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Short note
Short-offset seismic refraction results near Rothera Station, Antarctic Peninsula

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Introduction

Details are presented of seismic velocities at a site near Rothera Point, Adelaide Island, Antarctic Peninsula. The snow/firn velocity structure was obtained using a 24-channel Bison 9000 seismograph, recording the outputs of geophones of 40 Hz natural frequency attached to 150 mm snow spikes. The refraction velocity of the underlying bedrock was measured using a 48-channel DFS V recorder and 10 Hz geophones. The records were obtained during trials of equipment and techniques which took place in the 1988–89 and 1990–91 seasons. The data will be of interest to other investigators studying firn structure around Antarctica or considering crustal seismology in the Antarctic Peninsula region.

Geological setting and seismic results

The test site was on the Wormald Ice Piedmont (Fig. 1) which is adjacent to two outcrops, Reptile Ridge and Stork Ridge, of mixed basic to intermediate calc-alkaline intrusive and stratified volcanic rocks of Mesozoic age (Dewar, 1970).

The local ice flow regime is that of an ice piedmont with restricted area. The accumulation rate is *c.* 1–2 m a^{-1} and mass movement is by a short route to ice cliffs which calve frequently. The climate has a maritime influence and the maximum summer temperature is approximately +2°C. The resultant melting leads to the formation of denser ice layers in the firn.

Shot records from the site display a variety of arrivals (Fig. 2). Some of the energy is in the form of diving waves which are continuously refracted by the high velocity gradient found in the near-surface firn. Another class of arrivals are high amplitude, low velocity surface waves. Reflections, multiple reflections and refractions involving the ice-rock interface are all evident. In calm conditions the low level of ambient noise results in very high record quality.

Fig. 2a shows a record obtained from a 2.4 km long spread of 48 vertical geophones at 50 m intervals. The source was a total of 8 kg of explosive in four closely spaced holes drilled to a depth of 15 m. The first arrival shows two travel time branches with apparent P-wave refraction velocities of 3646 ± 82 m s^{-1} and 5183 ± 176 m s^{-1}. These are interpreted as ice and bedrock velocities respectively. Fig. 2b shows the same record after F-K (frequency-wavenumber) filtering to remove surface wave (ground roll) energy and the direct arrival. Fig. 2b shows the 5183±176 m s^{-1} refraction branch to be the post critical angle continuation of the base of ice reflection. This has a vertical incidence TWTT (two way travel time) of 206 ± 2 ms, after correction for the shot depth.

Interpretation of the continuously refracted first arrival (Kirchner & Bentley, 1979) from a 300 m shallow refraction record gives the near surface velocity-depth relationship for the firn and firn-ice transition region shown in Fig. 3. From the average velocity of 3133 ± 16 m s^{-1} for the top 100 m of firn and ice determined from shallow refraction interpretation and a velocity in ice of 3824 ± 6 m s^{-1} (Kohnen, 1974) we determine an ice thickness of 371.9 ± 3.8 m at the shot point.

The F-K filtered record (Fig. 2b) illustrates that the bedrock

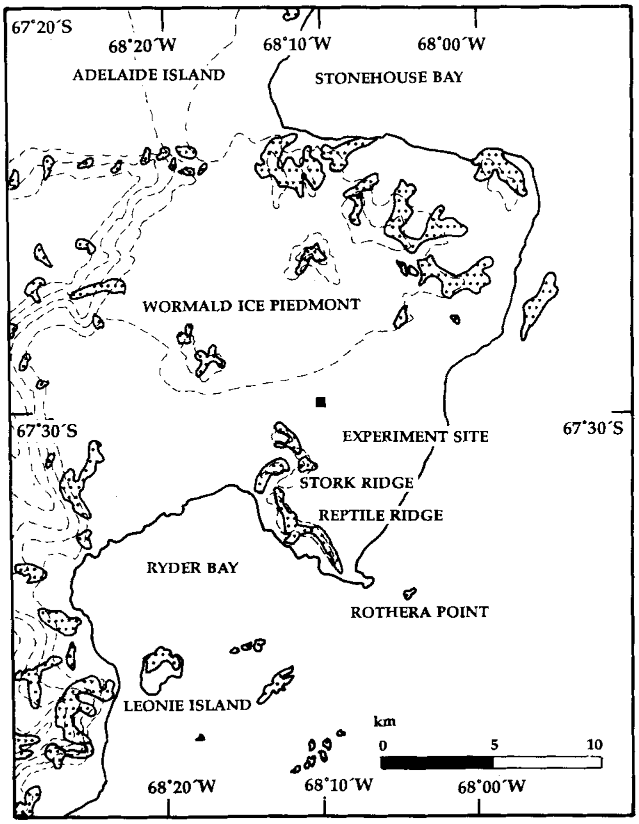

Fig. 1. Sketch map of part of the east coast of Adelaide Island, Antarctic Peninsula showing the location of the experiment site ■. The coast line is shown by a solid line, outcrop is stippled and form lines (500 m intervals) are shown by dashed lines.

