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DEVELOPMENT REPORT

ON

ORE CONTROL TECHNIQUES

AT THE ANDERSON MINE

YAVAPAI COUNTY, ARIZONA

BY

ROBERT LUCHT

SEPTEMBER 27, 1977

TABLE OF CONTENTS

ABSTRACT

Several methods for very fast assays for U_3O_8 have been considered for the Anderson Project since it was discovered that the equilibrium factors vary very significantly throughout the pit. Non-dispersive X-ray such as is to be used at the Sweetwater Mine was ruled out because of trace element interferences. Assay techniques such as atomic absorption, emission spectrometry, fluorometric and colorimetric have been ruled out because of the long time required. Energy and wavelength dispersive X-ray spectrometers have been demonstrated as effective with total turnaround times of six to seven minutes.

Princeton Gamma-Tech of Princeton, New Jersey, has demonstrated a gamma ray spectrometer using intrinsic germanium detectors which will assay ore in 60 seconds with no sample preparation. This unit measures the one mev gamma ray from Pa_{234} (a 26 day ½ life daughter product of U_{238}). Princeton Gamma-Tech will guarantee performance of ± .006 WT% at the .02% level with one minute count time on a two detector system. It is recommended that T probes be used in the pit with a probe tower gamma ray spectrometer.

ORE CONTROL

ORE TENOR

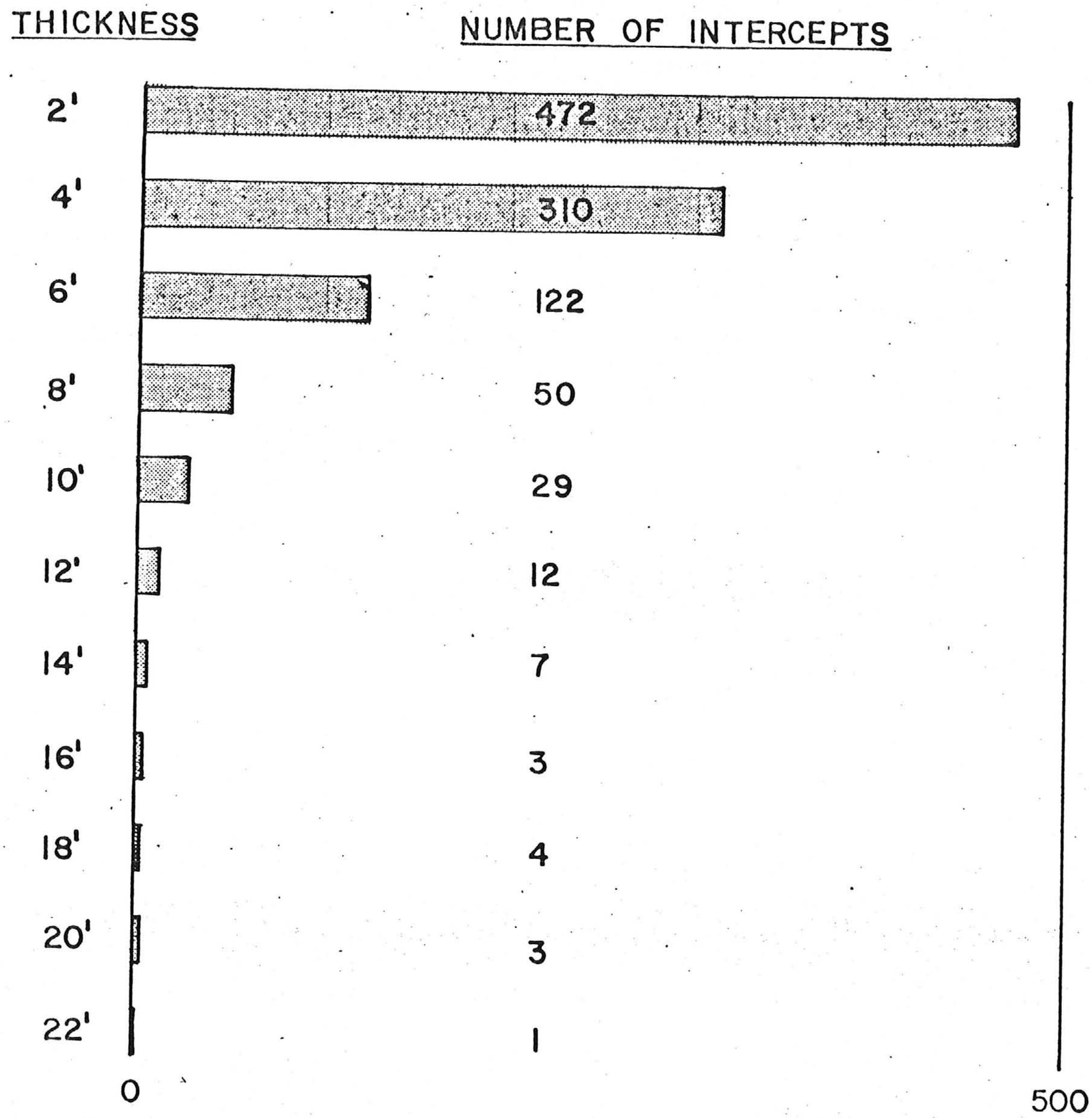
In order to determine the best ore control methods, a basic understanding of the makeup of the ore is needed. 21 emission spectrograph and 47 X-ray spectrograph analyses have been done. These tests reveal that the ore contains variable amounts of copper, zinc, tin, lead, iron, nickle, rubidium, barium, strontium, titanium, zirconium, vanadium, caromium, molybdenum, manganese, and yttrium. None of these elements are worthy of recovery. These elements, as well as the uranium, are present in a matrix of calcium carbonate and lignite with variable degrees of silicification. Appendix 1 contains the analytical data from these tests.

Maps have been constructed showing distribution of the trace elements as well as matrix calcium carbonate. The trace element maps were constructed using the maximum observed value for each hole. Maps 3 to 10 show the distribution of the most important trace elements. Map 11 shows the distribution of CO_2 percentages in the ore. Appendix 2 contains CO_2 raw data.

ORE GEOMETRY

The geometry of the ore will effect the methods used for ore control and mining. The ore occurs as lenticular bodies with varying lateral extent and an average thickness of 4.0 feet (this figure determined with a cutoff of .03% and a minimum thickness of 2.0 feet). A breakdown of the number of intercepts of each thickness shows that most of the ore occurs as lenses two and four feet thick. The maximum thickness observed was 22 feet. The following histograph illustrates the observed data.

HISTOGRAPH OF ORE THICKNESS



TOTAL NUMBER OF INTERCEPTS — 1013

AVERAGE THICKNESS — 4.0 FEET

INTERCEPTS PER HOLE — 3.1

THICKNESS PER HOLE — 12.3 FEET

UNION MINERALS EXPLORATION CO.

ANDERSON MINE PROJECT
YAVAPAI COUNTY, ARIZONA

ORE THICKNESS

SCALE	DATE: AUG 1, 1977	APPROVED	REVISIONS
H: 1"=100	DRAWN BY: LUCHT		
V: N/A	CHECKED:		
	DESIGN:		FILE:

METHODS OF ORE CONTROL

Ore control methods in uranium mining all amount to programs of analysis just before mining and subsequent sampling and analyzing each truck tentatively sent to the mill. This leads to a need for a quick method of analysis in the pit and an accurate, fast method in the probe tower. Several tools have been considered for each of these functions.

Pit (Pre-Mining) Analyses

Gamma Probe - The most common tool of ore control is the so-called T-handle probe. This tool is either a Geiger-Mueller tube or a sodium iodide scintillation counter mounted so that the detector can be pushed into the ore. This tool reads only the total amount of gamma radiation. It will not detect high beta ore. Fortunately, the Anderson project has not encountered appreciable amounts of high beta ore. Ore that is far out of equilibrium will be sent to the probe tower by this instrument. If the probe tower can sort out high gamma ore, then the T-handled probe can be effectively used in the pit.

Non-Dispersive X-Ray Fluorescence Spectrometer - The Texas Nuclear Corporation series 9200 portable analyzer was considered as a more accurate tool to substitute for or supplement the T-handled probe. This tool, which works very well in many uranium ores, is incapable of analyzing Anderson ore. Anderson ore contains molybdenum and strontium which cannot be separated from uranium by this tool.

Other Types of Tools - Several forms of X-ray spectrometers have been considered for pit analysis. They can be eliminated from consideration because of the problems in maintaining the close control of their environment to achieve accuracy.

Probe Towers

Beta Gamma Scalars - Most mines have been able to use the beta-gamma scalar as a probe tower analyzer. Data from beta gamma scalar analyses indicates that only a low order of accuracy can be expected from a beta-gamma scalar in the Anderson ore. Data from these analyses is tabulated in Appendix 2 of the equilibrium report.

Emission Spectroscope - This type of tool can be ruled out for use in the probe tower. Drawbacks include:

1) Assay too time consuming.
2) Assay accuracy depends too much on experience of operator.
3) Sample preparation too complicated.

Atomic Absorption Spectrometer - This tool can also be ruled out because of sample preparation time and the training required of the operator.

Energy Dispersive X-Ray (EDX) Spectrometer - This machine excites the sample with X-rays from a tube or from a radioisotope. The excited sample fluoresces and a single detector receives the emitted radiation. The detector has to be a very high resolution lithium drifted silicon (Si(Li)) so that the peaks from different elements can be separated. Energy dispersion produces wide peaks which overlap the adjacent elements. Mathematically removing the effects of the adjacent elements requires a relatively sophisticated computer. Other matrix effects caused by absorption of energy by other elements also must be compensated for by the computer. The net effect is that the computer software becomes very important to the accuracy of the assay. Several companies have applied this technology to uranium analysis.

Wavelength Dispersive X-Ray (WDX) Spectrometer - Wavelength dispersion differs from energy dispersion in that each element is detected by a separate detector setup optically to receive only a given wavelength. The peaks tend to be better defined than in energy dispersion, but a computer is still required for speedy operation. The computer has a slightly better signal input so that software, though important, is not as critical for accuracy. Several companies also report application of this technology to uranium analysis.

Gamma Ray Spectrometers (GRS) - This approach to the problem utilizes a high resolution detector to receive the natural radiation. The signal is resolved by computers in much the same way as an energy dispersive X-ray does. The primary difference is that the natural gamma spectrum is much simpler than the spectrum from an excited sample. Technology of this type is usually found in uranium fabrication, enrichment, or power plants. It has been applied to uranium exploration.

Summary - From the foregoing discussions, one can see that any of the last three machines can be applied to the probe tower. A gamma probe will work in the pit. The decision of whether to buy an EDX, a WDX, or a GRS boils down to cost, speed of analysis and sample preparation. Any of the three can produce the required accuracy. Versatility can be a further determining factor.

Machine by Machine Comparison

The following machines have been considered suitable for the probe tower. Each differs in cost, reliability, versatility and service.

Manufacturer:	Applied Research Labs
Model Number:	74000S
Type of Unit:	WAVELENGTH DISPERSIVE X-RAY SPECTROMETER
Cost of Basic Unit:	$118,980.00 FOB, Detroit, Mich.
Sample Preparation:	200 mesh pressed powder desirable. Possible to use loose powder with small loss in accuracy.
Analysis Time:	25-120 seconds, typically 40 seconds.
Total Turnaround Time:	6 minutes
Nearest Service:	Sunland, California
Versatility:	Determines up to eight elements simultaneously. Number of detectors ordered affects price.

Added Functions:

Type:

Cost:

Previous Application in Uranium Mining: None Known

Remarks: Cost based on six element analysis.

Manufacturer:	Applied Research Labs
Model Number:	72000
Type of Unit:	WAVELENGTH DISPERSIVE X-RAY
Cost of Basic Unit:	Significantly more than $120,000
Sample Preparation:	200 mesh pressed powder
Analysis Time:	20-120 seconds, typically 30 seconds.
Total Turnaround Time:	6 minutes
Nearest Service:	Sunland, California
Versatility:	Up to 30 elements simultaneously

Added Functions:

Type:

Cost:

Previous Application in Uranium Mining: None

Remarks: 72,000 has much more capability than is needed. Unit seen at Rillito Plant of Arizona Portland Cement. Very reliable if controlled conditions are maintained.

Manufacturer: Philips

Model Number: PW 1600

Type of Unit: WAVELENGTH DISPERSIVE X-RAY (Simultaneous Unit)

Cost of Basic Unit: $126,475.00

Sample Preparation: 200 Mesh Pressed Powder

Analysis Time: 30 Seconds

Total Turnaround Time: Six Minutes

Nearest Service: North Hollywood, California

Versatility: Up to 28 elements simultaneously, 31 analysis programs can be stored.

Added Functions:

Type:	Scanner	Manual Control	Water Chiller
Cost:	$15,300	$3,910	$3,641

Previous Application in Uranium Mining:

Remarks: Much more capability than needed.

Manufacturer:	Philips
Model Number:	PW 1410 - AXS System II
Type of Unit:	WAVELENGTH DISPERSIVE X-RAY
Cost of Basic Unit:	$99,925
Sample Preparation:	200 Mesh Pressed Powder
Analysis Time:	100 Seconds peak, 50 seconds each side of peak for background count
Total Turnaround Time:	Eight minutes
Nearest Service:	West Coast
Versatility:	Price is for machine that will analyze five elements.

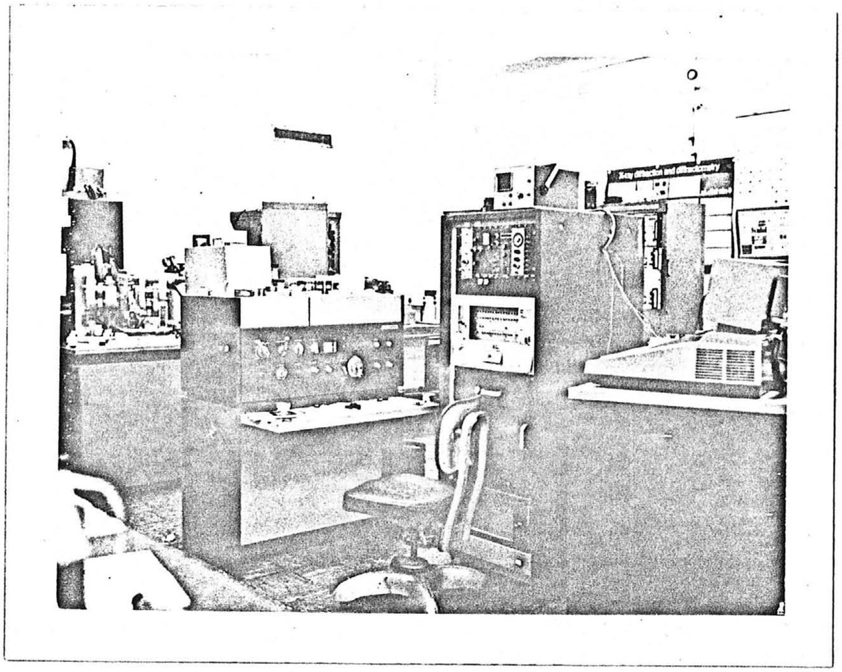
Added Functions:

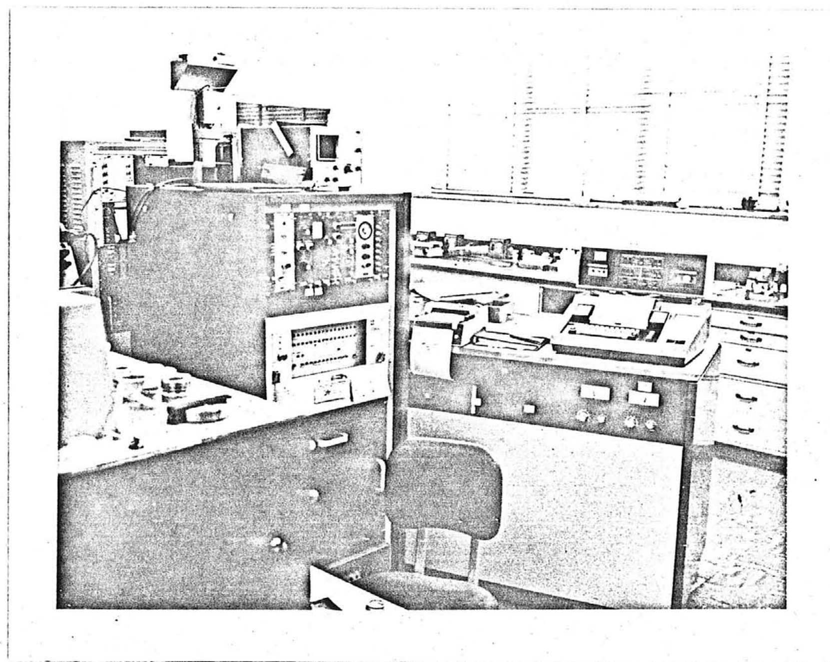
Type:	12 position sample changer	$10,670.00
	12 sample holders	600.00

Previous Application in Uranium Mining: None

Remarks: Kansas Geological Survey did applications work. They were able to read Anderson samples very well. (See Appendix 3)

Eliho Goldish, Research Associate at Union Oil Research Center reported some reliability problems with the PW1410 X-ray generator.





Philips PW 1410 Set Up in the Union Oil Research Center at Brea, California.

