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BOTTOM REFLECTION LOSS IN AN AREA IN THE HATTERAS ABYSSAL PLAIN

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ABSTRACT

Bottom reflection loss measurements were made along three tracks in a 1 degree quadrangle, designated Area C, extending from 33°00' to 34°00'N and 71°00' to 72°00'W. The area lies along the northwestern edge of the Hatteras Abyssal Plain. Explosive sound sources were used and, based on peak pressure, bottom reflection loss values were computed. Bottom loss at 1 and 3.5 kc for grazing angles between 20 and 60 degrees are reported. The results indicate that the bottom is frequency selective, which is suggested by the frequency crossings or inverse relationship between bottom loss and frequency exhibited by the data along one track. A uniform dependence of bottom loss on grazing angle is not observed.

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BOTTOM REFLECTION LOSS IN AN AREA IN THE HATTERAS ABYSSAL AREA

INTRODUCTION

During August 1964, bottom reflection loss data were obtained in the central section of the 1 degree quadrangle, designated Area C, extending from 33°00' to 34°00'N and 71°00' to 72°00'W. The data were collected along three lines at first bottom bounce grazing angles of about 20, 30, and 42 degrees. Mark 50 explosive sound sources were used with the USS WILLIS A LEE acting as the source ship. The USS BRATTLEBORO was used as the receiving ship. Frequency analyses were made at 1 and 3.5 kc and bottom reflection loss values for both first and second bottom reflection angles were determined.

FIELD PROCEDURES

The reflection loss measurements were made along three lines as shown in Figure 1. All measurements were made with the receiving ship lying to at positions A, B, and C as the source ship proceeded along the indicated tracks. At ranges from the receiving ship corresponding to first bottom reflection angles of about 20, 30, and 42 degrees, four or five Mark 50 sound signals were dropped to a detonation depth of 50 feet. Geographic position was determined by Loran-C while the distance between the ships was monitored by radar.

The bottom reflected signals were received by an LC-32 hydrophone at a depth of 50 feet. Signals from the hydrophone were passed through three amplifiers and recorded broad-band on three tracks of a multi-channel magnetic tape recorder. The magnetic tape recordings were made at 7 1/2 inches per second.

DATA REDUCTION AND ANALYSIS

The tape recordings were played back at either 71/2 or 1 7/8 inches per second through Allison band pass filters centered at equivalent frequencies of 1 and 3.5 kc in third octave bandwidths. The bottom reflected signals were displayed on a Sanborn logarithmic strip chart recorder.

Bottom reflection loss was determined by first computing the difference between the peak pressure level of the first and second bottom reflection arrivals read on the Sandborn paper tape. That is, the relative amplitude of the bottom-surface-bottom arrival (BSB) was subtracted from the relative amplitude of the first bottom arrival (B). By assuming spherical spreading, straight line ray geometry, and

