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Scientific Notebook #084
supporting the Geochemical
Natural Analog Research

RECORD

BRET W. LESLIE, Ph.D.
Research Scientist

CENTER FOR
NUCLEAR WASTE
REGULATORY ANALYSES

Crystal Gateway One, Suite 1102
1235 Jefferson Davis Hwy.
Arlington, VA 22202-3293
(703) 979-9129
Fax: (703) 920-2189

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Dr. Bret W. Leslie
Crystal Gateway One, Suite 1102
1235 Jefferson Davis Highway
Arlington, VA 22202-3293
(703) 979-9129

Initial Entry

7/7/93
BWL

These are the initial entries into Scientific Notebook #084. The contents of this notebook will document various aspects of the Geochemical Natural Analog Research Project. As I am planning to be in the DC office until 12/93 this notebook will allow me to document research conducted through me during the next 6 months. The entries in this notebook are a continuation of my entries in Scientific Notebook #024 (Analogs #1) and Scientific Notebook #031 (Radiochemistry). I am anticipating on being involved in three separate research efforts while in the DC office: rare-earth element analyses (REE); radioactive plants from Peña Blanca; and alpha-spectrometry of solid samples from Nopal I U deposit. I will reserve about ~~[illegible]~~ BWL 7/7/93 1/4 of the book for each project and list things sequentially in each section. The table of contents are on the reverse of this page (i.e. pg 2). My name is Dr. Bret W. Leslie and my entries will be signified by my initials BWL.

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EC 11/2/99

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Rare-Earth Element Analyses

Initial entries on this work can be found on pg 275 of #024 and pg 181 forward of #031. The purpose of the experiment is to make a few measurements of the REE content of bulk rock from a few select locations at the Nopal I site. REE are chemical to some of the transuranic and may provide insight into the mobility of these elements in a Yucca Mountain like environment. The REE analyses are complicated by the fact that U is an interfering element in the analysis by instrumental neutron activation analysis (INAA). If U concentrations are above about 30 ppm then INAA analysis of REE are adversely impacted. With this in mind several high U content solids were subjected to the chemical procedures of May and Pinto (1984) and submitted for INAA.

The samples were submitted in 4/93 for INAA at the University of Texas at El Paso by Dr. Elizabeth Anthony (915) 747-5501.

Additional Reference used to test results is Aniel et al 1991.
Volcanogenic U mineralization in the Sierra Pena Blanca District, Chihuahua, Mexico: Three Genetic Models Economic Geology V86 pg 233-248.

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4/11/93
BWL

41102 is an internationally recognized rock standard. It is USGS standard and represents Hawaiian Basalt and has REE concentrations comparable to that expected in the samples submitted for analysis. The REE concentrations for this sample are well known.

41103 represents the unaltered Nopal formation tuff and will be used to compare to REE analyses presented by Aniel et al. 1991 in Economic Geology.

41104 represents a sample in the middle of the acid altered portion of the orebody and may show loss of REE. It will be separated chemically, since U > 100 ppm.

41105 represents a sample from the outer U-mineralized wing of the orebody and contains the highest U concentration likely to be measured.

41106 represents a sample from the major E-W fracture between 13-14 m North on the +10 level. It is part of the fracture coating and consists of acid alteration minerals and Fe bearing minerals. High REE in this sample would indicate their mobility on the scale of meters.

Reagents:

1) di-Sodium Tetraborate Anhydrous Lot 9118
   QA accepted 3/29/93
2) Platinum crucible 20 ml
3) aluminum nitrate Lot No 917079
4) HCl - Lot# 905802
5) HNO_3 - Lot# 913941
6) HF - Lot# 910332
7) H_2SO_4 - Lot# 915740
8) BioRad AG 1-X8 Resin (100-200 mesh) # 44939A

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031/183

4/11/93
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REE analysis

Reference: S. May, G. Pinte: Determination of rare earths in uranium containing rocks by neutron activation: [Dosage par activation neutronique des terres rares dans des roches uraniferes]. Journal of Radioanalytical and Nuclear Chemistry, 81 (2), 273-281, 1984.

Motivation:

LREE may provide some insight into the relative mobility of transuranic elements under Yucca Mtn like conditions at Peña Blanca. REE can be measured using instrumental neutron activation analysis, or by ICP-AES or ICP-MS techniques. The latter techniques are labor intensive and require large volumes of reagents and extensive standardization precautions. INAA is practical for rocks containing low concentrations of U, but can not be used unless U is separated from uraniferous samples. To test this method and the analytical abilities of Libby Anthony at the University of Texas at El Paso I will submit a total of 6 samples for analysis.

Sample:
41101 ≡ NOP1-ECP-9.7/7.35 * WR
41102 ≡ BHVO-1
41103 ≡ 5912 * NOP-ECP-1
41104 ≡ NOP1-ECP-17.0/7.5 * WR
41105 ≡ NOP1-ECP-11.9/7.9 * WR
41106 ≡ NOP1-ECP-8.45/13.82 * WR

The first three samples are submitted as powdered rocks and the latter three samples will undergo chemical separation (a la May & Pinte, 1984).
41101 is an example of a low U rock (~20 ppm U) about 2 m away from edge of orebody on the E-W traverse on +10 m level.

7/22/93
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JUL-19-'93 MON 16:51 ID:GEOLOGY DEPT 5073 #415 P01

GEOLOGICAL SCIENCES DEPARTMENT

U.T.E.P.
The University of Texas at El Paso

THE UNIVERSITY OF TEXAS AT EL PASO

Telephone No. (915) 747-5501 Fax No. (915) 747-5073

TO: Bret Leslie

FROM: Elizabeth Anthony

No. of pages (including coversheet) 2

FAX NO.: (703)920-2189

DATE: 19 July 1993

MESSAGE

Analytical data for Bret Leslie from Libby Anthony.

Following page is from this Fax

El Paso, Texas 79968

7/22/93
BWL

ID	Identification
41101	NOPI-ECP-9.7/7.35*WR
41102	BHVO-1
41103	5912 NOP-ECP-1
41104	NOPI-ECP-17.0/7.5*WR
41105	NOPI-ECP-11.9/7.9*WR
41106	NOPI-ECP-8.45/13.82*WR

PRELIMINARY DATA FOR SAMPLES FROM THE NOPAL DISTRICT, PENA BLAN

PREPARED BY ELIZABETH Y. ANTHONY, UNIVERSITY OF TEXAS AT EL PAS

	41101	41102	41103	41104	41105	41106
Na2O	0.55	2.09	0.98	1.64	3.84	3.69
K2O	6.59	-	5.59	-	-	-
Sc	3.16	27.9	2.92	16.1	6.96	23.9
Cr	-	275	-	325	28	-
Fe2O3	0.6	11.7	1.6	-	-	-
Co	18	39	18	12	9	15
Rb	335	-	303	-	-	-
Zr	356	-	292	-	-	-
Mo	6.78	-	2.81	-	22.2	-
Cs	7.64	-	7.36	-	-	-
La	57.5	15.4	48.3	59.2	48.1	39.1
Ce	107	36.4	96.2	93.7	167	69
Nd	49.0	23.8	37.8	26	64	-
Sm	8.67	5.89	6.97	4.04	13.4	12.5
Eu	0.67	1.95	0.66	-	1.4	-
Yb	3.38	1.89	3.20	3.15	9.86	5.70
Lu	0.526	0.268	0.492	0.483	1.46	0.710
Hf	8.19	4.23	7.60	9.22	9.62	7.2
Ta	3.59	1.14	3.83	-	-	-
Th	42.8	1.20	39.2	45.8	57.5	212
U	15.7	-	5.53	-	49.0	-

Note Na_2O & K_2O are wt% all others ppm

41101 = NOPI-ECP-9.7/7.35 [illegible]
41102 = BHVO-1
41103 = 5912 NOP-ECP-1
41104 = NOPI-ECP-17.0/7.5 [illegible]
41105 = [illegible] 11.9/7.9 [illegible]
[illegible] NOP[illegible] 8.45/13.82 [illegible]

7/22/93
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JUL-22-'93 THU 14:33 ID:GEOLOGY DEPT 5073 #422 P01

GEOLOGICAL SCIENCES DEPARTMENT

U.T.E.P.
The University of Texas at El Paso

Telephone No. (915) 747-5501

Fax No. (915) 747-5073

TO: BRET LESLIF

FROM: E. ANTHONY

FAX NO.: 703 - 920 - 2189

No. of pages (including coversheet) 1

DATE: 22 JULY 93

MESSAGE

Sample Masses

1	41101	634.570 MG	1.0000	1.0000
2	41102	983.280 MG	1.0000	1.0000
3	41103	702.570 MG	1.0000	1.0000
4	41104	35.5700 MG	1.0000	1.0000
5	41105	51.9600 MG	1.0000	1.0000
6	41106	39.1400 MG	1.0000	1.0000
R69	NBS-278	546.270 MG	1.0000	1.0000
R71	G2	647.540 MG	1.0000	1.0000
R72	AGV	629.360 MG	1.0000	1.0000
R73	STM-1	693.600 MG	1.0000	1.0000
R74	RGM-1	599.140 MG	1.0000	1.0000
R79	SCO	828.940 MG	1.0000	1.0000

For samples 41104, 41105, & 41106 mass of $Al(OH)_3$ is mass cited above.

El Paso, Texas 79968

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This printout represents the preliminary data FAXed by Sibley on 7/19 & 7/22

These are raw #s and represent ppm.

to correct these measured values to actual values we will need to correct for the yield on those samples that used $Al(OH)_3$ precipitate (41104, 41105, & 41106)

To accomplish this will require correcting reported value as follows:

$$\frac{(\text{Reported value}) * \text{wt } Al(OH)_3}{\text{mass of sample dissolved}}$$

Nopal REE

Sample	La	Ce	Nd	Sm	Eu	Tb	Yb	Lu	Hf	Ta	Th	U	Sc	ICP-Sc
Nopal Tuff	48.3	96.2	37.8	6.97	0.66		3.2	0.492	7.6	3.83	39.2	5.53	2.92	
Aniel Nopal (f)	46	91		9.1	0.57	1.11	4.4	0.61	6.6	2.74	34.4	9.7		
An. N. (e)80 m	51	127	43	8.2	0.72	0.95	3.1	0.55	8.4	2.26	34.1	9.7		
9.7/7.35	57.5	107	49	8.67	0.67		3.38	0.526	8.19	3.59	42.8	15.7	3.16	3.1
11.9/7.9	48.1	167	64	13.4	1.4		9.86	1.46	9.62		57.5	49	6.96	4.4
17.0/7.5	59.2	93.7	26	4.04			3.15	0.483	9.22		45.8		16.1	9.4
8.45/13.82	39.1	69		12.5			5.7	0.71	7.2		212		23.9	

see all $Al(OH)_3$ used in analysis INAA ∴ mass on 084/10 is mass to use
see pg 031/185 for sample mass dissolved.

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REE

Nopal REE summa

Sample	La	Ce	Nd	Sm	Eu	Tb	Yb	Lu	Hf	Ta	Th	U	Sc	ICP-Sc
Nopal Tuff	48.3	96.2	37.8	6.97	0.66		3.2	0.49	7.6	3.83	39.2	5.53	2.92	2.5
Aniel Nopal (f)	46	91		9.1	0.57	1.11	4.4	0.61	6.6	2.74	34.4	9.7		
An. N. (e)80 m	51	127	43	8.2	0.72	0.95	3.1	0.55	8.4	2.26	34.1	9.7		
9.7/7.35	57.5	107	49	8.67	0.67		3.38	0.53	8.19	3.59	42.8	15.7	3.16	3.1
11.9/7.9	48.1	167	64	13.4	1.4		9.86	1.46	9.62		57.5	49	6.96	4.4
mass corr 11.9	25.22	87.56	33.56	7.026	0.734		5.17	0.766	5.044		30.15	25.69	3.649	
yield corr 11.9	30.422	105.62	40.478	8.4751	0.8855		6.2362	0.9234	6.0844		36.367	30.991	4.402	0.82938
17.0/7.5	59.2	93.7	26	4.04			3.15	0.48	9.22		45.8		16.1	9.4
corr 17.0	21.4	33.8	9.38	1.46			1.14	0.17	3.33		16.5		5.81	
yield corr 17.0	34.557	54.696	15.177	2.3583			1.8388	0.2819	5.3821		26.735		9.3982	0.61788
8.45/13.82	39.1	69		12.5			5.7	0.71	7.2		212		23.9	
corr8.45	15.4	27.1		4.91			2.24	0.28	2.83		83.3		9.39	
avg yield corr	21.341	37.66		6.8224			3.111	0.3875	3.92297		115.71		13.044	0.72

Summary
of
Preliminary
#'s.

Lines on spreadsheet with mass corr represents result of calculation from bottom of pg 084/11.

To determine the chemical yield of the May and Pinte procedure Sc is used to determine the chemical yield. Our Texas Tech ICP Sc values are used and compared to the mass corrected value to ICP value to get chemical yield.

eg. for 11.9/7.9

reported value 6.96 ppm

corrected for mass 3.65 ppm

actual from ICP 4.4 ppm

$$\text{yield} = \frac{3.65}{4.4} \Rightarrow 0.829$$

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This yield value is then applied to each of the mass corrected REE elements.

for 11.9/7.9 La & Ce

mass corrected	$\frac{25.22}{0.829}$	$\frac{87.56}{0.829}$

yield corr = 30.422 105.62 ppm, respectively.

ICP Sc values were only available for samples 11.9/7.9 & 17.0/7.5 and the yield (chemical) for 8.45/13.82 was determined by averaging the yield for the first two samples. A chemical yield of 0.72 was used for 8.45/13.82. The uncertainty for this sample will be larger than the other samples.

Final results will not be available for a month or two.

8/23/93
BWL

THE UNIVERSITY OF TEXAS AT EL PASO
UTEP

August 19, 1993

Department of
Geological Sciences

To: Dr. Bret Leslie

From: Prof. Elizabeth Y. Anthony Elizabeth Y. Anthony

Re: Neutron activation analyses

Enclosed are four pages of analytical data. We ran six standards with your unknowns, and their results are tabulated in the first pages. These standards are used to generate the calibration curve. Therefore, their reproduction to reported values is not a true measure of accuracy. The internal consistency, however, is a measure of the overall success of calibration. I have included some low precision data so that you can evaluate the concentrations at which we begin to develope poor counting statistics. Our programs exclude low precision values from the calibration curve.

Both the "% error" and the "D %" are very much in keeping with usual values for this lab with the exception of Sc. We often obtain agreement with the standards AGV and G2 of within a few percent. I would need some time to look back through the data reduction and determine the problem with these analyses and will do so if you feel it is necessary.

The second two pages report the data for your samples. Again I have included some low precision data for your information. The reported errors reflect true uncertainties and should be treated seriously. Where no data are given for an element, the peak was simply too small to include. I know that this includes some elements which are of interest to you, e.g. Cs. We can use this initial experiment to plan changes in either sample weight or longer count times to retrieve information on these elements if they are crucial to your interpretation.

Also, I think that we can definitely increase the accuracy of the Sc analyses and would suggest in future runs to include standards which reflect the higher concentrations of your unknowns.

I hope that these data are useful to you, and I look forward to talking with you about any questions that you have.

El Paso, Texas
79968-0555
(915) 747-5501
FAX: (915) 747-5073

8/8/93
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Standards run for Bret Leslie experiment: 18 August 1993

	G2					AGV					STM				
	rptd	obs	+/-	% error	D %	rptd	obs	+/-	% error	D %	rptd	obs	+/-	%error	D %
Na2O	4.08	4.02	0.02	0.5	1.5	4.26	4.33	0.06	1.5	-1.6	8.94	8.29	0.07	0.9	7.3
CaO	1.96	1.8	0.2	12.2	8.2	4.94	5.0	0.2	3.9	-1.2	-	-	-	-	-
Sc	3.5	3.15	0.03	1.1	10.0	12.2	11.09	0.04	0.4	9.1	0.61	0.51	0.06	12.7	16.4
Cr	8.7	8.7	0.4	4.2	0.0	10.1	10.5	0.3	2.8	-4.0	4.3	3.8	0.3	8.6	11.6
Fe2O3	2.66	2.66	0.02	0.9	0.0	6.76	6.79	0.01	0.2	-0.4	5.22	5.29	0.02	0.4	-1.3
Zn	86	83	1	1.6	3.5	88	85	2	2.0	3.4	235	238	2	1.0	-1.3
Rb	170	167	3	1.9	1.8	67.3	68	1	1.7	-1.0	118	114	2	2.1	3.4
Sr	478	465	11	2.4	2.7	662	670	18	2.7	-1.2	700	707	14	2.0	-1.0
Zr	309	298	12	4.0	3.6	227	241	52	21.7	-6.2	1210	1206	17	1.4	0.3
Cs	1.34	1.32	0.03	2.4	1.5	1.28	1.26	0.04	3.4	1.6	1.54	1.56	0.03	1.7	-1.3
Ba	1882	1873	13	0.7	0.5	1226	1250	18	1.4	-2.0	560	615	15	2.5	-9.8
La	89	86	1	1.5	3.4	38	38.2	0.2	0.5	-0.5	150	152	1	0.7	-1.3
Ce	160	158	1	0.9	1.3	67	67.5	0.3	0.5	-0.7	259	260	1	0.4	-0.4
Nd	55	53	1	1.7	3.6	33	32.0	0.5	1.5	3.0	79	81	1	1.4	-2.5
Sm	7.2	7.4	0.2	2.6	-2.8	5.9	6.07	0.05	0.9	-2.9	12.6	13.1	0.4	2.8	-4.0
Eu	1.4	1.41	0.02	1.3	-0.7	1.64	1.666	0.008	0.5	-1.6	3.6	3.58	0.02	0.5	0.6
Tb	0.48	0.48	0.01	3.0	0.0	0.70	0.56	0.02	3.3	20.0	1.55	1.55	0.02	1.5	0.0
Yb	0.8	0.65	0.03	4.2	18.8	1.72	1.64	0.03	1.8	4.7	4.4	4.26	0.03	0.8	3.2
Lu	0.11	0.099	0.008	8.3	10.0	0.27	0.237	0.005	2.2	12.2	0.6	0.617	0.004	0.7	-2.8
Hf	7.9	7.8	0.5	5.9	1.3	5.1	5.0	0.2	4.5	2.0	28	27.8	0.2	0.8	0.7
Ta	0.88	0.82	0.01	1.5	6.8	0.90	0.88	0.02	2.1	2.2	18.6	18.60	0.09	0.5	0.0
Th	24.7	24.7	0.3	1.3	0.0	6.5	6.38	0.07	1.1	1.8	31	31.15	0.09	0.3	-0.5
U	2.07	2.0	0.1	5.1	3.4	1.92	1.82	0.09	5.1	5.2	9.06	8.9	0.2	2.5	1.8

Reported values are from Govindaraju K.* (1989) Geostandards Newsletter, Vol. 13, 1-113.
% error is one standard deviation from the weighted mean value.
D % is calculated according to: (reported - observed)/reported * 100.

