CLIFFS MINERALS, INC.
EASTERN GAS SHALES PROJECT
KENTUCKY #3 WELL - PERRY COUNTY
PHASE III REPORT
SUMMARY OF LABORATORY ANALYSES AND MECHANICAL CHARACTERIZATION RESULTS
OCTOBER· 1982

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Summary of Mechanical Characterization Results

The purpose of mechanical characterization of samples from the EGSP-Kentucky #3 core is to determine the orientation of preferred planes of weakness in the Devonian gas shales at the Martin 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 N600E+15° as the preferred direction of fracturing in 130 out of 423 total induced fractures in the well composite.

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 N600E+15° as the preferred direction of fracturing in 9 out of 30 total velocity samples in the well composite.

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 241 directional tensile strength measurements indicate N60oE+lSo as the preferred plane of weakness in this well.

INTRODUCTION

The purpose of mechanical characterization of samples from the EGSP-Kentucky #3 core is to determine the direction of preferred planes of weakness in the Devonian gas shales at the Martin County well site.

A series of samples, representing 1,067 feet of core taken from the Kentucky #3 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 intervals extend from 2,488 feet to 3,555 feet below surface and are summarized in Table 1.

TABLE 1

EGSP-Kentucky #3
Martin County
Formations Tested

Lithology	Depth Log	Depth Tested	Type of Test
Cleveland Shale	2,430'-2,581'	2,496'-2,571'	Velocity
		2,488'-2,572'	Point Load
Chagrin Shale	2,581'-2,654'	2,585'-2,633'	Velocity
		2,585'-2,655'	Point Load
		2,605'-2,653'	DTS
Upper Huron Shale	2,654'-2,798'	2,693'-2,753'	Velocity
		2,665'-2,755'	Point Load
		2,665'-2,795'	DTS
Middle Huron Shale	2,798'-2,908'	2,805'	Velocity
		2,815'-2,903'	Point Load
		2,805'-2,905'	DTS
Lower Huron Shale	2,908'-3,125'	2,936'-3,117'	Velocity
		2,915'-3,095'	Point Load
		2,915'-3,095'	DTS

TABLE 1 Continued

EGSP-Kentucky #3

Martin County

Formations Tested

Lithology	Depth Log	Depth Tested	Type of Test
Upper Olentangy	3,125'-3,187'	3,143'-3,184'	Velocity
		3,155'-3,183'	Point Load
		3,155'-3,175'	DTS
Pipe Creek	3,187'-3,212'	3,197'	Velocity
		3,202'-3,210'	Point Load
		3,205'-3,211'	DTS
Angola	3,212'-3,361'	3,225'-3,355'	Point Load
		3,225'-3,305'	DTS
Rhinestreet	3,361'	3,396'-3,555'	Velocity
		3,365'-3,411'	Point Load
		3,385'-3,405'	DTS

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 containes 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 #3 Core
Martin County
Frequency Distribution of Preferred Direction of Fracturing

Formation	Test	Orientation in Degrees East of North						
		0°	30°	60°	90°	120°	150°	Total
Cleveland Shale	Velocity	0	1	5	2	0	0	8
2,488'-2,572' tested	Point Load	1	9	11	3	3	1	28
Chagrin Shale	Velocity	1	2	2	1	0	0	6
2,585'-2,655' tested	Point Load	2	4	8	4	4	2	24
	DTS*					*		27
Upper Huron Shale	Velocity	2	1	0	0	0	0	3
2,665'-2,795' tested	Point Load	16	20	34	23	11	7	III
	DTS*			*				55
Middle Huron Shale	Velocity	0	0	0	1	0	0	1
2,805'-2,905' tested	Point Load	0	2	1	3	0	3	9
	DTS*		*					8
Lower Huron Shale	Velocity	0	2	1	1	1	0	5
2,914'-3,117' tested	Point Load	16	27	53	36	18	9	159
	DTS*					*		73
Upper Olentangy	Velocity	0	1	0	1	1	0	3
3,143'-3,184' tested	Point Load	2	1	6	4	3	8	24
	DTS*			*				18

TABLE 2 continued

EGSP-Kentucky #3 Core
Martin County
Frequency Distribution of Preferred Direction of Fracturing

Formation	Test	Orientation in Degrees East of North						
		0°	30°	60°	90°	120°	150°	Total
Pipe Creek	Velocity	0	0	0	1	0	0	1
3,197'-3,211' tested	Point Load	0	1	2	0	0	1	4
	DTS*	*						9
Angola	Point Load	7	12	9	13	7	4	52
3,225'-3,355' tested	DTS*	*						39
Rhinestreet	Velocity	0	0	1	0	0	2	3
3,365'-3,555' tested	Point Load	2	1	6	1	2	0	12
	DTS*	*						12
Well Composite	Velocity	3	7	9	7	2	2	30
2,488'-3,555' tested	Point Load	46	77	130	87	48	35	423
	DTS*			*				241

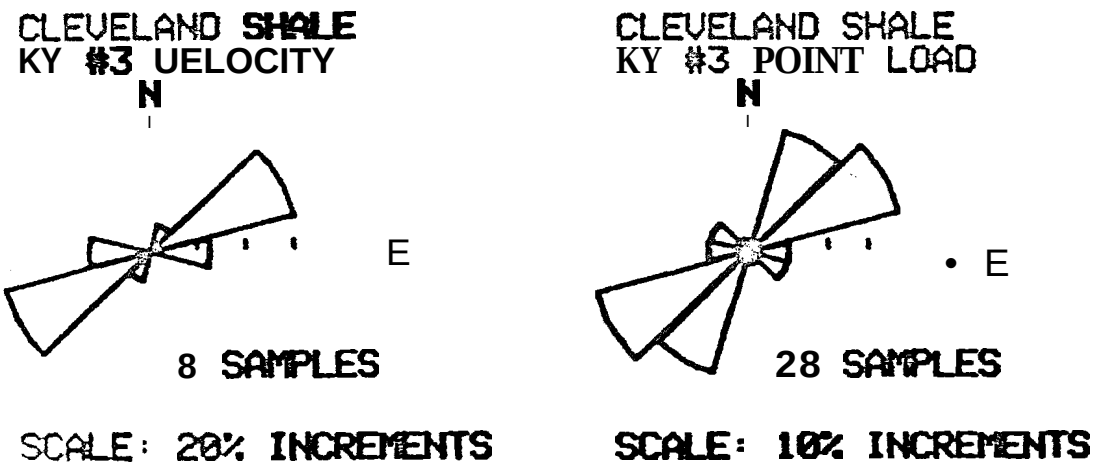
*The average of the directional tensile strength measurements in each orientation were used to determine this preferred plane of weakness.

Cleveland Shale; 2.488 to 2,572 feet tested:

Ultrasonic velocity measurements indicate N60°E+15° as the preferred direction of fracturing in five out of eight velocity samples. Point load induced fractures indicate N60°E+15° as the preferred direction of fracturing (11 out of 28 induced fractures). Figure 1 illustrates the frequency distribution rose diagrams of preferred direction of fracturing in the Cleveland Shale. Tabulated results are presented in Appendices A and **B.**

FIGURE 1

Cleveland Shale
Frequency Distribution Rose Diagrams of Results

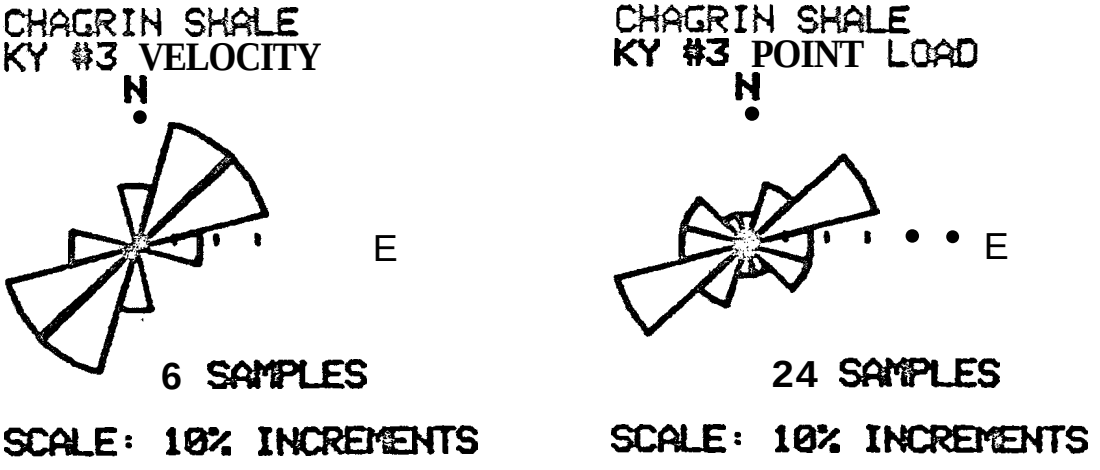


Chagrin Shale; 2,585 to 2,655 feet tested:

Four out of the six ultrasonic velocity measurements indicate N45°E+30° as the preferred direction of fracturing. Eight out of 24 point load induced fractures occur in the N60oE+15° direction. The directional tensile strength measurements on 27 total samples in the six orientations indicate N120oE+15° as the preferred plane 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, Band C.

FIGURE 2

Chagrin Shale
Frequency Distribution Rose Diagrams of Results

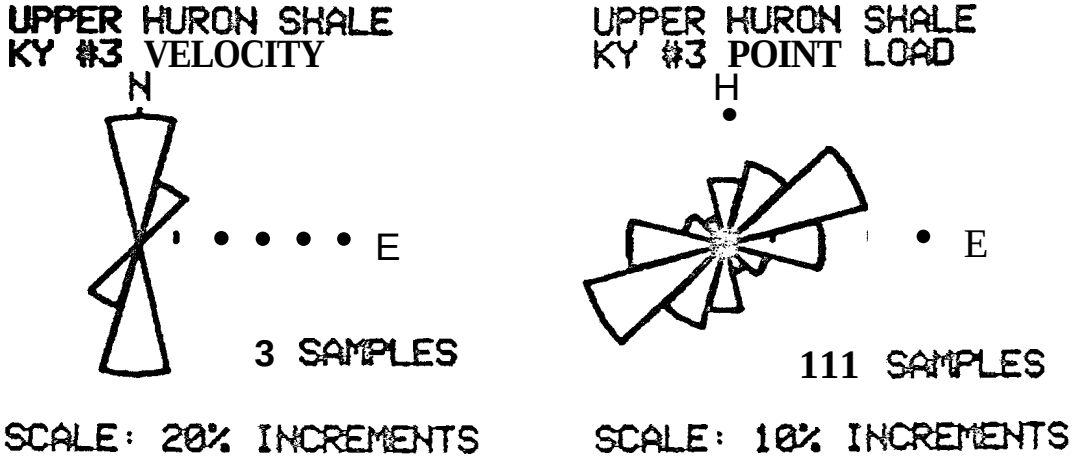


Upper Huron Shale; 2,665 to 2,795 feet tested:

Two out of the three ultrasonic velocity measurements indicate N0°E+15° as the preferred direction of fracturing. Point load induced fractures occur most frequently in the N60°E+15° orientation (34 out of 111 induced fractures). The 55 directional tensile strength measurements in the six orientations indicate N60°E+15° as the preferred plane of weakness. Figure 3 illustrates the frequency distribution rose diagrams of preferred direction of fracturing in the Upper Huron Shale. Tabulated results are presented in Appendices A, Band C.

