Upper Crustal Structure of Sôya Coast, Antarctica, Revealed by Explosion Seismology

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南極・宗谷海岸の地下構造

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要旨: 第20次日本南極地域観測隊は，1979年1月に，南極・昭和基地の近傍の宗谷海岸で人工地震観測を実施した．これは，日本隊としては初めて地下構造を求めることを目的とした大規模な実験の一環であり，次の諸テストを主な目的とした．1) 南極における人工地震観測システムの確立，2) ダイナマイト埋設用雪氷ボーリング機械，3) 低温下で使えるダイナマイト．

オングル海峡の海面下 110 m の水中で 1000 kg, および内陸の 62 m の掘削孔下で 560 kg の火薬を爆発させ，実験を行い，所期の目的を達した．

今回の測線は 80 km で，大陸内に10点の観測点を設置した．得られた地下構造で特徴的なことは，P 波速度にして 4～5 km/s の堆積層と思われる層が 500～1000 m の厚さに，氷床直下に存在することで，これは東南極地域で，これまでには見出されていない．

Abstract: The upper crustal structure of the Sôya Coast, Antarctica was estimated by a seismic refraction experiment which was carried out in January 1979. A surface thin layer with a P-wave velocity of 4–5 km/s was derived from the travel-time analysis for the first time in East Antarctica by explosion seismology.

1. Introduction

The summer field party of the 20th Japanese Antarctic Research Expedition (JARE-20) carried out observations of seismic waves generated by explosion to investigate the crustal structure of the Sôya Coast in Antarctica in January 1979. This was the first experiment with the explosion seismic method in Antarctica for JARE.

The objective of the present experiment by JARE-20 is to remove difficulties such as instrumentation, drilling shot holes in ice, dynamite for the use at low temperature, etc.

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The details of the observational operation have been already reported by IKAMI *et al.* (1980). This is a brief report on the experiment and results by JARE-20.

2. Description of Experiment

The location of shot and observation sites is given in Fig. 1. The profile is about 70 km in length eastward from Syowa Station.

The ice thickness around the profile in the Sôya Coast was observed by the inland traverse party (ISHIDA, 1972). The vertical section of the ice thickness is given in Fig. 2. The elevation of basement rock surface is nearly the same as the sea level as shown in Fig. 2. Ten observation points were set up every five kilometers along the profile from the so-called S16 point. S16 is located on the edge of the Antarctic Continent

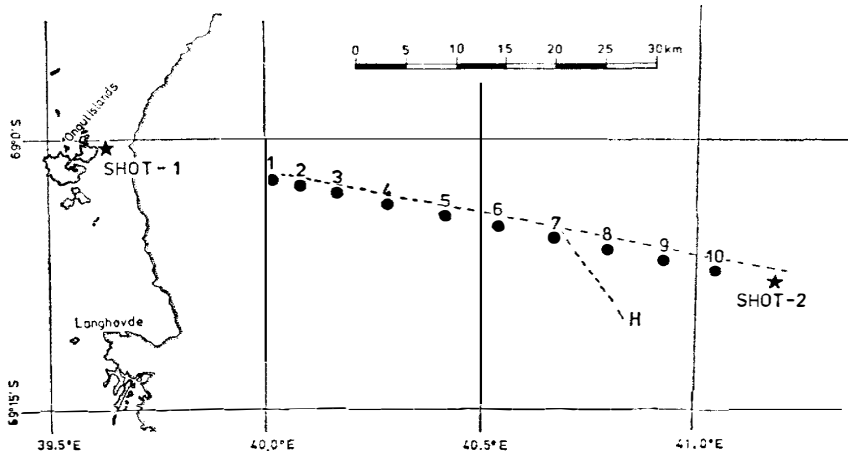

Fig. 1. Location of shot and observation sites. Solid circles show observation sites and numerals are station numbers.

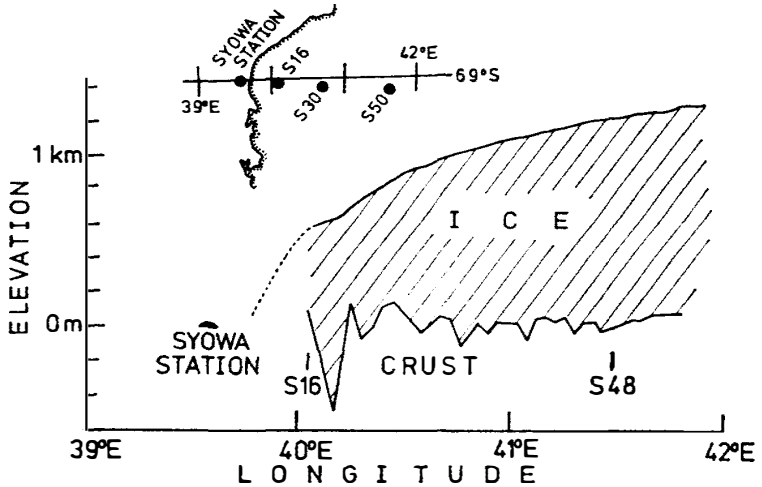

Fig. 2. Vertical sections of ice thickness along the profile.

about 20 km east of Syowa Station and is the depot for the inland traverse party of JARE.

