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# High Resolution Seismic Survey of Maxwell Bay, King George Island : Glacial Marine Sedimentation and Tectonics

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Abstract : High resolution seismic profiles in Maxwell Bay show that a trough of deeper than 500 m lies at the center. The trough is U shaped and covered by well laminated layers of 30 m thick. A fault which cut the laminated layers all the way to the top and a volcanic intrusion are observed in the profiles. These tectonic activities must have occurred in recent geologic times. The bottom topography goes up with a step-like pattern to the northern coast of basement highs with a steep slope at one side represent a series of high angle normal faults which are related to the extensional process of Bransfield Strait. Bathymetry of the region suggests that a main glacier covered the central trough and several valley glaciers developed perpendicular to the axis of the bay.

Key words : Maxwell Bay, seismic survey, sedimentation, tectonics

## Introduction

Maxwell Bay is an embayment which is located at the southwest end of King George Island and surrounded by both Fildes and Barton Peninsulas and Nelson Island (Fig. 1). Water depth is more than 500m at the central part, and the bay is open to Bransfield Strait at the south. The coastal area of Maxwell Bay is less heavily glaciated and ice cover is less continuous than on the other part of the island. The coast of Fildes Peninsula is sandy at the southwest and becomes rocky toward the northeast. A rocky beach is also exposed to Weaver, Barton, and Potter Cove. Ice cliffs occur at the Maxwell Bay side of Nelson Island, Collins Bay, Marian and Potter Coves. Tidewater glaciers contain dark layers of fine grained volcanic material of eolian origin. Meltwater streams are common and surface plumes of sediment-laden water are observed near all the tidewater glaciers of the bay during summer periods (Griffith and Anderson, 1989).

Previous sparker data by Anderson and Molina (1989) showed that the bay was covered by

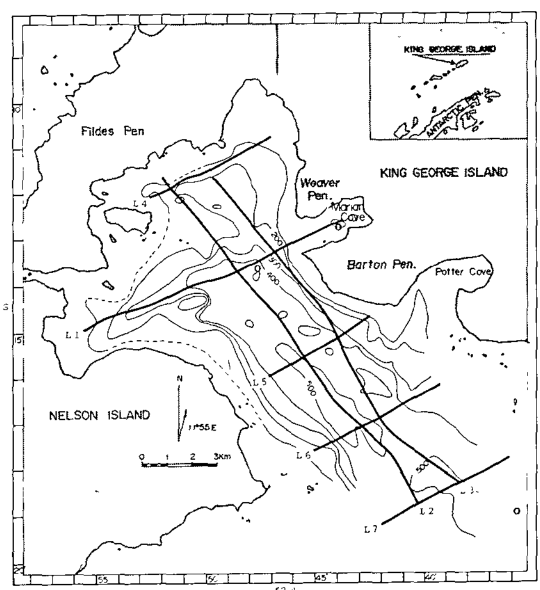


Fig. 1 . A map showing the locations of seismic profiles in Maxwell Bay, King George Island. Bold lines represent seismic lines.

a seaward thinning wedge of acoustically laminated sediments. Also, he found a distinct depositional mound in the bottom which was interpreted as a subaqueous moraine.

Surface geology of King George Island consists mainly of the upper Jurassic volcanics and early Tertiary igneous rocks (Barton, 1965). The oldest rocks exposed on King George Island are thick sequences of andesite lavas which can be correlated with the upper Jurassic volcanics of the Antarctic Peninsula. The Pluton of Noel Hill assigned to the Andean intrusive suite is the early Tertiary in age (Park, 1989). The Fildes Peninsula Group which is exposed mainly on Fildes Peninsula includes layers of andesite, agglomerate, and tuff with interbedded sedimentary rocks and has an age of early Tertiary (Watts, 1982).

