Public-data File 85-42e

NORTHWEST ALASKA RESOURCE MAPPING PROJECT
MINERAL POTENTIAL

By

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Geological and Geophysical Surveys

June 1986

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CONTENTS

INTRODUCTION

In late October, 1984, the Geologic Mapping and Geochemistry Sections of DGGS were asked to prepare a summary of existing knowledge on mineral potential in northwest Alaska (fig. 1 and Section 4 of this report) as one component of a broader DNR effort to synthesize various types of resource information for the 18-quadrangle area. The sections of this handbook describe methodology, preparation, and criteria used in developing the summary of potential depicted in separate map format and listed as a section of this report.

To this objective, a team of eleven DGGS people (fig. 2) have been involved either full or part-time or the NorWAAP project since November, 1984. The general method of attack used was to compile and analyze a "data stack" for each quadrangle at a scale of 1:250,000. The various layers of the data stack (fig. 3 and Section 6) were developed by a thorough literature search (see accompanying bibliography) and were compiled on 1:250,000 transparent acetate overlays to facilitate integration of various levels in the stack. Typical components of a stack include such information as geology, geochemistry, aeromag, mining claims, etc. (fig. 3 and Section 6).

Once the data stacks were compiled, two or three separate geologists analyzed each quadrangle data package on a township-by-township basis - carefully scrutinizing all elements of the data for signals indicating the presence of one or more of 26 mineral deposit types (Section 3, p. 1). Specific indicator criteria for each deposit type are listed in Section 3, p. 13-37 of this handbook. A potential score of 1 to 5 was determined for each township using the criteria listed in Section 3, p. 2. Also, while analyzing the data, each township was scored for quality of information available, again by criteria as listed in Section 3, p. 4. Needless to say, the mineral potential scores are heavily dependent on the level of information available; the correlation is plotted on figure 4. Despite the best efforts of the analysts, a good forecast of mineral potential cannot be made in the absence of good background information. Thus mineral scores in areas of low data quality should be viewed as very uncertain.

Recognizing the inherent limitation imposed by lack of data, mineral potential/data quality maps were prepared for all 1:250,000 quadrangles. Near the end of the scoring effort, pertinent mining industry groups were invited to review the maps and contribute new data as they desired. Additionally, smaller scale maps at 1:1.5 million were prepared to give a synoptic view of both mineral potential and data quality.

In summary the products of the NorWAAP mineral effort include:

(1) Data stacks for 18 quadrangles
(2) Mineral potential and data quality maps 1:250,000
(3) Bibliography
(4) Mineral potential maps 1:1.5 million
(5) Data quality maps 1:1.5 million
(6) Explanatory handbook

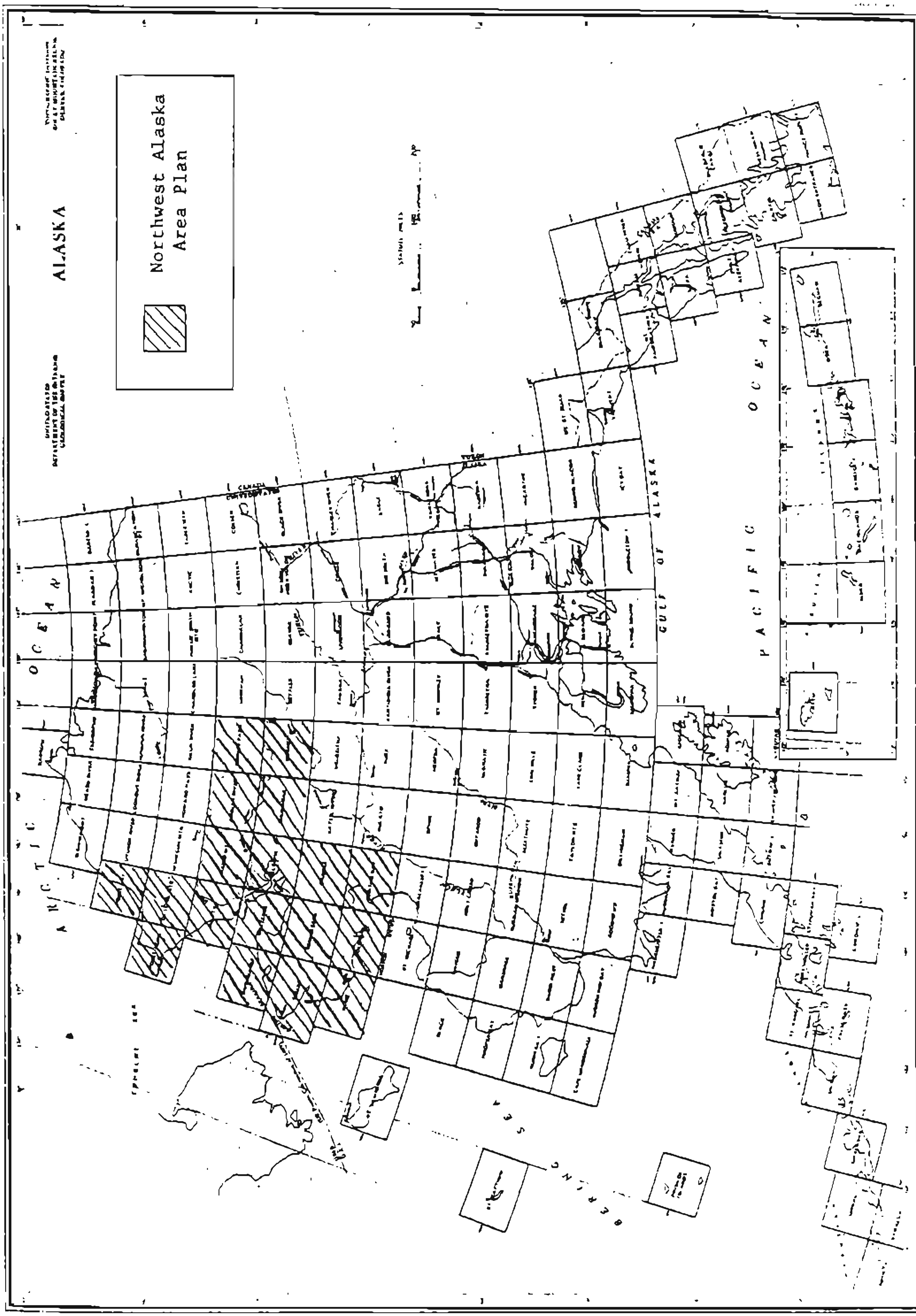

ALASKA
Northwest Alaska
Area Plan
ARCTIC OCEAN
PACIFIC OCEAN
GULF OF ALASKA
BERING SEA

Figure 1.

NORTHWEST ALASKA AREA PLAN (NorWAAP)

REGION	QUADS	REGIONAL TEAM	AREA TEAM
NorWAAP I Seward Peninsula	SHISMAREF TELLER NOME KOTZEBUE BENDELEBEN SOLOMON CANDLE NORTON BAY	M. S. ROBINSON (2 mo) TINA BALOG (4 mo) T. E. SMITH (1 mo)	↑
NorWAAP II	BAIRD MTNS SELAWIK AMBLER RIVER SHUNGNAK SURVEY PASS HUGHES	T. E. SMITH (2 mo) M. D. Albanese (3 mo) TINA BALOG (2 mo)	M. WILTSE (2 mo) (Geochem) GAIL MARCH (6 mo) (Geochem) INTERN (4 mo) (Geochem) DUNCAN HICKMOTT (3 mo) Drafting/Phot work TINA BALOG (4 mo) (Bibliography) KAREN CLAUTICE (1 mo) (Bibliography)
NorWAAP III	NOATAK POINT HOPE DE LONG MTNS POINT LAY	GAR PESSEL (1 mo) KAREN CLAUTICE (3 mo)	↓

SCHEDULE

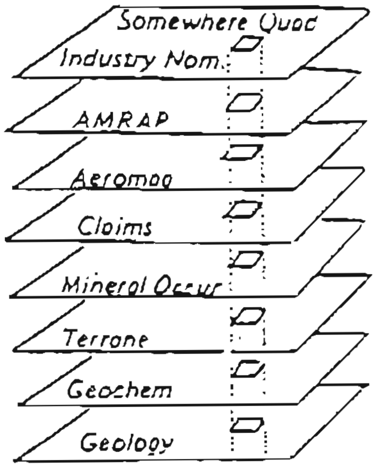
NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN
← ASSEMBLY OF DATA STACK →				← DATA ANALYSIS →		← FINAL DRAFTING COMPILATION →	

Figure 2

MINERAL APPRAISAL SEQUENCE

PHASE I ASSEMBLY OF DATA STACK

DATA STACK

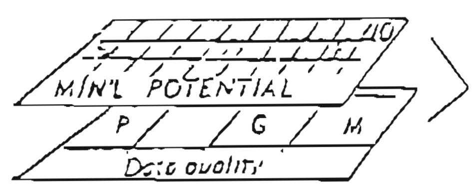


- Bibliography
- Short Report

PHASE II ANALYSIS AND QUANTIFICATION OF DATA STACK

- Numerical Scoring of each cell (e.g. township).
- Histogram of value
- Delineation of mineral belts, terrane.

DERIVATIVES



combined

DERIVATIVES TO USERS

Figure 3.

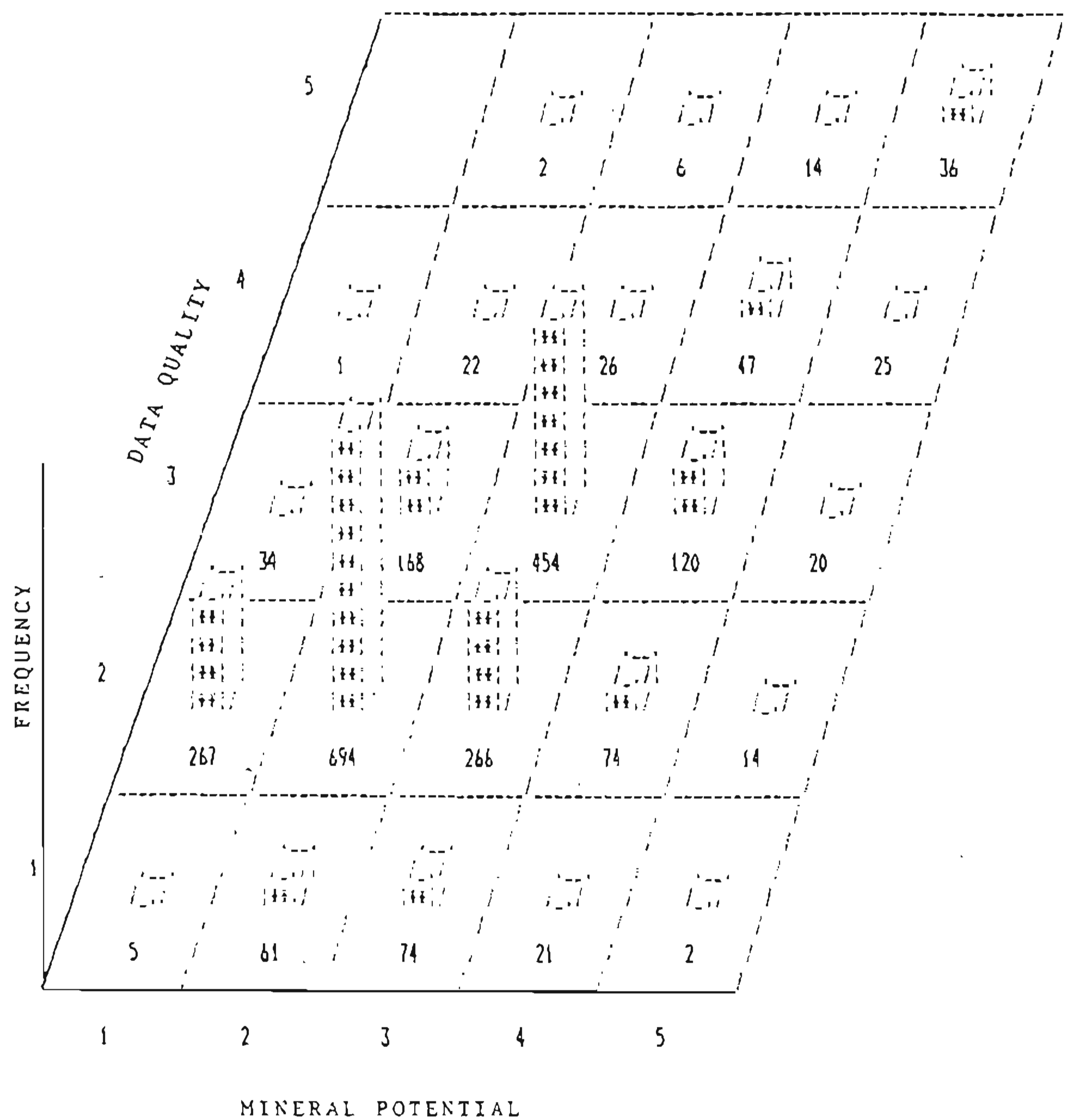


Figure 4. Frequency plot showing distribution of mineral potential vs. data quality scores, NorWAAP. Note the strong correlation of low mineral scores with areas of little mineral data; the mineral scores might well be higher if better mineral information were available.

MINERAL POTENTIAL
SCORING PARAMETERS
N O R W A A P

Contents

SECTION I: Mineral Potential Map

This overlay should portray a score for each cell, in our case township, linked to favorability for one or more of the 25 deposit types. Coming up with this score will involve a mental evaluation of geologic, historical, etc factors that are favorable for the occurrence of mineral deposits. Some call this a multivariate system; in the NORWAAP project we'll let the computer on our shoulders compute the scores. Let's take a crack at a five fold breakdown: Very High (5), High (4), Moderate (3), Low (2), Very Low (1).

Determining whether the geological environment is favorable will require learning most of the key features of the 25 deposit types.

Possible Scoring Criteria might be:

Very High (5)

.Geological environment very favorable

.Significant mineral deposits known

.Numerous active mining claims

.Geophysical and geochemical signatures favorable

.Very favorable metallogenic and tectonic terrane

High (4)

.Geological environment very favorable

.On trend or in some unit which hosts significant mineral occurrences nearby

.Significant deposits not known at present

.Some mining claim activity

.Geochemical and geophysical signatures favorable

.Favorable metallogenic and tectonic terrane

Moderate (3)

.Geologic environment favorable

.Significant deposits not known

.Low mining claim activity

.Geochemical and geophysical signatures may be favorable

.Cell may be distantly on trend with cells of higher favorability

Low (2)

.Some aspects of geological environment may be favorable, generally not favorable

.Few if any known deposits

.Little or no mining claim activity

.Geochemical and geophysical signatures generally negative

.Little bedrock exposed nearby (but don't forget placers and S.S.-hosted uranium)

.Generally unfavorable metallogenic and tectonic terrane

Very Low (I)

.Geologic environment generally unfavorable

.Little bedrock exposed, little possibility for placers or S.S.-hosted metals

.No known mineral occurrences

.Unfavorable geochemistry or geophysics

.Off trend with more favorable areas

.No mining claim activity

.Unfavorable metallogenic and tectonic terrane

SECTION II: Data Quality Map

This should be an attempt to assess the level of geologic, geochemical, mineral data available in each township. We might as well use the five fold breakdown: Very poor (1), Poor (2), Fair (3), Good (4), And Very good (5).

