CONTACT INFORMATION
Mining Records Curator
Arizona Geological Survey
416 W. Congress St., Suite 100
Tucson, Arizona 85701
520-770-3500
http://www.azgs.az.gov
inquiries@azgs.az.gov

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year	Tons	# Cu	# Pb	# Zn	oz Au	oz Ag
1936	5	12	—	—	3	14
1937	—					
1938	—					
1939 GH	129	529	7,935	—	49	940
1940 "	291	2,832	4,900	—	64	526
1941 "	184	3,300	200	—	19	239
1942	—					
1943	—					
1944	—					
1945						
1946	—					
1947	3	—	500	—	4	21
1948	2	—	200	—	1	11
1949	—	—	—	—	—	—
1950	2	—	—	—	1	10
1951	—				—	—
1952	—				—	—
1953 GH	10	—	1,300	—	1	46
1954	—	—	—	—	—	—
1955 GH	67	4,800	—	—	4	224
1936-1955	693	11,473	15,035	—	146	2,031
	△	○	○	—	○	○

Hudson District

Year	Tons	# Cu	# Pb	# Zn	oz Au	oz Ag
1908-1933 p.65	(42,039)	(290,374)	(3,899,624)	—	[illegible]	685,942
1880-1930 p.100	(-)	(400,000)	(13,600,000)	—	—	-
1880-1933	60,000	400,000	13,600,000	—	470	409,000
VB 1936	115	6,241	14,550	—	5	2,169
1937	7,360	28,241	2,097,587	—	94	109,335
1938	6,696	27,066	1,960,695	—	24	87,320
1939	37,740	50,567	4,574,320	2,149,769	61	233,232
1940	53,533	117,000	9,162,920	5,428,603	69	360,329
1941	68,652	213,900	11,082,400	7,062,000	125	367,027
1942	77,152	296,000	12,264,400	9,650,000	199	343,357
1943	61,252	151,900	6,991,000	6,795,000	81	204,404
1944	50,747	133,000	4,423,000	4,101,000	76	176,438
1945	44,547	126,200	2,132,000	3,332,800	49	144,841
1946	25,227	72,000	1,384,000	2,256,500	17	105,623
1947	43,222	108,100	2,786,800	4,011,400	33	168,800
1948	62,205	141,000	3,997,600	5,750,000	61	210,533
1949	48,189	152,600	3,091,000	5,894,200	87	140,011
1950	44,738	198,900	3,861,400	8,386,900	109	147,258
1951	46,[illegible]	180,500	3,336,800	8,152,000	108	152,366
1952	48,290	148,000	3,841,000	7,847,400	155	176,778
1953	50,665	412,700	4,208,500	8,372,000	121	176,073
1954	50,108	310,000	4,270,000	8,386,800	113	170,665
1955*	50,600 *	200,000	5,594,000	8,027,000	100	143,222
1956*	54,000	232,000	6,220,000	7,800,000	123	165,800
1957**	52,248	205,000	7,070,200	7,766,000	146	169,194
1958 Production since Mill Fire	25,000 ?	200,000 ?	3,500,000 ?	3,800,000 ?	70 ?	85,000 ?
1959 as above	12,500 ?	50,000 ?	1,250,000 ?	1,900,000 ?	35 ?	42,500 ?
1960	12,500 ?	50,000 ?	1,250,000 ?	1,900,000 ?	35 ?	42,500 ?
Minor Prod. from Tailings mine reprocessed for few years.						
1880-1960	1,096,257	4,130,935	124,072,172	128,769,372	2,578	4,524,825
	☐	7	7	7	7	7

* Prorated between Hudson & Tindall Zamotic

** [illegible]

Oro Blanco (Ruby).

1909-1933 p.65	(88,836	(353,560	(7,782,555	(57,960,002	(132,569)	502,478
1917-30 p.100	–	400,000)	7,750,000)	6,100,000)	240,000	
1909-1933	89,000	400,000	7,800,000	6,100,000	12,000	503,000
1934	45,000 ?	–	3,000,000 ?	1,800,000 ?	2,500 ?	200,000 ?
1935	108,000 ?	–	10,000,000 ?	6,000,000 ?	8,000 ?	600,000 ?
1936	130,260	574,855	9,434,525	6,540,707	8,383	670,944
1937	142,522	497,443	8,851,587	6,130,040	8,126	631,067
1938	140,138	488,281	7,727,966	5,400,000	6,134	641,382
1939	137,303	444,942	7,136,617	4,754,442	5,584	545,566
1940	54,564	183,573	1,582,200	967,397	2,342	214,477
1941	1,411	1,700	2,200	–	483	13,770
1942	1,811	9,800	12,000	–	269	28,149
1943	861	1,400	–	–	84	16,837
1944	546	800	–	–	71	11,557
1945	414	3,200	65,000	19,800	53	4,192
1946	641	6,000	104,000	32,000	25	4,094
1947	1,070	8,600	121,000	19,800	89	4,200
1948	803	7,000	56,600	68,400	42	2,602
1949	313	700	33,300	34,800	8	1,496
1950	474	4,200	76,000	37,500	37	4,707
1951	4	100	1,000	–	–	53
1952	144	500	19,600	–	19	1,390
1953	Cleanup 34	300	6,500	3,200	2	270
1954	29	300	1,500	2,800	–	96
1955*	22	–	1,800	3,600	–	24
1956**	35	1,700	1,200	–	1	463
1957***	30	1,500	1,500	–	1	400
1909-1957	855,429	2,576,804	56,036,095	37,944,506	54,753	4,071,530
	□	?	?	?	?	?

Palmetto (3R) District

p.100 1909-30	no fig.	10,000,000	—	no fig.	—	425,000**
~~1909-1930~~	~~10,000~~	~~500,000~~	~~—~~	~~—~~	~~—~~	~~3,200~~
1936	25	11,783	—	—	—	18
1937	110	10,913	2,826	—	5	829
1938	447	50,595	390	—	4	62
1939	294	28,163	3,341	—	6	333
1940	356	52,549	700	—	—	135
1941	176	9,400	2,900	—	—	208
1942	7	—	1,300	—	—	142
1943	49	2,400	—	—	—	—
1944	4,162	278,800	—	—	—	—
1945	5,251	295,000	—	—	—	—
1946	640	26,500	—	—	—	—
1947	—	—	—	—	—	—
1948	—	—	—	—	—	—
1949	—	—	—	—	—	—
1950	90	5,300	1,400	—	5	575
1951	4	—	2,900	—	1	105
1952	25	500	900	—	2	242
1953	21	1,400	—	—	—	14
1954	370	34,600	100	—	1	168
1955	177	15,300	—	—	—	9
1956	413	29,100	1,100	1,200	—	—
1936-1956	12,617	852,303	17,857	1,200	24	2,780
	0	7	0	0	0	0

p.65 1908-33 p.100 1857-1930	152,159	(10,846,542 23,200,000	(5,461,465 27,000,000	3,686,519	(27,541)	513,804
1908-33 ~~1857-1933~~	152,159 ~~200,000~~	10,846,542 ~~23,200,000~~	5,461,465 ~~27,000,000~~	3,686,519 ~~3,800,000~~	1,300	513,804
1936	[illegible]	[illegible]	[illegible]	—	[illegible]	1,233
1937	643	8,163	158,174	—	2	5,805
1938	456	20,813	65,966	—	28	4,596
1939	37	231	8,361	—	3	112
1940	17,619	273,221	1,134,740	1,980,000	37	57,181
1941	26,720	579,600	1,409,000	3,575,000	67	124,456
1942	31,374	886,300	1,380,300	3,826,700	38	138,659
1943	32,411	842,200	1,066,000	3,862,000	29	92,271
1944	19,391	633,600	586,200	2,522,500	22	52,671
1945	10,019	274,600	497,000	1,366,000	5	23,227
1946	13,293	362,000	961,000	1,665,000	58	41,479
1947	5,547	196,300	309,000	627,000	3	18,810
1948	4,178	77,600	302,600	699,400	4	16,018
1949	5,241	171,000	300,000	1,139,400	3	23,076
1950	3,667	101,800	236,000	736,500	—	16,925
1951	7,897	203,000	496,900	1,202,500	—	36,430
1952	12,744	366,800	901,100	2,098,000	—	70,733
1953	7,566	1,081,300	244,100	514,300	24	36,478
1954	2,869	246,300	33,400	108,600	8	6,031
1955	3,450	182,400	191,000	546,500	4	18,398
1956	10,402	497,500	652,100	1,085,500	6	57,867
1957	4,948	304,900	424,900	729,700	—	32,021
1908-1957	372,777	18,157,911	16,785,106	31,941,919	1,682	1,388,281
	☐	?	?	?	?	?

Tyson [illegible]

1908-33 p.65 1889-1917 p.100	10,027	(329,859 25,000	(2,939,925 400,000	148,192	(#15,452)	90,320
1908-33	10,027	329,859	2,939,925	148,192	7,500	90,320
1936	[illegible]	[illegible]	2,650	—	1	448
1937	63	3,325	13,587	—	8	847
1938	105	5,157	14,322	—	2	874
1939	9	866	2,533	—	1	741
1940	496	16,354	55,000	—	25	6,217
1941	438	200	400	—	13	1,589
1942	816	7,200	187,300	29,300	8	4,185
1943	519	6,000	182,600	—	23	3,167
1944	262	9,800	41,600	3,500	12	1,703
1945	1,677	20,000	205,500	9,600	66	6,404
1946	1,731	23,000	187,000	412,500	37	4,791
1947	1,155	25,600	166,200	48,200	36	4,242
1948	1,051	27,000	187,200	13,600	47	6,308
1949	541	11,300	75,000	36,600	10	1,738
1950	250	700	418,400	14,100	1	2,181
1951	587	2,100	125,300	11,500	5	2,495
1952	975	4,700	423,000	172,600	24	6,204
1953	1,015	4,200	468,800	214,500	8	5,604
1954	1,006	10,800	403,000	153,800	17	6,333
1955 *	1,037 *	6,100	405,000	150,900	19	6,400
1956 *	1,448	7,000	432,000	149,200	23	7,069
1957 **	1,000	5,000	400,000	150,100	19	6,000
1958	500 ?	2,500 ?	200,000 ?	125,000 ?	8 ?	3,000 ?
1959	250 ?	1,250 ?	100,000 ?	62,500 ?	4 ?	1,500 ?
1908-1959	26,980	530,157	7,265,496	1,535,492	7,917	181,260
	0	2	7	7	7	7

p.100 18? -1911					$10,000.00	$30,000.00
1936	54	347	[illegible]	-	1	905
1937	213	5,087	79,413	-	2	2,182
1938	139	3,281	18,813	-	12	673
1939	153	423	38,085	-	1	1,367
1940	26	186	300	-	1	1,807
1941	21	200	400	-	2	1,589
1942	37	1,700	7,700	-	1	353
1943	9	100	4,000	-	-	52
1944	-	-	-	-	-	-
1945	40	-	-	-	-	55
1946	-	-	-	-	-	-
1947	8	900	1,200	-	8	32
1948	-	-	-	-	-	-
1949	3	-	[illegible]	-	-	10
1950	28	[illegible]	[illegible]	-	1	411
1951	23	300	3,100	-	-	179
1952	-	-	-	-	-	-
1953	32	100	6,000	-	-	99
1954	-	-	-	-	-	-
1955	93	3,500	200	-	2	1,444
1956	-	-	-	-	-	-
1957	110	3,700	3,300	-	1	755
1936-1957	988	20,726	178,886	-	50	12,013
	0	0	2	-	0	2

Year	Tons	# Cu	# Pb	# Zn	# Au	# Ag
1936	-					
1947	1,239	12,000	-	-	6	3,137
Cave Creek 1952	28	1,500	-	-	1	263
1947-1952	1,267	13,500	-	-	7	3,500
	△	o	-	-	o	o

Pajarito Mesa

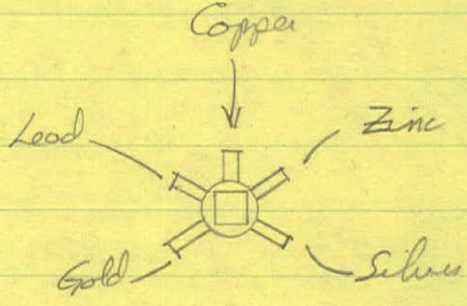
1936	9	–	3,[illegible]	–	1	384
1937	–					
1938	–					
1939	–					
1940	–					
1941	2	–	100	–	–	69
1942	1	–	300	–	–	–
1943	–	–	–	–	–	–
1944	55	–	2,200	–	–	547
1945	–	–	–	–	–	–
1946	–	–	–	–	–	–
1947	1	–	800	–	–	10
1948	–	–	–	–	–	–
1949	1	–	1,200	–	–	–
1950	56	200	9,[illegible]00	–	–	84
1951	–	–	–	–	–	–
1952	–	–	–	–	–	–
1953	4	–	2,800	–	–	58
1936-1953	129	200	20,025	–	1	1,152
	△	○	○	–	○	○

1954	321	8,000	—	—	—	342
1955	1,539	39,900	—	—	—	1,255
1954-1955	1,860	47,900	—	—	—	1,597

Redrock District
(La Plata)

1.100 1883	–	–	–	–	–	$10,000
1936	–					
1937	–					
1938	–					
1939	36	19,548	894	–	1	2,914
1940	10	1,345	460	–	–	38
1941	3	100	–	–	–	31
1942	–					
1943	–					
1944	–					
1945	–					
1946	–					
1947	–					
1948	47	400	7,400	3,000	–	200
1949	–	–	–	–	–	–
1950	5	–	600	–	–	53
1951	–	–	–	–	–	–
1952	1	–	400	–	–	21
1953	–					
1954	–					
1955	–					
1956	330	3,700	–	–	–	220
1939-1956	432	35,093	9,754	3,000	1	3,557
	0	0	0	0	0	0

	# Cu, Pb, Zn (1,000's) / g Ag (1,000's)	oz Au
Ultra	+50,000	+50,000
Large	1,000-50,000	10,000-50,000
Medium	100- 1,000	1,000 -10,000
Small	10 -100	100- 1,000
Prospect	<10	< 100



Disseminated (bulk)

Vein

Limestone Repl.

+100
10 to 100
-10

TABLE 1
PRODUCTION SUMMARY OF BASE AND PRECIOUS METALS THROUGH 1972
(Including estimates for years data not available)

MINING DISTRICT	Short Tons Ore (1,000's)	Pounds Copper (1,000's)	Pounds Lead (1,000's)	Pounds Zinc (1,000's)	Ounces Gold	Ounces Silver ~~(100's)~~ 1000's)	Total Value (1,000's)
~~Agua Dulce~~	(3 tons)	(230 lbs)	—	—	2	(9 ozs)	($86)
Ajo	350,015	5,659,953	—	—	1,548,253	18,992 ~~189,918~~	1,524,723
Amole	34	529	670	375	1,010	27 ~~272~~	289
Arivaca	9	72	230	17	5,620	46 ~~455~~	210
Baboquivari	57	244	24	(316 lbs)	13,850	174 ~~1,735~~	603
Cababi	6	184	364	3	3,450	102 ~~1,021~~	245
~~Canada del Oro~~	—	—	—	—	110	—	436
Catalina	5	415	—	—	1	22	107
Cerro Colorado	5	33	63	1	463	377 ~~3,767~~	362
Cimarron	(118 tons)	21	2	—	80	0.5 ~~5~~	6
Coyote	(712 tons)	140	—	—	21	1 ~~12~~	31
Empire	34	344	16,671	515	744	206 ~~2,064~~	1,178
Greaterville	2	39	343	32	28,838	19 ~~1,866~~	650
Growler	(51 tons)	12	—	—	2	0.2 ~~2~~	2
Gunsight	16	32	1,552	(229 lbs)	397	101 ~~1,006~~	176
Helvetia-Rosemont	426	34,860	521	1,360	1,581	347 ~~3,469~~	7,776
Montezuma	1	205	16	—	126	164 ~~1,641~~	213
~~Old Baldy~~	(206 tons)	37	—	—	2	1 ~~10~~	8
Oracle	136	6,117	188	50	387	118 ~~1,181~~	861
Papago	5	52	790	2	1,100	30 ~~301~~	104
Pima	369,707	4,119,854	85,195	232,953	53,720	311,936	1,884,887
Quijotoa	16	132	58	—	11,616	233 ~~2,325~~	509
~~Redington~~	(91 tons)	12	—	—	—	0.1 ~~1~~	2
Rincon	(193 tons)	14	36	—	112	0.5 ~~5~~	8
Roskruge	(377 tons)	5	5	—	23	11 ~~105~~	8
Santa Rosa	(206 tons)	18	7	—	60	1 ~~13~~	8
Silver Bell	61,200	1,008,839	1,804	48,087	1,490	5,294 ~~52,942~~	367,067
Waterman	25	1,502	1,563	978	106	130 ~~1,296~~	655
Whetstone	2	40	—	—	—	1 ~~10~~	12
Miscellaneous	2	175	143	4	170	1,032	61
Total	781,705	10,833,880 (5,416,940 tons)	110,245 (55,122 tons)	284,377 (142,189 tons)	1,673,334	~~578,412~~	3,791,197

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TABLE 1
PRODUCTION SUMMARY OF BASE AND PRECIOUS METALS
1879 -- 1970

	MINING DISTRICT	Short Tons Ore (1,000's)	Pounds Copper (1,000's)	Pounds Lead (1,000's)	Pounds Zinc (1,000's)	Ounces Gold	Ounces Silver (100's) (1000's)	Total Value (1,000's)
1	California (Chiricahua)	38	299	8,631	1,179	100	152	$ 1,750
2	Cochise (Johnson)	1,640	74,775	605	93,650	229	734	32,180
3	Dos Cabezas-Teviston	106	4,026	1,413	39	10,082	429	1,775
4	Dragoon (Golden Rule)	19	18	356	249	9,741	72	340
5	Hartford (Huachuca)	9	74	588	375	393	25	140
6	Middle Pass (S. Dragoon)	76	2,011	274	9,251	337	147	1,725
7	Pearce	1,341	55	16	—	138,409	12,020	10,660
8	Swisshelm	49	97	11,853	211	5,230	330	1,985
9	Tombstone	1,500	3,018	45,000	1,179	240,000	30,000	38,800
10	Turquoise (Courtland-Gleeson)	887	54,823	7,777	2,561	56,641	1,575	14,090
11	Warren (Bisbee)	150,991	7,693,257	309,756	378,450	2,630,572	100,312	1,834,365
12	Whetstone	2	37	—	—	8	620	15
	Total	156,658	7,832,490 (3,916,245 tons)	386,269 (193,135 tons)	487,144 (243,572 tons)	3,091,742	146,416	$1,937,825

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TABLE 1: SIZE LIMITS ADOPTED FOR VARIOUS COMMODITIES

COMMODITY (metal content unless otherwise stated)	SIZE LIMITS: Large deposit lower limit (tons)	Small deposit lower limit (tons)	Small deposit % of large deposit
Antimony	2 500	25	1
Aluminium	750 000	4 000	0.5
Asbestos	80 000	400	0.5
Barium ($BaSO_4$)	80 000	400	0.5
Beryllium (BeO)	50 (i.e. 450 tons beryl)	2 (beryl)	0.5
Chromium	425 000	2 300	0.5
Cobalt	1 750	10	0.57
Columbium (R_2O_5)	Combined with tantalum		
Copper	150 000	1 000	0.7
Fluorite (CaF_2)	50 000	500	1
Gold	1 500 000 (oz)	10 000 (oz)	0.7
Iron (Fe in 50+% ore)	40 000 000	500 000	1.2
Lead	68 000	350	0.5
Lithium (Li_2O)	16 000 lepidolite; 10 000 amblygonite; 20 000 petalite; 12 000 spodumene	Prod.	—
Magnesite	4 600 000	23 000	0.5
Manganese	500 000	2 000	0.4
Mercury	500 000	Prod.	—
Molybdenum	1 750	10	0.5
Nickel	20 000	500	0.5
Phosphate (P_2O_5)	25 000 000	120 000	0.5
Platinum	25 000 (oz)	120 (oz)	0.5
Osmiridium	5 000 (oz)	25 (oz)	0.5
Silver	13 000 000 (oz)	100 000 (oz)	0.7
Sulphur	500 000	2 500	0.5
Tantalum (R_2O_5)	50 (200 ton conc.)	1 ton conc.	0.5
Thorium (ThO_2)	310	Prod.	—
Tin	10 000	50	0.5
Titanium (TiO_2)	120 000	600	0.5
Tungsten (WO_3)	1 000	5	0.5
Uranium (U_3O_8)	750	5	0.5
Zinc	65 000	320	0.5
Zirconium (ZrO_2)	10 000	50	0.5

A Commentary on the Metallogenic Map of Australia & Papua New Guinea, by R G Warren. Bulletin 145, Bureau of Mineral Resources, Canberra, Australia (1972)

Over

p. 6 .... The European legend suggested that the division between large and small deposits should be taken at 0.05% of the total world production plus reserves of the metal concerned.

	Au+Ag	Au+Pb+Zn	Cu/Pb/Zn/Ag			
1	312,053,720	4,438,002,000	14.22	Pirin?	14	–
2	20,540,253	5,659,953,000	275.2		275	✓
3	102,942,572	8,381,769,000	81.42		81	+
4	5,295,490	1,058,730,000	199.93		200	✓
5	734,229	169,030,000	230.02		230	✓
6	30,240,000	49,197,000	1.63	Tombstone Lm		–
7	150,020	71,000	0.47	Pearce Lm		–
8	4,527,578	256,972,000	56.76		57	+
9	1,631,641	65,164,000	39.94		40	+
10	4,126,753	96,528,000	23.39		23	+
11	348,581	36,741,000	105.40		105	✓
12	1,389,682	66,885,000	48.13		48	+
13	118,387	6,355,000	53.68		54	+
14	439,082	5,478,000	12.48	Las Vegas LP?	12	–
15	147,337	11,536,000	78.30		78	+
16	187,850	268,000	1.43	Cabeguin LP?		–
17	335,230	12,161,000	36.28		36	+
18	152,100	10,109,000	66.51		67	+
19	28,010	1,574,000	56.19		56	+
20	206,744	17,530,000	84.79		85	+
21	188,917	9,330,000	49.39		49	+
22	130,106	4,043,000	31.07		31	+
23	81,741	623,000	7.62	Dorum LP?	8	–
24	101,397	1,585,000	15.63	Gunnison LP?	16	–
25	244,616	190,000	0.78	Quiz LP?		–
26	3,024	871,000	288.03		288	✓
27	25,393	1,037,000	40.83		41	+
28	51,620	319,000	6.18	Lucero LP?	6	–
29	105,450	557,000	5.23	Cabalin VP?	5	–
30	337,463	97,000	0.29	Cameo Colony		–
31	31,100	844,000	27.14		27	+
32	2,008	77,000	38.35		38	+
33	13,039	414,000	31.75		32	+
34	164,126	221,000	1.35	Montezuma?		–
35	1,000	140,000	140.00		140	✓
36	12,500	200,000	16.00	Washington?	16	–
37	2,146	26,000	12.12	Nicholas?	12	–

$\frac{Ag + Au}{Cu + Pb + Zn}$

1.	365,720 //	4,438,002,000	=
2.	1,567,245 //		=
3.	2,730,884 //		=
4.	6,784 //		
5.	963 //		
6.	270,000 //		
7.	12.158 //		
8.	7,103 //		
9.	68,216 //		
10	58,825 //		
11.	1,928 //		
12.	3,070 //		
13.	505 //		
14.	10,511 //		
15.	484 //		
16	14,024 //		
17.	5,560 //		
18	252 //		
19	1,037 //		
20	950 //		
21	8,098 //		
22	236 //		
23	9,813 //		
24	498 //		
25	11,849 //		
26	27 //		
27	418 //		
28	5.666 //		
29	3,552 //		
30	840 //		
31	1.130 //		
32	10 //		
33	52 //		
34	290 //		
35	22 //		
36	62 //		
37	148		

No d'Discontinuity

K+E ALBANENE GUIDE LINE
NON-ALBANENE

Potassium carbonate (FTG).

① Cu/Pb/Zn
② [illegible]
③ Cu/Au

Mine #	Cu	Pb	Zn	Au	Ag					Pb+Zn / Ag	Cu / Ag
Red Mtn District.											
1.	16,000	—	—	—	—		—				
2.	3,500	—	—	25	minor	③	140	V		—	—
3.	—	—	—	—	—		—				
4.	—	—	—	—	4,500		—				
5.	—	—	—	—	—		—				
6.	16,000	10,000	—	—	1,500	①	1.6	V	7	PL	11 VPL
7.	(159)	(50)	(9.4)	—	(9.9)	①	2.7	VP?	6	PL	16 VPL
8.	—	52,000	—	5	1,650	②	330	P	32	P?	—
9.	(5.4)	—	—	—	(3)		—		—		2 L
10.	(20)	—	—	(0.05)	—	③	400	P	—		—
11.	(14)	—	—	—	—		—				
12.	(56)	(1120)	(40)	(0.1)	(55)	① 0.05 P; ③ 550 VPL; ③ 560 VPL			21	P?	1 L
13.	(1)	—	—	—	—		—				
14.											
Harshaw District											
14.	?	?	?	?	?						
15.	30,000	200,000	200,000 ?	—	75,000	①	0.1	L	5	PL	0.4 L
16.	—	114,000	20,000	20	4,000	②	200	PL?	34	P?	—
16a.	—	—	—	—	—		—				
17	12,000	21,400	5,600	—	1,330	①	0.4	V	20	P?	9 VPL
18.	93	10,044	18,786	—	686	①	0.0	L	42	P?	0.1 L
19	(9.6)	—	—	—	(0.16)	Reconnaissance only					Co VPL?
20	—	127,621	148,763 (276,384)	—	22,872		—		12	PL	—
21	? dump passes on pond. town! 2,000	33,200	40,000	—	1,740 ?	①	0.0	L	42	P?	1 L
22.	—	—	—	—	—		—				
23	3,000,000	69,600,000	97,200,000	—	1,860,000	①	0.0	L	90	P?	2 L
23a	—	—	—	—	—		—				
24	using reserve figures. 14,000,000	252,000,000	140,000,000	—	40,950,000	①	0.0	L	10	PL	0.3 L
25	—	—	—	—	250,000		—				
26.	23,000	100,000	70,000	—	12,500	①	0.1	L	14	PL	2 L
27	(5)	(6)	(9)	—	(0.56)	①	0.3	V	27	P?	9 PL
28	—	5,888,800	8,660,000		572,560		—		25	P?	—
29.	860,000	—	7,300,000	—	48,000	①	0.1	L	152	P?	18 PL
30	—	—	—	—	—		—				
31.	21,000	123,000	195,000 72,000	—	145,600	①	0.1	L	1	L	0.1 L
32.	—	—	—	—	—		—				

(Signifies [illegible]). — over 50 [illegible]

#	Cu	Pb	Zn	Au	Ag				
33	100,000	—	—	—	3,000	—	—	33	PL
34	(12)	—	—	—	(2)	—	—	6	PL
35	—	26,951,600	21,413,600 (+1,363,200)	—	1,089,140	—	44 P?	—	
35a	—	—	—	—	—	—			
36	(14)	(2)	—	—	—	① 7 P			
37	152,000	800,000	520,000 (1,320,000)	400	390,000	① 0.1 L	3 PL	0.4	L
54	—	33,000,000	—	—	1,800,000	—	18 PL		
55	—	—	—	—	—	—			
57	—	(278)	nil	—	1.2	—	232 P?	—	
	Palmetto District								
38	—	—	—	—	—	—			
39	—	—	—	—	—	—			
40	—	—	—	—	—	—			
41	—	61,000	—	—	2,900	—	21 P?	—	
42	100	40,000	—	50	8,750	① 0.0 L, ② 175 P, ③ 2 L	5 PL	0.0	L
43	—	—	—	—	—	—			
44	—	—	—	—	—	—			
45	—	—	—	—	—	—			
46	(500)	—	—	4	100	③ 125 P?	—	5	PL
47	7,000,000	—	—	—	50,000	—	—	125	P
48	—	45,900	—	—	5,925	—	8 PL	—	
49	41,000	32,000 (252,000)	220,000	1.5	2,250	① 0.2 L, ② 150 L, ③ 2733 P	112 P?	18	PL
50	16,000,000	—	—	—	—	—			
	Patagonia East								
51	(6)	—	—	—	—	—			
52	—	—	—	—	—	—			
53	(14)	—	—	—	—	—			
54	—	—	—	—	—	—			
58	(5.4)	(5.6)	(9.6)	—	(0.93)	① 0.4 V, ② 23 V	16 PL	6	PL
59	3,484,000	—		400	13,200	③ 8710 P	—	264	P
90	16,840,000	25,260,000	67,360,000 (92,620,000)	—	1,684,000	① 0.2 L	55 P?	10	PL
60	—	—	—	—	—	—			

#	Cu	Pb	Zn	Au	Ag						
	Patagonia West										
61	—	—		—	—	—					
62	—	—	—	—	—	—					
63	280,000	14,400	—	100	12,880	① 19 P ② 129 V ③ 2800 P		1	L	22	PL
64	Reserves 80,000,000	15,000,000	—	—	600,000	① 5 V ??		25	P?	133	P
65	? —	—	—	—	—	—					
66	Reserves 24,000,000	—	—	—	—	—					
67	33,400	1,000	—	50	1,200	① 33 P ② 24 V ③ 66X P ④ 0.0 L ⑤ 816 P ⑥ 4,000 P		0.8	L	28	PL
68	20,000	71,000 (106,000)	135,000	5	4,050			51	P?	5	PL
69	—	—	—	—	—	—					
70	—	—	—	—	—	—					
71	—	—	—	—	—	—					
72	—	—	—	—	—	—					
73	—	130,000	—	—	6,000	—		22	P?	—	
74	8,000	—	—	—	1,000	—		—		8	PL?
75	(28)	(8)	(6)	—	—	① 2 V		—		—	
76	(332)	—	—	—	(2.2)	—		—		151	P
77	—	—	—	—	—	—					
78	—	—	—	—	—	—					
79	(3)	—	—	—	—	—					
	District, Total Resources										
Red Mtn	PL 35,500	62,000	—	—	7,750	① 0.6 V		8	PL	5	PL
Hawksnest	PL 4,168,000	139,727,463 (368,400)	135,468,955 (275,195,418)	—	6,674,465	① 0.0 L		41	P?	0.6	L
Blanette	PL 7,041,000	148,900	220,000 (92,620,000)	—	69,825	① 19 P		5	PL	101	P
Pat E	P 20,320,000	25,260,000	67,266,500 (350,400)	—	1,699,000	① 0.2 L		55	P?	12	PL
Pat W	LP 331,000	215,400	135,000	—	25,130	① 0.9 V		14	PL	13	PL

S Ag

	Pb + Zn (×1000)	Ratio Pb+Zn / Ag		Cu / Ag		Remarks
1	318,148	1.0	L	13.2		PPP
2.	—	—	-	298.0	P	LLP
3.	688,206	6.9	PL?	76.7	PL	PLP
4.	49,891	9.4		190.6	P	PPP
5.	94,255	128.4	P?	101.9	P	VPP
6	46,179	1.5	L	0.1	L	LLL
7	16	0.1	L	0.4	L	P?LL
8	252,841	55.9	P?	0.9	L	LP?P?
9	10,338	6.6	PL	34.8		P?V??
10	93,951	23.1		0.6	L	LLV
11	1,881	5.4	PL?	100.5	P	LL??
12	48,727	35.1	P?	13.1		??P
13	238	2.0	L	51.8	PL	P?P
14	1,452	3.4	PL	9.4		P?L?
15	9,525	64.8	P?	13.7	PL	L?P
16	24	0.1	L	1.4	L	PLL
17	12,064	36.6	P?	0.3	L	LLL
18	9,810	98.1	P?	2.0	L	LPP
19	1,045	1.0	L	19.6	PL	VP??
20	17,186	23.1	P?	1.7	L	LP?
21	8,800	48.6	P?	2.9	P?L	LP?V
22	2,541	19.5	P?	11.6	PL	VPP
23	605	8.4	PL	0.3	L	L?L
24	1,552	15.4	PL	0.3	L	LPV
25	58	0.2	L	0.6	L	P?P?L
26	19	6.3	PL	289.0	P	PPP
27	963	38.5	P?	3.0	P?L	LP?V?
28	247	5.4	PL	1.6	L	V?L
29	367	3.6	PL	1.8	L	VP?V
30	64	0.2	L	0.1	L	VPV
31	792	2.6	PL	1.7	L	LVV
32	—	—	-	38.5	PL	-P?P
33	375	2.9	PL?	3.0	P?L	LP?P?
34	16	0.1	L	1.3	L	PPP?
35	—	—	-	150	P	-LP
36	179	14.9	PL	1.8	L	LP?P?
37	15	7.5	PL	5.5	PL	VVV

TABLE I

GEOLOGIC FEATURES OF MINERAL DEPOSITS IN THE PATAGONIA MTNS., SANTA CRUZ COUNTY, ARIZONA

PROPERTY NAME[a]	HOST ROCK	STRUCTURE	ALTERATION-MINERALIZATION	PRODUCTION
			RED MOUNTAIN DISTRICT	
1. ANDES (AZTEC) (1,7)	rhyolite por.	20' vein strikes NE, 75°SE dip	py-cpy-cc-bn-mal in qtz-sericite-alunite alteration over large areas.	100 tons @ 8% Cu shipped. Aver. grade of workings = Cu - 1.1%
2. BASIN #1 (7)	andesite	fault-fissure N64W-50NE	azur-mal-cup-chrys-Au in slightly siliceous vein; Pb-Ag mined for shipping (?)	25 tons @ Cu-7%, Au-1 oz., Ag-tr.
3. BLUE BIRD (1)	andesite		minor py-cpy	minor
4. CHRISTMAS GIFT (7)	black andesite	fissure @ N65W-87S	Pb-Ag ore	50 tons @ 90 oz. Ag
5. DEWEY (7)	andesite	2' vein dips 75° NNE	cup-mal-azur-chry.	none
6. ELEVATION (7)	rhyolite, minor andesite	shear zone @ EW-V some bx.	py-cpy-gn-cc-Ag in argillized and silicified rhyolite	one vein (50 tons?) of Cu-16%, Pb-10%, Ag-30 oz.
7. EXPOSED REEF (1)		3 veins N70E-V, N20W-55S		dump sample Cu-7.95%, Pb-2.50%, Zn-4.70%, Ag-9.94 oz. Prod. unknown.
8. GREAT SILVER (7)	rhyolite	siliceous vein or bed dips 30° N	gn-Ag in qtz-gyp. vein	50 tons @ Pb-52%, Ag-35 oz., Au-0.1 oz.
9. HAMPSON (1,7)	red rhyolite por. near andesite	9"-3' fissure-fault with steep S. dip	py-cpy-cc in silicif., crushed rhyolite	one dump assay gives Cu-0.27%, Ag-3.00 oz. no prod.
10. INVINCIBLE (7)	mass. rhyolite por.	1.5" py vein N30E-30SE	dissem. py-cpy in qtz veins	runs 1% Cu, 0.05 oz. Au. Minor prod.
11. RED MTN. (1)	qtz. monzonite	dissem at 3900-5200' to top	argillic alteration on surface w. limonite after cc. which grades to potassic alteration at depth w. cpy.	average of 0.71% Cu with trace Au-Mo
12. LEAD QUEEN (1,7)	andesite por.	2 EW veins with N dip	gn-cc with enriched Pb-Ag on surface grading to Pb-Ag-Cu	2 assays of vein average : Pb-56%, Cu-2.8%, Zn-2%, Ag-55 oz. Au-0.1 oz. no prod.
13. ROPER TUNNEL (1)	andesite and rhyolite		strong argillization with dissem. sulfides	averaged 0.05% Cu over 600' with 100' averaging 0.12% Cu. no prod.
88. POWERS (COPPER MTN.) (7)	rhyolite	N60W zone of silica 70' wide, 150' high	py-copper oxides in red silicified rhyolite	none
89. SAN SIMONE (1)	rhyolite	small veins	py-Pb-Ag-cpy.	(20 tons)
			HARSHAW DISTRICT	
14. ALTA (7)	diabase-rhyolite	vein	gn-pyrar-py with trace spec-cpy, Ag halides present; all in qtz-fluorite gangue	estimate 10,000 tons
15. AMERICAN (1,7)	contact of limestone & rhyolite bx	3' vein strikes WNW dips NE.	py-gn-arg-sl-cpy-cerarg. in silicified & Mn-stained limestone & rhyolite	5000 tons ore averaging: Pb-2%, Zn-2% (?), Ag-15 oz., Cu-0.3%
16. AUGUSTA (7)		parallel veins		100 tons @ Pb-57%, Zn-10%, Ag-40 oz., Au-0.2 oz.
16a. BENDER - BLACK EAGLE (1,2)	limestone	conformable replacements, 2-10' thick, along limestone-silica bx contact	Mn-Ag replacement, Ag minor	100 tons (very roughly) of Mn ore
17. BLUE EAGLE (1,7)	qtz vein in rhyolite por.	EW-V. 2-1/2' vein	py-cpy-bn-arg. in qtz. vein	hand sorted ore aver. (100 tons) Cu-6.0%, Pb-10.7%, Zn-2.8%, Ag-13.3 oz.
18. BLUE NOSE (1,5,7)	Cretaceous sediments-limestone, rhyolite present	bedding replacement(?) N15W-54 SW, ore shoots at intersection of beds with E-W fractures	py-gn-cpy-sl; Mn in surface outcrops	93 tons of Cu-0.05%, Pb-5.4%, Ag-7.38 oz., Zn-10.10%

TABLE 1 (cont'd.)

