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Geology from Engineering, Urban or Otherwise
La géologie et le génie civil en milieu urbain ou autre

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Article abstract

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Essai

GEOLOGY FROM ENGINEERING, URBAN OR OTHERWISE

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ABSTRACT Exhortations of the mid-nineteenth century to take advantage of construction activities as sources of geological information have been paid heed only occasionally. While some advantage has been taken of information from engineering activity, most is unrecorded geologically. Geological study of urban areas is complicated by many difficulties and comprehensive treatment requires a permanent staff with appropriate experience. Even though geological data have clearly demonstrable practical use in better use of land resources, urban geology should embrace both practical and curiousity-based research. Thus far, opportunities to gain enormous amounts of information of great practical and scientific value have been commonly ignored. Toronto is Canada's largest and geologically most famous city. The fame is based on its unique Quaternary stratigraphy, which includes Illinoian, Sangamonian, and Wisconsinan deposits, many of which are fossiliferous. Tragic losses of important information about its Quaternary history occur nearly continuously as large scale surface mining continues and little record of the temporary exposures is kept.

RÉSUMÉ *La géologie et le génie civil en milieu urbain ou autre.* Les appels lancés au milieu du XIX^{e} s. à profiter de la présence des chantiers de construction pour en tirer des renseignements d'ordre géologique ont reçu bien peu d'attention. Bien qu'on ait tiré certains avantages de l'information fournie par les travaux d'ingénierie, on a rarement constitué de dossiers géologiques. Les études géologiques en milieu urbain font face à de nombreux obstacles et leur traitement exhaustif nécessite un personnel permanent et qualifié. Même si les données géologiques ont clairement démontré leur utilité pratique pour une utilisation plus rationnelle des ressources, la géologie en milieu urbain devrait comprendre à la fois les recherches appliquée et fondamentale. Jusqu'à maintenant on a rarement su saisir les occasions de tirer profit des énormes connaissances de nature scientifique et pratique. Toronto est la plus grande ville du Canada et aussi la plus renommée géologiquement parlant. Cette renommée lui vient de son site qui renferme une stratigraphie du Quaternaire unique, qui comprend des dépôts de l'Illionien, du Sangamonien et du Wisconsinien, dont beaucoup sont fossiles. Malheureusement, des renseignements de première importance sur son évolution quaternaire se perdent presque de façon continue pendant que se poursuit l'exploitation minière à grande échelle, puisqu'on ne consigne à peu près jamais les données sur les sites temporairement mis à nu.

"The stupendous railway operations now in progress in many parts of both Provinces, present rare opportunities for obtaining much needed information respecting the geological features of the country through which they pass."

With these words, the editor of the fledgling *Canadian Journal* (vol. 1, no. 1, p. 5, 1852) drew to his readers' attention a great opportunity to be seized. More than a century and a quarter later, the need is the same and the opportunity still greater. Had the words of 1852 been heeded and appropriate general practice become established, we would now know much more than we do about what lies beneath our feet.

Even earlier, in England in the 1840's, Adam Sedgewick, *in a talk to the Kendal Natural History Society "could point* out the 'glorious feast' opening out as the new railway links — particularly Wordsworth's detested Kendal-Windermere railway — exposed the rock, 'laying bare the muscle' to allow the enthusiastic fossil-hunters to follow the navvies" (Speakman, 1982).

It should not be claimed that nothing has been recorded from engineering works about the geological materials exposed (*e.g.* Walker, 1896, and numerous more recent examples) nor can it be suggested that those centrally involved in engineering construction have not been sensitive to their natural environment. One has only to look at the early issues of the *Canadian Journal* to see papers by one of Canada's foremost engineers of the last century, Sir Sandford Fleming (1853a, 1853b, 1861), which provide early observations on glacial lake shorelines near Georgian Bay and Toronto, and describe the processes which formed Toronto Island. Fleming also served as Secretary of the Canadian Institute, sponsor of the *Canadian Journal*, while Sir William E. Logan, Director of the Geological Survey of Canada, was President of the Institute.

Although the suggestion of 1852 never "caught on" in any general way, there have been spasmodic efforts by agencies, institutions, and individuals to record bits of the veritable

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mountain of information available from engineering construction. For example, St. Lawrence Seaway excavations were recorded by Terasmae (1965) and MacClintock and Stewart (1965) and Welland Canal excavations by Owen (1969). The information is generally a free by product, yet comparatively little is noted down to be incorporated into the body of generally available information on our geological heritage. What has not been noted down cannot become part of our synthesis of geological history.

