CLIFFS MINERALS, INC.
EASTERN GAS SHALES PROJECT
KENTUCKY #1 WELL - PERRY COUNTY
PHASE III REPORT
SUMMARY OF LABORATORY ANALYSES AND MECHANICAL CHARACTERIZATION RESULTS
OCTOBER 1982

TABLE OF CONTENTS

	Page No.
Summary of Mechanical Characterization Results	1
I. Introduction	3
Table 1: Formations Tested	
II. Results	5
Table 2: Frequency Distribution of Preferred Direction of Fracturing	
A. Berea	6
B. Cleveland Shale	7
C. Chagrin Shale	8
D. Upper Huron Shale	9
E. Middle Huron Shale	10
F. Lower Huron Shale	11
G. Olentangy	12
H. Lower Olentangy	13
I. Well Composite	14
III. **Conclusions**	15

APPENDICES

A. Results of Directional Ultrasonic Velocity Measurements	17
Figures: Histograms of Average Velocity	
B Results of Point Load Tests	30
C Results of Directional Tensile Strength Tests	31
Figures: Histograms of Average Tensile Strength	
D Results on Selected Samples	40
FigureD-l Gamma Ray and Bulk Density Logs	40
Table D-l Visible Fractures	41
Table D-2 Whole-Core Analysis	42
Table D-3 Directional Permeability Data	43
Table D-4 Modulus Measurements	44

Summary of Mechanical Characterization Results

The purpose of mechanical characterization of samples from the EGSP-Kentucky #1 core is to determine the orientation of preferred planes of weakness in the Devonian gas shales at the Perry County well site.

The physical property tests employed were: 1) directional ultrasonic velocity measurements; 2) point load induced fracturing; and 3) directional tensile strength tests.

In point load testing, fractures induced by applying a point load to the central axis of a disc are assumed to propagate parallel to the preferred direction of fracturing. Point load induced fractures indicate N300E+15° as the preferred direction of fracturing in 26 out of 120 total induced fractures.

In ultrasonic velocity testing, minimum velocity values are assumed to be perpendicular to the preferred direction of fracturing because large numbers of microcracks encountered along this direction will impede propagation of the sonic wave. Ultrasonic velocity measurements indicate N300E±l5° as the preferred direction of fracturing inl4 out of 45 total velocity samples.

In directional tensile strength testing, compressive loads are applied across the diameter of the specimen in order to induce diametrical fractures and thus determine tensile strength normal to the loading axis. Samples from a given interval are tested with the loading axis in six different orientations by this method. The preferred direction of fracture

will be parallel to the loading axis in the specimen for which the lowest tensile strength value was obtained. The twenty-five sets of directional tensile strength measurements do not indicate a statistically significant preferred direction of fracturing in this well.

INTRODUCTION

The purpose of mechanical characterization of samples from the EGSP-Kentucky #1 core is to determine the direction of preferred planes of weakness in the Devonian gas shales at the Perry County well site.

A series of samples, representing 338 feet of core taken from the Kentucky #1 well, were tested by other contractors through MERC in Morgantown, West Virginia. The raw lab data was interpreted and put into report form by the Rock Mechanics Research Facility at Michigan Technological University, Houghton, Michigan. The tested core interval extends from 2,369 feet to 2,707 feet below surface and are summarized in Table 1.

RESULTS

The results of the physical property measurements of directional ultrasonic velocity, point load induced fracturing, and directional tensile strength tests are compiled in Appendices A, Band C respectively. Appendix D contains all other tests performed on selected samples. The point load index was not calculated; the distance between load platens at failure had not been recorded. Table 2 is a summary of the mechanical property testing results for each stratigraphic formation.

TABLE 2

EGSP-Kentucky #1, Core
Perry County
Frequency Distribution of Preferred Direction of Fracturing

Formation	Test	Orientation in Degrees East of North						
		0°	30°	60°	90°	120°	150°	Total
Berea Shale	Point Load	0	0	0	1	0	0	1
2,369'-2,371' tested	DTS	0	0	1	0	0	0	1 set
Cleveland Shale	Velocity	0	3	2	2	1	1	9
2,376'-2,432' tested	Point Load	0	3	1	3	2	0	9
	DTS	1	1	0	4	1	0	7 sets
Chagrin Shale	Velocity	0	1	1	0	0	1	3
2,436'-2,453' tested	Point Load	0	0	1	0	0	0	1
	DTS	0	1	1	0	0	0	2 sets
Upper Huron Shale	Velocity	1	4	2	0	0	2	9
2,458'-2,526'	Point Load	0	13	3	1	2	0	19
	DTS	3	0	2	0	0	0	5 sets
Middle Huron Shale	Velocity	0	2	1	0	0	1	4
2,532.3'-2,588' tested	Point Load	5	3	0	4	1	7	20
	DTS	1	2	0	0	0	1	4 sets
Lower Huron Shale	Velocity	4	4	0	2	4	2	16
2,589'-2,671' tested	Point Load	9	5	6	4	7	10	41
	DTS	0	1	1	2	2	0	6 sets
01entangy Shale	Velcoity	0	0	0	0	2	0	2
2,672'-2,683' tested	Point Load	1	0	0	1	2	0	4
Lower Olentangy Shale	Velocity	0	0	1	0	0	1	2
2,685'-2,707' tested	Point Load	8	2	-1	1	6	7	25
Well Composite	Velocity	5	14	7	4	7	8	45
2,369'-2,707' tested	Point Load	23	26	12	15	20	24	·120
	DTS	5	5	5	6	3	1	25

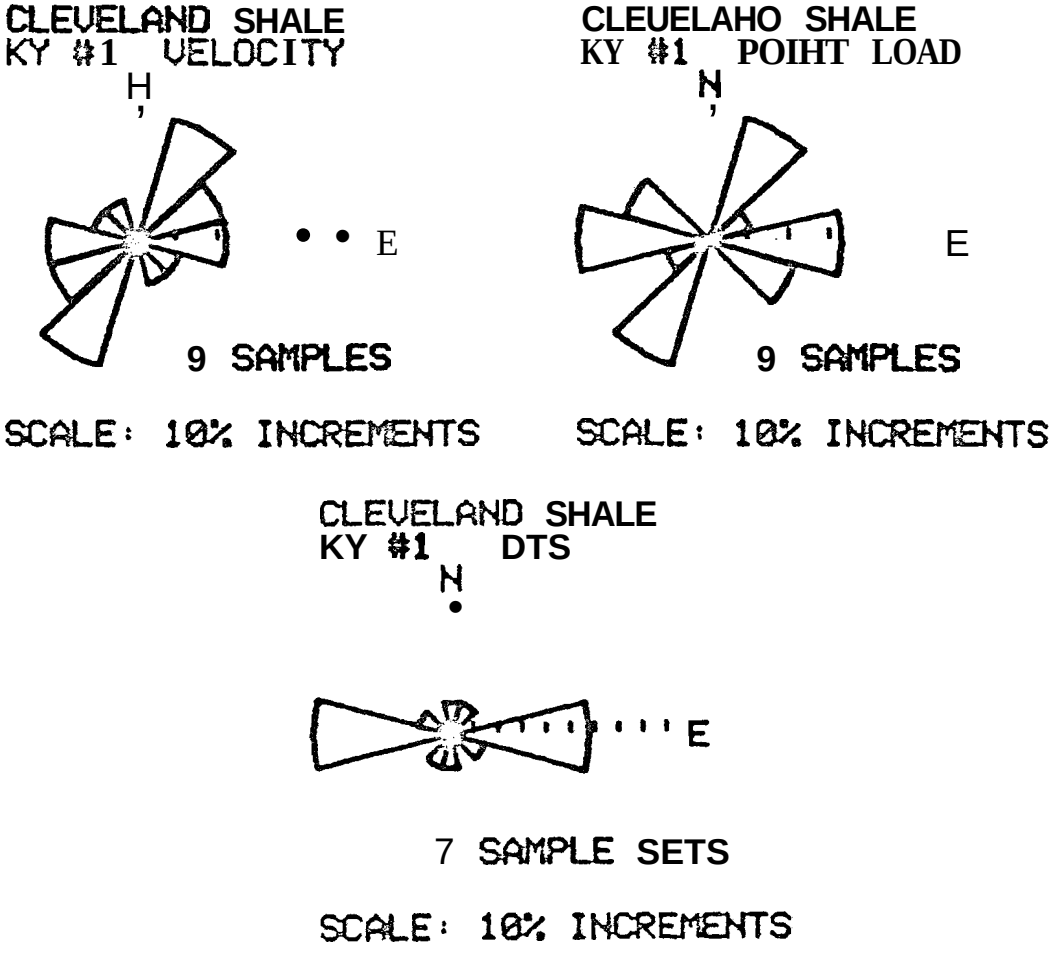
Berea; 2,369 to 2,371 feet tested:

The one point load induced fracture indicates N90oE+lSo as the preferred direction of fracture. The one directional tensile strength set of samples indicate N60oE+lSo as the preferred plane of weakness. Tabulated results are presented in Appendices Band C.

Cleveland Shale; 2,376 to 2,432 feet tested:

Ultrasonic velocity measurements indicate N30oE+15° as the preferred direction of fracturing in three out of nine velocity samples. Point load induced fractures indicate N30oE+15° and N90oE+15° as the preferred directions of fracturing (both three out of nine induced fractures). Directional tensile strength measurements indicate N90oE+15° as the preferred plane of weakness in four out of the seven sets of samples. Figure 1 illustrates the frequency distribution rose diagrams of preferred direction of fracturing in the Cleveland Shale. Tabulated results are presented in Appendices A, Band C.

FIGURE 1
Cleveland Shale
Frequency Distribution Rose Diagrams of Results

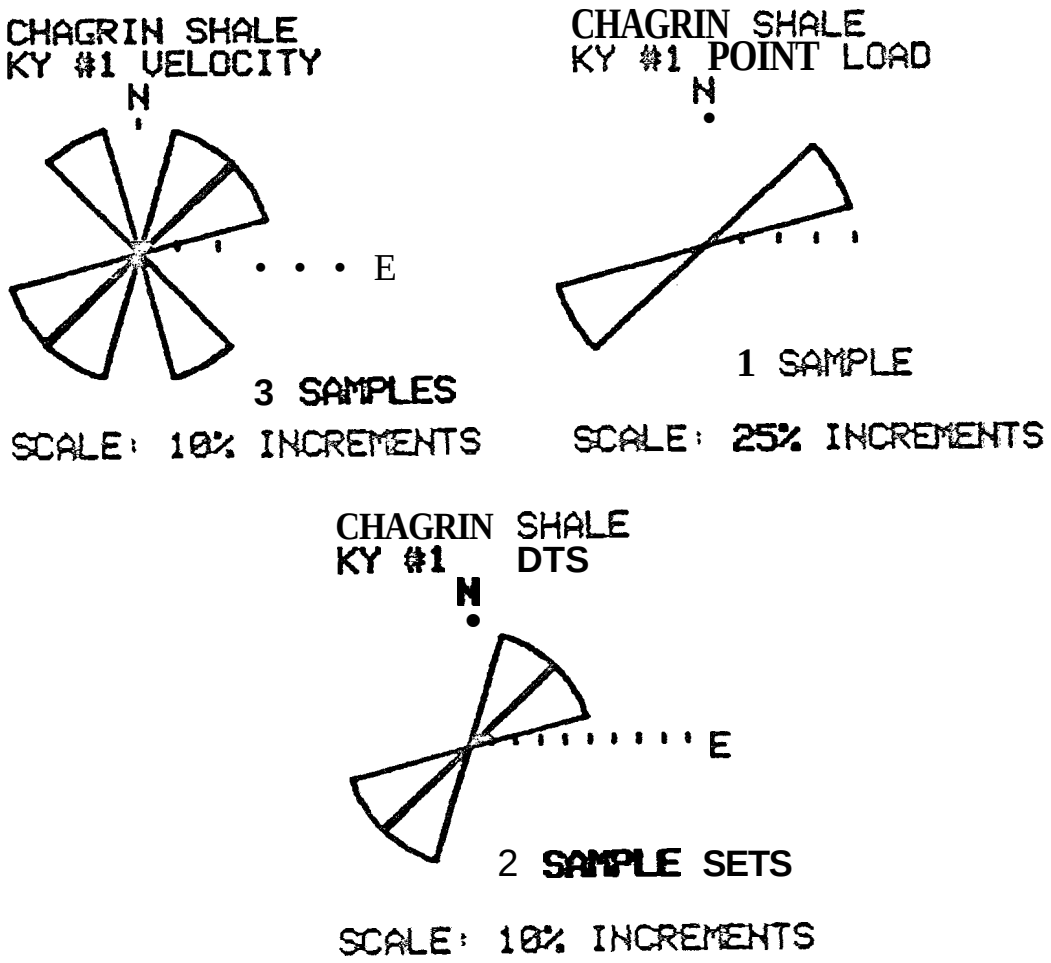


Chagrin Shale; 2,436 to 2,453 feet tested:

The three ultrasonic velocity measurements do not indicate a statistically significant preferred direction of fracturing. The one point load induced fracture was in the N60oE+15° direction. The two sets of directional tensile strength measurements indicate N30oE+1So and N60°E+15° directions as the preferred planes of weakness. Figure 2 illustrates the frequency distribution rose diagrams of preferred direction of fracturing in the Chagrin Shale. Tabulated results are presented in Appendices A, B and C.

