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EVALUATION OF RECLAMATION AND GEOCHEMICAL DATA FOR THE HECLA JOHNNY M MINE GRANTS MINERAL BELT, NEW MEXICO

PREPARED FOR:

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ATTENTION: MS. COLLEEN D. KELLEY

JOB NO. 6 007 86

MARCH 14, 1986

ABSTRACT

Under ideal conditions, Uranium-238 will be at equilibrium with its radioactive and stable decay products. In the real world, numerous factors exist which lead to conditions of disequilibrium, wherein decay products are present at concentrations less or greater than the equilibrium value. The natural presence of such disequilibrium is widely recognized in the geochemical literature, and is utilized in environmental applications such as age dating, geohydrological definition, and geological exploration.

Evaluation of the gamma data contained in various site reports is difficult due to the absence of scale, orientation, or procedural protocol which restrict direct spatial or temporal comparisons. Variations in natural gamma counts result from factors such as height of measurement, instrument standardization, soil moisture and other conditions, as well as actual radionuclide concentration.

In our opinion, comparison of radiochemical assays for Johnny M samples indicates the presence of a systematic bias in uranium assays between the NMEID and Eberline labs. Interlab comparisons of duplicates are needed to define the "correct" result.

URANIUM DISEQUILIBRIUM

The radioactive element uranium-238 is a naturally-occurring isotope which undergoes a series of uranium decays, as shown in attached Fig. 1, to form a series of uranium decay "daughter" products, finally leading to stable, nonradioactive elements. As noted by Snelling (June 1980):

"In most geological systems, the radionuclides in this series have had time to reach radioactive equilibrium, as this takes in the U-238 series approximately ten times the half life of the longest lived daughter isotope, that is U-234, namely 2,444,000 years. However, a recent geological event may interfere by removal or addition of one or more members of the series, and thus equilibrium occurs. Isotope fractionation of the decay products in the U-238 series may occur as members of the series have different chemical and physical properties from the parent U-238."

The occurrence of uranium disequilibrium in natural environments is widely recognized. Ivanovich and Harmon (1982) authored an entire book on the applications of this disequilibrium to solution of environmental problems such as age dating or geological source definition. They note "when a sedimentary deposit is formed, various geochemical processes occur which cause isotopic and elemental fractionation initiating a state of disequilibrium between parent and daughter nuclides." Boyle (1982) presents a rather extensive discussion of the subject of radioactive disequilibrium. He summarizes the prior work as follows:

"The subject of radioactive disequilibrium is discussed at length by Rosholt (1958, 1959) and good examples of the effect of weathering of rock and formation of soils on disequilibrium processes in the Lake Athabaska region of Canada and Japan are given by Dyck (1974) and Megumi (1979). The problems of radioactive disequilibrium in exploration have been recently reviewed by Smith, et al (1976), Levinson and Brand (1979), Levinson and Coetzee (1978), Levinson, et al (1978), Szoghy and Kish

(1978), Killen (1979), Lively, et al (1979), Snelling and Dixon (1979), and Dyck and Boyle (1980)."

Thus it can be seen that uranium disequilibrium with its daughter decay products is widespread and widely recognized throughout the world, in all manner of geochemical and climatic environments.

Levinson and Coetzee (1978) discuss conditions favorable to the development of uranium decay product disequilibrium. They conclude that there are four primary means of such disequilibrium formation. These are:

"(A) If uranium-234 forms as hexavalent uranium in a tetravalent site, it will be more soluble than uranium-238 in any ground water percolating through the ore body.

(B) When thoron-230, because of its low solubility remains in place as uranium is leached away.

(C) When radium-226, an alkaline earth element, is formed, because of its distinct difference chemically, and

(D) hen radon-222 is formed. This element is a gas and, given favorable porosity in the enclosing rocks, can migrate tens of meters before it decays."

These four modes of formation of disequilibrium are discussed at length by Snel.ing (June 1980).

Di.equilibrium of uranium in its decay process is widely recognized in ground water environments. For example, many thermal springs throughout the world, including Glenwood Springs in Colorado and LaVerkin Springs in Utah, contain extremely high levels of dissolved radium, but little or no dissolved uranium.

The feasibility of developing disequilibrium is utilized in the uranium recovery industry in both the solution mining recovery by dissolution of uranium, leaving behind the decayed products, and in conventional milling operations, wherein uranium reports as a product and the decay radioisotopes remain with the tailings solids.

