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from Mineral Deposit Models, USGS Bulletin #1693, Editors Dennis Cox, Donald Singer 1986

DESCRIPTIVE MODEL OF Sn GREISEN DEPOSITS

By Bruce L. Reed

DESCRIPTION Disseminated cassiterite, and cassiterite-bearing veinlets, stockworks, lenses, pipes, and breccia in greisenized granite (see fig. 44).

GENERAL REFERENCE Scherba (1970), Taylor (1979), Reed (1982), Tischendorf (1977).

GEOLOGICAL ENVIRONMENT

Rock Types Specialized biotite and(or) muscovite leucogranite (S-type); distinctive accessory minerals include topaz, fluorite, tourmaline, and beryl. Tin greisens are generally post-magmatic and associated with late fractionated melt.

Textures Common plutonic rock textures, miarolitic cavities may be common; generally nonfoliated; equigranular textures may be more evolved (Hudson and Arth, 1983); aplitic and porphyritic textures common.

Age Range May be any age; tin mineralization temporally related to later stages of granitoid emplacement.

Depositional Environment Mesozonal plutonic to deep volcanic environment.

Tectonic Setting(s) Foldbelts of thick sediments ± volcanic rocks deposited on stable cratonic shield; accreted margins; granitoids generally postdate major folding.

Associated Deposit Types Quartz-cassiterite sulfide lodes, quartz-cassiterite ± molybdenite stockworks, late complex tin-silver-sulfide veins.

DEPOSIT DESCRIPTION

Mineralogy General zonal development of cassiterite + molybdenite, cassiterite + molybdenite + arsenopyrite + beryl, wolframite + beryl + arsenopyrite + bismuthinite, Cu-Pb-Zn sulfide minerals + sulphostannates, quartz veins ± fluorite, calcite, pyrite.

Texture/Structure Exceedingly varied, the most common being disseminated cassiterite in massive greisen, and quartz veinlets and stockworks (in cupolas or in overlying wallrocks); less common are pipes, lenses, and tectonic breccia.

Alteration Incipient greisen (granite): muscovite ± chlorite, tourmaline, and fluorite. Greisenized granite: quartz-muscovite-topaz-fluorite, ± tourmaline (original texture of granites retained). Massive greisen: quartz-muscovite-topaz ± fluorite ± tourmaline (typically no original texture preserved). Tourmaline can be ubiquitous as disseminations, concentrated or diffuse clots, or late fracture fillings. Greisen may form in any wallrock environment, typical assemblages developed in aluminosilicates.

Ore Controls Greisen lodes located in or near cupolas and ridges developed on the roof or along margins of granitoids; faults and fractures may be important ore controls.

Weathering Granite may be "reddened" close to greisen veins. Although massive greisen may not be economic as lodes, rich placer deposits form by weathering and erosion.

Geochemical Signature Cassiterite, topaz, and tourmaline in streams that drain exposed tin-rich greisens. Specialized granites may have high contents of SiO (>73 percent) and K_2O (>4 percent), and are depleted in CaO, TiO_2, MgO, and total FeO. They are enriched in Sn, F, Rb, Li, Be, W, Mo, Pb, B, Nb, Cs, U, Th, Hf, Ta, and most REE, and impoverished in Ni, Cu, Cr, Co, V, Sc, Sr, La, and Ba.

EXAMPLES

Lost River, USAK	(Dobson, 1982; Sainsbury, 1964)
Anchor Mine, AUTS	(Groves and Taylor, 1973)
Erzgebirge, CZCL	(Janecka and Stemprok, 1967)

GRADE AND TONNAGE MODEL OF Sn GREISEN DEPOSITS

By W. David Menzie and Bruce L. Reed

COMMENTS See figs. 45, 46.

DEPOSITS

Name	Country	Name	Country
Altenberg	GRME	Coal Creek	USAK
Anchor	AUTS	E. Kempville	CNNS
Archer	AUTS	Hub	CZCL
Cinovec	CZCL	Potosi	BRZL
Cista	CZCL	Prebuz	CZCL

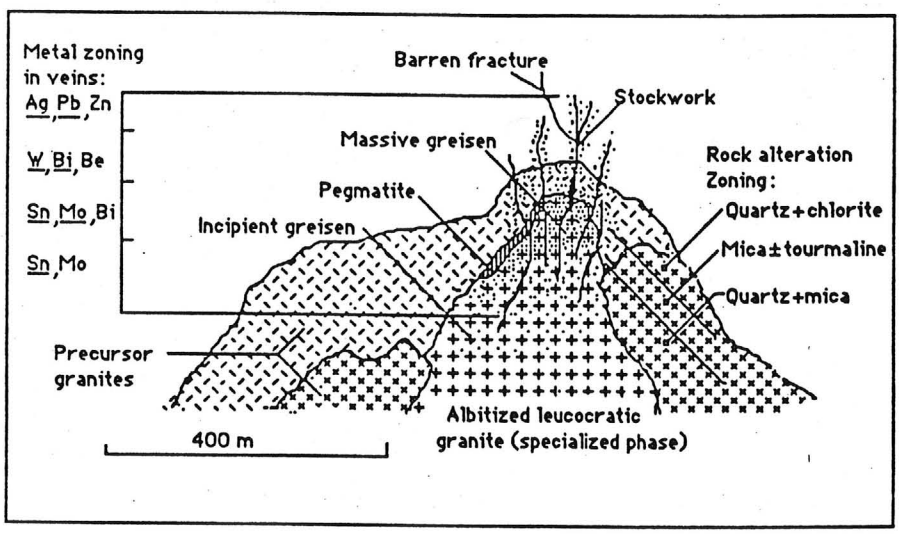

Figure 44. Cartoon cross section of a Sn greisen.

The University of Arizona

Arizona
Bureau of Geology and Mineral Technology
Geological Survey Branch
845 N. Park Ave., Tucson Arizona 85719
(602) 621-7906

1885

1985

A Proud Beginning

April 2, 1985

Robert F. Poley, Jr.
2020 Rockford Dr.
Prescott, AZ 86301

Dear Mr. Poley:

The pinkish fiberous sample submitted to the Arizona Bureau of Geology and Mineral Technology for examination is predominantly kyanite with, and in some areas mixed with, muscovite mica, quartz and limonite (hydrous iron oxide). A little tourmaline (complex silicate of boron, aluminum and iron) is also present in the sample. Microscopic analyses showed the optical properties which include birefringence, extinction angle, indices of refraction, optical sign (negative), orientation (fibers are length slow) and others fit perfectly for kyanite. Spectroscopic analysis showed the predominant mineral to be composed of aluminum and silicon with a trace of iron. Kyanite is an aluminum silicate. The trace of iron is just an impurity. No calcium nor lithium showed therefore, the mineral could not possibly be wollastonite, spodumene or amblygonite. I've been a mineralogist here at the University of Arizona for thirty years. I have found unless the mineral being tested by fusion, scratch, and other physical tests is pure, unaltered and of sufficent grain size these test can be misleading. This is why I rely on microscopic examination where I can separate good from bad grains and test only the good grains.

Spectroscopic analyses made on the black minerals in the four different samples showed they were predominantly composed of iron and titanium. One of the black minerals contained a little chromium. No neodymium (Nd) or tantalum (Ta) was detected by spectroscopic analyses.

I am returning your check as there is no charge for the testing work I performed.

Yours very truly,

Robert T. O'Haire

Robert T. O'Haire
Mineralogist

RTO:ef

Bondar-Clegg & Company Ltd.
130 Pemberton Ave.
North Vancouver, B.C.
Canada V7P 2R5
Phone: (604) 985-0681
Telex: 04-352667

BONDAR-CLEGG

Geochemical Lab Report

REPORT: V88-02177.0 (COMPLETE)

REFERENCE INFO:

CLIENT: MR. ROBERT POLEY JR.
PROJECT: D-1

SUBMITTED BY: R.F. POLEY JR.
DATE PRINTED: 21-JUN-88

SAMPLE TYPES	NUMBER	SIZE FRACTIONS	NUMBER	SAMPLE PREPARATIONS	NUMBER
C CONCENTRATE (PAN/HM)	16	2 -150	16	PULVERIZING	16
				BATCH SURCHARGE	16

NOTES: = indicates SEE OBS REMARKS

REMARKS: ELEVATED DETECTION LIMITS ON THE GOLD + 33
AND RARE EARTH ELEMENTS DUE TO HIGH La, Ce, Th.
= Y - INTERFERENCE NOTED DUE TO HIGH Fe.
TITANIUM SEMI-QUANTITATIVE VALUES:
#0015MAIN+FeOx LODE = 3.6% Ti
#0065WIRESPOOL LODE = 5.7% Ti
BWWC -40MESH WEAK = 2.9% Ti
BWWC -40MESH NON-MAG= 3.4% Ti
THE ELEMENTS ANALYSED IN THE RARE EARTH PACKAGE
WILL BE MORE ACCURATE THAN THE AU+33 PACKAGE.

REPORT COPIES TO: MR. ROBERT POLEY JR.

INVOICE TO: MR. ROBERT POLEY JR.

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Geochemical Lab Report

REPORT: V88-02177.0

PROJECT: D-1

SAMPLE NUMBER	ELEMENT UNITS	Au PPB	Ag PPM	As PPM	Ba PPM	Br PPM	Cd PPM	Ce PPM	Co PPM	Cr PPM	Cs PPM	Eu PPM
C2 #0015MAIN+FeOx LODE		643	<5	13	<1000	<5	<10	<10	25	400	<1	<2
C2 0030RAGGS RIDGE 2-5		<5	<5	2	1000	<5	<10	180	29	320	9	3
C2 #0065WIRESPOOL LODE		18	<5	4	<1000	<5	<10	<10	35	360	<1	<2
C2 0070Cu HILLGNEISS		<5	<5	<3	360	<5	<10	390	27	1300	3	5
[redacted]		[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
C2 BWWC MAGFRAC		<5	<5	5	<1000	<5	<10	98	65	1400	<1	<2
C2 BWWC -40MESH WEAK		28	<5	5	<1000	<5	<10	300	40	1200	1	2
C2 BWWC -40MESH DIGEST		<34	<13	<38	<2500	<17	<72	5490	34	1300	<2	42
C2 BWWC -40MESH NON-MAG		82	<17	<51	<3600	<23	<100	9280	21	1300	<3	81
C2 BWWC #IIZ-20MESH NON		<500	<18	<55	<3700	<25	<100	9260	49	1300	<3	82
[redacted]		[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
C2 RED BASIN 2CUFT		531	<12	<33	<2200	<16	<64	4680	43	980	5	37
C2 RED BASIN -16MESH		<5	<5	9	<1000	<5	<10	150	61	1100	2	<2
C2 S-S#1 -40MESH NON		<74	<20	<63	<3400	<29	<120	11300	36	1400	<4	95
C2 S-W BUT-SPR NON-MAG		<40	<11	39	<1000	<16	<66	4950	45	1100	4	36
C2 WIRESPOOL NON-MAG		<38	<11	<34	<1000	<15	<62	4160	45	1100	3	32

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SAMPLE NUMBER	ELEMENT UNITS	Fe PCT	Hf PPM	Ir PPB	La PPM	Lu PPM	Mo PPM	Na PCT	Ni PPM	Rb PPM	Sb PPM	Sc PPM
C2 #0015MAIN+FeOx LODE		56.7	<2	<100	7	<0.5	<2	<0.05	51	38	2.9	78.0
C2 0030RAGGS RIDGE 2-5		12.0	6	<100	93	<0.5	<2	0.36	59	200	0.3	18.0
C2 #0065WIRESPOOL LODE		59.2	2	<100	<5	<0.5	<2	<0.05	<50	58	0.9	97.0
C2 0070Cu HILI GNEISS		57.2	16	<100	190	1.0	<2	0.21	<50	53	1.2	45.0
[redacted]		[redacted]										
C2 BWWC MAGFRAC		71.6	12	<100	64	<0.5	<2	<0.05	140	51	0.7	8.3
C2 BWWC -40MESH WEAK		64.4	15	<100	180	1.4	<2	<0.05	74	23	0.7	23.0
C2 BWWC -40MESH DIGEST		55.7	32	<100	3620	41.0	<14	<6.60	<77	<40	1.2	36.0
C2 BWWC -40MESH NON-MAG		49.0	45	<100	6500	62.5	<22	<10.00	<86	<55	0.9	37.0
C2 BWWC #II%-20MESH NON		59.8	29	<100	6550	62.5	<23	<10.00	<90	<56	<0.9	44.0
[redacted]		[redacted]										
C2 RED BASIN 2CUFT		53.7	17	<100	3030	24.0	<13	<6.10	<56	54	<0.4	33.0
C2 RED BASIN -16MESH		64.7	9	<100	92	<0.5	<2	<0.05	120	53	0.5	11.0
C2 S-S#1 -40MESH NON		35.0	41	<220	7970	100.0	<27	<12.00	<100	120	<1.0	23.0
C2 S-W BUT-SPR NON-MAG		46.0	19	<100	3230	35.0	<14	<6.50	<83	64	0.8	18.0
C2 WIRESPOOL NON-MAG		50.0	14	<100	2750	25.0	<13	<6.00	<55	50	<0.6	27.0

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Geochemical Lab Report

REPORT: V88-02177.0

PROJECT: D-1 PAGE 1C

SAMPLE NUMBER	ELEMENT UNITS	Se PPM	Sm PPM	Sn PPM	Ta PPM	Tb PPM	Te PPM	Th PPM	U PPM	W PPM	Yb PPM	Zn PPM
C2 #0015MAIN+FeOx LODF		<10	1.3	<200	23	<1	<20	2.2	2.9	17	<5	390
C2 0030RAGGS RIDGE 2-5		<10	13.0	<200	1	2	<20	34.0	4.1	<4	<5	210
C2 #0065WIRESPOOL LODF		<10	0.6	<200	18	<1	<20	<0.5	1.8	<9	<5	240
C2 0070Cu HILLGNEISS		<10	29.0	<200	9	4	<20	63.4	12.0	<8	12	<200
[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
C2 BWWC MAGFRAC		<10	10.0	<200	3	2	<20	25.0	4.0	<6	<5	290
C2 BWWC -40MFSH WEAK		<10	28.0	<200	9	5	<20	70.0	7.8	11	11	<200
C2 BWWC -40MESH DIGEST		<27	570.0	<1300	24	94	<76	1310.0	117.0	<130	260	<200
C2 BWWC -40MFSH NON-MAG		<39	1000.0	<1900	26	158	<130	2610.0	217.0	<170	410	<200
C2 BWWC #11%-20MESH NON		<41	1030.0	<2100	28	164	<110	2870.0	182.0	<180	410	<200
[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
C2 RED BASIN 2CUFT		<24	473.0	<850	28	67	<79	1210.0	81.7	<110	150	<200
C2 RED BASIN -16MFSH		<10	14.0	<200	4	2	<20	38.0	4.7	7	<5	280
C2 S-S#1 -40MESH NON		<48	1270.0	<2500	29	217	<130	>3000.0	270.0	<210	644	<450
C2 S-W BUT-SPR NON-MAG		<25	554.0	<1400	12	89	<69	1430.0	93.1	<120	230	<200
C2 WIRESPOOL NON-MAG		<23	446.0	<850	13	68	<75	1200.0	86.0	<110	170	<200

