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December 10, 1976

MEMORANDUM

To: J. E. Litz

From: R. B. Balderrama

Subject: HRI Project 4133
Studies on Leaching of Anderson Mine Composites

Two series of acid and alkaline leaching tests were performed on the two samples of ore received from the Anderson Mine of Minerals Exploration Company, near Wickenburg, Arizona. The two sets of leaching tests were designed to study the variables which can affect the solubilization of values during the leaching of uranium-vanadium ores. The variables studied during the acid leaches included:

Temperature
Retention time
Oxidant addition
Ore size
Residual acid concentration
Acid addition.

The variables studies during the alkaline leaches included:

Temperature
Retention time
Ore size
Sodium carbonate
Addition (Lixiviant concentration)

The results from each series of tests are tabulated in Tables 1 and 2. The effects of each variable on the uranium and vanadium extractions was determined by fitting a logarithmic least square curve to the data. The quality of the fit was evaluated by calculating the Coefficient of Determination for each curve. The Coefficient of Determination, r^2, estimates the decimal percentage of the variance of the dependent variable which can be explained by changes in the independent variable. The closer r^2 is to unity, the more variance is explained. Values of r^2 approaching zero indicate the fit of the data has no statistical significance.

Evaluation of the acid leaching results indicates that none of the variables significantly affected the uranium solubility within the ranges studied. The vanadium solubility decreased with increasing oxidation and in the case of Composite 2 (lower zone) increased with increasing acid addition.

Acid leach extractions from the middle zone were 98% for uranium and less than 50% for vanadium from a head of 0.045% U_3O_8 and 0.07% V_2O_5. The required acid addition was 140 lb H_2SO_4 per ton ore. Acid leach extractions from the lower zone were about 95% for uranium and less than 50% for vanadium from a head of 0.05% U_3O_8 and 0.14% V_2O_5. The required acid addition was 260 lb H_2SO_4 per ton. 60°C

Evaluation of the alkaline leaching results showed that temperature was the most significant variable with the uranium dissolution increasing with increasing temperature. The data also indicate that the sodium carbonate addition should be a minimum of 120 lb/ton (30 g/l Na_2CO_3 at 33% solids). Alkaline leaching of the middle zone gave uranium extractions of 96%; whereas, the lower zone extractions were about 94-95%.

DESCRIPTION OF SAMPLES TESTED

Two sets of samples were received for compositing into blends representing the middle and lower zones of the Anderson ore body. The analyses of these samples were as follows:

	Middle Zone	Lower Zone
U_3O_8, % analyzed	0.039	0.043
average calculated	0.045	0.050
V_2O_5, %	0.07	0.14
Mo, %	0.001	0.001
CO_2, %	0.75	3.20
Fe, %	3.05	3.06

Splits were taken from each blend and dry ground to nominal 14-, 28-, and 48-mesh sizes. Figures 1 and 2 plot the screen analyses of the three sizes for each ore.

ACID LEACHING STUDIES

The acid leaching studies were performed in two sets. In the first set the additions of reagents were controlled by measurements of the leach pulp pH and emf. In the second set, the reagent additions were fixed. The leaching procedure was to pulp the dry ore in water, bring the pulp up to temperature, add the reagents and digest for a predetermined time. At the conclusion of the leach, the pulp was filtered and washed first with one displacement of 1.5 pH water, then one displacement of demineralized water.

The effect of temperature on the acid leaching of the uranium and vanadium is plotted in Figure 3. The plots show slight increases and decreases in the residual values as the temperature is increased. However, the only Coefficient of Determination having significance is the vanadium extraction from the lower zone which showed increasing vanadium extraction with increasing temperature.

The effect of time on the acid leaching of the uranium and vanadium is plotted in Figure 4. The plots show only slight changes in the residual values with time, indicating the leach time can be as short as four hours.

The effect of sodium chlorate addition on the acid leaching of the uranium and vanadium is plotted in Figure 5. For both ore zones, the uranium extraction improves slightly with oxidant addition; whereas the vanadium extraction decreases with oxidant addition. The Coefficients of Determination for the vanadium are fairly significant, 0.16 and 0.42, indicating that oxidant addition should be a minimum.

The effect of ore size on the acid leaching of the uranium and vanadium is plotted in Figure 6. The uranium extraction improves slightly with finer grinding; however, none of the curves show significant Coefficients of Determination. Figures 7, 8, 9, and 10 compare the screen analyses of the acid leached residues of the 14- and 28-mesh residues with their respective heads.

The effects of residual free acid and the acid addition of the leaching of the uranium and vanadium are plotted in Figures 11 and 12. The residual values from the middle zone decreased with increasing free acid; whereas, they increased with increasing acid addition. This infers that, although the residual free acid is affected by the acid addition, it is affected more by the acid consumption. The acid consumption during the leaching is affected by a combination of the ore size, leaching temperature, and retention time. The residual values from the lower zone did not show the above phenomena with the residual acid having little effect on the residual uranium and

vanadium. The vanadium and uranium extractions did increase slightly with increasing acid addition.

Analysis of the leaching tests indicated that the optimum leaching conditions considering all of the variables would be 60°C, for six hours, 50% solids using ore ground to 80% passing 28-mesh, and an addition of one lb/ton sodium chlorate. The acid addition should be controlled at 0.8 to 1.0 pH, requiring 140 lb/ton for the middle zone and 260 lb/ton for the lower zone. Tests at these conditions gave uranium extractions of 98% from the middle zone and 95% from the lower zone.

ALKALINE LEACHING STUDIES

The alkaline leaching procedure was to pulp the dry ore in water at 33% solids, bring the pulp up to temperature, add the reagents and digest for a predetermined time with air bubbling through the pulp at 10-20 cc/min (0.6-1.3 cfm/ton). At the conclusion of the leach, the pulp was filtered and washed with two displacements of three g/l sodium carbonate solution.

The effect of retention time on the leaching of uranium is plotted in Figure 13. The data indicates a slight decrease in uranium extraction with extended leaching time; however, the Coefficients of Determination do not show this to be statistically significant.

The effect of ore size on the leaching of uranium is plotted in Figure 14. The data indicate that the size had no effect on the uranium extraction.

The effect of the sodium carbonate addition of the uranium leaching is plotted in Figure 15. Both ore zones show increasing uranium solubilization with increasing sodium carbonate addition; however, the lowest residual values also were achieved in leaches with low sodium carbonate additions, 120 lb/ton.

The effect of temperature on the leaching of the uranium is plotted in Figure 16. Both ore zones show increasing uranium extraction with increasing temperature.

Analysis of the leaching data indicated that the optimum conditions appeared to be 80°C, for 16 hours, 33% solids using ore ground to 80% passing 48-mesh with a sodium carbonate addition of 120-160 lb/ton (30-40 g/l). Tests were run during the above program which approximated these conditions. Ninety-~~size~~ five percent of the uranium was extracted from the Middle Zone ore and ninety-four percent was extracted from the Lower Zone ore.

Robert Balderrama
R. B. Balderrama
Research Engineer

RBB:mgp

Table 1

Acid Leach Data

Test No.	976-1	976-2	976-3	976-4	976-9	976-10	976-11	976-12
Sample No. HRI-	10490-1	10490-2	10490-1	10490-2	10490-1	10490-2	10490-1	10490-2
Head Analysis								
% Uranium	0.039	0.043	0.039	0.043	0.039	0.043	0.039	0.043
% Vanadium	0.07	0.14	0.07	0.14	0.07	0.14	0.07	0.14
% Molybdenum	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001
Leach Conditions								
Feed size, mesh	-28	-28	-28	-28	-28	-28	-28	-28
Temperature, °C	80	80	80	80	60	60	60	60
Time, hour	24	24	24	24	24	24	24	24
H_2SO_4 addition, lb/ton	249.3	393.3	453.3	797.3	156	281.3	194.7	342.7
$NaClO_3$ addition, lb/ton	-	-	-	-	-	-	-	-
Leaching Data								
Final pH at temperature	1.5	1.5	0.9	0.7	1.5	1.5	1.2	1.3
Final pH at 25°C	1.1	1.1	0.8	0.6	1.1	1.1	1.0	1.0
Final emf at temperature	>700	>700	>700	560	510	510	520	525
Final emf at 25°C	640	635	580	465	455	465	460	460
Free acid, g/l H_2SO_4	7.29	8.40	24.50	40.59	6.50	6.09	11.18	13.32
Reagent Data								
H_2SO_4 consumed, lb/ton	203	324	293.3	524	125	253	149	281
Leach Residue								
% U_3O_8	0.003	0.005	0.001	0.002	0.002	0.002	0.002	0.002
% V_2O_5	0.07	0.13	0.06	0.02	0.04	0.10	0.04	0.09
Leach Extraction								
Uranium, %	94.5	92.5	98.3	97.2	95.6	96.2	95.8	96.4
Vanadium, %	9.5	14.3	23.8	88.1	47.6	33.3	47.6	40.5

Table 1

Acid Leach Data

Test No.	976-17	976-18	976-19	976-20	976-25	976-26	976-27	976-2
Sample No. HRI-	10490-1	10490-2	10490-1	10490-2	10490-1	10490-2	10490-1	10490-2
Head Analysis								
% Uranium	0.039	0.043	0.039	0.043	0.039	0.043	0.039	0.043
% Vanadium	0.07	0.14	0.07	0.14	0.07	0.14	0.07	0.14
% Molybdenum	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001
Leach Conditions								
Feed size, mesh	-28	-28	-28	-28	-28	-28	-28	-28
Temperature, ^{o}C	40	40	40	40	80	80	80	80
Time, hour	24	24	24	24	24	24	24	24
H_2SO_4 addition, lb/ton	113.3	233.3	149.3	280	186.6	329.3	289.3	452
$NaClO_3$ addition, lb/ton	1.3	1.3	0.7	1.3	0.7	0.7	0.3	0.0
Leaching Data								
Final pH at temperature	1.4	1.5	1.2	1.2	1.6	1.6	1.3	1.2
Final pH at 25°C	1.3	1.3	1.1	1.1	1.1	1.1	1.0	0.9
Final emf at temperature	650	655	680	540	515	520	525	520
Final emf at 25°C	630	625	625	505	460	460	460	455
Free acid, g/l H_2SO_4	4.85	4.12	18.72	9.13	16.8	17.4	24.3	31.1
Reagent Data								
H_2SO_4 consumed, lb/ton	92	215	69.3	239	112	252	192.4	303
Leach Residue								
% U_3O_8	0.001	0.002	0.001	0.002	0.001	0.002	0.006	0.002
% V_2O_5	0.07	0.14	0.06	0.10	0.06	0.10	0.05	0.08
Leach Extraction								
Uranium, %	97.6	95.7	97.7	96.2	98.0	96.5	88.0	96.6
Vanadium, %	4.8	4.8	19.0	33.3	19.0	33.3	33.3	47.6

Table 1

Acid Leach Data

Test No.	976-29	976-30	976-31	976-32	976-33	976-34	976-35	976-3
Sample No. HRI-	10490-1	10490-2	10490-1	10490-2	10490-1	10490-2	10490-1	10490-2
Head Analysis								
% Uranium	0.039	0.043	0.039	0.043	0.039	0.043	0.039	0.043
% Vanadium	0.07	0.14	0.07	0.14	0.07	0.14	0.07	0.14
% Molybdenum	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001
Leach Conditions								
Feed size, mesh	-28	-28	-28	-28	-28	-28	-28	-28
Temperature, °C	60	60	50	50	60	60	50	50
Time, hour	8	8	24	24	16	16	16	16
H_2SO_4 addition, lb/ton	170	290	170	290	155	275	140	260
$NaClO_3$ addition, lb/ton	0.5	0.5	1.0	1.0	0.0	0.0	0.5	0.5
Leaching Data								
Final pH at temperature	1.4	1.5	1.5	1.6	1.4	1.5	1.3	1.4
Final pH at 25°C	1.0	1.0	1.0	1.2	1.1	1.2	1.1	1.2
Final emf at temperature	480	495	520	635	435	455	>700	>700
Final emf at 25°C	445	475	480	525	422	430	640	640
Free acid, g/l H_2SO_4	9.42	7.52	7.49	6.30	5.70	4.57	7.14	5.04
Reagent Data								
H_2SO_4 consumed, lb/ton	129	255	141	265	129	256	112	244
Leach Residue								
% U_3O_8	0.001	0.003	0.006	0.002	0.002	0.006	0.002	0.007
% V_2O_5	0.04	0.09	0.05	0.10	0.05	0.09	0.06	0.13
Leach Extraction								
Uranium, %	97.9	94.6	87.0	96.3	95.8	89.1	95.6	85.9
Vanadium, %	47.6	38.1	33.3	28.6	33.3	40.5	19.0	9.5

Table 1

Acid Leach Data

Test No.	976-37	976-38	976-39	976-40	976-41	976-42	976-43	976-44
Sample No. HRI-	10490-1	10490-2	10490-1	10490-2	10490-1	10490-2	10490-1	10490-2
Head Analysis								
% Uranium	0.039	0.043	0.039	0.043	0.039	0.043	0.039	0.043
% Vanadium	0.07	0.14	0.07	0.14	0.07	0.14	0.07	0.14
% Molybdenum	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001
Leach Conditions								
Feed size, mesh	-28	-28	-14	-14	-14	-14	-14	-14
Temperature, °C	70	70	70	70	70	70	60	60
Time, hour	24	24	8	8	4	4	8	8
H_2SO_4 addition, lb/ton	140	260	155	275	170	290	155	275
$NaClO_3$ addition, lb/ton	1.0	1.0	0.0	0.0	0.0	0.0	0.5	0.5
Leaching Data								
Final pH at temperature	1.6	1.7	1.5	1.6	1.4	1.5	1.3	1.5
Final pH at 25°C	1.2	1.3	1.0	1.1	0.95	0.95	1.0	1.1
Final emf at temperature	550	570	450	460	465	480	495	515
Final emf at 25°C	475	490	430	445	435	450	465	480
Free acid, g/l H_2SO_4	3.25	3.33	7.23	7.71	9.83	9.61	10.47	6.85
Reagent Data								
H_2SO_4 consumed, lb/ton	127	245	130	242	127	250	110	246
Leach Residue								
% U_3O_8	0.002	0.006	0.007	0.003	0.001	0.003	0.002	0.003
% V_2O_5	0.07	0.14	0.05	0.08	0.05	0.08	0.04	0.09
Leach Extraction								
Uranium, %	95.6	88.4	85.2	95.0	97.9	95.2	95.7	95.4
Vanadium, %	4.8	2.4	28.6	42.9	33.3	42.9	47.6	40.5

