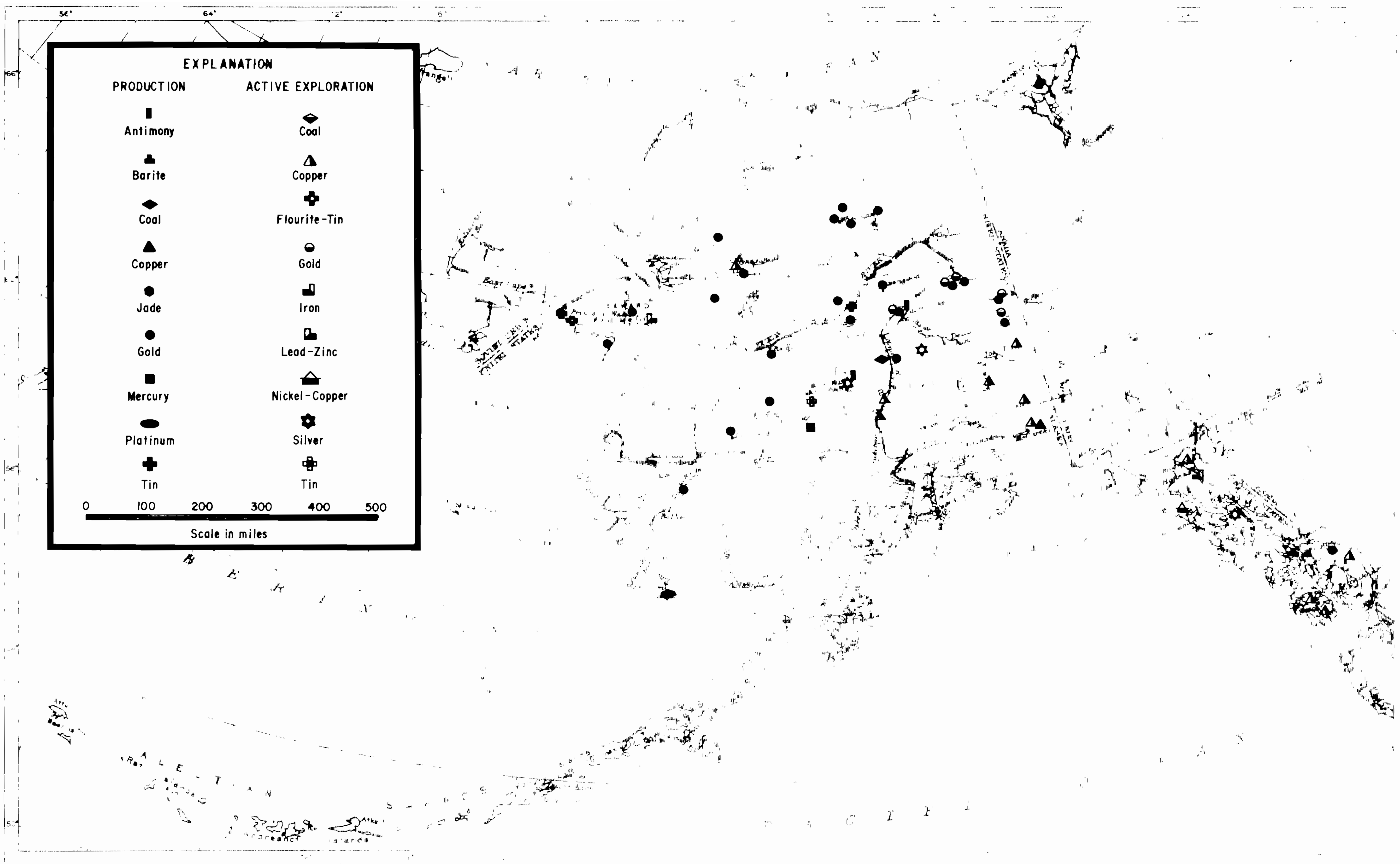
The total volume of gold production in 1973 increased. The increase was primarily from small producers, for whom production figures are sometimes unattainable.