8/23/93
BWL

	RGM rptd	RGM obs	RGM +/-	RGM % error	RGM D %	SCO rptd	SCO obs	SCO +/-	SCO % error	SCO D %	NBS 278 rptd	NBS 278 obs	NBS 278 +/-	NBS 278 % error	NBS 278 D %
Na2O	4.07	4.0	0.1	2.5	1.2	0.90	0.910	0.005	0.5	-1.1	4.84	5.23	0.03	0.6	-8.1
CaO	1.15	1.2	0.2	15.3	-4.3	2.62	2.6	0.1	5.5	0.8	0.983	1.0	0.3	28.2	-1.7
Sc	4.4	4.43	0.04	0.9	-0.7	10.8	10.83	0.05	0.5	-0.3	5.1	5.04	0.02	0.4	1.2
Cr	3.7	3.2	0.2	6.0	13.5	68	68.0	0.6	0.9	0.0	6.1	7.3	0.3	3.9	-19.7
Fe2O3	1.86	1.95	0.02	1.1	-4.8	5.14	5.09	0.03	0.5	1.0	2.04	2.21	0.01	0.5	-8.3
Zn	32	32	1	3.2	0.0	103	93	2	2.0	9.7	55	48	2	3.2	12.7
Rb	149	156	4	2.5	-4.7	112	113	3	2.4	-0.9	127.5	138	3	2.0	-8.2
Sr	108	123	7	5.8	-13.9	174	177	17	9.5	-1.7	-	-	-	-	-
Zr	219	257	12	4.6	-17.4	160	197	14	7.2	-23.1	295	285	22	7.6	3.4
Cs	9.6	10.6	0.3	2.6	-10.4	7.8	7.7	0.1	1.4	1.3	5.5	5.50	0.08	1.4	0.0
Ba	807	949	11	1.2	-17.6	570	601	20	3.4	-5.4	1140	1065	30	2.8	6.6
La	24	25.0	0.2	0.9	-4.2	29.5	29.2	0.3	1.0	1.0	33	32.6	0.2	0.5	1.2
Ce	47	50.4	0.3	0.5	-7.2	62	56.0	0.6	1.0	9.7	62.2	67.9	0.7	1.1	-9.2
Nd	19	21.2	0.8	3.9	-11.6	26	26.5	0.5	1.9	-1.9	-	30	1	4.0	-
Sm	4.3	4.61	0.09	2.0	-7.2	5.3	5.29	0.08	1.5	0.2	5.7	6.55	0.09	1.4	-14.9
Eu	0.66	0.69	0.01	1.5	-4.5	1.19	1.168	0.009	0.8	1.8	0.84	0.90	0.01	1.2	-7.1
Tb	0.66	0.68	0.01	2.1	-3.0	0.7	0.68	0.02	3.4	2.9	1	1.05	0.04	3.7	-5.0
Yb	2.6	2.60	0.02	0.8	0.0	2.27	2.20	0.02	1.0	3.1	4.5	4.74	0.04	0.9	-5.3
Lu	0.41	0.409	0.005	1.2	0.2	0.34	0.337	0.005	1.5	0.9	0.73	0.72	0.01	1.0	1.4
Hf	6.2	6.37	0.06	1.0	-2.7	4.6	4.4	0.2	4.5	4.3	8.4	8.33	0.07	0.9	0.8
Ta	0.95	0.99	0.01	1.1	-4.2	0.92	0.84	0.02	2.0	8.7	1.2	1.41	0.01	1.0	-17.5
Th	15.1	15.82	0.05	0.3	-4.8	9.7	9.3	0.1	1.3	4.1	12.4	13.37	0.07	0.5	-7.8
U	5.8	5.95	0.08	1.3	-2.6	3	2.90	0.06	2.0	3.3	4.58	4.73	0.08	1.6	-3.3

8/23/93
BWL

Samples run for Bret Leslie experiment: 18 August 1993

	41101 obs	41101 +/-	41101 % error	41102 obs	41102 +/-	41102 % error	41103 obs	41103 +/-	41103 % error
Na2O	0.548	0.003	0.5	2.09	0.01	0.6	0.982	0.008	0.8
CaO	-	-	-	-	-	-	-	-	-
Sc	3.1	0.1	3.9	28.3	0.2	0.6	2.92	0.06	2.2
Cr	2.9	0.4	13.1	273	2	0.6	3.8	0.3	8.8
Fe2O3	0.612	0.006	0.9	11.94	0.07	0.6	1.51	0.03	2.1
Rb	334	2	0.7	-	-	-	303	4	1.4
Sr	-	-	-	422	17	4.1	81	8	9.9
Zr	361	9	2.6	-	-	-	273	21	7.7
Cs	7.70	0.08	1.0	-	-	-	7.1	0.1	1.4
Ba	223	8	3.8	166	64	38.3	188	4	1.9
La	57	2	3.2	15.41	0.08	0.5	48.3	0.7	1.5
Ce	105.2	0.9	0.9	35.1	0.6	1.8	94	1	1.1
Nd	48.4	0.9	1.8	23.3	0.7	3.0	37.2	0.5	1.3
Sm	8.7	0.2	2.4	5.9	0.1	2.1	7.0	0.2	2.9
Eu	0.52	0.02	2.9	2.02	0.03	1.7	0.58	0.03	4.6
Tb	1.01	0.03	2.7	0.59	0.07	11.6	0.93	0.03	3.2
Yb	3.38	0.04	1.2	1.92	0.03	1.7	3.17	0.03	0.9
Lu	0.52	0.01	2.3	0.26	0.01	3.8	0.485	0.009	1.9
Hf	7.64	0.08	1.1	4.10	0.03	0.8	7.0	0.3	4.9
Ta	3.70	0.06	1.6	1.12	0.02	1.8	3.53	0.03	0.9
Th	42.3	0.8	1.8	1.17	0.04	3.0	38.6	0.4	1.1
U	15.7	0.5	3.2	-	-	-	5.53	0.08	1.5

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	41104			41105			41106		
	obs	+/-	% error	obs	+/-	% error	obs	+/-	% error
Na2O	1.637	0.008	0.5	3.84	0.02	0.5	3.69	0.02	0.5
CaO	-	-	-	-	-	-	-	-	-
Sc	16.3	0.3	1.7	6.94	0.06	0.9	24.6	0.4	1.5
Cr	325	3	0.9	21.2	0.8	3.9	21	2	7.2
Fe2O3	-	-	-	0.05	0.01	10.5	-	-	-
Rb	-	-	-	-	-	-	-	-	-
Sr	-	-	-	-	-	-	-	-	-
Zr	-	-	-	786	42	5.3	563	86	15.3
Cs	-	-	-	-	-	-	-	-	-
Ba	-	-	-	426	36	8.5	380	105	27.6
La	59.2	0.5	0.9	48	1	2.1	39.1	0.6	1.6
Ce	94	1	1.4	153	4	2.3	77	1	1.9
Nd	25	3	11.2	47	3	6.7	33	3	9.1
Sm	4.04	0.03	0.8	13.3	0.1	0.8	12.6	0.4	3.4
Eu	0.20	0.05	23.4	1.2	0.2	12.5	1.45	0.02	1.7
Tb	1.9	0.3	16.5	2.42	0.05	2.2	5	3	68.2
Yb	3.1	0.1	3.9	9.9	0.2	1.7	5.7	0.1	2.6
Lu	0.48	0.02	4.6	1.36	0.06	4.7	0.74	0.02	2.7
Hf	9.5	0.4	4.6	9.3	0.3	2.8	7.7	0.6	7.6
Ta	0.58	0.08	13.5	0.74	0.06	7.7	0.75	0.07	9.0
Th	45.8	0.2	0.5	56.7	0.4	0.7	214	1	0.6
U	-	-	-	49	2	3.6	-	-	-

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AUG-19-'93 THU 12:50 ID:GEOLOGY DEPT 5073 #501 P01

UTEP Department of Geological Sciences

Fax Transmittal

\# of pages (including cover sheet): 1

From:

Dept. of Geological Sciences
University of Texas at El Paso
El Paso, TX 79968
(915) 747-5501
Fax: (915) 747-5073
E-mail:

Date: 1-19-93

Urgent? Yes No Confidential? Yes No

To: Dr Bret Leslie **Fax #:**

Comments:

Bret -

This sample was run as a true unknown - that is, it was never included in a calibration curve. I didn't try to identify it until data reduction was complete.

Libby Anthony

The next page is comparison to known value of BHVO-1

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AUG-19-'93 THU 12:51 ID:GEOLOGY DEPT 5273 #501 P02

		41102			
	reptd	obs	+/-	% error	d %
Na2O	2.26	2.09	0.01	0.6	7.5
CaO		-	-	-	-
Sc	31.8	28.3	0.2	0.6	11.0
Cr	289	273	2	0.6	5.5
Fe2O3	12.23	11.94	0.07	0.6	2.4
Rb		-	-	-	
Sr	403	422	17	4.1	-4.7
Zr		-	-	-	
Cs		-	-	-	
Ba	139	166	64	38.3	-19.4
La	15.8	15.41	0.08	0.5	2.5
Ce	39	35.1	0.6	1.8	10.0
Nd	25.2	23.3	0.7	3.0	7.5
Sm	6.2	5.9	0.1	2.1	4.8
Eu	2.06	2.02	0.03	1.7	1.9
Tb	0.96	0.59	0.07	11.6	38.5
Yb	2.02	1.92	0.03	1.7	5.0
Lu	0.291	0.26	0.01	3.8	10.7
Hf	4.38	4.10	0.03	0.8	6.4
Ta	1.23	1.12	0.02	1.8	8.9
Th	1.08	1.17	0.04	3.0	-8.3
U		-	-	-	

Correction of these final reported values for samples 41104, 41105, 41106 follows the procedure outlined on pages 084/12 → 13.

In the following tables
Ariel Nopal (f) is sample (f) in table 1 of Aniel et al 1991.
and represents an unaltered Nopal formation sample and
Ariel N (e) 80 m is sample (e) in table 1 of Aniel et al 1991. It represents

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BWL a sample collected about 80 m from the edge of Nopal I ore deposit. It is representative of a slightly altered Nopal Formation rock.

Part of M.S. Excel worksheet to the right, but showing formulas
↓

	A	B	C
1	Sample	La	Ce
2	Nopal Tuff	48.3	96.2
3	Aniel Nopal (f)	46	91
4	An. N. (e)80 m	51	127
5	9.7/7.35	57.5	107
6	11.9/7.9	48	153
7	mass corr 11.9	=(B6/0.0991)*0.05196	=(C6/0.0991)*0.05196
8	yield corr 11.9	=B7/0.829	=C7/0.829
9	17.0/7.5	59.2	94
10	corr 17.0	=(B9/0.0986)*0.03557	=(C9/0.0986)*0.03557
11	yield corr 17.0	=B10/0.6256	=C10/0.6256
12	8.45/13.82	39.1	77
13	corr8.45	=(B12/0.0996)*0.03914	=(C12/0.0996)*0.03914
14	avg yield corr	=B13/0.72	=C13/0.72

mass sample powder
mass Al(OH)3

revised Nopal REE summa

Sample	La	Ce	Nd	Sm	Eu	Tb	Yb	Lu	Hf	Ta	Th	U	Sc	ICP-Sc
Nopal Tuff	48.3	96.2	37.8	6.97	0.66		3.2	0.49	7.6	3.83	39.2	5.53	2.92	2.5
Aniel Nopal (f)	46	91		9.1	0.57	1.11	4.4	0.61	6.6	2.74	34.4	9.7		
An. N. (e)80 m	51	127	43	8.2	0.72	0.95	3.1	0.55	8.4	2.26	34.1	9.7		
9.7/7.35	57.5	107	49	8.67	0.67		3.38	0.53	8.19	3.59	42.8	15.7	3.16	3.1
11.9/7.9	48	153	47	13.3	1.2	2.42	9.9	1.36	9.3	0.74	56.7	49	6.94	4.4
mass corr 11.9	25.17	80.22	24.64	6.973	0.629	1.269	5.191	0.713	4.876	0.388	29.73	25.69	3.639	
yield corr 11.9	30.359	96.768	29.726	8.4119	0.759	1.5306	6.2615	0.8602	5.882	0.468	35.861	30.991	4.3894	0.82699
17.0/7.5	59.2	94	25	4.04	0.2	1.9	3.1	0.48	9.5	0.58	45.8		16.3	9.4
corr 17.0	21.4	33.9	9.02	1.46	0.07	0.69	1.12	0.17	3.43	0.21	16.5		5.88	
yield corr 17.0	34.138	54.205	14.416	2.3297	0.1153	1.0956	1.7876	0.2785	5.4781	0.3345	26.41		9.3993	0.62556
8.45/13.82	39.1	77	33	12.6	1.45	5	5.7	0.74	7.7	0.75	214		24.6	
corr8.45	15.4	30.3	13	4.95	0.57	1.96	2.24	0.29	3.03	0.29	84.1		9.67	
avg yield corr	~~21.541~~	~~42.026~~	~~10.011~~	~~6.877~~	~~0.7914~~	~~2.729~~	~~3.111~~	~~0.4039~~	~~4.2036~~	~~0.4093~~	~~116.8~~ Bulk		13.427	0.72

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revised Nopal REE summa

Final REE #s ↑

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Columns D, E,F, G, H, I of worksheet on previous page showing formulas used in calculation

revised Nopal REE summa

	D	E	F
1	Nd	Sm	Eu
2	37.8	6.97	0.66
3		9.1	0.57
4	43	8.2	0.72
5	49	8.67	0.67
6	47	13.3	1.2
7	=(D6/0.0991)*0.05196	=(E6/0.0991)*0.05196	=(F6/0.0991)*0.05196
8	=D7/0.829	=E7/0.829	=F7/0.829
9	25	4.04	0.2
10	=(D9/0.0986)*0.03557	=(E9/0.0986)*0.03557	=(F9/0.0986)*0.03557
11	=D10/0.6256	=E10/0.6256	=F10/0.6256
12	33	12.6	1.45
13	=(D12/0.0996)*0.03914	=(E12/0.0996)*0.03914	=(F12/0.0996)*0.03914
14	=D13/0.72	=E13/0.72	=F13/0.72

revised Nopal REE summa

	G	H	I
1	Tb	Yb	Lu
2		3.2	0.492
3	1.11	4.4	0.61
4	0.95	3.1	0.55
5		3.38	0.526
6	2.42	9.9	1.36
7	=(G6/0.0991)*0.05196	=(H6/0.0991)*0.05196	=(I6/0.0991)*0.05196
8	=G7/0.829	=H7/0.829	=I7/0.829
9	1.9	3.1	0.483
10	=(G9/0.0986)*0.03557	=(H9/0.0986)*0.03557	=(I9/0.0986)*0.03557
11	=G10/0.6256	=H10/0.6256	=I10/0.6256
12	5	5.7	0.74
13	=(G12/0.0996)*0.03914	=(H12/0.0996)*0.03914	=(I12/0.0996)*0.03914
14	=G13/0.72	=H13/0.72	=I13/0.72

