WEATHERING COAL MINE WASTE
ASSESSING POTENTIAL SIDE EFFECTS AT LUSCAR ALBERTA

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ABSTRACT

In some areas the accelerated weathering of material disturbed by coal mining operations releases toxic concentrations of elements present. Also, water seeping through the mine waste may become quite acid. Knowledge of these detrimental side effects has been a concern to those planning coal mining operations in Alberta.

A study was undertaken to determine if there is a potential for adverse side effects resulting from weathering mine waste derived from the Luscar Formation inthe Alberta foothills. Steps involved included:

- mapping geological stratigraphy and lithology
- taking a continuous core through a representative profile
- performing detailed geochemical analyses on the core

Chemical analyses were selected to reveal base conditions present in the overburden profile and the potential for change during weathering. Constituents identified included total sulphur, macro and micro nutrients, water soluble cations and anions, extractable cations, and trace elements. Key indicators such as neutralization potential, cation exchange capacity and sodium absorption ratio were also determined.

The analyses revealed that:

- the total sulphur content is very low so acid mine water will not be a problem
- only normal amounts of water soluble ions, extractable ions or trace elements were found. Consequently weathering is not likely to release toxic concentrations of these elements.

- sodium concentrations in the hanging wall materials which will be most affected by mining were found to be suitable for revegetation.

It is concluded that weathering of the material disturbed by mining will not have any harmful side effects. Consequently, from a geochemical point of view, waste materials may be placed in waste dumps in any order convenient to the mining program.

It is also concluded that the investigation program reported was appropriate to evaluate conditions at the Luscar Site. Detailed investigation programs required in the U.S. where adverse side effects do occur are not warranted in this area.

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1. INTRODUCTION

In some areas of the world weathering of mine waste has created adverse side effects by releasing toxic concentrations of certain elements or by creating acid mine water. Knowledge of these detrimental side effects has been a concern to those planning coal mining operations in Alberta.

An investigation was undertaken to determine potential side effects from weathering of the Luscar Formation in the Foothills region at Luscar, Alberta. The paper which follows describes the sampling and testing program undertaken, presents the results and interprets them. Detailed chemical analysis performed on representative samples formed the core of the program. Interpreted results compare favourably with observations at old waste dumps in the area.

2. SAMPLING PROCEDURES

The site geology was studied to identify a representative stratigraphic profile. A core hole was then drilled at that location and the core logged and sampled for chemical testing.

Samples were selected from the core in accordance with selection procedures outlined in Table 1.

TABLE 1 - SAMPLE SELECTION PROCEDURES

1. Each lithographical unit more than two feet thick sampled separately.

2. Sandstone - sample entire bed up to 20 feet thick
   - grab samples selected at 5 foot intervals combined to make a representative sample.

3. Siltstone/Shale - sample entire bed up to 10 feet thick
   - grab samples selected at 2 foot intervals combined to make a representative sample.

4. Strata of lesser thickness - samples taken at top middle and bottom combined to make a composite sample.

3. CHEMICAL TESTING PROGRAM

Each sample was subjected to chemical tests indicated in Table 2. It shows the chemical analyses performed, the basic test methods and the reason for each test.

Results of the chemical analyses are summarized in Table 3. For comparison a summary of normal and hazardous concentrations of micro nutrients and trace elements is shown in Table 4.

