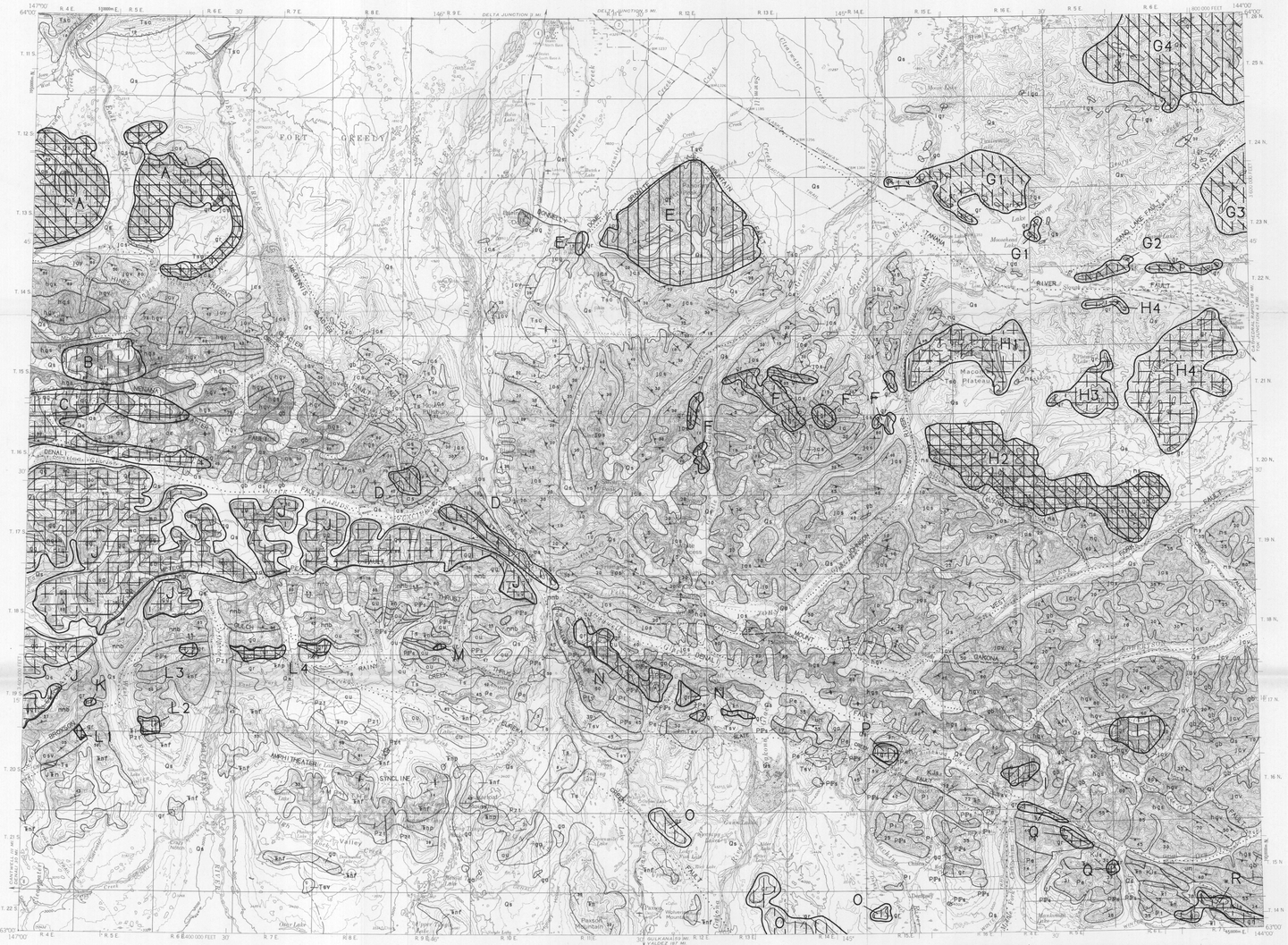
DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY



Base from U.S. Geological Survey, 1955
Universal Transverse Mercator projection

Generalized bedrock geologic map compiled by Warren J. Nokleberg from mapping by Warren J. Nokleberg, Ian M. Lange, John N. Aleinikoff, Ronny T. Miyaoka, and Richard E. Zehner, 1977-85