There was much discussion of urban geology in the 1960's and into the 1970's. On several occasions sessions were held at geological society meetings, which mainly comprised papers listing the practical importance of geology in cities because of the need for raw materials (so many tons of aggregate needed for a block of houses, etc.), problems with foundation conditions and waste disposal, and the "geologic hazards" (landslides, earthquakes, subsidence, etc.). Much of this interest grew along with the then new field of environmental geology, vigorously promoted by the Illinois State Geological Survey and taken up by many other agencies and individuals. Some papers were published on urban geology (*e.g.* McGill, 1964; Kaye, 1968; Kugler-Gagnon, 1977); later, books also appeared on urban geology (Legget, 1973) and environmental geology (Flawn, 1970).

Government agencies and individuals have taken some action to study the geology of urban areas (*e.g.* Bélanger and Harrison, 1980). Most authors have advocated more detailed mapping in and around urban areas, but there has been only limited progress on this first step. Compilation of engineering boring information for all the larger cities of Canada was undertaken by the Geological Survey of Canada in the early 1970's. While this was a major "shot-in-the-arm" for urban geology, in most cases, as far as I know, the resulting computerized data banks sit idle. From time to time one hears of a thesis based on the geology of an urban area, or of a government project to map an urban area. These usually include examination of at least the major excavations (Fig. 1), and many of the smaller ones, which happen to be open at the time. Taking a longer-term view, these can be only a small sample of available information. Short-term studies are of value, but besides their gross incompleteness they have been observed to offer a false sense of security making it possible to say "it's being looked after" or "it's been done".

Each year, consulting companies and government agencies such as highway departments throw away, literally, truck loads of soil and rock samples. These samples are costly to obtain, but after engineering logging and retention for a few months, must be disposed of because of the cost of storage space. Selected samples are analyzed in soil mechanics laboratories for grain size and, commonly, Atterberg limits. The results of testing, along with the engineer's logs of the samples are included in the consultant's report to the client, often an architect or municipal agency. Usually, the consultants retain copies of these reports, but their fate among clients varies.

While I was employed by the Ontario Department of Mines from 1957 to 1963 I arranged to examine periodically accumulated samples obtained by the Metropolitan Toronto Works Department and the Ontario Department of Highways. This was undertaken through personal interest and was a "spare-time" activity fitted around other duties. An example of information gained is a cross section based on borings for the Coxwell sewer tunnel in east central Toronto (Fig. 2). As time permitted, particularly on weekends when construction sites were quiet, some of the many excavations in Toronto were visited. I quickly found the time available was completely inadequate. In order to have something to show for the time and effort spent in compiling subsurface information, the simplest data on depth to rock were compiled into a bedrock topography map for Metropolitan Toronto (Rogers *et al.*, 1961); such maps need frequent revision.

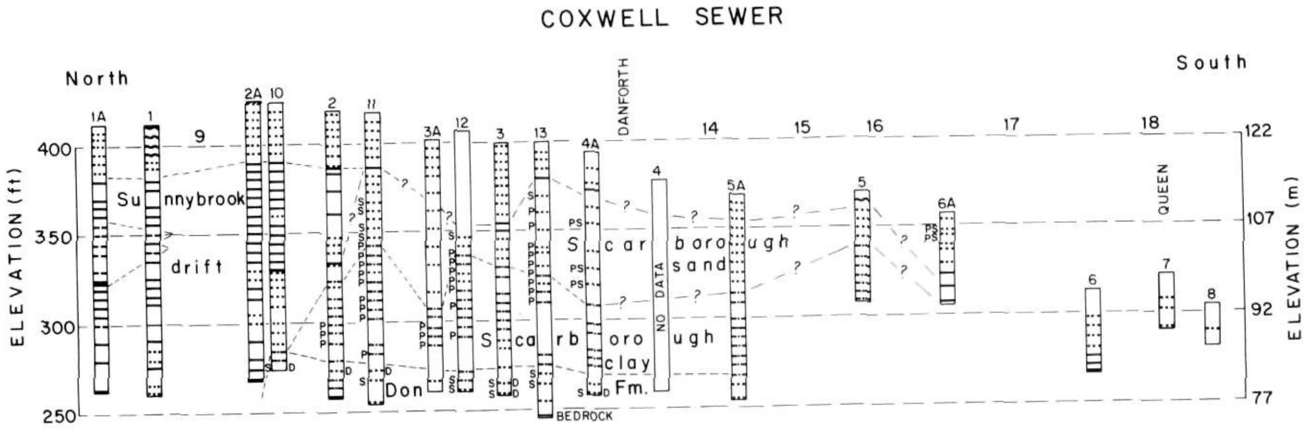
FIGURE 1. Excavations provide a major source of geological information.