In view of all the foregoing, it should come as no surprise when examples of disequilibrium occurs in rocks associated with prior reclamation activities at the Hecla Johnny M. Mine. The applied reclamation cover material contains high sulfate concentrations as a result of naturally occurring sulfate minerals. Radium sulfate has a low solubility, while the sulfate and oxidizing conditions in the near surface environment will maximize the solubility of the uranium. Such solubility is further enhanced by the presence of high carbonate content which enhances the complexation of the uranium.

DATA BASE DESCRIPTION

The existing data base which Chen & Associates reviewed was of varying quality and thoroughness of presentation, and is almost totally lacking in terms of sampling or analytical protocol. There is little overlap with consistent parameters or presentation and (in some cases) no defined "benchmark" from which to duplicate the reported data. Some of the NMEID data consists solely of very rough field sketches. The following is an attempt to summarize the data base as reviewed by Chen.

April-May, 1982 - Ranchers gamma survey ("Original Survey") as reported in Ranchers Termination Report - Scale needed.

June, 1982 - Ranchers gamma survey ("second cleanup") as reported in Ranchers Termination Report - Scale needed.

August, 1982 - Ranchers gamma survey ("final cleanup") as reported in Ranchers Termination Report - Scale needed.

September 1982 - Unknown origin radon and radiochemical (assumed radium) sampling as reported in 10/12/82 memo from Brough (NMEID, radon results) and unidentified "Memorandum for file" (radiochemical results on unspecified parameter, assumed to be radium). The location of the samples is not reproducible based on the sample description.

January 26, 1983 - NMEID gamma results on rough field sketch as provided by Brough. The scale can be assumed and (assuming grid is either magnetic or true north) might be reproduced. There is no description of survey procedure, meter height, or meter standardization on this (or any other) gamma survey.

March (?), 1985 - NMEID apparently conducted at least some gamma readings, as mentioned in 4/2/85 letter from Miera to Kelley, but no locations, data plot, or protocol described. There are also radiochemical data provided for U-238, U-234, Th-230, Ra-226, and Pb-210 on eight samples (J. Millard's 8-Soil Project). All results presented are pCi/g, without specification of wet or dry weight, and with only approximate locations on the basis of a sketch map containing a verbal (not graphic) scale. The results do not include counting-error data and as such are suspect.

September 30, 1985 - Joint Hecla-NMEID soil sampling and gamma survey. As reported in 10/2/85 memo from Kelley to Kahler. Mention is made of gamma survey, but no data plot is available. Locations are shown on sketch map but sample description do not always match sketch, as in Sample #1 (Is it 200' east or 100' north of north borehole?).

EVALUATION OF DATA

From the above, it can be seen that, while there are numerous data, the data cannot be directly compared, nor the locations of some sampling sites determined. Obviously, these difficulties severely limit the comparison or interpretation of the available data.

Data within the "Termination Report" seem to show an increase in gamma readings with succeeding reclamation efforts. This is not unusual, and likely results from one or more of the following factors:

1. High uranium decay product concentrations in the soil-cover material.
2. Upward migration of soluble radionuclides due to capillary action.
3. Variations in radon flux due to variation in soil moisture content between times of surveying.

The comparison (p. 2, termination report) between arroyo soil and "adjacent soils" illustrates the expected correlation between clay content and radionuclide concentrations. Coarser grained alluvium would be expected to be lower in radionuclides.

Since there were problems in the direct comparison between gamma readings, and since experience has shown that gamma readings can be influenced by a number of external factors, not described in the sampling results, it appeared that the greatest effect could be achieved by a comparison of past chemical assay results.

By far the most complete data base on chemical results are the assay reports from Eberline, on the September, 1985 joint Hecla-NMEID sampling. No results were available on sample splits which might have been submitted to the NMEID lab although it is understood samples were submitted to the NMEID lab. Another data base was associated with the March (?), 1985 NMEID sampling, results of which are summarized in an April 2, 1985 letter by Miera to Kelley.

To allow for comparison, various ratios between isotopes and elements were calculated. This approach is consistent with suggestions by Ivanovich and Harmon, (1982) and other workers. Similar ratios were also computed for data reported by others, such as Markos and Bush (December, 1981) for data from other sites to allow for comparison. These ratios are summarized on Table I.

The September 1985 Eberline U-234 and U-238 concentrations ranged from 71.9 to 10,248 pCi/g, a range of more than two orders of magnitude, while the Ra-226 concentration ranged from .5 to 633 pCi/g, or three orders of magnitude. The Ra/U ratio was in the 10^{-2} to 10^{-3} range, which indicates general correlation between uranium and its equilibrium products in these samples. An exception is Station 9, with a Ra/U ration of .25. The percentage of U-238 and U-234 varied within rather narrow bounds, for all samples, with Station 9 again being somewhat of an exception.