One vertical seismograph with a natural frequency of 1 Hz was installed at each observation site. One data recorder with four channels was also installed. Time code from the quartz crystal clock was fed into the fourth channel. Each clock in the data recorder was calibrated by the main clock before and after the observations. The observation was operated by using three channels of different dynamic range for the vertical seismograph.

The first explosion (SHOT-1) with 1000 kg charge was fired at a depth of 110 m in the Ongul Strait. The location of the second one (SHOT-2) was at the east end of the profile, so as to reverse the profile, and was fired in an ice hole with a depth of 62.8 m and a diameter of 14 cm. The ice hole was drilled by a new mechanical ice drill which was developed for this explosion operation. A total of 560 kg dynamite was installed from the depth of 17 m to the bottom. The density of ice at 41 m was 0.69 and that of the bottom (60 m) was 0.81.

3. Crustal Structure

Figs. 3 and 4 show seismograms of SHOT-1 and SHOT-2 respectively. The numerals in the figures are the station numbers corresponding to the numerals shown in Fig. 1. The recording at Station No. 5 was not successful because of mechanical trouble. The amplitude of seismogram in SHOT-1 is about ten times larger than that in SHOT-2 on the average. High frequency waves are remarkable in the seismograms of SHOT-2. This characteristic is clearly seen in Figs. 5 (for SHOT-1) and 6 (SHOT-2) which show the spectra of seismic waves of the initial two seconds. The peak of spectra of SHOT-1 is found in the frequency range of $2 \sim 10$ Hz and that of SHOT-2 is $10 \sim 20$ Hz.

Fig. 7 shows the reduced travel-time plots for SHOT-1 and SHOT-2 and an upper crustal structure estimated from travel-time plots. The shot time of SHOT-2 was not recorded because of mechanical trouble, so that the relative travel-time with a correction α is shown in Fig. 7. The surface of the basement is assumed to be at the sea level from Fig. 2. The layer of 6.1 km/s *P*-wave velocity is well identified from the travel-time curve.

The overlying thin layer of $4 \sim 5$ km/s is assumed because a sediment layer has to be estimated for adjusting the travel-time of 6.1 km/s zero at the shot points. The thickness of the layer is changed from 100 m to 1 km with the uncertainty of a few hundreds meters as shown with the hatched part at the bottom in Fig. 7. This uncertainty of the top layer thickness is corresponding to the uncertainty of $4 \sim 5$ km/s

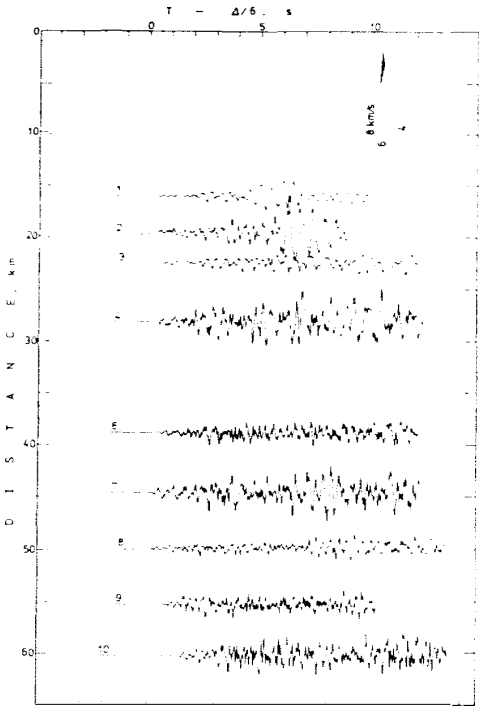

Fig. 3. Record section for SHOT-1. Numerals at the top of each seismogram are the station numbers in Fig. 1.

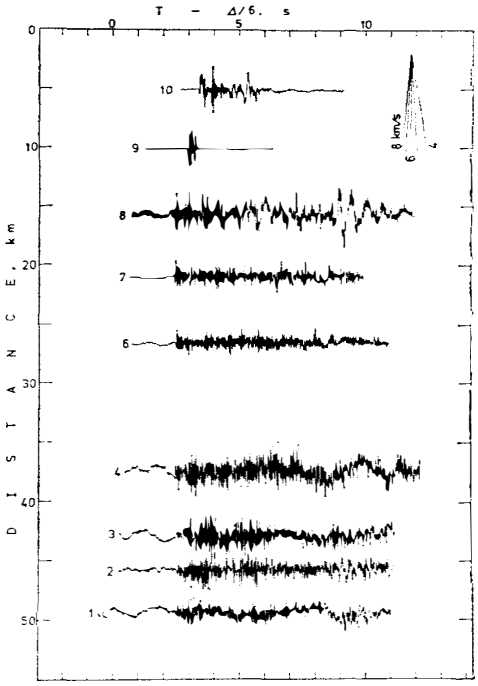

Fig. 4. Record section for SHOT-2.