UV Industries continued operating its dredge on

TABLE 3. *Mineral production in Alaska (Value columns in thousands of dollars)*

Mineral	1972		1973 [a]	
	Quantity	Value	Quantity	Value
Antimony - short-ton antimony content	80	28	210	108
Barite - thousand short tons	b	b	112	1,792
Coal - thousand short tons	b	b	700	6,230
Gold - troy ounces	8,639[c]	506	15,000	1,875[c]
Stone - thousand short tons	652	3,012	700	3,234
Natural Gas - million cubic feet	126,887	17,989	128,700[d]	20,592[d]
Petroleum, Crude - thousand barrels	73,560	221,747	72,730[d]	240,009[d]
Sand and Gravel - thousand short tons	14,187	15,214	19,350	19,010
Silver - thousand troy ounces	> 1	> 1	2.4	6
Undistributed	e	13,442	e	1,405
TOTALS	XXX	286,138	XXX	294,261

a. Figures for 1973 are preliminary and subject to revision.
b. Figures withheld to avoid disclosing confidential data of individual companies.
c. The gold production estimated from information from producers in various districts. Many individual producers did not respond to U.S. Bureau of Mines questionnaires.
d. Gas and petroleum figures differ from those published by the Division of Oil and Gas because of different methods of compiling and reporting. For complete details on fields, wells, etc., see the Division of Oil and Gas Annual Report.
e. Includes uranium, gemstones, mercury, platinum-group metals, and tin. Figures withheld to avoid disclosing confidential data of individual companies.


EXPLANATION
PRODUCTION
ACTIVE EXPLORATION
Antimony
Coal
Barite
Copper
Coal
Flourite-Tin
Copper
Gold
Jade
Iron
Gold
Lead-Zinc
Mercury
Nickel-Copper
Platinum
Silver
Tin
Tin
0
100
200
300
400
500
Scale in miles