Manufacturer: Philips

Model Number: Exam II & VI (Variations of Same Machine)

Type of Unit: ENERGY DISPERSIVE X-RAY

Cost of Basic Unit: $84,565.00

Sample Preparation: 200 Mesh Pressed Powder

Analysis Time: 100 Seconds

Total Turnaround Time: Seven Minutes

Nearest Service: West Coast

Versatility: Semi-Quant

Added Functions:

Type: 12 Position Sample Changer

Cost: $8,245.00

Previous Application in Uranium Mining: Anaconda at Grants, N.M., has Exam II system

Remarks: Anaconda's R.D. Warner reported that their Exam II had some problems in reliability. The Exam II as set up at Grants read Anderson ore as follows:

Sample #	Fluor U_3O_8	Anaconda Wet U_3O_8	U_3O_8
10958-172	.015	-	.0147
10958-302	.052	-	.0492
11253-25	.118	.1185	.0674
11253-27	.106	.0989	.0556
10958-277	.224	.2118	.1279

INTENSITY IN C/S

SAMPLE NO ? 1 *10958-172* *.015 % U_3O_8 HAZEN FLUOR.*

B1 I= 2.24
B2 I= 6.14
TH I= 2.9175
PB I= 12.6875
U I= 7.315
B1 C= 0
B2 C= 0
TH C= .0047
PB C= .0308
U C= .0147

SAMPLE NO ? 2 *10958-302* *.052 % U_3O_8 HAZEN FLUOR.*

B1 I= 2.06
B2 I= 5.8825
TH I= 2.56
PB I= 13.0725
U I= 18.145
B1 C= 0
B2 C= 0
TH C= .0035
PB C= .0336
U C= .0492

SAMPLE NO ? 3 *11253-25* *.118 % U_3O_8 SKYLINE FLUOR.*

B1 I= 2.0725
B2 I= 8.0125
TH I= 2.4025
PB I= 12.705
U I= 24.085
B1 C= 0
B2 C= 0
TH C= .0023
PB C= .0328
U C= .0674

SAMPLE NO ? 4 *11253-27* *.106 % U_3O_8 SKYLINE FLUOR.*

B1 I= 1.9925
B2 I= 7.0225
TH I= 2.2625
PB I= 9.5575
U I= 20.4425
B1 C= 0
B2 C= 0
TH C= .0019
PB C= .023
U C= .0556

SAMPLE NO ? 5 10958-277 .224% U_3O_8 SKYLINE FLUOR.

B1	I=	2.2475
B2	I=	8.7225
TH	I=	2.825
PB	I=	20.02
U	I=	42.425
B1	C=	0
B2	C=	0
TH	C=	.004
PB	C=	.0572
U	C=	.1279

Manufacturer:	Tracor-Northern, Inc.
Model Number:	TN 1710-Multichannel
Type of Unit:	ENERGY DISPERSIVE X-RAY
Cost of Basic Unit:	$32,750
Sample Preparation:	200 mesh pressed powder
Analysis Time:	100 Seconds
Total Turnaround Time:	Seven Minutes
Nearest Service:	
Versatility:	

Added Functions:

Type:

Cost:

Previous Application in Uranium Mining: None

Remarks:

Manufacturer:	Tracor - Northern
Model Number:	TN 880/8
Type of Unit:	ENERGY DISPERSIVE X-RAY
Cost of Basic Unit:	$47,155
Sample Preparation:	200 mesh pressed powder
Analysis Time:	~100 seconds
Total Turnaround Time:	7 minutes
Nearest Service:	Golden, Colorado Middleton, Wisconsin (factory)
Versatility:	Very versatile. Semi quant analysis of other elements easy. Can be set up for quantitative work on other elements by changing software.

Added Functions:	TN 880/16
Type:	16 K processor with one year warranty
Cost:	$1,500 (extra)

Previous Application in Uranium Mining: None

Remarks: Numerous applications in copper mining, including Kennecott at Hayden, Arizona. Very reliable if used in closely controlled environment.

Manufacturer: Nuclear Equipment Corporation

Model Number: EXAC 5000, + 5000R

Type of Unit: ENERGY DISPERSIVE

Cost of Basic Unit: $50,000 (approximately)

Sample Preparation: 200 mesh pressed powder

Analysis Time: 100 seconds

Total Turnaround Time: 6 minutes

Nearest Service: San Carlos, California

Versatility: Up to four elements simultaneously

Added Functions:

Type:

Cost:

Previous Application in Uranium Mining: Gallup, New Mexico
United Nuclear

Remarks: Numerous applications in copper, lead, zinc including Cananea, Mexico. Have not been able to see United Nuclear machine at Gallup, New Mexico.

Manufacturer:	Princeton Gamma-Tech
Model Number:	PGT 100
Type of Unit:	Energy Dispersive
Cost of Basic Unit:	$20,000
Sample Preparation:	200 Mesh Powder
Analysis Time:	~100 Seconds
Total Turnaround Time:	Six Minutes
Nearest Service:	1000 Oaks, California, Princeton, New Jersey
Versatility:	Up to three elements.

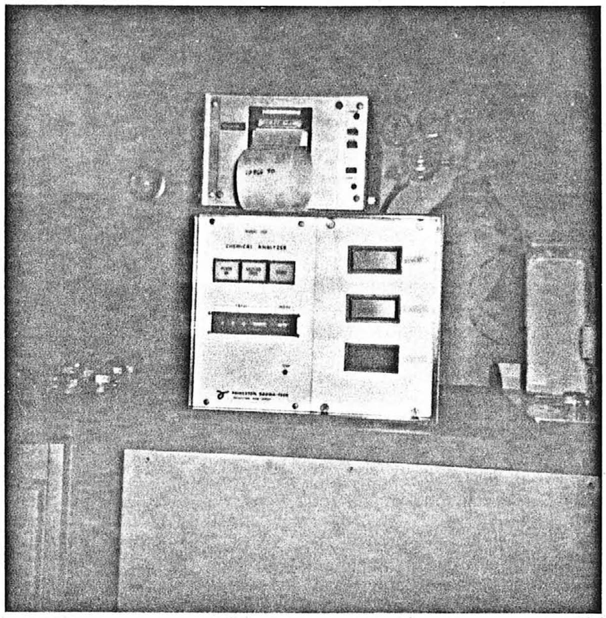
Added Functions:

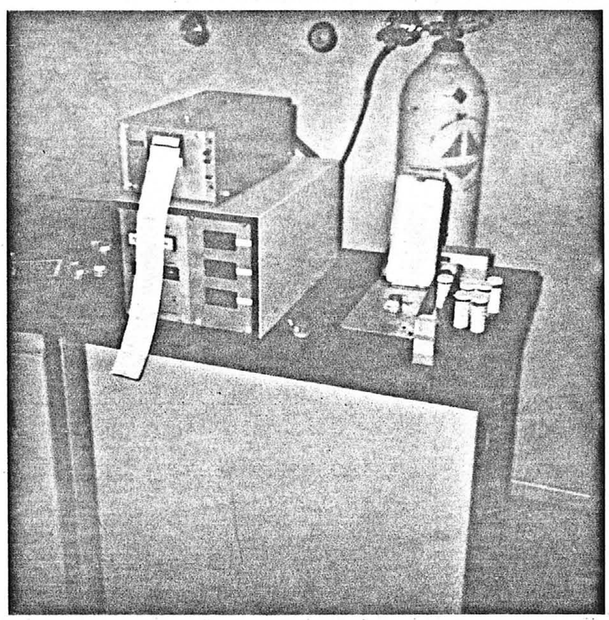
Type:

Cost:

Previous Application in Uranium Mining: Pipeline monitors, sulfur in fuel oil, lead in paint

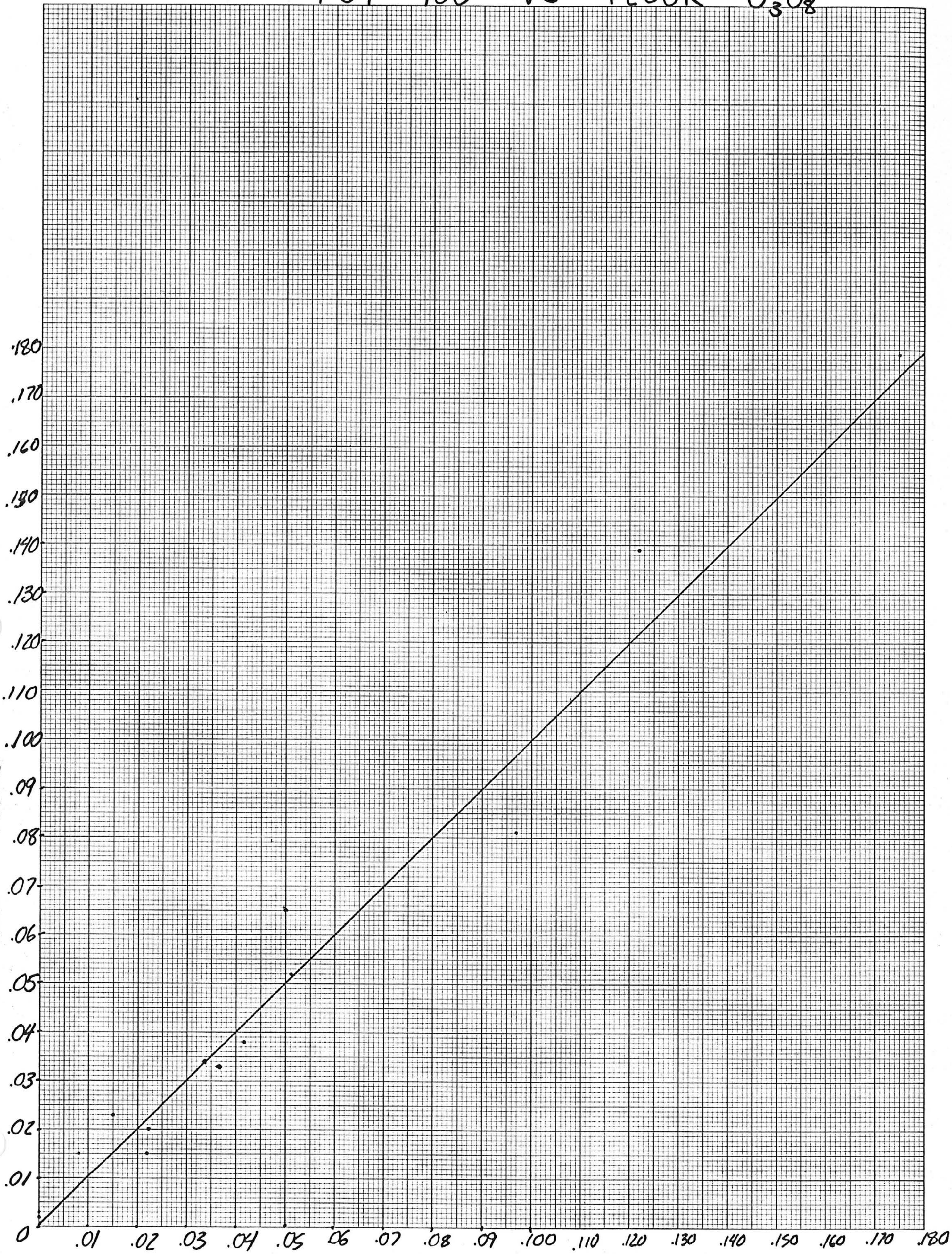
Remarks:





PGT Model 100 set up and analyzing Anderson Ore at Princeton, New Jersey.

PGT - 100 VS FLUOR U_3O_8



PγT - 100

Manufacturer:	Princeton Gamma-Tech
Model Number:	PGT 500
Type of Unit:	ENERGY DISPERSIVE
Cost of Basic Unit:	~$50,000
Sample Preparation:	200 Mesh Powder
Analysis Time:	100 Seconds
Total Turnaround Time:	Six Minutes
Nearest Service:	Princeton, New Jersey, 1000 Oaks, California
Versatility:	Semi-Quant, great versatility with trained operator.

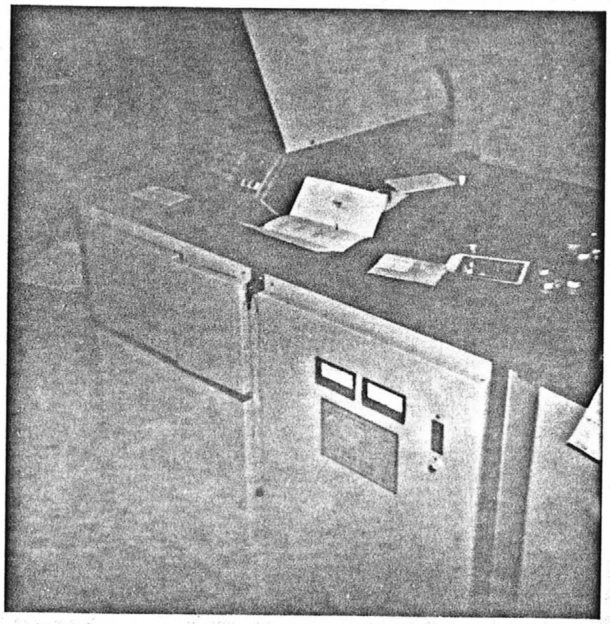
Added Functions:

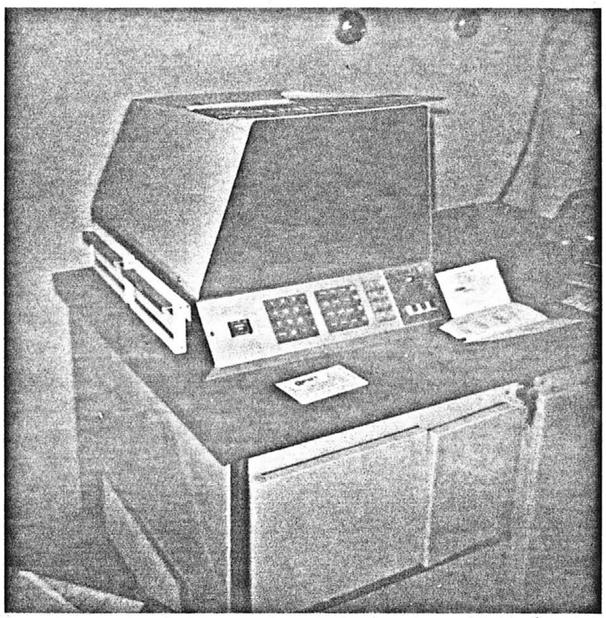
Type:

Cost:

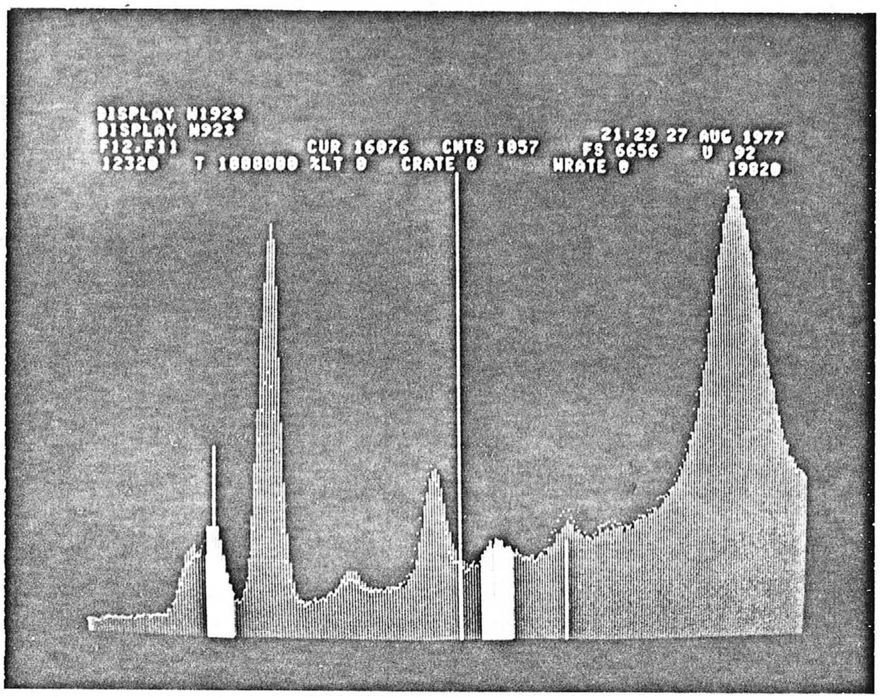
Previous Application in Uranium Mining: None

Remarks:

