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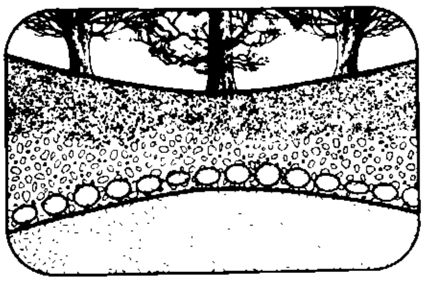

The Soil Column

Soil and Related Hazards as a Result of Strip Mining

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The decision to develop a particular natural resource is legally a decision made by a government, or by private groups with consent of government. Once it has been decided to investigate the feasibility of a particular kind of economic development affecting natural resources expert integrated survey and evaluation must be fully called into play. The engineering or technological feasibility of the project usually receives careful attention with the result that few projects fail because of lack of adequate engineering. However, deficiencies may develop because representatives of certain disciplines have not been involved. This is particularly true of projects in which the natural environment is affected. Until recently environmental scientists were rarely asked to assess the impact of development on the environment.

To-day, pedologists and geologists are being invited to take part in various environmental impact studies. One of these was an investigation of environmental problems which might arise from strip-mining in an area around Onakawana. Although specialists from many different disciplines were involved in studying this site, this column deals only with the work of consultants having to do with soils and surface geology. Emphasis was placed on problems associated with erosion, disposal of waste products, slope stability and site reclamation.

Onakawana is located in northeastern Ontario about 60 miles south of Moosonee on the Ontario Northland Railway line. Here is located a relatively large deposit of lignite which could be mined to produce energy. The proposed development of the lignite deposits would generally follow such as: (a) removal of the overburden including organic and clay deposits, (b) stockpiling the overburden, (c) removal of the lignite by open-pit mining, (d) combustion of the lignite, and (e) handling and ultimate disposal of by-products such as stack effluents, non-combustible and non-usable residues and warm water.

Obviously, an operation of this magnitude will significantly affect the local environment, and management during and after mining operations must be such that environmental upset is avoided. The objectives for managing soil, water and vegetation are:
1) to manipulate and handle the overburden in such a fashion that the materials are used to create elevated sites possessing a better drainage and better prospects for vegetation and wildlife than heretofore existed.
2) to use the native materials, primarily overburden, to create lakes and lagoons of a permanent nature that in the mining operation, are useful as sedimentation lagoons and for temperature equalization of waste water.
3) to create an area during operations and after operations that is essentially stabilized, that is revegetated and is so managed that erosion, runoff and sedimentation are controlled at acceptable levels.

Preliminary surveys were conducted to make meaningful and practical recommendations for management of the site while keeping the foregoing objectives in mind.

Inventory data acquired from on site inspection, airphoto interpretation and laboratory analyses included detailed characterization of surficial geology, landforms and soils, natural drainage pattern and characterization of the sub-surface clays. Other information about the area which would be useful in meeting the objectives was gleaned from other studies and publications.

The climate of the region may be classified as modified continental. A pattern of relatively low winter and high summer precipitation prevails. Cold polar air masses alternate with humid air masses from the south to produce a changeable climate in summer. In winter, the cold polar air prevails and dry, clear weather persists. As a result evapotranspiration rates are low and water accumulates to produce the saturated landscape familiar to this part of the province.

Direct knowledge of the solid geology comes principally from the extensive drilling program of the Ontario Department of Mines. Some idea of the bedrock sequence and surficial deposits can be gained from Table I. The average depth to bedrock is roughly 70 feet. At least three till sheets cover the bedrock with the upper two separated by interglacial deposits. About 7000-8000 years ago an arm of the sea invaded the region producing an early and more extensive form of Hudson Bay. This is known as the Tyrell Sea and the marine clays and silts deposited from its waters form the parent materials of the soils in the area.