Possible criteria for assigning a level to a particular township might be:

Very Good (5)

.Detailed (1:63,360 or larger) geologic mapping, numerous units/cell broken out, alteration zones, gossans shown (examples p. 7, 8)

.Comprehensive geochemical data base, ¼ mile spacing, possibly soil and rock chip geochem also (p. 10)

.Good aeromag, ½ to 1 mile spacing

.Other geophysical data

.Detailed studies of mines or prospects

.Good surficial geology

Good (4)

.Detailed (1:63,360 or larger) geologic mapping

.Ordinary geochemical coverage 1 sample per $mile^2$ to 1 sample per 5 $miles^2$ (p. 11)

.Aeromag coverage ½ to 1 mile spacing

.Some prospect studies

Fair (3)

.Good, careful 1:250,000 or 1:125,000 geologic mapping with units pertinent to mineral deposits shown

.Regional low density geophysical coverage

.Low density geochemical data base like AMRAP (p. 12)

.Some deposit studies

Poor (2)

.Lower quality 1:250,000 geologic mapping units generalized, pertinent units to mineral deposits not shown (p. 9)

.Regional low density geophysical coverage

.Low density geochem

.Few if any local deposit studies

Very Poor (1)

.Only geologic mapping 1:1 million or similar grossly generalized maps

.Low density or no regional geophysical coverage

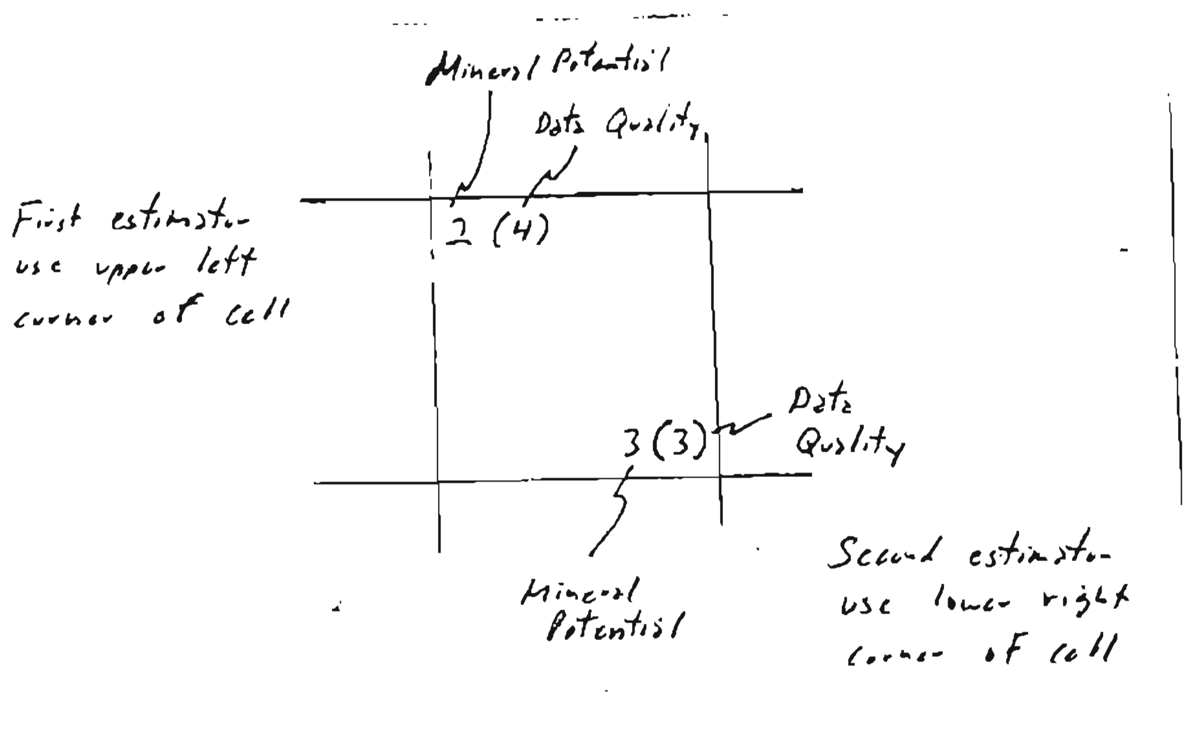
.Poor geochemical data base

.General lack of information

Map Portrayal of Scores

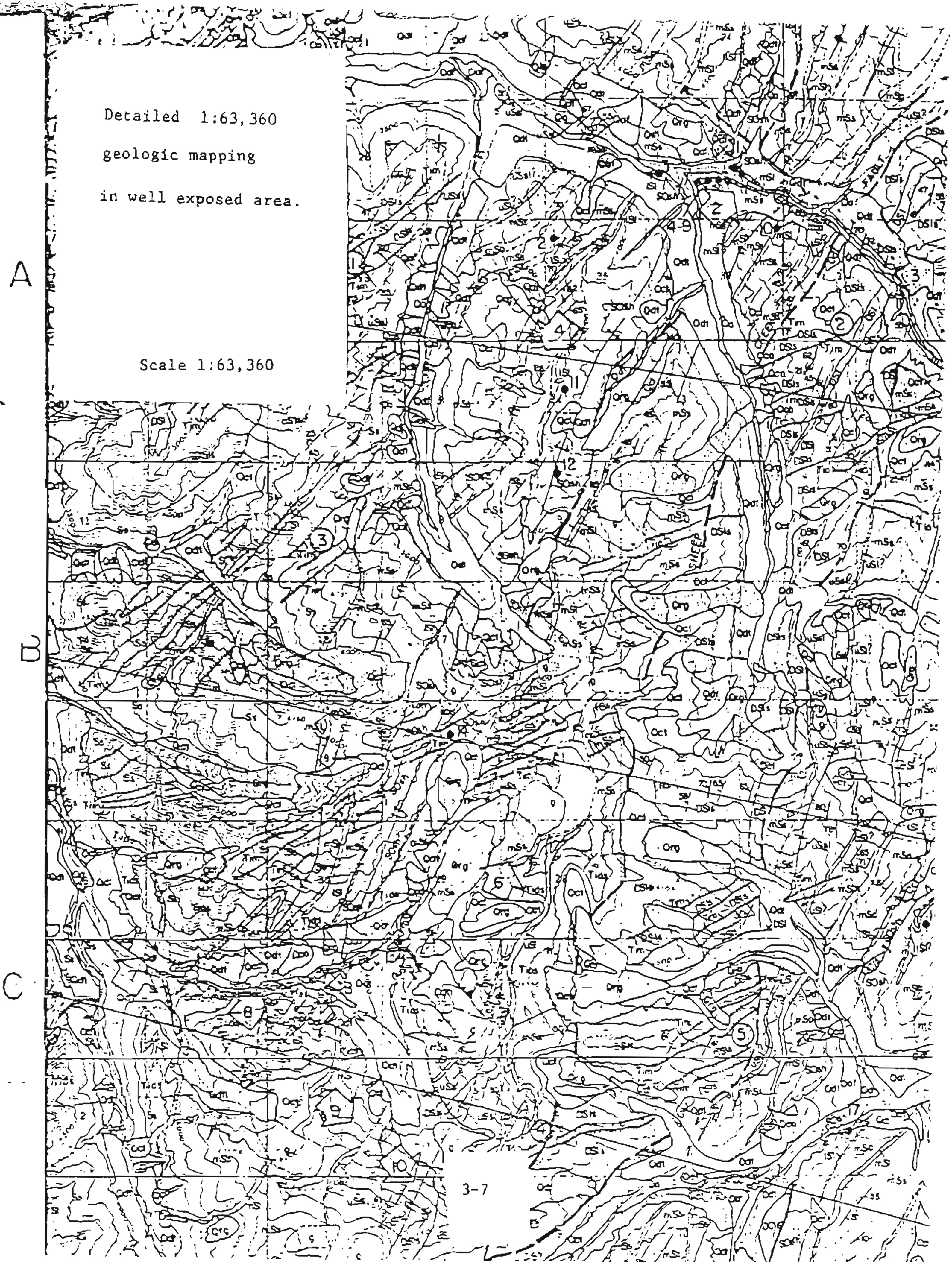
For the initial worksheet, let's compile the mineral potential scores and data quality scores together. Later, we will brainstorm best method of presenting the data to non specialists.

So, for each township (i.e., use a mylar with township grid),



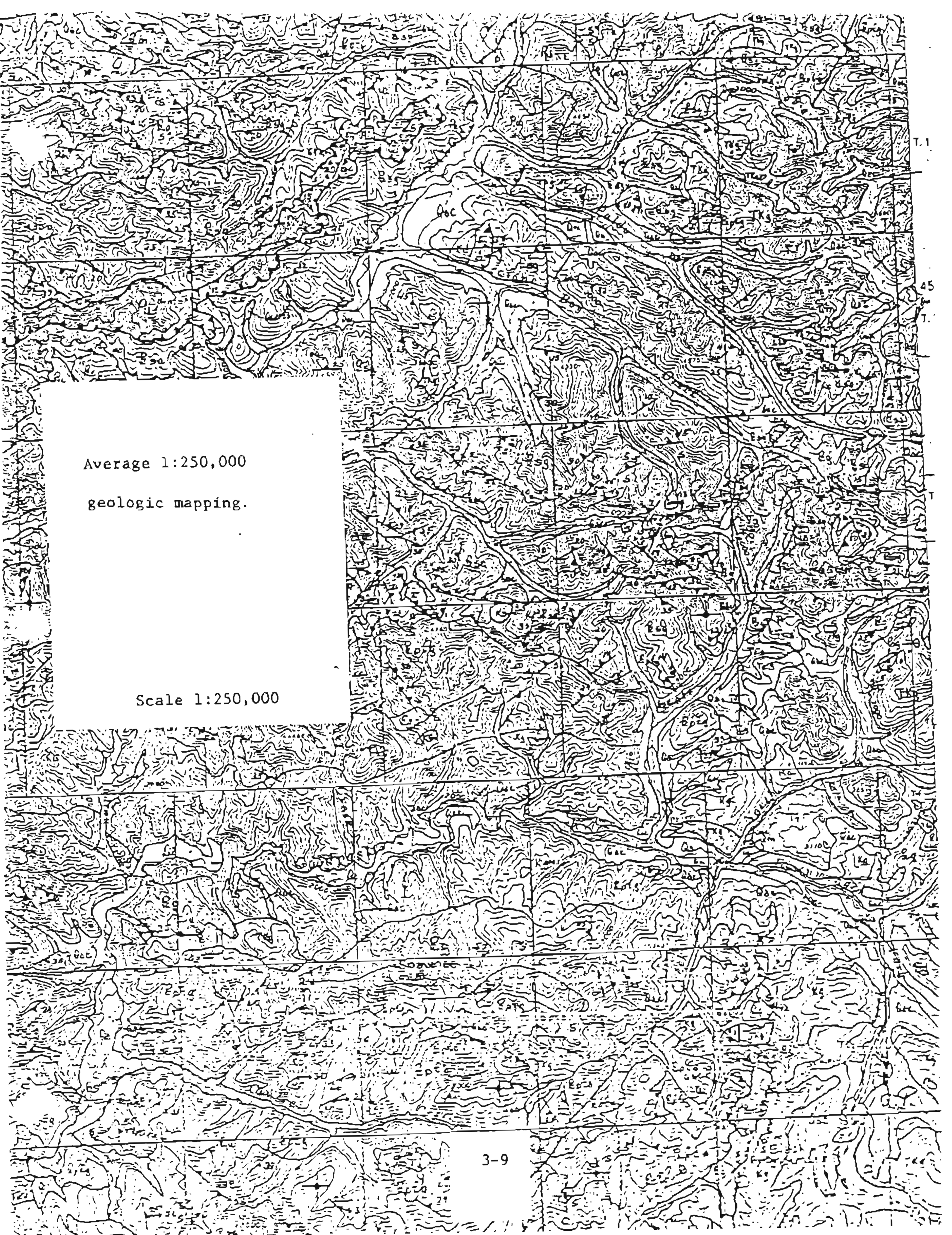
Detailed 1:63,360 geologic mapping in well exposed area.

Scale 1:63,360



Detailed 1:63,360 geologic mapping in poorly exposed area.

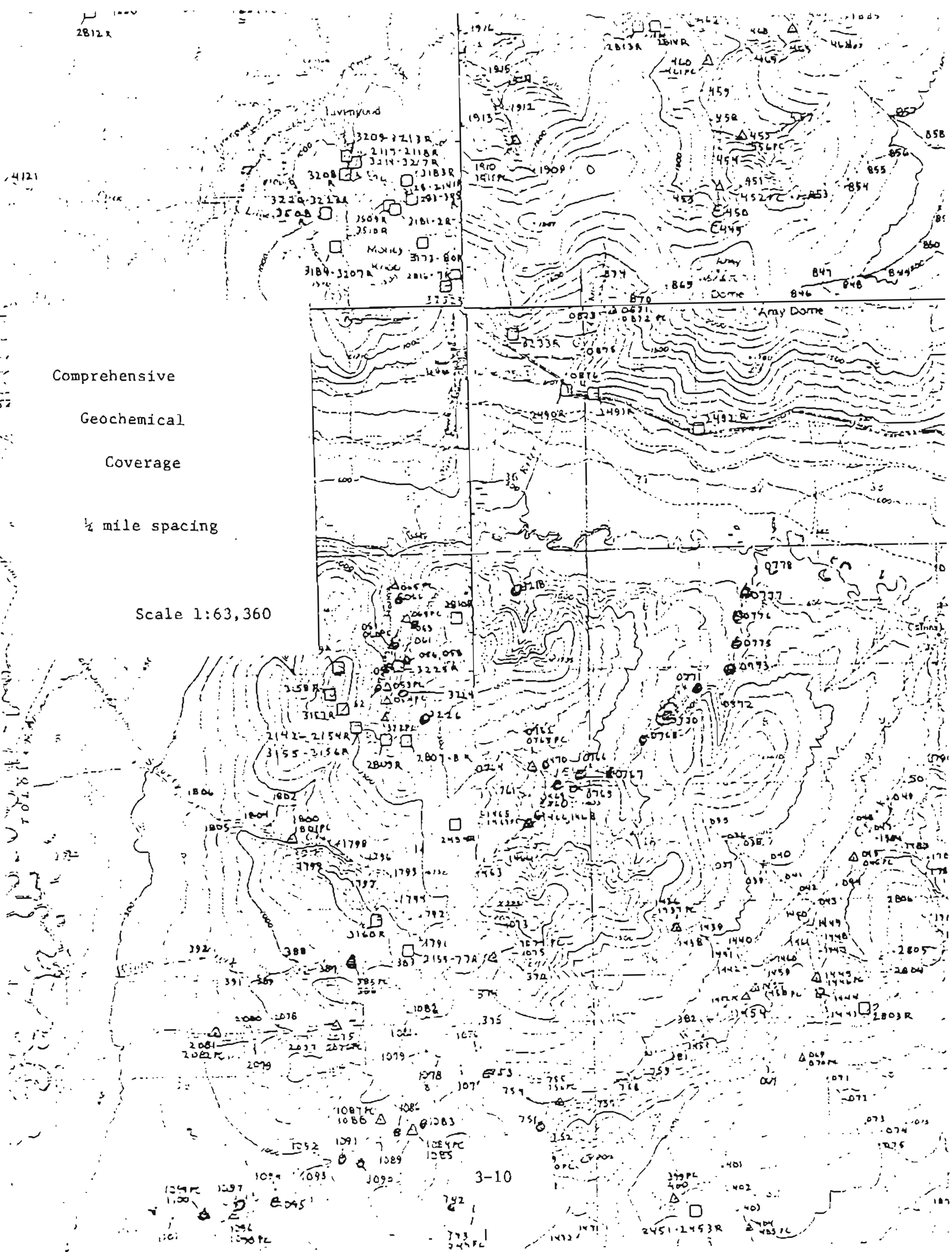
Scale 1:63,360



Average 1:250,000

geologic mapping.