TABLE 2

DETAILED CHEMICAL TESTING PROGRAM

CHEMICAL PARAMETERS	PROPOSED ANALYTIC PROCEDURES	PURPOSES OF TESTING
TOTAL SULPHUR	Leco-Induction Furnace (Potassium Iodate Method)	a) Define sulphur concentration and project pyritic sulphur content. b) Establish an acid-base account.
NEUTRALIZATION POTENTIAL (ESTIMATE OF TOTAL CALCIUM CARBONATE)	Acid Titration	a) Define carbonate content. b) Establish an acid-base account.
pH	1:1 Paste + pH Meter	a) Define H^+ ion concentration. b) To be used in lime reclamation c) Evaluate pH conditions as favourable to vegetation.
MACRO-NUTRIENTS		a) Define levels.
NITROGEN (NO_3^{-2})	Nitrate-Specific Ion Electrode	b) Evaluate revegetation potential.
POTASSIUM (K)	Extract-Atomic Absorption	c) Fertilization recommendation
PHOSPHOROUS (P)	Olson-Bicarbonate Method	
MICRO-NUTRIENTS		
COPPER (Cu)	DPTA Extractable	a) Define levels.
ZINC (Zn)	DPTA Extractable	b) Evaluate revegetation potential.
LEAD (Pb)	DPTA Extractable	c) Fertilization recommendation.
IRON (Fe)	DPTA Extractable	
SALINITY (ELECTRICAL CONDUCTIVITY) E.C.	Conductivity Bridge	a) Define base levels. b) Revegetation significance and potential
WATER SOLUBLE CATIONS	Saturation Extract of Paste and	a) Define base levels.
CALCIUM (Ca^{+2})	Atomic Absorption	b) Prediction of mine effluent constituents.
MAGNESIUM (Mg)		
POTASSIUM (K)		c) To be used in determining Sodium
SODIUM (Na^+)	Flame Emission Method	Adsorption Ratios.
WATER SOLUBLE ANIONS	Saturation Extract of Paste	a) Define base levels.
SO_4^{-2}	Barium Chloride - Spectrophotometer	b) Predice mine effluent levels and
NO_3^{-2}	Nitrate - Electrode	pollution evaluation.
HCO_3	Acid Titration	c) To be used in interpreting presence
Cl	Chloride - Electrode	of major salts
CATION EXCHANGE CAPACITY (C.E.C.)	Ammonium Acetate Method	a) Define base levels b) Significance to revegetation potential c) To be used in calculating ESP* and/or SAR**
SAR and/or ESP	$SAR = Na^+/(\frac{Ca + Mg}{2})^{1/2}$ Na = Sodium, meq/l Ca = Calcium, meq/l Mg = Magnesium, meq/l ESP = $(Na_e^{***} - Na_s^{****})$ 100/C.E.C.*****	a) Define base levels. b) Predict reaction of clay to weathering. c) Revegetation potential.
* (ESP) - Exchangeable Sodium Percentage		
** (SAR) - Sodium Adsorption Ratio		
*** (Na_e) - NH_4OAc Extractable Sodium, meq/100g		
**** (Na_s) - Water Soluble Sodium, meq/100g		
***** (CEC) - Cation Exchange Capacity, meq/100g		
TRACE ELEMENT(S), CONTENT OF:		a) Define base levels.
MERCURY (Hg)	Flameless Absorption Method	b) Predict revegetation potential
LEAD (Pb)	Atomic Absorption Method	c) Predict mine effluent pollution
CADMIUM (Cd)	Atomic Absorption Method	
SELENIUM (Se)	Hot Water Soluble-Spectrophotometer	
BORON (B)	Hot Water Soluble-Spectrophotometer	
MOLYBDENUM (Mo)	Flameless Atomic Absorption	
NICKEL (Ni)	Atomic Absorption Method	

