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HIGH RESOLUTION SHALLOW SEISMIC REFLECTION PROFILES FROM THE FRASER DELTA, TSAWWASSEN, BRITISH COLUMBIA

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Introduction

Since the disappearance of the late Pleistocene Cordilleran Ice Sheet approximately 10,000 years ago, the Fraser River has built a large delta at its mouth on the coast of British Columbia. The floodplain of the delta lies just to the south of downtown Vancouver, and is rapidly being urbanized as the population of Vancouver increases. In recent years much effort has been directed towards an understanding of the evolution and structure of the delta (e.g. Clague et al., 1983). This work is becoming increasingly more important as urbanization and industrialization of the Fraser Delta proceeds, as this area is located in one of the highest seismic risk zones in Canada.

The development of shallow seismic reflection techniques over the last few years has provided a tool with the potential of yielding detailed structural information on the Quaternary deposits below the Delta. A trial survey in August 1985 proved that excellent data could be obtained in the area (Luternauer et al., 1986). Further seismic work was carried out in August 1986. The data from these two surveys are presented in this Open File. In conjunction with the seismic surveys, some drilling, core sampling and testing, and downhole logging are being carried out as part of the project. It is planned to report fully on the work following the field season of 1987.

Method and Recording Parameters

The shallow seismic reflection sections shown in this Open File were produced using the "optimum offset" technique developed at the GSC (Hunter et al., 1984). This technique was originally developed as a tool for mapping overburden-bedrock contacts, but has also proved to be an excellent means of delineating structure within unconsolidated overburden. The resolution depends on the frequency of seismic energy that can be transmitted through the ground, and is highest when the near-surface materials are fine-grained and water-saturated. Thus the floodplain of the Fraser Delta provides an excellent site for high resolution shallow seismic surveying. The predominant frequency of the reflection data is between 300 and 500 Hz.

Two problems were encountered when trying to establish suitable survey lines in the area. The first is that much of the floodplain surface is heavily urbanized (e.g. Richmond), and therefore not easily accessible for seismic surveying. The second problem is that large zones of the eastern part of the Delta are covered by peat bogs

which preclude the use of shallow reflection methods because the near-surface organic layer strongly attenuates all high frequency energy. This effect is observed even outside the mapped peat bog areas, presumably due to thin peat layers below the surface or to trapped gas in the near-surface material. Because of these restrictions our "optimum offset" survey has been concentrated in the "rural" area of the southern part of the Delta, near Ladner and Tsawwassen (Figure 1).

Each trace on an "optimum offset" profile is obtained by using a geophone to record the ground motion in response to seismic energy that is produced at a predetermined source-geophone offset. The final section consists of a series of such measurements made at a constant geophone spacing.

Approximately 16 km of line have been collected on the Fraser Delta to date (Figure 2). Lines 100, 300 and 400 were shot in August 1985, with a source-geophone offset of 25 m and a geophone spacing of 2.5 m. Line 200, along the coalport causeway, was also shot in 1985, but with a source-geophone offset of 20 m and a geophone spacing of 5 m. Lines 500 and 600 were shot in August 1986, with a source-geophone offset of 24 m and a geophone spacing of 3 m. All lines have now been plotted with the same horizontal scale. The data were filtered in the field by high-frequency geophones (50 Hz for Lines 100 and 500, 100 Hz for all other lines), and by high pass analog filters on the seismograph (see below). The 12-gauge "Buffalo gun" (Pullan and MacAulay, 1987) was used as the seismic source for all lines. For optimum seismic coupling the geophones and the gun were planted in the bottom of water-filled irrigation ditches alongside roads.

The Nimbus 1210F engineering seismograph was used to record all the data except for Line 600. The analog filters on this instrument were set at 300 Hz HP. The records were stored on cassette tape in the field using the G724S tape recorder. Line 600 was recorded on a Bison 8012A 12-channel engineering seismograph with the analog filters set for a bandpass of 350-1000 Hz. The records were stored in solid state memory in the instrument and transferred to disk daily.