Table 1

Acid Leach Data

Test No.	976-45	976-46	976-47	976-48	976-	976-	976-	976-
Sample No. HRI-	10490-1	10490-2	10490-1	10490-2	10490-1	10490-2	10490-1	10490-2
Head Analysis								
% Uranium	0.039	0.043	0.039	0.043				
% Vanadium	0.07	0.14	0.07	0.14				
% Molybdenum	0.001	<0.001	0.001	<0.001				
Leach Conditions								
Feed size, mesh	-14	-14	-14	-14				
Temperature, °C	60	60	50	50				
Time, hour	4	4	4	4				
H_2SO_4 addition, lb/ton	140	260	155	275				
$NaClO_3$ addition, lb/ton	1.0	1.0	0.0	0.0				
Leaching Data								
Final pH at temperature	1.4	1.5	1.1	1.2				
Final pH at 25°C	1.0	1.0	0.9	0.9				
Final emf at temperature	645	645	445	460				
Final emf at 25°C	660	650	430	440				
Free acid, g/l H_2SO_4	9.28	8.44	10.04	8.94				
Reagent Data								
H_2SO_4 consumed, lb/ton	101	225	114	238				
Leach Residue								
% U_3O_8	0.001	0.004	0.001	0.007				
% V_2O_5	0.06	0.12	0.05	0.10				
Leach Extraction								
Uranium, %	98.0	93.7	97.7	88.1				
Vanadium, %	19.0	19.0	28.6	33.3				

Table 2

Alkaline Leach Data

Test No.	976-5	976-6	976-7	976-8	976-13	976-14	976-15	976-
Sample No. HRI-	10490-1	10490-2	10490-1	10490-2	10490-1	10490-2	10490-1	10490-
Head Analysis								
Uranium	0.039	0.043	0.039	0.043	0.039	0.043	0.039	0.04
Vanadium	0.07	0.14	0.07	0.14	0.07	0.14	0.07	0.14
Molybdenum	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.00
Leach Conditions								
Leach head, g	500	500	500	500	500	500	500	500
Ore size, mesh	-28	-28	-28	-28	-28	-28	-28	-28
Temperature, °C	80	80	80	80	60	60	60	60
Time, hour	24	24	24	24	24	24	24	24
Sodium carbonate addition, lb/ton	100	100	160	160	100	100	160	160
Sodium bicarbonate addition, lb/ton	20	20	40	40	20	20	40	40
Leach Filtrate								
Volume, ml	1150	1370	1280	1350	1520	1440	1340	1350
pH	9.8	9.9	9.8	9.9	9.9	9.8	9.9	9.9
emf, mv	+60	+30	+20	-10	-20	-30	-30	-30
U_3O_8, g/l	0.120	0.112	0.133	0.137	0.025	0.057	0.062	0.127
Leach Residue								
Weight, g	483.8	473.4	481.3	470.2	484.5	471.5	489.0	472.0
U_3O_8, %	0.011	0.013	0.004	0.005	0.030	0.028	0.019	0.010
Leach Extraction								
U_3O_8, %	72.2	71.4	89.8	88.7	20.7	38.3	47.2	78.4

Table 2

Alkaline Leach Data

est No.	976-21	976-22	976-23	976-24	976-	976-	976-	976-
ample No. HRI-	10490-1	10490-2	10490-1	10490-2	10490-1	10490-2	10490-1	10490-2
ead Analysis								
Uranium	0.039	0.043	0.039	0.043	0.039	0.043	0.039	0.043
Vanadium	0.07	0.14	0.07	0.14	0.07	0.14	0.07	0.14
Molybdenum	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001
each Conditions								
Leach head, g	500	500	500	500	500	500	500	500
Ore size, mesh	-28	-28	-28	-28				
Temperature, °C	40	40	40	40				
Time, hour	24	24	24	24				
Sodium carbonate addition, lb/ton	100	100	160	160				
Sodium bicarbonate addition, lb/ton	20	20	40	40				
each Filtrate								
Volume, ml	1240	1295	1200	1340				
pH	10.0	10.0	10.0	10.0				
emf, mv	-30	-30	-30	-30				
U_3O_8, g/l	0.010	0.012	0.021	0.036				
each Residue								
Weight, g	482.5	474.5	485.0	471.0				
U_3O_8, %	0.035	0.041	0.034	0.037				
each Extraction								
U_3O_8, %	7.2	7.6	13.3	21.8				

Table 2

Alkaline Leach Data

Test No.	976-49	976-50	976-51	976-52	976-53	976-54	976-55	976-5
Sample No. HRI-	10490-1	10490-2	10490-1	10490-2	10490-1	10490-2	10490-1	10490
Head Analysis								
Uranium	0.039	0.043	0.039	0.043	0.039	0.043	0.039	0.04
Vanadium	0.07	0.14	0.07	0.14	0.07	0.14	0.07	0.14
Molybdenum	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.00
Leach Conditions								
Leach head, g	500	500	500	500	500	500	500	500
Ore size, mesh	-14	-14	-28	-28	-28	-28	-48	-48
Temperature, °C	80	80	80	80	80	80	80	80
Time, hour	8	8	8	8	16	16	16	16
Sodium carbonate addition, lb/ton	160	160	120	120	160	160	160	160
Sodium bicarbonate addition, lb/ton	40	40	40	40	40	40	40	40
Leach Filtrate								
Volume, ml	1100	1160	1070	1120	1060	1130	1060	1130
pH	9.8	9.8	9.6	9.6	9.8	9.7	9.7	9.8
emf, mv	+150	+70	+90	+95	+90	+90	+90	+90
U_3O_8, g/l	0.130	0.185	0.112	0.182	0.187	0.200	0.187	0.192
Leach Residue								
Weight, g	487.9	475.4	488.0	475.7	484.5	485.5	497.0	480.6
U_3O_8, %	0.011	0.007	0.014	0.007	0.003	0.002	0.003	0.003
Leach Extraction								
U_3O_8, %	72.7	86.6	63.7	86.0	93.2	95.9	93.0	93.8

Table 2

Alkaline Leach Data

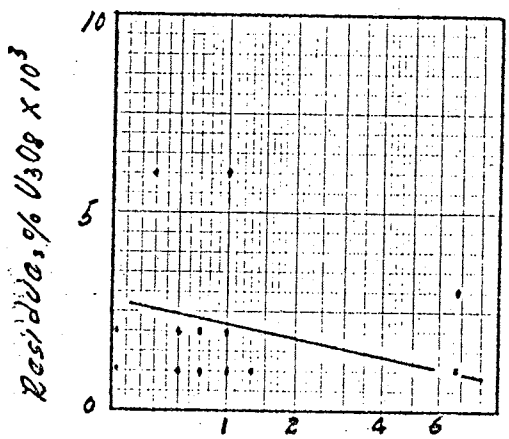
Test No.	976-57	976-58	976-59	976-60	976-61	976-62	976-63	976-64
Sample No. HRI-	10490-1	10490-2	10490-1	10490-2	10490-1	10490-2	10490-1	10490-2
Head Analysis								
Uranium	0.039	0.043	0.039	0.043	0.039	0.043	0.039	0.043
Vanadium	0.07	0.14	0.07	0.14	0.07	0.14	0.07	0.14
Molybdenum	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001
Leach Conditions								
Leach head, g	500	500	500	500	500	500	500	500
Ore size, mesh	-48	-48	-28	-28	-14	-14	-28	-28
Temperature, °C	80	80	90	90	90	90	90	90
Time, hour	8	8	16	16	16	16	24	24
Sodium carbonate addition, lb/ton	200	200	200	200	120	120	160	160
Sodium bicarbonate addition, lb/ton	40	40	40	40	40	40	40	40
Leach Filtrate								
Volume, ml	1070	1060	1100	1150	1010	1010	980	1040
pH	9.8	9.9	9.9	9.9	9.7	9.8	9.8	9.9
emf, mv	+85	+85	+75	+75	+70	+75	+70	+70
U_3O_8, g/l	0.185	0.200	0.178	0.187	0.163	0.245	0.196	0.221
Leach Residue								
Weight, g	485.7	482.5	481.6	471.9	482.0	471.7	482.0	471.0
U_3O_8, %	0.003	0.007	0.004	0.003	0.004	0.003	0.004	0.003
Leach Extraction								
U_3O_8, %	93.1	86.3	91.0	93.8	89.5	94.6	90.9	94.2

Table 2

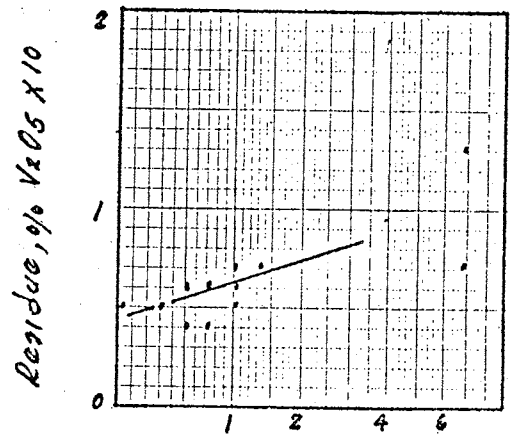
Alkaline Leach Data

Test No.	976-65	976-66	976-67	976-68	976-	976-	976-	976-
Sample No. HRI-	10490-1	10490-2	10490-1	10490-2	10490-1	10490-2	10490-1	10490-
Head Analysis								
Uranium	0.039	0.043	0.039	0.043	0.039	0.043	0.039	0.043
Vanadium	0.07	0.14	0.07	0.14	0.07	0.14	0.07	0.14
Molybdenum	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001
Leach Conditions								
Leach head, g	500	500	500	500	500	500	500	500
Ore size, mesh	-48	-48	-14	-14				
Temperature, °C	90	90	90	90				
Time, hour	24	24	24	24				
Sodium carbonate addition, lb/ton	120	120	200	200				
Sodium bicarbonate addition, lb/ton	40	40	40	40				
Leach Filtrate								
Volume, ml	960	990	1080	1090				
pH	9.7	9.7	9.8	9.9				
emf, mv	+60	+70	+60	+65				
U_3O_8, g/l	0.206	0.247	0.186	0.221				
Leach Residue								
Weight, g	483.0	480.0	481.5	473.0				
U_3O_8, %	0.004	0.004	0.004	0.003				
Leach Extraction								
U_3O_8, %	91.1	92.7	91.3	94.4				

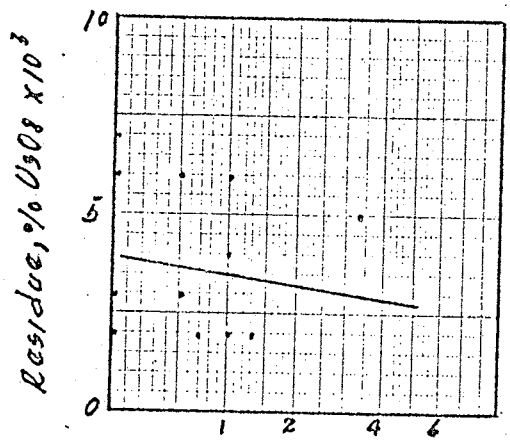
Effect of Oxidant Addition on Leaching of Anderson Mine Composites.



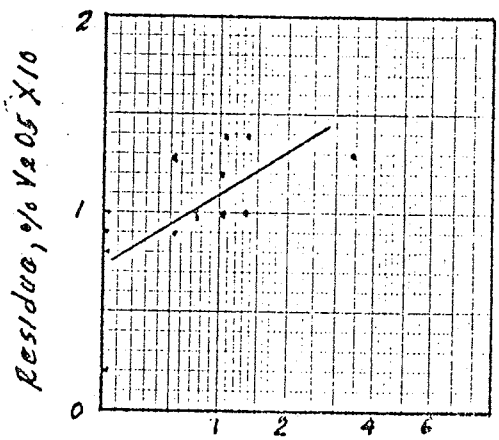
Oxidant Addition, Lb/T
$NaClO_3$
Middle Zone
Uranium: $r^2 = 0.02$



Oxidant Addition, Lb/T
$NaClO_3$
Middle Zone
Vanadium: $r^2 = 0.16$



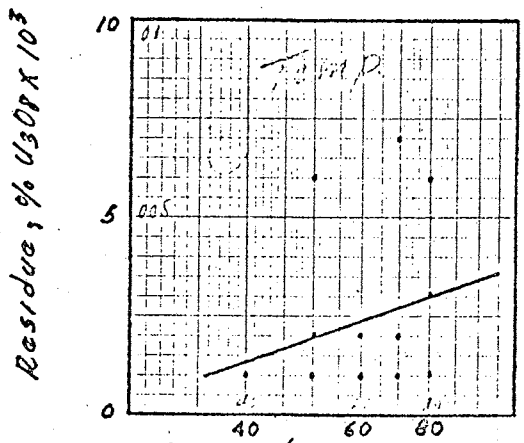
Oxidant Addition, Lb/T
$NaClO_3$
Lower Zone
Uranium: $r^2 = 0.02$



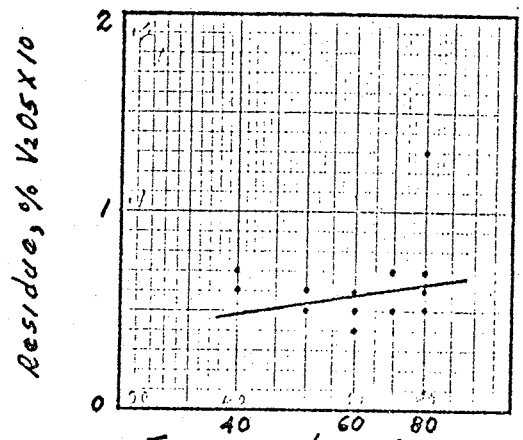
Oxidant Addition, Lb/T
$NaClO_3$
Lower Zone
Vanadium: $r^2 = 0.42$