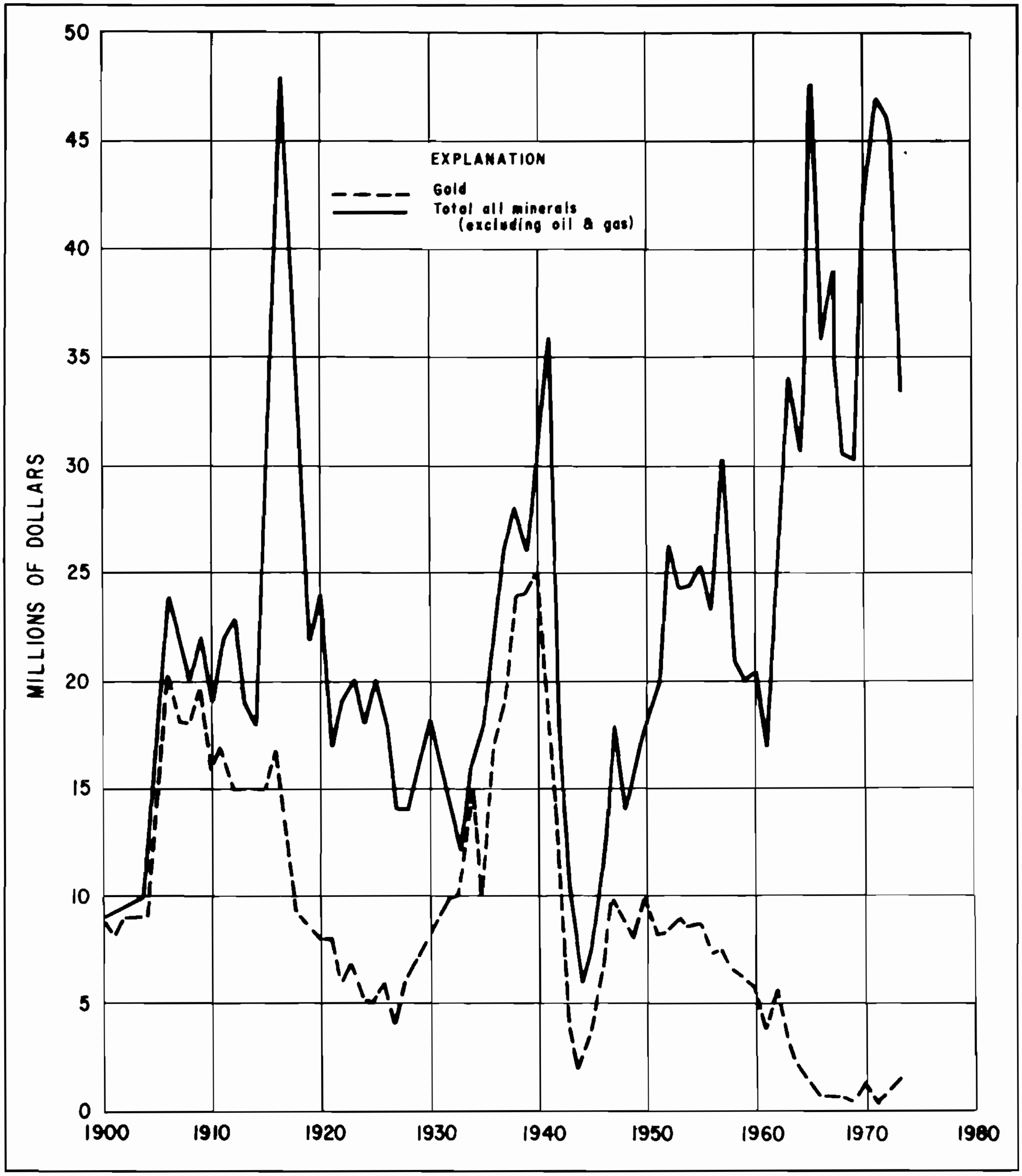


FIGURE 16. Annual mineral production in Alaska, 1900-1973

TABLE 4. *Production of major commodities, 1950-1973*

Year	Gold*	Mercury*	Coal*	Oil, Gas*	All Production, Total ($ million)
1950	10,125	-	3,033	-	17.9
1951	8,387	-	3,767	-	19.5
1952	8,420	6	5,779	-	26.3
1953	8,882	8	8,452	-	24.3
1954	8,699	277	6,442	-	24.4
1955	8,725	12	5,759	-	25.4
1956	7,325	853	6,374	-	23.4
1957	7,541	1,349	7,296	-	30.2
1958	6,525	774	6,931	-	20.9
1959	6,262	851	6,869	311	20.5
1960	5,887	940	6,318	1,496	21.9
1961	3,998	816	5,868	17,776	34.7
1962	5,784	711	6,409	31,657	54.2
1963	3,485	76	5,910	33,760	67.8
1964	2,045	95	5,008	35,490	66.1
1965	1,479	104	6,095	35,614	83.2
1966	956	101	6,953	50,418	86.3
1967	803	79	7,178	95,455	134.6
1968	835	78	5,034	191,083	221.7
1969	881	100	4,647	227,129	257.6
1970	835	1,260	4,059	279,132	338.2
1971	537	285	5,710	286,977	332.8
1972	910	44	5,696	239,736	286.1
1973	1,875	30	6,230	260,601	294.3
Total	111,326	8,805	141,817	1,786,635	2,512.3

*Values in thousands of dollars.

TABLE 5. *Physical volume of Alaska mineral production*

Mineral	Units	Quantity
Antimony, 1928-73	Short tons (approx. 53% Sb)	4,390
Coal, 1951-73	Short tons, thousands	24,255
Copper, 1880-1973	Short tons	690,035
Chromite, 1917-57	Long tons (approx. 45% Cr_2O_3)	29,000
Crude petroleum, 1958-73	42-gallon bbls, thousands	542,719a
Gold (total), 1880-1973	Troy ounces	30,045,901
Lead, 1906-73	Short tons	25,028
Mercury, 1902-72	76-lb flasks	29,224
Natural gas, 1948-73	Cubic feet, millions	742,981
Sand and gravel, 1958-73	Short tons, thousands	265,819
Silver (total), 1906-73	Troy ounces	19,082,518
Stone, 1921-73	Short tons, thousands	24,036
Tin, 1902-73	Short tons	2,464b
Tungsten, 1916-58	Short-ton units (WO_3)	7,000

a. The only other crude petroleum production recorded was from the Katalla area (about 154,000 barrels of oil, 1901-32).
b. Production data (if any) withheld in 1969-70.

