A small boat seismic reflection survey of the Lougheed Island Basin – Cameron Island Rise – Desbarats Strait region of the Arctic Island channels using open water leads

Project 820050

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Abstract

Lougheed Island Basin, Desbarats Strait, and Cameron Island Rise in the Arctic Island channels were geologically examined using helicopter-transported inflatable boats in open water leads through the near permanent ice cover. This experimental technique has allowed collection of the first continuous seismic reflection data in the region, as well as gravity cores and bottom photographs at four stations. Three stratigraphic units are identified from the seismic profiles: a lowermost unstratified sediment whose surface has irregular relief and variable thickness to 53 m., interpreted to be glacial drift; a localized stratified unit which reaches 10 m in thickness and overlies the drift; an uppermost ponded acoustically transparent mud which varies from 1 to 4 m in thickness and occurs in depths greater than 150 m.

Résumé

On a étudié la géologie du bassin de l'île Lougheed, du détroit de Desbarats et du massif de l'île Cameron dans les chenaux des îles arctiques à l'aide de bateaux gonflables transportés par hélicoptère dans des chenaux d'eau libre parcourant la couverture de glace presque permanente. Cette technique expérimentale a permis de collecter les premières données continues sur la sismique réflexion dans la région et a permis de prendre des carottes pour la gravimétrie et des photographies du fond dans quatre stations. On a pu identifier trois unités stratigraphiques grâce aux profils sismiques: un sédiment de base non stratifié dont la surface présente un relief irrégulier et qui a une puissance de 53 m a été interprété comme étant un sédiment fluvio-glaciaire; une unité stratifiée localisée qui atteint 10 m de puissance et qui recouvre l'unité précédente; une unité supérieure est constituée d'accumulation de boues acoustiquement transparentes dont la puissance varie entre 1 et 4 m et qui se trouve à des profondeurs supérieures à 150 m.

INTRODUCTION

From July 6 to August 12, 1986, the Atlantic Geoscience Centre conducted a marine seismic reflection and sampling program in the Lougheed Island Basin, Cameron Island Rise and Desbarats Strait area of the Arctic Island channels (Fig. 91.1). This project follows a 1985 through-ice sediment sampling project in the same area,. in which 78 cores and bottom sediment grabs were collected. These projects are part of a study of the geology of the Arctic Island channels supported by the Northern Oil and Gas Action Program (NOGAP) which is directed towards determining the composition, thickness, distribution, and geotechnics of the unconsolidated sediments, and identifying geological constraints to development.

The 1986 project was carried out from a basecamp on southern Lougheed Island (Fig. 91.1), with logistical and helicopter support organized through the Polar Continental Shelf Project. Continuous seismic reflection data were collected using helicopter-transportable systems deployed from five metre inflatable boats through open water leads (Fig. 91.2). The leads form seasonally in this area of near-permanent ice cover, which is normally inaccessible to conventional shipborne operations. One hundred and five line-kilometres of seismic reflection data were collected in eleven leads, and gravity cores and bottom photographs were taken at four locations.

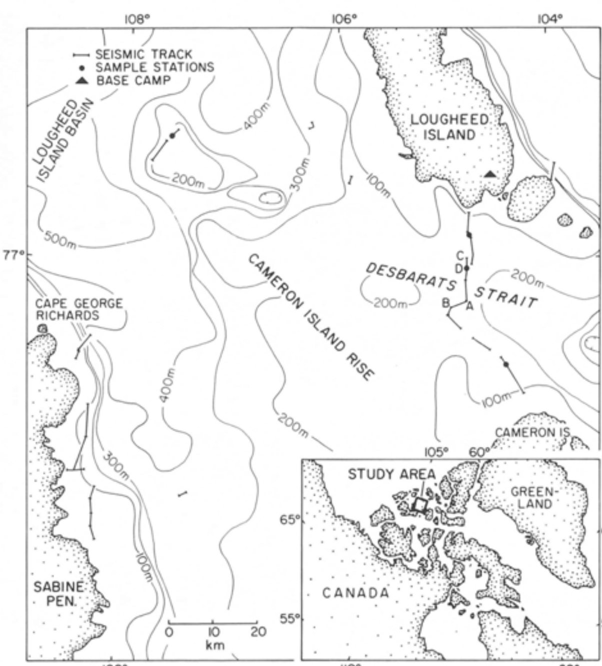

Figure 91.1. Index map of the 1986 field area, showing the location of the seismic reflection data and, sediment samples and bottom photographs collected, and of the base camp on Lougheed Island.

