Features

Active Earth

Canada's immense land surface, her rivers, lakes, and continental margins are part of a dynamic geological environment subject to relentless changes. Some of the changes are gradual, with rates ranging from the almost imperceptible (e.g., isostatic uplift, basin subsidence, solifluction) to the rapid (e.g., shoreline erosion, river channel migration). Others occur in sudden spurts, followed by years of quiescence (e.g., slope failures, earthquakes).

Most of us are not directly affected by or even aware of this ongoing change of Canada's land surface. As resource use, scientific studies, transportation networks, and housing penetrate into ever more remote regions of this country there will be a greater need for a wide appreciation of normal, abnormal, and catastrophic processes in our geological environment.

A sedimentologist examining cores from a lake bottom may need to know about historical slope failures along the shoreline; a groundwater investigator may encounter interesting patterns of subsidence; a city planner might be curious about the changes of a riverbank; a road builder might profit from a knowledge of slope behaviour during previous construction attempts; and others worry about erratic behaviour of glaciers and permafrost.

Field workers often witness spectacular landscape changes while carrying out their studies, but do not have the time to undertake thorough scientific investigations of these events. Nevertheless, others may be keenly interested in short, simple accounts of what happened and then carry out follow-up work!

For this purpose *Geoscience Canada* will devote a column entitled "Active Earth" to short contributions dealing with marked changes of the Canadian land mass or at least such changes that might have impact on human works. Hopefully, this column will give a wider readership a feeling for the type of slow or fast surface changes witnessed in the field by Canadian earth scientists. The notes might cover a single rare event or chronicle a period of historical change up to the present. It is hoped that contributions are not scholarly treatises, but informal interesting accounts. The editor welcomes articles in English or French, which should not, in general, exceed 1000 words and preferably should be accompanied by simple sketch maps and/or relevant photographs. A list of references is welcome, but not required. Contributors should consult the Guide to Authors published periodically in *Geoscience Canada.*

To initiate this column, J.J. Clague and I have written two short pieces on recently witnessed surface changes in western Canada; they are intended to provide some guidelines for the layout to be followed. However, because the column is loosely structured, there are no hard-and-fast rules regarding format. The success of this column depends entirely on potential contributors. If you know of somebody who witnessed something striking please tell him to submit a short write-up - others might like to read about it too! We are looking forward to your observations. Manuscripts should be sent to me at the address below.

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Erosion at Point Grey, British Columbia

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Major shoreline changes have occurred historically on many parts of the British Columbia coast (Clague and Bornhold, 1980). Nowhere are these changes more pronounced than at Point Grey, a headland projecting westward into the Strait of Georgia near Vancouver (Fig. 1). Here, steep sea cliffs up to 70 m high and composed largely of loose sand and silt of glaciofluvial origin have receded rapidly in response to wave attack during intense storms. Sediment displaced from the oversteepened cliffs by wind, water, mass movements, and the activities of people is deposited temporarily on the adjacent backshore of the beach. During winter storms, the backshore apron itself is eroded, and its constituent sand transported by longshore currents northeast and east towards downtown Vancouver. As a result of these processes, the cliff face remains in a permanently unstable state.

Maps and aerial photographs indicate that cliff retreat in areas of severe erosion has averaged about 30 cm/a, and locally has exceeded 50 cm/a, during the last several decades. Average erosion rates, however, are somewhat misleading in that cliff retreat has varied both in time and space. Retreat has been rapid in years of intense storm activity, but negligible in others. Even during periods of exceptional storms, some sections of cliff have remained relatively stable amid areas suffering severe erosion.

In addition to "normal" cliff retreat, measured in tens of centimetres per year and caused by waves, currents, and human activity, there is a potential for catastrophic cliff retreat due to cliff collapse during great earthquakes or to rapid trenching of loose sediments by uncontrolled surface runoff. For example, torrential rains in January 1935 created a raging torrent in a formerly minor gulley near Point Grey. Over a period of two days, this torrent removed about 100,000 m^3 of sand and created a badland canyon (Campus Canyon) that extended far back into the Point Grey upland.

The most severe erosion at Point Grey has occurred along a 500 m length of shoreline bounded by two concrete observation towers built during World War II (Fig. 2). Photographs of this area taken in 1926 indicate that much of the presently scarred and rapidly eroding cliff face was at that time vegetated and apparently relatively stable. This suggests that rapid erosion in this area was triggered relatively recently, perhaps as a result of accelerated development of the area during the 1920s and 1930s. At that time, land clearing and construction profoundly modified the upland surface near the Point Grey cliffs, causing an increase in surface runoff over the cliff face. In addition, crude paths were built down the cliffs, a cable was installed to haul building stone from the beach to the cliff top, and a spiral storm drain was constructed near the cliff edge to discharge surface drainage from the upland to the sea. Once established, unvegetated scars on the cliff face expanded rapidly, and cliff retreat accelerated. The problem was aggravated during World War II by construction of military facilities and access trails to the beach. Erosion continued unabated after the war, forcing relocation of some roads and threatening the stability of buildings near the edge of the upland.