Scale 1:250,000



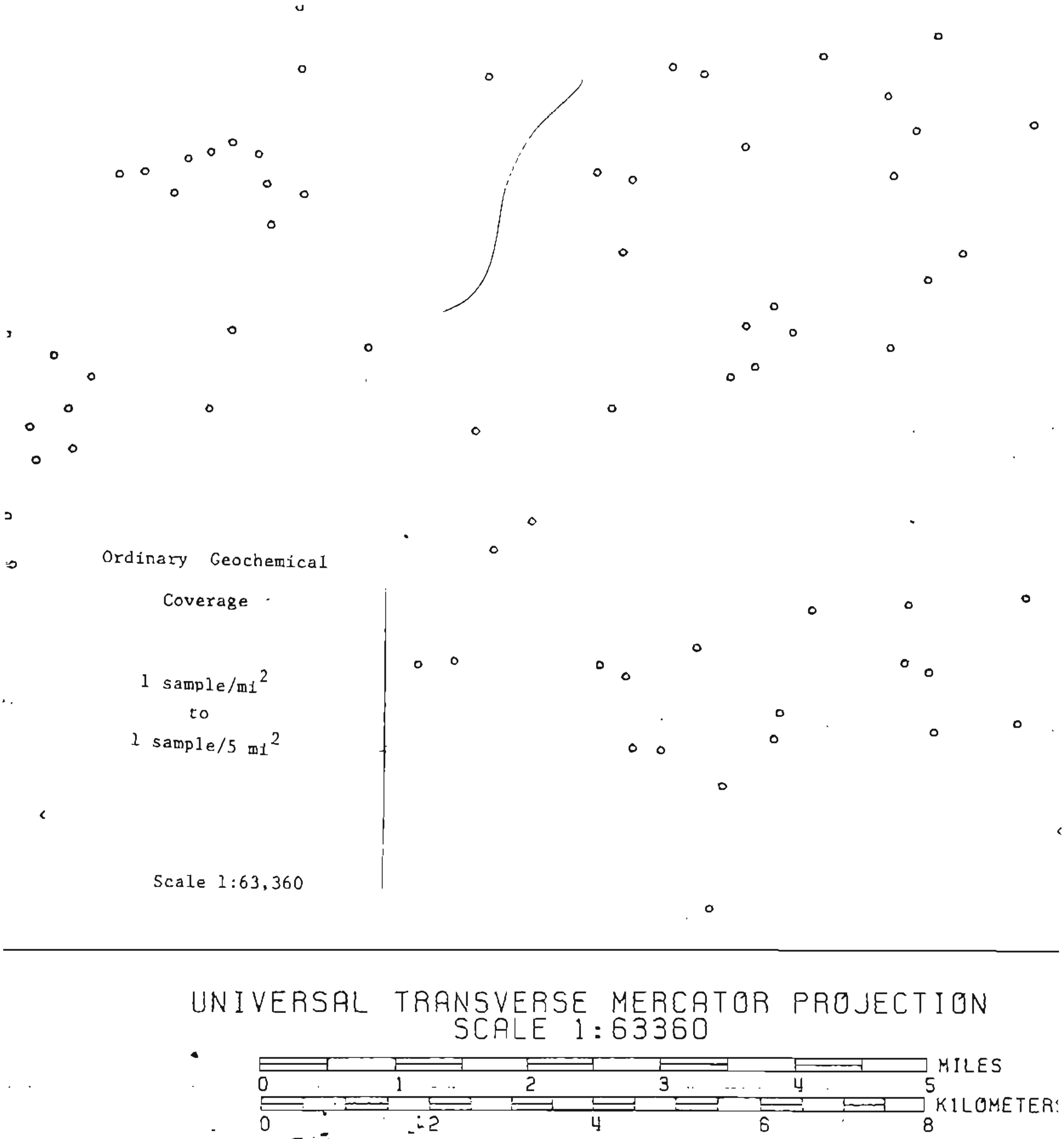
Comprehensive

Geochemical

Coverage

½ mile spacing

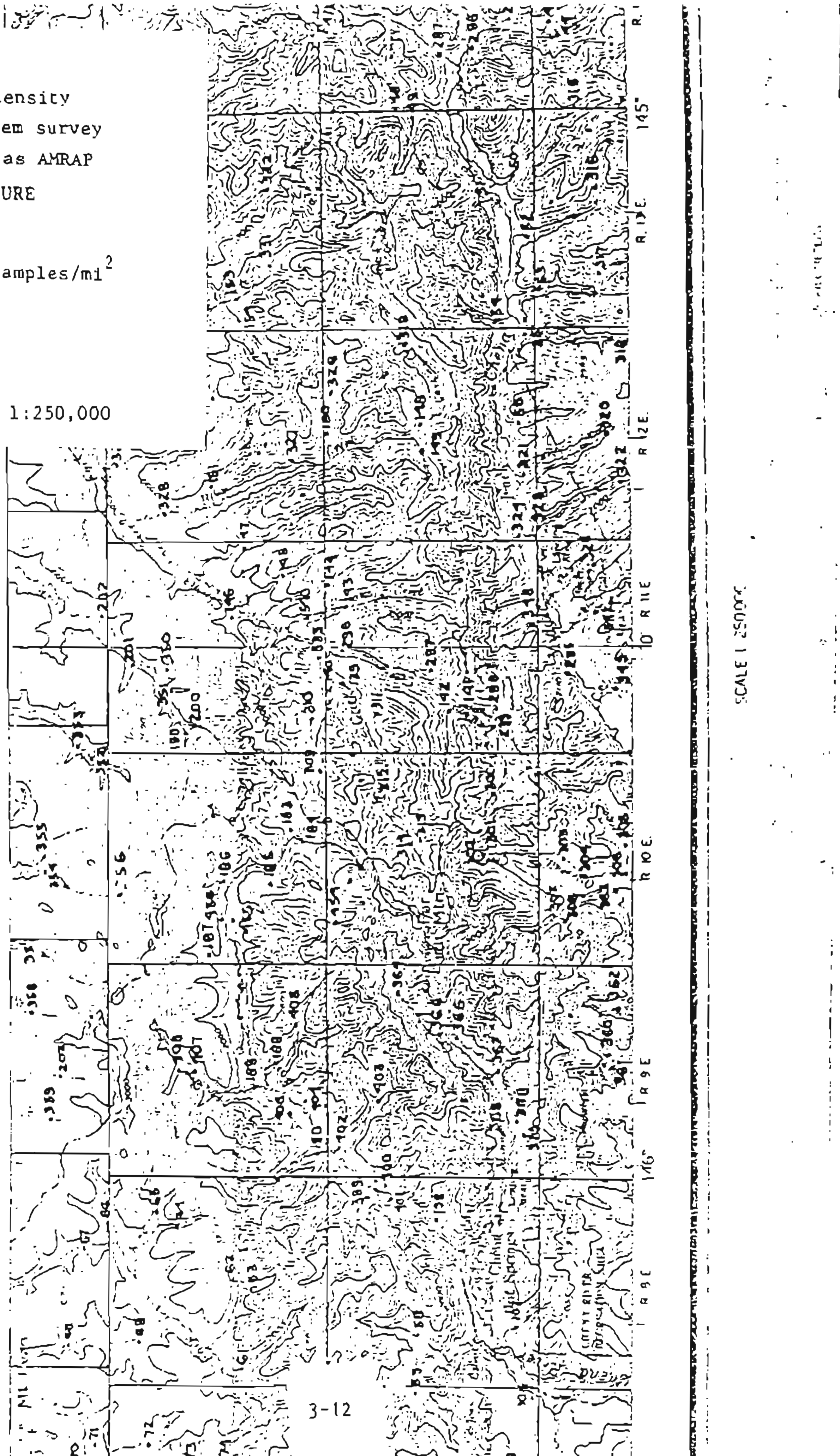
Scale 1:63,360


Ordinary Geochemical Coverage
1 sample/mi²
to
1 sample/5 mi²
Scale 1:63,360
UNIVERSAL TRANSVERSE MERCATOR PROJECTION
SCALE 1:63360
MILES
0 1 2 3 4 5
KILOMETERS
0 2 4 6 8

Low density geochem survey such as AMRAP and NURE

o.2 samples/mi^2

Scale 1:250,000



SECTION III: Sediment Hosted Zn, Pb, (Ag, Ba) Deposits

.Large scale (100s km) fault-bounded epicratonic and intracratonic sedimentary basins

.Smaller (10's km) fault-bounded subbasins with rapid changes of thickness and lithofacies

.Slump breccias, intraformational conglomerates, local soft sediment folding/faulting

.Middle Proterozoic and Lower-Middle Paleozoic ages have been most productive

.Chert and barite in small scale basins

.Minor volcanics and tuff in section

.Thick marine sedimentary sequences in basin

.Shallow marine lithologies: shale-carbonate-dolomite-(evaporite?)-chert-bedded barite

.Geochem Zn, Cu, Pb, Ba, Mn, (Cu, Sn, As at Sullivan)

.Basin edges may be reflected in gravity gradients

Volcanogenic Massive Sulfide Deposits

.Submarine volcanic rocks

.Mostly mafic volcanics - Cu-Au type, mafic to felsic - Zn-Pb-Cu type

.Evidence for synvolcanic rifting - bimodal compositions, abrupt thickening

.Known VMS deposits in same interval and area. They tend to cluster

.Fe-Mn chert in section (exhalite)

.Anomalous carbonates, Fe-rich (exhalite)

.Zones of chlorie-tale or muscovite-quartz

.Geochem Cu, Zn (Au) if mafic, or Zn, Pb, Cu, Bu (Ag) if felsic.

.Spilitic (ab -ep-chl-carb) alteration of volcanics

.FeOx gossan in favorable strata, tuffs, blk shale etc

.Pyroclastic rocks in section "Agglomerate, mill rock"

.If metamorphosed, felsics go to felsic schists or gneisses; black shales to basalts to greenschists or amphibolites; calcareous rocks to calc silicates. Silicious volcanics often miscalled metaquartzites

.Aeromag useful in tracking mafic volcanics or, less commonly, other magnetic horizons

Stratiform Barite

- Thin to thick (to 15 m) barite beds in sequence of dark chert, siliceous shale, limestone and siltstone
- Lateral extent of beds often several hundred meters
- Barite rosettes, nodules common in sediments
- Ord-Miss strata productive in U.S.
- Synsedimentary textures e.g. graded bedding, laminated barite, continuity of beds
- Geochem Ba

Hot Spring Gold-Silver Deposits

.Common in Tertiary felsic volcanic fields, extrusive plus intrusives

.Evidence for shallow, hot spring activity e.g. sinters, alteration.

.Can be large tonnage deposits in stockworks

.Host can be carbonate (Carlin) or volcanic or sedimentary

.Much complex high angle faulting

.Favorable environments include: (1) Caldera rim fracture zones, (2) Complex felsic volcanic centers with domes, flows plugs; faulting (3) Complex basin - range faulting (4) Complex lake basins with volcanic tuffs, ash flows, etc

.Hydrothermal brecciation, silica commented breccia/conglomerate

.Large (to several km^2) areas of intense silicification

.Alteration is argillic with quartz, adularia, alunite, Kaolinite, sericite

.Zones of stockwork quartz or chalcedony veins

.Greyish or bluish quartz veinlets (contain sulfides)

.Typical minerals are native gold, pyrite, stibnite, cinnabar, arsenopyrite, fluorite, (sphalerite), Ag-sulfosalts

.Geochemistry Au, Ag, As, Sb, (F, Sn, Mo)

.Associated placers and placer claims

Gold-Silver-Base Metal Veins

.Many characteristics similar to Hot Spring type, but thought to be generally deeper in system, with basic metals increasing with depth.

.Occur in strong fracture systems like caldera rings, basin-range faults, domes-faulted areas

.Silicification along veins, but not pervasive

.Irregular patchy argillic alteration

.Narrow fracture zones with sulfides, strong barren fractures with dikes.

.Most deposits either (1) Veins, stockworks, or replacements in volcanic rocks or (2) replacements and veins in associated sedimentary rocks

.If veins intersect premineral sediments, suspect large low grade Au, Ag accumulations in silicifed sediments around vein

.Multicolored, local gossans

.Geochem Ag, Ag, Cu, Pb, Zn, As, Sb

Polymetal Gold-Silver Veins

- .Associated with major volcanic piles dominated by intermediate calc-alkalic porphyritic volcanic rocks i.e. rhyodacites, trachyandesites, quartz latites.
- .Associated sediments often volcaniclastic
- .Evidence of volcanoplutonic environment e.g. intrusive relations between igneous rocks
- .Porphyritic domes and flow-dome complexes most favorable
- .Large areas of argillic - sulfate alteration and silicification.
- .May be associated with deeper porphyry copper systems
- .Much fracturing and brecciation of silicified areas
- .Multicolored gossans
- .Sometimes fault controlled
- .Ore mineralogy dominantly sulfosalts e.g. enargite, tetrahedrite-tennantite, Ag-sulfosalts, and pyrite +- bismuthinite, native gold, tellurides, chalcopyrite, galena, sphalerite
- .Geochem Au, Ag, As, Sb, Bi, Hg, (Mo, Te, Ba)
- .Associated placers and placer claims

Tungsten-Gold Veins

.Hosts variable from bimodal felsic-mafic volcanics to black slate or metamorphic equivalents

.Veins concordant and discordent, mineralized veins often one of many sets

.Ore mineralogy typically native gold, scheelite+-arsenopyrite, stibnite, pyrite, sulfosalts in quartz gangue

.Alteration minor, some silicification

.Veins can be stratabound (e.g. Fairbanks) or clustered in favorable structural sites or both

.Known deposits of this type

.Associated placers and placer claims

.Geochem Au, Ag, As, Sb

Porphyry Cu, Mo

.Shallow, small porphyritic plutons

.Quartz monzonite to granodiorite composition usually; syenite, monzonite, diorite less common

.Extensive pyritic alteration

.Known deposits

.peripheral mag highs sometimes

.Tertiary/Mesozoic intrusive ages most favorable

.Evidence for volcanoplutonic setting, caldera resurgence, ring fractures

.Porphyritic with sugary groundmass, multiple intrusion

.Passive emplacement: diking, brecciation, stoping

.I-type or Magnetite type intrusives

.Host rocks - variable, almost anything

.Much stockwork fracturing and microveining

.Alteration type - potassic/phyllic, argillic

.Geochem
Cu, Pb, Zn, Ag Typical
Te, Mn, Ba, As, Bi, also used

Porphyry Mo, W

.Shallow, small siliceous porphyritic plutons

.Quartz monzonite to granodiorite porphyry usually - I type

.Composite multiphase intrusions, complex igneous history, evidence for cupolas

.Known deposits of this type

.Extensive pyritic alteration

.Rhyolite dikes, especially garnet-bearing

.Cogenetic rhyolitic volcanics

.Abundant veining, stockwork fracturing, brecciation of host and intrusive

.Weak mag high in intrusive

.Flourite rich system

.Part of magmatic arc paralleling tectonic grain

.Tertiary (or Mesozoic) intrusive ages

.Geochem Mo, W, Sn, Ag, Zn, Pb, F, As

.Aeromag - poss lows in highly altered stocks

.Multicolored gossans

.Tendency to be found on edges of regional gravity lows (possibly reflecting deep batholith)

Skarn Cu, Fe, Au

.Diorite to grandiorite porphyries, many dikes

.Abundant veining - Secondary biotite, Kspar, Actinolite, Qtz-sericite-py

.Mag highs over intrusives and contact zones

.Abundant carbonate in section

.Irregular, extensive pluton-limestone contacts

.Known deposits in area

.Geochem
    Cu, Zn, Mo, As, Au, Bi

Skarn W (Cu)

.Equigranular to porphyritic biotite-Kspar granite, low hornblende

.Late Mesozoic age of intrusive favorable

.Pegmatite/aplite dikes common

.Propylitic alteration of intrusive (chl-ep-carb-ab)

.Absence of intense veining

.Mag anomalies around intrusives

.Thick carbonate sequences

.Shallow dipping pluton-limestone contacts

.Reentrants and irregularities in pluton-limestone contact

.Significant lengths of pluton-limestone contact

.Geochem
W, Cu, Mo, Sn, Bi, Be

.Known deposits

Skarn Pb-Zn

- .Felsic dike swarms (granodiorite to granitic)
- .Abundant carbonate in section
- .Regional propylitization
- .Fault control of skarns
- .Geochem
  Zn, Pb, Ag

Greisen-Stockwork-Skarn Sn

.High level granite to alkali granite stocks and dikes, rhyolitic to coarse grained texture-often S-type without hornblende.

