



GEOLOGICAL SURVEY OF CANADA

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BOREHOLE SHEAR-WAVE VELOCITY MEASUREMENTS, FRASER DELTA, BRITISH COLUMBIA

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**BOREHOLE SHEAR-WAVE VELOCITY
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GSC OPEN FILE #

BOREHOLE SHEARWAVE VELOCITY MEASUREMENTS, FRASER DELTA, 1989

by J.A. Hunter, R.A. Burns and R.L. Good

Uphole shear-wave velocity measurements were made in six boreholes in the southern Fraser River delta in October 1989. The holes were drilled for geological studies by J. Luternauer and J. Clague of GSC and M. Roberts of Simon Fraser University in 1987, 1988 and 1989. Upon completion of drilling, after the rods were pulled, 5 cm schedule 40 PVC casing was installed as deep as possible. Although no grouting was done, it was hoped that slumping with time would produce adequate coupling of the formation to the casing.

An Oyo 3-component well-lock seismometer was used as the detector at down-hole spacings of 0.5 or 1.0 m; recording was done with a Scintrex Echo-2 seismograph. The seismic source was a 30 kgm horizontal plate struck with a 7 kgm hammer. The plate consisted of 7.5 cm angle-iron welded to steel grating. Horizontal polarization was obtained by striking one face of the angle-iron at an angle of 45° to horizontal. The source was placed 3 m from the hole for all measurements in an attempt to reduce tube-wave coupling interference.

Two horizontal and one vertical component of motion were recorded for each well-locked position in each hole. Since the orientation of the geophone could not be easily controlled, polarity reversals were apparent on the records and corrections in processing were made. Composite seismograms were made from a selection of one of the horizontal components of motion. Digital filtering in the pass band 20-50 hz was done on record suites. First arrival times of shear motion were picked for all records; where noise interference obscured the first onset, first peaks were picked and migrated forward in time by one quarter cycle.

A running least-squares interval velocity analysis was computed for 3-point to 9-point fits; shot offset corrections were made assuming straight raypaths between source and detector. Probable errors of the velocities were computed for each least-squares fit and are shown as error bars on the plots. The results

for the six boreholes are shown in figs. 1 to 6. The travel-time depth data is given in Tables I to VI. Table VII gives the UTM coordinate locations of the holes.

It should be noted that the velocities given have not been corrected for non-linear refractive ray-bending (a near-surface effect) or for effective overburden stress. These corrections may result in overall lower velocities than indicated.

The data given here are some preliminary results of an on-going GSC project directed towards the testing and evaluation of techniques for the measurement of shear-wave velocity structure in the Fraser delta. Such information can be utilized for geotechnical estimates of liquefaction potential and ground motion amplification resulting from earthquake shaking.

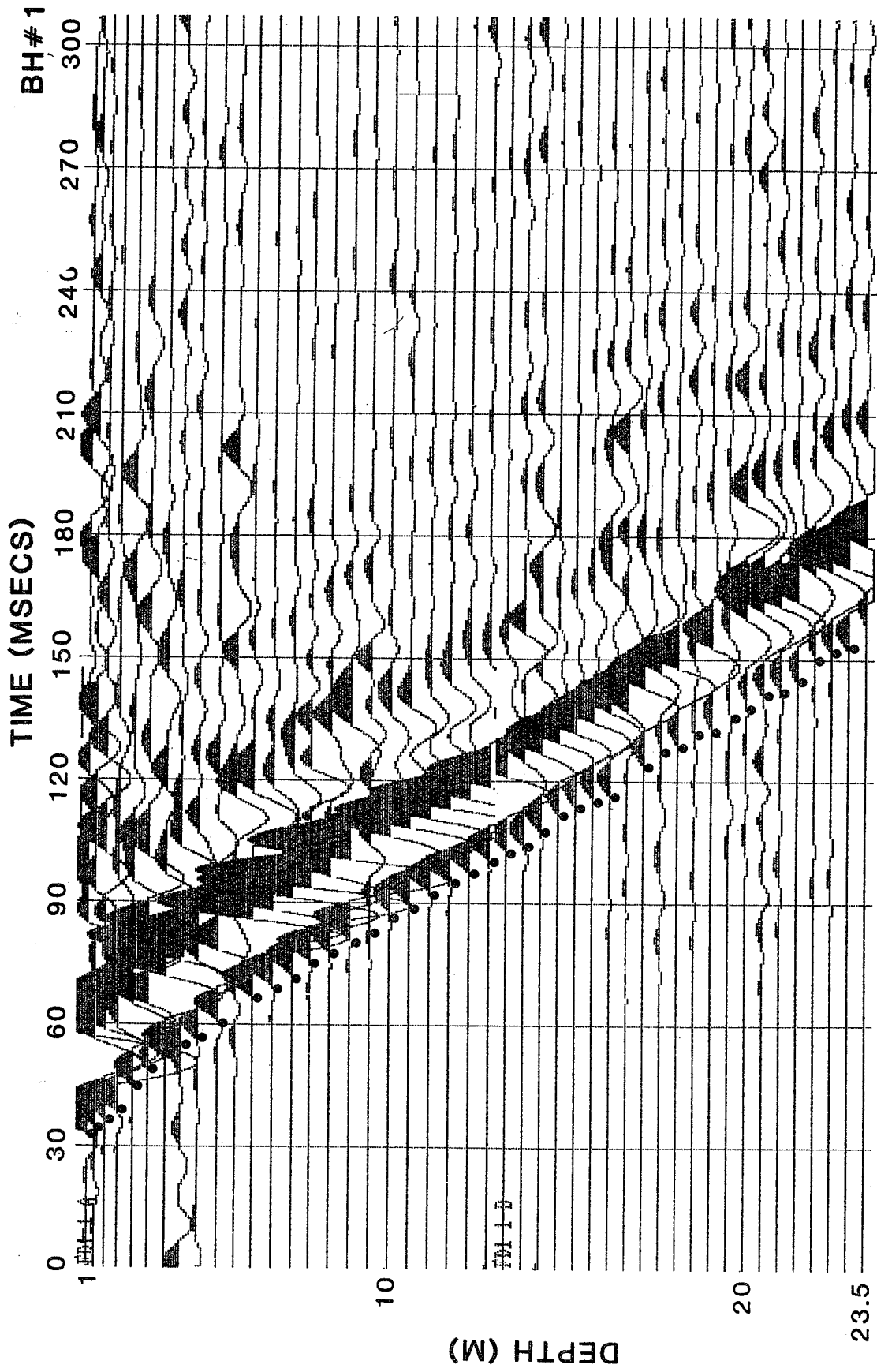
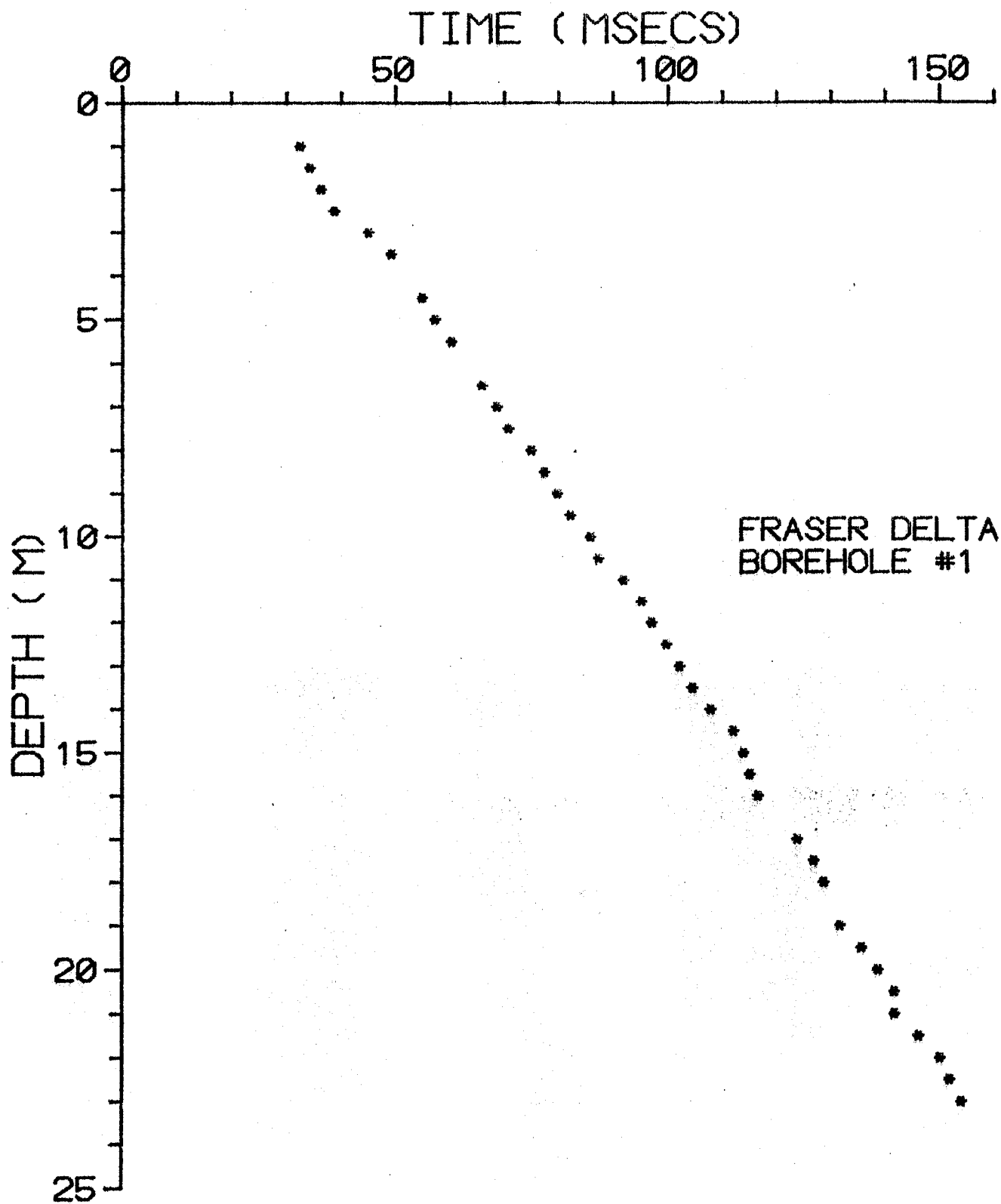


FIG 1(a)



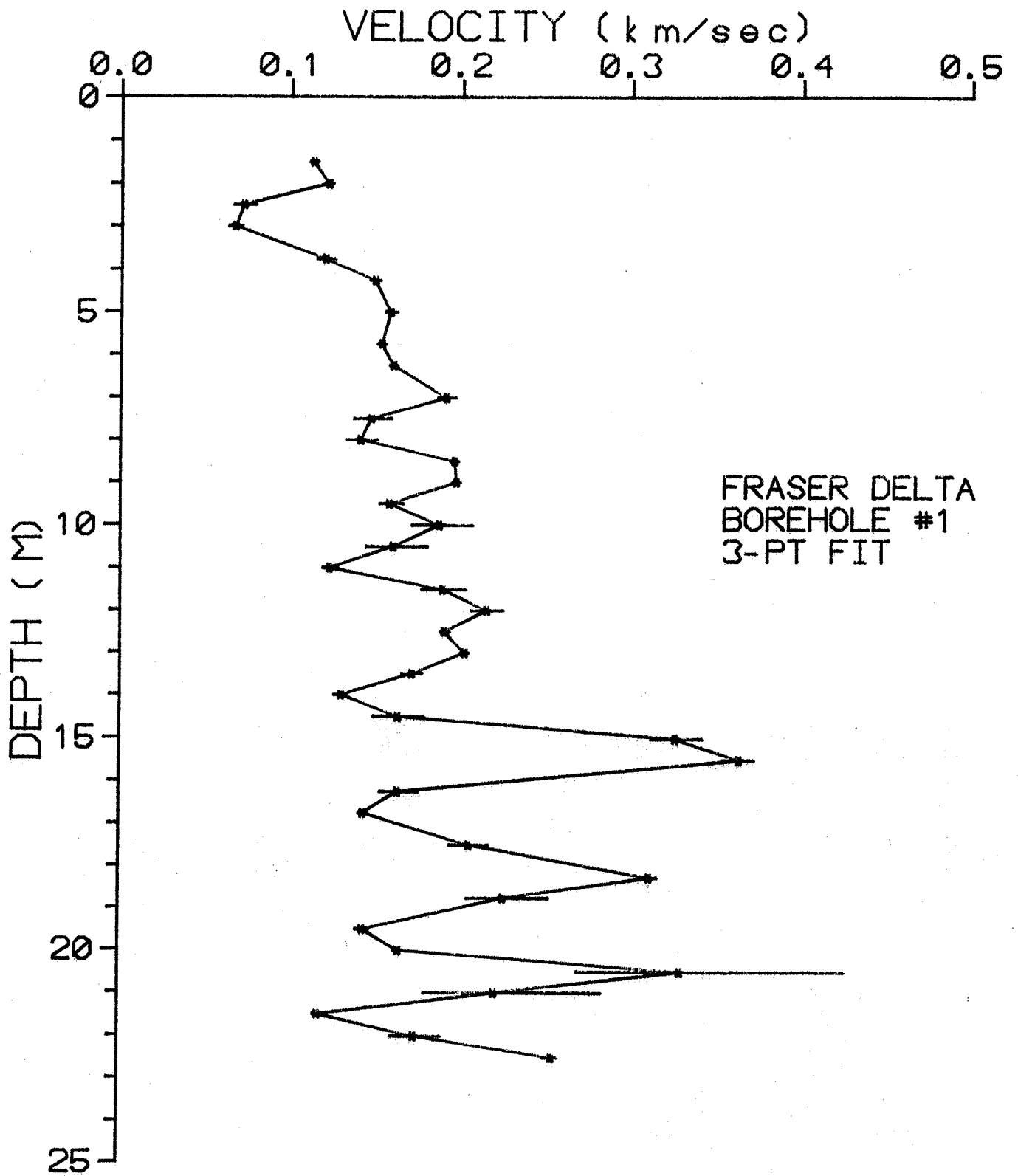
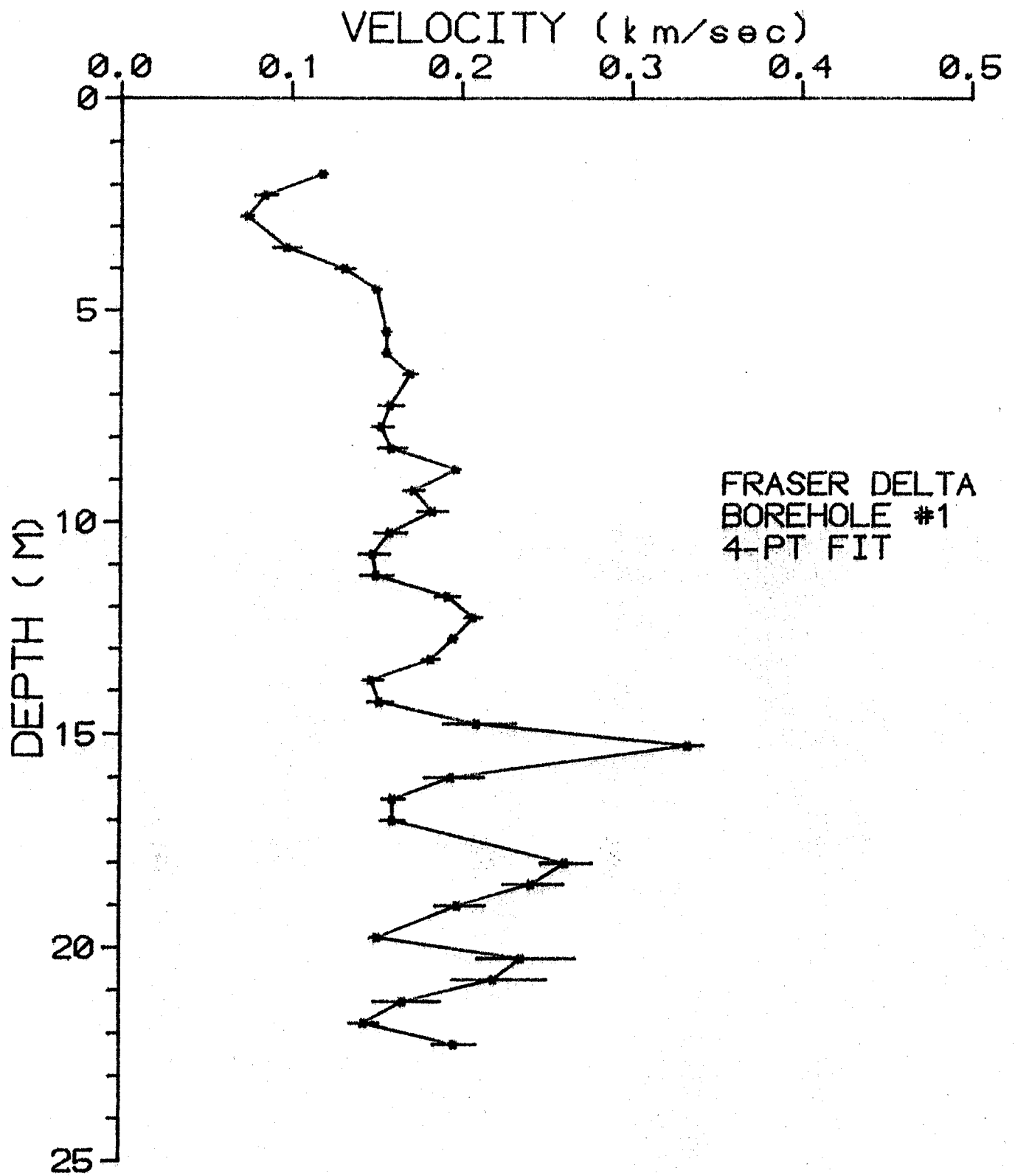
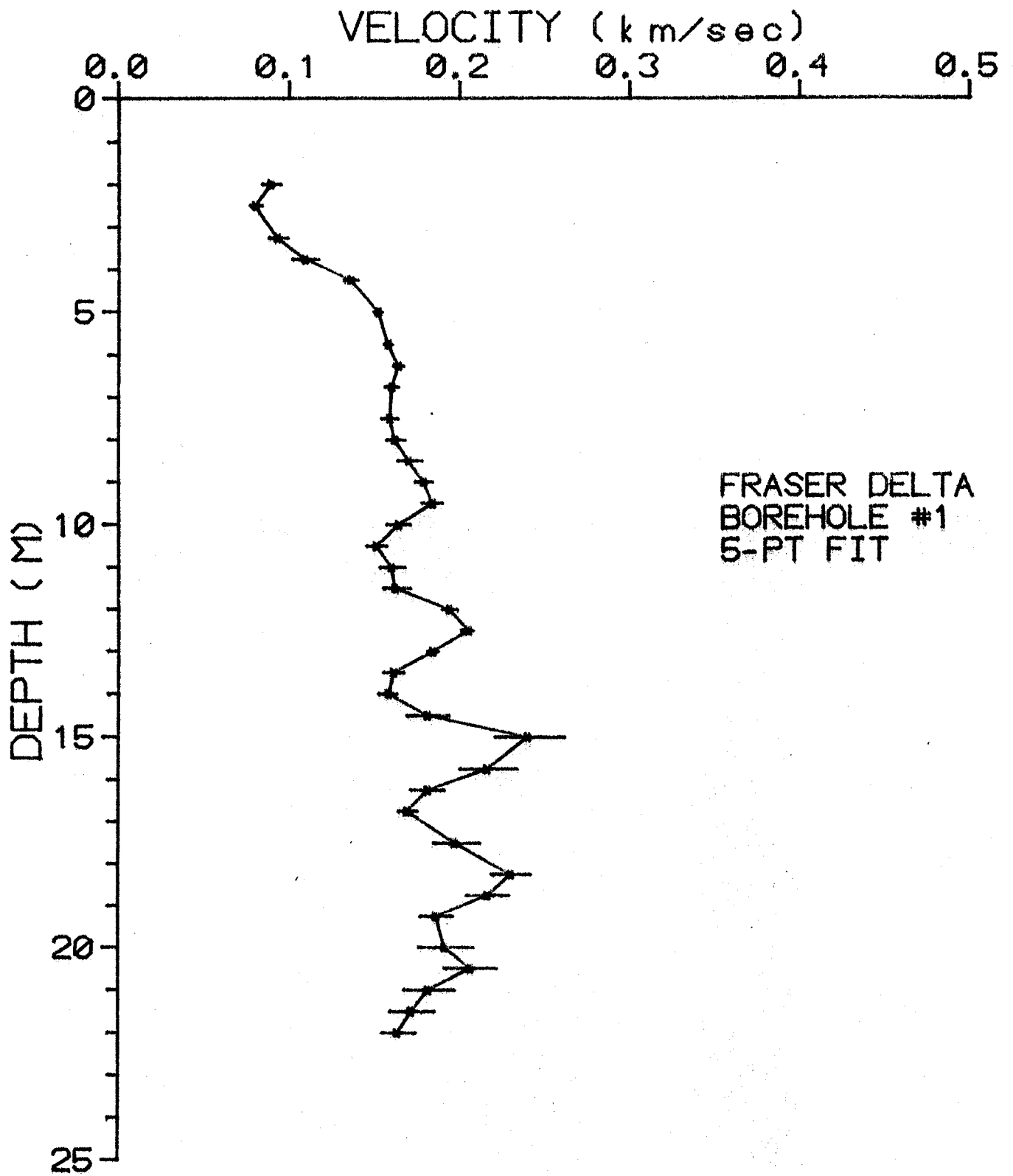
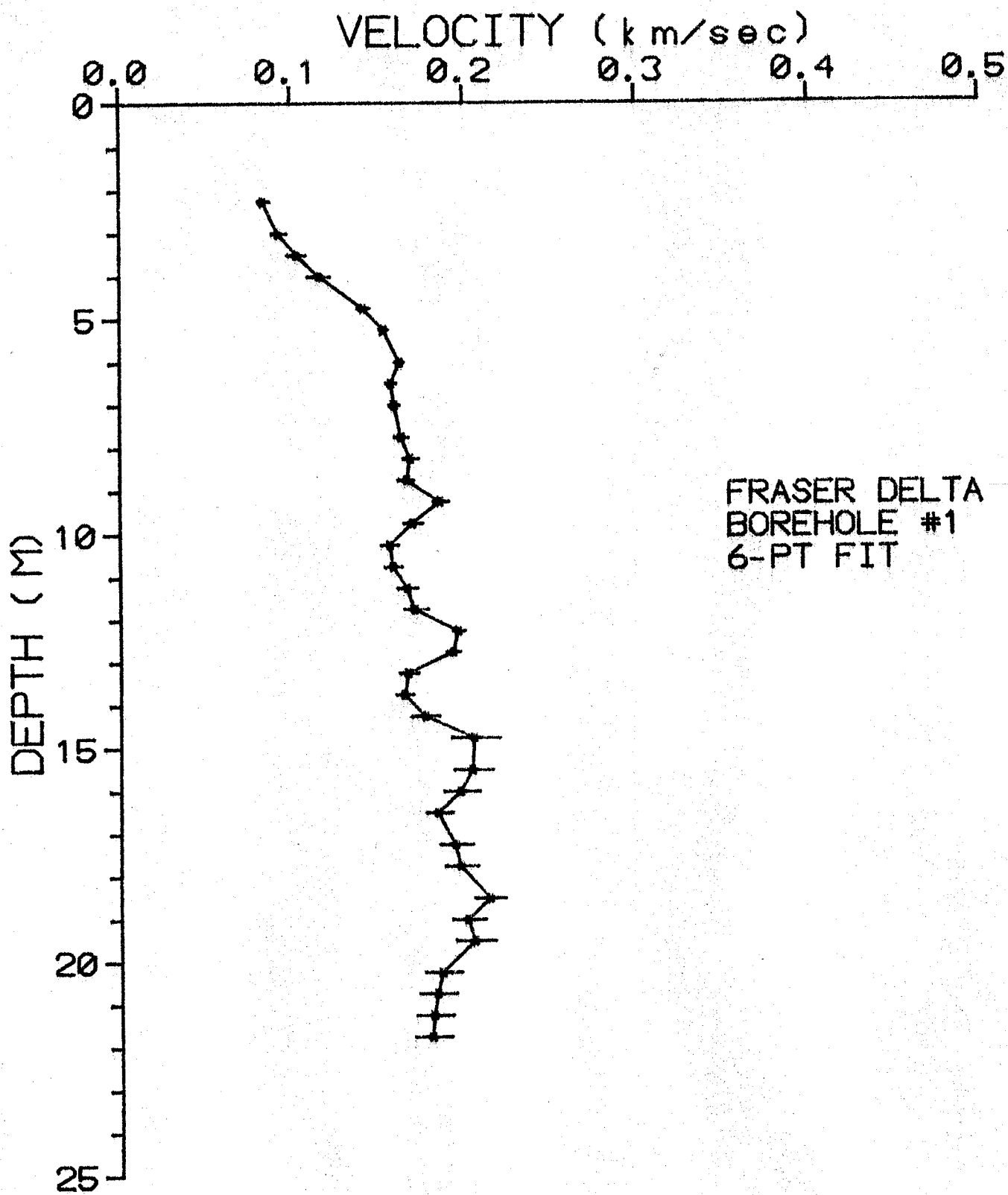
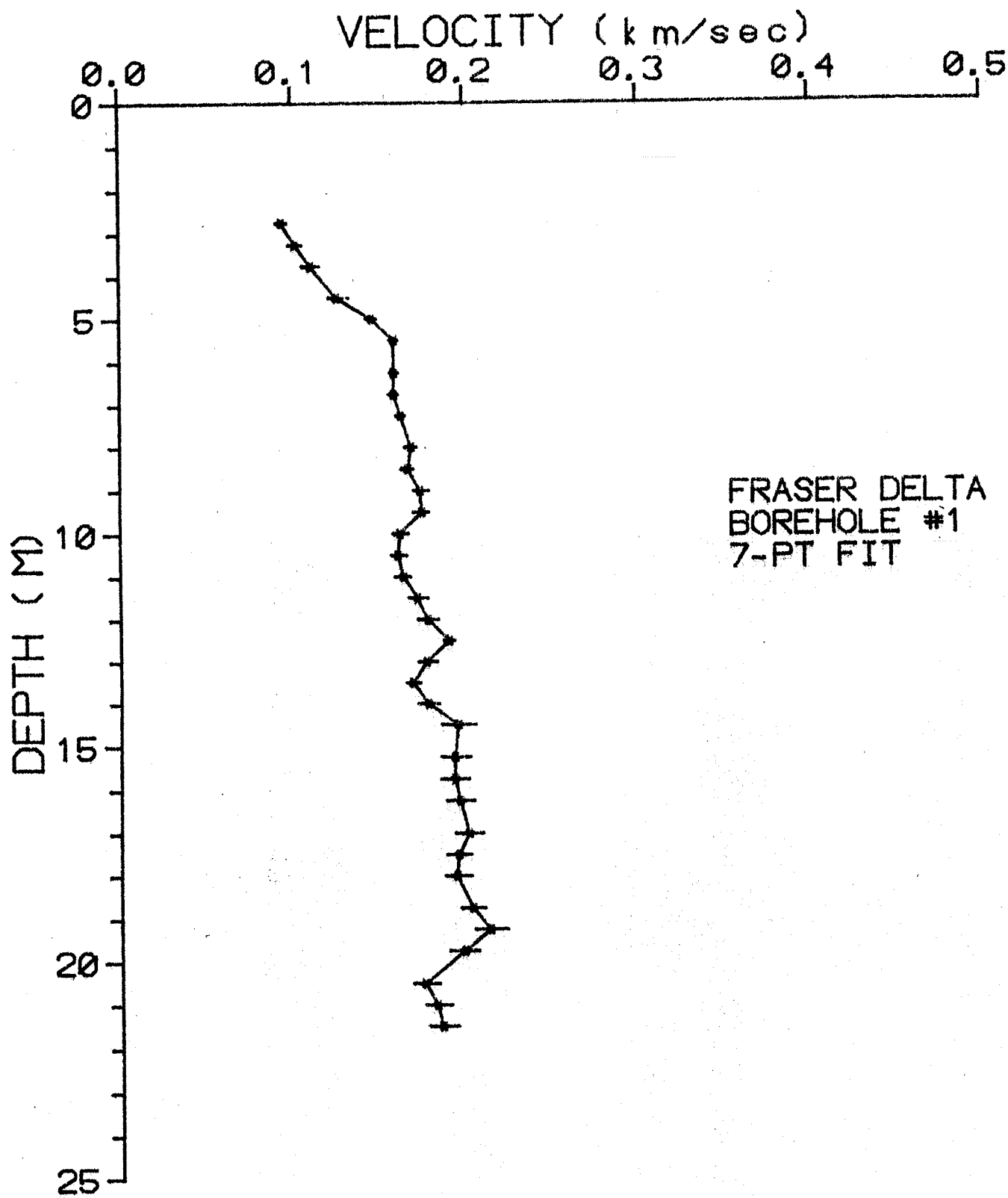