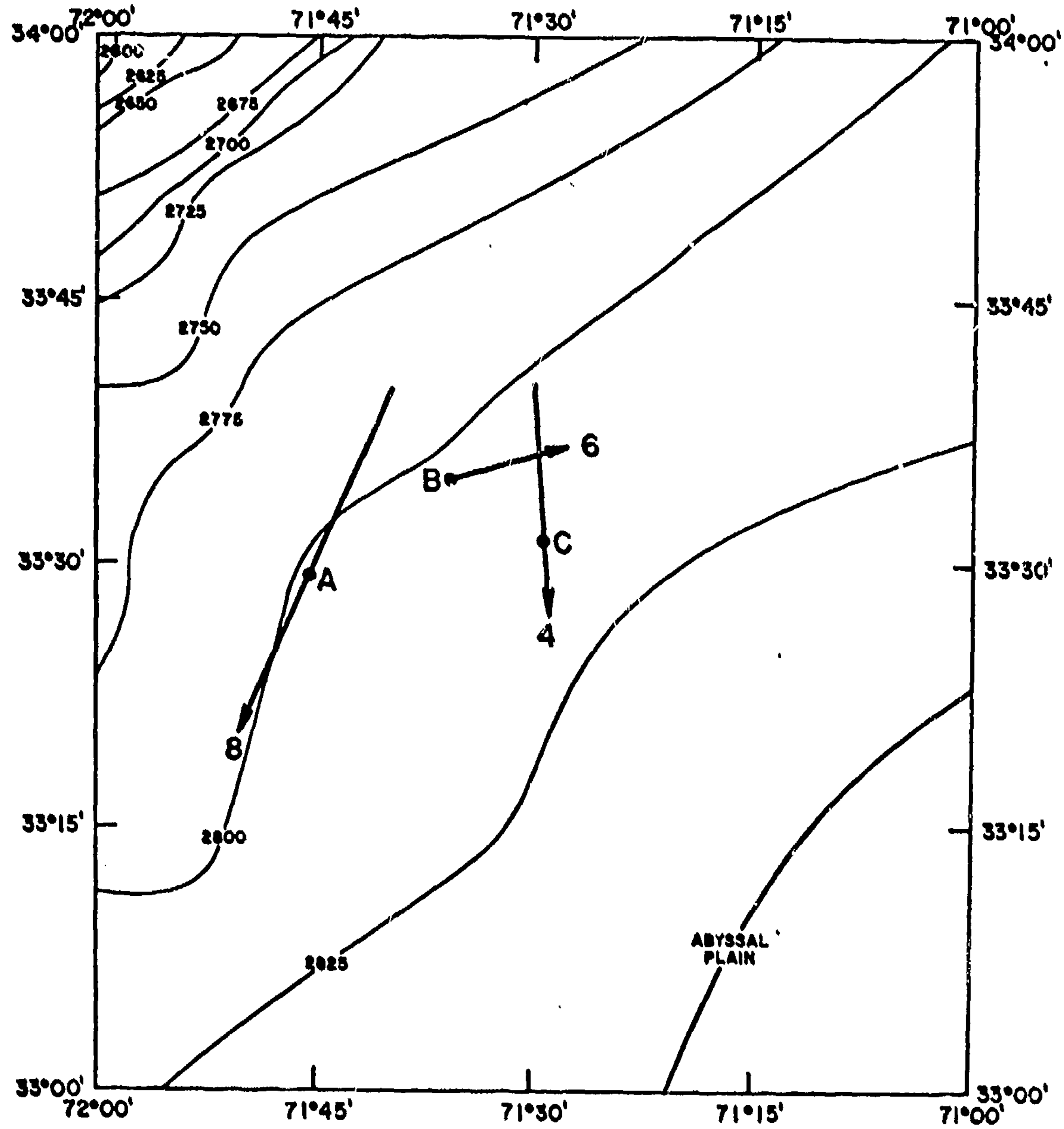

FIGURE 1 LOCATION OF BOTTOM REFLECTION LOSS MEASUREMENTS (A, B, C DESIGNATE RECEIVING SHIP AND ARROW INDICATES DIRECTION OF MOVING SOURCE SHIP)

perfect reflection at the sea surface this difference was then corrected for the difference in path length of the two arrivals. Bottom reflection loss is then given by:

$$B.\ L. = L_B(\theta_1) - L_{BSB}(\theta_2) - \left[N_{BSB} - N_B\right] \qquad (1)$$

where: B.L. = bottom reflection loss,
$L_B(\theta_1)$ = peak level of bottom arrival,
$L_{BSB}(\theta_2)$ = peak level of bottom-surface-bottom arrival,
N = propagation loss = 20 log R + α R,
R = slant range in yards,
σ = $0.0093f^2$ db kyd, and
f = frequency in kilocycles.

The advantage of this method is that it is independent of source level and system calibration. The main shortcoming of this method is that the grazing angle is not constant for the two arrivals used. Therefore, the computed bottom loss is treated as an apparent bottom loss for the average angle of the two arrivals. The apparent loss determined by using equation 1 is actually the loss at the second grazing angle plus the difference between the loss of the two grazing angles. The apparent loss can be expressed as:

$$\overline{B.L.} = B(\theta_2) + \left[B(\theta_2) - B(\theta_1)\right] \qquad (2)$$

where: $\overline{B.L.}$ = apparent bottom loss,
$B(\theta_2)$ = loss at second angle corresponding to BSB arrival, and
$B(\theta_1)$ = loss at first angle corresponding to B arrival.

It can be seen that the apparent bottom loss values determined by the above method will equal true bottom loss in those areas where bottom loss does not vary with grazing angle. The average bottom loss of 25 locations in Area C, obtained by Alpine Geophysical Associates (1964) for the U. S. Naval Oceanographic Office, indicates that there is no appreciable dependence of bottom loss on grazing angle (Figure 2); however, substantial variations do exist at each location and from location to location. In an attempt to minimize or average the errors present in the computed apparent loss, a second method, based on the results of equation 1, was utilized. In this instance bottom loss can be computed as follows:

$$B.\ L.\quad S-N-L \qquad (3)$$

where: B. L. = bottom reflection loss,
S = source level,
N = propagation loss = 20 Log R + αR, and
L = peak level of bottom reflected arrival after system calibrations.

