From geology to geoacoustics: uncertainty of converting geological data for input to acoustic models

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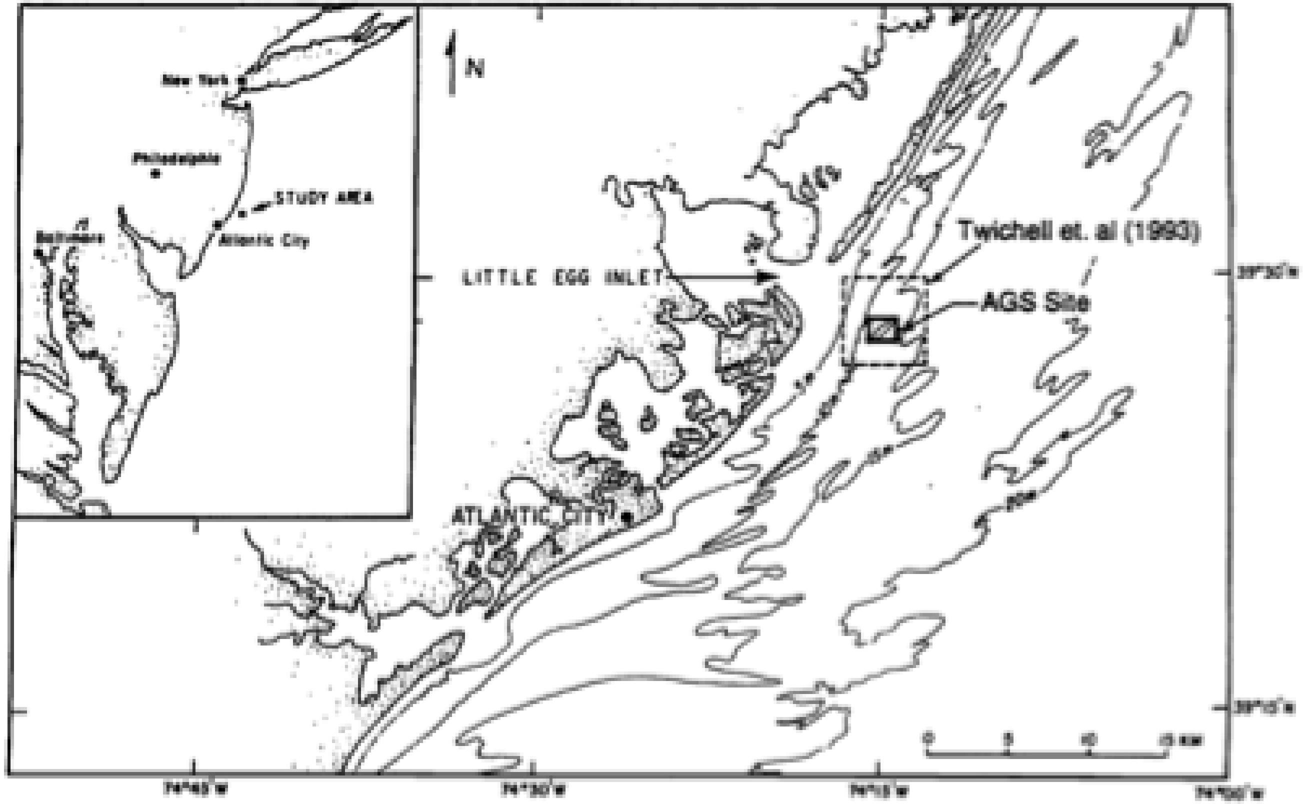

FIG. 1. Index map showing the study area of the Atlantic Generating Station site, New Jersey (see Ref. 4).

AGS site off shore New Jersey

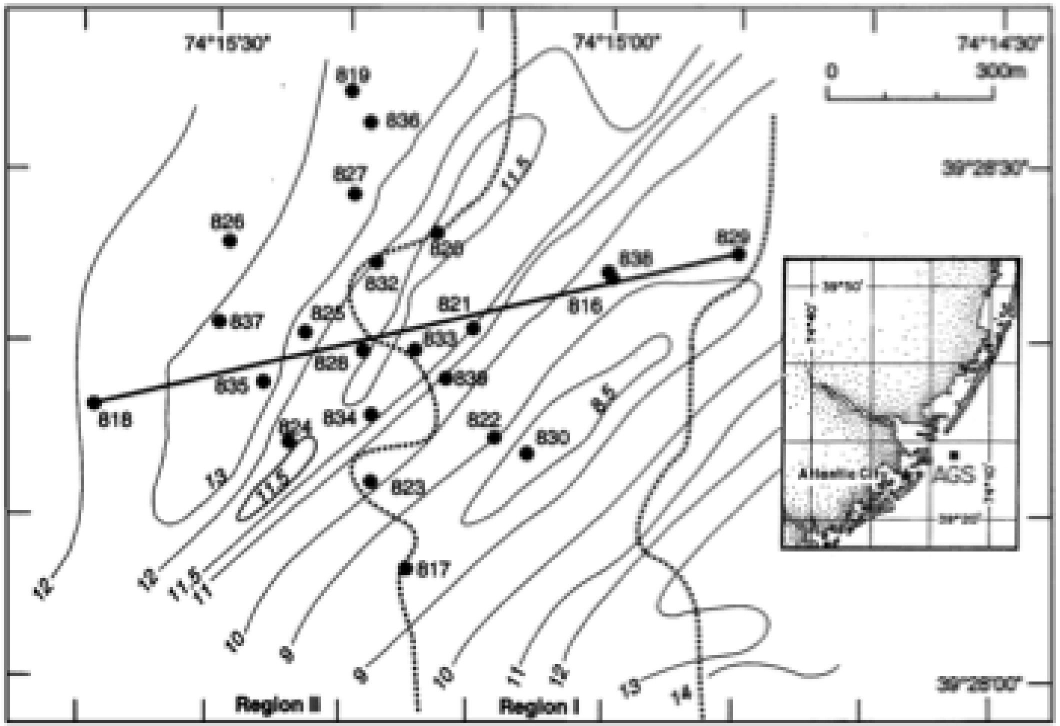

FIG. 2. Map of the Atlantic Generating Station drilling site (see Refs. 3 and 7).

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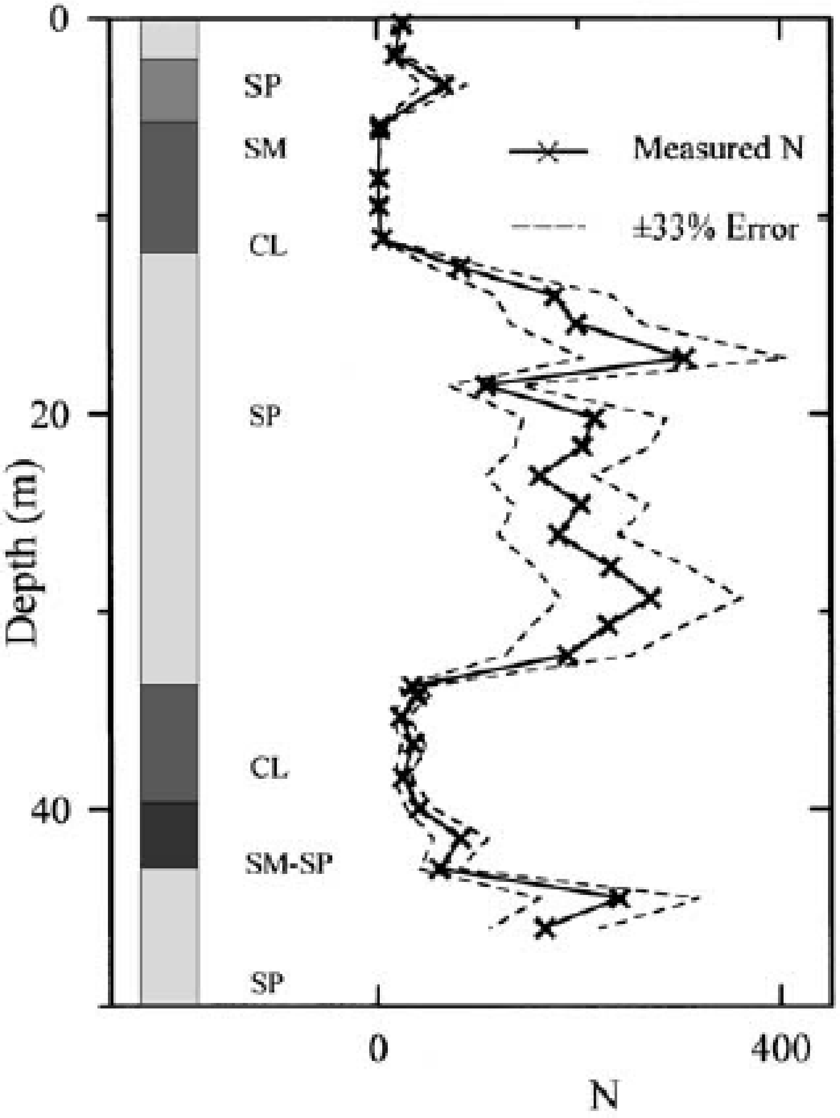


FIG. 4. Profile of core layer description and blow count number for core 816 at AGS site. Blow count is assumed to be normally distributed with an arbitrary standard deviation of 33%.

TABLE II. Sediment description and grain diameters reported in Hamilton (Ref. 18), at AGS site (Ref. 5) and AMCOR 6010 (Ref. 3).