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Geochemical Lab Report

REPORT: V88-02177.0

PROJECT: D-1 PAGE 10

SAMPLE NUMBER	ELEMENT UNITS	Zr PPM	Ce PPM	Dy PPM	Er PPM	Eu PPM	Gd PPM	Ho PPM	La PPM	Lu PPM	Nd PPM	Pr PPM
C2 #0015MAIN+FeOx LODE		<500										
C2 0030RAGGS RIDGE 2-5		<500										
C2 #0065WIRESPOOL LODE		<500										
C2 0070Cu HILLGNEISS		980										
C2 0085CW EPID PULV		<500										
C2 BWWC MAGFRAC		<500										
C2 BWWC -40MESH WEAK		<500	350	23	<100	3	<200	4	159.0	2.2	120	<50
C2 BWWC -40MESH DIGEST		2000	6170	403	470	50	<1000	101	3650.0	42.8	1780	<340
C2 BWWC -40MESH NON-MAG		5300	10600	699	<290	88	<1000	156	7000.0	66.7	2550	<630
C2 BWWC #II%-20MESH NON		2200	10500	929	<220	83	<1000	147	6630.0	63.0	2560	<590
C2 DELLS COMP-20MESH		4800										
C2 RED BASIN 2CUFT		3000	5410	358	<100	42	<1000	69	3230.0	25.8	1660	<320
C2 RED BASIN -16MESH		<500										
C2 S-S#1 -40MESH NON		5000	12000	1110	370	100	<1000	238	7790.0	97.9	2920	<710
C2 S-W BUT-SPR NON-MAG		2700	5630	439	490	41	<1000	88	3190.0	36.5	1640	<310
C2 WIRESPOOL NON-MAG		2900	4840	319	200	41	<1000	72	2780.0	27.1	1450	<290

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PROJECT: D-1

SAMPLE NUMBER	ELEMENT UNITS	Sc PPM	Sm PPM	Tb PPM	Th PPM	Tm PPM	U PPM	Yb PPM	Ti PPM	Y PPM
C2 #0015MAIN+FeOx LODE									>20000	
C2 0030RAGGS RIDGE 2-5									6750	
C2 #0065WIRESPOOL LODE									>20000	
C2 0070Cu HILLGNEISS										
C2 0085CW EPID PULV										10
C2 BWWC MAGFRAC									9850	
C2 BWWC -40MESH WEAK		17.30	24.5	2	65.4	<1.3	8	13.0	>20000	82=
C2 BWWC -40MESH DIGEST		26.00	488.0	61	1070.0	<4.0	87	297.0		2371=
C2 BWWC -40MESH NON-MAG		26.20	932.0	100	2040.0	<5.8	194	476.0	>20000	3872=
C2 BWWC #II%-20MESH NON		30.10	928.0	101	2220.0	<6.0	131	440.0		3717=
C2 DELLS COMP-20MESH										243
C2 RED BASIN 2CUFT		23.40	439.0	47	1050.0	<3.6	59	186.0		1540=
C2 RED BASIN -16MESH										
C2 S-S#1 -40MESH NON		17.50	1060.0	127	2320.0	<6.7	187	702.0	13700	5231=
C2 S-W BUT-SPR NON-MAG		12.70	463.0	60	1170.0	<3.7	62	252.0		2177=
C2 WIRESPOOL NON-MAG		20.10	380.0	46	1010.0	<3.4	64	185.0		1622=

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Geochemical Lab Report

REPORT: V88-10125.0

PROJECT: CW/K-4 PAGE 1A

SAMPLE NUMBER	ELEMENT UNITS	Au PPB	Ag PPM	As PPM	Ba PPM	Br PPM	Cd PPM	Ce PPM	Co PPM	Cr PPM	Cs PPM	Eu PPM
R2 D-1 CU ORIG. PIT		12	9	9	160	<1	<10	<10	15	350	<1	<2

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Geochemical Lab Report

REPORT: V88-10125.0

PROJECT: CW/K-4 PAGE 1B

SAMPLE NUMBER	ELEMENT UNITS	Fe PCT	Hf PPM	Ir PPB	La PPM	Lu PPM	Mo PPM	Na PCT	Ni PPM	Rb PPM	Sb PPM	Sc PPM
R2 D-1 CU ORIG. PIT		4.4	<2	<100	<5	<0.5	130	<0.05	<50	<10	0.4	<0.5

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Geochemical Lab Report

REPORT: V88-10125.0

PROJECT: CW/K-4 PAGE 1C

SAMPLE NUMBER	ELEMENT UNITS	Se PPM	Sm PPM	Sn PPM	Ta PPM	Tb PPM	Te PPM	Th PPM	U PPM	W PPM	Yb PPM	Zn PPM
R2 D-1 CU ORIG. PIT		14	2.1	<200	<1	1	<20	<0.5	19.0	774	<5	<200

NORTH AMERICAN LABORATORIES, INC.

CERTIFICATE OF ANALYSIS

Client Name: Robert Poley, Jr.
Address: 2020 Rockford Drive
Prescott, Arizona 86301
Telephone: 445-0356

Job Number: MA-1965
Date: May 31, 1985
Copies to:

Submitted by: Robert Poley, Jr.
Date Received: 4/20/85

Additional Info:

Client I.D.	Lab #	ICP Analysis	
		Fe_2O_3	TiO_2
		-----ppm------	
0008 Schist Ridge	1	91.76	11.92
0015 Main	2	92.82	10.76
0018 P.R.C.	3	74.66	5.92
0065 Wire Spool	4	80.49	11.19
0070 B.W.S. Wk Mag	5	81.02	4.27
0071 B.W.S. Non-Mag	6	73.15	9.58

Registered Assayer
CERTIFICATE NO. 15184
JAMES W. ANDERSON
Date Signed 6/1/85
ARIZONA, U.S.A.

These analyses are based on materials supplied by the client to whom and for whose exclusive and confidential use this report is made. North American Laboratories, Inc., and its officers and employees assume no responsibility and make no representations as to the productivity or profitability of any mineral deposit in connection with which this report is made.

We will store the PULPS for ONE YEAR in case you desire further analysis. They will be returned to you if you so request or be discarded after one year.

Mineral and Water Analysis

1022 West 23rd Street • Tempe, Az. 85282 • (602) 894-0919

FLUO RESCENT
X RAY
SPEC TROGRAPHIC
Analytical Laboratory

718 Sherman Street (rear)
Denver, Colorado 80203
Phone (303) 837-1396
Merlyn L. Salmon, Manager

XXXX QUALITATIVE
XXXX SEMI-QUANTITATIVE
____ QUANTITATIVE

ANALYTICAL REPORT

Job Number 32093
Page 1 of 3 Pages
Date 25 May 1985

TO: North American Labs J. Karolak

SAMPLE: MA-1965 #2
0015 Main

Copper	0.011	Iron	77.	Lanthanum	
Silver		Cobalt		Cerium	
Gold		Nickel		Praseodymium	
Zinc	0.014	Cesium		Neodymium	
Cadmium		Rubidium		Samarium	
Mercury		Barium	0.086	Europium	
Gallium		Strontium		Gadolinium	
Indium		Titanium	2.0	Terbium	
Thallium		Zirconium		Dysprosium	
Germanium		Hafnium		Holmium	
Tin		Thorium		Erbium	
Lead		Vanadium	0.13	Thulium	
Arsenic		Columbium	0.020	Ytterbium	
Antimony		Tantalum		Lutetium	
Bismuth		Chromium	0.041	Yttrium	
Selenium		Molybdenum			
Tellurium		Tungsten			
Bromine		Uranium			
Iodine		Manganese	0.078		

The values above are estimated elemental concentrations in:
XXXX per cent ____ parts per million ____ grams per liter

No check was made for elements with atomic numbers less than 22.

By Merlyn Salmon

NOTE: A PORTION OF THE REPORTED SAMPLES WILL BE RETAINED ON FILE FOR A PERIOD OF TWO YEARS FROM THE ABOVE DATE. THE REMAINDER OF THE SAMPLE WILL BE RETAINED FOR THIRTY DAYS PENDING RECEIPT OF WRITTEN INSTRUCTIONS FOR DISPOSAL FROM THE ADDRESSEE ABOVE.

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SPEC TROGRAPHIC
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Merlyn L. Salmon, Manager

XXXX QUALITATIVE
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ANALYTICAL REPORT

Job Number 32093
Page 3 of 3 Pages
Date 25 May 1985

TO: North American Labs

SAMPLE: MA-1965 #6
0071 B.W.S. Non-Mag

Copper	0.009	Iron	32.	Lanthanum	0.35
Silver		Cobalt		Cerium	0.87
Gold		Nickel	0.095	Praseodymium	
Zinc	0.043	Cesium		Neodymium	0.027
Cadmium		Rubidium	0.027	Samarium	
Mercury		Barium		Europium	
Gallium		Strontium	0.023	Gadolinium	
Indium		Titanium	0.87	Terbium	
Thallium		Zirconium	0.14	Dysprosium	
Germanium		Hafnium		Holmium	
Tin		Thorium	0.33	Erbium	
Lead	0.082	Vanadium	0.064	Thulium	
Arsenic		Columbium		Ytterbium	
Antimony		Tantalum		Lutetium	
Bismuth		Chromium	0.074	Yttrium	0.41
Selenium		Molybdenum			
Tellurium		Tungsten			
Bromine		Uranium			
Iodine		Manganese	0.11		

The values above are estimated elemental concentrations in:
XXXX per cent ____ parts per million ____ grams per liter

No check was made for elements with atomic numbers less than 22.

By Merlyn Salmon

NOTE: A PORTION OF THE REPORTED SAMPLES WILL BE RETAINED ON FILE FOR A PERIOD OF TWO YEARS FROM THE ABOVE DATE. THE REMAINDER OF THE SAMPLE WILL BE RETAINED FOR THIRTY DAYS PENDING RECEIPT OF WRITTEN INSTRUCTIONS FOR DISPOSAL FROM THE ADDRESSEE ABOVE.

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ANALYTICAL REPORT

Job Number 33749
Page 1 of 9 Pages
Date 11 Apr 1988

TO: R. Poley, Jr

SAMPLE: S-W Butt Spr Non Mag -20m

Copper	0.014	Iron	11.	Lanthanum	0.34
Silver		Cobalt		Cerium	0.65
Gold		Nickel	0.004	Praseodymium	0.018
Zinc	0.019	Cesium		Neodymium	0.084
Cadmium		Rubidium	0.004	Samarium	
Mercury		Barium	0.047	Europium	
Gallium		Strontium	0.006	Gadolinium	
Indium		Titanium	0.99	Terbium	
Thallium		Zirconium	0.047	Dysprosium	
Germanium		Hafnium		Holmium	
Tin		Thorium	0.13	Erbium	
Lead	0.029	Vanadium	0.087	Thulium	
Arsenic		Columbium	0.048	Ytterbium	
Antimony		Tantalum		Lutetium	
Bismuth		Chromium	0.11	Yttrium	0.21
Selenium		Molybdenum			
Tellurium		Tungsten			
Bromine		Uranium	0.007		
Iodine		Manganese	0.15		

The values above are estimated elemental concentrations in:
XXXX per cent ____ parts per million ____ grams per liter

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ANALYTICAL REPORT

Job Number 33749
Page 3 of 9 Pages
Date 11 Apr 1988

TO: R. Poley, Jr

SAMPLE: BWWC -40m digest

Copper	0.008	Iron	13.	Lanthanum	0.36
Silver		Cobalt		Cerium	0.83
Gold		Nickel	0.005	Praseodymium	0.090
Zinc	0.005	Cesium		Neodymium	0.093
Cadmium		Rubidium		Samarium	0.049
Mercury		Barium	0.056	Europium	
Gallium		Strontium	0.003	Gadolinium	
Indium		Titanium	2.8	Terbium	
Thallium		Zirconium	0.064	Dysprosium	
Germanium		Hafnium		Holmium	
Tin		Thorium	0.096	Erbium	
Lead		Vanadium	0.20	Thulium	
Arsenic		Columbium		Ytterbium	
Antimony		Tantalum		Lutetium	
Bismuth		Chromium	0.090	Yttrium	0.22
Selenium		Molybdenum			
Tellurium		Tungsten			
Bromine		Uranium			
Iodine		Manganese	0.36		

The values above are estimated elemental concentrations in:

XXXX per cent ____ parts per million ____ grams per liter

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ANALYTICAL REPORT

Job Number 33749
Page 7 of 9 Pages
Date 11 Apr 1988

TO: R. Poley, Jr

SAMPLE: Red Basin 2 cu ft -16m non mag

Copper	0.004	Iron	12.	Lanthanum	0.26
Silver		Cobalt		Cerium	0.63
Gold		Nickel	0.013	Praseodymium	
Zinc	0.011	Cesium		Neodymium	0.047
Cadmium		Rubidium		Samarium	
Mercury		Barium		Europium	
Gallium		Strontium	0.011	Gadolinium	
Indium		Titanium	1.8	Terbium	
Thallium		Zirconium	0.053	Dysprosium	
Germanium		Hafnium		Holmium	
Tin		Thorium	0.11	Erbium	
Lead		Vanadium	0.21	Thulium	
Arsenic	0.030	Columbium		Ytterbium	
Antimony		Tantalum		Lutetium	
Bismuth		Chromium	0.047	Yttrium	0.17
Selenium		Molybdenum			
Tellurium		Tungsten			
Bromine		Uranium			
Iodine		Manganese	0.25		