Since the 1940s, the Vancouver Parks Board, which administers the shorezone at Point Grey, and the University of British Columbia which is responsible for the land above the sea cliffs, have examined a number of remedial measures to stop or decelerate erosion. These include: 1) emplacement of structures to reduce wave erosion (for example, a road at the base of the cliffs, a seawall, a backshore berm, breakwaters, and groins); 2) revegetation of scarred portions of the sea cliffs; and 3) upgrading of the drainage system on the upland surface adjacent to the cliffs. In the 1970s, the matter became more than a coastal engineering problem as a result of heightened public concern that the beach at Point Grey might be despoiled if erosion control measures were implemented. An oftentimes heated debate over the future of the Point Grey cliffs raged for years at public meetings and in local newspapers. Throughout this period, of course, the cliffs continued to recede, further increasing the need for corrective action.

The final catalyst for corrective action was the construction of the University of British Columbia's Museum of Anthropology between 1973 and 1976. The museum, a magnificent multi-million dollar structure, housing one of the finest collections of Northwest Coast Indian artifacts in the world, sits atop Point Grey less than 100 m from the cliff edge. Once the museum was completed, its possible loss could not be countenanced, and immediate erosion control became essential.

An erosion control program was formulated in late 1979 by the Cliff Erosion Task Force, a group with a mandate from the Board of Governors of the University of British Columbia to recommend specific erosion control measures at Point Grey. The recommendations of the Task Force were based in part on written proposals in 1977-1978 by a local engineering firm, and in part on briefs presented by concerned citizens at public meetings at the end of 1979. These recommendations were accepted in modified form by the Board of Governors in 1980, and the first stage of the Point Grey erosion control program was implemented in 1980 and 1981 at a cost of approximately $725,000.

Wave action at the base of the sea cliffs, one of the main causes of erosion, has been curtailed by the construction of a sand-veneered gravel berm cored with ribs of crushed rock (Fig. 2). The berm is 30 to 40 m wide, an average of 1 m thick, and extends 320 m along the beach adjacent to the most severely eroding section of cliff. It will be extended an additional 275 m in 1982. "People erosion" has been significantly reduced by erecting fences along the top and base of the cliffs, and adding new, and improving old, access paths to the beach. Revegetation of scarred sections of the cliff was attempted by spraying a mixture of grass seed and fertilizer from aircraft. Trees at the top edge of the cliffs were cut down in order to prevent stripping of the protective soil mantle due to toppling.

Other measures advocated by the Cliff Erosion Task Force, but not yet implemented, include a restructuring of the University's spiral storm drain, better control of both surface and subsurface drainage on the cliff face and adjacent upland, and nourishment of the beach at Point Grey with sand dredged from the channel of the Fraser River.

The effectiveness of the Point Grey erosion control program cannot yet be evaluated because the protective berm has been in place for only one year. Although it is noteworthy that vegetation has become established on formerly barren cliff faces (Fig. 2), a final judgment on the efficacy of the program must await a winter of unusually strong storms when the protective berm will be put to a true test.

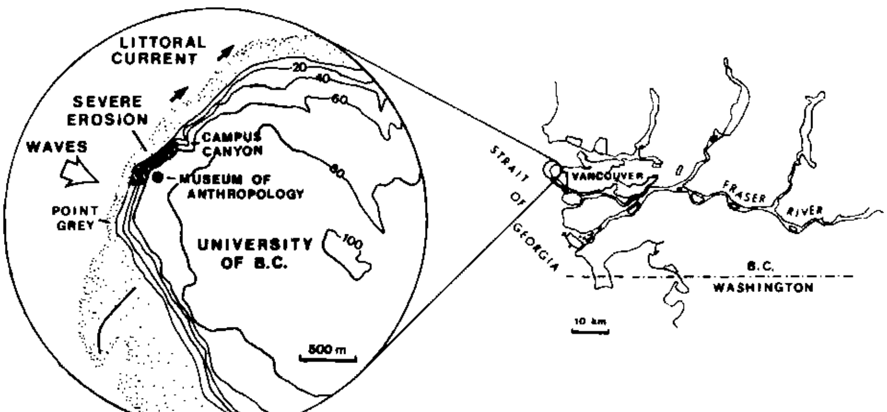

Figure 1 *Location map.*

References

Clague, J.J. and B.D. Bornhold, 1980, Morphology and littoral processes of the Pacific coast of Canada: in S.B. McCann, ed., The Coastline of Canada, Littoral Processes and Shore Morphology: Geol. Survey Canada Paper 80-10, p. 339-380.