.Abundant coarse grained muscovite +garnets, tourmaline, idocrase, fluorite in intrusive and contact rocks

.Poss Mag highs in contact rocks

.Irregular, shallow-dipping, contacts

.Abundant carbonates in section for skarns

.Geochem
Str sed Pb, Zn, Cu, Ag, Be, F, Mo,
Pan Con, Sn, W

.Known tin occurrences or placer tin nearby

.Multiphase intrusive (3-10 km^2 common)

.Evidence for cupolas or cusps over pluton

.Deposits may be greisen veins, stockwork, or disseminations in intrusive or skarns in adjacent carbonate

.Sometimes closed gravity low over intrusives

Replacement/Veins of Fluorite-Beryllium

- .Regional occurrence linked to Sn systems cutting carbonate sequences, may be distal edges of system.
- .Stockworks or vein sets cutting marmorized limestone with fluorite, quartz, ± beryllium silicates in vein material
- .Felsic dikes common
- .Known occurrences or nearby Sn systems
- .Geochem F, Be, (Sn, U)

Mafic-Ultramafic Cu-Ni-PGE (Excluding Komatiites)

.Presence of extensive plutonic ultramafic/ mafic rocks, especially troctolite

.Lack of hornblende in gabbros, except in hydrous alteration phases

.Thick layered cyclic mafic-ultramafic sequences, or plugs

.Sulfide-bearing diabase sills and chill phases

.Known Cu, Ni, or PGE phases, especially in basal zones

.Geochem Cu, Ni, Co, Au, PGE

.Contact of ultramafic plutons with silicious host rocks

.Strong magnetic anomalies

Mafic-Ultramafic Cr

.Abundant ultramafic rocks, layered or plug-like, especially dunite and hartzburgite with pods and veins of dunite in hartzburgite

.Cumulate and tectonized rocks in section

.Strong magnetic anomalies

.Geochem Cr, Cu, Ni, PGE

Mafic-Ultramafic Asbestos

.Presence of olivine bearing ultramafics, especially dunite

.Veins of serpentinite in serpentinized ultramafics

.Strong mag. anomalies

Shale Hosted and Redbed Copper

.Rift basins or shallow marine basins over rifts, often intracratonic, sometimes in tectonic belts

.Presence of (1) conglomerate-sandstone redbeds with basalt flows (2) thin bedded organic shale/limestone (host) (3) Evaporites at top of sequence

.Ore occurs in both reduced and oxidized part of section. Chalcocite, bornite, chalcopyrite, galena, sphalerite, pyrite common ore minerals. Occasionally grades laterally to zinc-rich shale over 10's of km.

.Known occurrences

.Geochem Cu, Mo, Pb, V, Zn, Ag, U

.Radiometric anomalies in shale

Iron Formation (BIF)

.Typically of Proterozoic age (2.2 m.y.)

.Large epicontinental basins, close to Archean cratons

.Thought to be of volcanic exhalative origin

.Banded, red silicious sediments and cherts common in sequence

.Great lateral extent

.Iron minerals variable: Fe-phyllosificates, Fe-carbonates, Fe-oxides, Fe-sulfides, and metamorphic products

.Sedimentary sequence often includes much chert and dolomite as well as volcanic derived tuffs and tuffaceous shales

.Supergene enrichment by silica removal common, either at base of weathering zone or along fractures

.Aeromag anomalies over magnetite-facies

Sedimentary Ironstone

.Evidence of shallow epicratonic landlocked basins

.Often oolitic (Clinton-type), sandy, clayey

.Abundant fossils, rip up clasts, ripple marks, crossbedding and other shallow water features

.Usually Phanerozoic age, climate controlled

.Low rate of sedimentation and availability of sediment

.Iron-oxide coated sand grains, iron oxide cement of clastic and bioclastic material common

.Thin beds of Fe-Phyllosilicate or Fe-oxide

.May overlie or be interstratified with coal seams

.Grade laterally into ferruginous sand and clay with sediments.

.Ore material 20-50 percent Fe

Carbonate Hosted Zn, Pb

.Basic margin shallow water carbonates, reefs etc., as host rocks

.Deep adjacent sedimentary basins, often growth-fault controlled, often in or adjacent to stable platforms

.Stratabound galena-sphalerite-pyrite replacements and veins, Sometimes with Cu, Co, Ni, Lower to Middle Paleozoic ages productive in U.S.

.Gangue-calcite, dolomite, quartz, clays, barite, fluorite

.Numerous lateral and vertical facies changes near limestone-dolomite transition

.Solution collapse breccias or algal reefs favorable sites

.Intersection of deep seated faults with favorable carbonates

.Precambrian basement knobs and highs

.Geochem
Zn, Pb, Cu, Bu, F; generally weak anomalies

.Known occurrences

.Evidence for hydrocarbons

Carbonate Hosted Cu

.Similar to Carb Hosted Pb, Zn

.Shallow water carbonates, reefs, etc. adjacent to basin controlled by growth faults

.Areas of hydrothermal dolomite and breccia in carbonates

.Geochem Cu, Co, (Pb, Zn) generally weak anomalies

.Known occurrences

.Evidence for hydrocarbons

Sandstone Hosted Uranium

- .Suitable U-enriched source rocks, e.g., granites, alkaline complexes, acid volcanics or tuffs

- .Stable structural setting usually

- .Sandstone-bearing sedimentary basins flanking host, usually continental sandstones or shoreline fluvial

- .Fluvial depositional environment., braided streams, fans, lacustrine, deltaic.

- .Unconformity at base of sandstone sequence, channels cut into impermeable shales

- .Host - clean quartzose or arkosic sandstone interbedded with mudstone. Tuffaceous or feldspathic with plant material or pyrite Qtz-only sandstone or graywackes unfavorable

- .Known deposits

- .Radiometric highs in region

- .Geochem U, V, Cu, Mo, Ba, As, Se

Igneous Associated Uranium

- .Associated with S-type leucogranites, often 2-mica
- .Thick sialic crust
- .Granites enriched in U (8-20 ppm), often Sn and W as well. Uranium as uraninite or in zircon, monazite, apatite
- .Deposits are of four types (1) primary disseminations in late stage granitic phases (2) mineralization in aplites and pegmatites (3) epigenetic veins and fracture fillings (4) Secondary hydrothermal veins and disseminations in overlying clastic rocks.
- .Known occurrences or nearby Sn, W systems
- .Distal areas around Sn systems
- .Carboniferous to Tertiary ages productive
- .Regional radiometric anomalies
- .Geochem U, (Cu, As, Mo, Sn, F)

Placer Sn, Au

.Historical placer mining

.Drainages or beaches downslope from known or potential lode or paleoplacer sources

.Mining claim activity along drainages

.Deep weathering of source rocks and moderately incised drainage system

.Absence of extensive glaciation (usually true)

MEMORANDUM

State of Alaska

DEPARTMENT OF NATURAL RESOURCES
DIVISION OF GEOLOGICAL AND GEOPHYSICAL SURVEYS

TO: M.A. Wiltse
G.D. March

DATE: December 7, 1984

FILE NO:

TELEPHONE NO:

FROM: T.E. Smith TES

SUBJECT: NorWAAP Geochem Suites

Further to our past discussions on geochem element suites to be composited on the quadrangle overlays for NorWAAP, we have sifted through geochemical signals characteristic of most deposit types and have come up with the five suites listed below. Various combinations of these five overlays should be useful in discriminating between deposit classes and, perhaps in some cases, between deposit types.

Suite 1	Cu, Pb, Zn, Ag, Ba
Suite 2	W, Mo, Sn, Be, Bo
Suite 3	U, V, Cu
Suite 4	Au, Ag, As, Bi, Sb
Suite 5	Cr, Ni, Co, Cu

My apologies for the late date of this memo, the Koniag travels preempted my energies last week.

cc NorWAAP Team
R. Reger

02-001A(Rev 10/79)

ANOMALY RECOGNITION STRATEGY FOR NORTHWEST REGIONAL AREA PLAN STREAM SEDIMENT, LAKE SEDIMENT, AND PANNED CONCENTRATE GEOCHEMICAL DATA

Milton Wiltse
Gail March

Three ~~preliminary~~ primary sources of geochemical data were reviewed for the North West Regional Area Plan (NORWAP) mineral appraisal: National Uranium Resource Evaluation (NURE) data; U.S. Geological Survey, Alaska Mineral Resource Assessment Program (AMRAP) data; and Alaska Division of Geological and Geophysical Surveys (ADGGS) data; U.S. Bureau of Mines (BOM) data. Each of these data sources provided subsets of data types as summarized below:

- NURE:
  - stream sediment
    - active streams
    - dry streams
  - lake sediment
- AMRAP:
  - stream sediment
- BOM:
  - stream sediment
- ADGGS:
  - stream sediment

Virtually no source provided regionally distributed lithogeochemistry data. Lithogeochemistry data were concentrated close to known mineral prospects, therefore prospect location maps made effective representations for these samples.

Chemical values for the various data sets were derived from four analytical methods as follows:

- NURE:
  - Energy Dispersive X-Ray fluorescence: As, Cu, Pb, Ni, Ag (Sn, W - virtually no data)
  - Neutron Activation Analysis: V, Sb, Cr, Co, Zn, U (Au - virtually no data)
  - Optical Emission Spectroscopy: Be - virtually no data
- AMRAP:
  - Optical Emission Spectrographic: Sn, W, V, Cr, Ni, Co, Ag, Mo, As, Sb, Bi, B, Ba, Be
  - Atomic Absorption: Cu, Pb, Zn, Au
- ADGGS:
  - Optical Emission Spectroscopy: Sn, W, V, Cr, Ni, Co, Ag, Mo, As, Sb, Bi, B, Ba, Be
  - Atomic Absorption: Cu, Pb, Zn, Au

Characteristics of the different data sets vary widely. Optical emission spectrographic data from the USGS and ADGGS reports are presented as discontinuous step values within the following range of steps: 1, 2, 3, 5, 7, 10, 20, 30, 50, 70, 100, 200, 300, 500, 700, 1000 ppm, etc. Data derived from atomic absorption, X-ray fluorescence, and neutron activation methods are essentially continuous in value to the nearest whole ppm value. NURE uranium values are an exception and are reported to the nearest hundredth ppm. Detection limits for each element vary with the analytical method employed in analyzing the sample.

Given the above differences in the fundamental methods of sample analysis and data presentation, it is impossible to merge the unprocessed elemental values. Within each data set, a single threshold value for each element was defined that separated background from anomalous samples. Thus each sample in a data set was classified as being a background or anomalous sample with respect to a given element. The anomalous samples for a given element from all data sets were combined in a single anomalous set of samples and their locations plotted on a map with an identifying element symbol. With this strategy samples having anomalous values for up to five different elements were displayed on one map.

The above procedure obscures the origin of samples, i.e., from the final maps it is impossible to tell from which original data set the various sample points were derived. From the maps alone, it is also impossible to determine the threshold value used to classify a sample as anomalous in a given element. In fact, if the map represents n data sets there may be n threshold values for each element represented on that map. For example, consider the hypothetical case of three distinctly different data sets for Pb, one data set derived from optical emission spectrographic data, the second data set derived from X-ray fluorescence spectroscopy, and the third data set derived from atomic absorption analyses. In practice, each of these data sets has a different mean , detection limit , variance, and distribution shape. In this study each set of Pb data is treated separately until anomalous samples are mapped. In general the top 5% of values in each data set is classified as anomalous. The remaining points in the data set are classified as background. The top cut-off value for a given distribution is not generally the same for all data sets. Thus each anomalous sample is anomalous only in relation to other samples in its original sample set. Once classified as anomalous it is placed in a new subset of samples derived from all samples classified as anomalous in Pb, no matter from what original sample set they were identified. This strategy also allows the merging of stream sediment and lake sediment anomalies on the final map.

It is impossible to be absolutely consistent in applying only one rule to choosing elemental anomaly threshold values. Although a choice of the top 5% of values for a given element in a single sample set was the first rule to be tried in all cases, it was not strictly applicable if:

1) the elements in question were precious metals and the detection limit was high enough that virtually all reported values were anomalous.
2) the data set had a restricted number of samples so that essentially no characteristic distribution was formed.
3) the data had been generated by optical emission spectroscopy so that the high value interval limits had wide ranges (e.g., 500 - 700, or 5000 - 7000 ppm), resulting in large cumulative frequency steps.
4) the data had extreme high value outliers that had to be trimmed from the data set so that the dominant data distribution could be displayed.

5) the data did not conform to regular distribution, but was multi-modal.

The following examples serve to illustrate the use of the general 5% rule, and the types of judgments made for the five different types of exceptions noted above.

Example 1: 5% rule.

The Seward Penninsula NURE vanadium data provides an example of a straight forward application of the general 5% rule. In Figure 1 note that an interpolation of the the histogram value at 95% gives 159 ppm as the nearest whole analytical value. Since the NURE lake sediment vanadium data is a continuous sequence of integer values such an interpolation can be made. Note that in Figure 2, NURE stream sediment vanadium data shows a very similar distribution but that the 95% value is in this case 182 ppm. Thus, on the final anomaly maps NURE lake sediments greater than 159 ppm and NURE stream sediments greater than 182 ppm are both classified simply as anomalous, and lake sediment samples points are indistinguishable from stream sediment sample points.

Example 2: Precious metal values.

Precious metal values for all samples were accepted as anomalous if any positive results were reported. The analytical methods used in the studies reviewed had high detection limits. For example, there were 2470 stream sediment samples collected on the Seward Penninsula. Any stream sediment or lake sediment sample whose precious metal content exceeded the detection limit was rare. Figure 3 shows the 15 samples from the Seward Penninsula NURE stream sediment data set that had detectable gold values.

Example 3: Restricted data set.

NURE lake sediment tin analyses shown in Figure 4 provide an example of a restricted data set. This histogram represents all Sn analyses that were above detection for all lake sediments from the Seward Penninsula that were analyzed for tin. In this case all samples represented on the histogram were arbitrarily classified as anomalous because most lake sediments analyzed for tin gave no response at all.

Example 4. Optical emission spectrographic data.

Because of the broad reporting intervals for optical emission spectrographic data, a choice must often be made whether to include less than 5% of the samples in the anomalous classification for an element, or as many a 20-30% of the samples. Figure 5 provides a typical example. Interpolated values have no meaning because the data have only discontinuous values equal to interval limits as described above.

Example 5. Data with extreme outliers.

The NURE stream sediment data for Pb for the Seward Penninsula is shown in Figures 6 and 7. In Figure 6 it is impossible to interpolate a threshold value of the upper 5% of samples because of the skewness induced in the distribution by a few extreme outlier values. In Figure 7, the same data set is displayed but the data has been trimmed of its 15 highest points (all clearly anomalous) so that the histogram range is decreased. This has the affect of stretching the most populous portion of the data distribution over more histogram intervals. As a result the structure of the major portion of the distribution is revealed and a threshold can be chosen by one of several methods: on the basis of inspection; on the basis of a value 2 standard deviations above the mean; or on the basis of a value that separates the highest 5% of remaining values from the lower values in the trimmed distribution. In this case the threshold was chosen as 25 ppm, or 2 standard deviations above the mean of the trimmed data.

