



NEOTECTONIC INVESTIGATIONS ON VANCOUVER ISLAND (92B, F)

By P.T. Bobrowsky, B.C. Geological Survey Branch
and J.J. Clague, Geological Survey of Canada

KEYWORDS: Geological hazards, neotectonics, Quaternary, Shoemaker Bay, tsunami, C^{14} , Port Alberni, Tofino, Island View Beach, Gyro Park, earthquakes, sedimentology.

INTRODUCTION

Quaternary geologic studies were undertaken by staff of the British Columbia Geological Survey Branch and Geological Survey of Canada at several locations during 1991. These studies are part of a multi-year program aimed at assessing the Holocene seismicity, neotectonism and sea level history of Vancouver Island and adjacent mainland British Columbia (Clague and Bobrowsky, 1990). This research will provide information on the probability and likely impacts of catastrophic natural events such as earthquakes and tsunamis. The 1991 field activities of this joint provincial-federal research effort consisted of three parts: a scientific cruise in Saanich Inlet in February; excavations near Port Alberni in June; and sonic drilling and excavation near Victoria and Port Alberni in September (Figure 3-4-1). A second cruise in Saanich Inlet to obtain air-gun seismic reflection data is tentatively planned for late 1991. The objective of the Saanich Inlet cruise was to recover sediment cores which might provide a record of late Holocene earthquakes. Cores up to 11 metres in length, spanning approximately the last 2000 years, were retrieved at five locations. These cores supplement three others collected and described previously (Bobrowsky and Clague, 1990). Detailed micropaleontological, sedimentological and geochronological analyses are currently in progress (Blaise, 1992).

Shovel excavations were made in undisturbed marsh sediments near Port Alberni to document historic and prehistoric tsunamis. Samples for Cs^{137} and C^{14} dating and micropaleontological analysis were collected and are now being processed; the results will be presented in a future publication. The Port Alberni work developed from the authors' discovery of possible tsunami deposits near Tofino in 1990 (Bobrowsky and Clague, 1991b). At the time of publication of the Tofino results, an absence of C^{14} dates precluded an adequate synthesis of some of the data. Two new dates of 7070 ± 120 years B.P. (AECV-1205C) and 7900 ± 100 years B.P. (GSC-5106) obtained from tree stumps rooted in marine muds below mean sea level now permit an expanded interpretation of Holocene sea level fluctuations in this area (Bobrowsky and Clague, 1991a). Briefly, these new dates, coupled with evidence for late Holocene raised shorelines (Friele, 1991) indicate a middle Holocene transgression followed by regression during the late Holocene (Figure 3-4-2).

Observations and preliminary results of the third component of our 1991 fieldwork (sonic drilling) are presented below.

DRILL SITES

Sonic drilling was done at three sites: Island View Beach ($48^{\circ}35'N$, $123^{\circ}22'W$) on the east side of Saanich Peninsula; Gyro Park ($48^{\circ}28'N$, $123^{\circ}18'W$) at Cadboro Bay, north of Victoria; and Shoemaker Bay ($49^{\circ}15'N$, $124^{\circ}0'W$) directly west of Port Alberni (Figure 3-4-1). One hole was drilled at Island View Beach north of the park access road on the west side of a Holocene spit complex (CIA-91-171). Some 500 metres of wetland separates the drill site from eroded Pleistocene bluffs to the west. Two holes were drilled at Gyro Park, one at the southern edge of the park at the upper limit of the beach (CIA-91-172) and the other approximately 10 metres northeast of the parking lot and 20 metres northwest of the park washrooms (CIA-91-173). Two holes were also drilled at Shoemaker Bay, one on a road extending into the marsh area some 100 metres south of the Alberni pulpmill water pipeline (CIA-91-174) and the other approximately 500 metres to the west of the first, at the edge of the marsh (CIA-91-175) (Plate 3-4-1).