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Columns J, K, L, M, N,O, showing formulas used to calculate final #s of REE from UTEP INAA

revised Nopal REE summa

	M	N	O
1	U	Sc	ICP-Sc
2	5.53	2.92	2.5
3	9.7		
4	9.7		
5	15.7	3.16	3.1
6	49	6.94	4.4
7	=(M6/0.0991)*0.05196	=(N6/0.0991)*0.05196	
8	=M7/0.829	=N7/0.829	=N7/O6
9		16.3	9.4
10		=(N9/0.0986)*0.03557	
11		=N10/0.6256	=N10/O9
12		24.6	
13		=(N12/0.0996)*0.03914	
14		=N13/0.72	0.72

revised Nopal REE summa

	J	K	L
1	Hf	Ta	Th
2	7.6	3.83	39.2
3	6.6	2.74	34.4
4	8.4	2.26	34.1
5	8.19	3.59	42.8
6	9.3	0.74	56.7
7	=(J6/0.0991)*0.05196	=(K6/0.0991)*0.05196	=(L6/0.0991)*0.05196
8	=J7/0.829	=K7/0.829	=L7/0.829
9	9.5	0.58	45.8
10	=(J9/0.0986)*0.03557	=(K9/0.0986)*0.03557	=(L9/0.0986)*0.03557
11	=J10/0.6256	=K10/0.6256	=L10/0.6256
12	7.7	0.75	214
13	=(J12/0.0996)*0.03914	=(K12/0.0996)*0.03914	=(L12/0.0996)*0.03914
14	=J13/0.72	=K13/0.72	=L13/0.72

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This sheet reflects a summary of all ICP measurements for sample NOP-ECP-1 or equivalent to 41103 (REE)

NOPI-ECP-1 trace/major

T T ID	ID	Sr)m	Ba)m	Zr)m	Y)m	Sc	V	Cr	Ni	Cu	Zn	Nb	Y	Zr	Ba	Sr	Rb
5909	NOP-ECP					3.1	16	4	3	0	32	30	32	222	183	63	303
5912	-WR1/2					3.2	16	3	2	0	30	27	32.5	207	180	72	291
3105	5912					3.1	17	0	0	3	29	32	36.6	230	164	70	293
1412	5912	70	159	227	34.1	3.1	15	6	3	0	28	31	31.2	239	163	65	294
41017	5909	63	159	228	33	3.2	14			2	33	34	32.1		168	62	304
Average						3.1	15.6	3.3	2.0	1.0	30.4	30.8	32.9	224.5	171.6	66.4	297.0
STD						0.1	1.1	2.5	1.4	1.4	2.1	2.6	2.1	13.6	9.3	4.4	6.0
5909 % diff						0.00	2.56	21.21	50	100	5.26	2.60	2.74	1.11	6.64	5.12	2.02
5912 % diff						3.23	2.56	9.09	0	100	1.32	12.34	1.22	7.80	4.90	8.43	2.02
3105 % diff						0.00	8.97	100.00	100	200	4.61	3.90	11.25	2.45	4.43	5.42	1.35
1412 % diff						0.00	3.85	81.82	50	100	7.89	0.65	5.17	6.46	5.01	2.11	1.01
41017 % diff						3.23	10.26	100.00	100	100	8.55	10.39	2.43		2.10	6.63	2.36
Average % diff						1.3	5.6	62.4	60.0	120.0	5.5	6.0	4.6	4.5	4.6	5.5	1.8

T T ID	ID	SiO2	TiO2	Al2O3	TFe2O3	FeO	Fe2O3	MnO	MgO	CaO	Na2O	K2O	P2O5	LOI	Total
5909	NOP-ECP	75.73	0.25	12.74	1.48	0.23	1.23	0.07	0.14	0.34	1.1	6.53	0.07	2.45	100.89
5912	-WR1/2	74.75	0.26	12.75	1.64	0.32	1.29	0.05	0.16	0.48	1.04	6.43	0.07	2.74	100.35
3105	5912	74.22	0.24	12.54	1.52			0.05	0.14	0.49	1.11	6.29	0.07	2.82	99.49
1412	5912	74.89	0.24	12.80	1.54	0.15	1.34	0.04	0.13	0.54	1.09	6.67	0.09	2.81	100.84
41017	5909	74.54	0.24	12.28	1.40	0.19	1.16	0.07	0.12	0.38	1.06	6.36	0.07	2.50	99.00
Average		74.83	0.25	12.62	1.52	0.22	1.25	0.06	0.14	0.45	1.08	6.46	0.07	2.66	100.11
STD		0.56	0.01	0.22	0.09	0.07	0.08	0.01	0.01	0.08	0.03	0.15	0.01	0.18	0.84
5909 % diff		1.20	0.00	0.95	2.63	4.55	1.60	16.67	0.00	24.44	1.85	1.08	0.00	7.89	0.78
5912 % diff		0.11	4.00	1.03	7.89	45.45	3.20	16.67	14.29	6.67	3.70	0.46	0.00	3.01	0.24
3105 % diff		0.82	4.00	0.63	0.00			16.67	0.00	8.89	2.78	2.63	0.00	6.02	0.62
1412 % diff		0.08	4.00	1.43	1.32	31.82	6.91	33.33	7.14	20.00	0.93	3.25	28.57	5.64	0.73
41017 % diff		0.39	4.00	2.69	7.89	13.64	7.35	16.67	14.29	15.56	1.85	1.55	0.00	6.02	1.11
Average % diff		0.5	3.2	1.3	3.9	23.9	4.8	20.0	7.1	15.1	2.2	1.8	5.7	7.1	0.7

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The highlighted values in the table on the previous ~~values~~ BWL 8/23/93 page can be used with ~~to~~ INAA measurements to compare for accuracy of INAA analysis of unaltered Nopal formation Tuff. Specifically the elements

- Na as Na_2O, Fe as TFe_2O_3, Sc, Cr, Zr, Ba, Sr, and Rb are measured using ICP & INAA analyses.

Comparing the two types of analyses

Element wt% or ppm	Mean ± 1σ ICP	41103 INAA	$\left(\frac{ICP-INAA}{ICP}\right) \times 100$ % dev
Na_2O	1.08±0.03	0.982 ± 0.008	-9
TFe_2O_3	1.52 ± 0.09	1.51 ± 0.03	-0.6
Sc	3.1 ± 0.1	2.92 ± 0.06	-6
Cr	3.3 ± 2.5	3.8 ± 0.3	15
Zr	225 ± 14	273 ± 21	21
Ba	172 ± 9	188 ± 4	9
Sr	66 ± 4	81 ± 8	23
Rb	297 ± 6.0	303 ± 4	2

With the exception of Sr, Zr, & Cr the two different methods are concordant within 10%. An additional test of accuracy is given by Libby Anthony and is reported on pages 084/15 → 16. Relative to the six standards only for low concentrations of STD RGM are Sr, Zr, Cr inaccurate by more than 10%.

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The following three tables will allow comparison to highlighted INAA samples

E-W Transect Trace

Sample ID	Distance West (m)	Sc	V	Cr	Ni	Cu	Zn	Nb	Y	Zr	Ba	Sr	Rb
1413	2.55	3.3	20	8	23	2	113	36	38.9	241	72	31	341
41001	4.00	3.8	24			3	130	35	35.3		74	22	360
41003	5.20	3.6	18			2	117	32	33.9		68	33	324
41004	6.20	4.0	25			2	101	35	34.3		70	41	318
41005	7.45	4.8	31			1	105	35	40.4		75	32	357
41106	8.15	3.0	27			1	125	41	35.5		66	64	368
41022	8.15	3.1	26			4	112	41	34.7		68	64	347
AVG	**8.15**	**3.1**	**27**			**3**	**113**	**41**	**35.1**	**0**	**67**	**64**	**358**
1418	9.00	4.4	56	5	9	5	88	36	77.4	305	85	33	300
1402	9.70	3.1	19	4	7	4	87	30	36.9	256	69	38	338
1421	10.30	2.6	64	7	18	5	140	35	33.3	243	128	52	245
1420	10.80	3.5	44	8	14	4	132	36	37.6	258	82	51	245
1405	11.55	1.6	169	7	8	18	312	33	41.7	249	119	43	245
1422	11.55	1.6	171	6	11	19	213	35	41.3	231	115	41	242
AVG	**11.55**	**1.6**	**170**	**7**	**10**	**19**	**213**	**34**	**41.5**	**240**	**117**	**42**	**244**
1403	11.90	4.4	184	40	13	45	870	50	77.4	291	397	100	81
1411	12.50	1.7	29	12	16	7	182	27	25.4	215	85	57	228
1401	12.95	2.5	87	10	3	12	206	19	31.4	257	492	49	137
1419	13.50	2.4	92	2	0	10	212	36	15.7	219	126	62	170
1423	13.50	2.4	93	4	5	11	232	34	17.3	219	126	61	168
AVG	**13.50**	**2.4**	**93**	**3**	**3**	**11**	**222**	**35**	**16.5**	**219**	**126**	**62**	**169**
1416	13.95	7.7	317	14	53	31	1000	24	56.5	539	241	54	41
1425	13.95	7.8	332	6	3	28	1000	24	54.4	508	251	55	42
AVG	**13.95**	**7.8**	**325**	**10**	**28**	**30**	**1000**	**24**	**55.5**	**524**	**246**	**55**	**42**
41008	14.45	3.0	74			6	190	52	16.9		125	62	144
41023	14.45	2.4	77			6	189	42	17.4		129	66	136
AVG	**14.45**	**2.7**	**76**			**6**	**-6**	**47**	**17.2**	**0**	**127**	**64**	**140**
41009	15.00	2.6	127			9	285	41	16.3		105	57	156
41010	15.60	13.2	332			22	374	37	43.0		294	231	67
41011	16.40	3.6	75			6	64	30	12.4		130	62	96
1406	17.00	9.4	60	36	69	9	30	32	11.9	213	144	118	59
41013	17.40	12.2	138			8	98	31	11.9		227	158	10
41014	18.05	15.8	116			6	37	30	11.1		519	292	10
41024	18.05	15.6	114			6	26	31	10.8		530	297	9
AVG	**18.05**	**15.7**	**115**			**6**	**-6**	**31**	**11.0**	**0**	**525**	**295**	**10**
Sample ID	**Distance West (m)**	**Sc**	**V**	**Cr**	**Ni**	**Cu**	**Zn**	**Nb**	**Y**	**Zr**	**Ba**	**Sr**	**Rb**
41015	18.35	36.8	124			4	37	38	12.1		451	362	12
41016	18.60	28.7	133			4	36	35	10.9		233	190	12
41018	19.00	26.7	112			6	42	36	11.9		409	177	14
41019	19.65	24.9	142			11	57	34	12.4		345	287	16
41020	20.10	18.6	191			8	56	35	11.0		292	194	39
41021	20.65	15.3	104			5	29	40	13.8		170	146	103
41025	20.65	15.7	105			5	22	38	13.7		159	148	105
AVG	**20.65**	**15.5**	**105**			**5**	**26**	**39**	**13.8**	**0**	**165**	**147**	**104**

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E-W Transect Majors

Sample ID	Distance West (m)	SiO2	TiO2	Al2O3	TFe2O3	Feo	Fe2O3	MnO	MgO	CaO	Na2O	K2O	P2O5	LOI	Total
1413	2.55	76.38	0.24	12.79	0.72	0.16	0.53	0.01	0.12	0.13	0.53	6.36	0.02	2.49	99.78
41001	4.00	76.57	0.23	12.32	0.93	0.27	0.62	0.01	0.07	0.19	0.59	6.43	0.03	2.25	99.62
41003	5.20	77.98	0.25	11.93	0.60	*1.19*	*-0.68*	0.01	0.06	0.17	0.57	5.88	0.02	2.38	99.84
41004	6.20	77.28	0.24	12.37	0.48	0.24	0.21	0.01	0.06	0.16	0.53	6.05	0.04	2.48	99.69
41005	7.45	76.33	0.25	13.03	0.54	0.08	0.44	0.00	0.06	0.17	0.54	6.38	0.03	2.51	99.84
41106	8.15	76.00	0.24	13.08	0.57	0.07	0.48	0.01	0.06	0.17	0.62	6.64	0.06	2.38	99.85
41022	8.15	76.54	0.25	13.33	0.65	0.05	0.58	0.01	0.05	0.13	0.58	6.58	0.02	2.41	100.56
AVG	**8.15**	**76.27**	**0.25**	**13.21**	**0.61**	**0.06**	**0.53**	**0.01**	**0.06**	**0.15**	**0.60**	**6.61**	**0.04**	**2.40**	**100.21**
1418	9.00	77.01	0.25	13.28	0.57	0.18	0.36	0.00	0.01	0.11	0.43	5.77	0.02	2.83	100.28
1402	9.70	76.42	0.25	12.87	0.59	0.10	0.47	0.00	0.03	0.10	0.54	6.06	0.01	2.41	99.28
1421	10.30	78.25	0.23	12.65	0.57	0.08	0.47	0.00	0.02	0.07	0.31	4.77	0.02	3.12	100.02
1420	10.80	77.02	0.26	13.73	0.44	0.10	0.32	0.00	0.03	0.10	0.31	4.63	0.01	3.26	99.80
1405	11.55	77.48	0.24	13.03	0.61	0.09	0.50	0.01	0.03	0.09	0.30	4.80	0.02	2.92	99.53
1422	11.55	77.18	0.24	12.71	0.60	0.08	0.50	0.01	0.03	0.10	0.32	5.04	0.04	2.95	99.19
AVG	**11.55**	**77.33**	**0.24**	**12.87**	**0.61**	**0.09**	**0.50**	**0.01**	**0.03**	**0.10**	**0.31**	**4.92**	**0.03**	**2.94**	**99.36**
1403	11.90	75.29	0.21	9.27	4.42	0.51	3.75	0.01	0.01	0.44	0.09	1.98	0.03	4.29	96.02
1411	12.50	77.46	0.22	12.37	0.71	0.01	0.68	0.00	0.02	0.13	0.31	4.25	0.01	3.22	98.72
1401	12.95	73.11	0.19	9.19	10.52	0.06	10.15	0.01	0.01	0.14	0.18	2.83	0.01	3.42	99.60
1419	13.50	76.57	0.22	10.97	4.09	0.09	3.88	0.01	0.02	0.10	0.23	3.61	0.00	3.42	99.25
1423	13.50	76.52	0.22	11.20	4.13	0.12	3.88	0.01	0.03	0.11	0.24	3.69	0.02	3.41	99.56
AVG	**13.50**	**76.55**	**0.22**	**11.09**	**4.11**	**0.11**	**3.88**	**0.01**	**0.03**	**0.11**	**0.24**	**3.65**	**0.01**	**3.42**	**99.41**
1416	13.95	59.95	0.15	8.56	26.01	0.31	24.92	0.01	0.01	0.14	0.06	0.97	0.01	4.72	100.60
1425	13.95	60.22	0.15	8.47	24.72	0.23	23.76	0.01	0.02	0.15	0.07	0.99	0.02	4.72	99.54
AVG	**13.95**	**60.09**	**0.15**	**8.52**	**25.37**	**0.27**	**24.34**	**0.01**	**0.02**	**0.15**	**0.07**	**0.98**	**0.02**	**4.72**	**100.07**
41008	14.45	79.43	0.25	10.81	2.39	0.16	2.15	0.01	0.05	0.15	0.25	3.27	0.04	3.43	100.07
41023	14.45	78.91	0.24	10.60	2.38	0.16	2.14	0.01	0.04	0.07	0.23	3.17	0.04	3.53	99.21
AVG	**14.45**	**79.17**	**0.25**	**10.71**	**2.39**	**0.16**	**2.15**	**0.01**	**0.05**	**0.11**	**0.24**	**3.22**	**0.04**	**3.48**	**99.64**
41009	15.00	74.66	0.22	10.97	6.56	0.09	6.27	0.01	0.05	0.19	0.26	3.38	0.03	3.71	100.05
41010	15.60	66.17	0.29	16.09	8.25	0.16	7.84	0.01	0.05	0.19	0.14	1.55	0.07	7.08	99.88
41011	16.40	74.95	0.21	11.24	6.90	0.13	6.56	0.00	0.03	0.10	0.14	2.13	0.02	4.22	99.93
1406	17.00	73.00	0.23	15.37	3.33	0.12	3.11	0.00	0.01	0.09	0.11	1.67	0.02	6.56	100.38
41013	17.40	71.77	0.20	15.45	3.25	0.13	3.02	0.00	0.04	0.06	0.06	0.55	0.01	8.21	99.60

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E-W Transect Majors

Sample ID	Distance West (m)	SiO2	TiO2	Al2O3	TFe2O3	Feo	Fe2O3	MnO	MgO	CaO	Na2O	K2O	P2O5	LOI	Total
41014	18.05	71.68	0.19	12.94	6.16	0.18	5.79	0.00	0.01	0.04	0.04	0.64	0.01	7.42	99.13
41024	18.05	72.02	0.20	13.19	6.52	0.20	6.12	0.00	0.03	0.06	0.06	0.65	0.01	7.49	100.21
AVG	**18.05**	**71.85**	**0.20**	**13.07**	**6.34**	**0.19**	**5.95**	**0.00**	**0.02**	**0.05**	**0.05**	**0.65**	**0.01**	**7.46**	**99.67**
41015	18.35	72.72	0.21	14.11	0.77	0.17	0.57	0.00	0.02	0.05	0.06	1.58	0.01	10.74	100.28
41016	18.60	74.47	0.22	14.61	0.64	0.15	0.46	0.00	0.02	0.07	0.07	0.89	0.02	8.33	99.33
41018	19.00	78.20	0.22	10.83	0.94	0.23	0.67	0.01	0.07	0.06	0.11	1.07	0.02	8.16	99.67
41019	19.65	74.18	0.21	12.45	1.37	0.23	1.09	0.00	0.08	0.07	0.06	1.32	0.01	9.31	99.08
41020	20.10	74.32	0.23	14.13	1.54	0.16	1.33	0.00	0.04	0.06	0.08	1.48	0.03	8.22	100.13
41021	20.65	77.55	0.24	12.29	0.56	0.14	0.40	0.00	0.04	0.06	0.20	2.82	0.04	6.08	99.90
41025	20.65	77.20	0.25	12.25	0.56	0.13	0.41	0.00	0.04	0.06	0.19	2.72	0.03	6.12	99.42
AVG	**20.65**	**77.38**	**0.25**	**12.27**	**0.56**	**0.14**	**0.40**	**0.00**	**0.04**	**0.06**	**0.20**	**2.77**	**0.04**	**6.10**	**99.66**

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BWL

Comparison to the INAA highlighted samples is limited since 2 of the three highlighted samples have been chemically extracted using May and Pinto method. Only the sample 1402 (ICP sample ID) from 9.7 m West can be compared to INAA results (sample 41101)

% INAA relative to ICP

Element	ICP	INAA	% Dev
Na_2O	0.54	0.548 ± 0.003	1.5
TFe_2O_3	0.59	0.612 ± 0.006	3.7
Sc	3.1	3.1	0
Cr	4	2.9	-28
Zr	256	361	41
Ba	69	223	223%
Sr	38	too low to report	—
Rb	338	334	-1.2

The high Zr (INAA) is a bit disturbing, but Zr # INAA will not be used as a precaution. Similarly although the Cr have a large relative error, accuracy is good considering ICP σ of 2.5ppm. The large relative error in Ba measurements is not surprising given that Ba at these low concentrations are poorly constrained by standard calibration curves used in INAA analysis. Ba ICP values are reliable and believable.