Note the means and standard deviations for the two histograms of Figure 6 and 7. The mean for the trimmed and untrimmed data vary by only about 2 ppm, but the standard deviation for the untrimmed data is 4 times greater than for the trimmed data. Had the outliers in the distribution not been removed prior to determining a threshold value, a sample would not have been classified as anomalous until it reported greater than 74 ppm. Inspection of the histogram for the majority of Seward Penninsula stream sediment Pb data shown in Figure 7 shows that 75 ppm is clearly an inappropriate threshold value.

Example 6: Complex distributions.

The distribution of stream sediment chemical values for some elements, e.g., Cr, are strongly influenced by source rock type. Figure 8 shows an example of this for a data set generated from part of the Nome quadrangle. Three distinct populations are in evidence on this histogram. The lowest mode is probably a background distribution for country rock schists devoid of greenstones and mafic intrusives. The concentration of values shown at 510 ppm represents values between 300 ppm and 500 ppm and probably is derived from areas having abundant mafic intrusive rocks. The three samples at 1020, which represent values from 700 ppm to 1000 ppm, are truly anomalous. In this study all of the points represented by 500 ppm values were plotted on the maps as anomalous and probably define an area having abundant mafic rocks.

PAGE 9 DMDP5D SEWARD PENINSULA NURE LAKE SEDS

HISTOGRAM OF VARIABLE 5 V

SYMBOL X, COUNT 57, MEAN 118.264, ST. DEV. 30.101

EACH SYMBOL REPRESENTS 1 OBSERVATIONS

INTERVAL NAME	5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80	FREQUENCY INT.	FREQUENCY CUM.	PERCENTAGE INT.	PERCENTAGE CUM.
*16.0000	+	0	0	0.0	0.0
*24.0000	+XX	2	2	0.3	0.3
*32.0000	+X	1	3	0.2	0.5
*40.0000	+XX	2	5	0.3	0.9
*48.0000	+XXXXXX	6	11	1.0	1.9
*56.0000	+XXXXXXXXXX	10	21	1.7	3.7
*64.0000	+XXXXX	5	26	0.9	4.5
*72.0000	+XXXXXXXXXXXX	12	38	2.1	6.6
*80.0000	+XXXXXXXXXXXXXXXXXXXXXXXX	24	62	4.2	10.8
*88.0000	+XXXXXXXXXXXXXXXXXXXX	20	82	3.5	14.3
*96.0000	+XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	41	123	7.1	21.4
*104.000	+XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	46	169	8.0	29.4
*112.000	+XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	49	218	8.5	37.9
*120.000	+XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	66	284	11.5	49.4
*128.000	+XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	69	353	12.0	61.4
*136.000	+XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	63	416	11.0	72.3
*144.000	+XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	54	470	9.4	81.7
*152.000	+XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	47	517	8.2	89.9
*160.000	+XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	33	550	5.7	95.7
*168.000	+XXXXXXXXXXX	11	561	1.9	97.6
*176.000	+XXXXXX	6	567	1.0	98.6
*184.000	+XX	2	569	0.3	99.0
*192.000	+XXX	3	572	0.5	99.5
*200.000	+X	1	573	0.2	99.7
*208.000	+X	1	574	0.2	99.8
*216.000	+	0	574	0.0	99.8
*224.000	+	0	574	0.0	99.8
*232.000	+	0	574	0.0	99.8
*240.000	+	0	574	0.0	99.8
*248.000	+	0	574	0.0	99.8
*256.000	+	0	574	0.0	99.8
*264.000	+	0	574	0.0	99.8
*272.000	+	0	574	0.0	99.8
*280.000	+	0	574	0.0	99.8
*288.000	+	0	574	0.0	99.8
*296.000	+	0	574	0.0	99.8
*304.000	+X	1	575	0.2	100.0
*312.000	+	0	575	0.0	100.0

5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80

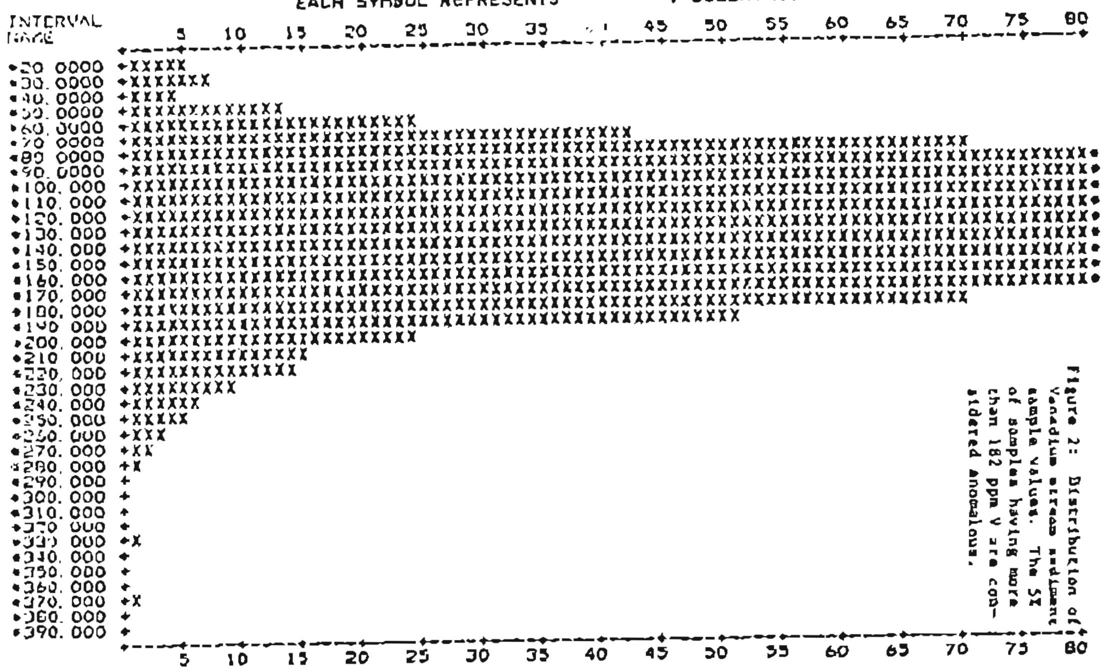
Figure 1: Distribution of Vanadium lake sediment sample values. The 5% of samples having more than 159 ppm V are considered anomalous.

PAGE 9 BMDP5D SEWARD PENINSULA NURE STREAM SEDS

HISTOGRAM OF VARIABLE 5 V

SYMBOL	COUNT	MEAN	ST. DEV.
X	2449	125.345	33.612

EACH SYMBOL REPRESENTS 1 OBSERVATIONS



FREQUENCY INT.	FREQUENCY CUM.	PERCENTAGE INT.	PERCENTAGE CUM.
5	5	0.2	0.2
7	12	0.3	0.5
4	16	0.2	0.7
13	29	0.5	1.2
24	53	1.0	2.2
42	95	1.7	3.9
70	165	2.9	6.7
111	276	4.5	11.3
221	497	9.0	20.3
302	799	12.3	32.6
346	1145	14.1	46.8
324	1469	13.2	60.0
282	1751	11.5	71.5
221	1972	9.0	80.5
177	2149	7.2	87.8
98	2247	4.0	91.8
70	2317	2.9	94.6
51	2368	2.1	96.7
24	2392	1.0	97.7
15	2407	0.6	98.3
14	2421	0.6	98.9
9	2430	0.4	99.2
6	2436	0.2	99.5
5	2441	0.2	99.7
3	2444	0.1	99.8
2	2446	0.1	99.9
1	2447	0.0	99.9
0	2447	0.0	99.9
0	2447	0.0	99.9
0	2447	0.0	99.9
1	2448	0.0	100.0
0	2448	0.0	100.0
0	2448	0.0	100.0
0	2448	0.0	100.0
1	2449	0.0	100.0
0	2449	0.0	100.0
0	2449	0.0	100.0

Figure 2: Distribution of Vanadium stream sediment sample values. The 5% of samples having more than 182 ppm V are considered anomalous.

PAGE 5 DMDPSD SEWARD PENINSULA NURE STREAM SEDS

HISTOGRAM OF VARIABLE 1 AU

SYMBOL	COUNT	MEAN	ST. DEV.
X	15	0.968	1.266

EACH SYMBOL REPRESENTS 1 OBSERVATIONS

INTERVAL NAME	5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80	FREQUENCY INT.	FREQUENCY CUM.	PERCENTAGE INT.	PERCENTAGE CUM.
.240000	XXXXXXX	7	7	46.7	46.7
.360000	XX	2	9	13.3	60.0
.480000		0	9	0.0	60.0
.600000	X	1	10	6.7	66.7
.720000		0	10	0.0	66.7
.840000		0	10	0.0	66.7
.960000		0	10	0.0	66.7
1.08000		0	10	0.0	66.7
1.20000		0	10	0.0	66.7
1.32000		0	10	0.0	66.7
1.44000	X	1	11	6.7	73.3
1.56000		0	11	0.0	73.3
1.68000		0	11	0.0	73.3
1.80000		0	11	0.0	73.3
1.92000	X	1	12	6.7	80.0
2.04000	X	1	13	6.7	86.7
2.16000		0	13	0.0	86.7
2.28000		0	13	0.0	86.7
2.40000		0	13	0.0	86.7
2.52000	X	1	14	6.7	93.3
2.64000		0	14	0.0	93.3
2.76000		0	14	0.0	93.3
2.88000		0	14	0.0	93.3
3.00000		0	14	0.0	93.3
3.12000		0	14	0.0	93.3
3.24000		0	14	0.0	93.3
3.36000		0	14	0.0	93.3
3.48000		0	14	0.0	93.3
3.60000		0	14	0.0	93.3
3.72000		0	14	0.0	93.3
3.84000		0	14	0.0	93.3
3.96000		0	14	0.0	93.3
4.08000		0	14	0.0	93.3
4.20000		0	14	0.0	93.3
4.32000		0	14	0.0	93.3
4.44000		0	14	0.0	93.3
4.56000	X	1	15	6.7	100.0
4.68000		0	15	0.0	100.0

Figure 3: Histogram of Seward Penninsula NURE stream sediment Au values. Fifteen of 2470 stream sediment samples collected on the Seward Penninsula had gold contents greater than detection limits.

PAGE 6 BMDP5D SEWARD PENINSULA NURE STREAM SEDS

HISTOGRAM OF VARIABLE 2 SN

SYMBOL X COUNT 73 MEAN 32.137 ST. DEV. 32.596

EACH SYMBOL REPRESENTS 1 OBSERVATIONS

INTERVAL NAME	5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80	FREQUENCY INT.	FREQUENCY CUM.	PERCENTAGE INT.	PERCENTAGE CUM.
*8.00000	+	0	0	0.0	0.0
*12.0000	+XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	32	32	43.8	43.8
*16.0000	+XXXXXXXX	8	40	11.0	54.8
*20.0000	+XXXXXX	6	46	8.2	63.0
*24.0000	+XX	2	48	2.7	65.8
*28.0000	+XXX	3	51	4.1	69.9
*32.0000	+	0	51	0.0	69.9
*36.0000	+	0	51	0.0	69.9
*40.0000	+X	1	52	1.4	71.2
*44.0000	+X	1	53	1.4	72.6
*48.0000	+XX	2	55	2.7	75.3
*52.0000	+X	1	56	1.4	76.7
*56.0000	+	0	56	0.0	76.7
*60.0000	+XX	2	58	2.7	79.5
*64.0000	+XXX	3	61	4.1	83.6
*68.0000	+XXX	3	64	4.1	87.7
*72.0000	+	0	64	0.0	87.7
*76.0000	+X	1	65	1.4	89.0
*80.0000	+	0	65	0.0	89.0
*84.0000	+X	1	66	1.4	90.4
*88.0000	+XX	2	68	2.7	93.2
*92.0000	+X	1	69	1.4	94.5
*96.0000	+	0	69	0.0	94.5
*100.000	+	0	69	0.0	94.5
*104.000	+	0	69	0.0	94.5
*108.000	+X	1	70	1.4	95.9
*112.000	+	0	70	0.0	95.9
*116.000	+	0	70	0.0	95.9
*120.000	+	0	70	0.0	95.9
*124.000	+X	1	71	1.4	97.3
*128.000	+	0	71	0.0	97.3
*132.000	+X	1	72	1.4	98.6
*136.000	+	0	72	0.0	98.6
*140.000	+	0	72	0.0	98.6
*144.000	+X	1	73	1.4	100.0
*148.000	+	0	73	0.0	100.0
*152.000	+	0	73	0.0	100.0
*156.000	+	0	73	0.0	100.0

5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80

Figure 4: Distribution of NURE lake sediment sample values for Tin. This histogram shows only those values obtained for samples having a Sn content greater than the analytical detection limit. Because most samples were reported to lie below the detection limit for Sn, all samples represented on figure 3 were classified as anomalous.

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PAGE   8  BMDP5D BENDELEBEN DGGSGCR22

HISTOGRAM OF VARIABLE    4 BA
                                   SYMBOL  COUNT      MEAN      ST.DEV.
                                     X      407     620.639     309.085
                            EACH SYMBOL REPRESENTS        1 OBSERVATIONS
                                                                                          FREQUENCY  PERCENTAGE
INTERVAL        5    10   15   20   25   30   35   40   45   50   55   60   65   70   75   80   INT. CUM.  INT.  CUM.
NAME     +----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+
*60.0000 +                                                                                  0     0    0.0    0.0
*120.000 +X                                                                                 1     1    0.2    0.2
*180.000 +                                                                                  0     1    0.0    0.2
*240.000 +XXXXXXXXXXXXXXXXXXXX                                                             20    21    4.9    5.2
*300.000 +                                                                                  0    21    0.0    5.2
*360.000 +                                                                                  0    21    0.0    5.2
*420.000 +                                                                                  0    21    0.0    5.2
*480.000 +                                                                                  0    21    0.0    5.2
*540.000 +XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX*  295   316   72.5   77.6
*600.000 +                                                                                  0   316    0.0   77.6
*660.000 +                                                                                  0   316    0.0   77.6
*720.000 +                                                                                  0   316    0.0   77.6
*780.000 +                                                                                  0   316    0.0   77.6
*840.000 +                                                                                  0   316    0.0   77.6
*900.000 +                                                                                  0   316    0.0   77.6
*960.000 +                                                                                  0   316    0.0   77.6
*1020.00 +XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX*   81   397   19.9   97.5
*1080.00 +                                                                                  0   397    0.0   97.5
*1140.00 +                                                                                  0   397    0.0   97.5
*1200.00 +                                                                                  0   397    0.0   97.5
*1260.00 +                                                                                  0   397    0.0   97.5
*1320.00 +                                                                                  0   397    0.0   97.5
*1380.00 +                                                                                  0   397    0.0   97.5
*1440.00 +                                                                                  0   397    0.0   97.5
*1500.00 +                                                                                  0   397    0.0   97.5
*1560.00 +                                                                                  0   397    0.0   97.5
*1620.00 +                                                                                  0   397    0.0   97.5
*1680.00 +                                                                                  0   397    0.0   97.5
*1740.00 +                                                                                  0   397    0.0   97.5
*1800.00 +                                                                                  0   397    0.0   97.5
*1060.00 +                                                                                  0   397    0.0   97.5
*1920.00 +                                                                                  0   397    0.0   97.5
*1700.00 +                                                                                  0   397    0.0   97.5
*2040.00 +XXXXXXXXXX                                                                       10   407    2.5  100.0
*2100.00 +                                                                                  0   407    0.0  100.0
*2160.00 +                                                                                  0   407    0.0  100.0
*2220.00 +                                                                                  0   407    0.0  100.0
*2280.00 +                                                                                  0   407    0.0  100.0
         +----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+
              5    10   15   20   25   30   35   40   45   50   55   60   65   70   75   80

NUMBER OF INTEGER WORDS OF STORAGE USED IN PRECEDING  ,  PROBLEM    1254
CPU TIME USED      15.000 SECONDS

BMDP5D - HISTOGRAM AND UNIVARIATE PLOTS
     3-JAN-85        AT 15 22:12
PROGRAM CONTROL INFORMATION
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Figure 5: Histogram of stream sediment Ba values for part of the Bendeleben quadrangle, Alaska, from ADGGS, Geochemical Report 22.