FIGURE 3

Upper Huron Shale
Frequency Distribution Rose Diagrams of Results

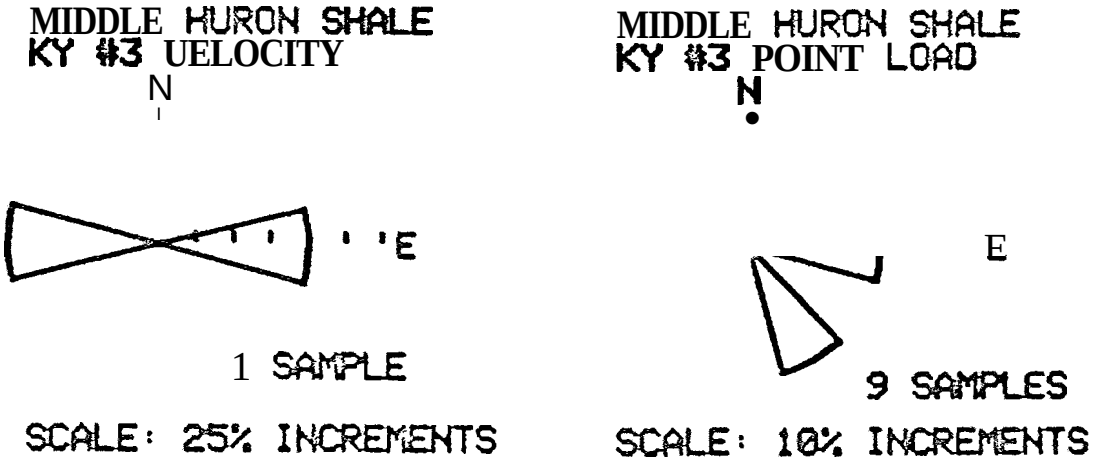


Middle Huron Shale; 2,805 to 2,905 feet tested:

The one ultrasonic velocity measurement and three out of nine point load induced fractures indicate N90oE+15° as the preferred direction of fracturing. The eight directional tensile strength measurements in the six orientations indicate N30oE+15° as the 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

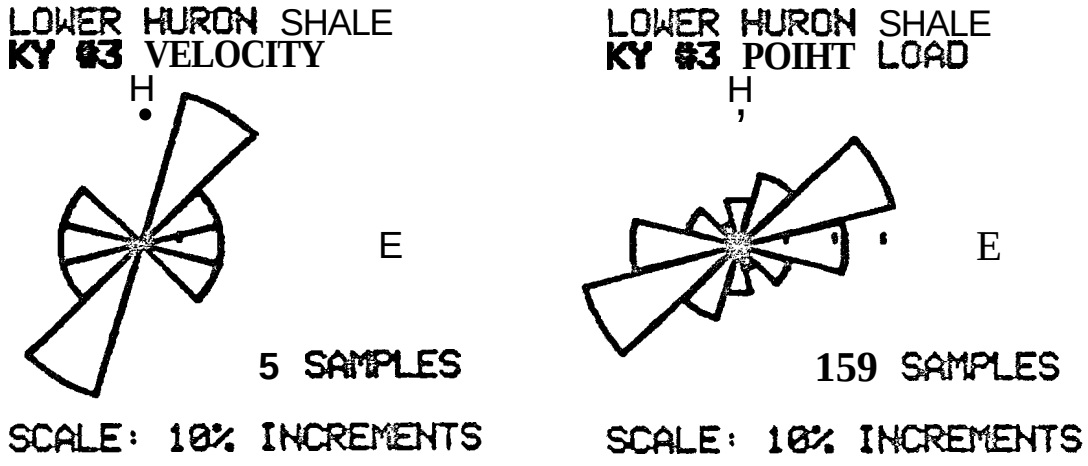


Lower Huron Shale; 2,914 to 3,117 feet tested:

Two out of the five ultrasonic velocity measurements indicate N300E+15° as the preferred direction of fracturing. Point load induced fractures occur most frequently in the N60oE+15° direction (53 out of 159 induced fractures). Directional tensile strength measurements of 73 samples indicate Nl20oE+15° as the 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, Band C.

FIGURE 5

Lower Huron Shale
Frequency Distribution Rose Diagram of Results

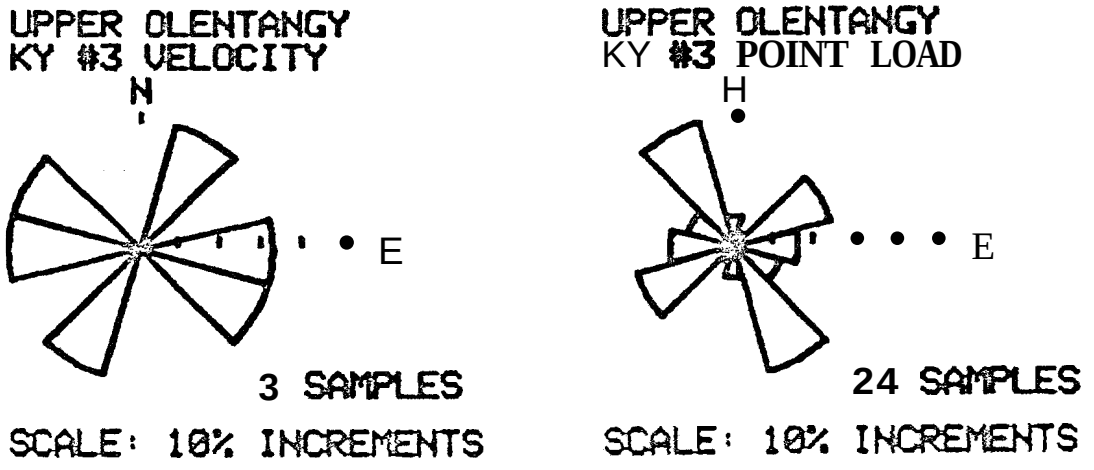


Upper 01entangy Shale; 3,143 to 3,184 feet tested:

The three ultrasonic velocity measurements do not indicate a statistically significant preferred direction of fracturing. Six out of the 24 point load induced fractures and the directional tensile strength measurements of 18 samples indicate N60oE+15° as the preferred direction of fracturing. Also, eight of the 24 point load induced fractures occur in the N150oE+15° orientation. Figure 6 illustrates the frequency distribution rose diagram of preferred direction of fracturing in the Upper 01entangy. Tabulated results are presented in Appendices A, Band C.

FIGURE 6

Upper Olentangy Shale
Frequency Distribution Rose Diagram of Results

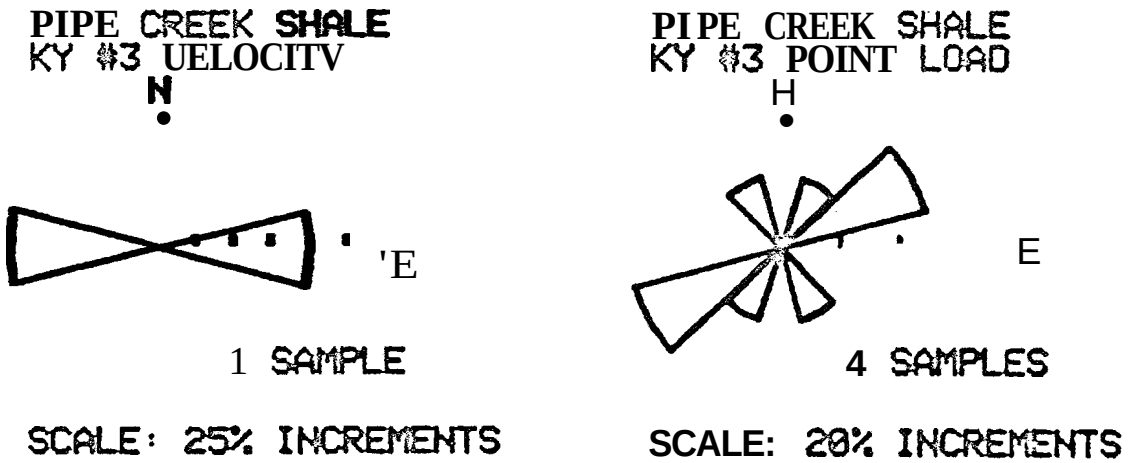


Pipe Creek Shale; 3,197 to 3,211 feet tested:

The one ultrasonic velocity sample indicates N90oE+15° as the preferred direction of fracturing. Two out of the four point load induced fractures occur in the N60oE+15° orientation. Directional tensile strength samples indicate NOoE+15° as the preferred plane of weakness. Figure 7 illustrates the frequency distribution rose diagram of preferred direction of fracturing in the Pipe Creek Shale. Tabulated results are presented in Appendices A, Band C.

FIGURE 7

Pipe Creek Shale
Frequency Distribution Rose Diagram of Results

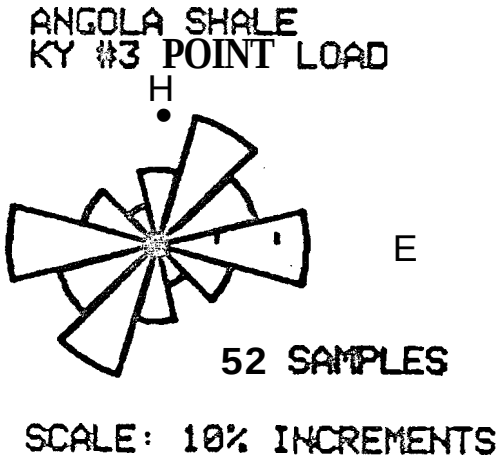


Angola Shale; 3,225 to 3,355 feet tested:

Point load induced fractures occur most frequently in the N30oE+15° and N90oE+15° orientations (12 and 13 respectively out of the 52 induced fractures). The 39 total directional tensile strength measurements in the six orientations indicate NOoE+15° as the preferred plane of weakness. Figure 8 illustrates the frequency distribution rose diagram of preferred direction of fracturing in the Angola Shale. Tabulated results are presented in Appendices Band C.

FIGURE 8

Angola Shale
Frequency Distribution Rose Diagram of Results

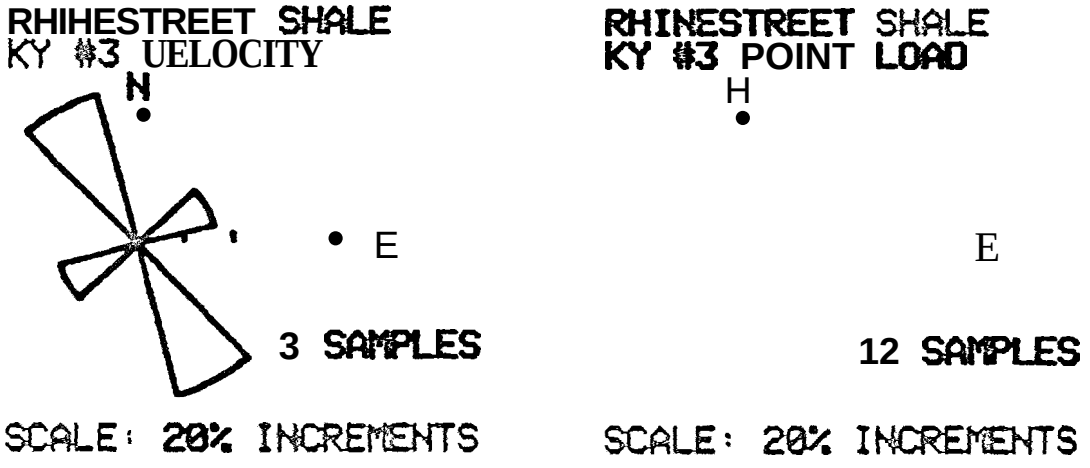


Rhinestreet Shale; 3,365 to 3,555 feet tested:

Out of the three ultrasonic velocity measurements, one indicates N600E±15° and two indicate N150oE+l5° as the preferred directions of fracturing. Point load induced fractures occur most frequently in the N60oE+l5° orientation (six out of the twelve induced fractures). The twelve total directional tensile strength measurements in the six orientations indicate NOoE+15° as the preferred plane of weakness. Figure 9 illustrates the frequency distribution rose diagrams of preferred direction of fracturing in the Rhinestreet Shale. Tabulated results are presented in Appendices A, Band C.

FIGURE 9

Rhinestreet Shale
Frequency Distribution Rose Diagrams of Results

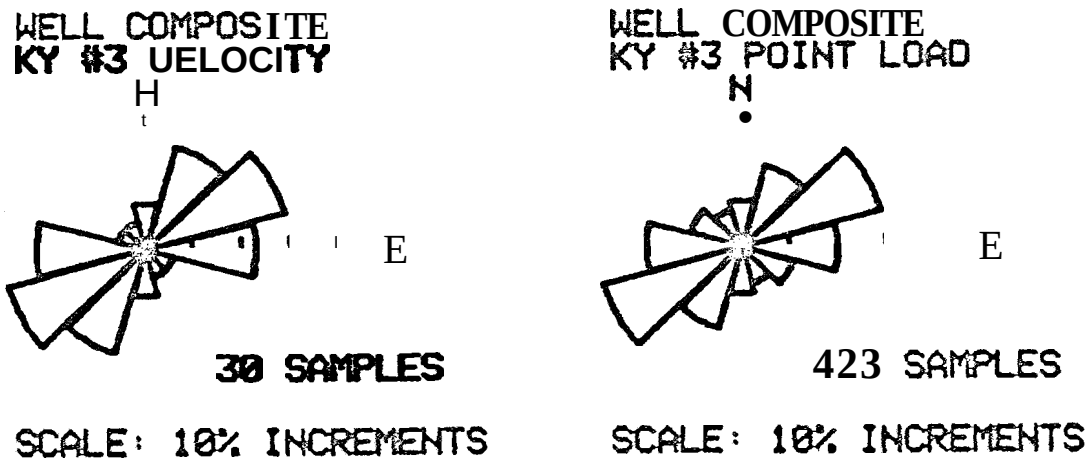


Kentucky #3 Well Composite; 2,488 to 3,555 feet tested:

Ultrasonic velocity measurements, point load induced fractures and directional tensile strength measurements indicate N60E$^{o+15°}$ as the preferred direction of fracturing (9 out of 30 total velocity samples; and 130 out of 423 total induced fractures; and the calculated average in the six orientations of 241 samples). Figure 10 illustrates the frequency distribution rose diagrams of preferred direction of fracturing in the EGSP-Kentucky #3 Martin County well composite. Tabulated results are presented in Appendices A, Band C.

FIGURE 10

Kentucky #3 Well Composite; 2,488' - 3,555' Tested
Frequency Distribution Rose Diagrams of Results



CONCLUSIONS

The data presented in this report indicate that core samples from the EGSP-Kentucky #3 well exhibit a directional variation in physical properties. Prediction of the preferred direction of induced fracturing at the Martin 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 by other contractors through the 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 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 Cleveland Shale (2,488 to 2,572 feet tested) is N60oE+15° as indicated by point load induced fracturing and ultrasonic velocity measurements.

(2) The preferred direction of fracturing in the Chagrin Shale (2,585 to 2,655 feet tested) is N60oE+15° as indicated by ultrasonic velocity measurements and point load induced fracturing.

(3) The preferred direction of fracturing in the Upper Huron Shale (2,665 to 2,795 feet tested) is N60oE±15° as indicated by point load induced fractures and directional tensile strength measurements.