PROPERTY NAME[a]	HOST ROCK	STRUCTURE	ALTERATION-MINERALIZATION	PRODUCTION
			HARSHAW DISTRICT (cont'd.)	
19. BX PIPE (1)	monzonite	bx pipe, 400' x 800' tapers downward	py-enar-cpy-cc; mostly enargite throughout, erratically distributed; Anaconda drilling cut cpy with no enargite at roughly 1500'	2.7 million tons reserves - 0.48% Cu, 0.16 oz. Ag, 0.005%-Mo
20. CALIFORNIA (1)	rhyolite and shale	4 N-S veins with dips @ 15-50°W	oxidized lenses less than 2' wide	961 tons @ Pb-6.64%, Zn-7.74%, Ag-2.38 oz.
21. CHIEF (1,5)	rhyolite & limestone, sim. to Flux	veins roughly N35W-40SW in area cut by fault @ N65E-80NW	py-gn-sl-td replacements in limestone.	200 tons, dump assays are Cu-0.5%, Pb-8.3%, Zn-10.0%, Ag-8.7 oz.
22. ENDLESS CHAIN (7)	2' bed of quartzite	ore bed dips 70°SE	py-cpy-td, somewhat banded	minor
23. FLUX (1)	limestone, minor shale and mudstone	vein @ N5W-40 SW, parallel to bedding, weak cross-jointing	gn-sl-Ag associated with massive py as lenses parallel to bedding; mostly replacement of lms; alteration is qtz-cal-chlor-ser, minor cpy.	roughly 600,000 tons Ag-3.1 oz., Pb-5.8%, Zn-8.1%, Cu-0.25% #1 orebody: Ag-3.3 oz., Pb-4.5%, Zn-10.5% #2 orebody: Ag-4.7 oz., Pb-10.7%, Zn-10.4%
23a. GARFIELD (1)	arkose	N80E-V vein 1' thick	Qtz vein with py, minor cpy-sl. Possible tr. arg or td.	None
24. HARDSHELL (1)	agglomerate unit in Chief fm	flat-lying manto, parallel to bedding, lies on strike of Trench veins	strong silicification of Chief and underlying lms, dissem py, ore minerals unclear, partly cryptomelane	7 million tons reserves of 5.0 oz. Ag. Typical assay: Mn-11.2%, Ag-5.85 oz., Pb-1.8%, Zn-1.0%, Cu-0.1%. Prod. perhaps 1/2 of Mowry (Ag = 500,000 oz.)
25. HERMOSA (7)	rhyolite	1-20' lode dips 33°N	AgCl-Mn in silicified rhyolite	very approx. guess @ 50,000 tons of 5 oz. Ag
26. HUMBOLDT (1,5,7)	rhyolite, 30' from andesite contact	veins - faults N60E-80NW	py-gn-sl-td-cpy; Pb-Ag ore nearer the surface	500 tons @ roughly Cu-2.3%, Pb-10%, Zn-7%, Ag-25 oz.
27. HULDA (1)		2' vein	one pit with minor sulfides exposed	2' sample of good mineraliz. Cu-0.25%, Pb-0.30%, Zn-0.45%, Ag-0.56 oz. no prod.
28. JANUARY (5,7)	rhyolite and andesite	vein is 6-7' wide @ N30W-75NE	py-gn-sl-arg-Mn	86,600 tons @ Pb-3.4%, Zn-5.0%, Ag-6.6 oz.
29. MORNING GLORY (1,7)	limestone near masses of rhyolite	bedding replacement dipping 40° WNW, rhyolite dike @ N25E 40 WNW	py-cpy-sl-Ag, massive & banded assoc. with qtz-cal-bar-spec, tr bn-cc; copper ores separate from zinc ores	approx. aver. of Cu & Zn pods. Cu-4.3%, Ag-4.8 oz.; Zn-36.5% prod. estimates 10,000 tons
30. RED BIRD (5,7)	along rhyolite dike contact in andesite	mineralized zone is N53W-75NE	py-gn-arg-Mn	25 tons ?
31. SALVADORE (1,7)	silicif. limestone or rhyolite	dips 35N, veins follow bedding; projects under Hardshell	Ag-Mn-Pb	estimate 3000 tons of Mn-20.6%, Pb-4.05%, Cu-0.35%, Ag-18.4 oz., Zn-1.2%
32. STANDARD (7)	granite por.	NW shearing	py-cpy-cc -enargite	None
33 SUNNYSIDE (5,7)	granite or rhyolite por.	shear zone @ N50W-V, 200' wide	mal-black copper oxides-Ag st. silicif. (Kerr-McGee reports enargite?) rock	1000 tons of malachite ore averaging: Cu-5%, Ag-3 oz.
34. THUNDER (7)	granite por.	NW shearing	py-cpy-td-moly. in silicified rock, sulfides dissem. & in veins	tunnel averages Cu-0.6%, Ag-2 oz. No prod.
35. TRENCH (JOSEPHINE) (1,5)	andesite	main vein N75W-70NE	py-gn-sl-alabandite-td-pearcite; vein is qtz-rhodochrosite, wall rock alteration is chlor-epid-ser-clay-bar	184,600 tons @ Pb-7.3%, Zn-5.8%, Ag-5.9 oz.
35a. VOLCANO (7,8)	rhyolite bx.	strong bx along N20W fault	abundant mal., alunite in strongly altered rhyolite, Kerr-McGee report enargite	minor
36. WELLINGTON (1)	rhyolite bx.		pervasive fine-grained, disseminated pyrite	several chip samples in adits gave Cu-0.7%, Pb-0.1%, no prod.
37. WORLDS FAIR (5,7)	along andesite-rhyolite contact	several veins @ N15E-25(?)E	py-gn-pearcite-td-cpy in barite-qtz veins; Mn is present	unclear from reports, estim. 10,000 tons @ Cu-0.76%, Pb-4.0%, Zn-2.6%, Ag-39.0 oz., Au-0.04 oz.

TABLE 1 (cont'd.)

PROPERTY NAME[a]	HOST ROCK	STRUCTURE	ALTERATION-MINERALIZATION	PRODUCTION
			HARSHAW DISTRICT (cont'd.)	
54. MOWRY (1,2,7)	In limestone along fault against pG granite	fault @ N75E-80N localized fissure ores, manto ores too.	gn-Ag-Mn in upper levels in silicified lms; Pb-Ag enrichment pronounced; py-cpy-aspy(?) below 400 level, Zn absent	1940 estimate in files is 75,000 tons @ Pb-22%, Ag-24 oz.
55. NORTH MOWRY (7)	same as Mowry		Same as Mowry	
57. PHOENIX (1)	Bolsa quartzite	bx zones in quartzite which parallel bedding at N10E-65SE, <1' wide	lead oxides of various types, fine-grained py in siliceous portions of vein	no prod., composite assay of pits: Pb-13.9%, Ag-1.2 oz., Zn-nil
			PALMETTO DISTRICT	
38. BIG STICK (7)	contact of sheared granite por & diorite		disseminations and veins of py-cpy-cc	minor
39. COX-EUROPEAN CANYON (7,8)	monzonite	thin veins, N70E-50S	py-cpy-cc-gn-sl in small qtz-ser veins	minor
40. DENVER (6)	qtz. monzonite	N65E veins, 8"-2'.	py-cpy-sl-gn-Mn in qtz-ser veins	minor
41. DOMINO (7)	diorite-qtz. monzonite	EW shear in diorite	cerussite-gn-Ag in several pockets, red-yellow color both in ore & in diorite	50 tons of Pb-61%, Ag-58 oz.
42. JARILLAS (6,7)	qtz. monzonite-diorite	2' fissure vein @ N65E-V, strong post-min. faulting	gn-cpy with Ag-Mn in banded qtz vein; some epidote, mod. oxidation, ore was enriched Pb-Ag	average 50 tons Pb-40%, Ag-175 oz., Au-1 oz., Cu-0.10%
43. LEDGE (7)	qtz. monzonite-diorite-granite por.	one vein 1000' long	Cu & Fe sulfides assoc. with qtz	minor
44. NATIVE SILVER (7)	granite por.	shear @ N75E-85S	red-yellow drusy qtz vn. with minor py (and Ag?)	minor
45. ROBERT E. LEE (PALMETTO) (1,6)	qtz. monzonite-diorite	2 veins (2-5') N65W-85S, N35W-V, strong shearing	py-cpy-gn (with Au-Ag) assoc. with qtz-epid-chlor-ser-barite; mostly argentiferous gn with Mn; tr. moly-vanadinite-wulfenite	50 (?) tons
46. SONOITA (6,7)	qtz. monzonite-diorite contact	intersecting N10E qtz vein with NW joint	gn-cc-ruby Ag in qtz vein with Mn oxides, weak epid-chlor in diorite, ser. in qtz. monzonite	minor prod., handsorted assay Cu-25%, Ag-100 oz., Au-4 oz.
47. THREE R (4)	granite	shear zone @ N10W-75SE, cut by N75E-60S joints	py-cc in well-developed shear zone; formed by enrichment of 0.01-0.05% Cu weathered from granite; position of ore within shear zone only where cut be NE joints	roughly 50,000 tons @ Cu-7%, Ag-1 oz. - all supergene
48. TRES DE MAYO (1,6)	qtz. monzonite	NE & NW veins, joints	Ag-Pb-Cu-Mn assoc. with qtz-ser-chlor; tr wulfenite-vanadinite-cal-barite	dump goes: Ag-22 oz., Pb-1.8%, Ag assays to 700 oz. as chlorides. One 75 ton shipment recorded @ Pb-30.6%, Ag-79.0 oz. (1919)
49. VENTURA ADITS (1)	monzonite and bx	NE-striking veins	py-cpy-gn-sl in qtz veins & in sericitized bx.	two assays given; combined to Cu-4.1%, Pb-3.2%, Zn-22%, Ag-4.5 oz., Au-0.03 oz. Estimate 500 tons prod.
50. VENTURA BRECCIA (3,8)	monzonite	N10W bx pipe 750' long, 100' wide	moly-tn-py in intense qtz-sertour breccia; grades downward to well-jointed monzonite with py-moly-cpy in qtz-sericite alt.	3.6 million tons @ 0.4% MoS_2, 0.25% Cu. larger tonnage at Cu:Mo = 1:1
			PATAGONIA - EAST	
51. BENTON (2,7)	qtz. monzonite	bx and along vein in a fault	py-cpy-moly assoc. with potassic alteration	one drill hole - 0.30% Cu, 0.007% Mo, no prod.
52. JUSTICE (2)	qtz. monzonite	"	similar to Benton & Line Boy	none

TABLE 1 (Cont'd)

PROPERTY NAME[a]	HOST ROCK	STRUCTURE	ALTERATION-MINERALIZATION	PRODUCTION
			PATAGONIA - EAST (cont'd.)	
53. LINE BOY (1,2,7)	qtz. monzonite	bx and along vein in a fault	py-cpy-moly-bn-cc; assoc. potassic alteration	one drill hole gave 35' @ 0.71% Cu, 0.01% Mo, no prod.
56. O'CONNOR (7)	granodiorite & granite por.	probably the small bx pipe SW of the Belmont	gn-cpy-py-moly	
58. RATTLESNAKE (1)	granodiorite & granodiorite por.	bx in N70W-striking joint system	py-cpy-moly-gn in strong qtz-ser altered bx.	one assay of dump material Cu-0.26%, MoS_2-0.35%, Pb-0.28%, Zn-0.48%, Ag-0.93 oz., no prod.
59. SANTA NINO (1,2)	granodiorite	NE-elongate pod of mineralization, crudely pipe-shaped; no veinlets	cpy-moly-py-aspy in intense secondary orthoclase alteration; cpy & moly occur separately	roughly 20,000 tons @ Cu-8.71%, Mo-13.50%, Ag-0.66 oz., Au-0.02 oz.
90. WASHINGTON - DUQUESNE (1,2,7)	limestone	igneous contacts and faults	py-sl-gn-cpy-mag-aspy along skarn-marble contacts, zoning not obvious within district	estimate from files of 421,000 @ (1890-1950) Cu-2%, Pb-3% (Pb may be too high), Zn-8%, Ag-4 oz.
60. WINIFRED (7)	rhyolite-quartzite	EW fault	copper oxide minerals in banded qtz. vein.	none
			PATAGONIA - WEST	
61. BENNETT (7)	qtz. monzonite-diorite	EW fissure	py-cpy in banded qtz. vein	minor
62. BIG LEAD (7)	granite por. dike in diorite, sheared	3-1/2' vein at N75E-V	gn-cpy with Au-Ag in qtz gangue	minor
63. BUENA VISTA (1,7)	qtz. monzonite-diorite	vein structure is N35E-60SE, 2-6' wide, well crushed in fault zone	py-cpy-bn-gn-cc in qtz-cal vein, mod gouge; some MoS_2	500 tons @ Mo-0.3%, Cu-28%, Ag-20 oz., Au-0.2 oz.; 24 tons @ Pb-30%, Ag-120 oz.
64. FOUR METALS (1,3,8)	granodiorite	bx pipe 800' by 1200', elongate NE	py-cpy-cc-moly in potassic alteration along SE side, rest of pipe has qtz-ser-py-carbonate; tr sl	5 million tons reserves of 0.8%-Cu, 0.12 oz.-Ag, 0.01%-MoS_2, 0.15% Pb
65. GOLDEN ROSE (7)	qtz diorite near granite por.	16-20' vein @ N70E-80S; ore is 3' wide	py-cpy-gn-stephanite-some Au in finely-banded qtz.	100 tons (?)
66. MINNESOTA (GROSS) (7,8)	qtz. monzonite	wk jointing along Paymaster structure	py-cpy-moly in weak potassic alteration, drilled by Hanna-McIntyre	4 million tons estimated reserves of 0.3% Cu & 0.05% MoS_2
67. GUAJOLOTE (ROY) (1,2)	granodiorite	1-2' vein at NS-N10E @ 80SE, on Paymaster vein	cpy-gn in qtz.	500 tons of Cu-3.34%, Pb-0.1%, Ag-2.4 oz., Au-0.1 oz., As-3.1%, Sb-0.5%, Bi-0.09%
68. HOMESTAKE (1)	granodiorite	1-4' qtz vein @ N30E-80SE	cpy-gn-py-sl, all coarse grained and banded	500 ton composite from dump: Cu-2.0%, Pb-7.1%, Zn-13.5%, Ag-8.1 oz., Au0.01 oz.
69. ISABELLA (SERENATA) (7)	granite por-diorite contact	2.5' qtz vein, 3000' long	Pb-Mn (Ag?) in drusy qtz. vein	minor
70. ITALIAN CANYON (8)	granodiorite	50' vein @ N10°W-75SW on grano-p€ contact	py-cpy in intense qtz-ser-chlor alteration	none
71. JABALINA (7)	granite por.	east-striking vein 9' wide, 2000' long	Pb-Ag-Mn in bx qtz vein	minor
72. KING (7)	qtz. monzonite	qtz vein	py-cpy-bn	minor
73. NATIONAL (7)	granite por-diorite contact	N65°E, (roughly) 70S qtz vein	gn-Ag vein with Fe staining, adjacent prospect has abundant cpy	100 tons @ Pb-65%, Ag-60 oz.
74. O'MARA (6,7)	granodiorite	5' vein @ N70E, 75SE	py-cpy-bn in banded qtz vein with qtz-ser-tour alt of wall rock	estimate 200 tons @ Cu-2%, Ag-5 oz.
75. PAYMASTER (2)	granodiorite	1-4' vein is N25E-75SE extends S side Soldier Basin to Provid.	cpy-bn-py-aspy-gn-sl-Au in order of abundance, sl very minor. Strong qtz-ser-chlor along border of veins with open space filling of finely banded qtz & sulfides	minor prod; surface grab - Cu-1.4%, Pb-0.4%, Zn-0.3%

TABLE I (cont'd.)

PROPERTY NAME[a]	HOST ROCK	STRUCTURE	ALTERATION-MINERALIZATION	PRODUCTION
			PATAGONIA - WEST (cont'd.)	
76. PROTO, JACKALO (2)	grano-diorite	Same as Paymaster	Same as Paymaster	minor prod. mine assay (1912) Cu-16.6%, Ag-2.2 oz.
77. RED TOP (8)	grano-diorite	bx. pipe	py-cpy-moly in qtz-ser altered bx structure	rock chip on surface gave - Cu-375 ppm, Mo-450 ppm, no prod.
78. SHAMROCK (KARAM-NOON) (1,7,8)	granite por-diorite	N75E-60S qtz. vein	Au-Ag-Mn in qtz gangue assoc. with py and tour-bearing bx, some U_3O_8	minor
79. SYCAMORE CANYON (1)	grano-diorite	mineralized joints @ N20W-25NE	cpy-moly-py in qtz-ser-kspar altered joints	rough estimate from adjacent drilling & surface - Cu-0.15%, Mo-0.05%, no prod.

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MINERAL DEPOSITS

The mineral deposits of the Patagonia Mtns. are grouped by district and are listed and numbered for the most part in alphabetical order on Table 1. A total of 83 mineral deposits have been included in this table. The production by district is given on Table 2; however, many estimates are low due to unrecorded and missing production figures and do not include ore reserves, proven or otherwise. The total value at Jan. 1972 metal prices is $101 million, 55 percent of which came from the Harshaw district.

TABLE 2 Metal Production in the Patagonia Mtns.(1)

	Red. Mtn.	Harshaw	Palmetto	Patagonia East	Patagonia West	TOTAL
Cu	35,500	4,168,000	7,041,000	20,320,000	331,000	31,895,500 lbs.
Pb	62,000	139,727,463	148,900	25,260,000	215,400	165,413,763 lbs.
Zn		135,468,955	220,000	67,360,000	135,000	203,183,955 lbs.
Ag	7,750	6,674,465	69,825	1,697,000	25,130	8,474,170 oz.
MoS_2				9,000,000	5,000	9,005,000 lbs.

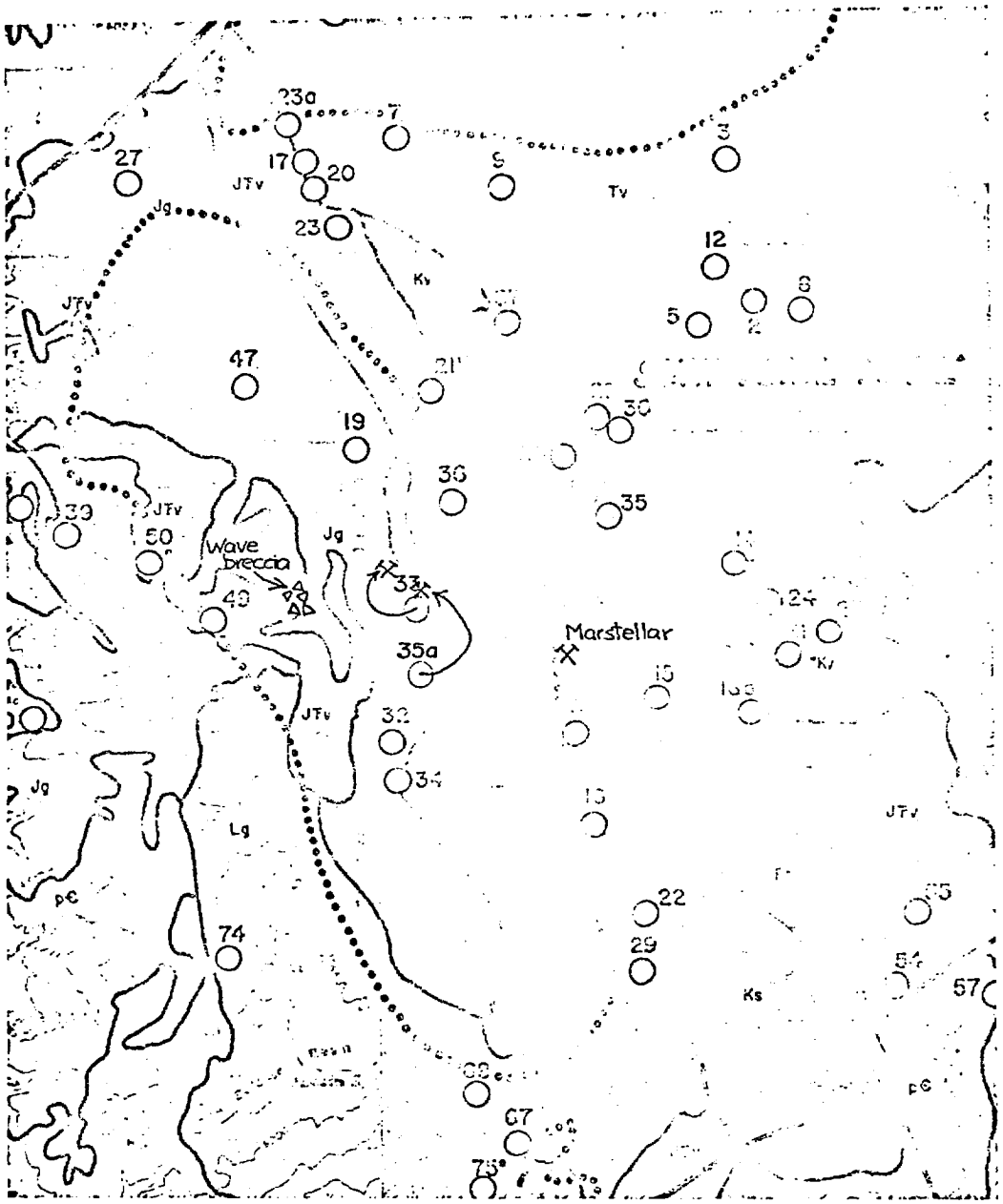
The Red Rock district, which lies in the Canelo Hills about 8 miles east of Red Mtn., was not included in this tabulation. Available records indicate that production from this area has been minor.

The distribution and size of mineral deposits in relation to the general geology is shown on Plate 1. These deposits are somewhat more abundant at the north end of the range in the vicinity of the two large altered zones and then disappear under the post-mineral gravels and volcanic rocks west of Red Mtn. In addition, the larger deposits are also more abundant at the north end.

The mineral deposits can be simplistically classified into igneous metamorphic, mesothermal, and epithermal groups. The igneous metamorphic and mesothermal deposits appear to lie within and along strike of the Laramide granodiorite. The epithermal deposits lie on either side of the Laramide intrusion and do not appear to wrap around its northward projection.

METAL ZONING

Detectable amounts of the metals tabulated in this report can be found in most of the mineral deposits in the Patagonia Mountains. Therefore, an attempt was made to separate the metal occurrences according to whether they formed a major or minor portion of the total metals present,



Map showing the corrected locations of the Sunnyside (33) and Volcano (35a) Mines

TABLE 1 — District Name and Production Compilation, with ratio numbers, affinities, status, and anomalous notations

ion	Mining District Name	Type Deposits	Short Tons Ore (1,000's)	Pounds Copper (1,000's)	Pounds Lead (1,000's)	Pounds Zinc (1,000's)	oz. Gold	oz. Silver (1,000's)	Ratio Cu/Pb+Zn	Ratio Ag/Au	Ratio Cu/Au	Affinity by Cu/Pb+Zn	Affinity by Ag/Au	Affinity by Cu/Au	Present Status	Anomalous
	1. Pima	D,V,L	369,707	4,119,854	85,195	232,953	53,720	312,000	12.95	5,807.9	76,691.3	P	P	P	Pvl	
	2. Ajo	D	350,015	5,659,953	---	---	1,548,253	18,992	---	12.3	3.655.7	-	L	P	P	
	3. Warren	D/L	150,991	7,693,257	309,756	378,450	2,630,572	100,312	11.18	38.1	2,918.8	P	L	P	PL	
	4. Silver Bell	D/L	61,200	1,008,839	1,804	48,087	1,490	5,294	20.22	3,553.0	677,073.1	P	P	P	PL	
al	5. Cochise	L	1,640	74,775	605	93,650	229	734	0.79	3,205.2	326,528.4	V	P	P	L	Yes
	6. Tombstone	L,v	1,500	3,018	45,000	1,179	240,000	30,000	0.07	125.0	12.6	L	L	L	Lv	---
	7. Pearce	V	1,341	55	16	---	12,020	138	-(3.44)	11.5	4.6	p?	L	L	V	Yes
	8. Harshaw	V	1,096	4,131	124,072	128,769	2,578	4,525	0.02	1,755.2	1,602.4	L	P?	P?	V	Yes
	9. Turquoise	L	887	54,823	7,777	2,561	56,641	1,575	5.30	27.8	967.9	P?	V	p?	L	Yes
	10. Oro Blanco	V	855	2,577	56,036	37,915	54,753	4,072	0.03	74.4	47.1	L	L	V	V	?
	11. Helvetia	L	426	34,860	521	1,360	1,581	347	0.08	63.6	188.3	L	L	p?	L	?
	12. Patagonia	V	373	18,158	16,785	31,942	1,682	1,388	0.37	825.2	10,795.5	v?l?	p?	P	V	Yes
	13. Oracle	L	136	6,117	188	50	387	118	25.70	304.9	15,806.2	P	p?	P	L	Yes
	14. Dos Cabezas	V,l	106	4,026	1,413	39	10,082	429	2.77	42.6	399.3	p?	L	p?	Vl	Yes
	15. Middle Pass	L	76	2,011	274	9,251	337	147	0.21	436.2	5,967.4	L	p?	P	L	Yes
	16. Baboquivari	V	57	244	24	<1	13,850	174	9.76	12.6	17.6	P	L	L	V	Yes
	17. Swisshelm	L	49	97	11,853	211	5,230	330	0.01	63.1	18.5	L	L	L	L	---
	18. California	L,v	38	299	8,631	1,179	100	152	0.03	1,520.0	2,998.0	L	P	P	Lv	Yes
	19. Amole	V,d,l	34	529	670	375	1,010	27	0.51	26.7	523.8	V	P?	p?	pvl	?
	20. Empire	L,v	34	344	16,671	515	744	206	0.02	276.9	462.4	L	P	p?	Lv	Yes
	21. Tyndall	V	27	530	7,265	1,535	7,917	181	0.06	22.9	66.9	L	P?	V	V	?
	22. Waterman	V,l	25	1,502	1,563	978	106	130	0.59	1,226.4	14,169.8	V	P	P	vl	Yes
	23. Dragoon	L	19	18	356	249	9,741	72	0.03	7.4	1.8	L	p?	L	L	---
	24. Gunsite	V	16	32	1,552	<1	397	101	0.02	254.4	80.6	L	P	V	V	?
	25. Quijotoa	V	16	132	58	---	11,616	233	-(2.28)	20.1	11.4	p?	P?	L	V	Yes
	26. Palmetto (3R)	V	13	852	18	1	24	3	44.84	125.0	35,500.0	P	P	P	V	Yes
	27. Hartford	L,v	9	74	588	375	393	25	0.08	63.6	188.3	L	P?	v?p?	lv	Yes
	28. Arivaca	V	9	72	230	17	5,620	46	0.29	8.2	12.8	v?	p?	L	V	?
	29. Cababi	V	6	184	364	3	3,450	102	0.50	29.6	53.3	V	P?	V	V	?
	30. Cerro Colorado	V	5	33	63	1	463	377	0.52	814.3	71.3	v	p	v	v	?
	31. Papago	L	5	52	790	2	1,100	30	0.07	27.3	47.3	l	v	v	l	?
	32. Whetstone	V,l	4	77	---	---	8	2	---	250.0	9,625.0	-	p?	p	v	Yes
	33. Greaterville	L,v	2	39	343	32	39(lode)	13(lode)	0.10	333.3	1,000.0	l	p?	p?	l	Yes
	34. Montezuma	V	1	205	16	---	126	164	-(12.81)	1,301.6	1,627.0	p	p	p?	v	Yes
	35. Coyote	V,l	<1	140	---	---	21	<1	---	142.9	6,666.7	-	l	p	v	?
	36. Wrightson	V	<1	21	179	---	50	12	-(0.12)	240.0	420.0	l	p?	p?	v	?
	37. Nogales (Gold Hill)	V	<1	11	15	---	146	2	-(0.73)	13.7	75.3	v	v	v	v	---

or Form of Mineralization or Affinity
- D Disseminated
- V Vein
- L Limestone Replacement

ondary Form of Mineralization or Affinity
- d disseminated
- v vein
- l limestone replacement

Not clearly defined

Insufficient data

AMERICAN SMELTING AND REFINING COMPANY
TUCSON ARIZONA

April 14, 1975

TO: W. L. Kurtz

FROM: J. D. Sell

Metallogenesis Affinity Follow-Up
Patagonia Mountains
Santa Cruz County, Arizona

In reviewing my memo on District Metallogenesis (dated March 20, 1975), it was evident that the meaning of the various ratio numbers was open and, further, that often the total district production affinity suggestions were not clear cut. Undoubtedly this is involved with the interpretation of district and regional metal zoning problems and also the utilization and projection of minor production data, which is often high-graded production and not characteristic of the total metal value available within the property. Also involved is the manner of recovery and sale of the production, i.e., smelter settlements, and other economic parameters.

The Patagonia Mountain compilation by Graybeal (Metal Zoning report dated February 15, 1972) was available and I have used his data for a follow-up into a district and the possible implications. In general, several problems are self evident when working with individual detailed district figures: 1) often only a minor amount of production is available from many of the workings within the district, and 2) often production is not inclusive for all five metals used, Cu, Pb, Zn, Ag, Au, but is restrictive to what was economically available at the time of production.

Table 1 below recaps the suggested affinities for various types of deposits. The affinity numbers were generated from the data of southern Arizona districts which had a record of over 100 thousand tons of production. As noted in my previous metallogenesis memo, the first three ratios appear to be more consistent than do the latter two in the affinity interpretation. The latter two were not included in the original memo, but are necessary for the individual deposit data available in the Patagonia Mountains.