This paper discusses both the experimental technique used to collect seismic reflection data in the study area, and the subbottom information obtained during the survey.

METHODS

A large area of the Arctic Island channels is covered with a near-permanent ice cover, which precludes collection of continuous seismic reflection data using conventional shipborne methods. An alternative method was conceived which used the small cracks or leads which form in the ice cover during the summer thaw (Fig. 91.2). An aerial reconnaissance of the proposed study area undertaken in July, 1985, determined that the abundance and distribution of these leads was sufficient to allow regional collection of continuous seismic reflection data within the marine channels. As a result, an experimental program was carried out using the following methods:

Seismic profiling equipment was towed in the leads with a five metre Zodiac inflatable boat, fitted with a 15 horsepower outboard motor (Fig. 91.3). A JetRange 206L-1 helicopter was used to sling the boat and seismic equipment (Fig. 91.4) to a survey lead, while the remainder of the equipment, as well as survival gear, gasoline and 2-3 technicians were transported in a second flight. Communications between the Zodiac, helicopter, and the basecamp were by SBX-11 VHF radios.

Three lightweight and mobile acoustic profiling systems were operated along separate transects of the leads. Single channel seismic reflection profiles were obtained using the

Figure 91.2. Photograph of one of the eleven leads surveyed during the 1986 field program. Lead lengths varied from 1.5 to 20 km, while average width was from 6 to 10 m (above photo) and up to a maximum of 50 m. The photograph was collected at an approximate altitude of 100 m and the lead shown is 6 to 10 m wide.

Ferranti ORE Geopulse subbottom profiler. This system provided sufficient energy to penetrate the unconsolidated sediment section, as well as to obtain limited penetration into the underlying bedrock. In addition, both 3.5 kHz and 12 kHz subottom profilers were attached to the side of the boat by an aluminum frame, and the returned signal was processed through a Raytheon PTR transceiver and recorded on the EPC Model 1600 recorder.

Navigation for the program was provided by a Global Navigation System mounted in the helicopter, and a Magnavox MX 5102 satellite navigation receiver which was operated from the Zodiac during survey operations. In the latter part of the program, a replacement MX 4102 satellite receiver was used after the first receiver became unserviceable.

One hundred and five line kilometres of seismic reflection data were collected (Fig. 91.1), although the project was seriously constrained by both ice and weather conditions. 1986 was considered an unusually severe year, with lower than average temperatures delaying normal ice breakup by approximately a month. This resulted in fewer and smaller leads in the study area than were observed in 1985. Leads were also more discontinuous and irregular than expected, possibly due to the high concentration of multiyear ice frozen into the first-year ice matrix. On average, surveyed leads were 6.5 km long and the longest lead was 30 km long. In the latter part of the season, high winds began shifting the ice floes so that lead conditions became unstable and often unworkable.

Some smaller leads surveyed in the project had a distinct freshwater layer on top, often associated with a subsurface ice layer that affected both the acoustic signal and actual towing of the instruments. Seismic and sampling operations were halted on five days and hindered on many others because of poor weather and visibility. Six additional days were lost to the project when a hydraulic failure grounded the helicopter until a new part arrived.

The problems encountered in 1986 indicate improvements are necessary to the seismic equipment and transport techniques to allow more efficient use of the leads, especially in a severe ice year such as 1986. Despite this, the use of helicopter-transportable boats in open water leads has been shown to be a feasible method of obtaining continuous seismic reflection data in northern Canadian areas of persistent ice cover.

