State of Alaska
Department of Natural Resources
Division of Geological and Geophysical Surveys
ENERGY RESOURCES SECTION
3001 Porcupine Drive
Anchorage, Alaska 99501

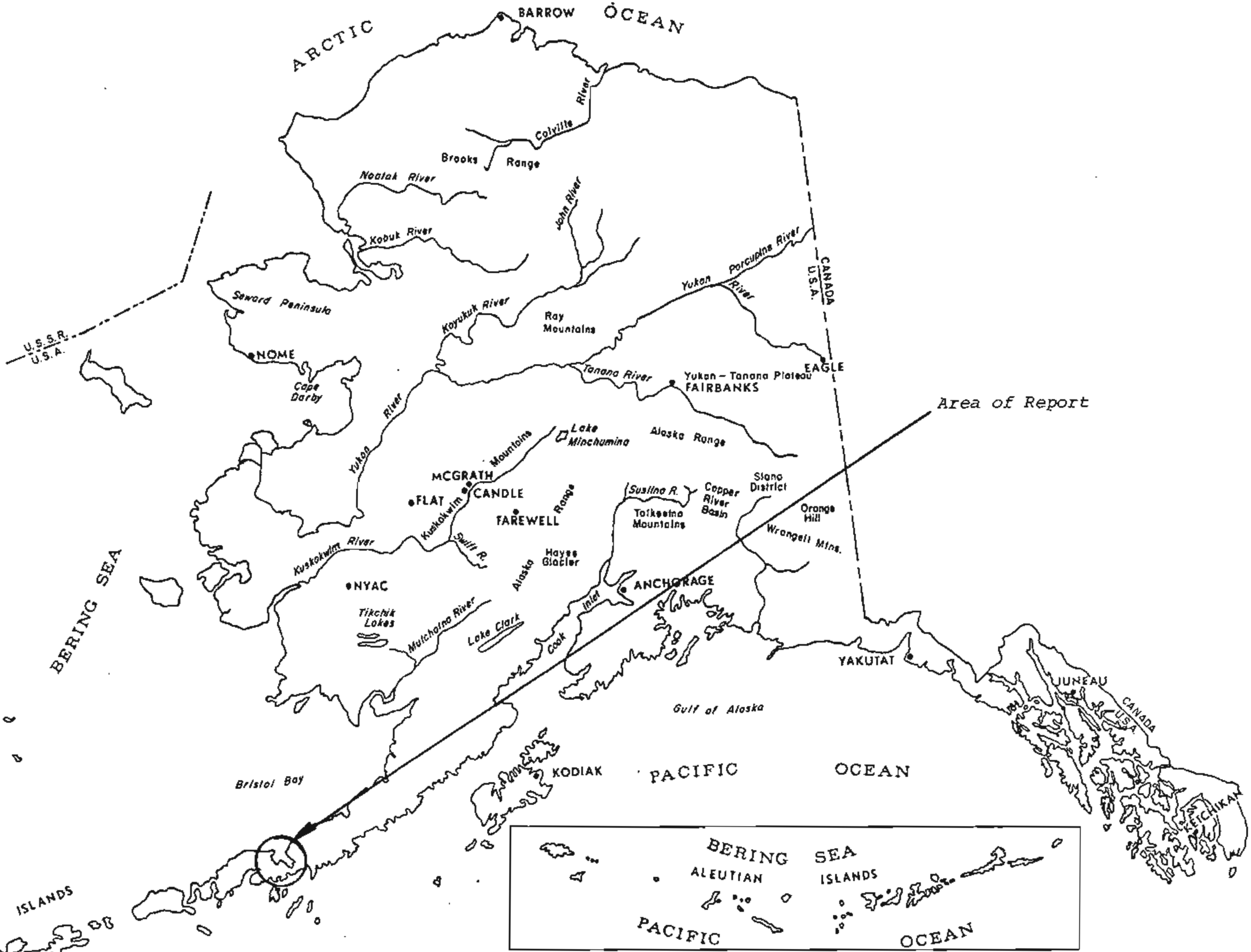
This report is preliminary and has not been edited or reviewed for conformity with Alaska Geological and Geophysical Surveys standards.

Alaska Open File Report #48

Geologic Evaluation of the Herendeen Bay Area, Alaska Peninsula

By W. M. Lyle and P. L. Dobey

October 1974



Location Map

TABLE OF CONTENTS

APPENDICES

TABLE

ILLUSTRATIONS

Preliminary Report

GEOLOGIC EVALUATION OF THE HERENDEEN BAY AREA, ALASKA PENINSULA

INTRODUCTION

This study was initiated to evaluate the oil, gas and mineral potential of a portion of the Alaska Peninsula. Reconnaissance geologic exploration was carried out in the Herendeen Bay area, Port Moller quadrangle, and in the Bear Lake- lack Lake area of the Chignik quadrangle in 1973. This report covers the results of the 1973 work in the Herendeen Bay area. The 1973 portion of the project was completed from an inflatable raft using fixed-wing (Cessna 180 on floats) support for camp moves.

Reconnaissance work will be carried out in the Cold Bay-Morzhovoi Bay area and in the balance of the Herendeen Bay and Bear Lake-Black Lake area in 1974.

CONCLUSIONS

Due to the limited nature of the 1973 project, the conclusions should be viewed with caution until the 1974 work has been completed. The following anomalies were studied: Over 400 feet of highly petroliferous sands were measured and described in the Cretaceous-Jurassic Staniukovich formation, and one lead and one zinc geochemical anomaly were located in the Herendeen Bay area. Additional field work will be completed in 1974 to further evaluate these leads.