TABLE 1
Ratio Affinities for Various Types of Deposits

Type of Deposit	Ratio*				
	Cu/Pb+Zn	Ag/Au	Cu/Au	Pb+Zn/Ag	Cu/Ag
Porphyry	+10	+3,000**	+3,000	+30	+100
Vein	±0.5	-50	+25	+15,-25	+10,-20
Limestone	±0.1	+50,-100	-25	-2	-2

*Notes: + Greater than; - Less than; ± Around

**Most diagnostic value; but number may be low or high.

Knowing the above discussed general features, the individual mines and prospects compiled by Graybeal were evaluated and have been tabulated in Table 2. The type of deposit as indicated by the affinity numbers is shown in the map symbol column and this notation has been plotted on Graybeal's Plate 1.

The greatest concentration of porphyry affinity prospects is across and along the east side of the Sunnyside Zone at deposit numbers 47, 19, 36, 35, and 16. Mixed porphyry-limestone affinities are found at locations 23, 21, 18, 29, 68, and 49 around the margin of the Sunnyside Zone. Only one vein (#33) affinity and one limestone (#34) affinity are within the Sunnyside Zone.

Other porphyry affinity numbers are at #10 in the Red Mountain Zone, #8 and #57 east and southeast of the Sunnyside Zone, and #76 west of the Four Metals Zone. The Four Metals Zone also contains two mixed vein-porphyry prospects at #64 and #67 and one vein affinity at #75.

A band of vein affinities lies around and outside the north end of the Sunnyside Zone at numbers 2, 7, 17, 27, and 41. Vein affinities #74 and #75 lie outside the southwest margin of the Sunnyside Zone.

A group of limestone replacement affinity prospects lie on the margin of the Sunnyside Zone at locations #9, 37, and 26 on the northeast; #24, 31, and 15 on the east; with number 34 in the central part of the zone.

In conclusion, this study suggests that detailed integration of production data within the Patagonia Mountains indicates that the eastern-central portion of the Sunnyside Zone contains the most concentration expression of porphyry affinity prospects and deposits. This area is presently being tested by ASARCO. Further, it is suggestive that expanded studies and integration of production data from other districts would be an aid in suggesting the main portion of the district most favorable in the search for porphyry systems.

James D. Sell

James D. Sell

JDS:lb
Atts.

TABLE 2 — Graybeal's Patagonia Mineral Deposit Number, Production Data, and Affinities.

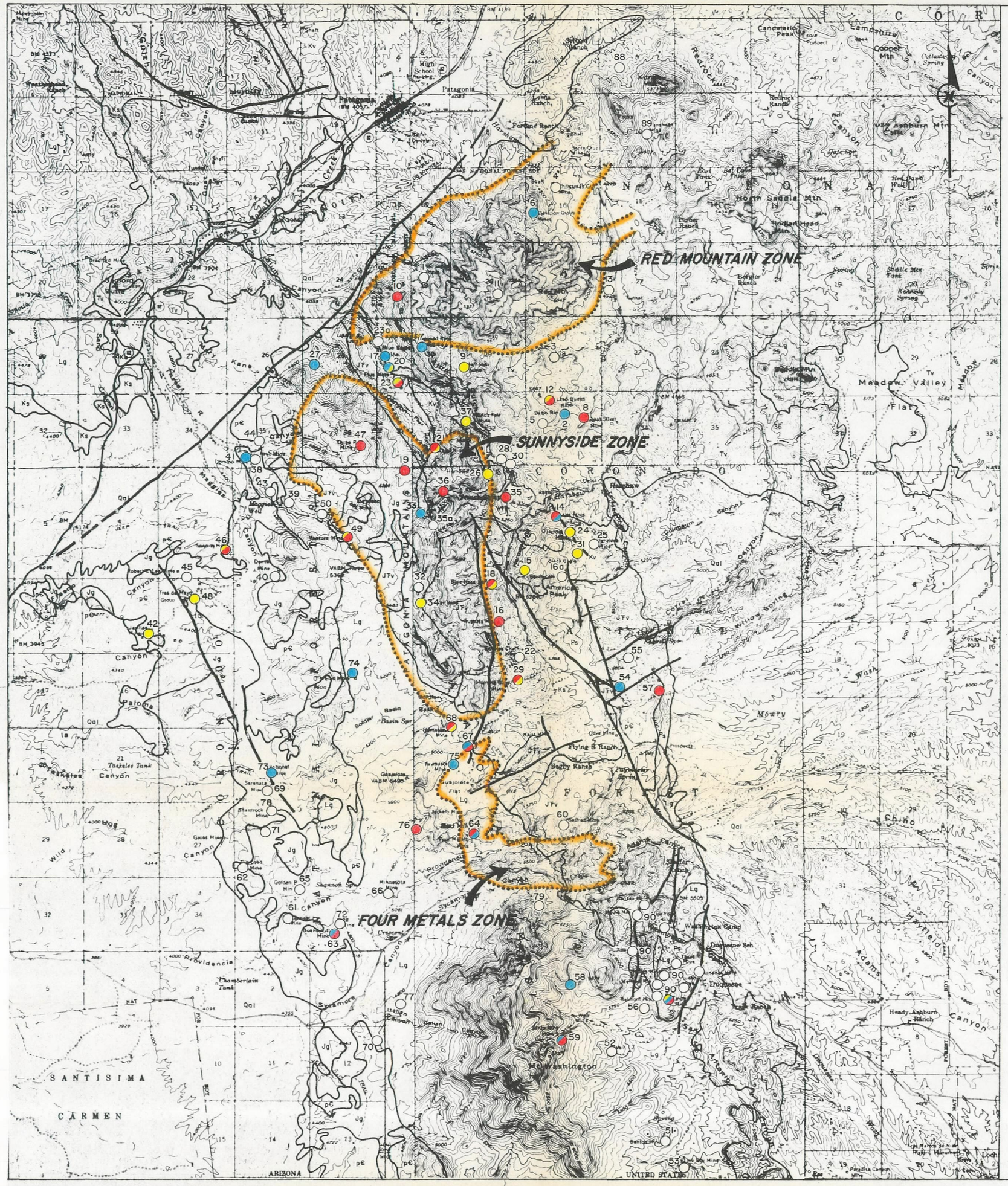
Deposit Number	Tons Ore	Pounds Copper	Pounds Lead	Pounds Zinc	Ounces Silver	Ounces Gold	Affinities Cu/Pb+Zn	Affinities Ag/Au	Affinities Cu/Au	Affinities Pb+Zn/Ag	Affinities Cu/Ag	Map Symbol	#
1	100	16,000	---	---	---	---	--	--	--	--	--	--	1
2	25	3,500	---	---	25	Minor	--	--	V	--	--	V	2
3	Minor	---	---	---	---	---	--	--	--	--	--	--	3
4	50	---	---	---	---	4,500	--	--	--	--	--	--	4
5	None	---	---	---	---	---	--	--	--	--	--	--	5
6	50?	16,000	10,000	---	---	1,500	V	--	--	L?	V	V	6
7	(Assay)	(159)	(50)	(9)	---	(10)	V?P?	--	--	L?	V	V	7
8	50	---	52,000	---	5	1,650	--	P	--	P	--	P	8
9	(Assay)	(5)	---	---	---	(3)	--	--	--	--	L	L	9
10	(Assay)	(20)	---	---	(0.05)	---	--	--	P	--	--	P	10
11	(Assay)	(14)	---	---	---	---	--	--	--	--	--	--	11
12	(Assay)	(56)	(1,120)	(40)	(0.1)	(55)	L	P	V?P?	V	L	L?P?	12
13	(Assay)	(1)	---	---	---	---	--	--	--	--	--	--	13
14	10,000?	?	(740)	---	(15)	(2)	--	V	--	P	--	VP	14
15	5,000	30,000	200,000	200,000?	---	75,000	L	--	--	L?	L	L	15
16	100	---	114,000	20,000	20	4,000	--	P?L?	--	P	--	P	16
16a	100	---	---	---	---	---	--	--	--	--	--	--	16a
17	100	12,000	21,400	5,600	---	1,330	V	--	--	V	V	V	17
18	93	93	10,044	18,786	---	686	L	--	--	P	L	P?L	18
19	(Assay)	(10)	---	---	---	(0.2)	--	--	--	--	P?	P?	19
20	961	---	127,621	148,763	---	22,872	--	--	--	L?V?	--	L?V?	20
21	200	2,000	33,200	40,000	---	1,740	L	--	--	P	L	P?L	21
22	Minor	---	---	---	---	---	--	--	--	--	--	--	22
23	600,000	3,000,000	69,600,000	97,200,000	---	1,860,000	L	--	--	P	L	P?L	23
23a	None	---	---	---	---	---	--	--	--	--	--	--	23a
24	(Assay)	(2)	(36)	---	(6)	---	L	--	--	V?L?	L	L	24
25	50,000?	---	---	---	---	250,000	--	--	--	--	--	--	25
26	500	23,000	100,000	70,000	---	12,500	L	--	--	V	L	L	26
27	(Assay)	(5)	(6)	(9)	---	(0.6)	V	--	--	V	V	V	27
28	86,600	---	5,888,800	8,660,000	---	572,560	--	--	--	--	--	--	28
29	100,000	860,000	---	7,300,000	---	48,000	L	--	--	P	V	PLV(?)	29
30	25?	---	---	---	---	---	--	--	--	--	--	--	30
31	3,000	21,000	123,000	72,000	---	165,600	L	--	--	L	L	L	31
32	None	---	---	---	---	---	--	--	--	--	--	--	32
33	1,000	100,000	---	---	---	3,000	--	--	--	--	V?	V?	33
34	(Assay)	(12)	---	---	---	(2)	--	--	--	--	L?	L?	34
35	184,600	---	26,951,600	21,413,600	---	1,089,140	--	--	--	P	--	P	35
35a	Minor	---	---	---	---	---	--	--	--	--	--	--	35a
36	(Assay)	(14)	(2)	---	---	---	P	--	--	--	--	P	36
37	10,000	152,000	800,000	520,000	400	390,000	L	--	--	L	L	L	37
38	Minor	---	---	---	---	---	--	--	--	--	--	--	38
39	Minor	---	---	---	---	---	--	--	--	--	--	--	39
40	Minor	---	---	---	---	---	--	--	--	--	--	--	40
41	50	---	61,000	---	---	2,900	--	--	--	V	--	V	41
42	50	100	40,000	---	50	8,750	L	P?	L	L?	L	L	42
43	Minor	---	---	---	---	---	--	--	--	--	--	--	43
44	Minor	---	---	---	---	---	--	--	--	--	--	--	44
45	50?	---	---	---	---	---	--	--	--	--	--	--	45
46	(Assay)	(500)	---	---	(4)	(100)	--	--	P?	--	L?	P?L?	46
47	50,000	7,000,000	---	---	---	50,000	--	--	--	--	P	P	47
48	75	---	45,900	---	---	5,925	--	--	--	L?	--	L?	48
49	500	41,000	32,000	220,000	15	2,250	L	L	P	P	V	LP	49
50	3.6M Reserve	18,000,000	---	---	---	---	--	--	--	--	--	--	50
51	(Assay)	(6)	---	---	---	---	--	--	--	--	--	--	51
52	None	---	---	---	---	---	--	--	--	--	--	--	52
53	(Assay)	(14)	---	---	---	---	--	--	--	--	--	--	53
54	75,000	---	33,000,000	---	---	1,800,000	--	--	--	V	--	V	54
55	See 54	---	---	---	---	---	--	--	--	--	--	--	55
56	None	---	---	---	---	---	--	--	--	--	--	--	56
57		---	(278)	nil	---	1	--	--	--	P	--	P	57
58	(Assay)	(5)	(5)	(10)	---	(0.9)	V	--	--	V	V?	V	58
59	20,000	3,484,000	---	---	400	13,200	--	V	P	--	P	VP	59
60	None	---	---	---	---	---	--	--	--	--	--	--	60
61	Minor	---	---	---	---	---	--	--	--	--	--	--	61
62	Minor	---	---	---	---	---	--	--	--	--	--	--	62
63	500	280,000	14,400	---	100	12,880	P	V	P	L	V?	V?P	63
64	(Assay)	(16)	(3)	---	(0.1)	---	V?P?	--	--	V	P	VP	64
65	100?	---	---	---	---	---	--	--	--	--	--	--	65
66	(Assay)	(6)	---	---	---	---	--	--	--	--	--	--	66
	500	33,400	1,000	---	50	1,200	P	V	P	L	V?	V?P	67
	(Assay)	(40)	(140)	(270)	(8)	(0.01)	L	P?	P	P	L?	L?P	68
	Minor	---	---	---	---	---	--	--	--	--	--	--	69
	None	---	---	---	---	---	--	--	--	--	--	--	70
	Minor	---	---	---	---	---	--	--	--	--	--	--	71
	Minor	---	---	---	---	---	--	--	--	--	--	--	72
	100	---	130,000	---	---	6,500	--	--	--	V	--	V	73
	200	8,000	---	---	---	1,000	--	--	--	--	V?	V?	74
	(Assay)	(28)	(8)	(6)	---	---	V	--	--	--	--	V	75
	(Assay)	(332)	---	---	---	(2)	--	--	--	--	P	P	76
	None	---	---	---	---	---	--	--	--	--	--	--	77
	Minor	---	---	---	---	---	--	--	--	--	--	--	78
	(Assay)	(3)	---	---	---	---	--	--	--	--	--	--	79
	421,000	16,840,000	25,260,000	67,360,000	---	1,684,000	L	--	--	P	V	LPV	90

()Signifies a single assay value.

TABLE 2 — Graybeal's Patagonia Mineral Deposit Number, Production Data, and Affinities.

Deposit Number	Tons Ore	Pounds Copper	Pounds Lead	Pounds Zinc	Ounces Silver	Ounces Gold	Affinities Cu Pb+Zn	Affinities Ag Au	Affinities Cu Au	Affinities Pb+Zn Ag	Affinities Cu Ag	Map Symbol	#
1	100	16,000	---	---	---	---	--	--	--	--	--	--	1
2	25	3,500	---	---	25	Minor	--	--	V	--	--	V	2
3	Minor	---	---	---	---	---	--	--	--	--	--	--	3
4	50	---	---	---	---	4,500	--	--	--	--	--	--	4
5	None	---	---	---	---	---	--	--	--	--	--	--	5
6	50?	16,000	10,000	---	---	1,500	V	--	--	L?	V	V	6
7	(Assay)	(159)	(50)	(9)	---	(10)	V?P?	--	--	L?	V	V	7
8	50	---	52,000	---	5	1,650	--	P	--	P	--	P	8
9	(Assay)	(5)	---	---	---	(3)	--	--	--	--	L	L	9
10	(Assay)	(20)	---	---	(0.05)	---	--	--	P	--	--	P	10
11	(Assay)	(14)	---	---	---	---	--	--	--	--	--	--	11
12	(Assay)	(56)	(1,120)	(40)	(0.1)	(55)	L	P	V?P?	V	L	L?P?	12
13	(Assay)	(1)	---	---	---	---	--	--	--	--	--	--	13
14	10,000?	?	(740)	---	(15)	(2)	--	V	--	P	--	VP	14
15	5,000	30,000	200,000	200,000?	---	75,000	L	--	--	L?	L	L	15
16	100	---	114,000	20,000	20	4,000	--	P?L?	--	P	--	P	16
[illegible]	100	---	---	---	---	---	--	--	--	--	--	--	16a
17	100	12,000	21,400	5,600	---	1,330	V	--	--	V	V	V	17
18	93	93	10,044	18,786	---	686	L	--	--	P	L	P?L	18
19	(Assay)	(10)	---	---	---	(0.2)	--	--	--	--	P?	P?	19
20	961	---	127,621	148,763	---	22,872	--	--	--	L?V?	--	L?V?	20
21	200	2,000	33,200	40,000	---	1,740	L	--	--	P	L	P?L	21
22	Minor	---	---	---	---	---	--	--	--	--	--	--	22
23	600,000	3,000,000	69,600,000	97,200,000	---	1,860,000	L	--	--	P	L	P?L	23
23a	None	---	---	---	---	---	--	--	--	--	--	--	23a
24	(Assay)	(2)	(36)	---	(6)	---	L	--	--	V?L?	L	L	24
25	50,000?	---	---	---	---	250,000	--	--	--	--	--	--	25
26	500	23,000	100,000	70,000	---	12,500	L	--	--	V	L	L	26
27	(Assay)	(5)	(6)	(9)	---	(0.6)	V	--	--	V	V	V	27
28	86,600	---	5,888,800	8,660,000	---	572,560	--	--	--	--	--	--	28
29	100,000	860,000	---	7,300,000	---	48,000	L	--	--	P	V	PLV(?)	29
30	25?	---	---	---	---	---	--	--	--	--	--	--	30
31	3,000	21,000	123,000	72,000	---	165,600	L	--	--	L	L	L	31
32	None	---	---	---	---	---	--	--	--	--	--	--	32
33	1,000	100,000	---	---	---	3,000	--	--	--	--	V?	V?	33
34	(Assay)	(12)	---	---	---	(2)	--	--	--	--	L?	L?	34
35	184,600	---	26,951,600	21,413,600	---	1,089,140	--	--	--	P	--	P	35
35a	Minor	---	---	---	---	---	--	--	--	--	--	--	35a
36	(Assay)	(14)	(2)	---	---	---	P	--	--	--	--	P	36
37	10,000	152,000	800,000	520,000	400	390,000	L	--	--	L	L	L	37
38	Minor	---	---	---	---	---	--	--	--	--	--	--	38
39	Minor	---	---	---	---	---	--	--	--	--	--	--	39
40	Minor	---	---	---	---	---	--	--	--	--	--	--	40
41	50	---	61,000	---	---	2,900	--	--	--	V	--	V	41
42	50	100	40,000	---	50	8,750	L	P?	L	L?	L	L	42
43	Minor	---	---	---	---	---	--	--	--	--	--	--	43
44	Minor	---	---	---	---	---	--	--	--	--	--	--	44
45	50?	---	---	---	---	---	--	--	--	--	--	--	45
46	(Assay)	(500)	---	---	(4)	(100)	--	--	P?	--	L?	P?L?	46
47	50,000	7,000,000	---	---	---	50,000	--	--	--	--	P	P	47
48	75	---	45,900	---	---	5,925	--	--	--	L?	--	L?	48
49	500	41,000	32,000	220,000	15	2,250	L	L	P	P	V	LP	49
50	3.6M Reserve	18,000,000	---	---	---	---	--	--	--	--	--	--	50
51	(Assay)	(6)	---	---	---	---	--	--	--	--	--	--	51
52	None	---	---	---	---	---	--	--	--	--	--	--	52
53	(Assay)	(14)	---	---	---	---	--	--	--	--	--	--	53
54	75,000	---	33,000,000	---	---	1,800,000	--	--	--	V	--	V	54
55	See 54	---	---	---	---	---	--	--	--	--	--	--	55
56	None	---	---	---	---	---	--	--	--	--	--	--	56
57		---	(278)	nil	---	1	--	--	--	P	--	P	57
58	(Assay)	(5)	(5)	(10)	---	(0.9)	V	--	--	V	V?	V	58
59	20,000	3,484,000	---	---	400	13,200	--	V	P	--	P	VP	59
60	None	---	---	---	---	---	--	--	--	--	--	--	60
61	Minor	---	---	---	---	---	--	--	--	--	--	--	61
62	Minor	---	---	---	---	---	--	--	--	--	--	--	62
63	500	280,000	14,400	---	100	12,880	P	V	P	L	V?	V?P	63
64	(Assay)	(16)	(3)	---	(0.1)	---	V?P?	--	--	V	P	VP	64
65	100?	---	---	---	---	---	--	--	--	--	--	--	65
66	(Assay)	(6)	---	---	---	---	--	--	--	--	--	--	66
67	500	33,400	1,000	---	50	1,200	P	V	P	L	V?	V?P	67
68	(Assay)	(40)	(140)	(270)	(8)	(0.01)	L	P?	P	P	L?	L?P	68
69	Minor	---	---	---	---	---	--	--	--	--	--	--	69
70	None	---	---	---	---	---	--	--	--	--	--	--	70
71	Minor	---	---	---	---	---	--	--	--	--	--	--	71
72	Minor	---	---	---	---	---	--	--	--	--	--	--	72
73	100	---	130,000	---	---	6,500	--	--	--	V	--	V	73
74	200	8,000	---	---	---	1,000	--	--	--	--	V?	V?	74
75	(Assay)	(28)	(8)	(6)	---	---	V	--	--	--	--	V	75
76	(Assay)	(332)	---	---	---	(2)	--	--	--	--	P	P	76
77	None	---	---	---	---	---	--	--	--	--	--	--	77
78	Minor	---	---	---	---	---	--	--	--	--	--	--	78
79	(Assay)	(3)	---	---	---	---	--	--	--	--	--	--	79
90	421,000	16,840,000	25,260,000	67,360,000	---	1,684,000	L	--	--	P	V	LPV	90

()Signifies a single assay value.



INDEX TO MINERAL DEPOSITS

RED MOUNTAIN DISTRICT

1 Andes (Aztec)
2 Basin No. 1
3 Blue Bird
4 Christmas Gift
5 Dewey
6 Elevation
7 Exposed Reef
8 Great Silver
9 Hampson
10 Invincible
11 Red Mountain
12 Lead Queen
13 Roper Tunnel
88 Powers
89 San Simone

HARSHAW DISTRICT

14 Alta
15 American
16 Augusta
16a Bender-Black Eagle
17 Blue Eagle
18 Blue Nose
19 BX
20 California
21 Chief
22 Endless Chain
23 Flux
23a Garfield
24 Hardshell
25 Hermosa
26 Humboldt
27 Hulda
28 January
29 Morning Glory
30 Red Bird
31 Salvadore
32 Standard
33 Sunnyside
34 Thunder
35 Trench (Josephine)
35a Volcano
36 Wellington
37 Worlds Fair
54 Mowry
55 North Mowry
57 Phoenix

PALMETTO DISTRICT

38 Big Stick
39 Cox-European Canyon
40 Denver
41 Domino
42 Jarillos
43 Ledge
44 Native Silver
45 Robert E. Lee (Palmetto)
46 Sonoita
47 Three R
48 Tres de Mayo
49 Ventura Adits
50 Ventura Breccia

PATAGONIA EAST DISTRICT

51 Benton
52 Justice
53 Line Boy
56 O'Conner
58 Rattlesnake
59 Santa Nino
90 Washington-Duquesne
60 Winifred

PATAGONIA WEST DISTRICT

61 Bennett
62 Big Lead
63 Buena Vista
64 Four Metals
65 Golden Rose
66 Minnesota (Gross)
67 Guajolote (Roy)
68 Homestake
69 Isabella (Serenata)
70 Italian Canyon
71 Jabalina
72 King
73 National
74 O'Mara
75 Paymaster
76 Proto-Jackalo
77 Red Top
78 Shamrock
79 Sycamore Canyon

GEOLOGIC LEGEND

Qal	Quaternary alluvium	Jg	Jurassic granite
Lg	Laramide granitic rocks	JTv	Jurassic-Triassic volcanics
Tv	Early Tertiary volcanics	Ps	Paleozoic sediments
Kv	Cretaceous volcanics	p€	Precambrian rocks
Ks	Cretaceous sediments		Fault

ZONES OF WIDESPREAD HYDROTHERMAL ALTERATION

PRODUCTION OR RESERVES OF MINERAL DEPOSITS
(IN DOLLARS AT JAN. 1972 PRICES)

AFFINITY
- Porphyry
- Vein
- Limestone Replacement

- + 100 million
- 1-100 million
- 10,000 - 1 million
- 0-10,000

GEOLOGIC MAP

PATAGONIA MOUNTAINS

Santa Cruz County, Arizona

SCALE : 1" = 1 mile

F.T.G. Feb. 1972

Note: Revisions by J.D. Sell, April 1975

AMERICAN SMELTING AND REFINING COMPANY
Tucson Arizona

February 15, 1972

Report to: W. L. Kurtz

From: F. T. Graybeal

Metal Zoning in The Patagonia Mountains, Santa Cruz County, Arizona

SUMMARY AND RECOMMENDATIONS

Data from 82 mineral deposits in the Patagonia Mtns. were used to construct metal and mineral zoning maps. The results are summarized on Plate II which shows that arsenic, copper-lead-zinc, and manganese zones are closely related to the large area of pervasive pyrite mineralization centered in the Sunnyside area. These zones clearly demonstrate the presence of a second, and perhaps more intense, center of mineraization in addition to the Red Mtn. area.

Evidence for the vertical zonation of enargite or tennantite in near surface rocks to chalcopyrite at depth is well established at Red Mtn., the BX breccia pipe, and the Ventura breccia pipe. However, the deepest known penetration in the Sunnyside area is believed to be the 1500 ft. hole drilled by Anaconda under the BX pipe.

Consideration of the lateral and vertical zoning patterns strongly indicates the presence of deep hypogene copper mineralization in this area and emphasizes the need for further drilling. I estimate that the depth to copper mineralization in the Sunnyside area should be less than the 3900 feet encountered at Red. Mtn.

In light of the current industry-wide interest in various Anaconda properties, I recommend that the current joint venture inquiries extended by ASARCO to Anaconda be advanced with all due haste.

INTRODUCTION

The purpose of this work is to evaluate the zonal distribution of mineral deposits in the Patagonia Mtns., an area notable for its abundance of sulfide occurrences. Consideration of silicate and sulfide mineral zoning should reveal whether the recently discovered porphyry copper deposit under Red Mtn. is the source of the known mineral deposits, or whether other centers of mineralization are also present. The discovery of new zoning centers, not yet known to contain porphyry copper deposits, should serve as a valuable guide for further exploration in the Patagonias.

The data used to prepare the zoning maps are summarized and listed on Table 1. The mineral deposits plotted are either known producers or prospects which have been explored by drilling or underground workings. Untested geochemical anomalies, altered zones, or prospects for which no data are available are not included.

Certain difficulties were encountered in the tabulation of mineralogy due to supergene leaching. Thus, some minerals are no longer present near the surface, although they may have been abundant in the primary sulfide zone. Also, production figures were difficult to estimate for many of the older mines for which no records were available. Finally the assays reported are strongly dependent on the uniformity of the primary mineralization and whether the samples were taken from within or below the level of supergene weathering. It is believed that the difficulties encountered do not adversely affect the data used to construct the accompanying maps.

The Patagonia Mtns. are particularly well suited to this study due to the abundance of mineral deposits and descriptions of them. In addition, prior ASARCO operations in the area have resulted in the accumulation of considerable file material which would not otherwise have been available.

GENERAL GEOLOGY

The generalized geology of the Patagonia Mtns. is shown on Plate 1 (taken mostly from F. S. Simons, USGS Open File map). The central portion is underlain by a Laramide granodiorite pluton which is flanked on the west by Precambrian and Jurassic granitic rocks and on the east by Paleozoic sedimentary and Mesozoic sedimentary and volcanic rocks. The granodiorite is deeply eroded at the south end of the range and appears to plunge northerly underneath the pre-mineral Mesozoic intrusive and volcanic rocks in the Three R-Flux Canyon area.

The Laramide pluton is elongate northwesterly and lies along the well-defined lineament which extends from Nacozari to Silver Bell. Several northwest-striking high angle faults of major displacement have been recognized in the eastern portion of the range; however, the majority of the mineralized veins strike northeasterly.

Three large areas of pyritic mineralization are also shown on Plate 1. The Sunnyside and Red Mtn. zones contain pyrite primarily as pervasive disseminated grains. The Four Metals zone contains pyrite primarily in quartz-sericite veins. Although mineralized breccia pipes are present in all pyritized areas, they are by far more abundant in the Sunnyside zone which is conservatively estimated to contain over 50 pipes.

TABLE 1

GEOLOGIC FEATURES OF MINERAL DEPOSITS IN THE PATAGONIA MTNS., SANTA CRUZ COUNTY, ARIZONA

PROPERTY NAME[a]	HOST ROCK	STRUCTURE	ALTERATION-MINERALIZATION	PRODUCTION
			RED MOUNTAIN DISTRICT	
1. ANDES (AZTEC) (1,7)	rhyolite por.	20' vein strikes NE, 75°SE dip	py-cpy-cc-bn-mal in qtz-sericite-alunite alteration over large areas.	100 tons @ 8% Cu shipped. Aver. grade of workings = Cu ~ 1.1%
2. BASIN #1 (7)	andesite	fault-fissure N64W-50NE	azur-mal-cup-chrys-Au in slightly siliceous vein; Pb-Ag mined for shipping (?)	25 tons @ Cu-7%, Au-1 oz., Ag-tr.
3. BLUE BIRD (1)	andesite		minor py-cpy	minor
4. CHRISTMAS GIFT (7)	black andesite	fissure @ N65W-87S	Pb-Ag ore	50 tons @ 90 oz. Ag
5. DEWEY (7)	andesite	2' vein dips 75° NNE	cup-mal-azur-chry.	none
6. ELEVATION (7)	rhyolite, minor andesite	shear zone @ EW-V some bx.	py-cpy-gn-cc-Ag in argillized and silicified rhyolite	one vein (50 tons?) of Cu-16%, Pb-10%, Ag-30 oz.
7. EXPOSED REEF (1)		3 veins N70E-V, N20W-55S		dump sample Cu-7.95%, Pb-2.50%, Zn-4.70%, Ag-9.94 oz. Prod. unknown
8. GREAT SILVER (7)	rhyolite	siliceous vein or bed dips 30° N	gn-Ag in qtz-gyp. vein	50 tons @ Pb-52%, Ag-35 oz., Au-0.1 oz.
9. HAMPSON (1,7)	red rhyolite por. near andesite	9"-3' fissure-fault with steep S. dip	py-cpy-cc in silicif., crushed rhyolite	one dump assay gives Cu-0.27%, Ag-3.00 oz. no prod.
10. INVINCIBLE (7)	mass. rhyolite por.	1.5" py vein N30E-30SE	dissem. py-cpy in qtz veins	runs 1% Cu, 0.05 oz. Au. Minor prod.
11. RED MTN. (1)	qtz. monzonite	dissem at 3900-5200' to top	argillic alteration on surface w. limonite after cc. which grades to potassic alteration at depth w. cpy.	average of 0.71% Cu with trace Au-Mo
12. LEAD QUEEN (1,7)	andesite por.	2 EW veins with N dip	gn-cc with enriched Pb-Ag on surface grading to Pb-Ag-Cu	2 assays of vein average : Pb-56%, Cu-2.8%, Zn-2%, Ag-55 oz. Au-0.1 oz. no prod.
13. ROPER TUNNEL (1)	andesite and rhyolite		strong argillization with dissem. sulfides	averaged 0.05% Cu over 600' with 100' averaging 0.12% Cu. no prod.
88. POWERS (COPPER MTN.) (7)	rhyolite	N60W zone of silica 70' wide, 150' high	py-copper oxides in red silicified rhyolite	none
89. SAN SIMONE (1)	rhyolite	small veins	py-Pb-Ag-cpy.	(20 tons)
			HARSHAW DISTRICT	
14. ALTA (7)	diabase-rhyolite	vein	gn-pyrar-py with trace spec-cpy, Ag halides present; all in qtz-fluorite gangue	estimate 10,000 tons
15. AMERICAN (1,7)	contact of limestone & rhyolite bx	3' vein strikes WNW dips NE.	py-gn-arg-sl-cpy-cerarg. in silicified & Mn-stained limestone & rhyolite	5000 tons ore averaging: Pb-2%, Zn-2% (?), Ag-15 oz., Cu-0.3%
16. AUGUSTA (7)		parallel veins		100 tons @ Pb-57%, Zn-10%, Ag-40 oz., Au-0.2 oz.
16a. BENDER - BLACK EAGLE (1,2)	limestone	conformable replacements, 2-10' thick, along limestone-silica bx contact	Mn-Ag replacement, Ag minor	100 tons (very roughly) of Mn ore
17. BLUE EAGLE (1,7)	qtz vein in rhyolite por.	EW-V. 2-1/2' vein	py-cpy-bn-arg. in qtz. vein	hand sorted ore aver. (100 tons) Cu-6.0%, Pb-10.7%, Zn-2.8%, Ag-13.3 oz.
18. BLUE NOSE (1,5,7)	Cretaceous sediments-limestone, rhyolite present	bedding replacement(?) N15W-54 SW, ore shoots at intersection of beds with E-W fractures	py-gn-cpy-sl; Mn in surface outcrops	93 tons of Cu-0.05%, Pb-5.4%, Ag-7.38 oz., Zn-10.10%

TABLE 1 (cont'd.)