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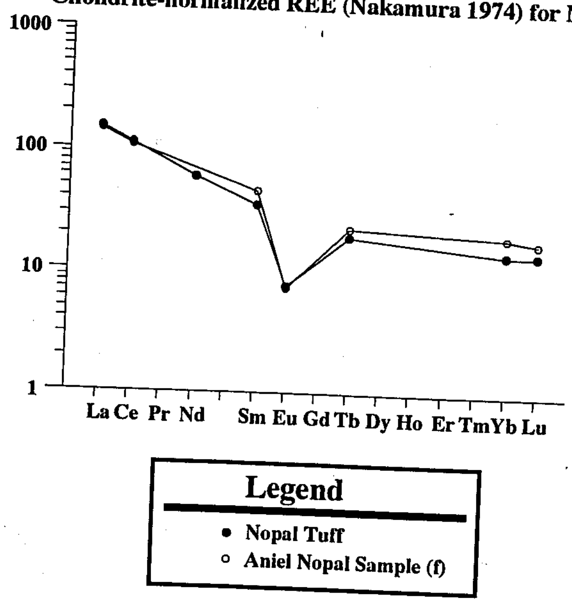
These final REE diagrams are derived from the final REE values reported on pg 21 of this notebook.

The graphs are generated using the MacSuite software program package. In particular the SPIDER program (American Mineralogist, v73 pg 919-921; Wheatley and Rock) was used. The REE contents of chondrites given by Nakamura (1974) were used in generating the figures

Nakamura, N. (1974) Geochimica et Cosmochimica Acta, 38, 757-775.

Chondrite-normalized REE (Nakamura 1974) for Nopal Tuff



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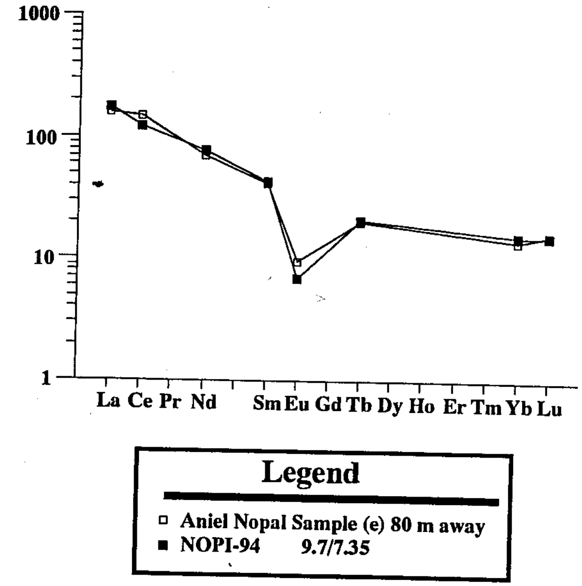
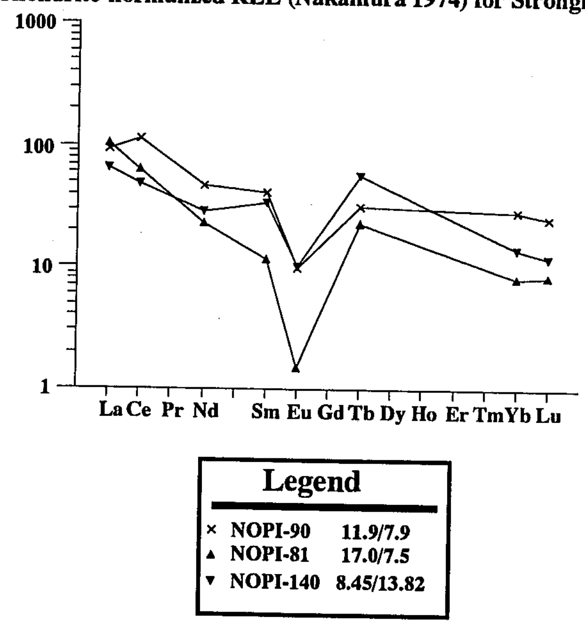
Chondrite-normalized REE (Nakamura 1974) for Slightly Altered Nopal Tuff



Chondrite-normalized REE (Nakamura 1974) for Strongly Altered Nopal Tuff



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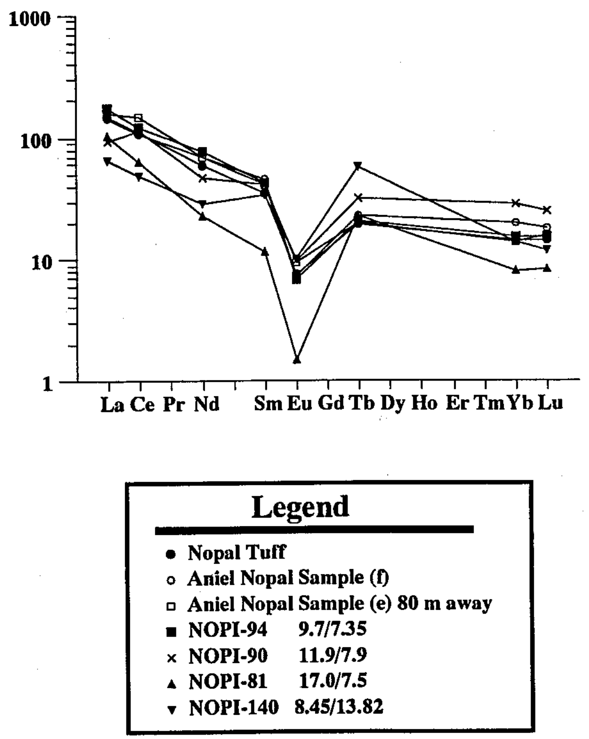
Chondrite-normalized REE (Nakamura 1974) for All Nopal Samples



So what does it all mean...

Points to address
1) Reliability of procedure
yield versus May & Pinte, cleanup of U
2) Accuracy
3) Comparison to Aniel Interpretation
4) Implications for Deposit
5) Prognosis for future...

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May and Pinte (1984) indicated an average chemical yield of 85%. The average yield of my samples was 72% suggesting that I didn't do to bad for my 1st attempt with this procedure. Even if the variability is 10% this would only cause a 15-30% error in the calculated concentration of REE for samples 41104, 41105, & 41106, or the last three samples listed in legend of figure on previous page. This error is negligible with respect to the reported values since the figures reflect a relative concentration with respect to chondritic meteorites and the results are plotted logarithmically. Thus the relative shape of REE plots and location of each REE in the plots previous should be approximately correct. May and Pinte argued that their procedure did not fractionate the REE, thus any change in the shape of the pattern would actually reflect the change in REE content of the whole rock samples.

Cleanup of U- note sample NOPI-90 has ≥3,249 ppm U, after separation the $Al(OH)_3$ only contained 31ppm. Thus chemical procedure effectively

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BWL

eliminates 99.87% of the U. That is a fantastic efficiency and argues strongly for the use of the procedure

accuracy of the INAA analyses appears to be acceptable. Comparison of ICP and INAA analyses, values of INAA of USGS standards, and a comparison of unaltered Nopal formation and slightly altered Nopal formation tuff values of Aniel et al 1991 (see pgs 30 & 31) support this conclusion. The REE results should be used with some caution when completing any quantitative modeling of the results because of the large uncertainties associated with individual REE in each sample. It will be necessary to look at calculated values and its % error and compare these values directly to the values of same element in the standards (pg 15 & 16) used in calibration before accepting the results for the element in the sample of interest. As Dr. Anthony pointed out (pg 14) the reported errors reflect true uncertainties and should be treated seriously!

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BWL

Comparison to previous REE analyses of the Nopal I deposit.
Figures on pg 30 & 31 indicate that our REE patterns are similar and REE concentrations are quite similar to those of Aniel et al 1991. Note that the altered sample of Aniel was collected about 80 m from edge of deposit, while sample NOPI-94 was only located about 2 m away from western boundary of ore deposit.

Implications for deposit -
Previously Aniel et al 1991 had argued that alteration by hydrothermal fluids had not mobilized REE. This conclusion was based on her analyses presented in the Nopal tuff and slightly altered tuff sample (see figures). Our results seem to substantiate her assertion for the lack of mobility of REE outside the ore body.

However, by choosing samples which were expected to show the largest variations, based on U and Major, Trace & S analyses, REE patterns and concentrations were demonstrated to be different from the slightly altered and unaltered Nopal formation rocks. see pg 32.

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First for the sample expected to have a depletion in REE (NOPI-81). This sample is from the "uranium hole" on the +10 m level of the deposit. This area is devoid of visible U mineralization and contains minerals associated with acid alteration (jarosite & alunite). See trace element, S, elemental analyses on following pages of E-W transect from which samples NOPI-81 & NOPI-90 were collected.

E N
17.0/7.5 NOPI-81 has highest S, low U & Zn, high Fe very low alkali, low Ca but high Sr & Ba & both Cr and Ni are

With the exception of Tb, all REE are depleted by a factor of 2-5 relative to unaltered tuff, with Eu depleted by a factor of 5-6. It appears LREE (La & Ce) are slightly depleted Sm & Eu more depleted & HREE slightly depleted. Thus there was at least some lost of REE from center of deposit, most likely under acid-sulfate conditions.

Sample 11.9/7.9 (NOPI-90) is the most U-enriched sample, Zn high, Ca, Br, Sr high, K, Na high but Rb low high V & Y, high Cr, Nb, Ni & Cu

Shows slight LREE depletion & pronounced (factor 2) enrichment of HREE.

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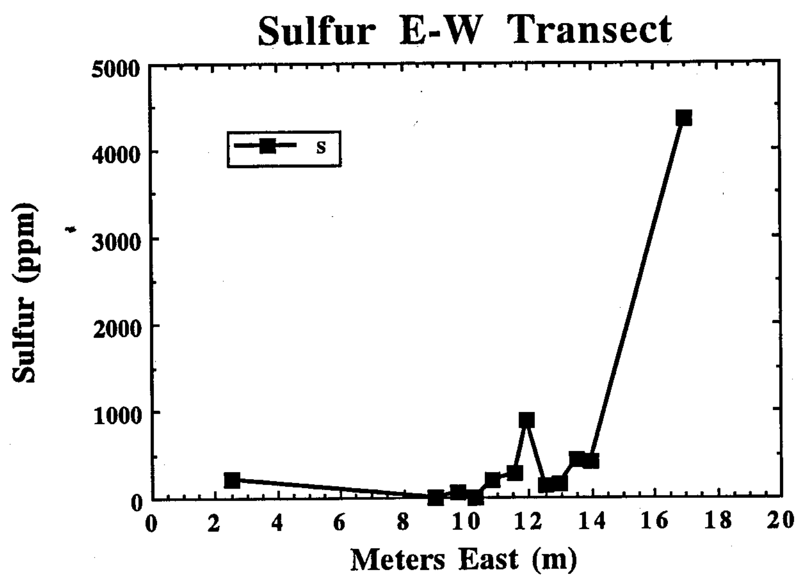

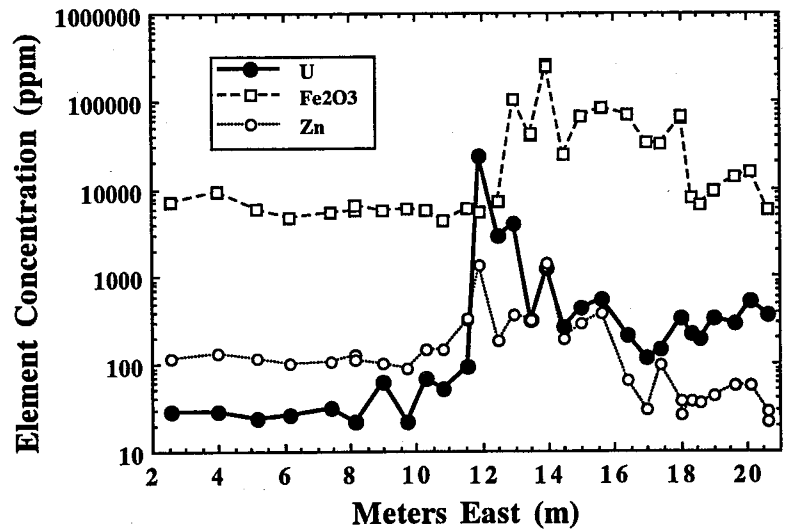

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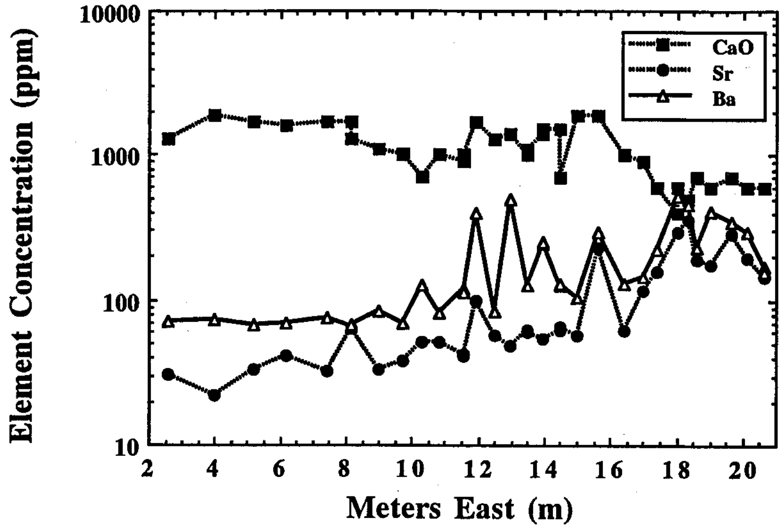
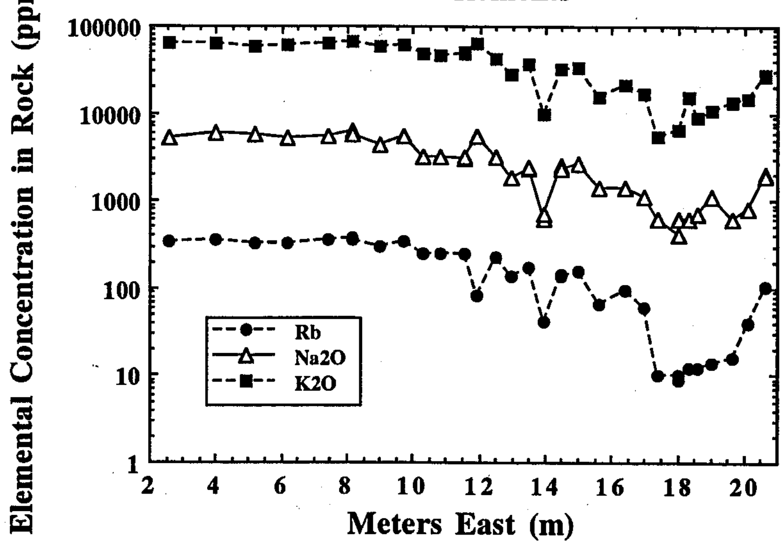