ACKNOWLEDGEMENTS

M. W. Henning completed the petrographic analyses of the samples.

REGIONAL GEOLOGY

Rocks as old as Late Jurassic are widespread on the Alaska Peninsula. Older rocks occur in isolated exposures at Puale Bay and in the vicinity of Lake Iliamna at the base of the peninsula (Burke, 1965, p. 17).

Marine Middle Permian fossils have been documented in limestone strata at Puale Bay. Post-Permian rocks at Puale Bay consist of a fossiliferous Upper Triassic limestone conformably overlying mafic volcanic flows, breccias, and tuffs which are also considered to be of Triassic age. A section of Lower Jurassic sediments and volcanics overlies the Triassic limestone on the northeast Alaska Peninsula, and these in turn overlie, locally, quartzose gneiss and schists that have been considered by some to be of Precambrian age. This age is questionable, as Burk (1065, p. 17) contends, and is more probably Permian to Early Mesozoic (Burk, 1965, p. 11). By Early Jurassic, volcanism had subsided and intrusions of the hornblende-biotite granite of the Naknek Lake Batholith began. Uplift, associated with the intrusion of the batholith, caused the Lower Jurassic and older rocks to be eroded and redeposited as Middle Jurassic. Upper Jurassic and early Cretaceous sediments are dominantly composed of these eroded rocks. The coarse arkoses of the thick Naknek and Staniukovich formations (Oxfordian to Valanginian age) record this period of erosion (Wisehart, 1971, p. 15) on the northeastern Alaska Peninsula. Fine-grained sands and thin pebble conglomerates are dominant in these two units in the Herendeen Bay area. The Middle and Upper Cretaceous is not represented on the Alaska Peninsula by sedimentary rocks and marks a period of minor uplift and deformation. This period is recorded by an unconformity between Campanian and Neocomian to Kimmeridgian strata. Thick flysch sequences north of the peninsula in the Kuskokwim highlands and south on the Shumagin-Kodiak Shelf are of mid to upper Cretaceous age and more than likely contain debris derived from the Peninsula during the mid-Cretaceous hiatus. The Campanian and Maestrichtian rocks of the Alaska Peninsula, identified as the Chignik and Hoodoo formations, respectively, represent a transgressive sequence of renewed sedimentation following the hiatus. They are characterized by basal non-marine strata grading upward through marine sandstone into black marine siltstone and shale (Wisehart, 1971, p. 15).

Cenozoic Rocks

The Mesozoic sequence is conformably overlain by 28-30,000 feet of early to late Tertiary strata.

The Paleocene-Oligocene Beaver Bay Group was named by Burk in 1965. This unit can be divided into the underlying Paleocene-Eocene Tolstoi and overlying Oligocene Stepovak Formations. Only the Tolstoi is present in the Herendeen area.

The Miocene Bear Lake Formation (Burk, 1965) is estimated to be from 5,000 to possibly 10,000 feet thick. Non-marine sandstones, conglomerates, thin coals, and marginal marine conglomerate sandstones and claystones make up this formation.

REGIONAL STRUCTURE

The dominant grain of the major folds and faults trends sub-parallel to the long axis of the Alaska Peninsula. The northeast-southwest trending Bruin Bay fault, although not documented southwest of Ugashik Lakes, is the largest single structural feature on the Alaska Peninsula. It separates the Naknek Lake Batholith from the adjacent depositional sink by a high angle reverse movement (downthrown on the southeast). Numerous other sub-parallel faults with similar movements suggest the structural history of the Alaska

Peninsula as one of the differential vertical movements associated with plutonic intrusions.

Five principal periods of deformation affected the geology of the Alaska Peninsula. They occurred during Early Jurassic, Early Tertiary and Mid-Tertiary (associated with plutonism) and during the Mid-Cretaceous and Pliocene (broad gentle deformations unrelated to plutonism). The Pliocene deformation created the topographic and structural grain of the present Alaska Peninsula.

HERENDEEN BAY PROJECT

Reconnaissance geologic and geochemical exploration was undertaken in the area of Herendeen Bay on the Alaska Peninsula (plate I). Five measured sections were sampled and described in detail (plate III). Rocks of reported Tertiary age were also sampled.

NAKNEK FORMATION (UPPER JURASSIC)

The oldest exposures in the Herendeen Bay area are the Jurassic Naknek Formation. The outcrops are composed of fossiliferous, dominantly marine, fine-grained sandstones with local small pods of fossils and pebble conglomerate. The sandstones are calcareous and exhibit poor to no effective porosity or permeability in outcrops. They are dominantly fine to very fine grained with large grain sizes limited to the local fossil and conglomerate pods.

STANIUKOVICH FORMATION (JURASSIC-CRETACEOUS)

The exposures of the Staniukovich Formation at Herendeen Bay are composed of light gray to gray-green, fine to very fine grained sandstone with low porosity. This unit has local small pods of conglomerate and fossil mollusks. The unit has a highly petroliferous odor throughout 400+ feet of measured section (see plate III).

CHIGNIK FORMATION (CRETACEOUS)

The Chignik Formation is at least 2500 feet thick and composed of mudstone, claystone, siltstone, sandstone, conglomerate, and coal. The unit has massive pebble to cobble conglomerate locally. The sandstones are gray to gray-brown in color and range from a few inches to over 100 feet thick. This unit is primarily non-marine stream channel, flood plain, and coal swamp deposits. The sandstones are more friable than the Jurassic sandstones and have low porosity in outcrop. About 30 feet of coal was measured in the Chignik section (plate III).