FIGURE 2

Chagrin Shale
Frequency Distribution Rose Diagrams of Results

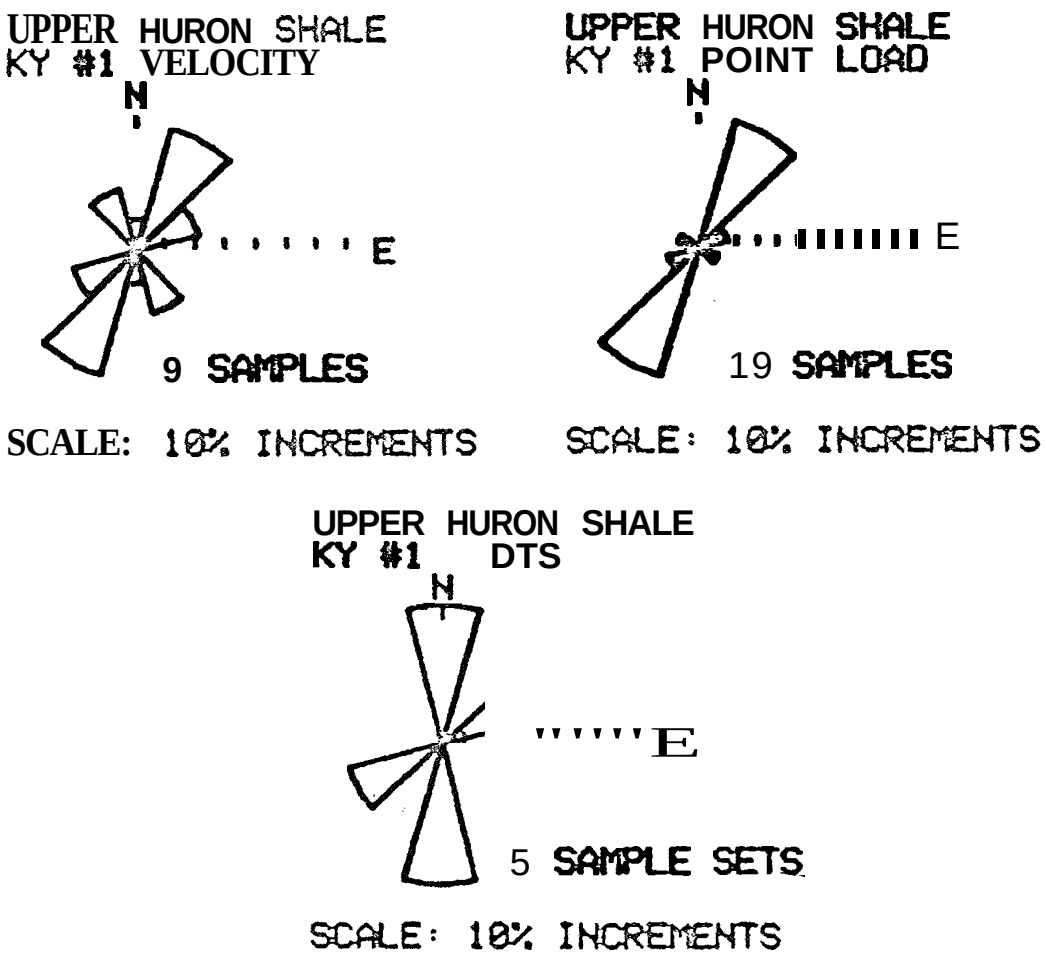


Upper Huron Shale; 2,458 to 2,526 feet tested:

Four out of the nine ultrasonic velocity measurements indicate N300E+15° as the preferred direction of fracturing. Point load induced fractures occur most frequently in the N30oE±15° orientation (13 out of 19 induced fractures). The five sets of directional tensile strength measurements do not indicate a statistically significant preferred plane of weakness. Figure 3 illustrates the frequency distribution rose diagrams of preferred direction of fracturing in the Upper Huron. Tabulated results are presented in Appendices A, Band C.

FIGURE 3

Upper Huron Shale
Frequency Distribution Rose Diagrams of Results

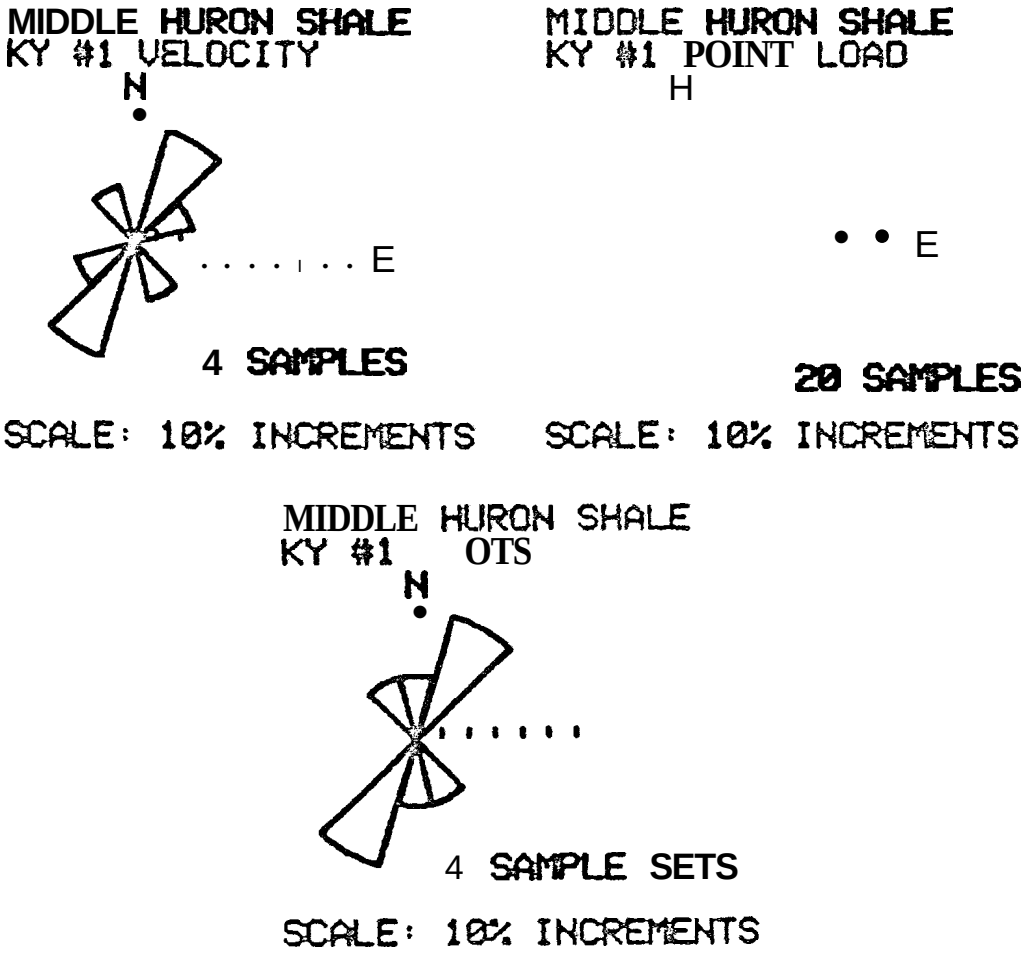


Middle Huron Shale; 2,532.3 to 2,588 feet tested:

Two out of the four ultrasonic velocity measurements and two out of the four sets of directional tensile strength measurements indicate N300E+15° as the preferred direction of fracturing. The twenty point load induced fractures do not indicate a statistically significant preferred direction of fracturing. Figure 4 illustrates the frequency distribution rose diagrams of preferred direction of fracturing in the Middle Huron Shale. Tabulated results are presented in Appendices A, Band C.

FIGURE 4

Middle Huron Shale
Frequency Distribution Rose Diagrams of Results

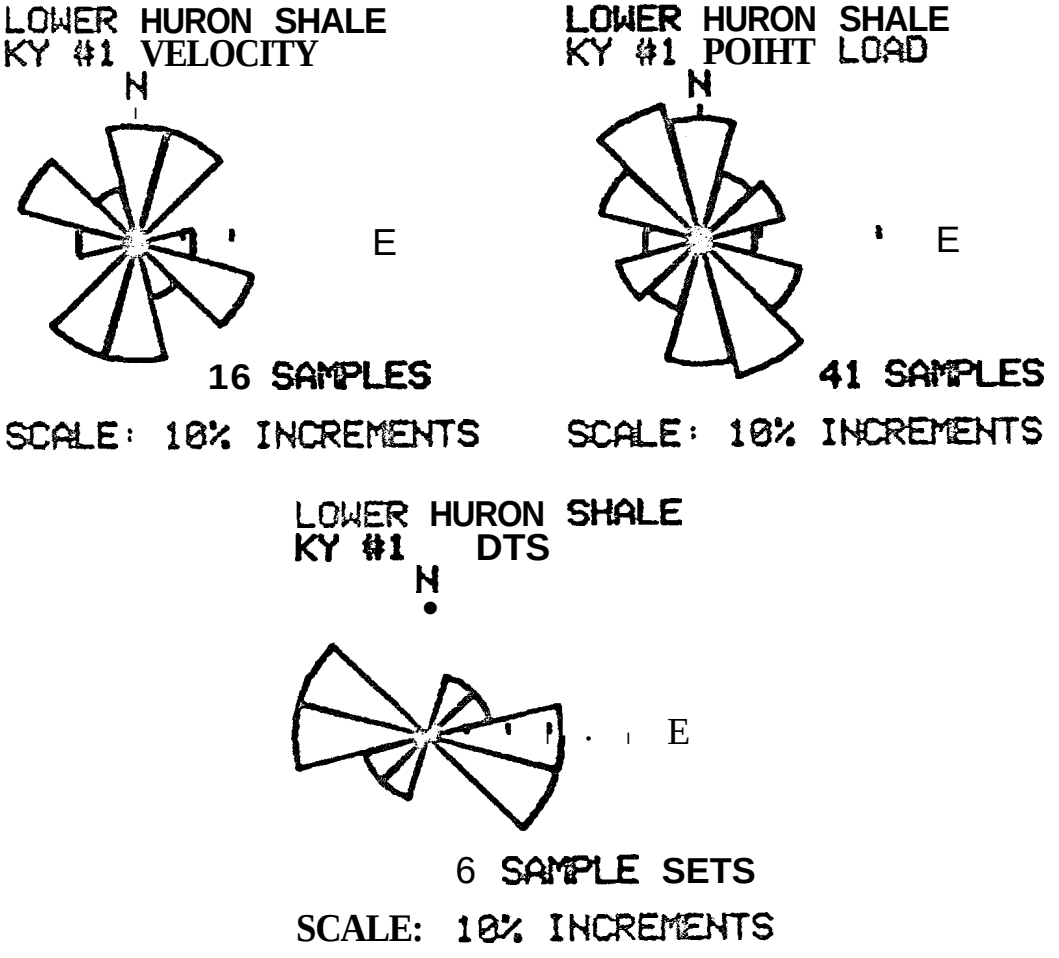


Lower Huron Shale; 2,589 to 2,671 feet tested:

Ten out of the 41 point load induced fractures occur in the N150oE+15° direction. The sixteen ultrasonic velocity samples and the six sets of directional tensile strength measurements do not indicate a statistically significant preferred plane of weakness. Figure 5 illustrates the frequency distribution rose diagrams of preferred direction of fracturing in the Lower Huron Shale. Tabulated results are presented in Appendices A, B and C.

FIGURE 5

Lower Huron Shale
Frequency Distribution Rose Diagram of Results

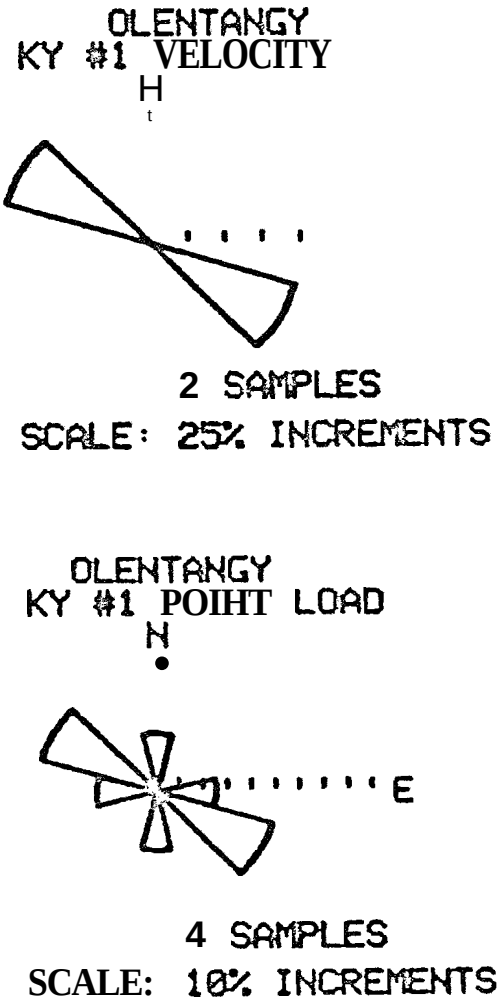


Olentangy Shale; 2,672 to 2,683 feet tested:

The two ultrasonic velocity measurements and two out of the four point load induced fractures indicate N120oE+15° as the preferred direction of fracturing. Figure 6 illustrates the frequency distribution rose diagrams of preferred direction of fracturing in the Olentangy. Tabulated results are presented in Appendices A and **B.**

FIGURE 6

Olentangy Shale
Frequency Distribution Rose Diagrams of Results

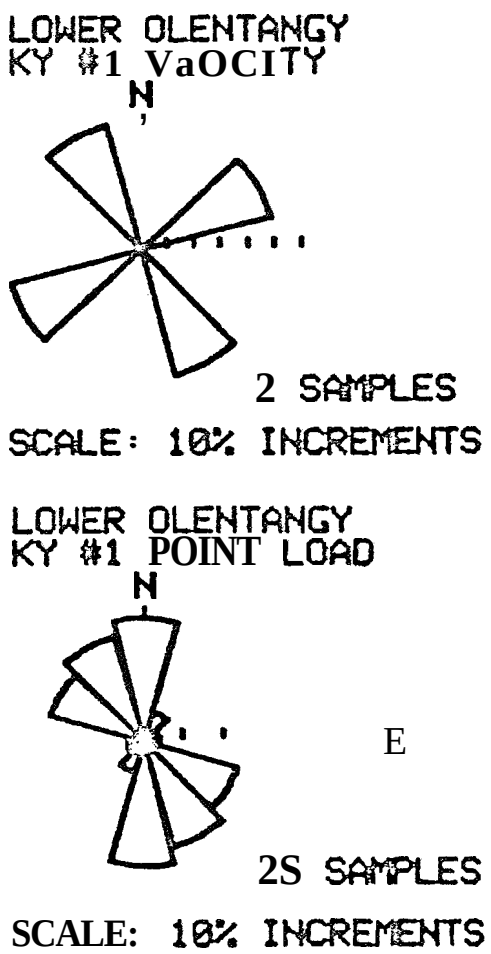


Lower Olentangy Shale; 2,685 to 2,707 feet tested:

The two ultrasonic velocity measurements indicate N60Eo+lSo and N150Eo±15° as the preferred directions of fracturing. Point load induced fractures indicate N1SOoE+45° as the preferred directions of fracturing in a sum of 21 out of 25 induced fractures. Figure 7 illustrates the frequency distribution rose diagrams of preferred direction of fracturing in the Lower Olentangy. Tabulated results are presented in Appendices A and **B.**