Hogatza River. Ernest Wolff and Associates refloated the dredge on Coal Creek and were in production by the end of the season. Other producing areas were Marvel Creek, Flat, Livengood (p. 9). Manley Hot Springs, the Seward Peninsula, Fortymile, Boundary, Wiseman, and Ruby. The primary operators on the Seward Peninsula continued to be the Tweet Brothers, who operate a dredge on the Kougarok River. There was no known lode production during the year; however, Ptarmigan Exploration was actively reworking the old tailings of the Nabesna mine, and a small mine in the Willow area was opened.

PLATINUM

The Goodnews Bay Mining Company continued to operate its floating dredge and a sluicebox on the Salmon River. The volume of mineral produced was about the same as 1972. Minor amounts of platinum were produced by a few small gold placer operations.

MAJOR BASE METALS

COPPER

One mine in the McCarthy area reportedly produced 400 tons of copper ore. The ore was chalcocite, and about 200 tons of copper will be produced. As of the first of the year, only one truckload of ore had been removed from the mine to the highway for shipment. The ore was produced by selectively sorting chalcocite containing 50%-60% copper while driving 330 feet of drift. Additional ore was recovered by hand-sorting from the old exploration drift dumps.

The ASARCO Smelter in Tacoma was unable to take Alaskan ores because of environmental pollution controls.

LEAD

One operator in the southern part of Fairbanks quadrangle shipped approximately 14 tons of silver-bearing lead ore, mined in 1972, to the smelter at Helena, Montana. A small amount of production continued in this area, but no further plans for shipping ore were made. An operator in the Kantishna district produced several hundred tons of ore during the summer months while sinking a preliminary production shaft. The ore was milled at a concentrator about 1 mile from the mine. The total lead production for the year is estimated at 10 tons.

TIN

Production continued from a tin placer operation near Tin City. Also, minor amounts of tin were recovered from gold placer operations near Manley Hot Springs.

MINOR BASE METALS

MERCURY

Although the price of mercury increased from $150 to nearly $300 per flask in 1973, there was very little activity. Robert Lyman continued mining and operating a small concentrator of cinnabar ore at White Mountain, southeast of McGrath. There was some exploration near Sleetmute, but no known production.

ANTIMONY

With an increase in the price of antimony during the summer, a renewed interest was shown in the mining of this metal. Producing antimony for shipment were at least three operators from the Kantishna area and two from the Fairbanks area. There was continued activity of mining of antimony in the Fortymile district, but no shipments were known.

INDUSTRIAL MINERALS - BARITE

Alaska Barite, a subsidiary of Inlet Oil, continued operating the underwater open-pit mine near Castle Island, about 12 miles southeast of Petersburg. A feasibility study was made on moving the mill from Kenai to Castle Island and restricting the operation to providing a finished ground-barite product for drilling mud. This would maintain about the same dollar value for the output from the mine, but would considerably reduce the barite tonnage.

COAL

There was only one coal producer in Alaska during 1973---the Usibelli mine near Healy. The production and consumption of coal continued at about the same level as in 1972, with the Healy field supplying most of the fuel for generation of electrical power in the Fairbanks area. Although the major mining effort was moved from Healy Creek to Lignite Creek, the same tipple and shipping facilities continued to be used.

Making camp by track vehicle, Valdez Creek Valley, central Alaska.

PROGRAMS PLANNED FOR 1974

BROOKS RANGE PROJECT

The data from the field investigations are currently being analyzed. This includes petrographic studies, assays of mineralized rock samples, and submittal of samples for age-dating. The results of the geochemical sampling program are being prepared for release in open-file format. Geologic maps are also being prepared for release; these maps, now scaled 1 inch to 1 mile, will eventually be compiled at a scale of 1 inch to 4 miles.

DGGS plans to continue participation in geologic investigations in the Brooks Range with the USGS. The data from the 1973 field season is currently being studied by geologists from both the DGGS and the USGS, and publication of results will be handled through the facilities of both surveys.

STATEWIDE ORE DEPOSITS STUDY

Future work by T.E. Smith will emphasize statewide aspects of metallization. Subject to budget approval, Smith plans a comprehensive program to investigate the temporal distribution of Alaska ore deposits. This work, to be carried out in collaboration with D.L. Turner, will initially apply potassium-argon and fission-track methods to the dating of alteration assemblages from hydrothermal deposits.