CONCLUSIONS Continued

(4) The preferred direction of fracturing in the Middle Huron Shale (2,805 to 2,905 feet tested) is N90oE+15° as indicated by ultrasonic velocity measurements and point load induced fractures. There was a statistically small number of samples tested from this depth interval.

(5) The preferred direction of fracturing in the Lower Huron Shale (2,914 to 3,117 feet tested) is N60oE+15° as indicated by the point load induced fracturing.

(6) The preferred direction of fracturing in the Upper Olentangy Shale (3,143 to 3,184 feet tested) is N60oE+15° as indicated by point load induced fracturing and directional tensile strength measurements.

(7) The preferred direction of fracturing in the Pipe Creek Shale (3,197 to 3,211 feet tested) is N60oE+15° as indicated by point load induced fracturing. There was a statistically small number of samples tested from this depth interval.

(8) The preferred direction of fracturing in the Angola Shale (3,225 to 3,355 feet tested) is N60oE+45° as indicated by point load induced fracturing.

(9) The preferred direction of fracturing in the Rhinestreet Shale (3,365 to 3,555 feet tested) is N60oE+15° as indicated by point load induced fracturing.

TABLE A-I

EGSP-Kentucky #3
Martin County

Directional Ultrasonic P Wave Velocity
Average Velocities in km/sec and Orientation'

	Degrees East of North					
Depth	0°	30°	60°	90°	120°	150°
Cleveland Shale						
2,496'	4.182	4.190	4.189	4.239	4.190	4.176*
2,505.4'	4.385*	4.409	4.423	4.389	4.395	4.423
2.515'	4.728	4.794	4.747	4.766	4.703*	4.767
2,530.7'	4.577	4.602	4.618	4.665	4.608	4.567*
2,536'	4.848	4.852	4.835	4.837	4.830	4.797*
2,551'	5.008	5.317	5.454	5.362	5.367	4.226*
2,560'	4.737*	4.759	4.784	4.769	4.751	4.738
2,571'	4.232	4.279	4.283	4.257	4.081	4.046*
Average	4.587	4.650	4.667	4.661	4.616	4.468*
Chagrin Shale						
2,585'	4.566	4.613	4.624	4.597	4.612	4.542*
2,593.0'	4.706	4.865	4.768	4.570	4.488	4.470*
2,614	5.183	5.224	5.203	5.170	5.114*	5.147
2,620.1'	4.665	4.737	4.694	4.617*	4.769	4.753
2,630	5.085	5.092	5.093	5.060	5.028*	5.042
2,633'	4.903*	4.966	4.986	5.017	5.090	5.002
Average	4.856	4.916	4.895	4.839	4.850	4.826*
Upper Huron Shale						
2,693'	4.124	4.206	4.182	3.923*	4.017	4.067
2,750'	4.199	4.317	4.309	4.076	4.049*	4.058
2,753'	4.270	4.315	4.187	3.608*	4.215	4.225
Average	4.198	4.279	4.226 .	3.869*	4.094	4.117
Middle Huron Shale						
2,805'	5.408*	5.424	5.445	5.444	5.438	5.410
Average	5.408*	5.424	5.445	5.444	5.438	5.410
Lower Huron Shale						
2,936'	4.216	4.202	4.256	4.229	4.185*	4.194
2,954'	4.129	4.229	4.233	3.978	3.037*	3.938
3,006'	4.607*	4.660	4.662	4.667	4.647	4.612
3,028'	4.785	4.780*	4.801	4.823	4.864	4.821
3,117'	4.420	4.479	4.510	4.377	4.313	4.266*
Average	4.431	4.470	4.492	4.415	4.209*	4.366

TABLE A-1 Continued

EGSP-Kentucky #3
Martin County

Directional Ultrasonic P Wave Velocity
Average Velocities in km/sec and Orientation

	Degrees East of North					
Depth	0°	30°	60°	90°	120°	150°
Upper 01entangy						
3,143'	4.725	4.677*	4.764	4.876	4.746	4.789
3,162'	4.306*	4.327	4.367	4.326	4.385	4.356
3,184'	4.584	4.598	4.625	4.623	4.516*	4.552
Average	4.538	4.534*	4.585	4.608	4.549	4.566
Pipe Creek						
3,197'	3.763*	4.387	4.385	4.312	4.211	4.117
Average	3.763*	4.387	4.385	4.312	4.211	4.117
Rhinestreet Shale						
3,396'	4.514	4.461	4.379*	4.493	4.507	4.481
3,405'	5.606	5.566	5.469*	5.610	5.571	5.545
3,555'	4.330	4.369	4.365	4.378	4.362	4.296*
Average	4.817	4.799	4.738*	4.827	4.813	4.774
Well Composite	4.594	4.657	4.655	4.602	··4.570	4.547*

*Minimum ultrasonic velocity for depth interval

FIGURE A-1

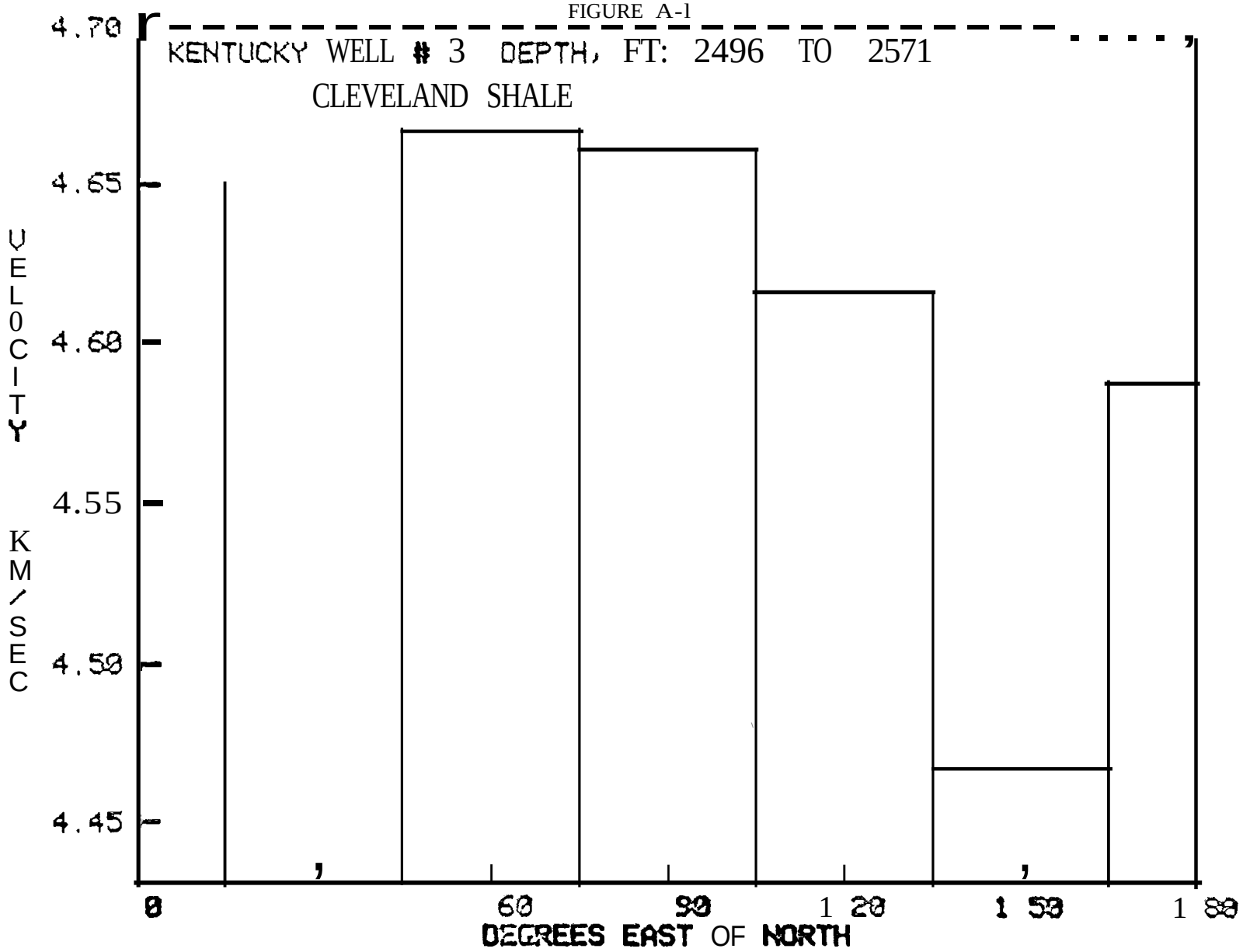

KENTUCKY WELL # 3 DEPTH, FT: 2496 TO 2571
CLEVELAND SHALE
4.70
4.65
4.60
4.55
4.50
4.45
VELOCITY
KM/SEC
0
60
90
120
150
180
DEGREES EAST OF NORTH

FIGURE A-2

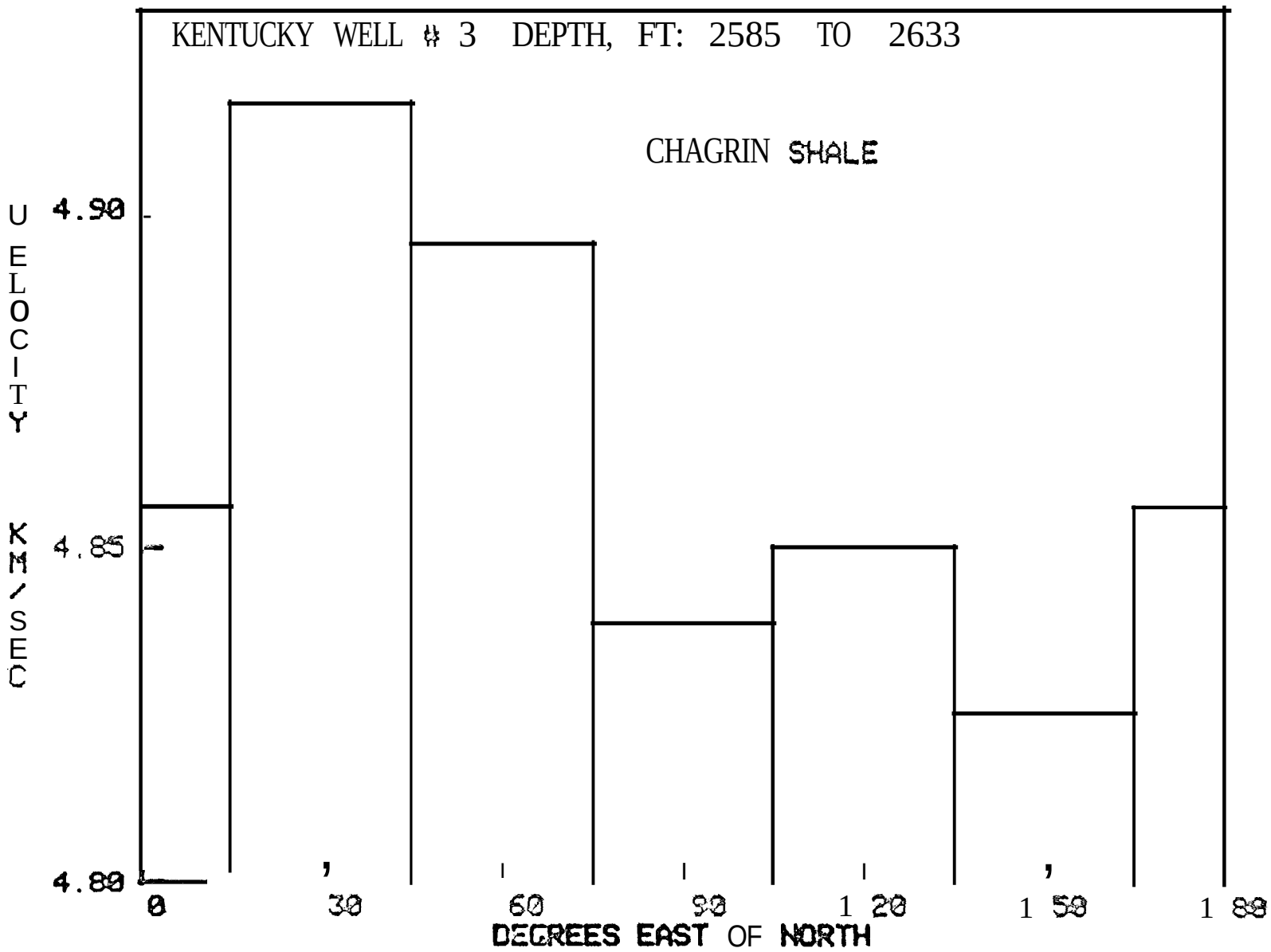

KENTUCKY WELL # 3 DEPTH, FT: 2585 TO 2633
CHAGRIN SHALE
VELOCITY KM/SEC
4.90
4.85
4.80
0
30
60
90
120
150
180
DEGREES EAST OF NORTH