TABLE 3

RESULTS OF CHEMICAL ANALYSIS

LITHOLOGY	DEPTH INTERVAL (FEET)	SAMPLE INTERVAL (FEET)	TOTAL SULPHUR (ppm)	TOTAL SULPHUR AFTER ACID LEACH (ppm)	NEUTRALIZATION POTENTIAL (TONS OF $CaCO_3$ EQUIVALENT PER 1000 TONS OF SOIL)	MOISTURE SATURATION (%)	SOIL PASTE pH *	SOIL PASTE pH	CONDUCTIVITY OF SATURATION EXTRACT (millimhos/cm.)	WATER SOLUBLE CATIONS (MeQ/L) Ca	Mg	Na	K	EXTRACTABLE CATIONS (MeQ/100 gs) Ca	Mg	Na	K
SANDSTONE	8 - 28	5	263	215	40.5	49.5	8.2	8.2	0.50	1.18	1.65	2.07	0.51	17.53	3.40	1.32	0.59
SANDSTONE	28 - 48	5	378	NOT TESTED	75.6	45.2	8.3	8.1	0.53	1.13	1.02	2.34	0.51	34.80	5.35	1.19	1.02
SANDSTONE	48 - 68	5	363	NOT TESTED	159.	47.7	8.5	8.3	0.66	1.45	1.32	2.87	0.68	125.61	4.94	4.20	1.34
SANDSTONE	68 - 79.5	5	237	NOT TESTED	79.3	41.2	8.6	8.1	0.60	0.98	0.55	2.29	0.51	5.32	5.14	1.67	0.97
SHALE/SANDSTONE	79.5 - 82	T-M-B	304	219	138.	52.9	8.6	8.0	0.85	1.70	1.88	3.61	0.99	11.09	5.45	1.24	1.11
SHALE	82 - 83	T-M-B	311	245	68.8	44.7	8.5	8.1	0.54	1.01	1.20	1.99	0.63	10.17	4.84	0.87	0.98
SANDSTONE	83 - 94	5	326	230	76.8	49.7	8.0	8.1	0.57	1.20	1.28	1.62	0.83	22.55	6.17	0.72	1.20
SHALE/SANDSTONE	94 - 98.5	2	422	388	141.	57.8	8.5	8.0	0.67	1.78	2.14	2.00	0.74	12.75	7.82	0.74	1.24
SANDSTONE	98.5 - 103	5	274	NOT TESTED	221.	45.8	8.2	7.8	0.83	1.24	3.54	2.57	1.02	144.00	7.72	0.60	1.01
SHALE	103 - 104	T-M-B	703	NOT TESTED	50.8	56.0	8.3	7.9	0.63	1.79	1.91	1.49	0.82	9.87	5.57	0.62	1.19
SHALE	104 - 114	2	546	437	118.	59.7	8.0	7.9	0.62	1.40	1.66	1.69	0.77	13.11	7.61	0.65	1.07
SHALE	114 - 122	2	753	674	60.8	43.0	8.0	7.8	0.67	1.94	1.78	2.21	0.54	11.95	5.04	0.69	0.77
COAL	122 - 187	10	2919	2892	14.8	72.2	8.5	8.3	0.27	0.53	0.38	1.87	0.10	13.05	1.54	0.53	0.04
SANDSTONE	187 - 207	5	3292	NOT TESTED	2.5	48.5	7.7	6.4	1.45	7.02	5.51	1.81	0.87	1.30	1.91	0.61	1.09
SANDSTONE	207 - 227	5	1429	NOT TESTED	122.	47.8	8.5	7.7	1.31	5.57	7.32	2.03	1.36	25.37	15.23	0.71	1.17
SANDSTONE	227 - 247	5	820	813	141.	43.4	8.8	8.1	0.73	1.68	2.84	1.52	0.81	22.08	17.90	0.70	0.66
SANDSTONE	247 - 267	5	321	NOT TESTED	240.	48.0	8.3	8.4	1.10	1.14	4.12	1.58	3.21	86.40	34.16	0.92	1.95
SANDSTONE	267 - 278	5	2395	NOT TESTED	186.	49.0	8.8	8.1	1.16	1.73	2.84	3.74	2.91	53.06	32.92	1.54	1.78
SHALE	278 - 282	2	6299	6274	76.6	42.1	9.0	8.3	1.03	0.73	0.55	8.79	0.40	10.63	8.13	3.59	0.67
SANDSTONE	282 - 302	5	355	NOT TESTED	68.3	49.5	8.8	8.1	0.82	0.70	0.53	6.79	0.85	53.41	8.85	3.04	1.42
SANDSTONE	302 - 320	5	.856	NOT TESTED	124.	53.5	9.4	8.6	1.35	0.32	0.72	12.53	0.72	63.48	14.61	6.63	1.69
SANDSTONE/SILTSTONE	320 - 340	5	1190	1115	88.3	49.7	9.4	8.8	1.11	0.24	0.39	10.92	0.38	30.52	9.05	7.28	1.21
SANDSTONE/SILTSTONE	340 - 356	5	579	NOT TESTED	96.8	61.5	9.1	8.6	1.75	0.52	0.72	6.35	2.46	61.15	25.72	5.00	5.44
SANDSTONE	356 - 370	5	1217	NOT TESTED	185.	50.0	8.9	8.3	0.97	1.75	2.45	2.62	2.93	59.01	41.15	1.12	2.05
SILTSTONE/SANDSTONE	370 - 399	5	934	849	148.	59.9	8.8	8.4	0.70	0.63	0.70	3.50	1.51	123.04	17.90	4.02	4.09
SILTSTONE	399 - 421	5	1491	NOT TESTED	106.	66.7	9.2	9.2	1.32	0.20	0.15	13.53	0.56	79.66	11.11	13.70	3.13
CONGLOMERATE	421 - 426	T-M-B	4642	3937	208.	62.2	9.2	8.9	2.00	0.39	0.54	15.83	2.89	78.31	23.05	10.87	6.57
SILTSTONE	426 - 446	5	3877	NOT TESTED	124.	65.9	9.3	9.4	1.63	0.17	0.12	20.49	0.82	70.83	12.76	14.13	2.53
SHALE	446 - 456	2	6065	5610	248.	62.7	9.4	9.6	1.11	0.21	0.14	15.05	0.44	286.77	12.14	10.33	3.07
SHALE/SILTSTONE	456 - 466	2	8415	NOT TESTED	> 250.	60.1	9.6	9.6	1.31	0.18	0.43	13.05	0.32	314.34	15.23	3.80	1.36
SHALE/SILTSTONE	466 - 478	2	5953	5659	> 250.	60.0	9.4	9.4	1.10	0.16	0.33	10.57	0.55	286.15	6.59	6.85	3.04
SHALE/SILTSTONE	478 - 488	2	2298	NOT TESTED	200.	60.8	8.9	9.4	1.40	0.30	0.65	10.48	0.31	176.72	5.57	12.39	1.63
SHALE/SANDSTONE	488 - 496	2	1017	NOT TESTED	239.	62.2	9.3	9.0	1.42	0.20	0.27	10.57	0.72	46.94	8.85	9.24	2.40

NOTES:
(1) ------ Indicates minimum
(2) ——— Indicates maximum
(3) * pH testing performed previously on the samples at same intervals
(4) ** (Negligible) - no testing necessary since corresponding pH values are less than 8.8.