Sediment description	Range of d_{mean} (μm)
Brown medium to coarse sand with gravel or sandy gravel	525–695
Coarse sand	528
Gray fine to medium sand with gravel	385–525
Gray fine sand with trace of silt and some shells	175–235
Brown and gray fine sand with trace of silt	185–225
Fine sand	164
Very fine sand	92
Gray very fine sand with rockets or organic silty clay	65–75
Silty sand	68
Gray very fine clayey sand or silty fine sand	49
Sandy silt	31
Silt	21
Dark gray and brown sandy silty clay with trace of fine to coarse sand	17–19
Sand-silt-clay	18
Dark gray silty clay with a little silt to clayey silt	7.7–9
Clayey silt	7.4
Dark gray organic silty clay with trace of silt	2.7–4.5
Silty clay	2.7

TABLE III. Core descriptions for Figs. 4 and 8.

Symbol	Core material
CL	Silty clay
CS	Sandy clay
SS	Silty clay mixed with fine sand
SP	Fine to medium sand
SM	Silty sand

Cross section of a 2D slice

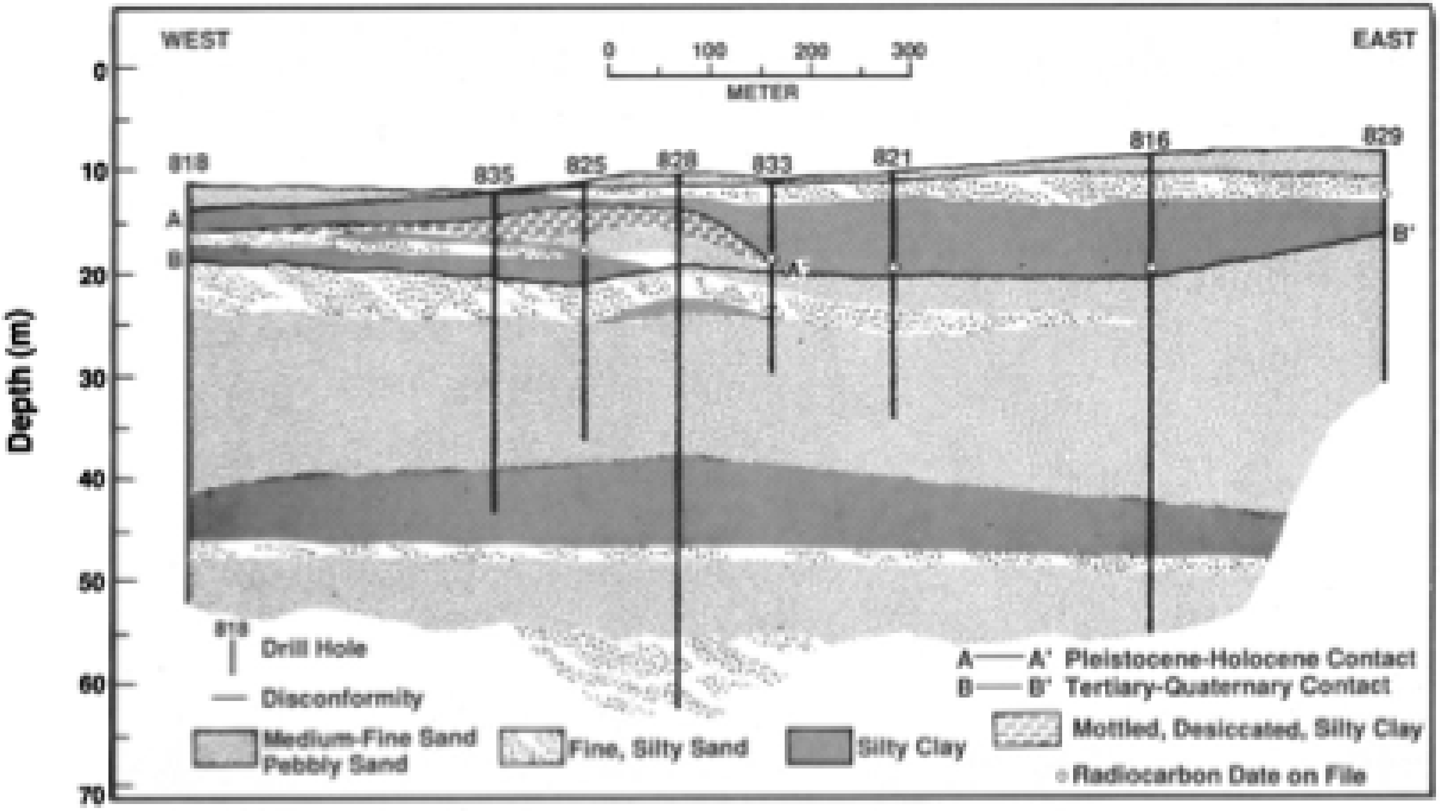


FIG. 3. Cross section of one of the propagation path across AGS site (see Ref. 5).

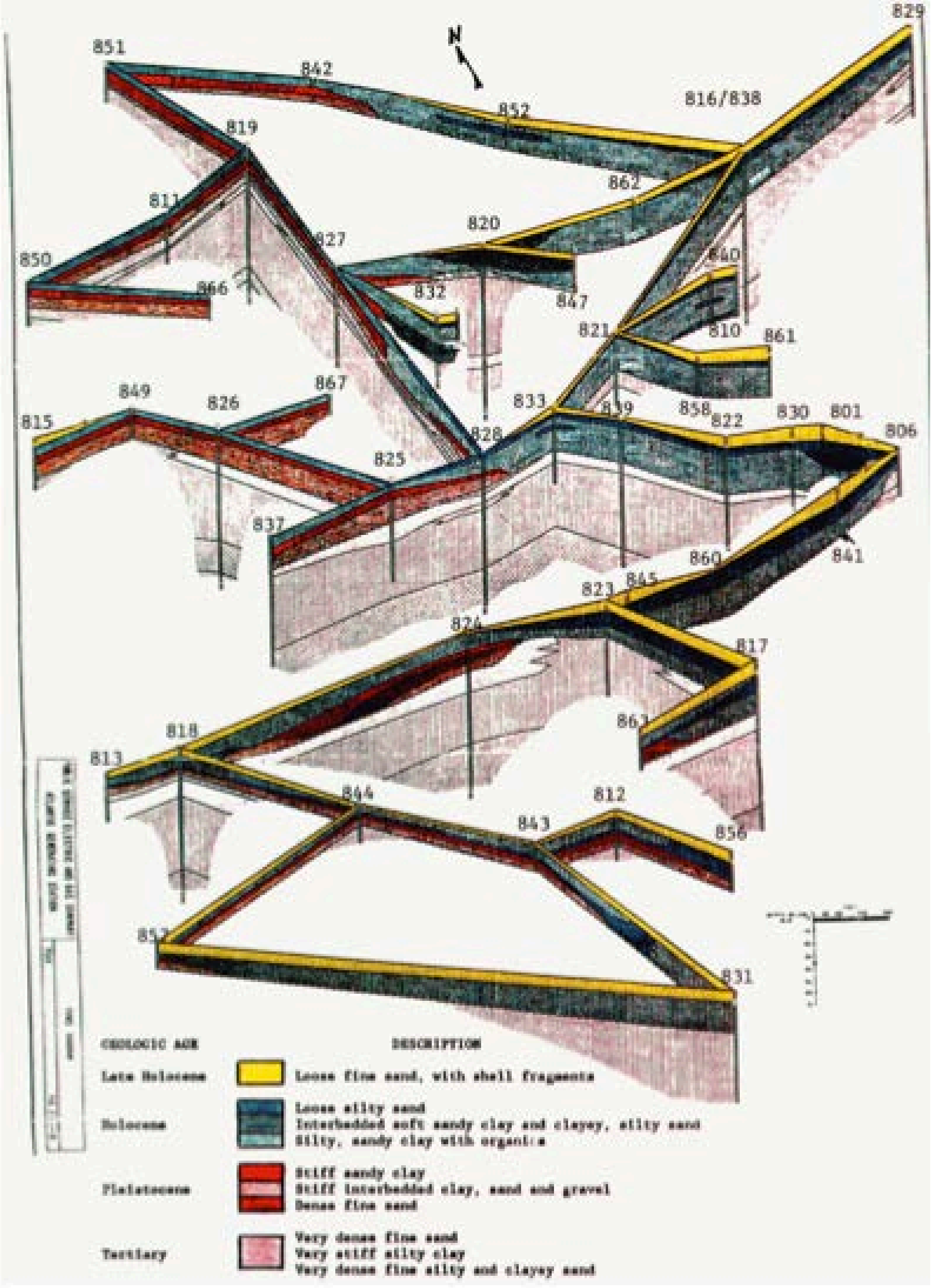


FIG. 4. Fence diagram of the AGS site stratigraphy (adopted from Ref. 7).

TABLE I. Input sediment parameters (Ref. 3).