RESULTS

The seismic reflection profiles collected in the area (Fig. 91.1) provide information on the character and thickness of unconsolidated Quaternary sediments, as well as information on the underlying bedrock (Fig. 91.5). Data previously available on the surficial sediments in the survey area were limited to the upper 1.5 m observed in gravity cores (Marlow and Vilks, 1963; Maclean and Vilks, 1985). Profiles obtained with the Geopulse sparker system show unconsolidated sediments up to 53 m thick, and total subbottom penetrations up to a maximum of 60 m. Three stratigraphic units are recognized.

The lowermost unit is well-defined on the sparker seismic profiles, but was not penetrated on the 3.5 or 12 kHz records. It is unstratified (no coherent reflections) and has a characteristic surface morphology which varies from gently undulating to hummocky and irregular and which is independant of the relief of the underlying bedrock surface (Fig. 91.6). The unit rests unconformably on the bedrock surface and ranges in thickness form 7 to 53 m. On the profiles collected to the south of Lougheed Island, at least two such unstratified intervals can be distinguished. This unit is widespread and thins toward shore and over bathymetric highs.

Figure 91.3. One of two five-metre Zodiac inflatable boats used during the 1986 program, shown in a lead equipped for sparker seismic reflection profiling.

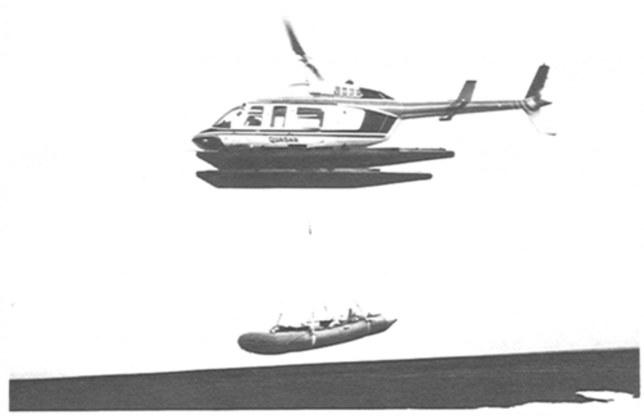

Figure 91.4. Photograph of a JetRanger 206L-1 helicopter slinging the Zodiac inflatable boat to a survey lead in the ice of the Arctic island channels. The outboard motor and acoustic and support equipment remained attached during transport to a new survey site.