FIGURE A-3

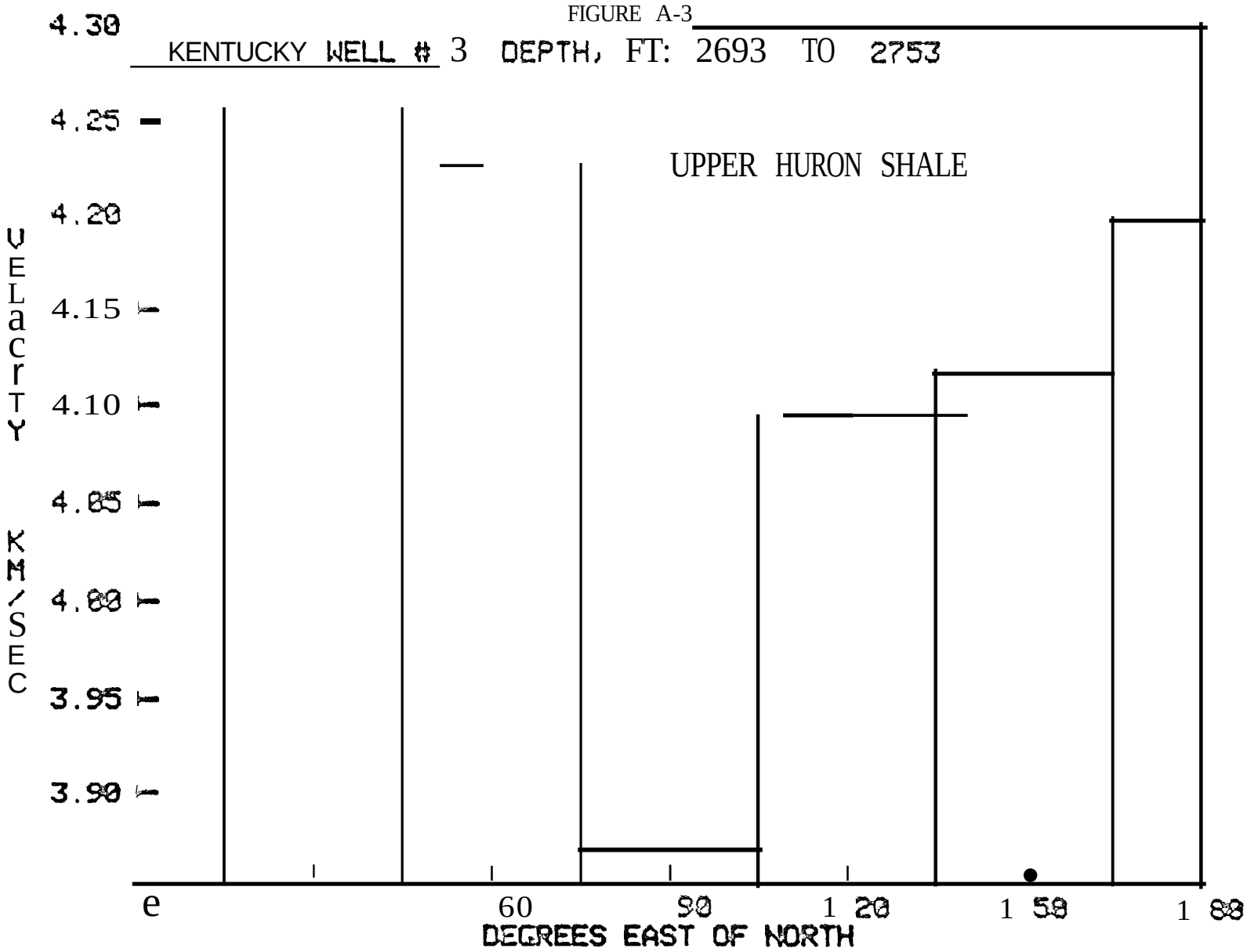

KENTUCKY WELL # 3 DEPTH, FT: 2693 TO 2753
UPPER HURON SHALE
VELOCITY KM/SEC
4.30
4.25
4.20
4.15
4.10
4.05
4.00
3.95
3.90
e
60
90
1 20
1 50
1 80
DEGREES EAST OF NORTH

FIGURE A-4

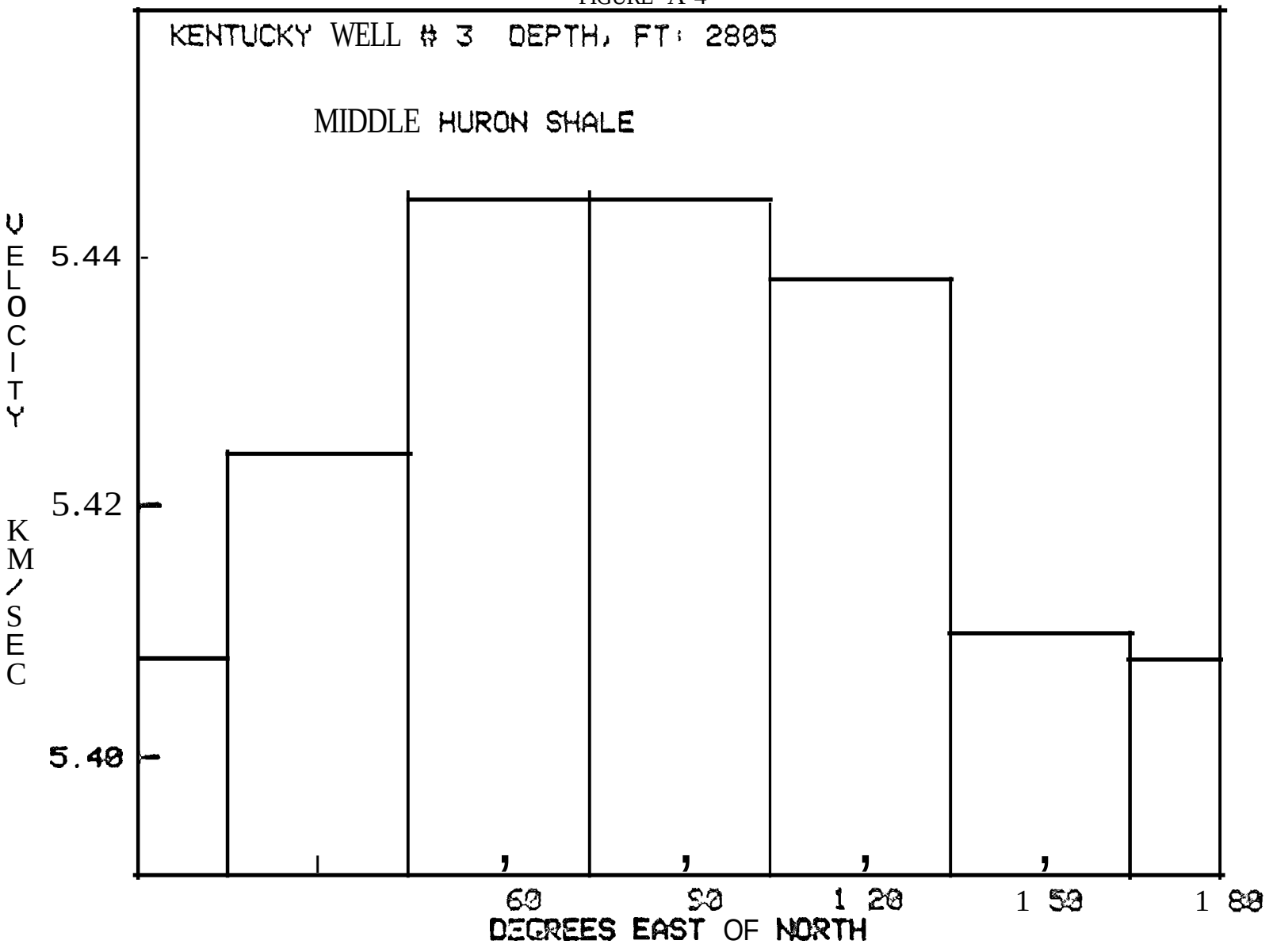

KENTUCKY WELL # 3 DEPTH, FT: 2805
MIDDLE HURON SHALE
VELOCITY KM/SEC
5.44
5.42
5.40
60
90
120
150
180
DEGREES EAST OF NORTH

FIGURE A-5

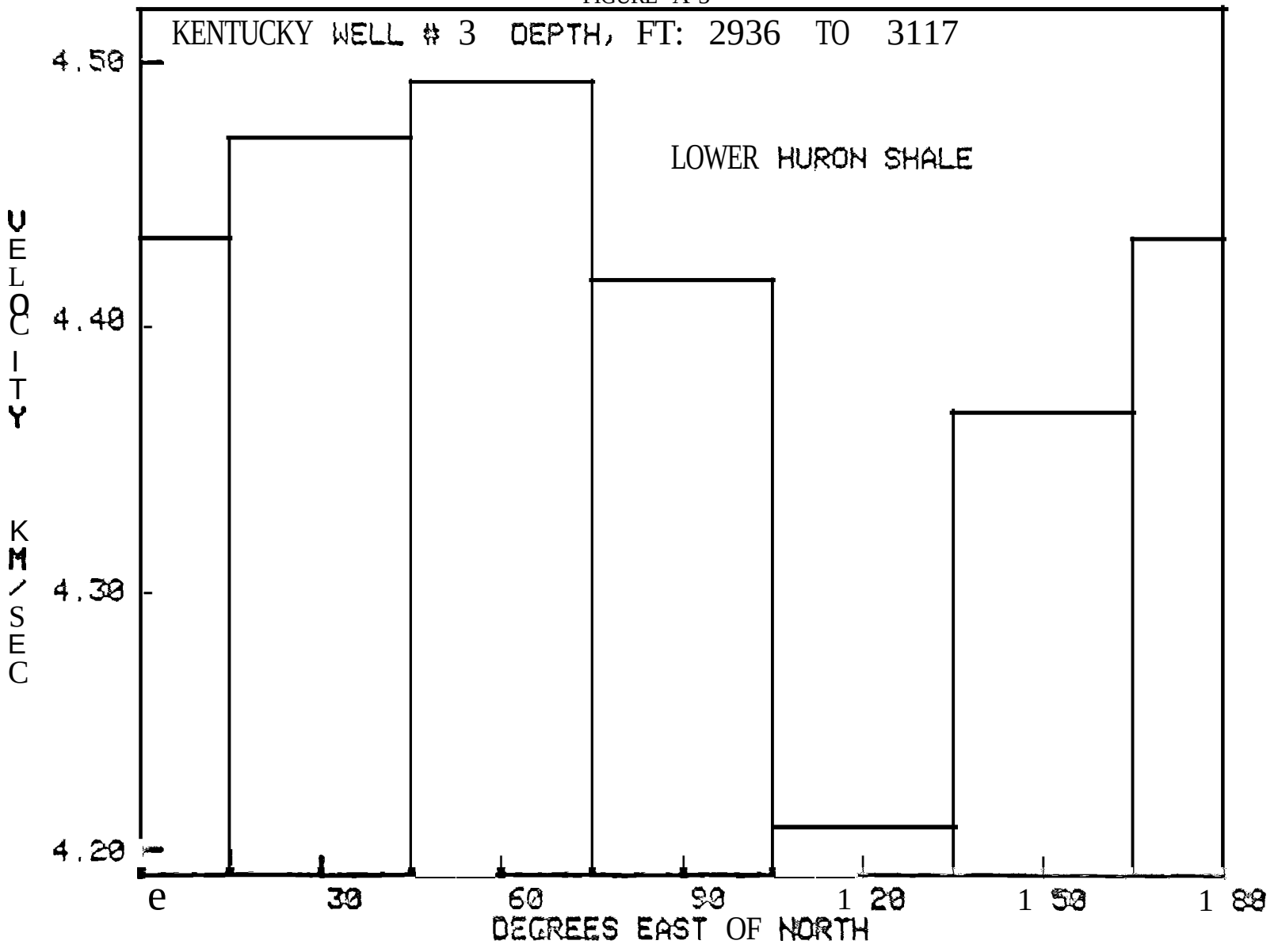

KENTUCKY WELL # 3 DEPTH, FT: 2936 TO 3117
LOWER HURON SHALE
VELOCITY KM/SEC
4.50
4.40
4.30
4.20
e
30
60
90
1 20
1 50
1 80
DEGREES EAST OF NORTH