FURTHER ZEOLITE STUDIES

A few samples of tuff collected by Hawkins during 1973 from the Tertiary volcanics at the head of Caribou Creek, upper Matanuska Valley, were not zeolitized. However, vesicular volcanics associated with the tuffs were zeolitized, suggesting that there may be local areas of zeolitization in the extensive tuff deposits of the area. Prospecting for zeolites in the silicic volcanics at the head of Caribou Creek and in the volcanics of the Talkeetna formation in the area between the upper parts of the Oshetna and Little Oshetna Rivers is planned for the summer of 1974.

In addition, several proposed studies to evaluate the gas-sorptive properties and ion-exchange properties of the zeolites of the Sheep Mountain and Horn Mountains area have been prepared by Hawkins and submitted to various funding agencies.

GEOPHYSICS

AEROMAGNETIC

The aeromagnetic program in 1974 is scheduled to be flown in the Brooks Range mineral belt. The program will be used to assist in the planning and selection of State lands, to aid in determining the mineral potential of the area, and to provide basic data to be used by the joint USGS-DGGS Brooks Range field project team in 1974.

The DGGS will also continue the magnetic susceptibility studies began in 1973. This is a long-range program to establish a magnetic-susceptibility data base throughout the state.

SEISMIC

DGGS personnel are periodically requested to regulate and monitor core-hole drilling in offshore areas of Alaska. Seismic records of the locations, usually provided by the contractor, are interpreted to ensure that the proposed core holes will not be drilled in potential oil or gas zones.

RADIOMETRIC

As soon as the necessary equipment can be obtained, the DGGS intends to initiate a long-range program to obtain radiometric samples throughout the state. The program will be a part of various existing field projects in 1974.

FIELD PROGRAMS

TALKEETNA MOUNTAINS

A field mapping project with helicopter support is planned for the summer of 1974 in the Talkeetna Mountains Emphasis will be on completing the geology of the Anchorage D-5 quadrangle. A part of this program is a detailed examination of mineralized alteration zones in the east portion of the quadrangle.

THEODORE RIVER AREA

DGGS proposes to examine Kenai sediments northeast of the Beluga River. This program, involving about 10 days of field work, will be concentrated along the Theodore River on the west side of Cook Inlet. The primary objective will be to examine the Lower Kenai sediments and relate these sediments to those along the Beluga River. Support will include a contract helicopter for access and fixed-wing aircraft for the return trip.

YUKON-KANDIK AREA

A field program in the Yukon Flats--Kandik Basin area has been proposed for the summer of 1974. The program is in conjunction with a geologic study to determine land-use priorities of the area. The program will involve investigation of Tertiary sedimentation and age relationships, some geologic mapping, and a reconnaissance radiometric survey.

BRISTOL BAY BASIN

The DGGS will continue the resource evaluation program on the Alaska Peninsula. Efforts will be directed toward evaluating the oil and gas potential of Cenozoic and Mesozoic rocks. Reconnaissance geochemical sampling will be carried on simultaneously in the areas of intrusive and volcanic activity in search for mineralized zones.

COLD BAY AREA

Approximately 10 days will be spent sampling, mapping, and measuring unmapped Tertiary rocks in this area.