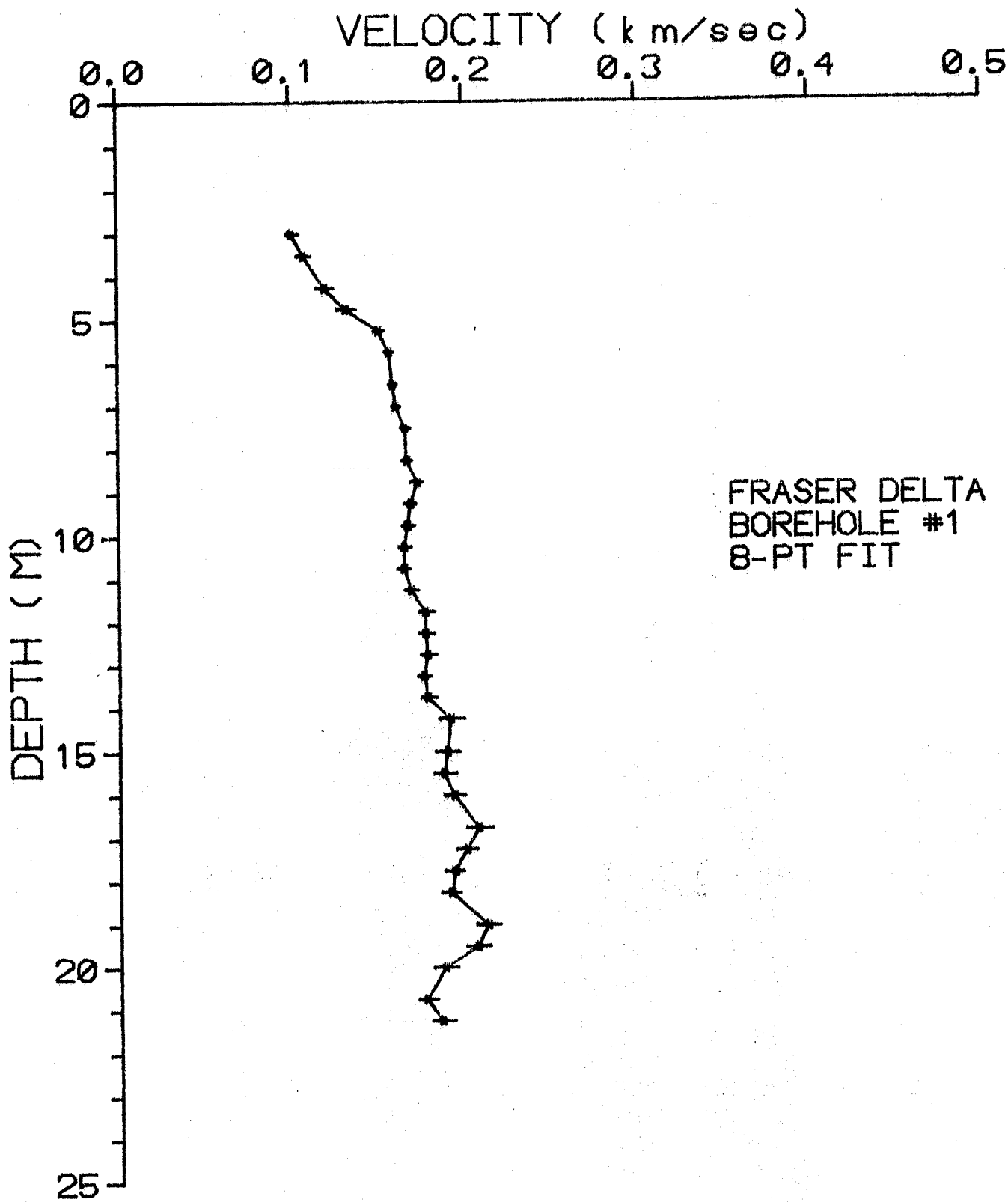
Fig. 1(c)











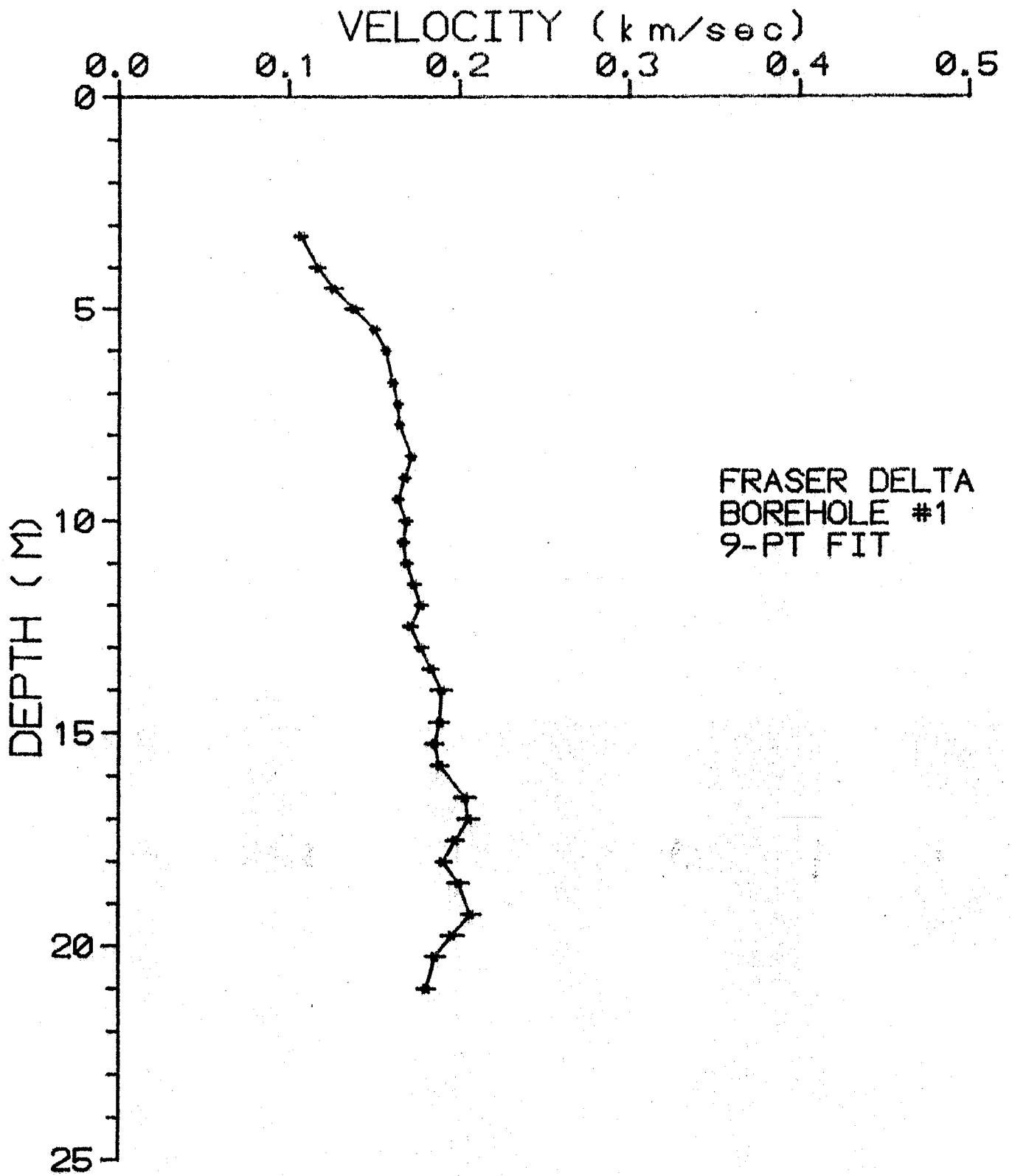


Fig. 1(i)

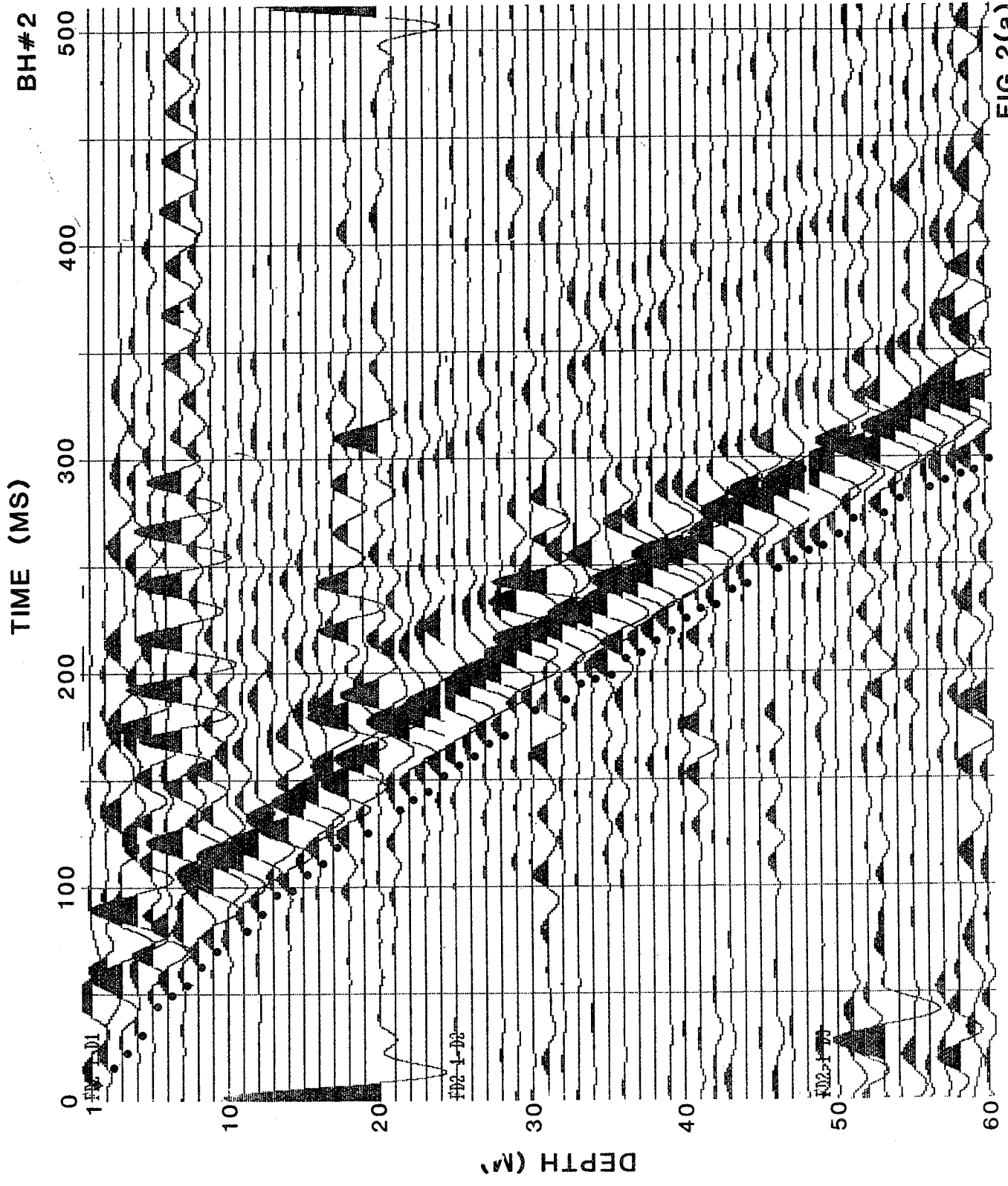
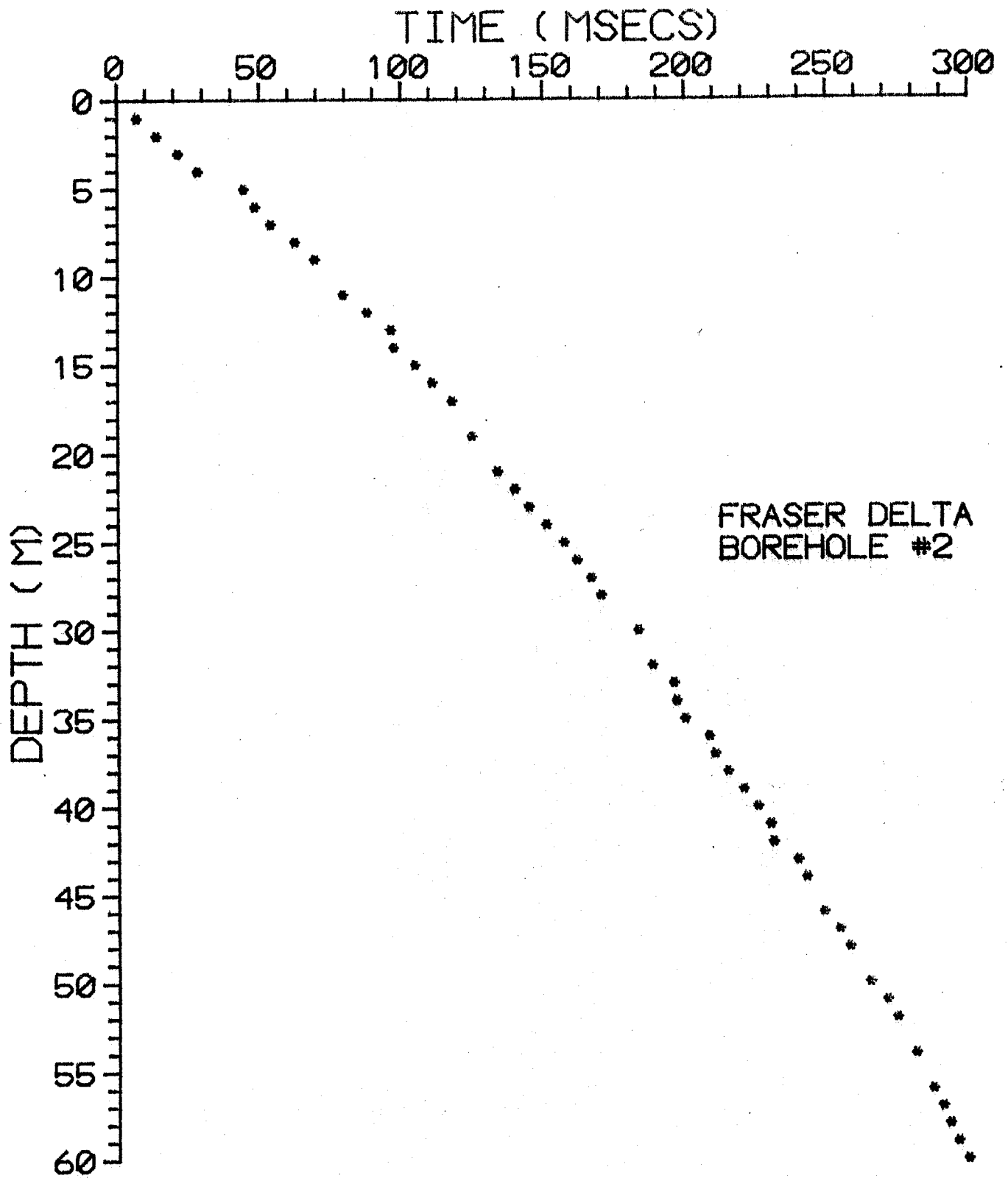
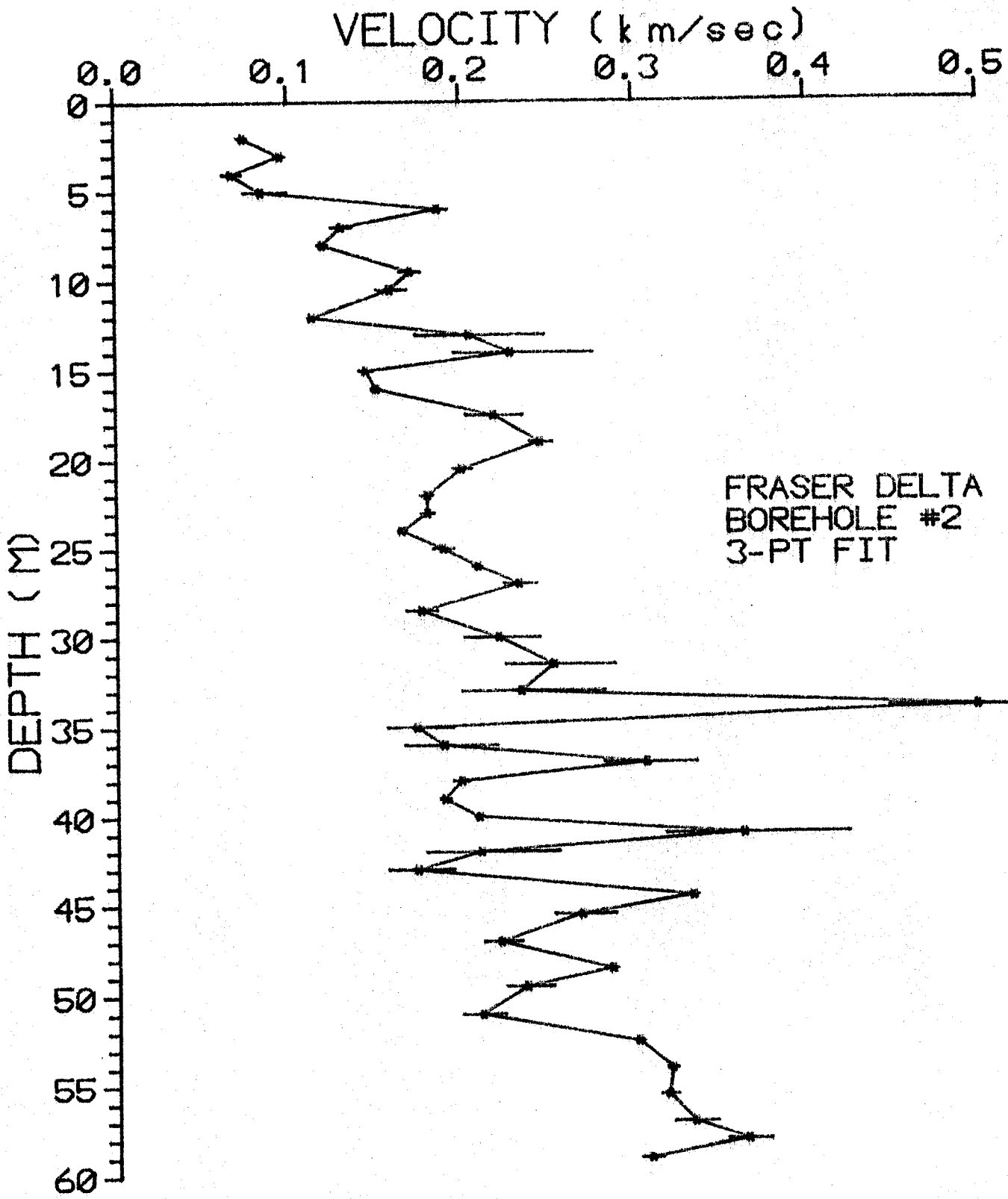
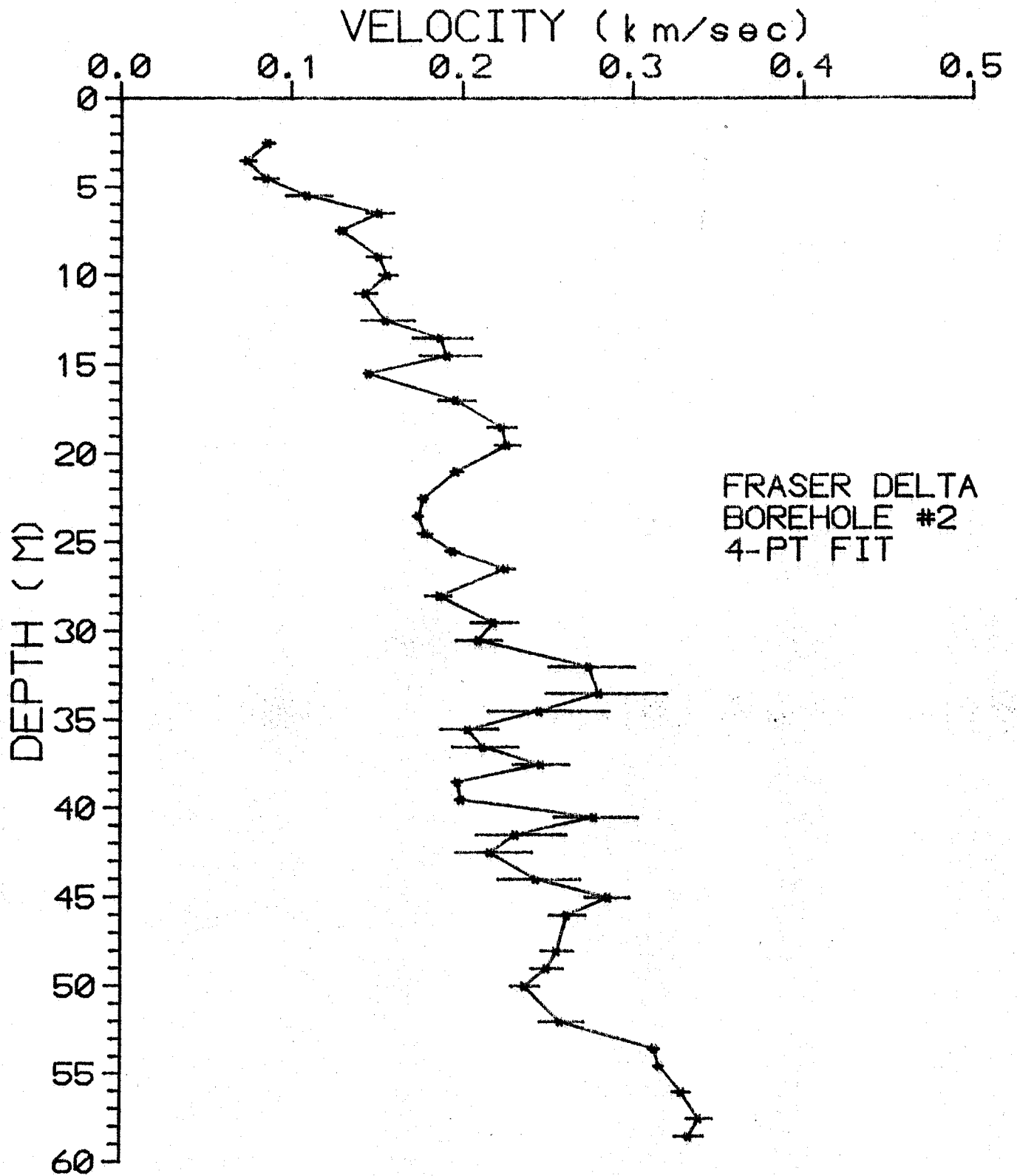
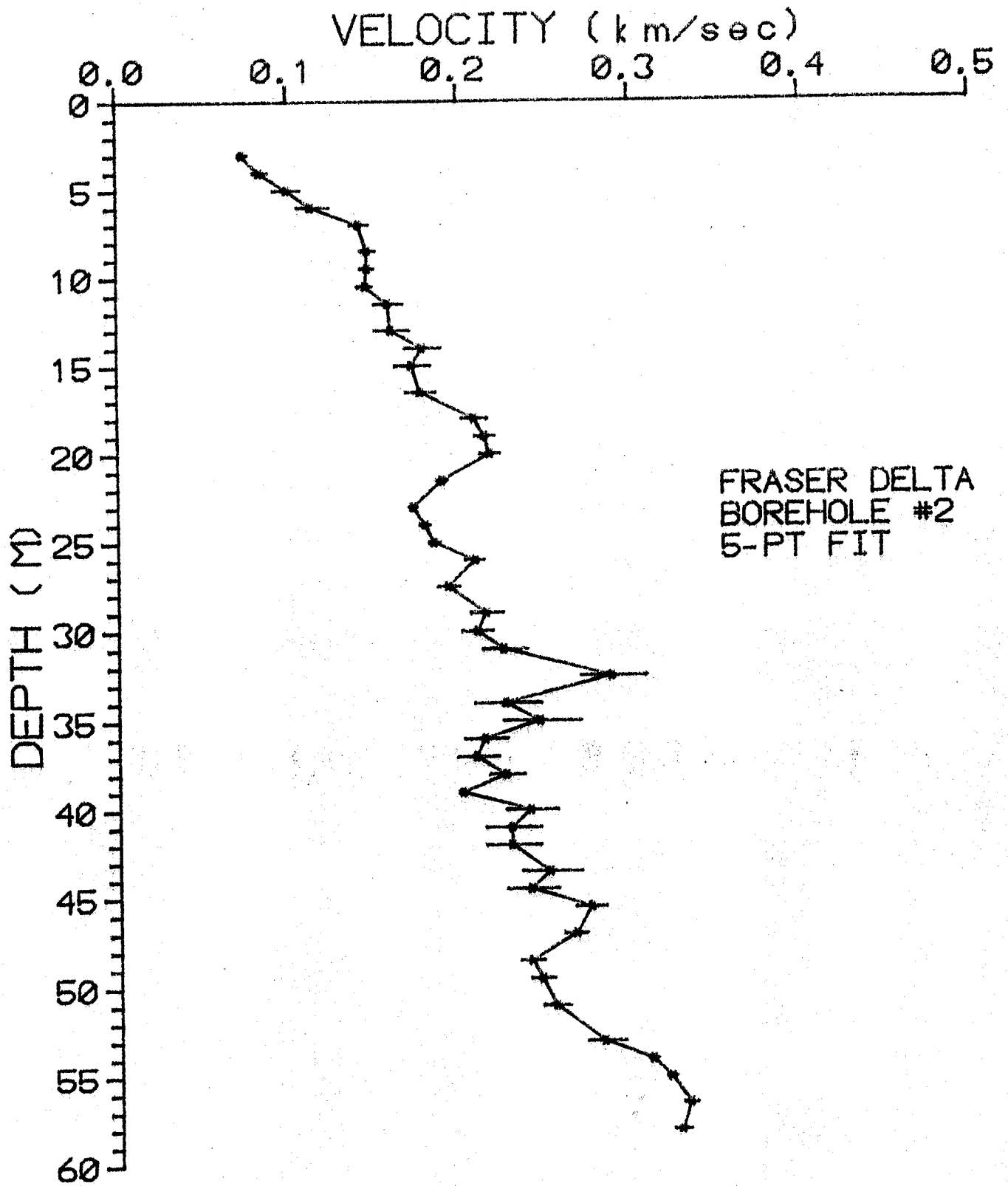