Uranium concentrations reported by NMEID for the March (?), 1985 samples were generally much lower than those reported by Eberline for the September 1985 samples, ranging from 2.6 to 32.1 pCi/g. Radium concentrations, on the other hand, were similar for the two sets. As a result, the Ra/U ratio were much higher in the NMEID data set, in comparison to the Eberline data set. This comparison raises a real question over the uranium assays of one of the two labs; a question which cannot be answered without either:

(1) direct comparison between the two labs, or

(2) indirect evaluation, from other sites.

Obviously, the first approach is desired and can be utilized upon receipt of the NMEID results.

Markos and Bush (December 1981) evaluated the radiochemical concentrations of tailings and underlying soil at the Salt Lake City mill site. The radium/uranium ratios they report tend to be more similar to those reported by NMEID. While such data would lead to favor the NMEID lab results, conclusive decisions must await receipt of results from NMEID, and possible duplicate, referee analyses, on duplicate samples remaining from the joint NMEIP-Hecla sampling. It is recommended that sample remainder be submitted to a third laboratory for referee analysis.

LIMITATIONS

This report has been prepared in accordance with generally accepted geochemical principals. The conclusions and recommendations contained herein are based on the existing data base and the geochemical literature. As additional data becomes available, it may be appropriate to modify or expand the conclusions. We will be pleased to discuss these conclusions, or to provide additional evaluations, as additional data becomes available.

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JOB NO 6-007-86 JOB TITLE Hecla Johnny M Geochemistry DATE Mar. 1[illegible], 1986 BY [illegible]

SUBJECT Uranium - Radium Family (without minor branches) CHECKED ____ SHEET 1 OF ____

$$ {}_{92}U^{238} \xrightarrow[\text{4.5 x } 10^{9} \text{ yr}]{\text{Alpha}} {}_{90}Th^{234} \xrightarrow[\text{24.1 day}]{\text{Beta}} {}_{91}Pa^{234} \xrightarrow[\text{1.1 min}]{\text{Beta}} {}_{92}U^{234} \xrightarrow[\text{2.5 x } 10^{5} \text{ yr}]{\text{Alpha}} {}_{90}Th^{230} $$

$$ \xrightarrow[\text{8.0 x } 10^{4} \text{ yr}]{\text{Alpha}} {}_{88}Ra^{226} \xrightarrow[\text{1620 yr}]{\text{Alpha}} {}_{86}Rn^{222} \xrightarrow[\text{3.8 day}]{\text{Alpha}} {}_{84}Po^{218} \xrightarrow[\text{3.05 min}]{\text{Alpha}} {}_{82}Pb^{214} $$

$$ \xrightarrow[\text{26.8 min}]{\text{Beta}} {}_{83}Bi^{214} \xrightarrow[\text{19.7 min}]{\text{Beta}} {}_{84}Po^{214} \xrightarrow[\text{1.6 x } 10^{-4} \text{ sec}]{\text{Alpha}} {}_{82}Pb^{210} \xrightarrow[\text{22 yr}]{\text{Beta}} {}_{83}Bi^{210} $$

$$ \xrightarrow[\text{5.0 day}]{\text{Beta}} {}_{84}Po^{210} \xrightarrow[\text{140 days}]{\text{Alpha}} {}_{82}Pb^{206} $$

STABLE

Table I

SUMMARY OF RADIOCHEMICAL ASSAY RESULTS
from various sources, indicated below
(Concentrations in pCi/g)