PROPERTY NAME (a)	HOST ROCK	STRUCTURE	ALTERATION-MINERALIZATION	PRODUCTION
			HARSHAW DISTRICT (cont'd.)	
19. BX PIPE (1)	monzonite	bx pipe, 400' x 800' tapers downward	py-enar-cpy-cc; mostly enargite throughout, erratically distributed; Anaconda drilling cut cpy with no enargite at roughly 1500'	2.7 million tons reserves - 0.48% Cu, 0.16 oz. Ag, 0.005%-Mo
20. CALIFORNIA (1)	rhyolite and shale	4 N-S veins with dips @ 15-50°W	oxidized lenses less than 2' wide	961 tons @ Pb-6.64%, Zn-7.74%, Ag-2.38 oz.
21. CHIEF (1,5)	rhyolite & limestone, sim. to Flux	veins roughly N35W-40SW in area cut by fault @ N65E-80NW	py-gn-sl-td replacements in limestone.	200 tons, dump assays are Cu-0.5%, Pb-8.3%, Zn-10.0%, Ag-8.7 oz.
22. ENDLESS CHAIN (7)	2' bed of quartzite	ore bed dips 70°SE	py-cpy-td, somewhat banded	minor
23. FLUX (1)	limestone, minor shale and mudstone	vein @ N5W-40 SW, parallel to bedding, weak cross-jointing	gn-sl-Ag associated with massive py as lenses parallel to bedding; mostly replacement of lms; alteration is qtz-cal-chlor-ser, minor cpy.	roughly 600,000 tons Ag-3.1 oz., Pb-5.8%, Zn-8.1%, Cu-0.25% #1 orebody: Ag-3.3 oz., Pb-4.5%, Zn-10.5% #2 orebody: Ag-4.7 oz., Pb-10.7%, Zn-10.4%
23a. GARFIELD (1)	arkose	N80E-V vein 1' thick	Qtz vein with py, minor cpy-sl. Possible tr. arg or td.	None
24. HARDSHELL (1)	agglomerate unit in Chief fm	flat-lying manto, parallel to bedding, lies on strike of Trench veins	strong silicification of Chief and underlying lms, dissem py, ore minerals unclear, partly cryptomelane	7 million tons reserves of 5.0 oz. Ag. Typical assay: Mn-11.2%, Ag-5.85 oz., Pb-1.8%, Zn-1.0%, Cu-0.1%. Prod. perhaps 1/2 of Mowry (Ag = 500,000 oz.)
25. HERMOSA (7)	rhyolite	1-20' lode dips 33°N	AgCl-Mn in silicified rhyolite	very approx. guess @ 50,000 tons of 5 oz. Ag
26. HUMBOLDT (1,5,7)	rhyolite, 30' from andesite contact	veins - faults N60E-80NW	py-gn-sl-td-cpy; Pb-Ag ore nearer the surface	500 tons @ roughly Cu-2.3%, Pb-10%, Zn-7%, Ag-25 oz.
27. HULDA (1)		2' vein	one pit with minor sulfides exposed	2' sample of good mineraliz. Cu-0.25%, Pb-0.30%, Zn-0.45%, Ag-0.56 oz. no prod.
28. JANUARY (5,7)	rhyolite and andesite	vein is 6-7' wide @ N30W-75NE	py-gn-sl-arg-Mn	86,600 tons @ Pb-3.4%, Zn-5.0%, Ag-6.6 oz.
29. MORNING GLORY (1,7)	limestone near masses of rhyolite	bedding replacement dipping 40° WNW, rhyolite dike @ N25E 40 WNW	py-cpy-sl-Ag, massive & banded assoc. with qtz-cal-bar-spec, tr bn-cc; copper ores separate from zinc ores	approx. aver. of Cu & Zn pods. Cu-4.3%, Ag-4.8 oz.; Zn-36.5% prod. estimates 10,000 tons
30. RED BIRD (5,7)	along rhyolite dike contact in andesite	mineralized zone is N53W-75NE	py-gn-arg-Mn	25 tons ?
31. SALVADORE (1,7)	silicif. limestone or rhyolite	dips 35N, veins follow bedding; projects under Hardshell	Ag-Mn-Pb	estimate 3000 tons of Mn-20.6%, Pb-4.05%, Cu-0.35%, Ag-18.4 oz., Zn-1.2%
32. STANDARD (7)	granite por.	NW shearing	py-cpy-cc - enargite	None
33 SUNNYSIDE (5,7)	granite or rhyolite por.	shear zone @ N50W-V, 200' wide	mal-black copper oxides-Ag st. silicif. (Kerr-McGee reports enargite?) rock	1000 tons of malachite ore averaging: Cu-5%, Ag-3 oz.
34. THUNDER (7)	granite por.	NW shearing	py-cpy-td-moly. in silicified rock, sulfides dissem. & in veins	tunnel averages Cu-0.6%, Ag-2 oz. No prod.
35. TRENCH (JOSEPHINE) (1,5)	andesite	main vein N75W-70NE	py-gn-sl-alabandite-td-pearcite; vein is qtz-rhodochrosite, wall rock alteration is chlor-epid-ser-clay-bar	184,600 tons @ Pb-7.3%, Zn-5.8%, Ag-5.9 oz.
35a. VOLCANO (7,8)	rhyolite bx.	strong bx along N20W fault	abundant mal., alunite in strongly altered rhyolite, Kerr-McGee report enargite	minor
36. WELLINGTON (1)	rhyolite bx.		pervasive fine-grained, disseminated pyrite	several chip samples in adits gave Cu-0.7%, Pb-0.1%, no prod.
37. WORLDS FAIR (5,7)	along andesite-rhyolite contact	several veins @ N15E-25(?)E	py-gn-pearcite-td-cpy in barite-qtz veins; Mn is present	unclear from reports, estim. 10,000 tons @ Cu-0.76%, Pb-4.0%, Zn-2.6%, Ag-39.0 oz., Au-0.04 oz.

TABLE 1 (cont'd.)

PROPERTY NAME[a]	HOST ROCK	STRUCTURE	ALTERATION-MINERALIZATION	PRODUCTION
			HARSHAW DISTRICT (cont'd.)	
54. MOWRY (1,2,7)	In limestone along fault against pG granite	fault @ N75E-80N localized fissure ores, manto ores too.	gn-Ag-Mn in upper levels in silicified lms; Pb-Ag enrichment pronounced; py-cpy-aspy(?) below 400 level, Zn absent	1940 estimate in files is 75,000 tons @ Pb-22%, Ag-24 oz.
55. NORTH MOWRY (7)	same as Mowry		Same as Mowry	
57. PHOENIX (1)	Bolsa quartzite	bx zones in quartzite which parallel bedding at N10E-65SE, <1' wide	lead oxides of various types, fine-grained py in siliceous portions of vein	no prod., composite assay of pits: Pb-13.9%, Ag-1.2 oz., Zn-nil
			PALMETTO DISTRICT	
38. BIG STICK (7)	contact of sheared granite por & diorite		disseminations and veins of py-cpy-cc	minor
39. COX-EUROPEAN CANYON (7,8)	monzonite	thin veins, N70E-50S	py-cpy-cc-gn-sl in small qtz-ser veins	minor
40. DENVER (6)	qtz. monzonite	N65E veins, 8"-2'.	py-cpy-sl-gn-Mn in qtz-ser veins	minor
41. DOMINO (7)	diorite-qtz. monzonite	EW shear in diorite	cerussite-gn-Ag in several pockets, red-yellow color both in ore & in diorite	50 tons of Pb-61%, Ag-58 oz.
42. JARILLAS (6,7)	qtz. monzonite-diorite	2' fissure vein @ N65E-V, strong post-min. faulting	gn-cpy with Ag-Mn in banded qtz vein; some epidote, mod. oxidation, ore was enriched Pb-Ag	average 50 tons Pb-40%, Ag-175 oz., Au-1 oz., Cu-0.10%
43. LEDGE (7)	qtz. monzonite-diorite-granite por.	one vein 1000' long	Cu & Fe sulfides assoc. with qtz	minor
44. NATIVE SILVER (7)	granite por.	shear @ N75E-85S	red-yellow drusy qtz vn. with minor py (and Ag?)	minor
45. ROBERT E. LEE (PALMETTO) (1,6)	qtz. monzonite-diorite	2 veins (2-5') N65W-85S, N35W-V, strong shearing	py-cpy-gn (with Au-Ag) assoc. with qtz-epid-chlor-ser-barite; mostly argentiferous gn with Mn; tr. moly-vanadinite-wulfenite	50 (?) tons
46. SONOITA (6,7)	qtz. monzonite-diorite contact	intersecting N10E qtz vein with NW joint	gn-cc-ruby Ag in qtz vein with Mn oxides, weak epid-chlor in diorite, ser. in qtz. monzonite	minor prod., handsorted assay Cu-25%, Ag-100 oz., Au-4 oz.
47. THREE R (4)	granite	shear zone @ N10W-75SE, cut by N75E-60S joints	py-cc in well-developed shear zone; formed by enrichment of 0.01-0.05% Cu weathered from granite; position of ore within shear zone only where cut be NE joints	roughly 50,000 tons @ Cu-7%, Ag-1 oz. - all supergene
48. TRES DE MAYO (1,6)	qtz. monzonite	NE & NW veins, joints	Ag-Pb-Cu-Mn assoc. with qtz-ser-chlor; tr wulfenite-vanadinite-cal-barite	dump goes: Ag-22 oz., Pb-1.8%, Ag assays to 700 oz. as chlorides. One 75 ton shipment recorded @ Pb-30.6%, Ag-79.0 oz. (1919)
49. VENTURA ADITS (1)	monzonite and bx	NE-striking veins	py-cpy-gn-sl in qtz veins & in sericitized bx.	two assays given; combined to - Cu-4.1%, Pb-3.2%, Zn-22%, Ag-4.5 oz., Au-0.03 oz. Estimate 500 tons prod.
50. VENTURA BRECCIA (3,8)	monzonite	N10W bx pipe 750' long, 100' wide	moly-tn-py in intense qtz-ser-tour breccia; grades downward to well-jointed monzonite with py-moly-cpy in qtz-sericite alt.	3.6 million tons @ 0.4% MoS_2, 0.25% Cu. larger tonnage at Cu:Mo = 1:1
			PATAGONIA - EAST	
51. BENTON (2,7)	qtz. monzonite	bx and along vein in a fault	py-cpy-moly assoc. with potassic alteration	one drill hole - 0.30% Cu, 0.007% Mo, no prod.
52. JUSTICE (2)	qtz. monzonite	"	similar to Benton & Line Boy	none

TABLE 1 (Cont'd)

PROPERTY NAME[a]	HOST ROCK	STRUCTURE	ALTERATION-MINERALIZATION	PRODUCTION
			PATAGONIA - EAST (cont'd.)	
53. LINE BOY (1,2,7)	qtz. monzonite	bx and along vein in a fault	py-cpy-moly-bn-cc; assoc. potassic alteration	one drill hole gave 35' @ 0.71% Cu, 0.01% Mo, no prod.
56. O'CONNOR (7)	granodiorite & granite por.	probably the small bx pipe SW of the Belmont	gn-cpy-py-moly	
58. RATTLESNAKE (1)	granodiorite & granodiorite por.	bx in N70W-striking joint system	py-cpy-moly-gn in strong qtz-ser altered bx.	one assay of dump material Cu-0.26%, MoS_2-0.35%, Pb-0.28%, Zn-0.48%, Ag-0.93 oz., no prod.
59. SANTA NINO (1,2)	granodiorite	NE-elongate pod of mineralization, crudely pipe-shaped; no veinlets	cpy-moly-py-aspy in intense secondary orthoclase alteration; cpy & moly occur separately	roughly 20,000 tons @ Cu-8.71%, Mo-13.50%, Ag-0.66 oz., Au-0.02 oz.
90. WASHINGTON - DUQUESNE (1,2,7)	limestone	igneous contacts and faults	py-sl-gn-cpy-mag-aspy along skarn-marble contacts, zoning not obvious within district	estimate from files of 421,000 @ (1890-1950) Cu-2%, Pb-3% (Pb may be too high), Zn-8%, Ag-4 oz.
60. WINIFRED (7)	rhyolite-quartzite	EW fault	copper oxide minerals in banded qtz. vein.	none
			PATAGONIA - WEST	
61. BENNETT (7)	qtz. monzonite-diorite	EW fissure	py-cpy in banded qtz. vein	minor
62. BIG LEAD (7)	granite por. dike in diorite, sheared	3-1/2' vein at N75E-V	gn-cpy with Au-Ag in qtz gangue	minor
63. BUENA VISTA (1,7)	qtz. monzonite-diorite	vein structure is N35E-60SE, 2-6' wide, well crushed in fault zone	py-cpy-bn-gn-cc in qtz-cal vein, mod gouge; some MoS_2	500 tons @ Mo-0.3%, Cu-28%, Ag-20 oz., Au-0.2 oz.; 24 tons @ Pb-30%, Ag-120 oz.
64. FOUR METALS (1,3,8)	granodiorite	bx pipe 800' by 1200', elongate NE	py-cpy-cc-moly in potassic alteration along SE side, rest of pipe has qtz-ser-py-carbonate; tr sl	5 million tons reserves of 0.8%-Cu, 0.12 oz.-Ag, 0.01%-MoS_2, 0.15% Pb
65. GOLDEN ROSE (7)	qtz diorite near granite por.	16-20' vein @ N70E-80S; ore is 3' wide	py-cpy-gn-stephanite-some Au in finely-banded qtz.	100 tons (7)
66. MINNESOTA (GROSS) (7,8)	qtz. monzonite	wk jointing along Paymaster structure	py-cpy-moly in weak potassic alteration, drilled by Hanna-McIntyre	4 million tons estimated reserves of 0.3% Cu & 0.05% MoS_2
67. GUAJOLOTE (ROY) (1,2)	granodiorite	1-2' vein at NS-N10E @ 80SE, on Paymaster vein	cpy-gn in qtz.	500 tons of Cu-3.34%, Pb-0.1%, Ag-2.4 oz., Au-0.1 oz., As-3.1%, Sb-0.5%, Bi-0.09%
68. HOMESTAKE (1)	granodiorite	1-4' qtz vein @ N30E-80SE	cpy-gn-py-sl, all coarse grained and banded	500 ton composite from dump: Cu-2.0%, Pb-7.1%, Zn-13.5%, Ag-8.1 oz., Au0.01 oz.
69. ISABELLA (SERENATA) (7)	granite por-diorite contact	2.5' qtz vein, 3000' long	Pb-Mn (Ag?) in drusy qtz. vein	minor
70. ITALIAN CANYON (8)	granodiorite	50' vein @ N10°W-75SW on grano-pЄ contact	py-cpy in intense qtz-ser-chlor alteration	none
71. JABALINA (7)	granite por.	east-striking vein 9' wide, 2000' long	Pb-Ag-Mn in bx qtz vein	minor
72. KING (7)	qtz. monzonite	qtz vein	py-cpy-bn	minor
73. NATIONAL (7)	granite por-diorite contact	N65°E, (roughly) 70S qtz vein	gn-Ag vein with Fe staining, adjacent prospect has abundant cpy	100 tons @ Pb-65%, Ag-60 oz.
74. O'MARA (6,7)	granodiorite	5' vein @ N70E, 75SE	py-cpy-bn in banded qtz vein with qtz-ser-tour alt of wall rock	estimate 200 tons @ Cu-2%, Ag-5 oz.
75. PAYMASTER (2)	granodiorite	1-4' vein is N25E-75SE extends S side Soldier Basin to Provid.	cpy-bn-py-aspy-gn-sl-Au in order of abundance, sl very minor. Strong qtz-ser-chlor along border of veins with open space filling of finely banded qtz & sulfides	minor prod; surface grab - Cu-1.4%, Pb-0.4%, Zn-0.3%

TABLE 1 (cont'd.)

PROPERTY NAME[a]	HOST ROCK	STRUCTURE	ALTERATION-MINERALIZATION	PRODUCTION
			PATAGONIA - WEST (cont'd.)	
76. PROTO, JACKALO (2)	grano-diorite	Same as Paymaster	Same as Paymaster	minor prod. mine assay (1912) Cu-16.6%, Ag-2.2 oz.
77. RED TOP (8)	grano-diorite	bx. pipe	py-cpy-moly in qtz-ser altered bx structure	rock chip on surface gave - Cu-375 ppm, Mo-450 ppm, no prod.
78. SHAMROCK (KARAM-NOON) (1,7,8)	granite por-diorite	N75E-60S qtz. vein	Au-Ag-Mn in qtz gangue assoc. with py and tour-bearing bx, some U_3O_8	minor
79. SYCAMORE CANYON (1)	grano-diorite	mineralized joints @ N20W-25NE	cpy-moly-py in qtz-ser-kspar altered joints	rough estimate from adjacent drilling & surface - Cu-0.15%, Mo-0.05%, no prod.

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MINERAL DEPOSITS

The mineral deposits of the Patagonia Mtns. are grouped by district and are listed and numbered for the most part in alphabetical order on Table 1. A total of 83 mineral deposits have been included in this table. The production by district is given on Table 2; however, many estimates are low due to unrecorded and missing production figures and do not include ore reserves, proven or otherwise. The total value at Jan. 1972 metal prices is $101 million, 55 percent of which came from the Harshaw district.

TABLE 2 Metal Production in the Patagonia Mtns.(1)

	Red. Mtn.	Harshaw	Palmetto	Patagonia East	Patagonia West	TOTAL
Cu	35,500	4,168,000	7,041,000	20,320,000	331,000	31,895,500 lbs.
Pb	62,000	139,727,463	148,900	25,260,000	215,400	165,413,763 lbs.
Zn		135,468,955	220,000	67,360,000	135,000	203,183,955 lbs.
Ag	7,750	6,674,465	69,825	1,697,000	25,130	8,474,170 oz.
MoS_2				9,000,000	5,000	9,005,000 lbs.

The Red Rock district, which lies in the Canelo Hills about 8 miles east of Red Mtn., was not included in this tabulation. Available records indicate that production from this area has been minor.

The distribution and size of mineral deposits in relation to the general geology is shown on Plate 1. These deposits are somewhat more abundant at the north end of the range in the vicinity of the two large altered zones and then disappear under the post-mineral gravels and volcanic rocks west of Red Mtn. In addition, the larger deposits are also more abundant at the north end.

The mineral deposits can be simplistically classified into igneous metamorphic, mesothermal, and epithermal groups. The igneous metamorphic and mesothermal deposits appear to lie within and along strike of the Laramide granodiorite. The epithermal deposits lie on either side of the Laramide intrusion and do not appear to wrap around its northward projection.

METAL ZONING

Detectable amounts of the metals tabulated in this report can be found in most of the mineral deposits in the Patagonia Mountains. Therefore, an attempt was made to separate the metal occurrences according to whether they formed a major or minor portion of the total metals present,

regardless of the size of the deposit. Although this involved some subjective decisions, the data were only used to provide greater refinement of preexisting relationships and were not used to develop previously unknown patterns.

Results

The distribution of copper is shown on Plate 2. Copper occurs mostly as chalcopyrite with minor tetrahedrite-tennantite, enargite, and chalcocite. It is rather uniformly distributed throughout the entire range in all rock types.

The distribution of molybdenum (as molybdenite) is shown on Plate 3. It is confined to the Laramide granodiorite or its northward projection, and appears to be more abundant at the south end of the range in the more deeply eroded areas.

The distribution of lead is shown on Plate 4. Lead occurs mostly as galena and its oxidation products, although some lead sulfosalts are reported. It is common in all rock types in the northern portion of the range except in areas of pervasive hydrothermal alteration.

The distribution of zinc (as sphalerite) is shown on Plate 5. It is most abundant in the northern part of the range adjacent to but outside the areas of pervasive pyrite mineralization. Although zinc is found in all rock types, the larger deposits occur as replacements of limestone such as the Flux and Washington Camp ores.

The distribution of silver is shown on Plate 6. Silver is closely associated with lead in approximately 90 percent of the deposits. Reported silver minerals include pearcite, stephanite, argentite, tetrahedrite, silver chlorides, and several unknown forms. Silver is rather uniformly distributed throughout the northern portion of the range in all rock types outside areas of pervasive alteration. It was the enriched silver chloride deposits which originally attracted miners to this area.

The distribution of manganese, mostly as oxides, is shown on Plate 7. It is restricted to the flanks of the northern portion of the Patagonia Mtns. Manganese occurs in several different rock types and appears to lie outside the area of abundant zinc occurrences.

The distribution of arsenic and antimony is shown on Plate 8. These elements occur in enargite, tennantite-tetrahedrite, silver sulfosalts, and arsenopyrite. The lateral zoning of these minerals with respect to the Sunnyside altered zone is well developed with enargite in the core, tennantite-tetrahedrite in the margins, and silver sulfosalts beyond the limits of pervasive disseminated pyrite. Arsenopyrite is found only within the Laramide granodiorite in the southern portions of the range.

The distribution of barite is shown on Plate 9. It occurs only in the northern portion of the range adjacent to but outside of the area of pervasive pyrite alteration in the Sunnyside area. Three additional

occurrences of barite were noted in the Red Rock district. The distribution of several types of alteration assemblages is also shown on Plate 9. The potassic assemblage is exposed only at the south end of the range although it is reported to be present at depths in excess of 4000 feet under Red Mtn. Phyllic and tourmaline occurrences are more abundant in the central and northern portion of the range.

The distribution of gold is not shown, as only a few very minor occurrences were noted, and no production other than as a trace constituent of more abundant ores has been recorded. Small amounts of wulfenite and vanadinite were noted in the Tres de Mayo area of the Palmetto district, and locally high radioactivity has been recorded in the Shamrock area of the Patagonia West district.

The distribution of individual metals or minerals, as shown on Figures 2 through 9, indicates that a lateral zoning of metals is present which is centered on the large area of hydrothermal alteration in the Sunnyside area. These zones consist of a core of enargite-tennantite, an intermediate zone of zinc, and an outer zone of manganese. A poorly-defined lead zone appears to lie in both the zinc and manganese zones. Similar zoning is very poorly developed around the Red Mountain alteration zone and is apparently absent in the Four Metals area. The coincidence of molybdenite and arsenopyrite zones at the south end of the range is interesting, however, no practical significance can presently be attached to this relationship.

To determine whether the great number of occurrences shown by most metals has obscured the zoning pattern and to refine known patterns, several maps were constructed for various metal associations.

The distribution of copper-molybdenum deposits is shown on Plate 10. The elongate shape and location of this zone along the east side of the granodiorite are well illustrated. In addition, two of the three other known copper-molybdenum occurrences in the Patagonia Mtns. lie along strike of this zone.

The distribution of copper-zinc and lead-zinc occurrences (with or without silver) is also shown on Plate 10. These deposits account for the majority of the production to date in the Patagonia Mtns. With only two exceptions out of 20 these deposits occur as replacements of Paleozoic limestone, with the copper-zinc zone at the south and the lead-zinc zone at the north end of the range. The reduced abundance of copper at the north end may suggest shallow or lower temperature ore deposition in this area. The extremely linear distribution of these deposits along the east side of the Laramide granodiorite is striking in light of the more widespread distribution of Paleozoic limestone.

The distribution of copper-lead-zinc deposits is also shown on Plate 10. Although deposits of this association are all small, their occurrence in several different rock types suggests that the distribution of this association may be more useful for interpreting zoning than other

associations which are confined to single rock types. In any case, this pattern approximates the zinc pattern shown on Plate 5, and emphasizes the well-defined distribution around the Sunnyside altered area.

A combination of the most definitive zoning patterns is shown on Plate 11. This demonstrates that an enargite-tennantite zone overlies both the Red Mtn. and Sunnyside altered areas, although the zone in the Sunnyside area is much larger. Two copper-lead-zinc zones lie immediately adjacent to, but not within, the enargite-tennantite zone in the Sunnyside area. Part of the copper-lead-zinc zone lies along the southwest side of Red Mtn., however the concentric distribution of this association strongly suggests that the source of this mineralization lies in the Sunnyside area. Two manganese zones lie adjacent to but outside the area enclosed by the copper-lead-zinc zone. The distribution of manganese again strongly suggests a source lying in (or under) the Sunnyside area.

Discussion

It is concluded that the majority of the mineralization in the northern portion of the Patagonia Mtns. was derived from a source lying within the Sunnyside alteration zone. This zone of alteration lies just east of the Laramide granodiorite and the northward projection of the copper-molybdenum zone.

Widespread copper mineralization is absent at the surface in the Sunnyside area. However, several lines of evidence are available which permit an evaluation of vertical zoning changes, and all suggest a probable increase of primary copper mineralization with depth. First the relative abundance of potassic alteration zones at the south end of the range and phyllic alteration zones at the north end suggest that the north end is higher in the hydrothermal system. Data from Red Mtn. in particular, and porphyry copper deposits in general, indicate that potassic alteration zones are often found below large areas of phyllic and argillic alteration and pyritic mineralization such as occurs in the Sunnyside area. It is the upper portion of these potassic zones which usually contain the highest grades of primary copper mineralization.

Secondly, it has been reported that upper portions of the Kerr-McGee drill holes on Red Mtn. encountered enargite as the dominant primary copper sulfide which subsequently gave way to chalcopyrite with depth. Drilling finally passed into the ore grade chalcopyrite now being reported from this area. In addition, drilling by Anaconda under the BX breccia pipe revealed that the enargite encountered in earlier drilling by ASARCO gave way to chalcopyrite at depth. Finally, drilling of the Ventura breccia pipe by West Range Co. revealed that although tennantite was the dominant copper sulfide in the breccia, it gave way at depth to chalcopyrite and increased copper grades where the brecciation was less well developed.

Thirdly, it is known that the deep zone of primary copper mineralization under Red Mtn. lies partly below a rock chip molybdenum anomaly, although the mineralization is not known to be confined to the

limits of this anomaly. A similar molybdenum anomaly is reported on the Kerr-McGee ground in the vicinity of the Volcano mine. It is not known whether a rock chip sampling program has been attempted by Anaconda on their ground.

The deepest known penetration in the Sunnyside area is the 1500 foot hole drilled by Anaconda under the BX breccia pipe. Consideration of the above examples of vertical zoning strongly indicates the presence of deep hypogene copper mineralization in this area and emphasizes the need for further drilling. The apparent greater intensity of mineralization in this area, as compared to the Red Mtn. altered zone, suggests that the depth to copper mineralization may be less than the 3900 feet encountered at Red Mtn. The tenor of the inferred deep mineralization in the Sunnyside area is estimated to be similar to that found under Red Mtn., or roughly 0.5-0.7% Cu.

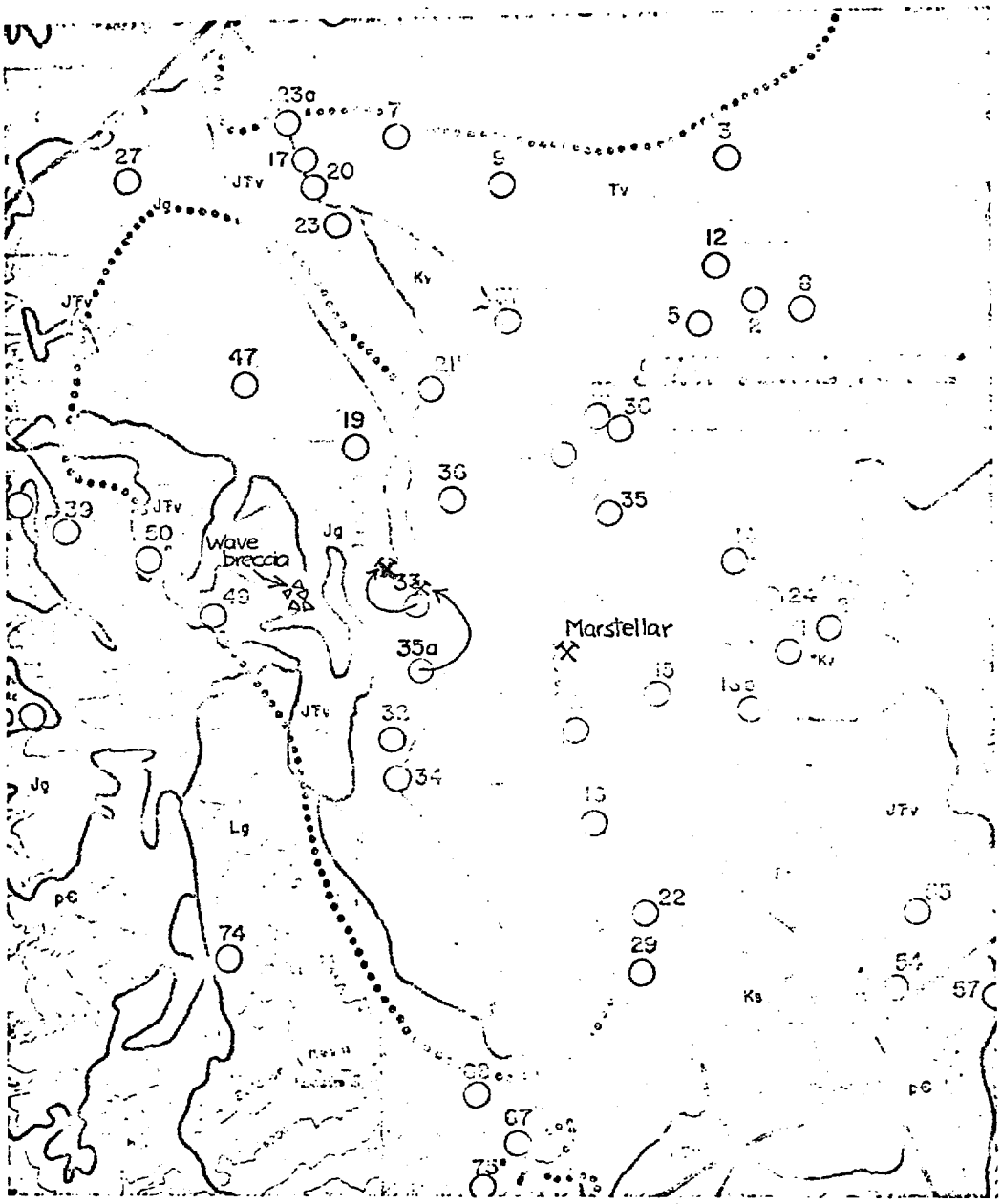
The Sunnyside altered area covers roughly 7 square miles. The area of coincident alteration and enargite-tennantite zones covers roughly 3 square miles and lies mostly within ground held by Kerr-McGee and Anaconda as shown on Plate 12. The location of ground held by ASARCO is also shown and, although it does not include any of the pervasively altered and mineralized rock in the Sunnyside area, it lies closely adjacent to this area on two sides.

Some joint venture inquiries have already been extended by ASARCO to Anaconda, and are being considered for the Kerr-McGee ground. I submit this report as evidence of the favorable geologic aspects of the Sunnyside area with respect to deep primary ore-grade copper mineralization.

F. T. Graybeal

F. T. Graybeal

FTG:sg
attach.



Map showing the corrected locations of the Sunnyside (33) and Volcano (35a) Mines

AMERICAN SMELTING AND REFINING COMPANY
TUCSON ARIZONA

March 20, 1975

TO: W. L. Kurtz

FROM: J. D. Sell

District Metallogenesis
Pima, Santa Cruz & Cochise Cos.
Southern Arizona

My evaluation of mineral districts in southern Arizona using production statistics has been completed and is submitted. Anomalous districts having a strong potential for substantial production are suggested from the study.

The top five anomalous districts are as follows:

1) Pearce. This district, with substantial gold and silver production from veins in volcanic rocks, has a strong affinity for limestone replacement deposits and a weaker porphyry affinity. The Pearce district is surrounded by replacement districts and a study is recommended for assessing this potential in the Pearce area.

2) Harshaw. Moderately indicative of both the porphyry and limestone replacement types in an area of production mainly from veins. It is suggestive that the district should be reevaluated for the additional potential indicated.

3) Oro Blanco. Similar to the Harshaw, the Oro Blanco district has produced from vein deposits which are mainly along volcanic conglomerate contacts, but has a strong limestone replacement affinity. Study should be directed for additional mineralized horizons.

If you are talking about the S end of the range (Finley Adams) I concur

4) Patagonia. Anomalous with a porphyry affinity and a lesser vein and limestone affinity. The present ASARCO project by F. T. Graybeal is specifically directed for the porphyry target concept and should be continued.

present projects are TM in the Harshaw dist

5) Oracle. This district has a strong porphyry affinity. Production has mainly been from limestone replacement types. Continental Materials has recently announced substantial new tonnages of the limestone type and reports suggest no porphyry association. The Little Hills subarea has a porphyry type which AMAX studied and drilled. They suggest the deposit is the root zone of a large system. Additional studies are justified. → Particularly to NE on E side of Catalina Mtns

James D. Sell

JDS:lb
Attach.

DISTRICT METALLOGENESIS IN SOUTHERN ARIZONA

Summary and Conclusions

A metallogenesis study of mineral production of copper, lead, zinc, gold, and silver in the districts within Pima, Cochise, and Santa Cruz Counties has suggested anomalous districts. It is sufficient to say that exploration should continue in the large districts of Pima, Ajo, Warren (Bisbee), and Silver Bell.

Of the substantial districts, those with between 1 million and 50 million tons of production, this study suggests that the Pearce, Cochise (Johnson Camp), and Harshaw districts need to be restudied and the search made for deposits other than for those known. Johnson Camp is presently being tested and it appears that Cyprus and Superior Oil have found moderate to large reserves of porphyry-limestone types.

The moderate districts, having production of between 100 thousand and 1 million tons, of Patagonia, Oracle, and Oro Blanco, are all anomalous. Patagonia and Oracle have a porphyry affinity system and Oro Blanco has a limestone replacement affinity.

The small districts may be the real sleepers in the search for new deposits. These districts have production records of between 10 thousand and 100 thousand tons. Of these, the Middle Pass and Baboquivari districts are anomalous, with both having porphyry and limestone affinities, followed by the California (Hill Top), Empire, and Waterman districts with similar affinities. The Palmetto (3R) is anomalous as is the Quijotoa district on a lesser scale, with both having the lowest tonnage production for the small district classification.

The prospect districts have less than 10 thousand tons of production and should be evaluated on their district geologic characteristics, but the production evaluation method suggests interest for porphyry affinity in the Hartford, Whetstone, Greaterville, and Montezuma (Copper Mountain) areas.

Introduction

The Arizona Bureau of Mines has recently published two bulletins (Keith, S.B., 1973, 1974) which include district production figures through 1970 for Cochise County and 1972 for Pima County, Arizona. This data plus my compilation of the Santa Cruz County district production has been tabulated in Table 1. Note that only production data is reported and that this study does not incorporate any reserve statistics. Utilization of the production data has been symbolized in a base and precious metal metallogenesis diagram by district and plotted on Attachment A. The district symbol contains the following information by categories: 1) the tons of ore produced, 2) the type of deposit, and 3) the production of copper, lead, zinc, gold, and silver.

Tonnage

The production tonnage has been subdivided into five classes.

The large districts, shown with a square box bordered by red, are those with a production in excess of 50 million tons. These districts include Warren (Bisbee), Pima, Silver Bell, and Ajo. The substantial districts, shown by a square bordered by blue, have produced between 1 million and 50 million tons. They include the Pearce, Tombstone, Cochise (Johnson Camp), and Harshaw districts. The moderate districts, circle bordered by green, have produced over 100 thousand tons but less than 1 million tons. The moderate districts include Dos Cabezas, Turquoise, Patagonia, Oro Blanco, Helvetia, and Oracle.