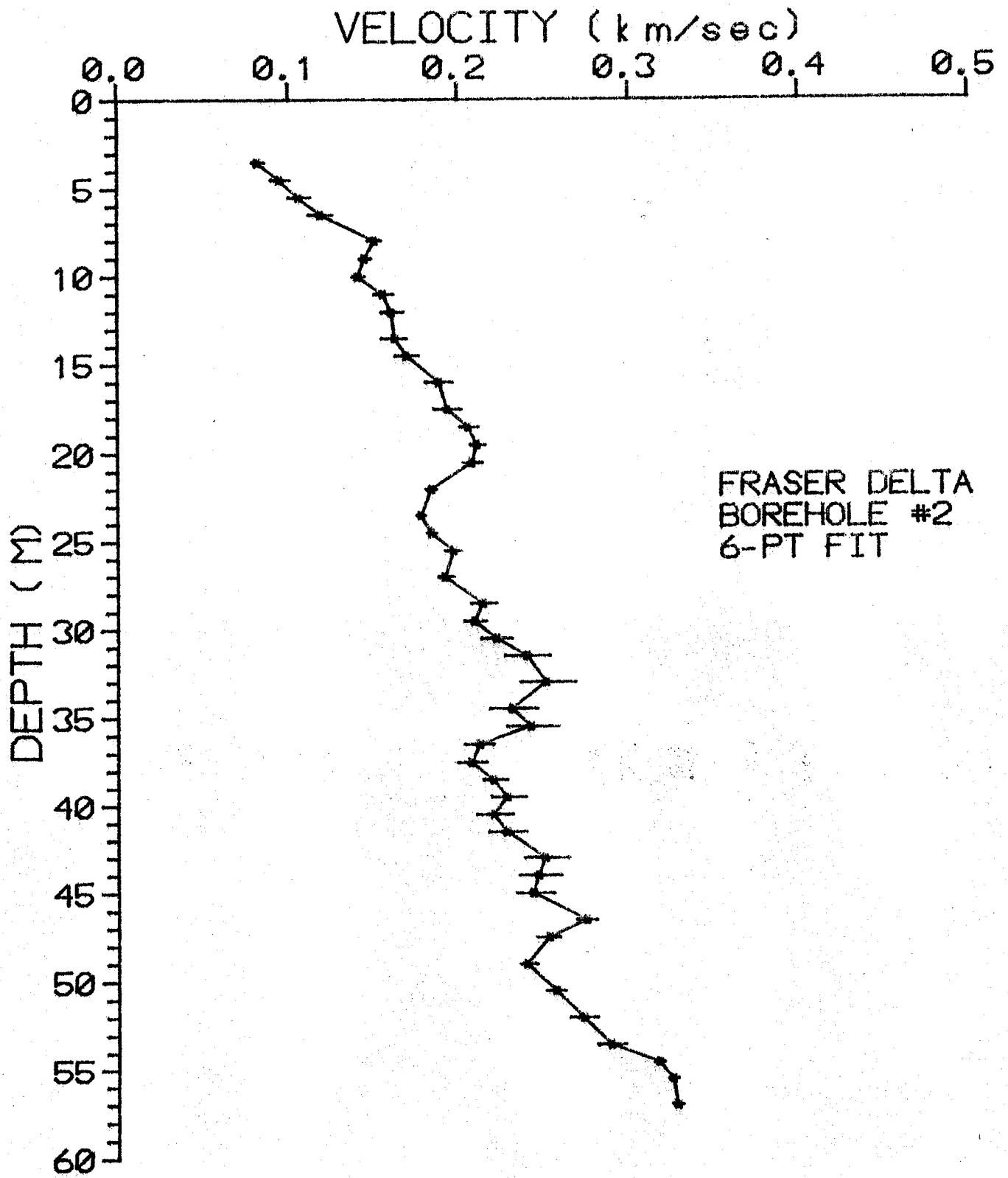
FIG 2(a)