The South Shetland Islands, including King George Island, lie on a continental crustal structure and it continues beneath the trough of Bransfield Strait. Geophysical studies suggest that the South Shetland Islands were a part of the Antarctic Peninsula and that Bransfield Strait extended and separated the two land masses after the cessation of subduction along the South Shetland Trench at 4 Ma (Barker, 1982). The crustal thickness of 14 km beneath Bransfield Strait (Fig. 2) also indicates that it is an extended feature with repeated normal faulting giving way to the generation of a near-oceanic crust (Barker and Dalziel, 1988). Normal faulting associated with Pliocene to recent volcanics is observed on the southeastern margin of South Shetland Islands and it continues offshore to the steep northwestern margin of Bransfield trough. Similar normal faulting but in a broader zone is found on the southwestern margin of the trough (Barton, 1965; Ashcroft, 1972). Recent volcanic activities on Deception Island in 1967, 1969, and 1970, and Penguin Island in 1905, may imply that extension is still taking place even though earthquake activity is rare in the Bransfield region. Petrochemistry of the Penguin Island volcano also shows an alkaline trend related to the Bransfield rift development (Birkenmajer, 1980).

King George and Nelson Islands consist of three tectonic blocks bounded by longitudinal faults : the downthrown Fildes, the upthrown Barton horst, and downthrown Warszawa blocks. These tectonic units were displaced by

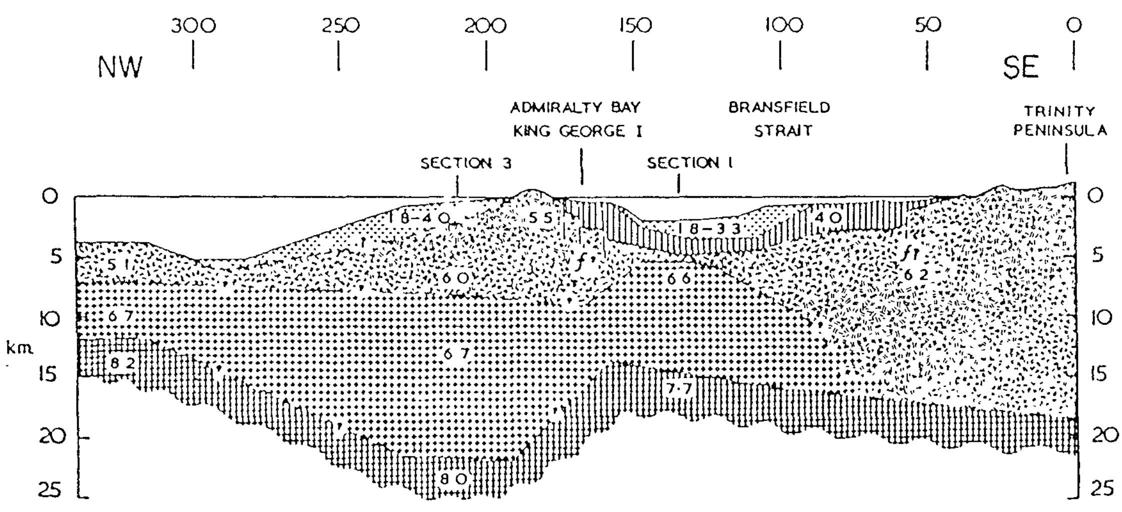


Fig. 2. Crustal structure beneath Bransfield Strait from seismic refraction measurements by Ashcroft (1972).

the strike-slip Collins and Ezcurra faults and continue due west in Nelson, Robert, Greenwich, and Linvingstone Islands (Birkenmajer, 1989).

The purpose of this study is to characterize the seismic signature of glacial marine sediments and to explain the tectonic implications of bottom topography and shallow structure which are shown in the single channel profiles in Maxwell Bay.

## Data Acquisition

3.5 kHz high resolution seismic profiles in Maxwell Bay consist of five short lines running NE-SW and two lines in the NW-SE direction which is parallel to the axis of the bay (Fig. 1). The data were acquired, filtered, and recorded by the O.R.E. subbottom profiling system during the 1987–88 austral summer season. Total length of profiles was about 77 km. A radar was used for positioning within the bay and the ship's speed was kept at 5 knots per hour even in strong wind and current. A boomer type source was used for seismic energy.