METHODS

Drilling was done with a truck-mounted otosonic drill operated by Sonic Drilling Ltd. of Surrey, B.C. (Plate 3-4-2). This machine uses high-frequency vibrations to retrieve intact sediment cores up to 6 metres in length and 10 centimetres in diameter. Rapid penetration of the sediment is achieved by the vibratory action of the drill pipe which causes soil particles to fluidize at the drill bit and along the pipe edge. Intact sediment slides into the pipes as drilling progresses. Individual core sections are extruded into plastic sleeves for storage, transport or on-site examination (Plate 3-4-3).

Extruded cores were split in the field and described in detail. Description includes observations on the type and texture of the sediment, primary and secondary structures, the thickness of lenses, laminae and beds, the nature of the bounding contacts, and the type and distribution of organic material. Photographs were taken of all cores. Samples were collected for C^{14} dating, geochemistry and micropaleontological analysis.

RESULTS

At Island View Beach (CIA-91-171), continuous core was recovered to a depth of 14 metres (Figure 3-4-3). Most of the sediment consists of clean, medium to coarse sand with scattered small rounded pebbles. Lenses and layers of sandy gravel are present throughout the sequence, and a silt bed 1 metre thick occurs at 9 to 10 metres depth. Basal contacts of muddy and gravelly interbeds are generally sharp. Three samples, comprising wood and shell, were recovered from the silt bed for C^{14} dating.