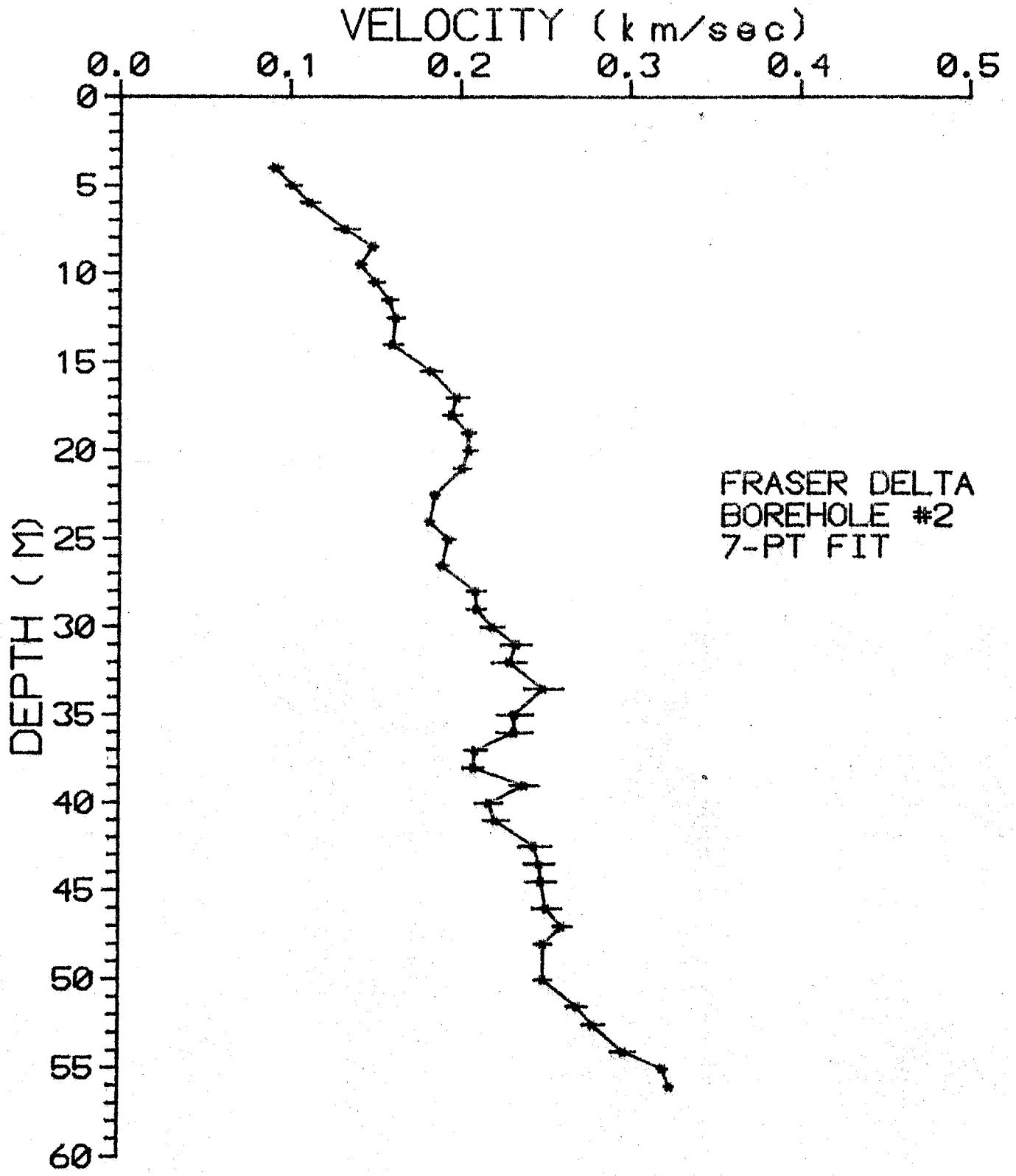


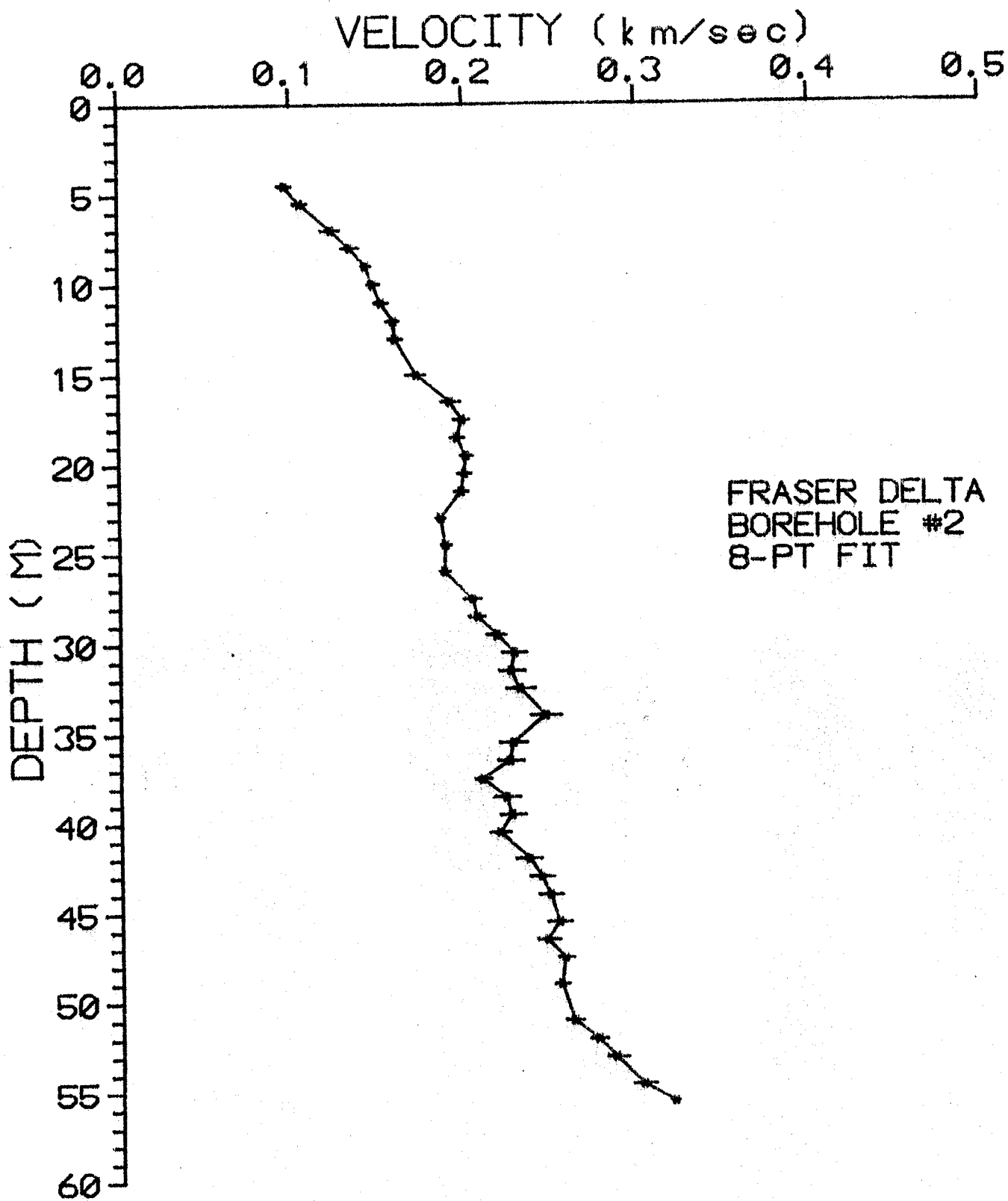


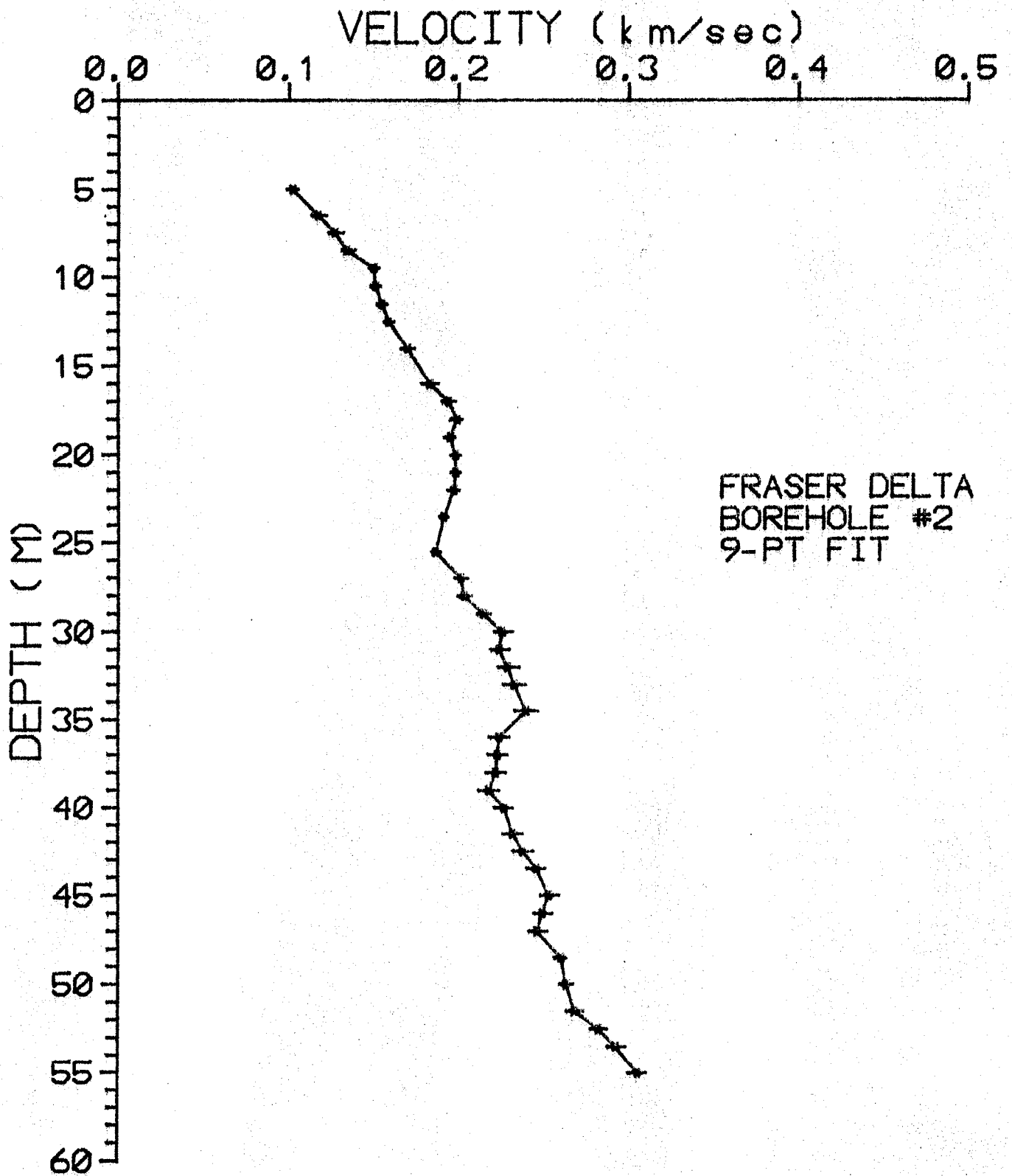


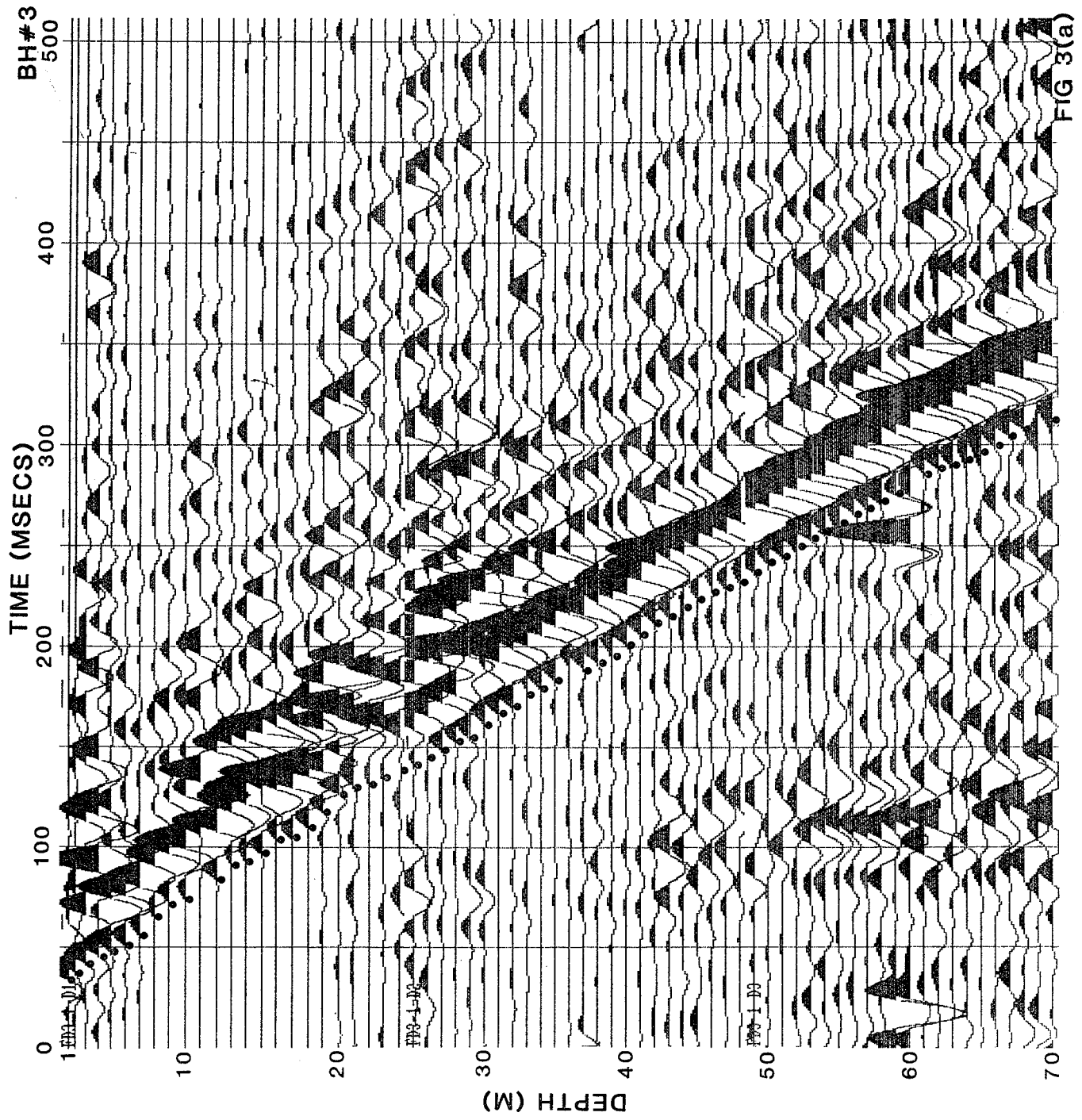


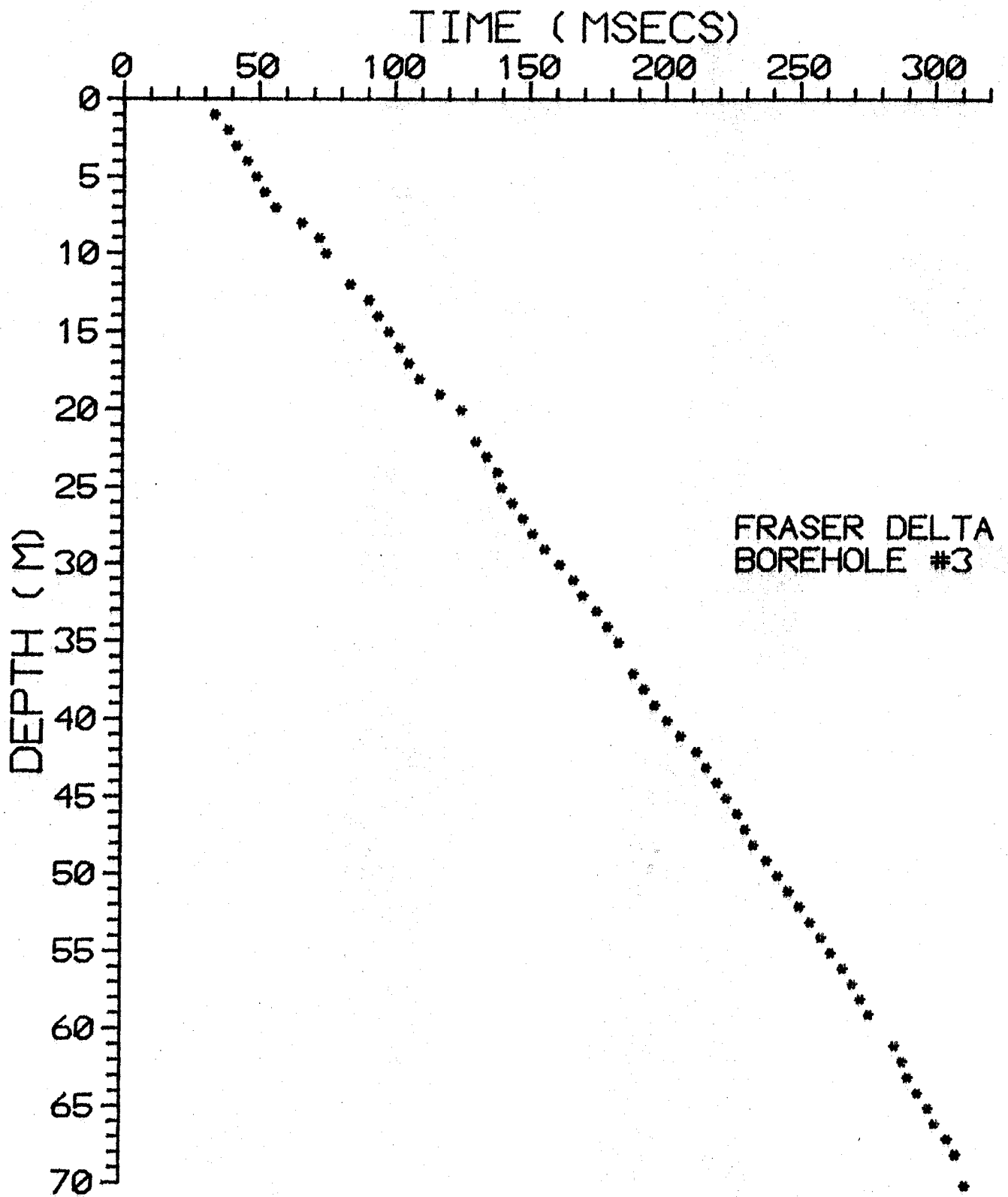


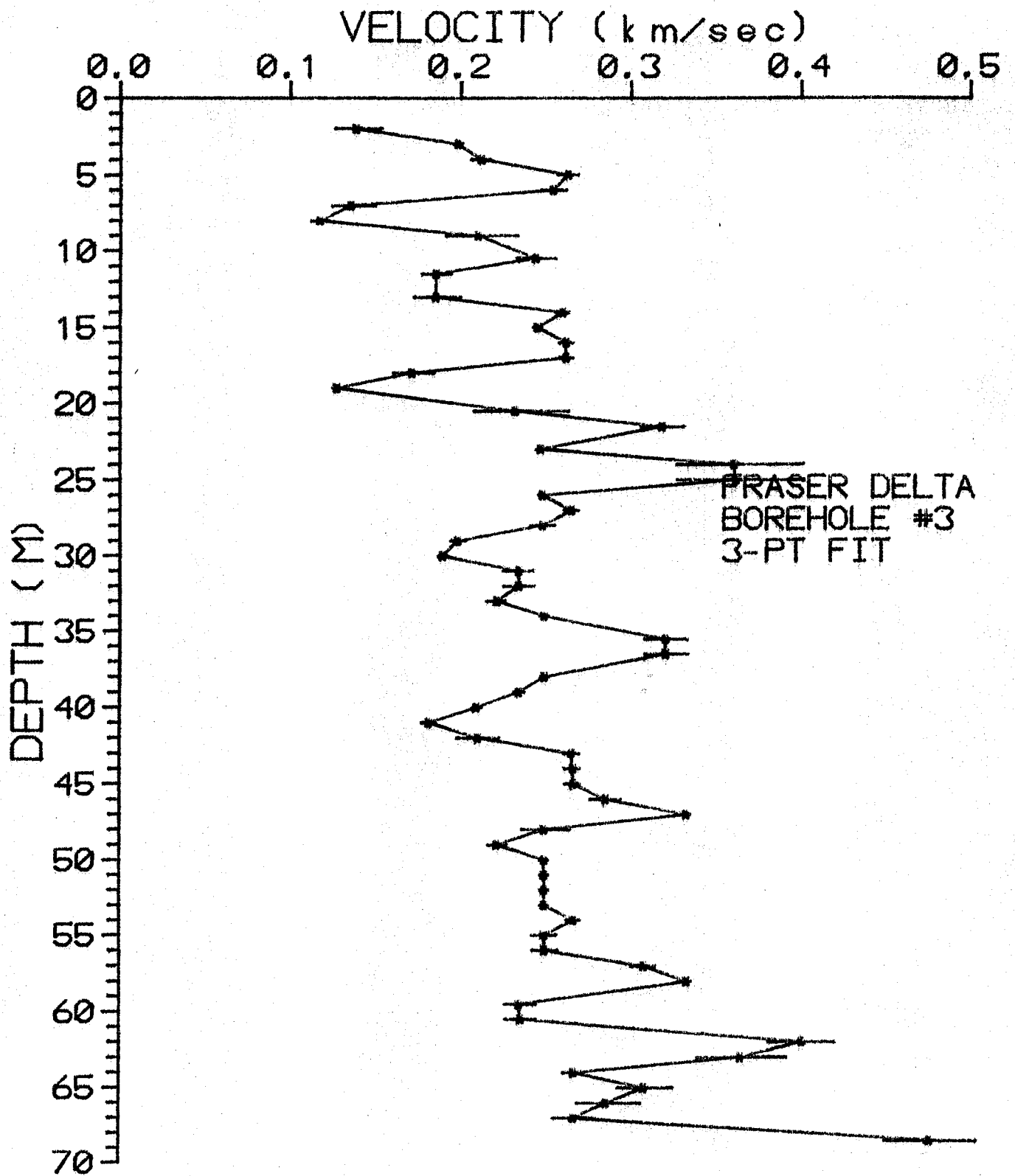


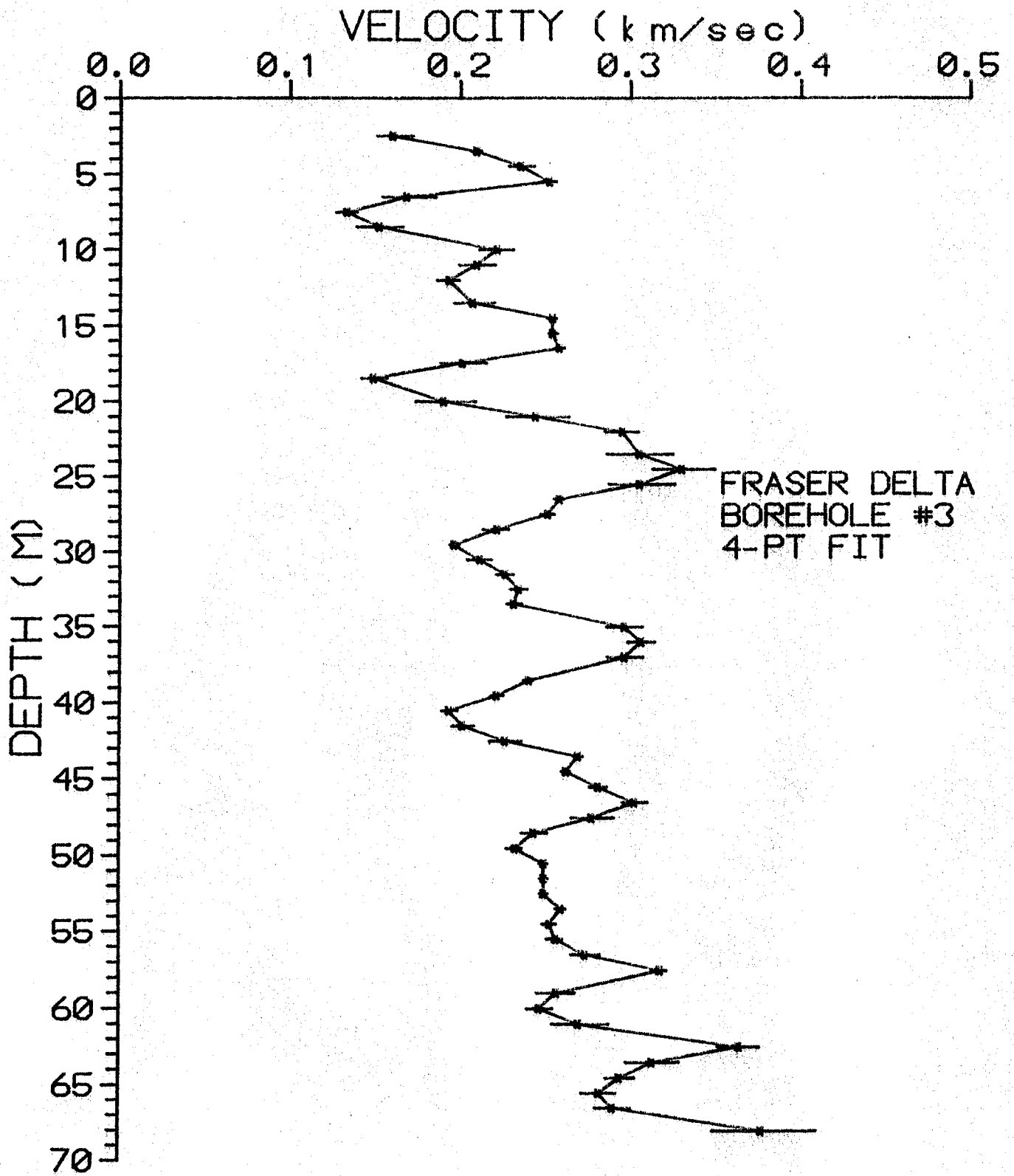


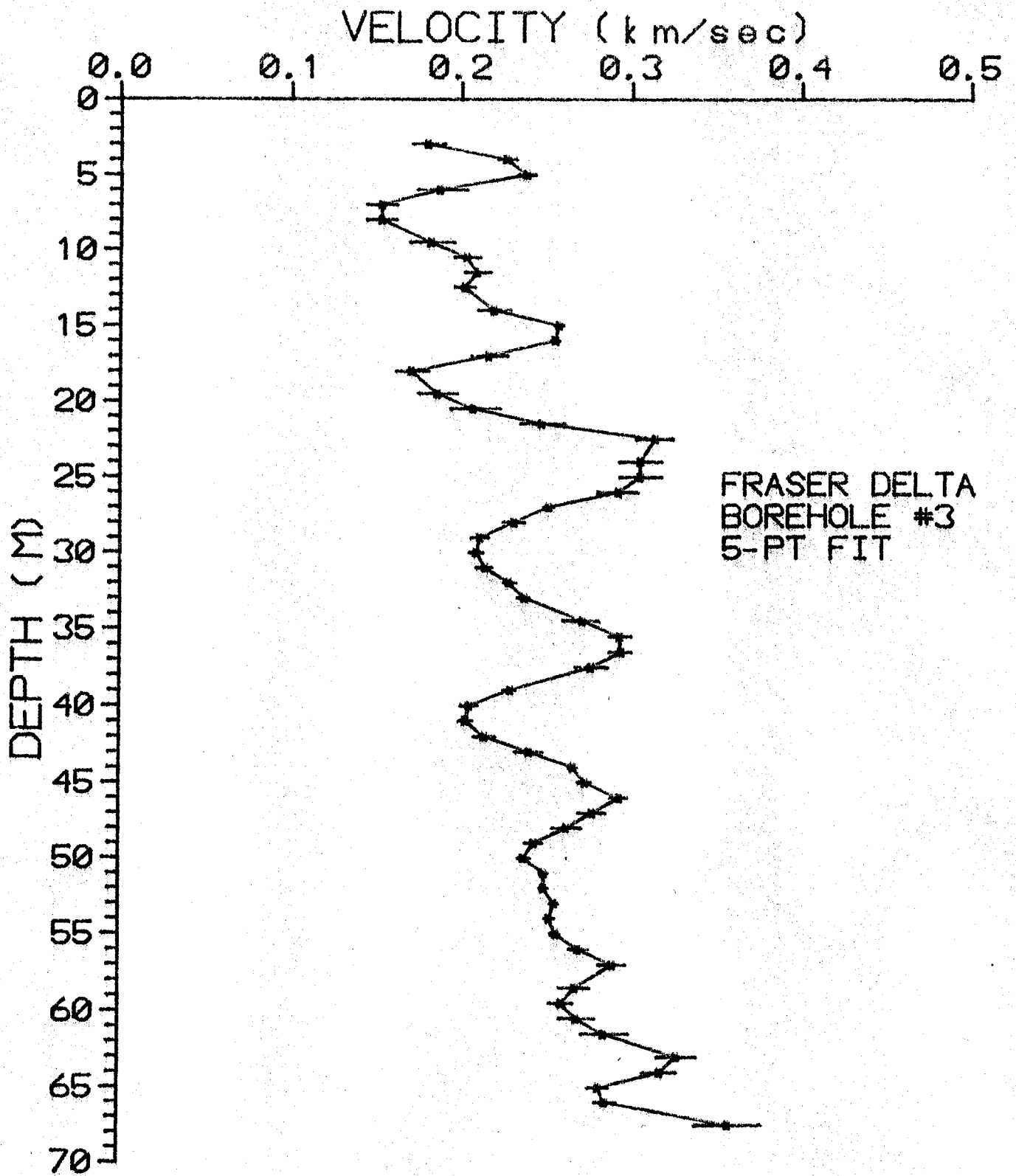


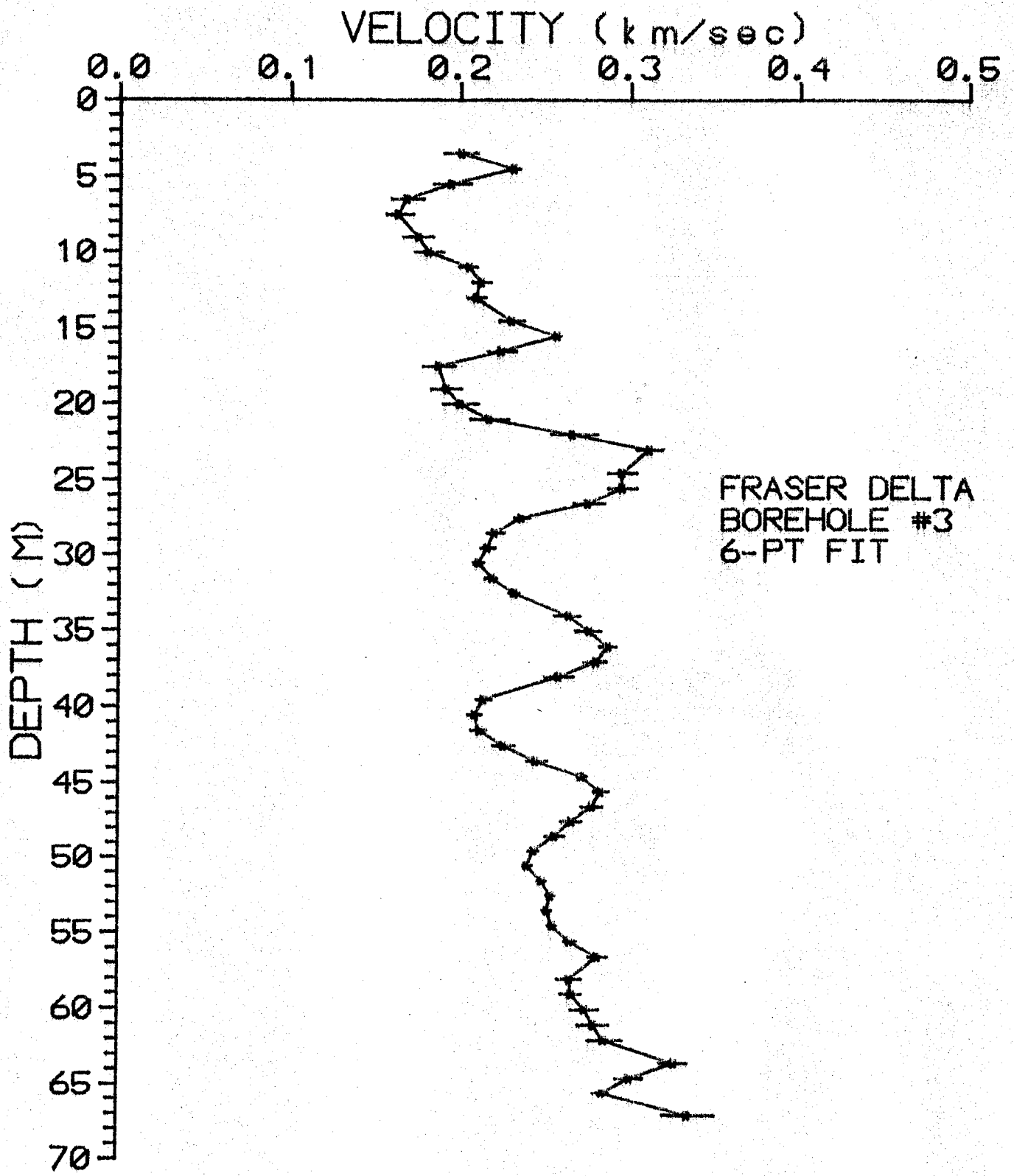