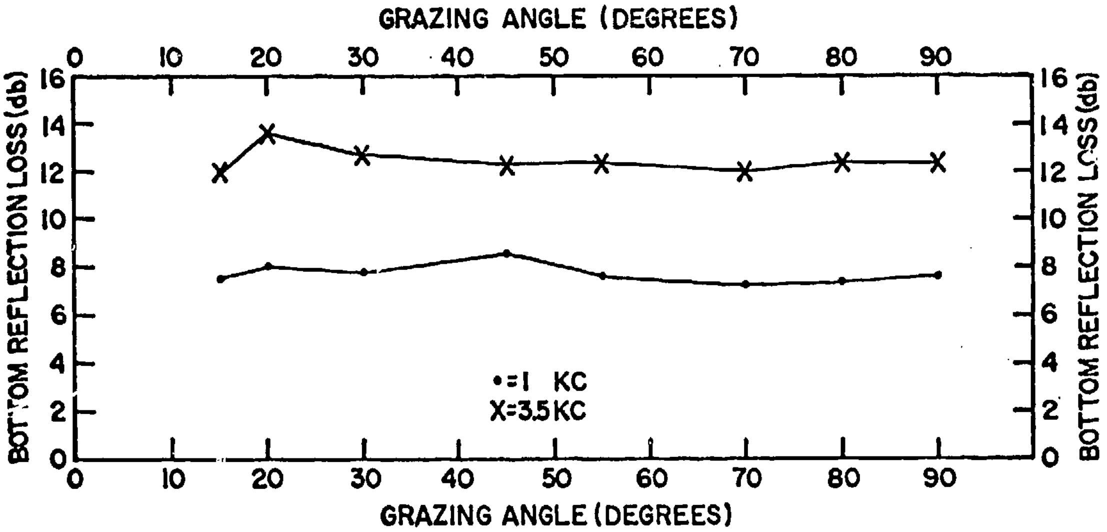

FIGURE 2 ALPINE BOTTOM REFLECTION LOSS VS GRAZING ANGLE (AVERAGE OF 25 STATIONS)

This equation requires that the source level of the explosive be known or calibrated. Assuming that the average bottom loss in this area is independent of grazing angle, the apparent losses determined by equation 1 can be used in conjunction with equation 3 to yield an apparent source level.

$$S_A = \overline{B.\ L.} + N_B + L_B \qquad (4)$$
$$S_A = 2\,\overline{B.\ L.} + N_{BSB} + L_{BSB}$$

where: S_A = apparent source level and

$\overline{B.\ L.}$ = apparent bottom loss determined from equation 1.

A value of S_A, at 1 and 3.5 kc, was computed for each shot and then all values were averaged to arrive at an apparent average source level for each frequency. The average source levels were then used to determine bottom loss values for each B and BSB arrival as follows:

$$B.\ L.\ (\theta_1) = \overline{S}_A - N_B - L_B \qquad (5)$$
$$2B.\ L.\ (\theta_2) = \overline{S}_A - N_{BSB} - L_{BSB}$$

where: $\overline{S}_A$ = apparent average source level.

For the purposes of this report the bottom loss values determined by the above method will be referred to as true bottom loss.

For comparison purposes a source level, equivalent to 1.8 pounds of TNT for a Mark 50 sound signal, was determined from Weston (1960). The source level, based on Weston, agreed within 3 db of the average source level determined by equation 4. Considering the assumptions made in arriving at the average source level, this agreement is extremely good.