The values above are estimated elemental concentrations in:
XXXX per cent ____ parts per million ____ grams per liter

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ANALYTICAL REPORT

Job Number 33749
Page 8 of 9 Pages
Date 11 Apr 1988

TO: R. Poley, Jr

SAMPLE: SS #1 -40m non mag

Copper	0.002	Iron	6.6	Lanthanum	0.75
Silver		Cobalt		Cerium	1.5
Gold		Nickel		Praseodymium	0.054
Zinc	0.008	Cesium		Neodymium	0.084
Cadmium		Rubidium	0.010	Samarium	0.012
Mercury		Barium	0.10	Europium	
Gallium		Strontium	0.017	Gadolinium	
Indium		Titanium	0.33	Terbium	
Thallium		Zirconium	0.080	Dysprosium	
Germanium		Hafnium		Holmium	
Tin		Thorium	0.16	Erbium	0.023
Lead	0.028	Vanadium		Thulium	
Arsenic		Columbium	0.022	Ytterbium	0.013
Antimony		Tantalum		Lutetium	
Bismuth		Chromium	0.021	Yttrium	0.39
Selenium		Molybdenum			
Tellurium		Tungsten			
Bromine		Uranium			
Iodine		Manganese	0.14		

The values above are estimated elemental concentrations in:
XXXX per cent ____ parts per million ____ grams per liter

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ANALYTICAL REPORT

Job Number 33749
Page 9 of 9 Pages
Date 11 Apr 1988

TO: R. Poley, Jr

SAMPLE: Deer Ear -20m non mag

Copper	0.002	Iron	13.	Lanthanum	0.12
Silver		Cobalt		Cerium	0.29
Gold		Nickel	0.012	Praseodymium	
Zinc	0.011	Cesium		Neodymium	0.028
Cadmium		Rubidium	0.009	Samarium	
Mercury		Barium	0.054	Europium	
Gallium		Strontium	0.006	Gadolinium	
Indium		Titanium	0.97	Terbium	
Thallium		Zirconium	0.050	Dysprosium	
Germanium		Hafnium		Holmium	
Tin		Thorium	0.022	Erbium	
Lead		Vanadium	0.075	Thulium	
Arsenic		Columbium	0.004	Ytterbium	
Antimony		Tantalum		Lutetium	
Bismuth		Chromium	0.022	Yttrium	0.043
Selenium		Molybdenum			
Tellurium		Tungsten			
Bromine		Uranium			
Iodine		Manganese	0.18		

The values above are estimated elemental concentrations in:
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SKYLINE LABS, INC.
SPECIALISTS IN EXPLORATION GEOCHEMISTRY
12090 WEST 50TH PLACE • WHEAT RIDGE, COLORADO 80033 • TEL.: (303) 424-7718

REPORT OF ANALYSIS

JOB NO. KGH 001
March 28, 1985
PROJECT NO. D-1
SHIPMENT NO. 1

Robert Poley, Jr.
2020 Rockford Drive
Prescott, Arizona 86301

Analysis of 3 Concentrates

ITEM	SAMPLE NUMBER	Ta (ppm)	Nb (ppm)
1	0015	<20.	255.
2	0008	<20.	160.
3	XL 0000	<20.	195.

Gordon H. VanSickle
Manager

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ANALYTICAL REPORT

Job Number 32664
Page 1 of 13 Pages
Date 25 Jan 1986

TO: R. Poley, Jr

D-1

SAMPLE: II 1

Copper	0.004	Iron	34.	Lanthanum	0.17
Silver		Cobalt		Cerium	0.36
Gold		Nickel	0.059	Praseodymium	
Zinc	0.008	Cesium		Neodymium	0.028
Cadmium		Rubidium		Samarium	
Mercury		Barium		Europium	
Gallium		Strontium	0.018	Gadolinium	
Indium		Titanium	1.2	Terbium	
Thallium		Zirconium	0.074	Dysprosium	
Germanium		Hafnium		Holmium	
Tin		Thorium	0.089	Erbium	
Lead		Vanadium	0.091	Thulium	
Arsenic		Columbium	0.012	Ytterbium	
Antimony		Tantalum		Lutetium	
Bismuth		Chromium	0.10	Yttrium	0.22
Selenium		Molybdenum			
Tellurium		Tungsten			
Bromine		Uranium			
Iodine		Manganese	0.21		

The values above are estimated elemental concentrations in:

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ANALYTICAL REPORT

Job Number 32664
Page 2 of 13 Pages
Date 25 Jan 1986

TO: R. Poley, Jr

SAMPLE: II 2

Copper	0.011	Iron	28.	Lanthanum	0.054
Silver		Cobalt		Cerium	0.19
Gold		Nickel	0.046	Praseodymium	
Zinc	0.018	Cesium		Neodymium	
Cadmium		Rubidium		Samarium	
Mercury		Barium		Europium	
Gallium		Strontium	0.023	Gadolinium	
Indium		Titanium	1.0	Terbium	
Thallium		Zirconium	0.067	Dysprosium	
Germanium		Hafnium		Holmium	
Tin		Thorium	0.044	Erbium	
Lead	0.022	Vanadium	0.11	Thulium	
Arsenic		Columbium	0.017	Ytterbium	
Antimony		Tantalum		Lutetium	
Bismuth		Chromium	0.084	Yttrium	0.14
Selenium		Molybdenum			
Tellurium		Tungsten			
Bromine		Uranium	0.019		
Iodine		Manganese	0.14		

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ANALYTICAL REPORT

Job Number 32664
Page 3 of 13 Pages
Date 25 Jan 1986

TO: R. Poley, Jr

SAMPLE: II 3

Copper	0.008	Iron	36.	Lanthanum	0.45
Silver		Cobalt		Cerium	1.1
Gold		Nickel	0.015	Praseodymium	
Zinc	0.032	Cesium		Neodymium	0.018
Cadmium		Rubidium		Samarium	
Mercury		Barium		Europium	
Gallium		Strontium	0.006	Gadolinium	
Indium		Titanium	1.4	Terbium	
Thallium		Zirconium	0.074	Dysprosium	
Germanium		Hafnium		Holmium	
Tin		Thorium	0.12	Erbium	
Lead	0.028	Vanadium	0.12	Thulium	
Arsenic		Columbium	0.025	Ytterbium	
Antimony		Tantalum		Lutetium	
Bismuth		Chromium	0.11	Yttrium	0.37
Selenium		Molybdenum			
Tellurium		Tungsten			
Bromine		Uranium			
Iodine		Manganese	0.21		

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ANALYTICAL REPORT

Job Number 32664
Page 4 of 13 Pages
Date 25 Jan 1986

TO: R. Poley, Jr

SAMPLE: H-4

Copper	0.009	Iron	29.	Lanthanum	0.093
Silver		Cobalt		Cerium	0.27
Gold		Nickel	0.032	Praseodymium	
Zinc	0.032	Cesium		Neodymium	0.009
Cadmium		Rubidium	0.020	Samarium	
Mercury		Barium		Europium	
Gallium		Strontium	0.012	Gadolinium	
Indium		Titanium		Terbium	
Thallium		Zirconium	0.045	Dysprosium	
Germanium		Hafnium		Holmium	
Tin		Thorium	0.10	Erbium	
Lead	0.032	Vanadium	0.10	Thulium	
Arsenic		Columbium	0.007	Ytterbium	
Antimony		Tantalum		Lutetium	
Bismuth		Chromium	0.093	Yttrium	0.083
Selenium		Molybdenum			
Tellurium		Tungsten			
Bromine		Uranium			
Iodine		Manganese	0.21		

The values above are estimated elemental concentrations in:

XXXX per cent ____ parts per million ____ grams per liter

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By Merlyn L. Salmon

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ANALYTICAL REPORT

Job Number 32664
Page 5 of 13 Pages
Date 25 Jan 1986

TO: R. Poley, Jr

SAMPLE: II 5

Copper	0.018	Iron	34.	Lanthanum	0.33
Silver		Cobalt		Cerium	0.81
Gold		Nickel	0.059	Praseodymium	0.018
Zinc	0.028	Cesium		Neodymium	0.037
Cadmium		Rubidium		Samarium	
Mercury		Barium	0.060	Europium	
Gallium		Strontium	0.012	Gadolinium	
Indium		Titanium	1.4	Terbium	
Thallium		Zirconium	0.072	Dysprosium	
Germanium		Hafnium		Holmium	
Tin		Thorium	0.12	Erbium	
Lead		Vanadium	0.091	Thulium	
Arsenic		Columbium	0.030	Ytterbium	
Antimony		Tantalum		Lutetium	
Bismuth		Chromium	0.090	Yttrium	0.19
Selenium		Molybdenum			
Tellurium		Tungsten			
Bromine		Uranium	0.035		
Iodine		Manganese	0.22		

The values above are estimated elemental concentrations in:
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ANALYTICAL REPORT

Job Number 32664
Page 6 of 13 Pages
Date 25 Jan 1986

TO: R. Poley, Jr

SAMPLE: II 6

Copper	0.021	Iron	51.	Lanthanum	0.11
Silver		Cobalt		Cerium	0.26
Gold		Nickel	0.073	Praseodymium	
Zinc	0.037	Cesium		Neodymium	0.009
Cadmium		Rubidium		Samarium	
Mercury		Barium		Europium	
Gallium		Strontium	0.014	Gadolinium	
Indium		Titanium	1.2	Terbium	
Thallium		Zirconium	0.092	Dysprosium	
Germanium		Hafnium		Holmium	
Tin		Thorium	0.20	Erbium	
Lead	0.036	Vanadium	0.10	Thulium	
Arsenic		Columbium	0.032	Ytterbium	
Antimony		Tantalum		Lutetium	
Bismuth		Chromium	0.12	Yttrium	0.16
Selenium		Molybdenum			
Tellurium		Tungsten			
Bromine		Uranium	0.070		
Iodine		Manganese	0.22		

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ANALYTICAL REPORT

Job Number 32664
Page 7 of 13 Pages
Date 25 Jan 1986

TO: R. Poley, Jr

SAMPLE: II 7

Copper	0.016	Iron	35.	Lanthanum	0.28
Silver		Cobalt		Cerium	0.66
Gold		Nickel	0.059	Praseodymium	
Zinc	0.008	Cesium		Neodymium	
Cadmium		Rubidium		Samarium	
Mercury		Barium		Europium	
Gallium		Strontium		Gadolinium	
Indium		Titanium	1.1	Terbium	
Thallium		Zirconium	0.053	Dysprosium	
Germanium		Hafnium		Holmium	
Tin		Thorium	0.14	Erbium	
Lead		Vanadium	0.11	Thulium	
Arsenic		Columbium		Ytterbium	
Antimony		Tantalum		Lutetium	
Bismuth		Chromium	0.14	Yttrium	0.24
Selenium		Molybdenum			
Tellurium		Tungsten			
Bromine		Uranium			
Iodine		Manganese	0.11		

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ANALYTICAL REPORT

Job Number 32664
Page 9 of 13 Pages
Date 25 Jan 1986

TO: [redacted]
R. Poley, Jr

SAMPLE: III 7

Copper	0.012	Iron	49.	Lanthanum	0.37
Silver		Cobalt		Cerium	0.82
Gold		Nickel	0.022	Praseodymium	
Zinc	0.023	Cesium		Neodymium	0.028
Cadmium		Rubidium		Samarium	
Mercury		Barium	0.068	Europium	
Gallium		Strontium	0.008	Gadolinium	
Indium		Titanium	1.5	Terbium	
Thallium		Zirconium	0.21	Dysprosium	
Germanium		Hafnium		Holmium	
Tin		Thorium	0.21	Erbium	
Lead		Vanadium	0.16	Thulium	
Arsenic		Columbium		Ytterbium	
Antimony		Tantalum		Lutetium	
Bismuth		Chromium	0.11	Yttrium	0.23
Selenium		Molybdenum			
Tellurium		Tungsten			
Bromine		Uranium			
Iodine		Manganese	0.25		

The values above are estimated elemental concentrations in:
XXXX per cent ____ parts per million ____ grams per liter

No check was made for elements with atomic numbers less than 22.

By Merlyn Salmon

NOTE: A PORTION OF THE REPORTED SAMPLES WILL BE RETAINED ON FILE FOR A PERIOD OF TWO YEARS FROM THE ABOVE DATE. THE REMAINDER OF THE SAMPLE WILL BE RETAINED FOR THIRTY DAYS PENDING RECEIPT OF WRITTEN INSTRUCTIONS FOR DISPOSAL FROM THE ADDRESSEE ABOVE.

FLUO RESCENT
X RAY
SPEC TROGRAPHIC
Analytical Laboratory

718 Sherman Street (rear)
Denver, Colorado 80203
Phone (303) 837-1396
Merlyn L. Salmon, Manager

XXXX QUALITATIVE
XXXX SEMI-QUANTITATIVE
_____ QUANTITATIVE

ANALYTICAL REPORT

Job Number 32664
Page 10 of 13 Pages
Date 25 Jan 1986

TO: R. Poley, Jr

SAMPLE: II 7 Mag

Copper	0.011	Iron	63.	Lanthanum	
Silver		Cobalt		Cerium	
Gold		Nickel	0.046	Praseodymium	
Zinc	0.024	Cesium		Neodymium	
Cadmium		Rubidium		Samarium	
Mercury		Barium	0.037	Europium	
Gallium		Strontium		Gadolinium	
Indium		Titanium	0.69	Terbium	
Thallium		Zirconium	0.048	Dysprosium	
Germanium		Hafnium		Holmium	
Tin		Thorium		Erbium	
Lead	0.082	Vanadium	0.018	Thulium	
Arsenic		Columbium	0.010	Ytterbium	
Antimony		Tantalum		Lutetium	
Bismuth		Chromium	0.18	Yttrium	
Selenium		Molybdenum			
Tellurium		Tungsten			
Bromine		Uranium			
Iodine		Manganese	0.11		

The values above are estimated elemental concentrations in:

XXXX per cent _____ parts per million _____ grams per liter

No check was made for elements with atomic numbers less than 22.