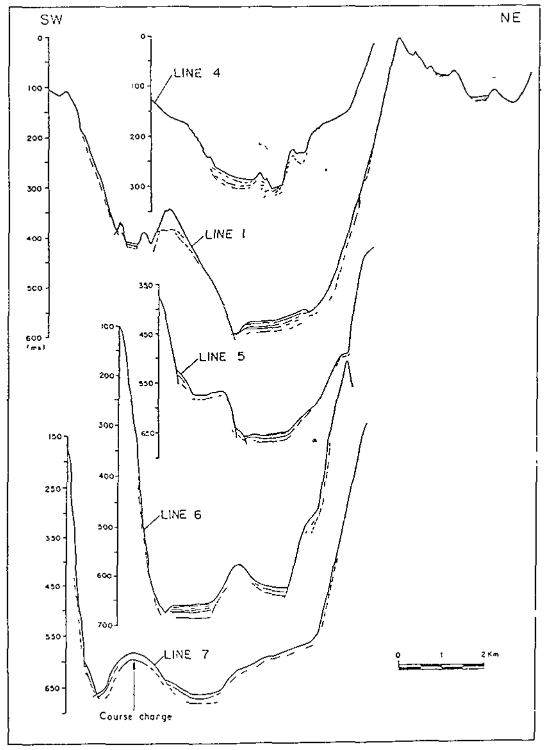


Fig. 3. NE-SW lines showing rapid topographic changes and laminated acoustic layers at the central trough in Maxwell Bay (Choi et al., 1990).

## Discussion

Bathymetry of the bay shows that a U shaped valley with a flat bottom of more than 400 m in depth lies at the center (Fig. 3). The valley elongates southeasterly along the axis of the bay and may continue further out toward Bransfield Strait. Bottom topography goes up rapidly to the coast at the east and west with an average slope of 13 degrees. At the north side of the bay profiles show rugged topography especially above 200 m depth. Line 1 which runs from Marian Cove to a littele bay near Nelson Island shows that Marian Cove is separated from Maxwell bay by a prominent basement high. An irregular acoustic basement appears to be covered by thin sediments and a reflection free layer of 3–4 m thick is trapped behind a basement high in Marian Cove (Fig. 4). The piston core which penetrated the trapped sediments consisted of a pebbly mud layer of 1 m thick at the top, rhythmic beds of 40 cm, and basal till at the bottom. Basal till is represented by the reflection free layer and indicates former grounding of a glacier in Marian Cove. The presence of rhythmic beds indicates a much warmer climate than now after the last glacial retreat in the region. Paleontologial study of the top 30cm core suggests Holocene in age and the sedimentary rate was relatively slow. Sedimentary rate deduced from Pb-210 data is 0.75 mm/yr (Kim, 1989). Diatom study from a 2.6 m long core at the south end of Maxwell Bay also suggests that water temperature was warmer than now below 1 m. Both