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PAGE    6  BMDP5D SEWARD PENINSULA NURE STREAM SEDS

HISTOGRAM OF VARIABLE     2 PB
                                  SYMBOL   COUNT      MEAN       ST. DEV.
                                    X       1671      14.131        29.826
                        EACH SYMBOL REPRESENTS           1 OBSERVATIONS
INTERVAL                                                                                  FREQUENCY PERCENTAGE
NAME            5    10   15   20   25   30   35   40   45   50   55   60   65   70   75   80  INT.  CUM.  INT.   CUM.
           +----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+
*30.0000   +XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX*1609  1609  96.3   96.3
*60.0000   +XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX                                         42  1651   2.5   98.8
*90.0000   +XXXXX                                                                              5  1656   0.3   99.1
*120.000   +XXXX                                                                               4  1660   0.2   99.3
*150.000   +XX                                                                                 2  1662   0.1   99.5
*180.000   +XXX                                                                                3  1665   0.2   99.6
*210.000   +X                                                                                  1  1666   0.1   99.7
*240.000   +XXX                                                                                3  1669   0.2   99.9
*270.000   +                                                                                   0  1669   0.0   99.9
*300.000   +                                                                                   0  1669   0.0   99.9
*330.000   +                                                                                   0  1669   0.0   99.9
*360.000   +                                                                                   0  1669   0.0   99.9
*390.000   +                                                                                   0  1669   0.0   99.9
*420.000   +                                                                                   0  1669   0.0   99.9
*450.000   +                                                                                   0  1669   0.0   99.9
*480.000   +                                                                                   0  1669   0.0   99.9
*510.000   +X                                                                                  1  1670   0.1   99.9
*540.000   +                                                                                   0  1670   0.0   99.9
*570.000   +                                                                                   0  1670   0.0   99.9
*600.000   +                                                                                   0  1670   0.0   99.9
*630.000   +                                                                                   0  1670   0.0   99.9
*660.000   +                                                                                   0  1670   0.0   99.9
*690.000   +                                                                                   0  1670   0.0   99.9
*720.000   +                                                                                   0  1670   0.0   99.9
*750.000   +                                                                                   0  1670   0.0   99.9
*780.000   +                                                                                   0  1670   0.0   99.9
*810.000   +                                                                                   0  1670   0.0   99.9
*840.000   +                                                                                   0  1670   0.0   99.9
*870.000   +                                                                                   0  1670   0.0   99.9
*900.000   +                                                                                   0  1670   0.0   99.9
*930.000   +                                                                                   0  1670   0.0   99.9
*960.000   +X                                                                                  1  1671   0.1  100.0
*990.000   +                                                                                   0  1671   0.0  100.0
*1020.00   +                                                                                   0  1671   0.0  100.0
*1050.00   +                                                                                   0  1671   0.0  100.0
*1080.00   +                                                                                   0  1671   0.0  100.0
*1110.00   +                                                                                   0  1671   0.0  100.0
*1140.00   +                                                                                   0  1671   0.0  100.0
           +----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+
                5    10   15   20   25   30   35   40   45   50   55   60   65   70   75   80
```

Figure 6: NURE stream sediment Pb values for Seward Penninsula stream sediment samples. Note the impossibility of interpolating the upper 5X threshold value.

PAGE 6 BMDP5D NORTHWEST NURE STREAM SEDS

HISTOGRAM OF VARIABLE 2 PB

SYMBOL X, COUNT 1655, MEAN 12.121, ST. DEV. 7.395

EACH SYMBOL REPRESENTS 1 OBSERVATIONS

INTERVAL NAME	FREQUENCY INT.	FREQUENCY CUM.	PERCENTAGE INT.	PERCENTAGE CUM.
*1.97368	0	0	0.0	0.0
*3.94737	0	0	0.0	0.0
*5.92105	140	140	8.5	8.5
*7.89474	277	417	16.7	25.2
*9.86842	300	717	18.1	43.3
*11.8421	247	964	14.9	58.2
*13.8158	225	1189	13.6	71.8
*15.7895	133	1322	8.0	79.9
*17.7632	91	1413	5.5	85.4
*19.7368	77	1490	4.7	90.0
*21.7105	37	1527	2.2	92.3
*23.6842	32	1559	1.9	94.2
*25.6579	29	1588	1.8	96.0
*27.6316	9	1597	0.5	96.5
*29.6053	9	1606	0.5	97.0
*31.5789	6	1612	0.4	97.4
*33.5526	4	1616	0.2	97.6
*35.5263	8	1624	0.5	98.1
*37.5000	3	1627	0.2	98.3
*39.4737	2	1629	0.1	98.4
*41.4474	5	1634	0.3	98.7
*43.4210	3	1637	0.2	98.9
*45.3947	3	1640	0.2	99.1
*47.3684	2	1642	0.1	99.2
*49.3421	0	1642	0.0	99.2
*51.3158	4	1646	0.2	99.5
*53.2895	2	1648	0.1	99.6
*55.2631	1	1649	0.1	99.6
*57.2368	2	1651	0.1	99.8
*59.2105	0	1651	0.0	99.8
*61.1842	0	1651	0.0	99.8
*63.1579	1	1652	0.1	99.8
*65.1316	2	1654	0.1	99.9
*67.1052	0	1654	0.0	99.9
*69.0789	1	1655	0.1	100.0
*71.0526	0	1655	0.0	100.0
*73.0263	0	1655	0.0	100.0
*75.0000	0	1655	0.0	100.0

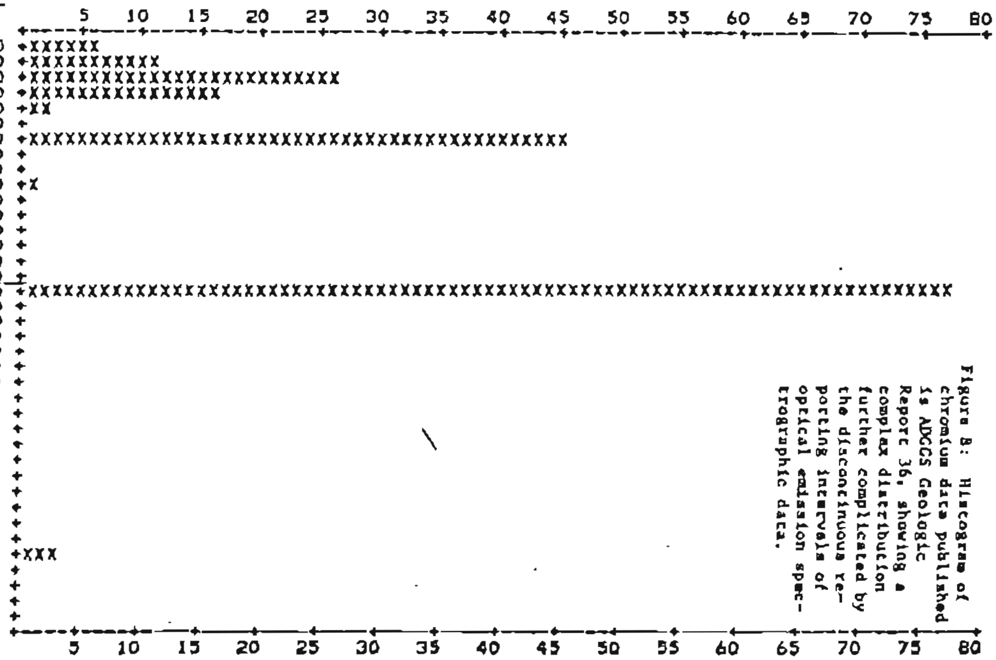
Figure 7: NURE stream sediment Pb values for Seward Penninsula stream sediment samples with the 16 highest sample values removed.

PAGE 6 BMDP5D NUME BBBLORDS

HISTOGRAM OF VARIABLE 2 CR

SYMBOL	COUNT	MEAN	ST. DEV.
X	187	295.401	209.798

EACH SYMBOL REPRESENTS 1 OBSERVATIONS



INTERVAL NAME	FREQUENCY INT.	FREQUENCY CUM.	PERCENTAGE INT.	PERCENTAGE CUM.
*30.0000	6	6	3.2	3.2
*60.0000	11	17	5.9	9.1
*90.0000	26	43	13.9	23.0
*120.000	16	59	8.6	31.6
*150.000	2	61	1.1	32.6
*180.000	0	61	0.0	32.6
*210.000	45	106	24.1	56.7
*240.000	0	106	0.0	56.7
*270.000	0	106	0.0	56.7
*300.000	1	107	0.5	57.2
*330.000	0	107	0.0	57.2
*360.000	0	107	0.0	57.2
*390.000	0	107	0.0	57.2
*420.000	0	107	0.0	57.2
*450.000	0	107	0.0	57.2
*480.000	0	107	0.0	57.2
*510.000	77	184	41.2	98.4
*540.000	0	184	0.0	98.4
*570.000	0	184	0.0	98.4
*600.000	0	184	0.0	98.4
*630.000	0	184	0.0	98.4
*660.000	0	184	0.0	98.4
*690.000	0	184	0.0	98.4
*720.000	0	184	0.0	98.4
*750.000	0	184	0.0	98.4
*780.000	0	184	0.0	98.4
*810.000	0	184	0.0	98.4
*840.000	0	184	0.0	98.4
*870.000	0	184	0.0	98.4
*900.000	0	184	0.0	98.4
*930.000	0	184	0.0	98.4
*960.000	0	184	0.0	98.4
*990.000	0	184	0.0	98.4
*1020.00	3	187	1.6	100.0
*1050.00	0	187	0.0	100.0
*1080.00	0	187	0.0	100.0
*1110.00	0	187	0.0	100.0