The above three classes contain the bulk of the production and were the districts used for subsequent ratio studies. The following two classes complete the tonnage symbols.

Small districts have produced between 10 thousand and 100 thousand tons and are shown with a triangle bordered in brown. The prospect districts have less than 10 thousand tons of reported production and are represented by a triangle bordered in yellow.

Type of Deposit

The districts have been divided into three types: 1) disseminated or porphyry, 2) vein, and 3) limestone replacement. The types are based on the general mode of occurrence of the metal production. On Attachment A the type is shown by the color scheme within the central symbol of the square, circle, or triangle.

The disseminated deposits, shown in red, occur at the Warren, Pima, Silver Bell, and Ajo districts, with a minor production in the Amole prospect district.

The major vein deposits, colored in blue, occur in the Dos Cabezas, Pearce, Patagonia, Harshaw, and Oro Blanco districts.

Limestone replacement districts, colored in yellow, are found in the Warren, Tombstone, Turquoise, Cochise, Helvetia, Oracle, Silver Bell, and Pima districts.

Some districts have more than one type of significant mineralization occurrence and are shown with multiple colors. The small and prospect districts follow the color system as described.

Metal Production

Outward from the outer circle of the symbol are spokes representing production of copper (vertical spoke), lead (upper left), zinc (upper right), gold (lower left), and silver (lower right). The symbol breakdown is shown on Attachment A, along with the production breakdown by a color system.

Copper. Copper (vertical spoke) production in excess of 50 million pounds (red colored) has been recorded for the Warren, Turquoise, Cochise, Pima, Silver Bell, and Ajo districts. The blue color representing production of between 1 million and 50 million pounds of copper is shown for the Dos Cabezas, Tombstone, Patagonia, Harshaw, Oro Blanco, Helvetia, and Oracle districts.

Pearce is the only district of substantial tonnage production which has had relatively little copper production. Laramide ?

Of the small districts, those having production records of 1 million to 50 million pounds of copper (vertical blue spoke) include the Middle Pass and Waterman districts. The small districts with over 100 thousand but less than 1 million pounds are shown with a green spoke and include the California (Hill Top), Palmetto (3R), Tyndall, Empire, Baboquivari, Amole, and Quijotoa districts. The prospect districts of Coyote, Cababi, and Montezuma also have more than 100 thousand pounds of copper production (green spoke).

Lead. Major lead production of over 50 million pounds (red colored spoke, upper left) is recorded from the Warren, Harshaw, Oro Blanco, and Pima districts.

Production from 1 million to 50 million pounds of lead are shown in blue and have been from the Dos Cabezas, Turquoise, Tombstone, Patagonia, and Silver Bell districts.

Between 100 thousand and 1 million pounds of lead, shown in green, have been produced in the Cochise, Helvetia, and Oracle districts.

Of the moderate to large districts, only Pearce and Ajo are noted for minor or no lead production.

However, in the small districts, those which have produced between 1 million and 50 million (blue spoke) pounds of lead include the California, Swisshelm, Tyndall, Empire, Waterman, and Gunsite districts. Lesser production, green spoke, in the small districts of Dragoon, Middle Pass, and Amole districts, with similar production from the prospect districts of Hartford, Arivaca, Cababi, Papago, Greaterville, and Wrightson.

Zinc. In excess of 50 million pounds of zinc (upper right, red colored spoke) is reported from Warren, Cochise, Harshaw, and Pima districts. Between 1 million and 50 million pounds (blue spoke) of zinc have been produced from

the Turquoise, Tombstone, Patagonia, Oro Blanco, Helvetia, and Silver Bell districts. Of the major districts, Dos Cabezas and Oracle have minor zinc production and Pearce and Ajo have no recorded production.

Of the small districts, those having more than 1 million pounds (blue spoke) of zinc production include the California, Middle Pass, and Tyndall districts, and lesser amounts (green spoke) from the Swisshelm, Dragoon, Empire, Amole, and Waterman districts. The Hartford prospect district also has a production of between 100 thousand and 1 million (green spoke) pounds of zinc.

Gold. Notable gold production, lower left, red spoke, in excess of 50 thousand ounces has been taken from the Warren, Tombstone, Turquoise, Oro Blanco, Pima, and Ajo districts. Districts with 10 thousand to 50 thousand ounces of production, blue spoke, include the Pearce and Dos Cabezas districts. More than 1 thousand but less than 10 thousand ounces of gold, green spoke, have been recovered from the Patagonia, Harshaw, Helvetia, and Silver Bell districts.

In the major districts, only Cochise and Oracle have less than 1 thousand ounces of gold production.

The small districts of Baboquivari and Quijotoa have each produced between 10 thousand and 50 thousand ounces of gold, blue spoke, some of which was placer gold. Of the other small districts, those with between 1 thousand and 10 thousand ounces, green spoke, include the Swisshelm, Dragoon, Tyndall, and Amole districts, along with the prospect districts of Arivaca, Cababi, and Papago.

Silver. Silver is shown in the lower right spoke, and those districts with an excess of 50 million ounces, red colored spoke, include the Warren and Pima districts. Those with between 1 million and 50 million ounces, blue spoke, include Pearce, Turquoise, Tombstone, Patagonia, Harshaw, Oro Blanco, Silver Bell, and Ajo districts. More than 100 thousand but less than 1 million ounces, green spoke, have been reported from the Dos Cabezas, Cochise, Helvetia, and Oracle districts. All of the major districts have produced over 100 thousand ounces of silver.

The small districts with over 100 thousand but less than 1 million ounces of silver production, shown by a green spoke, include the California, Swisshelm, Middle Pass, Tyndall, Empire, Baboquivari, Waterman, Quijotoa, and Gunsite districts. Of the prospect districts, those with a green spoke (plus 100 thousand ounces) include the Cababi, Cerro Colorado, and Montezuma.

Anomalous Districts

The major producing districts are obvious from the size and production data. All of the large districts — Warren, Pima, Silver Bell, and Ajo have porphyry copper or disseminated mineralization and all but Ajo have substantial limestone replacement association. The Pima district also includes numerous vein deposits.

Using various ratios of metal production, such as copper to lead plus zinc, or silver to gold, or copper to gold ratios, it is of interest that the three types of mineral occurrences have different ratios.

Based on the production figures of Table 1, the ratios have been calculated and are shown in Table 1.

Based on the ratios from the major districts, the following figures may represent the various "affinity" numbers for the three types of deposits (Table 2, below).

TABLE 2
Ratio Affinities for Various Types of Deposits

1. Using Cu/Pb + Zn Ratios:
   A. Porphyry types have numbers over 10.00
   B. Vein types have numbers around 0.50
   C. Limestone types have numbers around 0.10

2. Using Ag/Au Ratios:
   A. Porphyry types have both high and low numbers, but numbers above 3,000 are strongly indicative
   B. Vein types have numbers less than 50
   C. Limestone types have numbers greater than 50 and less than 100

3. Using Cu/Au Ratios:
   A. Porphyry types have numbers greater than 3,000
   B. Vein types have numbers greater than 25
   C. Limestone types have numbers less than 25

These numbers have been utilized for all the districts and Table 1 contains a three-column description of the mineral type affinity of each district. Also shown is a column showing the present status of the district as to the types of deposits found. If the affinity classification does not match the present status, then the district is considered anomalous. The anomalous notation is suggestive that a porphyry copper association should be expected in the district.

Comments on each district are made in Table 3 below.

TABLE 3 — Comments on Districts

Major Districts with plus 100 thousand tons of production:

1. Pima. Total district shows porphyry affinities. Individual deposits might show a variance.
2. Ajo. May have a limestone replacement affinity, but no limestones known in district. Question: Limestone present in Laramide time? If so, possible preserved areas?
3. Warren. Compatible numbers.
4. Silver Bell. Shows strong porphyry overprint.
5. Cochise (Johnson Camp). Anomalous, strong porphyry with vein association overprint in area of limestone replacement production.
6. Tombstone. Not anomalous, all affinities indicate limestone deposits.
7. Pearce. Anomalous. Strong limestone affinity with weak porphyry in area of production from veins in volcanic units. Strongly suggestive to test district for other productive horizons.
8. Harshaw. Anomalous. Moderately indicative of porphyry affinity and limestone replacement in area where most of production from veins. Suggestive for additional studies on other types of deposits.
9. Turquoise. Moderately anomalous with porphyry and vein affinities in area of predominant limestone production.
10. Oro Blanco. Anomalous in that a limestone affinity is dominant with vein secondary in an area of dominant vein production. Suggestive of restudy for additional mineralized horizons.
11. Helvetia. Moderately anomalous with strong limestone and weak porphyry affinities. Perhaps a breakdown of the district would be more informative since the information also contained the Rosemont figures.
12. Patagonia. Anomalous. Porphyry affinity with lesser vein and limestone affinities.
13. Oracle. Anomalous. Strong porphyry affinity though the production is from limestone. Present Continental Materials information suggests no porphyry mineralization of note under the area of present exploration. Some suggestion of structural complexities and thus the porphyry source may be separated from the present mineralization.
14. Dos Cabezas. Moderately anomalous. Limestone and weak porphyry affinities.

Minor Districts. Less than 100 thousand tons of production. At present it cannot be stated as to the reliability of the affinity concept as the amount of sample decreases. Projection of data below 10 thousand tons of production is extremely questionable. Therefore, only those with a porphyry affinity will be discussed (see Table 1 for all districts):

TABLE 3 - Continued

15. Middle Pass. Anomalous porphyry and limestone affinities in area of limestone production.
16. Baboquivari. Anomalous. Strong limestone and porphyry affinities in area of vein production. Study of district may afford clues to better host areas.
17. Swisshelm. Affinity data consistent with production data from limestone deposits. The data may suggest that additional areas of limestone replacement will be found.
18. California (Hill Top). Strong porphyry and limestone affinity in area of limestone and vein production.
20. Empire. A porphyry affinity, but not as strong as above.
22. Waterman. Strong porphyry and vein affinity in area of minor vein and limestone production. Structural complications are prevalent.
25. Quijotoa. Questionable porphyry and limestone affinity in area of vein production.
26. Palmetto. Strong porphyry affinity.
27. Hartford. Variable porphyry and limestone affinity.
32. Whetstone. Variable porphyry affinity in area of vein production.
33. Greaterville. Variable porphyry affinity in area of limestone production.
34. Montezuma (Copper Mtn.). Fairly strong porphyry affinity in area of vein production.

Bibliography

Keith, S.B., 1973, Index of Mining Properties in Cochise County, Arizona: Arizona Bureau of Mines Bulletin 187, 98 p., Tucson.

_____, 1974, Index of Mining Properties in Pima County, Arizona: Arizona Bureau of Mines Bulletin 189, 156 p., Tucson.

Sell, J.D., 1975, Compilation of Production Data in Santa Cruz County, Arizona.

Notes

Several errors occur in Bulletin 187, Table 1, when compared with written comments in bulletin text:

a) Ounces of silver are shown to be as times 100, but actually the figures are times 1,000 and top of column should be so marked. Example, California district silver production is 152,000 ounces, not 15,200 ounces.
b) The Pearce district gold and silver production is reversed in the table. Should be 12,020 oz. of gold, and 138 (times 1,000) oz. of silver (see p. 11 of bulletin text).
c) The Whetstone district silver figure should be only 620 oz. and not 620 times 100's as shown.

In Bulletin 189, Table 1:

a) The figures in the silver column are correct for "times 100's", but are awkward for computation or comparison. For example, the Ajo production is 189,918 times 100 or 18991800 ounces (or 18,991,800 ounces). Best to mark top of column as Ounces Silver (1,000's) and move comma in production figures one place to left to convert to less awkward notations.

b) The Pima district silver figures are correct for times 1,000 with a total silver production of 311,936,000 ounces of silver (see p. 39 of bulletin text).

TABLE 1 — District Name and Production Compilation, with ratio numbers, affinities, status, and anomalous notations

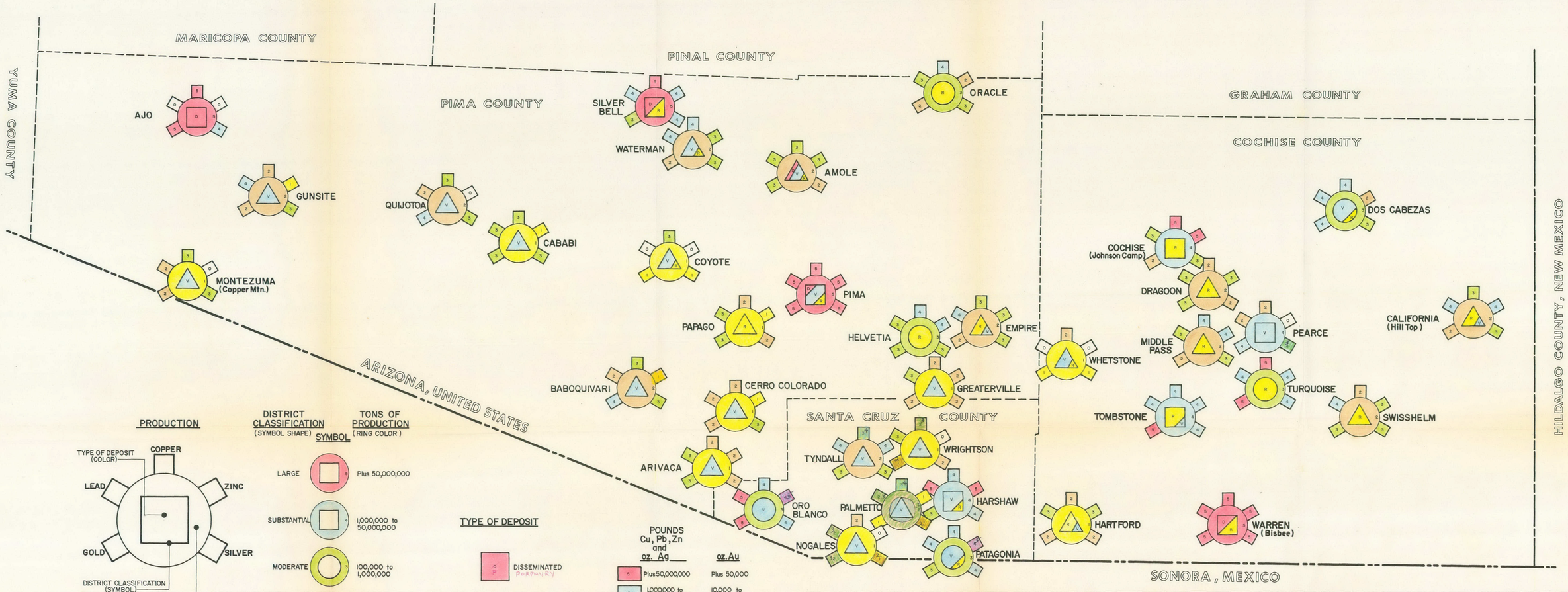
District Classification	Mining District Name	Type Deposits	Short Tons Ore (1,000's)	Pounds Copper (1,000's)	Pounds Lead (1,000's)	Pounds Zinc (1,000's)	oz. Gold	oz. Silver (1,000's)	Ratio Cu/(Pb+Zn)	Ratio Ag/Au	Ratio Cu/Au	Affinity by Cu/(Pb+Zn)	Affinity by Ag/Au	Affinity by Cu/Au	Present Status	Anomalous
MAJOR																
Large	1. Pima	D,V,L	369,707	4,119,854	85,195	232,953	53,720	312,000	12.95	5,807.9	76,691.3	P	P	P	Pvl	
	2. Ajo	D	350,015	5,659,953	---	---	1,548,253	18,992	---	12.3	3,655.7	-	L	P	P	
	3. Warren	D/L	150,991	7,693,257	309,756	378,450	2,630,572	100,312	11.18	38.1	2,918.8	P	L	P	PL	
	4. Silver Bell	D/L	61,200	1,008,839	1,804	48,087	1,490	5,294	20.22	3,553.0	677,073.1	P	P	P	PL	
Substantial	5. Cochise	L	1,640	74,775	605	93,650	229	734	0.79	3,205.2	326,528.4	V	P	P	L	Yes
	6. Tombstone	L,v	1,500	3,018	45,000	1,179	240,000	30,000	0.07	125.0	12.6	L	L	L	Lv	---
	7. Pearce	V	1,341	55	16	---	12,020	138	-(3.44)	11.5	4.6	p?	L	L	V	Yes
	8. Harshaw	V	1,096	4,131	124,072	128,769	2,578	4,525	0.02	1,755.2	1,602.4	L	P?	P?	V	Yes
Moderate	9. Turquoise	L	887	54,823	7,777	2,561	56,641	1,575	5.30	27.8	967.9	P?	V	p?	L	Yes
	10. Oro Blanco	V	855	2,577	56,036	37,915	54,753	4,072	0.03	74.4	47.1	L	L	V	V	?
	11. Helvetia	L	426	34,860	521	1,360	1,581	347	0.08	63.6	188.3	L	L	p?	L	?
	12. Patagonia	V	373	18,158	16,785	31,942	1,682	1,388	0.37	825.2	10,795.5	v?l?	p?	P	V	Yes
	13. Oracle	L	136	6,117	188	50	387	118	25.70	304.9	15,806.2	P	p?	P	L	Yes
	14. Dos Cabezas	V,l	106	4,026	1,413	39	10,082	429	2.77	42.6	399.3	p?	L	p?	Vl	Yes
MINOR																
Small	15. Middle Pass	L	76	2,011	274	9,251	337	147	0.21	436.2	5,967.4	L	p?	P	L	Yes
	16. Baboquivari	V	57	244	24	<1	13,850	174	9.76	12.6	17.6	P	L	L	V	Yes
	17. Swisshelm	L	49	97	11,853	211	5,230	330	0.01	63.1	18.5	L	L	L	L	---
	18. California	L,v	38	299	8,631	1,179	100	152	0.03	1,520.0	2,998.0	L	P	P	Lv	Yes
	19. Amole	V,d,l	34	529	670	375	1,010	27	0.51	26.7	523.8	V	P?	p?	pvl	?
	20. Empire	L,v	34	344	16,671	515	744	206	0.02	276.9	462.4	L	P	p?	Lv	Yes
	21. Tyndall	V	27	530	7,265	1,535	7,917	181	0.06	22.9	66.9	L	P?	V	V	?
	22. Waterman	V,l	25	1,502	1,563	978	106	130	0.59	1,226.4	14,169.8	V	P	P	vl	Yes
	23. Dragoon	L	19	18	356	249	9,741	72	0.03	7.4	1.8	L	p?	L	L	---
	24. Gunsite	V	16	32	1,552	<1	397	101	0.02	254.4	80.6	L	P	V	V	?
	25. Quijotoa	V	16	132	58	---	11,616	233	-(2.28)	20.1	11.4	p?	P?	L	V	Yes
	26. Palmetto (3R)	V	13	852	18	1	24	3	44.84	125.0	35,500.0	P	P	P	V	Yes
Prospect	27. Hartford	L,v	9	74	588	375	393	25	0.08	63.6	188.3	L	P?	v?p?	lv	Yes
	28. Arivaca	V	9	72	230	17	5,620	46	0.29	8.2	12.8	v?	p?	L	V	?
	29. Cababi	V	6	184	364	3	3,450	102	0.50	29.6	53.3	V	P?	V	V	?
	30. Cerro Colorado	V	5	33	63	1	463	377	0.52	814.3	71.3	v	p	v	v	?
	31. Papago	L	5	52	790	2	1,100	30	0.07	27.3	47.3	l	v	v	l	?
	32. Whetstone	V,l	4	77	---	---	8	2	---	250.0	9,625.0	-	p?	p	v	Yes
	33. Greaterville	L,v	2	39	343	32	39(lode)	13(lode)	0.10	333.3	1,000.0	l	p?	p?	l	Yes
	34. Montezuma	V	1	205	16	---	126	164	-(12.81)	1,301.6	1,627.0	p	p	p?	v	Yes
	35. Coyote	V,l	<1	140	---	---	21	<1	---	142.9	6,666.7	-	l	p	v	?
	36. Wrightson	V	<1	21	179	---	50	12	-(0.12)	240.0	420.0	l	p?	p?	v	?
	37. Nogales (Gold Hill)	V	<1	11	15	---	146	2	-(0.73)	13.7	75.3	v	v	v	v	---

Notes: Major Form of Mineralization or Affinity
- D Disseminated
- V Vein
- L Limestone Replacement

Secondary Form of Mineralization or Affinity
- d disseminated
- v vein
- l limestone replacement

? Not clearly defined

--- Insufficient data


MARICOPA COUNTY
PINAL COUNTY
PIMA COUNTY
GRAHAM COUNTY
COCHISE COUNTY
YUMA COUNTY
SANTA CRUZ COUNTY
ARIZONA, UNITED STATES
SONORA, MEXICO
HILDALGO COUNTY, NEW MEXICO
AJO
GUNSITE
MONTEZUMA (Copper Mtn.)
QUIJOTOA
CABABI
SILVER BELL
WATERMAN
ORACLE
AMOLE
COYOTE
PIMA
PAPAGO
HELVETIA
EMPIRE
BABOQUIVARI
CERRO COLORADO
GREATERVILLE
ARIVACA
ORO BLANCO
TYNDALL
WRIGHTSON
PALMETTO
HARSHAW
NOGALES
PATAGONIA
DOS CABEZAS
COCHISE (Johnson Camp)
DRAGOON
WHETSTONE
MIDDLE PASS
PEARCE
CALIFORNIA (Hill Top)
TURQUOISE
TOMBSTONE
SWISSHELM
HARTFORD
WARREN (Bisbee)
PRODUCTION
TYPE OF DEPOSIT (COLOR)
COPPER
LEAD
ZINC
GOLD
SILVER
DISTRICT CLASSIFICATION (SYMBOL)
TONS OF PRODUCTION (COLOR)
DISTRICT CLASSIFICATION (SYMBOL SHAPE)
SYMBOL
TONS OF PRODUCTION (RING COLOR)
LARGE
Plus 50,000,000
SUBSTANTIAL
1,000,000 to 50,000,000
MODERATE
100,000 to 1,000,000
SMALL
10,000 to 100,000
PROSPECT
less than 10,000
TYPE OF DEPOSIT
DISSEMINATED
VEIN
LIMESTONE REPLACEMENT
POUNDS Cu, Pb, Zn and oz. Ag
oz. Au
Plus 50,000,000
Plus 50,000
1,000,000 to 50,000,000
10,000 to 50,000
100,000 to 1,000,000
1,000 to 10,000
10,000 to 100,000
100 to 1,000
Less than 10,000
Less than 100
NONE REPORTED
BASE & PRECIOUS METAL DISTRICT METALLOGENESIS OF SOUTHERN ARIZONA
DISTRIBUTION
J.D.S.
3-18-75
8 0 8 16 24
Approx. miles
1:500,000
mn 2836 dam

Circulate to Geologists.

CIRCULATE:

~~T. C. BENAVIDEZ~~
~~R. B. CRIST~~
~~S. R. DAVIS~~
~~B. J. DEVERE~~
F. T. GRAYBEAL
~~H. G. KREIS~~

~~G. W. PICKARD~~
~~J. D. SELL~~
G. J. STATHIS
~~H. M. STONE~~
~~P. G. WHKRD~~
~~N. P. WHALEY~~

F.T.G.
RECEIVED
MAR 20 1978
S. W. U. S. EXPL. DIV.

New York, March 16, 1978

F. T. Graybeal
J. Manrique
J. J. Merz
L. Montoya
D. M. Smith
R. B. Sprague
H. C. Williamson

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ıx
chter
R. E. Gale
A. Giesecke
R. S. Gray

Permissive Environments
and Unexpected Elements

Although I've been unable to find a specific directive in our files, within my recollection it has always been standard operating procedure of our Exploration Department to run a semi-quantitative spectrographic analysis on a composite of samples taken, when examining a new prospect or if a new type of mineralization is encountered at an existing project. The attached memorandums by Messrs. Graybeal and James are being circulated herewith as a timely reminder that we expect you to follow this standard procedure. Also, please note a semi-quantitative spectrographic check is the very least that you should think about doing; as Messrs. Graybeal and James point out we need to be alert to the possibility that in some cases a spectrographic check may not be sufficient insurance, i.e. your judgment in each case may be required as to the possible necessity of analyzing for specific elements.

T. C. Osborne

Attachments

cc: WLKurtz

ASARCO

Southwestern Exploration Division

January 11, 1978

TO: JDS, GWP, GJS, HGK,
BJD, SRD, NPW, PGV

FROM: F. T. Graybeal

Permissive Environments

One of the points discussed in our meeting last December was the need to recognize permissive ore environments. A permissive environment might be defined as one where the geologic conditions required for a certain type of orebody are present, but mineralization is not exposed -- or is not visible under the hand lens. The obvious example is a Laramide-age porphyry stock which extends under cover within a favorable porphyry copper belt. A second, less obvious example is the property where an ore mineral is present in a suite of other ore minerals but is not megascopically obvious. The danger in the latter case is that the geologist will run his routine geochemical analysis for the obvious ore element and a few commonly associated elements, but will fail to recognize the potential for or presence of additional ore elements and not analyze for them.

Several examples of close encounters of the second kind may emphasize this point. The Cantung Mine in the Yukon Territory was originally drilled (10-12 holes) as a hypogene chalcopyrite target in skarn. The property was subsequently dropped because assays generally fell below 0.4% Cu. It was recognized shortly thereafter by the MacKenzie syndicate that scheelite occurred abundantly in the core, although it was virtually invisible, and the property ultimately became the highest grade tungsten mine in the world. The Telfer Gold Mine, recently brought to production in northwestern Australia by Newmont, was found by a prospector who collected several samples of the bedded gossan in limestone. The samples were taken to at least one mining company where they were assayed for Cu, Pb, Zn, and Ni. No anomalous values were found so the prospector eventually came to Newmont who included Au in their assay -- and the rest is history. A note was recently circulated on the Phosphoria Formation, a chemical sediment, which locally contains in excess of 1 oz. Ag, apparently syngenetic.

These and other examples demonstrate that you should be thorough when you have your geochemical samples analyzed. This does not mean you should routinely analyze for several dozen elements, but rather consider additional analyses of ore elements which may not be visually obvious and for which the geologic environment is permissive. Upon occasion a multi-element spectrographic analysis may be appropriate, but you should first check to see that the detection limit doesn't exceed anomalous values. Reviews of files or submittals should attempt to determine what elements might be present but lack an analysis.

F. T. Graybeal

F. T. Graybeal

FTG:lb

cc: WLKurtz

ASARCO

Southwestern Exploration Division JDS

January 10, 1978

TO: Geologists

FROM: F. T. Graybeal

Analytical error during
precious metal exploration

It is generally recognized that the most important asset in a precious metal exploration program is a reliable assayer, as it is rarely possible to determine visually whether or not a sample contains gold or silver. However, even reliable assayers can make the occasional mistake or use the wrong technique for a particular sample.

One example, brought to my attention by G. J. Stathis, occurred during early drilling on the FMC property, a Carlin-type occurrence in NE Nevada. The majority of the samples were in carbonaceous limestone and shale which assayed nil gold by atomic absorbtion and as a result the property was almost dropped. However, A. S. Radke of the U.S.G.S. suggested the samples be reanalyzed by fire assay which demonstrated that the carbonaceous material was gold bearing; this resulted in an increase in the tonnage of potential ore-grade rock and a continuation of the exploration program. A second example involved Hanna's exploration program in the Picacho District, Imperial County, California (GJS memo, April 3, 1975). Fire assaying by American Analytical during an early phase of the exploration program showed no gold across a line of drill holes which was thought to have been in mineralized ground, based on other data. The pulps were subsequently checked, also by fire assay, and found to be gold-bearing. A third example involved a recent mixup of Asarco rock chip samples; one containing .02 oz. Au and 0.16 oz. Ag, the other 2 oz. Au and 150 oz. Ag each from a different prospect.

Problems such as those noted above are less serious if the samples are part of a larger group which contains anomalous values in which the odd spurious assay is obvious and for which periodic check assays are routine. However, the problem can be very serious if the sample is the only sample collected or it is the only anomalous sample in a small group of barren exploration samples. Precious metals are not generally visible under the hand lens so we tend to believe the assay and since, to my knowledge, it is not standard practice to run check analyses of single or small groups of exploration samples a real danger exists. It is of interest that the Preble deposit and Asarco's Gold Run N. Project were both found by a single anomalous sample and the Cortez Mine by 2 anomalous samples.

I am certain that everyone recognizes the importance of a good sample and an accurate analysis. The question of how best to eliminate or recognize an analytical error in a single or limited number of samples is perhaps not given the attention it deserves and two possibilities appear reasonable. One is to take a duplicate sample or a cut from the reject of a single sample and submit to a different laboratory. The second is to run the sample for a

sufficient number of related elements so that if an error is made in the analysis of one element anomalous values for other elements would direct your interest back to the outcrop (such as Hg, Sb, As, Bi, W, Tl as well as Au and Ag in Carlin-type environments). Prospects such as the Picacho District mentioned above, where pathfinder elements may be absent, may require duplicate analyses. I leave the choice up to the individual, but remember that the cost of eliminating the possibility of analytical error is negligible. For your interest I am attaching a related memo by G. J. Stathis on gold exploration. Any comments you might have on this subject would be appreciated.

F. T. Graybeal

F. T. Graybeal

FTG:lb
Att.

cc: WLKurtz

AMERICAN SMELTING AND REFINING COMPANY
TUCSON ARIZONA

January 24, 1974

Memorandum

TO: W. L. Kurtz

FROM: G. J. Stathis

Peter E. Galli, Jr. on
Disseminated Gold Exploration

During the course of my review last month of Cordilleran Exploration's drill project area in the Winnemucca Mining District, Nevada, Pete Galli (Cordilleran partner and former Reno office manager for Union Carbide Corp.) made the following comments concerning his approach to exploring for "no see 'em"-type gold mineralization.

Galli prefers the atomic absorption over the fire assay method, because of the greater sensitivity of the former analysis method. This assumes, of course, that the lab doing the A.A. work is reliable and the results are reproducible. Galli checks on the lab by submitting one or two sample standards with every sample shipment. His past experience has been that Skyline Lab of Denver is erratic and Geochem Systems (now defunct) of Orange, California is very erratic. Galli's gold assaying, for the past few years, is done by Gary M. Fechko of Rocky Mountain Geochemical Corp.'s Reno, Nevada lab. Fechko reports gold down to 0.003 troy oz./ton (approx. 0.1 ppm). According to Galli, Fechko's gold assays are reproducible down to the 0.003 to 0.006 troy oz./ton range.

Galli considers 0.003 oz. gold as being anomalous (Rocky Mtn.'s gold detection limit!) and any surface area of 0.006 oz. gold is a definite drill target. Cordilleran has discovered two, 1 to 1-1/2 million ton, shallow gold ore bodies, averaging 0.12 ounces, near the Getchell mine and a similar size and grade deposit near Golconda. Plans call to heap leach these deposits in the near future. One of the two deposits near Getchell had surface values running 0.006 ounces or less, yet drilling showed gold values up to 0.4 oz./ton, 60 to 100 feet below the surface. The host rock at Getchell was described as occurring in siliceous, sedimentary rocks. Cordilleran does some fire assay checks on the A.A. results in the project stage of exploration.

As I mentioned in the Nevada competitor activity section of my 1973 4th period quarterly report, there is an increase in precious metal, mostly gold, exploration activity in Nevada. Recently the "Mining Record" reported a discovery by a group in the Cornucopia district of Elko County. A potential of 3 million tons of $12 gold-silver rock is claimed. Mineralization is said to occur in silicified andesites east of the Leopard Shaft. It is beginning

to appear that perhaps more of these small tonnage, plus 0.1 oz. gold deposits will be found in Nevada and possibly in other western states as well. According to Galli and Don Jennings (Cordilleran geologist), in detail, lithology and structure exercise an important control in the location of these disseminated gold deposits.

In conclusion, I feel that Galli's remarks on lab performance (i.e., use of standards as checks) and recognition that 0.1 to 0.2 ppm gold as being anomalous are well taken. Skyline Lab of Denver currently offers geochemical gold assays with a detection limit of 0.02 ppm. The average crustal abundance of gold is 0.004 ppm (S.R. Taylor, 1964). This can be broken down further as follows (after Vinogradov, 1962):

ULTRAMAFIC ROCKS (dunites, etc)	= 0.005 ppm
MAFIC ROCKS (basalts, gabbros, etc.)	= 0.004 ppm
INTERMEDIATE ROCKS (diorites, andesites, etc.)	= ?
FELSIC ROCKS (granites, granodiorites)	= 0.0045 ppm
SEDIMENTARY ROCKS (clays and shales)	= 0.001 ppm

Thus, labs offering low detection limits should be checked. Recognition and use of low range, possibly 0.01 to 0.02 ppm, gold assay values as anomalies may outline potential areas of better gold mineralization at depth.

George

George J. Stathis

GJS:lb

cc: JHCourtright

1 ppb = 0.001 ppm

GEOCHEMICAL OFFICE - EXPLORATION DEPARTMENT
3422 South 700 West
Salt Lake City, Utah 84119

RECEIVED
MAR 13 1978
EXPLORATION DEPT.

March 9, 1978

R.L.B.
MAR 13 1978

T. C. O.
MAR 16 1978

MEMORANDUM TO T. C. OSBORNE:

ANALYTICAL ERROR IN
PRECIOUS METAL EXPLORATION

Analytical error can cause serious problems in precious metal exploration programs. Some of these errors result from factors (e.g. sample mis-up, random analytical error, analytical technique unsuitability, etc.) common to all types of exploration programs. Others are related to factors especially characteristic of precious metal programs (e.g. sample inhomogeneity, etc.). Obviously some errors can be avoided by the implementation of careful sample collection and handling procedures but others require specific analytical solutions.