Alkali Elements



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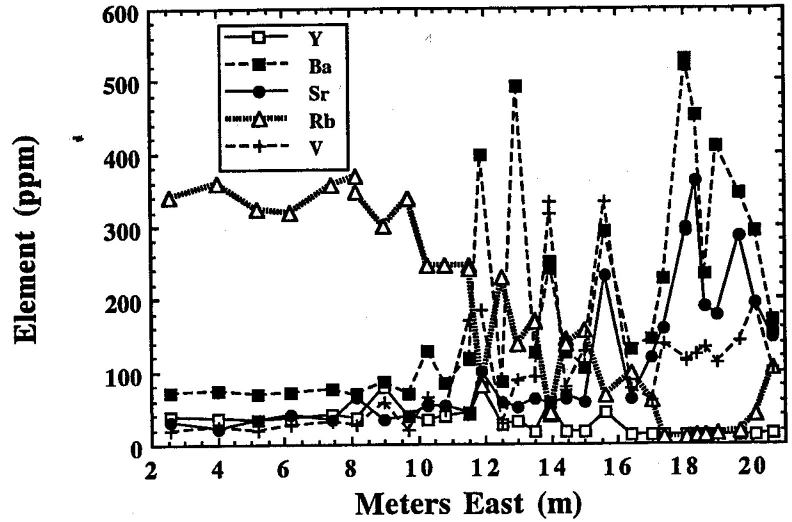
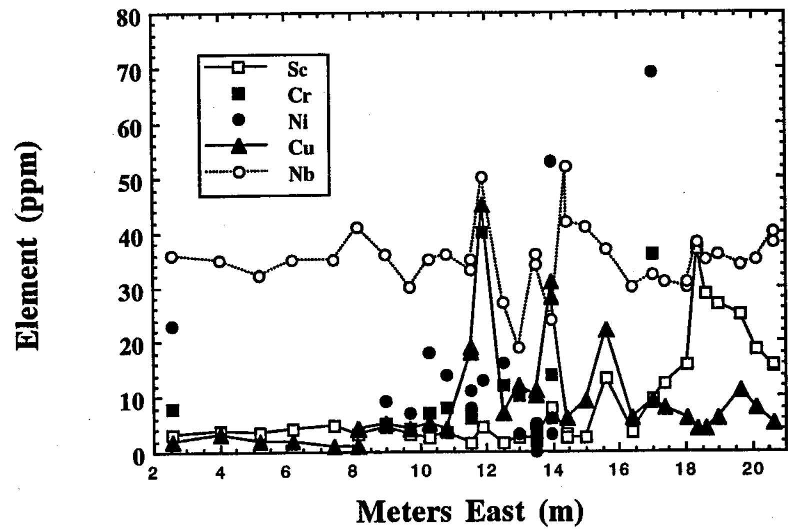
Trace Elements E-W Transect



Trace Elements E-W Transect



12/19/93
BWL

Finally sample NOPI-140 was collected from a fracture which contains elevated U concentration from outside ore body. This sample is located about 2-3 m west of edge of orebody. Fluids which transported U were S rich & probably acidic (acid alteration minerals)
This sample shows a significant LREE (La-Nd) depletion, Tb enrichment(?) & maybe a small depletion of HREE.
This pattern is different from unaltered rocks and substantiates REE mobility at Nopal I.

Further implications - sample NOPI-90 represents the most uranophane rich sample we have and it is suggestive that uranophane may HREE enriched. To test this we will need at least 0.1 gram of uranophane (pure) separate for separation (May & Pinto) & INAA analysis.

My feeling is that REE analyses will be only particularly useful for U-mineral separates since bulk rock samples show limited variability. We have tested the extremes only a factor of 2-5 variability.

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8/23/93
BWL

Plants

The purpose of this experiment is to determine the radioactivity of some plants which were collected during our most recent trip to Peña Blanca. A leaf of one species of plant had been exposed to CR-39 for alpha autoradiography. This experiment was documented in Scientific Notebook #024 (analogs #1) and the succeeding notebook AN #2 (080). This experiment is being conducted primarily by Omar Lagunas @ CNWRA in San Antonio under my direction. Most of the actual measurements and detailed notes are contained in AN-2. The following pages will refer to pages in that notebook. The documentation which follows provides an overview and a summary of all necessary data and calculations which will be used to calculate the final activities of the plants.

The overall scheme of analysis will be to dry the samples, ash the samples, grind and powder and prepare gamma vials for γ-spectrometric counting. It may be possible to perform alpha-spectrometry on ashed samples.

8/24/93
BWL

The sample had been collected from the site and placed into doubled ziplock baggies. Upon return the baggies were placed in the refrigerator. I had Peggy weigh the bags this past week and dry them all in drying oven

Wt of plants + bags		1495.2 g
wt of bags		100.8 g
		1394 g

wt of "natural samples"
some condensation so perhaps overestimate of wt of bags
wt of dried samples 353.55 g

The samples were dried for > 3 days @ 100°C in drying oven

The percent weight loss is 74.64%

To be able to recalculate reported analyses to plant in situ would require that samples reported as per gram of dried plant be multiplied by following correction factor

$$\text{Value } \frac{\text{dpm}}{\text{g dried}} \cdot \frac{353.55\text{ g dry}}{1394\text{ g wet}} = \text{Value/g wet}$$

8/24/93
BWL

In general wet weight has little meaning as plants water contents can fluctuate dramatically. Thus most results cited in literature are reported as per dried gram plant or per gram ashed plant.

Since the plants were growing on the ore pile it is necessary to assure ourselves that the radioactivity that we measure is reflective of the plant and not surface / foliar contamination of ore particles.

On 8/23/93 the plant samples were split into 2 groups (A & B, recorded on pg 080/35.

Group A samples will be washed & redried
Group B samples will be unwashed.

Both groups or aliquots from them will be ashed for >12 hours @ 450°C in the muffle furnace.

Samples will be designated as follows

FR - A - (# sample) washed
&
FR - B - (# sample) unwashed

8/24/93 BWL According to Omar (pg 36 in his book AW#2)

	Description	Mass dried
FR-B-1	Leaves & Stem from 1 Branch	5.252 g
FR-B-2	Leaves & Stem from large Clusters of Branches	11.845 g
FR-B-3	Leaves only	6.854 g
FR-B-4	Stems only	9.095 g

8/25/93 BWL Omar called and relayed following infor which is documented on pg 080/40.

Sample	Mass dried (g)	Mass Ash (g)	C F
FR-B-1	5.252	0.648	0.1234
FR-B-2	11.845	1.315	0.1110
FR-B-3	6.854	0.804	0.1173
FR-B-4	9.095	1.105	0.1215

CF is a correction factor that can be used to correct from wt of ash to wt of dried.

Thus if activity of FR-B-1 was $50 \frac{dpm}{g\ ash}$

then $\frac{dpm}{g\text{-dried plant}} = 50\,dpm * 0.1234$

The Group A samples were washed in deionized H_2O by dunking and rinsing with squirt bottle.

8/25/93 BWL Omar stated that gamma vials of FR-B samples were capped on 8/24/93.

Mass of gamma samples (grams ash)

Sample	mass
FR-B-1	0.731
FR-B-2	1.232
FR-B-3	0.922
FR-B-4	1.204

recorded 080/40.

8/26/93
BWL

Omar FAXed me the following information on ashed Group A samples

	mass of crucible + sample before ashing	mass after ashing	% change	CF
FR - A - 1 : *crucible weight 30.193 g*	**38.015 g** mass sample 7.822	**31.993 g** mass ash 1.800 g	**15.8411**	BWL 9/15/93 ~~0.2302~~ 0.2301
FR - A - 2 : *crucible weight 32.61 g*	**45.330 g** 12.72	**34.501 g** 1.89	**23.8893**	BWL 9/15/93 ~~0.1486~~ 0.1486
FR - A - 3 : *crucible weight 28.32 g*	**35.230 g** 6.91	**30.668 g** 2.348	**12.9500**	0.3398
FR - A - 4 : *crucible weight 32.651 g*	**37.500 g** 4.849	**33.950 g** 1.299	**9.4667**	0.2679

CF = Correction factor for recalculating activity/gram ash to activity/gram dried plant.

For instance if sample ash had ^{226}Ra activity of 1000 dpm/g ash and CF of 0.25 $\Rightarrow$ then 250 dpm/g of dried plant would be reported value.

8/26/93
BWL

Gamma vials of the ground, powdered ashed group A samples were capped today.

Sample	Mass ash in vial (g)
FR-A-1	1.705
FR-A-2	1.813
FR-A-3	1.895
FR-A-4	1.222

The gamma vials will be allowed to sit for a week or two, preferably a month before counting. Since we have degassed Rn any ^{226}Ra will not be in secular equilibrium with ^{222}Rn ($t_{1/2}$ 3.84 days). Secular equilibrium in $\approx 5\ t_{1/2}$.

9/8/93
BWL

Sample FR-A-1

Dos File Name → sample Description →

Page 1

MCA #1 - Canberra S100 - FRA1.MCA - FR-A-1 4.0cm

```
Tag Number:      56        Readout:          Tue 07 Sep 1993 @ 16:37:02 ~AS
Report Group:    2/4       Acquire Started:  Tue 07 Sep 1993 @ 16:34:00
Group Size:      4096
```

← printout so start time = AS-CT

```
Elapsed Live Time:     455.00 min.
Elapsed True Time:     455.17 min.
Dead Time:               0.04 %
```

← counting Time (CT)   MASS : 1.705 g

```
MCA Mode:            PHA+
Preset Conditions:   Live Time = 455.00 min.

Calibration:         0.0000*Ch^2 + 0.4996*Ch + 1.083 keV

Area Statistics:     Background Channels = 4
                     % Error Sigma = 1.65

Peak Statistics:     Sensitivity Factor = 4.0
                     Expected FWHM (ch) = 2.7 - 6.0

Iso. Id. Criteria:   Energy Window = +-1.300 keV
Iso. Library:        C:\WINDOWS\S100\SPECTRAN.ISO
```

Summary (dpm/g)

BWL 9/8/93

^{238}U (Th-234) = 149.43 ± 3.98

^{226}Ra (^{214}Pb, ^{214}Bi) = 2233.1 ± 0.2

^{210}Pb = 162.76 ± 117.86

if contamination we know rocks = activity

^{228}Ra = (Ac-228) 37.39 ± 7.65

^{228}Th (Tl-208) = -9.4 ± -13.19

$\frac{^{226}Ra}{^{228}Ra}$ = 59.72 ± 12.22

$\frac{^{210}Pb}{^{234}Th}$ = 1.09 ± 0.79

JP 9/7/93

DT = 455 min

Integral = CTS + BKG

Mass = 1.705 g

9/8/93
BWL

FR-A-1

Sample #	FR-A-1									
Weight(g)	1.705	Geometry	4.0 cm			Counting Time(min)		455		
time of background minutes			4320							
Nuclides	Total Counts	Bkgd(1)	Blank(2) (cpm)	Eblank cpm	Net counts	c. eff. (%)	intensity (%)	Activity (dpm/g)		
Pb-210	45 kev									
210	4335	4109	0.2666	0.00976	104.697	1.58	4.1	162.76	±	117.86
Th-234										
62	5907	5229	0.3939	0.01249	498.7755	6.3725	5.7	138.83	±	9.67
(93Kev)										
93	3906	2630	0.8309	0.01996	897.9405	8.835	6.8	151.58	±	4.37
Ra-226										
295	22098	1749	0.0927	0.00564	20306.822	5.4325	18	2259.00	±	0.61
352	37043	3260	0.1756	0.0029	33703.102	4.63	35	2237.84	±	0.28
609	23328	1488	0.223	0.0026	21738.535	2.51	43	2196.52	±	0.53
183.7	11611	3910	0.5414	0.0139	7454.663	17.7825	3.3	1340.03	±	1.62
Th-228	583 kev									
228	785	780	0.1591	0.00914	-67.3905	0.905	86	-9.40	±	-13.19
Ra-228										
338	1729	1529	0.0582	0.00591	173.519	4.7325	12	32.99	±	11.20
911	1272	990	0.1737	0.00936	202.9665	1.8025	29	43.60	±	11.70
964	1139	895	0.3092	0.00844	103.314	1.69	21.8	31.71	±	23.42
Ra-226 weighted average =			2233.10	±	0.23	U (ppm)=		2989	±	0.31
Ra-228 weighted average =			37.39	±	7.65	Th (ppm) =		138.3	±	28.3
234Th av 63 & 92 =			149.43	±	3.98	U (ppm)=		200	±	5.33
210PB			162.76	±	117.864					
Th-228 =			-9.40	±	-13.19	Th (ppm) =		-34.8	±	-49
Calculation of weighted average (up to 200 data sets can be input)										
	weighted average=		37.3861		average=	37.66				
	weighted error=		7.64714		std.=	8.407				
data	±	err	error^2	1/error^2	data/error^2					
32.99	±	11.20	125.44	0.007972	0.26299					
43.60	±	11.70	136.89	0.007305	0.3185					
31.71	±	23.42	548.496	0.001823	0.05781					
	±		0	0	0					

9/8/93
BWL

FR-A-2

SEP-08-93 13:55 FROM: CNWRA BLDG. 57 ID: 5125225184 PAGE

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MCA #1 - Canberra S100 - FRA2.MCA - FR-A-2 4.0cm

Tag Number: 58 Readout: Wed 08 Sep 1993 @ 08:32:44
Report Group: 2/4 Acquire Started: Wed 08 Sep 1993 @ 08:31:34
Group Size: 4096

Elapsed Live Time: 944.00 min.
Elapsed True Time: 944.54 min.
Dead Time: 0.06 %

MASS . 1.813 g

MCA Mode: PHA+
Preset Conditions: Live Time = 944.00 min.

Calibration: 0.0000*Ch^2 + 0.4996*Ch + 1.083 keV

Area Statistics: Background Channels = 4
% Error Sigma = 1.65

Peak Statistics: Sensitivity Factor = 4.0
Expected FWHM (ch) = 2.7 - 6.0

Iso. Id. Criteria: Energy Window = +-1.300 keV
Iso. Library: C:\WINDOWS\S100\SPECTRAN.ISO

Summary (dpm/g) BWL 9/8/93

^{238}U (^{234}Th) = 61.19 ± 4.19 could be 1.5x higher

1.13x higher

^{226}Ra (Rn-daughters) = 2631.10 ± 0.14

^{210}Pb = 465.31 ± 46.93

$\frac{^{226}Ra}{^{228}Ra}$ = 67.45 ± 8.82

^{228}Ra (Ac-228) = 39.01 ± 5.1

^{228}Th (Tl-208) = -11.33 ± -8.09

$\frac{^{210}Pb}{^{234}Th}$ = 7.60 ± 0.93

gp 9/8/93

ΔT = 944 min

Integral CTs + BKG

mass = 1.813

9/8/93
BWL

FR-A-2

Sample #	FR-A-2									
Weight(g)	1.813	Geometry	4.0 cm			Counting Time(min)		944		
time of background minutes			4320							
Nuclides	Total	Bkgd(1)	Blank(2)	Eblank	Net counts	c. eff.	intensity	Activity		
	Counts		(cpm)	cpm		(%)	(%)	(dpm/g)		
Pb-210	45 kev									
210	10786	9874	0.2666	0.00976	660.3296	1.58	4.1	465.31	±	46.93
Th-234										
62	14411	13548	0.3939	0.01249	491.1584	6.3725	5.7	61.97	±	9.74
(93Kev)										
93	8044	6462	0.8309	0.01996	797.6304	8.835	6.8	61.03	±	4.64
Ra-226										
295	58613	4628	0.0927	0.00564	53897.491	5.4325	18	2717.74	±	0.37
352	91826	4366	0.1756	0.0029	87294.234	4.63	35	2627.30	±	0.17
609	58590	2128	0.223	0.0026	56251.488	2.51	43	2576.35	±	0.33
183.7	29195	10438	0.5414	0.0139	18245.918	17.7825	3.3	1486.68	±	1.03
Th-228	583 kev									
228	1986	2015	0.1591	0.00914	-179.1904	0.905	86	-11.33	±	-8.09
Ra-228										
338	4497	4098	0.0582	0.00591	344.0592	4.7325	12	29.65	±	7.95
911	1878	1256	0.1737	0.00936	458.0272	1.8025	29	44.60	±	7.79
964	2797	2159	0.3092	0.00844	346.1152	1.69	21.8	48.15	±	12.80
Ra-226 weighted average =			2631.10	±	0.14	U (ppm)=		3522	±	0.19
Ra-228 weighted average =			39.01	±	5.1	Th (ppm) =		144.3	±	18.9
234Th av 63 & 92 =			61.19	±	4.19	U (ppm)=		81.91	±	5.61
210PB			465.31	±	46.93					
Th-228 =			-11.33	±	-8.09	Th (ppm) =		-41.9	±	-30
Calculation of weighted average (up to 200 data sets can be input)										
	weighted average=		61.185		average=	61				
	weighted error=		4.18895		std.=	####				
data	±	err	error^2	1/error^2	data/error^2					
62.00	±	9.74	94.8676	0.010541	0.65354					
61.00	±	4.64	21.5296	0.046448	2.83331					
	±		0	0	0					
	±		0	0	0					

9/8/93
BWL

FR-A-3

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MCA #1 - Canberra S100 - FRA3.MCA - FR-A-3 4.0cm

Tag Number: 60 Readout: Wed 08 Sep 1993 @ 15:20:58
Report Group: 2/4 Acquire Started: Wed 08 Sep 1993 @ 15:20:24
Group Size: 4096

Elapsed Live Time: 403.00 min.
Elapsed True Time: 403.16 min.
Dead Time: 0.04 %

mass: 1.895

MCA Mode: PHA+
Preset Conditions: Live Time = 403.00 min.

