Library

ARCTIC OCEAN BATHYMETRY USING THE SEISMIC SOUNDING METHOD

by

J.R. Weber,

Geophysics Division

and

L.W. Sobczak,

Lithosphere and Canadian Shield Division

Geological Survey of Canada

Observatory Crescent

Ottawa, Canada.

K1A 0Y3

Internal Report No. 86-13

Ice Island Contribution No. 4

INTRODUCTION

Since the early sixties, the Gravity Division of the Earth Physics Branch (EPB) has measured water depth using the seismic sounding method in conjunction with gravity measurements in the deep, ice-covered ocean beyond the continental shelf break, and in the polar area. This method was also used on LOREX (1979), on CESAR (1983) in addition to echo sounding, and on the 1985 Ice Island Survey, (Sobczak and Schmidt, 1985). Explosive charges ranged from booster caps to 1 kg geogel. A variety of recorders with fast chart speeds were used to measure two-way travel time. In 1985, a new recorder was purchased by EPB and modified by J.T. Thomas of the Seismology and Geomagnetic Division of EPB. It was used to obtain bathymetry on the gravity survey along seismic refraction lines established from the Ice Island in April, 1986 (Sobczak and Weber, 1986). This report briefly describes instrumentation and method of operation, compares this method with echo sounding, and recommends the use of the seismic sounding method in connection with geophysical measurements.

INSTRUMENTATION

The equipment for the seismic sounding method consists of a seismic recorder, two Electro-Tech 30 cps seismometers, a 30 m geophone cable complete with cable reel, a 100 m firing line with cable reel and a marker 42 m from the end, a CIL 10-shot hand-held blasting unit, a 12 vdc car battery and a snow shovel.

The recorder consists of an Astro-Med Dash II two-channel field chart recorder coupled with a TC-200 waveform capture/playback module. The former is powered from internal batteries and has a built-in charger while the latter operates from 110 vac, powered by a 12 vdc battery via a Heathkit MP-10 inverter. A more recent model has recorder and capture module built into one unit. The whole recorder package is mounted in a Technical Field Support Services fibre case and is insulated with styrofoam.

The chart recorder contains an input amplifier which has been modified by our instrument section. The capture/playback module digitizes the amplified seismic signal and stores it in memory. The signal can also be recorded in real time without storing it. The stored signal is played back in an expanded mode. Playback is at a constant 200 Hz. The expansion depends on the sampling rate and the output compression which allows either the 1st, 2nd, 5th, 10th, or 20th digitized point to be played back. In our application we sample at 10 KHz and playback at unity with a chart speed of 10 mm/s for an effective chart speed of 500 mm/s. Two-way travel time (TWTT) can be read to an accuracy of + 0.5 ms corresponding to 0.7 meters water depth. A 500 ms timing signal is provided by a built-in crystal controlled timer.

Fig. 1 illustrates two sample seismic records. The top record, using both geophones, shows a TWTT difference of 268 ms between first arrival (S) and echo (E). The bottom record, where only one geophone was used, shows a corresponding TWTT difference of 596 ms. To the TWTT difference 14 ms have to be added to compensate for the 42 m offset between shot point and geophone. The actual TWTT's of 282 and 610 ms correspond to water depths of 203 and 368 m, respectively.