Figure 5

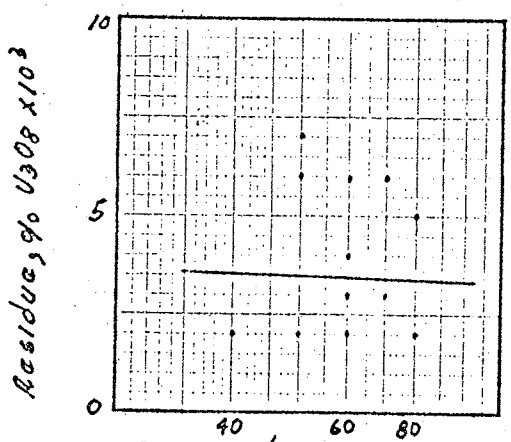
Effect of Temperature on Leaching of Anderson Mine Composites



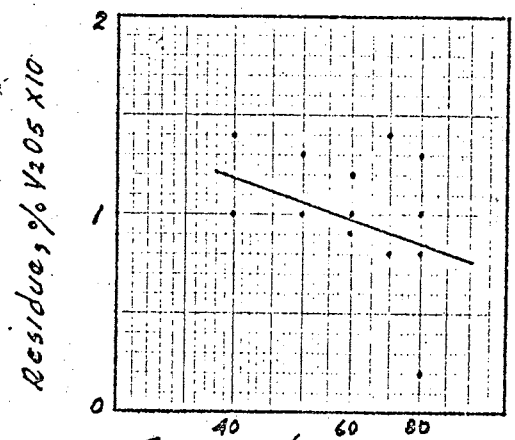
Temperature, °C
Middle Zone
Uranium: $r^2 = 0.05$



Temperature, °C
Middle Zone
Vanadium: $r^2 = 0.06$



Temperature, °C
Lower Zone
Uranium: $r^2 = 0.001$



Temperature, °C
Lower Zone
Vanadium: $r^2 = 0.16$

Figure 3

Effect of Time on Leaching of
Anderson Mine Composites

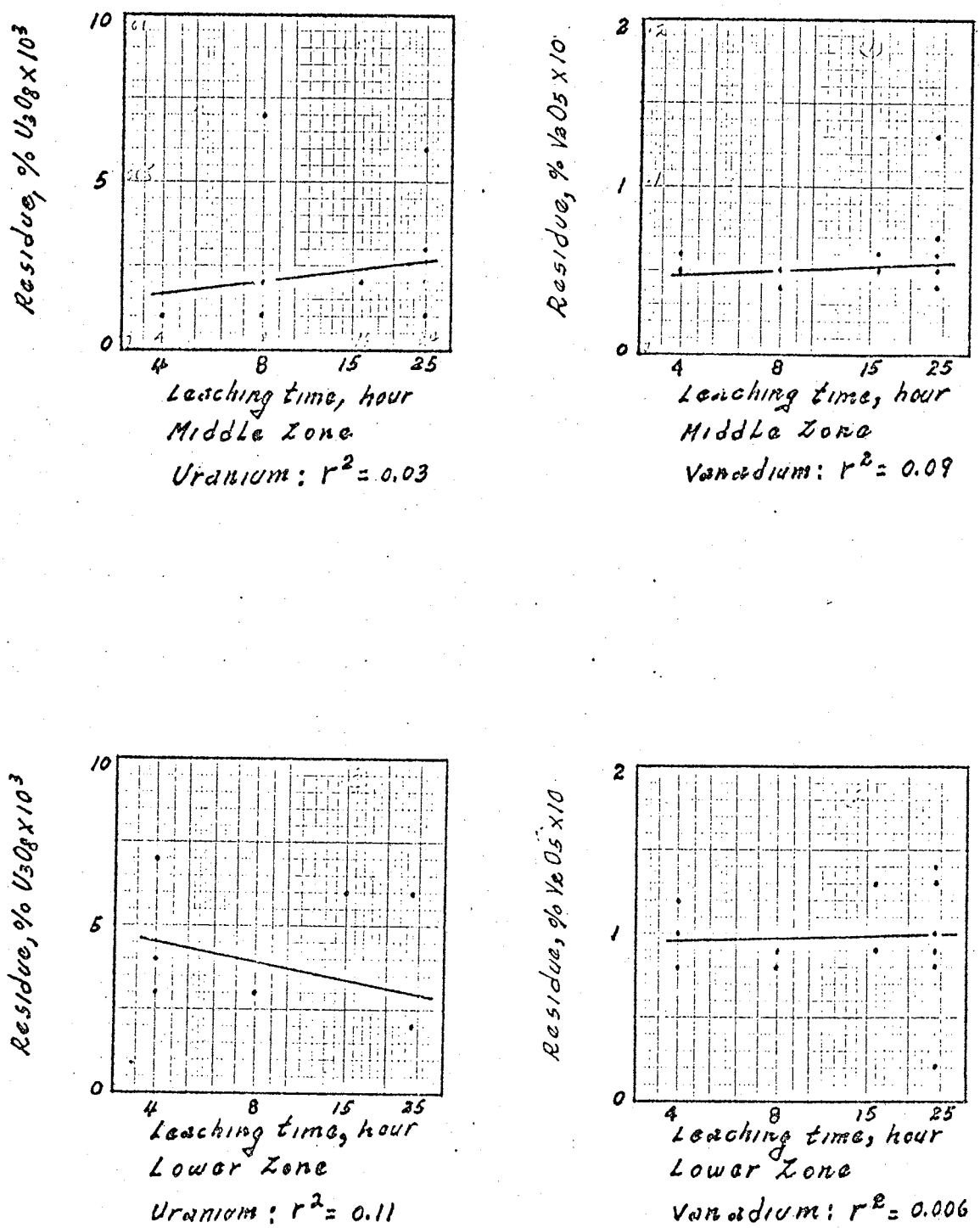
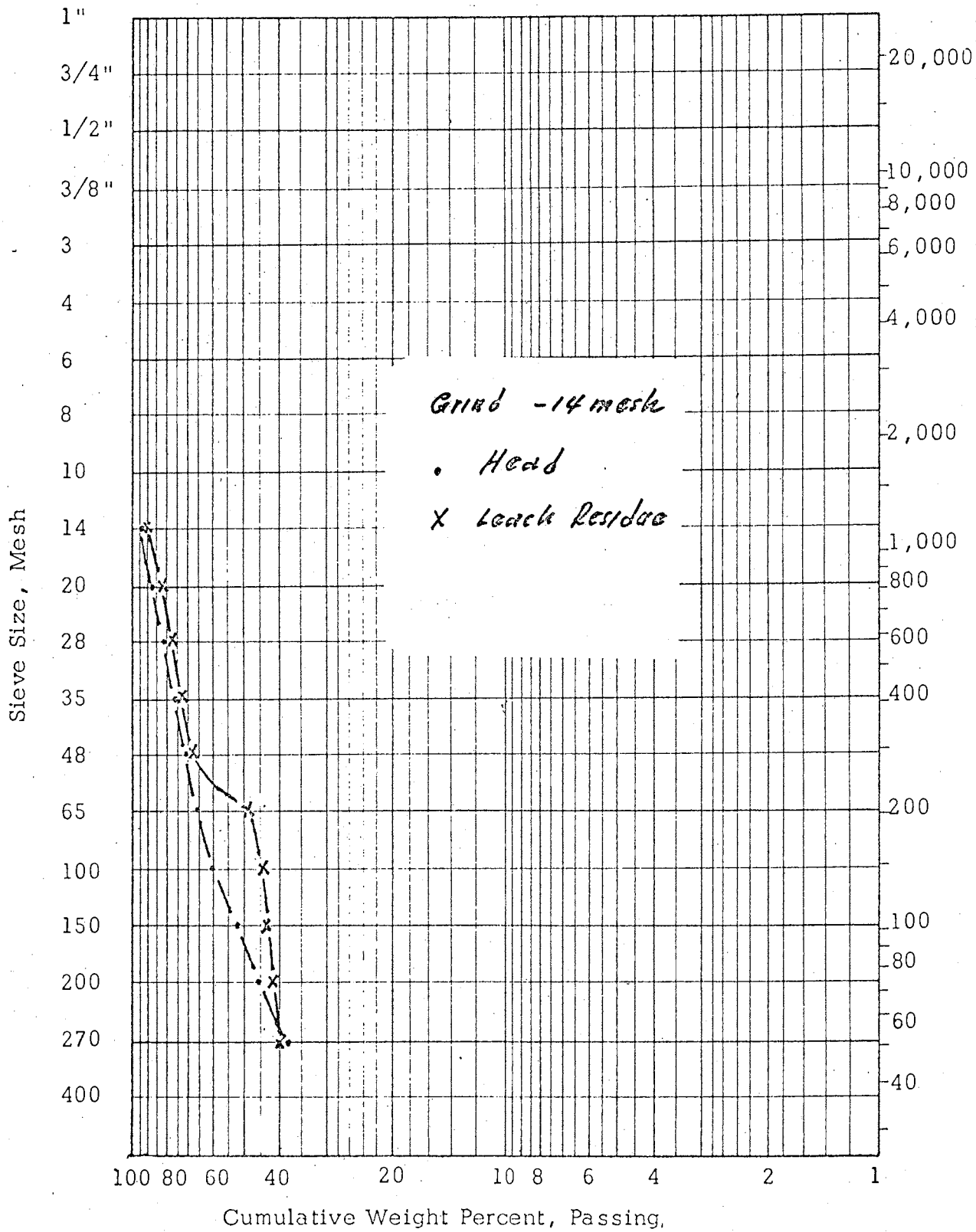


Figure 4

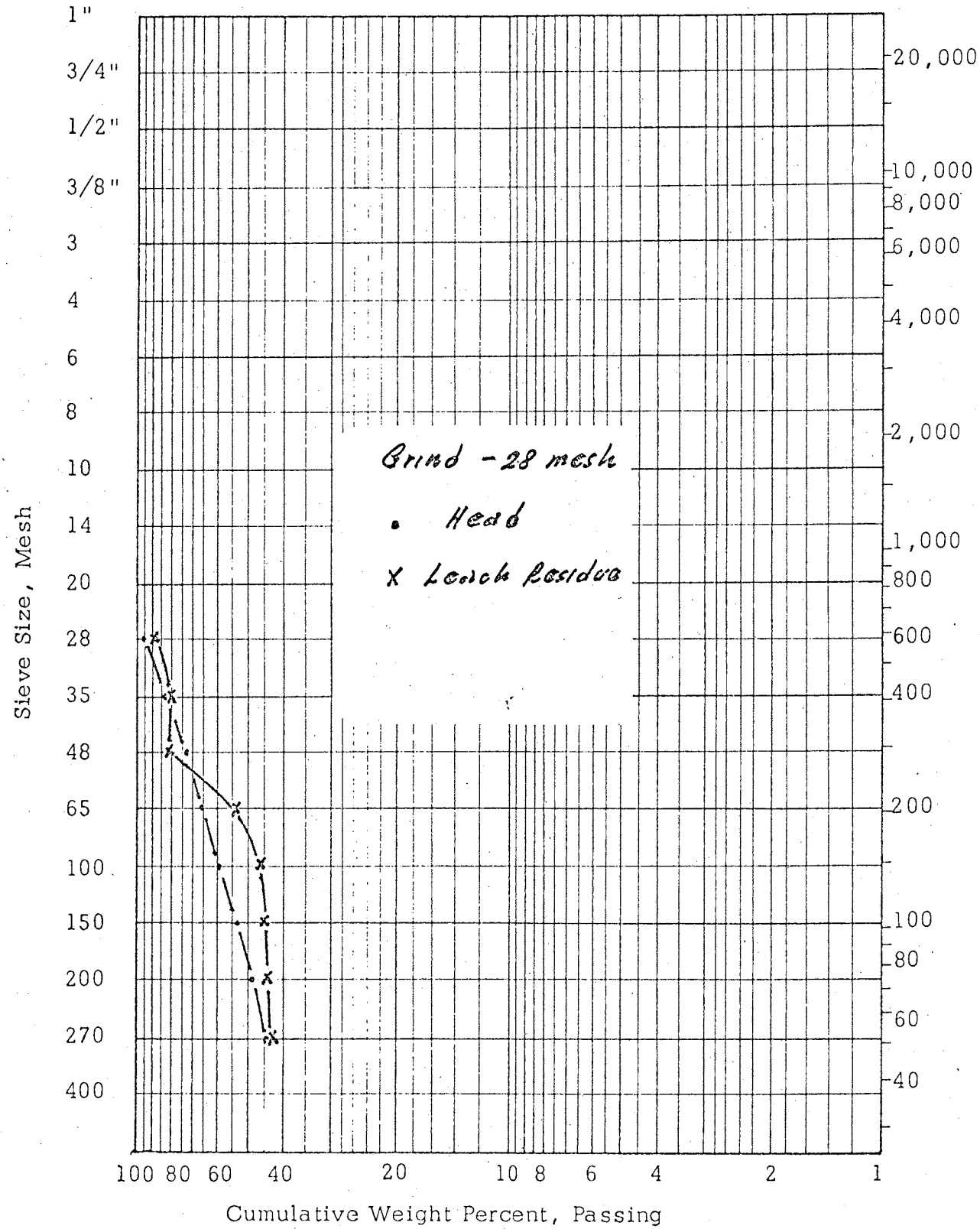
Screen Analysis on Head and Acid Leach residue of Anderson Mine Composite Lower Zone