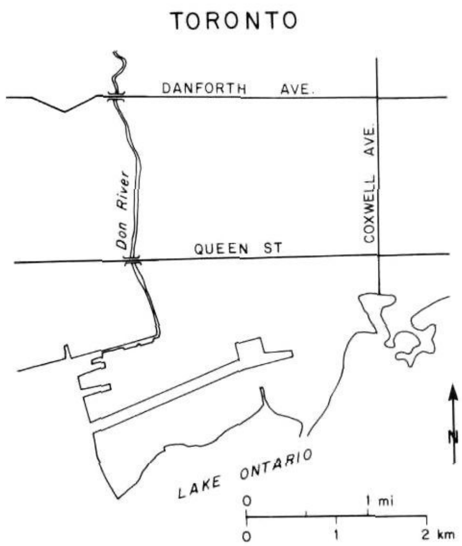
Les excavations sont une source précieuse de renseignements d'ordre géologique.

Cooperation between individuals and agencies can take many forms. The Ontario Department of Mines paid for extending three of the exploratory borings for the Bloor subway to bedrock. This added three more data points for bedrock elevation and completed the stratigraphic sections at those locations.

For the past two decades my attention has, naturally, turned to Kitchener-Waterloo. Even these communities, with a population about 1/15th that of Toronto, generate too much construction activity for one person to keep up with on a casual, intermittent, part-time basis. I have not even seen all excavations on the University campus where I work, although I do receive copies of the engineering reports and log as many of the samples as I can arrange to see.

In urban areas, the gathering of geological information is frustrated by human disturbance, jealously-guarded property rights, and the general pressure of human activity. Much of the ground surface is covered by pavement, buildings, or landscaping that must not be disturbed. Normal field methods of hand probing or test-pitting are mostly not applicable, although scattered patches of vacant ground can sometimes be found. Below ground, a maze of service lines (gas, water, telephone, sewer, electric) cause hazards for the prober, not to mention causing disturbance to the natural materials. Understandably, but unfortunately, most geologists prefer to work elsewhere.





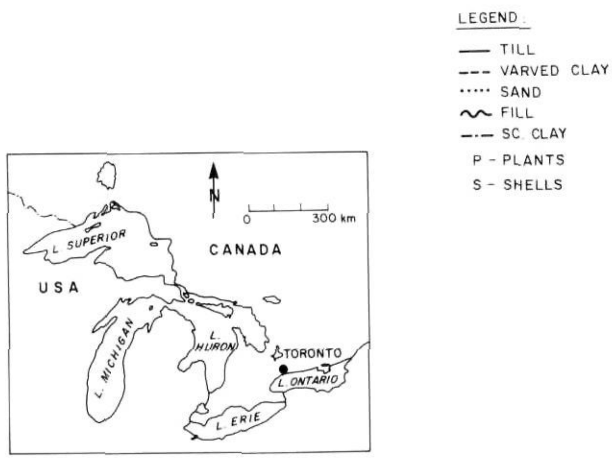


FIGURE 2. Cross-section based on logging of borehole samples for the Coxwell sewer, Toronto.

Coupe fondée sur les données de sondage pour l'égout de Coxwell, à Toronto.

On the other hand, other people are collecting and assessing large numbers of samples in urban areas and the geologist has only to make contact with appropriate persons to tap these sources of information. A full and complete picture of the geology of an urban area can only be gained by continuing efforts over decades and even generations, since information does not come available according to geological need but rather according to economic conditions, planning decisions, etc. In the suburban fringe early development of housing creates numerous small, shallow excavations. Redevelopment occurs in phases with gaps of inactivity in between, culminating in skyscrapers and subways in the city centre.

Comprehensive managing of geological information in a large city requires a permanent staff (continuity of experience being very important) capable of receiving and geologically logging all soil samples, visiting all excavations, and recording the exposures, conducting appropriate analyses of boring and excavation samples, compiling this first-hand information on maps and sections, and issuing progress reports from time to time. Boring reports and samples should have been examined before excavations are visited. Liaison with city and private engineers and building inspectors would help keep track of construction activity. Periodic reconnaissance by light plane (and perhaps even "ultralights") would be an excellent way of monitoring excavations. By regulation, copies of all foundation investigation reports would be kept on file. As knowledge of the geology was gained, examination of soil samples and excavations could be more selective and operating efficiency increased. A budget for stratigraphic drilling, down-hole geophysical logging (*e.g.* Eyles *et al.*, 1985; Farvolden *et al.*, 1987), and surface exploration geophysics, would make it possible to secure needed information below the commonly shallow depth of engineering borings, and in areas with few commercial borings. The staff should provide influential advice to the engineering and planning departments.

Urban geology is usually thought of as the application of geological knowledge of urban areas to the solution of engineering problems. A special term is used for this situation because of the concentration of human activity, including engineering construction, in urban areas. Nevertheless, the same principles can be applied anywhere, and the same kinds of good relationships between geologists, planners, engineers, and others, are needed everywhere.

All this, as has been said so many times, has great practical benefit for better exploitation of our natural resources, whether in terms of a specific mineral commodity or in general use of terrain. Recent increased interest in the use of underground space (Durand and Boivin, 1985; White, 1982) clearly demonstrates the need for improved knowledge of the geology.