Problems in the routine A.A. analysis of Ag are not generally severe when the concentrations present are greater than, say, 10 ppm. Below this concentration level serious errors can arise as a result of background interference (e.g. the presence of Ca in limestone samples can result in apparent Ag concentrations of as much as 3 ppm when the true content is <0.2 ppm, unless special correction procedures are applied). It should be noted that not all commercial laboratories make background corrections.

Our experience indicates the ideal method of geochemical analysis for Au is a combined fire assay fusion/A.A. procedure. When correctly carried out, it has a number of advantages including:

(a) an indisputably complete sample dissolution which ensures total Au extraction

(b) a large sample weight (i.e. generally around 30g) which helps minimize any problems with sample inhomogeneity

(c) low detection limits (i.e. 0.005 ppm or less)

(d) good accuracy and precision.

However, the method is fairly cumbersome, slow and high cost so alternative procedures are commonly employed. These alternatives are faster and cheaper as they generally use an acid digestion rather than a fusion for sample dissolution. Many commercial laboratories use aqua regia for the sample digestion, but our experience suggests this approach is not effective when dealing with samples containing "Carlin-type" gold. In an attempt to achieve complete silicate breakdown and solution of all gold present we utilize an hydrofluoric acid

PEÑOLES

SERVICIOS INDUSTRIALES PEÑOLES, S. C.

PASEO DE LA REFORMA 383 MEXICO 5 D.F. TEL. 5 25-92-20
APDO. POSTAL 686 MEXICO 1. D.F. TELEX 017-75-871 Y 017-72-487 CABLE PEÑOMEX

October 19, 1978

Mr. James D. Sell
Asarco Incorporated
1150 N 7th. Avenue
Tucson, Arizona 85715

Dear Jim:

At the recent IAGOD Symposium held in Utah, you gave a paper on District Mineralization, Production and Metal Ratios Southeastern Arizona, U. S. A.

Would you have a copy of this paper that you could send to me?

Sincerely yours,

Dave

David F. Coolbaugh

'eam

ASARCO

Exploration Department
Southwestern United States Division

November 28, 1978

Dr. David F. Coolbaugh
Servicios Industriales Penoles, S.C.
Apdo. Postal 686
Mexico City 1, D.F., Mexico

Dear Dave:

Your letter of October 19 arrived requesting a copy of the IAGOD paper. Unfortunately the paper was for oral presentation only and no copies are available for publication.

I may try to revise it for future publication and if done will be glad to send a copy. Thanks for your interest.

Regards to those that remember me.

Sincerely,

Jim

James D. Sell

JDS:lb

ASARCO Incorporated P. O. Box 5747 Tucson, Az 85703
1150 North 7th Avenue (602) 792-3010

Tombstone ± 1 mill tons ore

~~Pb~~ Ag	32,212,344 oz.	1879-1947	
Au	285,091 oz	" "	
Pb	49,454,361 lbs.	" "	
Zn	886,429 lbs	(incomplete	1908-09)
Cu	2,920,460 lbs.	("	1908-47)

$$\frac{Cu}{Pb+Zn} = \frac{2,920,460}{50,542,790} = 0.058 \quad Lms$$

$$\frac{Ag}{Au} = \frac{32,212,344}{285,091} = 112.99 \quad Lms$$

$$\frac{Cu}{Au} = \frac{2,920,460}{285,091} = 10.24 \quad Lms$$

$$\frac{Pb+Zn}{Ag} = \frac{50,542,790}{32,212,344} = 1.57 \quad Lms$$

$$\frac{Cu}{Ag} = \frac{2,920,460}{32,212,344} = 0.09 \quad Lms$$

Limestone Replacement Deposit Affinity

FIELD NOTES FROM THE ARIZONA BUREAU OF MINES

Vol. 2 No. 4 Earth Science and Mineral Resources in Arizona *Dec. 1972*

COPPER MINING AND ARIZONA LAND USE PLANNING A GEOLOGIST SPEAKS

Metallogenic Province

Dr. Spencer R. Titley
Professor of Geosciences
College of Earth Sciences
The University of Arizona

Ed. Note: This is the second article in a series on the factors influencing land use planning decision making.

INTRODUCTION

Copper deposits of Southern Arizona constitute a nearly unique resource on this planet. There are few other known locations were the forces and processes of nature combined to form such a concentration of metal in such a restricted region. The great number of discoveries on the Island of Luzon during the past ten years suggest that a small part of the Phillipines are similarly endowed and, although of a different origin, similar concentrations of copper are known in the Democratic Republic of the Congo and in Zambia in south-central Africa. Also, other large deposits of the type found in southern Arizona occur in the western hemisphere, but nowhere are these deposits found in the known abundance and concentration as in this part of the American southwest.

In deciding the best use of the gradually vanishing undeveloped land in the United States, many problems are being created by expanding population and man's requirement for a quality environment. Not the least of these requirements is the requirement for the preservation of certain areas in their natural state. Curiously, concern for the future of mineral resources has not appeared to be a factor in many of these decisions. In Arizona, the problems of land use involve another variable which must be considered: the presence of large bodies of ore. The professional voice of the exploration geologist seems to have been strangely muted while the debate on these decisions continues. Although the debate continues concerning the level of atmospheric contamination acceptable in extracting and processing copper, and heated words are being exchanged between various interest groups about land and mineral law reform in state and national capitals, the knowledgeable citizen hears or reads little, if any, strictly geological information in reports of these debates. He is generally presented statistics of economics and production, and the occasional sweeping generalization that copper deposits occur in the ground and must be mined to extract the metal.

The problems of contamination resulting from processing and extraction are rightfully those of the present, and their consideration is long overdue. Solutions, however, must be in terms which recognize the uniqueness of the known and potential copper occurring in this region. Equally important are the problems of land use and land acquisition. Many known and certainly some as yet undiscovered copper ore bodies exist in southern Arizona; these *must* be considered when land use decisions are being made and before the "system goes critical". Geologic understanding and the role of the professional geologist must no longer be ignored if wise policy is to be made. It should be the duty of the interested policymaker, the lawmaker, and his constituents to acquire, if not an understanding, at least an appreciation of the occurrence and distribution of certain natural resources in Arizona, the United States, the Western Hemisphere, and the world simply because world mineral economics and technology are becoming increasingly important in political decisions. Arizona cannot isolate herself from these broader aspects of mineral resource occurence and use. The decisions and plans which must be made must recognize that a major resource exists which is not only State, but national in scope, and that copper, as well as other metals, occurs only in certain regions and often to the exclusion of other metals.

Continued on page 2

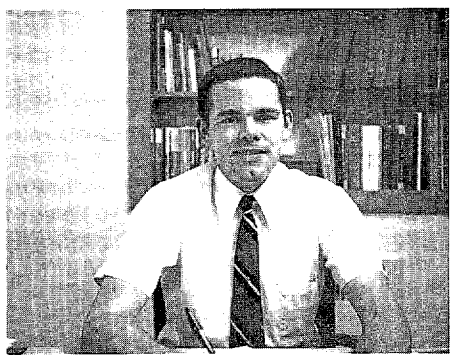
A NOTE FROM THE DIRECTOR:

DEPARTMENT HEAD NAMED

It is my pleasure to announce the appointment of Dr. Thomas J. O'Neil as Head, Department of Mining and Geological Engineering, College of Mines, The University of Arizona.

Dr. O'Neil, who is a specialist in the field of mineral economics, has been a graduate student and full-time faculty member of the Department of Mining and Geological Engineering since 1968. Prior to coming to The University of Arizona, Dr. O'Neil received a B.S. degree in mining engineering from Lehigh University, Bethlehem, Pennsylvania, and an M.S. degree in mining engineering from Pennsylvania State University, University Park, Pennsylvania. He has been a development engineer for Ingersoll-Rand Company, Rock Drill Division, and an industrial engineer for Kennecott Copper Corporation, Utah Copper Division.

Dr. O'Neil has been an active participant in professional society and College activities. He is currently the national secretary of the Mining and Exploration Division of the American Institute of Mining, Metallurgical and Petroleum Engineers, and a registered Professional Mining Engineer in the State of Arizona.



Dr. Thomas J. O'Neil, recently appointed Head, Department of Mining and Geological Engineering.

GEOLOGIST SPEAKS *Continued*

METALLOGENIC PROVINCES AND COPPER DEPOSITS

Most metals which man extracts occur in abundance in discrete (well defined) regions termed *Metallogenic Provinces.* Several metals may occur together in deposits in one region or province *(polymetallic provinces),* or provinces may contain only one metal. The copper deposits of southern Arizona compose a polymetallic province because they also contain as by-products molybdenum, zinc, and some gold and silver. For hundreds or thousands of years man has recognized the discrete nature of the occurrence of metals. However, it has been only during the past decade with the increased number of discoveries that the discrete nature of many provinces has been revealed, and that geological, geophysical, and geochemical data have provided what geologists now consider a firm basis for beginning to understand where and why discrete provinces might occur.

Historically, the recognition of a metallogenic province has had lasting political and economic implications. We are now concerned with the present and future importance of copper in Arizona. Curiously, this region indirectly figured in a major political decision based on concepts of metallogenics nearly 200 years ago. A belief propounded by the Greeks that gold resulted from the interaction of the sun's rays with certain types of fluids in the earth was propagated into the late part of the second millenia. With this belief, Spain concentrated her efforts at conquests in the New World to those regions where the sun's rays were strongest. After several hundred years of fruitless search based on this concept, Spain relinquished all territorial rights in the western hemisphere north of the Gulf of California in the treaty of 1790. (Godwin as cited by Adams, 1938, p. 283). Hopefully, our understanding of the processes of natural concentration of metals has advanced during the past 180 years. Hopefully, also, our growing understanding will aid in the development of policies which will further the clean, intelligent, and wise extraction of those metals which occur in this region, long ago mistakenly ignored by Spain.

There are more than thirty presently known copper deposits in southeastern Arizona and adjoining parts of Mexico and New Mexico. Of these, only ten were being mined in 1953; the remaining 21 deposits represent discoveries or rediscoveries made since then (see Table 1). All but four occur in southeastern Arizona. Not all of these are presently being mined or developed, but it seems certain that most have the potential for ultimate development and extraction. It takes only a simple arithmetic operation to appreciate the fact that since 1953 the rate of discovery in this region has been more than one per year, a record of discovery unparalleled in any other region of comparable size. The fact that these discoveries have been and continue to be made in this small part of the southwest attests to the unusual geologic quality of this region.

Table 1
MAJOR COPPER BODIES IN CONTIGUOUS SOUTHEASTERN ARIZONA, NEW MEXICO, AND SONORA

Producing Prior to 1953

Ajo
Bisbee
Castle Dome
Cananea
Chino (Santa Rita)
Copper Cities
Inspiration
Magma
Morenci
Silver Bell

(10)

Production Since 1953

Christmas
Esperanza
Mission
Pima
Sierrita
San Manuel
Twin Buttes

(7)

Discoveries and Developments

Copper Creek
Helvetia
La Caridad
Lake Shore
Kalamazoo
Poston Butte (Florence)
Red Mountain
Rosemont
Sacaton
Safford (KCC)
Safford (P.D.)
Morenci (Metcalf)
Tyrone
Vekol

(14)

Producers in northwestern Arizona (Not Shown on Map)

Mineral Park
Bagdad

(2)

Total 33

Exploration continues in this part of the North American continent because a large number of deposits occur in this region and thus the probability for discovery is certainly higher than in most other parts of the continent, and indeed, in most other parts of the world. The copper bodies which are being sought and which have been found belong for the most part to a distinct genetic type of deposit termed "porphyry copper". Although differing to varying degrees in the details of their geology, most of these deposits are broadly similar to each other in the way they came into being, in the nature in which the rocks containing copper have been modified, and in the amount of copper which they contain. They are correctly termed large, low-grade copper deposits. Despite their "low-grade", however, they represent very anomalous amounts of copper when the earth as a whole is considered.

The amount of copper in the deposits of Arizona is variable but averages between 0.4% and 0.6% (8 to 12 pounds of copper per ton of rock). The processes which act in and below the earth's crust produced this concentration. Parts of some deposits in Arizona have been upgraded to smaller volumes of around 1% copper or 20 pounds of copper per ton of rock by processes which have acted at the surface of the earth in the geologic past by dissolving and re-precipitating this lower grade copper. It is noteworthy that much of this copper has been mined in the past several decades and extraction of copper is now, in large part, that of the lower ore grades. Although of lower grade, the copper in these deposits is still present in amounts of from 8 to 12 pounds per ton of rock. This represents the end product of a natural upgrading of copper from 0.02 pounds per ton in the deep rocks of the earth to 12 pounds per ton in a copper deposit—an enrichment of 600 times the amount of copper present in the deep rocks below the crust! Clearly, unusual processes must have acted to bring this about, and although it is beyond the scope of this article to discuss modern arguments and thoughts about those processes in any detail, it is undeniably true that it has happened, *and only in special places on earth.* Southern Arizona is one such place.

One important aspect of this amount of copper in the rocks of Arizona deposits deserves further comment. This amount of copper, 0.4-0.6%, is the result of a complex sequence of geologic events. Nature has exceeded this level of concentration in only a few copper

bodies. Consequently, man has to work with rocks containing this small amount of copper. There is no way to upgrade or increase the amount of copper in these rocks, and we certainly cannot wait the millions of years necessary on the off chance that nature would upgrade it further. It should go without saying that the more copper in a rock, the more valuable it becomes, and those who search for and extract copper would desire nothing better than to find and produce copper from rocks of higher metal content. The fact that copper can be profitably produced from rocks of such low grade is basically a reflection of the necessity to do so but is also testimonial to the quality of man's technology and his imagination in devising low-cost extractive techniques.

Figure 1 shows the location of all operating large copper mines in southeastern Arizona and adjoining parts of New Mexico and the State of Sonora, Mexico. In addition, the map shows other known bodies of copper mineralization of this region that are either prospects where the amount of copper contained can be economically extracted or copper bodies presently undergoing development. Several characteristics of this map deserve comment.

First, the distribution of these mines and mineralized bodies is not erratic. They occur as features of a broad arcuate belt as illustrated in Figure 2. This belt starts near Nacozari, Sonora, and extends from there northwestward into Maricopa County, where it turns eastward, extending across Arizona into southwestern New Mexico. This belt and the copper deposits within and closely adjacent to it ignore county, state, and international boundaries. That more deposits occur in Arizona than in Mexico or New Mexico within the belt may simply reflect the lack of thoroughness with which those adjoining regions have been explored. We do not yet know if copper bodies of the sort which occur in the arcuate belt occur in any great quantity outside of or within the area enclosed by the belt in southern Arizona and adjoining regions, but the possibility is real.

Second, it is noteworthy that the known ore deposits occur as separate bodies of copper mineralization; that is, the bodies are isolated. There is no indication from geology as it is presently known and understood that there is any continuous mineralization by copper in economic quantities in this belt. It *is* significant that in many instances the copper deposits apparently occur in clusters. Such clustering is known in the Sierrita Mountains southwest of Tucson, where at least four separate bodies occur in a restricted area. Other clusters occur in the Globe-Miami area, and there is strong suggestion of clustering in the San Manuel-Copper Creek region, as well as in the group of deposits near Safford. Exploration is far from complete in and around many of the deposits of the region, but when it has been completed, it is likely that presently known bodies in many parts of the belt will be revealed to have been parts of a cluster of copper ore bodies. Reasons for the clustering are not known, but it is an important aspect of our knowledge of the nature of occurrence of copper bodies not only in this region but others as well.

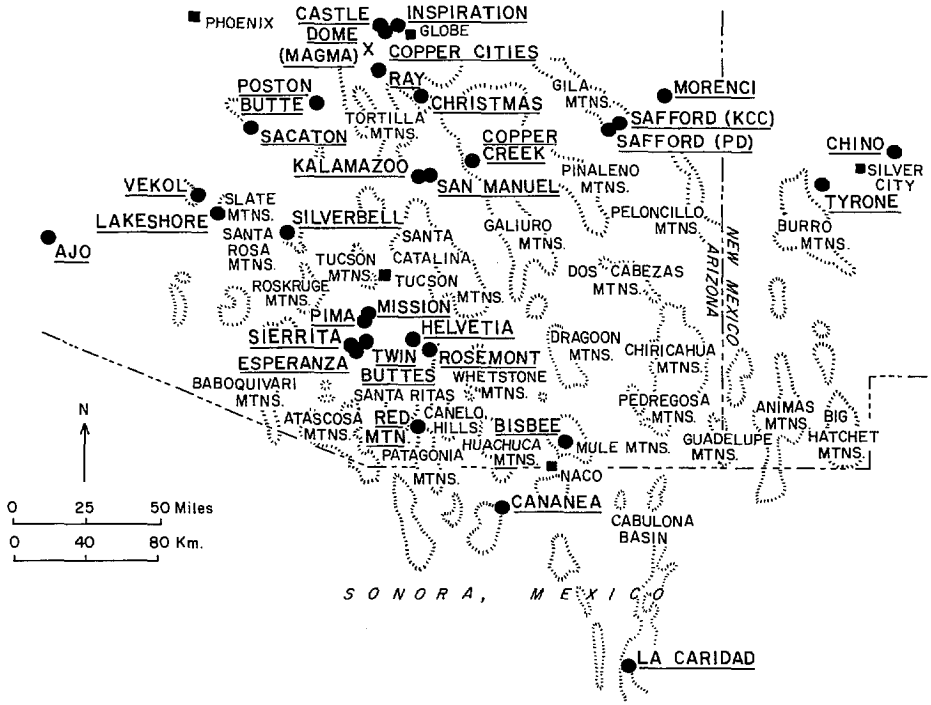


Fig. 1. Map showing principal copper mines, development, and prospects in the Southwestern Copper Province.

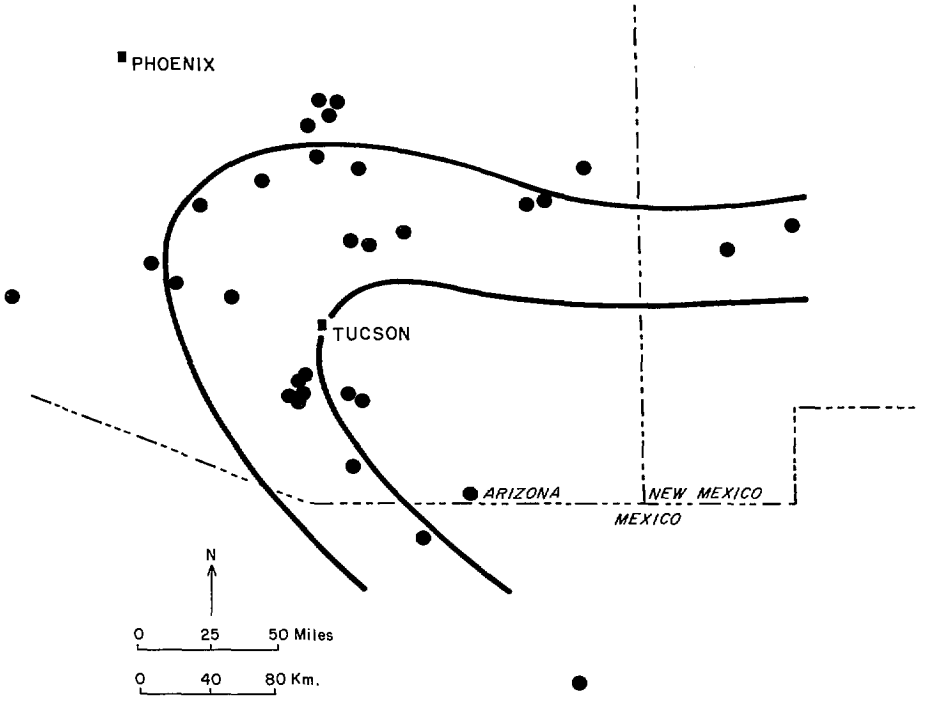
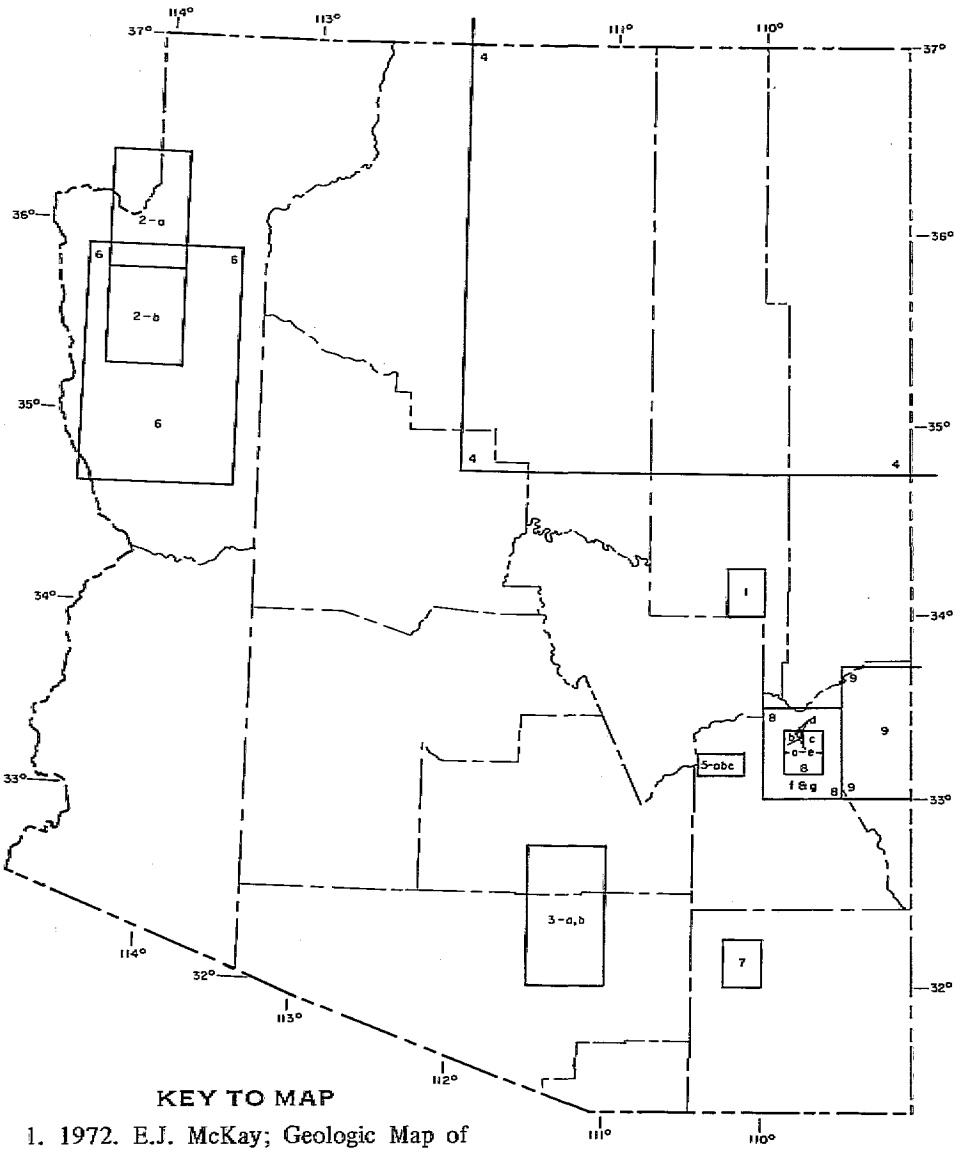


Fig. 2. Provisional geologic boundaries of the southwestern copper deposits.

Third, the ore deposits shown on the map reflect, with only one possible exception, the position of *old* mining districts. This in itself is a potentially valuable tool in land zoning decisions. Up to this time all the copper bodies except for the one at Sacaton reflect the results of thorough and sometimes deep exploration of some areas where mineralization was already

Continued on page 5

NEW GEOLOGIC AND AEROMAGNETIC MAPS OF ARIZONA



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   (a) Fig. 1. Reconnaissance Geologic Map, Point of Pines Region, San Carlos Indian Reservation, Arizona: scale 1:62,500.
   (b) Fig. 2. Geologic Map of the Point of Pines West Quadrangle, San Carlos Indian Reservation, Arizona: scale 1:24,000.
   (c) Fig. 3. Geologic Map of the Point of Pines East Quadrangle, San Carlos Indian Reservation, Arizona: scale 1:24,000.
   (d) Fig. 4. Geologic Sections, Point of Pines East and Point of Pines West Quadrangles, San Carlos Indian Reservation, Arizona: scale 1:24,000.
   (e) Fig. 5. Structure Map Point of Pines Region, San Carlos Indian Reservation, Arizona: scale 1:62,500.
   (f) Fig. 6. Complete Bouguer Gravity Map of the Point of Pines Region, Arizona: scale 1:62,500.
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GEOLOGIST SPEAKS *Continued*

known. The fact that one was found at Sacaton, apparently unrelated to previously recognized mineralization, however, is a fair portent of the future course of exploration and discovery of copper bodies in the arcuate belt. In some instances, old mining districts hold a high probability of having a deeply buried "heart" of copper ore somewhere near them, *but* there is also a high probability of discovery within the arcuate belt of copper deposits which have not yet revealed their presence in any way now recognizable.

Fourth, the arcuate belt of porphyry copper deposits is a belt of deposits of only one age and one type. Not included in this belt are copper deposits of other ages such as those at Bisbee, Ithaca Peak, near Kingman, and Bagdad. These deposits, together with a host of smaller base and precious metal deposits, occur within and near the area of the belt. Thus, the position of the belt as now defined should not be construed as the final outline of the position of known porphyry copper deposits. As discoveries increase in other parts of the region, it may be possible to better define the factors controling the location of other porphyry copper deposits in the areas adjoining the arcuate belt. The arcuate belt *is* an area in which the probability of discovering additional copper deposits of one age and type is very high. The areas adjoining the belt still manifest a good probability of at least some as yet undiscovered copper bodies occuring because of the presence within the area surrounded by the belt of Bisbee, and the presence of Ajo, Ithaca Peak, and Bagdad outside of it.

Finally, most of the copper deposits of southeastern Arizona occur in a region that once was the shallow shelf of an ancient sedimentary basin, although we cannot say for certain why they should be there, or if indeed there is any direct relationship. The basin, which extended through what is now most of Cochise County and into Sonora and Chihuahua Mexico, is no longer recognizable as such

Continued on page 8

The staff of the Arizona Bureau of Mines attempts to fulfill speaking requests, especially at schools. Among those asked to speak on a variety of geological subjects are David D. Rabb, Mining Engineer; Robert T. O'Haire, Associate Mineralogist, and Wes Peirce, Geologist, whose approach is to take along materials for the children to touch, taste, smell, hold, and see. The following thank-you letters were among those received by Dr. Peirce from members of Miss Jean Hansen's 4th grade class at Jefferson Park Elementary School in Tucson.

THE YOUNGER SET

Tucson Ariz
November 3, 1972

Dear Dr. Peirce
Thank you for coming
I enjoyed it a lot. I like the
halite rock the very best.
The antelope was very interesting
How many teeth does a mammoth
have? Why is the rock
in the valley softer than the rock
in the mountains? How do you get
the halite rock out of the ground
How old is it
How do you tell how old it
is?

Sincerely Brandt

A GOOD QUESTION ALWAYS PRECEDES A GOOD ANSWER. KEEP UP THE GOOD WORK, BRANDT.

Tucson Ariz.
October 16, 1972

Dear Dr. Peirce,
We all thank you for coming.
We all had different reasons to thank you for coming.
My reason was I enjoyed being with you.
I have always liked fossels.
One reason was I like to see how the rock formed around the animals or fos.
I had never seen a real fossil until you showed me them.
My Mother and Father did not believe that I had eaten something 200, Million years old and had held a Million fossles in my hand

Gratefully yours
Karen Elizabeth Martin.

EVEN MOMS AND DADS CAN STILL LEARN, SO BE PATIENT WITH THEM.

Tucson, A.z.
Oct. 16, 1972

Dear Dr. Peirce,
I enjoyed your visit very much.
I had never known anything about fossils until you came to our school. I loved the mammoths tooth you brought. And I remembered that I tasted something over 200,000,000 years old and that I held something with over 1,000,000 fossils in it. I really enjoyed your visit.

Verry Gratefully,
Abby Wine

DR. PEIRCE CONGRATULATES ABBY AND KAREN FOR CORRECTLY REMEMBERING SUCH BIG NUMBERS!

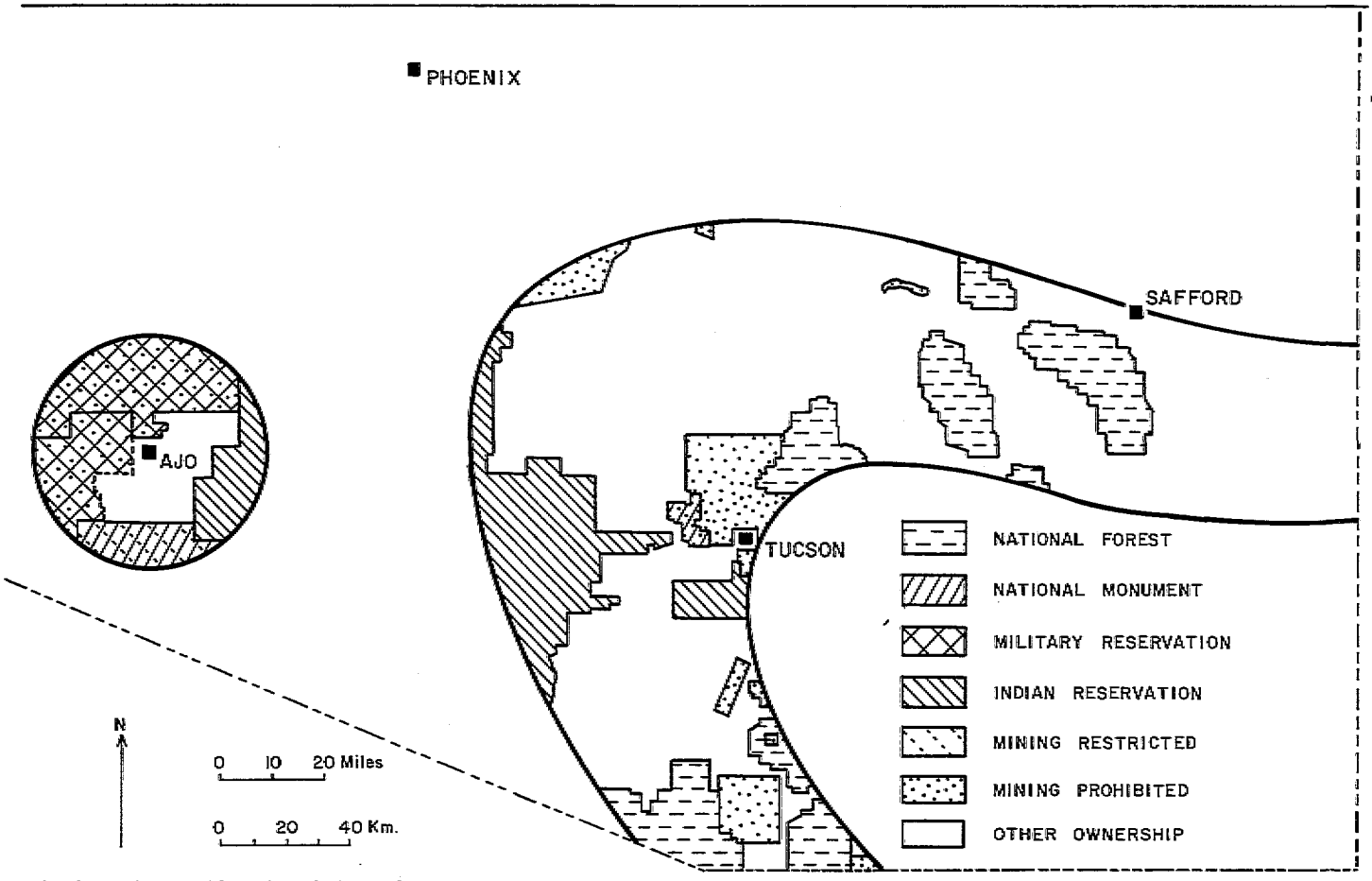

Fig. 3. Land ownership status within the Southwestern Copper Province and in the vicinity of Ajo (modified from land status map in Reference 2).

GEOLOGIST SPEAKS *Continued*

but is interpreted with a high degree of certainty from the distribution and thickness of rocks which formed in it. At about the end of the age of dinosaurs, the basin edge was the site of the evolution of a great number of volcanos. It was by these volcanic processes, which lasted about 15 million years, with their buried chambers of copper-bearing molten rock serving as a source, that nature formed the copper deposits of southern Arizona. Evidence for this is rather good—we can see the volcanic rocks near and about many of the deposits of southeastern Arizona, we can determine that they are of about the correct age to be related to the copper deposits, and in many places they contain copper mineralization. Where we see clusters of copper deposits, we are probably seeing the now-cooled granitic rock hearts of a cluster of ancient, long-gone volcanos.

Therefore, the arcuate belt containing the copper deposits can not only be drawn simply by including most of the known deposits of this region in the complete absence of geological knowledge, but also, it can be described in terms of lines grossly identifiable with rocks whose geologic importance is recognized.

LAND STATUS

The preceding discussion has been a summary of much geologic thought by many who have studied these deposits for a long time. There is not total agreement on certain concepts of genesis or formation of the deposits, but there is general concurrence that a large number of deposits occur here. Intense exploration underway here now attests to the general belief that more exist than have been found. There *is* a region in southeastern Arizona where, in comparison with most other regions on earth, the probability of finding copper deposits is very high. This *fact* leads to a consideration of the distribution of various types of land and land ownership in Southern Arizona.