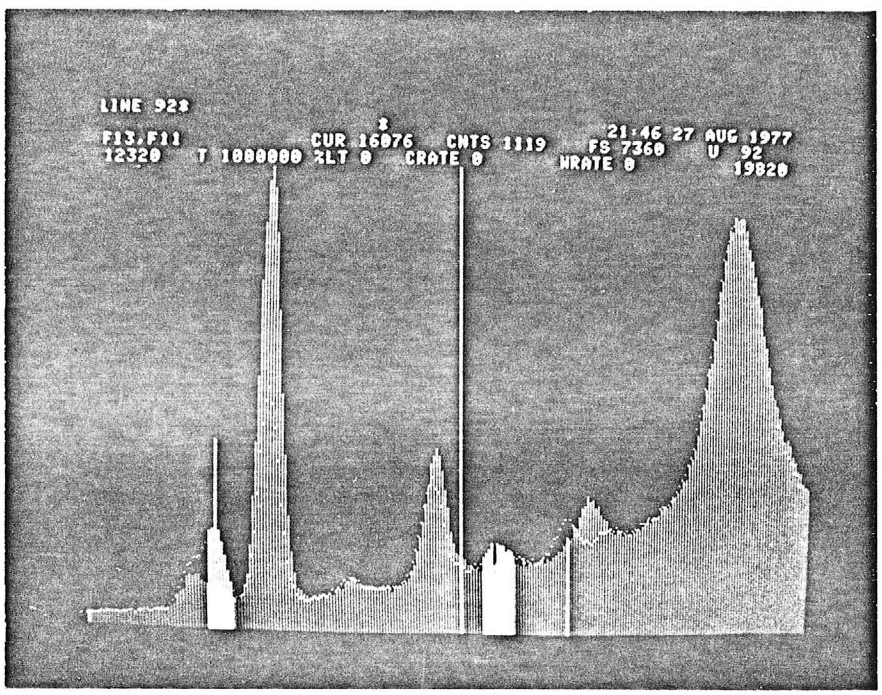




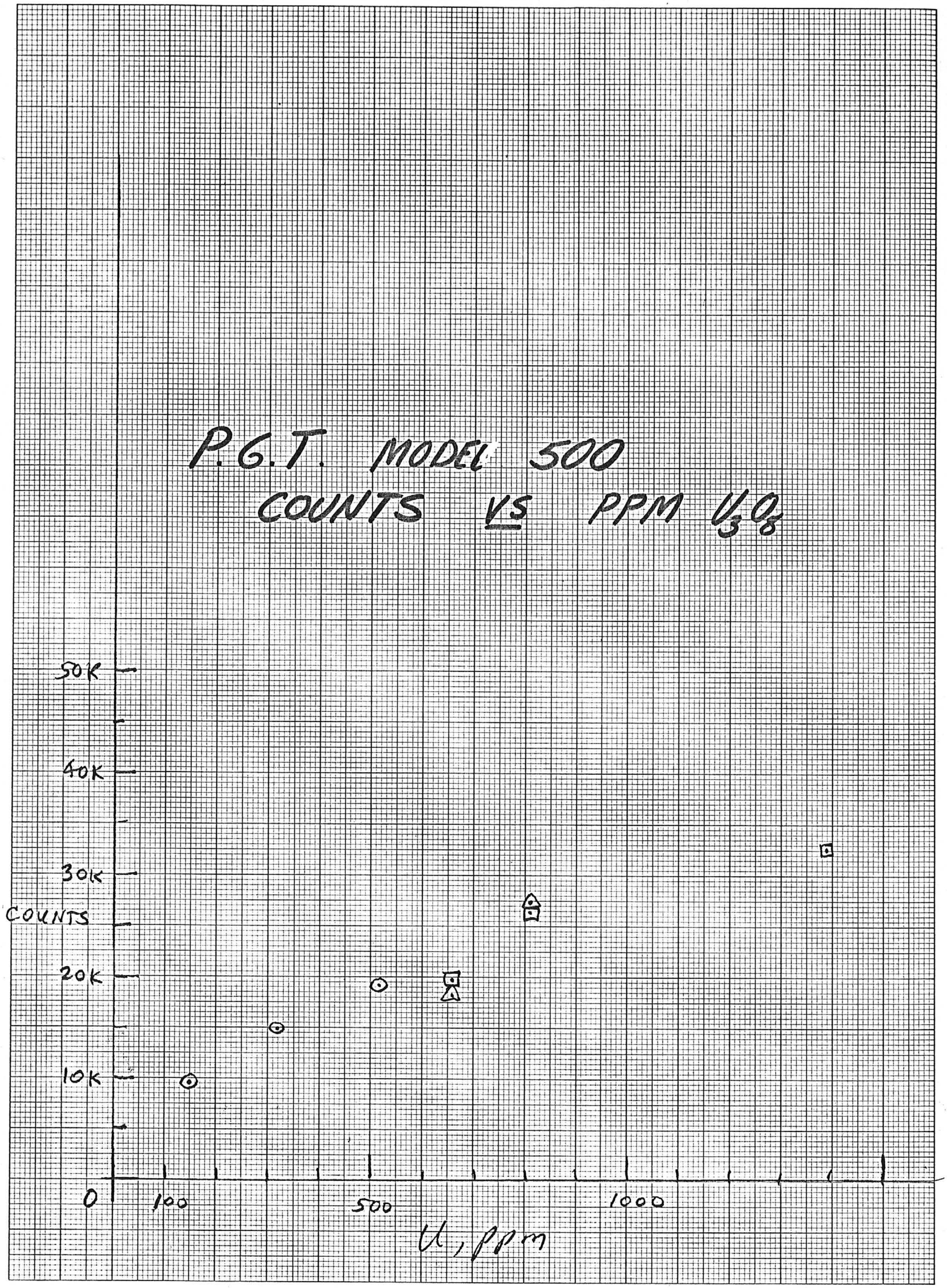
PGT Model 500 set up to analyze Anderson Ore at Princeton, New Jersey.



Bars - .05% U_3O_8 Anderson Ore
Dots - .02% U_3O_8 Anderson Ore
Read on PGT Model 500



Bars - .05% U_3O_8 Anderson Ore
Dots - .01% U_3O_8 Anderson Ore
Read on PGT Model 500



P.G.T. MODEL 500
COUNTS VS PPM U_3O_8
50K
40K
30K
COUNTS
20K
10K
0
100
500
1000
U, ppm

Manufacturer: Princeton Gamma-Tech

Model Number: Custom Built Probe Tower

Type of Unit: GAMMA RAY SPECTROMETER using Intrinsic Germanium Detectors.

Cost of Basic Unit: $70,000

Sample Preparation: None

Analysis Time: 60 Seconds

Total Turnaround Time: One Minute

Nearest Service: 1000 Oaks, California, Factory-Princeton, New Jersey

Versatility: Single Purpose

Added Functions:

Type:

Cost:

Previous Application in Uranium Mining: None

Remarks: Applied to downhole probe and cleanup program on Pacific Ocean atoll.

PGT
PRINCETON GAMMA-TECH
Box 641 ▪ Princeton, N.J. 08540
Telephone (609) 924-7310
Cable PRINGAMTEC ▪ Telex: 843486

September 21, 1977

Mr. Bob Lucht
Minerals Exploration Company
Box 50324
Tucson, Arizona 85703

Dear Bob:

It was a pleasure having you visit us a few weeks ago.

I believe you wanted "ballpark" prices for several analytical systems for Uranium for budgeting. Here they are for three systems we discussed.

1) Model 100-1C (I.G.) XRF analyzer with 10 mCi Co-57 source and Intrinsic Germanium detector. Single element readout for Uranium directly in weight percent or ppm. A single sample will consist of a few grams of finely granulated or pulverized material. This instrument will analyze for the $K\alpha_1$ X-ray line of Uranium. For a 1-minute counting time its repeatability will be about $\pm$0.003 wt.% at the 0.02 wt.% level.

Approximate Price: $20,000.00

2) Gamma-ray spectrometer(s) operating from probe tower, viewing ore in a truck and reading into a Model 100-style control and readout unit. Prices are for standard 15% efficiency (relative to NaI(Tl) scintillation) coaxial Intrinsic Germanium detectors, cryostats and electronics, and do not include holding and positioning mechanisms for the detectors. Analysis is based on the 1.0 MeV gamma-ray line from Pa-234m, daughter of U-238. For a 1-minute counting time repeatability will be $\pm$0.006 wt.% for a single detector and $\pm$0.004 wt.% for 2 detectors in tandem, at the 0.02 wt.% level. By going to a 4-minute count, the reproducibilities will be cut to $\pm$0.003 wt.% for a single detector and $\pm$0.002 wt.% for 2 detectors. (Prices include microprocessor-based analysis and electronic stabilization system, ultra-stable amplifier and analog-to-digital converter.

2a) Single detector system.

Approximate Price: $42,000.00

2b) Dual detector system. Includes 3-display readout: Detector #1, Detector #2 and the average of the two.

Approximate Price: $70,000.00

3) Single 15% Intrinsic Germanium detector (downward-looking) for field work with Model 100-style readout. Can be vehicle-mounted or cart mounted. Repeatability will be 0.006 wt.% for a 1-minute counting time and ±0.003 wt.% for a 4-minute counting time, at the 0.02 wt.% level.

Approximate Price: $42,000.00

Your interest in our products is appreciated. Please let Fred or me know if there are any questions.

Sincerely,

PRINCETON GAMMA-TECH, INC.

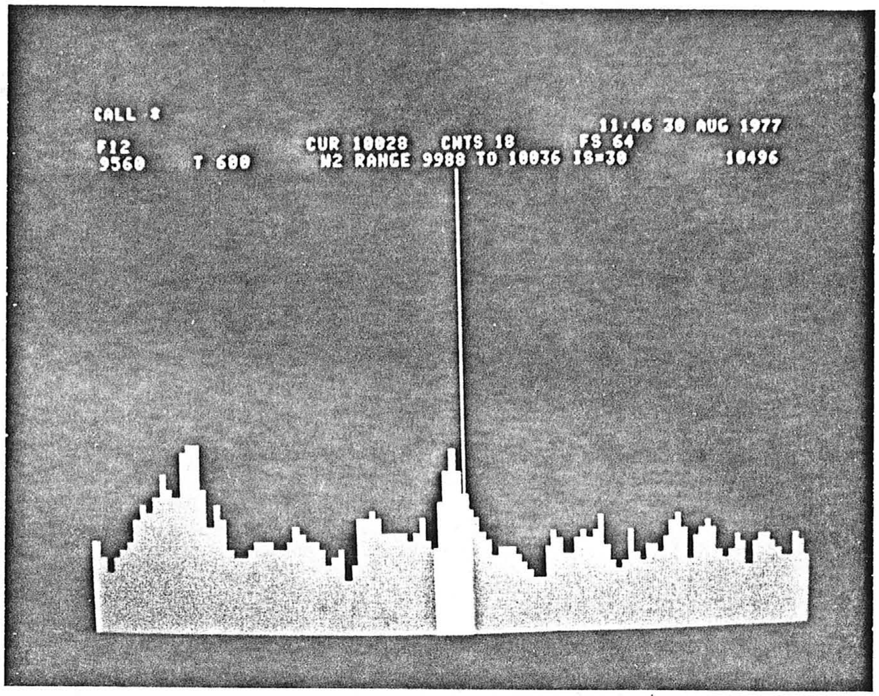
Dan Lister

Daniel B. Lister, Ph. D.
Marketing Manager,
Industrial Systems

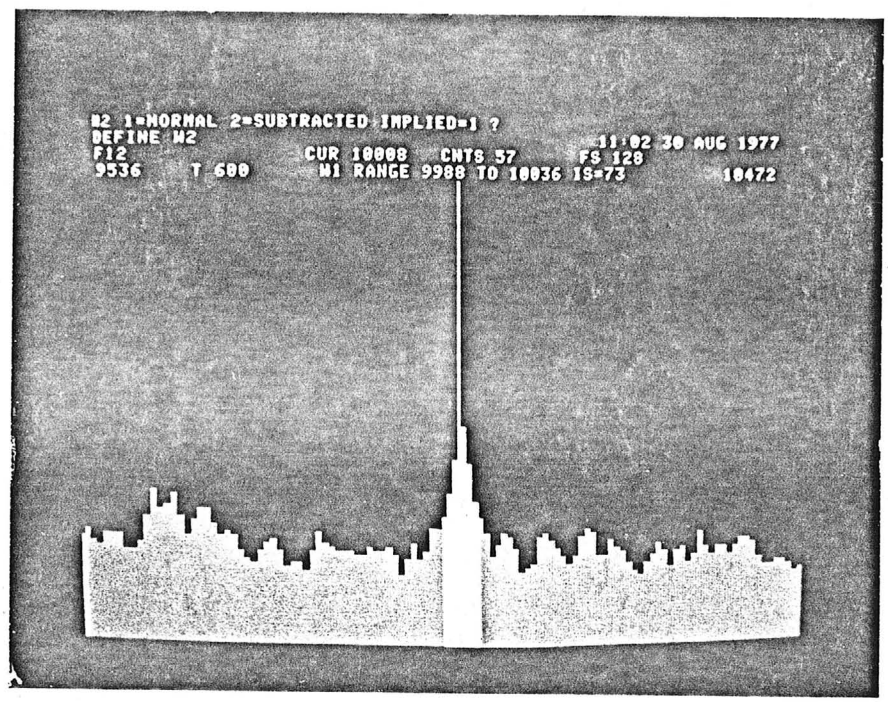
DBL:cab

cc: Fred Feeley
Western Regional Sales Manager
P. O. Box 4319
Thousand Oaks, CA 91359
805-497-2427

Len Goldman, PGT
Gary Schnerr, PGT
Walter Binns, PGT



.012% U_3O_8 in Anderson Ore reading by Gamma Ray Spectrometer. 600 Seconds count time. One Mev Peak.



.052% U_3O_8 Anderson Ore. 600 Seconds count time. One Mev Peak.

Intrinsic Germanium Detector in liquid nitrogen gyrogen. Anderson pulp was placed directly on top of this arrangement using a standard .5 L cup.

CONCLUSIONS

The gamma ray spectrometer as conceived by Princeton Gamma-Tech using two intrinsic germanium detectors is the best solution for fast turnaround time and reliability. The cost of approximately $70,000 is competitive with an automated energy dispersive spectrometer without the time consuming sample preparation.

RECOMMENDATION

It is recommended that the ore control program at Anderson Mine consist of standard T probes in the pit and a probe tower using an intrinsic germanium gamma ray spectrometer.

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 20986
Page 1 of 17 Pages
Date 2 Mar 1977

TO: Hazen Research, Inc

SAMPLE: AM 184C 475-476'
A342-1

NOTE: The values below are estimated concentrations in ppm for the metal equivalent of the indicated elements. No check was made for elements with atomic numbers less than 22 (below titanium).

Copper	230	Iron	42000	Lanthanum	
Silver		Cobalt		Cerium	
Gold		Nickel	230	Praseodymium	
Zinc	310	Cesium		Neodymium	
Cadmium		Rubidium	430	Samarium	
Mercury		Barium	780	Europium	
Gallium		Strontium	640	Gadolinium	
Indium		Titanium	850	Terbium	
Thallium		Zirconium	320	Dysprosium	
Germanium		Hafnium		Holmium	
Tin		Thorium		Erbium	
Lead	300	Vanadium	760	Thulium	
Arsenic	250	Columbium		Ytterbium	
Antimony		Tantalum		Lutetium	
Bismuth		Chromium		Yttrium	170
Selenium		Molybdenum	81		
Tellurium		Tungsten			
Bromine		Uranium	750		
Iodine		Manganese	250		

By Merlyn L Salmon

NOTE: A PORTION OF THE REPORTED SAMPLES WILL BE RETAINED ON FILE FOR A PERIOD OF FIVE 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)
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Phone (303) 837-1396
Merlyn L. Salmon, Manager

XXXX QUALITATIVE
XXXX SEMI-QUANTITATIVE
______ QUANTITATIVE

ANALYTICAL REPORT

Job Number 20986
Page 2 of 17 Pages
Date 2 Mar 1977

TO:

Hazen Research, Inc

SAMPLE: AM 184C 507-508'
A342-2

NOTE: The values below are estimated concentrations in ppm for the metal equivalent of the indicated elements. No check was made for elements with atomic numbers less than 22 (below titanium).

Copper	100	Iron	7100	Lanthanum	
Silver		Cobalt		Cerium	
Gold		Nickel	35	Praseodymium	
Zinc	110	Cesium		Neodymium	
Cadmium		Rubidium	72	Samarium	
Mercury		Barium	350	Europium	
Gallium		Strontium	2400	Gadolinium	
Indium		Titanium	490	Terbium	
Thallium		Zirconium	410	Dysprosium	
Germanium		Hafnium		Holmium	
Tin		Thorium		Erbium	
Lead	100	Vanadium	240	Thulium	
Arsenic	79	Columbium		Ytterbium	
Antimony		Tantalum		Lutetium	
Bismuth		Chromium		Yttrium	45
Selenium		Molybdenum	24		
Tellurium		Tungsten			
Bromine		Uranium	600		
Iodine		Manganese	790		

By Merlyn L Salmon

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ANALYTICAL REPORT

Job Number 20986
Page 3 of 17 Pages
Date 2 Mar 1977

TO:
Hazen Research, Inc

SAMPLE: AM 184C 532-533'
A342-3

NOTE: The values below are estimated concentrations in ppm for the metal equivalent of the indicated elements. No check was made for elements with atomic numbers less than 22 (below titanium).

Copper	180	Iron	15000	Lanthanum	
Silver		Cobalt		Cerium	
Gold		Nickel	84	Praseodymium	
Zinc	130	Cesium		Neodymium	
Cadmium		Rubidium	160	Samarium	
Mercury		Barium	600	Europium	
Gallium		Strontium	530	Gadolinium	
Indium		Titanium	1100	Terbium	
Thallium		Zirconium	200	Dysprosium	
Germanium		Hafnium		Holmium	
Tin		Thorium		Erbium	
Lead	87	Vanadium	1000	Thulium	
Arsenic	270	Columbium		Ytterbium	
Antimony		Tantalum		Lutetium	
Bismuth		Chromium	190	Yttrium	
Selenium		Molybdenum	140		
Tellurium		Tungsten			
Bromine		Uranium	720		
Iodine		Manganese	220		

By Merlyn L Salmon

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ANALYTICAL REPORT

Job Number 20986
Page 4 of 17 Pages
Date 2 Mar 1977

TO:

Hazen Research, Inc

SAMPLE: AM 184C 672-673'
A342-4

NOTE: The values below are estimated concentrations in ppm for the metal equivalent of the indicated elements. No check was made for elements with atomic numbers less than 22 (below titanium).

Copper	160	Iron	25000	Lanthanum	
Silver		Cobalt		Cerium	
Gold		Nickel	150	Praseodymium	
Zinc	360	Cesium		Neodymium	
Cadmium		Rubidium	340	Samarium	
Mercury		Barium	620	Europium	
Gallium		Strontium	390	Gadolinium	
Indium		Titanium	830	Terbium	
Thallium		Zirconium	180	Dysprosium	
Germanium		Hafnium		Holmium	
Tin		Thorium		Erbium	
Lead		Vanadium	2200	Thulium	
Arsenic	320	Columbium		Ytterbium	
Antimony		Tantalum		Lutetium	
Bismuth		Chromium	230	Yttrium	76
Selenium		Molybdenum	360		
Tellurium		Tungsten			
Bromine		Uranium	1500		
Iodine		Manganese	350		

By [signature]

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ANALYTICAL REPORT

Job Number 20986
Page 5 of 17 Pages
Date 2 Mar 1977

TO:

Hazen Research, Inc

SAMPLE: AM 289C 81-82'
A342-5

NOTE: The values below are estimated concentrations in ppm for the metal equivalent of the indicated elements. No check was made for elements with atomic numbers less than 22 (below titanium).