FIGURE A-6

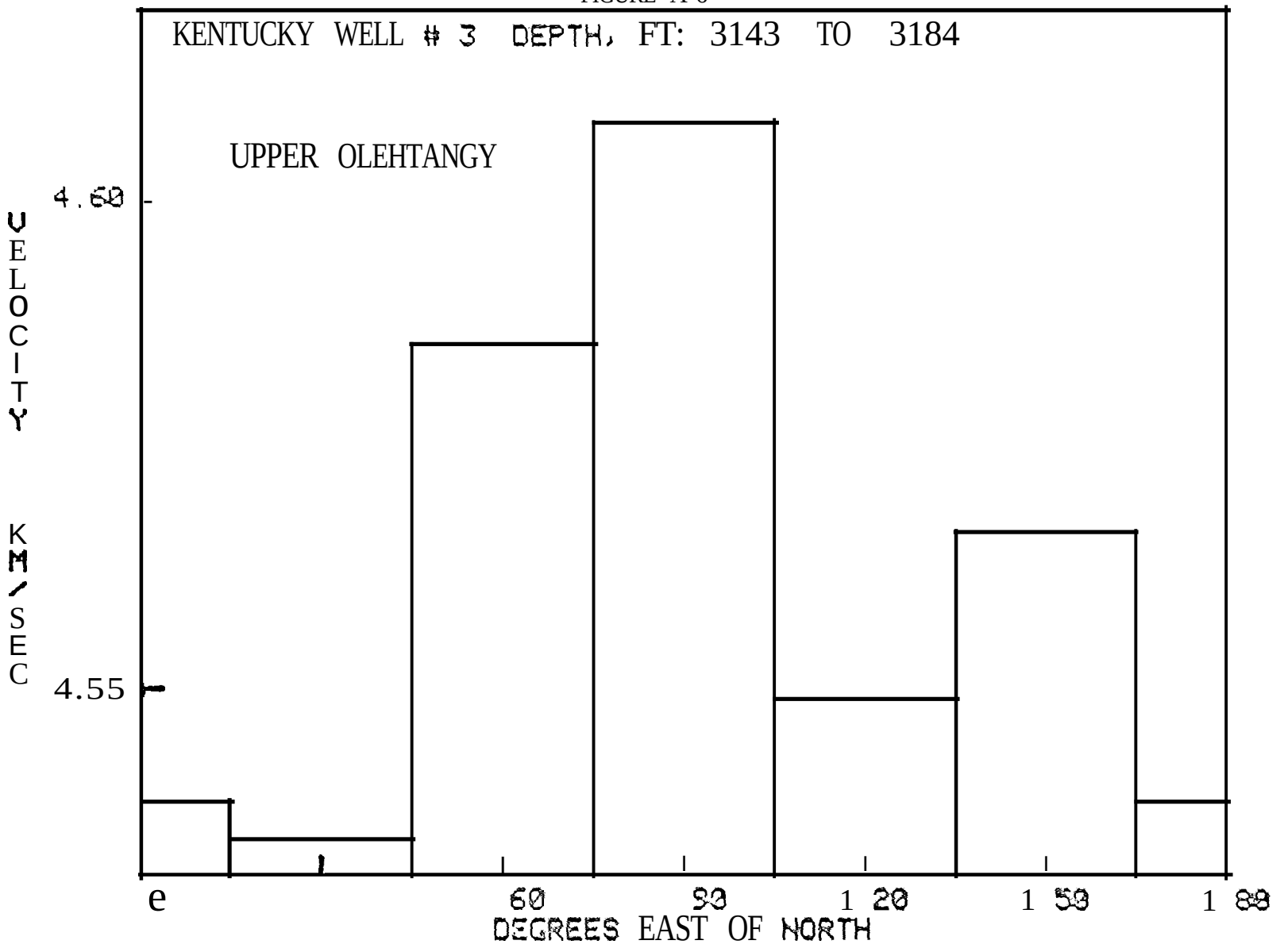

KENTUCKY WELL # 3 DEPTH, FT: 3143 TO 3184
UPPER OLEHTANGY
4.60
4.55
VELOCITY KM/SEC
e
60
90
1 20
1 50
1 80
DEGREES EAST OF NORTH

FIGURE A-7

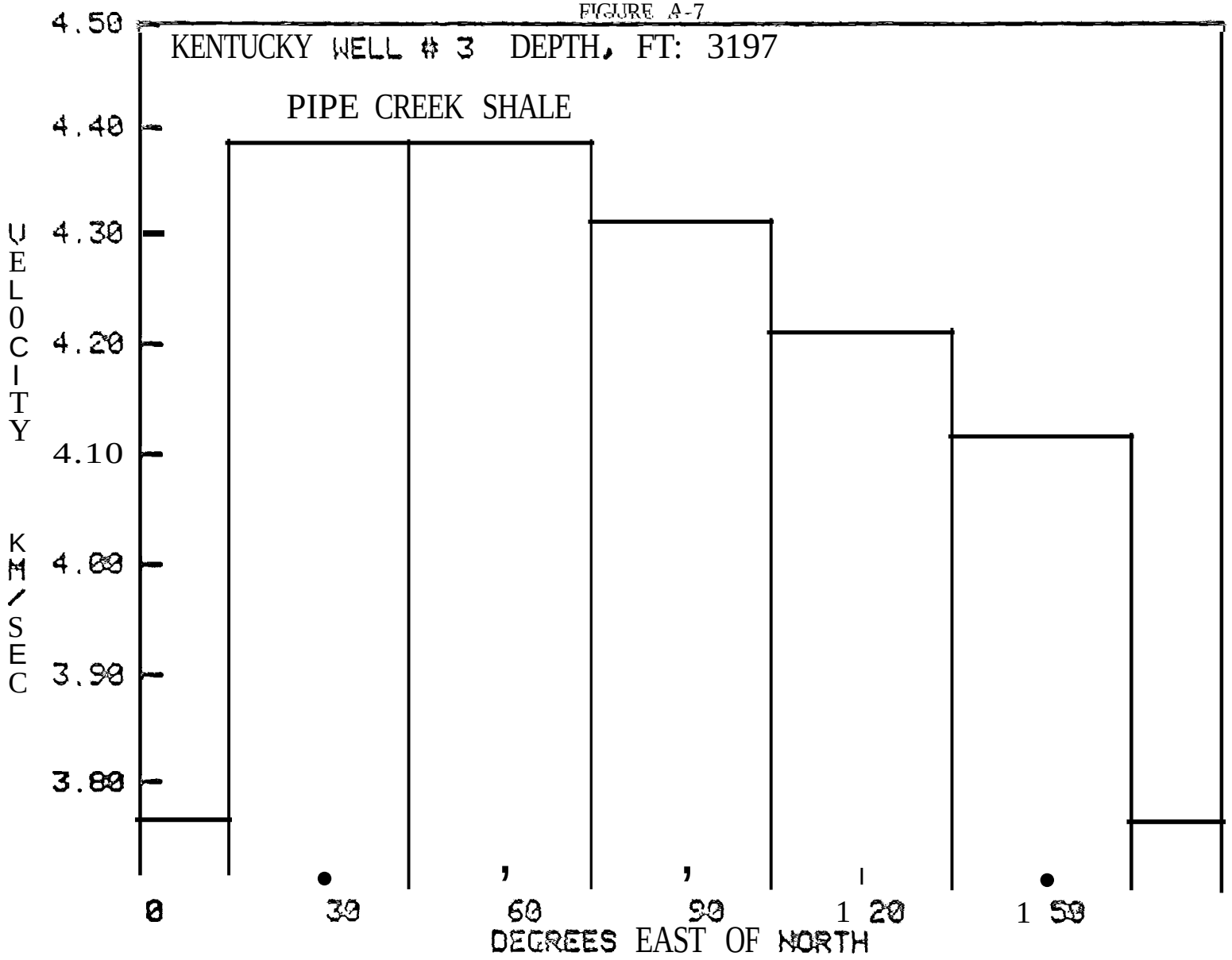

KENTUCKY WELL # 3 DEPTH, FT: 3197
PIPE CREEK SHALE
VELOCITY KM/SEC
4.50
4.40
4.30
4.20
4.10
4.00
3.90
3.80
0
30
60
90
120
150
DEGREES EAST OF NORTH

FIGURE A-8

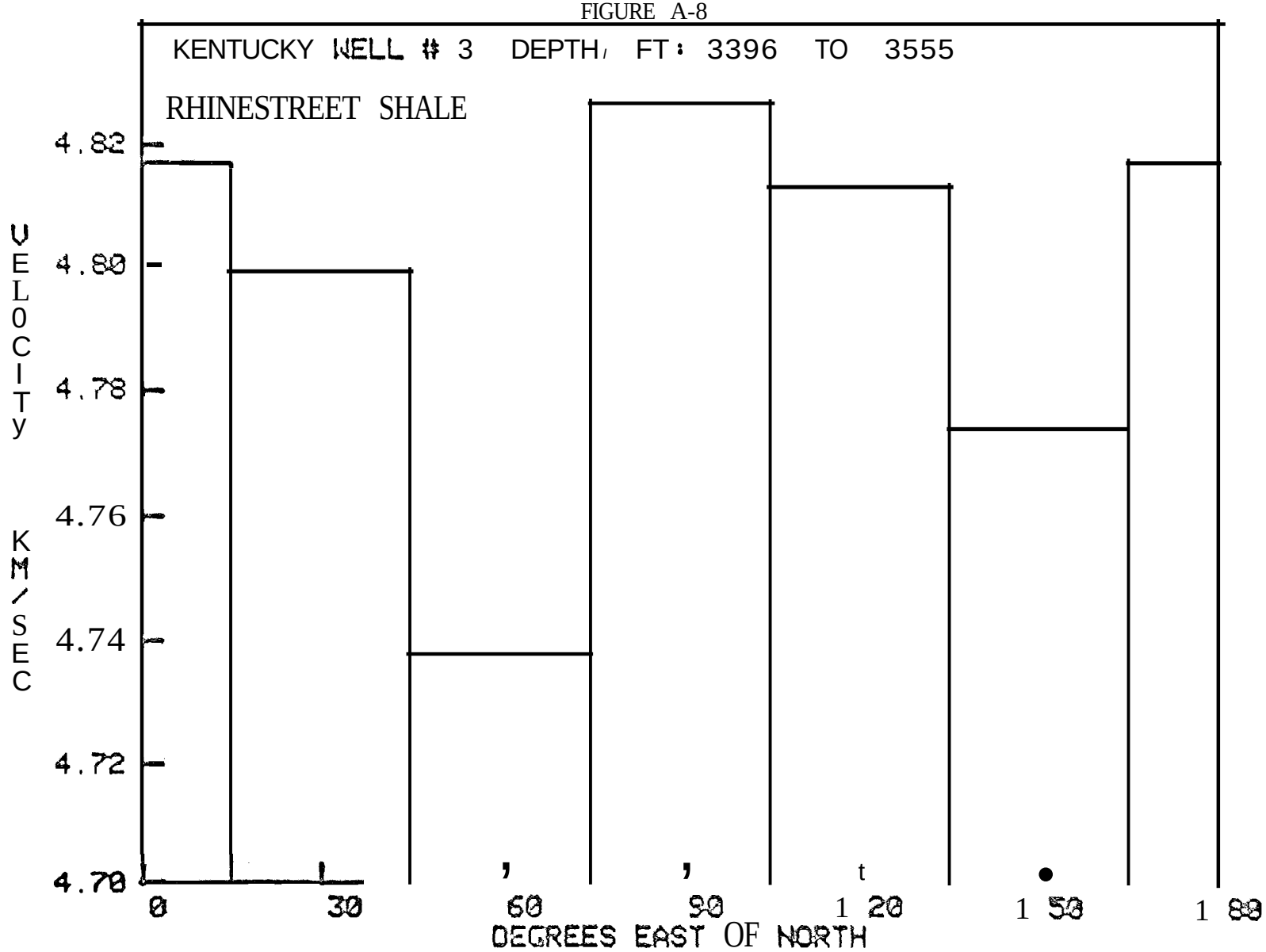

KENTUCKY WELL # 3 DEPTH, FT: 3396 TO 3555
RHINESTREET SHALE
VELOCITY KM/SEC
4.82
4.80
4.78
4.76
4.74
4.72
4.70
0
30
60
90
120
150
180
DEGREES EAST OF NORTH

FIGURE A-9

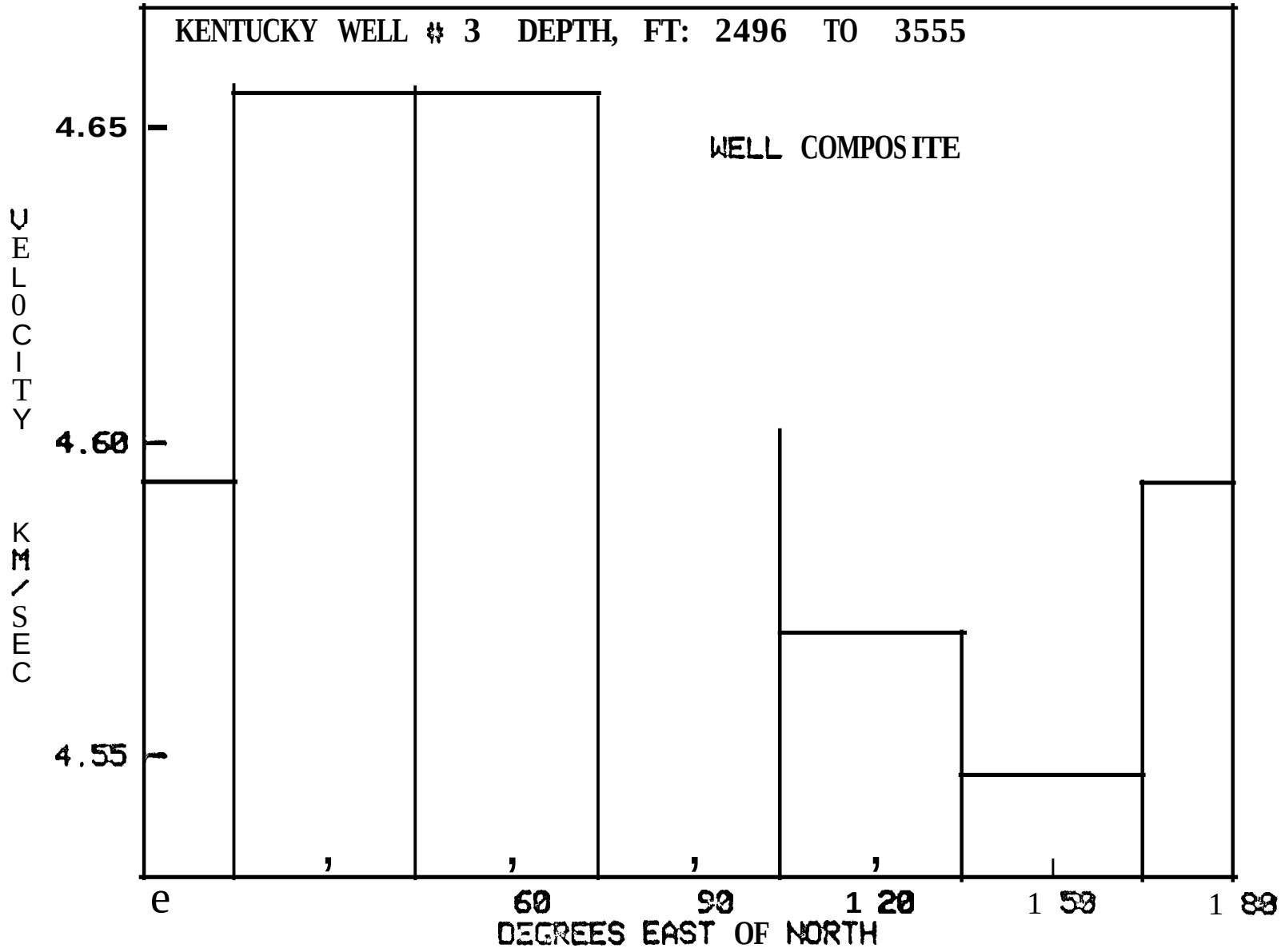

KENTUCKY WELL # 3 DEPTH, FT: 2496 TO 3555
WELL COMPOSITE
VELOCITY KM/SEC
4.65
4.60
4.55
e
60
90
1 20
1 50
1 80
DEGREES EAST OF NORTH