TABLE 3 (contd)

RESULTS OF CHEMICAL ANALYSIS

LITHOLOGY	DEPTH INTERVAL (FEET)	WATER SOLUBLE ANIONS (MeQ/L) SO_4	NO_3 as N	HCO_3	CO_3	Cl	MACRO NUTRIENTS (ppm) NO_3 as N	K	P	MICRO NUTRIENTS (ppm) Cu	Zn	Mn	Fe	CATION EXCHANGE CAPACITY (MeQ/100gms)	SODIUM ADSORPTION RATIO	EXCHANGEABLE SODIUM PERCENTAGE	TRACE ELEMENTS (ppm) Hg	Pb	Cd	Se	B	Mo	Ni
SANDSTONE	8 - 28	1.44	0.05	3.1	NEGLIGIBLE**	2.05	2.3	385	2.0	4.4	3.2	235	584.0	10.43	2.0	11.8	0.12	9.1	0.1	0.10	0.03	6.50	16.9
SANDSTONE	23 - 48	1.34	0.03	3.4	NEGLIGIBLE	1.20	1.0	399	3.0	3.2	2.6	277	624.0	8.91	2.2	12.2	0.14	26.9	0.2	0.30	0.10	6.70	15.8
SANDSTONE	43 - 68	1.69	0.03	3.8	NEGLIGIBLE	1.03	0.8	525	5.0	4.5	2.0	185	707.0	9.13	2.4	51.0	0.13	10.7	0.1	0.50	0.14	11.20	21.9
SANDSTONE	68 - 79.5	0.94	0.01	4.1	NEGLIGIBLE	0.94	0.7	379	1.5	3.8	3.3	61	468.0	8.48	2.3	18.6	0.10	9.6	0.4	0.34	0.16	4.60	16.3
SHALE/SANDSTONE	79.5 - 82	1.25	0.01	7.0	NEGLIGIBLE	0.77	0.9	433	6.0	5.9	3.9	13.9	649.0	8.26	2.7	12.7	0.13	7.7	0.3	0.24	0.13	5.80	16.8
SHALE	82 - 83	0.94	0.02	4.6	NEGLIGIBLE	0.43	1.7	383	0.6	4.5	2.8	13.0	584.0	7.17	1.9	10.7	0.11	24.9	0.5	1.10	0.13	4.10	22.8
SANDSTONE	83 - 94	1.38	0.03	4.8	NEGLIGIBLE	0.68	1.1	469	0.5	3.7	4.3	11.2	422.0	9.46	1.5	6.8	0.13	19.0	0.7	1.12	0.16	3.00	20.5
SHALE/SANDSTONE	94 - 98.5	1.16	0.01	6.0	NEGLIGIBLE	0.43	2.2	484	0.5	6.9	5.0	15.3	372.0	8.59	1.4	7.3	0.12	10.3	1.2	0.70	0.20	3.30	15.4
SANDSTONE	98.5 - 103	1.44	0.03	6.8	NEGLIGIBLE	0.60	1.0	394	17.0	2.6	2.8	32.2	808.0	6.63	1.7	7.2	0.09	9.8	0.7	0.88	0.14	4.50	7.9
SHALE	103 - 104	1.56	0.05	4.6	NEGLIGIBLE	0.34	0.8	465	8.0	4.3	3.0	9.1	164.0	8.80	1.1	6.1	0.16	9.7	1.0	0.99	0.72	3.90	23.6
SHALE	104 - 114	1.13	0.01	5.4	NEGLIGIBLE	0.34	0.1	420	5.0	5.4	2.8	12.0	302.0	7.61	1.4	7.2	0.35	10.8	1.0	0.90	0.16	7.40	15.8
SHALE	114 - 122	2.38	0.02	4.5	NEGLIGIBLE	0.26	0.4	302	3.0	6.0	5.6	6.6	209.0	8.80	1.6	6.6	0.33	9.4	0.4	0.45	0.18	2.60	18.2
COAL	122 - 187	0.78	0.01	2.0	NEGLIGIBLE	0.09	0.5	18	1.0	0.8	1.2	0.8	20.2	5.11	2.7	13.1	0.07	1.7	<0.1	0.35	<0.02	0.61	0.2
SANDSTONE	187 - 207	12.13	0.07	0.0	NEGLIGIBLE	0.09	1.0	428	5.0	2.1	4.4	19.4	1268.0	5.49	0.7	9.5	0.25	9.4	0.1	0.90	0.47	11.50	61.4
SANDSTONE	207 - 227	8.91	0.05	7.1	NEGLIGIBLE	0.43	3.2	459	4.0	6.1	5.8	18.0	1294.0	5.11	0.8	11.9	0.13	11.0	0.4	0.23	0.18	5.60	46.0