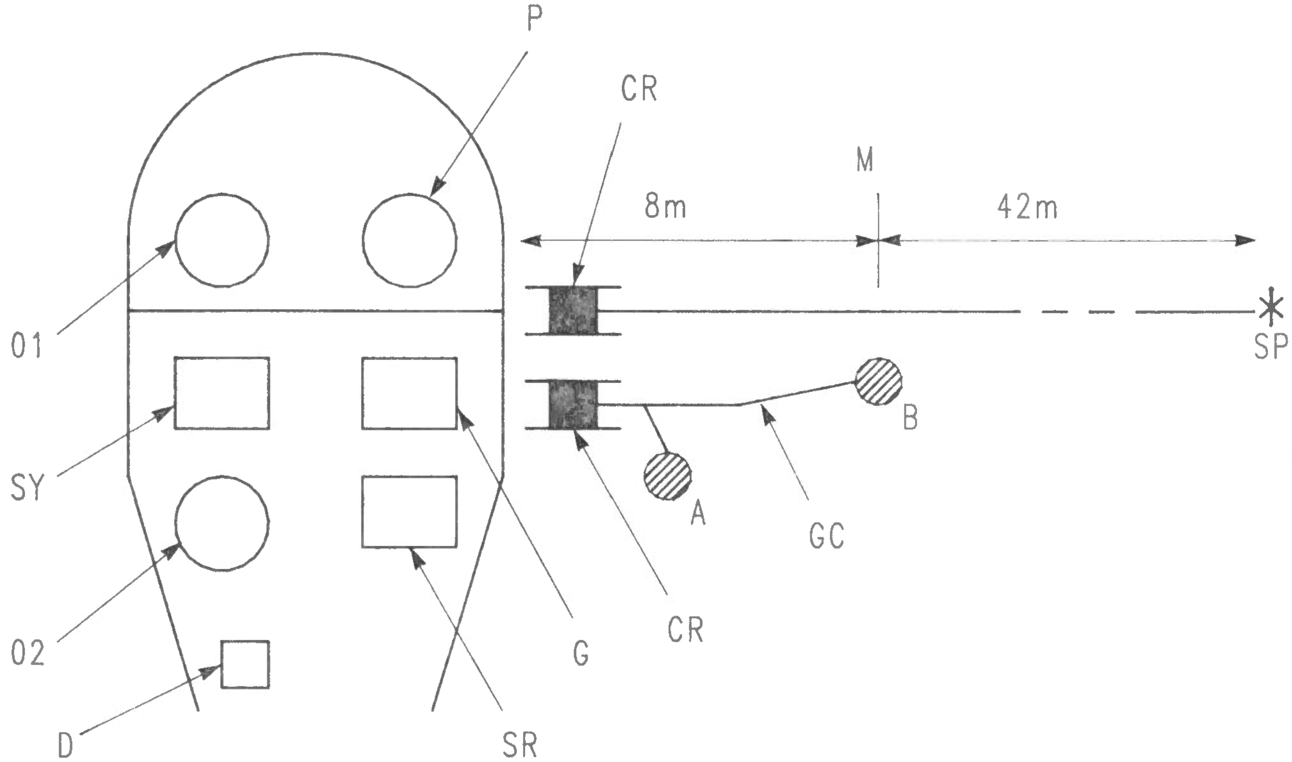
#11
1925
Apr 26/86
STN 10002
T = 268 + 14 = 282 ms
S
E
268 ms
500 ms
T = 596 + 14 = 610 ms
500 ms
#30
1628
Apr. 27
STN. 10053
S
E
596 ms

Figure 1

METHOD OF OPERATION

After the helicopter has landed, observer 1 exits and takes out gravimeter, both firing and geophone cable reels and shovel, then takes a gravity reading some 20 m away from the helicopter (Fig. 2). After observer 2 has written down the Syledis coordinates, he exits with one stick of geogel and picks up one seismocap from the luggage compartment. He then circles the front of the helicopter, picks up the two geophones, the ends of the firing and geophone lines and the shovel. He drops geophone A and starts walking away from the helicopter. After about 8 m he drops geophone B and geophone cable and continues pacing about 42 m. There, if necessary, he digs a hole to the ice surface, inserts a cap into the geogel, places the stick of dynamite on the ice in the direction perpendicular to the helicopter and connects the cap wires to the firing line. He then walks back towards the helicopter, connects geophone B to the geophone cable and places it near the 42 m marker M, and re-enters the helicopter. By that time, observer 1 has finished taking a gravity reading and returns the gravimeter into the helicopter. He then installs geophone B, connects the geophone cable reel output to the seismograph and the blasting machine to the firing line reel. In the meantime, observer 2 starts the seismic recorder, checks the seismometer background noise in the "real time" mode, and turns on the "record" switch. Observer 1 activates the blasting machine, and when the light appears, indicating that the machine is ready to fire, observer 2 pushes the "manual" switch of the capture module which opens the 3-second window, and observer 1 fires. Observer 1 then disconnects the blasting machine from the cable reel, shorts the output of the firing line with a shorting plug, disconnects the geophones, reels in both geophone cable and firing line and puts all equipment into the aircraft while observer 2 plays back the signals in expanded mode on