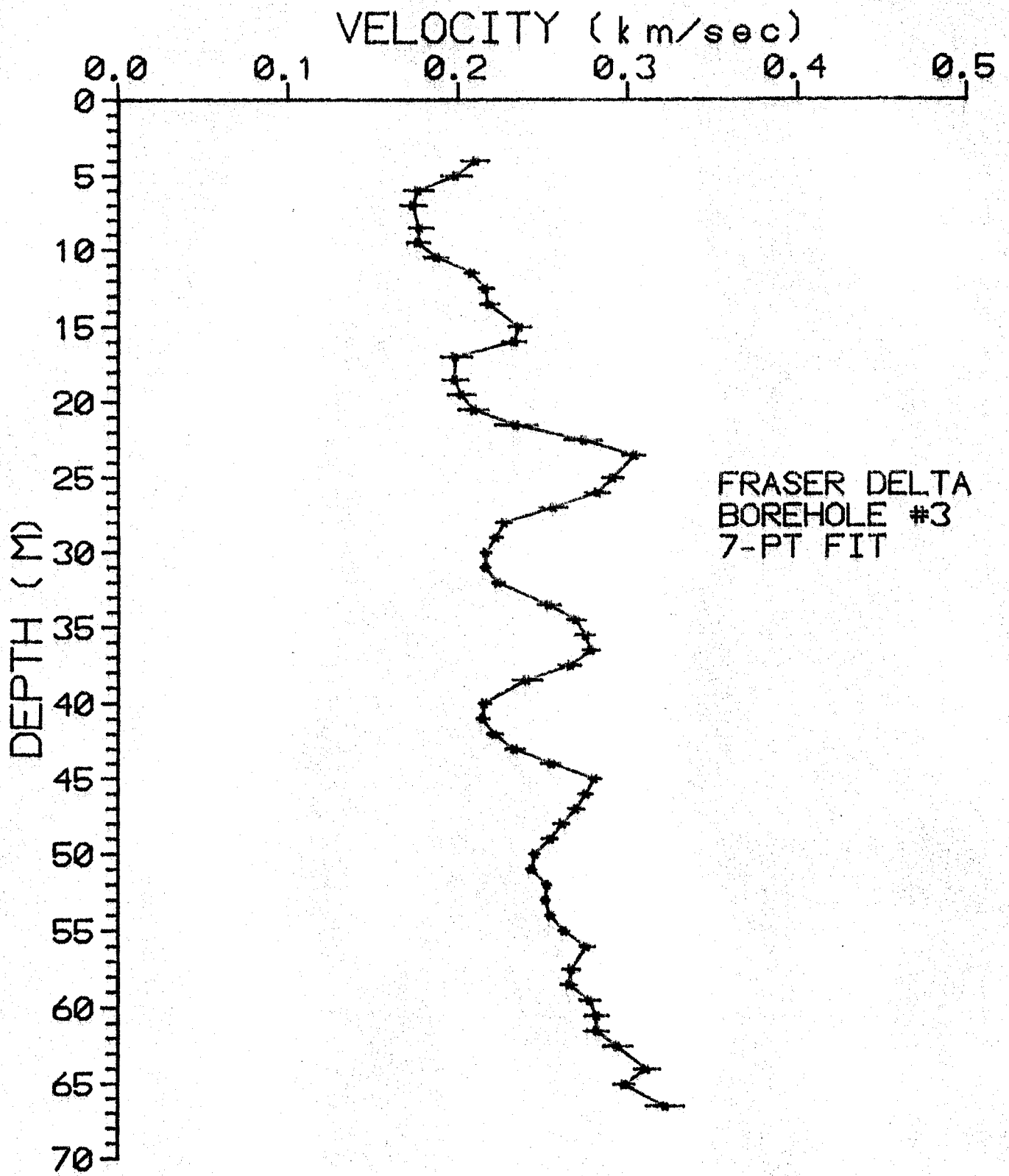


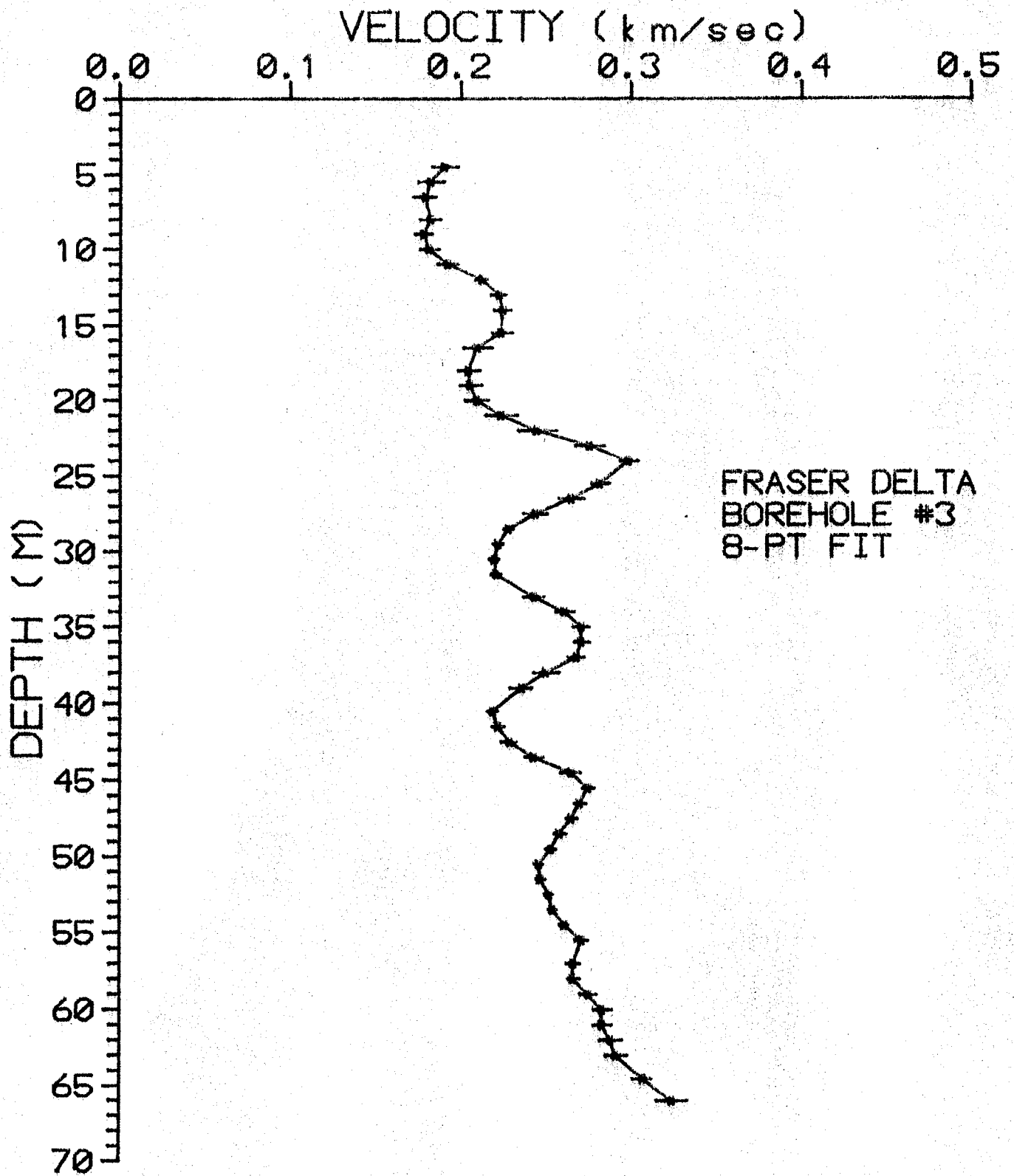


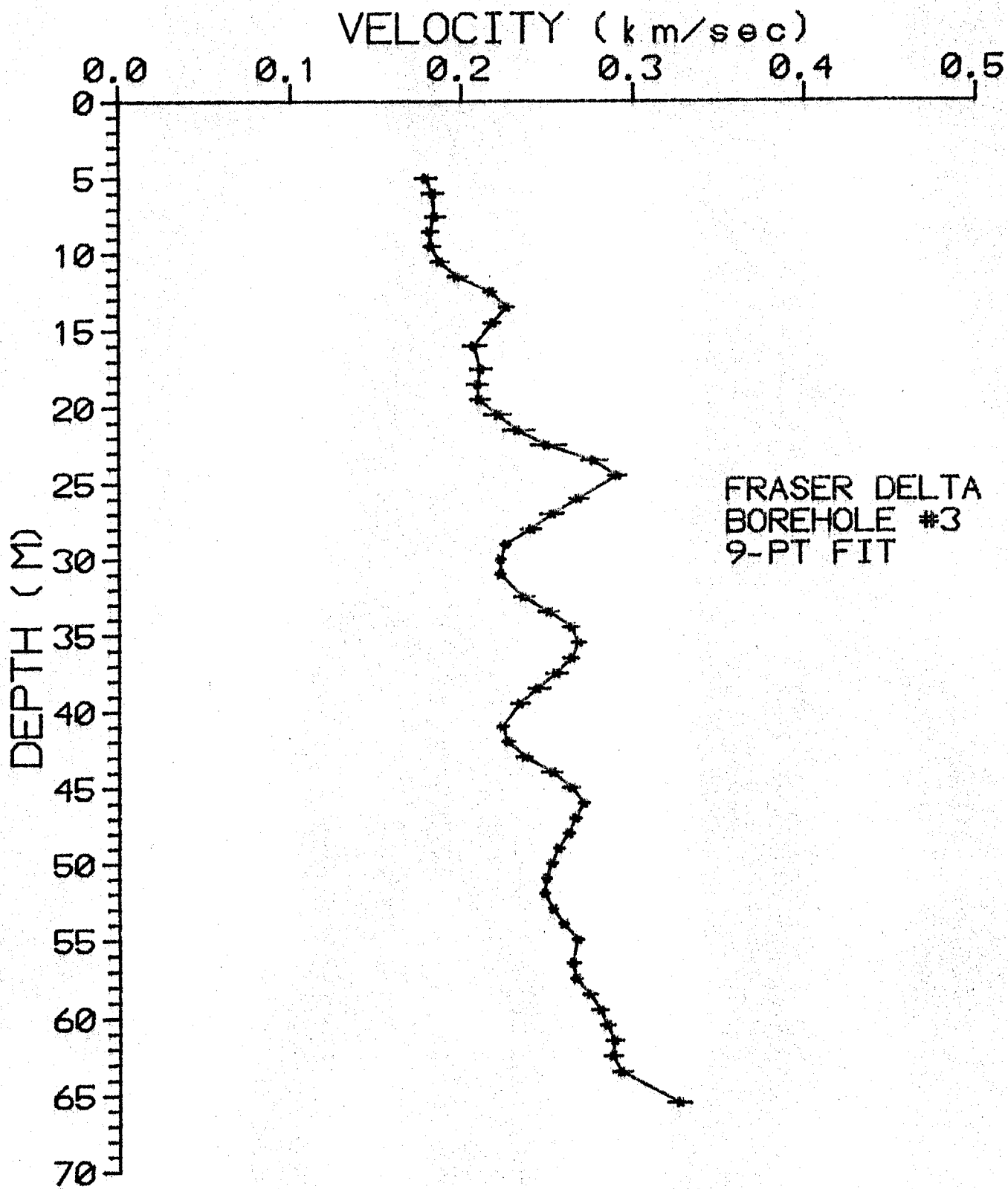












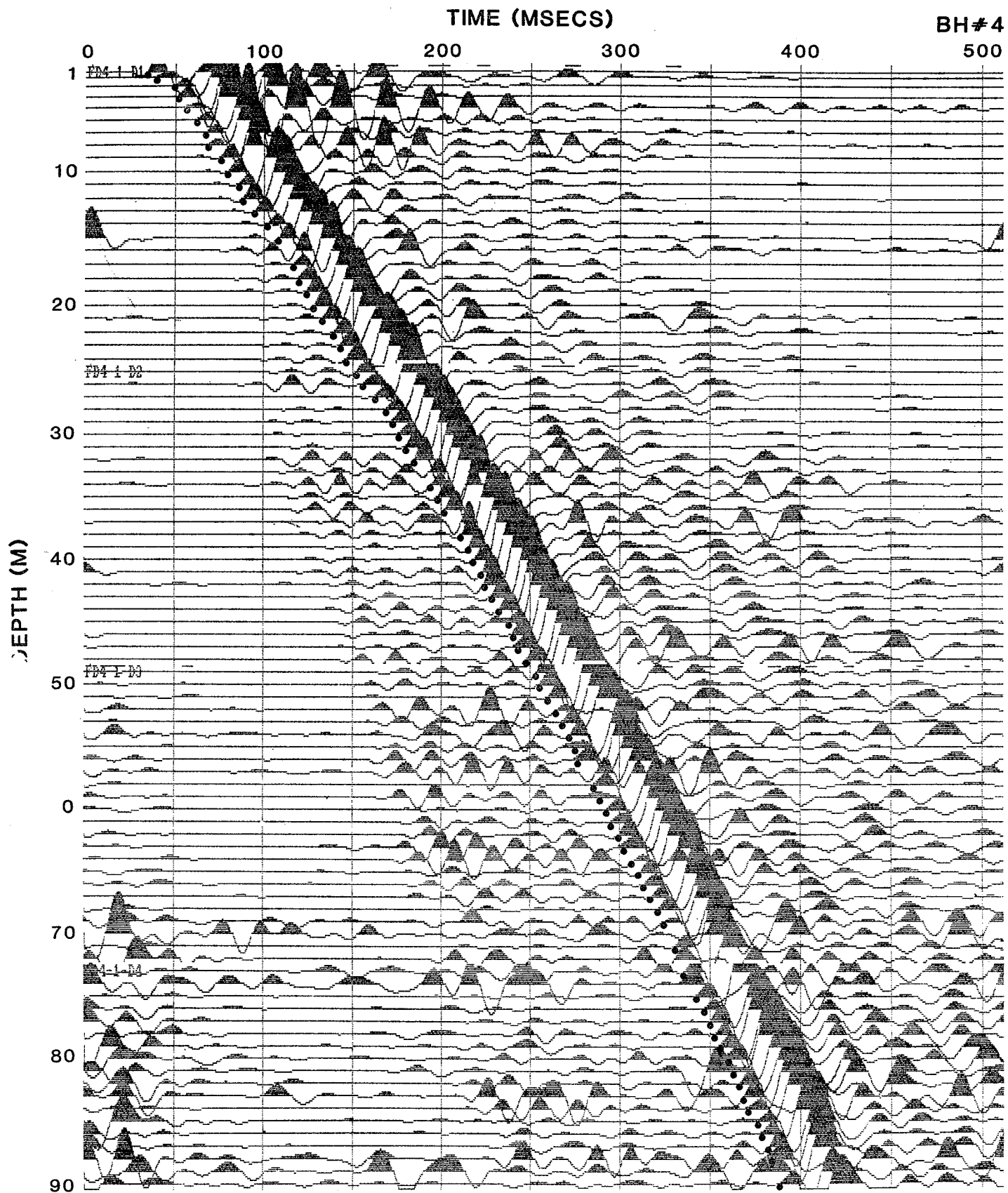
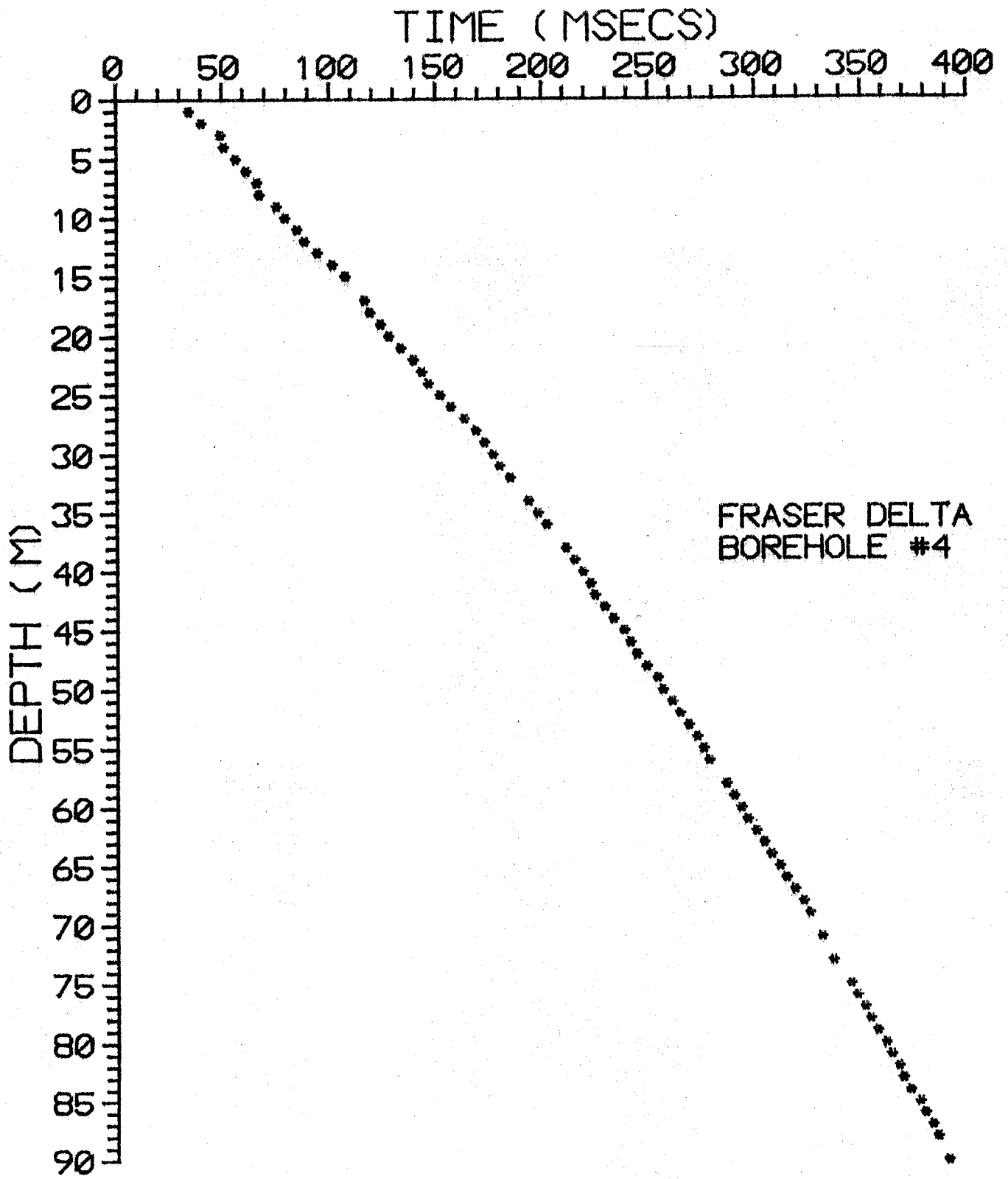
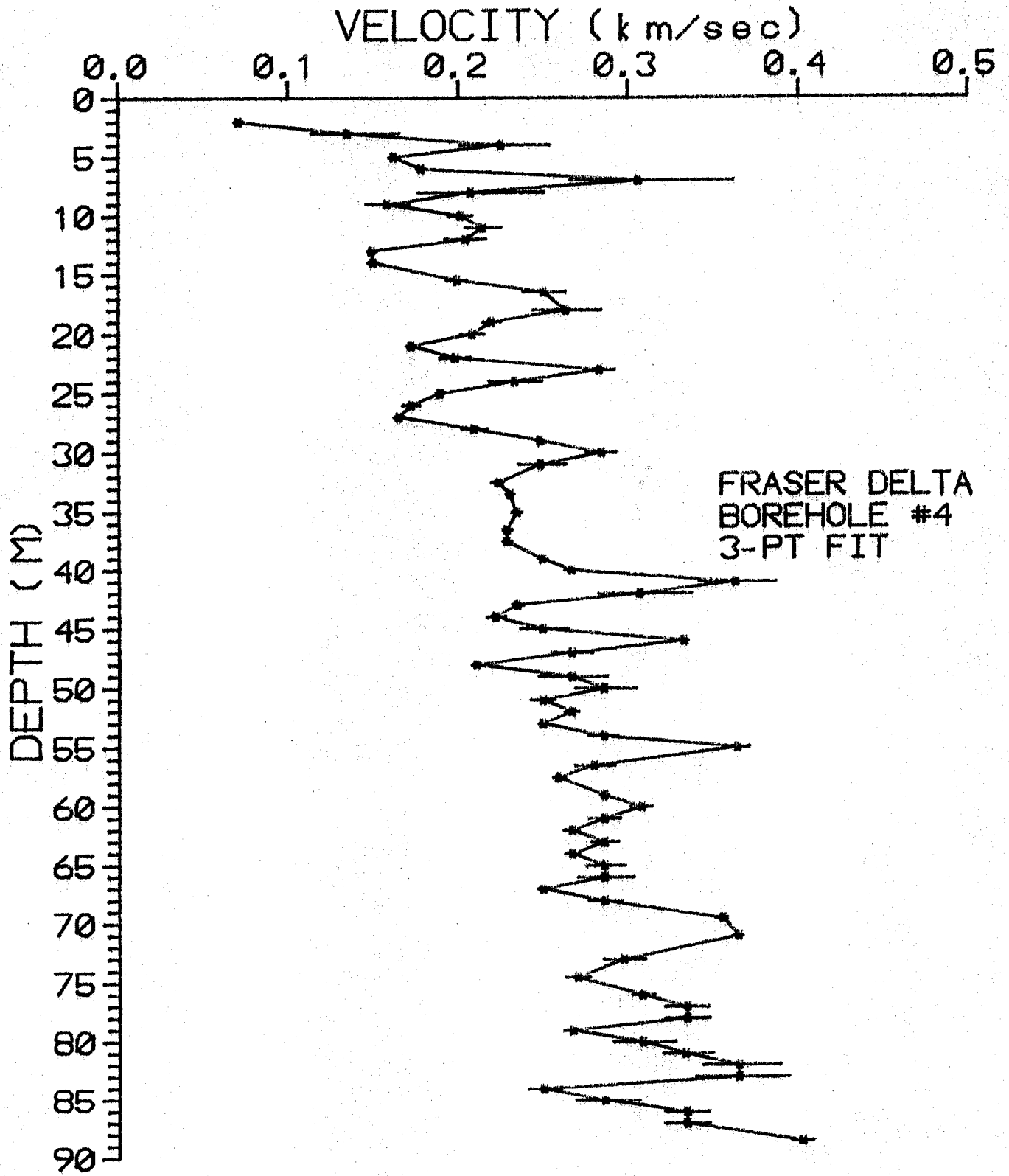
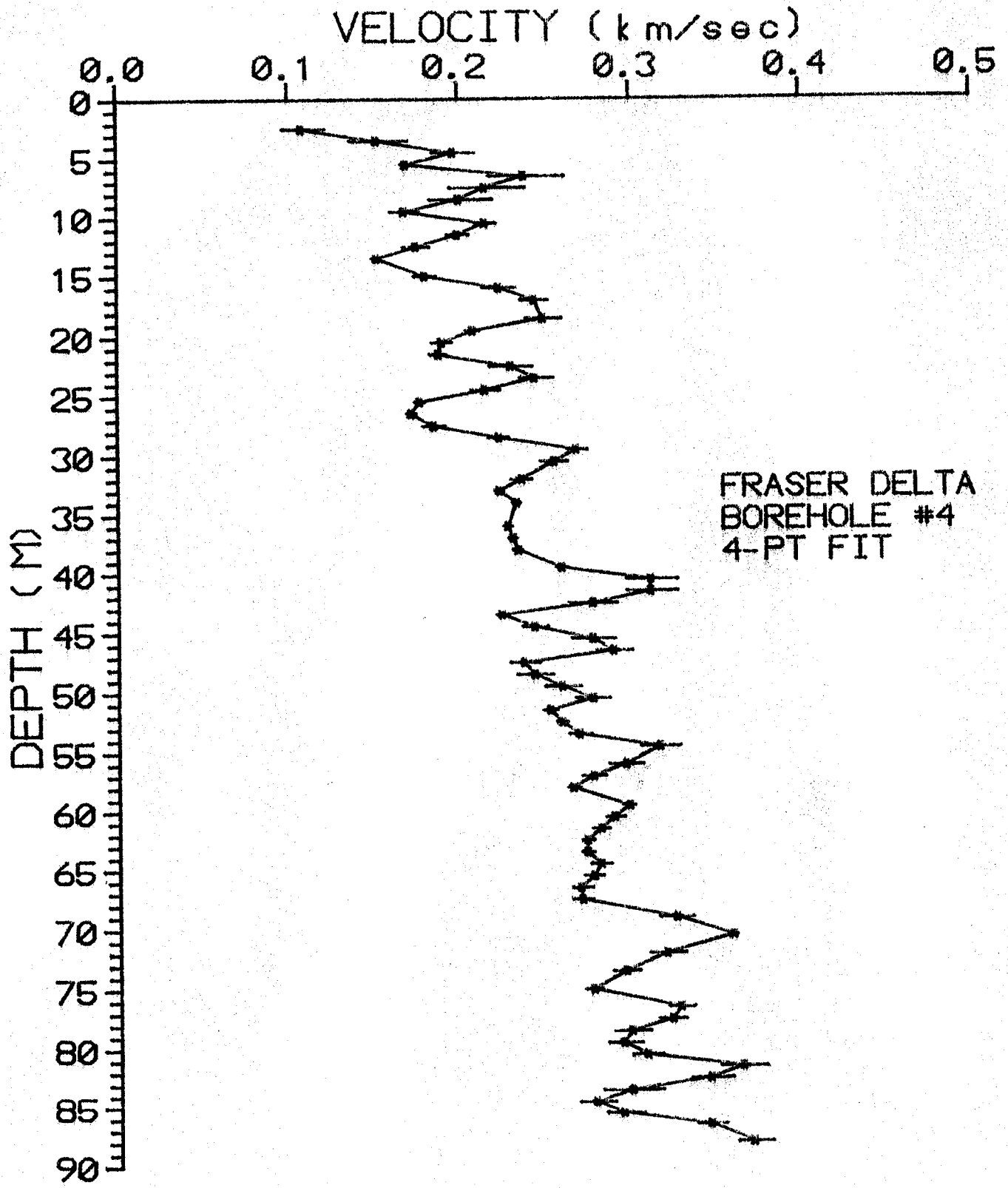
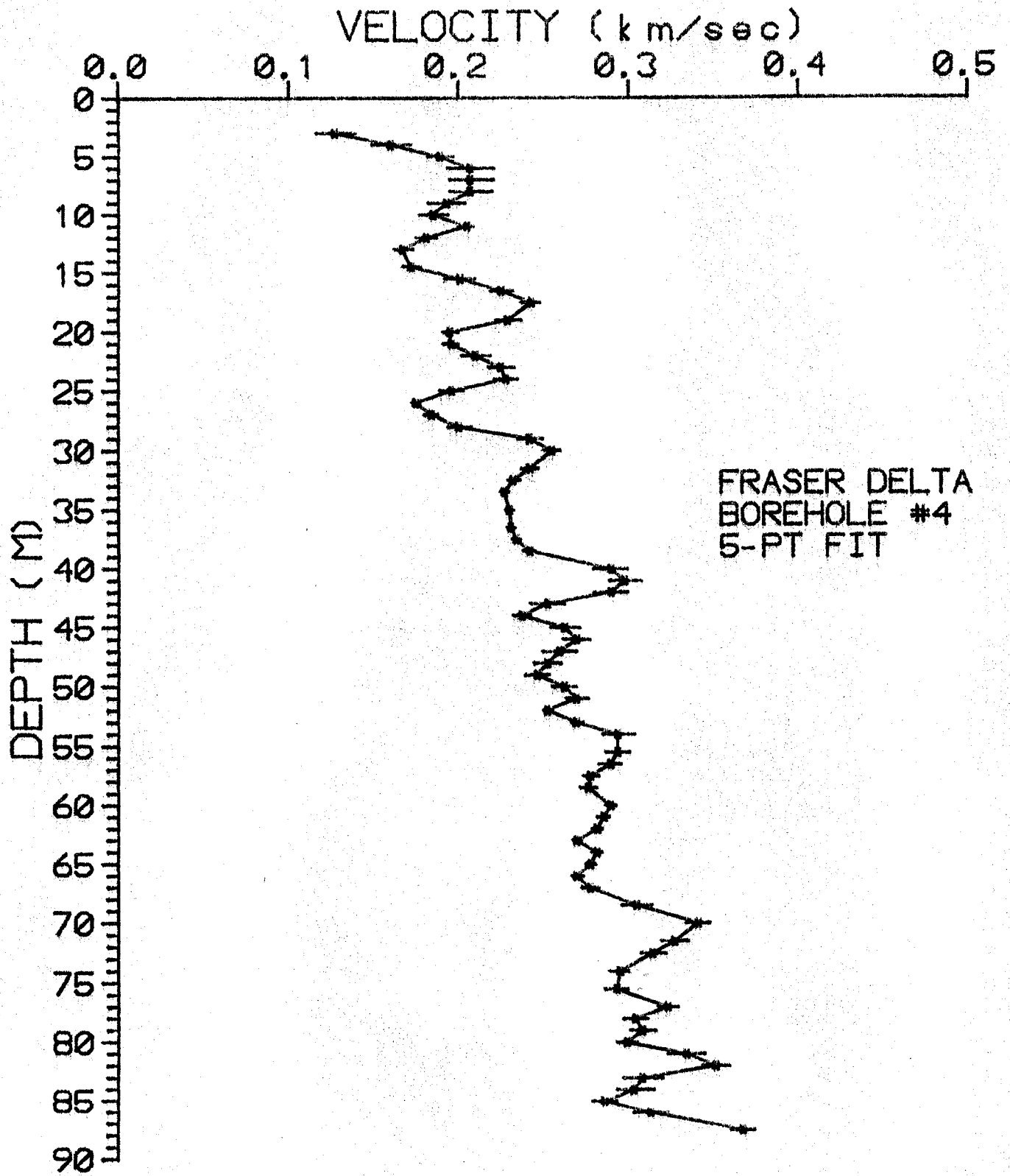


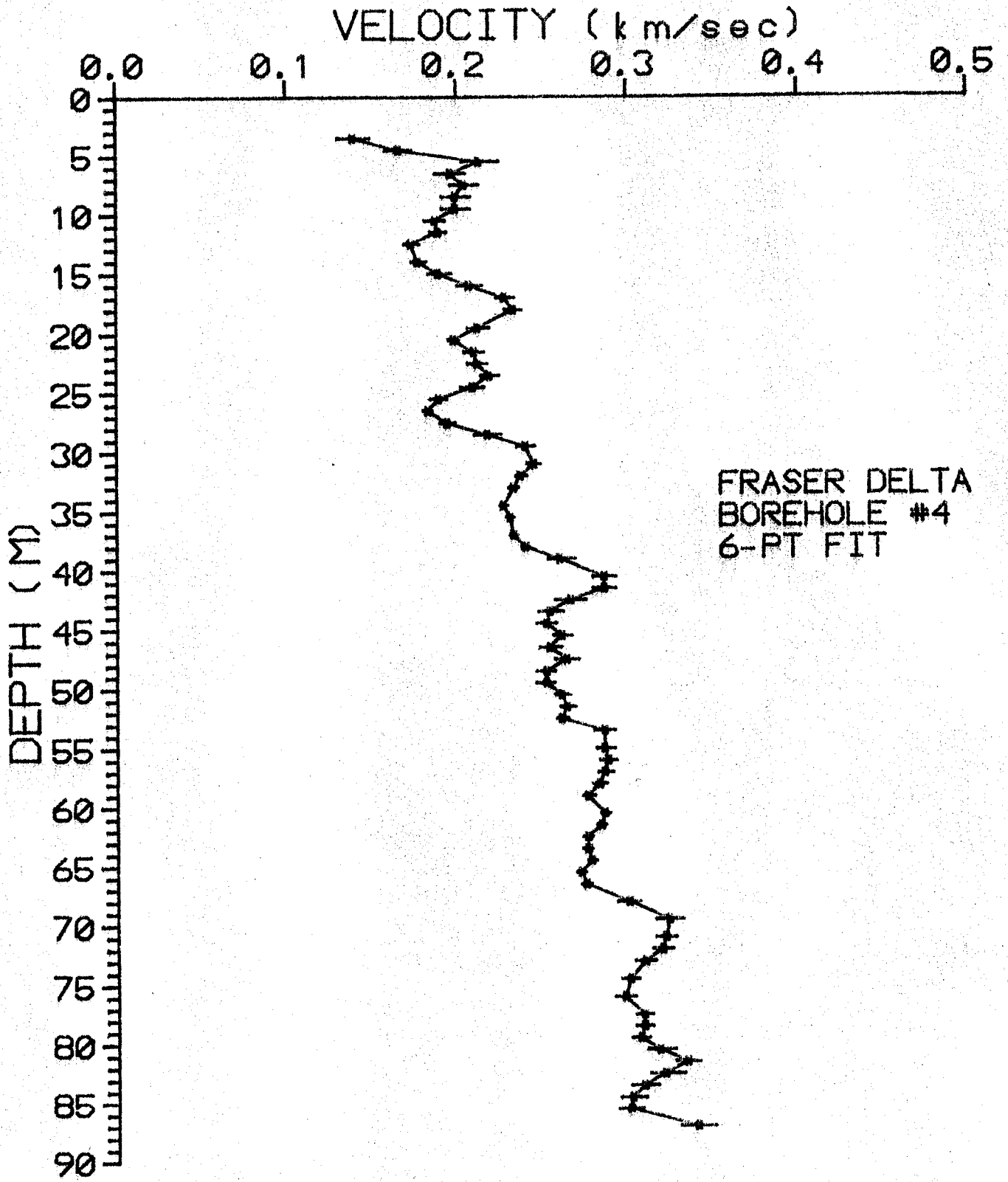
FIG 4(a)