Calibration: 0.0000*Ch^2 + 0.4996*Ch + 1.083 keV

Area Statistics: Background Channels = 4
% Error Sigma = 1.65

Peak Statistics: Sensitivity Factor = 4.0
Expected FWHM (ch) = 2.7 - 6.0

Iso. Id. Criteria: Energy Window = +-1.300 keV
Iso. Library: C:\WINDOWS\S100\SPECTRAN.ISO

BWL 9/9/93

$t = \Delta 403$ minutes

Summary 9/9/93

$^{238}U(^{234}Th) = 89.73 \pm 5.2$

$^{226}Ra\left(\begin{smallmatrix}^{214}Pb\\ ^{214}Bi\end{smallmatrix}\right) = 2182.20 \pm 0.14$

$\frac{^{226}Ra}{^{228}Ra} = 52.49 \pm 9.50$

$^{210}Pb = 190.39 \pm 109.84$

$^{228}Ra(Ac\text{-}228) = 41.57 \pm 7.53$

$\frac{^{210}Pb}{^{234}Th} = 2.12 \pm 1.23$

$^{228}Th(Tl\text{-}208) = -14.90 \pm -10.56$

9/8/93
BWL

FR-A-3

Sample #	FR-A-3									
Weight(g)	1.895	Geometry	4.0 cm				Counting Time(min)	403		
time of background minutes			4320							
Nuclides	Total Counts	Bkgd(1)	Blank(2) (cpm)	Eblank cpm	Net counts	c. eff. (%)	intensity (%)	Activity (dpm/g)		
Pb-210	45 kev									
210	4000	3772	0.2666	0.00976	120.5602	1.58	4.1	190.39	±	109.84
Th-234										
62	5555	5018	0.3939	0.01249	378.2583	6.3725	5.7	106.95	±	11.10
(93Kev)										
93	3332	2502	0.8309	0.01996	495.1473	8.835	6.8	84.91	±	5.89
Ra-226										
295	21557	1779	0.0927	0.00564	19740.642	5.4325	18	2230.78	±	0.61
352	33884	1562	0.1756	0.0029	32251.233	4.63	35	2175.34	±	0.29
609	21958	743	0.223	0.0026	21125.131	2.51	43	2168.33	±	0.54
183.7	10885	3840	0.5414	0.0139	6826.8158	17.7825	3.3	1246.60	±	1.69
Th-228	583 kev									
228	750	791	0.1591	0.00914	-105.1173	0.905	86	-14.90	±	-10.56
Ra-228										
338	1670	1393	0.0582	0.00591	253.5454	4.7325	12	48.96	±	9.26
911	632	433	0.1737	0.00936	128.9989	1.8025	29	28.15	±	14.67
964	1026	825	0.3092	0.00844	76.3924	1.69	21.8	23.82	±	27.24
Ra-226 weighted average =			2182.20	±	0.14	U (ppm)=		2921	±	0.19
Ra-228 weighted average =			41.57	±	7.53	Th (ppm) =		153.8	±	27.9
234Th av 63 & 92 =			89.73	±	5.2	U (ppm)=		120.1	±	6.96
210PB			190.39	±	109.84					
Th-228 =			-14.90	±	-10.56	Th (ppm) =		-55.1	±	-39
Calculation of weighted average (up to 200 data sets can be input)										
	weighted average=		89.7335		average=	84.9				
	weighted error=		5.20289		std.=	####				
data	±	err	error^2	1/error^2	data/error^2					
106.90	±	11.10	123.21	0.008116	0.86762					
84.90	±	5.89	34.6921	0.028825	2.44724					
	±		0	0	0					
	±		0	0	0					

9/8/93
BWL

FR-A-4

08-93 08:18 FROM: CNWRA BLDG. 57 ID: 5125225184 PAGE

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MCA #1 - Canberra S100 - FRA4.MCA - FR-A-4 3.0cm

```
Tag Number:      62        Readout:         Thu 09 Sep 1993 @ 08:41:08
Report Group:    2/4       Acquire Started: Thu 09 Sep 1993 @ 08:40:16
Group Size:      4096

Elapsed Live Time:    1036.00 min.
Elapsed True Time:    1036.38 min.
Dead Time:               0.04 %

MCA Mode:             PHA+
Preset Conditions:    Live Time = 1036.00 min.

Calibration:          0.0000*Ch^2 + 0.4996*Ch + 1.083 keV

Area Statistics:      Background Channels = 4
                      % Error Sigma = 1.65

Peak Statistics:      Sensitivity Factor = 4.0
                      Expected FWHM (ch) = 2.7 - 6.0

Iso. Id. Criteria:    Energy Window = +-1.300 keV
Iso. Library:         C:\WINDOWS\S100\SPECTRAN.ISO
```

mass 1.222

9/9/93
BWL

$\Delta t = 1036$ min

Summary dpm/g

$^{238}U\,(^{234}Th) = 46.73 \pm 5.48$

$^{226}Ra\,\left(\frac{^{214}Pb}{^{214}Ra}\right) = 2625.3 \pm 0.16$

$^{210}Pb = 270.89 \pm 69.87$

$^{228}Ra = 38.72 \pm 5.79$

$^{228}Th\,(^{212}Pb\ 208) = -25.97 \pm -6.15$

$\frac{^{226}Ra}{^{228}Ra} = 67.80 \pm 10.14$

$\frac{^{210}Pb}{^{234}Th} = 5.80 \pm 1.64$

9/8/93
BWL

FR-A-4

Sample #	FR-A-4									
Weight(g)	1.222	Geometry	3.0 cm			Counting Time(min)		1036		
time of background minutes			4320							
Nuclides	Total	Bkgd(1)	Blank(2)	Eblank	Net counts	c. eff.	intensity	Activity		
	Counts		(cpm)	cpm		(%)	(%)	(dpm/g)		
Pb-210	45 kev									
210	8360	7795	0.2666	0.00976	288.8024	1.58	4.1	270.89	±	69.87
Th-234										
62	11090	10373	0.3939	0.01249	308.9196	6.3725	5.7	51.88	±	12.10
(93Kev)										
93	6277	4972	0.8309	0.01996	444.1876	8.835	6.8	45.38	±	6.14
Ra-226										
295	43560	3721	0.0927	0.00564	39742.963	5.4325	18	2697.80	±	0.43
352	68620	3308	0.1756	0.0029	65130.078	4.63	35	2625.88	±	0.20
609	43627	1666	0.223	0.0026	41729.972	2.51	43	2566.42	±	0.38
183.7	21962	7789	0.5414	0.0139	13612.11	17.7825	3.3	1489.64	±	1.19
Th-228	583 kev									
228	1532	1673	0.1591	0.00914	-305.8276	0.905	86	-25.97	±	-6.15
Ra-228										
338	3557	3182	0.0582	0.00591	314.7048	4.7325	12	36.36	±	8.24
911	1565	1066	0.1737	0.00936	319.0468	1.8025	29	41.92	±	9.31
964	2341	1818	0.3092	0.00844	202.6688	1.69	21.8	38.12	±	16.72
Ra-226 weighted average =			2625.30	±	0.16	U (ppm)=		3514	±	0.21
Ra-228 weighted average =			38.72	±	5.79	Th (ppm) =		143.3	±	21.4
210PB=			270.89	±	69.87	U (ppm)=		362.6	±	93.5
234Th av 63 &92 =			46.73	±	5.48					
Th228 =			-25.97	±	-6.15	Th (ppm) =		-96.1	±	-23
Calculation of weighted average (up to 200 data sets can be input)										
	weighted average=		46.731		average=	45.4				
	weighted error=		5.4754		std.=	####				
data	±	err	error^2	1/error^2	data/error^2					
51.90	±	12.10	146.41	0.00683	0.35448					
45.40	±	6.14	37.6996	0.026525	1.20426					
	±		0	0	0					
	±		0	0	0					

9/10/93
BWL

FR-B-1

10-93 09:12 FROM: CNWRA BLDG. 57 ID: 5125225184 PAGE 2

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MCA #1 - Canberra S100 - FRB1.MCA - FR-B-1 1.0cm

Tag Number: 64 Readout: Thu 09 Sep 1993 @ 15:25:25
Report Group: 2/4 Acquire Started: Thu 09 Sep 1993 @ 15:24:51
Group Size: 4096

Elapsed Live Time: 400.00 min.
Elapsed True Time: 400.12 min.
Dead Time: 0.03 %

MCA Mode: PHA+
Preset Conditions: Live Time = 400.00 min.

Calibration: 0.0000*Ch^2 + 0.4996*Ch + 1.083 keV

Area Statistics: Background Channels = 4
% Error Sigma = 1.65

Peak Statistics: Sensitivity Factor = 4.0
Expected FWHM (ch) = 2.7 - 6.0

Iso. Id. Criteria: Energy Window = +-1.300 keV
Iso. Library: C:\WINDOWS\S100\SPECTRAN.ISO

$^{238}U(Th\text{-}234) = \cancel{4200.2 \pm 0.3}$ 860.8 ± 3.2

$^{226}Ra(Rn\text{-}dau) = 4200.2 \pm 0.3$

$^{210}Pb = 1367.8 \pm 78.8$

$^{228}Ra = 34.42 \pm 14.73$

$^{228}Th = 33.23 \pm 14.28$

$^{226}Ra/^{228}Ra = 122.03 \pm 52.22$

$\frac{^{210}Pb}{^{234}Th} = 1.59 \pm 0.09$

BWL
9/10/93
unwashed

$\cancel{\frac{^{228}Th}{^{228}Ra} = 1}$

MASS : .731 g

FR-B-1 :
(leaves + stem from one single branch)

mass sample + crucible before ashing	mass sample + crucible after ashing
38.906 g	34.302 g
5.252 g sample	0.648 g ash

$\frac{^{228}Th}{^{228}Ra} = 0.97 \pm 0.59 \approx 1$

wt. crucible : 33.654 g

CF = 0.1234

% CHANGE : 87.66

9/10/93
BWL

FR-B-1

Sample #	FR-B-1									
Weight(g)	0.731	Geometry	1.0 cm			Counting Time(min)		400		
time of background minutes			4320							
Nuclides	Total	Bkgd(1)	Blank(2)	Eblank	Net counts	c. eff.	intensity	Activity		
	Counts		(cpm)	cpm		(%)	(%)	(dpm/g)		
Pb-210	45 kev									
210	3312	2910	0.2666	0.00976	295.36	1.58	4.1	1367.82	±	78.79
Th-234										
62	4971	3781	0.3939	0.01249	1032.44	6.3725	5.7	856.46	±	7.55
(93Kev)										
93	4151	2102	0.8309	0.01996	1716.64	8.835	6.8	861.73	±	3.54
Ra-226										
295	14152	1251	0.0927	0.00564	12863.92	5.4325	18	4170.06	±	0.84
352	22606	1143	0.1756	0.0029	21392.76	4.63	35	4188.14	±	0.39
609	14421	577	0.223	0.0026	13754.8	2.51	43	4273.02	±	0.77
183.7	4695	2958	0.5414	0.0139	1520.44	17.7825	3.3	791.17	±	3.90
Th-228	583 kev									
228	562	421	0.1591	0.00914	77.36	0.905	86	33.23	±	14.28
Ra-228										
338	1195	1114	0.0582	0.00591	57.72	4.7325	12	32.33	±	21.56
911	497	363	0.1737	0.00936	64.52	1.8025	29	39.09	±	22.05
964	762	613	0.3092	0.00844	25.32	1.69	21.8	21.76	±	49.95
Ra-226 weighted average =			4200.20	±	0.32	U (ppm)=		5622	±	0.43
Ra-228 weighted average =			34.42	±	14.73	Th (ppm) =		127.4	±	54.5
210PB/ =			1367.82	±	78.79	U (ppm)=		1831	±	105
234Th av 63 7& 92			860.76	±	3.21					
Th228 =			33.23	±	14.28	Th (ppm) =		123	±	52.8
Calculation of weighted average (up to 200 data sets can be input)										
	weighted average=		4200.18		average=	4231				
	weighted error=		0.32144		std.=	60.1				
data	±	err	error^2	1/error^2	data/error^2					
#####	±	0.84	0.7056	1.417234	5909.86					
#####	±	0.39	0.1521	6.574622	27534.5					
#####	±	0.77	0.5929	1.686625	7206.95					
	±		0	0	0					

9/13/93
BWL

FR-B-2

MCA #1 - Canberra S100 - FRB2.MCA - FR-B-2 2.5cm

Tag Number: 54
Report Group: 2/4
Group Size: 4096

Readout: Sat 11 Sep 1993 @ 09:25:36
Acquire Started: Sat 11 Sep 1993 @ 09:24:07

Elapsed Live Time: 1140.00 min.
Elapsed True Time: 1140.34 min.
Dead Time: 0.03 %

MCA Mode: PHA+
Preset Conditions: Live Time = 1140.00 min.

Calibration: 0.0000*Ch^2 + 0.4996*Ch + 1.083 keV

Area Statistics: Background Channels = 4
% Error Sigma = 1.65

Peak Statistics: Sensitivity Factor = 4.0
Expected FWHM (ch) = 2.7 - 6.0

Iso. Id. Criteria: Energy Window = +-1.300 keV
Iso. Library: C:\WINDOWS\S100\SPECTRAN.ISO

BWL 9/13/93

$^{238}U = 263.82 \pm 2.25$

MASS: 1.232 g

$^{226}Ra = 2294.90 \pm 0.52$

$^{210}Pb = 228.34 \pm 72.26$

GAMMA VIAL MADE: 8/24/93

$^{228}Ra = 38.32 \pm 6.05$

$^{228}Th = -22.25 \pm -6.55$

Sample description: leaves + stem from 1 large cluster of branches.

$$\frac{^{226}Ra}{^{228}Ra} = 59.89 \pm 9.45$$

$$\frac{^{210}Pb}{^{234}Th} = 0.87 \pm 0.27$$

9/13/93
BWL

FR-B-2

Sample #	FR_B-2									
Weight(g)	1.232	Geometry	2.5 cm			Counting Time(min)		1140		
time of background minutes			4320							
Nuclides	Total	Bkgd(1)	Blank(2)	Eblank	Net counts	c. eff.	intensity	Activity		
	Counts		(cpm)	cpm		(%)	(%)	(dpm/g)		
Pb-210	45 kev									
210	8611	8037	0.2666	0.00976	270.076	1.58	4.1	228.34	±	72.26
Th-234										
62	12685	10418	0.3939	0.01249	1817.954	6.3725	5.7	278.40	±	5.04
(93Kev)										
93	9280	5566	0.8309	0.01996	2766.774	8.835	6.8	260.24	±	2.51
Ra-226										
295	41815	3700	0.0927	0.00564	38009.322	5.4325	18	2339.47	±	0.44
352	65425	3231	0.1756	0.0029	61993.816	4.63	35	2287.03	±	0.21
609	41956	1566	0.223	0.0026	40135.78	2.51	43	2286.47	±	0.40
183.7	22117	8126	0.5414	0.0139	13373.804	17.7825	3.3	1346.62	±	1.22
Th-228	583 kev									
228	1580	1682	0.1591	0.00914	-283.374	0.905	86	-22.25	±	-6.55
Ra-228										
338	3609	3128	0.0582	0.00591	414.652	4.7325	12	43.87	±	7.30
911	1394	968	0.1737	0.00936	227.982	1.8025	29	27.00	±	11.02
964	2115	1745	0.3092	0.00844	17.512	1.69	21.8	2.97	±	56.90
Ra-226 weighted average =			2294.90	±	0.52	U (ppm)=		3072	±	0.70
Ra-228 weighted average =			38.32	±	6.05	Th (ppm) =		141.8	±	22.4
210PBav =			228.34	±	72.26	U (ppm)=		305.7	±	96.7
234Th	63 & 92kev		263.82	±	2.25					
Th228 =			-22.25	±	-6.55	Th (ppm) =		-82.3	±	-24
Calculation of weighted average (up to 200 data sets can be input)										
	weighted average=		38.3205		average=	14.99				
	weighted error=		6.05132		std.=	16.99				
data	±	err	error^2	1/error^2	data/error^2					
43.87	±	7.30	53.29	0.018765	0.82323					
27.00	±	11.02	121.44	0.008234	0.22233					
2.97	±	56.90	3237.61	0.000309	0.00092					
	±		0	0	0					

9/13/93
BWL

FR-B-3

09:38 FROM: CNWRA BLDG. 57 ID: 5125225184 P

Page 1

MCA #1 - Canberra S100 - FRB3.MCA - FR-B-3 1.5cm

```
Tag Number:     56        Readout:          Sat 11 Sep 1993 @ 15:35:39
Report Group:   1/4       Acquire Started:  Sat 11 Sep 1993 @ 15:34:40
Group Size:     4096

Elapsed Live Time:    366.00 min.
Elapsed True Time:    366.08 min.
Dead Time:              0.02 %

MCA Mode:             PHA+
Preset Conditions:    Live Time = 6000.00 min.

Calibration:          0.0000*Ch^2 + 0.4996*Ch + 1.083 keV

Area Statistics:      Background Channels = 4
                      % Error Sigma = 1.65

Peak Statistics:      Sensitivity Factor = 4.0
                      Expected FWHM (ch) = 2.7 - 6.0

Iso. Id. Criteria:    Energy Window = +-1.300 keV
Iso. Library:         C:\WINDOWS\S100\SPECTRAN.ISO
```