All data were transferred to an Apple II+ or IIe microcomputer, stored on floppy disk, and processed using software developed by the GSC (Norminton and Pullan, 1986). Preliminary sections were produced on an Epson widetrack, dot-matrix printer in the field office, with static corrections, a digital filter, an automatic gain control (AGC) and gain tapers applied to the data. Final sections were produced on a flatbed plotter after the field work was completed. The depth scale was calculated from a velocity-depth function determined from uphole seismic surveys in several boreholes in the area.

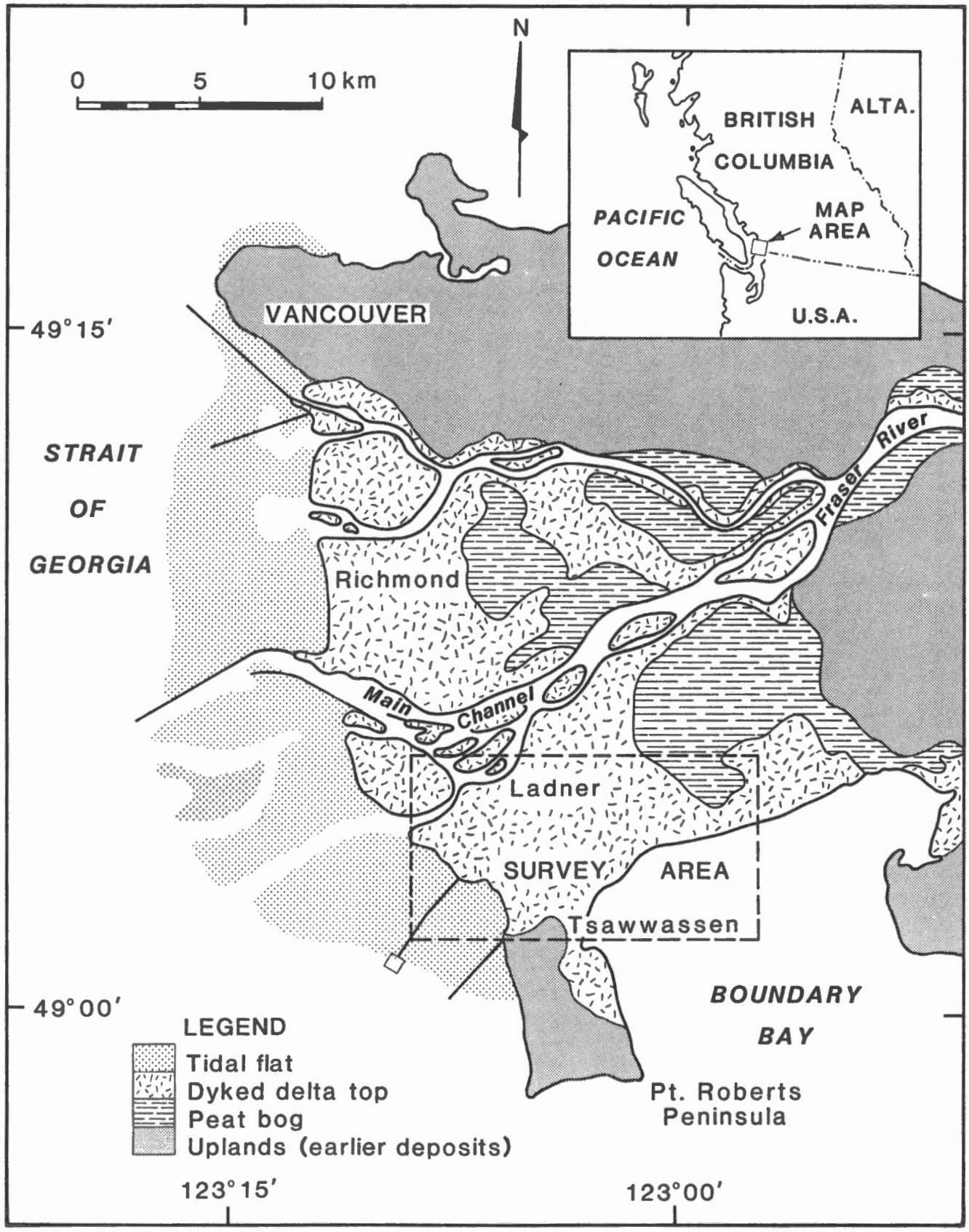

Figure 1 Location and geographic setting of survey area (from Luternauer et al., 1986).