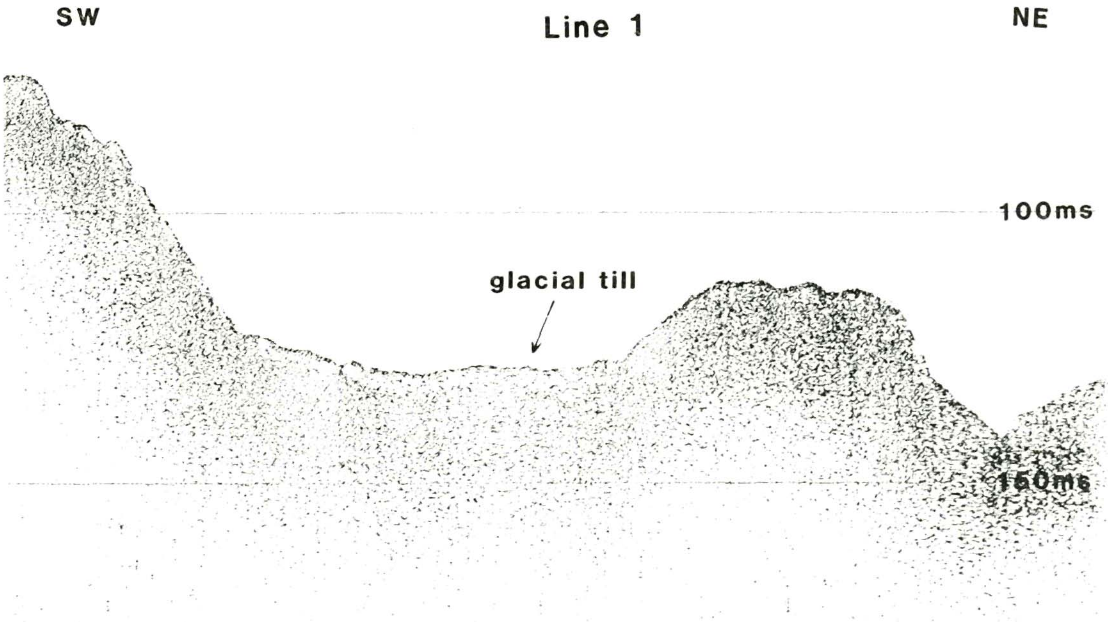


Fig. 4. The seismic profile in Marian Cove showing glacial till covered acoustic basement. Marian Cove separates from Maxwell Bay by a basement high at the SW end of profile.

core data indicate recent glacial fluctuations in the region.

Bathymetry drops rapidly from Marian Cove toward the central part of the bay (Fig.3) and well laminated layers are seen at the bottom. The laminated layers tilt southwesterly and a fault which cuts sediments all the way to the top is observed in Figure 5. Although this fault is in small scale, it represents a recent tectonic movement.

A trough of 18 m deep is located at the left end of Figure 5 and this feature can be traced down to the south at other lines (Fig. 6). Previously it was interpreted as an erosional structure formed by a bottom turbidity current (Choi et al., 1990). However because there is no clear indication of the existence of such a strong current, it is more reasonable to interpret the trough as a subglacial meltwater stream channel. The slope direction of bottom tilting shown in Figure 5 supports this idea.

Line 2 (Fig. 7) which runs along the axis of the bay shows flat lying laminated layers of 50 milliseconds thick at 5 km offshore from Fildes Peninsula. The piston core which penetrated these layers consisted of near pelagic sediments and shows the sign of severe bioturbation (Yoon et al., 1989). The source of sediments is terrigenous but the content of ice rafted debris is relatively low. This means the sediments were derived by sediment-laden meltwater rather than ice. Actually most of the icebergs observed in Maxwell Bay are relatively small in size and contain thin layers of fine material.

The acoustic basement can not be discerned clearly in the profiles but the thickness of laminated layers at the center is presumed to be at least 50 milliseconds(30m). However, Anderson's profile (1989) in the same area shows the laminated layers of greater than 120 milliseconds(70m) thick. Therefore the lower 40m sediments in the Anderson's profile can be considered as a poorly laminated glacial deposit. Anderson's core data show noevidence of bioturbation or cross bedding.