PORT MOLLER AREA

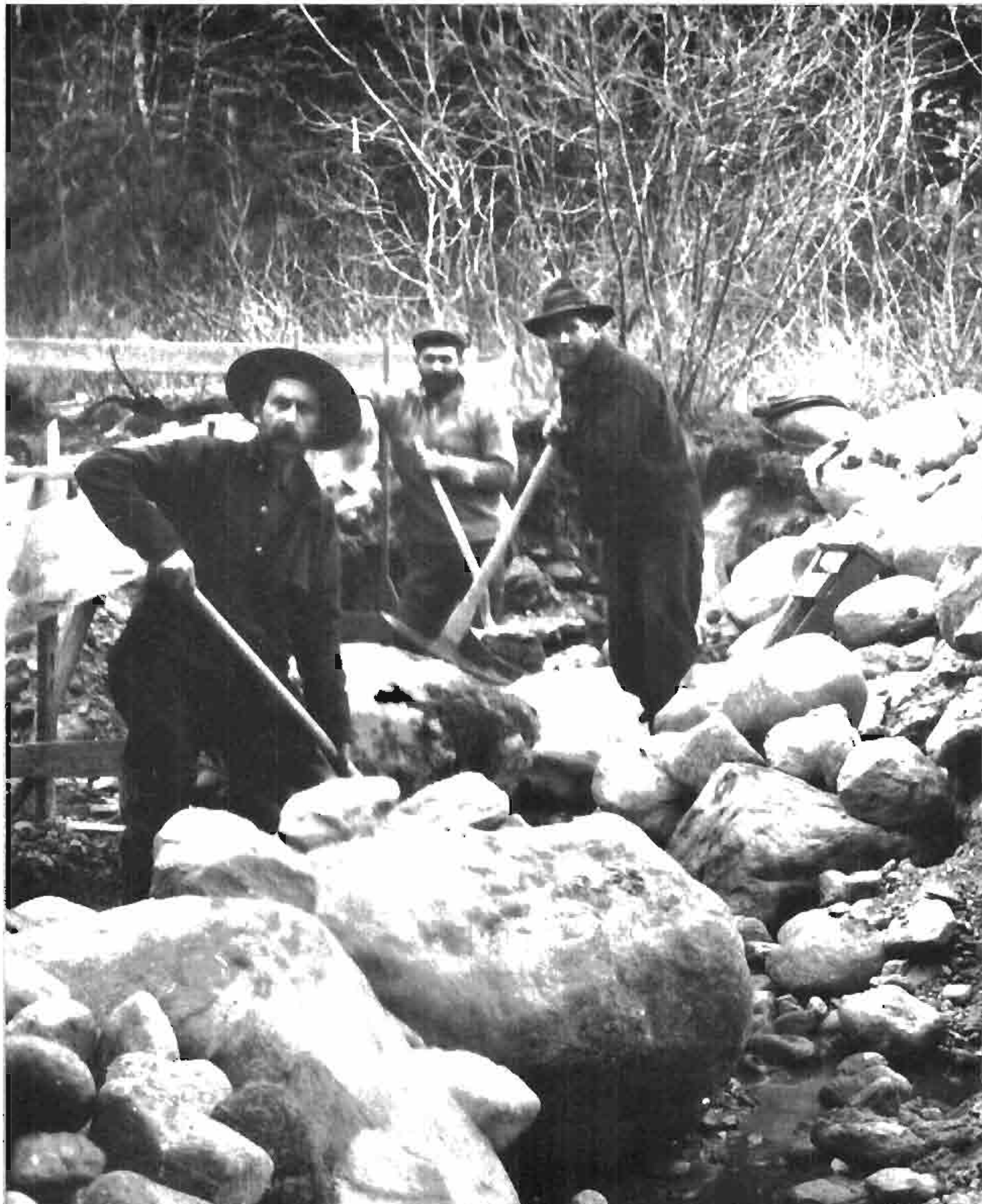
Thick early Tertiary sediments will be measured and sampled for oil and gas potential. (This is most of the Tertiary section not examined in 1973.)

CHIGNIK AREA

Reconnaissance geochemical sampling will be continued in the Black Lake and Warner Bay areas.

SHUMAGIN ISLANDS

Reconnaissance geochemical sampling of a part of the Shumagin Islands will be initiated if weather conditions and time permit.



Gold miners working Lemon Creek, Juneau quadrangle, about 1890. (Photo courtesy of Winter-Pond collection)

PUBLICATIONS

DGGS publications available to the public are the following:

- Annual and Biennial Reports, 1912-1972
- Information Circulars
- Miscellaneous Papers
- Geologic Reports
- Geochemical Reports
- Open-File Reports
- Special Reports
- Laboratory Notes
- Bibliographies
- Papers Given at National Conferences
- DGGS Contributions to National Publications

There is a $1.00 charge for the Geologic, Geochemical, and Special Reports. The Bibliographies are also $1.00, unless otherwise noted. The Open File reports are available solely through commercial printers, and vary in price. All other publications (except those designated Out of Print) are available free of charge.