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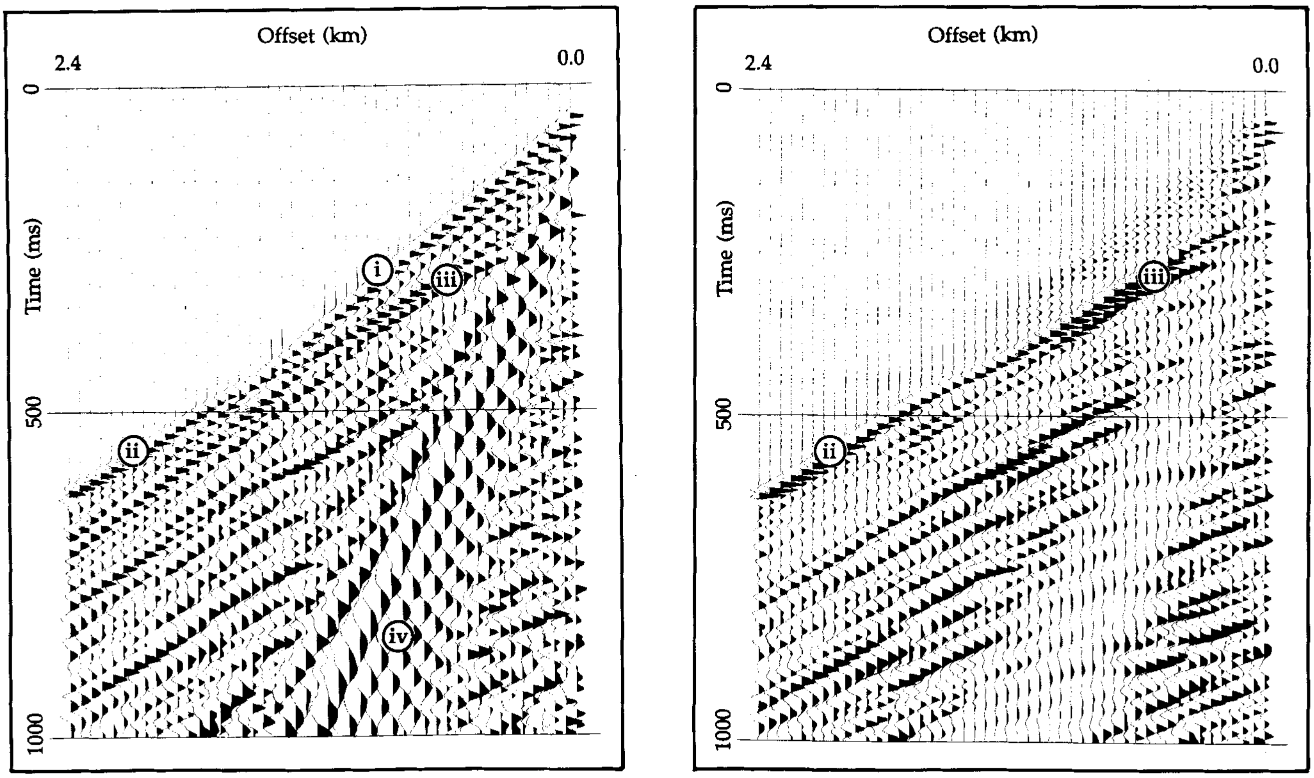

Fig. 2a. A 48 channel shot record from the DFS V recorder with 10 Hz geophones; source =8 kg of explosive in four 15 m deep holes; geophone interval =50 m. A 100 ms automatic gain control has been applied. i. ice refraction, velocity =3646 ± 82 m s^{-1}, ii. bedrock refraction, apparent velocity =5183 ± 176 m s^{-1}, iii. base of ice reflection, iv. ground roll. **b.** The same record after F-K (frequency-wavenumber) filtering to remove surface noise and direct arrivals.

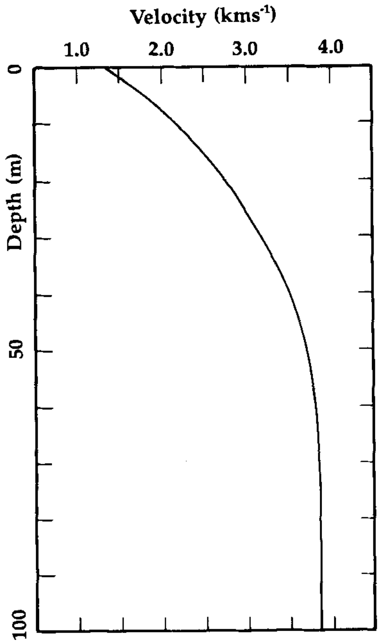

Fig. 3. Velocity-depth profile for the near surface, derived from a 300 m shallow refraction record.

refraction arrival is not linear throughout, indicating topography on the ice-rock interface. The line was not fully reversed. However, a base of ice reflection was recorded from a shot in the middle of the 2.4 km spread at a TWTT of 200 ± 2 ms after correction for shot depth. This gives an ice thickness of 360.4 ± 3.9 m and indicates a bedrock relief of 11.5 ± 5.4 m over the 1.2 km offset between shots. Including the effect of the dipping ice-rock interface on the observed bedrock refraction velocity gives a revised bedrock seismic refraction velocity estimate of 5133 ± 236 m s^{-1}. This figure is within the range of typical velocities for volcanic and intrusive igneous rocks suggesting continuation of the local outcrop geology beneath the ice.

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