FIGURE 7

Lower Olentangy Shale
Frequency Distribution Rose Diagrams of Results

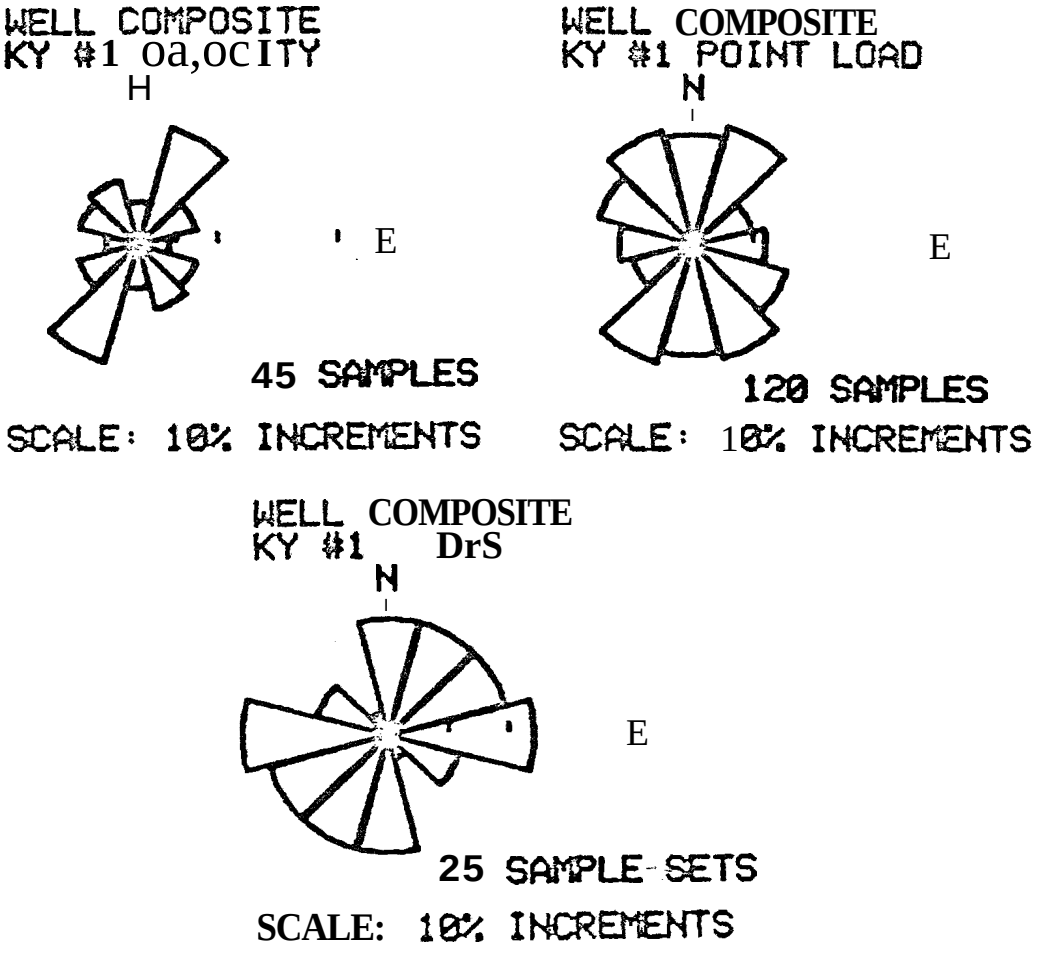


Kentucky #1, Well Composite; 2,369 to 2,707 feet tested:

Ultrasonic velocity measurements and point load fractures indicate N30E$^{O+15°}$ as the preferred direction of fracturing (14 out of 45 total velocity samples and 26 out of 120 total induced fractures). The twenty-five sets of directional tensile strength measurements do not indicate a statistically significant preferred direction of fracturing. Figure 8 illustrates the frequency distribution rose diagrams of preferred direction of fracturing in the EGSP-Kentucky #1 Perry County well composite. Tabulated results are presented in Appendices A, Band C.

FIGURE 8

Kentucky #1 Well Composite; 2,369' - 2,707' Tested
Frequency Distribution Rose Diagrams of Results



CONCLUSIONS

The data presented in this report indicate that core samples from the EGSP-Kentucky #1 well exhibit a directional variation in physical properties. Prediction of the preferred direction of induced fracturing at the Perry County well site was based on inherent weaknesses in the core samples found by: (1) point load induced fractures; (2) directional tensile strength measurements; and (3) normality to measured ultrasonic velocity minimums. These tests were performed through the Morgantown Energy Technology Center. The raw lab data was interpreted and put into report form by the Rock Mechanics Research Facility at Michigan Technological University, Houghton, Michigan. The overall agreement between these tests in each stratigraphic interval suggests that these physical property measurements do indicate a preferred direction of fracturing in core samples.

The following conclusions may be drawn from this data:

(1) The preferred direction of fracturing in the Berea (2,369 to 2,371 feet tested) is N90°E+1S° as indicated by the one point load induced fracture and N60°E+1S° as indicated by the one set of directional tensile strength measurements.

(2) The preferred direction of fracturing in the Cleveland Shale (2,376 to 2,432 feet tested) is N30°E+1S° as indicated by point load induced fracturing and ultrasonic velocity measurements and N90°E+1S° as indicated by directional tensile strength measurements and point load induced fractures.

CONCLUSIONS Continued

(3) The preferred direction of fracturing in the Chagrin Shale (2,436 to 2,453 feet tested) is N60oE+15° as indicated by ultrasonic velocity measurements, point load induced fracturing and directional tensile strength measurements.

(4) The preferred direction of fracturing in the Upper Huron Shale (2,458 to 2,526 feet tested) is N30oE+15° as indicated by ultrasonic velocity measurements and point load induced fractures.

(5) The preferred direction of fracturing in the Middle Huron Shale (2,532.3 to 2,588 feet tested) is N30oE+15° as indicated by ultrasonic velocity measurements and directional tensile strength tests. Point load induced fractures occur most frequently in the N150oE+15° direction.

(6) The preferred direction of fracturing in the Lower Huron Shale (2,589 to 2,671 feet tested) is N150oE+4So as indicated by the point load induced fracturing.

(7) The preferred direction of fracturing in the 01entangy (2,672 to 2,683 feet tested) is N120oE+lSo as indicated by ultrasonic velocity measurements and point load induced fracturing.

(8) The preferred direction of fracturing in the Lower Olentangy (2,685 to 2,707 feet tested) is N150oE+45° as indicated by point load induced fracturing.

WELL # 1 IN KENTUCKY TABLE A-I

DIRECTIONAL P WAVE VELOCITIES

AVERAGE VELOCITIES IN KM/SEC & ORIENTATION IN DEGREES EAST OF NORTH

	DEPTH IN FEET	0 DEG	30 DEG	60 DEG	90 DEG	120 DEG	150 DEG
Cleveland	2378.7	3.879	4.051	3.797	3.846	3.832	3.877
	2391.3	4.154	4.192	4.225	4.21	4.199	4.1'7
	2392.5	4.313	4.299	4.305	4.339	4.332	4.333
	2401.5	4.419	4.444	4.445	4.395	4.385	4.374
	2406.7	4.551	4.56	4.566	4.612	4.508	4.517
	2415.2	4.273	4.309	4.323	4.287	4.24	4.258
	2420.5	4.42	4.438	4.4'79	4.513	4.551	4.496
	2425.7	4.566	4.59	4.588	4.518	4.495	4.445
	2432.1	4.558	4.614	4.667	4".601	4.544	4.58
Chagrin	2436.4	5.041	5.031	4.985	5.164	5.054	5.045
	2445.7	4.551	4.576	4.575	4.446	4.437	4.407
	2451.6	4.413	4.441	4.496	4.344	4.192	4.33
Upper Huron	2465.2	4.525	4.51	4.5	4.518	4.498 "	4.503
	2470	4.479	4.499	4.512	4.481	4.362	4.281
	2477.4	4.458	4.556	4.399	4.335	4.303	4.396
	2487.6	4.213	4.205	4.215	4.221	4.206	4.196
	2498.2	4.451	4.55	4.301	4.032	4.342	4.394
	2504	4.341	4.423	4.299	4.325	4.319	4.312
	2511.5	4.415	4.41	4.38	4.383	4.443	4.395
	2518.7	4.468	4.523	4.424	4.41	4.367	4.43
	2526.6	4.62	4.71	4.712	4.593	4.57	4.589
Middle Huron	2532.3	4.644	4.684	4.686	4.635	4.755	4.632
	2543.3	4.438	4.451	4.438	4.295	4.272	4.407
	2571.2	4.662	4.71	4.715	4.668	4.605	4.644
	2583.2	4.615	4.595	4.273	4.428	4.463	4.6
Lower Huron	2591.1	4.556	4.511	4.474	4.459	4.52	4.55

TABLE A-I Continued

	KYf/l Cant.						
Lower Huron Cant.	2596.9	4.134	4.128	4.113	4.106	4.061	4.121
	2597.6	4.156	4.151	4.145	4.133	4.101	4.148
	2606.7	4.541	4.384	4.45	4.407	4.4	4.482
	2612.8	4.357	4.331	4.346	4.43	4.493	4.383
	2616	4.391	4.391	4.401	4.31	4.381	4.396
	2620.8	5.304	5.329	5.317	5.309	5.38	5.355
	2622.7	4.84	4.822	4.666	4.717	4.779	4.772
	2626.2	4.147	4.221	4.211	4.169	4.22	4.179
	2631.7	4.328	4.345	4.269	4.308	4.369	4.382
	2636.6	4.655	4.625	4.592	4.549	4.497	4.635
	2641.3	4.156	4.146	4.13	4.101	-i.ese	4.134
	2645.7	4.221	4.137	4.145	4.131	4.17	4.215
	2653	4.333	4.268	4.35	4.361	4.399	4.409
	2657.3	4.809	4.792	4.728	4.695	4.741	4.778
	2664	4.264	4.064	4.118	4.252	4.273	4.282
Olentangy	2672.9	4.968	4.929	4.937	5.014	4.994	4.994
	2678.3	5.023	5.012	5.035	5.032	5.057	5.05
Lower Olentangy	2687.5	5.1	5.067	5.077	5.063	5.114	5.053
	2693.5	4.957	4.95	4.942	4.953	4.965	4.98
	AVERAGE VELOCITY	4.505	4.511	4.483	4.469	4.473	4.487

TABLE A-2

ORIENTATION OF ULTRASONIC VELOCITY MINIMUM

WELL # 1 IN KENTUCKY

	DEPTH IN FEET	DEGREES EAST OF NORTH 0	30	60	90	120	150
Cleveland	2378.7			MIN			
	2391.3	MIN					
	2392.5		MIN				
	2401.5						MIN
	2406.7					MIN	
	2415.2					MIN	
	2420.5	MIN					
	2425.7						MIN
	2432.1					MIN	
Chagrin	2436.4			MIN			
	2445.7						MIN
	2451.6					MIN	

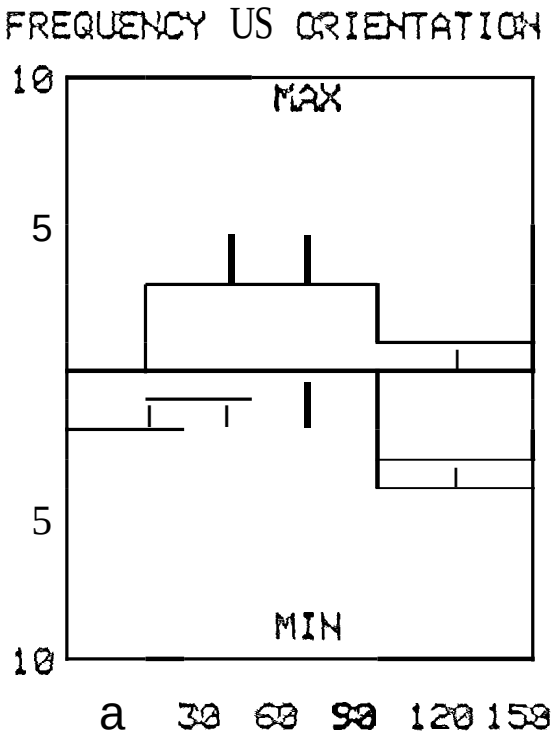


TABLE A-2 continued

ORIENTATION OF ULTRASONIC VELOCITY MINIMUM
WELL # 1 IN KENTUCI<Y

	DEPTH IN FEET	DEGREES EAST OF NORTH 0	30	60	90	120	150
Upper Huron	2465.2					MIN	
	2470						MIN
	2477.4					MIN	
	2487.6						MIN
	2498.2				MIN		
	2504			MIN			
	2511.5			MIN			
	2518.7					MIN	
	2526.6					MIN	
Middle Huron	2532.3						MIN
	2543.3					MIN	
	2571.2					MIN	
	2583.2			MIN			

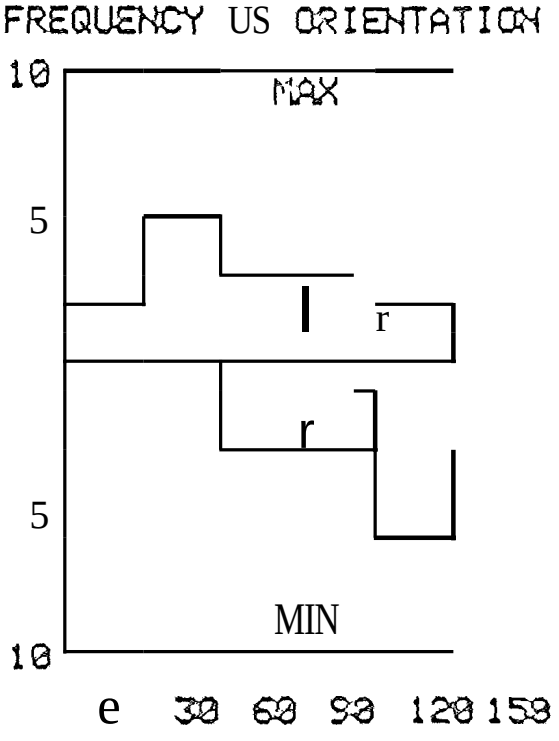


TABLE A-2 continued

ORIENTATION OF ULTRASONIC VELOCITY MINIMUM
WELL # 1 IN KENTUCKY

	DEPTH IN FEET	DEGREES EAST OF NORTH 0	30	60	90	120	150
Lower Huron	2591.1				MIN		
	2596.9					MIN	
	2597.6					MIN	
	2606.7		MIN				
	2612.8		MIN				
	2616				MIN		
	2620.8	MIN					
	2622.7			MIN			
	2626.2	MIN					
	2631.7			MIN			
	2636.6					MIN	
	2641.3					MIN	
	2645.7				MIH		
	2653		MIN				
	2657.3				MIH		
	2664		MIN				
Olentangy	2672.9		MIN				
	2678.3		MIN				
Lower Olentangy	2687.5						MIH
	2693.5			MIN			