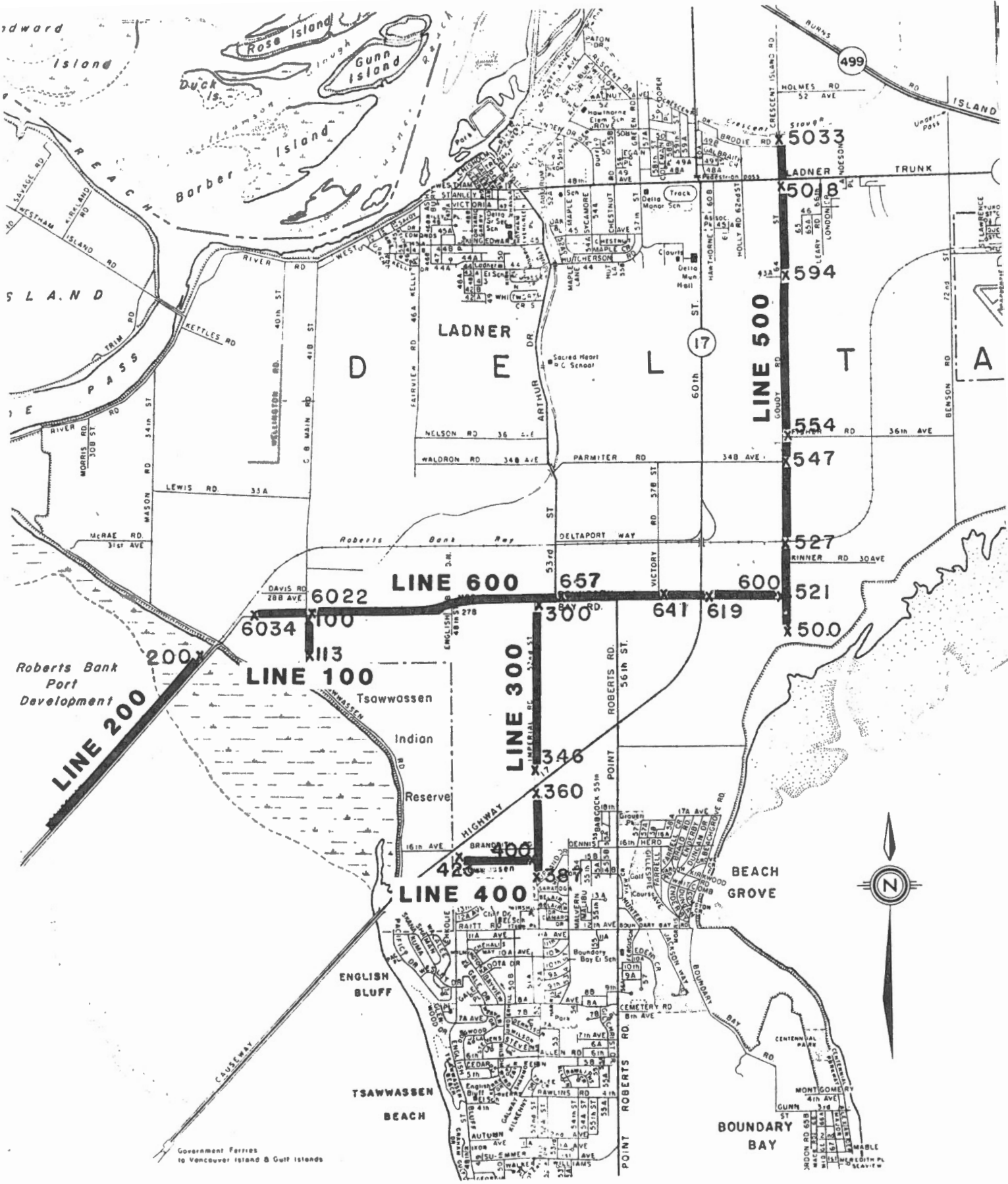

Figure 2 Location of survey lines 1985 and 1986.