By Merlyn Salmon

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XXXX SEMI-QUANTITATIVE
____ QUANTITATIVE

ANALYTICAL REPORT

Job Number 32664
Page 12 of 13 Pages
Date 25 Jan 1986

TO: R. Poley, Jr

SAMPLE: BWWC II

Copper	0.005	Iron	31.	Lanthanum	0.92
Silver		Cobalt		Cerium	2.4
Gold		Nickel	0.026	Praseodymium	0.018
Zinc	0.018	Cesium		Neodymium	0.047
Cadmium		Rubidium		Samarium	0.012
Mercury		Barium	0.11	Europium	
Gallium		Strontium	0.006	Gadolinium	
Indium		Titanium	2.1	Terbium	
Thallium		Zirconium	0.10	Dysprosium	
Germanium		Hafnium		Holmium	
Tin		Thorium	0.45	Erbium	
Lead		Vanadium	0.12	Thulium	
Arsenic		Columbium	0.059	Ytterbium	
Antimony		Tantalum		Lutetium	
Bismuth		Chromium	0.097	Yttrium	0.61
Selenium		Molybdenum			
Tellurium		Tungsten			
Bromine		Uranium			
Iodine		Manganese	0.27		

The values above are estimated elemental concentrations in:
XXXX per cent ____ parts per million ____ grams per liter

No check was made for elements with atomic numbers less than 22.

By Merlyn L Salmon

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Merlyn L. Salmon, Manager

XXXX QUALITATIVE
XXXX SEMI-QUANTITATIVE
____ QUANTITATIVE

ANALYTICAL REPORT

Job Number 32664
Page 13 of 13 Pages
Date 25 Jan 1986

TO: R. Poley, Jr

SAMPLE: BWWC TI Mag

Copper	0.005	Iron	63.	Lanthanum	0.022
Silver		Cobalt		Cerium	0.068
Gold		Nickel	0.030	Praseodymium	
Zinc	0.018	Cesium		Neodymium	
Cadmium		Rubidium		Samarium	
Mercury		Barium	0.037	Europium	
Gallium		Strontium		Gadolinium	
Indium		Titanium	0.91	Terbium	
Thallium		Zirconium	0.072	Dysprosium	
Germanium		Hafnium		Holmium	
Tin		Thorium		Erbium	
Lead		Vanadium	0.082	Thulium	
Arsenic		Columbium	0.010	Ytterbium	
Antimony		Tantalum		Lutetium	
Bismuth		Chromium	0.22	Yttrium	0.010
Selenium		Molybdenum			
Tellurium		Tungsten			
Bromine		Uranium			
Iodine		Manganese	0.13		

The values above are estimated elemental concentrations in:
XXXX per cent ____ parts per million ____ grams per liter

No check was made for elements with atomic numbers less than 22.

By Merlyn L. Salmon

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IRON KING ASSAY INC.

29-Nov-86

LAB JOB #: MSC01137

Client name: Bob Poley, Jr.

Billing address: 2020 Rockford Dr.
Prescott, AZ 86301

Phone number: 445-0356

No. Samples: 10
Date Received: 11-19-86
Submitted by: same

INVOICE ATTACHED

ANALYTICAL REPORT

Client ID MSC01137	Lab ID	FA/AA Au oz/ton
Fe-Si Hill	1137- 1	0.0006
1/4 Corner Diss.	1137- 2	<.0003
Fe Cube Vein	1137- 3	<.0003
Fe Cube Diss.	1137- 4	<.0003
Ky-Sulf. Diss.	1137- 5	<.0003
Main Cu Prospect Wallrock	1137- 6	<.0003
N.E. Corn. Ridge Diss.	1137- 7	<.0003
W. Ridge Vein Comp.	1137- 8	<.0003
NE Corn. Ridge Vein	1137- 9	<.0003
Main #015 Ti	1137- 10	<.0003

REGISTERED ASSAYER CERTIFICATE No. 14315 ROBERT G. BROOK Signed 11-30-86 ARIZONA, U.S.A.

P.O. Box 56 • Humboldt, Arizona 86329 • Phone (602) 632-7410

2. FIELD GUIDE AND CHECK LIST FOR PLACER INVESTIGATIONS

1. Date of examination Summer And Fall 1989

2. NAME OF CLAIM(s) OR PROPERTY Zuma placer claims: 37 660 foot by 1320 foot contigous claim group, approximately 20 ACRES each

3. State Arizona, County Yavapai District none

4. Township 15 North, Range 4 45 West, Section(s) See Claim Group MAP

5. REASON FOR EXAMINATION Determine economic mineral content, concentration, yardage, markets And processing for gravels on Zuma placer claims

6. EXAMINED BY Robert Poley Jr. - Minerals Consultant

7. Assisted by Robert Poley Sr.

8. Others present None

9. Number of claims or acres 37 contigous placer claims of approximately 20 Acres each; 740 total

10. NAMES OF LOCATORS AND PRESENT OWNER Located And presently owned by Robert Poley Jr And Robert Poley Sr.

11. Owner's Address 2020 Rockford Dr., Prescott, Ariz. 86301 Tele: (602) 445-0356

12. TYPE OF DEPOSIT (stream, bench, desert, etc.) Several washes from mineralized lodes empty into A wide low gradient basin dropping thier heavy minerals.

13. Terrain Dissected low rolling hills feed washes which in turn dump into low gradient basin.

14. Gradient of deposit: Less than 5% (X); More than 5% ( ).
Remarks Gradient drop combined with unconfined basin results in deposition of heavy minerals

15. Is the deposit dissected by deep washes or old workings? Yes ( ); No ( ).
Remarks Washes dissect gravels At the head of the basin to A depth of 6 to 8 feet. No old workings.

16. Type and extent of overburden Surface gravels mineralized And minerals Appear to occur throughout the total thickness of gravels.

17. Depth to permanent water table Several springs surface on And around the claim group.

18. Depth to bedrock Unknown, topography Adjacent to washes And basin can be used to predict depth to bedrock.

19. Kind of bedrock (rock type) Micaseous Schist & Gneiss And Kyanite, Magnetite, Ilmenite Schist And Gneiss

20. Hardness of bedrock Moderate - no gold concentration no bedrock need removal

21. Bedrock slope or contour to be expected Unknown
Probably undulation bedrock due to different rock types, topography adjacent to basin can be used to predict bedrock slope

22. Are high bedrock pinnacles or reefs in evidence? Yes ( ); No (X).
Remarks No pinnacles or reefs observed in upper reaches of washes where bedrock is exposed

23. Gravel is: Well-rounded ( ); Sub-rounded or Sub-angular (X); Angular ( ).
Remarks Gravels fairly close to source drainage within several miles of headwaters

24. Does gravel contain rocks over 10-inch ring size? Yes (X); No ( ).
Remarks Where washes empty into basin scattered small boulders Are present.

25. BOULDERS (Max. size, number, distribution, etc.) Boulders occur sporadically in the source washes up to several feet in diameter but rarely over 10" in major washes and alluvial valley.

26. Rock types noted in gravel Schists, Gneiss, Migmatites, Aplite pegmatite quartz gabbro in order of abundance. Predominately schist and gneiss.

27. Predominent rock type (if any) Kyanite, ilmenite, mica quartz schist and gneiss

28. SAND (kind, amount, distribution, etc.) Coarse and medium grained sand predominates in the basin especially the low portion of the basin.

29. Sorting or bedding patterns (if apparent) Mineralized gravels travel down confined washes to unconfined basin where coarse and heavy material is dropped and braided and sheet-flow occurs.

30. STICKY CLAY? Yes ( ); No (X). Remarks Gradient of drainages and weathering products of host rocks produces little clay and only a couple % deposited.

31. Cemented gravel? Yes ( ); No (X). Remarks Recent deposition and lack of calcium carbonate is characteristic

32. Caliche? Yes ( ); No (X). Remarks No caliche or cementation exists in the gravels or alluvium in the gravels

33. Permafrost? Yes ( ); No (X). Remarks Too hot in Arizona.

34. Buried timber? Yes ( ); No (X). Remarks No timber

35. Hard or abrasive digging conditions? Yes ( ); No (X). Remarks Gravels are recent with no compaction from lithostatic lodes. Gravels loose and not more abrasive than normal gravels

36. Character of gold: Coarse ( ); Flaky ( ); Fine ( ); Rough ( ); Shotty ( ); Smooth ( ); Bright ( ); Stained or coated ( ). Remarks No gold but description of economic minerals is attached. Economic minerals: 95% between -20 to +100 mesh

37. Can good recovery be expected by use of riffles or jigs? Yes ( ); No ( ). Remarks Prelimenary tests suggest spirals, low intensity wet magnetics and hi-intensity magnetics work.

38. Is recovery said to depend on secret process or special equipment? Yes ( ); No (X). Remarks Standard heavy mineral separation equipment; Carpco or riechart spirals used on beach sand heavy mineral deposits will recover.

39. Are black sands said to contain locked gold values? Yes ( ); No (X). Remarks Analysis shows no interesting gold values

40. Have black sands been checked for valuable minerals other than gold? Yes (X); No ( ). Remarks See attached geochemistry in Tire-Tiky report and Mineralogical descriptions of Zuma Placer Claim Group Yavapai Co. Ariz.

41. Distribution of values in deposit (if known) Probably similar to alluvial fan where values concentrate at head of fan and decrease toward tail of fan.

42. Record or evidence of previous sampling Extensive presence/absence sampling has been done on regional level. Anomalous rare-earths are confined to the claim groups.

43. Results of prior sampling (if known) No sampling done prior to attached geochemistry.

44. Are old workings in evidence? Yes ( ); No (X). Remarks Small pits in mineralized quartz veins occur sporatically

45. Past production (if known) None

46. Date of last production or work N/A

47. Reason for quitting N/A

48. Present work (if any) Sampling and separation tests, concentration tests and potential market studies.

49. APPLICABLE MINING METHOD Track excavator, trommel or screen plant, spirals, wet drum magnetic separator, spirals, wet variable intensity magnetic separator

Possible cost to bring property into production Unknown
Mineral separation studies need to be completed first. Also commodity uses and markets need additional studies.

51. POSSIBLE MINING COST See Attached Sheet: USBM Rare earth production costs

52. Dimensions of (physically) minable ground ~ 2,890,000 square yards of minable ground

53. Possible extensions Erosion dikes built across sandwashes would retain substantial yardage of material washed from barren hillsides during heavy rains.

54. Maximum yardage indicated to date 2,890,000 sq. yds
90 feet deep (30 yards)
86,700,000 cubic yards

55. Mining equipment on ground None

56. Accessory equipment or improvements on ground None

57. Water supply Numerous springs dot the area some are located on the claim groups. Wells below the property on the Z3 ranch produce an ample flow of water for irrigation.

58. Power supply Power lines cross the southernmost extent of the claim group.

59. DOES PROPERTY HAVE ADEQUATE TAILINGS DUMP ROOM? Yes (X); No ( ). Remarks
Large areas available for tailing disposal

60. Would mining in this area come under County, State or Federal water Quality control regulations?

Yes (X); No ( ). Remarks

61. Fish and Game regulations? Yes ( ); No (X). Remarks

62. CAN SETTLING PONDS BE BUILT TO EFFECTIVELY RETAIN OR CLARIFY THE MUDDY WATER? Yes (X); No ( ). Remarks

63. IS PROPERTY SUBJECT TO RESOILING OR OTHER SURFACE RESTORATION REGULATIONS?

Yes ( ); No ( ). Remarks unknown

64. Elevation of property ~ 4800 feet

65. Climate Mild winters and summers

66. Working season year round

67. Season governed by Ambition

68. Surface cover and its effect on mining Scrub oak brush and some juniper, generally barren. Scant cover should not affect mining.

69. Merchantable timber or other surface values Some firewood marginal grazing for livestock

70. Nearest town Prescott pop. 60,000 20 miles.

71. Access 16 miles paved state highway from Prescott Arizona plus 4 miles improved all weather dirt road to property.

72. Reference maps See Tire-Tiky report

73. Aerial photos (USGS, Forest Service, etc.) Available USFS and EROS Data Center
I have color Air photos

74. Reference literature See Tire-Tiky Report References, Mineralogical description of Zuma Claim Group, Attached literature

75. Previous examinations or reports Tire-Tiky Lode Claim Report

76. Other reference sources Numerous papers and articles on commodities and markets available on request

77. SAMPLING (describe or attach notes) Sampling started regionally as presence/absence testing to delinate extent of mineralization. Representative bulk samples have been taken, and a multi-ton sample is being processed.

78. Additional information and remarks Any question please call (602) 445-0356
Mineral separation test are currently being conducted at two test labs operated by equipment manufactures

79. Attach suitable map or sketches (if needed). See Tire-Tiky Geologic map

80. Attach photographs of pertinent features (if available).

Mineralogy of the Heavy Mineral fraction from the Zuma Placer Claim Group Yavapai County Arizona

Prelimenary observations and tests on the heavy mineral fraction derived from the Zuma placer claim group whose source areas are the Tire-Tiky Lode claim group is herein described by suspected mineralogy. Prelimenary mineralogical determination was accomplished by common physical tests, visual examination with 10X handlens and 40X microscope, magnetic separation tests, Acid digestion tests, ultra violet mineral lamp examination, gamma-ray scintillometer tests and frequent examination of mineralogical handbooks.

Chemical analysis of heavy mineral concentrates was achieved by the use of Neutron Activation, Flourescent X-Ray Spectrometry, Inductively Coupled Plasma Spectrometry, Fire Assay - Atomic Absorption

Copies of all Assay results and companies which performed the analysis can be reviewed in the appendicies of the Tire-Tiky Lode Claim Group Prelimenary Report.

Comparison of chemical analysis with physical tests and observations helped determine the mineralogy of the different minerals comprising the magnetic and non-magnetic portions of the heavy mineral fraction. Sieve analysis also helps isolate different minerals in the non-magnetic heavy mineral fraction.

Mineralogy - Zuma Placer Claim Group

Kyanite, Al_2SiO_5 Triclinic-pinacoidal

Physical properties: Color white to creamy sometimes greenish; luster glassy; hardness 5 along prism, 7 across; specific gravity 3.6-3.7; fracture splintery across crystals; clevage perfect pinacoidal; transparent to translucent.

Grain/Crystal description: Grains subangular to angular bladed crystal laths with splintery appearance. Placer grains predominatly 1-2 mm mono mineralic laths. Kyanite found in pegmatite margins comprise boulders of several hundred pounds with crystals up to a foot long common.