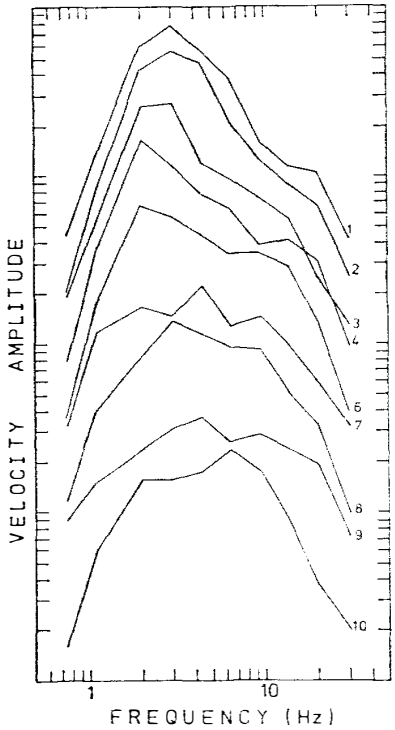

Fig. 5. Spectrum of seismogram of initial two seconds for SHOT-1.

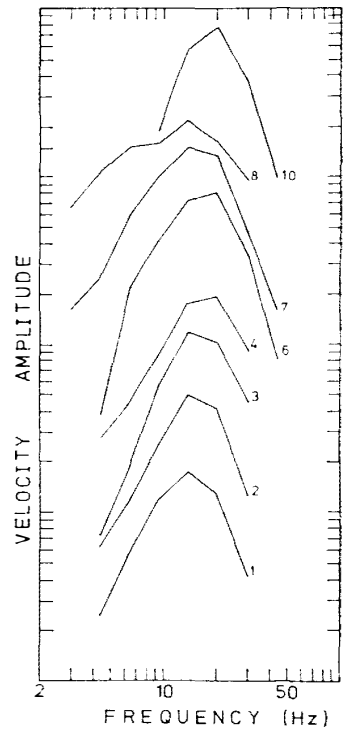

Fig. 6. Spectrum of seismogram of initial two seconds for SHOT-2.

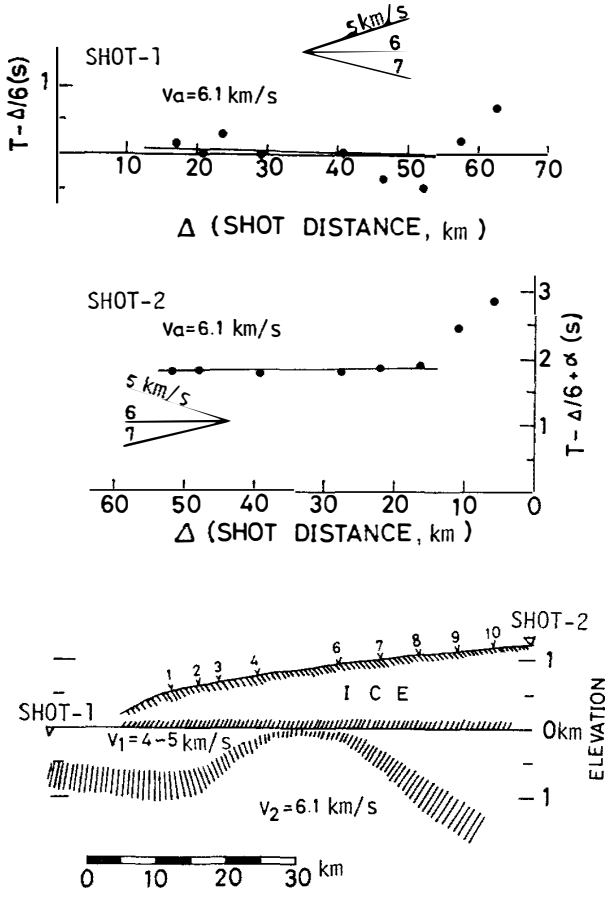

Fig. 7. Travel-time curve of SHOT-1 and SHOT-2, and vertical profile of the upper crustal structure.

P-wave velocity of the layer.

The results of explosion seismic investigation in Antarctica were summarized by BENTLEY (1972). The first big explosion seismic experiment for the study of crustal structure was carried out in East Antarctica by the Soviet Antarctic Expedition near Novolazarevskaya Station (KOGAN, 1972). However, no overlying layer of 4～5 km/s *P*-wave velocity was identified in East Antarctica. Therefore, the layer with a velocity of 4～5 km/s has been found for the first time by the explosion seismic experiment in East Antarctica.

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