MS received January 28, 1982.

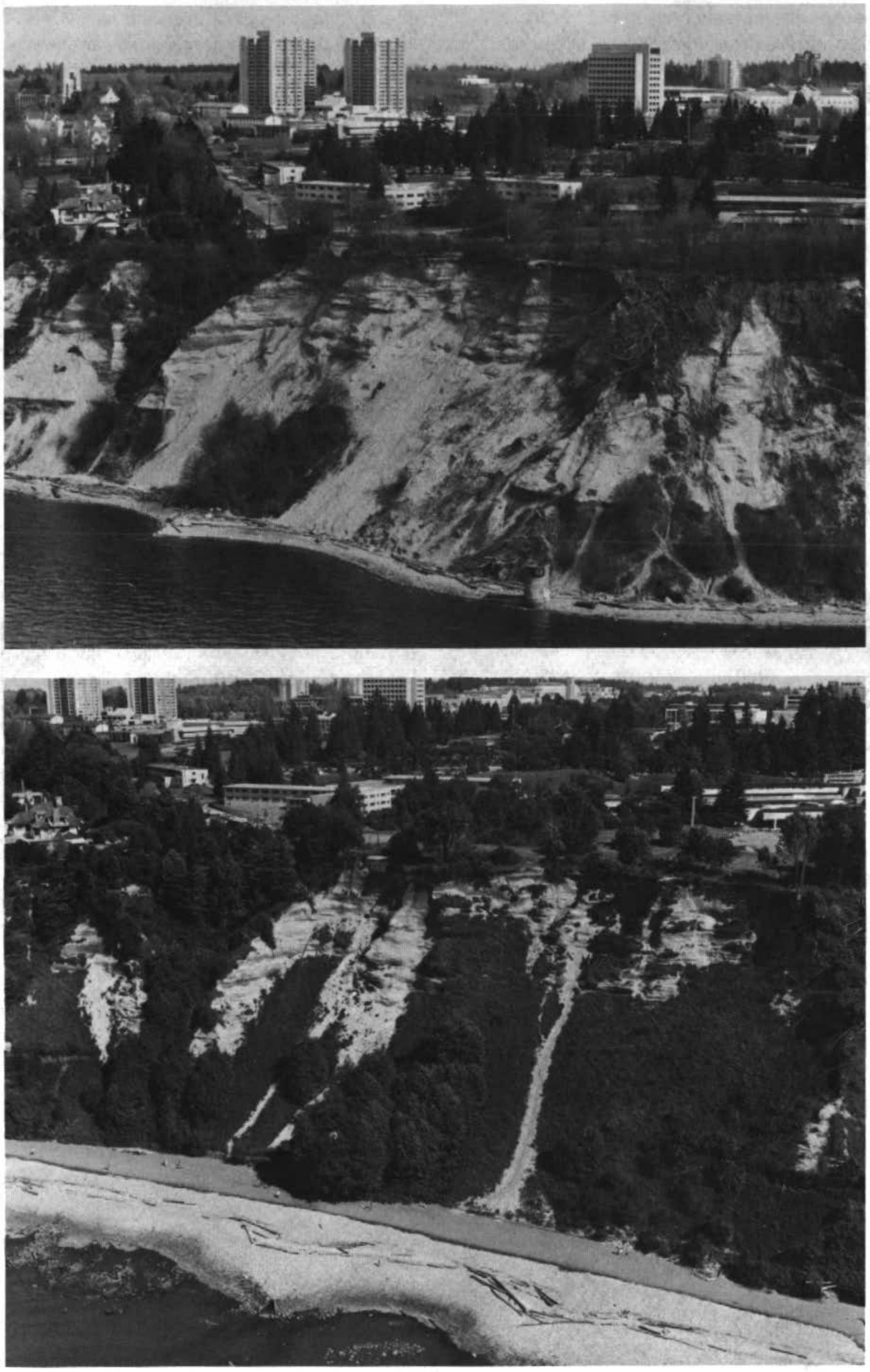

Figure 2 *The Point Grey cliffs. Top: View east towards the University of British Columbia prior to construction of the beach berm, April 1980. Note downed trees near the cliff edge that were cut to prevent stripping of soil by wind toppling. The Museum of Anthropology is the structure nearest the cliff edge at the far right. Bottom: The same sea cliffs in July 1981 after berm construction. The grey strip at the base of the cliffs is sand veneering the newly constructed berm. Note the new vegetation on formerly barren parts of the cliffs. Photographs courtesy of Neville Smith, University of British Columbia.*

Howe Sound Debris Flows

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On October 27 and December 4, 1981, two debris flows debouched from steep bedrock ravines across British Columbia Highway 99, north of Vancouver, onto small delta cones along Howe Sound. These two disastrous debris flows accentuated a phase of flooding, rock falls, and washouts in the southernmost Coast Mountains and contributed to the emerging image of the highway (only partly justified) as a 'killer'.