TACHILNI FORMATION (TERTIARY)

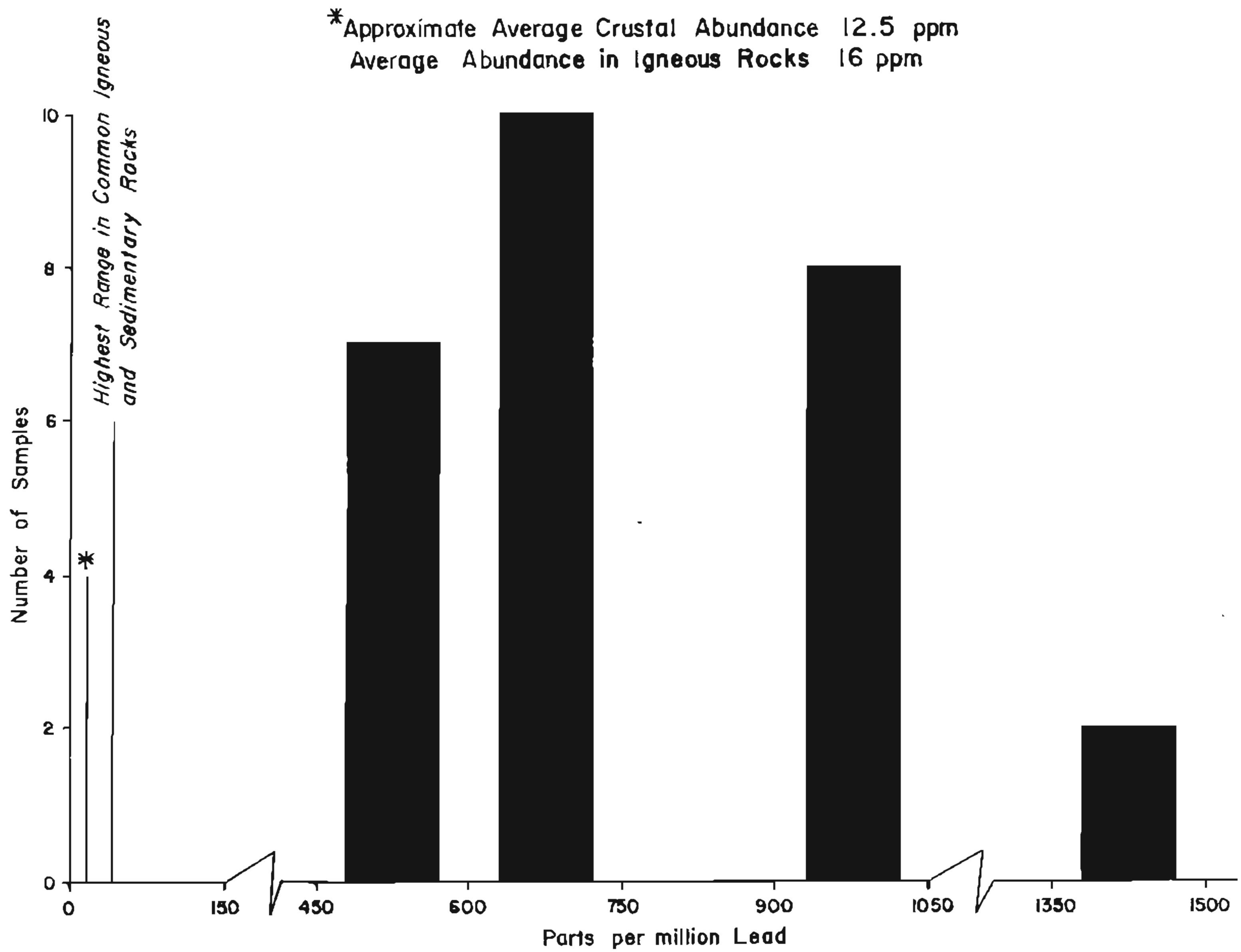
Beds mapped as Tertiary (Burk, 1956) were sampled and examined on the southwest side of Herendeen Bay. They are an alternating sequence of sandstones, siltstones, and thin coals. The sands are light gray to gray-green and weather light tan to rust color. They are fine to coarse-grained, poorly sorted and have poor to fair porosity. They are friable in outcrop and appear similar to the Kenai Group of the Cook Inlet. High angle cross-bedding, coals, channel-deposited sands and flood plain deposits indicate a non-marine environment.

TERTIARY INTRUSIVES

The Tertiary intrusive rocks (see Table 1) were not examined in detail in this area and will be described and sampled during the 1974 field season. Streams originating near one of the intrusive units in Portage Valley had high geochemical values of copper (see Table 1).