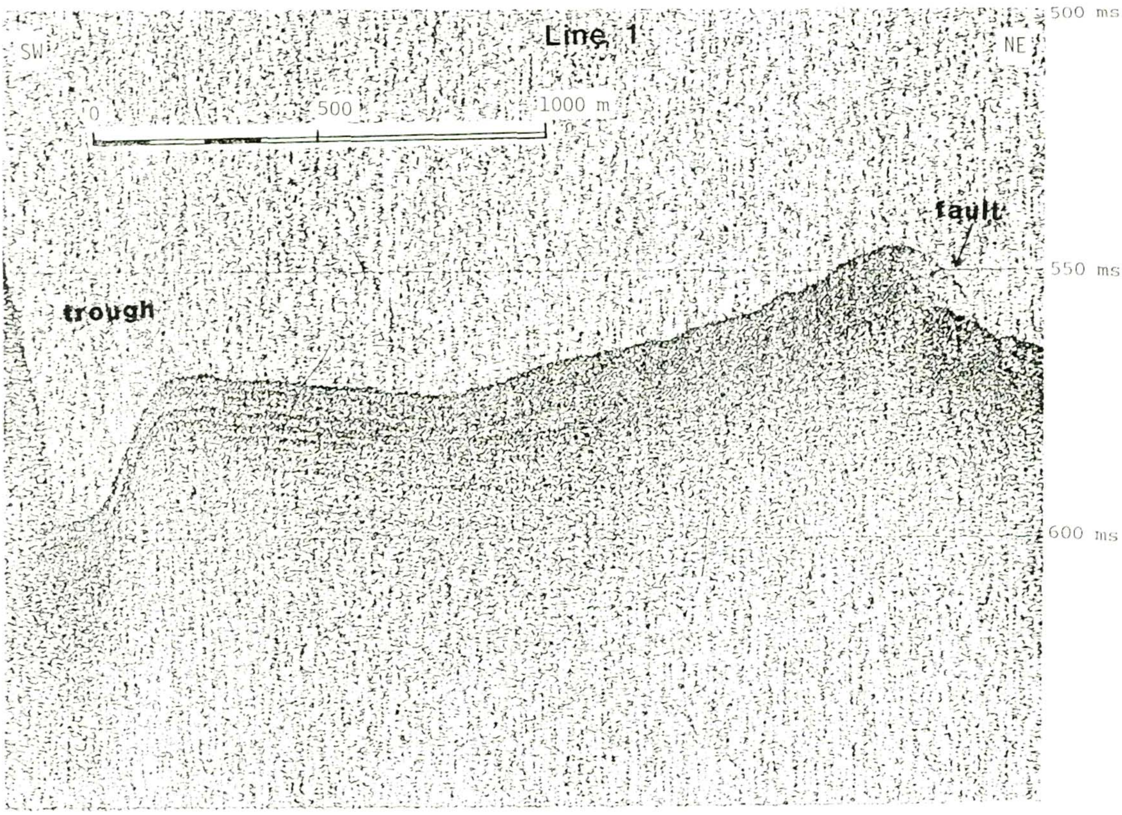


Fig. 5. A part of seismic line 1 which runs perpendicular to the axis of the bay. The central part is covered with laminated layers and a fault is located at the NE end. The trough at the SW end represents a subglacial meltwater channel.

At the northwest end of Figure 7 the sediments behind a basement high look poorly laminated and even big boulders are shown in the seismic profile. These deposits are obviously glacial till and indicate previous grounding of glacial ice. Also there is an abrupt facies change from glacial to a well laminated pelagic environment at the position which is bounded by the basement high.

Another basement high which locates at the southeast half of Figure 7 is a volcanic intrusion. Bottom sediments are sharply truncated and the bathymetry at the southeast side is tilted and lowered by 15 milliseconds. Whereas the layers at the northwest side are almost horizontal but bulged upward at the center between the intrusinon and northwest margin of the bottom. This bulge was formed by compression caused by intrusion and it must be a recent activity.

Redrawn north-south profiles (Fig. 8) show that bathymetry goes up to the northwest with several basement highs and small U shaped valleys between them. The valleys filled with reflection free or poorly laminated sediments. Bottom topography changes with a step like pattern which consists of basement highs of steep slope at one side and little valleys behind them. The slopes may represent a series of normal faulting which continues offshore from Fildes Peninsula. This fault system is still, or has been, active until recent times.

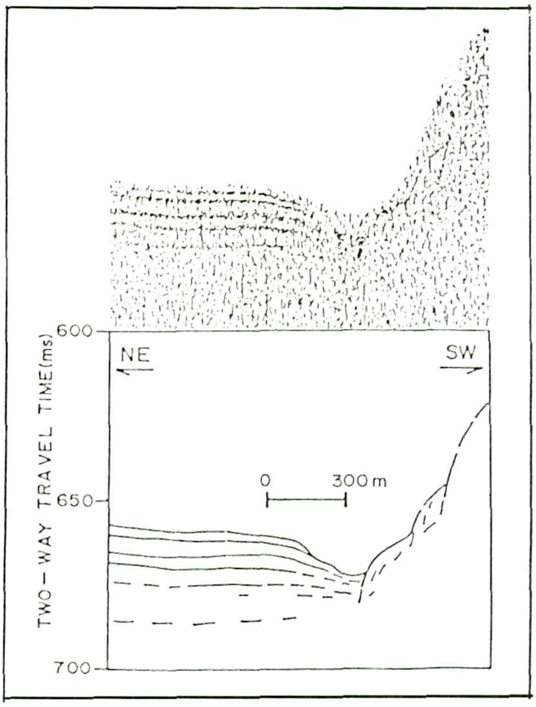


Fig. 6. The channel in Figure. 5 can be traced down to the south at line 5 (Choi et al., 1990). Note the direction of NE–SW is reversed.