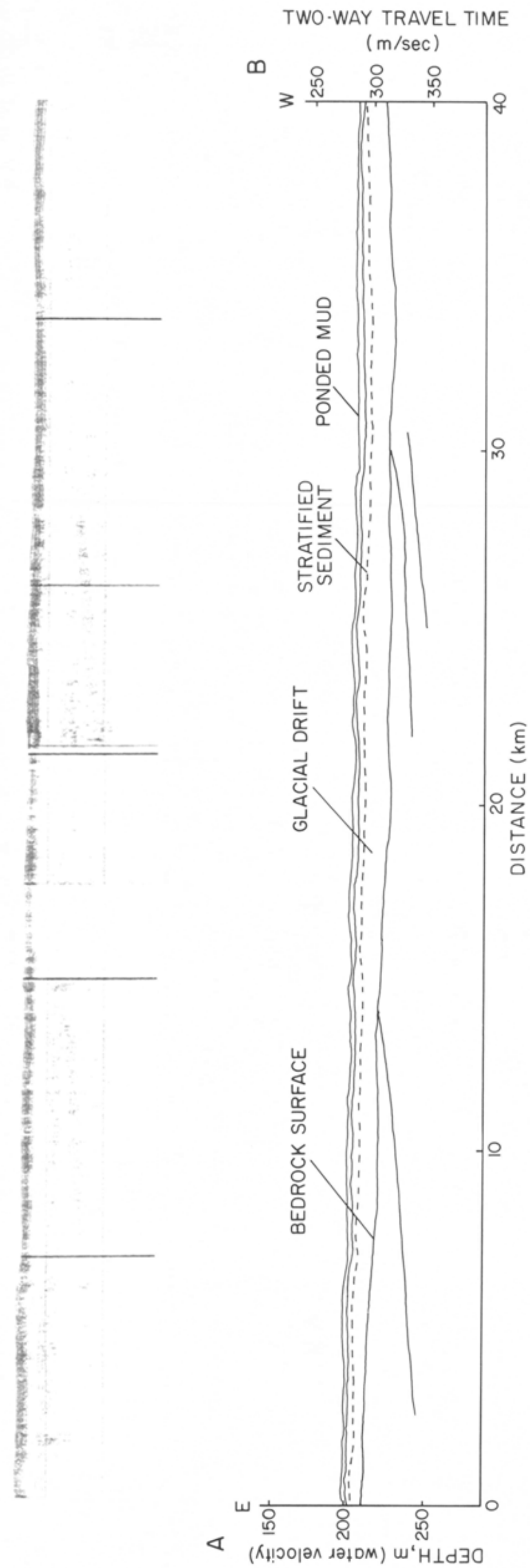

Figure 91.5. Geopulse sparker seismic reflection profile and composite interpretation derived from both the sparker and 12 kHz profiles, showing the unconsolidated sediment unconformably overlying the sedimentary bedrock.

The second unit directly overlies the first locally, mostly in depressions, and is recognized on 3.5 and 12 kHz profiles as a moderately transparent stratified unit of coherent reflections, with thicknesses of up to 10 m. Surface topography ranges from smooth to moderately hummocky with relief of 5 m. It is identified on profiles to the south and west of Lougheed Island in water depths from 130 to 240 m.

The uppermost unit is recognized on 12 kHz profiles as an unstratified and highly transparent unit up to four meters thick. The unit is observed in water depths greater than 150 m where it mantles underlying sediments or fills in bathymetric depressions. The transparent acoustic character of these sediments is consistent with the fine grained texture of sediment samples collected from this unit. Gravity cores collected from the this region typically contain 20-30 cm of brown unstratified silt and clay underlain by grey ryhthmically banded clayey sediments. These sediments are considered representative of the uppermost unit, and the sample distribution suggests that they are present throughout the region. In many places however, they may be too thin to be resolved by the 0.5 m resolution of the 12 kHz system.

Based on their seismic characteristics, the three stratigraphic units identified in the Arctic Island Channels are tentatively correlated to the stratigraphic sequence of glacial and post-glacial sediments recognized from much of offshore eastern Canada (King and Fader, 1986; Josenhans et al., 1986; Praeg et. al., 1986). The lowermost unit resembles sediments interpreted to be glacial till, while the second unit is similar to associated glacial marine sediments. The uppermost unit is acoustically and texturally similar to sediments interpreted as postglacial muds.

GLACIAL CHRONOLOGY

Land evidence from the adjacent Arctic Islands indicate the presence of glacial advances during the Quaternary. Hodgson (1981) recognized till deposits on Lougheed Island which he suggested may relate to pre-late Quaternary glacial advances. On the basis of glacial landforms and source erratics, he suggested a glacial movement from the southeast. Two hundred and fifty kilometres to the south, land evidence for the maximum extent of late-Quaternary grounded ice is seen in the Winter Harbour Moraine on Melville and Byam Martin Islands which has been dated at ca. 10 000 b.p. (Fyles, 1967; Hodgson and Vincent, 1984). The acoustic records from Lougheed Island Basin, Desbarats Strait and Cameron Island Rise show sediments which are interpreted to indicate the presence of at least one episode of grounded glacial ice and subsequent marine sedimentation. More extensive seismic data and lithologic and age control are needed to correlate the offshore drift deposits with either the younger tills on southern Melville or the older till on Lougheed Island.