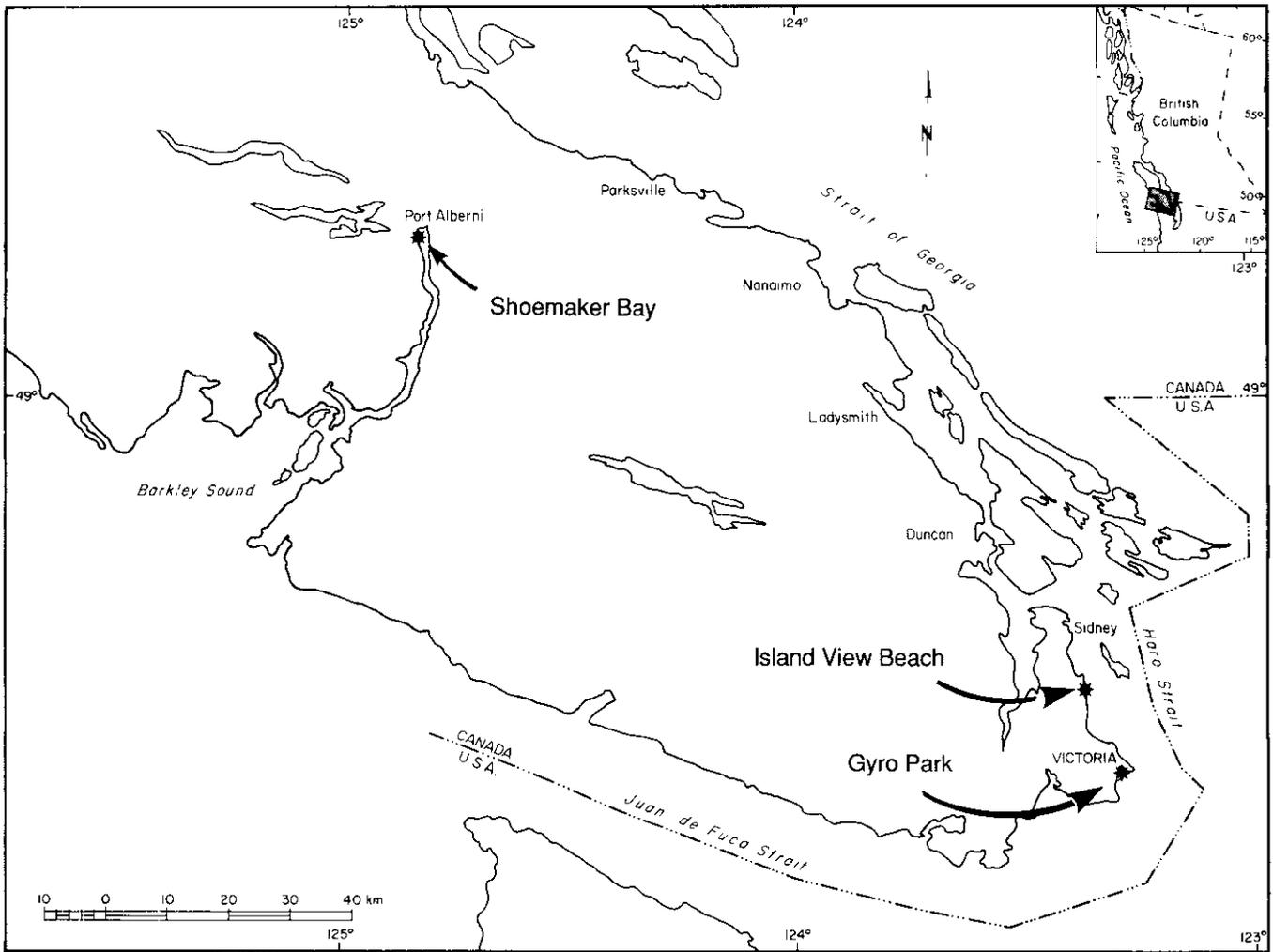


Figure 3-4-1. Location map of 1991 drilling sites.

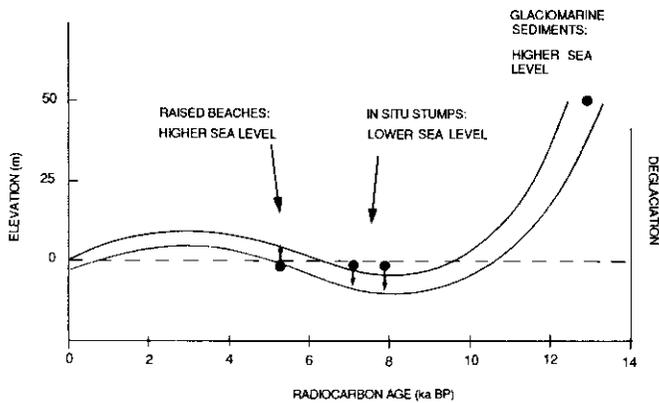


Figure 3-4-2. Sea-level curve for the Tofino area. Interpretation based on radiocarbon dates by the authors and raised shoreline data by Friele (1991).

Cores were collected to 7.9 metres depth at the Gyro Park beach site (CIA-91-172). The sequence, from top to bottom, is: approximately 3 metres of well sorted coarse sand and

gravel (modern beach facies), 3 metres of Holocene peat, and approximately 2 metres of pebbly sand and sandy gravel. The basal contacts of the units are gradational. Eight samples for foraminiferal analysis and two wood samples for C^{14} dating were collected from the lower part of the peat unit and from a thin muddy zone just below the peat. The second set of cores at Gyro Park (CIA-91-173) totalled 12.5 metres in length (Figure 3-4-4). Five major units are recognized; from top to bottom, these are: approximately 0.5 metre of fill, 2.5 metres of compacted peat, 6.5 metres of sand and gravel, 3 metres of silty clay and sandy silt, and shelly pebbly sand. All contacts, except that between the fill and peat, are gradational.

About 27 metres of sediment were cored at the first Shoemaker Bay drill site (CIA-91-174). Approximately 3 metres of road fill abruptly overlies 2 metres of silty mud with sandy interbeds, which in turn sharply overlies 22 metres of alternating lenses and beds of sandy gravel and pebbly sand. Six wood samples were collected at depths of 4.5 to 6 metres for C^{14} dating. The second Shoemaker Bay drill hole cored 11.5 metres (CIA-91-175; Figure 3-4-5). The upper 3.7 metres is road fill. This sharply overlies about 0.5 metre of muddy peat and organic mud containing sandy