TABLE B-1

Kentucky #3, Martin County

Frequency of Fractures Induced by Point Load
Depth is Midpoint of 10 ft. Interval
Orientation in Degrees East of North

Depth	0°	30°	60°	90°	120°	150°	Total
Cleveland							
2,488'	0	1	0	0	0	0	1
2,495'	0	0	4	0	1	0	5
2,505'	0	2	2	2	0	0	6
2,519'	0	0	1	0	0	0	1
2,521'	0	2	0	0	0	0	2
2,533'	0	1	1	0	0	0	2
2,545'	0	2	1	0	1	0	4
2,555'	0	0	1	1	1	0	3
2,566'	1	1	0	0	0	1	3
2,572'	0	0	1	0	0	0	1
Total	1	9	11	3	3	1	28
Chagrin							
2,585'	0	1	2	0	0	0	3
2,595'	0	0	1	1	1	1	4
2,604'	0	1	1	0	0	0	2
2,623'	0	0	0	0	1	0	1
2,635'	1	0	2	2	1	0	6
2,645'	1	2	0	1	0	1	5
2,655'	0	0	2	0	1	0	3
Total	2	4	8	4	4	2	24
Upper Huron							
2,665'	5	1	2	1	2	3	14
2,675'	4	1	1	4	1	0	11
2,685'	2	2	6	5	1	0	16
2,695'	0	5	4	6	2	3	20
2,705'	1	0	4	0	1	0	6
2,725'	0	1	0	2	0	1	4
2,735'	3	1	3	0	1	0	8
2,745'	0	4	3	2	2	0	11
2,755'	1	5	11	3	1	0	21
Total	16	20	34	23	11	7	111
Middle Huron							
2,815'	0	0	0	2	0	0	2
2,842'	0	1	0	0	0	0	1
2,856'	0	1	0	0	0	0	1
2,866'	0	0	0	1	0	1	2
2,903'	0	0	1	0	0	2	3
Total	0	2	1	3	0	3	9

TABLE B-1 Cant.

Kentucky #3, Martin County

Frequency of Fractures Induced by Point Load
Depth is Midpoint of 10 ft. Interval
Orientation in Degrees East of North

Depth	0°	30°	60°	90°	120°	150°	Total
Angola Cant.							
3,325'	0	1	0	1	1	0	3
3,345'	0	0	0	1	0	2	3
3,355'	0	1	0	0	0	0	1
Total	7	12	9	13	7	4	52
Rhinestreet							
3,365'	0	0	0	0	1	0	1
3,404'	2	1	4	1	1	0	9
3,411'	0	0	2	0	0	0	2
Total	2	1	6	1	2	0	12
Well Composite	46	77	130	87	48	35	423

TABLE C-1

EGSP-Kentucky rs
Martin County

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

Depth	0°	30°	60°	90°	120°	150°
Cleveland						
2,541.6'					1,731	
Average						
Chagrin						
2,605'	1,074	1,308	668	1,265	*430	3,385
2,615'					1,967	1,856
2,625'	1,524	1,946	1,541	1,613		
2,635'	3,653	913	1,365		366	1,083
2,645'	1,038	1,150		1,162	2,129	860
2,653'	1,141		1,307	1,215	720	1,189
Average	1,686	1,329	1,220	1,314	1,122	1,675
Upper Huron						
2,665'		964	829	1,259	664	324
2,675'	1,119	1,053	945	945	2,636	1,370
2,685'	1,245	1,387	911	1,050	888	802
2,695'	1,097	1,113	1,157	846		
2,705'	784	943	1,325	1,201	611	830
2,715'	1,145	725	1,013	1,217	764	1,339
2,735'	1,554	1,165	1,371		787	2,009
2,745'				1,261	1,363	1,371
2,755'	1,045	1,158	488	563		
2,777'					597	
2,785'	548	1,343	306	701		903
2,795'	1,595	1,975			951	1,425
Average	1,126	1,183	927	1,005	1,029	1,153
Middle Huron						
2,805'			1,276	901		
2,896'					947	
2,905'	835	485	617	1,393		966
Average	835	485	947	1,147	947	966
Lower Huron						
2,915'	1,534	1,184	1,178	1,463	1,346	1,498
2,935'	777				929	1,293
2,945'		1,301	922	1,275		
2,955'	417	1,102	1,060	1,428	878	1,443
2,965'					1,340	719
2,975'	1,283	995	726	779	995	1,087
2,985'	534	1,103	1,093	1,370		
2,995'	595	425			856	990
3,005'	1,210	1,369	1,047	1,501	1,097	908
3,015'	1,276	1,221	1,202	1,219	432	768
3,025'	2,212		849	560	1,016	1,344
3,035'		1,356	1,258	1,329		

TABLE C-1 Cont.

EGSP-Kentucky #3
Martin County

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

Depth	0°	30°	60°	90°	120°	150°
Lower Huron Cont.						
3,045'	1,202	1,134			1,147	908
3,055'	889	1,142	874	1,158	1,028	1,019
3,065'			716	1,056		
3,085'	1,117	1,110			865	1,092
3,095'			1,350	1,044		
Average	1,087	1,120	1,023	1,182	994	1,005
Upper 01entangy						
3,155'	1,105	964	688		1,283	1,127
3,165'	1,239	1,318	645	1,249, 1,172	1,131	1,194
3,175'	366	909	925	1,000	1,041	889
Average	903	1,064	753	1,140	1,152	1,070
Pipe Creek						
3,205'	874				1,463	544
3,211'	727	943	1,071	1,182	1,450	1,205
Average	801	943	1,071	1,182	1,457	875
Angola						
3,225'	941	975	1,403	944	1,459	1,522
3,235'	990	1,079, 885	765	890	1,192	787
3,245'			996	1,292		
3,255'	800	608	1,264		681	1,618
3,265'	1,361	894	766	1,239	1,253	631
3,275'	188			648	908	1,073
3,285'		743	321	859		
3,291'					1,173	
3,305'	555	479	390	719		1,024
Average	806	809	844	942	1,111	1,109
Rhinestreet						
3,385'					1,338	1,400
3,395'	814	802	454	1,247		
3,405'	583	980	2,834	1,768	3,177	1,200
Average	699	891	1,644	1,508	2,258	1,300
Well Composite	1,075	1,066	998	1,125	1,147	1,146

FIGURE C-1

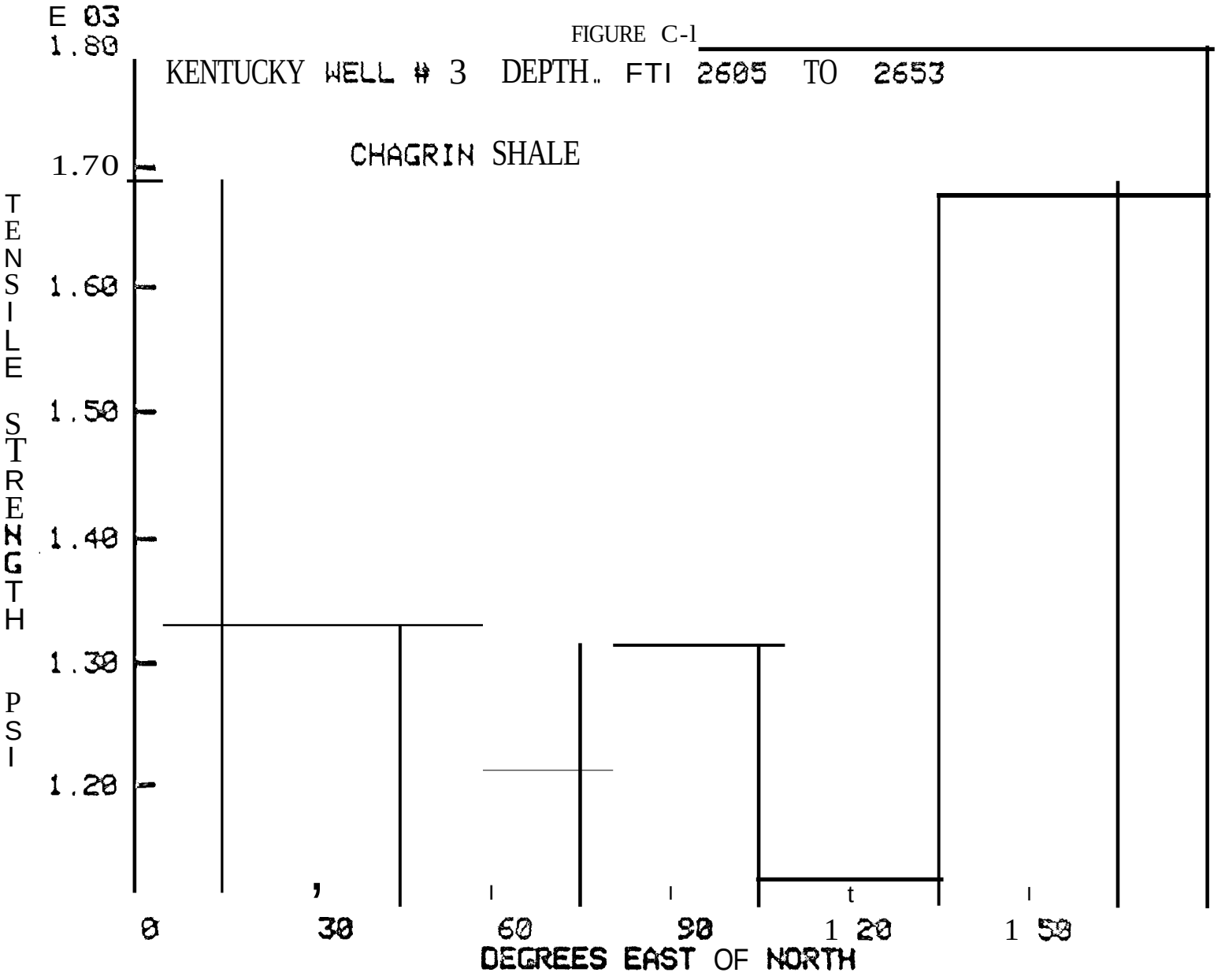
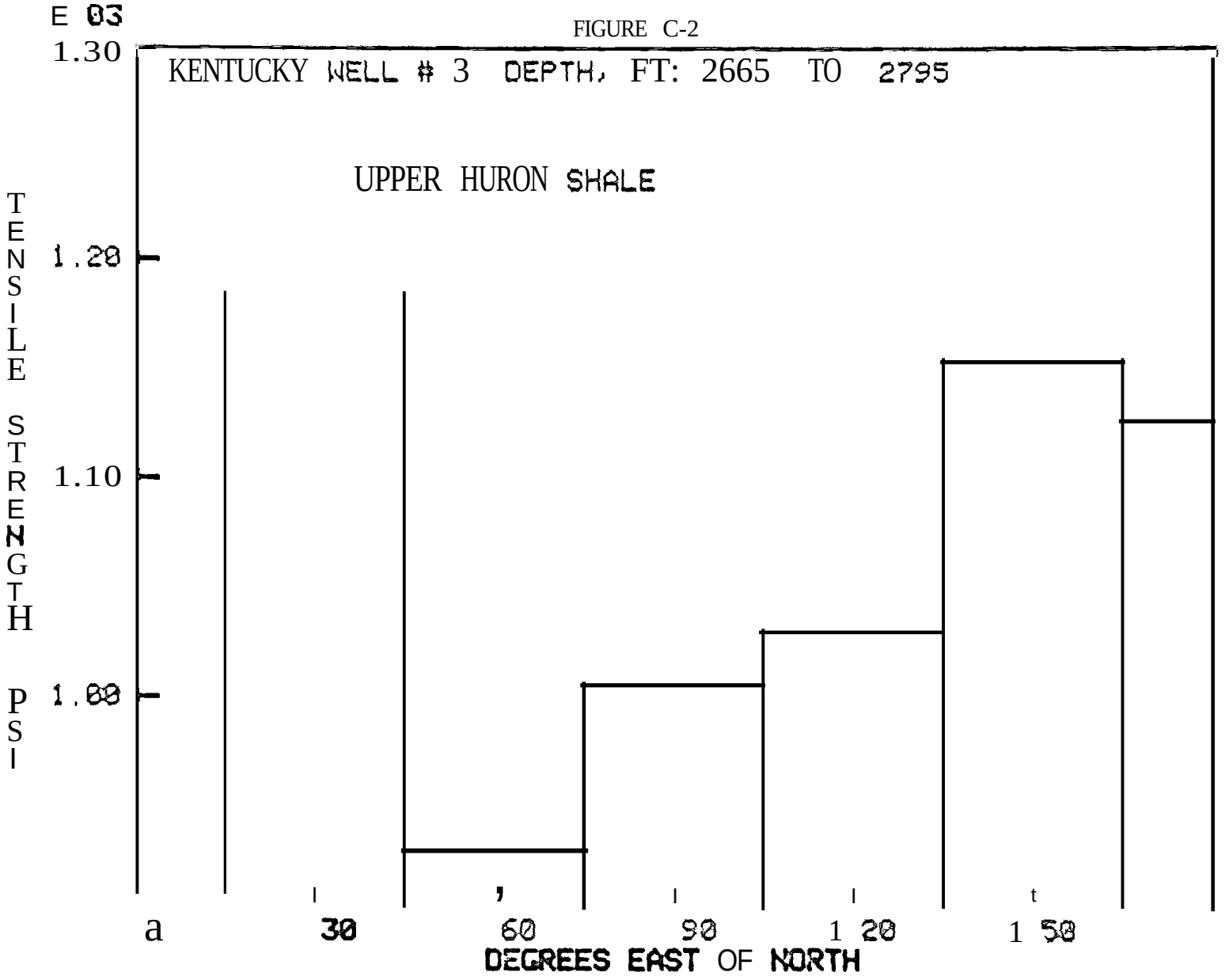