*1140.00	0	187	0.0	100.0

Figure 8: Histogram of chromium data published is ADGGS Geologic Report 36, showing a complex distribution further complicated by the discontinuous reporting intervals of optical emission spectrographic data.

5/21/85

Northwest Alaska Area Plan
Progress Chart

QUADRANGLES

OVERLA

	Shismaref	Teller	Nome	Kotzebue	Bendeleben	Solomon	Candle	Norton Bay	Baird Mtns	Selawik	Ambler River	Shungnak	Survey Pass	Hughes	Noatak	Point Hope	Point Lay	De Long Mtns
	NORWAAP I								NORWAAP II						NORWAAP III			
Claims	X	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒
Aeromag	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒
Mineral Occur	X	▒	▒	X	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	X	X	▒
AMRAP	X	X	X	X	X	X	X	X	▒	X	▒	X	▒	X	X	X	X	X
Industry Nom	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒
Terrane*	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒
Geology	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒
Radiometrics	X	▒	▒	X	▒	▒	▒	▒	▒	▒	X	▒	X	▒	X	X	▒	X
Gravity	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒
NURE Histograms	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒
Other Histograms	X	▒	▒	X	▒	▒	▒	X	▒	▒	▒	▒	▒	▒	X	X	X	X
GEOCHEMISTRY: Cu Pb Zn Ag Ba	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒
GEOCHEMISTRY: W Mo Sn Be B	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒
GEOCHEMISTRY: U V Cu	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒
GEOCHEMISTRY: Au Ag As Bi Sb	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒
GEOCHEMISTRY: Cr Ni Co Cu	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒
References	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒
Bibliography	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒
Topography	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒
Grids	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒
Library	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒
Data Quality	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒
Potential	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒

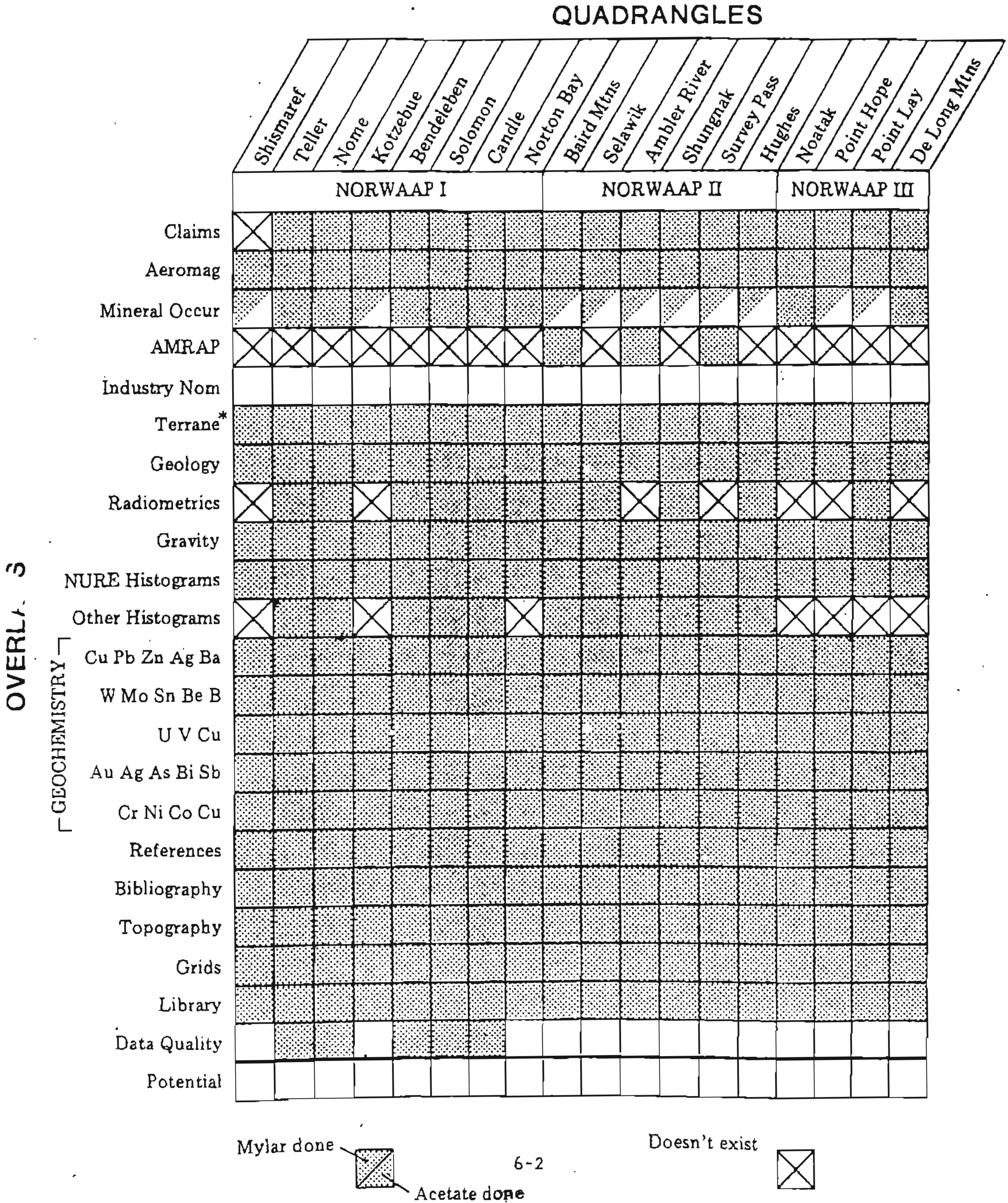
Mylar done / Acetate done

Doesn't exist: X

* Includes USGS, USBM, and Hawley & AEIDC mineral terrane maps; and USGS mineral potential maps.

Northwest Alaska Area Plan
Progress Chart

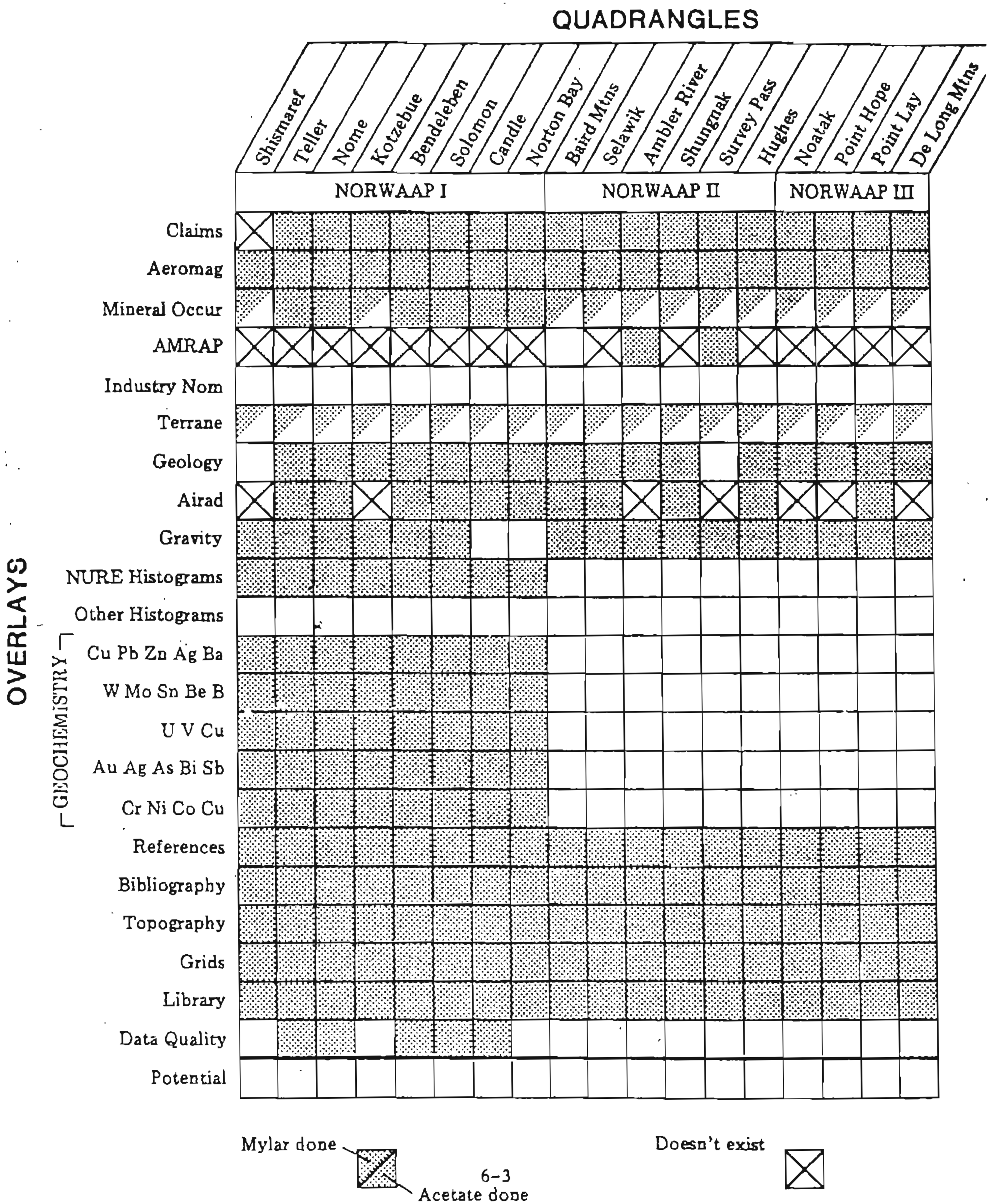
3/20/85



* Includes USGS, USBM, and Hawley & AEIDC mineral terrane maps; and USGS mineral potential maps.

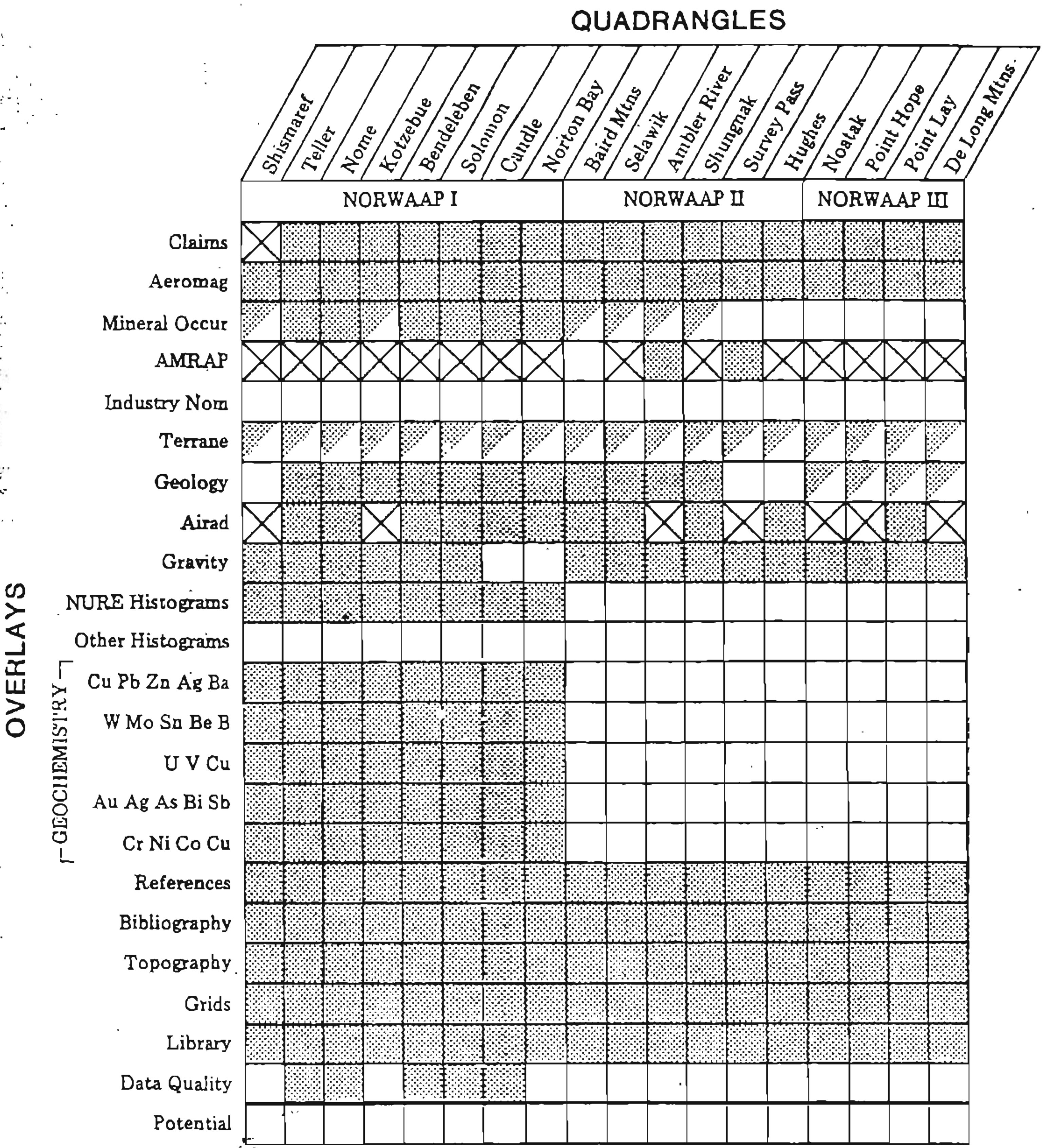
Northwest Alaska Area Plan Progress Chart

Date 3/4/85



Date 2/1/85

Northwest Alaska Area Plan
Progress Chart



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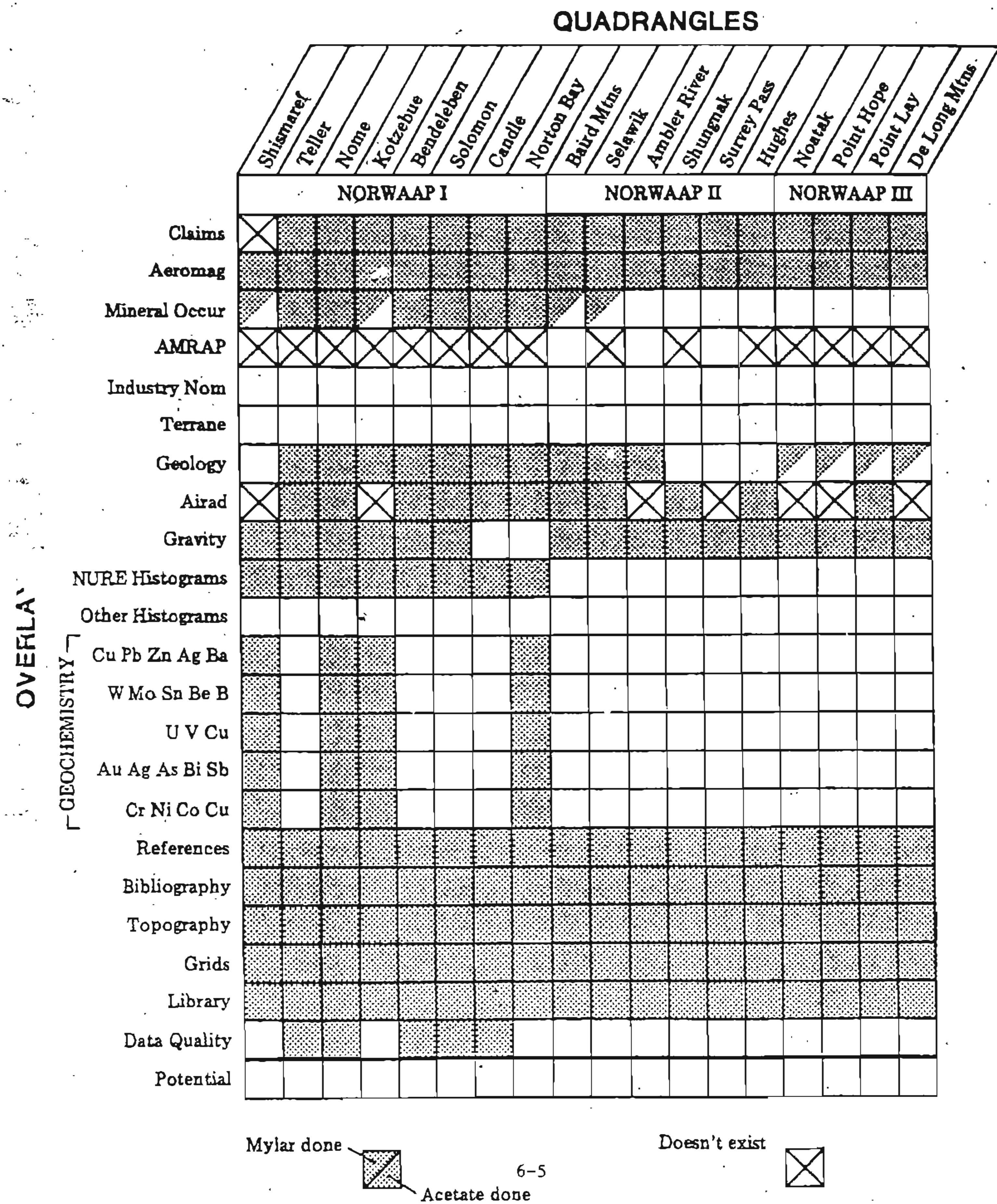
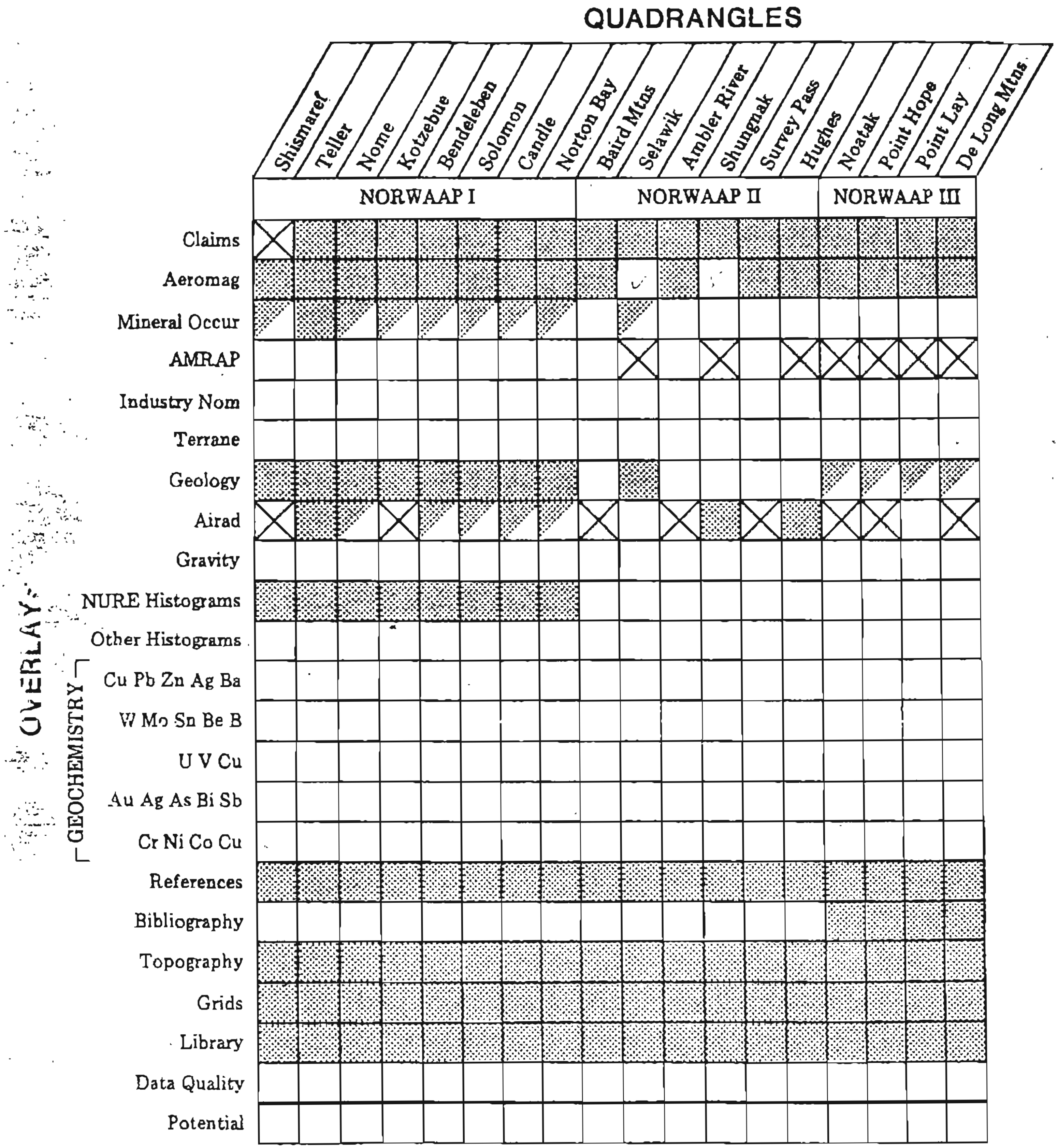
1/4/85

Northwest Alaska Area Plan
Progress Chart



Date 12/20/84

Northwest Alaska Area Plan Progress Chart



Mylar done — Acetate done — Doesn't exist

MEMORANDUM

State of Alaska

DEPARTMENT OF NATURAL RESOURCES

DIVISION OF GEOLOGICAL AND GEOPHYSICAL SURVEYS

TO: Dick Reger, Chief
Geologic Mapping
& Milt Wiltse, Chief
Geochemical Section

DATE: November 28, 1984

FILE NO:

TELEPHONE NO. 786-2168

FROM: Merlin Wibbenmeyer MW
Resource Analysis Section

SUBJECT: N.W. Alaska RMM Project-Minerals

This memo is to document a scope of work agreement with your section to prepare mineral appraisal information for the Northwest project. Attached to this memorandum is a copy of the minutes from our meeting with the Division of Mining, a copy of Tom Smith's handout on the mineral appraisal sequence, and your work up on the budget to accomplish this task. The memo to DOM is yet to be reviewed and confirmed by them, however, it should be fairly close to the understanding held among all parties.

As for the budget, RAS will assign the equivalent of four months of Karen Clautice's time to assist Tom Smith on this task. In addition up to $15,000 previously allocated for this task can be used for covering either general expenses for both the Geologic Mapping Sections and the Geochemical Section. Also, up to $31,700 (10,308 plus 21,400) is available to cover student intern time. This should leave approximately and $7,000 general expenses (from Geologic Mapping and Geochemical) not covered. These funds are definitely available to begin work and will continue so through June 30th. All work requiring funding from Resource Analysis Section should be used by June 30, 1985.

The following products are expected from this task:

1) The mineral potential map compiled from the data layers suggested in Tom Smith's handout. This should be accompanied by a data quality map which indicates the relative reliability of the information presented across each quad.

2) A bibliography of sources found and distinguishing those sources actually used. This will be incorporated into the project bibliography.

3) A short report will be prepared to describe how the information was prepared and explain in layman's terms, how to apply the information presented. Prior to preparing this report, please get with Scott Christy to go over content and format.

Once the data stack has been prepared, I would like Scott Christy, George Dickison and myself to review all of the related data elements used to see if any of the data elements layers should be made a part of the final data base as independent elements. There may be data element layers which would be of use to other information applications besides mineral appraisal. Also as soon as the first draft map with the mineral appraisal interpretation is available, this should also be reviewed by RAS and eventually DOM to make sure the final products will indeed meet expectations.

A brief monthly status report, should be provided either written or a phone call to me, so that this task can be tracked along with the other project activities. This work should cover all of the quads contained in the N.W. Area Plan boundary. As discussed, these products should be completed in final form by June 30, 1985. The second phase of this project will include automation, so final products means map overlays which can be used to digitize the information for entry into the computerized data base.

If there are problems or I have misunderstood the arrangements described above, please let me know so they can be worked out immediately.

In addition to the above project assistance, up to $5,000 is available for a student intern to assist John Dillon this fiscal year between January and June. This assistance is offered in exchange for some resource modelling needs anticipated in FY86. Please let me know if this meets with your approval.

MW/mw

cc: Bill Barnwell, Deputy State Geologist
Scott Christy
George Dickison
Karen Clautice
Tom Smith
Milt Wiltse

MEMORANDUM

State of Alaska

DEPARTMENT OF NATURAL RESOURCES

DIVISION OF GEOLOGICAL AND GEOPHYSICAL SURVEYS

TO: Laurel Murphy, Deputy Director
Division of Mining

DATE: November 28, 1984

FILE NO:

THRU: Bill Barnwell
Deputy Director

TELEPHONE NO: 786-2168

FROM: Merlin Wibbenmeyer MW
Acting Chief, Resource Analysis Section

SUBJECT: October 30, 1984 Meeting N.W. Mapping Project

This memo summarizes our meeting concerning your request for information in the Northwest Resource Management Mapping Project area. The understanding I have as a result of our meeting follows.

1) The DGGS Geologic Mapping Section will be producing a mineral potential map that will interpret several factors including known mineral occurrences, mineral terranes, and state/federal claims, into a single map overlay for each of the seventeen quadrangles (1:250,000 scale) as outlined by the Northwest Area Plan boundary. This map will protray five classes of mineral potential as outlined in the handout prepared by Tom Smith and will be accompanied by a data-quality map indicating the relative reliability of the information used to develop the derivative map.