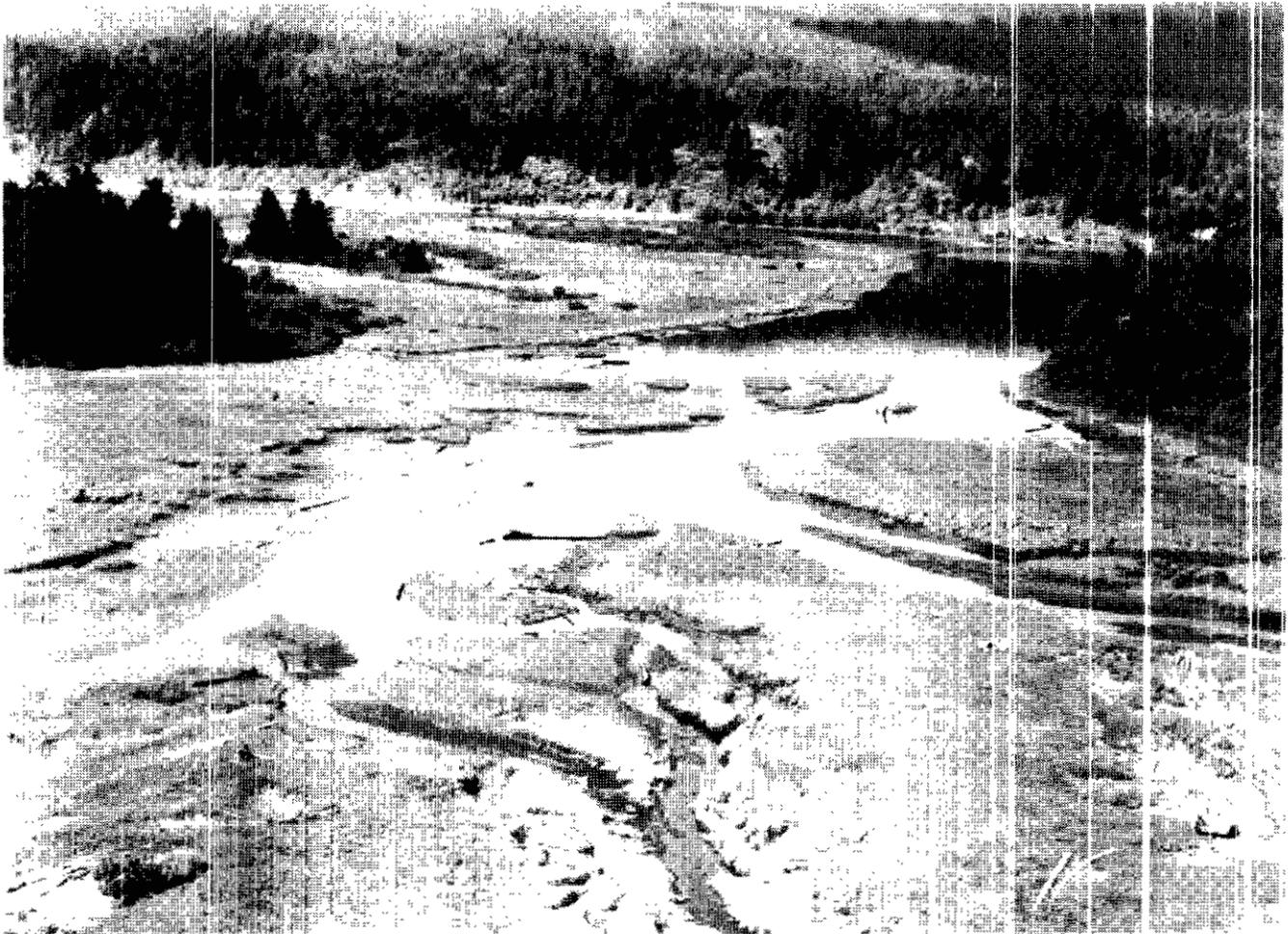


Plate 3-4-1. General view of drilled marsh sediments at Shoemaker Bay area Port Alberni.

interbeds. This unit grades downwards over a short distance into 0.8 metre of sedgy sand with scattered stones. The remaining 6.5 metres of the sequence consists of massive fossiliferous muddy silt intercalated with thin beds of clean sand. One thick (ca. 60 cm) pebbly sand bed occurs at a depth of 8 to 9 metres. Eight C¹⁴ samples were recovered from the sediments at depths ranging from 5 to 11.5 metres.