Kyanite is abundant and obvious in sand size grain in the placer gravels and mineralized zones. Heavy mineral fractions were processed to retain minerals with specific gravity of 4.5 or greater removing the kyanite from the heavy concentrate.

Composition: Aluminum silicate (63.2% Al_2O_3, 36.8% SiO_2)
Kyanite is the predominate Al_2SiO_5 mineral occuring on the Tire-Tiky claim group, other Al_2SiO_5 minerals observed are andalusite and sillimanite in lesser abundance.

Distinguishing Characteristics: Distinctive crystal laths with splintery appearance, hardness tests on large remobilized bladed crystal aggregates confirm identification. Infusible and insoluble. Concentrates in middlings not heavy mineral fraction.

Occurence-Environment on Tire-Tiky claim group: Kyanite generally occurs as bladed crystal laths enveloping porphyroblasts of magnetite, ilmenite and quartz in the Alumino silicate-magnetite-ilmenite-rare earth isograd extending 6000 feet in width and 10,000 feet in length.

Estimated amount per yard bank run: Prelimenary tests indicate approximately 20% of bank run material is kyanite. Large areas of lode mineralization contain 20-30% kyanite.

Mineralogy - Zuma Placer Claim Group

Xenotime $Y(PO_4)$ Tetragonal; ditetragonal bipyramidal
Physical properties: Color: Colorless to yellow, pale brown yellow-brown, flesh, reddish-yellow orange, light greenish yellow; luster vitreous to resinous; hardness 4-5; specific gravity 4.5-5.1; fracture uneven to splintery; cleavage 1/100? imperfect, transparent to opaque streak pale brown to yellowish; Moderately paramagnetic. Slightly radioactive; tetragonal

Grain/Crystal description: Grains resemble zircon but not fluorescent. Small-40mesh 10% euhedral to subhedral 20% crystal grains. rare Detrital grains are sometimes doubly terminated euhedra, slightly abraded or somewhat rounded prisms. -60mesh (2.0-2.5 ø) subhedral to subangular grains frosted appearance variable color

Xenotime comprises 7-10% of the -60mesh non-magnetic concentrate. Less than 10% -100 mesh (3.0 ø) to +200mesh; no xenotime grains smaller than 200 m. (3.5 ø) 80% of the -60mesh grains appear to be between -60 and +80 mesh.

Composition: Yttrium phosphate $Y(PO_4)$
Substitution of yttrium in considerable part by heavy rare earth elements. Xenotime from Tire-Tiky claim group contains abundant heavy rare earths including

Distinguishing Characteristics: Some xenotime shows strong electromagnetism (near that of ilmenite) and may display distinct yellow fluorescence (Tb). Isostructural with zircon but zircon usually fluorescent and not paramagnetic. Xenotime and zircon from Zuma placers look very much alike.

Occurence - Environment on Tire-Tiky claim group:
Xenotime occur as disseminated grains throughout the Aluminosilicate-magnetite-ilmenite-rare earth isograd extending 6000 feet wide by 10,000 feet long. Xenotime is most highly concentrated in biotite rich zones.

Estimated Amount per yard bankrun: Prelimenary tests indicate approximately 1 pound of xenotime per yard.

Mineralogy - Zuma Placer Claim Group

Ilmenite $FeTiO_3$ Hexagonal - rhombohedron

Physical properties: Color black to brownish black luster metallic to submetallic; hardness 5-6; Specific gravity 4.1 - 4.8; streak black to brownish red fracture conchoidal to subconchodial; no clevage; brittle; weakly magnetic with hand magnet.

Grain/Crystal description: Microscopic exam of heavy mineral fractions derived from Tire-Tiky Lode Claims contain 30-35% ilmenite grains in the -20 mesh fraction. The grains are Angular to subangular with granular texture, uneven fracture, some hematite stain, Abundant intergrowths with magnetite, quartz, and Aluminosilicate minerals, 90% of placer grains -40 to +80 mesh. Handsamples containing ilmenite are of variable texture and composition including graphic quartz-ilmenite veins, equigranular quartz-mica-feldspar-ilmenite nonfoliated rocks and numerous foliated and crenulated texture with highly variable mineral composition.

Composition: An iron titanium oxide (36.8% Fe, 31.6% Ti, 31.6% O) Ilmenite is one of the easily seprable Titanium minerals occuring in the Zuma placer claims. Other titanium minerals; rutile, Anatase and leucoxene are thought to be recognizable in non-magnetic heavy mineral concentrates. Intergrown commonly with magnetite

Distinguishing Characteristics: Similar to magnetite but weakly magnetic, color of streak distinguishes it from hematite.

Occurence - Environment on Tire-Tiky claim group: Ilmenite generally occurs as porphyroblasts in the Aluminosilicate-magnetite-ilmenite-rare earth isograd extending 6000 feet in width and 10,000 feet in length. Ilmenite grains occuring in the lode range in size from 1cm to .1mm but generally are ~1mm, subrounded porphyroblasts encased in kyanite sheaths and quartz, commonly intergrown with magnetite.

Mineralogy - Zuma Placer Claim Group

Magnetite, Fe_3O_4 Cubic-hexoctahedral

Physical properties: color black to reddish brown; luster metallic sometimes dull; hardness 6½-7; specific gravity 5.3; streak black to reddish brown; fracture subconchoidal to uneven, no clevage; strongly magnetic.

Grain/Crystal description: Grains subangular to subrounded 95% > 5% octahedron crystals; 98% of placer magnetic fraction -20 mesh; -20 mesh to +40 mesh 17→20% of total -40 mesh 83→80% of total -20 mesh fraction. ~80% of -40 mesh fraction between 40 and 80 mesh.

Composition: (72.4% Fe, 27.6% O); Elements which substitute for Fe on the Tire-Tiky Claim group are chromium, columbium, barium, nickel, manganese, cerium, lanthanum, yttrium, titanium vanadium, zinc, zirconium intergrowth of other mineral could explain elements.

Distinguishing Characteristics: The strong magnetism distinguishes it from other similar minerals.

Occurence-Environment on Tire-Tiky claim group: Magnetite occurs as porphyroblasts in the Aluminosilicate-magnetite-ilmenite-rare earth isograd extending 6000 feet in width and 10,000 feet in length. Magnetite grains occuring in the lode range in size from 1 cm to .1mm but generally are ~1 mm, subrounded porphroblasts encased in sheaths of kyanite and quartz; commonly intergrown with ilmenite and related minerals.

Estimated Amount per yard bankrun: Prelimenary tests indicate approximately 100 lbs of magnetite is recoverable per yard of bank run material. Magnetite comprises ~50% of the heavy mineral fraction recovered by simple gravity methods.

Mineralogy - Zuma Placer Claim Group

Monazite $(Ce, La, Th)(PO_4)$ Monoclinic - prismatic

Physical properties: Color yellow to reddish brown to reddish orange; luster subadamantine to resinous; hardness 5-5.5; specific gravity 4.9-5.3; streak light yellow brown; fracture conchoidal to uneven; clevage one good, several poor, with well developed basal partings; brittle; transparent to translucent; slightly radioactive

Grain Crystal description: Grains euhedral to anhedral, 50% of BWWC grains euhedral to subhedral tabular and blocky crystals; semi-translucent with yellow dendritic inclusions. Surfaces of crystals and grains have frosted to etched textures. Surface of grains fairly dull on weathered surface. Inclusions are rare and intergrowths with other minerals rare. Grain size is -20 mesh to +80 mesh, most grains tend to be from 35 to 60 mesh in size. Grains appear to be competent with few internal fractures.

Composition: Phosphate of cerium, lanthanum and other light rare earths with a little uranium and some thorium and silica. (About 35% Ce_2O_3, 35% La_2O_3 and 30% P_2O_5) Refer to Bondar-Clegg rare-earth analysis for Tire-Tiky light rare earths.

Distinguishing Characteristics: Crystal shape, color, clevage and slight radioactivity combined help to identify monazite. Check with gamma-ray scintillometer help simplify detection.

Occurence - Environment on tire-tiky claim group: Monazite occurs as disseminated mineral grains in the aluminosilicate-magnetite-ilmenite-rare earth isograd extending 6000 feet in width and 10,000 feet in length. Higher concentrations on monazite and xenotime occur in biotite rich zones throughout the claim groups.

Estimated Amount per yard bank run: Prelimenary tests indicate approximately 3 to 5 pounds of monazite per yard of bank run material is present in placer gravels.

Rare-Earth Minerals and Metals

By James B. Hedrick[1]
202-634-1058

Domestic production of rare-earth concentrates in 1987 increased as a result of increased demand for television and lighting phosphors, glass-polishing compounds, and permanent magnets. However, mines continued to operate at about two-thirds of their rated production capacity. Foreign sources of rare earths obtained a smaller share of the U.S. market, while domestic exports increased from 1986 levels. Molycorp Inc. and Associated Minerals (USA) Ltd. Inc. were the only domestic mine producers of commercial quantities of rare-earth minerals.

Domestic Data Coverage.—Domestic mine production data for rare earths are developed by the Bureau of Mines from the voluntary "Rare-Earths and Thorium" survey. The two mines to which a survey form was sent responded, representing 100% of total production. Production data are withheld to avoid disclosing company proprietary data.

Table 1.—Salient U.S. rare-earth statistics

(Metric tons of rare-earth oxides (REO) unless otherwise specified)

	1983	1984	1985	1986	1987
Production of rare-earth concentrates[1]	17,083	25,311	13,428	11,094	16,710
Exports:[e]					
Ore and concentrate	2,684	4,304	4,419	3,433	4,534
Ferrocerium and pyrophoric alloys	59	27	23	29	82
Imports for consumption:[e]					
Monazite	2,215	3,114	3,132	1,628	617
Metals, alloys, oxides, compounds	1,857	2,926	1,124	1,155	625
Stocks, Dec. 31: Producers' and processors'	W	W	W	W	W
Consumption, apparent[e]	19,600	21,400	12,100	11,800	9,400
Prices, Dec. 31: Dollars per kilogram:					
Bastnasite concentrate, REO basis	$2.14	$2.14	$2.14	$2.14	$2.31
Monazite concentrate, REO basis	$0.71	$0.64	$1.09	$1.06	$0.90
Mischmetal, metal basis	$12.35	$12.35	$12.35	$12.35	$12.35
Employment, mine and mill[e] [2]	266	321	330	283	299
Net import reliance[e] [3] as a percent of apparent consumption	12	([4])	([4])	5.94	([4])

[e]Estimated. W Withheld to avoid disclosing company proprietary data.

[1]Comprises only the rare earths derived from bastnasite, as reported in Unocal Corp. annual reports.

[2]Employment at a rare-earth mine in California and at mineral sands operations in Florida and Georgia. The latter mines produced monazite concentrate as a byproduct of mining ilmenite, rutile, and zircon, and employees were not assigned to specific commodities.

[3]Imports minus exports plus adjustments for Government and industry stock changes.

[4]Increase in industry stocks exceeded net imports.

Legislation and Government Programs.—Sales of materials held in the National Defense Stockpile (NDS), including rare earths in sodium sulfate, continued to be suspended during 1987 because the $250 million limit imposed on the NDS Transaction Fund was exceeded during 1985. Under the Department of Defense Authorization Act, 1987 (Public Law 99-661), no rare earths were authorized for disposal in fiscal year 1987. In fiscal year 1988, beginning October 1, 1987, the Department of Defense Authorization Act for fiscal years 1988 and 1989 (Public Law 100-180) continued authorization in effect on September 30, 1987. It authorized the President to change the stockpile requirements by less than 10% by submitting an explanation and justification to Congress, to be effective on or after the first day of the next fiscal year. Changes greater than 10% were to require congressional approval. Public Law 100-180 also directed the President to designate a single Federal office to have responsibility for the NDS. At yearend, it was expected that the Defense Logistics Agency, under the U.S. Department of Defense, would be directed to this task.

Environmental Issues.—The California Desert Protection Act of 1987 proposed to close approximately 8 million acres of California desert to mining exploration and development. Minerals known to occur in the region covered by the act include gold, rare earths, silver, and various industrial minerals. The proposed area is also bordered by the principal world producer of rare earths, the Mountain Pass Mine. The area has been identified as having high-to-moderate resource potential. Exclusion of exploration in this area could be critical if the United States needs additional supplies of rare earths.[2]

DOMESTIC PRODUCTION

In 1987, rare earths were mined and concentrated at Molycorp's Mountain Pass Mine in California and Associated Minerals' Green Cove Springs Mine in Florida. Molycorp, Rhône-Poulenc Inc., W. R. Grace & Co.'s Davison Chemical Div., and Research Chemicals Div. of NUCOR Corp. were the principal processors of rare earths in the United States.

Molycorp, the only domestic producer of the mineral bastnasite, a rare-earth fluocarbonate, announced a 5-year modernization and expansion program to increase its production of refined oxides and metals, especially neodymium, for use in permanent magnets, and cerium for use in automotive catalysts. The company reported sales of rare earths were up 14% from that of 1986.[3]

Australian-owned Associated Minerals was the only commercial mineral sands operation in the United States to recover the mineral monazite, a rare-earth phosphate. Monazite was recovered at Associated Minerals' Florida operations as a byproduct of processing heavy-mineral sands for the titanium minerals ilmenite, leucoxene, and rutile, and for the zirconium mineral zircon.

Neomet Corp., a joint venture of REMACOR and Mitsubishi Metal Corp., began commercial production of neodymium metal for use in high-strength permanent magnets from its plant at West Pittsburgh, PA.

Rhône-Poulenc continued engineering studies at its iron ore tailings deposit at Mineville, NY. Owing to the complex nature of the ore, which is a rare-earth-bearing apatite with magnetite and other iron minerals, a new separation process was being developed. Rhône-Poulenc had not set a date for production, but expected to supplement its existing separation plants in Freeport, TX, and La Rochelle, France.

W. R. Grace, Shin-Etsu Chemical Co. Ltd., and Mitsui & Co. Ltd. announced the opening of a new plant to produce separated rare earths at the Davison Chemical Div. of W. R. Grace's rare-earth-processing facilities in Chattanooga, TN. The new plant will reportedly employ separation technology licensed from Shin-Etsu.[4]

CONSUMPTION AND USES

Domestic rare-earth processors consumed an estimated 9,400 metric tons of equivalent rare-earth oxides (REO) in various forms in 1987, 20% less than was consumed in 1986. Bastnasite consumption was 9% lower and monazite consumption was 164% higher compared with those of 1986.