In spite of this general conception of urban geology as a kind of applied geology, or engineering geology, there is also a more general meaning to be taken from the term urban geology. It can also embrace the use of information derived from engineering projects for geological purposes, specifically the enhancement of our knowledge of the past. Geology can often be sold as an area of practical knowledge, but in the public (and political) mind it seems it must be thought of *only* in terms of practical use. In contrast, archeology is thought of as of cultural importance and is accepted as knowledge people want for its own sake. There is considerable overlap in how geologists and archeologists go about their business of reconstructing the past, yet it seems practicality is a cross geology must bear, but archeology does not. Archeology has achieved an important role in planning and the constructional development of land, as witnessed by recent newspaper articles with all-too-sensational headlines "Archeological discoveries bad news for developers" (Kitchener-Waterloo Record, January 8, 1988) and "Developers are turning to archeologists to review 'heritage potential' of the land they plan to use. But builders worry about what happens when some is found" (Toronto Globe and Mail, December 12, 1987). Geology lags far behind in achieving such recognized significance. Archeology is accepted as pursuit of knowledge for its own sake, but geology is expected to have some practical end. Instead, geological studies should embrace both practical and pure or curiousity-based ends. In fact, the distinction is probably only on the basis of time scale since in the long run, just about *any* geological information will be useful to planners, engineers, developers, and even politicians.

Toronto

Toronto is Canada's largest city (Fig. 3). It is, geologically, also Canada's most famous city. Its fame grew largely through the work of A. P. Coleman, who studied its Quaternary stratigraphy over a period of several decades and made its unique interglacial beds known to an international audience (Coleman, 1895, 1913, 1933). We are fortunate to have available to us in his papers and field notes descriptions of exposures in excavations, as well as of natural exposures along the Lake Ontario shorebluffs, now extensively concealed by urban construction and protective works. Coleman's studies were carried out to learn more of the geological history of the area and of the Pleistocene in general. Reference to his work continues (*e.g.* Karrow, 1969; Eyles, 1987). Coleman (1913, 1933) also prepared maps of the surface deposits. Not until Sharpe (1980) was a revision attempted, based in part on mapping of the urban fringe by Watt (1957, 1968) and Karrow (1967, 1970).

After World War II, Toronto, like most other cities, underwent enormous growth. Associated with that growth was intense construction activity which has transformed the appearance of the city almost everywhere (Fig. 3). A few of the major projects were recorded geologically and some of the findings have been published, such as for the subways (Watt, 1954; Lajtai, 1969). Most excavations have not been studied, recorded, and added to the geological knowledge of the area, and thus a great opportunity has been lost.

FIGURE 3. Toronto: tall buildings, thousands of borings and deep excavations.

Toronto: des gratte-ciel, des milliers de forage et de profondes excavations.

The same situation exists in most cities, but in the case of Toronto the loss is all the more tragic, because of the unusual nature of its Quaternary stratigraphy, embracing deposits believed to represent the penultimate glaciation, the last interglacial, and a broad range of ages through the last glaciation. This stratigraphy is so rich, with fossiliferous beds interspersed between glacial deposits, that it should be considered a national treasure. Designation as a World Heritage Site should be considered. The Toronto area can be compared to a large natural museum without curators. Nobody looks after the collections and many valuable items are completely missed, while many others are destroyed.

One of the latest incidents in the saga of "lost geology" is the closing on the Don Valley Brickyard, the last survivor of several active operations of Coleman's day. These exposures have been visited by numerous groups of geologists during the century they have been open. It was specifically this site that was the major source of information on the Toronto interglacial beds, now known as the Don Formation. Only there could the full sequence of the older beds be seen in exposure. Plans to include the property in park development fell through in 1983 and in 1984 the property was sold to a developer. The Ontario Government has since expropriated the property. At this time efforts to preserve the site for future study are continuing, but access for class field trips and continued research has not been possible since 1985. Ironically, the site was more accessible while held by the developer than it has proven to be under government ownership. Here is an outstanding example of a site important to our scientific and natural heritage.

Thus far no level of government accepts the responsibility for curating Toronto geology. Federal, Provincial, and Municipal agencies point to one another as the one who should pay. The practical benefits accrue most to the municipality, but because of Toronto's unique story, a strong case can be made for Provincial involvement (they are responsible for municipal affairs) and Federal (because of its national scientific significance).

The *Toronto Star* for January 29, 1985, in an article on the controversial Spadina Expressway, showed maps of planned transit and freeway routes in the Metropolitan Toronto area. Other major projects are announced frequently. Large holes continue to be dug in downtown Toronto and what amounts to surface mining of the Quaternary deposits, including the intergacial beds, continues. Who, working for what agency will record what is encountered?

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