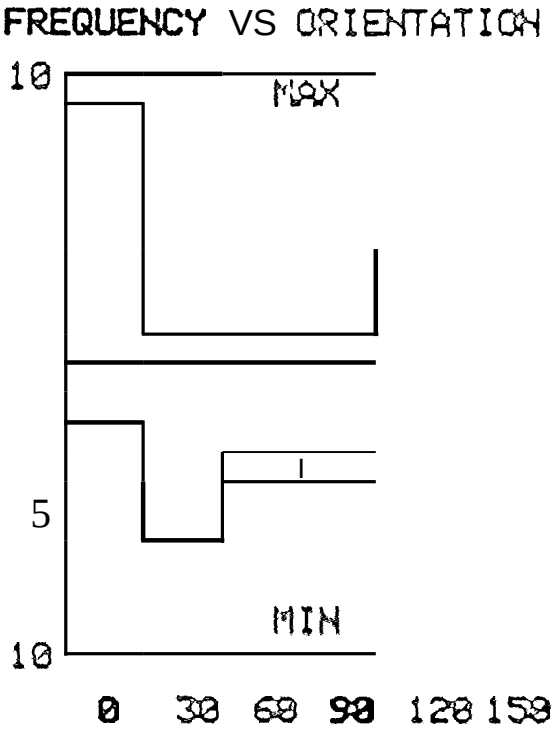


FIGURE A-I

ULTRASONIC VELOCITY US. ORIENTATION

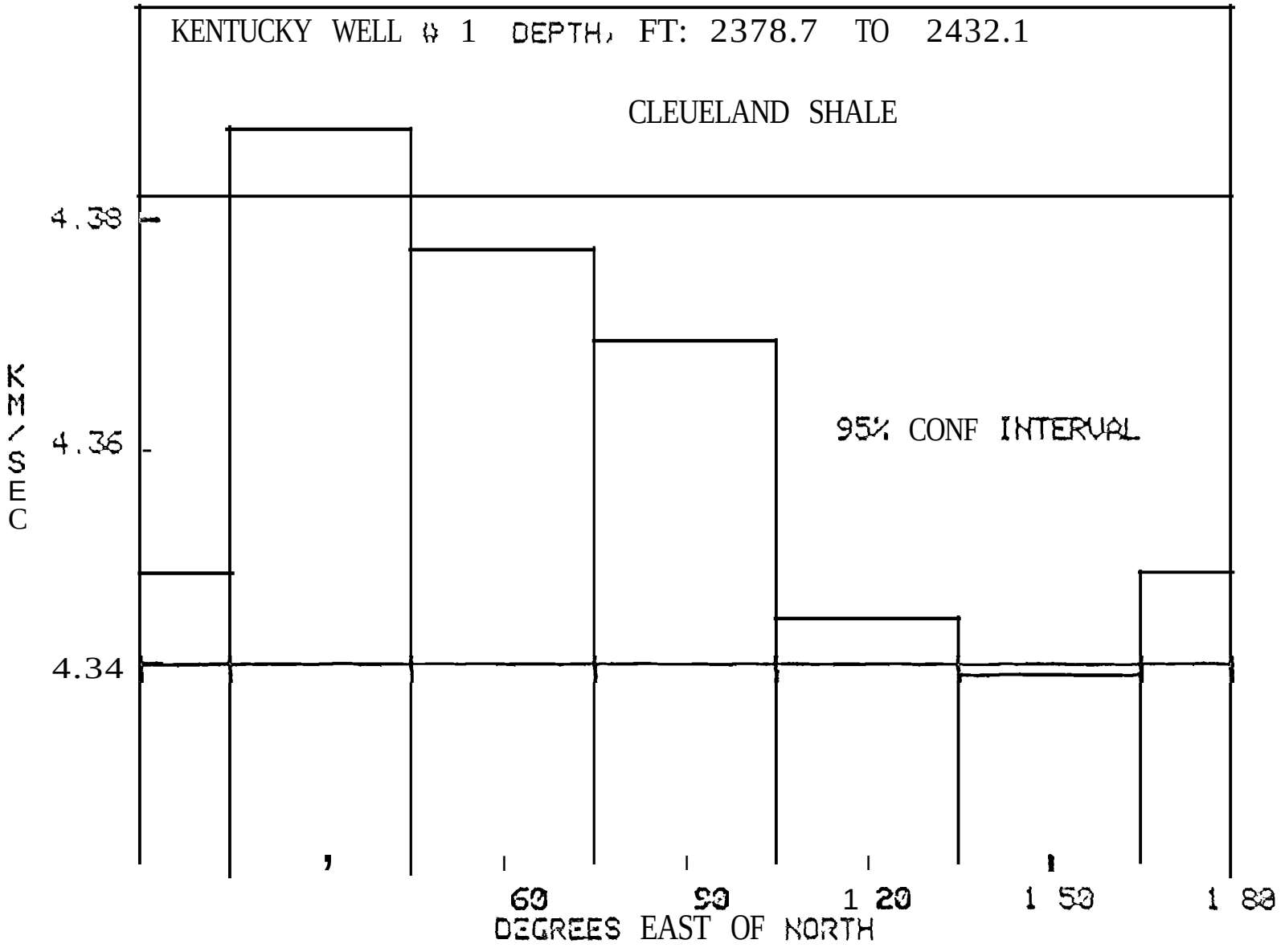


FIGURE A-2

ULTRASONIC UELOCITY US. ORIENTATION

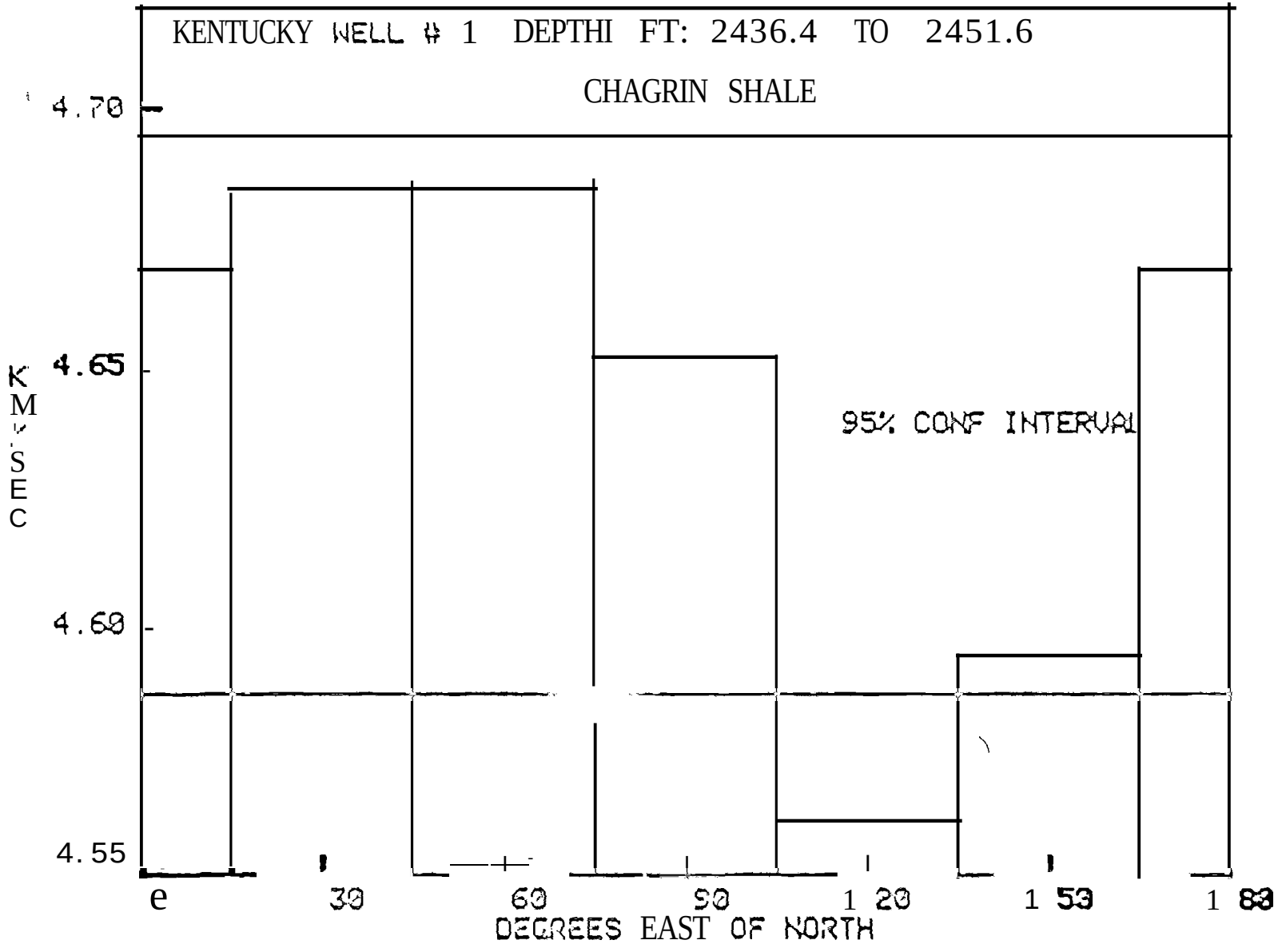


FIGURE A-3

ULTRASONIC UELOCITY US. ORIENTATION

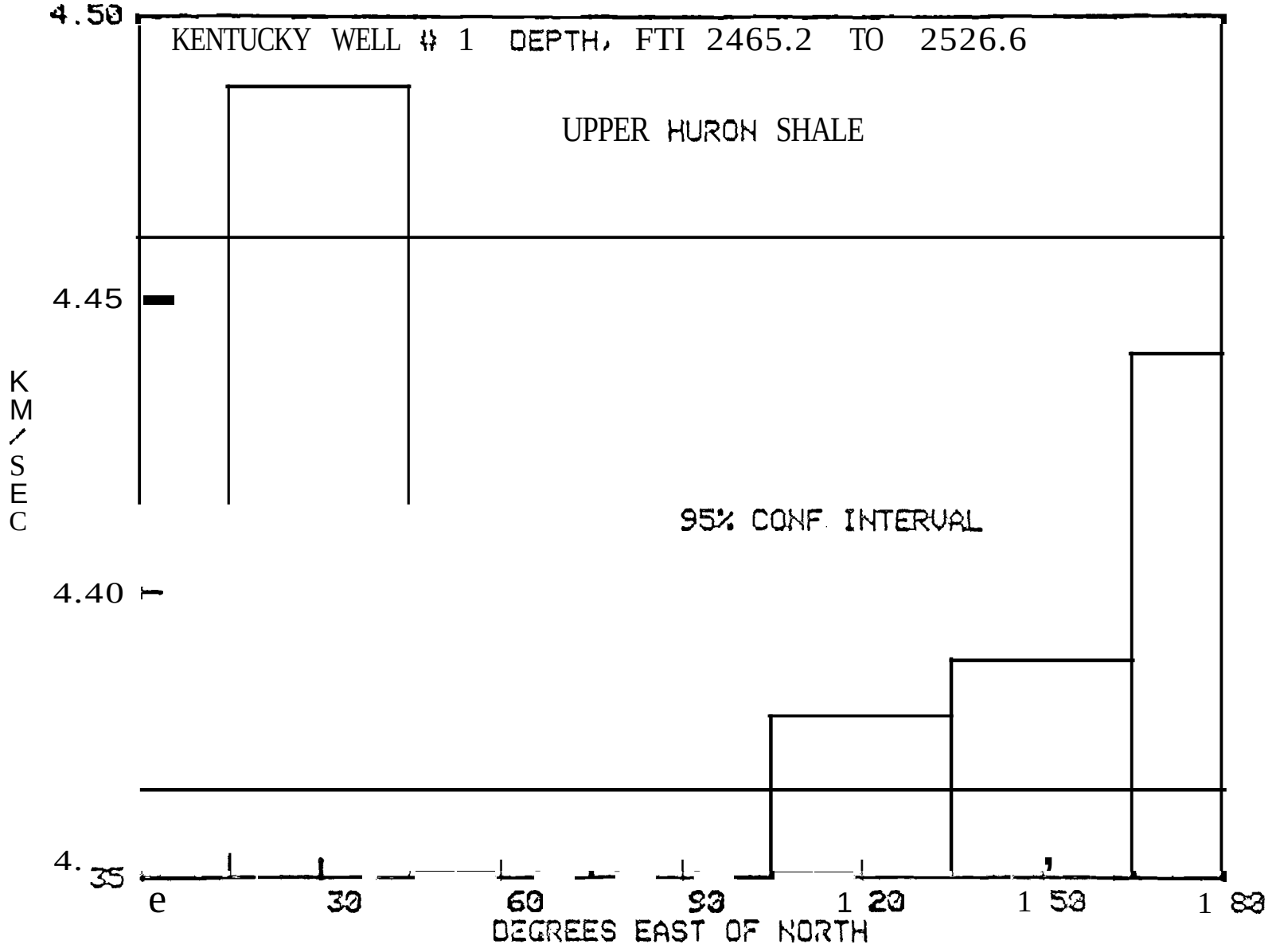