SANDSTONE	227 - 247	1.13	0.04	6.3	NEGLIGIBLE	0.34	0.7	260	6.0	5.6	2.0	9.8	992.0	1.82	1.0	34.6	0.09	9.5	0.3	0.03	0.26	10.10	31.0
SANDSTONE	247 - 267	1.25	0.02	8.4	NEGLIGIBLE	0.51	0.4	763	7.0	3.2	2.8	13.9	743.0	3.21	1.0	23.1	0.10	10.4	0.2	0.14	0.28	11.10	21.9
SANDSTONE	267 - 278	1.16	0.06	7.5	NEGLIGIBLE	0.86	0.6	698	5.0	7.2	4.2	12.4	1058.0	7.07	2.5	19.2	0.16	28.6	0.3	0.90	0.24	5.50	21.9
SHALE	279 - 282	1.88	0.07	6.0	NEGLIGIBLE	0.43	0.3	264	4.0	8.1	4.4	11.8	1478.0	8.70	11.0	37.0	0.25	23.6	0.5	0.89	0.35	5.10	49.0
SANDSTONE	282 - 302	0.53	0.02	7.4	NEGLIGIBLE	0.60	0.7	554	3.0	6.2	3.3	13.2	1336.0	13.91	8.7	19.5	0.03	19.6	0.5	0.70	0.03	6.60	35.1
SANDSTONE	302 - 320	2.25	0.01	13.0	NEGLIGIBLE	0.43	0.6	663	2.0	5.8	3.3	11.4	1050.0	12.39	17.4	48.0	0.09	9.9	0.4	0.63	0.26	7.70	31.1
SANDSTONE/SILTSTONE	320 - 340	2.22	<0.01	10.9	TRACE	0.43	2.3	474	3.0	5.6	4.4	7.1	593.0	14.35	19.5	47.0	0.10	17.7	0.4	0.70	0.32	3.50	29.5
SANDSTONE/SILTSTONE	340 - 356	1.38	0.03	9.7	NEGLIGIBLE	0.68	3.5	2130	3.0	5.9	4.3	10.8	576.0	19.35	8.0	23.8	0.13	26.2	0.6	0.76	0.67	2.20	34.1
SANDSTONE	356 - 370	1.63	0.01	8.2	NEGLIGIBLE	0.51	1.1	800	2.0	5.4	2.6	10.0	1034.0	9.02	1.8	11.1	0.15	18.2	0.4	0.74	0.26	5.10	25.5
SILTSTONE/SANDSTONE	370 - 399	1.00	0.03	6.2	NEGLIGIBLE	0.09	3.4	1600	3.0	6.3	3.4	16.4	580.0	15.87	4.3	24.0	0.11	18.5	0.3	1.50	0.49	2.80	26.2
SILTSTONE	399 - 421	0.66	0.05	11.1	3.1	0.34	0.7	1255	6.0	6.4	3.8	10.4	611.0	18.78	32.2	68.2	0.11	17.5	0.1	0.38	0.20	5.69	28.8
CONGLOMERATE	421 - 426	1.00	0.11	17.2	3.4	0.34	0.3	2550	7.0	6.3	4.1	21.5	1805.0	20.43	23.3	48.5	0.11	13.9	0.3	0.44	0.46	7.90	43.2
SILTSTONE	426 - 446	1.78	0.02	13.5	2.6	0.256	1.1	1125	3.0	5.0	3.7	5.8	435.0	20.00	53.9	64.0	0.06	13.3	0.5	0.88	0.42	5.10	37.0
SHALE	446 - 456	2.22	0.05	9.3	3.7	<0.05	0.4	1200	6.0	4.1	2.1	8.0	397.0	16.54	35.8	57.7	0.15	26.5	0.7	0.74	0.44	2.00	23.2
SHALE/SILTSTONE	456 - 466	2.16	<0.01	8.5	2.8	0.43	0.3	530	7.0	6.3	2.2	11.4	1080.0	6.74	23.7	45.0	0.30	31.5	0.7	0.35	0.24	7.20	29.9
SHALE/SILTSTONE	466 - 478	2.03	0.01	9.6	0.5	0.43	<0.1	1190	17.0	6.7	3.6	8.9	502.0	11.30	21.6	53.7	0.77	27.5	0.8	0.35	0.72	6.40	28.2
SHALE/SILTSTONE	479 - 488	1.63	<0.01	8.6	2.6	0.17	0.1	638	27.0	5.4	2.2	12.1	1460.0	15.26	15.2	76.9	0.26	19.9	0.5	0.76	0.49	7.90	39.0
SHALE/SANDSTONE	488 - 496	1.09	0.01	8.4	1.6	<0.05	0.6	938	4.0	4.7	2.5	21.0	1520.0	13.33	20.7	64.4	0.06	14.5	0.3	1.50	0.72	9.40	48.3