Parameter	Symbol	Unit	Sediment	
			Hard	Soft
Grain density	ρ_s	kg/m^3	2650	2650
Fluid density	ρ_f	kg/m^3	1000	1000
Grain bulk modulus	K_s	Pa	3.6×10^{10}	3.6×10^{10}
Fluid bulk modulus	K_f	Pa	2.25×10^{9}	2.25×10^{9}
Frame bulk modulus	K_0	Pa	4.36×10^{7}	3.69×10^{7}
Frame shear modulus	G_0	Pa	2.61×10^{7}	2.21×10^{7}
Fluid viscosity	μ_f	kg/m s	1.0×10^{-3}	1.0×10^{-3}
Permeability	k	m^2	1.0×10^{-10}	1.0×10^{-11}
Porosity	ϕ	⋯	0.47	0.76
Degree of saturation	S	⋯	1.0	1.0
Shear specific loss	δ'	⋯	0.01	0.03
Volumetric specific loss	δ''	⋯	0.0075	0.0225
Added mass coefficient	c	⋯	0.25	0.25

$$\begin{pmatrix} V_{p1} \\ V_{p2} \end{pmatrix} = \left[\frac{2(HM - C^2)}{(\rho M + m'H - 2\rho_f C) \mp A^{1/2}} \right]^{1/2},$$

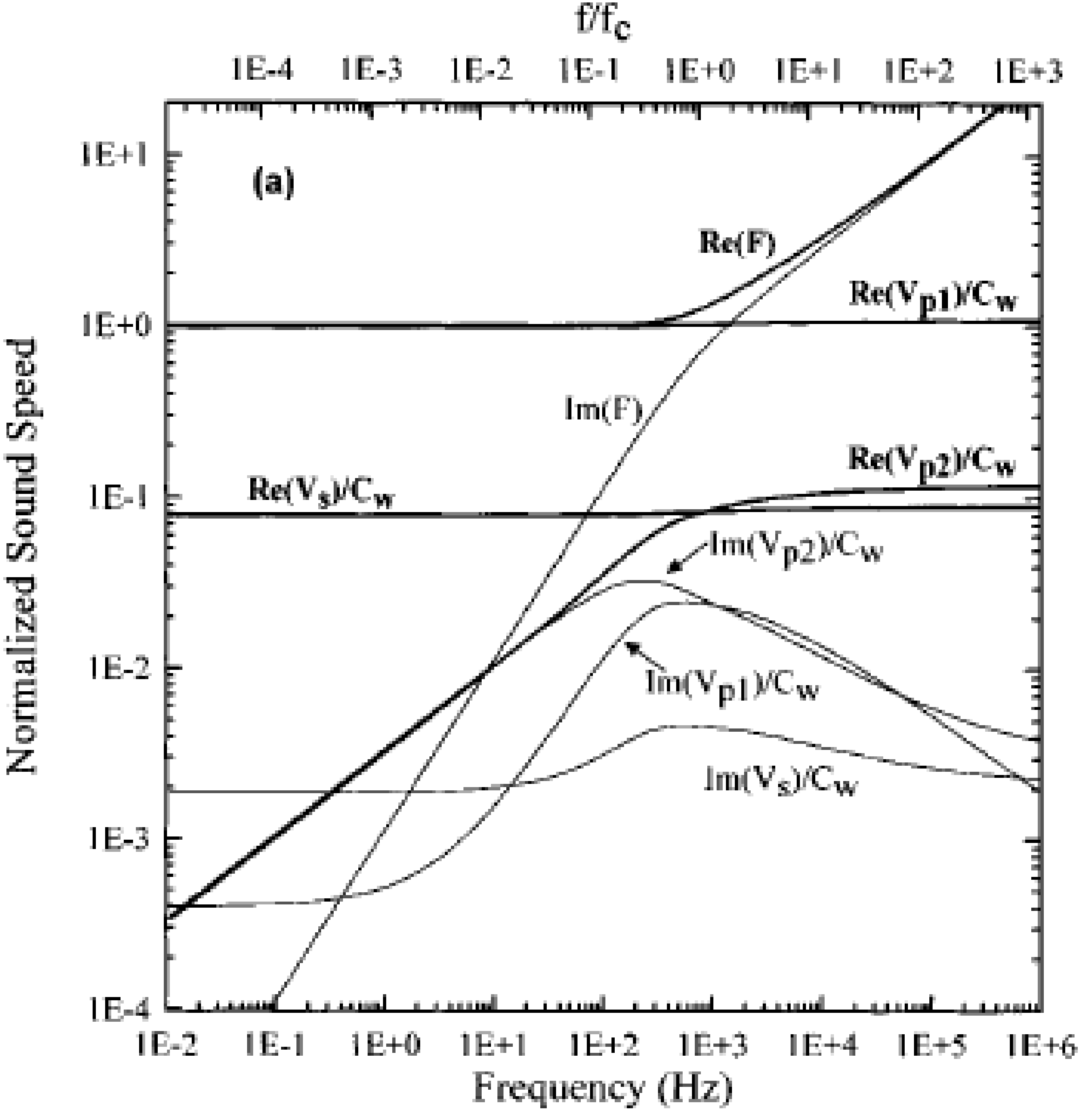
$$V_s = \left(\frac{Gm'}{\rho m' - \rho_f^2} \right)^{1/2},$$

where

$$\rho = (1 - \phi)\rho_s + \phi\rho_f$$

$$Q^{-1} = \frac{\alpha v}{\pi f} = \frac{\delta}{\pi}, \qquad Q^{-1} = 2\left|\frac{V_i}{V_r}\right|$$

$$\alpha = 2\pi f \frac{|V_i|}{|V|^2}, \qquad \alpha(\mathrm{dB}/\lambda) = 8.686\pi \frac{2|V_i|}{|V_r|}$$


f/f_c
1E-4
1E-3
1E-2
1E-1
1E+0
1E+1
1E+2
1E+3
(a)
Re(F)
Re(V_p1)/C_w
Im(F)
Re(V_p2)/C_w
Re(V_s)/C_w
Im(V_p2)/C_w
Im(V_p1)/C_w
Im(V_s)/C_w
1E+1
1E+0
1E-1
1E-2
1E-3
1E-4
Normalized Sound Speed
1E-2
1E-1
1E+0
1E+1
1E+2
1E+3
1E+4
1E+5
1E+6
Frequency (Hz)

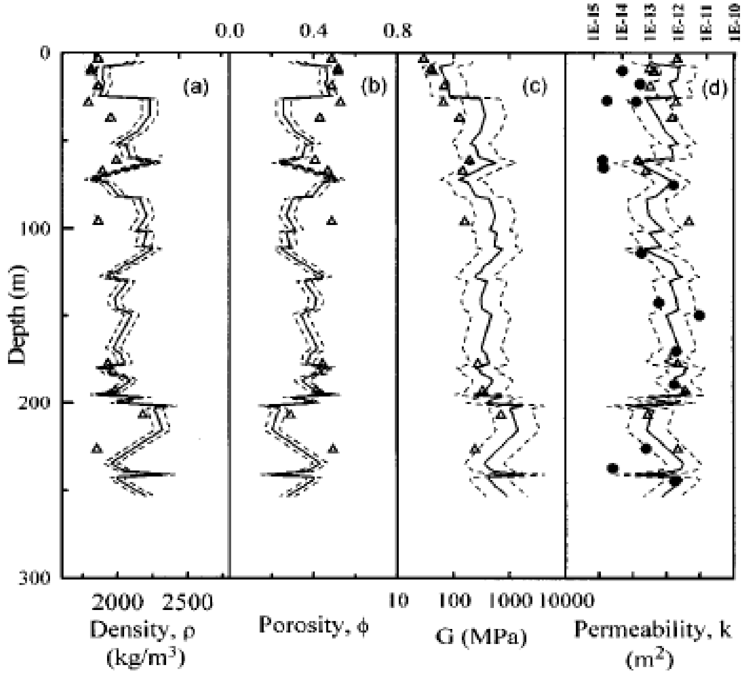


FIG. 9. Measured density profile and calculated profiles of porosity, shear modulus, and permeability for AMCOR 6010. △ corresponding to data based on laboratory measured density, and ● are based on measured grain diameters. Solid lines are mean values and dash lines are ±one standard deviation.

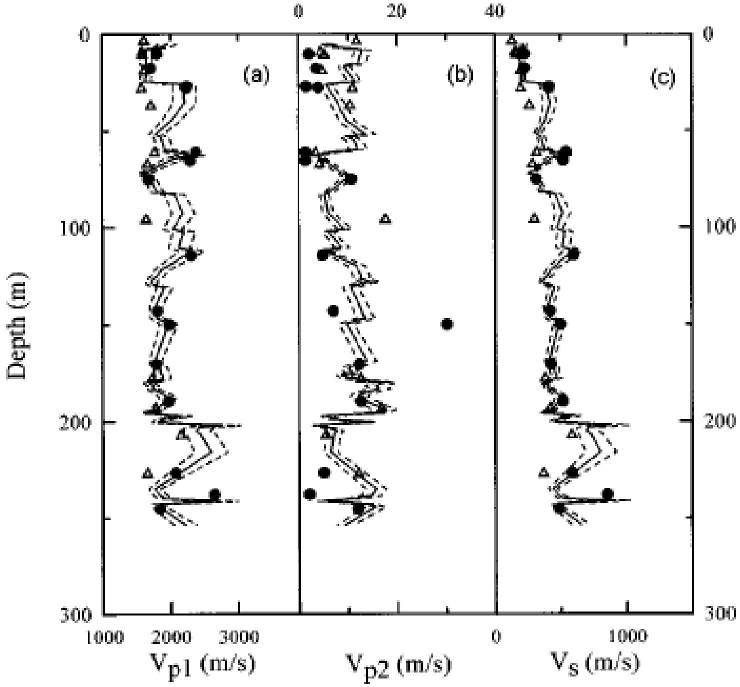


FIG. 10. Predicted sound speed of the first compressional (V_{p1}), second compressional (V_{p2}), and shear (V_s) waves for AMCOR 6010. △ corresponds to data based on laboratory measured density, and ● is based on measured grain diameters. Solid lines are mean values and dash lines are ±one standard deviation.