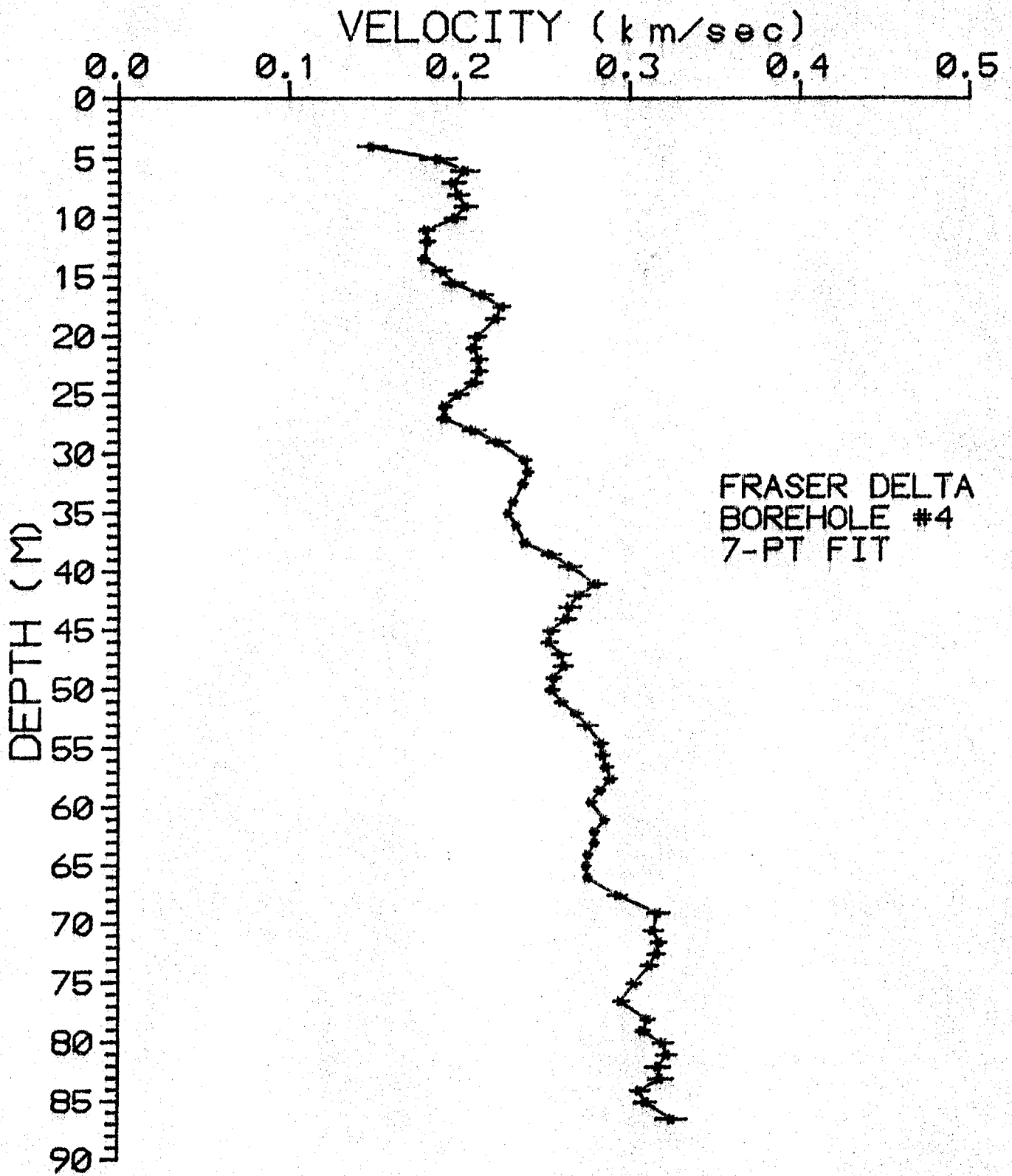


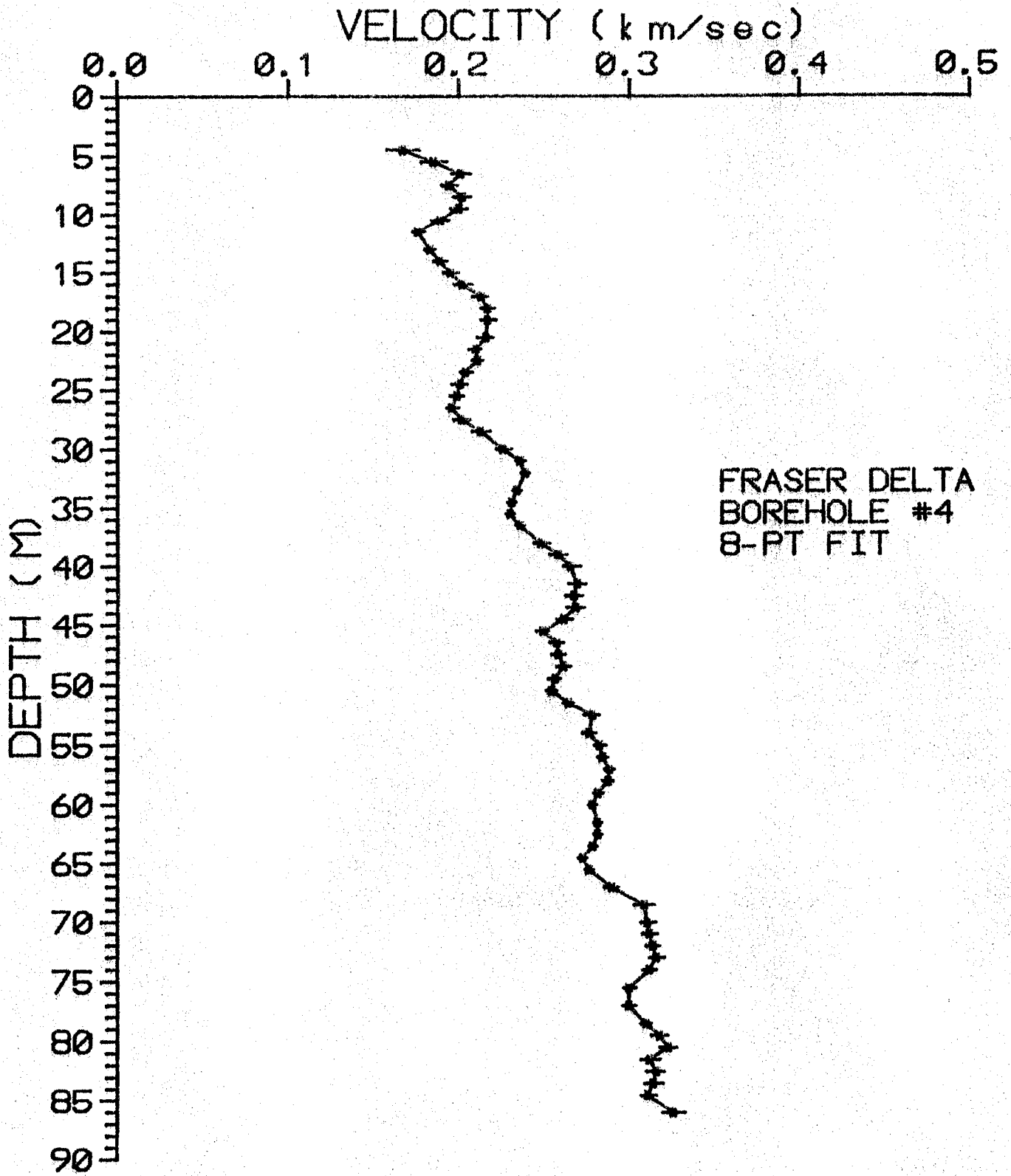


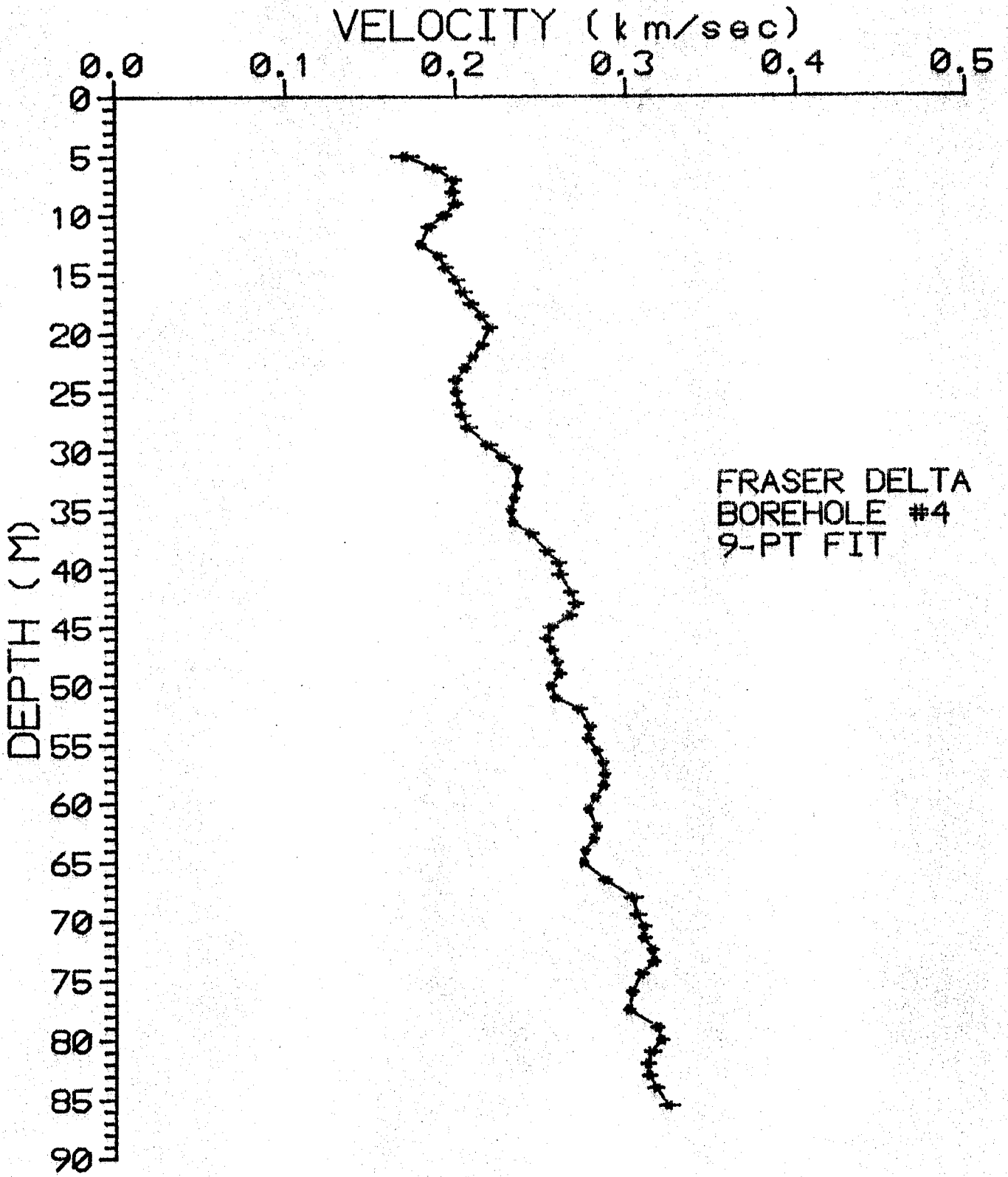












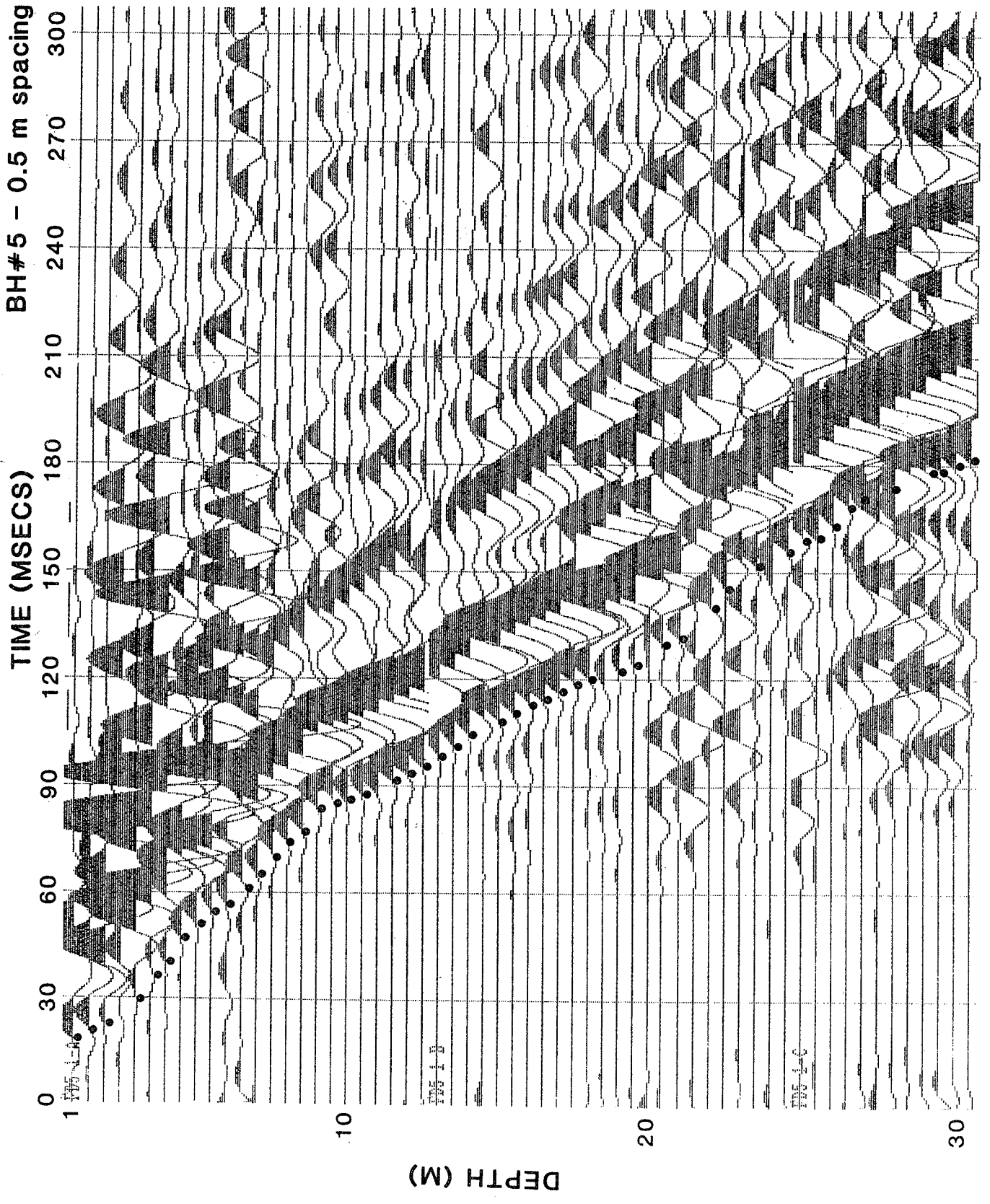
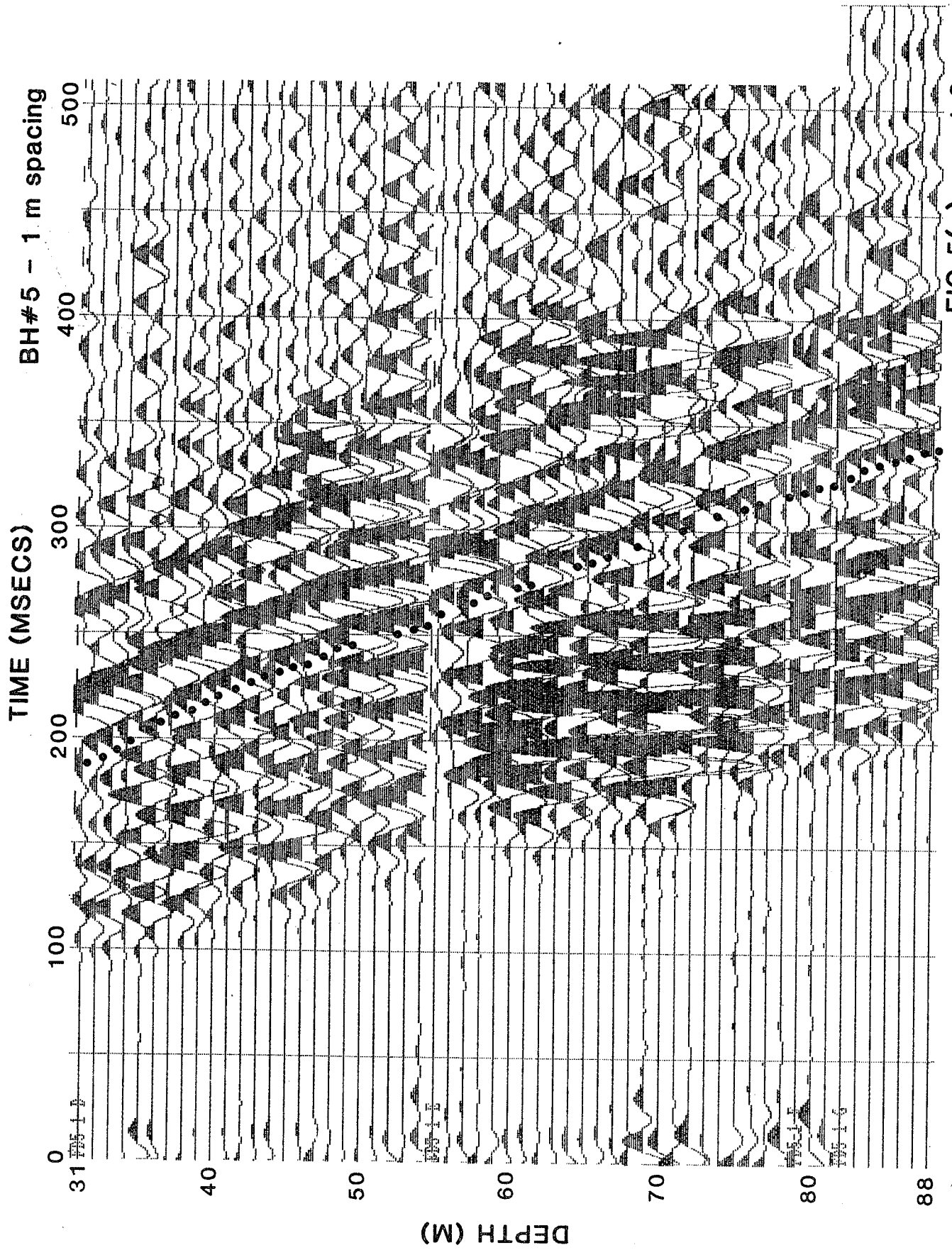
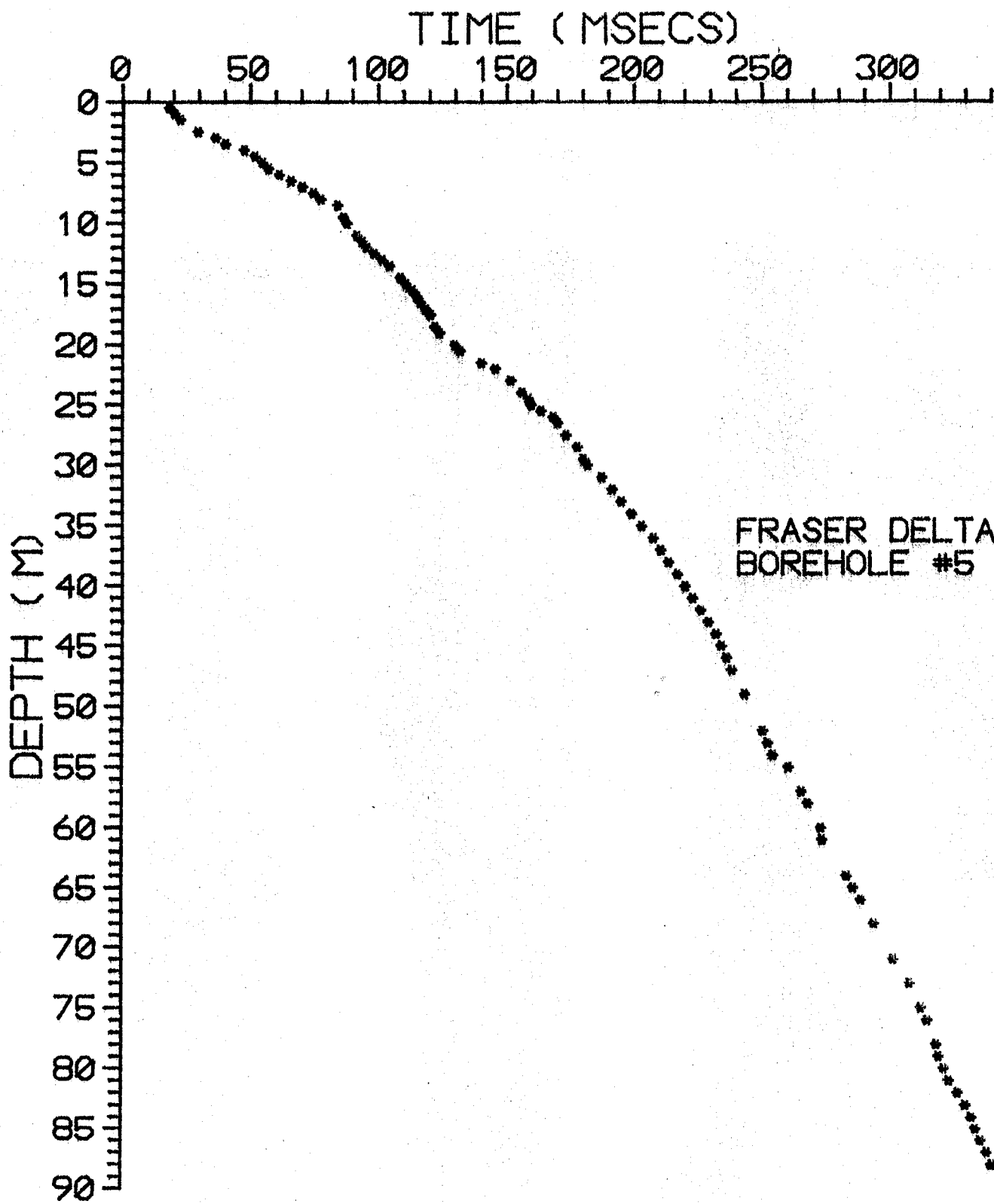