TABLE 4

NORMAL AND HAZARDOUS CONCENTRATIONS OF MICRO NUTRIENTS AND TRACE ELEMENTS

GROUP	ELEMENT	NORMAL CONCENTRATION	HAZARDOUS LEVEL
MICRO NUTRIENTS	Cu	0.5 to 40 ppm Extractable	Above 40 ppm Extractable
	Zn	10 to 300 ppm (Total)	Above 10 ppm Extractable
	Mn	0.5 to 40 ppm Extract.	Above 40 ppm Extractable
	Fe	1.5 to 2% (Total)	No Potential Direct Hazard
TRACE ELEMENTS	Hg	0.1 to 0.5 ppm	Above 0.5 ppm Extractable
	Pb	15 to 70 ppm (Total)	1 to 5 ppm Extractable
	Cd	---	0.1 to 1 ppm Extractable
	Se	---	Above 1 ppm Extractable
	B	---	Above 2 to 3 ppm Extractab
	Mo	---	5 ppm (Total) Under Neutra to Alkaline pH Conditions
	Ni	---	Above 1 ppm Extractable

3. INTERPRETATION

3.1 Rate of Weathering

Degradation in the waste pile involves both physical and chemical weathering. Physical breakdown is an important factor governing the release of highly erodeable materials. It is also an important factor governing the rate of subsequent chemical weathering.

Physical breakdown of rock fragments buried in the waste pits is expected to take place slowly. Breakdown of material exposed to surface weathering was assessed as follows:

Shale	-	rapidly break down to clay soil upon exposure
Sandstone-Siltstone	-	1/3 will break down to silt and sand sized particles in one year
		1/3 will break down to smaller rock fragments and silt and sand sized particles in 5 years
		1/3 will resist break down for a long time.

Examination of 20 year old waste dumps in the area confirmed the above prediction. The surface was typically a stoney sandy clayey silt. Widespread breakdown to erodeable silt sizes was not evident. Rock fragments within the waste pile appeared to remain intact.

Chemical weathering within the waste pile will be related to minerology, temperature, type and amount of percolating groundwater and time. By design the amount of infiltrating water will be small. Thus the rate of chemical weathering is expected to be very slow.

3.2 Concentrations Present

Chemical make-up of the bedrock is related to lithology. The composition of the sandstone was quite uniform while that of the siltstone or shale was more variable.

Trace element concentrations were found to be quite uniform. This suggests that the trace elements are tied to the mineral lattice and are not free to migrate except under extreme weathering.

Normal concentrations were found for all elements except for manganese, lead and nickel. Concentrations of the latter elements are not severe and represent the upper limit that would be made available under sudden extreme weathering. With the slow rate of weathering anticipated, release of harmful concentrations is not expected.

3.3 Potential for Acid Mine Waste

The concentration of Sulphur is low. Consequently, there is little chance of extreme weathering creating acid mine waste. The potential for acid mine waste is further reduced by the presence of neutralizing carborate.

3.4 Potential Toxicity

The potential for weathering causing the release of toxic concentrations of any element is very low.

3.5 Revegetation Potential

Revegetation potential is indicated by the availability of nutrients, pH and sodium absorption ratio. The rock does not possess an abundance of nutrients but an ability to support vegetation without repeated fertilizing is indicated. This has been supported by field experience.

On the basis of sodium absorption ratio the potential for revegetation is greater in hangingwall sediments than it is in footwall material. Most mining activity will involve the hangingwall material.

3.6 Implication to Mining

No beds were found that should react adversely to weathering so it is concluded that weathering of material disturbed by mining will not have harmful side effects. Consequently, from a geotechnical point of view, mined material may be placed in waste dumps in any order convenient to the mining program.

4.0 CONCLUSIONS

A representative profile of materials in the proposed mining zone were sampled and analysed.

Physical weathering at surface is predicted to yield clayey soil that is not highly erodeable. Field observations support this prediction. Rock fragments within the waste pile will degrade slowly.

Chemical weathering is also expected to take place very slowly.

Most elements were found to be present in normal concentrations so there is little chance of weathering causing toxic concentrations of them to be released.

Acid mine water is not a problem here.

Mining can proceed without regard for placement priorities because of the uniform chemical make-up of the waste material.

The subject sampling program was necessary to indicate that there are no problems anticipated from weathering at this site. A similar testing program is advocated at each new mine site. However, detailed testing need only be carried out if adverse conditions are detected.

PROCEEDINGS

OF

THE SECOND ANNUAL GENERAL MEETING

OF THE

CANADIAN LAND RECLAMATION ASSOCIATION

August 17, 18, 19 & 20 — 1977 Edmonton, Alberta

(Sponsored by the Faculty of Extension, University of Alberta)

P R O G R A M

Canadian Land Reclamation Association

Second Annual General Meeting

August 17, 18, 19, 20, 1977

Edmonton, Alberta

Wednesday, August 17 (Optional Field Trips)

Field Trip No. 1 (Athabasca Tar Sands)

Leader: Philip Lulman (Syncrude Canada Ltd.)