Results

Final sections of the data collected to date from the Fraser Delta are presented in this Open File. No interpretation is attempted at this time. This seismic work is part of an ongoing project involving several other groups and methods of investigation, and data collected in the near future will undoubtably make any interpretation significantly more valid.

Several interesting features can be pointed out however. It is immediately obvious that the subsurface structure beneath this part of the Fraser Delta is extremely complex and several different depositional environments are represented on these sections.

The most striking example is the classic display of foreset bedding on Line 500. This line is very close to being a dip section: Line 600 intersects it at right angles and indicates that there is only a small component of dip to the west. At the south end of Line 500 the foreset bed sequence is approximately 150 m thick. The foreset beds appear to have been deposited on a surface that is represented by a high-amplitude, discontinuous, complex reflector which also dips to the south. It is not known at this time what causes this reflector. Drilling has determined that the foreset beds consist predominantly of sand.

Two anomalous features are observed on Line 600, centred on records FD-650 and FD-681. Both are characterized by a shallow, large-amplitude reflector that appears to mask any deeper structure. The nature, as well as the lateral extent, of these anomalies has not yet been determined. Possible explanations include depositional features (presumably glacial in origin), the presence of gas trapped below the reflector, or tectonic activity in the form of diapirism and/or faulting. The limited drilling information available at this time has not resolved this question. However, it has been established that the anomaly centred on record FD-650 is <u>not</u> associated with a till or gravel layer, making the interpretation of the anomalies as glacial depositional features rather unlikely.

The easternmost anomaly on Line 600 appears to separate two depositional environments. To the east of the anomaly is the thick sequence of foreset beds indicated on Line 500. To the west, at the intersection of Lines 300 and 600, is a small basin which dips gently to the north (see Line 300) and to the east (see Line 600).

South of Highway 17 on Line 300 is a very shallow, high-amplitude reflector which dives sharply to the south of record FD-369. Drilling has established that this is an overconsolidated till. This till is presumably older than the Pleistocene sediments that make up Point Roberts Peninsula because, according to the seismic section (Line 300 (S)), the erosional surface that marks the top of the till dips to the south and is approximately 110 m below surface at the base of the Tsawwassen heights. Thus, lines 300 (S) and 400 apparently define a depositional basin of Pleistocene (?) sediments overlain by a thin veneer of modern delta deposits.

Summary

Use of the "optimum offset" shallow seismic reflection method on the southern part of the Fraser Delta has revealed the subsurface character of the delta to be far more complex than previously thought. To date the survey has delineated several different depositional environments beneath the modern floodplain of the Fraser River within this small survey area. Two anomalous features observed on one line are as yet unexplained. Further shallow seismic profiling, in conjunction with drilling and other geophysical investigations, should contribute to an improved understanding of the structure of this delta and to the assessment of seismic risk in the area.

Acknowledgments

Our initial testing of the shallow seismic reflection technique in the Fraser Delta was carried out at the suggestion of J.L. Luternauer. The project has since grown into a multi-faceted one involving J.L. Luternauer and J.J. Clague from the Geological Survey of Canada, Vancouver, and M.C. Roberts from Simon Fraser University, as well as our group. The drilling and geological interpretation are being handled primarily by Luternauer, Clague and Roberts, though they cannot be held responsible for the preliminary interpretations alluded to in this Open File. The seismic data presented here were collected with the valuable assistance of H. Jol from S.F.U., R. Heard and B. Felix, among others. The use of Simon Fraser University's Bison Geopro for recording the data from Line 600 is gratefully acknowledged.

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