Howe Sound is similar to other fiords in the Coast Mountains of British Columbia. Sheer granitic walls or steep forest-covered slopes rise directly from the sea to heights between 1000 and 2000 metres (Fig. 1). Small bowl-shaped upland basins are the source of torrents which discharge via bedrock gorges into the sea. Sporadic debris flows along the torrent channels have created small high-gradient delta cones composed mainly of coarse granitic debris. Bridges cross the normally harmless creeks and residential buildings adorn some of the cones. Debris flows of destructive potential are generally set off by intense autumn rainstorms (e.g., 1969, 1972, 1979, 1980). Bouldery debris incorporated in the flows is derived from bedrock or benches of coarse colluvium in the upper reaches of the torrents.

On October 27, 1981, near mid-night, approximately 15,000 m^3 of rock and trees failed as a thin-skinned debris avalanche at an elevation of 1200 metres astride the narrow channel of M-Creek. Soon thereafter a debris flow scoured down the torrent channel (average gradient 50%) and, having attained considerable momentum, took out the bridge carrying Highway 99; it then picked up an unoccupied residence along the shore and pushed it out to sea (Fig. 2). As visibility on the highway at the time was poor, the wide slash across the road bed was noticed only too late by drivers of several vehicles that plunged into the gap. The accidents claimed 9 lives.

On December 4, 1981, a rainstorm, coupled with snowmelt set in motion another debris mass which descended through the gorge of Strachan 2 Creek, a few kilometres south of M-Creek. Strachan 2 Creek had experienced debris flows in previous years. The most serious, in autumn 1969, demolished a highway bridge which was replaced by a modern steel-concrete structure. This time the slowly moving lobe of blocky debris included slabs of granite up to 2 metres in diameter and had a total volume of 30,000 to 40,000 m^3. The new highway bridge and a railroad bridge below it were strong enough to impede the mass flow, thus protecting several residential buildings that had sprung up on a steep debris cone along shore since 1969. Nevertheless, the flow claimed one life.

During this series of storms other debris spilled into Capilano Lake, a water reservoir north of Vancouver. For more than two weeks the city's drinking water changed into a rather murky brew.

Debris flows with destructive potential along some of the torrents in the Howe Sound region seem to have average recurrence intervals of only a few decades; in detail, the complexities of the meteorological-geological parameters determining debris flow occurrence near Vancouver are well illustrated by the fact that an urban area only 20 km southeast of Howe Sound (Port Moody - North Vancouver) which had been severely affected by slope failures during a rainstorm in December 1979 did not suffer damages in 1981. The problem of the future is that many deceivingly pleasant debris cones in Coastal British Columbia have become very desirable development land.

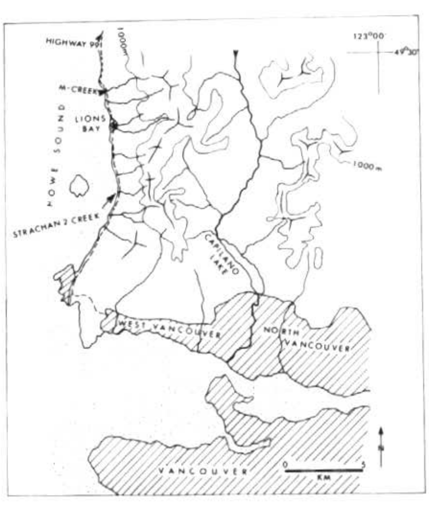

Figure 1 *Index map of the Howe Sound area north of Vancouver.*

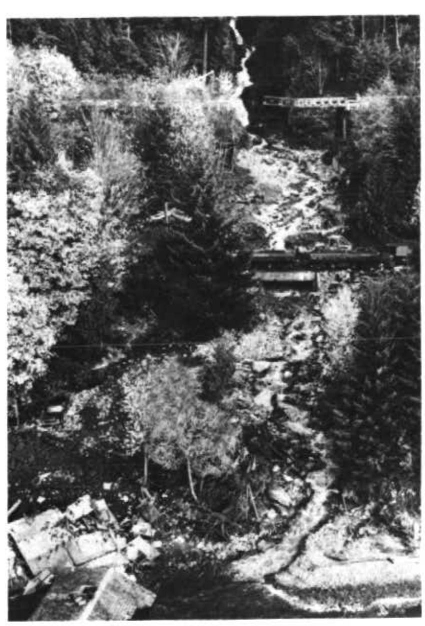

Figure 2 *View of the mouth of M-Creek. Note remainders of demolished residence drifting in the sea and highway bridge under reconstruction.*

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