BELL 206L HELICOPTER



P	Pilot	GC	Geophone cable
01	Observer 1	CR	Cable reels
02	Observer 2	A,B	Geophones
SY	Syledes	D	Detonator caps
FL	Firing line	SP	Shot points
SR	Seismic recorder	M	42m marker
G	Gravimeter, geogel, cable reels during transport		

Figure 2

the chart, notes way point number and time on the record, and keys in the next way point number on the Syledis. In the meantime observer 1 has re-entered the aircraft which is now ready to take off. The whole operation takes about 8 to 10 minutes.

Two geophones were used in order to distinguish between sea floor return signal and ice noise. However, the return signal with the new recording system is so strong that in future surveys only one geophone will be required.

ECHO SOUNDERS

Two model Edo 9040 echo sounders, on loan from Canadian Hydrographic Service (CHS) Department of Fisheries and Oceans (DFO), were tried in the 1985 and 1986 Ice Island surveys. They proved to be unusable both years. In 1985, the Edo sounder was found to be unserviceable (Sobczak and Schmidt, 1985). In 1986, the two sounders, checked out in February by CHS in Burlington, worked only marginally after they had been fine-tuned on the Ice Island by Morley Wright, an AGC technician (Sobczak and Weber, 1986). When tested off the Ice Island through 0.5 m of new ice they gave a clear echo at 228 m. But no echo whatever could be obtained at 550 m and 611 m, respectively, whereupon the echo sounder was abandoned in favour of the seismic sounder.

The Atlantic Geoscience Centre owned a number of these Edo 9040 echo sounders which were disposed of a number of years ago. CHS has newer echo sounders capable of sounding in deep water, such as the one used on CESAR. However, sounding through the ice is not easy, the quality of the echo depends on the structure of the ice cover, and the interpretation of what constitutes a true echo is sometimes ambiguous.

COMPARISON BETWEEN SEISMIC AND ECHO SOUNDING

Seismic soundings with the new recorder and 1 kg explosive charges proved to be very clear and unambiguous even in rough, rafted, multiyear ice. The records are permanent and can always be re-checked. Soundings rarely have to be repeated.

Echos from echo sounders, on the other hand, are not always clear. Sometimes more than one echo appear, and sometimes the sounding location has to be changed. Occasionally, the helicopter has to be moved in order to obtain more favorable ice conditions. If the soundings are closely spaced, and the approximate depth is known, echo soundings are usually acceptable. If on the other hand depths are unknown, such as over rugged terrain and/or with widely spaced soundings, as was the case on CESAR, seismic sounding is superior.

The time required to carry out a gravity observation and to take an echo sounding is about the same. Therefore, to take an individual echo sounding is about 3 minutes faster than a seismic sounding. However, considering that with the seismic method no soundings have to be repeated, and that there are no doubtful data that may have to be rejected later on, the overall efficiency of the seismic method is superior over the echo sounding technique.

RECOMMENDATIONS

Where soundings are carried out in conjunction with geophysical measurements which require precise depth, and where available helicopter support is limited, it is recommended that the seismic sounding method be used.

It is also recommended that a second seismic recorder of the later model (recorder and capture module in one unit) be purchased that can be carried in the helipcopter as a back-up.

As a minor modification it is recommended that the power switches of both recovered and capture module be protected against accidental turn-on or turn-off.

REFERENCES

Sobczak, L.W. and Schmidt, M. 1985. Gravity survey along the seismic refraction line from Ice Island, N.W.T. Prelimimary report. Earth Physics Branch, EMR, Internal Report No. 85-15, 5p.

Sobczak, L.W. and Weber, J.R., 1986. Gravity and bathymetry along seismic refraction lines, Canadian Ice Island, N.W.T., 1986. Geological Survey of Canada, Geophysics Division, EMR, Internal Report No. 86-14.