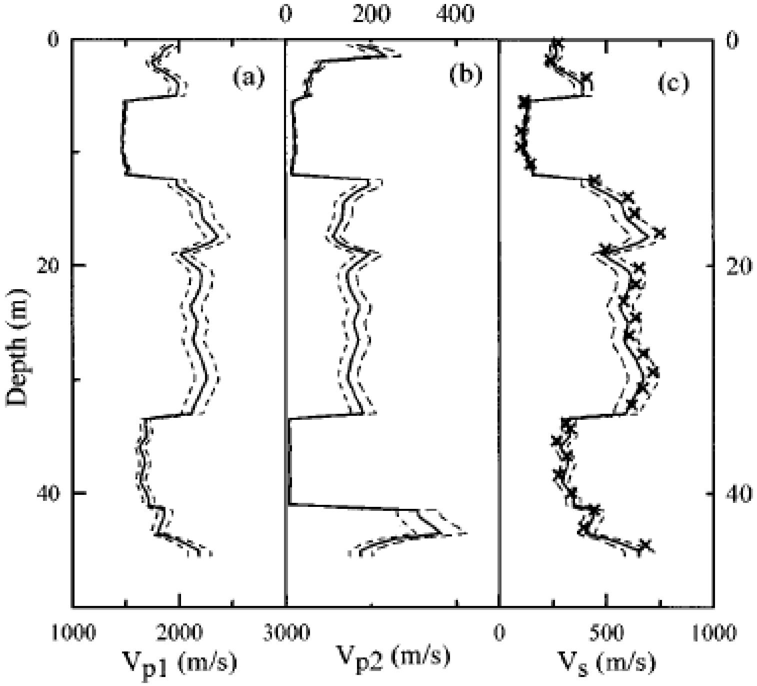


FIG. 6. Predicted sound speed of the (a) first compressional (V_{p1}), (b) second compressional (V_{p2}), and (c) shear (V_s) waves for AGS core 816; (×) shows the calculated shear wave speed using a simplified formula provided in Ref. 33. Solid lines are mean values and dash lines are ±one standard deviation.

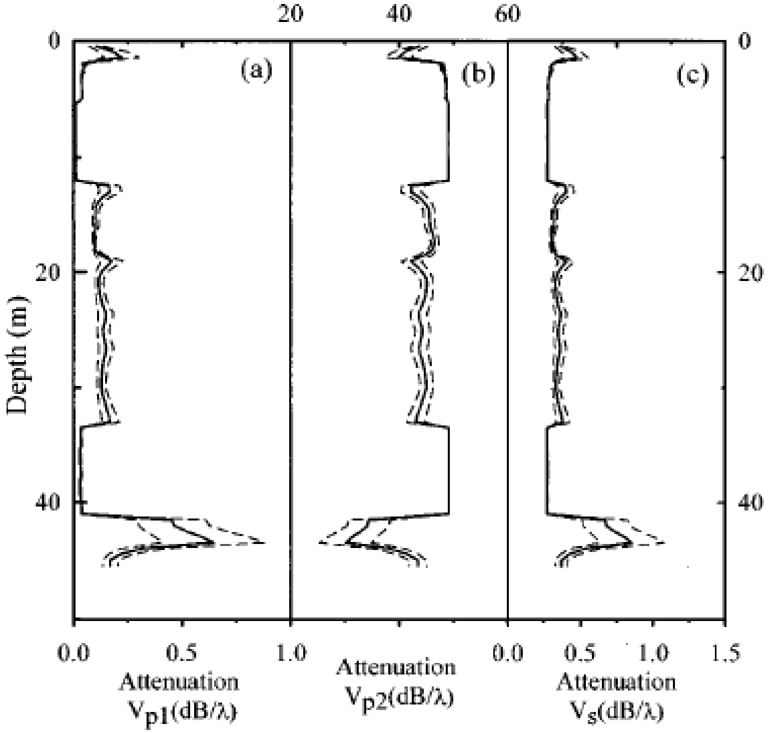


FIG. 7. Predicted attenuation at 300 Hz for first compressional (α_{p1}), second compressional (α_{p2}), and shear (α_s) waves for AGS core 816. Solid lines are mean values and dash lines are ±one standard deviation.

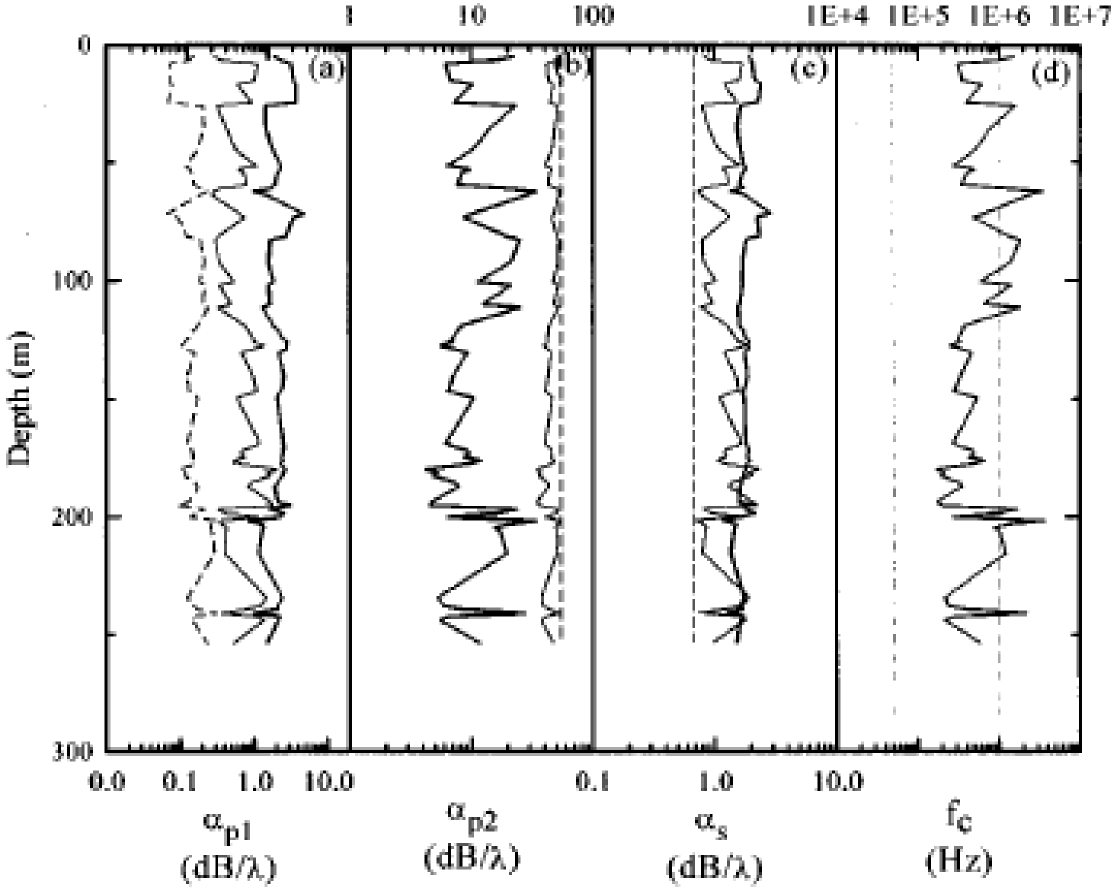


FIG. 12. Effect of frequency on attenuation profiles: (a) α_{p1}, (b) α_{p2}, and (c) α_s for AMCOR 6010. Dash lines are calculated at frequency 50 Hz, thin solid lines are at 10^5 Hz, and thick solid lines are at 5×10^6 Hz. (d) Critical frequency f_c as a function of depth (solid line). The two dashed lines mark $f=10^5$ Hz and 5×10^6 Hz.