Shipments of rare-earth products from domestic processors of ore, concentrates, and intermediate concentrates amounted to 14,500 tons of equivalent REO, an increase of 10% from the 1986 shipments of 13,200 tons.

Consumption of mixed rare-earth compounds decreased 88% from the 1986 level, while consumption of purified compounds increased 34%. Higher consumption of purified compounds was the result of continued strong demand for dysprosium, neodymium, samarium, and certain other rare earths used in high-strength permanent magnets, for yttrium and europium oxides used in phosphors, and for yttrium oxides used in high-temperature ceramic and refractory applications.

The producers of mischmetal, rare-earth silicide, and other rare-earth alloys consumed 4% more rare earths in 1987 than in 1986, although shipments of these goods fell 91% during the same period. Shipments of high-purity rare-earth metals decreased 18% during the year.

The approximate distribution of rare earths by use, based on information supplied by primary processors and some consumers, was as follows: catalysts (including petroleum, chemical, and pollution), 53%; metallurgical uses (including iron and steel additives, alloys, and mischmetal), 22%; ceramics and glass (including polishing compounds and glass additives), 18%; and miscellaneous uses (including phosphors, electronics, permanent magnets, lighting, and research), 7%.

Major end uses were in petroleum fluid cracking catalysts, metallurgical applications, glass and ceramics, permanent magnets, and phosphors. Rare earths were used in high-technology applications to produce synthetic crystals used in lasers, high-strength permanent magnets, optical fibers, magnetic resonance imaging scanners, and high-temperature superconductors.

STOCKS

U.S. Government stocks of rare earths in the NDS, all classified as excess to goal, remained at 457 tons throughout 1987. Rare-earth stocks held in the NDS were contained in sodium sulfate and were inventoried on a contained-REO basis.

Industry stocks of rare-earth ores and concentrates held by six producing, processing, and consuming companies increased 28%. Bastnasite stocks held by the principal producer and four other processors increased 167% over the 1986 level. Yearend stocks of monazite increased 10%, while stocks of yttrium concentrates increased 21%. Stocks of other rare-earth concentrates fell 86%.

Stocks of mixed rare-earth compounds increased 23%, while stocks of purified compounds, mostly separated rare-earth oxides, increased 17%. Yearend stocks of mischmetal, rare-earth silicide, and other alloys containing rare earths were down 96%, while inventories of high-purity rare-earth metals were down 82%.

PRICES

The price range of Australian monazite (minimum 55% REO including thoria, f.o.b./f.i.d.),[5] as quoted in Australian dollars (A$),[6] decreased from A$850-A$900 per ton at yearend 1986 to A$660-A$710 per ton by yearend 1987. Changes in the United States-Australian foreign exchange rate in 1987 caused the corresponding U.S. price to decline a lesser amount, about 6 cents on the dollar. The U.S. price range, converted from Australian dollars, decreased from US$565-US$598[7] in 1986 to US$477-US$513[8] in 1987. The average declared value of imported monazite increased in 1987 to $560 per ton, up $186 from the 1986 value.

The yearend price quoted in Industrial Minerals (London) for yttrium concentrate (60% Y_2O_3, f.o.b. Malaysia) was $35 per kilogram. Domestic prices quoted for yttrium concentrate during 1987, developed by the Bureau of Mines from various sources, ranged from $55 to $65 per kilogram of

contained yttrium oxide.

Prices quoted by Molycorp for unleached, leached, and calcined bastnasite in truckload or trainload quantities, containing 60%, 70%, and 85% REO, were $1.00, $1.05, and $1.25 per pound of contained REO, respectively, at yearend 1987.

The price of cerium concentrate quoted by American Metal Market was $1.40 per pound of contained cerium oxide at yearend 1987, unchanged for the third consecutive year. The price of lanthanum concentrate was also unchanged at $1.40 per pound of contained REO.

The mischmetal (99.8%, lots over 100 pounds, f.o.b. shipping point) price for 1987, quoted in American Metal Market, remained unchanged from the 1986 price range of $4.90 to $5.60 per pound.

Molycorp quoted prices for lanthanide (rare earth) and yttrium oxides, net 30 days, f.o.b. Louviers, CO, Mountain Pass, CA, or York, PA, effective July 1, 1987, as follows:

Product (oxide)	Percent[1] purity	Quantity (pounds)	Price per pound
Cerium	99.0	200	$8.00
Europium	99.99	25	725.00
Gadolinium	99.99	55	60.00
Lanthanum	99.99	300	8.75
Neodymium	96.0	300	5.00
Do	99.9	50	40.00
Praseodymium	96.0	300	16.80
Samarium	96.0	55	85.00
Terbium	99.9	55	375.00
Yttrium	99.99	50	52.50

[1]Purity expressed as percent of total REO.

Molycorp also quoted prices for lanthanide (rare earth) compounds, net 30 days, f.o.b. York, PA, or Louviers, CO, effective January 2, 1987, as follows:

Product (compound)	Percent purity	Quantity (pounds)	Price[1] per pound
Cerium carbonate	99.0	150	$4.00
Cerium fluoride	Tech grade	250	3.00
Cerium nitrate	95.0	250	2.15
Lanthanide chloride	46.0	525	1.00
Lanthanum carbonate	99.9	300	5.90
Lanthanum chloride	46.0	525	.95
Lanthanum-lanthanide carbonate	60.0	200	2.15
Lanthanum-lanthanide nitrate	39.0	250	1.50
Neodymium carbonate	96.0	300	4.00

[1]Priced on a contained REO basis.

Rhône-Poulenc quoted rare-earth prices, per kilogram, net 30 days, f.o.b. New Brunswick, NJ, or duty paid at point of entry, effective January 1, 1987, as follows:

Product[1] (oxide)	Percent purity	Quantity (kilograms)	Price per kilogram
Cerium	99.5	20	$21.25
Erbium	96.0	50	200.00
Europium	99.99	40	1,960.00
Gadolinium	99.99	50	136.50
Lanthanum	99.99	25	18.10
Praseodymium	96.0	20	38.85
Samarium	96.0	25	132.50
Terbium	99.9	20	880.00
Yttrium	99.99	50	115.50

[1]Dysprosium, holmium, lutetium, thulium, and ytterbium oxide prices on request from Rhône-Poulenc Inc.

Rhône-Poulenc also quoted prices for rare earths produced at its Freeport, TX, plant, net 30 days, f.o.b. Freeport, TX, effective January 1, 1987, as follows:

Product (compound)	Percent[1] purity	Quantity (kilograms)	Price[2] per kilogram
Cerium carbonate	95.0	20	$8.90
Cerium hydroxide	95.0	20	11.25
Cerium nitrate	95.0	200	11.05
Cerium oxide	99.5	20	17.75
Lanthanum carbonate	99.5	20	12.60
Lanthanum-neodymium carbonate	98.0	20	8.70
Lanthanum nitrate	99.5	200	11.90
Lanthanum oxide	99.5	20	13.25
Neodymium carbonate	95.0	20	9.25
Neodymium nitrate	95.0	200	10.05
Neodymium oxide	95.0	20	11.05

[1]Purity expressed as percent of total REO.
[2]Priced on a contained REO basis.

Nominal prices for various rare-earth oxides and metals were quoted per kilogram by Research Chemicals, net 30 days, f.o.b. Phoenix, AZ, effective November 1, 1986, and throughout 1987, as follows:

Element	Oxide[1] price per kilogram	Metal[2] price per kilogram
Cerium	$40	$175
Dysprosium	200	630
Erbium	250	725
Europium	1,900	7,600
Gadolinium	140	500
Holmium	600	1,600
Lanthanum	20	150
Lutetium	4,900	14,200
Neodymium	80	280
Praseodymium	130	400
Samarium	200	395
Terbium	1,200	2,800
Thulium	3,300	8,000
Ytterbium	225	1,000
Yttrium	118	510

[1]Minimum 99.9%-pure, 1- to 20-kilogram quantities.
[2]Ingot form, 1 to 5 kilograms, from 99.9%-grade oxides.

FOREIGN TRADE

Exports of rare-earth concentrates originated mainly from Molycorp's Mountain Pass Mine in California. Exports of rare-earth metal ores, including bastnasite and a variety of mixed and individual rare-earth concentrates, but excluding monazite, decreased from 6.0 million kilograms in 1986 to 4.5 million kilograms in 1987. Exports of rare-earth metal ores, excluding monazite, were valued at $11.8 million in 1987. Major destinations were Japan (60%), Austria (10%), and the United Kingdom (8%).

Exports of ferrocerium and other pyrophoric alloys containing rare earths totaled 81,626 kilograms, 146% higher than 1986 exports. Major destinations for these exports were Japan (31%), Canada (21%), and Venezuela (12%).

Exports of thorium ore, including monazite, were essentially unchanged from the 1986 level. France was the destination of almost all of the reported total of 582,995 kilograms valued at $427,838, or $733.86 per ton.

Table 2.—U.S. import duties on rare earths

Item	TSUS No.	Most favored nation (MFN)	Non-MFN
		Jan. 1, 1987	Jan. 1, 1986
Ore and concentrate[1]	601.12, 601.45	Free	Free.
Cerium chloride, oxide, compounds	418.40, 418.42, 418.44	7.2% ad valorem	35% ad valorem.
Rare-earth oxides except cerium oxide	423.0030	3.7% ad valorem	25% ad valorem.
Rare-earth metals (including scandium and yttrium).	632.38	do	Do.
Alloys wholly or almost wholly of rare-earth metals (mischmetal).	632.78	32 cents per pound.	$2 per pound.
Other alloys wholly or almost wholly of rare-earth metals.	632.79	20 cents per pound plus 2.4% ad valorem.	$2 per pound plus 25% ad valorem.
Ferrocerium and other pyrophoric alloys	755.35	22 cents per pound plus 2.6% ad valorem.	Do.
Yttrium-bearing materials and compounds (includes yttrium concentrates).	907.51	Free	25% ad valorem or 30% ad valorem.[2]

[1]Crude or concentrated by crushing, flotation, washing, or by other physical or mechanical processes that do not involve substantial chemical change.
[2]Tariff is 25% if previous import item classification was 423.00 or 423.96, part 2, schedule 4, or 30% if 603.70, part 1, schedule 6.

Table 3.—U.S. imports for consumption of monazite, by country

Country	1983		1984		1985		1986		1987	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Australia	3,726	$1,395	5,610	$2,156	5,694	$1,984	2,660	$978	--	--
India	--	--	--	--	--	--	300	128	--	--
Malaysia	302	122	--	--	--	--	--	--	527	$298
South Africa, Republic of	--	--	51	46	--	--	--	--	--	--
Thailand	--	--	--	--	--	--	--	--	594	329
Total	4,028	1,517	5,661	2,202	5,694	1,984	2,960	1,106	1,121	627
REO content[e]	2,215	XX	3,114	XX	3,132	XX	1,628	XX	617	XX

[e]Estimated. XX Not applicable.

Source: Bureau of the Census. REO content estimated by the Bureau of Mines.

Table 4.—U.S. imports for consumption of rare earths, by country

Country	1985 Quantity (kilograms)	1985 Value	1986 Quantity (kilograms)	1986 Value	1987 Quantity (kilograms)	1987 Value
Cerium chloride:						
Mali	--	--	--	--	34,499	$39,240
Morocco	--	--	--	--	20,892	36,661
Singapore	--	--	34,500	$39,871	105,017	109,982
United Kingdom	--	--	--	--	1,624	5,603
Total	--	--	34,500	39,871	162,032	191,486
Cerium compounds:						
Canada	--	--	11,987	8,328	--	--
France	1,770	$8,981	247,420	354,290	80	1,068
Germany, Federal Republic of	206	34,469	188	32,141	370	34,223
Switzerland	--	--	--	--	2	2,863
United Kingdom	10	2,306	--	--	--	--
Total	1,986	45,756	259,595	394,759	452	38,154
Cerium oxide:						
Austria	--	--	91	1,195	91	1,142
Canada	--	--	117	7,561	--	--
China	--	--	100	1,083	--	--
France	5,327	81,670	4,595	76,014	2,336	37,542
Germany, Federal Republic of	94	2,283	--	--	--	--
Japan	--	--	561	18,844	44,200	1,054,727
United Kingdom	27	1,707	--	--	--	--
Total	5,448	85,660	5,464	104,697	46,627	1,093,411
Cerium salts:						
France	--	--	--	--	5,338	15,378
Japan	--	--	11	4,099	--	--
Netherlands	--	--	5,296	11,647	--	--
Total	--	--	5,307	15,746	5,338	15,378
Rare-earth oxide excluding cerium oxide:						
Belgium-Luxembourg	110	46,342	963	31,269	--	--
Brazil	--	--	500	15,383	--	--
Canada	--	--	22	3,270	430	54,197
Chile	--	--	--	--	100	8,334
China	3,830	348,923	41,943	2,082,324	9,319	1,015,770
France	170,556	11,132,432	200,601	12,535,724	216,869	13,995,531
Germany, Federal Republic of	811	266,213	1,839	486,350	10,848	263,889
Hong Kong	--	--	981	63,551	20	29,188
Italy	--	--	3	3,750	--	--
Ivory Coast	--	--	514	90,074	--	--
Japan	7,814	872,783	10,130	1,094,614	5,595	611,937
Malaysia	6,210	186,534	--	--	5,980	119,364
Netherlands	513	36,372	--	--	3,815	915,912
Norway	5,996	655,382	2,478	402,216	3,073	426,143
South Africa, Republic of	--	--	--	--	3	38,594
Switzerland	318	111,800	35	13,050	--	--
U.S.S.R.	6,506	691,201	22,776	1,809,588	26,516	1,663,127
United Kingdom	197	38,133	5,468	311,050	744	328,392
Total	202,861	14,386,115	288,253	18,942,213	283,312	19,470,378
Rare-earth alloys:[1]						
Argentina	--	--	--	--	2,000	14,231
Brazil	162,998	817,875	47,359	239,274	129,632	609,135
Canada	--	--	--	--	4,535	72,551
China	--	--	--	--	56	13,440
France	1,062	9,946	--	--	--	--
Germany, Federal Republic of	17,211	167,343	3,665	49,148	3,194	63,388
Japan	--	--	11	1,130	737	30,746
United Kingdom	5,057	35,535	15,100	119,729	102	18,367
Total	186,328	1,030,699	66,135	409,281	140,256	821,858
Rare-earth metals including scandium and yttrium:						
Austria	100	2,968	786	24,395	1,284	35,487
China	--	--	5,655	299,929	6,619	392,069
Germany, Federal Republic of	--	--	--	--	1,541	114,011
Hong Kong	--	--	--	--	5	12,738
Ivory Coast	--	--	97	15,611	--	--
Japan	1,000	76,099	1,000	76,099	1,724	181,385
U.S.S.R.	2,061	183,044	9,666	805,497	500	32,469
United Kingdom	24	22,642	2,354	615,271	1,817	581,821
Total	3,185	284,753	19,558	1,836,802	13,490	1,349,980

See footnote at end of table.