Copper	180	Iron	13000	Lanthanum	
Silver		Cobalt		Cerium	
Gold		Nickel	100	Praseodymium	
Zinc	250	Cesium		Neodymium	
Cadmium		Rubidium	140	Samarium	
Mercury		Barium	630	Europium	
Gallium		Strontium	1500	Gadolinium	
Indium		Titanium	1000	Terbium	
Thallium		Zirconium	350	Dysprosium	
Germanium		Hafnium		Holmium	
Tin		Thorium		Erbium	
Lead		Vanadium		Thulium	
Arsenic		Columbium		Ytterbium	
Antimony		Tantalum		Lutetium	
Bismuth		Chromium		Yttrium	85
Selenium		Molybdenum	39		
Tellurium		Tungsten			
Bromine		Uranium	1100		
Iodine		Manganese	380		

By [signature]

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ANALYTICAL REPORT

Job Number 20986
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Date 2 Mar 1977

TO:
Hazen Research, Inc

SAMPLE: AM 289C 143-144'
A342-6

NOTE: The values below are estimated concentrations in ppm for the metal equivalent of the indicated elements. No check was made for elements with atomic numbers less then 22 (below titanium).

Copper	210	Iron	11000	Lanthanum	
Silver		Cobalt		Cerium	
Gold		Nickel	21	Praseodymium	
Zinc	130	Cesium		Neodymium	
Cadmium		Rubidium	120	Samarium	
Mercury		Barium	510	Europium	
Gallium		Strontium	2400	Gadolinium	
Indium		Titanium	980	Terbium	
Thallium		Zirconium	500	Dysprosium	
Germanium		Hafnium		Holmium	
Tin		Thorium		Erbium	
Lead	120	Vanadium		Thulium	
Arsenic	90	Columbium		Ytterbium	
Antimony		Tantalum		Lutetium	
Bismuth		Chromium	180	Yttrium	
Selenium		Molybdenum	49		
Tellurium		Tungsten			
Bromine		Uranium	250		
Iodine		Manganese	540		

By [signature]

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ANALYTICAL REPORT

Job Number 20986

Date 2 Mar 1977

TO: Hazen Research, Inc

SAMPLE: AM 337C 425-426'
A342-7

NOTE: The values below are estimated concentrations in ppm for the metal equivalent of the indicated elements. No check was made for elements with atomic numbers less than 22 (below titanium).

Copper	72	Iron	17000	Lanthanum	
Silver		Cobalt		Cerium	
Gold		Nickel	150	Praseodymium	
Zinc	120	Cesium		Neodymium	
Cadmium		Rubidium	96	Samarium	
Mercury		Barium	1400	Europium	
Gallium		Strontium	2500	Gadolinium	
Indium		Titanium	660	Terbium	
Thallium		Zirconium	560	Dysprosium	
Germanium		Hafnium		Holmium	
Tin		Thorium		Erbium	
Lead	200	Vanadium		Thulium	
Arsenic	77	Columbium		Ytterbium	
Antimony		Tantalum		Lutetium	
Bismuth		Chromium	250	Yttrium	96
Selenium		Molybdenum	45		
Tellurium		Tungsten			
Bromine		Uranium	750		
Iodine		Manganese	230		

By Merlyn L Salmon

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ANALYTICAL REPORT

Job Number 20986
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Date 2 Mar 1977

TO:
Hazen Research, Inc

SAMPLE: AM 412C 130-131'
A342-8

NOTE: The values below are estimated concentrations in ppm for the metal equivalent of the indicated elements. No check was made for elements with atomic numbers less than 22 (below titanium).

Copper	190	Iron	24000	Lanthanum	
Silver		Cobalt		Cerium	
Gold		Nickel	83	Praseodymium	
Zinc	290	Cesium		Neodymium	
Cadmium		Rubidium	390	Samarium	
Mercury		Barium	1000	Europium	
Gallium		Strontium	550	Gadolinium	
Indium		Titanium	1200	Terbium	
Thallium		Zirconium	370	Dysprosium	
Germanium		Hafnium		Holmium	
Tin		Thorium		Erbium	
Lead	55	Vanadium	1000	Thulium	
Arsenic	170	Columbium		Ytterbium	
Antimony		Tantalum		Lutetium	
Bismuth		Chromium	70	Yttrium	72
Selenium		Molybdenum	170		
Tellurium		Tungsten			
Bromine		Uranium	4000		
Iodine		Manganese	160		

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ANALYTICAL REPORT

Job Number 20986
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Date 2 Mar 1977

TO:
Hazen Research, Inc

SAMPLE: AM 412C 141-142'
A342-9

NOTE: The values below are estimated concentrations in ppm for the metal equivalent of the indicated elements. No check was made for elements with atomic numbers less than 22 (below titanium).

Copper	220	Iron	47000	Lanthanum	
Silver		Cobalt		Cerium	
Gold		Nickel	200	Praseodymium	
Zinc	340	Cesium		Neodymium	
Cadmium		Rubidium	240	Samarium	
Mercury		Barium	1400	Europium	
Gallium		Strontium	1600	Gadolinium	
Indium		Titanium	1900	Terbium	
Thallium		Zirconium	560	Dysprosium	
Germanium		Hafnium		Holmium	
Tin		Thorium		Erbium	
Lead	46	Vanadium	1700	Thulium	
Arsenic	170	Columbium		Ytterbium	
Antimony		Tantalum		Lutetium	
Bismuth		Chromium		Yttrium	32
Selenium		Molybdenum	100		
Tellurium		Tungsten			
Bromine		Uranium	1500		
Iodine		Manganese	480		

By Merlyn L. Salmon

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ANALYTICAL REPORT

Job Number 20986
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TO:
Hazen Research, Inc

SAMPLE: AM 275C 47-48'
A342-10

NOTE: The values below are estimated concentrations in ppm for the metal equivalent of the indicated elements. No check was made for elements with atomic numbers less than 22 (below titanium).

Copper	110	Iron	8600	Lanthanum	
Silver		Cobalt		Cerium	
Gold		Nickel	66	Praseodymium	
Zinc	270	Cesium		Neodymium	
Cadmium		Rubidium	310	Samarium	
Mercury		Barium	680	Europium	
Gallium		Strontium	2400	Gadolinium	
Indium		Titanium	1000	Terbium	
Thallium		Zirconium	560	Dysprosium	
Germanium		Hafnium		Holmium	
Tin		Thorium		Erbium	
Lead	71	Vanadium	2400	Thulium	
Arsenic	120	Columbium		Ytterbium	
Antimony		Tantalum		Lutetium	
Bismuth		Chromium	120	Yttrium	
Selenium		Molybdenum	87		
Tellurium		Tungsten			
Bromine		Uranium	3900		
Iodine		Manganese	290		

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ANALYTICAL REPORT

Job Number 20986
Page 11 of 17 Pages
Date 2 Mar 1977

TO:
Hazen Research, Inc

SAMPLE: AM 390C 279-280'
A342-11

NOTE: The values below are estimated concentrations in ppm for the metal equivalent of the indicated elements. No check was made for elements with atomic numbers less than 22 (below titanium).

Copper	140	Iron	19000	Lanthanum	
Silver		Cobalt	14	Cerium	
Gold		Nickel	74	Praseodymium	
Zinc	280	Cesium		Neodymium	
Cadmium		Rubidium	210	Samarium	
Mercury		Barium	580	Europium	
Gallium		Strontium	720	Gadolinium	
Indium		Titanium	810	Terbium	
Thallium		Zirconium	420	Dysprosium	
Germanium		Hafnium		Holmium	
Tin		Thorium		Erbium	
Lead	81	Vanadium	1100	Thulium	
Arsenic	70	Columbium		Ytterbium	
Antimony		Tantalum		Lutetium	
Bismuth		Chromium	140	Yttrium	35
Selenium		Molybdenum	170		
Tellurium		Tungsten			
Bromine		Uranium	1300		
Iodine		Manganese	370		

By Merlyn L. Salmon

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ANALYTICAL REPORT

Job Number 20986
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Date 2 Mar 1977

TO:
Hazen Research, Inc

SAMPLE: AM 222C 110-111'
A342-12

NOTE: The values below are estimated concentrations in ppm for the metal equivalent of the indicated elements. No check was made for elements with atomic numbers less than 22 (below titanium).

Copper	100	Iron	5300	Lanthanum	
Silver		Cobalt		Cerium	
Gold		Nickel	84	Praseodymium	
Zinc	150	Cesium		Neodymium	
Cadmium		Rubidium	150	Samarium	
Mercury		Barium	120	Europium	
Gallium		Strontium	1700	Gadolinium	
Indium		Titanium	500	Terbium	
Thallium		Zirconium	360	Dysprosium	
Germanium		Hafnium		Holmium	
Tin		Thorium		Erbium	
Lead	49	Vanadium	79	Thulium	
Arsenic	33	Columbium		Ytterbium	
Antimony		Tantalum		Lutetium	
Bismuth		Chromium	10	Yttrium	47
Selenium		Molybdenum	82		
Tellurium		Tungsten			
Bromine		Uranium	1200		
Iodine		Manganese	410		

By [signature]

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ANALYTICAL REPORT

Job Number 20986
Page 13 of 17 Pages
Date 2 Mar 1977

TO:
Hazen Research, Inc

SAMPLE: AM 229C 124-125'
A342-13

NOTE: The values below are estimated concentrations in ppm for the metal equivalent of the indicated elements. No check was made for elements with atomic numbers less than 22 (below titanium).

Copper	54	Iron	16000	Lanthanum	
Silver		Cobalt	34	Cerium	
Gold		Nickel	150	Praseodymium	
Zinc	220	Cesium		Neodymium	
Cadmium		Rubidium	230	Samarium	
Mercury		Barium	1100	Europium	
Gallium		Strontium	1000	Gadolinium	
Indium		Titanium	1000	Terbium	
Thallium		Zirconium	310	Dysprosium	
Germanium		Hafnium		Holmium	
Tin		Thorium	59	Erbium	
Lead	49	Vanadium	240	Thulium	
Arsenic	44	Columbium		Ytterbium	
Antimony		Tantalum		Lutetium	
Bismuth		Chromium		Yttrium	62
Selenium		Molybdenum	23		
Tellurium		Tungsten			
Bromine		Uranium	800		
Iodine		Manganese	180		

By [signature]

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ANALYTICAL REPORT

Job Number 20986
Page 14 of 17 Pages
Date 2 Mar 1977

TO:
Hazen Research, Inc

SAMPLE: AM-244C 78-79
A342-14

NOTE: The values below are estimated concentrations in ppm for the metal equivalent of the indicated elements. No check was made for elements with atomic numbers less than 22 (below titanium).

Copper	240	Iron	22000	Lanthanum	
Silver		Cobalt		Cerium	
Gold		Nickel	130	Praseodymium	
Zinc	150	Cesium		Neodymium	
Cadmium		Rubidium	130	Samarium	
Mercury		Barium	420	Europium	
Gallium		Strontium	530	Gadolinium	
Indium		Titanium	1200	Terbium	
Thallium		Zirconium	180	Dysprosium	
Germanium		Hafnium		Holmium	
Tin		Thorium		Erbium	
Lead	46	Vanadium	320	Thulium	
Arsenic	65	Columbium		Ytterbium	
Antimony		Tantalum		Lutetium	
Bismuth		Chromium		Yttrium	56
Selenium		Molybdenum	44		
Tellurium		Tungsten			
Bromine		Uranium	380		
Iodine		Manganese	260		

By Merlyn L. Salmon

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ANALYTICAL REPORT

Job Number 20986
Page 15 of 17 Pages
Date 2 Mar 1977

TO:
Hazen Research, Inc

SAMPLE: AM 273C 139-140'
A342-15

NOTE: The values below are estimated concentrations in ppm for the metal equivalent of the indicated elements. No check was made for elements with atomic numbers less than 22 (below titanium).

Copper	170	Iron	15000	Lanthanum	
Silver		Cobalt	34	Cerium	
Gold		Nickel	150	Praseodymium	
Zinc	69	Cesium		Neodymium	
Cadmium		Rubidium	36	Samarium	
Mercury		Barium	630	Europium	
Gallium		Strontium	1800	Gadolinium	
Indium		Titanium	1300	Terbium	
Thallium		Zirconium	390	Dysprosium	
Germanium		Hafnium		Holmium	
Tin		Thorium		Erbium	
Lead		Vanadium	480	Thulium	
Arsenic	30	Columbium		Ytterbium	
Antimony		Tantalum		Lutetium	
Bismuth		Chromium		Yttrium	25
Selenium		Molybdenum	92		
Tellurium		Tungsten			
Bromine		Uranium	180		
Iodine		Manganese	150		

By [signature]

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ANALYTICAL REPORT

Job Number 20986
Page 16 of 17 Pages
Date 2 Mar 1977

TO:
Hazen Research, Inc

SAMPLE: AM 273C 158-159'
A342-16

NOTE: The values below are estimated concentrations in ppm for the metal equivalent of the indicated elements. No check was made for elements with atomic numbers less than 22 (below titanium).

Copper	140	Iron	16000	Lanthanum	
Silver		Cobalt		Cerium	
Gold		Nickel	65	Praseodymium	
Zinc	150	Cesium		Neodymium	
Cadmium		Rubidium	190	Samarium	
Mercury		Barium	570	Europium	
Gallium		Strontium	440	Gadolinium	
Indium		Titanium	1200	Terbium	
Thallium		Zirconium	250	Dysprosium	
Germanium		Hafnium		Holmium	
Tin		Thorium		Erbium	
Lead	170	Vanadium		Thulium	
Arsenic	300	Columbium		Ytterbium	
Antimony		Tantalum		Lutetium	
Bismuth		Chromium	74	Yttrium	78
Selenium		Molybdenum	180		
Tellurium		Tungsten			
Bromine		Uranium	480		
Iodine		Manganese	260		

By Merlyn Salmon

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ANALYTICAL REPORT

Job Number 20986
Page 17 of 17 Pages
Date 2 Mar 1977

TO:
Hazen Research, Inc

SAMPLE: AM 273C 176-177'
A342-17

NOTE: The values below are estimated concentrations in ppm for the metal equivalent of the indicated elements. No check was made for elements with atomic numbers less than 22 (below titanium).

Copper	110	Iron	35000	Lanthanum	
Silver		Cobalt		Cerium	
Gold		Nickel	150	Praseodymium	
Zinc	260	Cesium		Neodymium	
Cadmium		Rubidium	320	Samarium	
Mercury		Barium	1000	Europium	
Gallium		Strontium	500	Gadolinium	
Indium		Titanium	2300	Terbium	
Thallium		Zirconium	370	Dysprosium	
Germanium		Hafnium		Holmium	
Tin		Thorium		Erbium	
Lead	110	Vanadium	960	Thulium	
Arsenic	39	Columbium		Ytterbium	
Antimony		Tantalum		Lutetium	
Bismuth		Chromium	140	Yttrium	130
Selenium		Molybdenum	100		
Tellurium		Tungsten			
Bromine		Uranium	380		
Iodine		Manganese	350		

By Merlyn L. Salmon

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ANALYTICAL REPORT

Job Number 20996
Page 1 of 4 Pages
Date 4 Mar 1977

TO:
Hazen Research, Inc

SAMPLE: AM-222C 116-117'
B151-3

NOTE: The values below are estimated concentrations in ppm for the metal equivalent of the indicated elements. No check was made for elements with atomic numbers less than 22 (below titanium).

Copper	120	Iron	12000	Lanthanum	
Silver		Cobalt		Cerium	
Gold		Nickel	65	Praseodymium	
Zinc	110	Cesium		Neodymium	
Cadmium		Rubidium	100	Samarium	
Mercury		Barium	830	Europium	
Gallium		Strontium	620	Gadolinium	
Indium		Titanium	1600	Terbium	
Thallium		Zirconium	260	Dysprosium	
Germanium		Hafnium		Holmium	
Tin		Thorium		Erbium	
Lead		Vanadium		Thulium	
Arsenic		Columbium		Ytterbium	
Antimony		Tantalum		Lutetium	
Bismuth		Chromium	140	Yttrium	42
Selenium		Molybdenum	38		
Tellurium		Tungsten			
Bromine		Uranium	210		
Iodine		Manganese	130		

By Merlyn L. Salmon

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ANALYTICAL REPORT

Job Number 20996
Page 2 of 4 Pages
Date 4 Mar 1977

TO:
Hazen Research, Inc

SAMPLE: AM 254C 124-125'
B151-7

NOTE: The values below are estimated concentrations in ppm for the metal equivalent of the indicated elements. No check was made for elements with atomic numbers less than 22 (below titanium).

Copper	96	Iron	13000	Lanthanum	
Silver		Cobalt		Cerium	
Gold		Nickel	70	Praseodymium	
Zinc	150	Cesium		Neodymium	
Cadmium		Rubidium	170	Samarium	
Mercury		Barium	1100	Europium	
Gallium		Strontium	250	Gadolinium	
Indium		Titanium	1100	Terbium	
Thallium		Zirconium	140	Dysprosium	
Germanium		Hafnium		Holmium	
Tin		Thorium		Erbium	
Lead	100	Vanadium		Thulium	
Arsenic		Columbium		Ytterbium	
Antimony		Tantalum		Lutetium	
Bismuth		Chromium		Yttrium	54
Selenium		Molybdenum			
Tellurium		Tungsten			
Bromine		Uranium	180		
Iodine		Manganese	130		

By [signature]

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ANALYTICAL REPORT

Job Number 20996
Page 3 of 4 Pages
Date 4 Mar 1977

TO:

Hazen Research, Inc

SAMPLE: AM 273C 41-42'
B151-9

NOTE: The values below are estimated concentrations in ppm for the metal equivalent of the indicated elements. No check was made for elements with atomic numbers less than 22 (below titanium).