hri 50-23, 2/75

Figure 8

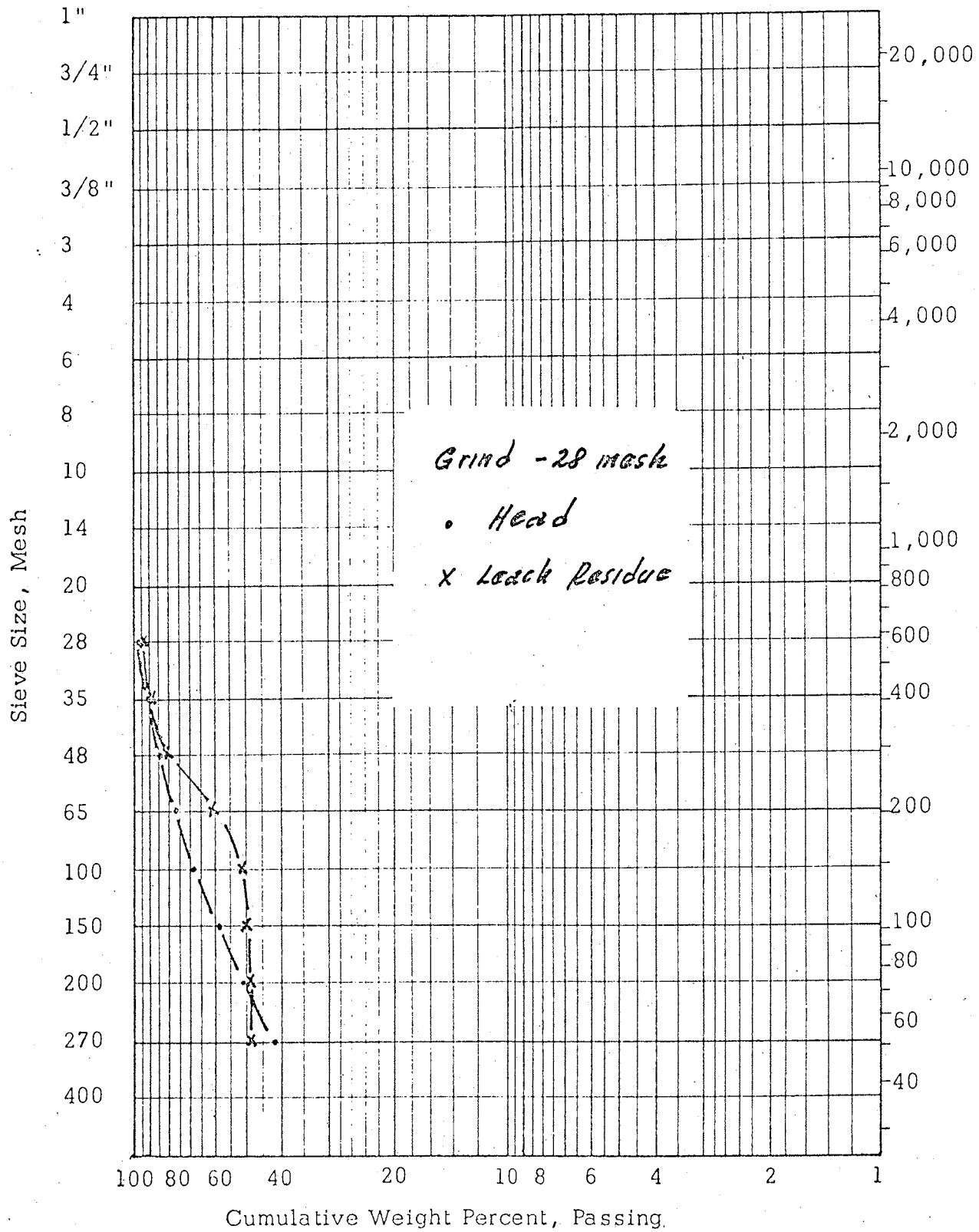
Screen Analysis on Head and Acid Leach residue of Anderson Mine Composite Middle Zone



hri 50-23, 2/75

Figure 9

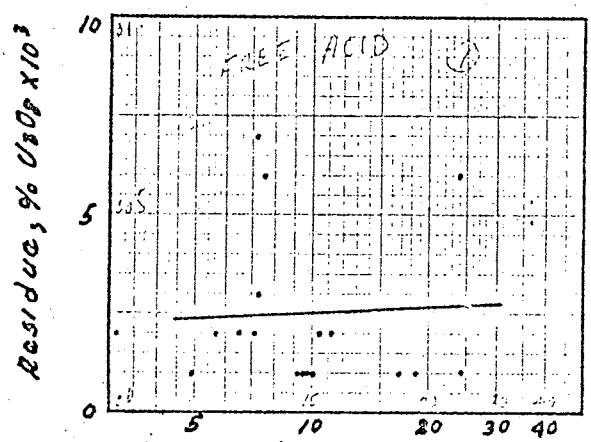
Screen Analysis on Head and Acid Leach residue of Anderson Mine Composite Lower Zone



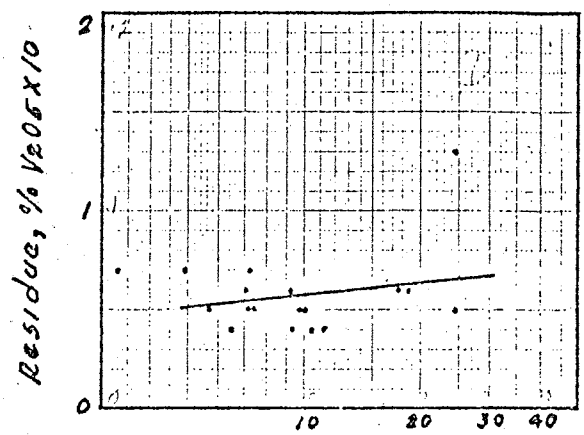
hri 50-23, 2/75

Figure 10

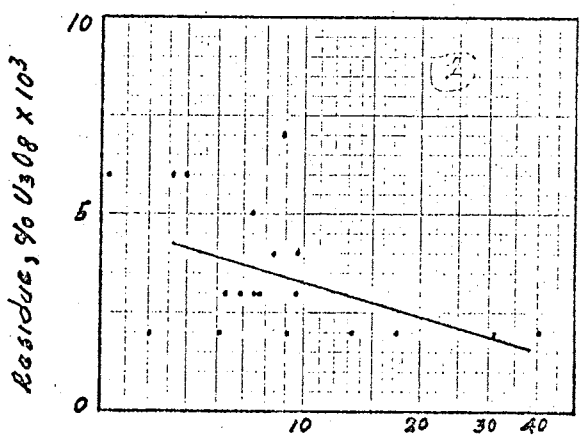
Effect of Final Free Acid Concentration on Leaching of Anderson Mine Composites



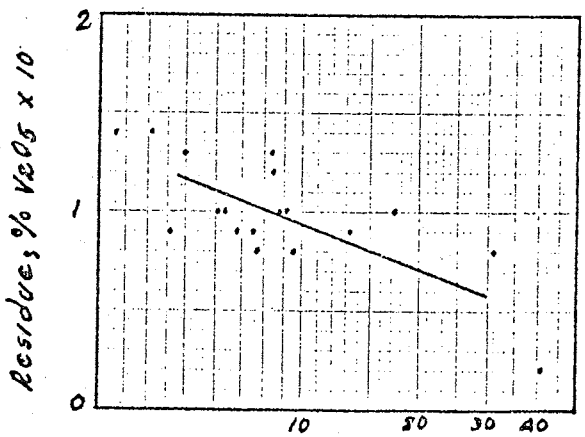
Free Acid, g/l H_2SO_4
Middle Zone
Uranium: $r^2 = 0.0004$



Free Acid, g/l H_2SO_4
Middle Zone
Vanadium: $r^2 = 0.07$



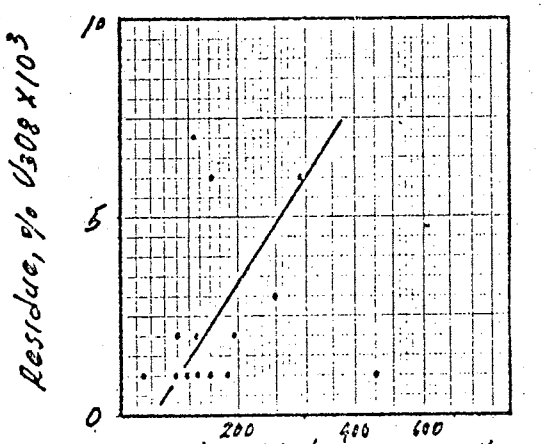
Free Acid, g/l H_2SO_4
Lower Zone
Uranium: $r^2 = 0.21$



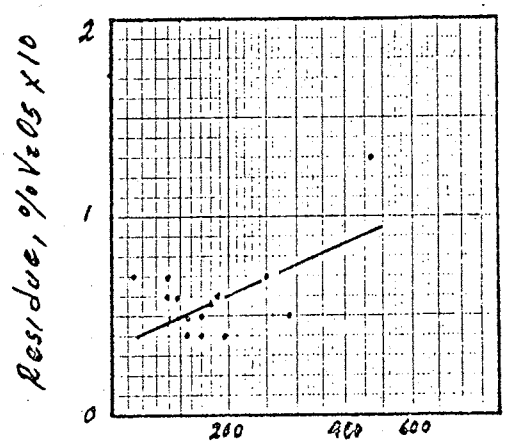
Free Acid, g/l H_2SO_4
Lower Zone
Vanadium: $r^2 = 0.55$

Figure 11

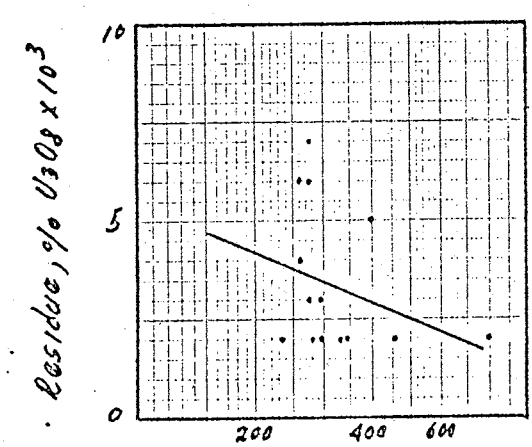
Effect of Sulfuric Acid Addition on Leaching of Anderson Mine Composites



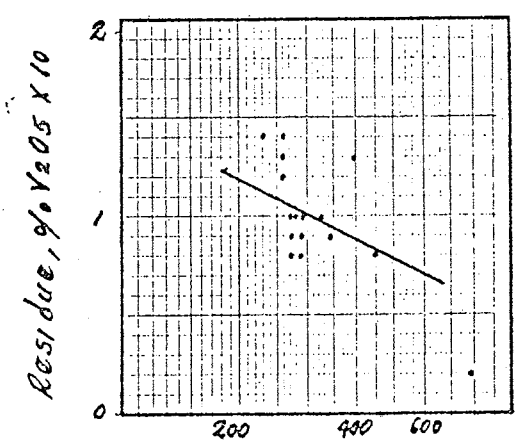
Middle Zone
Uranium: $r^2 = 0.02$



Middle Zone
Vanadium: $r^2 = 0.34$



Lower Zone
Uranium: $r^2 = 0.09$

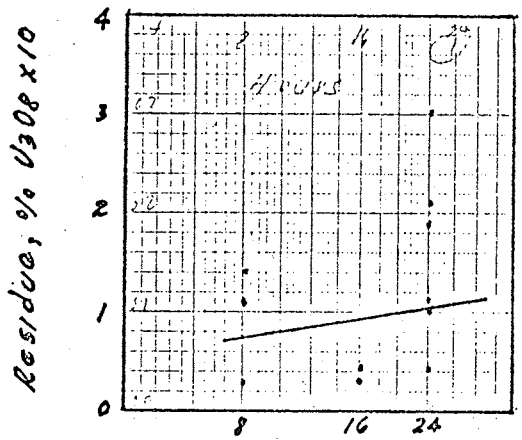


Lower Zone
Vanadium: $r^2 = 0.52$

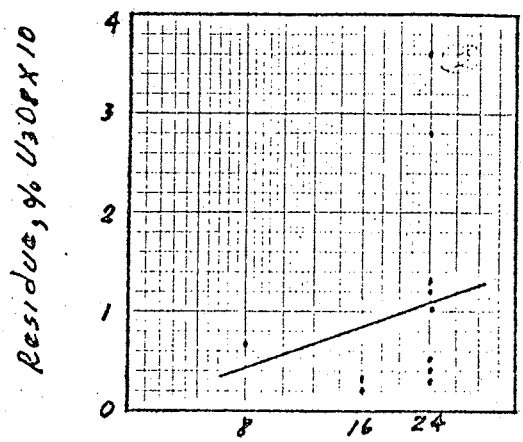
Figure 12

ALKALINE

Effect of Time and Grind on Carbonate Leaching of Anderson Mine Composites

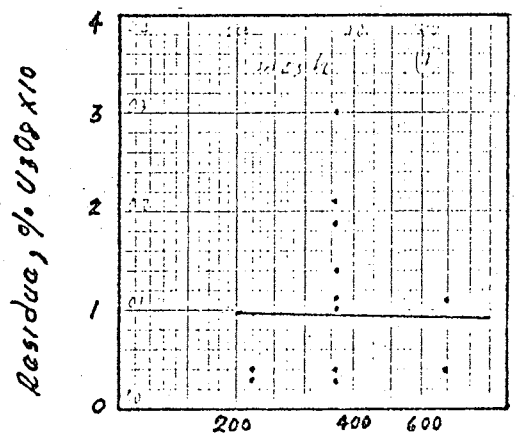


Leaching time, hour
Middle Zone
Uranium : $r^2 = 0.03$

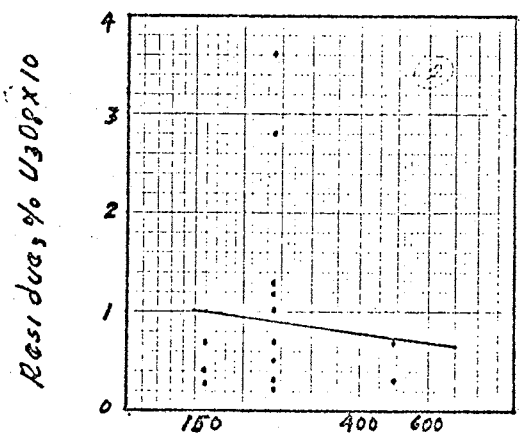


Leaching time, hour
Lower Zone
Uranium : $r^2 = 0.08$

Figure 13



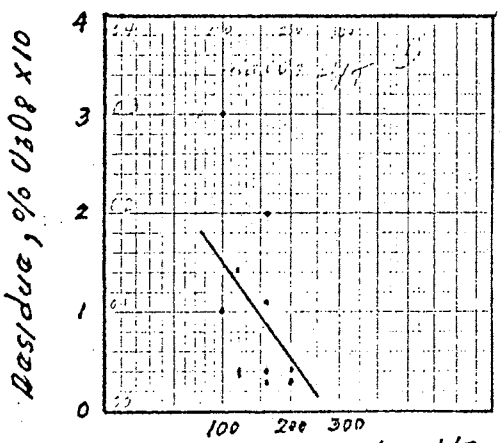
Maximum size, microns
Middle Zone
Uranium : $r^2 = 0.0001$