ANNUAL AND BIENNIAL REPORTS, 1912-1972

* Report of the Mine Inspector for the Territory of Alaska to the Secretary of the Interior, 1912

* Report of the Mine Inspector for the Territory of Alaska to the Secretary of the Interior, 1913

* Report of the Mine Inspector for the Territory of Alaska to the Secretary of the Interior, 1914

* Report of the Territorial Mine Inspector to the Governor of Alaska, 1915

* Report of the Territorial Mine Inspector to the Governor of Alaska, 1916

* Report of the Territorial Mine Inspector to the Governor of Alaska, 1917

* Biennial Report of the Territorial Labor Commissioner to the Governor of Alaska, 1919-1920

* Annual Report of the Territorial Mine Inspector to the Governor of Alaska, 1920

* Annual Report of the Territorial Mine Inspector to the Governor of Alaska, 1921

* Biennial Report of the Territorial Labor Commissioner to the Governor of Alaska, 1921-1922

* Annual Report of the Mine Inspector to the Governor of Alaska, 1922

* Annual Report of the Mine Inspector to the Governor of Alaska, 1923

* Out of print. On file at DGGS Fairbanks office (p. 2) and at certain public and university libraries.

° Report upon Industrial Accidents Compensation and Insurance in Alaska, 1924

° Report of the Territorial Mine Inspector, 1925-1926

° Report of Cooperation between the Territory of Alaska and the United States in Making Mining Investigations and in the Inspection of Mines, 1929

° Report of Cooperation between the Territory of Alaska and the United States in Making Mining Investigations and in the Inspection of Mines, 1931

° Report of the Commissioner of Mines to the Governor, 1936

° Report of the Commissioner of Mines to the Governor, 1938

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° Report of the Division of Mines and Minerals, 1966

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Report of the Division of Mines and Minerals, 1968

Report of the Division of Mines and Minerals, 1969

° Annual Report of the Division of Geological Survey, 1970

° Annual Report of the Division of Geological Survey, 1971

Annual Report of the Division of Geological and Geophysical Surveys, 1972

INFORMATION CIRCULARS

No. 1. *Proper Claim Staking in Alaska*, Revised November 12, 1970

No. 2. *Mineral Rights of Aliens in the State of Alaska*, Revised March 1, 1968

No. 3 *Hand Placer Mining Methods*, Revised March 5, 1968

No. 4 *Uranium Prospecting in Alaska*, Revised March 7, 1968

No. 5 *General Alaskan Mineral Information*, Revised July 8, 1971

No. 6 *Alaska Prospecting Information*, Revised April 8, 1971

No. 7. *Alaskan Companies and Prospectors-1973*, November 27, 1972

No. 8. *Consultants Available for Work in Alaska*, Revised November 18, 1972

No. 9. *Alaska Rockhound Information*, Revised March 23, 1972

No. 10. *Skin Diving for Gold in Alaska*, Revised April 2, 1968

No. 11. *List of Reports Issued by the Division of Geological and Geophysical Surveys*, Revised November 16, 1973

No. 12. *Services of the Division of Geological Survey*, Revised July 8, 1971

No. 13. *Dangers in Old Mine Openings*, Revised November 6, 1972

No. 14. *Mining Laws Applicable in Alaska*, Revised February 25, 1971

No. 15. *A Prospectors Guide to the Sale and Lease of Mineral Properties*, Revised June 12, 1969

No. 16. *Alaska Map Information*, Revised September 29, 1972

No. 17. *Companies Interested in Alaskan Mining Possibilities*, Revised March 1, 1973

No. 18. *Amateur Gold Prospecting in Alaska*, November 15, 1973

MISCELLANEOUS PAPERS

No. 1 *The Great Alaska Earthquake, March 27, 1964:* May 19, 1964.

No. 2 ***Preliminary Results of Stream Sediment Sampling, Upper Maclaren River Area, South-Central Alaska,*** by Thomas E. Smith, Thomas C. Trible, and Donald R. Stein

-- *The Mineral Industry of the Kenai-Cook Inlet-Susitna Region, 1962*, by William H. Race

-- *Some High-Calcium Limestone Deposits in Southeastern Alaska*, Pamphlet 6, March 1946

GEOLOGIC REPORTS

No. 1 *Preliminary Report on Geologic Mapping in the Coast Range Mineral Belt*, by Gordon Herreid. This report was formerly included in Annual Report of the Division of Mines and Minerals for the year 1962. Price $1.00

No. 2 *Bedrock Geology of the Rainbow Mountain Area, Alaska Range, Alaska; an M.S. thesis prepared by Larry G. Hanson of the University of Alaska in cooperation with the Division of Mines and Minerals, November 1963. Out of print*

No. 3 *Geology of the Portage Creek-Susitna River Area,* by Donald Richter, 1963 (2 large sheets). Out of print.