E 03
KENTUCKY WELL # 3 DEPTH. FTI 2605 TO 2653
CHAGRIN SHALE
1.80
1.70
1.60
1.50
1.40
1.30
1.20
TENSILE STRENGTH PSI
0
30
60
90
1 20
1 50
DEGREES EAST OF NORTH

FIGURE C-2


E 03
KENTUCKY WELL # 3 DEPTH, FT: 2665 TO 2795
UPPER HURON SHALE
TENSILE STRENGTH PSI
1.30
1.20
1.10
1.00
a
30
60
90
120
150
DEGREES EAST OF NORTH

E 03

FIGURE C-3

KENTUCKY WELL # 3 DEPTH, FT: 2805 TO 2905

MIDDLE HURON SHALE

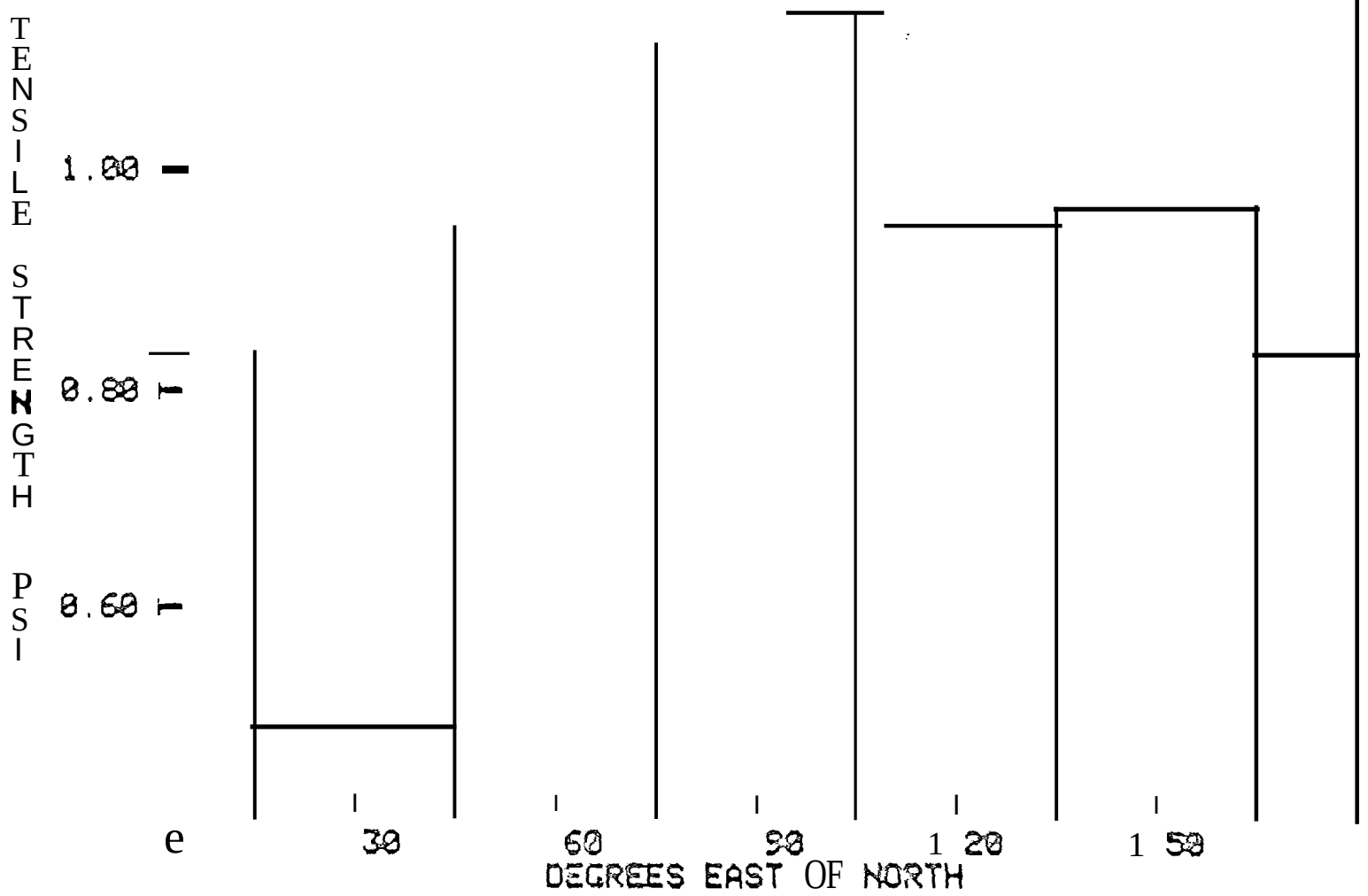


FIGURE C-4

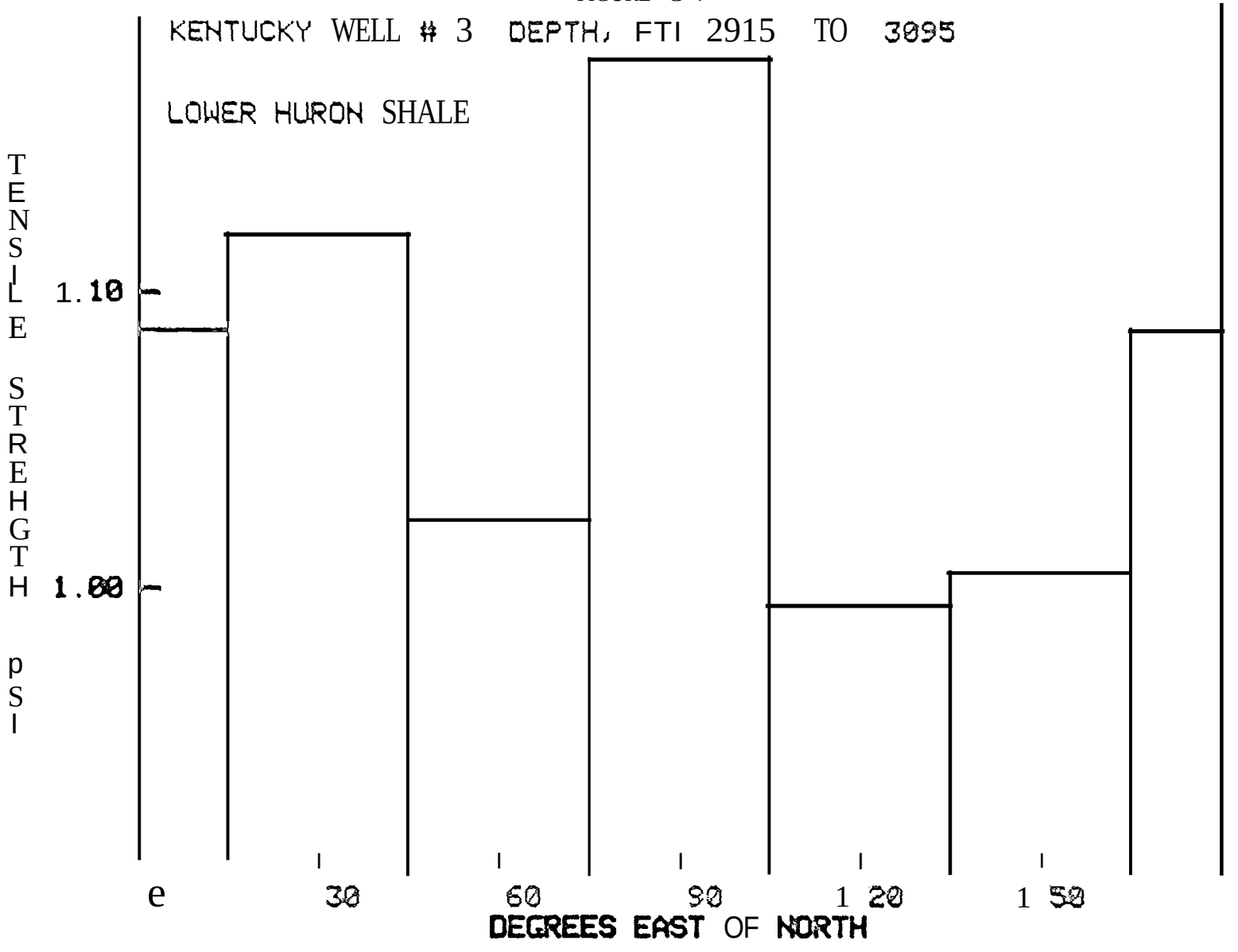

KENTUCKY WELL # 3 DEPTH, FTI 2915 TO 3095
LOWER HURON SHALE
TENSILE STREHGTH psi
1.10
1.00
e
30
60
90
1 20
1 50
DEGREES EAST OF NORTH

FIGURE C-5

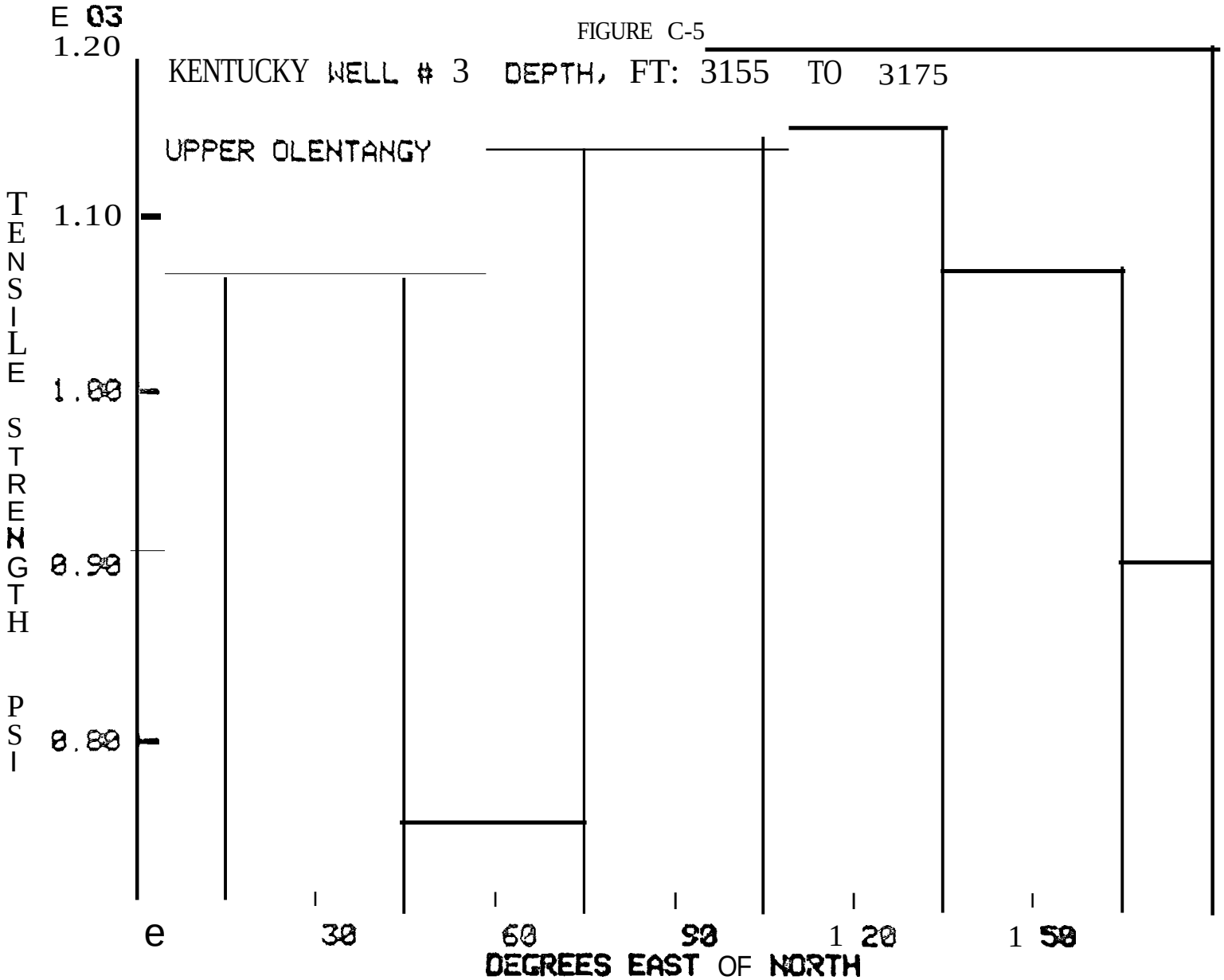

E 03
1.20
KENTUCKY WELL # 3 DEPTH, FT: 3155 TO 3175
UPPER OLENTANGY
TENSILE STRENGTH PSI
1.10
1.00
0.90
0.80
e
30
60
90
1 20
1 50
DEGREES EAST OF NORTH