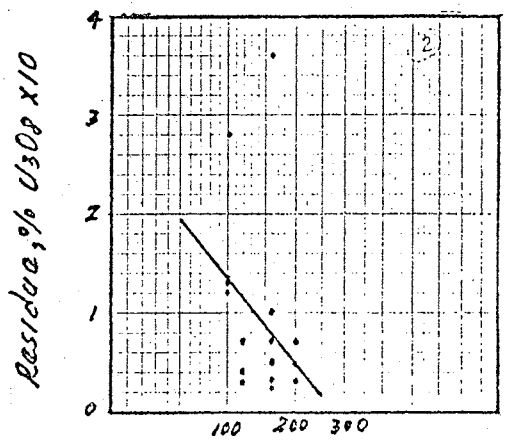
Maximum size, microns
Lower Zone
Uranium : $r^2 = 0.008$

Figure 14

Effect of Sodium Carbonate and Temperature on Leaching of Anderson Mine Composites

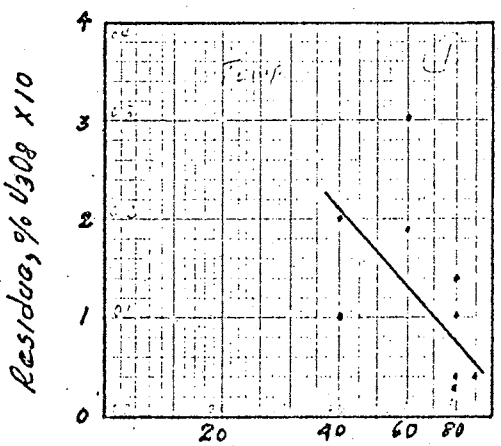


Sodium Carbonate, Lb/T
Middle Zone
Uranium: $r^2 = 0.19$

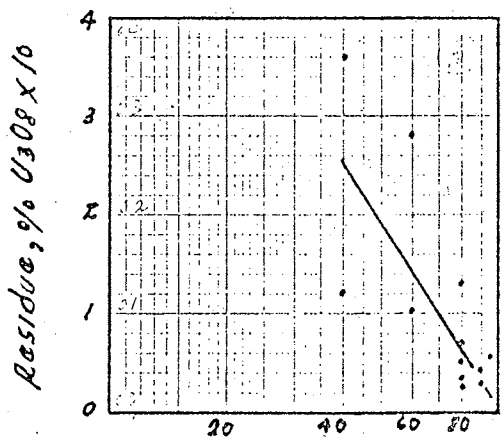


Sodium Carbonate, Lb/T
Lower Zone
Uranium: $r^2 = 0.10$

Figure 15



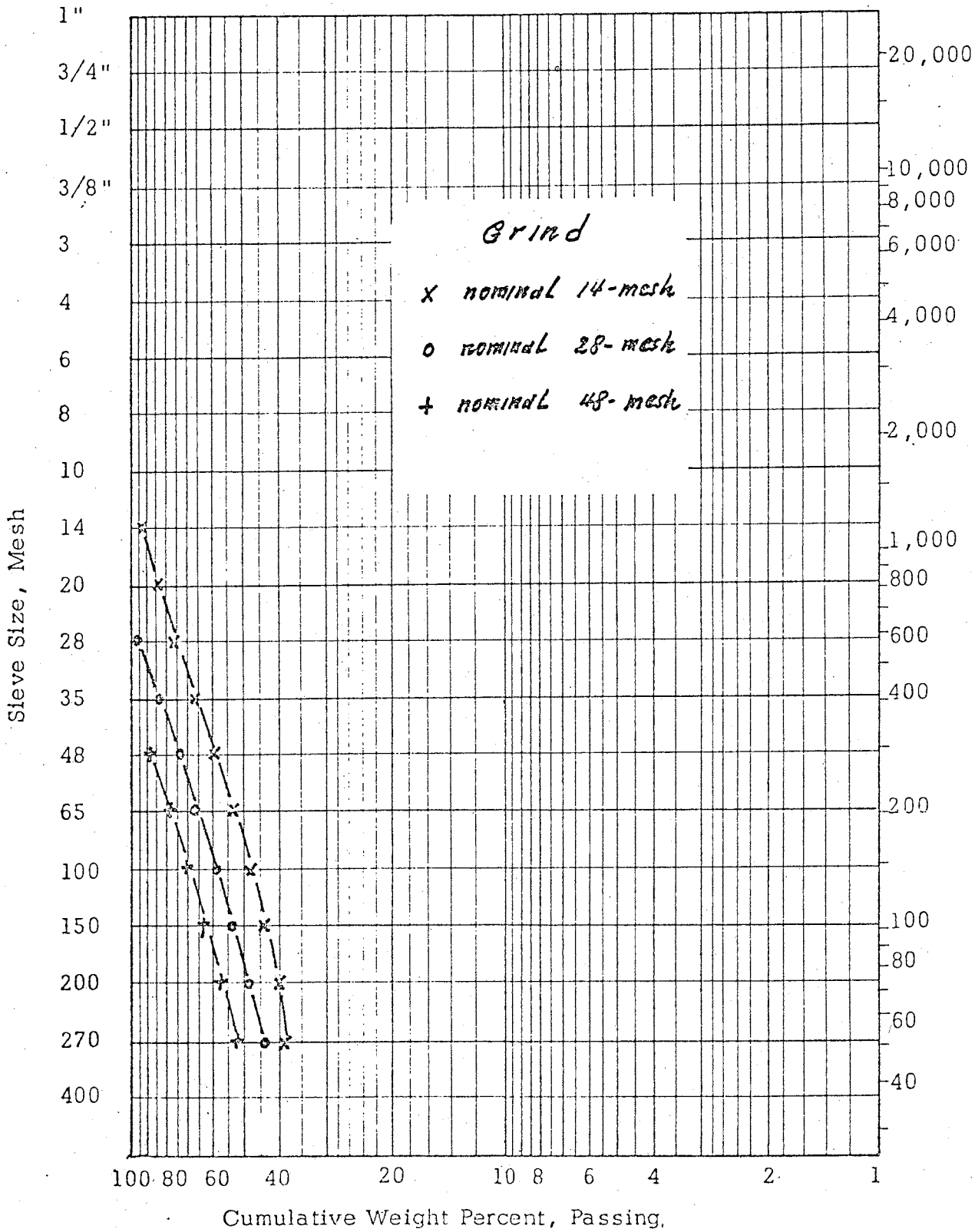
Temperature, °C
Middle Zone
Uranium: $r^2 = 0.40$



Temperature, °C
Lower Zone
Uranium: $r^2 = 0.59$

Figure 16

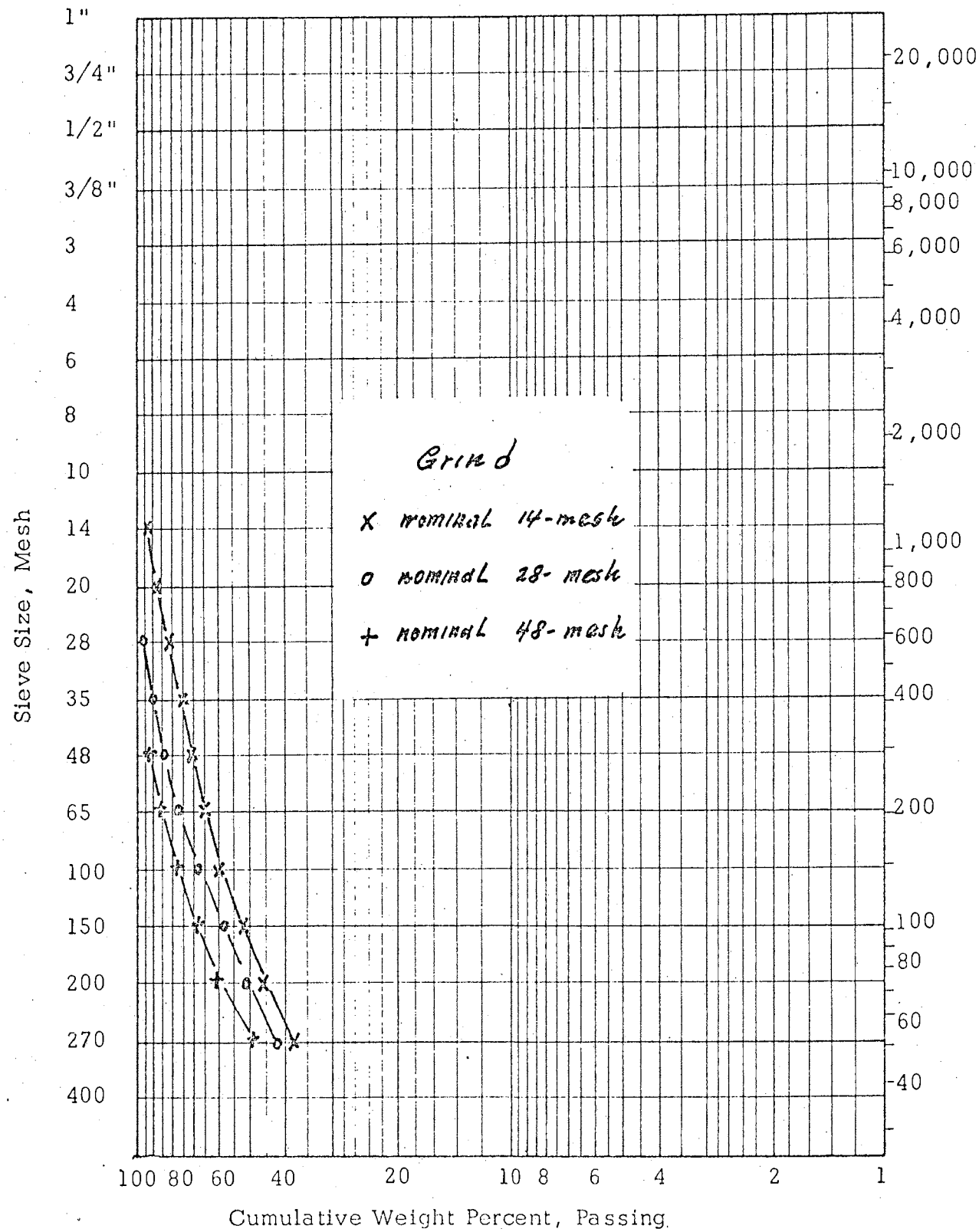
Screen Analysis of Middle Zone
Anderson Mine Composite



hri 50-23, 2/75

Figura 1

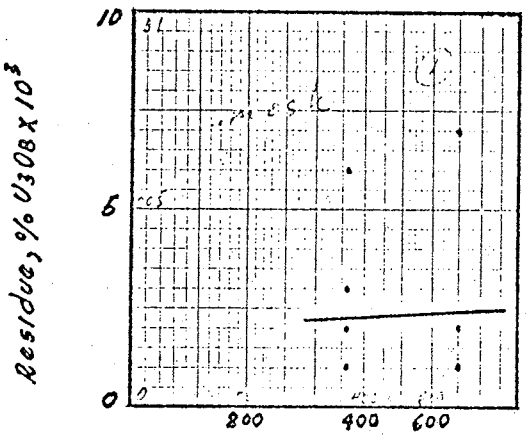
Screen Analysis of Lower Zone
Anderson Mine Composite



hri 50-23, 2/75

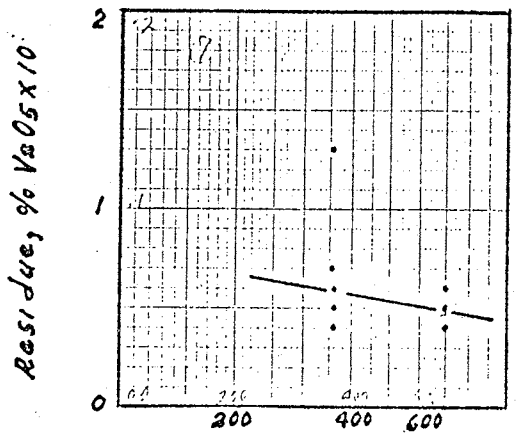
Figure 2

Effect of Grind on Leaching of Anderson Mine Composites



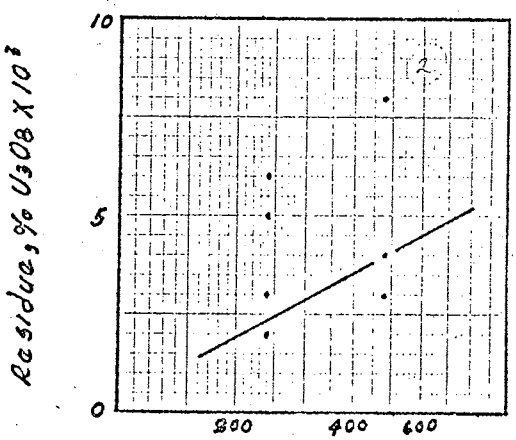
Middle Zone

Uranium: $r^2 = 0.0005$



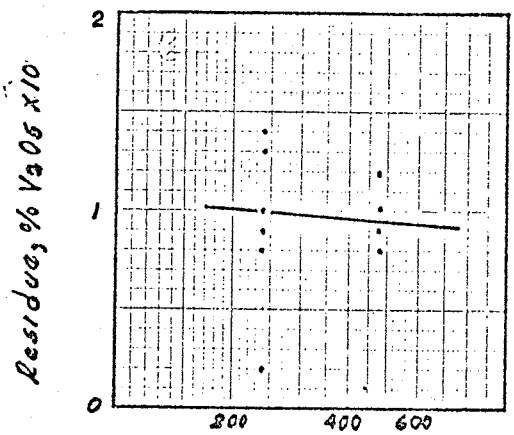
Middle Zone

Vanadium: $r^2 = 0.06$



Lower Zone

Uranium: $r^2 = 0.04$



Lower Zone

Vanadium: $r^2 = 0.01$

Figure 6

URANGESELLSCHAFT
U.S.A., Inc.

6000 East Evans Avenue
Building 3, Suite 200
Denver, Colo. 80222
Telephone (303) 753-0411
Telex 45-951 UGD DVR

Mr. Dean Soderstrom
Minerals Exploration Co.
Box 50324
Tucson, Az 85705

July 7, 1978

SUBJECT:

Dear Dean:

For your information and files, I am forwarding the latest Hazen report concerning the Date Creek Project cores. Included are analytical data from the five core intervals taken during our Spring, 1978 drilling program. These cores are a bit complex with respect to the carbon and carbonate values. At this time we are considering separate tests for each of the five core intervals and/or selected composites. Both acid and alkaline leaching should be done. Intervals with both high carbon and high carbonate values are particularly troublesome.