   The data stack and bibliography of sources used to develop the mineral potential map will be available as historical information if someone needs to verify the mineral-potential data.

2) a) Detailed land use will be provided as one of the information elements in the total data base.

   b) Existing land-use plans will be available as part of the bibliography and literature search conducted at the beginning of each project. Where copies of the background materials are provided to DGGS, they will be made available to other DNR staff for their use. Sources of information will be provided for those wishing to follow up on outside agency plans.

   c) Engineering geology will be provided by the Engineering Geology Section for state lands and major road corridors. Where sea bottom geology characteristics are available for the near shore (3 mile limit) they can be included in this element.

   d) Pipeline outfalls and potential port facilities would be contained in the infrastructure element map.

e) Fish and wildlife resource/habitat information will be provided by ADF&G, included will be substantial information on subsistence resources and access.

f) Socio-economic data is a new information element. To the extent that information is readily available in summarized form from such agencies as the Department of Labor or the Alaska Department of Community and Regional Affairs. Efforts will be made to acquire or provide access to information found during the literature search.

3) Coal resources information is available, the exact format in which this information will be presented is still being explored. These data will be provided by the Minerals and Energy Section.

4) Assistance is requested from your division in updating and acquiring the mineral-claims information. Approximately six weeks of Fred Sterman's time (beginning November 5) is needed to acquire this information.

Your assistance is requested in prioritizing areas along the shoreline which are of high interest in mineral leasing and identifying future planning information needs in order to focus specifically on areas of marine-placer potential.

Lastly, a list of other specific commodities in which you are interested is requested. This list could be used to evaluate our ability to deliver additional information by June 30th.

If there are any questions or additions to the above summary, please let me know immediately.

MW/mw

cc: Jerry Gallagher
Scott Christy
Karen Clautice
George Dickison
Dick Reger
Tom Smith
Milt Wiltse
Randy Updike
Kerwin Krause

MEMORANDUM

State of Alaska

DEPARTMENT OF NATURAL RESOURCES
DIVISION OF GEOLOGICAL AND GEOPHYSICAL SURVEYS

TO: M. Robinson, T. Balog, M. Albanese
G. Pessel, K. Clautice, M. Wiltse
G. March, D. Hickmott, R. Reger

DATE: October 26, 1984

FILE NO:

TELEPHONE NO: (907) 474-7147

FROM: T. E. Smith
Geologist

SUBJECT: Northwest Area Plan - Tasks and other Specifics

As you may have heard by now, DGGS will be providing a summary on mineral potential of Northwest Alaska as part of a DNR area plan. We, the "A" team, have been assigned the objective of completing this effort by early summer. A general methodology for attacking the problem evolved recently during a meeting with the minerals geologists. Now we are faced with implementing the methodology, task and personnel allocation, etc. To this end, I would like to schedule a meeting on Tuesday, November 6, 2:00 p.m. to get us underway. We look foreward to seeing you there. Think NorWAAP!

02-001A (Rev 10/79)

STATE OF ALASKA

DEPARTMENT OF NATURAL RESOURCES

DIVISION OF GEOLOGICAL & GEOPHYSICAL SURVEYS

BILL SHEFFIELD, GOVERNOR

☐ POUCH 7-028
ANCHORAGE, ALASKA 99510
PHONE: (907) 276-2653

☒ 794 UNIVERSITY AVENUE, BASEMENT
FAIRBANKS, ALASKA 99701
PHONE: (907) 474-7147

December 6, 1984

Mr. James Barker
Supervisory Physical Scientist
U.S. Bureau of Mines
O'Niel Bldg
University of Alaska
Fairbanks, AK 99701

Dear Jim:

The State Survey is currently involved in a literature-based mineral appraisal of 18 quadrangles in Northwest Alaska as part of a management plan for Northwest Alaska Area (NorWAAP). Geochemical information is incomplete for some of these quadrangles, particularly the Selawik Quadrangle. We understand you are working on a report of the Selawik Hills region and would appreciate incorporating any published or unpublished geochemical information you might have in the Selawik Quadrangle. We would be most appreciative if you could accomodate this request.

Sincerely,

Thomas E. Smith
Geologist

c.c. R. Reger

MEMORANDUM

State of Alaska

DEPARTMENT OF NATURAL RESOURCES
DIVISION OF GEOLOGICAL AND GEOPHYSICAL SURVEYS

TO: Merlin Wibbenmeyer,
Resource Analysis Section

DATE: June 17, 1985

FILE NO:

TELEPHONE NO: 474-7147

FROM: Mary Albanese, MA
Geologist

SUBJECT: NorWAAP Products

We are sending, under separate cover, one set of mylar overlays of the mineral potential and data quality maps of the 18 NorWAAP quadrangles at 1:250,000 scale and at 1:1,5000,000 scale, along with a manual which includes an explanation of our scoring system, an extensive bibliography, and other pertinent information. This material concludes our obligation to this phase of the NorWAAP investigation. Please let us know if you have any questions on this material.

cc: Doug Jones
Tom Smith

02-001A(Rev 10/79)

Definitions used in the development of the mineral occurrence overlay for the Seward Peninsula phase of the NORWAP appraisal.

SIGNIFICANT DEPOSIT OR OCCURRENCE

For the purpose of developing the mineral deposit overlay, a significant mineral deposit was defined as a mineral deposit that contains known reserves (either published or unpublished) and/or from which a considerable amount of mineral commodities have been produced. The significant deposit catagory is the highest ranking catagory used in this evaluation and includes deposits such as Lost River, Kougarok Mountain, Hannum Creek, Omalik, Big Harrah, and so forth.

DEPOSIT OR OCCURRENCE

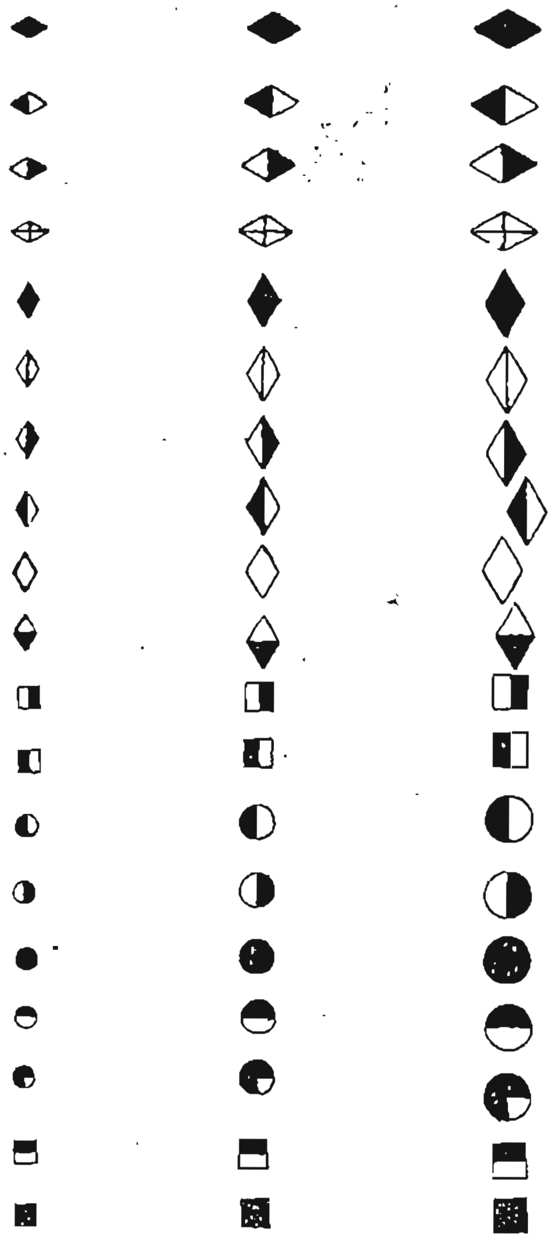
For the purpose of developing the mineral deposit overlay, a mineral deposit or occurrence was defined as a mineral deposit or occurrence for which there is no significant reserve base or production, and for which there is minor production and/or a potential for reserves

MINOR OCCURRENCE

For the purpose of developing the mineral deposit overlay, a minor occurrence was defined as a mineral occurrence that does not contain known reserves and has no potential to contain reserves. This deposit catagory is important only as an indicator of mineral trends and fovorable environments, but in them selves have no economic significance.

EXPLANATION FOR THE MINERAL OCCURRENCE OVERLAY

SYMBOL			
minor occurrence	occurrence	significant occurrence	DEPOSIT TYPE

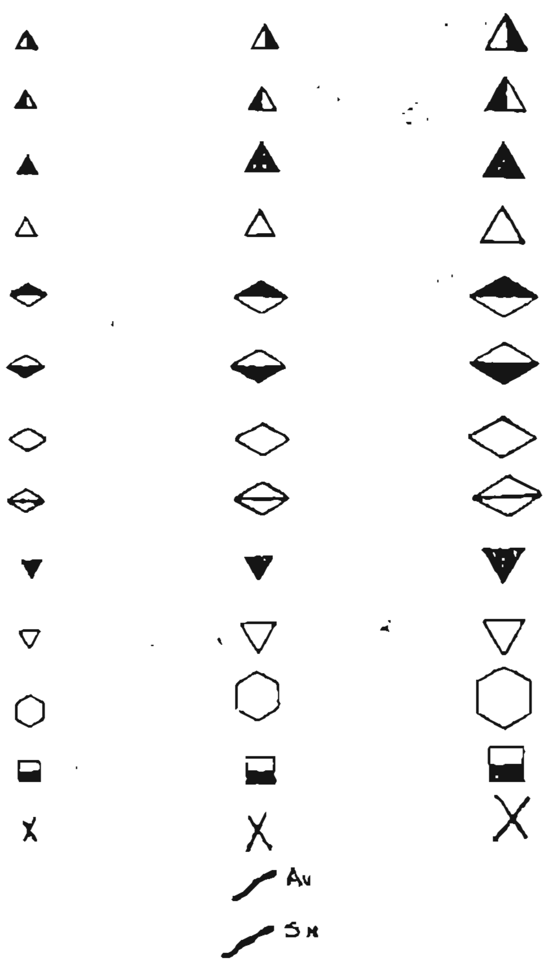


DEPOSIT TYPE:

- Stratiform Pb-Zn-Cu-Ag-Fe-Ba
  - Sedex type
  - Volcanogenic type
- Stratiform Ba
- Vein Ag-Pb-Zn +- Au
- Vein Au-Ag +- W
- Vein Cu +- Pb-Ag-Au
- Vein W
- Vein unclassified (Sb, Mn, Ba)
- Stockwork Au
- Porphyry Cu-Mo
- Porphyry Mo-W
- Skarn Cu-Fe
- Skarn W-Cu
- Skarn Zn-Pb +- Ag-Sn-F-Be
- Skarn Sn
- Replacement F +- Be
- Replacement Sn (greisen)
- Stockwork Sn

EXPLANATION FOR THE MINERAL OCCURRENCE OVERLAY

SYMBOL			
minor occurrence	occurrence	significant occurrence	DEPOSIT TYPE



Mafic-Ultramafic associated Cu-Ni

Mafic-Ultramafic Cr

Mafic-Ultramafic Pt-Pd (PGM)

Asbestos

Sedimentary Cu

Volcanic red bed Cu

Metamorphosed Cu deposits ? origin

Iron formation and/or ironstone

Carbonate hosted Zn-Pb

Carbonate hosted Cu

Sandstone hosted U

Igneous associated U

Miscellaneous - unclassified

Placer Au

Placer Sn

See Public-data File 85-58, 'Bibliography and index of northwestern Alaska geology,' by M.S. Robinson, M.D. Albanese, K.H. Clautice, G.H. Pessel, and C.C. Fraser, 331 p.