Table I
GEOCHEMICAL VALUES

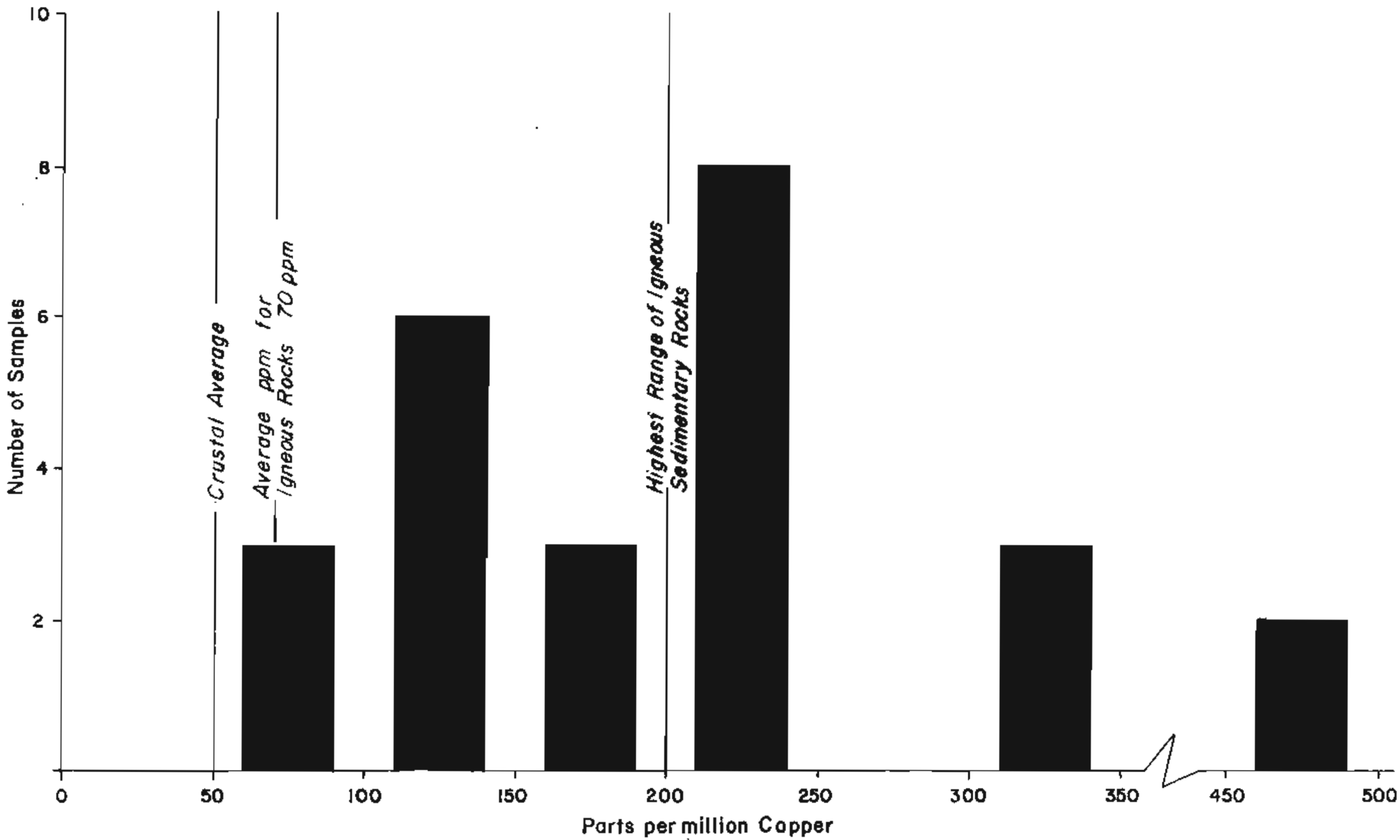
Elements:	Cr	Sr	Co	Ni	Sc	Zn	Y	Ag	Zr	Cu	Cd	Mo	Ti	Be	V	Bi	Mn	Pb	B	Ba	Nd	Ca	Fe	Mg	Av
L-33	12	150	300	10	30	25	-	30	-	200	30	-	2	2K	-	70	-	1K	30	70	700	10	1.5	-	.7
L-47	18	700	300	20	20	50	-	20	-	300	100	70	7	10K	-	150	-	700	100	70	700	15	1	-	1.5
L-49 #1	29	100	200	7	20	30	50	200	-	150	50	-	1	3K	1	100	-	500	15	10	700	10	1	-	1
L-49 #2	3	70	150	15	30	10	-	10	-	50	30	-	-	3K	1	100	-	500	10	-	200	10	1	-	1
L-51	23	300	200	7	100	15	50	10	-	100	30	-	2	5K	-	70	-	700	10	20	500	10	1.5	-	1
L-54	20	70	300	10	30	15	50	10	-	150	50	-	-	5K	-	70	-	1500	15	20	500	10	1	-	.7
L-59	4	50	100	15	30	30	-	15	-	200	30	-	7	5K	1	200	-	700	20	15	500	15	1.5	-	1
L-59	16	50	100	15	20	20	20	15	-	300	50	-	-	5K	2	100	-	700	20	30	500	10	.7	-	.5
L-62	19	50	150	20	30	30	-	20	-	200	70	-	2	7K	-	150	-	500	30	30	500	15	1.5	-	1
L-63	22	30	-	10	15	20	30	15	-	500	30	-	-	3K	1	100	-	700	15	20	500	20	1	-	1
L-64	5	30	100	15	15	30	30	20	-	300	70	-	2	10K	1	100	-	1K	20	30	700	10	1.5	-	1.5
L-65	8	50	-	15	20	30	50	20	-	350	70	-	1	5K	1	100	-	700	15	30	500	15	1	-	.7
L-67	14	30	100	15	15	30	-	15	-	200	50	-	2	5K	-	100	-	700	20	30	500	10	1	-	.7
L-72	10	150	300	20	50	30	-	10	-	100	70	-	-	7K	-	100	-	700	50	20	700	10	1.5	-	1.5
L-73	13	50	150	10	20	20	-	15	-	100	50	-	2	3K	-	100	-	1K	10	20	500	15	1.5	-	1
L-75	25	30	300	10	20	30	-	10	-	50	30	-	5	3K	-	100	-	700	15	15	500	15	2	-	1
L-76	6	50	200	10	20	20	-	15	-	200	30	-	-	5K	-	150	-	1K	10	10	700	10	1.5	-	1
L-78	3	70	200	20	20	30	-	10	1	500	50	-	3	5K	-	150	-	1500	15	20	700	15	1.5	-	1
L-86	3	50	-	7	7	20	100	10	-	100	20	-	2	5K	-	150	-	1K	10	20	300	15	2	-	1
L-87	29	50	300	15	30	30	-	15	-	100	70	-	2	5k	-	150	-	1K	20	70	500	20	5	-	1
L-89	20	30	300	15	20	30	-	15	-	150	30	-	3	3K	1	100	-	500	20	50	500	15	5	-	1
L-90	21	100	200	15	50	30	-	20	-	200	50	-	3	5K	-	150	-	500	30	70	500	15	1.5	-	1
L-91	4	50	100	10	20	15	20	10	-	100	30	-	-	5K	-	100	-	700	10	30	300	10	1	-	1
L-92	2	50	200	15	10	20	-	10	-	200	30	-	-	5K	1	100	-	1K	10	30	500	10	1.5	-	1
L-93	2	50	300	15	30	15	-	5	-	50	30	-	-	5K	-	100	-	1K	10	30	200	10	2	-	1
L-95	4	70	100	5	20	15	-	-	-	20	50	30	-	3K	-	70	-	500	20	30	100	10	1.5	-	.7
L-96	17	70	100	10	20	30	20	15	-	100	70	-	2	5K	1	100	-	500	30	50	500	-	1.5	-	1
L-104	13	50	100	10	20	20	20	10	-	100	100	-	-	5K	-	100	-	1K	20	30	300	10	1	-	.7
L-105	11	30	300	7	7	20	-	-	-	50	15	-	-	5K	-	100	-	700	10	150	700	10	3	-	1.5