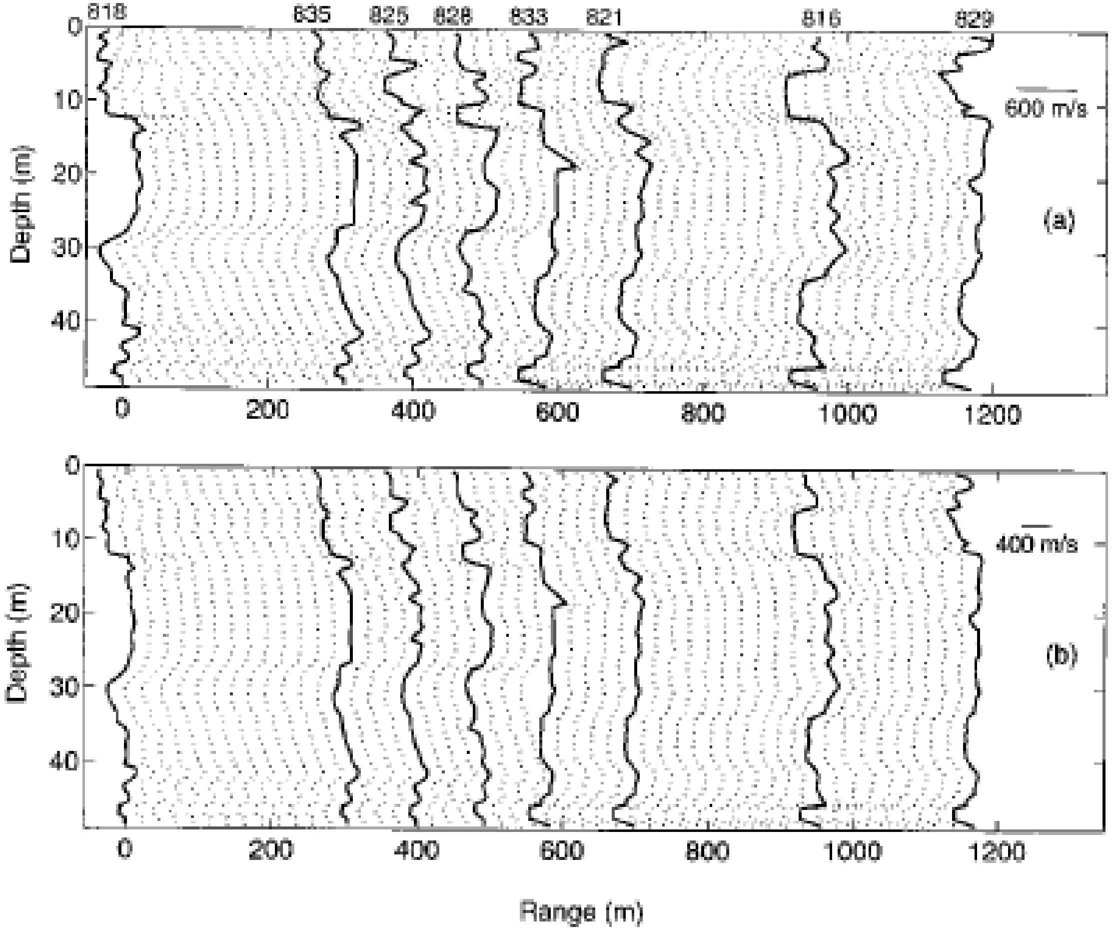


Fig. 3. Dotted curves represent fifty depth profiles obtained from EOF interpolations of: (a) Ccompressional sound speed; (b) Shear sound speed along transect $C - C'$. Solid curves show profiles from nearby cores (core numbers shown at top).

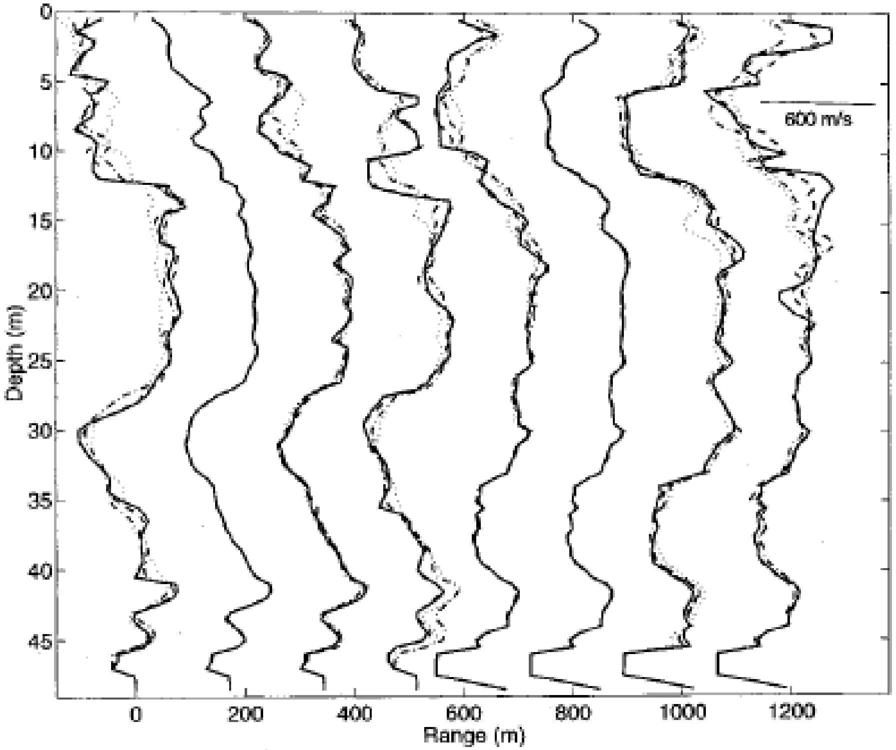


Fig. 4. Compressional sound speed interpolations versus depth at eight locations along transect $C - C'$. Interpolations obtained using 11 (solid curves), 7 (dashed), 3 (dash-dotted) and 1 (dotted) EOFs.

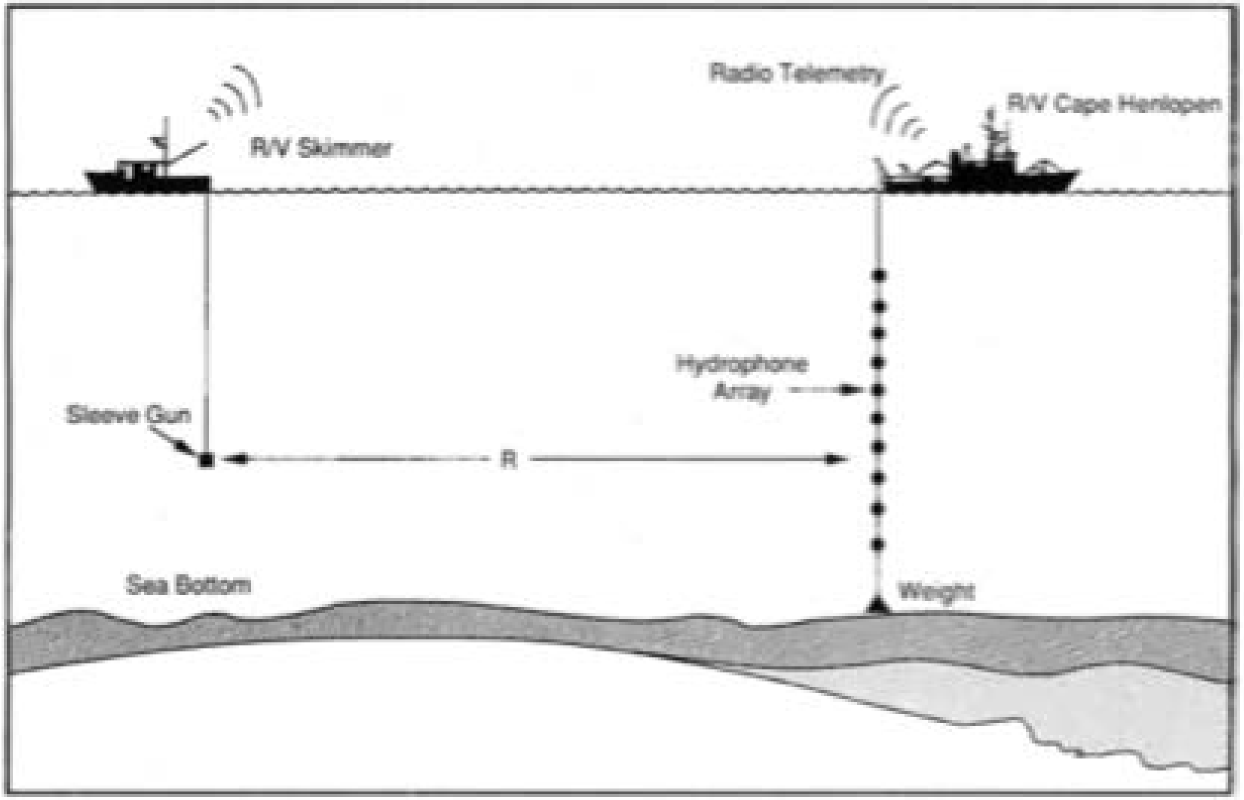
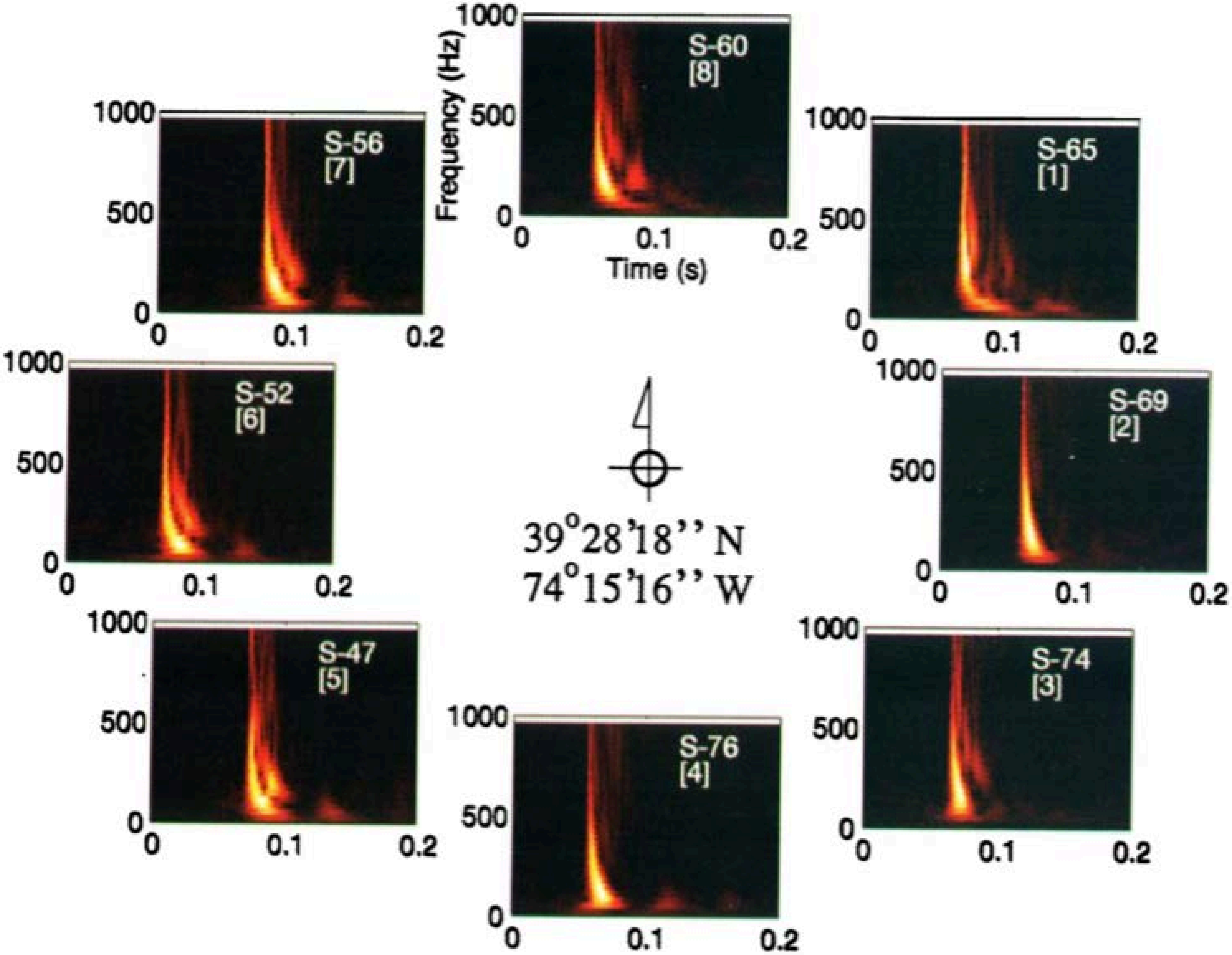