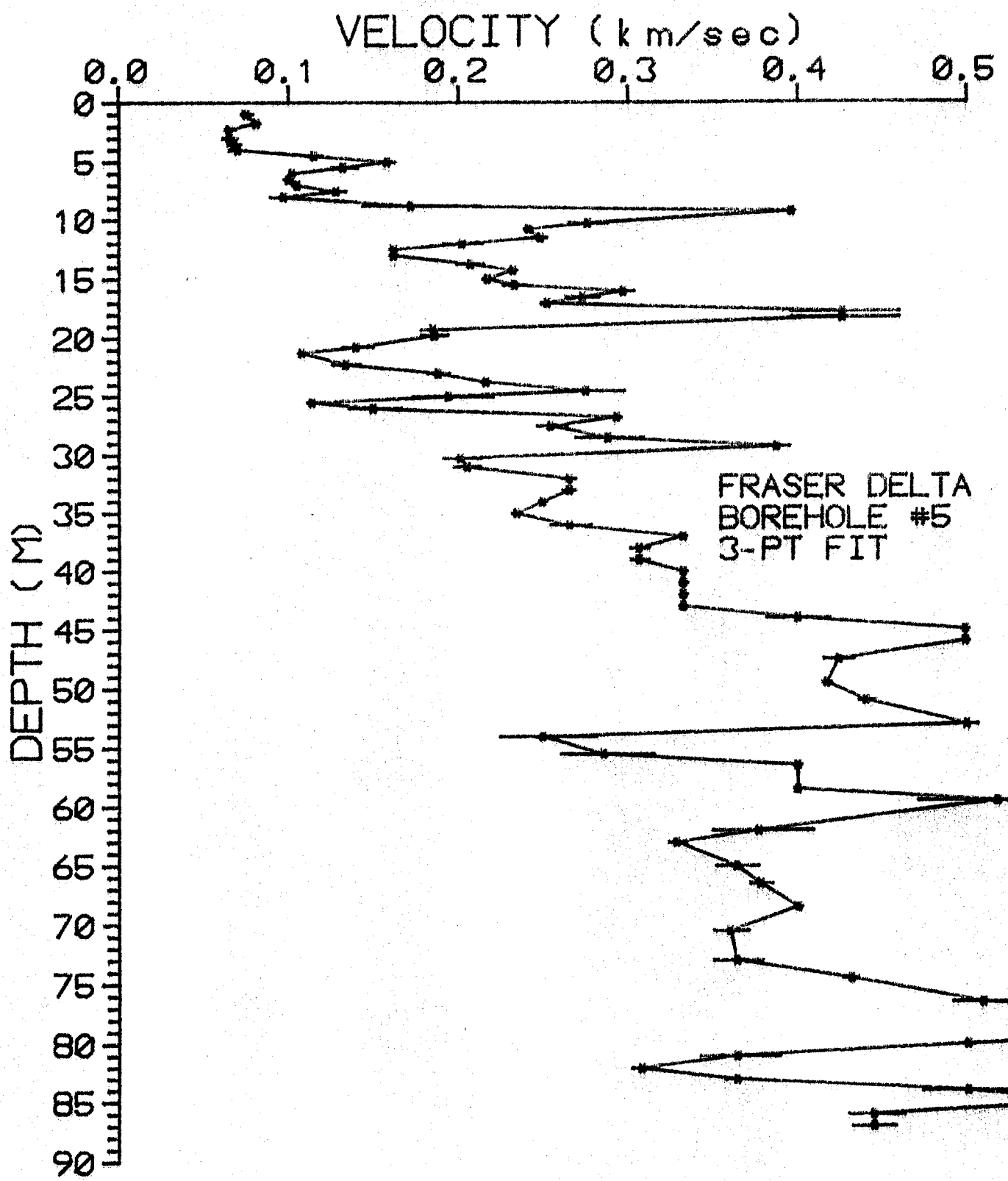
FIG 5(a) - part 1

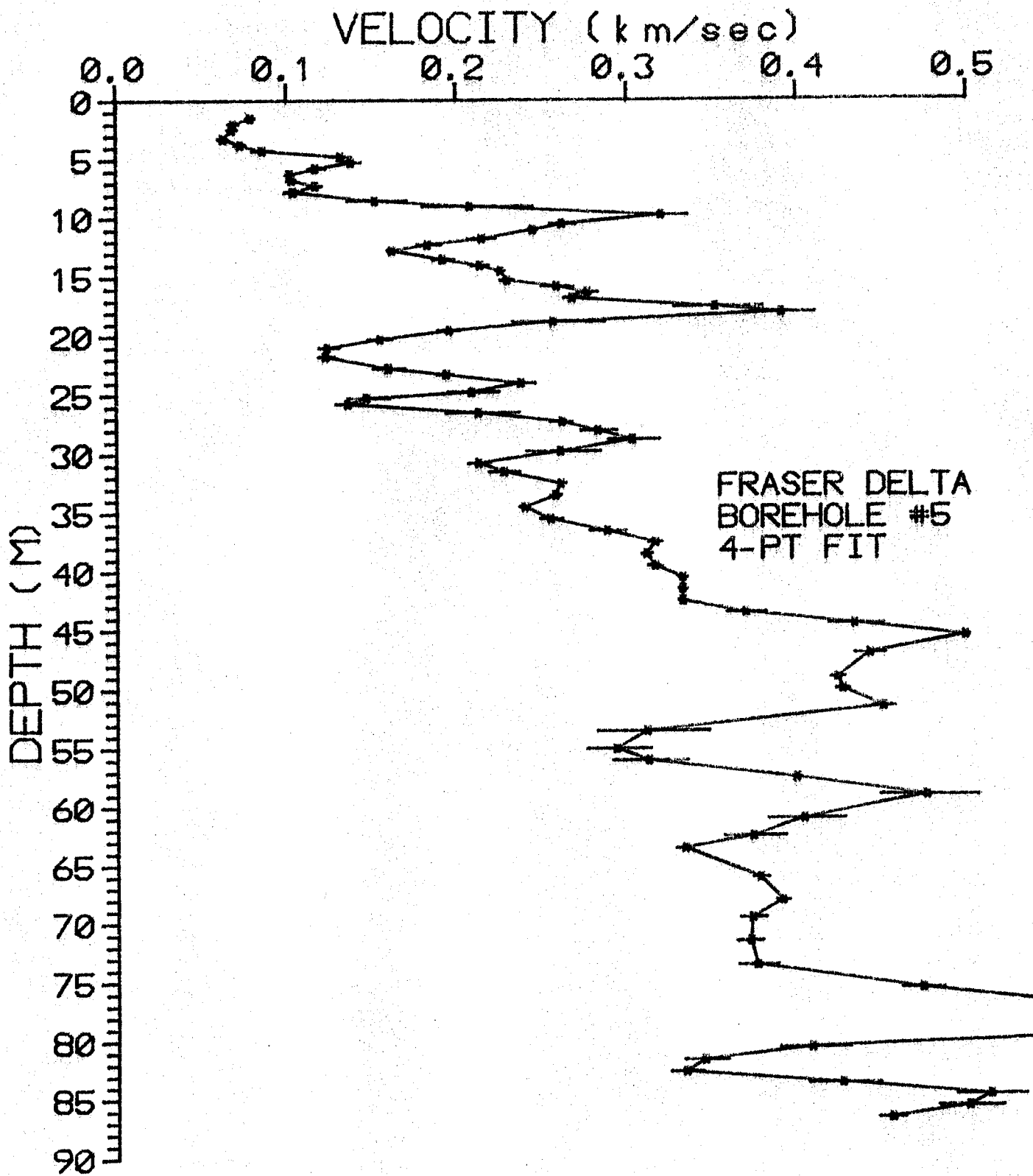


BH#5 - 1 m spacing

FIG 5(a) - part 2







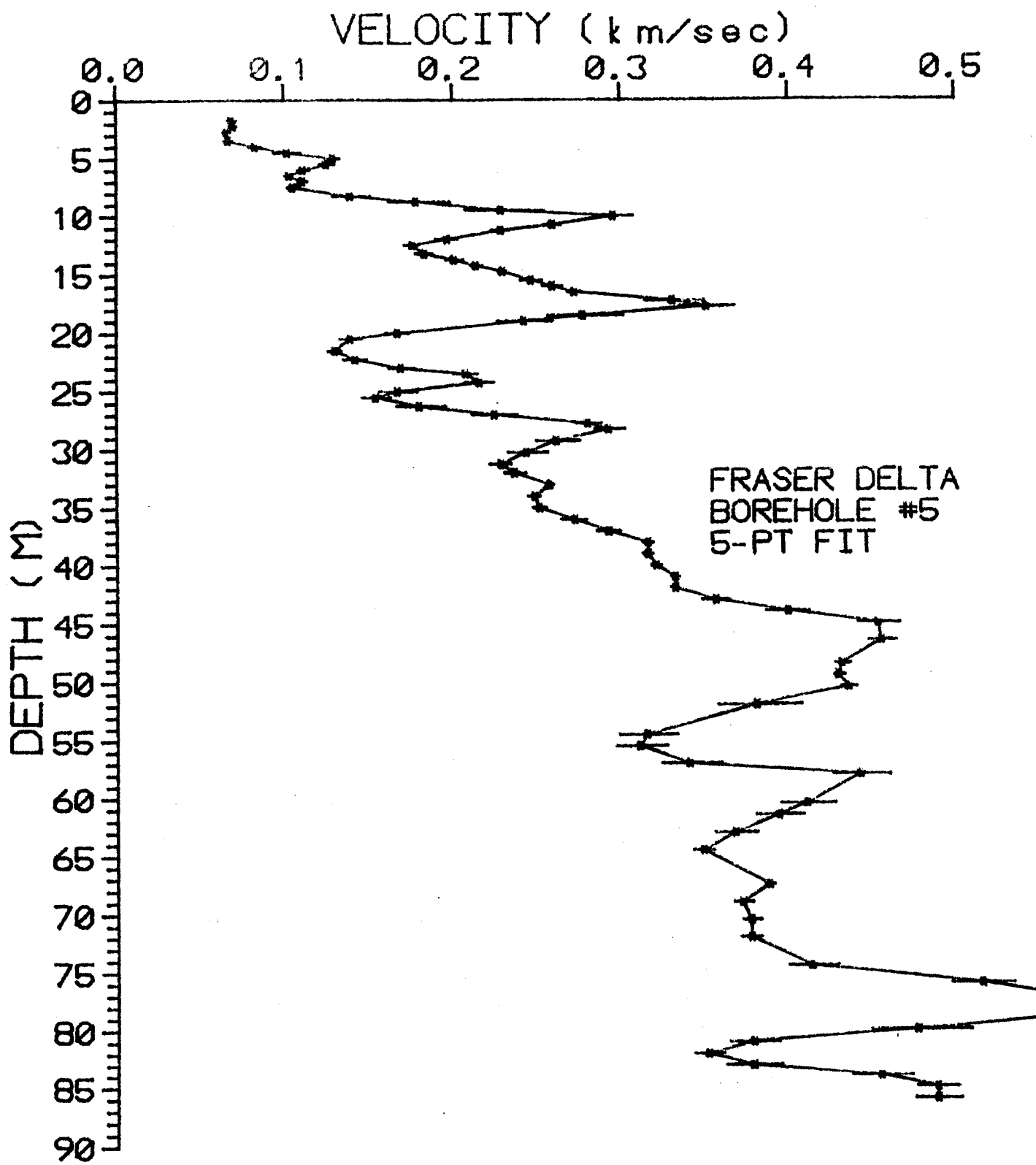
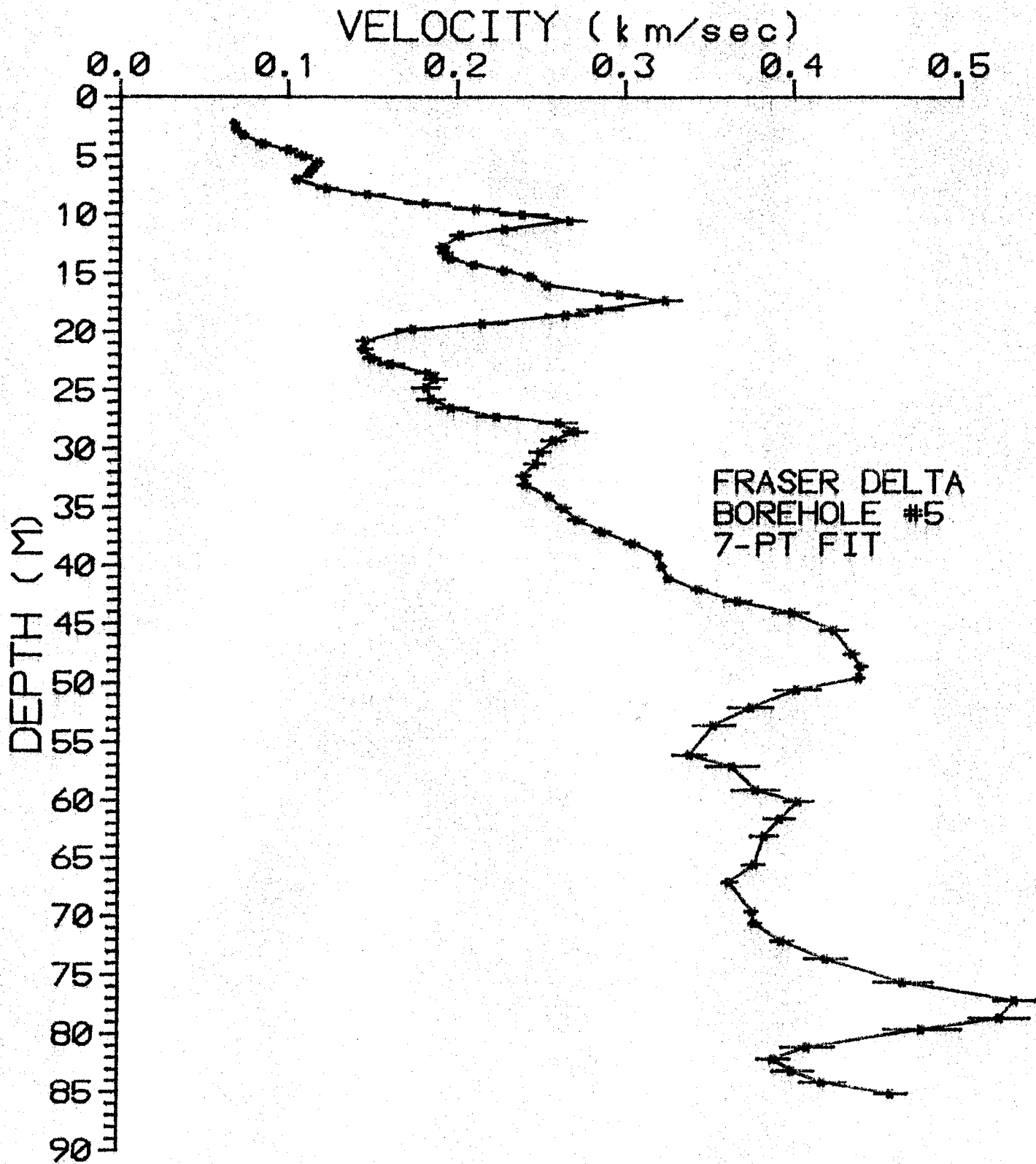
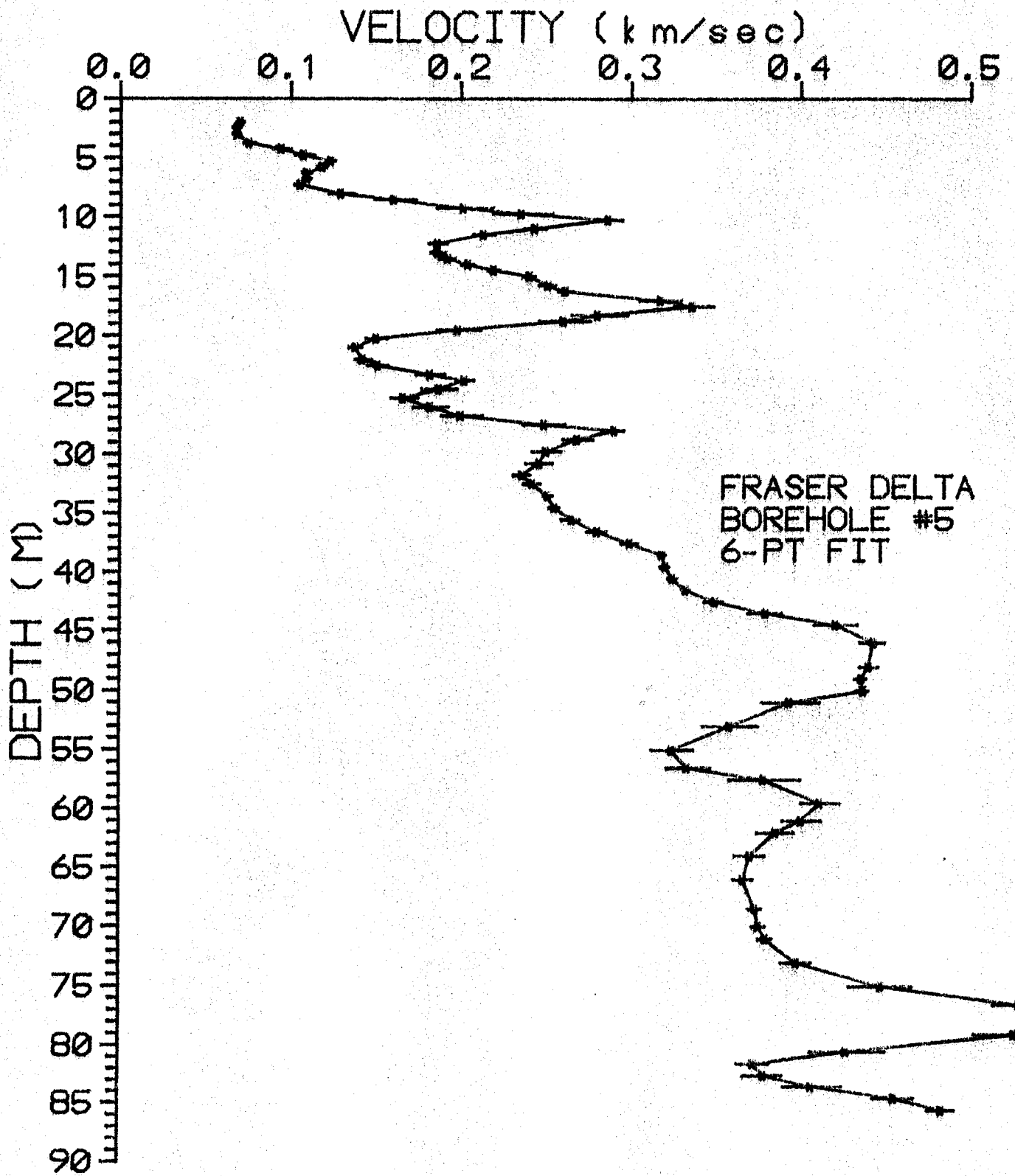
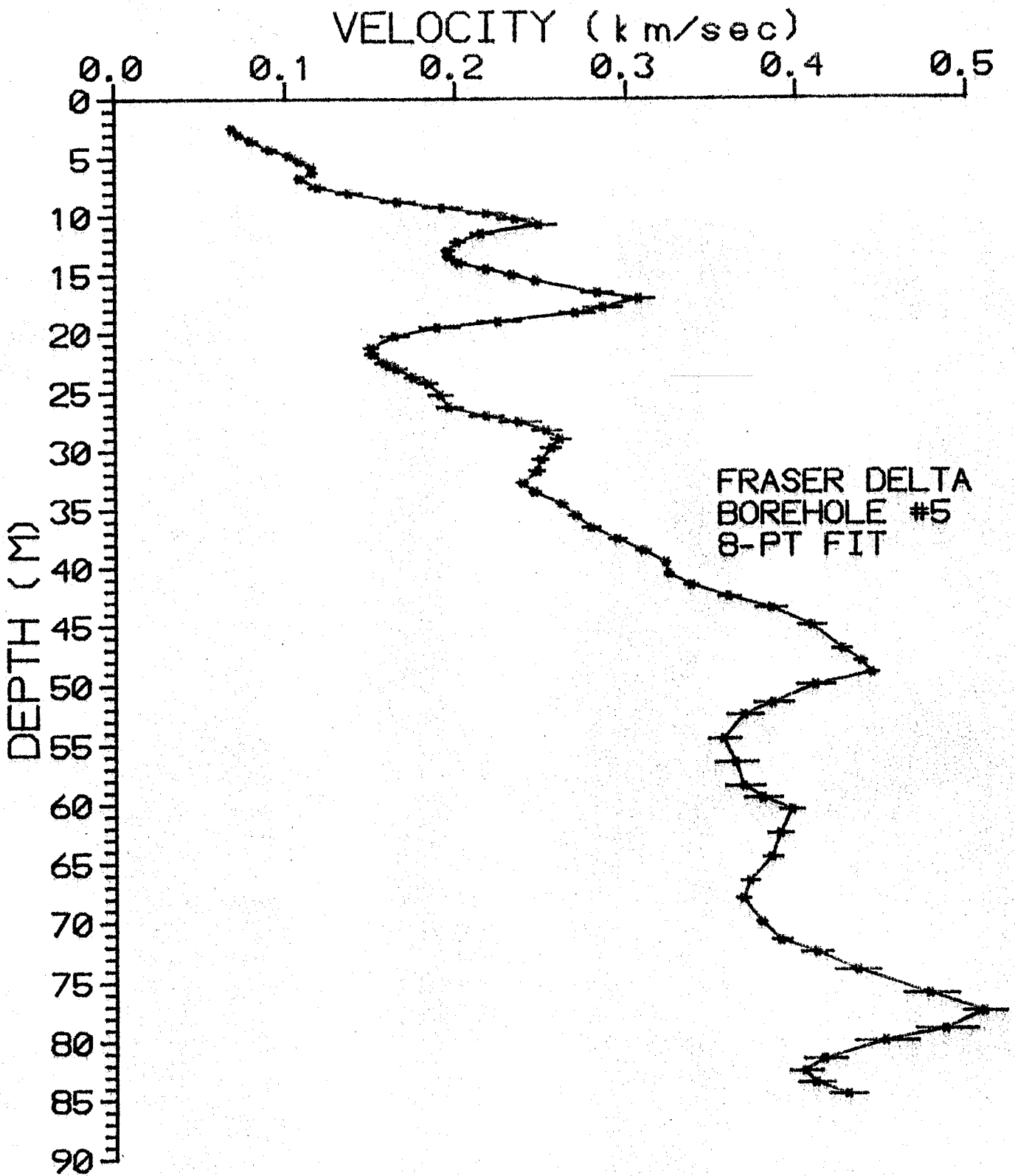
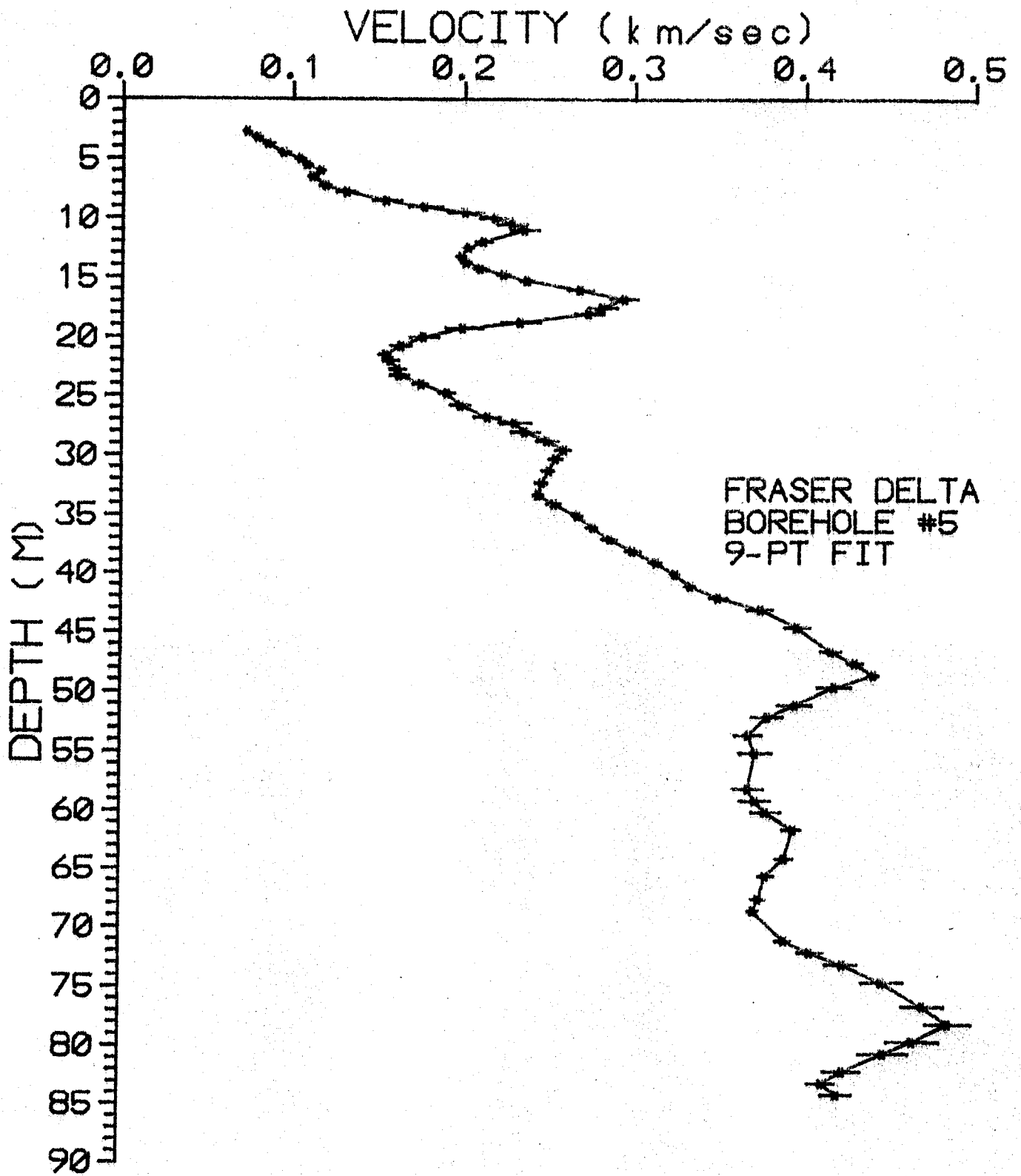


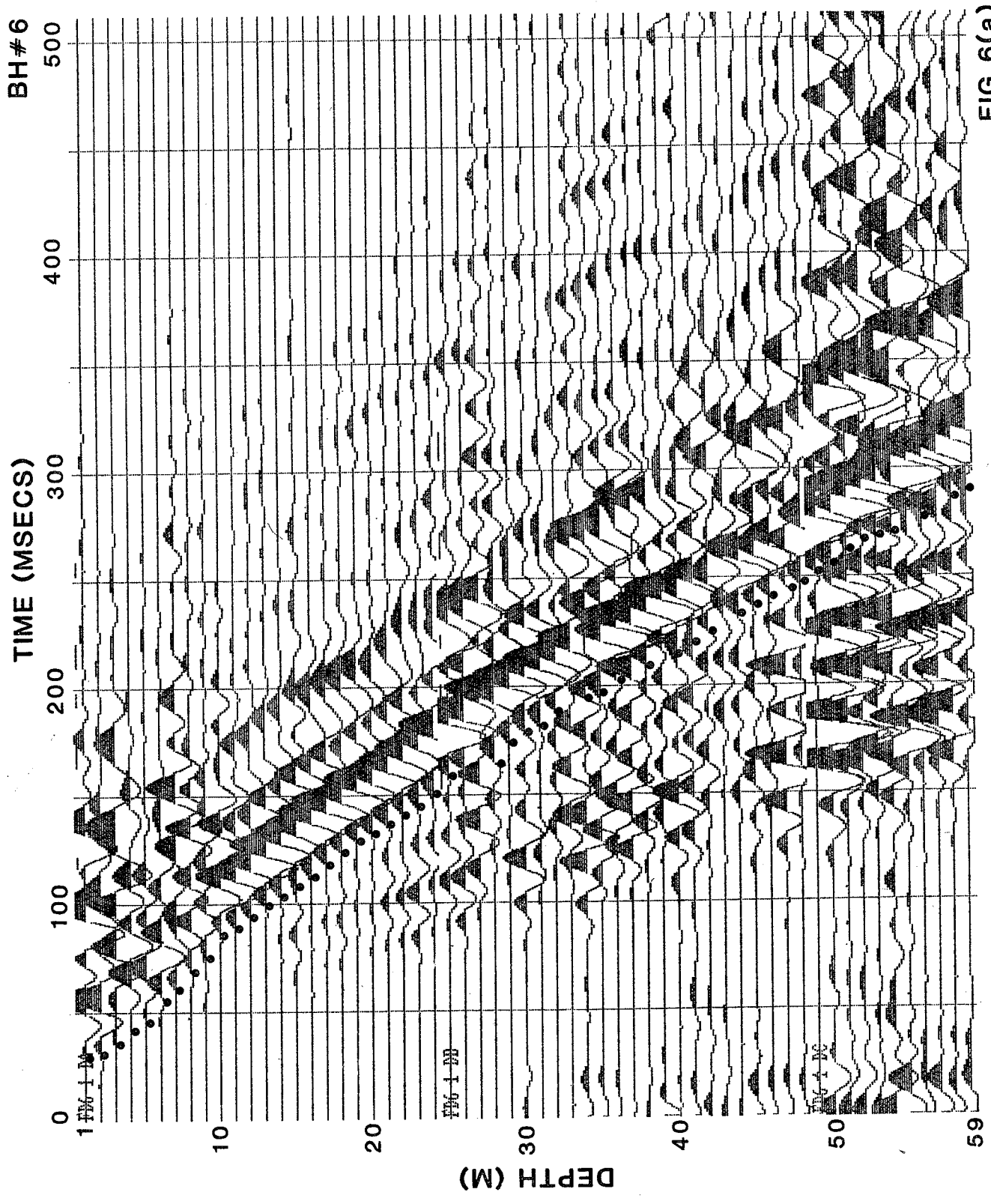
Fig. 5(e)

