geologically stable and is relatively distant in terms of man's activities. The biological transport is low, the sediments are normally red clays of sufficient lateral continuity or homogeneity to ensure high predictability in terms of sedimentary processes.

Some work has been done on the engineering aspects of the problem. The manufacture of waste containers has been studied in conjuction with the vitrification processes of the liquid waste. The longevity of materials in sea water at great depths and the presence of radioactive emissions in a high temperature environment is important for the concept of the barrier system and requires a great deal of additional work.

It is necessary to make a requirement that no radioactive emissions resulting from the sea-bed disposal may reach any part of the ocean biota and man. To meet this requirement, potential barriers are identified, tested and accepted on the basis of satisfactory safety margins.

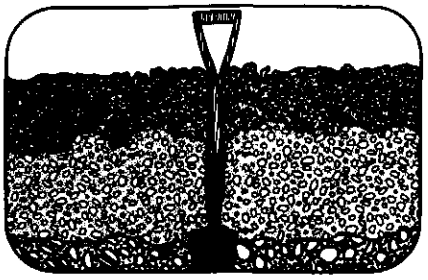
In view of the encouraging initial results and the need for a wide range of alternatives for the storage of nuclear waste, it was suggested that future feasibility studies for the disposal of high level radioactive waste in the marine environment should continue. More exact data must be gathered. In terms of biology, *in situ* experiments are needed to ensure a better understanding of the transfer of organic matter through the marine ecosystems. In terms of geology, a better understanding of the physical and chemical response to the heat and radio-activity in the sediment has a priority. It is important to know the interstitial fluid behaviour and ion exchange capacity of the sediment, mass fluidization of sediment by heat, physical and chemical modification of the sedimentary medium by high temperatures and finally, the visco-elastic properties of the sediment.

Survey of the sea-floor for prospective dumping sites must continue using progressively improved instrumentation. For this phase, Canada has both expertise and equipment to participate, given the necessary priority. The advantages of participation are many, despite the fact that serious consideration has not been given to sea-bed disposal at the present time. Even a limited participation will ensure that Canadian marine expertise will be keeping up with the developments in the technology of nuclear waste disposal in ocean environments. During the workshop it became evident that some nations may want to take greater risks in nuclear waste disposal and management on the sea-floor. To protect one of the largest marine coastlines of the world, Canada should be able to assess on a sound technical basis the feasibility of placing nuclear waste in the sea-bed. More detailed studies may produce overwhelming evidence that nuclear waste should not be dumped in the marine environment or at least that modification of existing disposal criteria is warranted. Convincing arguments can only be produced on a broad information base.

The theme of the workshop was to study criteria and techniques for the disposal of high level nuclear waste in the ocean environment without considering the retrieval of the waste. For all practical purposes the disposal of the waste on or in the sea-bed must be considered as final, owing to the difficulties of safe recovery. The impractical retrieval of the waste may be an important criterion in making final decisions for or against the usage of the sea-bed.

The prevailing policy in Canada is to store spent fuel from reactors in near-surface land based engineered structures for a possible retrieval. Once a decision has been made to re-utilize the reprocessed fissile material, the unusable high level waste will have to be disposed of. Besides long term management in surface facilities, the options are emplacement in geological formations accessible by land or sea-bed disposal. Although the former is the currently favoured option, sea-bed disposal has attractive features with regard to the degree of isolation and inaccessibility. If well understood, the sea-bed may offer an acceptable solution to the very long term disposal of high level radioactive wastes.

MS received June 15, 1976



Symposium on Quaternary Soils

B. D. Fahey
Department of Geography
University of Guelph
Guelph, Ontario N1G 2W1

This was the third symposium on Quaternary Research organized by W. C. Mahaney of the Geography Department, Atkinson College, York University in the last three years. It took place at York University, May 21-23, 1976, and offered a varied but well-balanced program on Quaternary soils, including papers whose themes ranged from the soils of the deserts of California to those of the Yukon and the Eastern Canadian Arctic. Such a broad geographical spectrum of investigations into Quaternary soils was conducive to an exchange of information and views among Quaternary scientists from different disciplines, and as such, many of the discussions (formal and otherwise) were lively and informative. The two sessions on the first day dealt with soil dynamics and soil stratigraphy respectively. The latter session continued the following day, with a third session on soil morphogenesis on the final afternoon.

R. W. Simonson, former director of the Soil Classification and Correlation division, U. S. Department of Agriculture, opened the session on soil dynamics with a review of soil genesis in terms of a multiple-process model. Using numerous anecdotes and personal reflections based on years of experience, he discussed the various processes which may promote or inhibit soil horizonation.

Current viewpoints on the origin and classification of Podzolic soils in Canada were reviewed by J. A. McKeague, G. J. Ross, and D. S. Gamble (Agriculture

Canada). S. Pawluck (Univ. Alberta) warned that Quaternary scientists must choose with care those morphological features in a buried soil profile which might best serve as a guide in reconstructing past environments. The task can be facilitated if the dynamic nature of the pedogenic profile is recognized and understood.

Concepts, methods, and problems of Quaternary soil stratigraphy were outlined by R. B. Morrison (Univ. Arizona). He stressed the importance of soils in the stratigraphic column as environmental indicators, and called for the term "geosol" to encompass all soil stratigraphic units, thereby circumventing the ambiguities traditionally associated with the term "soil". Recent studies undertaken on sequences of buried geosols at various localities in North America and Europe have reinforced the author's conclusion reached more than a decade ago that soil profile development was climatically inhibited during "pleniglacials" (i.e., periods when there was a dry, cold, tundra environment developed immediately beyond the margins of continental ice), and enhanced when environments were warm and humid. On these grounds he feels that Quaternary geosols can still be regarded as reliable stratigraphic markers despite some recent views to the contrary.