FIG. 6. The geometrical configuration of the shallow-water experiments.


Frequency (Hz)
Time (s)
1000
500
0
0
0.1
0.2
S-60
[8]
S-56
[7]
S-65
[1]
S-52
[6]
S-69
[2]
S-47
[5]
S-76
[4]
S-74
[3]
39°28'18'' N
74°15'16'' W

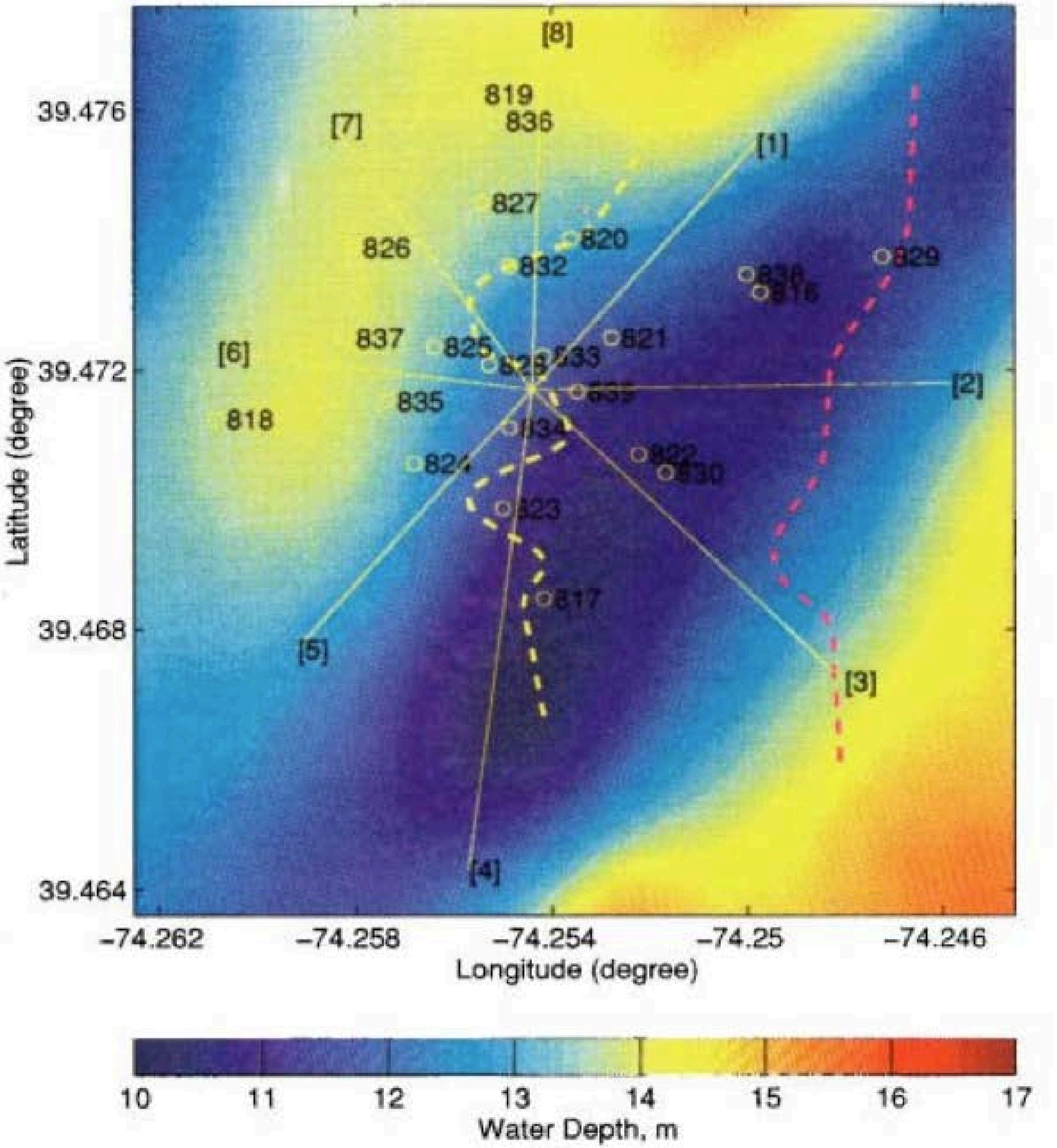


FIG. 1. Measured bottom topography at the Atlantic Generating Station (AGS) site. Core positions along with the eight source–receiver tracks are shown. The receiver is located at the center and subsurface channel boundaries are shown with dashed lines.

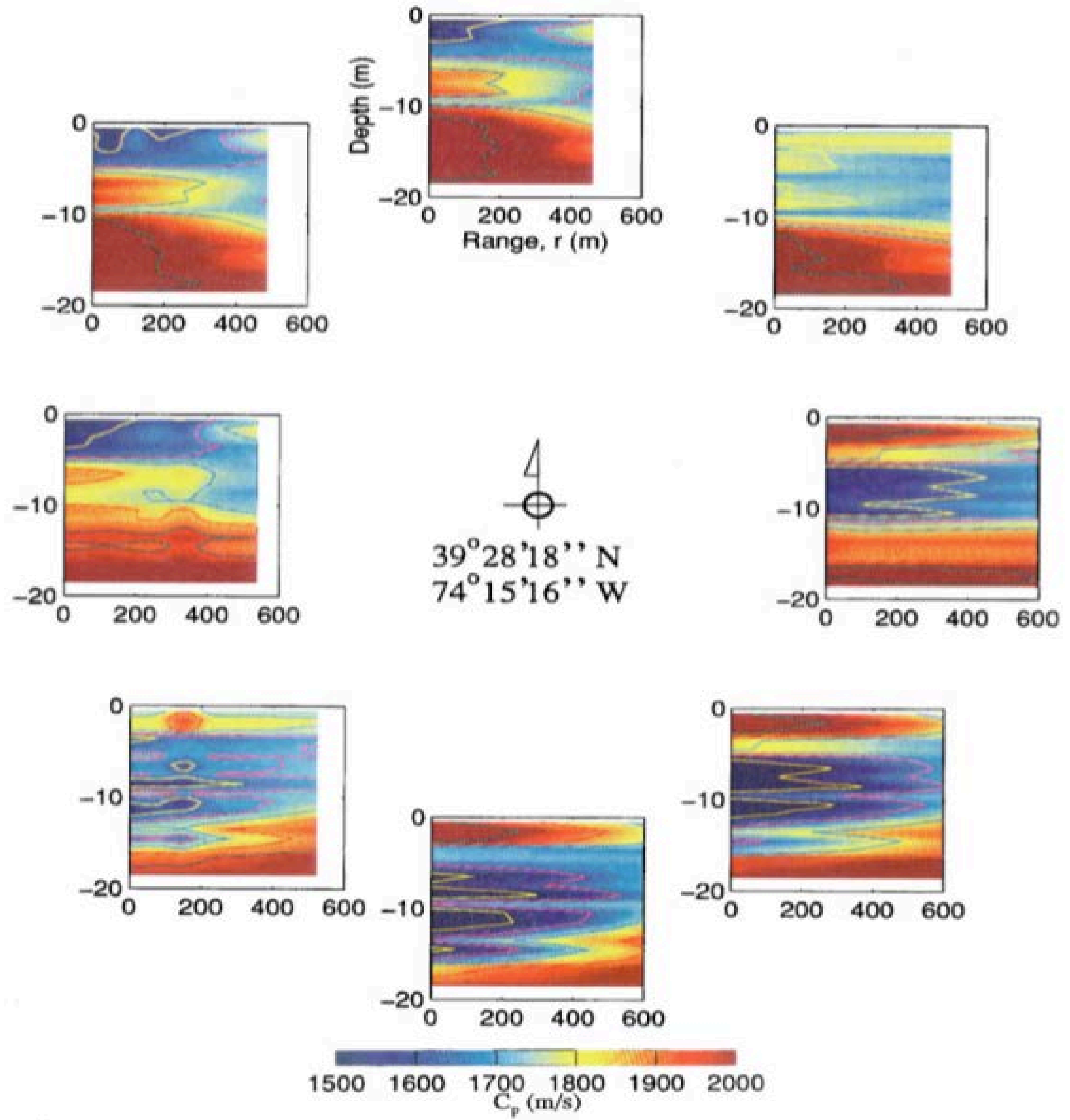


FIG. 2. Compressional wave speed versus sediment depth and range for each of the eight propagation track [1] to [8], arranged in the same positions as Figs. 1 and 3.