DISCUSSION

The stratigraphy at Island View Beach supports the earlier sea-level interpretations of Clague (1989). The predominantly coarse sediments record a lengthy period of intertidal and perhaps shallow subtidal sedimentation at a time when sea level was lower than at present. The sediments are part of a complex spit that was deposited by waves and longshore currents. The source of the sediments is Pleistocene bluffs at Cowichan Head to the south. Interbeds of fine sediment (silt and clay) indicate periods of quiescence, whereas coarser gravel beds record episodic storms.

At Gyro Park, the lowest cored sediments contain a marine shelly fauna and thus record a marine depositional environment (probably shallow subtidal or intertidal). Over-

lying interbeds of sand and gravel were deposited in an inshore or foreshore environment. Subsequent emergence of the site is indicated by the accumulation of peat. The uppermost unit of sand and gravel at site CIA-91-172 indicates that a transgression has occurred in the last few thousand years.

The thick sand and gravel sequence at drill site CIA-91-174 at Shoemaker Bay is probably fluvio-deltaic in origin and may have been deposited, in part, during a period when sea level was lower than today. Of greater interest, however, are the sharply bounded layers of sand in the overlying mud unit. These may be tsunami deposits and are the focus of our ongoing work in this area.

ACKNOWLEDGMENTS

The drilling was done by R. Foussy (Sonic Drilling Ltd.).

REFERENCES

- Blaise, A. (1992): Holocene Sediments from Saanich Inlet, British Columbia, and their Neotectonic Implications; in Current Research, Part A, Cordillera and Pacific Margin, *Geological Survey of Canada*, Paper 92-1A, in press.

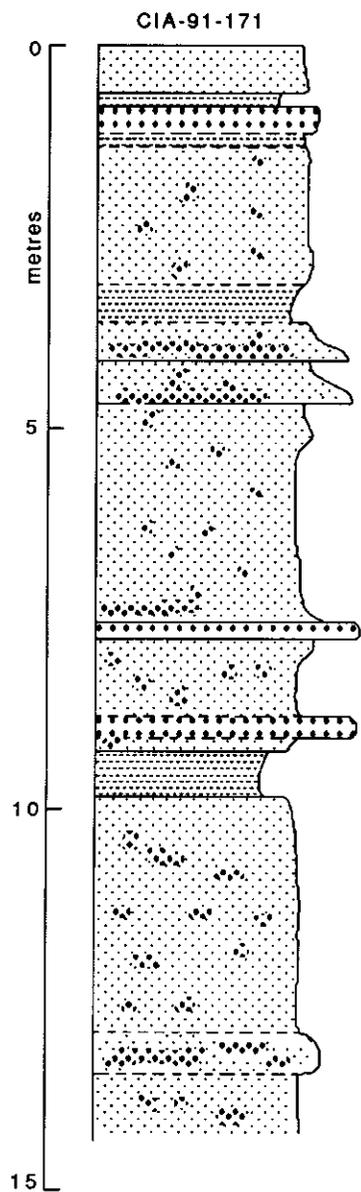


Figure 3-4-3. Composite core stratigraphy at Island View Beach (CIA-91-171).