BWL 9/13/93

MASS : .922 g

MADE ON : 8/24/93

^{238}U = 159.22 ± 6.54
^{226}Ra = 2114.90 ± 0.39
^{210}Pb = 401.89 ± 125.29
^{228}Ra = 40.63 ± 12.8
^{228}Th = 21.68 ± 24.65

sample description : MOSTLY leaves from 1 main branch

$\frac{^{226}Ra}{^{228}Ra}$ = 52.05 ± 16.40

$\frac{^{210}Pb}{^{234}Th}$ = 2.52 ± 0.79

9/13/93
BWL

FR-B-3

Sample #	FR-B-3									
Weight(g)	0.922	Geometry	1.5 cm			Counting Time(min)		366		
time of background minutes			4320							
Nuclides	Total	Bkgd(1)	Blank(2)	Eblank	Net counts	c. eff.	intensity	Activity		
	Counts		(cpm)	cpm		(%)	(%)	(dpm/g)		
Pb-210	45 kev									
210	1954	1751	0.2666	0.00976	105.4244	1.58	4.1	401.89	±	125.29
Th-234										
62	2675	2244	0.3939	0.01249	286.8326	6.3725	5.7	196.65	±	13.66
(93Kev)										
93	1930	1270	0.8309	0.01996	355.8906	8.835	6.8	148.14	±	7.45
Ra-226										
295	8687	878	0.0927	0.00564	7775.0718	5.4325	18	2087.02	±	1.03
352	13852	766	0.1756	0.0029	13021.73	4.63	35	2105.45	±	0.48
609	9176	370	0.223	0.0026	8724.382	2.51	43	2171.73	±	0.90
183.7	4812	1803	0.5414	0.0139	2810.8476	17.7825	3.3	1256.15	±	2.84
Th-228	583 kev									
228	409	399	0.1591	0.00914	-48.2306	0.905	86	-16.54	±	-16.67
Ra-228										
338	858	733	0.0582	0.00591	103.6988	4.7325	12	47.89	±	15.30
911	356	247	0.1737	0.00936	45.4258	1.8025	29	24.29	±	26.78
964	593	451	0.3092	0.00844	28.8328	1.69	21.8	21.88	±	47.69
Ra-226 weighted average =			2114.90	±	0.39	U (ppm)=		2831	±	0.52
Ra-228 weighted average =			40.63	±	12.8	Th (ppm) =		150.3	±	47.4
210PB =			401.89	±	125.29	U (ppm)=		538	±	168
234Th	63 & 92 kev av		159.22	±	6.54					
Th228 =			21.68	±	24.65	Th (ppm) =		80.22	±	91.2
Calculation of weighted average (up to 200 data sets can be input)										
	weighted average=		2114.9		average=	2138				
	weighted error=		0.39171		std.=	46.67				
data	±	err	error^2	1/error^2	data/error^2					
#####	±	1.03	1.0609	0.942596	1967.2					
#####	±	0.48	0.2304	4.340278	9136.28					
#####	±	0.90	0.81	1.234568	2680.25					
	±		0	0	0					

9/13/93
BWL

FR-B-4

3 09:40 FROM: CNWRA BLDG. 57 ID: 5125225184 PA

Page 1

MCA #1 - Canberra S100 - (Untitled) - FR-B-4 2.0cm

Tag Number: 57
Report Group: 2/4
Group Size: 4096

Readout: Mon 13 Sep 1993 @ 08:46:30
Acquire Started: Sat 11 Sep 1993 @ 15:37:59

Elapsed Live Time: 1500.00 min.
Elapsed True Time: 1500.51 min.
Dead Time: 0.03 %

MCA Mode: PHA+
Preset Conditions: Live Time = 1500.00 min.

Calibration: 0.0000*Ch^2 + 0.4996*Ch + 1.083 keV

Area Statistics: Background Channels = 4
% Error Sigma = 1.65

Peak Statistics: Sensitivity Factor = 4.0
Expected FWHM (ch) = 2.7 - 6.0

Iso. Id. Criteria: Energy Window = +-1.300 keV
Iso. Library: C:\WINDOWS\S100\SPECTRAN.ISO

BWL 9/13/93

MASS : 1.204 g

MADE ON : 8/24/93

$^{238}U = 43.78 \pm 5.08$

$^{226}Ra = 2837.30 \pm 0.14$

$^{210}Pb = 177.91 \pm 77.49$

$^{228}Ra = 44.09 \pm 4.69$

$^{228}Th = -25.66 \pm -5.45$

sample description : stems only

$$\frac{^{226}Ra}{^{228}Ra} = 64.35 \pm 6.84$$

$$\frac{^{210}Pb}{^{234}Th} = 4.06 \pm 1.83$$

9/13/93
BWL

FR-B-4

Sample #	FR-B-4									
Weight(g)	1.204	Geometry	2.0 cm			Counting Time(min)		1500		
time of background minutes			4320							
Nuclides	Total Counts	Bkgd(1)	Blank(2) (cpm)	Eblank cpm	Net counts	c. eff. (%)	intensity (%)	Activity (dpm/g)		
Pb-210	45 kev									
210	12066	11408	0.2666	0.00976	258.1	1.58	4.1	177.91	±	77.49
Th-234										
62	16205	15372	0.3939	0.01249	242.15	6.3725	5.7	29.82	±	14.29
(93Kev)										
93	9203	7342	0.8309	0.01996	614.65	8.835	6.8	45.80	±	5.43
Ra-226										
295	65236	5454	0.0927	0.00564	59642.95	5.4325	18	2911.46	±	0.36
352	102274	5041	0.1756	0.0029	96969.6	4.63	35	2819.88	±	0.17
609	66395	2384	0.223	0.0026	63676.5	2.51	43	2840.67	±	0.32
183.7	31207	11759	0.5414	0.0139	18635.9	17.7825	3.3	1477.67	±	1.05
Th-228	583 kev									
228	2361	2539	0.1591	0.00914	-416.65	0.905	86	-25.66	±	-5.45
Ra-228										
338	5361	4685	0.0582	0.00591	588.7	4.7325	12	49.06	±	6.20
911	2208	1554	0.1737	0.00936	393.45	1.8025	29	36.40	±	8.42
964	3428	2659	0.3092	0.00844	305.2	1.69	21.8	40.24	±	13.63
Ra-226 weighted average =			2837.30	±	0.14	U (ppm)=		3798	±	0.19
Ra-228 weighted average =			44.09	±	4.69	Th (ppm) =		163.1	±	17.4
210PB =			177.91	±	77.49	U (ppm)=		238.2	±	104
234Th av 63&92 kev =			43.78	±	5.08					
Th228 =			-25.66	±	-5.45	Th (ppm) =		-94.9	±	-20
Calculation of weighted average (up to 200 data sets can be input)										
	weighted average=		2837.35		average=	2830				
	weighted error=		0.13856		std.=	14.7				
data	±	err	error^2	1/error^2	data/error^2					
#####	±	0.36	0.1296	7.716049	22465					
#####	±	0.17	0.0289	34.60208	97573.7					
#####	±	0.32	0.1024	9.765625	27740.9					
	±		0	0	0					

9/13/93
BWL

The gamma spectrometry results for each of the eight samples, with a copy of the M.S Excel workbsheet used to calculate the activity of each of the isotopes, were placed into the book today starting on page 52. The gamma calculations are final results, corrected for blank, sample mass, counting geometry/efficiency.

The results have been calculated in dpm / gram ash, where dpm = decay per minute. These values are quite high!

To compare them to the ore requires some estimate of the radioactivity of the ore. There are two ways to estimate the average U content. First the early Mexican workers provided some average U content #s. Also I can average all the measured E-W traverse samples within the orebody.

For those samples within orebody the average U = 1980 ppm U this 83% of the number give by Ajuria of .283 wt% average grade

9/13/93
BWL

This translate to .24% U or 2400 ppm U.

since 1 ppm U = 0.747 $\frac{dpm}{g}$ $\Rightarrow$ 1793 $\frac{dpm}{g}$

1793 ÷ 60 $\frac{dps}{dpm}$ $\Rightarrow$ 30 Bq/g

average ^{232}Th from E-W = 0.14 Bq/g

The worksheet below converts dpm/gram-ash to Bq/gram dried plant

dpm/gram ash to Bq/gram dried

Sample	238	226	210	228ra	228th	CF
FR-A-1	149.43	2233.100	162.76	37.39	-9.4	0.2301
	3.98	0.200	117.86	7.65	-13.19	
	0.57	**8.564**	**0.62**	**0.14**	**-0.04**	
	0.02	**0.001**	**0.45**	**0.03**	**-0.05**	
FR-A-2	61.19	2631.100	465.31	39.01	-11.33	0.1486
	4.19	0.140	46.93	5.1	-8.09	
	0.15	**6.5164**	**1.15**	**0.10**	**-0.03**	
	0.01	**0.0003**	**0.12**	**0.01**	**-0.02**	
FR-A-3	89.73	2182.200	190.39	41.57	-14.9	0.3398
	5.2	0.140	109.84	7.53	-10.56	
	0.51	**12.359**	**1.08**	**0.24**	**-0.08**	
	0.03	**0.001**	**0.62**	**0.04**	**-0.06**	
FR-A-4	46.73	2625.300	270.89	38.72	-25.97	0.2679
	5.48	0.160	69.87	5.79	-6.15	
	0.21	**11.722**	**1.21**	**0.17**	**-0.12**	
	0.02	**0.001**	**0.31**	**0.03**	**-0.03**	
FR-B-1	860.8	4200.200	1367.8	34.42	33.23	0.1234
	3.2	0.300	78.8	14.73	14.28	
	1.77	**8.638**	**2.81**	**0.07**	**0.07**	
	0.01	**0.001**	**0.16**	**0.03**	**0.03**	
FR-B-2	263.82	2294.900	228.34	38.32	-22.25	0.111
	2.25	0.520	72.26	6.05	-6.55	
	0.488	**4.246**	**0.42**	**0.07**	**-0.04**	
	0.004	**0.001**	**0.13**	**0.01**	**-0.01**	
FR-B-3	159.22	2114.900	401.89	40.63	21.68	0.1173
	6.54	0.390	125.29	12.8	24.65	
	0.31	**4.135**	**0.79**	**0.08**	**0.04**	
	0.01	**0.001**	**0.24**	**0.03**	**0.05**	
FR-B-4	43.78	2837.300	177.91	44.09	-25.66	0.1215
	5.08	0.140	77.49	4.69	-5.45	
	0.09	**5.7455**	**0.36**	**0.09**	**-0.05**	
	0.01	**0.0003**	**0.16**	**0.01**	**-0.01**	

9/13/93
BWL

Using the correction values on pg 48 & 49 and the conversion 60 Bq = 1 dpm The formulas used in worksheet on previous page are given below.

dpm/gram ash to Bq/gram dried

Sample	238	226	210	228ra	228th	CF
FR-A-1	149.43	2233.1	162.76	37.39	-9.4	0.2301
	3.98	0.2	117.86	7.65	-13.19	
	=(B2*0.2301)/60	=(C2*0.2301)/60	=(D2*0.2301)/60	=(E2*0.2301)/60	=(F2*0.2301)/60	
	=(B3*0.2301)/60	=(C3*0.2301)/60	=(D3*0.2301)/60	=(E3*0.2301)/60	=(F3*0.2301)/60	
FR-A-2	61.19	2631.1	465.31	39.01	-11.33	0.1486
	4.19	0.14	46.93	5.1	-8.09	
	=(B6*0.1486)/60	=(C6*0.1486)/60	=(D6*0.1486)/60	=(E6*0.1486)/60	=(F6*0.1486)/60	
	=(B7*0.1486)/60	=(C7*0.1486)/60	=(D7*0.1486)/60	=(E7*0.1486)/60	=(F7*0.1486)/60	
FR-A-3	89.73	2182.2	190.39	41.57	-14.9	0.3398
	5.2	0.14	109.84	7.53	-10.56	
	=(B10*0.3398)/60	=(C10*0.3398)/60	=(D10*0.3398)/60	=(E10*0.3398)/60	=(F10*0.3398)/60	
	=(B11*0.3398)/60	=(C11*0.3398)/60	=(D11*0.3398)/60	=(E11*0.3398)/60	=(F11*0.3398)/60	
FR-A-4	46.73	2625.3	270.89	38.72	-25.97	0.2679
	5.48	0.16	69.87	5.79	-6.15	
	=(B14*0.2679)/60	=(C14*0.2679)/60	=(D14*0.2679)/60	=(E14*0.2679)/60	=(F14*0.2679)/60	
	=(B15*0.2679)/60	=(C15*0.2679)/60	=(D15*0.2679)/60	=(E15*0.2679)/60	=(F15*0.2679)/60	
FR-B-1	860.8	4200.2	1367.8	34.42	33.23	0.1234
	3.2	0.3	78.8	14.73	14.28	
	=(B18*0.1234)/60	=(C18*0.1234)/60	=(D18*0.1234)/60	=(E18*0.1234)/60	=(F18*0.1234)/60	
	=(B19*0.1234)/60	=(C19*0.1234)/60	=(D19*0.1234)/60	=(E19*0.1234)/60	=(F19*0.1234)/60	
FR-B-2	263.82	2294.9	228.34	38.32	-22.25	0.111
	2.25	0.52	72.26	6.05	-6.55	
	=(B22*0.111)/60	=(C22*0.111)/60	=(D22*0.111)/60	=(E22*0.111)/60	=(F22*0.111)/60	
	=(B23*0.111)/60	=(C23*0.111)/60	=(D23*0.111)/60	=(E23*0.111)/60	=(F23*0.111)/60	
FR-B-3	159.22	2114.9	401.89	40.63	21.68	0.1173
	6.54	0.39	125.29	12.8	24.65	
	=(B26*0.1173)/60	=(C26*0.1173)/60	=(D26*0.1173)/60	=(E26*0.1173)/60	=(F26*0.1173)/60	
	=(B27*0.1173)/60	=(C27*0.1173)/60	=(D27*0.1173)/60	=(E27*0.1173)/60	=(F27*0.1173)/60	
FR-B-4	43.78	2837.3	177.91	44.09	-25.66	0.1215
	5.08	0.14	77.49	4.69	-5.45	
	=(B30*0.1215)/60	=(C30*0.1215)/60	=(D30*0.1215)/60	=(E30*0.1215)/60	=(F30*0.1215)/60	
	=(B31*0.1215)/60	=(C31*0.1215)/60	=(D31*0.1215)/60	=(E31*0.1215)/60	=(F31*0.1215)/60	

9/13/93
BWL

A test of the truth of the measurements the rocks are expected to have a secular equilibrium condition. $^{234}Th = {}^{226}Ra = {}^{210}Pb$. Thus if signal we measured is just contamination then equal activities would have been measured.

238U	226Ra	210Pb	228Ra	228Th	ra/u	pb/u	pb/ra
0.57	8.564	0.62	0.14(3)	-0.04(5)	15.025	1.0877	0.0724
0.15	6.5164	1.15	0.10(1)	-0.03(2)	43.443	7.6667	0.1765
0.51	12.359	1.08	0.24(4)	-0.08(6)	24.233	2.1176	0.0874
0.21	11.722	1.21	0.17(3)	-0.12(3)	55.819	5.7619	0.1032
0.36	9.79	1.02	0.16(6)	-0.07(4)	27.194	2.8333	0.1042
1.77	8.638	2.81	0.07(3)	0.07(3)	4.8802	1.5876	0.3253
0.488	4.246	0.42	0.07(1)	-0.04(1)	8.7008	0.8607	0.0989
0.31	4.135	0.79	0.08(3)	0.04(5)	13.339	2.5484	0.1911
0.09	5.7455	0.36	0.09(1)	-0.05(1)	63.839	4	0.0627
0.66	5.69	1.1	0.078(10)	0.005(59)	8.6212	1.6667	0.1933

		unwashed
$^{226}Ra/^{234}Th$ ratios for washed	$\simeq 27$	$\simeq 9$
$^{210}Pb/^{234}Th$	$\simeq 3$	1.7
$^{210}Pb/^{226}Ra$	$\simeq .1$	$\simeq .2$

9/13/93
BWL

These values indicate that the radioactivity we measured is really reflective of radioactivity contained with in the plant and is not surface contamination

These are extremely high radioactive plants. To obtain a more comfortable feeling about these numbers I will try to contact Dr Simon or Dr Ibrahim at Colorado State University. These professors have written a comprehensive chapter on radium in plants

Dr Simon is in Marshall Islands

Dr Shawki Ibrahim
(303) 491-1593 called & left message

9/14/93
BWL

Final Plant Radium, Pb, Th
Based on Preliminary γ Analyses

Table 1. Activity of radionuclides (Bq/g of dried plant) in samples of *Phacelia robusta* collected on ore dump piles. The analytical uncertainties in the last digit (± 1 σ from counting statistics) are shown in parentheses. The average and standard deviation (in parentheses) of the radionuclide content for the washed and unwashed plant samples are given.