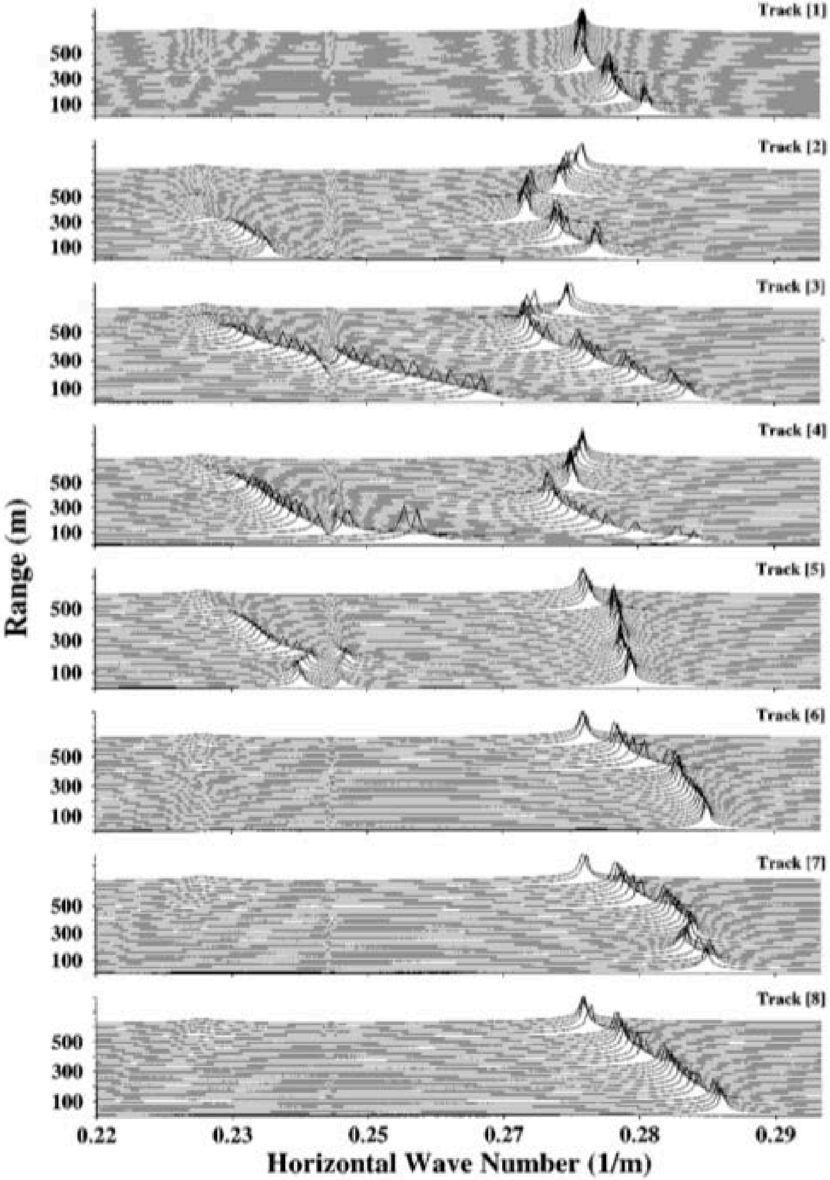


FIG. 16. Range-dependent simulations of horizontal wave number versus range for all eight tracks at 75 Hz.