Fee: $100.00 (covers bus and air transportation, lunch, and field trip information pamphlets)

Schedule: 7:30 am.- delegates board bus at Parking Lot T, located immediately south of the Lister Hall Student Residence complex. Air transportation from Edmonton Industrial Airport to Fort McMurray and return. Guided bus tour of surface mining and reclamation operations on Syncrude Canada Ltd. and Great Canadian Oil Sands Ltd. leases.
6:30 p.m.- delegates arrive back at Parking Lot T, University of Alberta campus.

Field Trip No. 2 (Aspen Parkland; Forestburg Coal Mine Reclamation)

Leader: George Robbins (Luscar Ltd.)

Fee: $25.00 (covers bus transportation, lunch, and field trip information pamphlets)

Schedule: 8:00 a.m. - delegates board bus at Parking Lot T, located immediately south of the Lister Hall student residence complex. Guided bus tour southeast of Edmonton, stopping at various points of interest (oil spill reclamation field plots; Black Nugget Park [abandoned minesite]; trench plots on Dodds-Roundhill Coal Field; solonetzic soil deep ploughing site) on the way to the Luscar Ltd. Coal Mine at Forestburg.
6:30 p.m. - delegates arrive back at Parking Lot T, University of Alberta campus.

Thursday, August 18

Events:	Opening of Formal Meeting; Presentation of Papers
Location:	Multi-Media Room, located on second floor of Education Building, University of Alberta.
8:00 a.m.	Authors of papers being presented on August 18 meet with paper presentation chairmen and audio-visual co-ordinator (Douglas Patching)
9:00 a.m.	Meeting Opened by Dr. Jack Winch (President of the C.L.R.A.; Head of the Department of Crop Science, University of Guelph). Comments by Dr. Winch.
9:15 a.m.	Welcome to delegates on behalf of the Government of Alberta by the Hon. Mr. Dallas Schmidt, (Associate Minister Responsible for Lands, Alberta Department of Energy and Natural Resources)
9:25 a.m.	Commencement of Paper Presentations. Morning session chaired by Mr. Henry Thiessen (Chairman of the Land Surface Conservation and Reclamation Council and Assistant Deputy Minister, Alberta Department of Environment).
9:30 a.m.	Paper 1. Combined Overburden Revegetation and Wastewater Disposal in the Southern Alberta Foothills by H.F. Thimm, G.J. Clark and G. Baker (presented by Harald Thimm of Chemex Reclamation and Sump Disposal Services Ltd., Calgary, Alberta).
10:00 a.m.	Paper 2. Brine Spillage in the Oil Industry; The Natural Recovery of an Area Affected by a Salt Water Spill near Swan Hills, Alberta by M.J. Rowell and J.M. Crepin (presented by Michael Rowell of Norwest Soils Research Ltd., Edmonton, Alberta)
10:30 a.m.	Coffee Recess
11:00 a.m.	Paper 3. The Interaction of Groundwater and Surface Materials in Mine Reclamation by Philip L. Hall of Groundwater Consultants Group Ltd., Edmonton, Alberta.
11:30 a.m.	Paper 4. Subsurface Water Chemistry in Mined Land Reclamation; Key to Development of a Productive Post-Mining Landscape by S.R. Moran and J.A. Cherry (presented by Stephen Moran of the Research Council of Alberta, Edmonton, Alberta).
12:00 noon	Lunch Recess

1:25 p.m. Continuation of Paper Presentations. Afternoon session chaired by Mr. Philip Lulman (member of C.L.R.A. executive; reclamation research ecologist with Syncrude Canada Ltd.).

1:30 p.m. Paper 5. Coal Mine Spoils and Their Revegetation Patterns in Central Alberta by A.E.A. Schumacher, R. Hermesh and A.L. Bedwany (presented by Alex Schumacher of Montreal Engineering Company Ltd., Calgary, Alberta).

2:00 p.m. Paper 6. Surface Reclamation Situations and Practices on Coal Exploration and Surface Mine Sites at Sparwood, B.C. by R.J. Berdusco and A.W. Milligan (presented by Roger Berdusco of Kaiser Resources Ltd., Sparwood, B.C.).

2:30 p.m. Paper 7. Agronomic Properties and Reclamation Possibilities for Surface Materials on Syncrude Lease #17 by H.M. Etter and G.L. Lesko (presented by Harold Etter of Thurber Consultants Ltd., Victoria, B.C.).