SCALE 1:250 000

5 0 5 10 15 20 25 MILES
5 0 5 10 15 20 25 KILOMETERS

CONTOUR INTERVAL 200 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

PORPHYRY Cu-Mo DEPOSITS, W-Mo AND Cu-Zn-Pb SKARN DEPOSITS,
AND PORPHYRY Sn DEPOSITS

METALLIFEROUS MINERAL RESOURCE ASSESSMENT MAPS OF THE MOUNT HAYES QUADRANGLE, EASTERN ALASKA RANGE, ALASKA

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FOLIO OF THE MOUNT HAYES QUADRANGLE
MISCELLANEOUS FIELD STUDIES
MAP MF-1996-A
SHEET 4 OF 4
Explanatory pamphlet accompanies map

PORPHYRY Cu-Mo DEPOSITS, W-Mo AND Cu-Zn-Pb SKARN DEPOSITS, AND PORPHYRY Sn DEPOSITS

EXPLANATION

Porphyry Cu-Mo deposits--Area of potential for undiscovered deposits. Letters and numbers refer to table 10

Moderate

Low

W-Mo and Cu-Zn-Pb skarn deposits--Area of potential for undiscovered deposits. Letters and numbers refer to table 11

High or moderate

Low

Porphyry Sn deposits--Area of potential for undiscovered deposits. Letters and numbers refer to table 12

Moderate

Low

NOTE: See sheet 1 for explanation of geologic symbols.

Table 10.--Potential and recognition criteria for porphyry Cu-Mo deposits, Mount Hayes quadrangle, eastern Alaska Range, Alaska

(+, letter, element, or mineral indicates criterion present; 0 indicates criterion not observed)

Potential	Recognition criteria present in each area																	
	Diagnostic						Secondary											
	Area 1	2	3	4	5	6	1	2	3	4	5	6	7	8	9	10		
Low	A	+	0	+	0	+	+	0	+	+	0	Cu, Mo, Pb, Zn, As, Au	Mo, Pb, Zn, Ag	Sb	op, sh	0			
Low	B	0	+	+	0	0	0	0	0	0	0	0	0	0	0	0				
Low	C	0	0	+	0	0	+	0	0	0	0	Mo	0	0	op, sh, mo, py	0				
Low	D	0	0	+	0	0	+	0	0	0	0	Cu	0	0	0	0				
Moderate	E	0	0	+	0	+	+	0	+	0	0	Mo	Mo	Cu, Mo, Ag, Au, Sb	op, mo, py, gn, sh	+				
Low	F	0	+	+	0	+	+	0	0	0	0	Mo, Pb, Zn	Pb	Cu, Mo, Pb, Ag	op, mo, sp, gn, sh	+				
Low	G1	0	+	+	0	0	+	0	+	0	0	0	0	0	sh	+				
Low	G2	0	+	+	0	0	+	0	+	0	0	0	0	0	0	0				
Low	G3	0	+	+	0	0	+	0	+	0	0	0	0	0	sh	0				
Moderate	G4	+	+	+	0	+	+	0	+	0	0	Pb	0	Ag	sh	0				
Low	H1	0	0	+	0	0	+	0	0	0	0	As	Pb	0	sh	0				
Moderate	H2	0	0	+	0	0	+	0	0	0	0	Mo	Pb, Zn, Ag	Cu, Mo, Pb, Zn, Ag, Sb	op, mo, py, sp, gn, sh, fl	0				
Low	H3	0	0	+	0	0	+	0	0	0	0	0	Mo, Pb	Ag, Au, Sb	sp, gn, sh, fl	0				
Low	H4	0	0	+	0	0	+	0	0	0	0	Pb, As, Au,	Pb, Ag	Pb, Sb	sh	0				
Moderate	I	0	0	+	0	0	+	0	+	0	0	0	Cu, Mo, Pb, Zn	Cu, Mo, Pb, Zn, Ag	op, sh, fl	+				
Low	J	0	0	+	0	0	+	+	0	0	0	Mo	Mo, Zn	Cu, Mo, Au, Zn	op, mo, py, sh	0				
High	K	+	+	+	0	+	0	0	0	0	0	Cu, Mo, Pb, Zn	Cu, Mo	0	op, mo, py, sh	0				
Moderate	L1	0	0	+	0	+	0	0	0	+	0	Mo, Pb, Zn, As, Sb	Cu, Mo, Zn, Ag	Ag, Au	op, py, gn, sh	0				
Low	L2	0	0	+	0	0	0	0	0	+	0	Cu, Mo, Au	Cu	0	sh	0				
Low	L3	0	0	+	0	0	0	0	0	0	0	Cu, Mo	Ag	Mo, Pb, Ag	op, sh	0				
Moderate	L4	0	0	+	0	+	0	0	0	+	0	Cu, Pb, Zn, As, Sb	Mo, Zn	Pb, Zn	op, py, sp, gn, sh	0				
High	M	+	0	+	0	+	0	0	+	0	0	Cu, Mo, Pb, Au	Cu	Cu	op	0				
Moderate	N	+	0	+	0	+	0	0	+	0	0	Cu, Pb, Zn, As, Au	Cu	Cu	op, py, sh	0				
Low	O	0	0	+	0	0	0	0	0	0	0	Cu, Pb, Au	0	0	sh	+				
Low	P	+	0	+	0	0	0	0	0	0	0	Cu	Zn	Cu	op, sp, gn, sh	0				
Low	Q	0	0	+	0	0	0	0	0	0	0	0	Cu, Mo, Zn	Cu, Zn, Ag	op, py, sp, sh	0				
Low	R	0	0	+	0	0	0	0	0	0	0	0	Mo, Zn	Pb, Zn	op, py, sp, gn, sh	0				