Any suggestions would be appreciated.

Sincerely,

David C. Hertzke
Project Manager

DCH:slk

Enclosure

7-10-78

Dave Hetzke -

B horizon ore only with a 0.04% cutoff
10,900,000 lb reserve @ an average grade of 0.089% U_3O_8

The other horizons with an .04 cutoff will give 4-6 x 10^6 additional lbs.

These are preliminary figures

UG-MX

Parameters costs etc

Cases theirs ours extra Equipment

2000 Ton/day

1500 Ton/day

2500 Ton/day

Case Independent Increment

MinX	UG	Total/Tons	Years
2000	—	2000	10
2000	2000	2000	10+x
1500	500	2000	10+x
2000	500	2500	10+x

Mill Costs Acids from Dean 2 Numbers

Memorandum
Union Oil Company of California
UNION

MEMO TO: J. A. Abramo

DATE: May 3, 1978

FROM: D. J. Soderstrom

SUBJECT: UG Metallurgical Test Data

From information received from UG the Tonto 5 drill hole is the only hole which should be used for predicting metallurgical performance of their ore in our circuit. From data received Tonto 5 went into the test sample marked "Composite 1". There were a total of 4 composities prepared from various drill holes. The calculated composite assays are compared below with the actual reported assays.

	CALCULATED ASSAYS			ACTUAL ASSAYS		
Composite	U_3O_8	CO_2	Corg	U_3O_8	CO_2	Corg
1	.0896	0.75	4.21	.044	21.80	-
2	.0483	7.90	.095	.036	7.11	-
3	.0439	17.55	.1275	.030	0.70	3.5
4	.0396	24.03	4.49	.056	14.50	1.7

From the data presented in some of the report, Tonto 5 is identified as a high organic carbon low carbonate interval. Obviously the interval could not have gone into composite 1. When pressed for further information it was stated that it was felt that Tonto 5 had actually been put into Composite 3 but that it could not be verified.

Acid additions to the 4 composites varied from 147 to 1180 lbs/ton of ore. An oxidant addition of 4 lbs/ton was adequate in all cases. Hazen was requested to give acid and oxidant requirements to use for estimated processing costs. The following figures were supplied and they are the basis for the costs on the attached memo.

Sulphuric Acid 600 to 900 lbs/ton

Sodium Chlorate 4 lbs/ton

DJS/m

Memorandum

Union Oil Company of California

UNION 76

MEMO TO: J. A. Abramo

DATE: April 24, 2978

FROM: D. J. Soderstrom

SUBJECT: Milling of UG Ore

Based on reagent consumptions received from John Litz this date, direct milling cost of the ore through the Anderson Mill circuit will range from $17.17/ton minimum to $21.67/ton maximum. This cost is based upon the assumption that no major change will be made in the tailings disposal system in order to handle the toll ore.

DJS/m

HAZEN RESEARCH, INC.

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

June 28, 1978

Mr. David Hertzke
Urangesellschaft, U.S.A., Inc.
Building 3, Suite 200
6000 East Evans Avenue
Denver, Colorado 80222

RECEIVED
JUN 30 1978

Re: HRI Project 4441
Uranium Extraction from Date Creek Ore

Dear David:

The percolation leach on the Date Creek composite has been terminated. The results are listed in Table 1. The ore was leached using a recirculating solution of 5 g/l sulfuric acid. It appears from the data that up to 70% of the uranium was solubilized during the first few volumes of solution. This probably was due to the formation of carbonic acid, which solubilized and held the uranium in solution as the carbonate complex. During this period, the flow through the column was fairly good, 0.2 gal/day/ft^2. The flow then dropped to less than 0.1 gal/day/ft^2 and the uranium content of the effluents decreased to about 5 ppm.

No increase in the uranium content of the effluent was achieved for about 45 days during which time the acid addition had increased from about 300 lb/ton to almost 700 lb/ton of ore. At this point the effluent pH had dropped to almost 2.0 and the soluble uranium had increased to 111 ppm U_3O_8. The test was terminated with this sample, so I do not know if additional volumes would have increased the solubilization further. The column residue contained 0.03% U_3O_8, indicating an overall solubilization of 79%.

It would appear that heap leaching would be a method of salvaging some return from ores too low for conventional processing. However, the low recovery (70%) probably would not provide sufficient cash flow to support the mining and other costs. Some other techniques to enhance the flow rate were tested, but showed negative results.

Also enclosed are the analyses for the five drill core intervals received May 12. Included are fluorimetric U_3O_8 and CO_2 analyses for each interval, organic carbons for the ore zone intervals, plus some others, and radiometric uranium, core moisture, core specific gravity, and core density for each ore zone plus some intervals above and below the ore zones.

The results from the seven ore zones which indicate widely varying ore types.

DC 28C, 488-499	6.6% $CaCO_3$, 1% C. Light density, high limestone at the top and a lignite interval at the bottom.
DC 28C, 516-520	0.1% $CaCO_3$, 3.8% C. Light density, lignitic with very low limestone.
DC 60C, 896-902	2.3% $CaCO_3$. Carbon analysis in progress. Low in both limestone and lignite.
DC 77C, 584-590	48% $CaCO_3$, 4.4% C. Moderately heavy, high limestone at the top and very light, high U_3O_8 lignite at the bottom.
DC ~~84~~ 81C, 754-760	21% $CaCO_3$, 5% C. Light density with adjacent limestone and lignite intervals at center of the zone.
DC ~~84~~ 81C, 764-770	13% $CaCO_3$, 3.7% C. Very light density, high grade, high lignite with a moderate limestone content.
DC 102C, 1029-1041	45% $CaCO_3$, 0.5% C. Moderately dense limestone with very low carbon content.

The generally high limestone content of all intervals indicates that acid leaching would probably not be economical. The average for the zones is 19% $CaCO_3$ indicating a minimum acid addition to neutralize the limestone of 400 lb H_2SO_4 per ton of ore. The high lignite content, 2.6% C, would present significant soluble organic problems with any alkaline leach. Therefore, I

would recommend that any metallurgical evaluation of these core intervals include both acid leaching and roasting followed by alkaline leaching.

Since the seven intervals are quite different, all of them should be evaluated by each method of processing. We have treated similar samples by both processes on previous projects, so the conditions for the tests can be standardized as follows:

Acid Leach	28-mesh, 50% solids, 60°C, 6 hours, 0.8-1.0 pH with 1-2 lb/ton $NaClO_3$.
Alkaline Leach	350°C roast for 2 hours on 4-mesh ore, 80°C 40% solids, 16-hour leach on 35-mesh calcines using oxygen and 50 g/l Na_2CO_3-$NaHCO_3$ lixiviant.

The estimated charges for the acid leaches are $1,750 and the estimated charges for the roast-alkaline leaches are $2,450. Preparation of the composites for leaching and roasting would bear about $400 in charges. The total for the tests, plus reporting, should be less than $5,000.

The above program could be completed within about four weeks of authorization and would give a fairly good indication of the most economical process to pursue for the treatment of the Date Creek ores. If you have any questions, or desire a more formal proposal, please do not hestitate to call.

Yours truly,

HAZEN RESEARCH, INC.

John E. Litz

John E. Litz
Project Manager

JEL:mgp
Enclosures

Attachment to Letter
Mr. David Hertzke

June 28, 1978

Table 1

Acid Percolation Leach of Date Creek Ore

Lixiviant: 5 g/l H_2SO_4; Feed: 1200 g, 0.082% U_3O_8

Date	Sample	Volume ml	Fluid Conduct. gal/day ft^2	Volume Cum ml	Gal per Ton	Addition lb/ton H_2SO_4	pH	emf	U_3O_8 g/l	U_3O_8 Extraction %
4-11	0					33.33				
12	1	1885	0.27	1885	377	176.76	6.29	-	0.110	≤25
13	2	1810	0.26	3695	739	285.00	6.48	+110	0.042	≤34
14	3	1000	0.14	4695	939	318.33	6.74	+125	0.104	≤47
17	4	1600	0.23	6295	1259	351.67	6.42	-25	0.120	≤70
20	5	1020	0.08	7315	1463	378.33	6.65	-40	0.0059	
24	7	1130	0.04	8445	1689	408.33	6.82	-70	0.0056	
27	8	860	0.04	9305	1861	428.33	6.50	-60	0.0044	
5-1	9	1440	0.04	10745	2149	477.33	6.47	-55	0.0033	
4	10	1220	0.06	11965	2393	486.33	6.54	-55	0.0048	
10	11	2360	0.06	14325	2865	536.00	6.35	-30	0.0051	
12		1570	0.11	15895	3179	568.83	6.23	-5		
15		1570	0.08	17465	3493	576.17	6.02	+5		
18		1840	0.09	19305	3861	611.83	4.74	-		
22		1480	0.05	20785	4157	641.00	4.93	+130		
24	12	1640	0.12	22425	4485		2.53	+360	0.013	
26	14	1320	0.10	23745	4749	659.33	2.28	-	0.007	
30	16	1200	0.04	24945	4989	684.67	2.38	+335	0.0055	
6-6	19	2200	0.05	27145	5429		2.08	+380	0.111	79
		1112 g							0.03%	

hri

Uranium Analyses of Core Number: DC-28-C
HRI No. 13455-1 through 25

HRI Sub No.	Interval ft	% U_3O_8 Fluori-metric	Beta-Gamma	Beta-Equiv.	Gamma Equiv.	Sealed Gamma Equiv.	% Radon Loss	% CO_2	% Organic	% Moisture	Specific Gravity	Density ft^3/ton
1	470-471	0.002						19.2	0.20			
2	471-472	0.001						0.25	0.10			
3	472-473	0.001						24.9	0.03			
4	473-474	0.002						12.6	0.58			
5	474-475	<0.001						5.89	0.12			
6	475-476	<0.001						0.30	0.08			
7	476-477	<0.001						0.05	0.04			
8	477-478	0.002						3.82	0.03			
9	478-479	0.001						1.52	0			
10	479-480	0.006						0.36	0			
11	480-481	<0.001						0.09	0.05			
12	481-482	<0.001						0.30	0.04			
13	482-483	<0.001						0.50	0.06			
14	483-484	<0.001						1.09	0.23			
15	484-485	<0.001						3.53	0.02			
16	485-486	0.001						8.80	0.28			
17	486-487	0.004	<0.01	0.008	0.009	0.009	0	10.7	0.03	6.0	1.87	17.1
18	487-488	0.003						6.09	0.03			
19	488-489	0.004	<0.01	0.005	0.005	0.013	62	5.39	0.06	8.6	1.89	16.9
20	489-490	0.007	<0.01	0.013	0.019	0.027	30	7.30	0.06	13.5	1.87	17.1
21	490-491	0.138	0.17	0.133	0.114	0.122	7	12.1	0.13	4.2	2.16	14.8
22	491-492	0.380	0.52	0.330	0.226	0.240	6	6.19	0.23	15.6	1.82	17.5
23	492-493	0.024	0.05	0.042	0.038	0.049	22	0.13	0.06	7.1	1.76	18.1
24	493-494	0.014	0.02	0.013	0.010	0.018	44	0.08	0.16	14.5	1.67	19.1
25	494-495	0.014	0.02	0.009	0.006	0.013	54	0.05	0.35	10.1	1.71	18.8

1.24

hri

Uranium Analyses of Core Number: DC-28-C
HRI No. 13455-26 through 50

HRI Sub No.	Interval ft	% U_3O_8 Fluorimetric	% U_3O_8 Beta-Gamma	% U_3O_8 Beta-Equiv.	% U_3O_8 Gamma Equiv.	% U_3O_8 Sealed Gamma Equiv.	% Radon Loss	% CO_2	% Organic	% Moisture	Specific Gravity	Density ft^3/ton
26	495-496	0.009	0.01	0.007	0.004	0.011	64	0.05	0.39	13.0	1.68	19.1
27	496-497	0.012	0.01	0.011	0.012	0.018	33	0.06	0.70	6.8	1.65	19.4
28	497-498	0.045	0.05	0.039	0.032	0.036	11	0.06	9.01	14.6	1.55	20.7
29	498-499	0.005	<0.01	0.005	0.005	0.009	44	0.05	0.64	6.7	1.97	16.2
30	499-500	0.007							0.39			
31	500-501	0.005	<0.01	0.005	0.009	0.009	0	4.29	0.39			
32	501-502	0.004						1.01	0.31			
33	502-503	0.012						0.08	0.14			
34	503-504	0.016						5.91	0.22			
35	504-505	0.012						4.10	0.54			
36	505-506	0.013						2.15	0.47			
37	506-507	0.010						1.65	0.26			
38	507-508	0.019						6.01	0.27			
39	508-509	0.047						28.1	1.02			
40	509-510	0.011						2.71	1.83			
41	510-511	0.010						1.49	0.73			
42	511-512	0.010						1.24	0.62			
43	512-513	0.008						11.9	0.72			
44	513-514	0.008						0.11	0.38			
45	514-515	0.008	<0.01	0.009	0.009	0.009	0	0.09	0.19			
46	515-516	0.012						0.10	0.39			
47	516-516.4	0.012	<0.01	0.011	0.012	0.018	33	0.07	2.70	8.2	1.75	18.3
48	516.4-517.4	0.014	0.02	0.012	0.009	0.013	31	0.05	0.43	6.2	1.87	17.1
49	517.4-518.4	0.023	0.02	0.018	0.018	0.024	25	0.03	3.12	9.0	1.73	18.5
50	518.4-519.4	0.082	0.07	0.047	0.033	0.037	11	0.03	12.09	9.7	1.64	19.5

hri

Uranium Analyses of Core Number: DC-28-C
HRI No. 13455-51 through 63

HRI Sub No.	Interval ft	% U_3O_8 Fluori-metric	Beta-Gamma	Beta-Equiv.	Gamma Equiv.	Sealed Gamma Equiv.	% Radon Loss	% CO_2	% Organic	% Moisture	Specific Gravity	Density ft^3/ton
51	519.4-520.4	0.013						0.06	0.75	15.5	1.72	18.7
52	520.4-521.4	0.008						0.02	0.21			
53	521.4-522.4	0.005	<0.01	0.009	0.012	0.012	0	0.74	0.11			
54	522.4-523.4	0.006						0.75	0.22			
55	523.4-524.4	0.006						0.75	0.10			
56	524.4-525.4	0.006						0.73	0.07			
57	525.4-526.4	0.008						1.35	0.37			
58	526.4-527.4	0.007						1.52	0			
59	527.4-528.4	0.012						5.40	0.14			
60	528.4-529.4	0.011						9.65	0.13			
61	529.4-530.4	0.013						14.3	0.13			
62	530.4-531.4	0.007						12.1	0.18			
63	531.4-532.4	0.005						0.40	0.49			