Site	U-234	U-238	U-234+238	U234/U238	Ra-226	Ra-226/U234 + 238	Remarks
			NMEID Results, "J.Millard's 8-soil Project"				
#1	2.1	2.2	4.3	0.97	2.3	0.53	"Shale", background
#2	17.3	10.8	28.1	1.59	315	11.2	boundary
#3	1.9	2.4	4.3	0.81	0.9	0.21	"Shale", background
#4	4.0	5.2	9.2	0.76	4.2	0.46	Sandstone
#5	36	30	66	1.22	270	4.1	Post Reclamation
#6	1.7	1.6	3.3	1.10	1.2	0.36	"Shale", background
#7	1.1	1.5	2.6	0.72	1.0	0.38	background
#8	19.5	12.6	32.1	1.56	225	7.0	Post Reclamation
			Hecla/NMEID, September 1985, Sampling, Eberline Results				
Backgr. #1	82.9+/-15.5	95.5+/-17.1	178.4	0.87	0.96+/-0.04	5.38×10^{-3}	Top of road
Sta. #1	1394+/-65	1284+/-62	2678	1.09	107.9+/-.4	4.03×10^{-2}	100' N of borehole
Backgr. #2	102+/-20	101+/-21	203	1.01	1.46+/-0.5	7.19×10^{-3}	N borehole side, canyon
Sta. 2N	5232+/-178	5016+/-173	10248	10.04	201.1+/-.5	1.96×10^{-2}	E of borehole
Backgr. #3	106+/-19	102+/-18	208	1.04	0.99+/-.04	4.76×10^{-3}	S borehole
Sta. #3	260+/-31	264+/-31	524	0.985	7.67+/-.12	1.46×10^{-2}	N borehole
Sta. #4	1626+/-76	1457+/-72	3083	1.12	123.3+/-.4	4.00×10^{-2}	
Sta. #5	121+/-21	172+/-22	293	0.70	1.91+/-.06	6.52×10^{-3}	
Sta. #6	237+/-26	222+/-25	459	1.07	16.7+/-.2	3.64×10^{-2}	
Sta. #7	1047+/-56	903+/-52	1950	1.16	105.7+/-.3	5.42×10^{-2}	
Sta. #8	221+/-4	190+/-22	411	1.16	0.50+/-.03	1.22×10^{-3}	
Sta. #9	1500+/-100	1000+/-100	2500	1.50	633+/-2	0.253	
Sta. #10	39.9+/-11.6	32.0+/-10.2	71.9	1.25	0.74+/-.03	1.03×10^{-2}	
			Markos and Bush, Salt Lake City Mill*				
20-305/320	69	41	110	1.68	4370	39.7	Tailings
20-320/326	72	67	139	1.07	1600	11.5	Soil undertails
20-345/350	6	5.3	11.3	1.13	5.01	0.44	Soil
20-381/394	6.03	6.36	12.39	0.95	[illegible]	0.14	Soil
20-420/432	14	14	28	1.00	1.90	0.07	Soil
20-457/464	11.9	11.8	23.7	1.01	2.65	0.11	Soil
20-495/503	1.32	1.35	2.67	0.98	2.0	0.75	Soil
21-234/274	147	144	291	1.02	1300	4.47	Tailings
21-373/386	160	163	320	1.00	1390	4.34	Tailings
21-391/400	36.1	36.4	72.5	0.99	19.5	0.27	Soil under tailings
21-412/434	4.7	2.66	7.36	1.77	0.69	0.09	Soil
21-458/480	2.4	2.44	4.84	0.98	1.05	0.21	Soil
21-480/502	2.14	1.61	3.75	1.33	.92	0.24	Soil
21-520/530	1.13	.84	2.02	1.27	1.68	0.83	Soil

*Site I.D. is hole number and start/stop depths in centimeters.

ALBUQUERQUE LABORATORY

REPORT OF ANALYSIS

CUSTOMER Hecla Mining Company
ATTENTION Colleen Kelley
Wallace Office
ADDRESS 7th and Cedar Street
CITY Wallace, ID 83873
S.O. NO. E-5253

TYPE OF ANALYSIS Polonium-210, radium 226, Isotopic Uranium in soil

CUSTOMER ORDER NUMBER WO-03740

SAMPLES RECEIVED 10/1/85

Customer Identification	Date Collected	Type of Analysis	Total Wt. g(wet) g(dry)	pCi/g (dry)
Background #1	9/30/85	Po-210	1181	1.64±0.18
Roads (top of road)	12:45 AM	Ra-226	1117	0.96±0.04
		U-234		82.9±15.5
		U-235		<5
		U-238		95.5±17.1
Station #1	9/30/85	Po-210	1094	118±2
Borehole	12:30 AM	Ra-226	1058	107.9±0.4
100 ft. N. of		U-234		1394±65
Borehole		U-235		83.0±16.0
		U-238		1284±62
Background #2	9/30/85	Po-210	780	1.55±0.25
N. Borehole side	1:15 PM	Ra-226	750	1.46±0.05
of canyon wall		U-234		102±20
		U-235		<7
		U-238		101±21
Station #2 N.	9/30/85	Po-210	1094	198±2
Borderhole E.	1:10 PM	Ra-226	1051	201.1±0.5
of Borehole up		U-234		5232±178
against road		U-235		222±36
		U-238		5016±173
Background #3	9/30/85	Po-210	892	1.96±0.27
S. Borehole	2:40 PM	Ra-226	824	0.99±0.04
		U-234		106±19
		U-235		<5
		U-238		102±18

☐ REPORTED VIA TELEPHONE

☐ REPORTED VIA TWX

APPROVED BY R. Melgard

Rod Melgard, Mgr.