No. 4 *Geology and Mineral Deposits of the Denali-Maclaren River Area, Alaska,* by M.A. Kaufman, May 1964. (14 p. and map). Price $1.00 Out of print

No. 5 *Geology of the Niblack Anchorage Area, Southeastern Alaska,* by Gordon Herreid, May 1964. Out of print

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No. 7 *Geology of the Dry Pass Area, Southeastern Alaska,* by Gordon Herreid and M.A. Kaufman, June 1964. (16 p.). Price $1.00

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No. 12 *Geology of the Bear Creek Area, Seward Peninsula, Candle Quadrangle, Alaska,* by Gordon Herreid, May 1965 (15 p. and maps). Out of print

No. 13 *Geology and Geochemical Investigations near Paxson, Northern Copper River Basin, Alaska,* by A.W. Rose and R.H. Saunders, June 1965. (35 p.) Price $1.00

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No. 15 *Geology and Mineralization of the Midas Mine and Sulphide Gulch Areas near Valdez, Alaska,* by A.W. Rose, March 1965. (21 p., map, and tables). Price $1.00

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GEOCHEMICAL REPORTS

No. 1. *Geochemical Investigations of Selected Areas in Southeastern Alaska, 1964,* by C.F. Herbert and W.H. Race, November 1964. (27 p., numerous tables and maps). Out of print. Has been mostly included with the 1965 work in Geochemical Report No. 6 and partly in Geologic Report No. 17.

No. 2. *Geochemical Investigation of the Slana District, Southcentral Alaska, 1963 and 1964,* by D.H. Richter, March 1965. (14 p. and map). Out of print

No. 3. *A Geochemical Investigation in the Richardson Area, Big Delta Quadrangle, Alaska,* by R.H. Saunders, April 1965. (11 p. and maps). Out of print

No. 4. *Geochemical Investigation of Selected Areas in Southcentral Alaska, 1964,* by M.W. Jasper, May 1965. (31 p., map, and tables). Price $1.00

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Sup. No. 17 *A Geochemical Investigation of the Wood River-Tikchik Lakes Area, Southwestern Alaska,* by G.R. Eakins, March 1969. (3 p., table and figures). No charge

No. 18. *Geology and Geochemistry of Part of the Iron Creek Area, Solomon D-6 Quadrangle, Seward Peninsula, Alaska,* by R.R. Asher, April 1969. (18 p, and Appendix). Price $1.00

No. 19. *Preliminary Geochemistry and Geology, Little Falls Creek Area, Talkeetna Mountains Quadrangle, Alaska,* by R.E. Anderson, March 1969. (16 p., map, and tables). Price $1.00

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No. 23 *Geochemistry and Geology, Boundary Area, Fortymile District Eagle A-1 Quadrangle, Alaska,* by R.R. Asher, September 1970. (32 p., maps and tables). Price $1.00

A Geochemical Investigation in the Eagle A-1 Quadrangle, Fortymile District, Alaska, by R.R. Asher, May 1970. (4 p., map and tables). No charge

No. 24 *Analyses of Rock and Stream-Sediment Samples, Hetta Inlet Area, Prince of Wales Island, Craig Quadrangle, Alaska,* by Gordon Herreid, November 1971. (map and tables). Price $1.00

No. 25. *Analyses of Rock and Stream Sediment Samples, Wild Lake Area, Wiseman Quadrangle, Arctic Alaska,* by E.R. Chipp, 1972. (map and table). Price $1.00

No. 26. *Analyses of Rock and Stream Sediment Samples, Mt. Hayes A-6 Quadrangle, South-Central Alaska,* by Thomas E. Smith, Thomas C. Trible, and Donald R. Stein (map and table). Price $1.00

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