FIGURE A-4

ULTRASONIC UELOCITY US. ORIENTATION

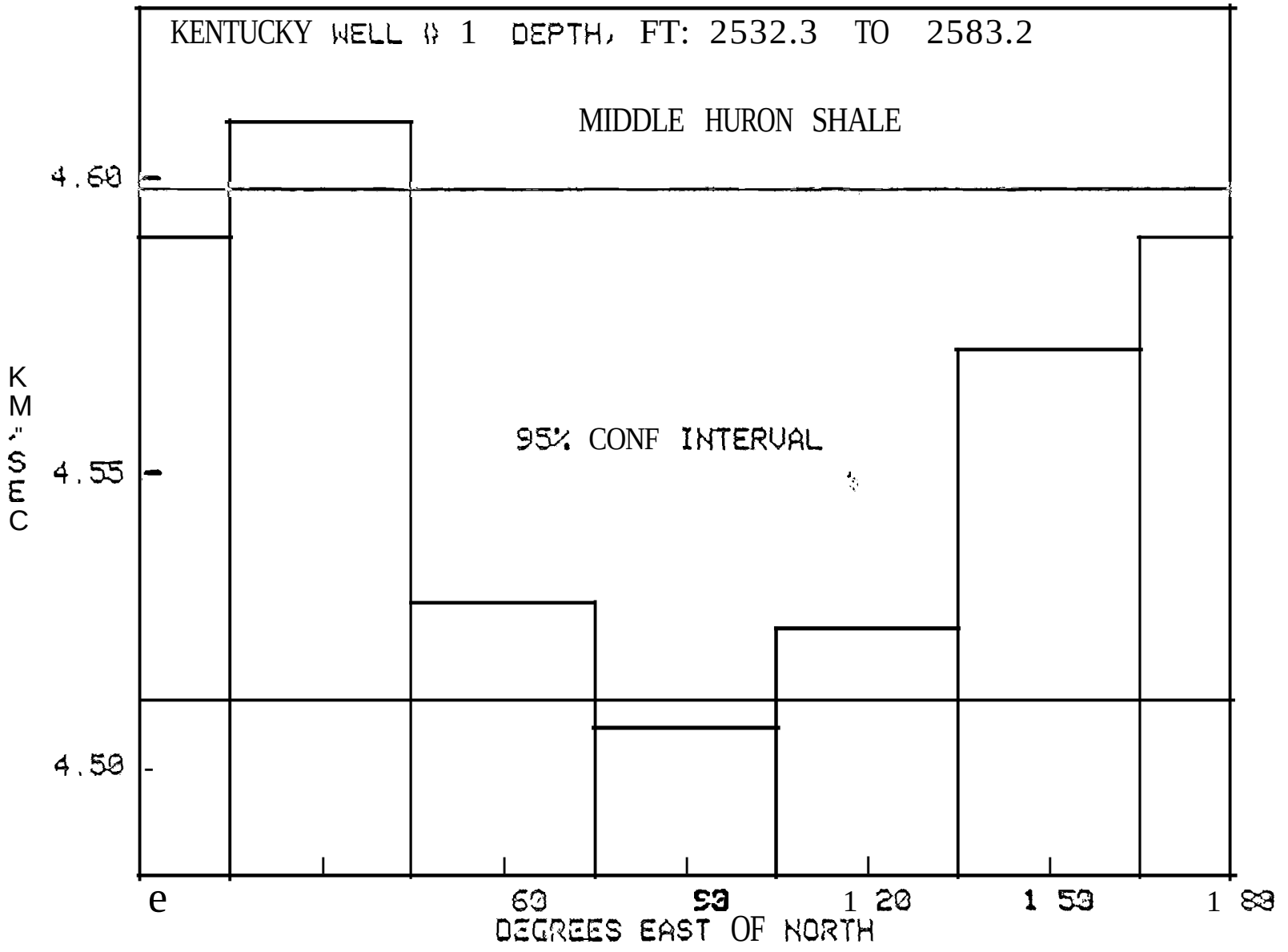


FIGURE A-5

ULTRASONIC VELOCITY US. ORIENTATION

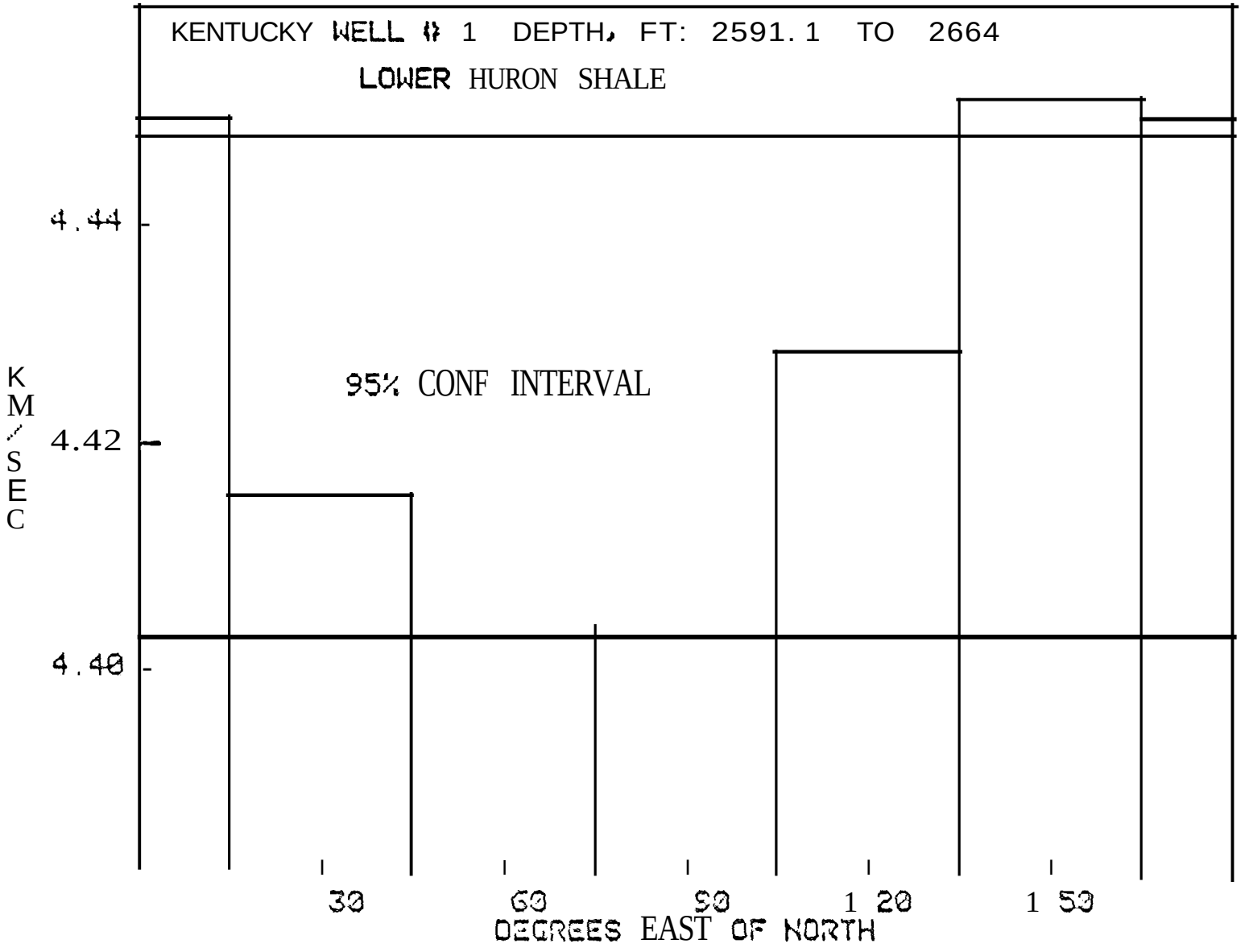


FIGURE A-6

ULTRASONIC UELOCITY US. ORIENTATION

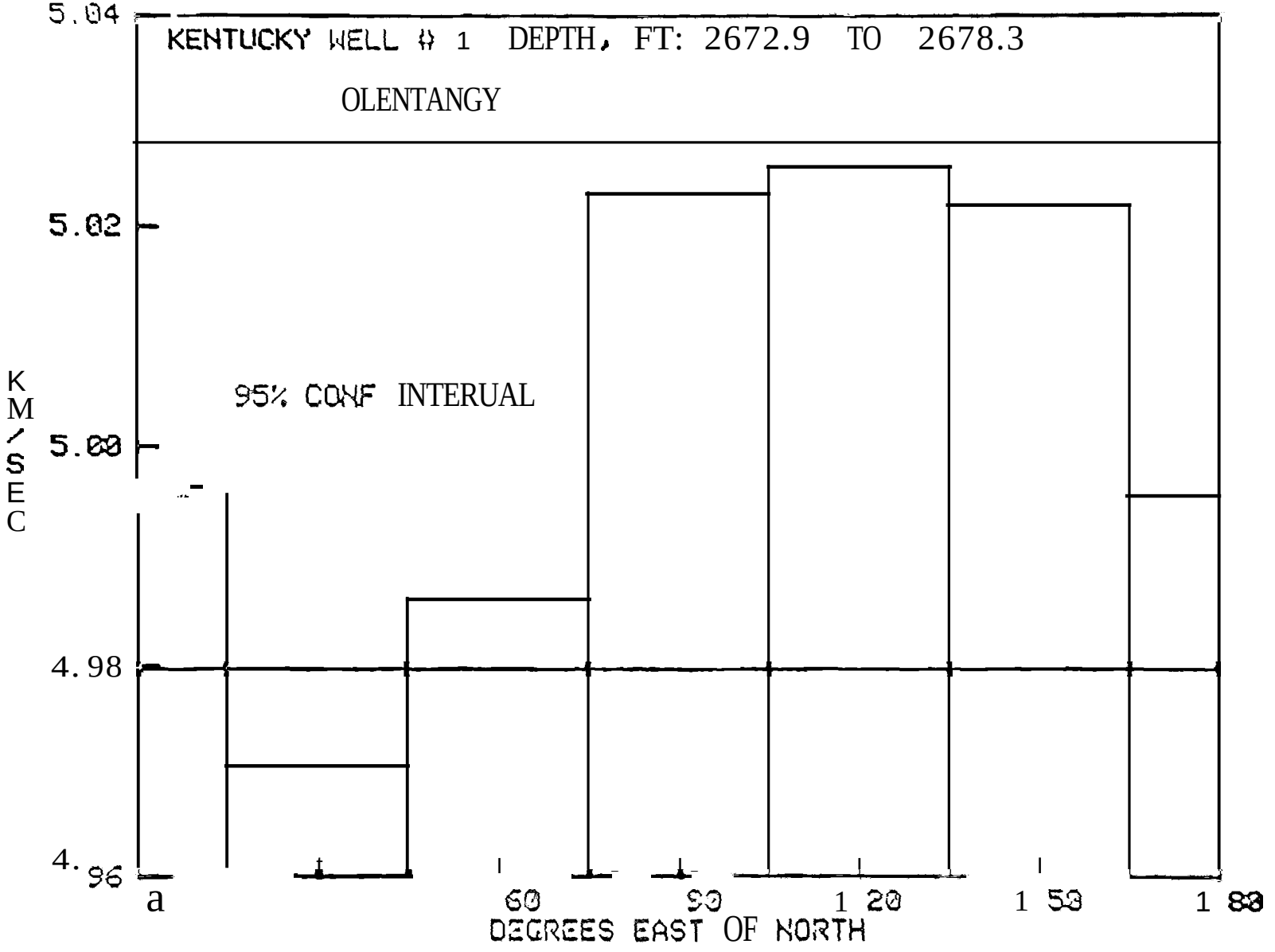
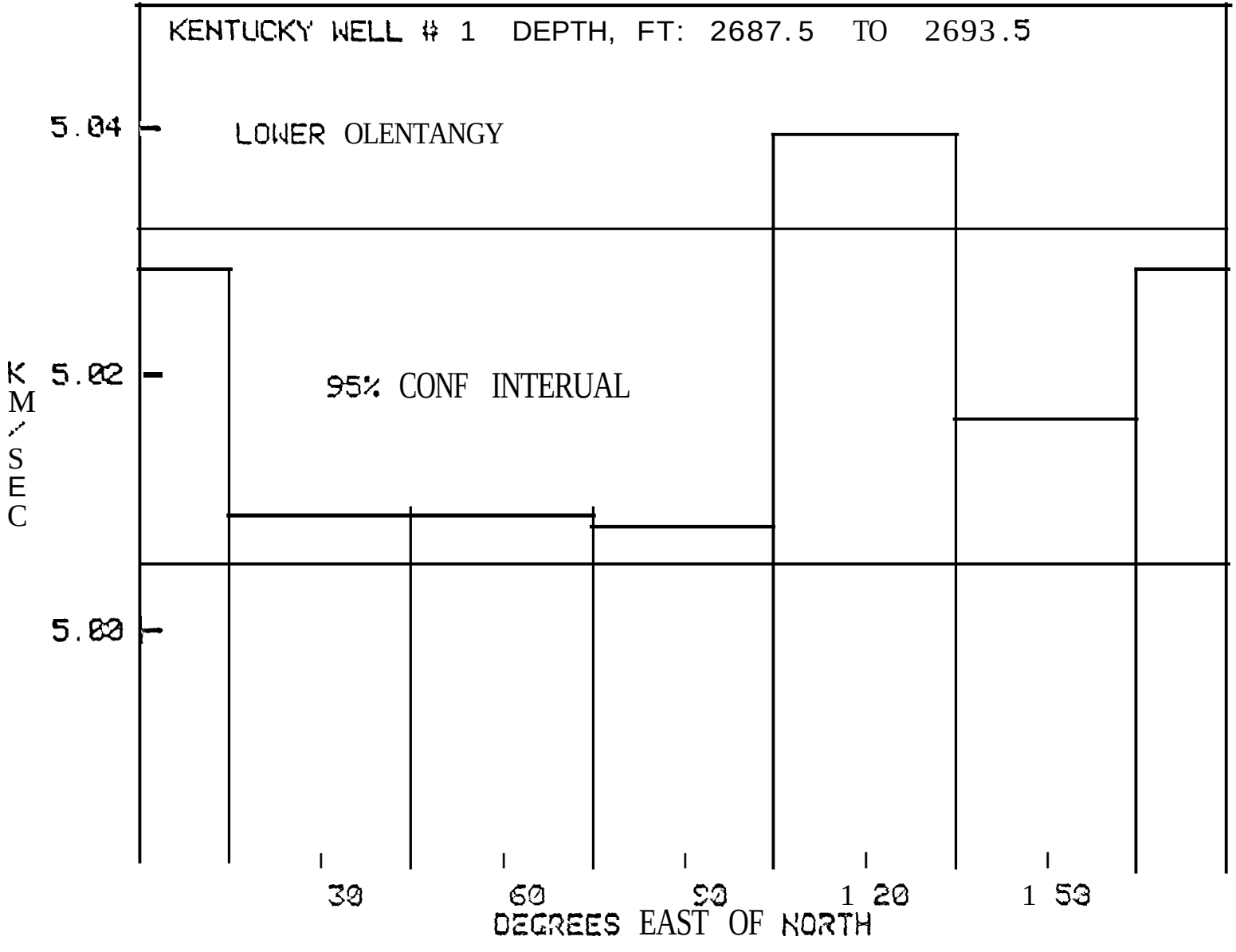