HISTOGRAM OF LEAD VALUES IN STREAM SEDIMENTS

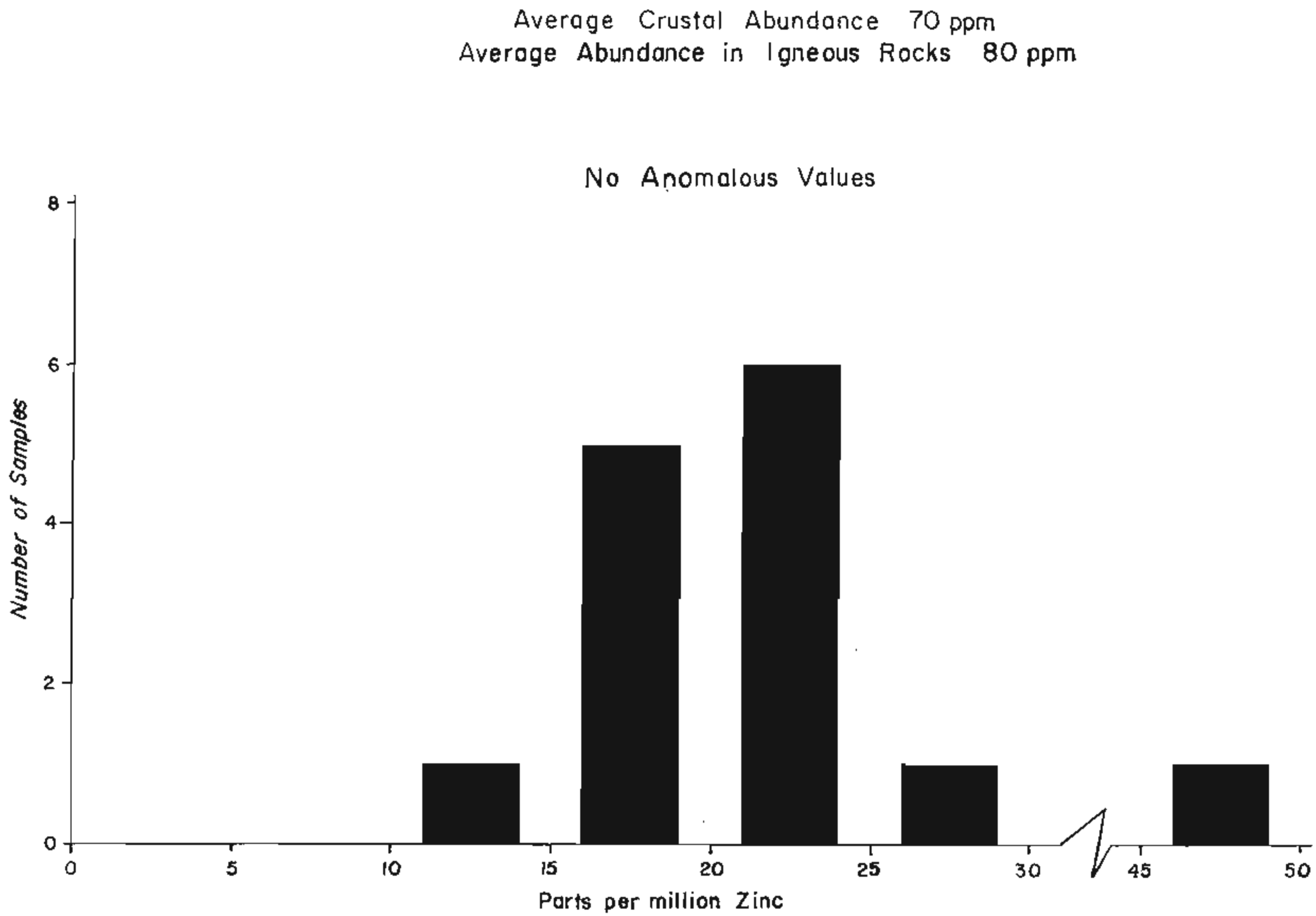
Figure 1

Value occurring at the boundary 100, 200, etc. are carried in the higher numeral bracket. Example: a 100 value is carried as 100-150 ppm.



HISTOGRAM OF COPPER VALUES IN STREAM SEDIMENTS

Figure 2



HISTOGRAM OF ZINC VALUES IN STREAM SEDIMENTS

Figure 3

REFERENCES

Burk, C. A., 1965, Geology of the Alaskan Peninsula, Island Arc and Continental Margin: Geol. Soc. Am., Memoir 99, 250 pp.

Eakins, G. R., 1970, A Petrified Forest on Unga Island Alaska: Ak. Div. of Mines and Geology, Special Rept. No. 3.

Grim, R. E., 1968, Clay Mineralogy: McGraw-Hill, New York, 596 pp.

Krumbein, W. C. and Graybill, F. A., 1965, An Introduction to Statistical Models in Geology: McGraw-Hill, New York, 475 pp.

Note: Thin sections, rock samples, 35 MM color slides and photographs of outcrop locations, etc., may be viewed or examined at the State Survey office, 3001 Porcupine Drive, Anchorage, Alaska 99501.

APPENDIX I

FOSSIL IDENTIFICATION by D. L. Jones & J. W. Miller

L-7-73 (USGS Mesozoic loc. M6247). Staniukovich Formation, Herendeen Bay
BUCHIA RUGOSA (Fischer)
Belemnite
Age: Upper Jurassic (middle Kimmeridgian to early Portlandian)

L-36-73 (USGS Mesozoic loc. M6248). Herendeen Bay
Nothing identifiable

L-57-73 (USGS Mesozoic loc. M6249). Staniukovich Formation, Herendeen Bay
BUCHIA CRASSICOLLIS SOLIDA (Lahusen)
BUCHIA SUBLAEVIS Keyserling
Age: Lower Cretaceous (Valanginian)

APPENDIX II

COAL EXAMINATION by W. McClintock

On Herendeen Bay, 1-1/2 miles east from the mount of Mine Harbor (plate 3)

SAMPLE

L-20-73 Cretaceous - Chignik Formation
Rank - high volatile bituminous B

The sample has a mean vitrinite reflectance of .63. It should agglomerate with a potential for coking, but does not; the laboratory therefore concludes that the sample is oxidized. A sample 10 to 20 feet into the section should have coking characteristics. The coal is relatively clean with mineral matter confined to the grain boundaries.

L-21-73 Cretaceous - Chignik Formation
Rank - high volatile bituminous C

The sample has a vitrinite reflectance of .57. It is, therefore, classified as a high volatile C, probably oxidized. There is more mineral matter in L-21-73 than in L-20-73. The grain size of the mineral free coal is smaller than in sample L-20-73.