DISCUSSION OF RESULTS

Figure 3 illustrates apparent bottom reflection loss versus grazing angle, as determined by equation 1, along the three tracks. For tracks 4 and 8 at the lower grazing angles the 1 kc losses are greater than the 3.5 kc losses, while at the higher angles a frequency crossing occurs which produces an increase in bottom loss with increasing frequency. Along track 6 the 3.5 kc loss is everywhere about 1 db greater than the 1 kc values. Data collected by Alpine Geophysical Associates (1964) in Area A (36°00' to 37°00'N, 66°00' to 67°00'W) for the U. S. Naval Oceanographic Office exhibit similar frequency crossings; however, it is believed that the results illustrated in Figure 3 do not result from the character of the ocean bottom, but are, in part, a result of the method of analysis employed. The frequency crossings can be partially explained by equation 2 and Table 1. Table 1 is a summary of the bottom loss data

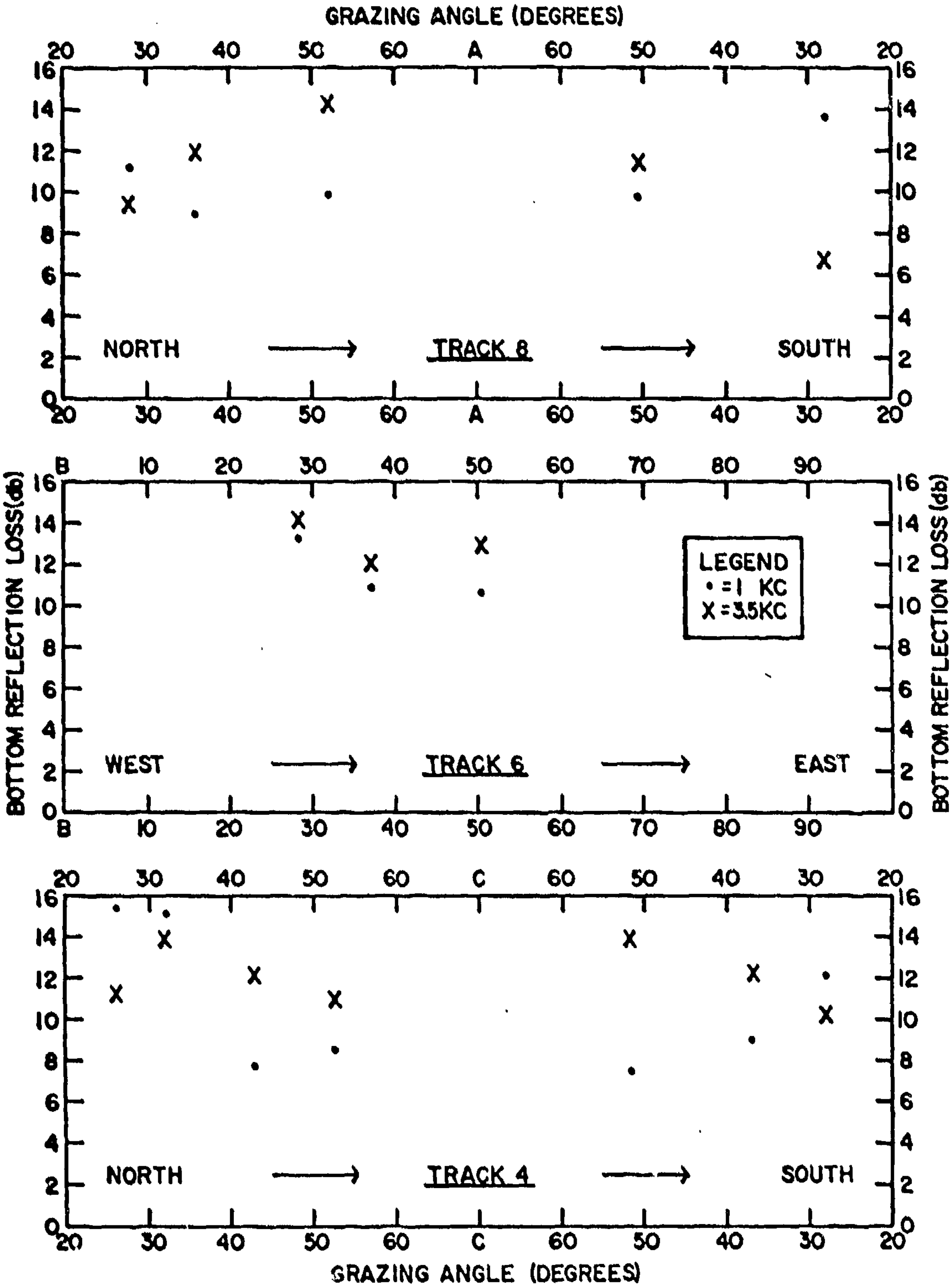

FIGURE 3 BOTTOM REFLECTION LOSS VS GRAZING ANGLE DETERMINED BY EQ. 1 (ARROW INDICATES DIRECTION OF SOURCE SHIP RELATIVE TO RECEIVING SHIP)