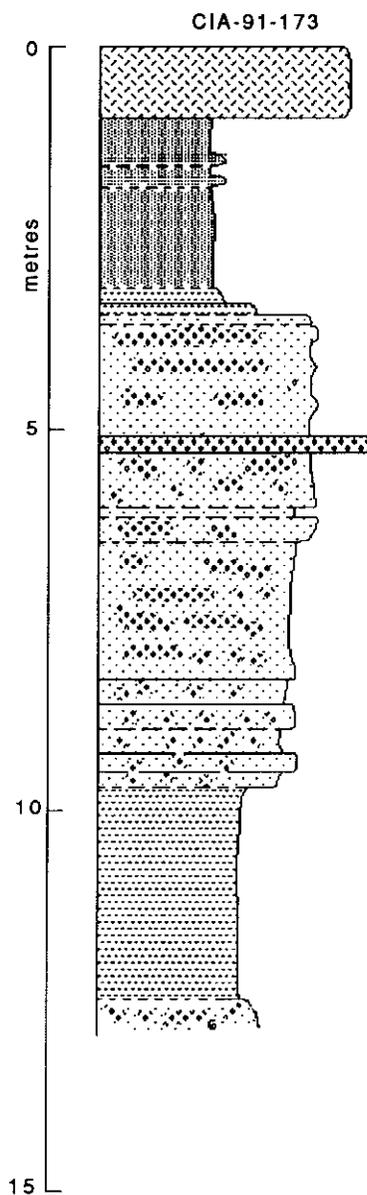


Figure 3-4-4. Composite core stratigraphy at Gyro Park (CIA-91-173).

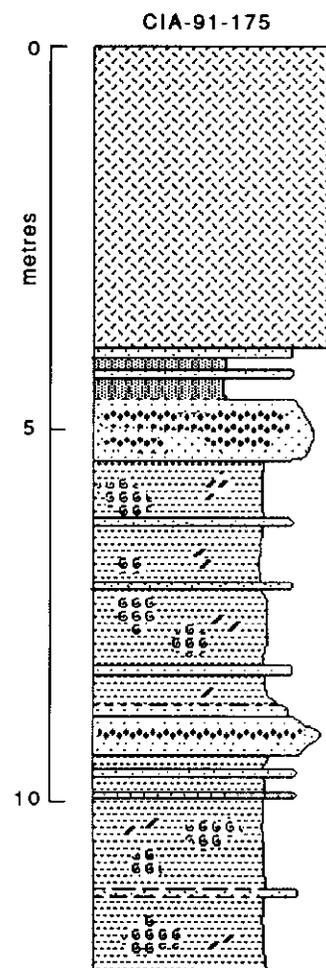
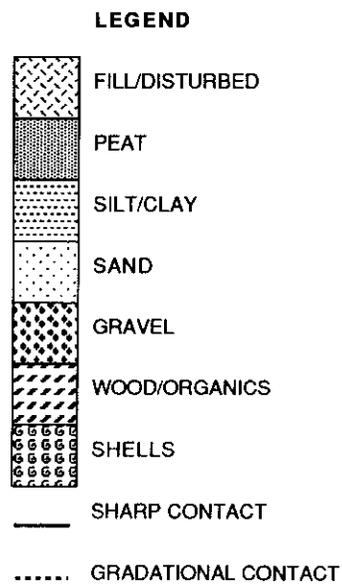


Figure 3-4-5. Composite core stratigraphy at Shoemaker Bay (CIA-91-175).



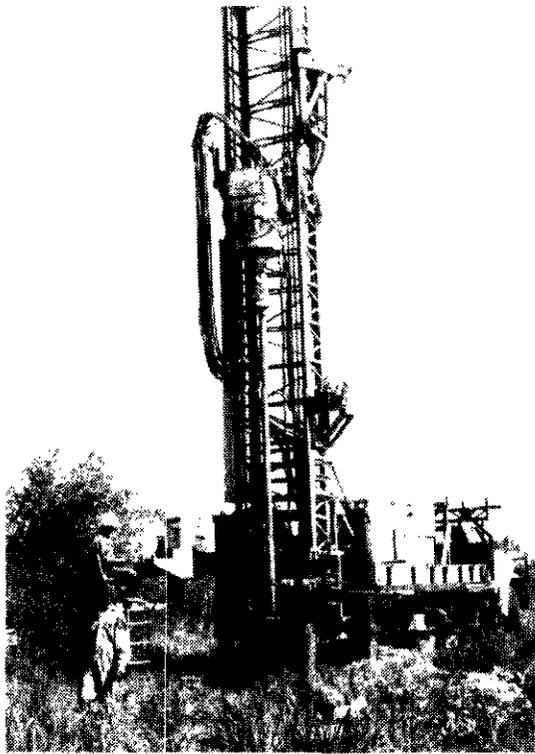


Plate 3-4-2. View of sonic drill used in neotectonic study to obtain solid core of unconsolidated sediment.