Uranium Analyses of Core Number: DC-60-C
HRI No. 13455-64 through 88

HRI Sub No.	Interval ft	% U_3O_8 Fluori-metric	Beta-Gamma	Beta-Equiv.	Gamma Equiv.	Sealed Gamma Equiv.	% Radon Loss	% CO_2	% Organic	% Moisture	Specific Gravity	Density ft^3/ton
64	880-881	0.008						4.15	5.17			
65	881-882	0.004						0.38	1.03			
66	882-883	0.002						0.06	2.81			
67	883-884	0.004						0.10	5.03			
68	884-885	0.002						0.16	1.90			
69	885-886	<0.001						0.21	0.39			
70	886-887	<0.001						0.12	0.23			
71	887-888	<0.001						0.92	0.47			
72	888-889	<0.001						1.20	0.10			
73	889-890	<0.001						0.06	-			
74	890-891	0.004						0.12	-			
75	891-892	0.004						0.02	-			
76	892-893	0.022						0.02	-			
77	893-894	0.018						0.06	-			
78	894-895	0.003	<0.01	0.009	0.013	0.013	0	0.01	0.07	12.3	1.98	16.2
79	895-896	0.003						0.02	-			
80	896-897	0.005	<0.01	0.005	0.010	0.017	41	<0.01	-	1.4	2.02	15.8
81	897-898	0.009	<0.01	0.014	0.018	0.025	28	0.03	-	1.6	1.82	17.6
82	898-899	0.144	0.16	0.121	0.103	0.111	7	0.72	-	5.0	1.83	17.5
83	899-900	0.123	0.13	0.119	0.113	0.124	9	2.46	-	10.2	1.87	17.1
84	900-901 1/	0.053	0.05	0.046	0.042	0.050	16	2.43	-	1.3	2.07	15.5
85	901-902	0.005	<0.01	0.011	0.022	0.026	15	0.27	-	3.6	1.87	17.1
86	902-903	0.003						0.93	-			
87	903-904	<0.001	<0.01	0.006	0.008	0.008	0	3.87	0.14	1.3	1.92	16.7
88	904-905	0.001						9.25	0.12			

1/ Some core loss between 900-905 feet. Intervals listed ignore any loss of core.

hri

Uranium Analyses of Core Number: DC-60-C
HRI No. p3455078 through 91

HRI Sub No.	Interval ft	% U_3O_8 Fluori-metric	Beta-Gamma	Beta-Equiv.	Gamma Equiv.	Sealed Gamma Equiv.	% Radon Loss	% CO_2	% Organic	% Moisture	Specific Gravity	Density ft^3/ton
89	905-906	0.002						8.42	0.11			
90	906-907	0.003						0.61	0.16			
91	907-908	0.002						1.29	0			

Uranium Analyses of Core Number: DC-77-C
HRI No. 13455-92 through 116

HRI Sub No.	Interval ft	% U_3O_8 Fluorimetric	Beta-Gamma	Beta-Equiv.	Gamma Equiv.	Sealed Gamma Equiv.	% Radon Loss	% CO_2	% Organic	% Moisture	Specific Gravity	Density ft^3/ton
92	560-561	<0.001						2.17	0.33			
93	561-562	<0.001						18.7	0.03			
94	562-563	<0.001						4.60	0.05			
95	563-564	<0.001						1.67	0			
96	564-565	0.001						10.2	0.06			
97	565-566	0.001						20.5	2.10			
98	566-567	0.001						10.8	0.35			
99	567-567.6	0.003						23.0	2.01			
100	567.6-568.6	<0.001						17.0	0.36			
101	568.6-569.6	<0.001						1.75	0.50			
102	569.6-570.6	0.004						2.92	0.02			
103	570.6-571.6	<0.001						10.2	0.28			
104	571.6-572.6	<0.001						14.7	0.28			
105	572.6-573.6	<0.001						55.5	3.89			
106	573.6-574.6	0.002						28.8	3.27			
107	574.6-574.10	<0.001						25.2	4.58			
108	574.10-575.10	<0.001						27.8	2.92			
109	575.10-576.10	<0.001						25.2	3.61			
110	576.10-577.10	<0.001						28.5	-			
111	577.10-578.10	0.001						23.7	-			
112	578.10-579.10	0.001						1.55	-			
113	579.10-580.10	0.003						18.3	-			
114	580.10-581.10	0.002						33.2	-			
115	581.10-582	0.002						24.0	-			
116	582-583	0.004	<0.01	0.007	0.008	0.008		35.9	-	0.3	2.44	13.1

hri

Uranium Analyses of Core Number: DC-77-C
HRI No. 13455-117 through 123

HRI Sub No.	Interval ft	% U_3O_8 Fluori-metric	Beta-Gamma	Beta-Equiv.	Gamma Equiv.	Sealed Gamma Equiv.	% Radon Loss	% CO_2	% Organic	% Moisture	Specific Gravity	Density ft^3/ton
117	583-584	0.004						32.3				
118	584-585	0.005	<0.01	0.002	0.004	0.006	60	35.7	2.20	2.2	2.27	14.1
119	585-586	0.007	<0.01	0.006	0.006	0.014	57	38.0	0.0	16.8	1.70	18.8
120	586-587	0.010	0.01	0.024	0.030	0.036	17	30.2	1.32	3.8	1.93	16.6
121	587-588	0.630	0.88	0.587	0.424	0.452	6	3.78	10.27	16.4	1.59	20.2
122	588-589	0.454	0.55	0.342	0.212	0.212	0	1.66	12.65	22.9	1.19	27.0
123	589-590	0.007	<0.01	0.015	0.020	0.026	23	17.3	0.23	11.3	1.77	18.0

1.49

hri

Uranium Analyses of Core Number: DC-81-C
HRI No. 13455-124 through 148

HRI Sub No.	Interval ft	% U_3O_8 Fluorimetric	Beta-Gamma	Beta-Equiv.	Gamma Equiv.	Sealed Gamma Equiv.	% Radon Loss	% CO_2	% Organic	% Moisture	Specific Gravity	Density ft^3/ton
124	750-751	0.002						0.44				
125	751-752	0.002						0.16				
126	752-753	0.006	<0.01	0.008	0.009	0.009	0	13.9		7.7	1.62	19.7
127	753-754	0.010						21.5				
128	754-755	0.003	<0.01	0.003	0.004	0.010	60	7.89	0.08	9.5	1.77	18.1
129	755-756	0.006	<0.01	0.008	0.008	0.008	0	2.67	0.13	5.9	1.94	16.5
130	756-757	0.025	0.02	0.014	0.012	0.016	25	31.6	0.64	5.9	1.99	16.1
131	757-758	0.047	0.07	0.064	0.060	0.060	0	0.45	18.68	16.1	1.66	19.2
132	758-759	0.025	0.03	0.022	0.019	0.019	0	1.13	2.99	4.8	1.81	17.7
133	759-760	0.015	0.02	0.023	0.024	0.032	25	13.1	7.39	17.2	1.48	21.6
134	760-761	0.013						29.3				
135	761-762	0.004	<0.01	0.004	0.007	0.007	0	10.9		2.4	1.66	19.3
136	762-763	0.005	<0.01	0.005	0.008	0.008	0	20.5		3.7	2.07	15.5
137	763-764	0.001						23.3				
138	764-765	0.006	<0.01	0.021	0.028	0.035	20	6.19	≈0.03	5.3	1.99	16.1
139	765-765.6	0.565	0.62	0.346	0.195	0.201	3	10.5	2.63	12.3	1.89	16.9
140	765.6-766.6	0.230	0.30	0.194	0.137	0.152	10	11.5	1.93	3.2	1.76	18.2
141	766.6-767.6	0.264	0.34	0.220	0.157	0.167	6	4.86	10.21	22.3	1.25	25.6
142	767.6-768.6	0.116	0.13	0.097	0.078	0.078	0	0.17	7.18	22.5	1.44	22.2
143	768.6-769.6	0.013	0.02	0.024	0.031	0.031	0	0.56	0.20	3.3	1.77	18.1
144	769.6-770.6	0.012						0.95				
145	770.6-771.6	0.008	<0.01	0.012	0.016	0.016	0	1.35		2.4	1.81	17.7
146	771.6-772.6	0.008						1.52				
147	772.6-77.3	0.010						7.97				
148	773-774	0.014						2.21				

.83

1.8

hri

Uranium Analyses of Core Number: DC-81-C
HRI No. 13455-149 through 154

HRI Sub No.	Interval ft	% U_3O_8 Fluori-metric	Beta-Gamma	Beta-Equiv.	Gamma Equiv.	Sealed Gamma Equiv.	% Radon Loss	% CO_2	% Organic	% Moisture	Specific Gravity	Density ft^3/ton
149	774-775	0.004						2.26				
150	775-776	0.007						4.60				
151	776-777	0.001						2.84				
152	777-778	<0.001						4.47				
153	778-779	<0.001						46.4				
154	779-780	0.004						17.7				

Uranium Analyses of Core Number: DC-102-C
HRI No. 13455-155 through 179

HRI Sub No.	Interval ft	% U_3O_8 Fluori-metric	Beta-Gamma	Beta-Equiv.	Gamma Equiv.	Sealed Gamma Equiv.	% Radon Loss	% CO_2	% Organic	% Moisture	Specific Gravity	Density ft^3/ton
155	1010-1011	0.002						6.45				
156	1011-1012	0.014						39.6				
157	1012-1013	0.008						21.3				
158	1013-1014	0.003						1.91				
159	1014-1015	0.002						19.4				
160	1015-1016	0.003						6.62				
161	1016-1017	0.003						8.01				
162	1017-1017.6	0.002						0.24				
163	1017.6-1018.6	0.011						13.2				
164	1018.6-1019.6	0.012						9.63				
165	1019.6-1020.6	0.001						5.51				
166	1020.6-1021.6	0.001						1.30				
167	1021.6-1022.6	0.002						0.18				
168	1022.6-1023.6	0.011						0.26				
169	1023.6-1024.6	0.001						1.02				
170	1024.6-1025.6	0.004						2.32				
171	1025.6-1026.6	0.011						8.63				
172	1026.6-1027.6	0.001	<0.01	0.007	0.008	0.008	0	0.17		9.5	1.82	17.6
173	1027.6-1028.6	0.006						7.81				
174	1028.6-1029.6	0.017	0.01	0.019	0.021	0.032	34	25.9	1.16	5.5	1.84	17.4
175	1029.6-1030.6	0.044	0.06	0.047	0.037	0.050	26	28.7	0.90	2.8	2.12	15.1
176	1030.6-1031.3	0.138	0.16	0.150	0.143	0.158	9	26.3	0.39	2.6	2.09	15.3
177	1031.3-1032.3	0.338	0.43	0.303	0.231	0.235	2	13.5	0.47	5.6	1.92	16.7
178	1032.3-1033.3	0.191	0.23	0.194	0.169	0.169	0	18.6	0.0	13.8	1.81	17.6
179	1033.3-1034.3	0.046	0.05	0.063	0.073	0.073	0	10.5	0.12	10.8	1.80	17.8

hri

Uranium Analyses of Core Number: DC-102-C
HRI No. 13455-180 through 197

HRI Sub No.	Interval ft	% U_3O_8 Fluorimetric	Beta-Gamma	Beta-Equiv.	Gamma Equiv.	Sealed Gamma Equiv.	% Radon Loss	% CO_2	% Organic	% Moisture	Specific Gravity	Density ft^3/ton
180	1034.3-1035.3	0.048	0.04	0.049	0.051	0.051	0	23.3	1.85	12.3	1.82	17.6
181	1035.3-1036.3	0.059	0.05	0.060	0.065	0.065	0	29.1	0.0	5.3	1.91	16.8
182	1036.3-1037.3	0.051	0.03	0.066	0.092	0.092	0	26.0	1.44	10.4	1.83	17.5
183	1037.3-1038.3	0.017	<0.01	0.037	0.099	0.099	0	10.4	0.24	10.1	1.76	18.2
184	1038.3-1038.11	0.026	<0.01	0.037	0.097	0.097	0	9.70	0.15	9.4	1.74	18.4
185	1038.3-1039.11	0.031	<0.01	0.044	0.100	0.100	0	17.5	0.24	5.5	1.78	18.0
186	1040.11-1041.11	0.017	<0.01	0.037	0.105	0.105	0	18.4	0.34	6.2	2.08	15.4
187	1041.11-1041.11	0.027	<0.01	0.032	0.093	0.093	0	20.1	0.28	10.8	1.74	18.4
188	1041.11-1042.11	0.016						12.4				
189	1042.11-1043.11	0.006	0.01	0.010	0.012	0.012	0	5.86		7.1	1.92	16.6
190	1043.11-1044.11	0.004						12.5				
191	1044.11-1045.11	0.012						15.3				
192	1045.11-1046.11	0.010						19.9				
193	1046.9-1047.9	0.012						23.2				
194	1047.9-1048.9	0.010						18.2				
195	1048.9-1049.9	0.008						16.5				
196	1049.9-1050.9	0.008						20.8				
197	1050.9-1051.10	0.008						22.5				

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HAZEN RESEARCH, INC.

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

May 4, 1978

Mr. David Hertzke
Urangesellschaft, U.S.A., Inc.
Building 3, Suite 200
6000 East Evans Avenue
Denver, CO 80222

Re: HRI Project 4441
Uranium Extraction from Date Creek Ore

Dear David:

Pieces of core from 26 intervals were measured to determine the ore density. The results are shown in Table 1. The mean density was 17.0 cu ft/ton with a standard deviation of 1.7 cu ft/ton. The densities ranged from 14.1 to 20.9 cu ft/ton. Most of the higher uranium grade intervals had pieces which were high density.

A linear, least-squares fit was made of the uranium grade versus the density. The curve had a coefficient of determination (r^2) of 0.28, which is not too good a fit, but shows some correlation. The formula for the curve is:

$$\% \ U_3O_8 = 0.79 - 0.04 \ (\text{cu ft/ton}).$$

Solutions of the formula at 14 and 20 cu ft/ton show uranium grades of minus 0.001 and 0.24% U_3O_8 respectively.

