

periods plus the audio-visual packages permits the students a choice of ways to learn geology, thus allowing for different learning preferences.

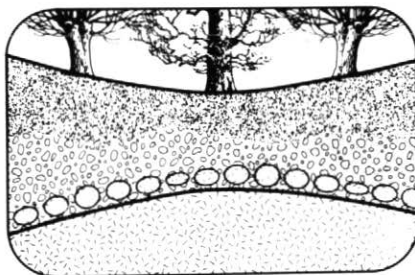
A second observation is that the tape-slide packages are easy to prepare, and do not require a great deal of technical know-how. We collected the slides from various professors at the Department, and copied them ourselves. We also recorded the tapes ourselves, using equipment at, and the help of, Queen's radio station, CFRC. The most difficult part of the project is in designing a lab unit; a great deal of careful planning and forethought must go into the preparation of individualized instruction. But, the effort is worth it, because individualized instruction, which tries to duplicate one-to-one teaching, has been found to be highly effective. Its usefulness is not limited to basic introductory courses, but applies equally well at more advanced levels. Beyond the university setting, individualized audio-visual instruction could be most useful for a wide variety of professional training courses, both at managerial and craft level.

The importance of this method of instruction is not that it is new, nor that it is "audio-visual" (since all too often that only means "gimmicky"), but that it allows each student, as an individual, to learn at his own speed, and to review as often as he feels is necessary. By using individualized audio-visual instruction as a supplement to regular classroom instruction at Queen's, we are hoping to give students the best possible chance of learning geology, and of learning it well.

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Note. Lucinda Bray, who is the daughter of R. C. E. Bray, is working on her Master's degree in Educational Technology at Sir George Williams University, Montreal. The Queen's project described in this feature will form part of her thesis (John Usher).

The Soil Column



Pipelines, Soils and Farming

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The impact of pipelines on farm productivity is far greater than is

generally realized and in many instances the farmer can never be compensated for short and long term damage.

Although this article devotes itself to the effects of disrupting a soil column on a typical farm in southern Ontario (*Fig. 1*) the problem is applicable to any area crossed by pipelines. Some 50,000 miles of pipelines have been installed in Canada, many of them affecting class I land, but there have been no adequate environmental impact studies. The May 1974, National Energy Board hearing of an application to extend a pipeline from Sarnia to Montreal was the first to require environmental studies since the Board itself established federal environmental guidelines for federally chartered pipelines crossing provincial boundaries.

Soil Composition

A typical soil profile is broken into a series of horizons (A,B,C)



Figure 1
A pipeline excavation illustrating severe side calving.

representing different degrees of weathering. The most important horizons are those within which the feeding roots of crops develop. In southwestern Ontario, the dark organic topsoils at surface have been developing since glacial retreat (8,000 to 10,000 years) and are typically eight to 12 inches thick. Carbonates which are abundant below two feet depth are usually completely leached from the topsoil and often from the underlying 12 inches of soil also. The topsoils exhibit little or no reaction to 10 per cent HC1 compared to vigorous reaction between acid and soil carbonates not far below the topsoil layer. The pH is likewise significantly lower in the organic topsoils compared to the underlying carbonate rich soils. The clay minerals in the root zone consist of illite, chlorite and montmorillonite. The chlorite is relatively unstable and near the surface is usually oxidized with resultant alteration to montmorillonite swelling clay. Since the zone of oxidation extends well below the topsoil layer, the secondary montmorillonite is found in significant amounts throughout the brown crust, and cannot be used as a critical test regarding soil profile disturbance.

Topsoil is a very precious, non-renewable resource which all too frequently is wasted and buried at depth by pipeline contractors unless they are subjected to strict environmental controls. Since pipeline easements are some 90 feet wide, some four acres of a 100 acre farm may be adversely affected. At Larigmoor Farm, requests to strip and replace topsoil, made prior to construction of the first pipeline, were refused.

Soil Fissures

Highly developed fissure systems generated by carbonate leaching, ice lense action and seasonal desiccation-wetting are characteristic of most clayey soils. In southwestern Ontario the surface clayey soils are very closely fissured, yielding a nuggetty, crumbly texture. The fissure spacing increases with depth but even at three to five feet they still occur at spacings of two to five inches. Most clayey soils (which

are those requiring drainage) have a permeability of 10^{-6} to 10^{-9} cm/sec, compared to a much higher bulk value estimated to be 10^{-3} or 10^{-4} cm/sec in the fissure zone. The fissuring, therefore, plays a vital role in water drainage into drainage tiles, which are typically installed at three to five feet depth.

Heavy construction equipment effectively compacts fissure systems to depths of up to one and one-half times the vehicle width, altering the soil from an agriculturally desirable material to a hard, tight, non draining clay. Permanent surface compressions of up to six inches or more attest to this fissure closure as does *Figure 2* which shows extensive ponding above an easement where downward drainage has been destroyed.

Land Surface Modification

Drainage tile outlets into topographic lows or valleys offer easy drainage of farms developed on rolling land. To

flat land farms, drainage outlets become a major engineering problem frequently requiring excavation of large drainage ditch systems or deep drains crossing several farms to reach an adequate outlet. A shallow water shed on a flat farm becomes one of its greatest assets since it may provide a very cheap outlet for a system of shallow tile drains.

Pipeline gradient and cover requirements may be difficult for utilities to achieve over a long distance, and it may be more expedient to fill certain critical areas to obtain adequate cover rather than lowering the invert elevation. If this accidentally obstructs a drainage outlet system or causes silting that shallows a previous outlet drain, the exit of water from main drains is greatly inhibited and the entire drainage system on a farm may be jeopardized. It is extremely unlikely that adequate compensation can ever be obtained for this type of damage to the land surface topography.



Figure 2
Post-construction ponding above a pipeline easement.

Other Factors

It is now recognized that good pipeline construction should involve excavation, soil stock piling, pipeline distribution and placement, backfilling operations and finally replacement of drainage tiles and topsoil. Since open trenches such as that shown in Figure 1 may be left for several weeks, the resultant caving may disrupt soil columns to distances even beyond the easement width. Tremendous difficulties in access to crops or animal herds are left to the farmer to solve.

Post-construction hazards to the soil columns and drainage system include line breakages, spills, reconstruction and spill disposal which may be by incendiary methods in the case of crude oil.

It would seem that much more stringent environmental controls should be applied to pipeline owners and operators to protect the soil column and drainage systems, particularly on class I and class II farm lands.

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