FIGURE A-7

ULTRASONIC VELOCITY VS. ORIENTATION



N
CO

FIGURE A-8

ULTRASONIC VELOCITY US. ORIENTATION

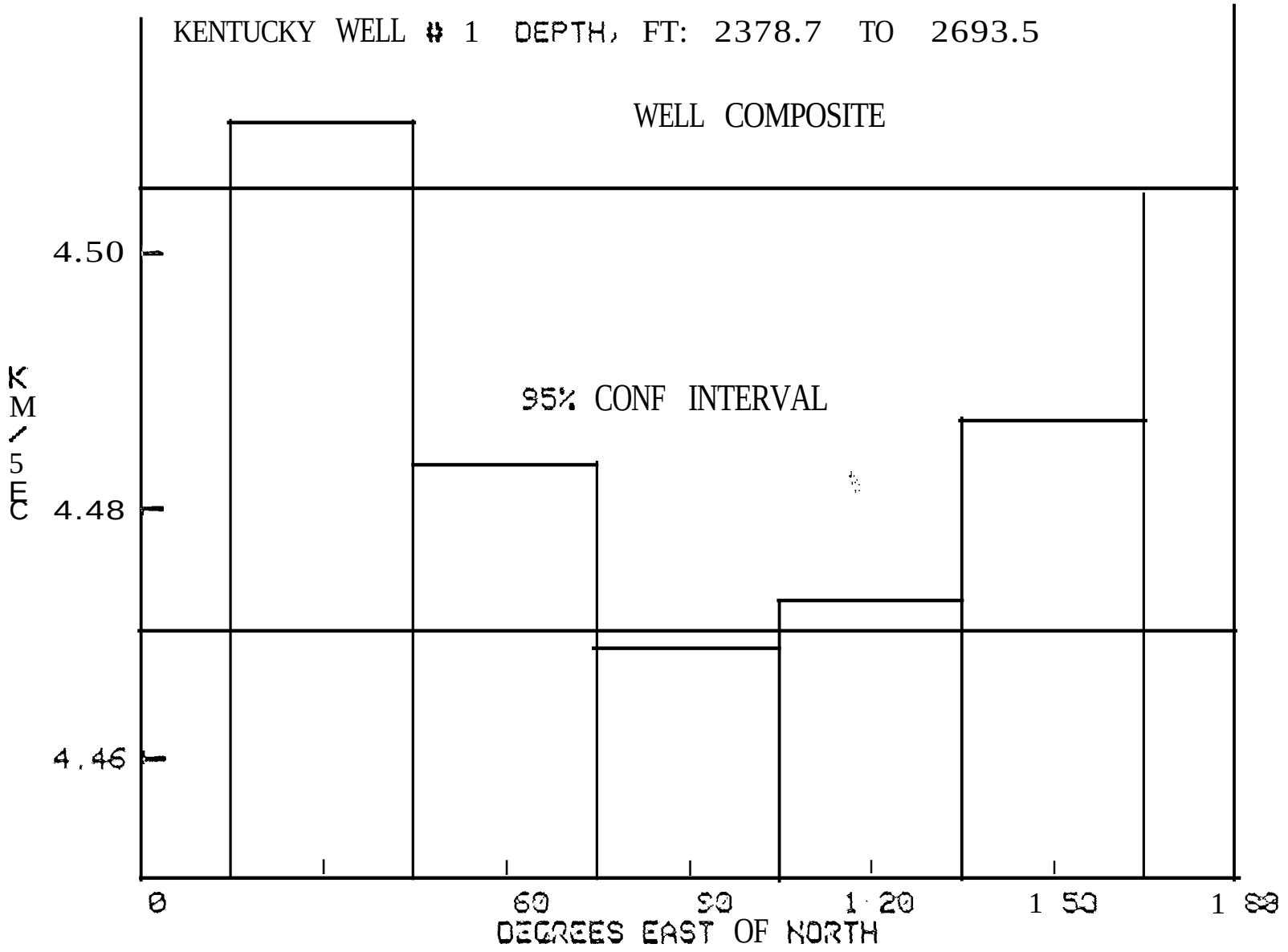


TABLE B-1

KENTUCKY 111

Frequency of Fractures Induced by Point Load
Depth is Midpoint of 10 ft. Interval

Depth	Orientation in Degrees East of North 0°	30°	60°	90°	120°	150°	Total
Berea							
2,371.0'	0	0	0	1	0	0	1
Total	0	0	0	1	0	0	1
Cleveland							
2,379.3'	0	0	0	0	1	0	1
2,385.0'		1	0	1	0	0	2
2,394.5'	0	1	0	0	0	0	1
2,404.6'	0	1	0	0	0	0	1
2,415.0'	0	0	0	2	0	0	2
2,425.0'	0	0	1	0	1	0	2
Total	0	3	1	3	2	0	9
Chagrin							
2,439.2'	0	0	1	0	0	0	1
Total	0	0	1	0	0	0	1
Upper Huron							
2,370.1'	0	0	0	0	1	0	1
2,485.0'	0	7	3	0	1	0	1
2,495.0'	0	4	0	1	0	0	5
2,501.5'	0	1	0	0	0	0	1
2,512.4'	0	1	0	0	0	0	1
Total	0	13	3	1	2	0	19
Middle Huron							
2,557.7'	0	1	0	0	0	0	1
2,560.6'	0	0	0	0	0	1	1
2,575.0'	0	2	0	3	1	4	10
2,585.0'	5	0	0	1	0	2	8
Total	5	3	0	4	1	7	20
Lower Huron							
2,599.0'	0	0	1	0	0	0	1
2,610.5'	0	0	0	0	1	0	1
2,605.0'	0	0	1	0	0	0	1
2,615.0'	1	1	0	1	1	3	7
2,625.0'	3	1	1	3	1	1	10
2,635.0'	2	1	0	0	1	3	7
2,645.0'	0	1	2	0	1	2	6
2,655.0'	3	1	0	0	2	1	7
2,664.4'	0	0	1	0	0	0	1
Total	9	5	6	4	7	10	41
OLENTANGY							
2,678.8'	1	0	0	1	2	0	4
Total	1	0	0	1	2	0	4
Lower OLENTANGY							
2,685.0'	0	0	0	0	2	3	5
2,695.0'	5	1	0	0	1	0	7
2,705.0'	3	1	1	1	3	4	13
Total	8	2	1	1	6	7	25
Well Composite							
	23	26	12	15	20	24	120

TABLE C-1

KENTUCKY #1

Directional Tensile Strengths
Tensile Strength in psi and Orientation of
Load Axis in Degrees East of North

Depth	0°	30°	60°	90°	120°	150°
OHIO SHALE						
Berea						
2,365'	816	680	*524	872	848	776
Average	816	680	*524	872	848	776
Cleveland						
2,375'	912, 957	*479, 1,072	737, 1,068	1,030	925, 1,021	874, 980
2,385'	965	783	1,020	414, 963	*490	1,045
2,395'	766	814	1,154	*597	1,354	1,168
2,405'	674, 938	797, 720	830, 691	*152, 769	418, 991	251, 1,025
2,415'	682, 776	823	601	*592	657, 756	674, 783
2,425'	505	475, 753	760, 91	*363, 456	598	745
2,435'	*112	662	505	509	571	694
Average	729	738	746	*584	778	824
Chagrin						
2,445'	424, 937	342, 1,206	*365, 675	425, 1,348	938	525, 1,023
2,455'	561	*467	564	508	961	806
Average	641	672	*535	760	1,008	785
Upper Huron						
2,465'	799	803	*749	1,118	798	875
2,475'	281	539	*186	823	826	660
2,491'						1,150
2,505'	*486	1,150	959	698	606	
2,515'	*688, 255	205, 1,106	319, 1,423	668, 1,046	617	604, 1,140
2,525'	*290	336	634	408	372, 426	776
Average	*463	690	712	784	606	868

TABLE C-1 cont.

KENTUCKY #1 cont.

Directional Tensile Strengths
Tensile Strength in psi and Orientation of
Load Axis in Degrees East of North

Depth	0°	30°	60°	90°	120°	150°
Middle Huron						
2,535'	545	*250	616	600	549	844
2,545'	*229.	983	1,101	993	368	747
2,555'	809	626	652	707	1,018	*237
2,565	942	*852	964	1,098	1,286	1,046
Average	*631	678	833	850	805	719
Lower Huron						
2,585'	977				980	1,126
2,595'	1,004	1,141, 729	1,175, 1,043	*581, 1,032	1,125	1,279
2,605'	834	870	759	838	*381	781
2,615'	835	1,086	*408	934	1,188	1,021
2,635	932	*867	1,099	991	1,014	1,264
2,652'	1,221	1,303	1,007	1,596	*325	1,504
2,665'	1,257, 1,316	1,237, 1,141	1,062	*907	1,210, 1,050	1,202, 1,097
Average	1,047	1,047	936	983	909	1,159
OLENTANGY						
2,675'		920	1,158			
Average		920	1,158			
Well Composite	*741	791	771	787	806	898

*Minimum strength for ten foot interval in Load Axis Orientation; the tensile strength calculated is for the orientation perpendicular the load axis.

FIGURE C-i

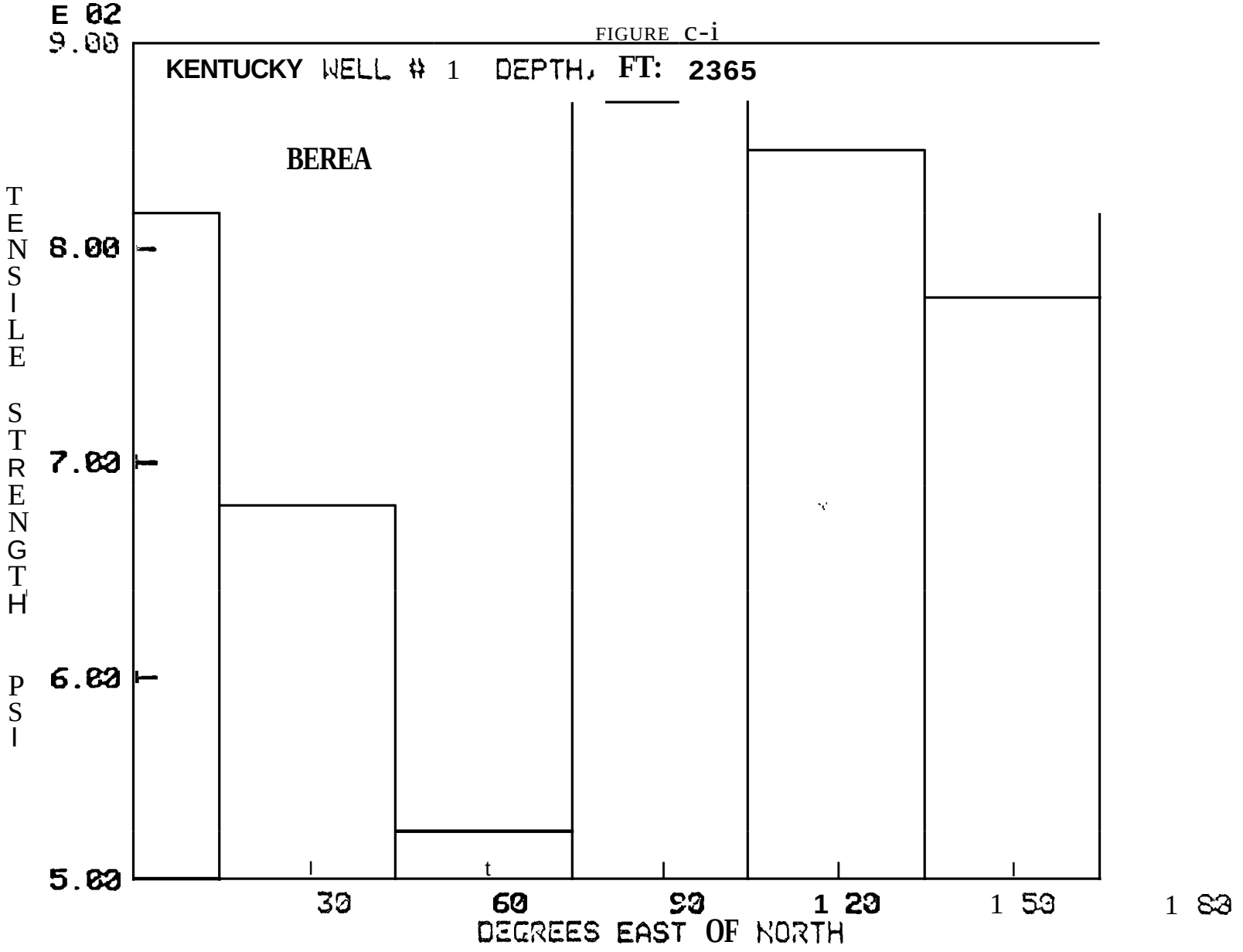

E 02
9.00
KENTUCKY WELL # 1 DEPTH, FT: 2365
BEREA
TENSILE STRENGTH PSI
8.00
7.00
6.00
5.00
30
60
90
1 20
1 50
1 80
DEGREES EAST OF NORTH