TABLE 1

SUMMARY OF BOTTOM LOSS DATA

Track-station	Bottom Angle (θ_1)	True Loss[1] (db)		BSB Angle (θ_2)	True Loss[1] (db)		Average Angle	Apparent Loss[2] (db)	
		1 kc	3.5 kc		1 kc	3.5 kc		1 kc	3.5 kc
8-1	20°	9.1	15.2	36°	10.1	11.3	28	11.1	9.4
8-2	27	11.2	14.0	45	10.1	12.9	36	8.9	12.0
8-3	42	13.2	14.2	62	11.1	14.2	52	9.9	14.2
8-4	41	12.9	12.8	60	11.4	12.1	50.5	9.8	11.4
8-5	20	11.0	14.0	36	12.3	17.0	28	13.6	6.8
6-1	20	7.2	9.5	37	10.2	11.2	28.5	13.2	14.2
6-2	28	7.2	13.5	47	9.0	12.6	37.5	10.8	12.0
6-3	41	11.2	13.4	60	11.2	13.0	50.5	10.6	12.8
4-1	19	10.2	14.6	34	13.8	11.4	26.5	15.3	11.2
4-2	24	8.2	10.2	41	11.6	12.0	32.5	15.0	13.8
4-3	33	12.9	12.8	53	10.2	12.5	43	7.7	12.2
4-4	43	12.2	14.4	62	10.3	12.7	52.5	8.5	11.0
4-5	42	14.1	11.5	61	10.8	12.7	51.5	7.4	13.8
4-6	27	13.0	8.1	47	11.0	10.0	37	8.9	12.2
4-7	20	9.9	9.7	36	11.0	9.9	28	12.0	10.1

(1) Determined from equations 4 and 5

(2) Determined from equation 1

illustrated in Figures 3 and 4. For example, the frequency crossing at the 32 degree angle of track 4, in Figure 3, can be examined by referring to the computed true losses associated with the bottom and bottom-surface-bottom arrival angles used in determining the apparent loss. Data for station 4-2, in Table 1, show that the 3.5 kc loss values are greater than those for 1 kc; however, by substituting these values in equation 2 we get apparent losses of 13.8 db at 3.5 kc and 15 db at 1 kc and, consequently, a frequency inversion. It is evident that when the true bottom loss is a function of grazing angle the apparent losses arrived at by using equation 1 are either greater than or less than the true values. It then follows that the source levels attained by equation 4 will also be in error; however, by averaging all apparent source levels to arrive at one value, it is assumed that the errors are minimized.

The dependence of true bottom loss on frequency and grazing angle can be seen in Figure 4. Two types of variations can be seen along the individual tracks. The first type involves changes in bottom loss that are not uniform with frequency and results in frequency crossings. This can be seen along track 4 where the 1 kc losses are sometimes higher than the 3.5 kc losses. Tracks 6 and 8 illustrate the expected frequency dependence of increasing bottom loss with increasing frequency illustrated by Marsh and Schulkin (1955) in the results of Project AMOS.

A second type of variation involves changes in bottom loss with grazing angle. A uniform dependence on grazing angle is not observed as 1 to 4 db fluctuations are seen to occur from one grazing angle to the next. In addition, these fluctuations do not equally effect both frequencies.

Since the measurements were made with the source ship opening or closing range on the receiving ship it is not known if the variations in bottom loss as a function of grazing angle are real or if they result from lateral variations in the bottom as the point of reflection changes. No attempt will be made in this report to explain theoretically the results illustrated in Figure 4, but it should be noted that a multilayered bottom, consisting of sand and silt layers, can produce theoretical frequency crossings. Area C lies within the Hatteras Abyssal Plain and the presence of sand and silt layers in cored sediments in abyssal plain regions has been established by Ericson et al. (1952, 1955).

COMPARISON WITH OTHER DATA

Figure 5 is a comparison of the average Alpine bottom loss for Area C with a composite of the data presented in this report (Figure 4). For 3.5 kc the Alpine average curve appears to be an approximate mean of the composite, while the Alpine 1 kc average appears to be the lower limit of the composite.