L-170-73 Cretaceous - Chignik Formation
Rank - high volatile bituminous C

The sample is fine-grained, with a great deal of mineral matter mixed in the grains of coal. It is estimated that coal as small as 20 microns would still contain mineral matter.

APPENDIX III

SAMPLE DESCRIPTION AND THIN SECTION ANALYSES

By

M. W. Henning and W. M. Lyle

L-1 Calcareous sandstone, light gray to gray green, very fine-grained, quartz, angular to sub-angular, strained and sheared plagioclase, shows some embayments, strained in many crystals, biotite altering, large laths of calcite, matrix cemented by calcite.

L-8 Sandy limestone, medium to fine-grained calcareous, quartz is angular to sub-angular, feldspar is plagioclase and a few grains of microcline, matrix is calcite, composed between 50-60% of the rock, some hornblende, altering to chlorite.

L-9 Calcareous sandstone, light gray green, very fine-grained, quartz, angular to sub-angular, plagioclase altering to sericite, some biotite altering to chlorite, small grains of epidote, large laths of calcite, matrix cement is calcite.

L-11 Calcareous sandstone, light gray green, very fine-grained, quartz angular to sub-angular, strained, plagioclase feldspar predominates, biotite in small %, epidote in small %, calcite in crystals and matrix cement.

L-12 Sandy limestone, quartz angular to sub-angular, shows straining, feldspars are plagioclase, some glauconite grains, a few grains of epidote, matrix is calcite.

L-13 Sandstone, light gray, fine-grained, angular calcite matrix, tight, quartz, plagioclase feldspar, muscovite mica, microcline.

L-14 Sandy limestone and sandstone, light gray green, very calcareous, petroliferous, quartz, plagioclase feldspar, calcite + 50%.

L-15 Calcareous sandstone, light gray to gray green, very fine-grained, quartz angular to sub-angular, strained and sheared plagioclase, shows some embayments, strained in many crystals, biotite altering, large laths of calcite, matrix cement is calcite.

L-16 Sandstone, light gray, very fine-grained, angular to sub-angular, petroliferous odor, calcite cement, quartz, plagioclase feldspar, hornblende.

