SOILS AND VEGETATION WITHIN COAL STRIP-MINE SPOILS NEAR ESTEVAN, SASKATCHEWAN

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This research was carried out in co-operation with R.E. Redmann and M.E. Jonescu under contract with Energy, Mines and Resources, Canada.

Underground mining for lignite coal in the Estevan-Bienfait coalfield began in the 1890's and expanded to a maximum of 241 mines in the years 1936-37 (Smith, 1974). The last shaft mine was closed in 1946. The stripping method was introduced in 1930, with most stripping near the Souris River where depths of overburden were less than 35 feet. Strip-mining expanded slowly until about 1970 when the development of Boundary Dam Generating Station resulted in a rapid increase in coal production. Approximately 9,700 acres have been disturbed by stripping, with a predicted annual increase of 500-600 acres.

Early stripping methods utilized relatively small (by today's standards) electric shovels or tractor-powered scrapers. This early equipment was able to mine economically coal seams within 30 to 40 feet of the surface. Larger dragline shovels introduced recently are able to strip up to 100 feet of overburden. Each machine leaves a spoil embankment of characteristic shape. The scrapers built large, rounded spoils, relatively flat on top. The electric shovels built relatively continuous ridges 10 to 20 feet in height, while the draglines leave a large discontinuous ridge or series of interconnected cones up to 35 or 40 feet in height.

The stripping of overburden results in an inversion and mixing of the materials within that portion of the geological section. In the Estevan coalfield this section is composed of thin to relatively thick glacial till deposits overlying the sand, silt and friable shale units of the Ravenscrag formation (Table 1). The glacial till deposits, which may include as many as three recognizable stratigraphic units, are loam to clay loam in texture, generally non-sodic, slightly to moderately saline and 10 to 15% lime carbonate. The Ravenscrag bedrock materials are sandy to clayey, but most commonly silty, in texture. These materials are slightly to moderately saline and are usually strongly sodic, with sodium absorption ratios of up to 47.8 and exchangeable sodium percentages of up to 25%. Carbonate content ranges from 2 to 35% calcium carbonate equivalent.

The dominant clay minerals of all materials are montmorillonite and illite. Montmorillonite when combined with the high levels of soluble and exchangeable sodium in the siltstone or shale-derived spoils results in adverse soil properties. These include extremely strong surface crusts, low infiltration and permeability rates, susceptibility to volume change with change in moisture content, and reduced strength when wet. Similar properties have been reported for lignite mine spoils in North Dakota (Sandoval et al., 1973). The spoils are susceptible to erosion, with many poorly vegetated spoils still eroding after 40 years.

There is a wide range in soil properties and the type and amount of vegetation within the spoil area. Although age, slope and aspect of ridges are important in determining plant cover, the properties of the substrate are also of considerable importance. Some ridges composed primarily of loamy glacial till are non-saline, low in sodium and contain significant amounts of nitrogen and phosphorus (Table 2, sample O). These ridges are vegetated with many native species such as the wheat grasses, fescue, snowberry, sage, cottonwood and willow, as well as sweet clover and brome grass.

Other areas, sample Q for example, are composed of mixtures of glacial till and bedrock-derived materials. Significant proportions of each ridge are made up of somewhat saline, sodic siltstone or shale with little or no vegetative cover. Alkali or saline tolerant species such as alkali grass, foxtail, gumweed and broomweed are common on these substrates. In the inter-ridge areas or bottoms a wide variety of plants grow on the generally non-saline, non-sodic silty alluvial sediments derived from the erosion of adjacent ridges.

Where ridges are composed primarily of siltstone or shale, problems of high sodium contents are of greater magnitude (Sample B). These ridges, particularly the large, recently constructed ones, are extremely erodible. The materials are severely deficient in nitrogen and phosphorus. Alkali or saline tolerant species may cover up to 10 or 20% of the surface. Weedy species such as Kochia, Russian thistle and sow thistle are most common.

Natural revegetation and recent reclamation attempts have been relatively successful on the more desireable, predominantly glacial till materials. When nitrogen and phosphorus deficiencies were overcome good stands were noted. The revegetation of highly sodic, sometimes saline, silty or clayey bedrock derived spoils is a more serious problem. Research in North Dakota indicates that revegetation is only possible after grading to acceptable levels and additions of topsoil (Sandoval et al., 1974). At Estevan, where considerable thicknesses of till are usual, it seems practical to modify mining methods so as to bury the sodic bedrock materials under the glacial till, thereby providing more suitable substrates for revegetation.