Copper	170	Iron	20000	Lanthanum	
Silver		Cobalt		Cerium	
Gold		Nickel	51	Praseodymium	
Zinc	200	Cesium		Neodymium	
Cadmium		Rubidium	270	Samarium	
Mercury		Barium	680	Europium	
Gallium		Strontium	350	Gadolinium	
Indium		Titanium	650	Terbium	
Thallium		Zirconium	190	Dysprosium	
Germanium		Hafnium		Holmium	
Tin		Thorium		Erbium	
Lead	28	Vanadium		Thulium	
Arsenic	35	Columbium	33	Ytterbium	
Antimony		Tantalum		Lutetium	
Bismuth		Chromium	24	Yttrium	92
Selenium		Molybdenum	17		
Tellurium		Tungsten			
Bromine		Uranium	240		
Iodine		Manganese	1100		

By [signature: Merlyn L. Salmon]

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ANALYTICAL REPORT

Job Number 20996
Page 4 of 4 Pages
Date 4 Mar 1977

TO:
Hazen Research, Inc

SAMPLE: AM 273C 42-43'
B151-10

NOTE: The values below are estimated concentrations in ppm for the metal equivalent of the indicated elements. No check was made for elements with atomic numbers less than 22 (below titanium).

Copper	170	Iron	32000	Lanthanum	
Silver		Cobalt		Cerium	
Gold		Nickel	95	Praseodymium	
Zinc	220	Cesium		Neodymium	
Cadmium		Rubidium	260	Samarium	
Mercury		Barium	550	Europium	
Gallium		Strontium	410	Gadolinium	
Indium		Titanium	1700	Terbium	
Thallium		Zirconium	200	Dysprosium	
Germanium		Hafnium		Holmium	
Tin		Thorium		Erbium	
Lead	93	Vanadium		Thulium	
Arsenic		Columbium		Ytterbium	
Antimony		Tantalum		Lutetium	
Bismuth		Chromium		Yttrium	72
Selenium		Molybdenum			
Tellurium		Tungsten			
Bromine		Uranium	180		
Iodine		Manganese	390		

By Merlyn L. Salmon

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ANALYTICAL REPORT

Job Number 21018
Page 1 of 26 Pages
Date 11 Mar 1977

TO:

Hazen Research, Inc

SAMPLE: AM 444C 344-345'
B141-3

NOTE: The values below are estimated concentrations in ppm for the metal equivalent of the indicated elements. No check was made for elements with atomic numbers less than 22 (below titanium).

Copper	91	Iron	11000	Lanthanum	
Silver		Cobalt		Cerium	
Gold		Nickel	20	Praseodymium	
Zinc	170	Cesium		Neodymium	
Cadmium		Rubidium	330	Samarium	
Mercury		Barium	580	Europium	
Gallium		Strontium	410	Gadolinium	
Indium		Titanium	970	Terbium	
Thallium		Zirconium	170	Dysprosium	
Germanium		Hafnium		Holmium	
Tin		Thorium		Erbium	
Lead	28	Vanadium		Thulium	
Arsenic	140	Columbium		Ytterbium	
Antimony		Tantalum		Lutetium	
Bismuth		Chromium		Yttrium	32
Selenium		Molybdenum	80		
Tellurium		Tungsten			
Bromine		Uranium	2600		
Iodine		Manganese	130		

By Merlyn Salmon

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ANALYTICAL REPORT

Job Number 21018
Page 2 of 26 Pages
Date 11 Mar 1977

TO:
Hazen Research, Inc

AM 444C 365-366'
SAMPLE: B141-7

NOTE: The values below are estimated concentrations in ppm for the metal equivalent of the indicated elements. No check was made for elements with atomic numbers less than 22 (below titanium).

Copper	70	Iron	18000	Lanthanum	
Silver		Cobalt		Cerium	
Gold		Nickel	50	Praseodymium	
Zinc	190	Cesium		Neodymium	
Cadmium		Rubidium	200	Samarium	
Mercury		Barium	1100	Europium	
Gallium		Strontium	320	Gadolinium	
Indium		Titanium	1100	Terbium	
Thallium		Zirconium	270	Dysprosium	
Germanium		Hafnium		Holmium	
Tin		Thorium		Erbium	
Lead	110	Vanadium	610	Thulium	
Arsenic	180	Columbium		Ytterbium	
Antimony		Tantalum		Lutetium	
Bismuth		Chromium	230	Yttrium	48
Selenium		Molybdenum	65		
Tellurium		Tungsten			
Bromine		Uranium	340		
Iodine		Manganese	530		

By Merlyn Salmon

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ANALYTICAL REPORT

Job Number 21018
Page 3 of 26 Pages
Date 11 Mar 1977

TO: Hazen Research, Inc

SAMPLE: AM 444C 388-389'
B141-10

NOTE: The values below are estimated concentrations in ppm for the metal equivalent of the indicated elements. No check was made for elements with atomic numbers less than 22 (below titanium).

Copper	84	Iron	13000	Lanthanum	
Silver		Cobalt		Cerium	
Gold		Nickel	50	Praseodymium	
Zinc	130	Cesium		Neodymium	
Cadmium		Rubidium	200	Samarium	
Mercury		Barium	840	Europium	
Gallium		Strontium	540	Gadolinium	
Indium		Titanium	1100	Terbium	
Thallium		Zirconium	290	Dysprosium	
Germanium		Hafnium		Holmium	
Tin		Thorium		Erbium	
Lead	81	Vanadium		Thulium	
Arsenic	100	Columbium		Ytterbium	
Antimony		Tantalum		Lutetium	
Bismuth		Chromium	100	Yttrium	44
Selenium		Molybdenum	51		
Tellurium		Tungsten			
Bromine		Uranium	330		
Iodine		Manganese	260		

By Merlyn L. Salmon

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ANALYTICAL REPORT

Job Number 21018
Page 4 of 26 Pages
Date 11 Mar 1977

TO:
Hazen Research, Inc

SAMPLE: AM 444C 389-390'
B141-11

NOTE: The values below are estimated concentrations in ppm for the metal equivalent of the indicated elements. No check was made for elements with atomic numbers less than 22 (below titanium).

Copper	170	Iron	14000	Lanthanum	
Silver		Cobalt		Cerium	
Gold		Nickel	86	Praseodymium	
Zinc	190	Cesium		Neodymium	
Cadmium		Rubidium	240	Samarium	
Mercury		Barium	620	Europium	
Gallium		Strontium	410	Gadolinium	
Indium		Titanium	1300	Terbium	
Thallium		Zirconium	210	Dysprosium	
Germanium		Hafnium		Holmium	
Tin		Thorium		Erbium	
Lead	34	Vanadium	620	Thulium	
Arsenic	170	Columbium		Ytterbium	
Antimony		Tantalum		Lutetium	
Bismuth		Chromium		Yttrium	81
Selenium		Molybdenum	88		
Tellurium		Tungsten			
Bromine		Uranium	450		
Iodine		Manganese	260		

By Merlyn Salmon

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ANALYTICAL REPORT

Job Number 21018

Date 11 Mar 1977

TO:
Hazen Research, Inc

SAMPLE: AM 444C 390-391'
B141-12

NOTE: The values below are estimated concentrations in ppm for the metal equivalent of the indicated elements. No check was made for elements with atomic numbers less than 22 (below titanium).

Copper	200	Iron	25000	Lanthanum	
Silver		Cobalt		Cerium	
Gold		Nickel	110	Praseodymium	
Zinc	220	Cesium		Neodymium	
Cadmium		Rubidium	360	Samarium	
Mercury		Barium	870	Europium	
Gallium		Strontium	480	Gadolinium	
Indium		Titanium	1600	Terbium	
Thallium		Zirconium	340	Dysprosium	
Germanium		Hafnium		Holmium	
Tin		Thorium		Erbium	
Lead		Vanadium		Thulium	
Arsenic	92	Columbium		Ytterbium	
Antimony		Tantalum		Lutetium	
Bismuth		Chromium		Yttrium	130
Selenium		Molybdenum	65		
Tellurium		Tungsten			
Bromine		Uranium	290		
Iodine		Manganese	450		

By Merlyn Salmon

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ANALYTICAL REPORT

Job Number 21018
Page 6 of 26 Pages
Date 11 Mar 1977

TO:
Hazen Research, Inc

SAMPLE: AM 444C 392-393'
B141-13

NOTE: The values below are estimated concentrations in ppm for the metal equivalent of the indicated elements. No check was made for elements with atomic numbers less than 22 (below titanium).

Copper	180	Iron	24000	Lanthanum	
Silver		Cobalt		Cerium	
Gold		Nickel	110	Praseodymium	
Zinc	180	Cesium		Neodymium	
Cadmium		Rubidium	330	Samarium	
Mercury		Barium	1200	Europium	
Gallium		Strontium	560	Gadolinium	
Indium		Titanium	1900	Terbium	
Thallium		Zirconium	280	Dysprosium	
Germanium		Hafnium		Holmium	
Tin		Thorium		Erbium	
Lead	84	Vanadium		Thulium	
Arsenic		Columbium		Ytterbium	
Antimony		Tantalum		Lutetium	
Bismuth		Chromium	24	Yttrium	43
Selenium		Molybdenum	42		
Tellurium		Tungsten			
Bromine		Uranium	300		
Iodine		Manganese	420		

By Merlyn L. Salmon

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ANALYTICAL REPORT

Job Number 21018
Page 7 of 26 Pages
Date 11 Mar 1977

TO:
Hazen Research, Inc

SAMPLE: AM 444C 422-423'
B141-18

NOTE: The values below are estimated concentrations in ppm for the metal equivalent of the indicated elements. No check was made for elements with atomic numbers less than 22 (below titanium).

Copper	110	Iron	16000	Lanthanum	
Silver		Cobalt	32	Cerium	
Gold		Nickel	110	Praseodymium	
Zinc	120	Cesium		Neodymium	
Cadmium		Rubidium	200	Samarium	
Mercury		Barium	580	Europium	
Gallium		Strontium	1200	Gadolinium	
Indium		Titanium	970	Terbium	
Thallium		Zirconium	270	Dysprosium	
Germanium		Hafnium		Holmium	
Tin		Thorium		Erbium	
Lead	87	Vanadium	300	Thulium	
Arsenic	72	Columbium		Ytterbium	
Antimony		Tantalum		Lutetium	
Bismuth		Chromium		Yttrium	74
Selenium		Molybdenum	220		
Tellurium		Tungsten			
Bromine		Uranium	260		
Iodine		Manganese	250		

By Merlyn L. Salmon

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ANALYTICAL REPORT

Job Number 21018
Page 8 of 26 Pages
Date 11 Mar 1977

TO:
Hazen Research, Inc

SAMPLE: AM 444C 423-424'
B141-19

NOTE: The values below are estimated concentrations in ppm for the metal equivalent of the indicated elements. No check was made for elements with atomic numbers less than 22 (below titanium).

Copper	160	Iron	31000	Lanthanum	
Silver		Cobalt		Cerium	
Gold		Nickel	130	Praseodymium	
Zinc	230	Cesium		Neodymium	
Cadmium		Rubidium	460	Samarium	
Mercury		Barium	560	Europium	
Gallium		Strontium	520	Gadolinium	
Indium		Titanium	1800	Terbium	
Thallium		Zirconium	200	Dysprosium	
Germanium		Hafnium		Holmium	
Tin		Thorium		Erbium	
Lead		Vanadium		Thulium	
Arsenic	250	Columbium		Ytterbium	
Antimony		Tantalum		Lutetium	
Bismuth		Chromium	260	Yttrium	84
Selenium		Molybdenum	170		
Tellurium		Tungsten			
Bromine		Uranium	600		
Iodine		Manganese	280		

By [signature]

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ANALYTICAL REPORT

Job Number 21018
Page 9 of 26 Pages
Date 11 Mar 1977

TO:
Hazen Research, Inc

SAMPLE: AM 424C 425-426'
B141-21

NOTE: The values below are estimated concentrations in ppm for the metal equivalent of the indicated elements. No check was made for elements with atomic numbers less than 22 (below titanium).

Copper	94	Iron	21000	Lanthanum	
Silver		Cobalt		Cerium	
Gold		Nickel	40	Praseodymium	
Zinc	360	Cesium		Neodymium	
Cadmium		Rubidium	160	Samarium	
Mercury		Barium	540	Europium	
Gallium		Strontium	350	Gadolinium	
Indium		Titanium	500	Terbium	
Thallium		Zirconium	200	Dysprosium	
Germanium		Hafnium		Holmium	
Tin		Thorium		Erbium	
Lead	530	Vanadium	310	Thulium	
Arsenic		Columbium		Ytterbium	
Antimony		Tantalum		Lutetium	
Bismuth		Chromium	150	Yttrium	69
Selenium		Molybdenum	220		
Tellurium		Tungsten			
Bromine		Uranium	310		
Iodine		Manganese	240		

By [signature]

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ANALYTICAL REPORT

Job Number 21018
Page 10 of 26 Pages
Date 11 Mar 1977

TO:
Hazen Research, Inc

SAMPLE: AM 4350 98-99'
B141-25

NOTE: The values below are estimated concentrations in ppm for the metal equivalent of the indicated elements. No check was made for elements with atomic numbers less than 22 (below titanium).

Copper	130	Iron	30000	Lanthanum	
Silver		Cobalt		Cerium	
Gold		Nickel	42	Praseodymium	
Zinc	260	Cesium		Neodymium	
Cadmium		Rubidium	240	Samarium	
Mercury		Barium	690	Europium	
Gallium		Strontium	360	Gadolinium	
Indium		Titanium	1600	Terbium	
Thallium		Zirconium	260	Dysprosium	
Germanium		Hafnium		Holmium	
Tin		Thorium		Erbium	
Lead	110	Vanadium	230	Thulium	
Arsenic		Columbium		Ytterbium	
Antimony		Tantalum		Lutetium	
Bismuth		Chromium	130	Yttrium	120
Selenium		Molybdenum	10		
Tellurium		Tungsten			
Bromine		Uranium	490		
Iodine		Manganese	370		

By [signature]

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ANALYTICAL REPORT

Job Number 21018
Page 11 of 26 Pages
Date 11 Mar 1977

TO:

Hazen Research, Inc

SAMPLE: AM 435C 100-101'
B141-27

NOTE: The values below are estimated concentrations in ppm for the metal equivalent of the indicated elements. No check was made for elements with atomic numbers less than 22 (below titanium).

Copper	81	Iron	22000	Lanthanum	
Silver		Cobalt		Cerium	
Gold		Nickel	130	Praseodymium	
Zinc	170	Cesium		Neodymium	
Cadmium		Rubidium	320	Samarium	
Mercury		Barium	1200	Europium	
Gallium		Strontium	640	Gadolinium	
Indium		Titanium	1800	Terbium	
Thallium		Zirconium	480	Dysprosium	
Germanium		Hafnium		Holmium	
Tin		Thorium		Erbium	
Lead	62	Vanadium	530	Thulium	
Arsenic	19	Columbium		Ytterbium	
Antimony		Tantalum		Lutetium	
Bismuth		Chromium	62	Yttrium	120
Selenium		Molybdenum	35		
Tellurium		Tungsten			
Bromine		Uranium	280		
Iodine		Manganese	370		

By Merlyn L. Salmon

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ANALYTICAL REPORT

Job Number 21018
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Date 11 Mar 1977

TO:
Hazen Research, Inc

SAMPLE: AM 435C 132-133'
B141-35

NOTE: The values below are estimated concentrations in ppm for the metal equivalent of the indicated elements. No check was made for elements with atomic numbers less than 22 (below titanium).

Copper	170	Iron	20000	Lanthanum	
Silver		Cobalt		Cerium	
Gold		Nickel	84	Praseodymium	
Zinc	180	Cesium		Neodymium	
Cadmium		Rubidium	180	Samarium	
Mercury		Barium	400	Europium	
Gallium		Strontium	370	Gadolinium	
Indium		Titanium	1900	Terbium	
Thallium		Zirconium	280	Dysprosium	
Germanium		Hafnium		Holmium	
Tin		Thorium		Erbium	
Lead		Vanadium		Thulium	
Arsenic	28	Columbium	35	Ytterbium	
Antimony		Tantalum		Lutetium	
Bismuth		Chromium		Yttrium	120
Selenium		Molybdenum			
Tellurium		Tungsten			
Bromine		Uranium	62		
Iodine		Manganese	220		

By Merlyn Salmon

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TO:
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NOTE: The values below are estimated concentrations in ppm for the metal equivalent of the indicated elements. No check was made for elements with atomic numbers less than 22 (below titanium).

SAMPLE: AM 435C 133-134'
B141-36

Copper	110	Iron	22000	Lanthanum	
Silver		Cobalt		Cerium	
Gold		Nickel	130	Praseodymium	
Zinc	210	Cesium		Neodymium	
Cadmium		Rubidium	260	Samarium	
Mercury		Barium	900	Europium	
Gallium		Strontium	560	Gadolinium	
Indium		Titanium	2000	Terbium	
Thallium		Zirconium	460	Dysprosium	
Germanium		Hafnium		Holmium	
Tin		Thorium		Erbium	
Lead		Vanadium		Thulium	
Arsenic		Columbium		Ytterbium	
Antimony		Tantalum		Lutetium	
Bismuth		Chromium	230	Yttrium	85
Selenium		Molybdenum			
Tellurium		Tungsten			
Bromine		Uranium	96		
Iodine		Manganese	340		

By [signature]

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ANALYTICAL REPORT

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TO:

Hazen Research, Inc

SAMPLE: AM 435C 135-136'
B141-38

NOTE: The values below are estimated concentrations in ppm for the metal equivalent of the indicated elements. No check was made for elements with atomic numbers less than 22 (below titanium).