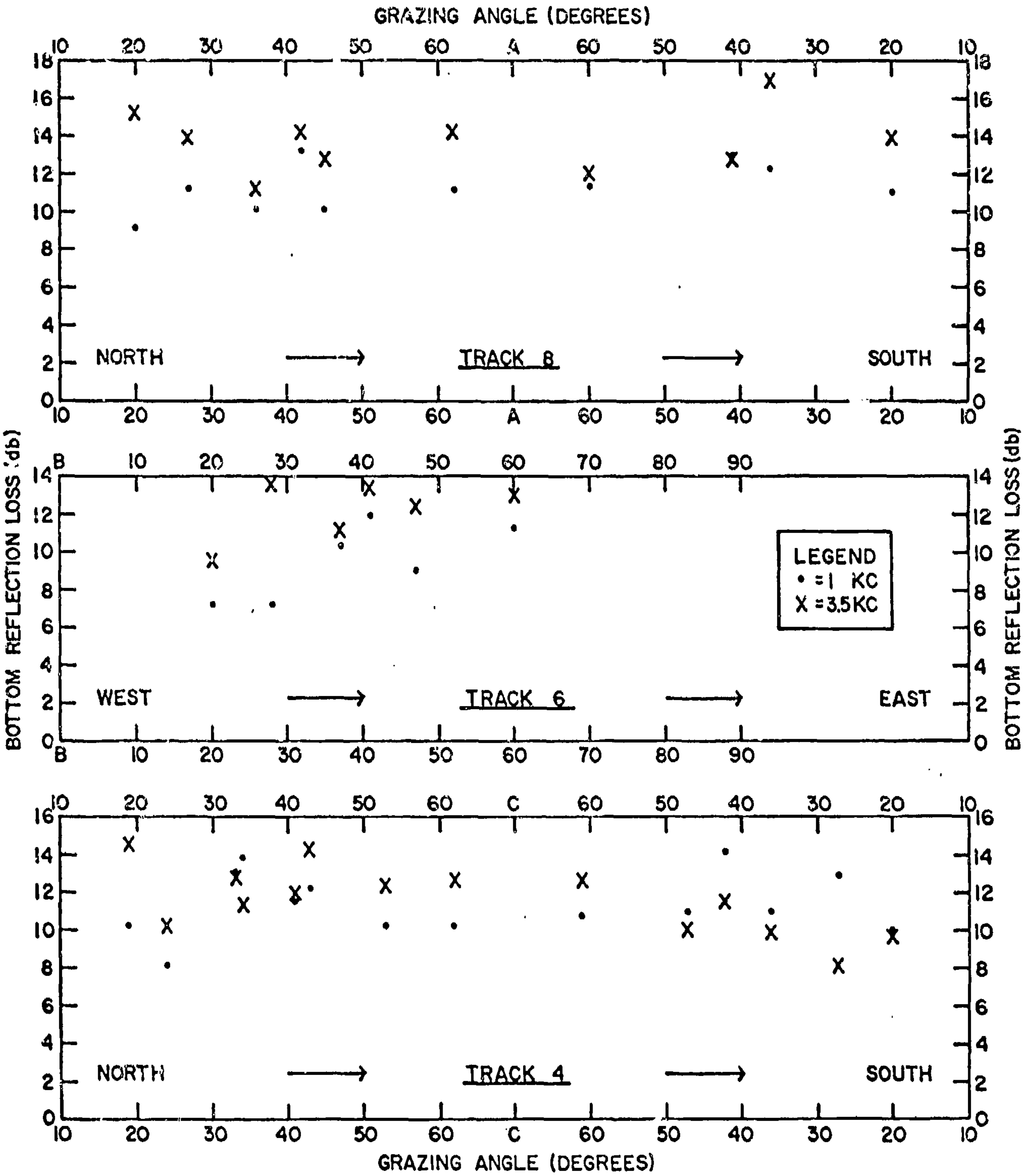

FIGURE 4 BOTTOM REFLECTION LOSS VS GRAZING ANGLE DETERMINED BY EQUATIONS 4 and 5 (ARROW INDICATES DIRECTION OF SOURCE SHIP RELATIVE TO RECEIVING SHIP)