Bathymetry of Maxwell Bay shows that a main trough lies along the axis of the bay and many small U shaped valleys are perpendiculour to it. It suggests that a main glacier once covered the central trough and several small valley glaciers developed perpendicular to it. However as it is indicated by core data the trough and all valleys were not formed in a single glacial episode but through several repetitive events. If the faulting took place during glacial periods, it complicates delineation of the time sequence of tectonic and glacial events.

## Conclusions

1. Bathymetry of Maxwell Bay shows a central trough deeper than 500 m which lies along the axis of the bay and topography changes rapidly toward the east and west coast with an average slope of 13 degrees.
2. The flat bottom of the central valley is covered with well laminated layers which were cut by a subglacial meltwater channel at the western margin.

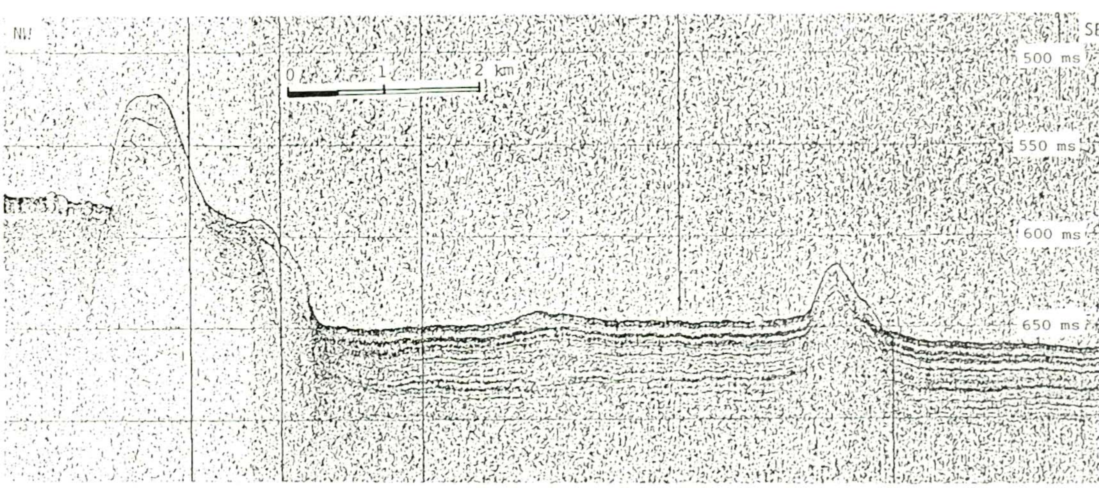


Fig. 7. A part of seismic line 2 which runs along the axis of the bay. Well laminated layers in the bottom are truncated by a volcanic intrusion at the SE side. Glacial deposit lies at NWend behind a basement high.

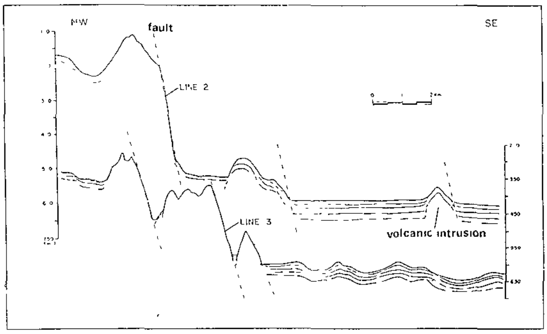


Fig. 8. NW-SE lines showing step-like increase of bathymetry to the NW coast. Steep slopes at the SE side represent high angle normal faults which relate to the extensional process of Bransfield Strait (Choi et al., 1990).

3. Marian Cove is separated from Maxwell Bay by a prominent basement high and is covered with glacial till of 3–4 m thick at the top. The seismic signature of glacial till is a reflection free layer.
4. A volcanic intrusion and a fault observed at the central part indicate this area is tectonically still active.
5. U shaped valleys in Maxwell Bay suggest that a main glacier once covered the central trough and several valley glaciers developed perpendicular to the axis of the bay. However sedimentary record indicates this topography was formed by several glavial events rather than single one.
6. Step-like increase of topography at the northern margin may represent a series of normal faults which are associated with the Pliocene to recent extensional processes of Bransfield Strait.

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