L-18 Sandstone, (quartzite), gray, medium grained, 90% or greater quartz, sub-angular to angular, cement appears to be clay, plagioclase present in small amounts, altering to sericite and clay.

L-19 Calcareous sandstone, light gray to gray green, very-fine grained, quartz angular to sub-angular, strained and sheared plagioclase, shows some embayments, strained in many crystals, biotite altering, large laths of calcite, matrix cemented by calcite.

L-22A Sandstone, light gray, medium to fine-grained, quartz angular to sub-angular, some rounded grains, feldspar is plagioclase, probably less than 30%, some small grains of epidote, matrix is calcite, aragonite, and clay, low permeability and porosity.

L-25 Sandstone, light gray green, medium to coarse-grained, clay, calcite cement, quartzite, no permeability and porosity, quartz, plagioclase feldspar, microcline, hornblende, basalt.

L-26 Calcareous sandstone, quartz angular to sub-angular, shows some straining, some grains of quartzite, feldspars are plagioclase, some show straining and bending, small percentage of andesitic grains, small percentage of glauconite grains, matrix is calcite.

L-28 Conglomerate, with a fine-grained matrix, matrix entirely quartz (extremely fine-grained). Larger quartz grains sub-angular to sub-round, feldspar grains are large, mostly plagioclase and perthite with some microcline.

L-29A Sandstone, gray, very-fine grain to fine grain, poorly sorted, quartz, plagioclase feldspar, microcline, and hornblende, (marine sandstone, composed of volcanic sediments) fossiliferous.

L-30 Same as L-29, trace magnetite, and grains of basalt and magnetite.

L-31 Sandstone, light gray green, fine-grained to coarse grains, poorly sorted, quartz, plagioclase feldspar, microcline.

L-32 Sandstone, granite source, crystals are altering rather rapidly, quartz, plagioclase and hornblende predominate, cement in matrix appears to be clays.

L-35 Sandstone, light gray, fine to medium, with some coarse grains, very angular, poorly sorted, calcareous matrix, (intra-formational slump), quartz, plagioclase feldspar, microcline, calcite, trace biotite.

L-35A Sandstone, light gray, coarse and fine-grained, poorly sorted, arkosic, fine-grained sand is well sorted. No permeability and porosity, quartz, plagioclase feldspar, amphiboles (probable granitic source).

L-37 Calcareous sandstone, light gray green, very fine-grained, quartz angular to sub-angular, some strained plagioclase, feldspar, some altering to sericite, biotite altering to chlorite, some epidote, calcite crystals and matrix cement.

L-39 Sandstone, light gray, quartz, angular to sub-angular, strained and shattered, some grains of quartzite, feldspars are plagioclase with progressive zoning, some grains of microcline, feldspars are altering to sericite, a few isolated crystals of epidote, grains of andesite and basalt, some grains of vitric tuff, cement is probably clay.

L-40 Sandstone, quartz angular to sub-angular, grains strained, some grains of quartzite, plagioclase strained, some altering to sericite, some biotite, cement in matrix probably clay and limonite.

L-41 Sandstone, light gray green, fine-grained, quartz, angular to sub-angular, some grains strained and shattered, feldspars are plagioclase with progressive zonation and some microcline, some rutilated quartz, some small grains of quartzite, minute grains of hornblende, grains probably cemented with clays.

L-43 Calcareous sandstone, light gray to gray green, very fine-grained, quartz angular to sub-angular, strained and sheared plagioclase, shows some embayments, strained in many crystals, biotite altering, large laths of calcite, matrix cemented by calcite.

L-45 Sandstone, light gray, fine-grained, quartz is angular to sub-angular, some quartzite grains, shows some foliation, microcline and perthite, some albite veining in plagioclase, matrix is calcite, some feldspars show good zoning, low permeability and porosity, large clasts of basalt.

L-46 Sandstone, light gray green, very-fine grained to fine-grained quartz angular to sub-angular, strained and embayed in some crystals, some grains of quartzite, plagioclase, feldspar, altering to sericite, some biotite, altering to chlorite, rock cemented with clay, no permeability and porosity.

L-50 Sandstone, quartz angular to sub-angular, strained and sheared in places, plagioclase predominates with a few grains of microcline, biotite present, altering to chlorite and phlogopite, some grains of epidote, cement in matrix probably clay, granite source rock.

L-52 Sandstone, light gray to gray green, quartz angular to sub-angular, sheared and strained, many inclusions in some grains, plagioclase feldspar, altering to sericite, many inclusions in some grains, some calcite cementing in matrix, but predominantly clays.

L-60 Sandstone, light gray to gray green, quartz angular to sub-angular, quartzite grains present, feldspar, high temperature plagioclase with a few grains of microcline, rock composed mostly of volcanic fragments with calcite and limonite, some small grains of epidote.

L-61 Sandstone, light gray, fine-grained, calcite and clay matrix, no permeability and porosity, quartz, plagioclase, feldspar, grains of basalt.

L-68 Andesite, volcanic dike rock.

L-71 Sandstone, light gray green, composed almost entirely of grains of basalt and andesite, some quartz grains, some calcite grains, chlorite in some of the interstitial voids.

L-74 Calcareous sandstone, light gray to gray green, very fine-grained to fine-grained, quartz angular to sub-angular, strained and shattered, some inclusions, plagioclase and perthite, many crystals show straining and shattering, small amount of biotite, large laths of calcite, matrix cemented by calcite.