Description of recognition criteria

Diagnostic

1. Geologically favorable environment of plutons of generally porphyritic quartz diorite to quartz monzonite, or hypabyssal stocks of andesite to rhyolite.
2. Known deposit, prospect, or occurrence.
3. Coeval shallow-granitic, hypabyssal, or volcanic rocks.
4. Numerous faults and brecciated country rock.
5. Intrusion of igneous rocks controlled by regional-scale faulting.
6. Hydrothermal alteration.

Secondary

1. Multiple intrusive phases, some porphyritic.
2. Volcanic or intrusive breccias, locally with disseminated or massive sulfides.
3. Dikes, quartz veins, or stockwork veinlets with sulfide minerals.
4. Replacement massive sulfide minerals or skarns in country rock.
5. Breccia pipes locally with sulfides.
6. Anomalous values of Cu, Mo, Pb, Zn, As, Au, or Sb in rock samples.
7. Anomalous values of Cu, Mo, Pb, Zn, Ag, Au, or Sb in stream-sediment samples.
8. Anomalous values of Cu, Mo, Pb, Zn, Ag, Au, or Sb in heavy-mineral-concentrate samples.
9. Occurrence of chalcopyrite, molybdenite, pyrite, sphalerite, galena, scheelite-powellite, or fluorite in heavy-mineral concentrate samples.
10. U-shaped aeromagnetic anomaly patterns, for example, strong, local equidimensional aeromagnetic highs with reentrant or central lows.

Table 11.--Potential and recognition criteria for W-Mo and Cu-Zn-Pb skarn deposits, Mount Hayes quadrangle, Alaska Range, Alaska

(+, letter, element, or mineral indicates criterion present; 0 indicates criterion not observed)

Potential	Recognition criteria present in each area															
	Diagnostic				Secondary											
	Area 1	2	3	4	1	2	3	4	5	6	7	8				
Moderate	A	0	+	0	+	0	+	Mo, Pb, Zn, Au	W, Mo, Pb, Zn, Ag	W	op, sp, gold	+				
Moderate	C	0	0	0	+	0	0	Mo, Ag	0	0	op, sh, mo, py, ar	0				
Low	H1	0	0	0	+	0	0	0	W, Sn	W	sh	+				
Moderate	H2	0	0	0	+	0	0	Mo, Pb, Zn, Ag, Sn	W, Mo, Cu, Pb, Zn, Ag, fl, gold	W, Mo, Cu, sp, gn, py,	sh, mo, op,	+				
Moderate	H3	0	0	0	+	0	0	0	W, Ag, Au, Sn	W, Ag, Au fl	sh, sp, gn,	+				
Low	H4	0	0	0	+	0	0	W, Pb, Au	W, Pb, Sn	W, Pb	sh	+				
Low	J	0	0	0	+	0	0	0	0	W	sh, py	+				
Moderate	L1	0	0	+	+	0	+	W, Mo, Pb, Zn	W, Mo, Cu, Zn, Ag	Ag, Au	sh, op, gn, py, gold	+				
High	L2	+	+	+	+	0	0	Cu, Mo, Au	Cu	0	sh, gold	+				
Moderate	L3	0	0	0	+	0	0	Cu, Mo	Ag	W, Mo, Pb, Ag	sh, op, gold	0				
Moderate	L4	0	+	0	+	0	+	W, Cu, Pb, Zn	Mo, Zn	Pb, Zn gn, py, gold	sh, op, sp,	0				
Moderate	P	0	0	0	+	0	0	W, Cu	Zn	W, Cu	sh, op, sp, gn	0				
Moderate	Q	0	0	0	+	0	0	0	Mo, Cu, Zn	Cu, Zn, Ag py	sh, op, sp,	+				
Moderate	R	0	0	0	+	0	0	0	Mo, Zn	W gn, py, gold	sh, op, sp,	+				