Copper	78	Iron	12000	Lanthanum	
Silver		Cobalt		Cerium	
Gold		Nickel	120	Praseodymium	
Zinc	170	Cesium		Neodymium	
Cadmium		Rubidium	84	Samarium	
Mercury		Barium	420	Europium	
Gallium		Strontium	240	Gadolinium	
Indium		Titanium	810	Terbium	
Thallium		Zirconium	270	Dysprosium	
Germanium		Hafnium		Holmium	
Tin		Thorium		Erbium	
Lead	120	Vanadium		Thulium	
Arsenic		Columbium		Ytterbium	
Antimony		Tantalum		Lutetium	
Bismuth		Chromium		Yttrium	64
Selenium		Molybdenum	17		
Tellurium		Tungsten			
Bromine		Uranium	120		
Iodine		Manganese	130		

By Merlyn Salmon

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ANALYTICAL REPORT

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TO:

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NOTE: The values below are estimated concentrations in ppm for the metal equivalent of the indicated elements. No check was made for elements with atomic numbers less than 22 (below titanium).

SAMPLE: AM 435C 173-174'
B141-41

Copper	140	Iron	32000	Lanthanum	
Silver		Cobalt		Cerium	
Gold		Nickel	150	Praseodymium	
Zinc	230	Cesium		Neodymium	
Cadmium		Rubidium	410	Samarium	
Mercury		Barium	890	Europium	
Gallium		Strontium	390	Gadolinium	
Indium		Titanium	2300	Terbium	
Thallium		Zirconium	250	Dysprosium	
Germanium		Hafnium		Holmium	
Tin		Thorium		Erbium	
Lead	130	Vanadium		Thulium	
Arsenic		Columbium		Ytterbium	
Antimony		Tantalum		Lutetium	
Bismuth		Chromium		Yttrium	100
Selenium		Molybdenum			
Tellurium	87	Tungsten			
Bromine		Uranium	180		
Iodine		Manganese	420		

By Merlyn Salmon

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Job Number 21018

Date 11 Mar 1977

TO: Hazen Research, Inc

SAMPLE: AM 435C 180-181'
B141-43

NOTE: The values below are estimated concentrations in ppm for the metal equivalent of the indicated elements. No check was made for elements with atomic numbers less than 22 (below titanium).

Copper	98	Iron	19000	Lanthanum	
Silver		Cobalt		Cerium	
Gold		Nickel	62	Praseodymium	
Zinc	88	Cesium		Neodymium	
Cadmium		Rubidium	100	Samarium	
Mercury		Barium	680	Europium	
Gallium		Strontium	430	Gadolinium	
Indium		Titanium	330	Terbium	
Thallium		Zirconium	200	Dysprosium	
Germanium		Hafnium		Holmium	
Tin		Thorium		Erbium	
Lead	200	Vanadium	390	Thulium	
Arsenic	19	Columbium		Ytterbium	
Antimony		Tantalum		Lutetium	
Bismuth		Chromium	70	Yttrium	56
Selenium		Molybdenum			
Tellurium		Tungsten			
Bromine		Uranium	150		
Iodine		Manganese	210		

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Date 11 Mar 1977

TO:
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NOTE: The values below are estimated concentrations in ppm for the metal equivalent of the indicated elements. No check was made for elements with atomic numbers less than 22 (below titanium).

SAMPLE: AM 436C 221-222'
B141-45

Copper	200	Iron	16000	Lanthanum	
Silver		Cobalt		Cerium	
Gold		Nickel	30	Praseodymium	
Zinc	210	Cesium		Neodymium	
Cadmium		Rubidium	220	Samarium	
Mercury		Barium	420	Europium	
Gallium		Strontium	640	Gadolinium	
Indium		Titanium	970	Terbium	
Thallium		Zirconium	310	Dysprosium	
Germanium		Hafnium		Holmium	
Tin		Thorium	42	Erbium	
Lead	64	Vanadium	530	Thulium	
Arsenic	28	Columbium		Ytterbium	
Antimony		Tantalum		Lutetium	
Bismuth		Chromium		Yttrium	33
Selenium		Molybdenum	54		
Tellurium		Tungsten			
Bromine		Uranium	1200		
Iodine		Manganese	200		

By [signature]

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ANALYTICAL REPORT

Job Number 21018

Date 11 Mar 1977

TO:

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SAMPLE: AM 436C 222-223'
B141-46

NOTE: The values below are estimated concentrations in ppm for the metal equivalent of the indicated elements. No check was made for elements with atomic numbers less than 22 (below titanium).

Copper	180	Iron	21000	Lanthanum	
Silver		Cobalt		Cerium	
Gold		Nickel	110	Praseodymium	
Zinc	150	Cesium		Neodymium	
Cadmium		Rubidium	210	Samarium	
Mercury		Barium	1100	Europium	
Gallium		Strontium	520	Gadolinium	
Indium		Titanium	1600	Terbium	
Thallium		Zirconium	320	Dysprosium	
Germanium		Hafnium		Holmium	
Tin		Thorium		Erbium	
Lead	110	Vanadium		Thulium	
Arsenic	70	Columbium		Ytterbium	
Antimony		Tantalum		Lutetium	
Bismuth		Chromium	180	Yttrium	77
Selenium		Molybdenum	26		
Tellurium		Tungsten			
Bromine		Uranium	290		
Iodine		Manganese	370		

By Merlyn L. Salmon

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TO: Hazen Research, Inc

SAMPLE: AM 434C 529-530'
B141-48

NOTE: The values below are estimated concentrations in ppm for the metal equivalent of the indicated elements. No check was made for elements with atomic numbers less than 22 (below titanium).

Copper	160	Iron	16000	Lanthanum	
Silver		Cobalt		Cerium	
Gold		Nickel	130	Praseodymium	
Zinc	130	Cesium		Neodymium	
Cadmium		Rubidium	130	Samarium	
Mercury		Barium	510	Europium	
Gallium		Strontium	340	Gadolinium	
Indium		Titanium	500	Terbium	
Thallium		Zirconium	170	Dysprosium	
Germanium		Hafnium		Holmium	
Tin		Thorium		Erbium	
Lead	74	Vanadium	240	Thulium	
Arsenic		Columbium		Ytterbium	
Antimony		Tantalum		Lutetium	
Bismuth		Chromium		Yttrium	27
Selenium		Molybdenum	20		
Tellurium		Tungsten			
Bromine		Uranium	440		
Iodine		Manganese	230		

By Merlyn L Salmon

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ANALYTICAL REPORT

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TO:

Hazen Research, Inc

SAMPLE: AM 434C 536-537'
B141-50

NOTE: The values below are estimated concentrations in ppm for the metal equivalent of the indicated elements. No check was made for elements with atomic numbers less than 22 (below titanium).

Copper	120	Iron	18000	Lanthanum	
Silver		Cobalt		Cerium	
Gold		Nickel	29	Praseodymium	
Zinc	140	Cesium		Neodymium	
Cadmium		Rubidium	180	Samarium	
Mercury		Barium	990	Europium	
Gallium		Strontium	600	Gadolinium	
Indium		Titanium	970	Terbium	
Thallium		Zirconium	350	Dysprosium	
Germanium		Hafnium		Holmium	
Tin		Thorium		Erbium	
Lead	93	Vanadium		Thulium	
Arsenic		Columbium		Ytterbium	
Antimony		Tantalum		Lutetium	
Bismuth		Chromium		Yttrium	57
Selenium		Molybdenum	73		
Tellurium		Tungsten			
Bromine		Uranium	180		
Iodine		Manganese	220		

By Merlyn L Salmon

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ANALYTICAL REPORT

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TO:

Hazen Research, Inc

SAMPLE: AM 434C 537-538'
B141-51

NOTE: The values below are estimated concentrations in ppm for the metal equivalent of the indicated elements. No check was made for elements with atomic numbers less than 22 (below titanium).

Copper	150	Iron	24000	Lanthanum	
Silver		Cobalt		Cerium	
Gold		Nickel	73	Praseodymium	
Zinc	160	Cesium		Neodymium	
Cadmium		Rubidium	240	Samarium	
Mercury		Barium	750	Europium	
Gallium		Strontium	600	Gadolinium	
Indium		Titanium	1700	Terbium	
Thallium		Zirconium	480	Dysprosium	
Germanium		Hafnium		Holmium	
Tin		Thorium		Erbium	
Lead	120	Vanadium	310	Thulium	
Arsenic	31	Columbium		Ytterbium	
Antimony		Tantalum		Lutetium	
Bismuth		Chromium	10	Yttrium	110
Selenium		Molybdenum	23		
Tellurium		Tungsten			
Bromine		Uranium	220		
Iodine		Manganese	230		

By Merlyn Salmon

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Date 11 Mar 1977

TO:
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SAMPLE: AM 431C 562-563'
B141-53

NOTE: The values below are estimated concentrations in ppm for the metal equivalent of the indicated elements. No check was made for elements with atomic numbers less than 22 (below titanium).

Copper	110	Iron	7700	Lanthanum	
Silver		Cobalt		Cerium	
Gold		Nickel	38	Praseodymium	
Zinc	160	Cesium		Neodymium	
Cadmium		Rubidium	220	Samarium	
Mercury		Barium	450	Europium	
Gallium		Strontium	2400	Gadolinium	
Indium		Titanium	1100	Terbium	
Thallium		Zirconium	620	Dysprosium	
Germanium		Hafnium		Holmium	
Tin		Thorium		Erbium	
Lead		Vanadium		Thulium	
Arsenic	71	Columbium		Ytterbium	
Antimony		Tantalum		Lutetium	
Bismuth		Chromium		Yttrium	62
Selenium		Molybdenum	300		
Tellurium		Tungsten			
Bromine		Uranium	690		
Iodine		Manganese	300		

By [signature]

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ANALYTICAL REPORT

Job Number 21018

Date 11 Mar 1977

TO:

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SAMPLE: AM 431C 563-564'
B141-54

NOTE: The values below are estimated concentrations in ppm for the metal equivalent of the indicated elements. No check was made for elements with atomic numbers less than 22 (below titanium).

Copper	110	Iron	10000	Lanthanum	
Silver		Cobalt		Cerium	
Gold		Nickel	62	Praseodymium	
Zinc	110	Cesium		Neodymium	
Cadmium		Rubidium	40	Samarium	
Mercury		Barium	230	Europium	
Gallium		Strontium	1700	Gadolinium	
Indium		Titanium	970	Terbium	
Thallium		Zirconium	360	Dysprosium	
Germanium		Hafnium		Holmium	
Tin		Thorium		Erbium	
Lead		Vanadium		Thulium	
Arsenic	92	Columbium		Ytterbium	
Antimony		Tantalum		Lutetium	
Bismuth		Chromium	160	Yttrium	
Selenium		Molybdenum	110		
Tellurium		Tungsten			
Bromine		Uranium	260		
Iodine		Manganese	320		

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ANALYTICAL REPORT

Job Number 21018

Date 11 Mar 1977

TO:
Hazen Research, Inc

SAMPLE: AM 431C 575-576'
B141-58

NOTE: The values below are estimated concentrations in ppm for the metal equivalent of the indicated elements. No check was made for elements with atomic numbers less than 22 (below titanium).

Copper	90	Iron	18000	Lanthanum	
Silver		Cobalt		Cerium	
Gold		Nickel	74	Praseodymium	
Zinc	120	Cesium		Neodymium	
Cadmium		Rubidium	210	Samarium	
Mercury		Barium	540	Europium	
Gallium		Strontium	590	Gadolinium	
Indium		Titanium	1300	Terbium	
Thallium		Zirconium	220	Dysprosium	
Germanium		Hafnium		Holmium	
Tin		Thorium		Erbium	
Lead	150	Vanadium		Thulium	
Arsenic	290	Columbium		Ytterbium	
Antimony		Tantalum		Lutetium	
Bismuth		Chromium	10	Yttrium	40
Selenium		Molybdenum	450		
Tellurium		Tungsten			
Bromine		Uranium	340		
Iodine		Manganese	250		

By [signature]

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ANALYTICAL REPORT

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TO: Hazen Research, Inc

SAMPLE: AM 431C 576-577'
B141-59

NOTE: The values below are estimated concentrations in ppm for the metal equivalent of the indicated elements. No check was made for elements with atomic numbers less than 22 (below titanium).

Copper	74	Iron	11000	Lanthanum	
Silver		Cobalt		Cerium	
Gold		Nickel	40	Praseodymium	
Zinc	170	Cesium		Neodymium	
Cadmium		Rubidium	72	Samarium	
Mercury		Barium	540	Europium	
Gallium		Strontium	1500	Gadolinium	
Indium		Titanium		Terbium	
Thallium		Zirconium	360	Dysprosium	
Germanium		Hafnium		Holmium	
Tin		Thorium		Erbium	
Lead	86	Vanadium		Thulium	
Arsenic	190	Columbium		Ytterbium	
Antimony		Tantalum		Lutetium	
Bismuth		Chromium		Yttrium	13
Selenium		Molybdenum	220		
Tellurium		Tungsten			
Bromine		Uranium	180		
Iodine		Manganese	290		

By Merlyn L. Salmon

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Job Number 21018

Date 11 Mar 1977

TO:
Hazen Research, Inc

SAMPLE: AM 431C 578-579'
B141-61

NOTE: The values below are estimated concentrations in ppm for the metal equivalent of the indicated elements. No check was made for elements with atomic numbers less than 22 (below titanium).

Copper	110	Iron	6800	Lanthanum	
Silver		Cobalt		Cerium	
Gold		Nickel	38	Praseodymium	
Zinc	48	Cesium		Neodymium	
Cadmium		Rubidium	130	Samarium	
Mercury		Barium	680	Europium	
Gallium		Strontium	1300	Gadolinium	
Indium		Titanium	990	Terbium	
Thallium		Zirconium	280	Dysprosium	
Germanium		Hafnium		Holmium	
Tin		Thorium		Erbium	
Lead	43	Vanadium		Thulium	
Arsenic	140	Columbium		Ytterbium	
Antimony		Tantalum		Lutetium	
Bismuth		Chromium	11	Yttrium	14
Selenium		Molybdenum	190		
Tellurium		Tungsten			
Bromine		Uranium	300		
Iodine		Manganese	310		

By Merlyn L. Salmon

NOTE: A PORTION OF THE REPORTED SAMPLES WILL BE RETAINED ON FILE FOR A PERIOD OF FIVE 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.

ANDERSON MINE CO_2 STUDY

HOLE #	GRADE % U_3O_8 (FLUORIMETRIC)				HOLE #	GRADE % U_3O_8 (FLUORIMETRIC)			
	.015 - .030	.030 - .050	.050 - .090	.090 -		.015 - .030	.030 - .050	.050 - .090	.090 -
	% CO_2					% CO_2			
7	.32	-0-		.06					
	.01			-0-					
	-0-								
	-0-								
	-0-								
	-0-								
	-0-								
	-0-								
AVE	.05	-0-		-.03-					

ANDERSON MINE CO_2 STUDY

HOLE #	GRADE % U_3O_8 (FLUORIMETRIC) .015 - .030	.030 - .050	.050 - .090	.090 -
	% CO_2			
13	24.67	9.23		
	1.62	7.16		
	6.87			
	6.20			
	10.49			
	8.20			
	15.95			
	14.84			
	11.45			
	9.08			
	16.62			
	26.22			
	18.31			
	3.18			
	26.44			
	13.44			
	.30			
	14.11			
	14.77			
	2.14			
	9.67			
AVG	12.13	8.20	–	–

HOLE #	GRADE % U_3O_8 (FLUORIMETRIC) .015 - .030	.030 - .050	.050 - .090	.090 -
	% CO_2			
17	11.58	11.49	0	0
	.40	.07		
	.35	0		
	.01	0		
	0	0		
	.07	.15		
	0			
	0			
	0			
	0			
	0			
	0			
	0			
	0			
	0			
	0			
	0			
	0			
	0			
	0			
	0			
AVG	.59	1.96	0	0

ANDERSON MINE CO_2 STUDY

HOLE #	GRADE % U_3O_8 (FLUORIMETRIC)				HOLE #	GRADE % U_3O_8 (FLUORIMETRIC)			
	.015 – .030	.030 – .050	.050 – .090	.090 –		.015 – .030	.030 – .050	.050 – .090	.090 –
	% CO_2					% CO_2			
18	21.56	22.23	23.12	16.62	26	8.24	15.88	.01	36.93
	8.64	22.08	.74	22.82		3.72	15.36	22.01	27.99
	6.94		13.07	3.77		.03	6.79	18.09	26.00
	11.67		12.48	3.03		.01	29.91	.06	.07
	15.43					8.68	0		
	.22					.06	.09		
	.15					.72			
						4.95			
						9.90			
						9.16			
						27.32			
						30.06			
						8.35			
	9.23	22.16	12.36	11.56		8.56	11.34	10.05	22.75

ANDERSON MINE CO_2 STUDY

HOLE #	GRADE % U_3O_8 (FLUORIMETRIC) .015 - .030	.030 - .050	.050 - .090	.090 -
	% CO_2			
49	1.99	.01	26.51	.09
	11.89	30.72	25.33	
	33.60	6.65	25.63	
	2.73	5.98	2.29	
	.06	.22	2.51	
	.65	.22		
	.99			
	9.01			
	7.62	7.30	16.46	.09