Sample	^{238}U decay chain isotopes			^{232}Th decay chain isotopes	
	^{238}U	^{226}Ra	^{210}Pb	^{228}Ra	^{228}Th
Washed					
FR-A-1	0.57(2)	8.564(1)	0.62(45)	0.14(3)	-0.04(5)
FR-A-2	0.15(1)	6.5164(3)	1.15(12)	0.10(1)	-0.03(2)
FR-A-3	0.51(3)	12.359(1)	1.08(62)	0.24(4)	-0.08(6)
FR-A-4	0.21(2)	11.722(1)	1.21(31)	0.17(3)	-0.12(3)
Average	0.36(21)	9.79(274)	1.02(27)	0.16(6)	-0.07(4)
Unwashed					
FR-B-1	1.77(1)	8.638(1)	2.81(16)	0.07(3)	0.07(3)
FR-B-2	0.488(4)	4.246(1)	0.42(13)	0.07(1)	-0.04(1)
FR-B-3	0.31(1)	4.135(1)	0.79(24)	0.08(3)	0.04(5)
FR-B-4	0.09(1)	5.7455(3)	0.36(16)	0.09(1)	-0.05(1)
Average	0.66(75)	5.69(210)	1.10(116)	0.078(10)	0.005(59)

9/14/93
BWL

Phone call to Dr Ibrahim
1) uptake via root system Ra
2) radium is quite mobile

My numbers are believable, he would be happy to review any manuscript we would put together.

We might do water leaching study to determine Ra mobility

Significant Rn in plants
dissolved in plant fluids

Branjelmett example of high #Ra

ours are extremely high relative to #s they report only
australia / New Zealand study of Dickinson(?) reported higher #s for higher order plants

9/14/93
BWL

Calculation of CR

Concentration ratio of dry plant/soil

since substrate is 30 Bq/g ^{238}U & daughter
0.14 Bq/g ^{232}Th & daughter

CR	^{226}Ra	^{228}Ra
	$\frac{9.8}{30}$	$\frac{.16}{.14}$
	$\simeq 0.3$	$\simeq 1$

9/14/93
BWL

It was decided that one washed sample ash would be totally dissolved and counted for U & Th isotopes.
The sample would be split into 3 portions: 1 spiked with $^{232}U/^{228}Th$ spike; one unspiked and plated for U & Th isotopes; and one to be kept for possible cation analysis.

Omar called and stated that the ash readely dissolved in aqua regia. The solution was evaporated then diluted with H_2O.

The Sample was FR-A-2

The total solution mass ≃ 95.97 grams

Subsample #3 for chem = 47.94 grams

Subsample #2 (unspiked) = 26.11 grams

Subsample #1 (spiked) = 23.86 grams

these are ~~pepo~~ 9/14/93 BWL relative to a total mass of ash 1.813 grams

Subsample #1 = 0.4418 grams ash
#2 = 0.4835 " "
#3 = 0.8877 " "

Tomorrow is last day for Omar

9/27/93
BWL

It has become clear that during the last week of Omar's stay he did not adequately record the necessary information to calculate radioactivity of U & Th plates of FR-A-2.
The U & Th were plated for both spiked & unspiked subsamples.
A Po spike may been used by the actual data show no affect of a ^{208}Po spike. There was only one large peak.

The following calculations are derived from the alpha spec files counted during the period of ≃ 9/15 → 9/30/93. See log book for name of samples and file name.

This experiment was pretty unsuccessful since recoveries were poor, spike mass used was not recorded.

10/30/93
BWL

Alpha spectrometry analysis of FR-A-2
spiked sample

Phacelia-2 spike

MEASUREMENT OF ACTIVITIES OF U & Th ISOTOPES

sample # **FRA-2**
Analyst **B W L**

Sep. date 9/27/93

sample weight(g)	spike weight(g)	U-232 (dpm/g)	Ref. date of spike	Days btwn ref. & sep.	U-232* (dpm/g)
0.4413	0.05	45.459	1/22/93	248	*45.149394*

Th228/U232 *0.2998*

Counting time for Th = 18382.35 (min.)
Days btwn. sep. & count. = 1 (days)
CF for Th-228 = *.9927*

Counting time for U = 18381.55 (min.)
Days btwn. sep. & count. = 2 (days)
CF for U-232 = *1.0080*

	Th-232	Th-230	Th-228	Ra-224
counts	15	330	100	24
bkgd	0.00054	0.00027	0.0001	0.00027

bkgd time 1 (min.)

Th-232* counts	Th-230* counts	Th-228sp counts	Ra-224* counts
5.073531	*325.036766*	*92.793113*	*19.0368*

	U-238	U-234	U-232
counts	1222	1454	43
bkgd	0.000536	0.0001	0.0001

bkgd time 1 (min.)

U-238* counts	U-234* counts	U-232sp counts
1212.1475	*1452.16*	*40.833*

		±
U-238(dpm/g) =	1.52E+02	2.36E+01
U-234(dpm/g) =	1.82E+02	2.82E+01
Th-232(dpm/g) =	8.38E-02	2.32E-02
Th-230(dpm/g) =	5.37E+00	6.13E-01
U-234/U-238 =	1.1980	0.0465
Th-230/U-234 =	0.0295	0.0018
Th-230/Th-232 =	64.0652	16.9133
U-234/Th-232 =	2169.9358	688.2845

Decay constant (m-1)	U-238	Th-232
	2.94965E-16	9.4178E-17

U (ppm) = 203.458 ± 31.568

Th (ppm) = 0.343

See p86 for hand calculation of above datasheet.

10/30/93
BWL

FR-A-2 unspiked
U & Th isotopic analysis

Phacelia-2 unspike

MEASUREMENT OF ACTIVITIES OF U & Th ISOTOPES

sample # **FRA-2**
Analyst **B W L**

Sep. date 9/27/93

sample weight(g)	spike weight(g)	U-232 (dpm/g)	Ref. date of spike	Days btwn ref. & sep.	U-232* (dpm/g)
0.4413	1	45.459	1/22/93	248	*45.149394*

Th228/U232 *0.2998*

Counting time for Th = 18370 (min.)
Days btwn. sep. & count. = 1 (days)
CF for Th-228 = *.9927*

Counting time for U = 18381.55 (min.)
Days btwn. sep. & count. = 2 (days)
CF for U-232 = *1.0080*

	Th-232	Th-230	Th-228	Ra-224
counts	25	8033	448	866
bkgd	0.000865	0.000865	0.0001	0.00027

bkgd time 1 (min.)

Th-232* counts	Th-230* counts	Th-228 counts	Ra-224* counts
9.10995	*8017.10995*	*403.46903*	*861.04*

	U-238	U-234	U-232
counts	1222	1454	43
bkgd	0.000536	0.0001	0.0001

bkgd time 1 (min.)

U-238* counts	U-234* counts	U-232sp counts
1212.1475	*1452.16*	*40.833*

		±
U-238(dpm/g) =	3.04E+03	4.71E+02
U-234(dpm/g) =	3.64E+03	5.63E+02
Th-232(dpm/g) =	6.92E-01	1.42E-01
Th-230(dpm/g) =	6.09E+02	2.96E+01
U-234/U-238 =	1.1980	0.0465
Th-230/U-234 =	0.1675	0.0048
Th-230/Th-232 =	880.0389	176.2814
U-234/Th-232 =	5254.5518	1351.7146

Decay constant (m-1)	U-238	Th-232
	2.94965E-16	9.4178E-17

U (ppm) = 4069.169 ± 631.366

Th (ppm) = 2.833

		±
Th-230/Th-232 =	880.0389	291.7363
Th-228/Th-232 =	44.29	9.10
Th-230/Th-228 =	19.87	0.96

11/3/93
BWL

So What does these analyses mean?

First since I don't have a feeling for how much spike Omar Used I assumed a minimal amount (1 drop ≈ 0.05 grams) I don't know which spike he used.

alpha spec files for spiked sample ≡
FRa2thsp.chn, (FRA2usp.chn
(Th) (U)

	Channel #16				Channel #15		
Region of Interest (channels)	^{232}Th	^{230}Th	^{228}Th	^{224}Ra	^{238}U	^{234}U	^{232}U
	17-89	224-367	445-515	555-627	11-151	266-415	573-626
cts Background	2	1	0	1	2	0	0
Bkg time	3730 minutes				3729.68 minutes		
Bkg cpm	.00054	.00027	.0001	.00027	.000536	.0001	.0001

I have assumed he used spike #25C. This will minimize the calculated concentrations. (By minimizing mass of spike also causes minimization of the calculated concentration)

11/3/93
BWL

For example using data as presented on page 78 and assuming different mass of spiked used you obtain the following concentrations

Mass Spike #25C	U (ppm)	Th (ppm)
0.05	203	0.34
0.15	610	1.02
1.0	4069	6.86

The calculated concentration of U from 0.05 grams spike #25C and the alpha spectrometry results can be compared

^{234}Th γ counting indicated ≈ 82 ppm U (pg 55).
If plant collected on 8/20/93 and counted on 9/8/93 then $\Delta t = 19$ days
since $^{234}Th\ t_{1/2} = 24.1$ days, if sample had originally 0 ^{234}Th then measured ^{234}Th by gamma would underestimate U concentration

$A = A_0 e^{-\lambda t}$ since less than 1 half life had elapsed calculated concentration might be too low by slightly > a factor of 2.

$\lambda_{234} = \frac{.693}{24.1\,d}$ $\lambda t = 0.54635$

$1 - e^{-\lambda t} = 0.4209$ ~~$1 - \lambda t = 0.45365$~~ BWL

Thus only ~~45.365~~ 42.094% of U was counted by ^{234}Th γ if low ^{234}Th uptake.

$\left(\frac{1}{.4209}\right)$ ~~$\left(\frac{1}{.45365}\right)$~~ (82 ppm) ≈ 195 ppm

11/3/93
BWL

This remarkable calculated consistency

U(ppm) via γ assuming $^{234}Th|_0 = 0$ = 195 ppm U

while α-spec using 0.05 gram spike #25C = 203 ppm U.

These are per gram ash!!

∴ Concentrations of U by alpha spectrometry is probably correct ≃ 200 ppm U.
or precisely 203 ± 32 ppm U.

However the Th concentrations derived from α-spect measurements are also suspect since each spike has a different $^{232}U/^{228}Th$ ratio, and it is this ratio which is used in concentration calculation.

The Th concentration calculated on page 78 assumed spike #25C was used by Omar.

The calculated ^{232}Th, ^{230}Th concentrations are also adversely affected since the spreadsheet calculation assumes $^{232}Th/^{228}Th = 1$ and an equal number of counts (# in ^{232}Th) is subtracted from ^{228}Th peak.

Note Th plate from spiked sample is poor & #s are really uncertain.

11/3/93
BWL

Conclusions from spiked sample

1) U ≃ 200 ppm in plant

2) CR for U $\frac{200}{2400} \simeq 0.083$ $\frac{\text{plant}}{\text{soil}}$

3) $^{234}U/^{238}U = 1.198 \pm 0.047$
This should be reflective of pore water in vadose zone.

4) $^{230}Th/^{234}U \geq 0.030 \pm 0.002$
This value is minimum since no correction of $^{232}Th/^{228}Th$ ratio $\neq 1$ since $^{228}Th \gg {}^{232}Th$ probably the calculated ^{230}Th concentrations would be too low.

5) Plant should be reanalyzed.
(better bookkeeping, plating & counting)

11/15/93
BWL

Unspiked FR-A-2

Th alpha spectrum file FRA2Th.chA for unspiked sample.

Uranium spectrum is useless since it was a poor plate with very large tail corrections & low energy ^{238}U cutoffs

	Region of Interest Ch	Cts Bkg	BKg cpm
^{232}Th	11-54	1	0.000865
^{230}Th	200-357	1	0.000865
^{228}Th	596-675	0	0.0001
^{224}Ra	704-796	0	0.0001

Δt Background 1155.7 minutes

The unspiked sample will only be used for Th isotopic information.
Note ^{228}Th was not corrected for a ratio of $^{232}Th/^{228}Th = 1 \therefore$ ^{228}Th is actual ^{228}Th only corrected for 5% peak of ^{224}Ra. see pg 79.

$$\frac{^{230}Th}{^{232}Th} = 880 \pm 292$$

$$\frac{^{228}Th}{^{232}Th} = 44.3 \pm 9.1$$

$$\frac{^{230}Th}{^{228}Th} = 19.9 \pm 1.0$$

11/15/93
BWL

Remember $^{238}U \to {}^{230}Th \cong 214\ {}^{232}Th$ on activity basis in rock since ^{238}U & daughters are $\simeq 30$ Bq/g while ^{232}Th & daughters are $\simeq 0.14$ Bq/g

on equal activity basis

$$\frac{^{230}Th}{^{228}Th} = \frac{19.9 \pm 1.0}{214} = \frac{1}{10.75}$$

so on an equal activity basis the plants take up 10.75 times as much ^{228}Th as ^{230}Th. as Ibraheim suggested & as is to be expected shorter-lived isotopes are more mobile.

$$\frac{^{228}Th}{^{232}Th} \times \frac{^{230}Th}{^{228}Th} \Rightarrow 44.3 \times \frac{1}{10.75} \Rightarrow 4.1$$

This implies that ^{230}Th is about 4.1 times more mobile as ^{232}Th

Therefore the mobility in vadose zone in ore region is as follows. and we expect $^{230}Th/^{234}U$ in rock $\simeq 1$

Since $\frac{^{230}Th}{^{234}U} = .03 \Rightarrow {}^{234}U = 33\ {}^{230}Th$

$\frac{^{234}U}{^{238}U} = \sim 1.2$ if mobility is X

This is true

$135.3\text{x}\ {}^{234}U \quad 112.75\text{x}\ {}^{238}U \quad \boxed{44\text{x}\ {}^{228}Th \quad 4.1\text{x}\ {}^{230}Th \quad \text{x}\ {}^{232}Th}$

★ Still can't compare U & Th mobility cause U & Th uptake different!
This is an extremely important conclusion!

11/7/94 JP Hand calculation of datasheet on p.78 for QA

Sample # = FRA-2

Separation date = 9/27/93

Sample wt = .4413 g

Spike (#25C, 031/170) wt = 0.05 g

^{232}U (dpm/g) = 20.477 pCi/g $*$ 2.22 = 45.459

Ref. date of spike = 1/22/93

Days between separation + reference =

9/27/93 − 1/22/93 = 248 days

^{232}U corrected for decay =
$45.459 * e^{-\ln(2)/72/365.25*248} = 45.149$ dpm/g

$^{228}Th = 45.589 * 1.0273 * (1 - e^{(-.00096545*(9/27/93-10/9/92))}) = 13.536$ dpm/g

$^{228}Th/^{232}U = 13.536/\cancel{25}.149 = .2998$

Counting time for Th = 18382.35 min

Days between sep and counting = 1

$$\text{CF for } ^{228}Th = \frac{e^{-\ln(2)/1.913/365.25*1} - e^{-\ln(2)/1.913/365.25*(1+18382.35/1440)} * 1.913*365.25/\ln(2)/18382.35*1440}{}$$

= .9927

^{232}Th counts = 15 − (.00054 $*$ 18382.35) = 5.0735
^{230}Th counts = 330 − (.00027 $*$ 18382.35) = 325.0367
^{228}Th counts = 100 − (.0001 $*$ 18382.35) = 92.793
^{224}Ra counts = 24 − (.00027 $*$ 18382.35) = 19.6368

Counting time for U = 18381.55 min
Days between sep and counting = 2

$$\text{CF for } ^{232}U = e^{-\ln(2)/72/365.25*2} - e^{-\ln(2)/72/365.25*(2+18381.55/1440)} * 2*72-1.913) - e^{-\ln(2)/1.913/365.25*2)} - e^{-\ln(2)/1.913/365.25(2+18381.55/1440)} * 1.913 * 365.25/\ln(2)*72/(72-1.913/2*1440$$

= 1.0080

^{238}U counts = 1222 − (.000536 $*$ 18381.55) = 1212.1475
^{234}U counts = 1454 − (.0001 $*$ 18381.55) = 1452.16
^{232}U counts = 43 − (.0001 $*$ 18381.55) = 40.833

$^{238}U = 1212.1475 * 45.149 * 0.05 / 40.833 / .443$
$= 1.52E+02$

$^{234}U = 1452.16 * 45.149 * 0.05 / 40.833 / .4413$
$= 1.82E+02$

$^{232}Th = 5.0735 * 45.149 * 0.05 * .2998 / 92.793 / .443$
$= 8.38E-02$

$^{230}Th = 325.0367 * 45.149 * 0.05 * .2998 / 92.793 / .4413$
$= 5.37$

$^{234}U / ^{238}U = 182 / 152 = 1.1974$

$^{230}Th / ^{234}U = 5.37 / 182 = .0295$

$^{230}Th / ^{232}Th = 5.37 / .0838 = 64.081$

$^{234}U / ^{232}Th = 182 / .0838 = 2169.936$

$U\ ppm = (238.029 * (152 / 2.94965E-16) / 6.023E+23)$
$* 1000000 = 203.458$

$Th\ ppm = (232.0381 * (.0838 / 9.4178E-17) / 6.023E+23)$
$* 1000000 = .343$

Pages 1 through 88 of this Scientific Notebook were reviewed for compliance with QAP-001 in response to Corrective Action Request 94-02. Corrections and clarifications were made as appropriate. In some cases, the date of a change will reflect the date of this review rather than the date of the original Scientific Notebook entry.

Randy Folck
SwRI - QA
11/28/94

The activities documented in this notebook were concluded due to Bret Leslie's leaving the CNWRA.

This notebook is hereby turned over to QA records.

DRP 12/20/95

(David Pickett)