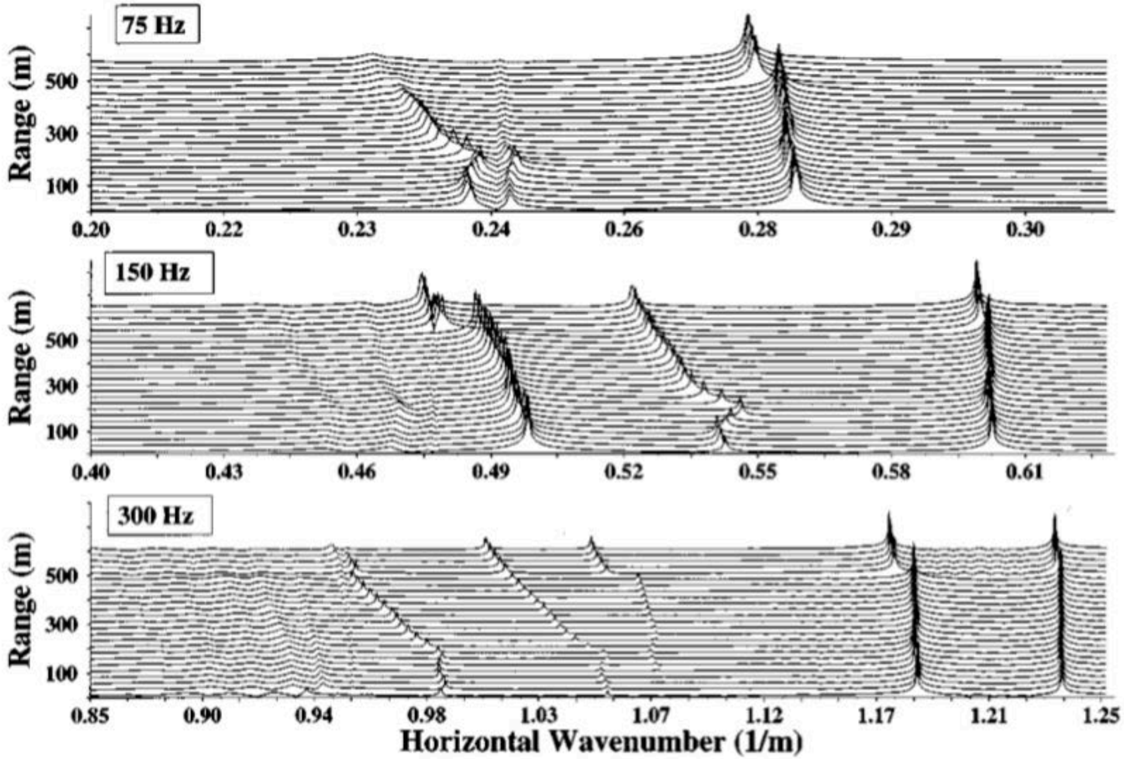
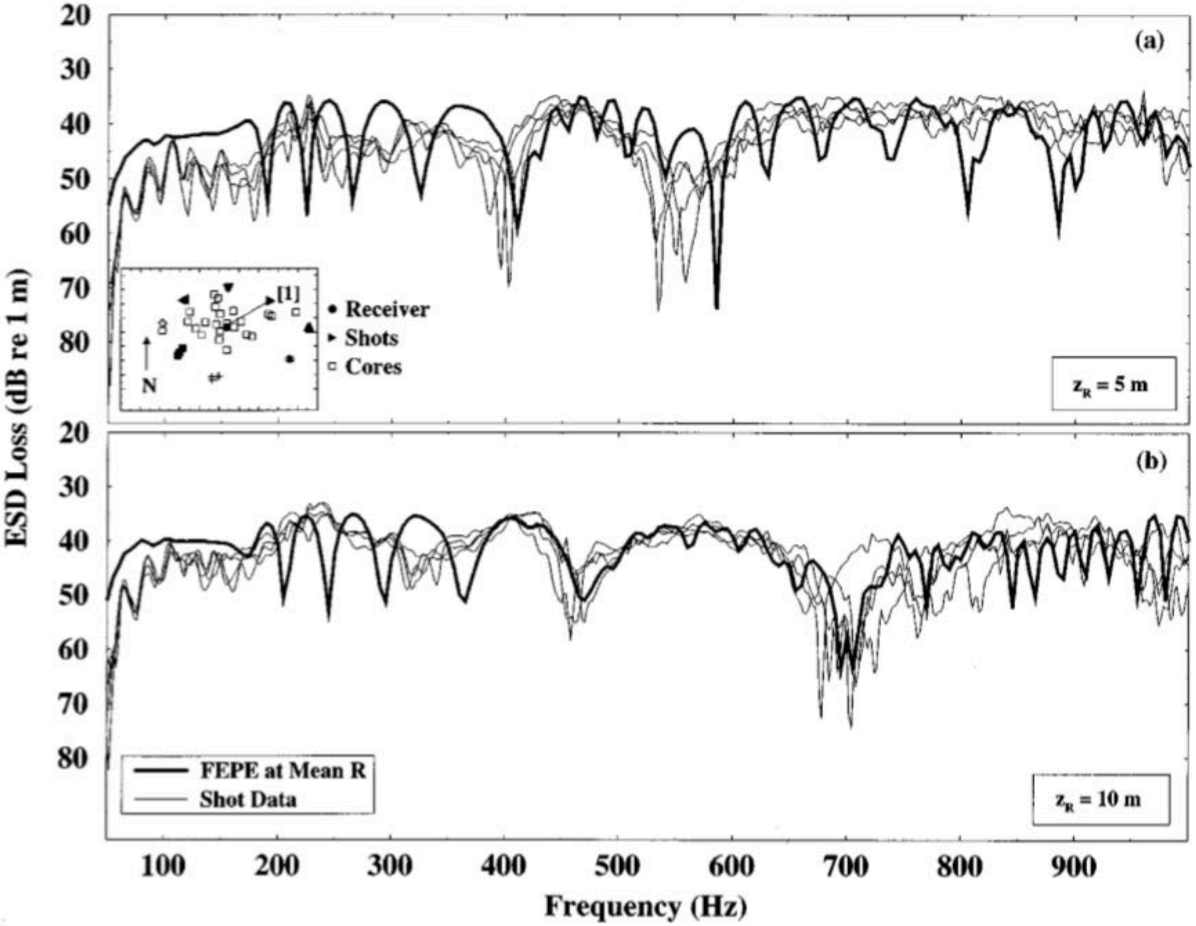
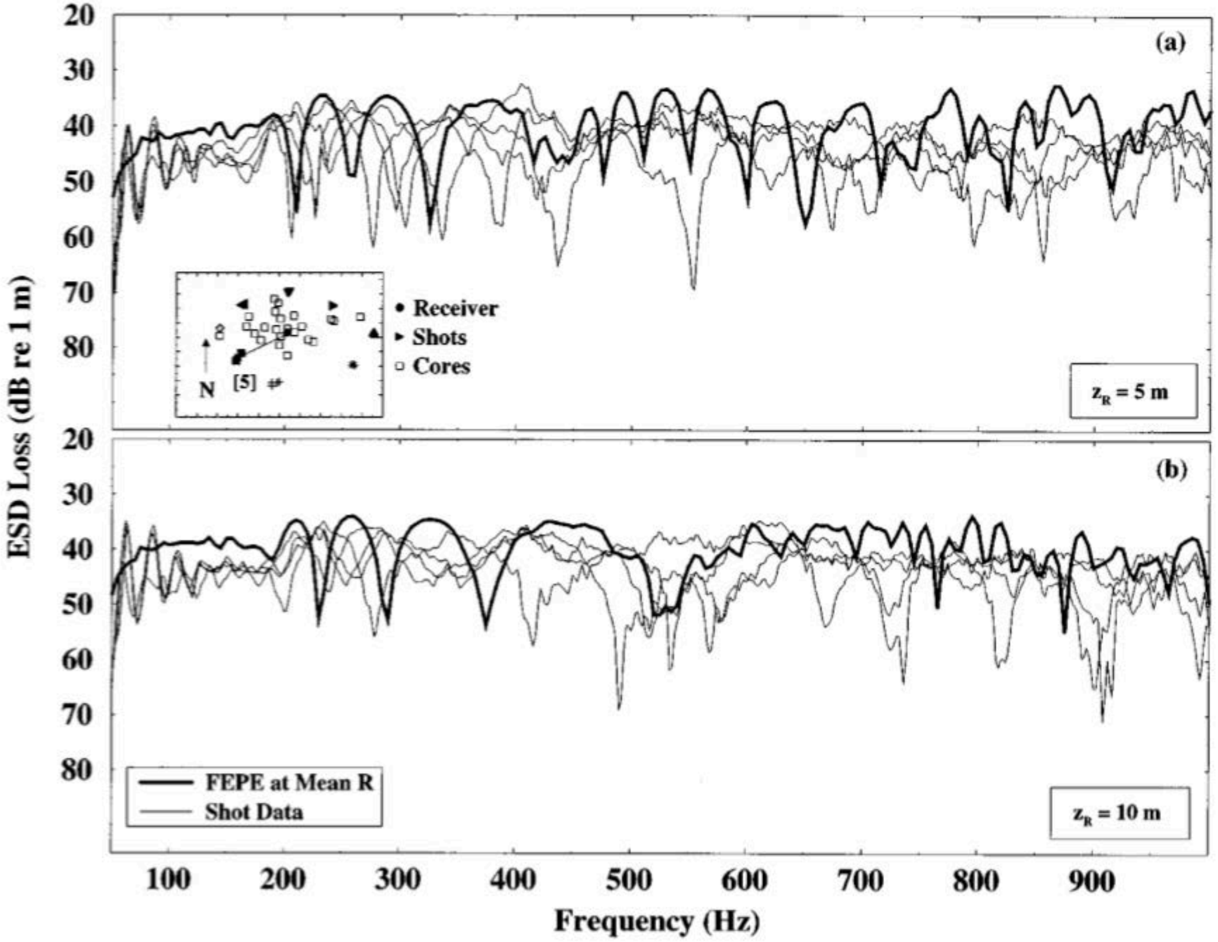


FIG. 7. Horizontal wave number spectra versus range for track 5 at (a) 75 Hz, (b) 150 Hz, and (c) 300 Hz.


(a)
(b)
ESD Loss (dB re 1 m)
20
30
40
50
60
70
80
Frequency (Hz)
100
200
300
400
500
600
700
800
900
[1]
N
● Receiver
▸ Shots
□ Cores
$z_R = 5$ m
$z_R = 10$ m
FEPE at Mean R
Shot Data


(a)
(b)
ESD Loss (dB re 1 m)
20
30
40
50
60
70
80
Frequency (Hz)
100
200
300
400
500
600
700
800
900
● Receiver
► Shots
□ Cores
N
[5]
$z_R = 5$ m
$z_R = 10$ m
FEPE at Mean R
Shot Data

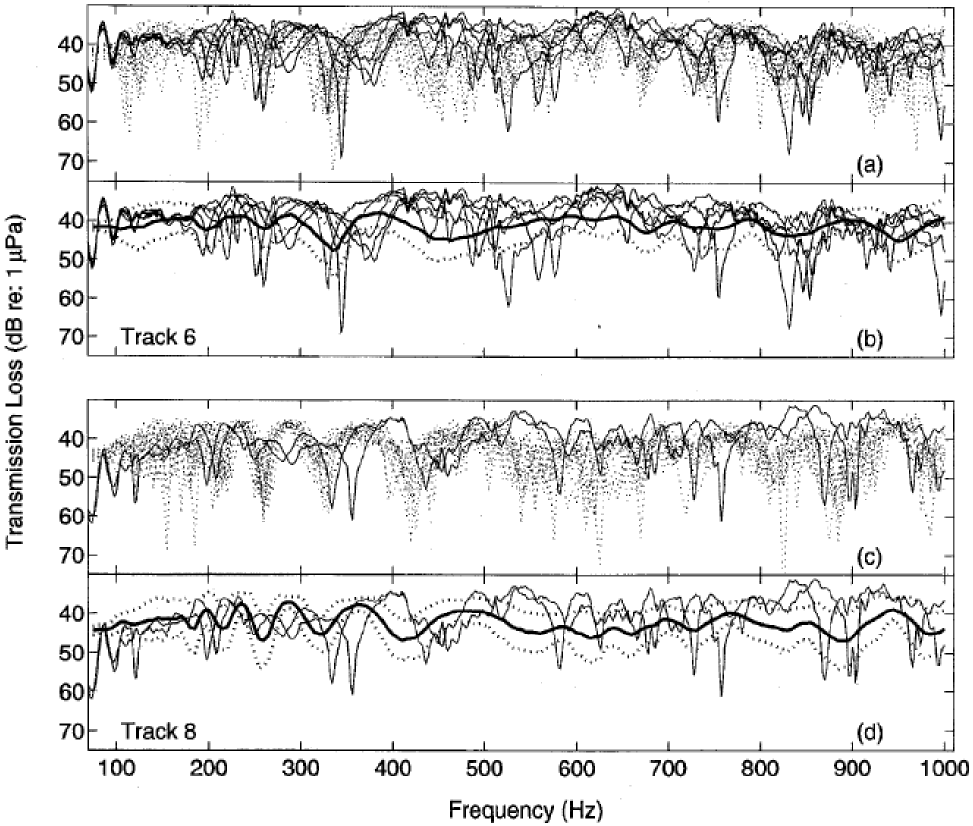


Fig. 11. TL versus frequency using a fluid-bottom PE model along Track 6 [(a) and (b)] and Track 8 [(c) and (d)]. Thin solid curves in all plots represent processed experimental shot data. Bold solid curves in (b) and (d) represent means of realizations depicted as dotted curves in (a) and (c), respectively, at locations within 15 m from receiver location. Bold dotted curves in (b) and (d) represent first standard deviations from means.

Uncertainty related to the process of converting geology to geoacoustic parameters

- The sources of uncertainty in the process
  - Collection of Core data
  - Converting geological data to sound speed and attenuation profile
  - Coherence length of the sea floor properties, what is the Min/Max distance between two known cores
  - Method of interpolation can also cause variability
  - What kind of confidence levels can we place on values
  - Above will influence the interpolation between the cores/layers
  - All above will dramatically influence the prediction of the acoustic field