K. L. Brunson, C. G. Olson, and R. V. Ruhe (Univ. Indiana) compared the soil morphology and clay mineral sequence in currently forming soils with that of the Sangamon paleosol formed in Illinoian till, Loveland Loess, and upper Paleozoic bedrock in southwest Indiana. They found Sangamon Soil to be basically similar in its mineralogy and morphology to ground soils although it did exhibit more intensely weathered characteristics than its modern-day counterparts. Further information on the Sangamon Soil was provided by L. R. Follmer (Illinois State Geol. Survey). He pointed out that despite the lack of work performed at the type locality of the Sangamon Soil, numerous studies have been conducted in an area of central Illinois which he defines as the type area for this soil. However, several controversies have arisen over the noticeable lack of uniformity in profile characteristics within the type area. According to Follmer, such controversies could be resolved by a thorough analysis of the spatial variability of the soil across a transect encompassing a range of drainage and topographic situations. On the basis of rock and soil stratigraphic evidence from Arrowhead Park north of St. Louis, Missouri, W. H. Allen (Arizona State Land Dept.) suggested that the recent rejection of the Brussels Formation as a stratigraphic unit may have been premature.

R. J. Shlemon (Newport Beach, California) outlined the Quaternary stratigraphy on alluvial piedmont and pediment fans of different ages in the vicinity of the proposed Sundesert nuclear power plant near Blythe, California. In the final paper of the afternoon, J. F. Dormaar (Agriculture Canada) presented a broad survey of paleosol studies undertaken in Western Canada, and also of the research techniques most applicable in their analysis.

The following morning the second part of the session of soil stratigraphy began with attention being focussed on Quaternary soils in mountain environments. The first paper (W. C. Mahaney, York Univ.) described the late Quaternary soil stratigraphy of part of the Wind River mountains in Western Wyoming. The author touched briefly on the current controversies over the status of the Temple Lake Glacial Stade, the length of the Altithermal, and the duration of the Bull Lake Glaciation in the Rocky Mountains. E. B. Evenson, W. C. Wigley, and T. A. Pasquini (Lehigh Univ.) demonstrated the usefulness of soils in differentiating glacial deposits of pre-Bull Lake through Neoglacial age in the Copper Basin of south central Idaho, after having little success with traditional procedures such as thickness of boulder rinds. They also found that subjecting the soil data to factor analysis was helpful in differentiating the deposits.

N. W. Rutter (Univ. Alberta), and A. E. Foscolos and O. L. Hughes (Geol. Survey of Canada) investigated Quaternary paleosols and associated cryomorphic features in outwash deposits of three different ages in the Stewart River area, Central Yukon. The information obtained enabled them to make inferences on basic climatic trends over the last 500,000 years. They concluded that the Luvisol on the oldest surface (older than 500,000 years) had developed from a Brunisol as a result of a climatic change. The two younger surfaces exhibit Brunisolic characteristics.

The session on soil morphogenesis was opened by L. J. Evans (Univ. Guelph) who stressed that the quantification of pedologic processes can best be achieved by assuming that certain minerals in the parent material such as quartz, rutile, and zircon remain unaltered. This requires a thorough knowledge of the parent material which itself must be relatively uniform. The author attempted to demonstrate the utility of this principle by describing its application to soils in Ireland and Wales.

The development of the concept of polar desert soils was traced by J. C. F. Tedrow (Rutgers Univ.) who introduced it ten years ago, followed by J. G. Bockheim (Univ. Wisconsin) who compared the morphology and genesis of Arctic Brown and Alpine Brown soils in North America on the basis of profile information from four locations: Mt. Baker (Washington), Western Maine, Pangnirtung (Baffin Island), and Cornwallis Island.

In keeping with the session's emphasis on northern environments, T. R. Moore (McGill Univ.) described the soils from nine sites which comprised a transect from the boreal forest of Quebec to the Canadian Eastern Arctic. As expected, evidence of podzolization became less noticeable with increasing latitude, a characteristic the author attributed to a lower rate of organic matter production and decompositon in more northerly environments.

The genisis of organic soils in Manitoba, and a number of locations in the Northwest Territories was discussed by C. Tarnocai (Univ. Manitoba). Two basic processes, in-filling and build-up, are recognized as basic to the depositon of organic soil materials.

In the final paper of the symposium, L. M. Lavkulich and J. I. Sneddon (Univ. British Columbia) examined the pedogenesis of alpine soils in the western Cordillera of Canada. They described the soils of this diverse region as highly complex, exhibiting several cycles of pedogenesis, and reflecting the combined effect of wind, volcanic ash, cryoturbation, fauna, and flora.

On the day following the paper sessions, the activities of the symposium closed with a field trip

around the Toronto Centred Region led by D. W. Hoffman (Univ. Guelph). It was designed to acquaint the participants with the local soils and to demonstrate the effects of geological materials of different composition on soil development. Some of the problems of soil classification confronting local pedologists were also introduced.

During the course of the symposium it became apparent that the views held by spokesmen from the various disciplines represented on such basic concepts as the role of parent material in soil development, the rate of mineral weathering, and the dynamics of organic soil formation, were not consistent. This points to the need for a greater dialogue among pedologists, geomorphologists, geologists, and physical geographers, a need which can best be fulfilled by symposia with themes which transcend traditional academic boundaries as this one did.

Information concerning the publication of the proceedings of this symposium, and others in the Quaternary Environment series can be obtained from W. C. Mahaney, Department of Geography, Atkinson College, York University, Downsview, Ontario.

MS received July 29,1976