HOLE #	GRADE % U_3O_8 (FLUORIMETRIC) .015 - .030	.030 - .050	.050 - .090	.090 -
	% CO_2			
51	0	0	23.25	.01
	0	14.24	.17	30.84
	0		.01	.19
	.02			.01
	.01			.13
	.02			.02
	.04			
	.02			
	.04			
	0			
	0			
	0			
	0			
	.1			
	0			
	0			
	0			
	3.63			
	14.02			
	7.81			
	.68			
	.11			
	.01			
	.02			
	.01			
	.02			
	.07			
	.02			
	.96	7.12	7.81	5.20

ANDERSON MINE CO_2 STUDY

HOLE #	GRADE % U_3O_8 (FLUORIMETRIC) .015-.030	.030-.050	.050-.090	.090-	HOLE #	GRADE % U_3O_8 (FLUORIMETRIC) .015-.030	.030-.050	.050-.090	.090-
	% CO_2					% CO_2			
79	6.40	32.35			113	7.75	0	0	0
	9.17					.44	0	0	
	12.10					11.15	0	0	
	12.36					14.84	0		
	31.68					7.39			
	30.28					0			
	23.48					0			
	1.02					0			
	3.84					0			
						0			
						0			
						0			
						0			
						0			
	17.07	32.35	—	—		2.97	0	0	0

ANDERSON MINE CO_2 STUDY

HOLE #	GRADE % U_3O_8 (FLUORIMETRIC)				HOLE #	GRADE % U_3O_8 (FLUORIMETRIC)			
	.015 - .030	.030 - .050	.050 - .090	.090 -		.015 - .030	.030 - .050	.050 - .090	.090 -
	% CO_2					% CO_2			
119	.15	31.24	0	10.63	135	0	0	0	.10
	20.86		27.03	24.52		.34	0	0	1.43
	35.45		12.26	.37		.16	0	.01	4.61
	26.81					.06	0	.01	6.99
	0						8.85	.01	.37
								28.06	16.84
								22.01	15.58
								.01	4.71
									.22
									1.09
	16.66	31.24	13.10	11.84		.14	1.77	6.27	5.20

ANDERSON MINE CO_2 STUDY

HOLE #	GRADE % U_3O_8 (FLUORIMETRIC)				HOLE #	GRADE % U_3O_8 (FLUORIMETRIC)			
	.015 – .030	.030 – .050	.050 – .090	.090 –		.015 – .030	.030 – .050	.050 – .090	.090 –
	% CO_2					% CO_2			
149	3.07	.38	.14	0					
	3.38	.02	.13						
	.17	0	.01						
	.07	0							
	.20	0							
	.26								
	.06								
	.04								
	.04								
	.01								
	.01								
	0								
	3.45								
	.10								
	0								
	.01								
	0								
	0								
	0								
	0								
	0								
	.01								
	.01								
	0								
	.46	.08	.10	0					

ANDERSON MINE CO_2 STUDY

HOLE #	GRADE % U_3O_8 (FLUORIMETRIC) .015–.030	.030–.050	.050–.090	.090–
	% CO_2			
184	.09	7.1	.11	.25
	.54	.07	28.9	
	15.9			
	11.4			
	.1			
	.2			
	.02			
	11.9			
	13.5			
	13.4			
	1.8			
	.49			
	.7			
	.2			
	.1			
	11.2			
	14.9			
	5.68	3.9	14.51	.25
222				32.6
	—	—	—	32.6
229				16.5
	—	—	—	16.5
244		.16		
	—	.16	—	—
273	10.1	32.6		
	.11			
	5.10	32.6	—	—

HOLE #	GRADE % U_3O_8 (FLUORIMETRIC) .015–.030	.030–.050	.050–.090	.090–
	% CO_2			
275	.7		14.2	
	16.8		32.2	9.8
AVE	8.8	—	23.2	9.8
289	.25	12.2	15.4	
	6.8	10.0		
	7.8	11.8		
	5.8	.1		
	35.0			
	33.3			
	27.4			
	19.9			
	29.8			
	37.4			
	20.6			
	27.0			
	.1			
	19.32	8.53	15.4	—
337	.4		21.2	
	.4	—	21.2	—
390	.1			.23
	.1	—	—	.23
412				2.4
				.15
	—	—	—	1.27

ANDERSON MINE CO_2 STUDY

HOLE #	GRADE % U_3O_8 (FLUORIMETRIC)				HOLE #	GRADE % U_3O_8 (FLUORIMETRIC)			
	.015 - .030	.030 - .050	.050 - .090	.090 -		.015 - .030	.030 - .050	.050 - .090	.090 -
	% CO_2					% CO_2			
431		9.7		23.1					
	—	9.7	—	23.1					
434	NIL								
	0	—	—	—					
435	.02			.06					
	.02	—	—	.06					
436				.06					
	—	—	—	.06					
444		.14	15.7	.24					
	—	.14	15.7	.24					
422	1.31	.10		10.5					
	21.10			13.5					
	5.36			.025					
	18.4			.05					
				19.9					
	11.55	.10	—	8.80					

ANDERSON MINE CO_2 STUDY

HOLE #	GRADE % U_3O_8 (FLUORIMETRIC) .015-.030	.030-.050	.050-.090	.090-
	% CO_2			
213		10.4		
	—	10.4	—	—
216	8.17			
	8.17	—	—	—
223	26.7			
	20.7			
	22.2			
	23.20	—	—	—
229	2.92			
	2.92	—	—	—
230	1.68			
	1.68	—	—	—
238	1.43			
	1.43	—	—	—
224	14.3			
	14.3	—	—	—
249			.47	
	—	—	.47	—
252	20.0	1.43		
	20.7			
	20.3	1.43	—	—
253			.83	
	—	—	.83	—
258		.72		
	—	.72	—	—

HOLE #	GRADE % U_3O_8 (FLUORIMETRIC) .015-.030	.030-.050	.050-.090	.090-
	% CO_2			
278	2.57			
	15.9			
	9.23	—	—	—
280	15.0			
	15.0	—	—	—
289	5.14	8.24		
	4.87			
	7.22			
	5.75	8.24	—	—
294	3.75	2.06		
		18.6		
	3.75	10.33	—	—
323			17.5	6.61
				9.64
	—	—	17.5	8.12
324			12.5	
	—	—	12.5	—
325	8.07	13.7		
	8.07	13.7	—	—
332		16.6		14.0
	—	16.6	—	14.0
333		10.8		
	—	10.8	—	—
336	5.28			1.69
	8.53			
	6.90	—	—	1.69

HOLE #	GRADE % U_3O_8 (FLUORIMETRIC) .015–.030	.030–.050	.050–.090	.090–
	% CO_2			
338	14.6	7.93		
	14.6	7.93	—	—
340	3.12	1.26	3.57 / .99	
	3.12	1.26	2.28	—
343	1.64			
	1.28			
	1.46	—	—	—
345	.65			
	.65	—	—	—
346	6.10	9.34	4.39	5.60
	6.10	9.34	4.39	5.60
348	7.72	2.82		
	7.72	2.82	—	—
349	4.03			
	4.26			
	4.15	—	—	—
352	4.20	5.04	3.95	
	8.83	4.92	6.55	
			6.75	
	6.52	4.98	5.75	—
354	6.95			
	6.56			
	6.60			
	3.69			
	5.95	—	—	—

HOLE #	GRADE % U_3O_8 (FLUORIMETRIC) .015–.030	.030–.050	.050–.090	.090–
	% CO_2			
357	18.20			
	18.20	—	—	—
358	13.80	10.10		
	13.80	10.10	—	—
359		6.20		5.05
		5.85		
		9.60		
		1.23		
		2.62		
	—	5.10	—	5.05
360	3.21			
	2.92			
	3.07	—	—	—
362	8.05			
	7.86			
	6.97			
	7.63	—	—	—
363	4.56	5.15		
	4.04			
	5.04			
	5.46			
	16.5			
	7.12	5.15	—	—
364	6.01	2.41		
	6.89			
	6.45	2.41	—	—

ANDERSON MINE CO_2 STUDY

HOLE #	GRADE % U_3O_8 (FLUORIMETRIC) .015–.030	.030–.050	.050–.090	.090–
	% CO_2			
366	.62	3.93		
	.88			
	.78			
	4.58			
	1.72	3.93	—	—
368	6.80	4.98	2.56	
		11.80		
	6.80	8.39	2.56	—
369	9.47	9.64		
	8.97			
	9.22	9.64	—	—
370	8.65			
	4.40			
	6.53	—	—	—
372		.38		
	—	.38	—	—
380	.75	.75	.38	
	.67			
	.26			
	.56	.75	.38	—
381	.71	2.05	.81	
	.63			
	.66	2.05	.81	—
382	1.76			
	1.26			
	1.61	—	—	—

HOLE #	GRADE % U_3O_8 (FLUORIMETRIC) .015–.030	.030–.050	.050–.090	.090–
	% CO_2			
383	.64	.83		
	2.52			
	4.15			
	21.93	.83	—	—
384	.37	.75		
	.14			
	7.91			
	2.81	.75	—	—
398			7.72	
	—	—	7.72	—
412		.56		
		5.86		
	—	3.21	—	—
426			10.5	
	—	—	10.5	—
430	15.5	9.31	12.1	
	5.52	17.3		
	10.51	13.30	12.10	—
435		1.14		
		1.64		
	—	1.39	—	—
437	3.91	2.37		
	3.35			
	3.63	2.37	—	—

ANDERSON MINE CO_2 STUDY

HOLE #	GRADE % U_3O_8 (FLUORIMETRIC) .015 - .030	.030 - .050	.050 - .090	.090 -	HOLE #	GRADE % U_3O_8 (FLUORIMETRIC) .015 - .030	.030 - .050	.050 - .090	.090 -
	% CO_2					% CO_2			
438	2.08	.60							
	4.72								
	3.35	.60	—	—					
440		2.45		3.13					
		1.25							
		1.20							
		1.64							
	—	1.64	—	3.13					
447		.94		.48					
	—	.94	—	.48					
448		5.77							
	—	5.77	—	—					
460	.72								
	.72	—	—	—					
463	.31								
	.26								
	.28	—	—	—					
486	5.93								
	8.56								
	7.25	—	—	—					

HAZEN RESEARCH, INC.

4601 INDIANA STREET
GOLDEN, COLORADO • 80401
TELEPHONE 303/279-4501

REPORT OF ANALYSIS

Mr. Bob Lucht
Minerals Exploration
P. O. Box 50324
Tucson, Arizona 85703

Date: June 15, 1977

HRI Project No. 4107
HRI Series No. 11608
Samples Rec'd 5/25/77

Analysis No.	Sample Designation		% CO_2
11608-1	A.M.-213	140	10.4
-9	A.M.-216	5	8.17
-12	A.M.-223	85	26.7
-13	A.M.-223	90	20.7
-15	A.M.-223	100	22.2
-17	A.M.-229	65	2.92
-28	A.M.-230	120	1.68
-46	A.M.-238	60	1.43
-57	A.M.-224	85	14.3
-62	A.M.-249	45	0.47
-64	A.M.-252	5	1.43
-66	A.M.-252	60	20.0
-68	A.M.-252	70	20.7
-70	A.M.-253	20	0.83
-76	A.M.-258	25	0.72
-81	A.M.-278	70	2.57
-82	A.M.-278	75	15.9
-87	A.M.-280	50	15.0
-99	A.M.-289	90	8.24
-102	A.M.-289	145	5.14
-103	A.M.-289	150	4.87
-104	A.M.-289	160	7.22
-108	A.M.-294	60	3.75
-109	A.M.-294	65	2.06
-110	A.M.-294	70	18.6

Analysis No.	Sample Designation		% CO_2
11608-115	A.M.-323	145	6.61
-116	A.M.-323	150	9.64
-117	A.M.-323	155	17.5
-122	A.M.-324	155	12.5
-125	A.M.-325	120	8.07
-128	A.M.-325	145	13.7
-139	A.M.-332	195	14.0
-140	A.M.-332	200	16.6
-146	A.M.-333	215	10.8
-148	A.M.-336	215	5.28
-149	A.M.-336	220	1.69
-152	A.M.-336	255	8.53
-161	A.M.-338	355	7.93
-162	A.M.-338	360	14.6
-172	A.M.-340	300	1.26
-174	A.M.-340	310	3.57
-175	A.M.-340	315	3.12
-191	A.M.-343	170	1.64
-195	A.M.-343	280	1.28
-197	A.M.-345	380	0.65
-211	A.M.-346	360	9.34
-171	A.M.-340	295	0.99

By: [signature]
John C. Jarvis
Manager, Analytical Laboratory

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HAZEN RESEARCH, INC.

4601 INDIANA STREET
GOLDEN, COLORADO • 80401
TELEPHONE 303/279-4501

REPORT OF ANALYSIS

Mr. Bob Lucht
Minerals Exploration Company

Date: June 22, 1977

HRI Project No. 4107
HRI Series No. 11608
Samples Rec'd 5/25/77

Analysis No.	Sample Designation		% CO_2
11608-212	A.M.-346	365	6.10
-213	A.M.-346	370	5.60
-214	A.M.-346	375	4.39
-221	A.M.-348	305	2.82
-222	A.M.-348	310	7.72
-227	A.M.-349	435	4.03
-228	A.M.-349	440	4.26
-244	A.M.-352	330	4.20
-247	A.M.-352	380	3.95
-249	A.M.-352	390	5.04
-250	A.M.-352	395	6.55
-252	A.M.-352	420	6.75
-253	A.M.-352	425	8.83
-254	A.M.-352	430	4.92
-260	A.M.-354	445	6.95
-265	A.M.-354	470	6.56
-266	A.M.-354	475	6.60
-271	A.M.-354	640	3.69
-274	A.M.-357	620	18.2
-289	A.M.-358	550	10.1
-294	A.M.-358	650	13.8
-300	A.M.-359	495	6.20
-301	A.M.-359	500	5.85

Analysis No.	Sample Designation		% CO_2
11608-303	A.M.-359	530	9.60
-305	A.M.-359	540	5.05
-307	A.M.-359	580	1.23
-308	A.M.-359	585	2.62
-312	A.M.-360	590	3.21
-313	A.M.-360	595	2.92
-325	A.M.-362	620	8.05
-326	A.M.-362	625	7.86
-330	A.M.-362	655	6.97
-331	A.M.-363	535	4.56
-332	A.M.-363	540	4.04
-333	A.M.-363	545	5.04
-334	A.M.-363	550	5.15
-335	A.M.-363	555	5.46
-337	A.M.-363	565	16.5
-349	A.M.-364	515	6.01
-350	A.M.-364	520	6.89
-354	A.M.-364	735	2.41
-368	A.M.-366	445	0.62
-369	A.M.-366	450	3.93
-371	A.M.-366	460	0.88
-372	A.M.-366	465	0.78
-373	A.M.-366	585	4.58
-382	A.M.-368	365	4.98
-383	A.M.-368	370	2.56
-384	A.M.-368	395	6.80
-386	A.M.-368	410	11.8
-390	A.M.-369	450	9.64
-391	A.M.-369	455	9.47
-392	A.M.-369	460	8.97
-396	A.M.-370	290	8.65
-399	A.M.-370	350	4.40
-406	A.M.-372	460	0.38

Analysis No.	Sample Designation		% CO_2
11608-414	A.M.-380	410	0.75
-415	A.M.-380	415	0.38
-416	A.M.-380	430	0.67
-418	A.M.-380	440	0.26
-419	A.M.-380	445	0.75
-422	A.M.-381	425	2.05
-423	A.M.-381	430	0.71
-424	A.M.-381	435	0.63
-425	A.M.-381	440	0.81

By: [signature]
John C. Jarvis
Manager, Analytical Laboratory

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HAZEN RESEARCH, INC.

4601 INDIANA STREET
GOLDEN, COLORADO • 80401
TELEPHONE 303/279-4501

REPORT OF ANALYSIS

Mr. Bob Lucht
Minerals Exploration Company
P. O. Box 50324
Tucson, Arizona 85703

Date: June 24, 1977

HRI Project No. 4107
HRI Series No. 11608
Samples Rec'd 5/25/77

Analysis No.	Sample Designation		% CO_2
11608-431	A.M.-382	355	1.76
-434	A.M.-382	370	1.26
-440	A.M.-383	445	0.83
-443	A.M.-383	460	0.64
-444	A.M.-383	465	2.52
-446	A.M.-383	475	4.15
-454	A.M.-384	400	0.37
-455	A.M.-384	405	0.14
-458	A.M.-384	425	0.75
-461	A.M.-384	455	7.91
-468	A.M.-398	340	7.72
-471	A.M.-412	135	0.56
-472	A.M.-412	140	5.86
-476	A.M.-426	470	10.5
-489	A.M.-430	500	15.5
-490	A.M.-430	505	9.31
-491	A.M.-430	510	12.1
-492	A.M.-430	515	17.3
-498	A.M.-430	545	5.52
-516	A.M.-435	100	1.14
-517	A.M.-435	105	1.64
-524	A.M.-437	370	3.91
-525	A.M.-437	375	3.35
-526	A.M.-437	380	2.37
-533	A.M.-438	385	2.08

Analysis No.	Sample Designation		% CO_2
11608-534	A.M.-438	390	0.60
-535	A.M.-438	420	4.72
-555	A.M.-440	360	3.13
-556	A.M.-440	365	2.45
-557	A.M.-440	370	1.25
-558	A.M.-440	375	1.20
-559	A.M.-440	380	1.64
-575	A.M.-447	385	0.94
-578	A.M.-447	400	0.48
-585	A.M.-448	450	5.77
-598	A.M.-460	190	0.72
-609	A.M.-463	225	0.31
-610	A.M.-463	230	0.26
-613	A.M.-486	450	5.93
-617	A.M.-486	505	8.56

By: John C. Jarvis
John C. Jarvis
Manager, Analytical Laboratory

eah

UNION MINERALS EXPLORATION CO.