3:00 p.m. Paper 8. The Use of Peat, Fertilizers and Mine Overburden to Stabilize Steep Tailings Sand Slopes by Michael J. Rowell of Norwest Soils Research Ltd., Edmonton, Alberta.

3:30 p.m. Coffee Recess

4:00 p.m. Paper 9. Oil Sands Tailings; Integrated Planning to Provide Long-Term Stabilization by David W. Devenny of E.B.A. Engineering Consultants Ltd., Edmonton, Alberta.

4:30 p.m. Paper 10. Bioengineering. The Use of Plant Biomass to Stabilize and Reclaim Highly Disturbed Sites by H. Schiechtel an sK. (Nick) Horstmann (presented by Margit Kuttler).

5:00 p.m. End of August 18 Sessions.

Friday, August 19

Events:	Presentation of Papers; C.L.R.A. Annual General Business Meeting; C.L.R.A. Annual Dinner.
Locations:	Paper presentations and C.L.R.A. Annual General Business Meeting in Multi-Media Room, located on second floor of Education Building, University of Alberta. - Annual Dinner held in Banquet Room located on second floor of Lister Hall.
8:00 a.m.	Authors of Papers being presented on August 19 meet with paper presentation chairmen and audio-visual co-ordinator (Douglas Patching).
8:30 a.m.	Showing of Film Rye on the Rocks. This film depicts reclamation situations at Copper Cliff, Ontario and is being shown for the purpose of introducing delegates to the site of the 1978 C.L.R.A. meeting (Sudbury, Ontario).
8:55 a.m.	Continuation of Paper Presentations. Morning session chaired by Dr. J.V. Thirgood (Vice-President of C.L.R.A.; member of Forestry Faculty, University of British Columbia).
9:00 a.m.	Paper 11. Reclamation of Coal Refuse Material on an Abandoned Mine Site at Staunton, Illinois by M.L. Wilkey and S.D. Zellmer (presented by Michael Wilkey of the Argonne National Laboratory, Argonne, Illinois).
9:30 a.m.	Paper 12. A Case Study of Materials and Techniques Used in the Rehabilitation of a Pit and a Quarry in Southern Ontario by Sherry E. Yundt of the Ontario Ministry of Natural Resources, Toronto, Ontario).
10:00 a.m.	Coffee Recess.
10:30 a.m.	Paper 13. Amelioration and Revegetation of Smelter-Contaminated Soils in the Coeur D'Alene Mining District of Northern Idaho by D.B. Carter, H. Loewenstein and F.H. Pitkin (presented by Daniel Carter of Technicolor Graphic Services Inc., Sioux Falls, South Dakota).
11:00 a.m.	Paper 14. The Influence of Uranium Mine Tailings on Tree Growth at Elliot Lake, Ontario by David R. Murray of the Elliot Lake Laboratory, Elliot Lake, Ontario.

11:30 a.m. Paper 15. Weathering Coal Mine Waste. Assessing Potential Side Effects at Luscar, Alberta by D.W. Devenny and D.E. Ryder (presented by David Devenny of E.B.A. Engineering Consultants Ltd., Edmonton, Alberta).

12:00 noon Lunch Recess.

1:25 p.m. Continuation of Paper Presentations. Afternoon session chaired by Dr. John Railton, (Manager, Environmental Planning, Calgary Power Ltd., Calgary, Alberta).

1:30 p.m. Paper 16. The Distribution of Nutrients and Organic Matter in Native Mountain Grasslands and Reclaimed Coalmined Areas in Southeastern B.C. by Paul F. Ziemkiewicz of the Faculty of Forestry, University of B.C., Vancouver, British Columbia.

2:00 p.m. Paper 17. Systems Inventory of Surficial Disturbance, Peace River Coal Block, B.C. by D.M. (Murray) Galbraith of the British Columbia Ministry of Mines and Petroleum Resources, Victoria, British Columbia.

2:30 p.m. Paper 18. The Selection and Utilization of Native Grasses for Reclamation in the Rocky Mountains of Alberta by D. Walker, R.S. Sadasivaiah and J. Weijer (presented by David Walker of the Department of Genetics, University of Alberta, Edmonton, Alberta).

3:00 p.m. Coffee Recess; Distribution of Proceedings.

3:30 p.m. Commencement of 1977 General Business Meeting of the Canadian Land Reclamation Association. Meeting chaired by Dr. J.V. Winch, C.L.R.A. President.

7:30 p.m. Commencement of C.L.R.A. Annual Dinner in Banquet Room, second floor of Lister Hall.

Guest Speaker: William T. Plass, Principal Plant Ecologist, U.S.D.A. Forest Service, Northeastern Forest Experiment Station, Princeton, West Virginia.

Topic of Speech: Challenges in Co-operative Reclamation Research.

Note: Following the Annual Dinner and Mr. Plass's speech, delegates may retire to the adjacent Gold Room. A bartender will be on service until midnight.