Table 4.—U.S. imports for consumption of rare earths, by country —Continued

Country	1985 Quantity (kilograms)	1985 Value	1986 Quantity (kilograms)	1986 Value	1987 Quantity (kilograms)	1987 Value
Other rare-earth metals:						
Austria	--	--	--	--	3,733	$97,314
France	329	$9,870	7,066	$149,562	17,971	593,959
Germany, Federal Republic of	655	15,275	2	1,207	469	13,211
Japan	--	--	80	4,695	72	5,872
United Kingdom	209	9,225	60	2,842	(2)	1,272
Total	1,193	34,370	7,208	158,306	22,245	711,628
Ferrocerium and other pyrophoric alloys:						
Austria	1,000	13,240	655	10,032	--	--
Brazil	45,349	632,014	32,799	434,340	35,890	475,256
Canada	--	--	--	--	10,142	75,057
France	66,771	641,505	50,123	640,986	43,701	656,671
Germany, Federal Republic of	--	--	765	15,092	890	24,633
Hong Kong	--	--	892	2,943	--	--
Japan	20	1,699	796	14,953	202	5,203
Korea, Republic of	--	--	8,778	21,276	--	--
Netherlands	--	--	58	1,153	3,280	43,434
Taiwan	--	--	--	--	319	1,273
Thailand	--	--	--	--	257	2,329
United Kingdom	245	13,080	396	13,526	148	10,301
Total	113,385	1,301,538	95,262	1,154,301	94,829	1,294,157

[1]Essentially all mischmetal.
[2]Less than 1/2 unit.

Source: Bureau of the Census.

WORLD REVIEW

Bastnasite, the world's principal source of rare earths, was mined as a primary product in the United States and as a byproduct of iron ore mining in China. Significant quantities of rare earths were also recovered from monazite, which was primarily a byproduct of mineral sands mined for titanium and zirconium minerals or tin in Australia, Brazil, China, India, and Malaysia. Smaller amounts of rare earths, especially yttrium, were obtained from byproduct xenotime. Xenotime was recovered primarily as a byproduct of processing tin ore in Malaysia and Thailand but was also produced in Australia and China. Small quantities of rare earths, including yttrium (which reportedly is adsorbed on some residual clays), were also produced in China. Yttrium and rare earths were also recovered from spent uranium leach solutions in Canada.

World reserves of rare earths were estimated by the Bureau of Mines at 48 million tons of contained REO, of which 23% is in market economy countries.[9] China, with 76%, had the largest share of world reserves.

Australia.—The Mineral Sands Div. of Renison Goldfields Consolidated Ltd. (RGC) announced that exploration west of its Allied Eneabba Mine, Western Australia, was successful in finding mineral sands resources of 150 million tons grading 3.5% heavy minerals. Further exploration in the area was planned. To optimize mining at its Eneabba properties, RGC reportedly planned to mine selected areas by dredging rather than by its present dry mining method. RGC also completed redesign of its processing plant for mineral sands at Eneabba, which allowed increased recovery of all minerals, including monazite.[10]

RGC continued exploration for heavy-mineral sands on Moreton Island, Queensland. The Queensland government adopted the recommendation of a report that would allow mining on 1,200 hectares (6.4%) of the island as short-term use.[11]

The government of Western Australia announced that Rhône-Poulenc of France was to build a 6,000-ton-(REO)-per-year, rare-earth separation plant at Pinjarra, Western Australia.[12] The plant, scheduled for completion in 1989, reportedly will process monazite by liquid-liquid solvent extraction. Monazite feed for the plant will come primarily from RGC's mineral sands operations in Western Australia.[13]

Mineral Deposits Ltd., a subsidiary of The Broken Hill Pty. Co. Ltd. (BHP), announced the opening of a heavy-mineral sands mining operation at Viney Creek, New South Wales, in 1987. Mineral Deposits recovered heavy-mineral sands, including monazite, using twin dredges connected to a floating, wet concentrator. Monazite and other heavy-mineral concentrates were produced at Mineral Deposits' nearby dry concentrator plant at Hawks Nest.[14]

TiO_2 Corp. completed feasibility studies of its heavy-mineral sands deposit at Cooljarloo, Western Australia, and declared it viable. The deposit reportedly contains 12 million tons of ore with a cutoff grade of 2% heavy-mineral sands.[15]

A rare-earth deposit was discovered in the Northern Territory 100 kilometers east of Alice Springs. The deposit reportedly contains significant quantities of rare earths in the mineral allanite. As part of an Australian consortium formed to study the deposit, Australia's Commonwealth Scientific and Industrial Research Organization is undertaking prefeasibility studies.[16]

West Coast Holdings Ltd. announced plans to install a pilot plant at its Brockman multimineral deposit in Western Australia. The deposit reportedly contains columbium (niobium), gallium, hafnium, rare earths, tantalum, thorium, and zirconium. The Brockman deposit, 15 kilometers southeast of Halls Creek, is a joint venture of West Coast Holdings and Greater Pacific Investments Ltd. If additional feasibility reports are favorable, a plant to process 200,000 tons per year of ore was to be built.[17] West Coast Holdings estimated potential annual rare-earth production at 170 tons of yttrium, 37 tons of mixed heavy rare earths, 24 tons of dysprosium, 17 tons of erbium, 6 tons of samarium, and 3 tons of terbium.[18]

Brazil.—Production of monazite concentrates in 1985 was 3,953 tons. The State of Espírito Santo produced 281 tons, a decrease from the 451 tons produced in 1984. The State of Rio de Janeiro produced 3,672 tons, an increase from the 1984 production of 3,161 tons.

Measured reserves of monazite were 17,274 tons. Estimated REO content based on these reserves was 8,506 tons. Monazite reserves were in the States of Bahia, Espírito Santo, Paraná, and Rio de Janeiro.[19]

Canada.—Joint-venture partners Hecla Mining Co. and Highwood Resources Ltd. continued development of their beryllium-yttrium-rare-earth-zirconium deposit at Thor Lake, Northwest Territories. The partners have already completed pilot plant and market research studies. Funding from Hecla was reportedly allocated to improve chemical processing, full-scale plant design, and market development.[20]

China.—The China Rare Earth Information Centre reported 1987 production of 15,100 tons of REO, an increase from the 11,860 tons produced in 1986. The record-high level of production ranks China a close second to the United States in overall production. China reportedly consumed 4,800 tons of equivalent REO, up 13% from that of 1986. Rare-earth consumption in fertilizers and by the oil industry was 600 tons (250 tons REO) and 900 tons, respectively. Export volume also reportedly increased to 6,500 tons REO with an estimated value of $60 million.[21]

Jiangxi Province announced the startup of a 170-ton-per-year refinery at Shangrao to produce heavy-group rare earths. The annual yttrium oxide capacity of the plant was estimated at 40 tons.[22]

Can-Pacific Rare Earths & Metals Corp. (Canada) announced plans to build a 1,000-ton-per-year REO separation plant in Jiangxi Province. The joint-venture project with China was scheduled to commence in 1988.[23]

Gabon.—A columbium (niobium) deposit containing rare earths was discovered 40 kilometers east of Lambaréné in middle Ogooué. Although the deposit is reportedly sizable, no reserve figures were released.[24]

Japan.—Imports of rare earths in 1987 were reported in the Japan Metal Journal, as follows:

Product	Quantity (kilograms)
Cerium fluoride	1,636
Cerium oxide	257,880
Ferrocerium and other pyrophoric alloys	52,306
Lanthanum oxide	101,922
Rare-earth chloride	3,751,481
Rare-earth metals including yttrium and scandium	278,405
Yttrium oxide	390,998

Principal sources of imported compounds by weight were Brazil, China, India, and the United States.

Data on Japanese demand for rare earths in 1987 was reported as follows:[25] cerium oxide, 3,150 tons; lanthanum oxide, 380 tons; samarium oxide, 350 tons; mischmetal,

250 tons; yttrium oxide, 240 tons; rare-earth fluoride, 60 tons; europium oxide, 10 tons; and other REO's, 450 tons.

Rhône-Poulenc announced that it will build a small rare-earth processing and separation plant on an island off the coast of Osaka. The plant is owned 59% by Rhône-Poulenc's Japanese company, Nippon Rare Earths Co. Ltd., and 41% by Sumitomo Metal Mining Co. Ltd. Construction started in 1987 and was expected to be completed in 1988.

A deposit containing rare-earth-bearing sphene was discovered in 1987 near Kamioka, Gifu Prefecture. The silicate mineral, sphene, reportedly contains 0.5% rare earths. The Agency of Natural Resources and Energy, under the Ministry of International Trade and Industry, announced plans to develop technology to recover rare earths from sphene and determine its commercial feasibility.[26]

Dowa Mining Co. Ltd. announced it would construct a rare-earth extraction plant at Hanaoka, Akita Prefecture. Planned capacity for the separation plant was 300 tons of REO per year. Dowa Mining reportedly will process Chinese concentrates purchased under long-term contract.[27]

Madagascar.—QIT-Fer et Titane Inc. of Canada announced that it had completed initial feasibility studies of a heavy-mineral sands deposit in southeast Madagascar. The joint-venture project was 51% owned by the Government of Madagascar and 49% by QIT. The drilling program confirmed the existence of an ore body containing mineral sands, including monazite. Further drilling and the construction of a pilot plant at the site were planned.[28]

Malaysia.—Environmental concerns over the processing and disposal of radioactive thorium hydroxide, produced as a byproduct of processing the naturally radioactive mineral monazite for rare earths and yttrium, resulted in the 1985-86 closing of Asian Rare Earth's (ARE) refining plant near Ipoh. The ARE plant remained closed from October 1985 through February 1986, while ARE reportedly complied with 12 court-ordered safety measures, including construction of an above-ground temporary storage facility. Radioactive thorium hydroxide was previously shipped for burial to a storage site at Papan. A new, reportedly safer site, was selected 5 kilometers north of the city in 1986.[29] The ARE plant is also a major producer of yttrium concentrate from the mineral xenotime. Production of xenotime from Malaysia through 1986 was as follows:

	Quantity (metric tons)
1982	14
1983	13
1984	384
1985	1,124
1986	145

Thailand.—A heavy-mineral sands mine at Chumphon began operation in November 1986. Monazite production from the mine for the final 2 months of 1986 was 140 tons.[30]

Monazite and xenotime were produced as byproducts of processing mineral sands for tin. Monazite was produced in 1986 at Prachuap Khiri Khan in the central region, and at Chumphon, Phuket, Ranong, and Takua Pa in the southern region. Thailand reportedly exported 1,205 tons of monazite in 1986 to Canada, France, and the United Kingdom. During the same year, xenotime was produced only from the mine at Phuket, and 33 tons was reportedly exported to France and the Netherlands. Production of xenotime concentrates through 1986 was as follows:

	Quantity (metric tons)
1982	46
1983	38
1984	28
1985	158
1986	28

United Kingdom.—Swift Levick Supermagloy Ltd. (SLS), part of the rare-earth permanent magnet division of the Magnetic Materials Group of the United Kingdom, announced the commissioning of a new plant to supply magnets. SLS currently produces 12 tons per year of rare-earth magnets from a plant at Swindon. The new plant, to be built at Rotherham, has a planned capacity of 50 tons per year.[31]

Table 5.—Monazite concentrate: World production, by country[1]

(Metric tons)

Country[2]	1983	1984	1985	1986[p]	1987[e]
Australia	15,141	16,260	18,735	14,822	12,000
Brazil	5,256	3,622	1,895	1,947	2,000
India[e] [3]	4,000	4,000	4,000	4,000	4,000
Malaysia[4]	1,051	[r]4,980	5,808	5,959	6,000
Mozambique[e]	[5]4	4	4	4	4
Sri Lanka[e]	300	[5]147	200	200	200
Thailand	277	298	245	1,609	1,500
United States	W	W	W	W	W
Zaire	15	2	--	--	--
Total	26,044	[r]29,313	30,887	28,541	25,704

[e]Estimated. [p]Preliminary. [r]Revised. W Withheld to avoid disclosing company proprietary data; not included in "Total."

[1]Table includes data available through Apr. 29, 1988.

[2]In addition to the countries listed, China, Indonesia, North Korea, the Republic of Korea, Nigeria, and the U.S.S.R. may produce monazite, but output, if any, is not reported quantitatively, and available information is inadequate to make reliable estimates of output levels.

[3]Data are for year beginning Apr. 1 of that stated.

[4]The 1983 figure is exports and the 1984-87 figures are production.

[5]Reported figure.

Table 6.—Rare earths: World production, by country

(Metric tons of REO equivalent)

Country	1985	1986[p]	1987[e]
Australia	10,304	8,152	6,600
Brazil	1,042	1,071	1,100
Canada	--	NA	NA
China	8,500	11,860	15,100
India[e]	2,200	2,200	2,200
Malaysia	3,869	3,364	3,300
Mozambique[e]	2	2	2
Sri Lanka[e]	110	110	110
Thailand	230	902	825
United States[1]	13,428	11,094	16,710
Total	39,685	38,755	45,947

[e]Estimated. [p]Preliminary. NA Not available.

[1]Comprises only the rare earths derived from bastnasite as reported in Unocal Corp. annual report, 1987.