Figure 3 is a base map outlining those areas with differing regulations governing mining. The gross outline of the arcuate belt of copper deposits in southeastern Arizona has been superimposed. As can be observed, the land types within the belt include virtually all types of lands set aside or recognized for some special purpose. Indian reservations, national forests, areas of definite mining prohibition, game and special ranges, and national monuments as well as a variety of public and privately held lands compose the varied ownership, and reflect the diverse nature of regulations governing or prohibiting land acquisition for mining purposes. The small scale of the map precludes showing a great amount of detail but this information may be gained from a study of the larger scale state publications (2). What is significant about this map and its superimposed geologic information is the great diversity of ways in which land is already designated for purposes other than extraction of mineral resources in a region now recognized as having an unusual and unique potential for copper mineralization.

SUMMARY

Regarding land status and potential ultimate use in southern Arizona, in my opinion the following comments and questions merit more than passing consideration *now*, in the early 1970's.

This nation, bounteously endowed with mineral resources and mineral wealth, seems always to have taken them for granted. So long as land was plentiful in the West, there seemed no reason to consider them otherwise. With few exceptions, when designating the status

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THE NEW AMERICA OF THE YEAR 2000 A.D.

The following is an interview with Dr. W.H. Dresher by KTUC Radio Station, Tucson, on May 30, 1972.

Dr. William H. Dresher,

Dr. Dresher, You were telling me earlier about "The Second America". What do you mean by this?

A number of recent events have caused us to realize that the United States isn't as healthy as it should be in providing for the material needs of its people—the recent repatriation of American interests in the copper mines of Chile, our recent reliance on the Soviet Union for chrome ore for use in our manufacture of stainless steel, our total dependence on Latin American countries for bauxite for manufacture of aluminum, and the growing list of other mineral imports required for American industry. These realizations coupled with the fact that Americans are still growing in number and our average standard of living is still increasing has caused our planners in Washington to become increasingly concerned. Dr. Vincent McKelvey, Director of the United States Geological Survey, coined the phrase, "The Second America" to emphasize the fact that, to satisfy the needs of our people, we must essentially double the physical resources of the United States between now and the year 2000. What Dr. McKelvey is saying is that we must duplicate the Nation's "entire physical plant"—replace obsolete and worn out highways, automobiles, buildings, communications systems, power plants, etc. as well as provide new facilities to accommodate the people who will be here by the year 2000 in an amount which will essentially double all of the production which we have accomplished to date—and we have only about 28 years to accomplish this if our standard of living is not to be severely reduced!

This is a startling realization. Why are we just now hearing of this?

This really isn't new. After W.W. II, a government study group—The Paley Commission—warned of this; however, we chose to establish our material priorities around defense and space accomplishments rather than around establishing a secure basis for the needs of our people. The Korean War, Sputnick, and the Vietnam War have diverted our attention from these issues. However, the fact remains that since 1948 we have *tripled* our consumption of energy—heat and electricity—per capita and with it the material goods which we consume so that today we have the highest standard of living in the entire world *but* we have the poorest prospects for maintaining it. As a nation, we are 5% of the World's population, occupy 7% of its land area, and consume 30% of its mineral and energy output. Yet, we do not have rich resources of minerals and fuels within our boundaries.

This is indeed an accomplishment for us, but isn't this a little unfair to the rest of the world?

This, of course, is the argument of the Environmentalists and the Conservationists and, to some extent, they are correct. We *are* using more of the World's goods than we deserve! Yet, who among us is willing to give up what he already has? Except for war time restrictions, we have never had to step back in our standard of living. You and I can certainly hold the line where we are. But that isn't the real problem before us. The problem is how to bring those "have nots" among us up to what you and I have. How do we provide for *these* people over the next 25 years? As for the rest of the world, the developing nations are beginning to emerge. This is one reason why our mineral imports are being restricted. These countries must develop their own manufacturing industry if they are going to catch up to us. They would prefer to sell us manufactured goods than raw materials and by doing so strengthen their own economy.

Wouldn't importation of finished goods be the answer to our problems? This would help us and help the developing nations.

Only partially, for we cannot afford to allow our domestic industry to become weakened. Last year was the first year we have had a deficit in foreign payments since 1894. We must balance our payments or face unemployment and deprivation ourselves. The deficit was partially caused by the 8 *billion* dollar shortage of U.S. mineral production. By the year 2000, this shortage is projected to reach 64 billion dollars—a cause for great concern. The steel industry has already been forced to lay off nearly 13,000 men with the permanent shut down of Jones and Laughlin Steel Corp., Bethlehem Steel Corp., and U.S. Steel Corp. facilities. President Nixon recently asked the major European countries and Japan to limit their exports of steel to this country for the next 3 years to help alleviate this problem. Our problems are just beginning. A serious recession could result if our domestic industry is not kept strong.

What seems to be the answer to these problems? What are we to do about them?

The answers are not simple. However, positive steps are being taken. *First,* the Congress of the United States passed an act, The Mining and Minerals industry in the United States, one which will operate through private enterprise with a minimum of Federal control. *Second,* the President has established a commission—The Natural Materials Policy Commission—to report to him by June, 1973 on a recommended course of action. This Commission is now in operation and considering several facets of the problem. *Third,* steps are being taken to improve our technology. Regardless of the outcome of any decision-making, one thing is clear: we must increase our level of sophistication and proficiency in providing raw materials for our manufacturing industry. The reasons for this are twofold: (1) increased domestic production of power and minerals could mean increased pollution, and we cannot tolerate any deterioration in our environmental quality in achieving our goals, and (2) domestic ores are plentiful but too low in grade to economically compete in the world market by the use of conventional technology. Therefore, the Senate and, last week, the House of Representatives in Washington, have now both passed bills to aid in mineral industry education and to establish mineral technology research centers in every state. The College of Mines of the University of Arizona expects to play a major role in the training of young men and women for the minerals industry and in the development of improved technology, both of which are

Continued on page 10

YEAR 2000 *Continued*

required to meet the challenge ahead of us in meeting the needs of "The Second America". Our young people have a challenge which has been unequalled in history . . . the challenge of assuring a quality life for every American while preserving our environment and our natural resources. For, if the solutions to the problems we have been discussing are to be found, they must be found during the working life of these young men and women.

GEOLOGIST SPEAKS *Continued*

of lands, their characteristic as specifically mineral-bearing or of high mineral potential has received little attention. With no intent to suggest that any special formal status be given southern Arizona and her known and potential copper resources, can we perhaps now at least recognize that there exists here a unique planetary resource? And cannot this recognition be "factored" into future decisions regarding all sorts of land use planning?

There has been an indifference towards the way the land has been spoiled in not only the extraction of mineral resources but sometimes the search for them. This indifference has resulted from our mineral wealth and the immense land in which to search for them. Public pressure and the recognition of some sort of problem have led to steps to improve this situation. We need only look to the future of the development of additional copper in this region, however, to gain some idea of the immense nature of the potential and continuing problems that extraction and processing will bring to the State.

It is perhaps a major understatement to say that the problems posed by the present and potential incompatibility of extraction and processing on one hand, and urban growth and maintenance of environmental quality on the other, are challenging. They are like no others known on earth at this time. It is fair to say, however, that the first steps towards their solution will come from an awareness of their existence on the part of the citizenry, state policymakers, and industry.

Do we not now, then, have a two-fold obligation, first, to recognize the value to Arizona and to the nation of the unique copper resource that is Arizona's and, second, to recognize the need *now* for imaginative planning for development of that resource with a minimum of environmental and esthetical impact? Problems are solved by cooperation. They cannot be solved by completely ignoring their existence, or by ignoring them until they have reached a point where their solution is attended by emotion and a lack of cooperation rather than reason.

Primarily, should we not now be considering the potential impact of sharply increasing demands on copper by present and developing technologically-oriented nations and its influence on Arizona copper during the next two decades or longer? Should it not now be possible to begin considering the problem in its entirety rather than the piecemeal fashion which is now and has been the pattern of the past? Is it not time to begin to consider the potential overall problems and take the first steps toward some wise policies and decisions?

Shouldn't we *now* become aware of the potential impact of the ultimate development and exploitation of most of the copper bodies known today over the next 15 years, and the continuing impact of the discovery and development of bodies not yet known? Are we undertaking any research now on the best ways to minimize this impact? Not to my knowledge.

Long range problems exist which we cannot yet even define. But for the present, could we not ask some specific questions? For example, should we not now be planning for the eventuality of development of copper bodies where the arcuate belt crosses the Tucson-Phoenix corridor? Already discoveries encroach upon the path of planned urbanization.

Is it too soon to consider the possibility of a "consolidated" smelting center in Arizona, developed and built by the producers of copper well away from areas of potential urbanization where, through present and developing techniques of low-pollution level processing, Arizona can ultimately derive the economic benefits from the processing of copper and its associated metals?

With a view toward maintenance of the esthetical qualities of the region and lowered extractive costs for ores, should we not now begin to recognize the advantages of certain methods of mining by underground breakage of certain types of orebodies and subsequent leaching of copper—or even extraction of copper by methods as yet unknown? And should we not be seeking the counsel of ground-water hydrologists on this problem. And is it not time for the federal government to become aware of the fact that major research and "breakthroughs" in extractive processes, not only for copper but for other resources as well, are sorely needed in the national good?

Should we not now adopt an extremely cautious attitude in acts which modify land status in this region through either zoning or withdrawal for some special purpose which result in restrictions and prohibitions on exploration and ultimate development of any mineral-bearing or untested lands in these mineralized regions of Arizona? And should not this same caution apply to other parts of the United States where we can identify metallogenic provinces of the other metals and minerals necessary to our well being?

On an international basis, should we not be considering these same problems with our neighbors to the south in Mexico? Prevailing southeasterly winds do not portend well for the Tucson or Phoenix region in the likely event more copper is discovered and processed in the arcuate belt south of the international border. We must again remember the Metallogenic Provinces are not aware of county, state, or national boundaries.

Finally, is it not time for far-seeing leaders to begin evolving far-seeing plans to accommodate the total resources of this region? There are few places on earth at this time where the juxtaposition of so many potentially incompatible activities have the potential for mismanagement and conflict. Given the proper education, the proper cooperation, and the ability to evolve the proper policies *before* the problems become critical, Arizona may be able to have her cake and eat it too!

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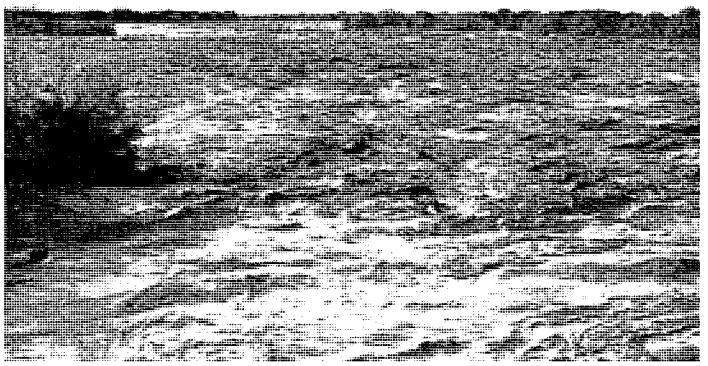
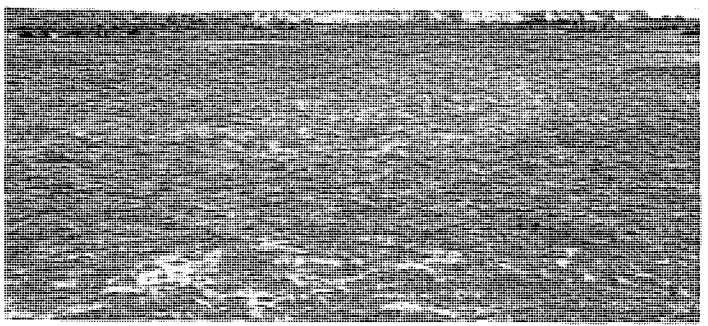
THE MIGHTY MISSISSIPPI? — NO — THE NORMALLY DRY GILA — DOING WHAT COMES NATURALLY

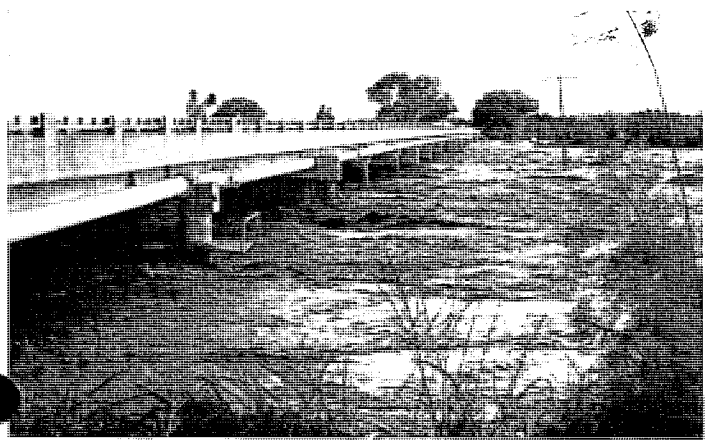
(H.W. Peirce pictures – Oct. 20, 1972)



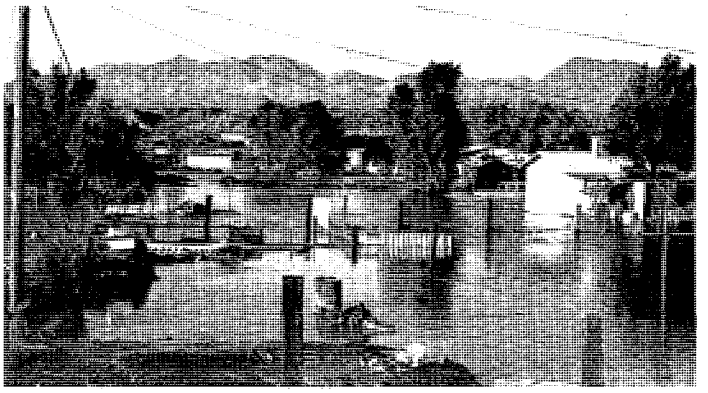


GILA RIVER FLOW AT SAFFORD, ARIZONA—NEAR FLOOD CREST

The U.S. Geological Survey, Tucson, estimates the peak flow at about 70,000 cfs (cubic feet per second). This is reported to be the highest flow since records began in 1914. The highest flow, about 100,000 cfs, occurred in January, 1916.



AS GOES THE BRIDGE SO GOES SAFFORD'S WATER SUPPLY (PIPE).



THE GILA FINDS ANOTHER CONFLICT ON ITS FLOODPLAIN.

The much photographed lowland community of Little Hollywood near Safford. It might be fair to say that a high river and a low community combined to produce these results.

THE GILA FINDS A CONFLICT ON ITS FLOODPLAIN—COTTON.

Whether floods are to be considered constructive or destructive depends upon one's viewpoint. The floodplain, exploited by man the world over, owes its flatness, fertility, and texture to natural processes associated with flooding. A long—range view suggests that floodplains are renewed by repetitive flooding events. Too, one's view would be affected by location, whether above or below a "protecting" dam, in this case Coolidge Dam, which is down-river. River channels are recharge zones for vital groundwater and flow is essential for renewal of water supplies. On balance, the longer ranging view is the more natural. It is possible that temporary crop losses will be made up by enhanced future production because of increased fertility, water supply, leaching of detrimental salts that collect in irrigated fields, etc.

GEOLOGIC HAZARDS — CONTRIBUTE YOUR OBSERVATIONS

The Arizona Bureau of Mines, in the continuing interest of promoting safety and proper adjustment to geologic circumstances, presented GEOLOGIC HAZARDS AND LAND-USE PLANNING in Vol. 2, No. 3 of FIELDNOTES.

Our stated goal was to help stimulate awareness on the part of individuals searching for residential sites in Arizona. Although emphasis was placed on Tucson examples, the principles involved are widely applicable.

In the interest of gaining additional insight, we are asking you, the reader, and your acquaintances, to help assemble a more comprehensive file on geologically precarious or potentially precarious situations in Arizona.

We also are interested in, besides threats stemming from floods, erosion, rock falls, land slides, slumping, earthquakes, and volcanism, etc., manifestations of minor earth movements that result either in cracks in the ground or in man-made structures. We are especially interested in learning more about residence cracking in Arizona.

If you have a concern, or think that concern should be generated about any of these or other earth phenomena, we invite you to write to us—better sooner than later! Observe and report. Please address correspondence to:

GEOLOGIC HAZARDS
ARIZONA BUREAU OF MINES
THE UNIVERSITY OF ARIZONA
TUCSON, ARIZONA 85721

FIELDNOTES Mailing List
New Request ( ) Change of Address ( )
(please attach old label)

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(City) (State) (Zip)

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FIELD NOTES
Volume 2, No. 4 *Dec. 1972*
State of Arizona
Governor ..... Hon. Jack Williams
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Editor ..... F. Catherine Cate
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THE UNIVERSITY OF ARIZONA
TUCSON, ARIZONA 85721

Pinal Mtn AIME Talk

Modified IAGOD talk
See Pinal Mountain Region Discussion.

DISTRICT MINERALIZATION, PRODUCTION, AND METAL RATIOS SOUTHEASTERN ARIZONA, U.S.A.

James D. Sell
ASARCO Incorporated
Tucson, Arizona U.S.A.

Oral Presentation
1978 IAGOD Symposium, Alta, Utah
Working Group on Genesis of Ore Deposits as a Basis for Exploration
August 18, 1978.

DISTRICT MINERALIZATION, PRODUCTION, AND METAL RATIOS SOUTHEASTERN ARIZONA, U.S.A.

James D. Sell
ASARCO Incorporated
Tucson, Arizona U.S.A.

A metallogenesis study of metal production of copper, lead, zinc, gold, and silver in districts within Cochise, Pima, and Santa Cruz Counties of Southeastern Arizona, U.S.A. has been undertaken.

Within each district the metal production was compared to the type of host deposit -- porphyry, vein, or limestone replacement. Differences were noted for different metals and hosts by the use of various metal ratios. Using these ratios criteria were developed which suggested that additional deposit types may be present in some districts.

Thirty-seven districts were studied and five will be discussed in detail.

District Mineralization, Production, and Metal Ratios
Southeastern Arizona, U.S.A.

Introduction

A study of metal production of copper, lead, zinc, gold, and silver in mining districts within Cochise, Pima, and Santa Cruz Counties, Southeastern Arizona, U.S.A. (Fig. 1) (slide ONE) has been undertaken. The Arizona Bureau of Mines has published bulletins covering the production through 1970 for Cochise County (Keith, 1973) and 1972 for Pima (Keith, 1974) and Santa Cruz (Keith, 1975) Counties. It is these data that are used in the study and include only production data -- no reserve statistics are included.

The three counties of Southeastern Arizona produced about 52% of the total mine production of Arizona in 1972. In 1972 the State of Arizona, with 1.8 billion pounds of copper, accounted for nearly 12-1/2% of the free world's copper production. Of the other metals, Arizona produced 20.2 million pounds of zinc, 3.5 million pounds of lead, 6.7 million ounces of silver, 103,000 ounces of gold, and 27.2 million pounds of molybdenum (Greenspoon and Schroeder, 1973).

Districts

Thirty-seven districts were included in the study with twelve from Cochise, eighteen from Pima, and seven from Santa Cruz. District size ranged from 18 km^2 (7 sq. miles) to 464 km^2 (179 sq. miles) and incorporated from 2 to 44 deposits per district. Most districts have only one major producer with numerous smaller producers. However, the Pima District compilation includes not only Pima Mine but also the Mission, Twin Buttes, Esperanza, and Sierrita deposits of similar size and production magnitude.

Table 1 contains the base and precious metal production of the districts by: 1) the tons of ore produced, 2) the type of deposit, and 3) the production of copper, lead, zinc, gold, and silver. Plate 1 also plots this information.

Tonnage

The production tonnage has been subdivided into five classes.

The large districts (slide TWO) (Plate 1) are those with a production in excess of 50 million tons of ore. These districts include Warren, Pima, Silver Bell, and Ajo. The substantial districts (slide THREE) have produced between 1 million and 50 million tons. They include the Harshaw, Tombstone, Pearce, and Cochise districts. The moderate districts (slide FOUR) have produced over 100 thousand tons but less than 1 million tons. The moderate districts include Oro Blanco, Palmetto, Patagonia, Helvetia, Turquoise, Dos Cabezas, and Oracle.

The above three classes contain the bulk of the production and were the districts used for subsequent ratio studies. The following two classes complete the tonnage symbols (slide FIVE). Small districts have produced between 10 thousand and 100 thousand tons and are shown with a triangle bordered in brown. The prospect districts have less than 10 thousand tons of reported production and are represented by a triangle bordered in yellow.

Type of Deposit

The districts have been divided into three types: 1) porphyry, 2) vein, and 3) limestone replacement. The types are based on the general mode of occurrence of the metal production. The type is shown by the color scheme within the central symbol of the square, circle, or triangle on Plate 1.

The porphyry (slide SIX) deposits occur at the Warren, Pima, Silver Bell, and Ajo districts.

The major vein (slide SEVEN) deposits occur in the Oro Blanco, Palmetto, Harshaw, Patagonia, Pearce, and Dos Cabezas districts with minor vein deposits at Tombstone and Pima.

The limestone replacement (slide EIGHT) districts are found in the Warren, Tombstone, Turquoise, Cochise, Helvetia, Pima, Oracle, and Silver Bell districts

with minor deposits at Patagonia, Harshaw, and Dos Cabezas.

Some districts have more than one type of significant mineralization occurrence and are shown with multiple notations. The (slide NINE) small and prospect districts follow the notation system as described above.

Metal Production

Outward from the outer circle of the symbol are spokes representing production of copper (vertical spoke), lead (upper left), zinc (upper right), gold (lower left), and silver (lower right). The production breakdown is shown on Plate 1 by a number system.

Copper. In the major districts (slide TEN), copper production in excess of 50 million pounds has been recorded for the Warren, Turquoise, Cochise, Pima, Silver Bell, and Ajo districts. Production (slide ELEVEN) of between 1 million and 50 million pounds of copper is shown for the Oro Blanco, Palmetto, Harshaw, Patagonia, Tombstone, Dos Cabezas, Helvetia, and Oracle districts. Pearce is the only district of substantial tonnage production which has had relatively little copper production.

Of the small districts (slide TWELVE), those having production records of 1 million to 50 million pounds of copper include the Middle Pass, Tyndall, and Waterman districts. The small districts (slide THIRTEEN) with over 100 thousand but less than 1 million pounds of copper include the California, Empire, Amole, Baboquivari, and Quijotoa districts. The prospect districts of Wrightson, Coyote, Cababi, and Montezuma also have more than 100 thousand pounds of copper production.

Lead. Major lead production (slide FOURTEEN) of over 50 million pounds is recorded from the Warren, Harshaw, Oro Blanco, and Pima districts.

Production (slide FIFTEEN) from 1 million to 50 million pounds of lead has been recorded from the Dos Cabezas, Turquoise, Tombstone, Patagonia, and Silver Bell districts.

(Slide SIXTEEN) Between 100 thousand and 1 million pounds of lead have been produced in the Palmetto, Helvetia, Cochise, and Oracle districts.

Of the moderate to large districts, only Pearce and Ajo are noted for minor or no lead production.

However, in the small districts (slide SEVENTEEN), those which have produced between 1 million and 50 million pounds of lead include the California, Swisshelm, Empire, Tyndall, Waterman, and Gunsite districts. Lesser production (slide EIGHTEEN) in the small districts of Dragoon, Middle Pass, and Amole, with similar production from the prospect districts of Hartford, Greaterville, Wrightson, Nogales, Arivaca, Papago, and Cobabi.

Zinc. (Slide NINETEEN) In excess of 50 million pounds of zinc is reported from Cochise, Warren, Patagonia, Harshaw, Oro Blanco, and Pima districts. Between (slide TWENTY) 1 million and 50 million pounds of zinc have been produced from Turquoise, Tombstone, Helvetia, and Silver Bell districts. Of the major districts (slide TWENTY-ONE), Palmetto, Dos Cabezas, and Oracle have minor zinc production and Pearce and Ajo have no recorded production.

Of the small districts (slide TWENTY-TWO), those having more than 1 million pounds of zinc production include the California, Middle Pass, and Tyndall districts. Lesser amounts of zinc (slide TWENTY-THREE) from the small districts of Swisshelm, Dragoon, Empire, Amole, and Waterman. The Hartford prospect district also has a production of between 100 thousand and 1 million pounds of zinc.

Gold. (Slide TWENTY-FOUR) Notable gold production, in excess of 50 thousand ounces, has been taken from the Warren, Tombstone, Turquoise, Oro Blanco, Pima, and Ajo districts. Districts (slide TWENTY-FIVE) with 10 thousand to 50 thousand ounces of production include Pearce and Dos Cabezas districts. More (slide TWENTY-SIX) than 1 thousand but less than 10 thousand ounces of gold have been recovered from the Patagonia, Harshaw, Helvetia, and Silver Bell districts.

In the major districts (slide TWENTY-SEVEN) only Palmetto, Cochise, and Oracle have less than 1 thousand ounces of gold production.

The (slide TWENTY-EIGHT) small districts of Baboquivari and Quijotoa have each produced between 10 thousand and 50 thousand ounces of gold, some of which was placer gold. Of (slide TWENTY-NINE) the other small districts, those with between 1 thousand and 10 thousand ounces include the Swisshelm, Dragoon, Tyndall, and Amole districts, along with the prospect districts of Nogales, Arivaca, Papago, and Cababi.

Silver. Silver (slide THIRTY) districts with an excess of 50 million ounces include the Warren and Pima districts. Those (slide THIRTY-ONE) with between 1 million and 50 million ounces include Turquoise, Tombstone, Patagonia, Harshaw, Oro Blanco, Silver Bell, and Ajo districts. More (slide THIRTY-TWO) than 100 thousand but less than 1 million ounces have been reported from the Dos Cabezas, Cochise, Pearce, Helvetia, and Oracle districts. All of the major districts except Palmetto have produced over 100 thousand ounces of silver.

The (slide THIRTY-THREE) small districts with over 100 thousand but less than 1 million ounces of silver production include the California, Swisshelm, Middle Pass, Empire, Tyndall, Baboquivari, Waterman, Quijotoa, and Gunsite districts. Of the prospect districts, those with plus 100 thousand ounces include the Cerro Colorado, Cababi, and Montezuma.

Combination (slide THIRTY-FOUR) of all the production data is shown in Plate 1 and includes the additional three categories which were not discussed above.

Metal Ratios

The major producing districts are obvious from the tonnage data. All of the larger districts -- Warren, Pima, Silver Bell, and Ajo -- have porphyry copper mineralization and all but Ajo have substantial limestone replacement association.

The greater Pima district also includes numerous vein deposits.

Based on the production figures recorded in Table 1, various metal production ratios can be calculated. Doing so reveals that the ratios have a wide spread in value but tend to group into sets which outline and indicate the apparent form of the deposit, whether from a porphyry, vein, or limestone replacement deposit.

Three different columns of metal ratio criteria, labeled A, B, and C, have been generated from the ratio data and other factors. Figure 2 (slide THIRTY-FIVE) is an example of the distribution of deposits used in formulating Criteria A. Plots of Criteria B and C were also generated. Only the major districts were used in the basic criteria selection for this study.

Each district in the study was reviewed and assigned to the resultant host deposit based on its location within the criteria field. Table 1 (slide THIRTY-SIX) records the apparent host for each of the metal ratio criteria columns under investigation. Also shown is the present status or known host for each district. When the present status is compared with the host indicated by the metal ratio criteria, it can be determined whether the metal ratios suggest the presence of a form of mineralization not presently known to occur in the district. This comparison would suggest what type of deposits might be as-yet-undiscovered in the district.

District Discussion

Thirty-seven districts were studied and five of these will be discussed in detail.

1. The Cochise district (slide THIRTY-SEVEN), Figure 3, has 41 listed producing properties having a total production of over 1.6 million tons of ore containing 93.7 million pounds of zinc, 74.8 million pounds of copper, 0.6 million pounds of lead, 737 thousand ounces of silver, and minor gold. The

major production as of this study has been from limestone replacement deposits. The metal ratio criteria factors suggest a porphyry host and a vein host should also be present in the district.

Detailed study shows numerous veins with minor production where the veins cut both limestone and/or porphyry, but having only minor disseminated type mineralization outward from the veins. Tactite or skarn development similar to that found in other districts intimately associated with porphyry deposits is also present (Kantor, 1975; Weitz, 1976). Kantor, 1977, concluded that the tactite deposits of Johnson Camp and Strong and Harris areas, with 100 million tons of ore-bearing material, probably had a porphyry sill which has subsequently been eroded off. In 1975 (Argall, 1976) Cyprus Mining Company opened a new pit mining disseminated mineralization in the lower, shaly portion of the Abrigo Formation. The new pit is adjacent to the old main workings of Johnson Camp and has a reserve of 15 million tons of 0.8% oxide copper mineralization.

2. The Harshaw district (slide THIRTY-EIGHT), Figure 4, located in Santa Cruz County has 20 mines listed with a total production of only 691 thousand tons of ore but containing 53.8 million pounds of zinc, 43.0 million pounds of lead, 36.7 million pounds of copper, 3.3 million ounces of silver, and 7,000 ounces of gold.

The main production was from the vein deposits with minor replacement of lenses of limestone within fault zones. The metal ratio criteria indicates a porphyry overprint for the district.

Corn (1975) describes the deep disseminated, porphyry type of alteration-mineralization encountered at Red Mountain at the north end of the district.

3. The Oracle district (slide THIRTY-NINE), Figure 5, is located in Pima County (8 deposits) and adjacent Pinal County (2 deposits). Within Pima County, 136 thousand tons of ore have been mined with 6.1 million pounds of copper,

0.2 million pounds of lead, 50 thousand pounds of zinc, 118 thousand ounces of silver, and minor gold production from limestone replacement deposits. One deposit in the adjacent county has produced in excess of 300 thousand tons of siliceous material as smelter flux feed.

The metal ratio criteria indicate a porphyry host possibility for the district and Durning (1975, 1976) described an area containing porphyry copper characteristics but concluded that the drilled area represented the roots of the porphyry system with the probability that the main production portion had been either eroded or faulted off. Present reserves in the area are at the Control or Marble Peak property where Continental Material Corporation (1970-1976) has delineated 11.3 million tons at average undiluted grade of 2.28% copper and 0.64 ounces of silver per ton in a tactite limestone replacement deposit.

4. The Baboquivari district (slide FORTY), Figure 6, is one of the representative small districts with production from 20 vein deposits. The tonnage and production of copper, lead, and zinc are minor but the 174 thousand ounces of silver and nearly 14 thousand ounces of gold are noteworthy. The metal ratio criteria suggest strong limestone host with a possible porphyry host. Scheelite has been produced from several limestone localities but base and precious metal production is nil from the limestones. Several areas of porphyry characteristics are known but the work to date has not been productive.

5. The Montezuma district (slide FORTY-ONE), Figure 7, is a prospect district with only two groups of mines. Both groups produced small tonnages of very high grade ore running between 4-9% copper, 50-60% lead, and 4-600 ounces of silver per ton. All three metal ratio criteria models suggest porphyry host but the production is from vein zones in or nearby to porphyritic intrusions. Drilling to date has failed to find viable porphyry-type mineralization.

Summary and Acknowledgements

Based on the production since 1972 plus the published reserves of the three counties of Southeastern Arizona, it is obvious that substantial future production is forthcoming. This study suggests that additional deposits may also be found within some of the districts.

ASARCO Incorporated granted permission for publication of the study and I thank members of the Tucson staff for review and improvement of the paper.

I acknowledge the excellent compilation of production data by the Arizona Bureau of Mines upon which this study was based.

Pinal Mountain Region Discussion

The extension of the southeastern Arizona study into the Ray-Superior-Globe-Christmas triangle (SLIDE) should be viewed with caution for several reasons: 1) there is a question as to how far outward one can take data and evaluate using the previously developed parameters, and 2) only incomplete published data exist for this region for copper, lead, zinc, gold, and silver production.

However, certain data are available scattered in a number of sources and by using this and the previously developed criteria, the following recap is presented:

A) (SLIDE) Ray, 1911-1969, produced over 3 billion pounds of copper from 194 million tons of ore. The criteria ratios indicate a strong porphyry affinity with a subordinate replacement affinity.

B) (SLIDE) Magma, 1912-1964, produced nearly 1-1/2 billion pounds of copper from 13-1/2 million tons of ore, with criteria indicators of mixed porphyry-vein- and replacement affinities.

C) (SLIDE) Miami-Inspiration, 1911-1953, produced over 6 billion pounds of copper from nearly 300 million tons of ore, with strong porphyry and moderate replacement affinity criteria.

D) (SLIDE) Old Dominion, 1882-1931, with over 765 million pounds of copper from 8 million tons of ore has strong porphyry with subordinate replacement affinity criteria.

E) (SLIDE) Christmas, 1905-1955, had over 90 million pounds of copper production from 2 million tons of ore with criteria suggesting strong porphyry and moderate replacement affinity.

Past and present production (SLIDE) from the Ray and Miami area deposits are of the porphyry class, being large tonnage deposits, even though much of

the ore is contained within Pinal Schist and/or diabase-Apache Group sediments, and having a variable amount of porphyry nearby. Based on the criteria results, one might wonder at what mineral deposits might have been emplaced within the limestone sequence which once undoubtedly covered the deposits, but was subsequently eroded and removed.

The Magma area (SLIDE) indicates a mixed replacement-porphyry affinity in the production records from the upper-central workings, while the deeper-western production indicates strong vein with porphyry affinities. Do the upper values reflect the massive replacement ores that are presently being mined?

At the Old Dominion (SLIDE) the production came mainly from replacement zones within the sedimentary-diabase sequence with disseminated mineralization also being present in part of the diabase. One can only speculate that important "porphyry" values may be present in the area.