DISCUSSION

Question: How many acres have been strip mined?

Answer: In the Estevan area, approximately 9,700 acres. At present they are mining 500-600 acres per year.

Table 1. Properties of the upper geological section, Estevan coalfield area (NE Corner 4-11-2-6 W2).

Sample Description	Mech. Anal. % S	% Si	% C	pH	Cond. $mmhos/cm^2$ 25 C	S.A.R.*	$CaCO_3$ %
Friable, grayish brown till 0-2.5 m	51.1	32.1	16.8	8.3	0.9	6.3	10.5
Jointed, stained, dark grayish brown till 2.5-6.0 m	28.0	36.8	35.3	7.6	4.1	2.8	15.6
Massive, olive gray till 6.0-9.0 m	27.1	36.4	36.5	7.5	4.3	5.8	15.7
Light gray siltstone 9.0-14.0 m	19.7	68.7	11.6	8.6	2.7	39.2	14.9
Olive gray siltstone 14.0-18.0 m	29.5	60.4	10.1	8.4	5.3	47.8	32.7

* Sodium Absorption Ratio

Table 2 . Selected chemical analyses of soil from representative spoil ridges.

Sample	Description	pH	Cond. mmhos/cm^2 25°C	Soluble Cations, me/100 g soil			
				Na^+	Ca^{++}	Mg^{++}	K^+
Q1	0-15 cm, silty weathered rock	7.9	0.52	0.05	0.06	0.05	0.02
Q2	15-50 cm, silty weathered bedrock	8.4	1.21	0.42	0.02	0.02	0.01
Q3	50-100 cm, silt loam	8.4	6.45	2.25	0.22	0.33	0.02
Q5	0-15 cm, silty shale, no vegetation	7.3	9.60	4.26	4.07	0.88	0.04
B-1	0-10 cm, silty loam weathered bedrock	8.0	1.24	0.31	0.06	0.03	0.01
B-2	10-50 cm, silty	8.0	6.29	2.74	0.66	0.42	0.04
B-3	50-100 cm, silty clay, soft bedrock	7.5	6.67	3.53	1.25	0.83	0.06
B-4	0-10 cm, bottom area, silty	7.6	0.82	0.08	0.14	0.06	0.02
B-5	Barren silty shale, 0-10 cm depth	8.1	9.78	4.85	1.01	0.58	0.06
O-1	0-15 cm, loamy glacial till	7.4	0.67	0.02	0.15	0.13	0.02
O-2	15-50 cm, loamy glacial till	7.7	0.52	0.05	0.06	0.05	0.01
O-3	50-100 cm, loamy glacial till	7.8	1.52	0.31	0.14	0.15	0.01
O-4	0-15 cm, sandy inter-ridge area	7.6	0.49	0.01	0.09	0.05	0.01

Table 2 (continued)

Sample	Soluble Anions me/100 g soil		Sodium Abs. Ratio	Exchangeable Cations me/100 g soil				ESP^{+}	Available ppm		
	Cl^{-}	$SO_4^{=}$		Na	Ca	Mg	K	%	N	P	K
Q1	0.01	0.06	1.1	0	21.3	4.1	0.38	0	4	1	190
Q2	0.01		15.3	1.7	18.0	3.3	0.22	7.3	1	2	120
Q3	0.01	3.24	21.4	4.6	17.8	3.3	0.30	17.7	0	0	110
Q5	0.02	6.39	20.8	8.4	25.3	4.9	0.29	21.6	15	3	155
B-1	0.01	0.14	7.8	0.7	15.3	0.8	0.12	4.1	0	0	90
B-2	0.04	1.26	15.9	3.5	17.3	2.1	0.20	15.1	1	0	130
B-3	0.03	3.19	13.1	4.4	21.3	3.3	0.29	15.0	1	1	185
B-4	0.01	0.06	1.3	0.4	16.3	1.2	0.17	2.2	0	0	100
B-5	0.06	2.18	23.8	6.8	18.0	2.5	0.33	24.6	4	0	155
O-1	0.02	0.05	0.2	0	23.0	7.0	0.52	0	12	5	250
O-2	0.01	0.08	1.2	0.04	21.8	5.8	0.35	0.1	4	2	165
O-3	0.01	0.65	4.12	1.1	21.5	5.4	0.42	3.8	2	1	190
O-4	0.01	0.05	0.20	0.0	22.3	3.7	0.64	0	5	1	290

$^{+}$ESP - Exchangeable Sodium Percentage

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