The density values indicate that calculation of the ore reserves will be very complicated. It might be beneficial to obtain uranium values for the specific pieces of core used for the densities, to either simplify or further complicate the ore reserve calculations.

Leaching studies on a composite of the four cores have begun. The composite consists of one-half the reject pulp from each interval supplied. The analysis of the ore composite is shown in Table 2. The high carbon dioxide value indicates 33.5% $CaCO_3$ equivalent.

Four acid and three alkaline agitation leaches have been completed. The tests are summarized in Table 3, and data sheets are attached. The results indicate uranium solubilizations of >90% with acid additions of >850 lb/ton. The alkaline leach solubilizations are only 81-82%.

Two heap leach tests have been started. The first is a conventional test using a 10-15 g/l H_2SO_4 solution. At this point, about 480 lb/t acid has been added to the ore. The effluent pH is 6.5. The first few volumes of the ore contained up to 120 ppm U_3O_8. Although no balance was attempted, the indication is that 60% of the uranium solubilized due to carbonate ions being formed during the leach. The 60% value was achieved with an acid addition of less than 250 lb/ton. The last few volumes have contained only 3-6 ppm U_3O_8 and I do not anticipate any improvement until the acid addition approaches 700-800 lb/ton.

The second leach was started May 3 and is using an acid pug of the ore with 600 lb/ton H_2SO_4 prior to starting the heap leach. Considerable CO_2 evolution was evident when percolation of solution through the heap started, so it may be that a longer cure of the pugged material would be necessary.

At this point, I see little value in continuing agitation leaches as the results are quite predictable. If additional leaches were performed, there would be some value in using the pulps as feed for thickening tests. However, unless you are confident that the cores are "representative," the data from such tests may not be of significant value.

The poor settling and filtering characteristics of the ore indicate that Resin-in-Pulp recovery of the solubilized uranium may be the most feasible in terms of capital and operating costs. Hazen recently has performed some cost analyses which show economic advantage to Resin-in-Pulp systems. Study of Resin-in-Pulp recovery from the Date Creek ore may be premature at this point; however, we feel at some point it should be considered.

The results of the heap leaches will be transmitted as soon as available. Unfortunately, heap leaching is a time consuming process, but it is inexpensive.

Yours truly,

HAZEN RESEARCH, INC.

John E. Litz

John E. Litz
Project Manager

JEL/skb
cc: Dean Soderstrom
Minerals Exploration Company
Box 50324
Tucson, AZ 85705

Table 1

Core Moisture and Density

Hole No.	Footage	% Moisture	Specific Gravity	Density ft^3/ton	% U_3O_8
DC-62-C	787-788	1.84	1.93	16.6	0.035
	788-789	1.34	2.28	14.1	0.210
	789-790	1.59	2.10	15.2	0.064
	799-800	4.98	1.54	20.8	0.024
	800-801	2.65	2.00	16.0	0.200
DC-56-C	861-862	4.43	1.79	17.9	0.094
	862-863	4.34	1.82	17.6	0.037
	865-866	2.19	1.76	18.2	0.118
	866-867	1.59	1.97	16.2	0.109
	869-870	1.37	1.93	16.6	0.041
	870-871	2.11	1.82	17.6	0.106
	871-872	1.27	2.00	16.0	0.057
DC-49-C	766-767	2.06	1.80	17.8	0.057
	767-768	3.39	1.81	17.7	0.218
	768-769	1.46	1.96	16.3	0.015
	771-772	1.10	1.75	18.3	0.020
	772-773	0.38	2.21	14.5	0.251
	773-774	0.89	1.76	18.2	0.034
DC-33-OC	652-653	1.37	1.72	18.6	0.042
	653-654	1.26	2.08	15.4	0.250
	654-655	0.61	2.15	14.9	0.450
	655-656	0.92	1.80	17.8	0.064
	659-660	0.88	1.98	16.2	0.019
	661-662	0.52	2.04	15.7	0.059
	662-663	0.45	1.76	18.2	0.125
	663-664	0.49	1.53	20.9	0.046

Table 2

Date Creek Composite
(1053-14-0)

Chemical	
U_3O_8	0.028
V_2O_5	0.02
CO_2	14.7
X-ray Fluorescence	
Cu	0.004
Zn	0.006
Pb	0.003
As	0.005
Fe	0.87
Ni	0.003
Rb	0.010
Ba	0.062
Sr	0.13
Zr	0.035
Mo	0.005
Mn	0.024
Yt	0.005

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Table 3

Summary of Acid and Alkaline Leaches
(0.082% U_3O_8, 40% Solids, 28-mesh Grind)

No.	Temp °C	Time hrs	H_2SO_4 Added	lb/ton Consumed	$NaClO_3$ lb/ton Added	H_2SO_4 g/l Residual	Residue % U_3O_8	Uranium Extraction, %
16	60	4	1040	910	3	28	0.006	94.1
17	75	24	1210	920	5	65	0.005	95.3
21	75	6	900	860	2	9.2	0.007	92.3
22	75	6	850	830	2	4.6	0.008	91.8

No.	Temp °C	Time hrs	Leach Concn, g/l		Na_2CO_3 lb/ton Consumed	Residue % U_3O_8	Uranium Extraction, %
			Na_2CO_3	$NaHCO_3$			
18	80	24	50	10	1	0.032	58.1
19	80	24	50	10 1/	49	0.016	82.0
20	80	24	50	10 2/	53	0.017	81.1

1/ With 20-40 cc/min oxygen bubbling.
2/ With 20-40 cc/min oxygen bubbling and $Cu(NH_3)_6SO_4$ catalyst.

URANIUM ACID LEACH AMENABILITY
No. 1053-16

Sample No. 1053-14-0 (28-mesh) | 0.082 %U_3O_8 | 0.02 %V_2O_5 | % | % | %

Conditions: 60 °C, 4 hr, 40 % solids

Data

Elapsed Time, min	Temp °C	pH Read	pH Adjusted	emf mv	H_2SO_4 Cum lb/ton	$NaClO_3$ Cum lb/ton
0	60	7.62	0.55	330	1,000	
5	60	0.58	0.55	330	1,040	
10	60			490		3
60	60	0.99		510		
120	60	0.60		495		
180	60	0.60		485		
240	60	0.61		485		

Metallurgical Balance

	Weight/ Volume	Uranium U_3O_8	H_2SO_4	V_2O_5		
Leach head						
%		0.082		0.02		
Grams	200	0.164		0.04		
Filtrate						
g/l		0.386	28.20	0.059		
Grams	205	0.079	5.8	0.012		
Wash						
g/l		0.154				
Grams	630	0.097	7.1	0.015		
Residue						
4 hour, %		0.006		0.01		
___ hour, %						
___ hour, %						
___ hour, %						
Grams	183.6	0.011		0.018		
Percent solubilized						
4 hour		94.1		59.5		
___ hour						
___ hour						
___ hour						
Calculated head, %		0.094		0.023		

Acid consumption, 910 lb/ton

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URANIUM ACID LEACH AMENABILITY
No. 1053-17

Sample No. 1053-14-0 — 0.082 % U_3O_8 — ____ %
____ — 0.02 % V_2O_5 — ____ %
____ — ____ % — ____ %

Conditions: 75 °C, 24 hr, 40 % solids

Data

Elapsed Time, hr	Temp °C	pH Read	pH Adjusted	emf mv	H_2SO_4 Cum lb/ton	$NaClO_3$ Cum lb/ton
0	60	7.62	0.50	370	1,210	5
1	60	0.15		585		
2	60	0.13		540		
3	65	0.43		520		
4	77	0.36		520		
5	80	0.87		515		
24	75	0.58		455		

Metallurgical Balance

	Weight/ Volume	Uranium U_3O_8	H_2SO_4	V_2O_5		
Leach head						
%		0.082		0.02		
Grams	200	0.164		0.04		
Filtrate						
g/l		0.411	64.73	0.091		
Grams	235	0.097	15.2	0.021		
Wash						
g/l		0.149				
Grams	605	0.090	14.1	0.020		
Residue						
24 hour, %		0.005		<0.001		
___ hour, %						
___ hour, %						
___ hour, %						
Grams	180.6	0.009		0.002		
Percent solubilized						
24 hour		95.3		95.8		
___ hour						
___ hour						
___ hour						
Calculated head, %		0.098		0.021		

Acid consumption, 920 lb/ton

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URANIUM ACID LEACH AMENABILITY
No. 1053-21

Sample No. 1053-14-0 (28-mesh) — 0.082 %U_3O_8, 0.02 %V_2O_5, ____ %

Conditions: 75 °C, 6 hr, ≈40 % solids

Data

Elapsed Time, hr	Temp °C	pH Read/Adjusted	emf mv	H_2SO_4 Cum lb/ton	$NaClO_3$ Cum lb/ton
0				900	2
1	70	1.11	440		
2	73	1.32	420		
3	73	1.40	405		
4	80	1.88	400		
6	80	1.95	380		

Metallurgical Balance

	Weight/ Volume	Uranium U_3O_8	H_2SO_4	V_2O_5		
Leach head						
%		0.082				
Grams	200	0.164				
Filtrate						
g/l		0.402	9.24	0.039		
Grams	155	0.062	1.4			
Wash						
g/l		0.167				
Grams	595	0.099	2.3			
Residue						
6 hour, %		0.007				
___ hour, %						
___ hour, %						
___ hour, %						
Grams	193.2	0.014				
Percent solubilized						
6 hour		92.3				
___ hour						
___ hour						
___ hour						
Calculated head, %		0.088				

Acid consumption, 860 lb/ton

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URANIUM ACID LEACH AMENABILITY
No. 1053-22

Sample No. 1053-14-0 (28-mesh) — 0.082 % U_3O_8 — ____ %
0.02 % V_2O_5 — ____ %
____ % — ____ %

Conditions: 75 °C, 6 hr, ≈40 % solids

Data

Elapsed Time, hr	Temp °C	pH Read/Adjusted	emf mv	H_2SO_4 Cum lb/ton	$NaClO_3$ Cum lb/ton
0				850	2
1	70	1.35	430		
2	73	1.40	410		
3	73	1.58	390		
4	80	2.10	370		
6	80	2.20	350		

Metallurgical Balance

	Weight/ Volume	Uranium U_3O_8	H_2SO_4	V_2O_5		
Leach head						
%		0.082				
Grams	200	0.164				
Filtrate						
g/l		0.460	4.56	0.030		
Grams	183	0.084	0.8			
Wash						
g/l		0.149				
Grams	600	0.089	0.9			
Residue						
6 hour, %		0.008				
___ hour, %						
___ hour, %						
___ hour, %						
Grams	195.1	0.016				
Percent solubilized						
6 hour		91.8				
___ hour						
___ hour						
___ hour						
Calculated head, %		0.095				

Acid consumption, 830 lb/ton

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URANIUM ALKALINE LEACH AMENABILITY
No. 1053-18

Sample No. 1053-14-0 0.082 % U_3O_8 _____ %
_____ 0.02 % V_2O_5 _____ %
_____ _____ % _____ %

Conditions: 80 °C _____ psi _____, 24 hr
40 % solids 50 g/l Na_2CO_3 10 g/l $NaHCO_3$

Filtrate: 10.08 pH -100 mv

Metallurgical Balance

	Weight/ Volume	Uranium U_3O_8	Na_2CO_3	$NaHCO_3$	V_2O_5	
Leach head						
%		0.082			0.02	
Grams	200	0.164			0.04	
Filtrate						
g/l		0.226	33.07	19.07	0.004	
Grams	200	0.045	6.6	3.8	0.0008	
Wash						
g/l		0.090				
Grams	430	0.039	5.7	3.3	0.0007	
Residue						
24 hour, %		0.032			0.02	
___ hour, %						
___ hour, %						
___ hour, %						
Grams	189.0	0.060			0.038	
Percent solubilized						
24 hour		58.1			3.8	
___ hour						
___ hour						
___ hour						
Calculated head, %		0.072			0.020	

Calculated soda ash consumption, 1 lb/ton Na_2CO_3

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URANIUM ALKALINE LEACH AMENABILITY
No. 1053-19

Sample No. 1053-14-0 0.082 % U_3O_8 _____ %

_____ _____ % _____ %

_____ _____ % _____ %

Conditions: 80 °C 20-40 cc/min O_2, 24 hr

40 % solids 50 g/l Na_2CO_3 10 g/l $NaHCO_3$

Filtrate: 10.06 pH -100 mv

Metallurgical Balance

	Weight/ Volume	Uranium U_3O_8	Na_2CO_3	$NaHCO_3$		
Leach head						
%		0.082				
Grams	200	0.164				
Filtrate						
g/l		0.462	29.15	15.02		
Grams	195	0.090	5.7	2.9		
Wash						
g/l		0.151				
Grams	350	0.053	3.3	1.7		
Residue						
24 hour, %		0.016				
___ hour, %						
___ hour, %						
___ hour, %						
Grams	195.7	0.031				
Percent solubilized						
24 hour		82.0				
___ hour						
___ hour						
___ hour						
Calculated head, %		0.087				

Calculated soda ash consumption, 49 lb/ton Na_2CO_3

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URANIUM ALKALINE LEACH AMENABILITY
No. 1053-20

Sample No. 1053-20-0 0.082 % U_3O_8 _____ %

(65-mesh) _____ % _____ %

_____ % _____ %

Conditions: 80 °C 20-40 cc/min O_2 1/, 24 hr

40 % solids 50 g/l Na_2CO_3 10 g/l $NaHCO_3$

Filtrate: 10.08 pH -110 mv

Metallurgical Balance

	Weight/ Volume	Uranium U_3O_8	Na_2CO_3	$NaHCO_3$		
Leach head						
%		0.082				
Grams	200	0.164				
Filtrate						
g/l		0.462	29.04	13.61		
Grams	185	0.085	5.4	2.5		
Wash						
g/l		0.151				
Grams	380	0.057	3.6	1.7		
Residue						
24 hour, %		0.017				
___ hour, %						
___ hour, %						
___ hour, %						
Grams	195.8	0.033				
Percent solubilized						
24 hour		81.1				
___ hour						
___ hour						
___ hour						
Calculated head, %		0.088				

Calculated soda ash consumption, 53 lb/ton Na_2CO_3

1/ With $Cu(NH_3)_6SO_4$ catalyst.