ANDERSON MINE PROJECT
YAVAPAI COUNTY, ARIZONA
DISTRIBUTION OF STRONTIUM

MAP 3

SCALE	DATE: JUNE 1, 77	APPROVED	REVISIONS
H:	DRAWN BY: LUCHT		
V:	CHECKED:		
C.I. 250 PPM	DESIGN:		FILE:

APPENDIX 3

Determination of Uranium in Geologic Samples

by

Wavelength Dispersive X-Ray Spectrometry

Gerard W. James
Chief, Geochemistry
Kansas Geological Survey

KANSAS GEOLOGICAL SURVEY
Geochemistry Section

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August 5, 1977

DETERMINATION OF URANIUM IN GEOLOGIC SAMPLES
BY
WAVELENGTH DISPERSIVE X-RAY SPECTROMETRY

GERARD W. JAMES
Chief, Geochemistry

Prepared for the Union Minerals Exploration Company at the request of Philips Electronic Instruments.

KANSAS GEOLOGICAL SURVEY
Geochemistry Section
G.W. James 8-5-77

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Lawrence, Kansas 66044
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Determination of Uranium in Geologic Samples

S U M M A R Y

Ore-grade levels of uranium (.01 to .27 % U_3O_8) present in complex matrices of organic material, lime, and silt may be determined rapidly and accurately by wavelength-dispersive x-ray emission spectrometry. Problems associated with sample matrix variation can be reduced to an acceptable minimum by utilizing the intensity of the Compton scattered portion of the molybdenum K_α primary radiation as an internal standard, thus allowing one calibration curve for the types of samples likely to be encountered in the Anderson Project. The mean difference between values obtained fluorimetrically and by x-ray spectrometry for 18 samples containing .01 to .27 % U_3O_8 was 0.003 %; the correlation coefficient (goodness of fit) of the regression line was 0.995. The uranium contents of thirty samples can be determined in one hour, under the conditions described in this report.

Instrumentation: Philips PW 1410 Manual Vacuum X-Ray Spectrometer
Philips XRG 3000 X-Ray Generator
Philips DCP Data Control & Processor

Operating Conditions: Molybdenum target X-ray tube [50kV-50mA]
LiF_{220} analyzing crystal
Fine collimation - Air path
Scintillation detector
PHA baseline 2.0V; no window [integral]
Peak 2θ: 37.30° [U L_α] Fixed time = 50 sec.
Mo K_α Compton 2θ: 29.91° Fixed time = 50 sec.
Background 2θ: 36.88°

Sample History & Preparation:

Samples were submitted for analysis by Mr. Robert L. Smick of Philips Electronic Instruments on behalf of Mr. Robert Lucht of the Union Minerals Exploration Company [P.O. Box 50324, Mine Development Group, 1846 W. Grant Road, Suite 108, Tuscon, Arizona 85705].

Eighteen standards and seven unkown geologic samples from the "Anderson Mine Project" had been prepared for analysis by Union Minerals by unknown crushing and grinding techniques. Accuracy of the reported values of the standards are also unkown to this investigator. Although no size analyses were performed, the powdered standards and samples as received appear to easily pass through U.S. Standard mesh screens of 200 mesh.

No geologic descriptions of the samples were provided, but the ore in the Anderson Mine project was described by Mr. Lucht as being very complex, with the uranium generally being tied up in organic material with a matrix of lime and silt. High, but undefined, concentrations of molybdenum, rubidium, and strontium were also reported to be in these samples by Mr. Lucht. The potential influence of these characteristics will be discussed in the appropriate sections of this report.

All standards and samples were analyzed without further grinding by placing about 10 grams of the powders in mylar covered 50 mm sample holders.

Analytical Procedure:

The highly variable lithologic characteristics of these samples dictated the use of scattered tube radiation as an internal standard. The analytical approach utilized by this investigator is a modification of a procedure published by R.C. Reynolds, Jr. [American Mineralogist, 1963, vol. 48, 1133-1143]. The results of the analyses of the 18 standards are presented in Table 1. The results of the analyses of the 7 unknowns plus 5 additional standards are presented in Table 2.

Table 1. Anderson Mine Standards

Standards	% U_3O_8 [1]	% U_3O_8 [2]	% U_3O_8 [3]
S - 1	.032	.034	.034
S - 2	.021	.022	.021
S - 3	.021	.017	.017
S - 4	.025	.024	.024
S - 5	.060	.052	.051
S - 6	.066	.065	.065
S - 7	.055	.060	.059
S - 8	.032	.036	.035
S - 9	.048	.052	.054
S - 10	.020	.022	.022
S - 11	.273	.271	.271
S - 12	.013	.013	.013
S - 13	.033	.039	.040
S - 14	.016	.017	.018
S - 15	.025	.026	.026
S - 16	.009	.004	.004
S - 17	.012	.005	.005
S - 18	.021	.024	.023

1 = U_3O_8 by fluorimetric assay

2 = U_3O_8 by X-ray with background correction

3 = U_3O_8 by X-ray without background correction

Table 2. Anderson Mine Unknowns

Sample	% U_3O_8 [1]	% U_3O_8 [2]	% U_3O_8 [3]
U - 1	?	.026 .026	.027 .027
U - 2	?	.021 .021	.021 .020
U - 3	?	.025 .024	.026 .026
U - 4	?	.033 .033	.032 .032
U - 5	?	.059 .061	.057 .059
U - 6	?	.004 .004	.004 .004
U - 7	?	.045 .046	.045 .046
AEC Std 1 [phosphate rock]	.029	.028 .029	.032 .033
AEC Std 4 [carnotite ore]	.18	.183 .183	.183 .184
KGS 3 [sandstone]	.060	.064 .064	.064 .064
KGS 2 [sandstone]	.012	.012 .012	.011 .011
KGS 1 [sandstone]	.000	-.001 -.001	-.002 -.002

1 = Recommended Value

2 = U_3O_8 by x-ray with background correction

3 = U_3O_8 by x-ray without background correction

Discussion of Results:

The analytical calibration curve determined from a least squares fit of the ratio of the U L_α to the Mo K_α Compton of the eighteen standards does not differ significantly from the analytical calibration curve determined from the ratio of the background corrected U L_α to the Mo K_α Compton. The equations for the curves are as follows:

$$\% \; U_3O_8 = -0.00067 + 0.18989 \; \frac{U_{R_p} - R_b}{Mo\ C}$$

$$\% \; U_3O_8 = -0.01850 + 0.18903 \; \frac{U_{R_p}}{Mo\ C}$$

where U R_p = count rate @ 37.30° 2θ

R_b = count rate @ 36.88° 2θ

Mo C = count rate @ 29.91° 2θ

The goodness of fit improved only slightly with background correction [.9949 to .9956]. Since analytical time is increased 50 % if a background count-rate correction is made, the slight improvement is not thought to be worth the time it takes to make it.

The raw data that lead to the predicted x-ray concentrations in Table 1 is presented in Appendix I.

The analytical calibrations curves derived from the Anderson Mine standards were applied to the data obtained for the seven unknowns. The raw data for the unkowns is presented in Appendix II. The unknowns were analyzed twice to illustrate the precision of the x-ray measurements.

In an effort to evaluate the validity of the calibration curve derived from the Union standards, two U.S. Atomic Energy Commission standards and three Kansas Geological Survey standards were analyzed by the same procedures, again in duplicate. These results indicate the slope of the calibration curve may need a slight adjustment. Considering the quenching and enhancement effects of organic compounds, Ca, Fe, Mn, Si, Ti, V, etc. that may interfere with the fluorimetric determination of U in acid extractions from rocks, the fluorimetric assays of the

Union-Anderson Mine standards may contain a considerable amount of uncertainity. Never-the-less, the mean difference of .003 % U_3O_8 between the reported values for the 18 standards and the x-ray predicted values, over the range of .01 to .27 % U_3O_8 is considered by this investigator to be good enough for accurate quality control purposes. This is particularly impressive when viewed in light of the highly variable lithologic characteristics of these rocks, as is indicated by a range of ratios of the Mo Compton radiation to the Mo Compton radiation scattered from pure quartz -- 0.592 to 1.045.

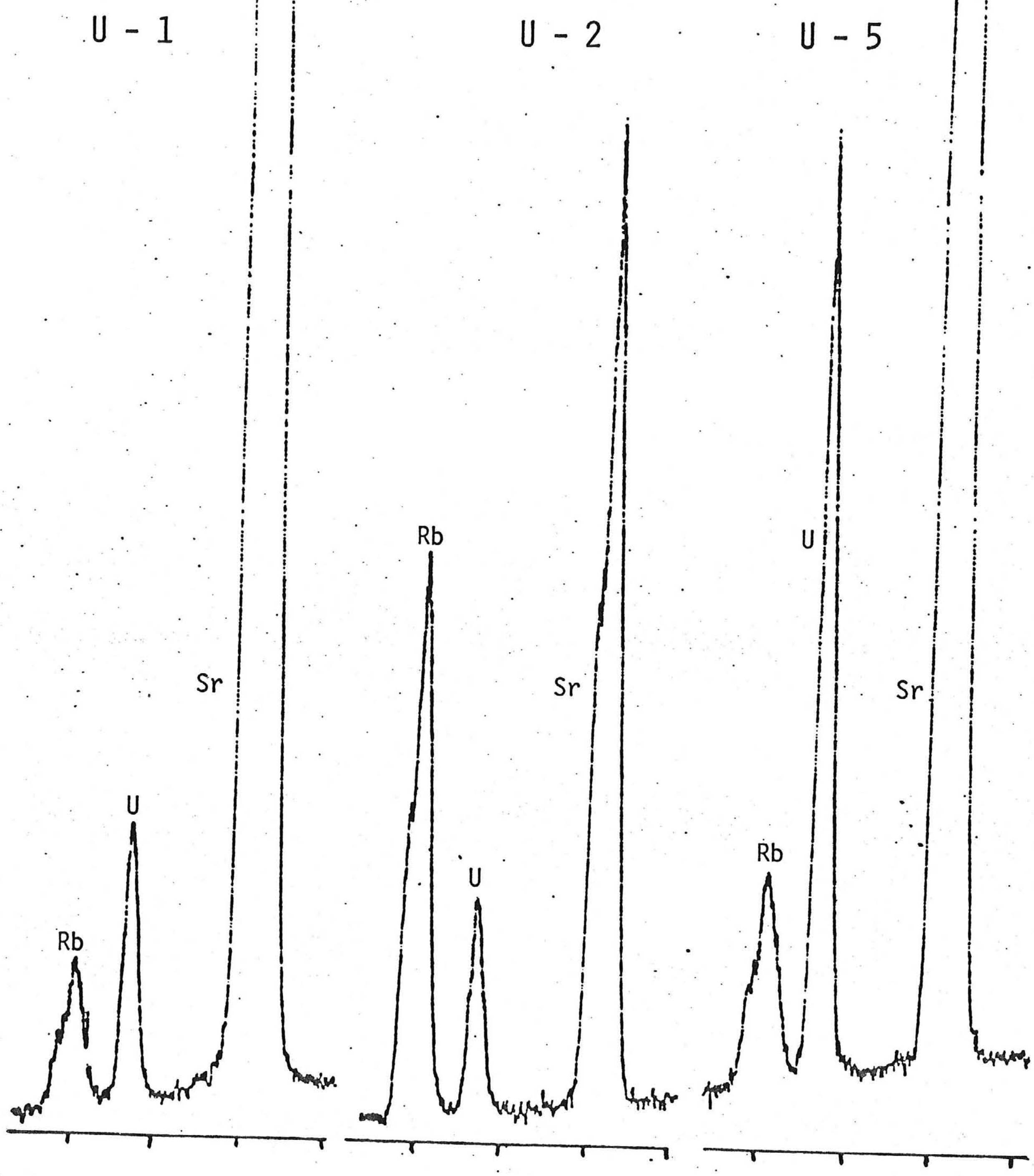
Discussion of Methodology:

Factors governing the choice of X-ray tube target material, analyzing crystal, and analytical counting times for the analysis of uranium have been discussed by G.W. James and L.R. Hathaway (1976, Exploration For Uranium Ore Deposits, International Atomic Energy Agency, Vienna, Austria 311-320). The optimum choice of operating parameters for the determination of uranium by x-ray spectrometry usually consists of the molybdenum target x-ray tube and the LiF_{220} analyzing crystal.

Spectral interferences, matrix considerations, and analytical precision and detection limits for the determination of uranium and thorium in geologic samples by x-ray spectrometry have been discussed by G.W. James [Analytical Chemistry, 1977, vol.49, 967-969]. With fine collimation and the LiF_{220} analyzing crystal, the amounts of Rb and Sr found in most rock types do not interfer with the determination of uranium. Characteristic line spectra from three of the unknowns are illustrated in Figure 1. The Rb contents of the seven unknowns range from 40 to 230 ppm; the Sr contents ranged from 160 to 1880 ppm. Large variations in the lithologic characteristics of sedimentary rocks cause large changes in matrix absorption characteristics; however the use of scattered radiation as an internal standard allows the determination of uranium from one calibration curve with a considerable degree of accuracy. The peak-to-background ratio method of data reduction described by James (1977) was not utilized in this study because uranium

Figure 1. Characteristic Line Spectra

Sample	% U_3O_8	% Rb	% Sr
U - 1	.026	.0040	.1800
U - 2	.021	.0205	.0315
U - 5	.060	.0045	.0700



present in concentrations greater than 500 ppm contributes counts to the background position, and hence leads to x-ray predicted concentrations that are lower than actual values. Although the effects of trace amounts of molybdenum on the Mo Compton radiation have not been published, the use of the Mo Compton radiation as an internal standard for the Anderson Mine project samples appears warranted.

Conclusions

Although Mr. Lucht did not state the degree of accuracy, nor the number of samples per hour, he would like to have for an analytical system for the Anderson probe tower, an automated wavelength-dispersive x-ray system such as the Philips PW 1410/80 AXS would be an ideal choice. Such a system could easily be set up for routine quality control analyses of ore-grade samples, as well as for monitoring the uranium content of leach solutions at the ppm level [with no preconcentration] in mill operations or in subsurface insitu leach mines. Part-per-billion levels of uranium in solution can also easily be analyzed by using chelating ion-exchange resins, and part-per-million levels of uranium and thorium in exploration samples could also be determined rapidly and accurately by the same system. [The routine exploration determination of uranium and thorium at the Kansas Geological Survey consists of duplicate 10 second measurements at the U peak position, the Th peak position, and the background position; the three-sigma detection limits (99.6 confidence level) for a total analytical time of one minute are 2.7 ppm U and 3.2 ppm Th.] Rather than take some sort of analytical instrumentation into the mine pit operations, I would suggest the rapid determinations of uranium present in well-cuttings or mine face sample could be done more satisfactorily by taking the sample to a laboratory x-ray system with rapid turn-around capabilities.

Respectfully submitted,

Gerard W. James

Gerard W. James

APPENDIX I.

Count Data for the Anderson Mine Standards

Sample	Lab. No.	Mo C*	R_p*	U R_p*	$\frac{U\ R_p - R_b}{Mo\ C}$	$\frac{U\ R_p}{Mo\ C}$
10723- 12	S- 1	6875	639	1900	.183	.276
-169	S- 2	6703	607	1388	.117	.207
-186	S- 3	6273	584	1165	.093	.186
-188	S- 4	5671	545	1277	.129	.225
10866- 6	S- 5	6327	590	2343	.277	.370
- 7	S- 6	6257	596	2753	.345	.440
- 8	S- 7	8477	760	3475	.320	.410
- 9	S- 8	7019	646	1988	.191	.283
- 14	S- 9	5233	559	2019	.279	.386
- 25	S-10	6671	608	1420	.122	.213
- 26	S-11	6571	660	10070	1.432	1.532
- 27	S-12	5450	509	892	.070	.164
- 40	S-13	5051	530	1576	.207	.312
- 43	S-14	4799	495	937	.092	.195
- 59	S-15	5776	549	1368	.142	.237
10958-181	S-16	5523	527	665	.025	.120
-183	S-17	5480	514	677	.030	.124
-242	S-18	6330	576	1385	.128	.219

* counts per second

APPENDIX II.

Count Data for the Anderson Mine Unknowns.

Sample	Lab. No.	Mo C*	R_p *	U R_p *	$\frac{U R_p - R_b}{Mo C}$	$\frac{U R_p}{Mo C}$
10866- 11	U-1	5502	555	1336	.142	.243
		5527	551	1335	.142	.242
10723-189	U-2	5612	530	1163	.113	.207
		5668	533	1165	.112	.206
10866- 10	U-3	4789	501	1136	.133	.237
		4801	501	1128	.131	.235
10867- 14	U-4	6748	607	1806	.178	.268
		6792	609	1797	.175	.265
12937- 34	U-5	8261	705	3296	.314	.399
		8254	713	3378	.323	.409
11764- 43	U-6	5539	521	671	.027	.121
		5529	517	661	.026	.120
10347-149	U-7	6253	587	2096	.241	.335
		6197	583	2104	.245	.340
U.S. A.E.C. #1		3409	395	916	.163	.269
		3412	391	920	.155	.270
U.S. A.E.C. #4		6630	661	7084	.969	1.068
		6618	669	7072	.968	1.069
Kan. Geol. Surv. #3		7487	717	3272	.341	.437
		7473	715	3276	.343	.438
Kan. Geol. Surv. #2		7966	706	1243	.067	.156
		7968	712	1249	.067	.157
Kan. Geol. Surv. #1		8106	705	687	-.002	.085
		8120	701	685	-.002	.084

* counts per second