The flat land surface at Onakawana is part of a larger plain that slopes gradually down to the shore of James Bay at a gradient averaging between two and three feet per mile. This lack of significant relief in combination with compact, dense surficial deposits has resulted in an area of poor drainage. The surface expression of this is the predominantly swampy and moss-covered ground between the rivers.

In many respects the soils around Onakawana are remarkably alike. In general, the uppermost mineral deposits are stone-free, silty clay loams overlain by moderately well decomposed organic materials. The organic deposit is of uniform thickness varying from 3 to 4 feet over the whole of the region. The organic materials have a fibre content of 32 to 36 per cent and a pH of about 5.0. Some of the physical, chemical and mineralogical properties of the silts and clays are shown in Table II.

A number of conclusions from which management decisions can be made were derived from the information gathered. These conclusions dealt with the problems of surface drainage, erosion, slope stability and leachate disposal. It was recognized that the large amount of surface water present would create erosion and siltation problems and that sedimentation ponds and a revegetation program would be needed to control these problems. Steep slopes should be avoided since they not only increase the problems of slope stability but they are difficult to revegetate. Due to the pH of the coal-leachate and water associated with the coal beds it was not anticipated that acid leachate would be a problem in strip mining at Onakawana. However, heavy metals could constitute an environmental hazard. Coals and the seat earths (fireclay in this instance) are to some extent sources of high trace element concentrations. Mercury, zinc, cadmium, germanium and selenium for example, may be present in abnormal amounts. Indeed, it has been reported that fish caught in the Abitibi River below Onakawana have unusually high amounts of selenium in their tissues.

Numerous other conclusions have been made from the data but do not bear repeating here. It is sufficient to note the roles of geologists and soil scientists in providing information needed in making environmental assessments.

Table I
Bedrock Sequence

	Surficial deposits (6 feet of muskeg, 72 feet of Pleistocene)
	Unconformity
Lower Cretaceous	Predominantly fireclay 43 ft. thick LIGNITE 23 ft. bed Fireclays and sand, minor lignite - 27 ft. LIGNITE 21 ft. bed Dark to light coloured fireclays with minor lignite 56 ft.
	Unconformity
Devonian	Shales, clays and sandstones, with some calcareous rocks in Middle and Lower Devonian. Some shales are bituminous and pyritiferous. Gypsum occurs. Total thickness 777 ft.
	Large Unconformity
	Precambrian Plutonic Rocks (at depth of 1,027 ft.)

Source: Mackintosh, Hoffman and Chesworth (1972).

Table II
Physical, Chemical and Mineralogical Analysis of the Marine Silts and Boulder Clay

Analysis		**Marine Silts** Site #1		**Marine Silts** Site #2		**Boulder "Clay"**	
(1) pH		7.95		7.90		7.70	
(2) Bulk density (g/cc)		—		1.70-1.80		2.15-2.22	
(3) %CaCo^3 equivalent		10-15		18-23		18-23	
(4) Particle size (%)							
	1-2 mm.	0.10		0.10		6.98	
	0.5-1.0	0.13		0.30		8.13	
Sand	0.25-0.5	0.10	5.65	0.46	9.96	8.40	57.88*
	0.10-0.25	0.22		1.70		19.69	
	0.05-0.10	5.10		7.40		14.65	
Silt	0.002-0.05	62.45		78.73		33.36	
Clay	<0.002 mm.	31.90		11.31		8.76	
(5) Mineralogy							
<0.002 mm		dominant - vermiculite, mica, chlorite minor - kaolin, quartz, feldspar, amphibole				dominant - mica, vermiculite; chlorite minor - kaolin; interstratified mica-vermiculite; expanding minerals; quartz, feldspar, amphibole	

** This sample contains 13% of material > 2 mm.*
Source: Mackintosh, Hoffman and Chesworth (1972).

Reference

Mackintosh, E. E., D. W. Hoffman and W. Chesworth, 1972, Soil and related development problems for the proposed strip mining operation at Onakawana: Unpublished report submitted to Ontario Ministry of the Environment, Nov. 1972, 33p.

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