FIGURE C-2

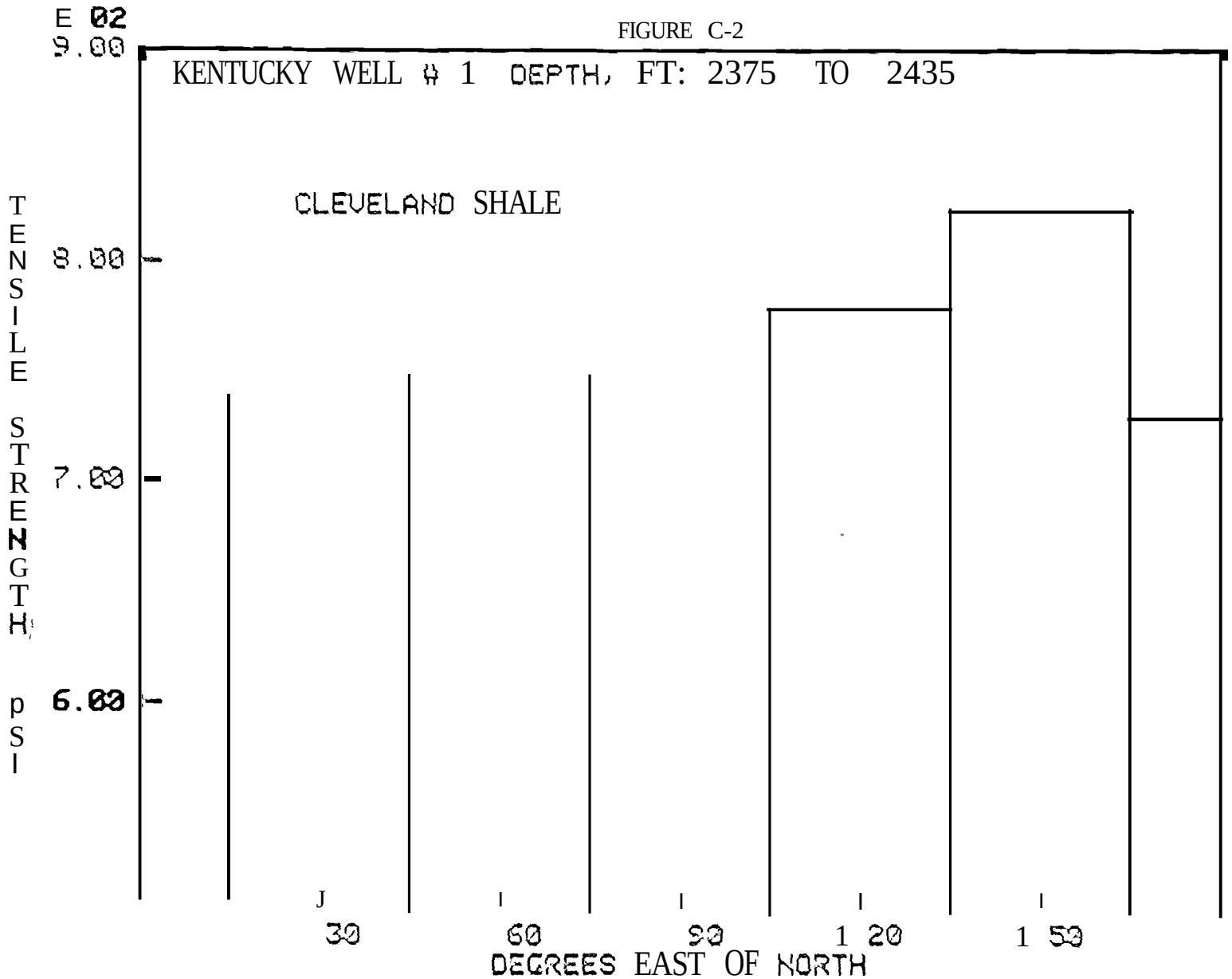
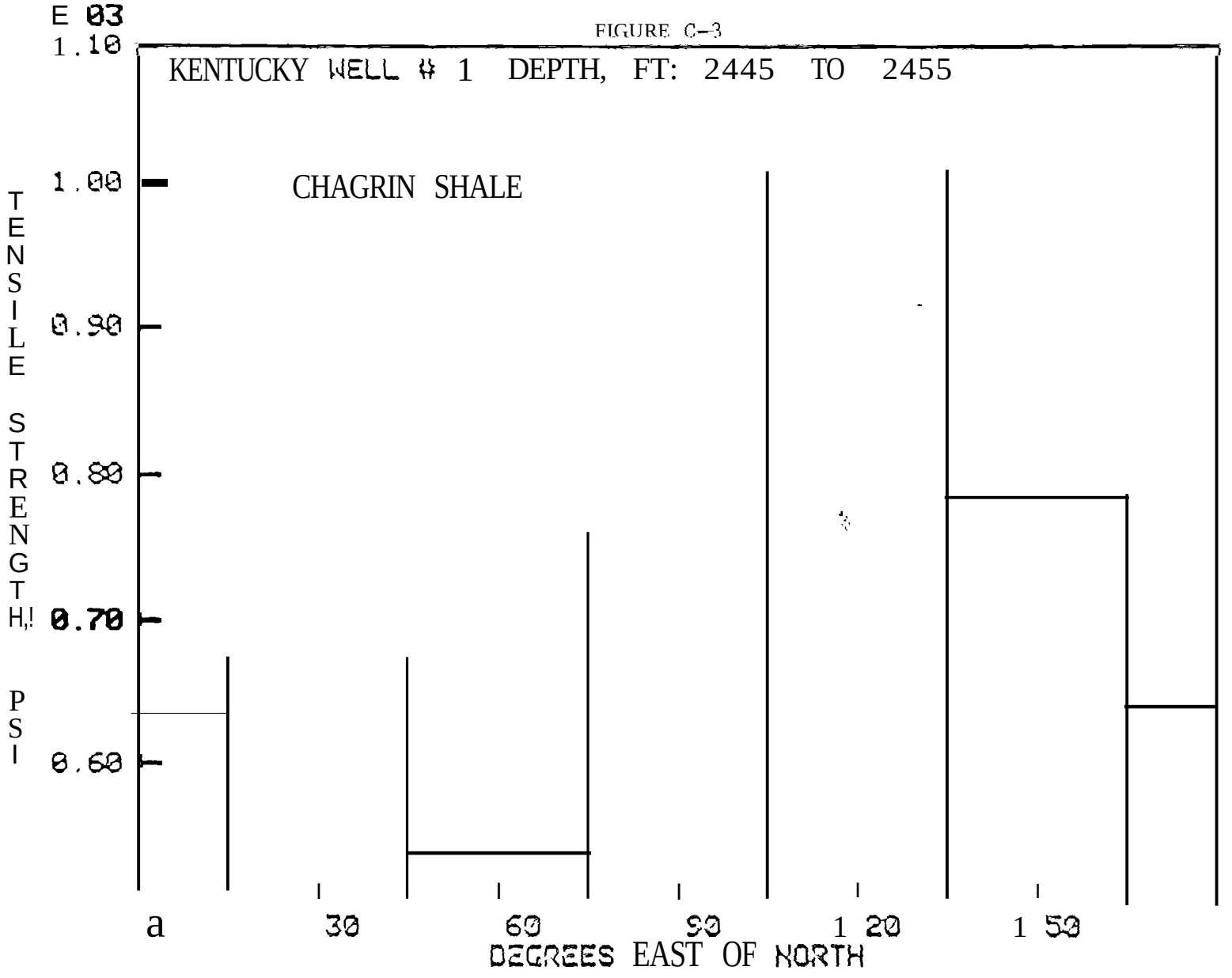

KENTUCKY WELL # 1 DEPTH, FT: 2375 TO 2435
CLEVELAND SHALE
TENSILE STRENGTH, psi
E 02
9.00
8.00
7.00
6.00
30
60
90
1 20
1 50
DEGREES EAST OF NORTH

FIGURE C-3


E 03
1.10
KENTUCKY WELL # 1 DEPTH, FT: 2445 TO 2455
1.00
CHAGRIN SHALE
0.90
0.80
0.70
0.60
TENSILE STRENGTH, PSI
a
30
60
90
1 20
1 50
DEGREES EAST OF NORTH

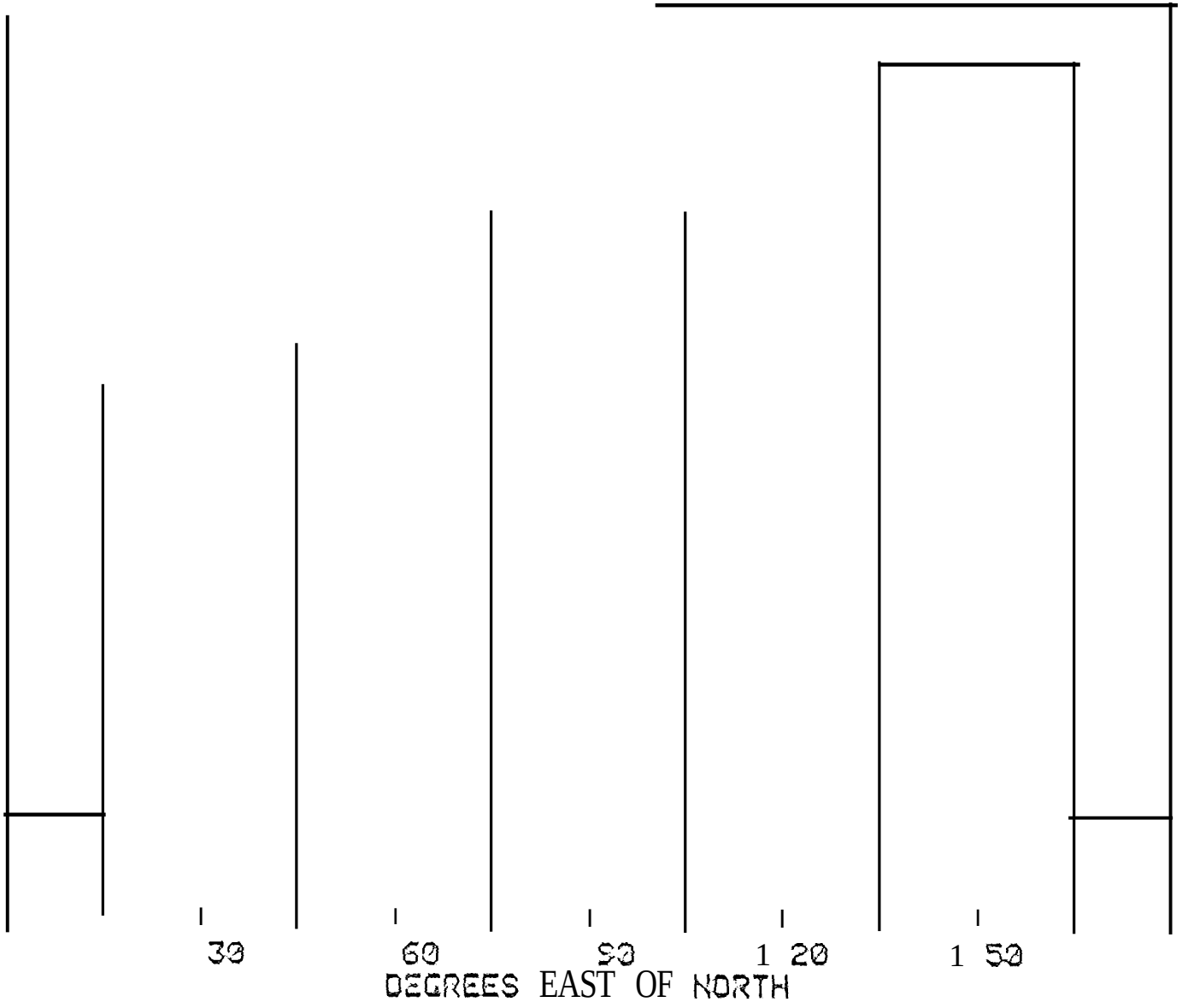

30
60
90
1 20
1 50
DEGREES EAST OF NORTH

FIGURE C-5

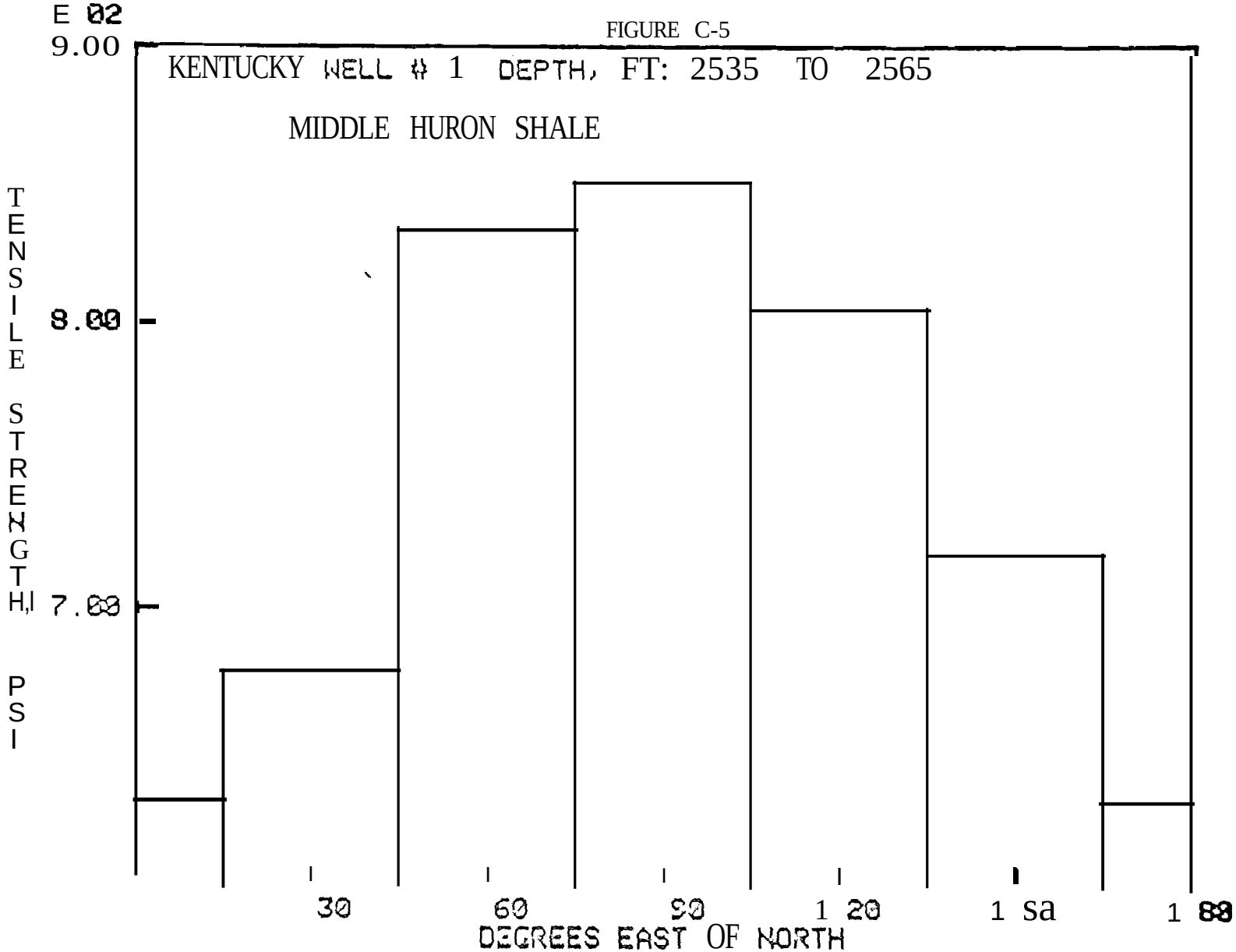

E 02
9.00
KENTUCKY WELL # 1 DEPTH, FT: 2535 TO 2565
MIDDLE HURON SHALE
TENSILE STRENGTH, PSI
8.00
7.00
30
60
90
1 20
1 sa
1 80
DEGREES EAST OF NORTH