TECHNOLOGY

The Rare-Earth Information Center at Iowa State University, Ames, IA, inaugurated a limited circulation monthly newsletter entitled "RIC Insight." The publication will deal with current technological advances and conferences related to rare earths.[32]

Researchers at General Motors Corp. designed a solar-powered car using rare-earth permanent magnets that won the 3,200-kilometer World Solar Challenge in Australia. The high-efficiency (92%) electric motors used in the car each incorporated 6 neodymium-iron-boron magnets and produced 2 horsepower at 4,000 revolutions per minute at a weight of 3.7 kilograms.

A fiber-optic temperature sensor was developed using neodymium-doped glass bonded to two optical fibers: one to deliver laser-emitted radiation and the other to transmit the resulting fluorescence to a receiver. Based on the change of fluorescence decay time with temperature, the sensor used glass doped with 9% neodymium. It was operable in the range of -50° to 300° C.[33]

A magnesium alloy containing zirconium, along with yttrium and other rare earths, was developed by researchers at Magnesium Elektron Ltd. in the United Kingdom. Designated WE54, the new alloy has high-temperature stability up to 300° C, reportedly higher than any magnesium alloy now available. The alloy contains 0.5% zirconium, 5.5% yttrium, and 3.5% other rare earths. The new alloy will probably be used in aerospace applications.[34]

Rare-earth fertilizers have reportedly increased yields of wheat. Agricultural specialists in China's Henan Province conducted experiments on more than 27,300 hectares of land planted in wheat. By adding rare earths over a 3-year period, the crop yield improved 5% to 8% and had higher contents of protein and lysine.[35]

Researchers used rare earths to determine the source of an impact that occurred 65 million years ago at the boundary of the Cretaceous and Tertiary periods (K-T boundary). The cause of the impact, which triggered a mass extinction, including possibly that of the dinosaurs, remains in controversy. The relative abundance of rare-earth elements produces patterns that reflect the origins of the rock.[36] The rare-earth pattern in the K-T boundary indicated material excavated near a continent, possibly in the eastern Pacific. If true, the location of the impact may never be found. Since part of the ocean crust has been subducted beneath North America.[37]

A rare-earth laser system was developed that rapidly detects airborne beryllium particles, a known carcinogen. Scientists at Los Alamos National Laboratory in New Mexico used a neodymium:yttrium-aluminum garnet (Nd:YAG) laser to perform laser-induced spectroscopy to vaporize and analyze material on a target filter. The new rare-earth system can analyze for beryllium in 2.5 minutes compared to as much as 8 hours for chemical analysis.[38]

An Nd:YAG laser was also used in a recently developed measurement system for water depth. The system, known as a scanning lidar bathymeter, is used for airborne hydrographic surveying down to depths of 40 meters in clear coastal water. It operates by emitting a short pulse of infrared and a short pulse of visible (green) radiation from a dual frequency Nd:YAG laser. The infrared pulse is scattered from the water surface, while the green pulse penetrates and is scattered by the bottom. Both pulses are detected by a receiver that computes the water depth based on the time elapsed between pulse scatterings.[39]

Yttria-stabilized composite materials of zirconia bonded-zirconia fibers were produced with highly efficient thermal insulating properties. Able to withstand temperatures up to 2,316° C, the insulation, designated ZZX-4200, was developed by scientists at Martin-Marietta Energy Systems in Oak Ridge, TN. Insulating efficiency was improved by orienting the fibers perpendicularly to the wall thickness of the structure, reportedly halving heat flow when compared to homogeneous and randomly oriented fibers. Comparable materials have been efficient up to about 1,760° C.[40]

A review of processes used to produce neodymium metal and certain neodymium alloys was published. Electrolytic and metallothermic processes were discussed, including calciothermic reduction for producing neodymium commercially for use in high-strength permanent magnets.[41]

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Preliminary Geologic Investigation of the Tire-Tiky Lode Claim Groups Yavapai County, Arizona

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Summary

The Tire-Tiky claim group lies within Central Yavapai County between the Santa Maria Mountains and the Bradshaw Mountains. The area is within the Mountain Region, which lies between the Colorado Plateau to the northeast and the Desert Section of the Basin and Range to the southwest. The claim group is located about 20 miles west of Prescott, Arizona. Widespread disseminated kyanite,ilmenite, monazite, xenotime, sillmanite, and magnetite mineralization occurs in appreciable enough amounts to warrant further exploration to assure that an ore deposit exists.

The economic minerals present on the Tire-Tiky claim groups are ilmenite and other titanium minerals (leucoxene and rutile). Kyanite and sillimanite are Al_2O_3 minerals which are used in the manufacture of ceramics and refractories. Magnetite occurs in large amounts throughout the claim group it is marketable to the Department of Energy in southern Nevada as packing for blastholes at the Nevada Test Site.

during neutralization of acidic solutions by country rocks. The resulting altered rocks are alkali-poor and contain clay minerals such as kaolonite and pyrophyllite in place of feldspars and muscovite. Regional metamorphism, possibly related to the emplacement of the Cornfield Mountain intrusive, then produced rocks consisting of the minerals previously mentioned.

The rare earth bearing mineral monazite, found in metamorphic rocks participates in a metamorphic cycle whose chief feature is the loss of detrital monazite and the formation of authigenic metamorphic monazite. Detrital monazite is unstable in early stages of regional metamorphism. It breaks down and shares its components with other minerals. As the grade of regional metamorphism increases, an environment is reached in which monazite becomes stable. Metamorphic monazite begins to form at a few centers of crystalization; these centers multiply with increasing grade of metamorphism until the rock finally contains far more metamorphic monazite than it originally had detrital monazite. The main sources for the metamorphic monazite are thorium, rare earths, and phosphorus held by other detrital components of the original sediments, chiefly hydrolyzates, clays, mica, and apatite.

The rare earth minerals monazite and xenotime are most highly concentrated in biotite-rich pods, lenses and folia. These minerals are also concentrated in the kyanite-ilmenite-magnetite schists and gneisses.

The results of field observations suggest that clastic sediments and possibly water-laid rhyolites were deposited in a shallow water environment; altered, leached,metamorphosed and subjected to metasomatic transport of selected mobile ions, some being concentrated others being removed. The environment in a back-arc basin would provide the clastic sediments from a continental source concentrated in a shallow water beach environment. The proximity to source areas for water-laid rhyolites and hydrothermal solutions capable of altering the clastic sediments and water-laid rhyolites. Long shore currents and wave action would concentrate the heavy mineral fraction in a similar fashion as beach sand deposites are today. A shallow water model for the deposits permits an oxidizing environment, the formation of the heavy mineral concentrations including rare earth minerals and the opportunity for weathering. The environment in a back-arc basin would provide the source for water-laid tuffs and rhyolites in a shallow water environment plus a probable source for acidic hydrothermal fluids which could alter and transport the mobile components and create an environment condusive for the concentration of the economic minerals found on the Tire-Tiky claim group. The emplacement of the Cornfield Mountain intrusive could have also provided the metamorphic-hydrothermal environment necessary to produce the mineral assemblage now present.

Explanation for Submittal Geologic Map Tire-Tiky-Zuma Claim Groups and surrounding region.

Red - Yavapai Series - Mineralized aluminosilicate schist-gneiss-migmatites bearing disseminated rare-earths, yttrium, titanium, tin, magnetite and zirconium. Kyanite occuring in probable economic amounts over large zones.

Blue - Yavapai Series - Mineralized aluminosilicate schist-gneiss-migmatites bearing abundant kyanite. Numerous greisen veins and disseminations many subparallel. Abundant tourmaline in quartz veins and as disseminations in schists.

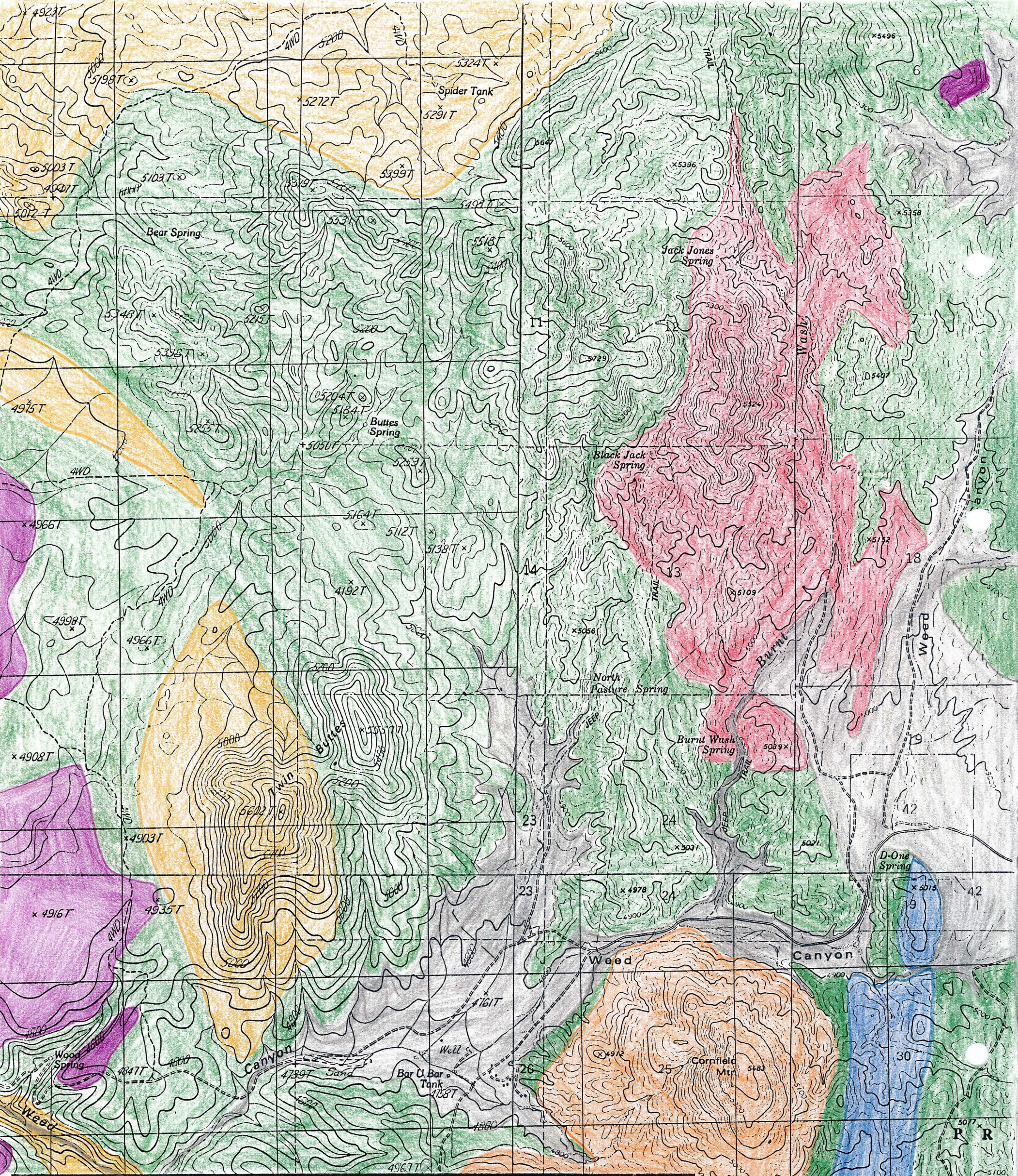
Yellow - Santa Fe Granite - Prescott Granodiorite - Regionally encircling porphyritic to equigranular granodiorite-quartz monzonite in composition. 1.7 bybp? Distinct orthogonal fracture pattern weathers to spherodial boulders.

Orange - Cornfield Mountain Intrusive - Leucrocratic two mica "granite" consisting of several phases of felsic rock. Local pegmatites and aplites probably late stage derivatives. Greisen veins and disseminations and tourmaline-quartz veins and disseminations indicate tin greisen system related to Cornfield Mountain Intrusive. Mineralized Yavapai Series (Red) possibly mineralized by hydrothermal fluids from late stage Cornfield Mountain Intrusive.

Green - Pegmatites-Aplites-Granitic Undifferentiated, compositionally similar, coarse to fine grained granitic rock, equigranular texture comprised of quartz, plagioclase, albite, muscovite orthoclase and minor minerals. Unit almost void of alumino-silicates, rare-earths, yttrium, greisen zones and associated minerals and metals.

Purple - Tertiary basalt flows occur as mesas in the surrounding region obscuring the older units.

Grey - Alluvium and Colluvium cover derived from local drainages and containing abundant heavy mineral fraction containing magnetite, rare-earths, yttrium, tin, titanium, kyanite and zirconium



GEOLOGIC MAP for Tire-Tiky-Zuma Claim Groups and surrounding area included in submittal report. Explanation for Geologic Map attached, and units further described in sections of report.

SCALE 1:24 000

1 ½ 0 1 MILE

1000 0 1000 2000 3000 4000 5000 6000 7000 FEET

1 .5 0 1 KILOMETER

CONTOUR INTERVAL 20 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

GN MN 0°58' 17 MILS 14° 249 MILS

ARIZONA
QUADRANGLE LOCATION

GEOCHEMICAL SAMPLE LOCATION MAP

for Tire-Tiky-Zuma Claim Groups and surrounding Area.
Gold assays not plotted because values insignificant.
Several samples split and submitted to Bondar-Clegg Inc.
and Fluo-X-Spec for comparison of results.

SCALE 1:24 000

1 ½ 0 1 MILE

1000 0 1000 2000 3000 4000 5000 6000 7000 FEET

1 .5 0 1 KILOMETER

GN MN

0°58′ 17 MILS

14° 249 MILS

CONTOUR INTERVAL 20 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

ARIZONA

QUADRANGLE LOCATION

Rock Spring
Spider Tank
Sheep Camp Springs
Corral
Jack Jones Spring
Buttes Spring
Black Jack Spring
Mount Josh
North Pasture Spring
Burnt Wash Spring
D-One Spring
Cornfield Mtn
Bar U Bar Tank
Juniper Spring
PRESCOTT

SS #1
II3
Wirespool Lode
Wirespool Non-MAg
Raggs Ridge
II7
SW But. Spr. Non-MAg
II4
Deer Camp
BWS Non-MAg
Red Basin Z Cu. Ft
II6
II2
D1 Cu. Orig. Pit
Main 0015
Schist Ridge
II5
BWWC II
II1 BWWC
Deer Flat
III7
Cuthill Gneiss PRC