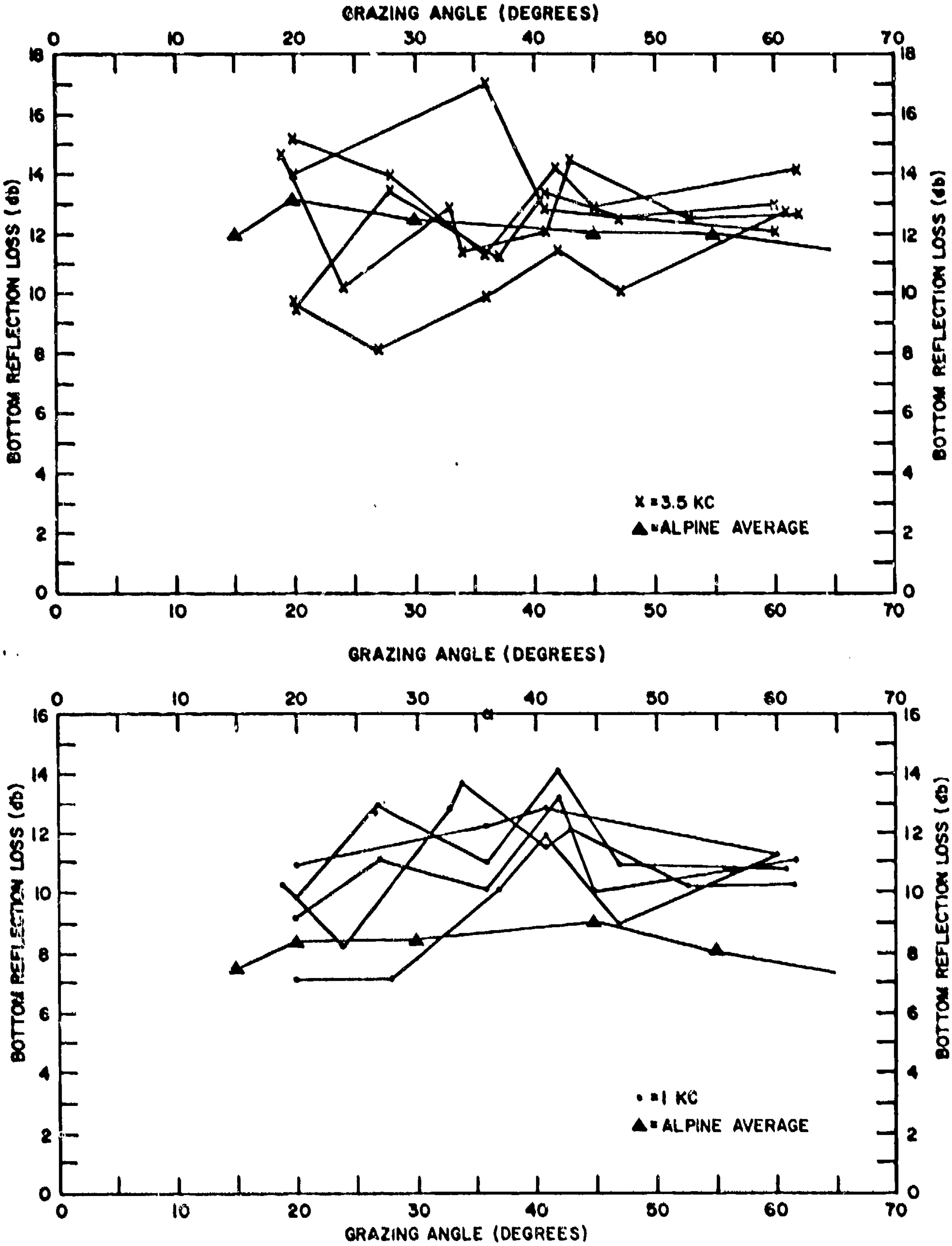

FIGURE 5 COMPOSITE OF TRUE BOTTOM LOSS (FIGURE 4) AND ALPINE AVERAGE BOTTOM LOSS

Although the Alpine average bottom loss does not exhibit an appreciable dependence on grazing angle an examination of their 25 individual stations shows variations in bottom loss similar to those illustrated in this report.

Figure 6 is a comparison of the AMOS bottom loss curve, as modified by Bell (1959), with the composite of Figure 5. For 3.5 kc the AMOS curve shows general agreement at 20 degrees, but everywhere else tends to be about 3 to 4 db higher. The 1 kc AMOS curve appears to form the upper limit of the composite from 20 to 35 degrees and from 35 to 60 degrees the AMOS curve appears to be the mean of the composite.

CONSLUSION

Apparent bottom reflection loss values were computed by a method independent of source level and system calibration. The apparent loss values were used to compute an apparent source level and finally to arrive at true bottom loss. The errors introduced by the method employed appear to be no larger than the errors introduced by assuming a source level.