FIGURE C-6

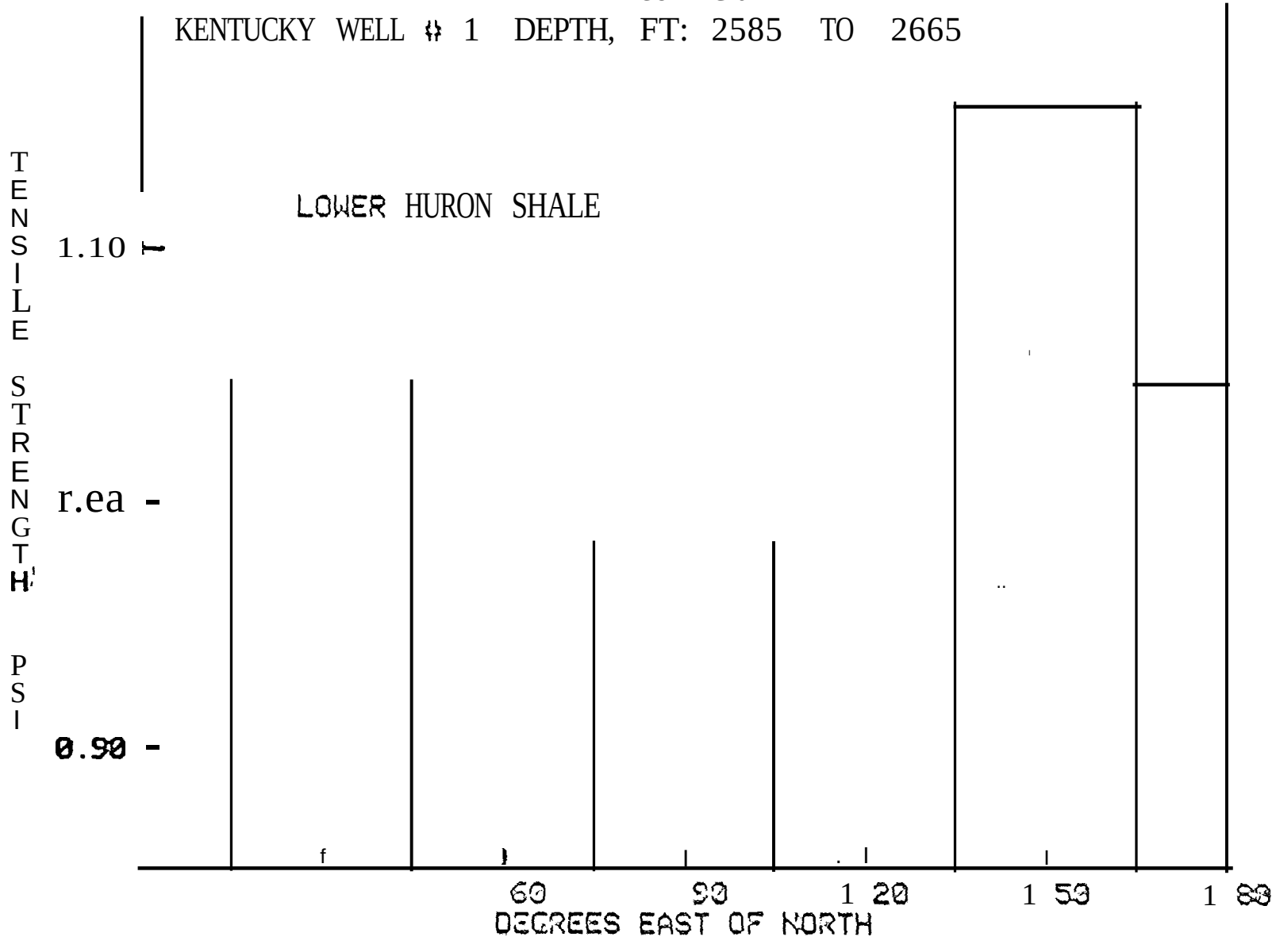

KENTUCKY WELL # 1 DEPTH, FT: 2585 TO 2665
LOWER HURON SHALE
TENSILE STRENGTH PSI
1.10
r.ea
0.90
60
90
1 20
1 50
1 80
DEGREES EAST OF NORTH

FIGURE C-7

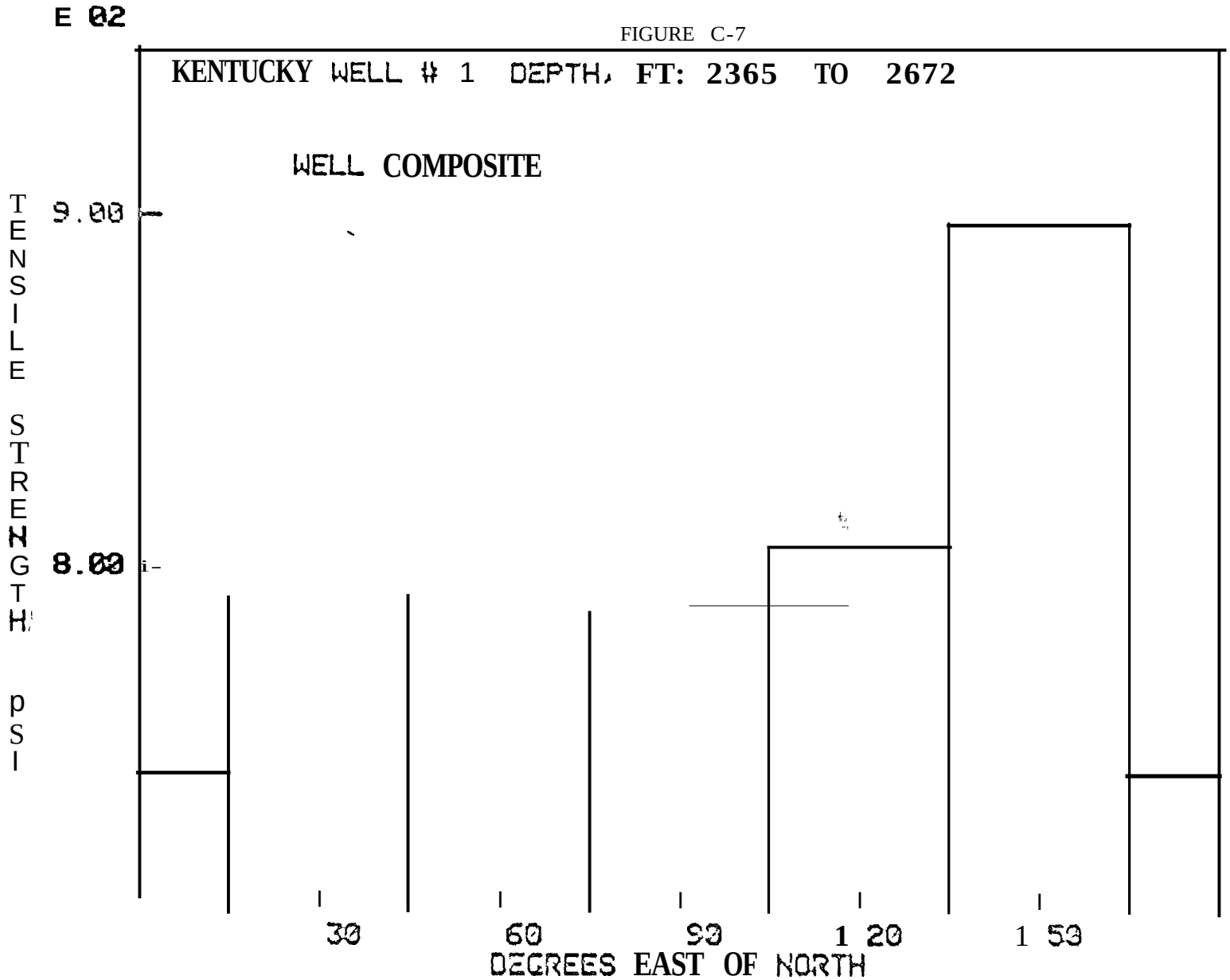

E 02
KENTUCKY WELL # 1 DEPTH, FT: 2365 TO 2672
WELL COMPOSITE
TENSILE STRENGTH psi
9.00
8.00
30
60
90
1 20
1 50
DEGREES EAST OF NORTH

FIGURE D-1
KENTUCKY #1, Perry County

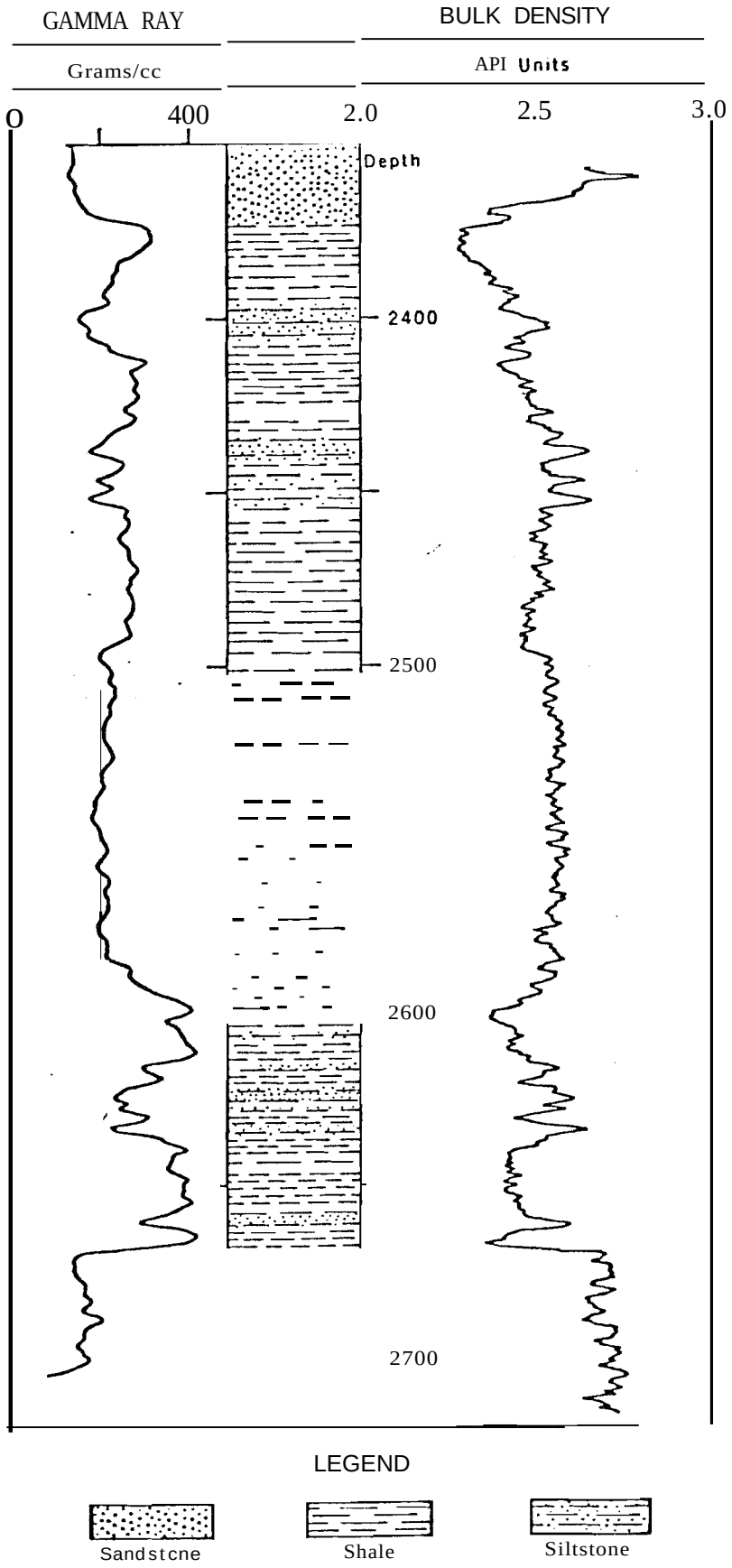


TABLE D-1

EGSP-Kentucky #1, Perry County

VISIBLE FRACTURES

Well Composite 2,371.2 to 2,706.3 Feet

Northwest Quadrant		Northeast Quadrant	
Degree Group	Total Fractures	Degree Group	Total Fractures
90-86	7	0-4	11
85-81	4	5-9	8
80-76	2	10-14	5
75-71	10	15-19	9
70-66	4	20-24	6
65-61	8	25-29	20
60-56	9	30-34	11
55-51	11	35-39	9
50-46	7	40-44	8
45-41	14	45-49	12
40-36	5	50-54	10
35-31	5	55-59	7
30-26	8	60-64	7
25-21	7	65-69	3
20-16	7	70-74	6
15-11	4	75-79	7
10-6	7	80-84	7
5-1	2	85-89	5
Total	121		151

TABLE D-2

EGSP-Kentucky #1, Perry County

WHOLE-CORE ANALYSIS

Depth, Feet	Permeability, Md. N-S	E-W	Porosity, Percent	Fluid Saturation Oil	Water	Grain Density	NaC1, PPM
2,399.86-00.52	0.1	0.1	4.6	57.0	24.8	2.51	132,600
2,409.10-09.77	0.4	0.5	3.5	39.7	31.9	2.48	113,800
2,381.78-82.70	*0.3	*0.1	2.5	60.4	38.9	2.41	104,500
2,391.86-92.52	0.4	0.1	3.0	63.3	31.1	2.48	107,500
2,421.80-22.47	0.8	0.3	4.7	34.0	38.3	2.60	146,400
2,447.22-47.89	8.9	1.6	5.7	11.7	74.4	2.78	140,300
2,488.95-89.61	0.3	0.1	2.8	34.8	33.4	2.55	117,000
2,527.13-27.78	0.4	0.1	3.4	50.0	31.0	2.64	132,700
2,597.05-97.62	0.9	0.1	4.7	70.2	14.3	2.50	172,000
2,621.96-22.68	23	0.1	4.9	20.1	63.7	2.83	160,900
2,640.65-41.33	0.3	1.1	4.5	55.5	28.9	2.60	101,500
2,663.00-63.68	0.6	0.1	2.8	75.0	18.5	2.43	127,600

*Sample Not Oriented

TABLE D-3

EGSP-Kentucky #1, Perry County

DIRECTIONAL PERMEABILITY DATA

Depth, Feet	Permeability, Md. Max.	Permeability, Md. 90°	Direction of Flow, Maximum	Permeability, Md. Counter-Clockwise From Maximum Permeability 30°	60°	120°	150°
2,399.86-00.52	0.1	0.1	N-S	0.1	0.1	0.1	0.8
2,409.10-09.77	0.5	0.4	E-W	0.5	0.4	0.6	0.8
2,381.78-82.70	0.3	0.1	*	0.5	0.3	0.3	0.2
2,391.86-92.52	0.4	0.1	N-S	0.6	0.2	0.1	0.2
2,421.80-22.47	0.8	0.3	N-S	0.3	0.2	0.8	2.2
2,447.22-47.89	8.9	1.6	N-S	0.9	1.4	5.3	5.2
2,488.95-89.61	0.3	0.1	N-S	0.3	0.1	0.1	0.1
2,527.13-27.78	0.4	0.1	N-S	0.2	0.1	0.2	0.3
2,597.05-97.62	0.9	0.1	N-S	0.8	0.1	0.2	0.1
2,621.96-22.68	23	0.1	N-S	0.1	0.1	0.1	0.5
2,640.65-41.33	1.1	0.3	E-W	0.9	0.8	1.4	0.7
2,663.00-63.68	0.6	0.1	N-S	0.7	0.7	0.1	0.1

*Sample Not Oriented

TABLE D-4

EGSP-Kentucky #1, Perry County

MODULUS MEASUREMENTS

Depth		Modulus of Elasticity Primary (PSI xlO^{6})	Modulus of Elasticity Secondary (PSI x10^{6})	Poisson Ratio Primary	Poisson Ratio Secondary
2,413.9' 2,414.55'	D = 3 15" / 16	1.86	2.46	0.1	0.13
2,437.85' 2,438.5'	D = 3 15" / 16	3.179	3.89	0.30	
2,642.2' 2,642.85'	D = 3 15" / 16	2.02		0.24	0.12
2,614.35' 2,615.0'	D = 3 15" / 16	3.29		0.46	
2,664.7' 2,665.4'	D = 3 15" / 16	2.78		0.22	
*2,371.2' 2,372.1'	D = 2 1 / 32	0.85	1.76	0.134	0.18

*possibly not reliable