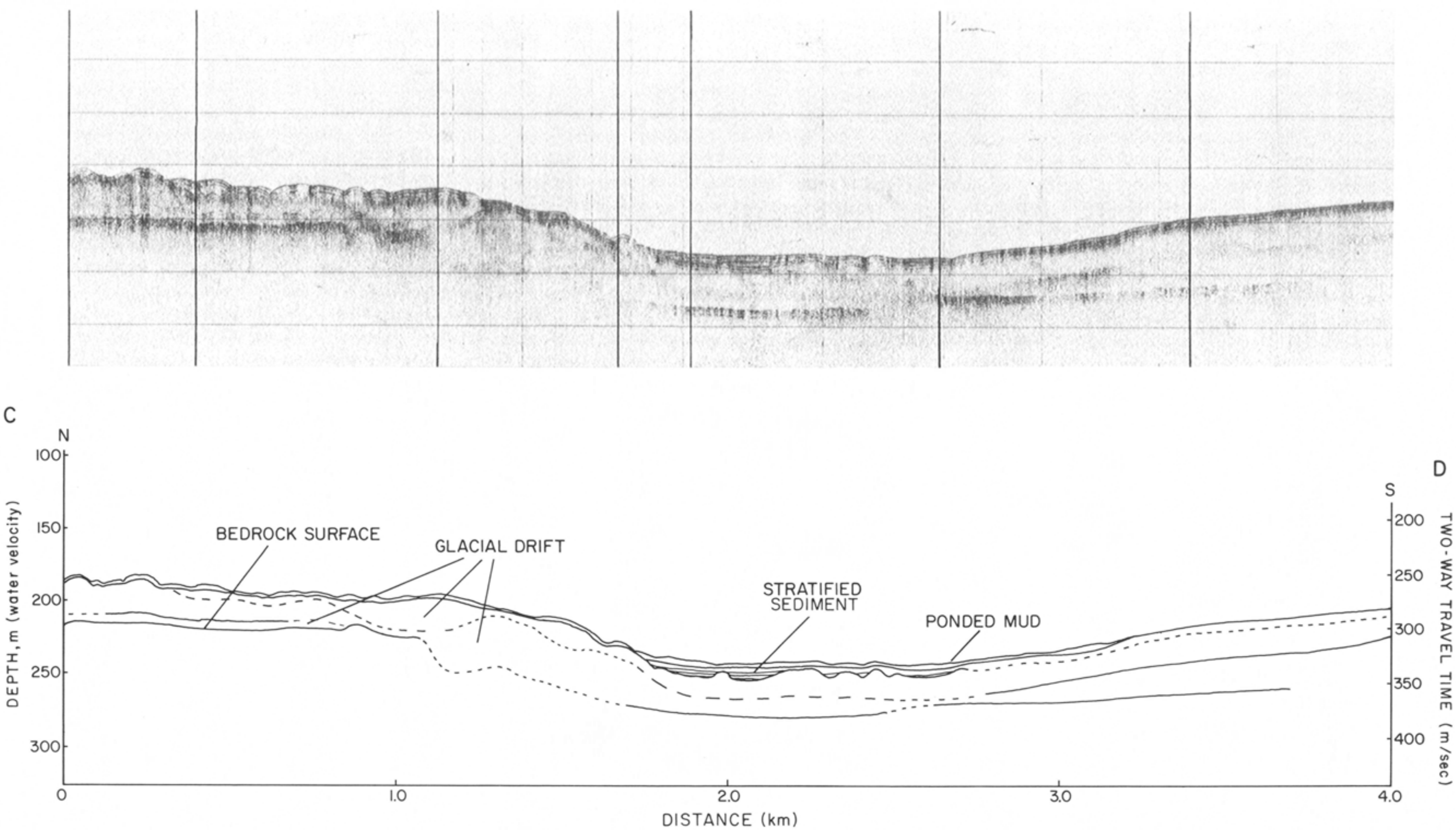

Figure 91.6. Sparker seismic reflection profile and composite interpretation derived from both the sparker and 12 kHz profiles, showing the three surficial units overlying the bedrock. Note the presence of three glacial drift units.

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