The data indicate that there are variations in bottom loss from one angle to the next and from track to track. Generally, the results are in overall agreement with the Alpine bottom loss data for this area.

The bottom loss data suggest that the bottom is frequency selective in that the 1 kc loss values can be greater than those for 3.5 kc. This is in contrast to the uniform increase in bottom loss with increasing frequency suggested by the AMOS results.

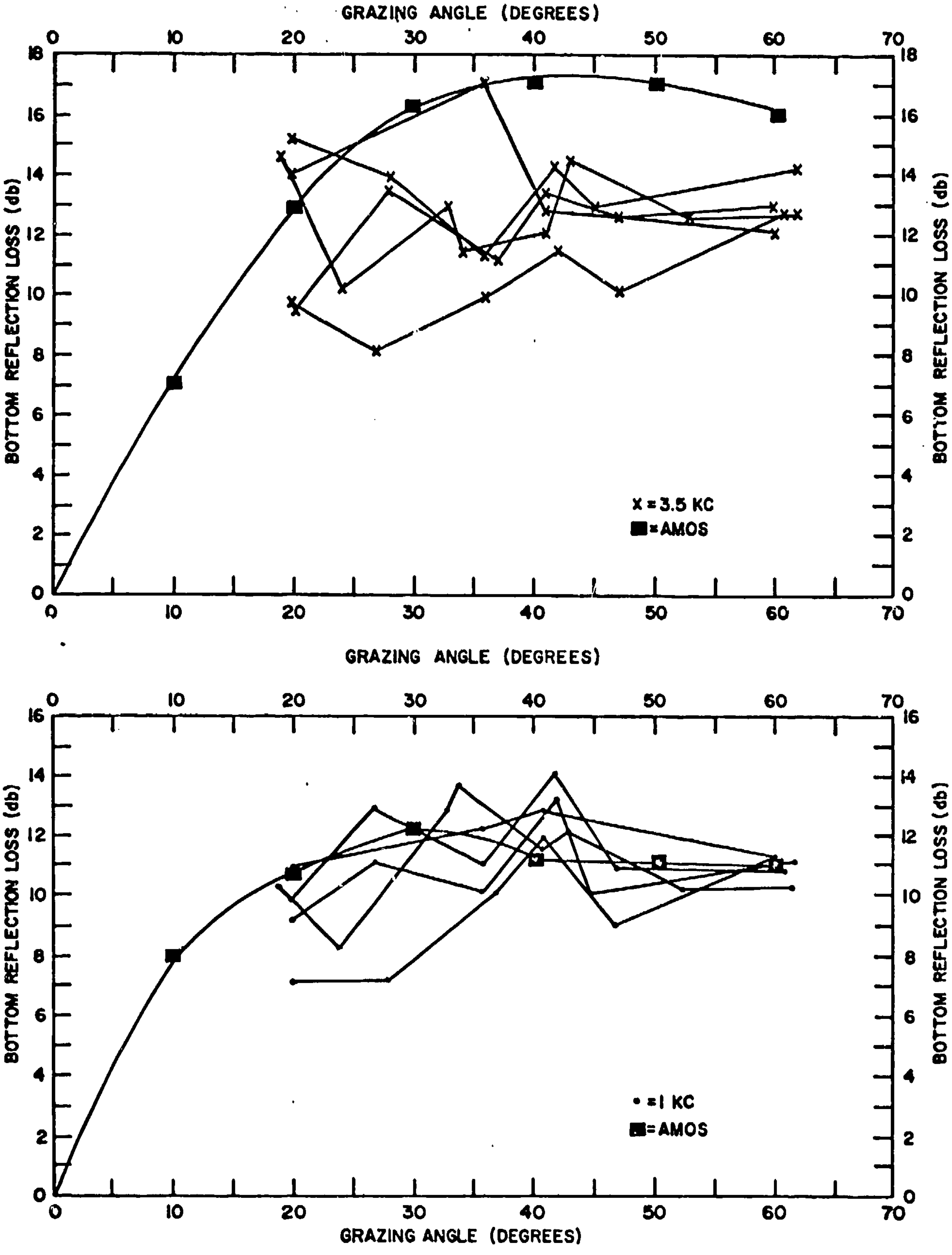

FIGURE 6 COMPOSITE OF TRUE BOTTOM LOSS AND AMOS BOTTOM LOSS

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