DATE 12/9/85

Eberline
A DIVISION OF Thermo Electron CORPORATION

P. O. BOX 3874 ALBUQUERQUE, NEW MEXICO 87190
PHONE (505) 345-3461 twx 910-985-0678

CUSTOMER Hecla Mining Co.

ATTENTION

ADDRESS

CITY

S.O. NO. E-5253

ALBUQUERQUE LABORATORY

REPORT OF ANALYSIS

TYPE OF ANALYSIS

WO-03740

CUSTOMER ORDER NUMBER

SAMPLES RECEIVED 10/1/85

Customer Identification	Date Collected	Type of Analysis	Total Wt. g(wet) g(dry)	pCi/g (dry)
Station #3		Po-210	890	10.4±0.6
N. Borehole		Ra-226	853	7.67±0.12
		U-234		260±31
		U-235		<10
		U-238		264±31
Station #4	9/30/85	Po-210	1275	207±2
Borehole 1/2 way	1:45	Ra-226	1243	123.3±0.4
between stakes		U-234		1626±76
		U-235		56.2±14.7
		U-238		1457±72
Station #5	9/30/85	Po-210	1087	5.22±0.61
Borehole	2:00 PM	Ra-226	887	1.91±0.06
		U-234		121±21
		U-235		<6
		U-238		172±22
Station #6	9/30/85	Po-210	1036	21.7±0.8
S. Borehole	2:10 PM	Ra-226	990	16.7±0.2
		U-234		237±26
		U-235		9.63±5.15
		U-238		222±25
Station #7	9/30/85	Po-210	1317	120±1
S. Borehole	2:15 PM	Ra-226	1275	105.7±0.3
		U-234		1047±56
		U-235		48.6±12.2
		U-238		903±52

☐ REPORTED VIA TELEPHONE

☐ REPORTED VIA TWX

APPROVED BY R. Melgard Rod Melgard, Mgr.

DATE 12/9/85

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ALBUQUERQUE LABORATORY

REPORT OF ANALYSIS

CUSTOMER Hecla Mining Co.

ATTENTION

ADDRESS

CITY

S.O. NO. E-5253

TYPE OF ANALYSIS

WO-03740
CUSTOMER ORDER NUMBER

SAMPLES RECEIVED 10/1/85

Customer Identification	Date Collected	Type of Analysis	Total Wt. g(wet) g(dry)	pCi/g (dry)
Station #8	9/30/85	Po-210	1126	15.3±0.6
S. Borehole	2:20 PM	Ra-226	1072	0.50±0.03
		U-234		221±4
		U-235		<8
		U-238		190±22
Station #9	9/30/85	Po-210	1215	280±2
S. Borehole	2:25 PM	Ra-226	1185	633±2
		U-234		*
		U-235		*
		U-238		*
Station #10	9/30/85	Po-210	1085	0.94±0.14
S. Borehole	2:35 PM	Ra-226	1045	0.74±0.03
		U-234		39.9±11.6
		U-235		<3
		U-238		32.0±10.2

*Sample being recounted, will report data later.

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☐ REPORTED VIA TWX

APPROVED BY R. Melgard DATE 12/9/85

Rod Melgard, Mgr.

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ALBUQUERQUE LABORATORY

REPORT OF ANALYSIS

CUSTOMER Hecla Mining Company
ATTENTION Colleen Kelley
ADDRESS Wallace Office
7th and Cedar Street
CITY Wallace, ID 83873
S.O. NO. E-5253

Radiochemical analysis of soil
TYPE OF ANALYSIS

WO-03740
CUSTOMER ORDER NUMBER

SAMPLES RECEIVED 10/1/85

SUPPLEMENTAL REPORT

Customer Identification	Date Collected	Type of Analysis	pCi/g (dry)
Station #9	9/30/85	U-234	1500±100
S. Borehole	2:25 PM	U-235	40±8
		U-238	1000±100

☐ REPORTED VIA TELEPHONE

☐ REPORTED VIA TWX

APPROVED BY Kathy Burnham for Rod Melgard, Mgr.

DATE 1/30/86

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