L-81 Sandstone, light gray green, coarse-grained, quartz angular to sub-angular some secondary growth represented by suture structures, less than 10% plagioclase feldspar, calcite occurs as secondary vein fillings and as matrix cement with clays, some magnetite, poorly sorted, low permeability and porosity.

L-84 Sandstone, light gray, mostly quartz, angular to sub-angular, strained, plagioclase, some epidote, small amount of calcite crystals.

L-85 Limestone, white calcite, probably preciptitated.

L-102 Conglomerate, sandstone to boulders, very poorly sorted, sandstone matrix, (sandstone is calcareous), granite, andesite, chert.

L-110A Sandstone, gray green, medium to coarse-grained, angular to sub-angular quartz, many detrital grains of quartzite with extreme suturing, plagioclase feldspars altering to sericites, some crystals show veining of albite, detrital grains of amphibole altering to chlorite, some small crystals of epidote, some small grains of detrital basalt, cement probably clay, no permeability and porosity.

L-111 Conglomerate and sandstone, gray to gray green, angular to sub-angular quartz, plagioclase feldspar altering to sericite, microcline present in small amounts, cement is calcite and aragonite, the sandstone is poorly sorted.

L-121 Conglomerate, with fine-grained matrix, quartz grains are sub-angular to sub-round, some large grains of quartzite, with small vein quartz cutting grains, many grains of basalt and andesite, some small inclusions of epidote, feldspar is plagioclase, many grains show zonation, most likely high temperature plagioclase, cement in matrix appears to be aragonite, feldspar altering to sericite.

L-123 Calcareous sandstone, light gray, fine-grained, quartz angular to sub-angular, small percentage of quartzite grains present, suturing is well developed, feldspar composition is plagioclase, small percentage of hornblende altering to chlorite, grains cemented with calcite and aragonite.

L-125 Graywacke, shows some lamination, sub-angular to angular quartz, matrix of silt and clay.

L-130 Sandstone, light gray, coarse-grained, angular to sub-angular, quartz, grains of quartzite that show lineation and high development of suturing, grains of basalt well rounded, plagioclase feldspar with albite veining, microcline is also present but in small percentage, hornblende and epidote in small percentage, hornblende altering to chlorite, cement probably clay and limonite, low permeability and porosity.

L-131 Sandstone, light gray green, very coarse grained to coarse grained, conglomeratic, basalt, andesite, quartzite, quartz, plagioclase, feldspar, calcite (?).

L-139 Sandstone, gray to gray green, fine-grained, quartz is angular to sub-angular, grains of quartzite present, quartz is highly sutured, feldspar consists of zoned plagioclase, small percentage of hornblende and epidote, many grains of basalt, these grains are well rounded, matrix consists of calcite, with secondary calcite replacement of some feldspars and quartz.

L-142 Sandstone, light gray to gray green, angular to sub-angular quartz, plagioclase feldspar, microcline K-spar, hornblende altering to chlorite grains, cemented by calcite matrix.

L-148 Sandstone, light gray, weathers rust brown, quartz angular to sub-angular, grains show straining, some grains of quartzite, plagioclase feldspars, some volcanic grains with high temperature feldspars, some hornblende and epidote altering to chlorite, cement probably clay and limonite.

L-150 Sandstone, fine to medium-grained, very angular, limonite, and clay cement, quartz, plagioclase feldspar, microcline, trace biotite, trace hornblende.

L-151 Conglomerate, gray to gray green, angular to sub-angular grains of quartz, rounded grains of quartzite, these grains show good suturing and linear structure, most likely have been subjected to low temperature metamorphism, small grains of hornblende, altering to chlorite, matrix is calcite and limonite.

L-172 Sandy Limestone, very fine-grained, sand well sorted, small percentage of plagioclase, matrix is calcite, aragonite and limonite.

L-1818 Conglomerate, gray, quartz sub-angular to round, large pebbles of quartzite, which have been fractured and show secondary veining, large laths of albite, grains appear to be cemented by clay.

L-183 Sandstone, light gray to gray green, fine to medium-grained calcareous, plant fragments, mudballs, quartz, feldspar, plagioclase, fair to good permeability and porosity.

L-185 Sandstone, gray green, weathers rust brown, quartz angular to sub-angular, rounded grains of quartzite, both plagioclase and microcline are present, well rounded grains of basalt and andesite, cement appears to be clays produced by feldspar alteration.

L-188 Sandstone, light tan, coarse, angular, poorly sorted 40-60% quartz, plagioclase feldspar, weathered matrix, traces of biotite, clay matrix, no permeability and porosity.

L-188A Sandstone, light gray green, fine-grained, angular, clay cement, tight, quartz, plagioclase feldspar (zoning), hornblende.

L-189 Sandstone, light gray, fine-grained, quartz is angular to sub-angular, plagioclase present in small amounts, the grains appear to be cemented by limonite, rock is extremely tight, no permeability and porosity.

L-191 Sandstone, light gray, fine grained, predominantly composed of volcanic detritus, quartz angular to sub-angular, shows straining and shearing, feldspars are high temperature plagioclase, some rounded grains of quartzite, matrix cement is probably clay.

L-193 Calcareous sandstone, light gray, quartz angular to sub-angular, some straining, feldspars are plagioclase, some crystals show progressive zonation, both brown and green hornblende occur, some in good euhedral crystals, some grains of epidote, one or two large grains of basalt, matrix is calcite.