Bobrowsky, P.T. and Clague, J.J. (1990): Holocene Sediments from Saanich Inlet, British Columbia, and their Neotectonic Implications; in *Current Research, Part E, Geological Survey of Canada, Paper 90-1E*, pages 251-256.

Bobrowsky, P.T. and Clague, J.J. (1991a): Late Glacial and Post-glacial History of the Tofino Area, British Columbia; *Canadian Quaternary Association, Biennial Meeting, Programs and Abstracts*, page 16.

Bobrowsky, P.T. and Clague, J.J. (1991b): Neotectonic Investigations on Western Vancouver Island, British Columbia (92F/4); in *Geological Fieldwork 1990, E.C. Ministry of Energy, Mines and Petroleum Resources, Paper 1991-1*, pages 307-313.

Clague, J.J. (1989): Late Quaternary Sea Level Change and Crustal Deformation, Southwestern British Columbia; in *Current Research, Part E, Geological Survey of Canada, Paper 89-1E*, pages 234-236.

Clague, J.J. and Bobrowsky, P.T. (1990): Holocene Sea Level Change and Crustal Deformation, Southwestern British Columbia; in *Current Research, Part E, Geological Survey of Canada, Paper 90-1E*, pages 244-250.

Friele, P.A. (1991): Holocene Relative Sea-level Change: Vargas Island, British Columbia; unpublished M.Sc. thesis, *Simon Fraser University*, 106 pages.

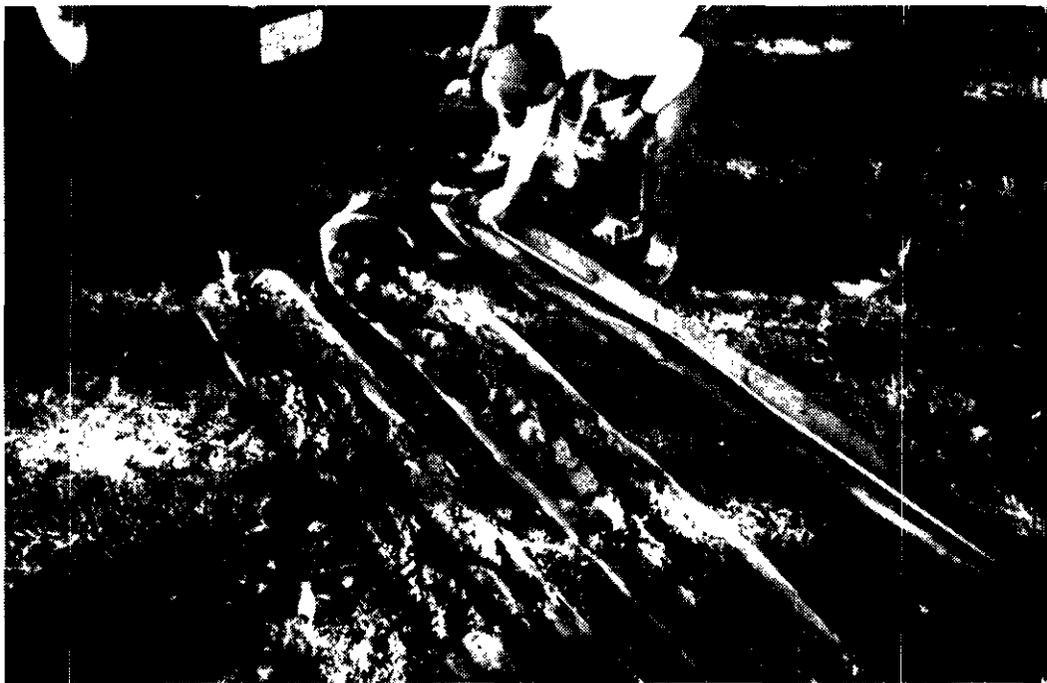


Plate 3-4-3. Extruded core being examined during sectioning and logging at the drill site.

NOTES