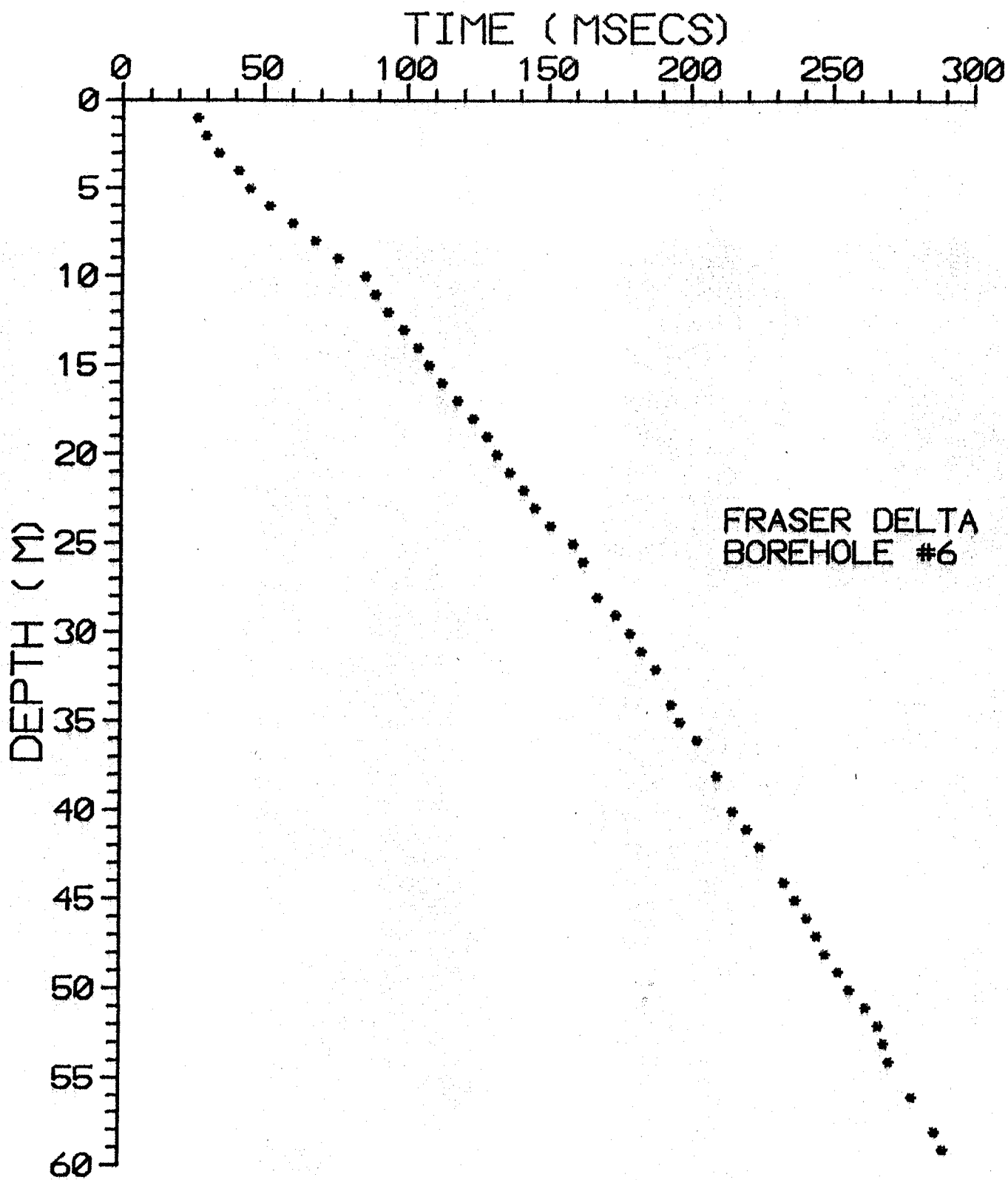


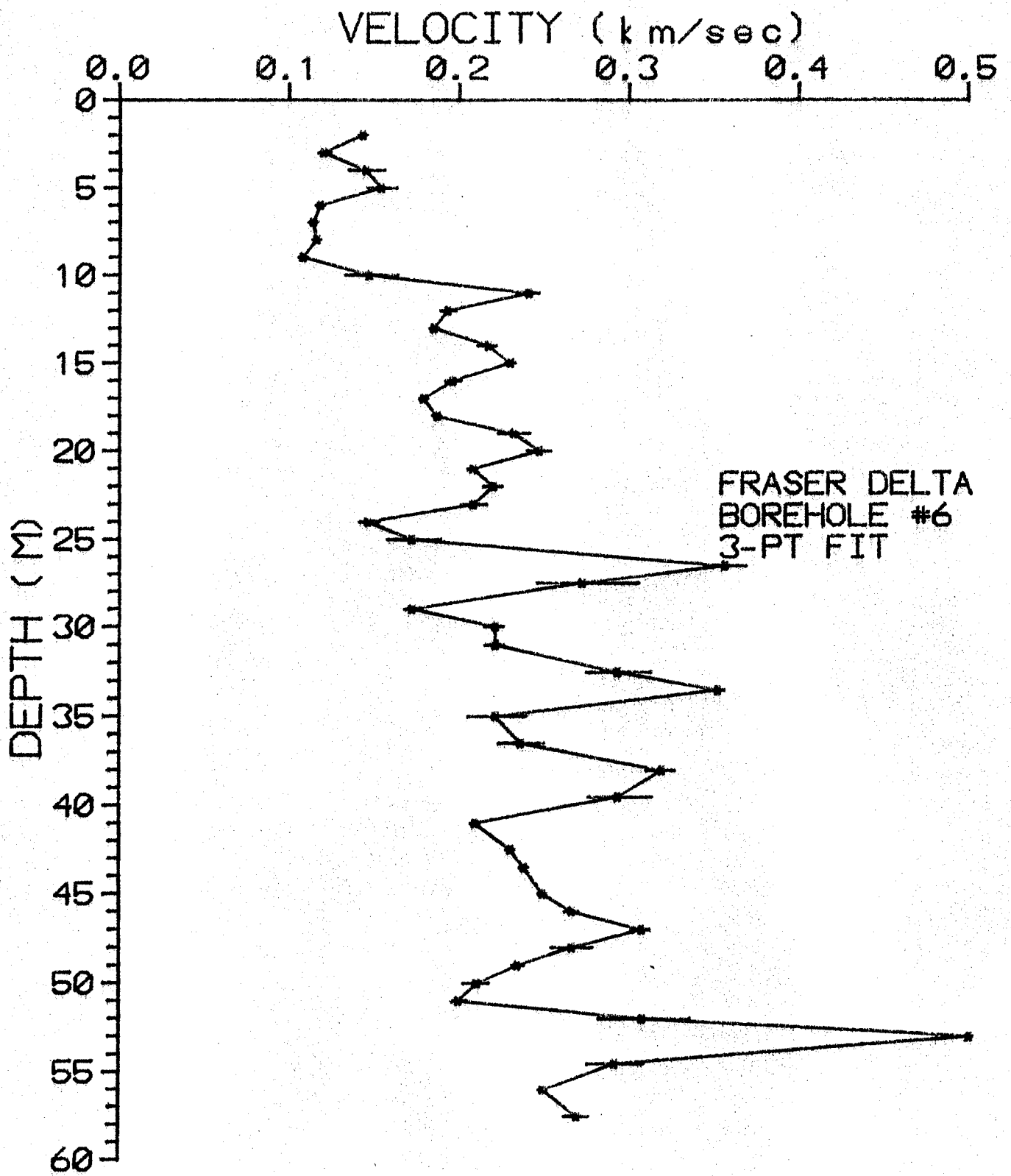


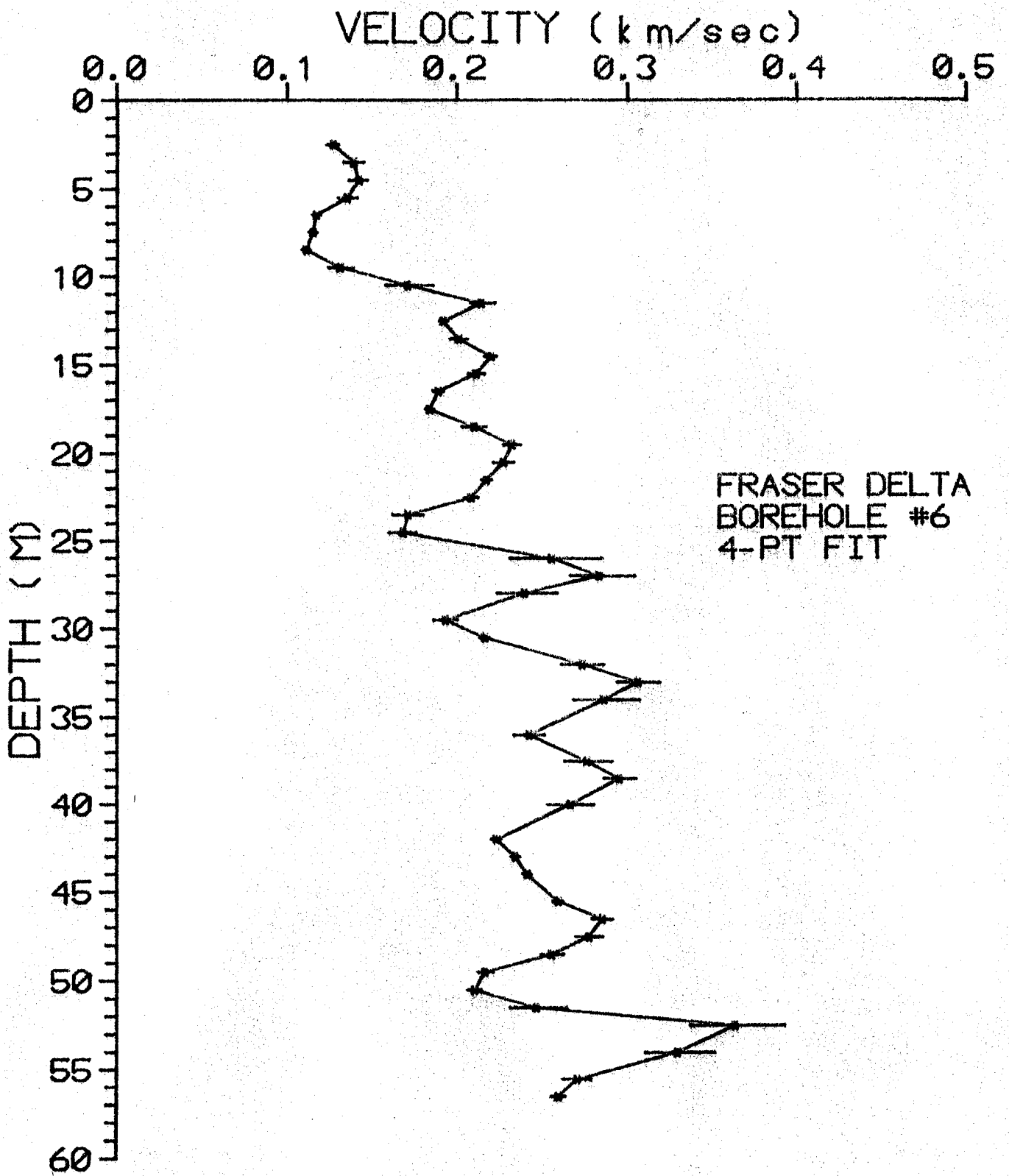


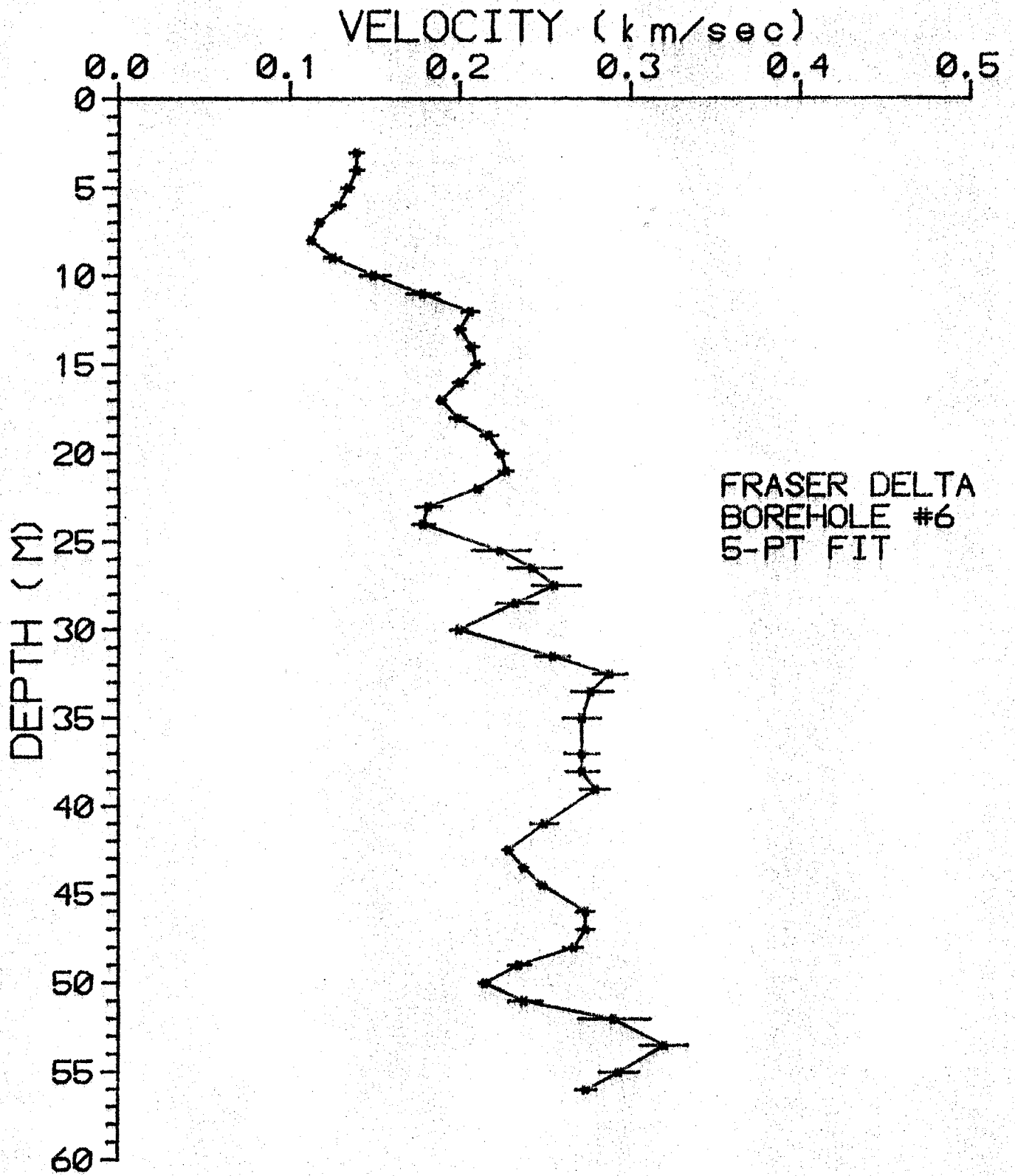


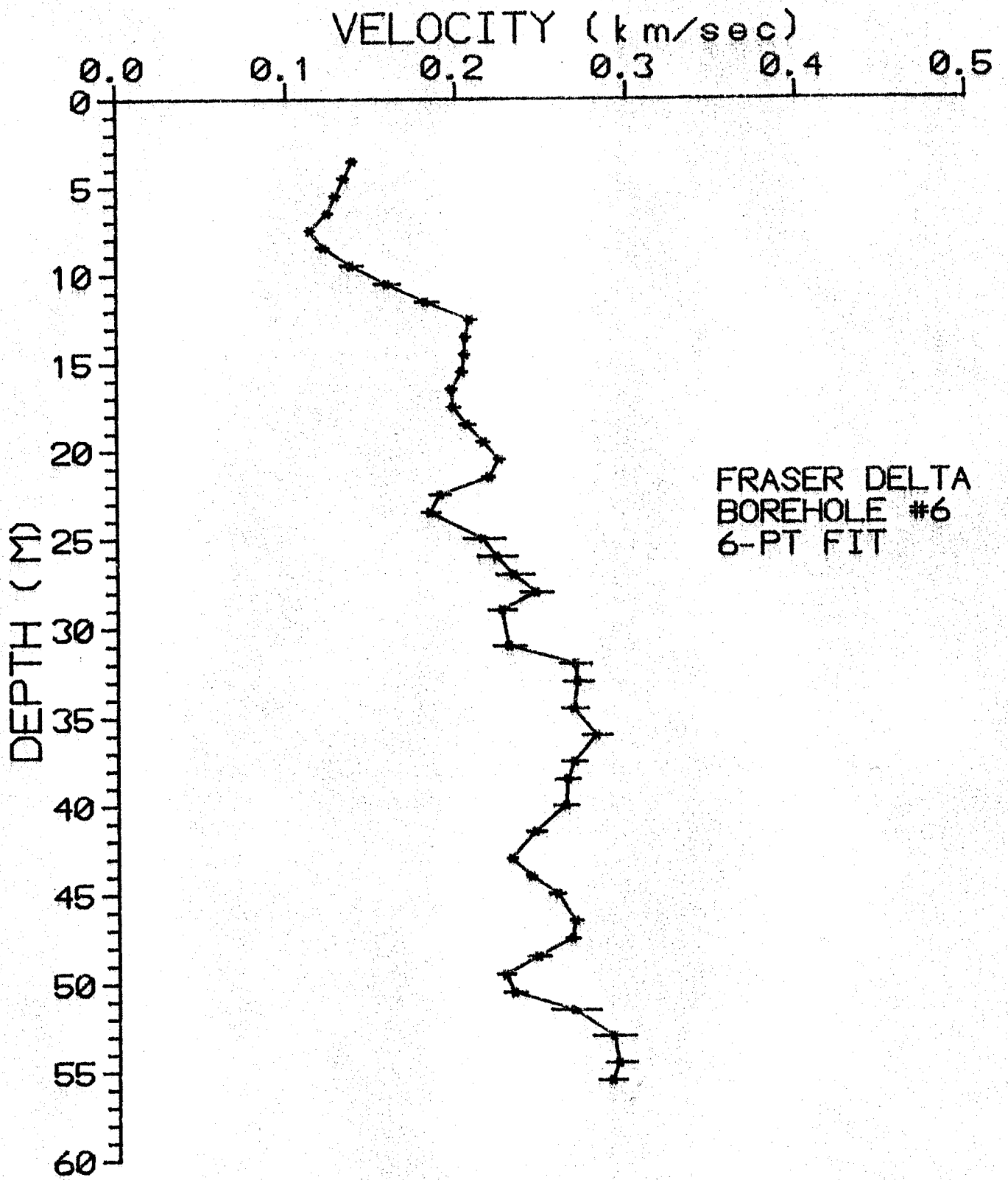


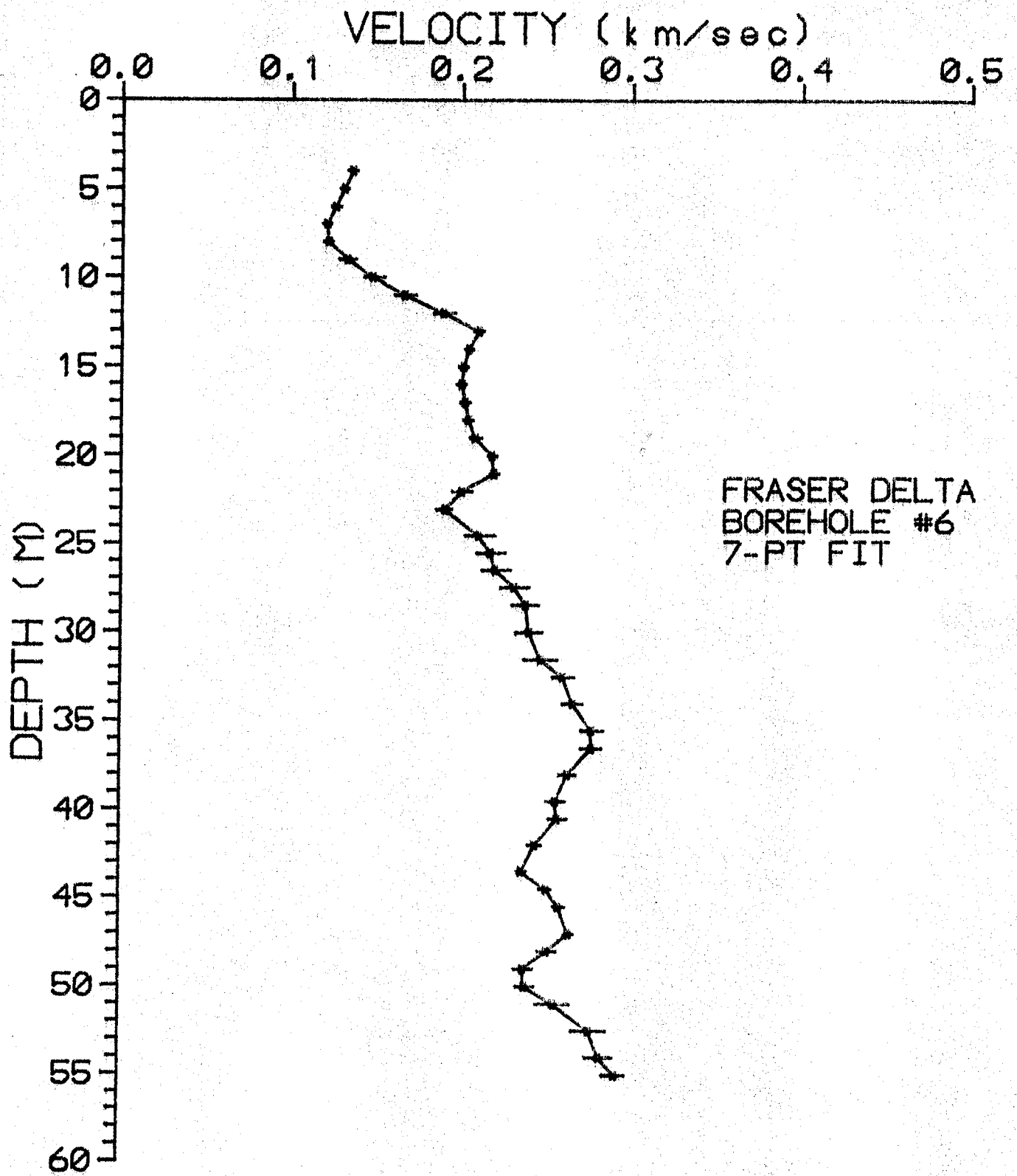


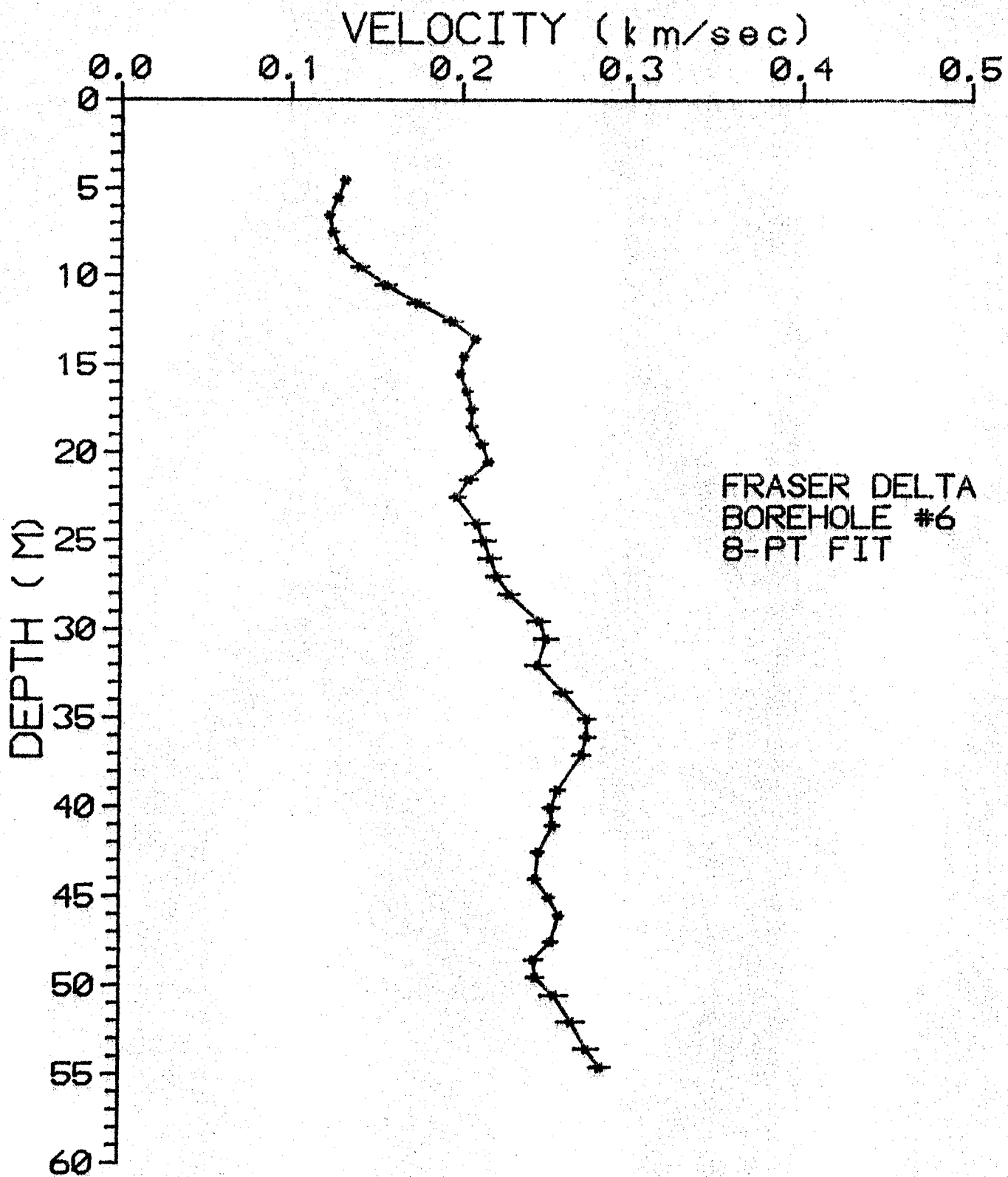












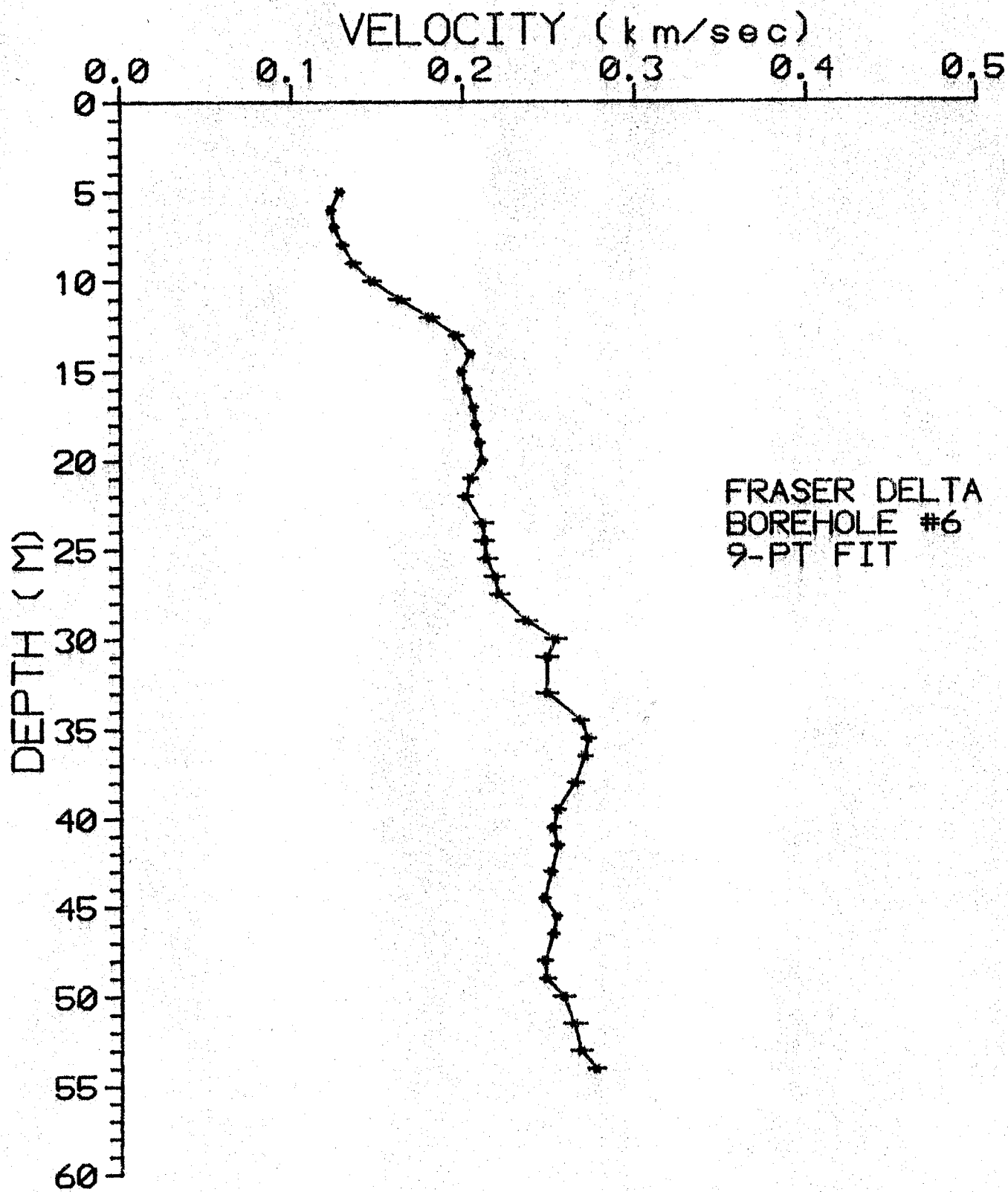


TABLE I

FRASER DELTA BH#1

Depth (m)	Travel Time (ms)	Depth (m)	Travel Time (ms)
1.0	32.4	12.5	99.6
1.5	34.2	13.0	102.0
2.0	36.3	13.5	104.4
2.5	38.7	14.0	107.7
3.0	45.0	14.5	111.9
3.5	49.2	15.0	113.7
4.5	54.9	15.5	114.9
5.0	57.3	16.0	116.4
5.5	60.3	17.0	123.6
6.5	66.0	17.5	126.6
7.0	68.7	18.0	128.4
7.5	70.8	19.0	131.4
8.0	75.0	19.5	135.3
8.5	77.4	20.0	138.3
9.0	79.8	20.5	141.3
9.5	82.2	21.0	141.3
10.0	85.8	21.5	145.8
10.5	87.3	22.0	149.7
11.0	91.8	22.5	151.5
11.5	95.1	23.0	153.6
12.0	96.9		

TABLE II

FRASER DELTA BH#2

Depth (m)	Travel Time (ms)	Depth (m)	Travel Time (ms)	Depth (m)	Travel Time (ms)
1.0	7.0	161.5	273.5	52.0	273.5
2.0	14.0	166.5	280.0	54.0	280.0
3.0	21.5	170.0	286.0	56.0	286.0
4.0	28.5	183.0	289.5	57.0	289.5
5.0	44.5	188.0	292.0	58.0	292.0
6.0	48.5	195.5	295.0	59.0	295.0
7.0	54.0	196.5	298.5	60.0	298.5
8.0	62.5	199.5			
9.0	69.5	208.0			
11.0	79.5	210.0			
12.0	88.0	214.5			
13.0	96.5	220.0			
14.0	97.5	225.0			
15.0	105.0	229.5			
16.0	111.0	230.5			
17.0	118.0	239.0			
19.0	125.0	242.0			
21.0	134.0	248.0			
22.0	140.0	253.5			
23.0	145.0	257.0			
24.0	151.0	264.0			
25.0	157.0	270.0			
		26.0			
		27.0			
		28.0			
		30.0			
		32.0			
		33.0			
		34.0			
		35.0			
		36.0			
		37.0			
		38.0			
		39.0			
		40.0			
		41.0			
		42.0			
		43.0			
		44.0			
		46.0			
		47.0			
		48.0			
		50.0			
		51.0			

TABLE III

FRASER DELTA BH#3

Depth (m)	Travel Time (ms)	Depth (m)	Travel Time (ms)	Depth (m)	Travel Time (ms)
1.0	33.5	25.0	140.0	48.0	233.0
2.0	38.5	26.0	144.0	49.0	238.0
3.0	41.5	27.0	148.0	50.0	242.0
4.0	45.5	28.0	151.5	51.0	246.0
5.0	49.0	29.0	156.0	52.0	250.0
6.0	52.0	30.0	161.5	53.0	254.0
7.0	56.0	31.0	166.5	54.0	258.0
8.0	65.5	32.0	170.0	55.0	261.5
9.0	72.0	33.0	175.0	56.0	266.0
10.0	74.5	34.0	179.0	57.0	269.5
12.0	83.5	35.0	183.0	58.0	272.5
13.0	90.5	37.0	188.5	59.0	275.5
14.0	94.0	38.0	192.5	61.0	285.0
15.0	98.0	39.0	196.5	62.0	288.0
16.0	102.0	40.0	201.0	63.0	290.0
17.0	105.5	41.0	206.0	64.0	293.5
18.0	109.5	42.0	212.0	65.0	297.5
19.0	117.0	43.0	215.5	66.0	300.0
20.0	125.0	44.0	219.5	67.0	304.5
22.0	130.5	45.0	223.0	68.0	307.5
23.0	134.5	46.0	227.0	70.0	311.0
24.0	138.5	47.0	230.0		

TABLE IV

FRASER DELTA BH#4

Depth (m)	Time (ms)	Depth (m)	Time (ms)	Depth (m)	Time (ms)	Depth (m)	Time (ms)
1.0	34.5	24.0	146.5	48.0	248.5	73.0	335.5
2.0	40.5	25.0	152.0	49.0	253.6	75.0	343.5
3.0	49.5	26.0	157.0	50.0	256.0	76.0	346.5
4.0	51.0	27.0	163.5	51.0	260.5	77.0	350.0
5.0	56.5	28.0	169.0	52.0	264.0	78.0	352.5
6.0	61.5	29.0	173.0	53.0	268.0	79.0	356.0
7.0	66.5	30.0	177.0	54.0	272.0	80.0	360.0
8.0	67.5	31.0	180.0	55.0	275.0	81.0	362.5
9.0	75.5	32.0	185.0	56.0	277.5	82.0	366.0
10.0	79.5	34.0	193.5	58.0	285.5	83.0	368.0
11.0	85.0	35.0	198.0	59.0	289.0	84.0	371.5
12.0	88.5	36.0	202.0	60.0	292.5	85.0	376.0
13.0	94.5	38.0	211.0	61.0	295.5	86.0	378.5
14.0	101.5	39.0	215.0	62.0	299.5	87.0	382.0
15.0	107.5	40.0	219.0	63.0	303.0	88.0	384.5
17.0	116.5	41.0	222.5	64.0	306.5	90.0	389.5
18.0	119.0	42.0	224.5	65.0	310.5		
19.0	124.0	43.0	229.0	66.0	313.5		
20.0	128.0	44.0	233.0	67.0	317.5		
21.0	133.5	45.0	238.0	68.0	321.5		
22.0	139.5	46.0	241.0	69.0	324.5		
23.0	143.5	47.0	244.0	71.0	330.0		

TABLE V
FRASER DELTA BH#5

Depth (m)	Time (ms)	Depth (m)	Time (ms)	Depth (m)	Time (ms)	Depth (m)	Time (ms)	Depth (m)	Time (ms)
0.5	18.3	13.0	101.4	27.5	173.4	52.0	250.0	84.0	331.5
1.0	20.4	13.5	104.4	28.5	177.9	53.0	252.0	85.0	333.0
1.5	22.5	14.5	108.6	29.5	180.3	54.0	254.0	86.0	335.0
2.5	29.4	15.0	110.7	30.0	181.8	55.0	260.0	87.0	337.5
3.0	36.3	15.5	113.1	31.0	187.5	57.0	265.0	88.0	339.5
3.5	40.2	16.0	114.9	32.0	191.5	58.0	267.5		
4.0	47.4	16.5	116.4	33.0	195.0	60.0	272.5		
4.5	51.6	17.0	118.5	34.0	199.0	61.0	273.0		
5.0	54.6	17.5	120.3	35.0	203.0	64.0	282.5		
5.5	57.0	18.5	122.1	36.0	207.5	65.0	285.0		
6.0	61.2	19.0	123.9	37.0	210.5	66.0	288.0		
6.5	65.7	20.0	129.9	38.0	213.5	68.0	293.0		
7.0	70.2	20.5	131.7	39.0	217.0	71.0	300.5		
7.5	74.4	21.5	140.1	40.0	220.0	73.0	307.0		
8.0	77.4	22.0	145.5	41.0	223.0	75.0	311.5		
8.5	84.0	23.0	151.5	42.0	226.0	76.0	314.0		
9.5	86.4	24.0	156.0	43.0	229.0	78.0	317.5		
10.0	87.6	24.5	158.4	44.0	232.0	79.0	318.5		
11.0	91.5	25.0	159.6	45.0	234.0	80.0	320.5		
11.5	93.6	25.5	163.5	46.0	236.0	81.0	322.5		
12.0	95.4	26.0	168.3	47.0	238.0	82.0	326.0		
12.5	98.4	26.5	170.1	49.0	243.0	83.0	329.0		

TABLE VI
FRASER DELTA BH#6

Depth (m)	Time (ms)	Depth (m)	Time (ms)	Depth (m)	Time (ms)
1.0	26.5	23.0	145.5	50.0	256.0
2.0	29.5	24.0	151.0	51.0	261.5
3.0	34.0	25.0	159.0	52.0	266.0
4.0	41.0	26.0	162.5	53.0	268.0
5.0	45.0	28.0	167.5	54.0	270.0
6.0	52.0	29.0	174.0	56.0	278.0
7.0	60.0	30.0	179.0	58.0	286.0
8.0	68.0	31.0	183.0	59.0	289.0
9.0	76.0	32.0	188.0		
10.0	85.5	34.0	193.5		
11.0	89.0	35.0	196.5		
12.0	93.5	36.0	202.5		
13.0	99.0	38.0	209.5		
14.0	104.0	40.0	215.0		
15.0	108.0	41.0	220.0		
16.0	112.5	42.0	224.5		
17.0	118.0	44.0	233.0		
18.0	123.5	45.0	237.0		
19.0	128.5	46.0	241.0		
20.0	132.0	47.0	244.5		
21.0	136.5	48.0	247.5		
22.0	141.5	49.0	252.0		

TABLE VII

APPROXIMATE BOREHOLE LOCATIONS IN U.T.M.

(MAPSHEETS MCE 349, MCE 351)

<u>HOLE</u>	<u>NORTHING</u>	<u>EASTING</u>
#1	5434150	492050
#2	5444600	485800
#3	5433275	495120
#4	5433210	494250
#5	5432650	492080
#6	5433200	494630