Description of recognition criteria

Diagnostic

1. Geologically favorable environment of calc-alkaline plutonic rocks intruding calcareous or impure calcareous sedimentary rocks.
2. Known deposit, prospect, or occurrence.
3. Replacement of calcareous wall rocks by irregular masses of contact metasomatic minerals, including andradite-grossularite, diopside-hedenbergite, hornblende, wollastonite, epidote, actinolite, idocrase, and quartz.
4. Bleaching of calcareous wall rocks, for example, disappearance of graphite and local silicification.

Secondary

1. Abundant fractures, folds, or faults in calcareous sedimentary rocks.
2. Replacement of granitic rocks adjacent to calcareous sedimentary rocks by andradite-grossularite, diopside-hedenbergite, epidote, hornblende or actinolite, chlorite, calcite, or quartz.
3. Hydrothermal alteration of plutonic rocks.
4. Anomalous values of W, Mo, Cu, Pb, Zn, Ag, Au, or Sn in rock samples.
5. Anomalous values of W, Mo, Cu, Pb, Zn, Ag, Au, or Sn in stream-sediment samples.
6. Anomalous values of W, Mo, Cu, Pb, Zn, Ag, or Au in heavy-mineral-concentrate samples.
7. Occurrence of scheelite-powellite, molybdenite, chalcopyrite, bornite, sphalerite, galena, pyrite, arsenopyrite, gold, or fluorite in heavy-mineral-concentrate samples.
8. Local aeromagnetic highs, particularly geographically small highs of low to moderate amplitude in regions of otherwise low-magnetic fields.

Table 12.--Potential and recognition criteria for porphyry Sn deposits, Mount Hayes quadrangle, eastern Alaska Range, Alaska

(+, letter, element, or mineral indicates criterion present; 0 indicates criterion not observed)

Potential	Recognition criteria present in each area																
	Diagnostic				Secondary												
	Area 1	2	3	4	1	2	3	4	5	6	7	8	9				
Moderate	A	0	+	0	0	+	+	0	0	Mo, As	W, Mo	Sn, W	ca				
Moderate	D	0	+	0	0	+	+	0	0	Mo	Mo	Sn, W, Mo	ca, mo				
Moderate	F	0	+	+	+	+	+	0	0	Sn, Mo	Mo	Sn, W, Mo	ca, mo				
Low	G1	0	+	+	0	0	0	0	0	Sn, W	0	0	0				
Low	G2	0	+	+	0	0	+	0	0	0	0	0	0				
Low	G3	0	+	+	0	0	+	0	0	0	0	Sn, W	0				
Low	G4	0	+	+	+	+	+	0	0	0	0	Sn, W	0				
Low	H1	0	+	+	0	0	0	0	0	0	Sn, W	Sn	ca				
Moderate	H2	0	+	+	0	0	0	0	0	Sn, Mo	Sn, W	Sn, W, Mo	ca, mo, fl				
Moderate	H3	0	+	+	0	0	0	0	0	Sn, Mo	Sn, W, Mo	Sn, W	ca, fl				
Moderate	H4	0	+	+	0	0	0	0	0	Sn, W	Sn, W	Sn, W	ca				

Description of recognition criteria

Diagnostic

1. Geologically favorable environment of granite intruded into continental platform sedimentary rocks.
2. Known deposit, prospect, or occurrence.
3. Continental fold belt of thick platform sedimentary rocks and minor volcanic rocks.
4. Epizonal multiphase stocks of granitic rocks.

Secondary

1. Upper level cupolas and roof zones of plutons.
2. Locally extensive alteration in granitic rocks consisting of replacement K-feldspar, albite, sericite, chlorite, fluorite, or arsenopyrite.
3. Post orogenic intrusion of granitic rocks.
4. Associated tin greisen.
5. Associated tin placer deposits.
6. Anomalous values of Sn, Mo, As, or W in rock samples.
7. Anomalous values of Sn, Mo, As, or W in stream-sediment samples.
8. Anomalous values of Sn, Mo, As, or W in heavy-mineral-concentrate samples.
9. Occurrence of cassiterite, fluorite, molybdenite, or arsenopyrite in heavy-mineral-concentrate samples.