Christmas (SLIDE) production was from replacement units, and important reserves are still carried in the limestone sequence. The porphyry affinity suggested by the criteria may be exemplified by the skarn mineralization being mined by open-pit methods and the large tonnage values developed by recent drilling.

The End Slide

Thank you.

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TABLE 1. DISTRICT PRODUCTION COMPILATION, STATUS, AND METAL RATIO CRITERIA

District Classification	District Name	Status*	Short Tons Ore (1,000's)	Pounds Copper (1,000's)	Pounds Lead (1,000's)	Pounds Zinc (1,000's)	Ounces Gold	Ounces Silver (1,000's)	Metal Ratio Criteria* A	B	C	Match
MAJOR												
Large	1. Pima	Pvl	369,707	4,119,854	85,195	232,953	53,720	312,000	P	P	P	Yes
	2. Ajo	P	350,015	5,659,953	---	---	1,548,253	18,992	-	L	P	No
	3. Warren	PL	150,991	7,693,257	309,756	378,450	2,630,572	100,312	P	L	P	Yes
	4. Silver Bell	Pl	61,200	1,008,839	1,804	48,087	1,490	5,294	P	P	P	Yes
Substantial	5. Cochise	L	1,640	74,775	605	93,650	229	734	V	P	P	No
	6. Tombstone	Lv	1,500	3,018	45,000	1,179	240,000	30,000	L	L	L	Yes
	7. Pearce	V	1,341	55	16	---	12,020	138	p?	L	L	No
	8. Harshaw	Vl	1,312	6,286	143,609	172,720	4,347	9,199	l	P	p	No
Moderate	9. Oro Blance	V	909	5,113	60,987	52,723	126,723	4,622	l	V	V	?
	10. Turquoise	L	887	54,823	7,777	2,561	56,641	1,575	P?	V	p?	No
	11. Patagonia	Vl	691	36,665	43,025	53,771	7,267	3,264	lv	p	P	No
	12. Helvetia	L	426	34,860	521	1,360	1,581	347	L	L	p?	?
	13. Oracle	L	136	6,117	188	50	387	118	P	p?	P	No
	14. Palmetto	V	132	11,004	449	2	242	75	P	p	V	No
	15. Dos Cabezas	Vl	106	4,026	1,413	39	10,082	429	p?	L	p?	No
MINOR												
Small	16. Middle Pass	L	76	2,011	274	9,251	337	147	L	p?	P	No
	17. Baboquivari	V	57	244	24	<1	13,850	174	P	L	L	No
	18. Tyndall	V	56	1,036	18,782	5,513	1,261	477	l	p	p	No
	19. Swisshelm	L	49	97	11,853	211	5,230	330	L	L	L	Yes
	20. California	Lv	38	299	8,631	1,179	100	152	L	P	P	No
	21. Amole	Vpl	34	529	670	375	1,010	27	V	P?	p?	No?
	22. Empire	Lv	34	344	16,671	515	744	206	L	P	p?	No
	23. Waterman	Vl	25	1,502	1,563	978	106	130	V	P	P	No
	24. Dragoon	L	19	18	356	249	9,741	72	L	p?	L	?
	25. Gunsite	V	16	32	1,552	<1	397	101	L	P	V	No
	26. Quijotoa	V	16	132	58	---	11,616	233	p?	P?	L	No
Prospect	27. Hartford	Lv	9	74	588	375	393	25	L	P?	v?p?	No?
	28. Arivaca	V	9	72	230	17	5,620	46	v?	p?	L	No
	29. Cobabi	V	6	184	364	3	3,450	102	V	P?	V	No?
	30. Cerro Colorado	V	5	33	63	1	463	377	v	p	v	?
	31. Papago	L	5	52	790	2	1,100	30	l	v	v	No?
	32. Whetstone	Vl	4	77	---	---	8	2	-	p?	p	No
	33. Wrightson	V	4	237	951	---	386	51	lv	Lp	p	No
	34. Greaterville	Lv	4	79	344	32	51	19	lv	p	p	No
	35. Montezuma	V	1	205	16	---	126	164	p	p	p?	No
	36. Nogales	V	<1	17	191	---	1,019	14	L	V	L	No
	37. Coyote	Vl	<1	140	---	---	21	<1	-	l	p	No?

*NOTES: Major Mineralization within:
- P Porphyry
- V Vein
- L Limestone Replacement

Minor Mineralization within:
- p porphyry
- v vein
- l limestone replacement

? Not Clearly Defined

--- Insufficient Data

Slide One

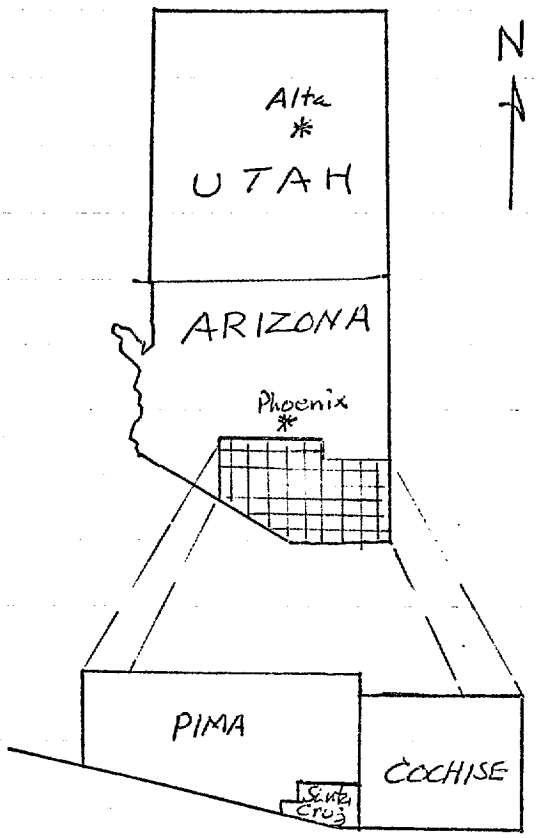
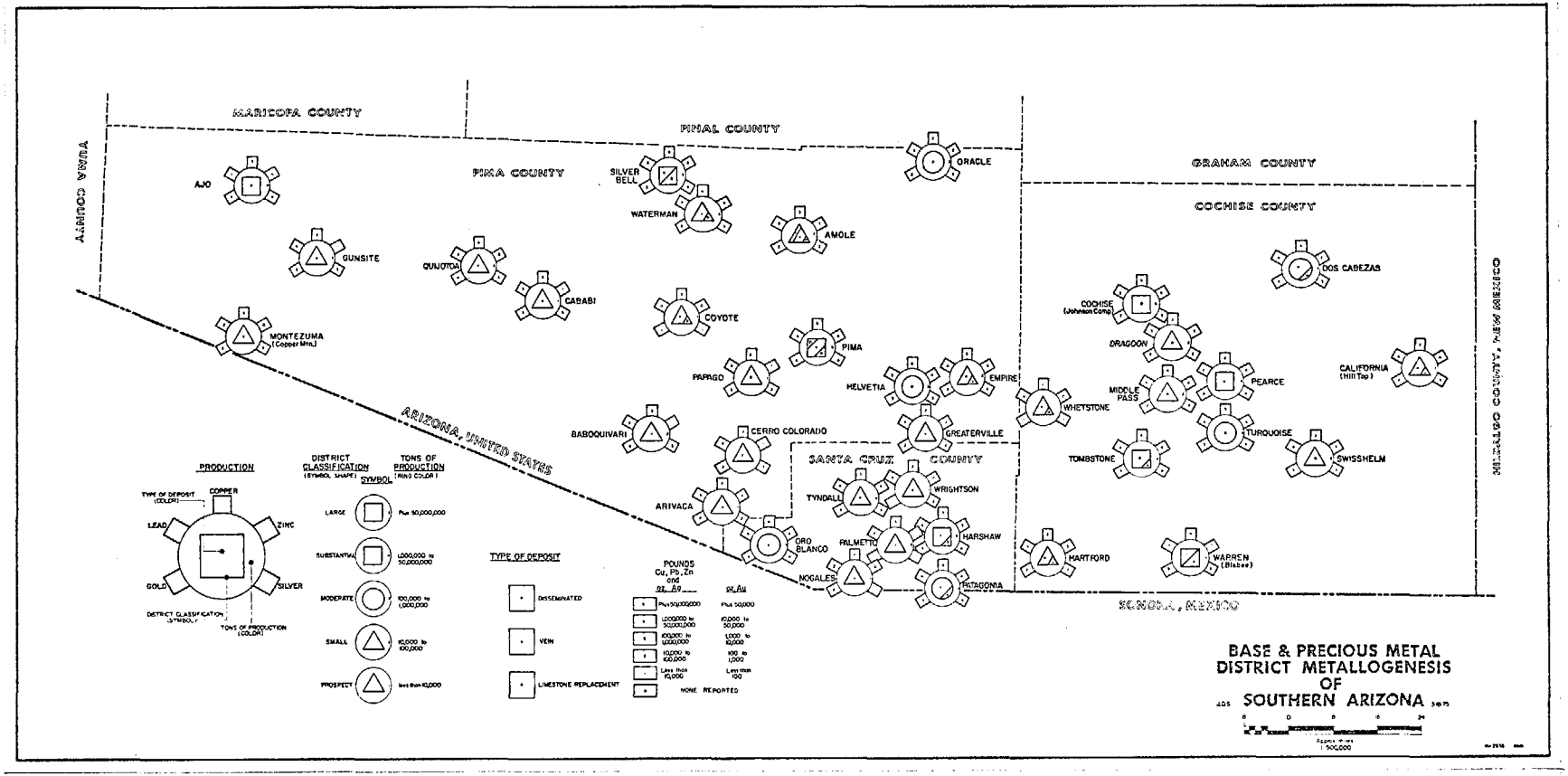


Figure 1. Location Map of Counties in Study Area, Southeastern Arizona.

NOTE:

Slide Two through Slide Thirty Four are separates from PLATE 1.


MARICOPA COUNTY
PINAL COUNTY
PIMA COUNTY
GRAHAM COUNTY
COCHISE COUNTY
SANTA CRUZ COUNTY
ARIZONA, UNITED STATES
SONORA, MEXICO
AJO
GUNSITE
QUIJOTOA
CABABI
MONTEZUMA (Copper Mtn.)
SILVER BELL
WATERMAN
COYOTE
AMOLE
ORACLE
PIMA
PAPAGO
BABOQUIVARI
CERRO COLORADO
ARIVACA
ORO BLANCO
NOGALES
TYNDALL
PALMETTO
WRIGHTSON
HARSHAW
PATAGONIA
HELVETIA
EMPIRE
GREATERVILLE
WHETSTONE
COCHISE (Johnson Camp)
DRAGOON
MIDDLE PASS
PEARCE
TOMBSTONE
TURQUOISE
SWISSHELM
DOS CABEZAS
CALIFORNIA (Hill Top)
HARTFORD
WARREN (Bisbee)
PRODUCTION
TYPE OF DEPOSIT (COLOR)
COPPER
LEAD
ZINC
GOLD
SILVER
DISTRICT CLASSIFICATION (SYMBOL)
TONS OF PRODUCTION (COLOR)
DISTRICT CLASSIFICATION (SYMBOL SHAPE)
TONS OF PRODUCTION (RING COLOR)
SYMBOL
LARGE
Plus 50,000,000
SUBSTANTIAL
1,000,000 to 50,000,000
MODERATE
100,000 to 1,000,000
SMALL
10,000 to 100,000
PROSPECT
less than 10,000
TYPE OF DEPOSIT
DISSEMINATED
VEIN
LIMESTONE REPLACEMENT
POUNDS Cu, Pb, Zn and oz. Ag
oz. Au
Plus 50,000,000
Plus 50,000
1,000,000 to 50,000,000
10,000 to 50,000
100,000 to 1,000,000
1,000 to 10,000
10,000 to 100,000
100 to 1,000
Less than 10,000
Less than 100
NONE REPORTED
BASE & PRECIOUS METAL DISTRICT METALLOGENESIS OF SOUTHERN ARIZONA
Miles
1:500,000

Page 1

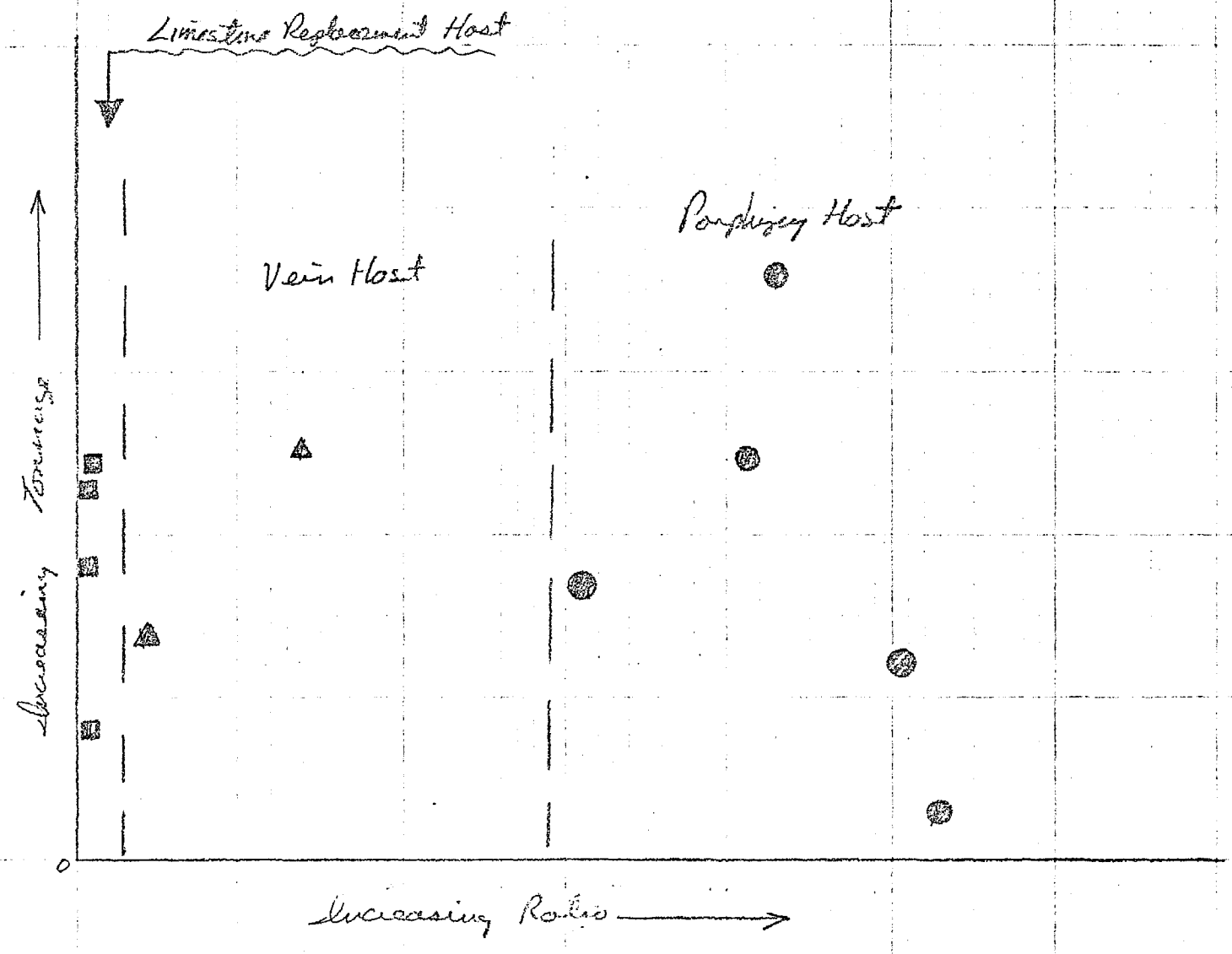


Figure 2 Plot of Criteria A showing Host fields.

TABLE 1. DISTRICT PRODUCTION COMPILATION, STATUS, AND METAL RATIO CRITERIA

District Classification	District Name	Status*	Short Tons Ore (1,000's)	Pounds Copper (1,000's)	Pounds Lead (1,000's)	Pounds Zinc (1,000's)	Ounces Gold	Ounces Silver (1,000's)	Metal Ratio Criteria* A	B	C	Match
MAJOR												
Large	1. Pima	Pvl	369,707	4,119,854	85,195	232,953	53,720	312,000	P	P	P	Yes
	2. Ajo	P	350,015	5,659,953	---	---	1,548,253	18,992	-	L	P	No
	3. Warren	PL	150,991	7,693,257	309,756	378,450	2,630,572	100,312	P	L	P	Yes
	4. Silver Bell	Pl	61,200	1,008,839	1,804	48,087	1,490	5,294	P	P	P	Yes
Substantial	5. Cochise	L	1,640	74,775	605	93,650	229	734	V	P	P	No
	6. Tombstone	Lv	1,500	3,018	45,000	1,179	240,000	30,000	L	L	L	Yes
	7. Pearce	V	1,341	55	16	---	12,020	138	p?	L	L	No
	8. Harshaw	Vl	1,312	6,286	143,609	172,720	4,347	9,199	l	P	p	No
Moderate	9. Oro Blance	V	909	5,113	60,987	52,723	126,723	4,622	l	V	V	?
	10. Turquoise	L	887	54,823	7,777	2,561	56,641	1,575	P?	V	p?	No
	11. Patagonia	Vl	691	36,665	43,025	53,771	7,267	3,264	lv	p	P	No
	12. Helvetia	L	426	34,860	521	1,360	1,581	347	L	L	p?	?
	13. Oracle	L	136	6,117	188	50	387	118	P	p?	P	No
	14. Palmetto	V	132	11,004	449	2	242	75	P	p	V	No
	15. Dos Cabezas	Vl	106	4,026	1,413	39	10,082	429	p?	L	p?	No
MINOR												
Small	16. Middle Pass	L	76	2,011	274	9,251	337	147	L	p?	P	No
	17. Baboquivari	V	57	244	24	<1	13,850	174	P	L	L	No
	18. Tyndall	V	56	1,036	18,782	5,513	1,261	477	l	p	p	No
	19. Swisshelm	L	49	97	11,853	211	5,230	330	L	L	L	Yes
	20. California	Lv	38	299	8,631	1,179	100	152	L	P	P	No
	21. Amole	Vpl	34	529	670	375	1,010	27	V	P?	p?	No?
	22. Empire	Lv	34	344	16,671	515	744	206	L	P	p?	No
	23. Waterman	Vl	25	1,502	1,563	978	106	130	V	P	P	No
	24. Dragoon	L	19	18	356	249	9,741	72	L	p?	L	?
	25. Gunsite	V	16	32	1,552	<1	397	101	L	P	V	No
	26. Quijotoa	V	16	132	58	---	11,616	233	p?	P?	L	No
Prospect	27. Hartford	Lv	9	74	588	375	393	25	L	P?	v?p?	No?
	28. Arivaca	V	9	72	230	17	5,620	46	v?	p?	L	No
	29. Cobabi	V	6	184	364	3	3,450	102	V	P?	V	No?
	30. Cerro Colorado	V	5	33	63	1	463	377	v	p	v	?
	31. Papago	L	5	52	790	2	1,100	30	l	v	v	No?
	32. Whetstone	Vl	4	77	---	---	8	2	-	p?	p	No
	33. Wrightson	V	4	237	951	---	386	51	lv	Lp	p	No
	34. Greaterville	Lv	4	79	344	32	51	19	lv	p	p	No
	35. Montezuma	V	1	205	16	---	126	164	p	p	p?	No
	36. Nogales	V	<1	17	191	---	1,019	14	L	V	L	No
	37. Coyote	Vl	<1	140	---	---	21	<1	-	l	p	No?

*NOTES: Major Mineralization within:
- P Porphyry
- V Vein
- L Limestone Replacement

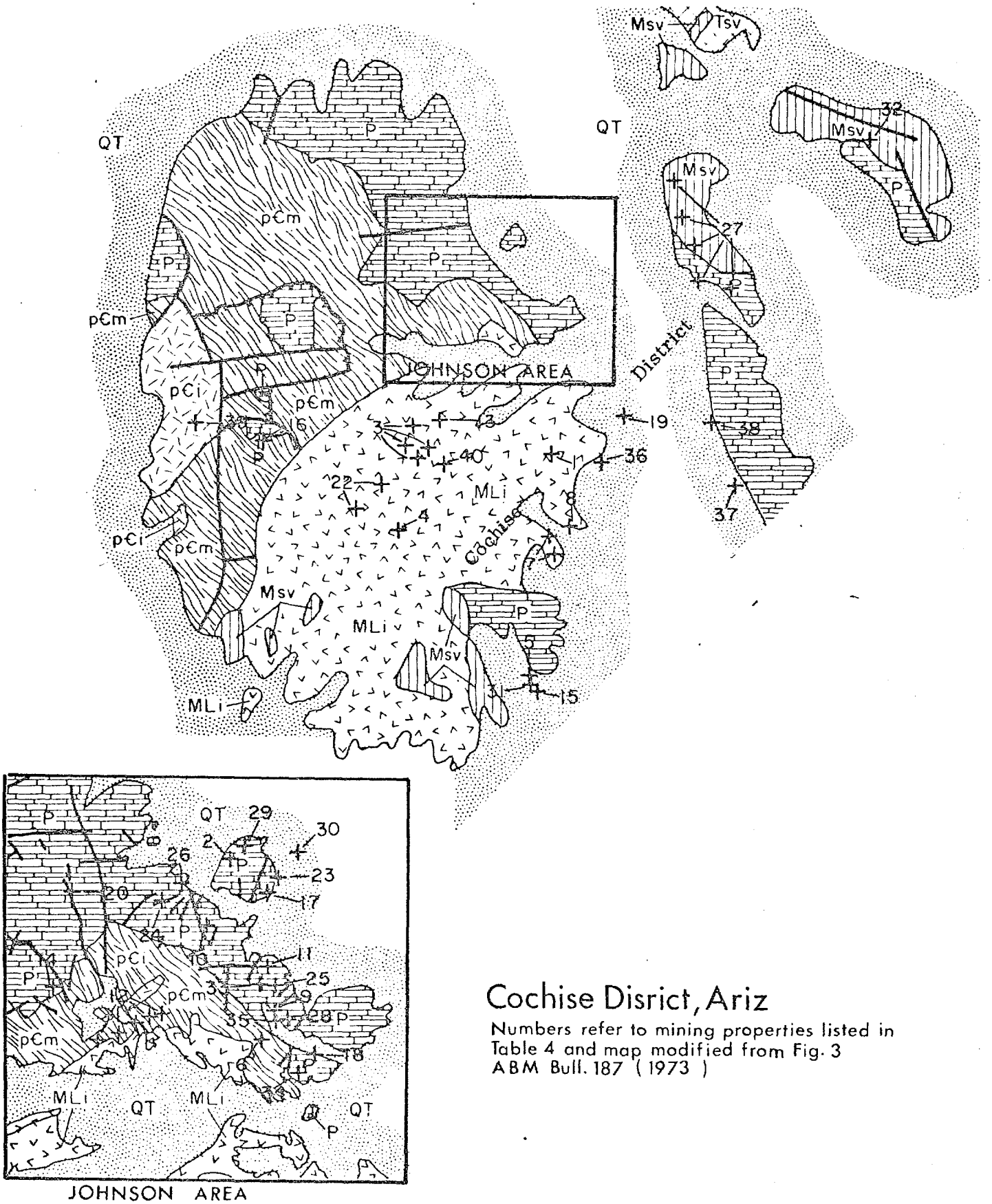
Minor Mineralization within:
- p porphyry
- v vein
- l limestone replacement

? Not Clearly Defined

--- Insufficient Data

(Slide 36)

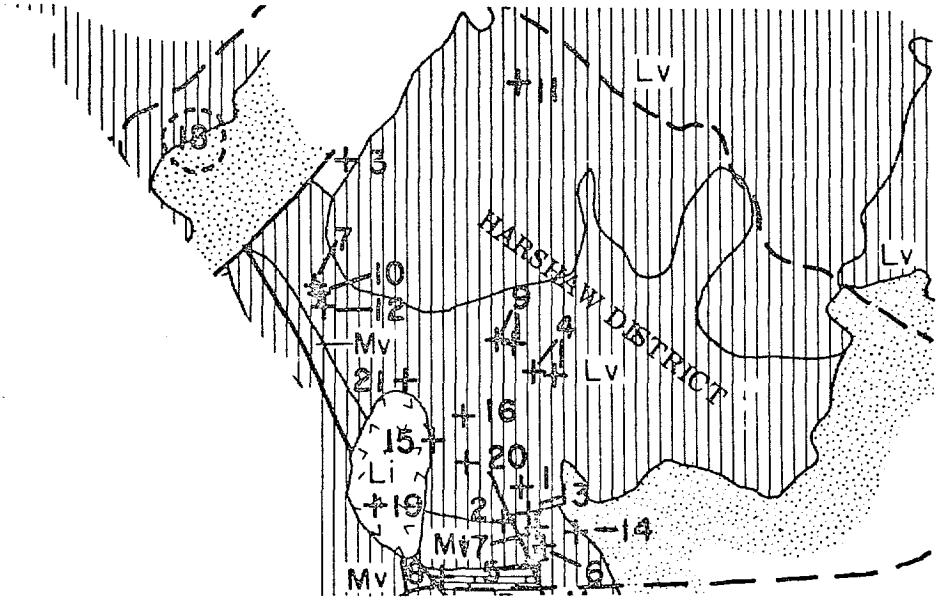
(Slide 37)



Cochise Disrict, Ariz

Numbers refer to mining properties listed in Table 4 and map modified from Fig. 3 ABM Bull. 187 (1973)

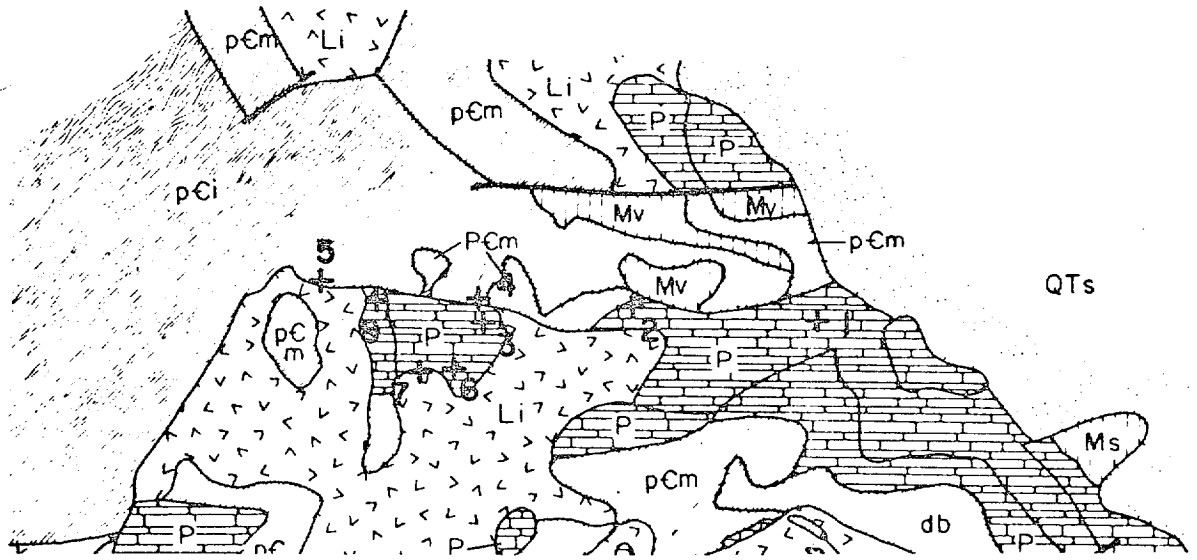
(Slide 38)



Harshaw District, Santa Cruz Co., Ariz.

Numbers refer to mining properties listed in Table 4 and map modified from Fig. 3 ABM Bull. 191 (1975)

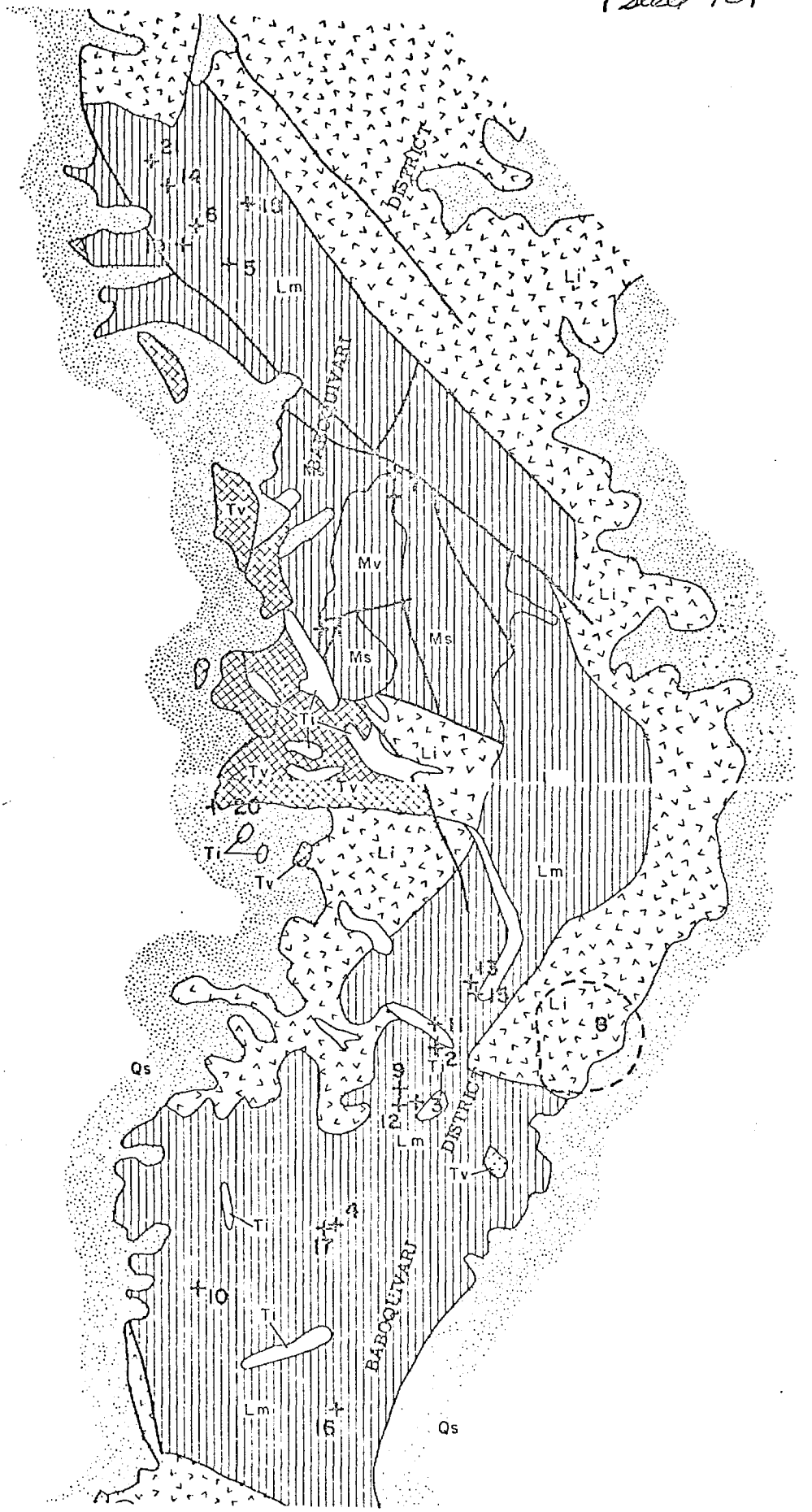
(Slide 39)



Oracle District, Pima Co., Ariz.

Numbers refer to mining properties listed in Table 4 and map modified from Fig. 11 ABM Bull. 189 (1974)

(Slide 40)



Baboquivari District, Pima Co., Ariz.

Numbers refer to mining properties listed in Table 4 and map modified from Fig. 5a & 5b ABM Bull. 189 (1974)

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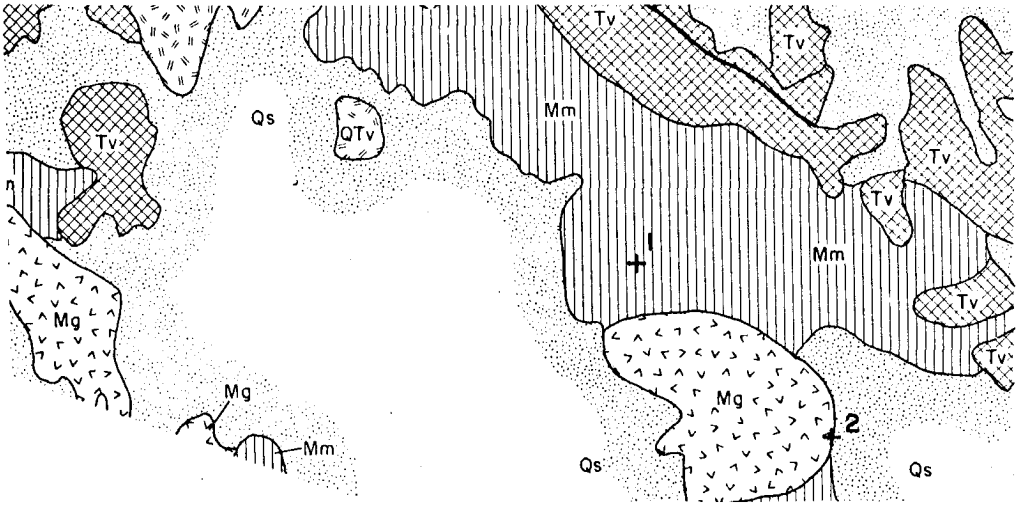

Montezuma District, Pima Co., Ariz.

Numbers refer to mining properties listed in Table 4 and map modified from Fig. 10 ABM Bull. 189 (1974)