FIGURE C-6

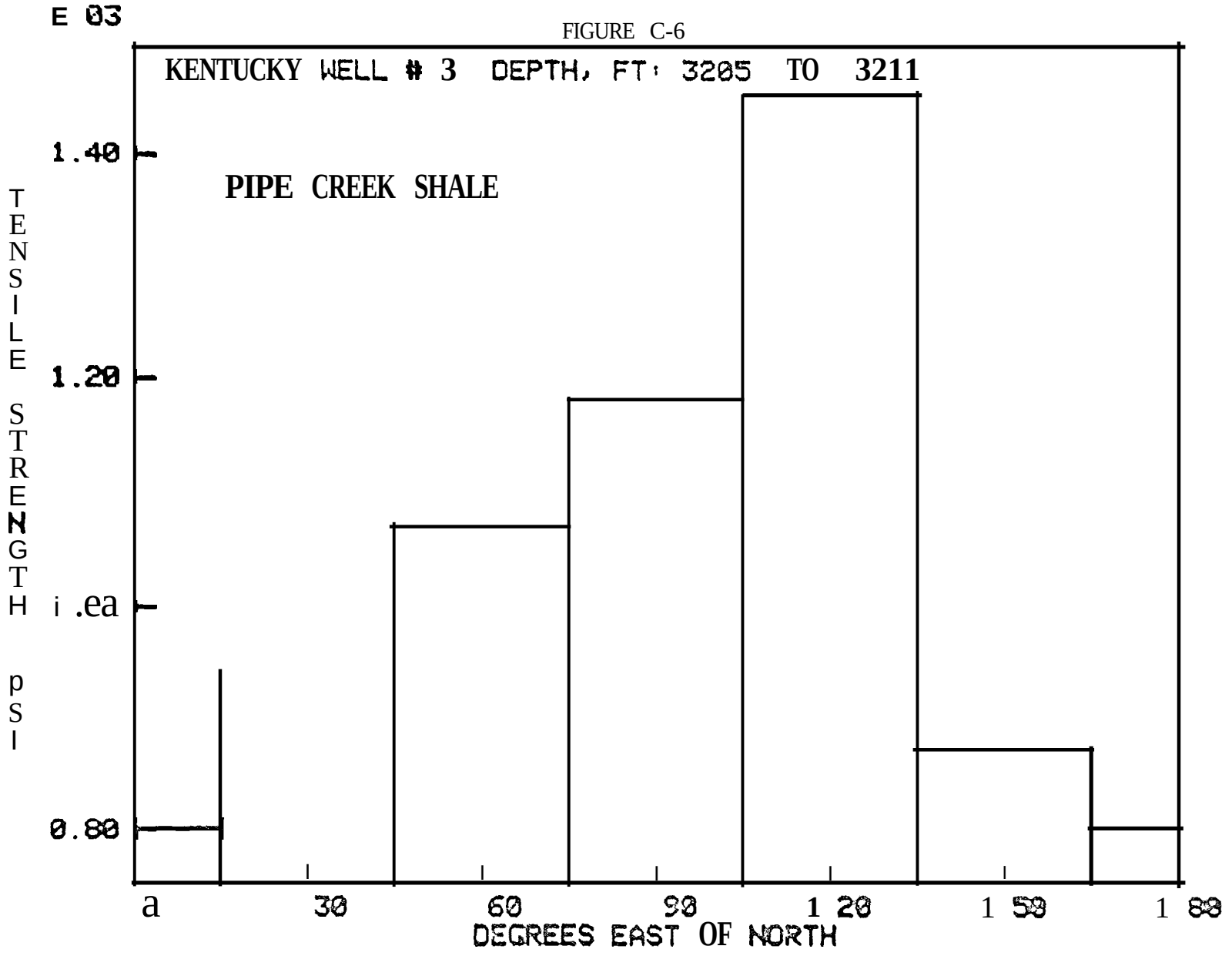

E 03
KENTUCKY WELL # 3 DEPTH, FT: 3205 TO 3211
PIPE CREEK SHALE
1.40
1.20
i .ea
0.80
TENSILE STRENGTH psi
a
30
60
90
1 20
1 50
1 80
DEGREES EAST OF NORTH

FIGURE C-7

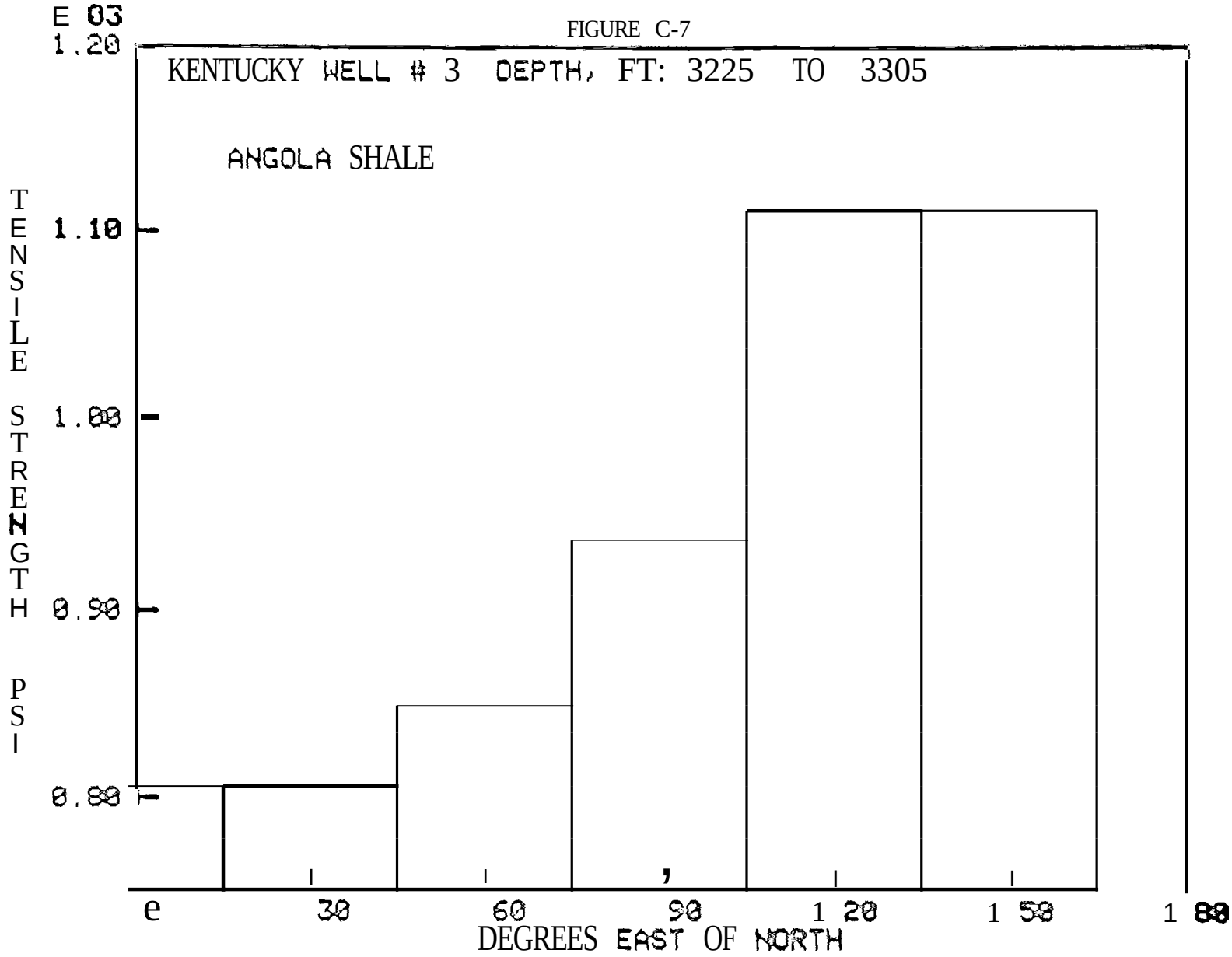

E 03
1.20
KENTUCKY WELL # 3 DEPTH, FT: 3225 TO 3305
ANGOLA SHALE
TENSILE STRENGTH PSI
1.10
1.00
0.90
0.80
e
30
60
90
1 20
1 50
1 80
DEGREES EAST OF NORTH

FIGURE C-8

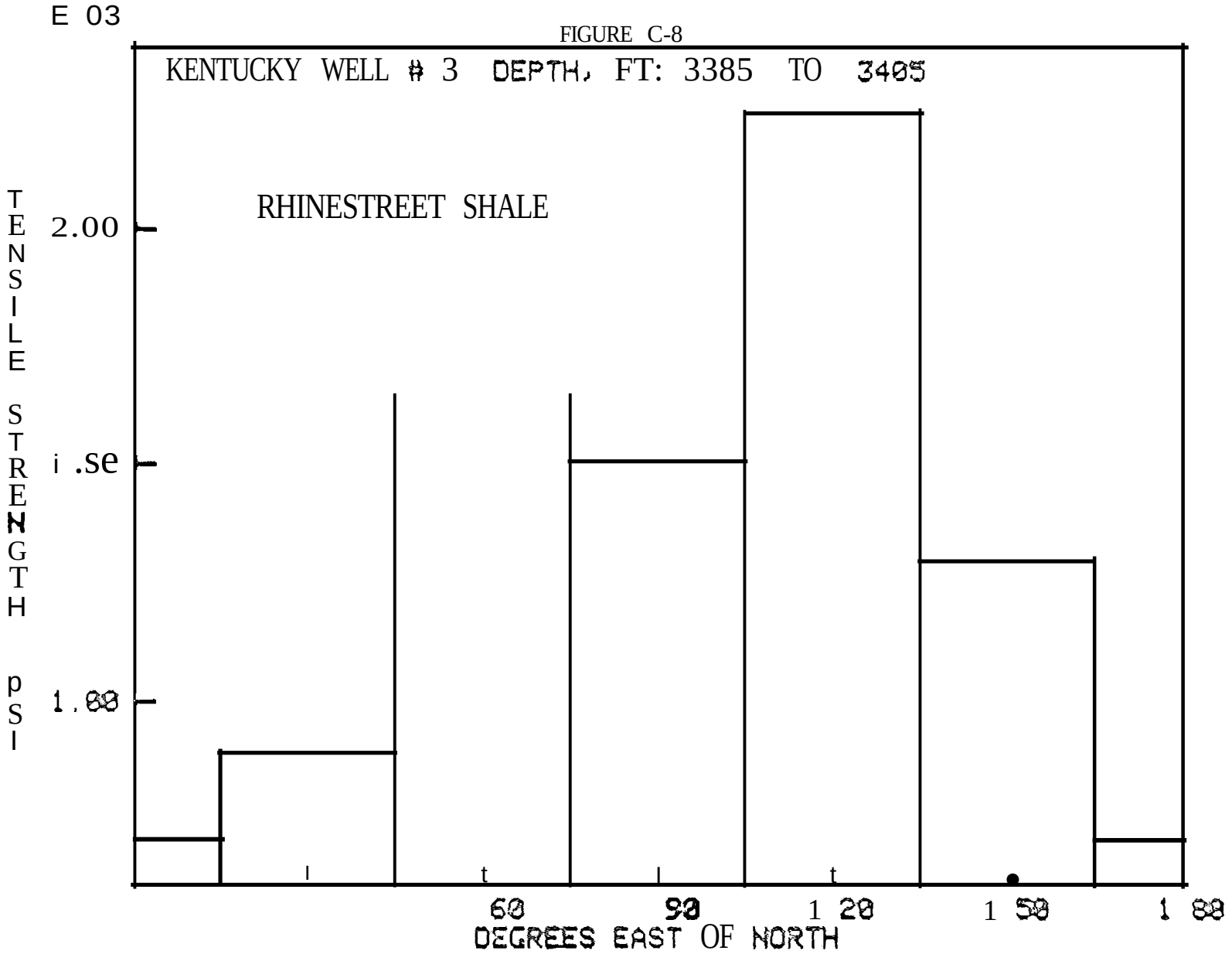

E 03
KENTUCKY WELL # 3 DEPTH, FT: 3385 TO 3405
RHINESTREET SHALE
TENSILE STRENGTH psi
2.00
i .se
1.00
60
90
1 20
1 50
1 80
DEGREES EAST OF NORTH

FIGURE C-9

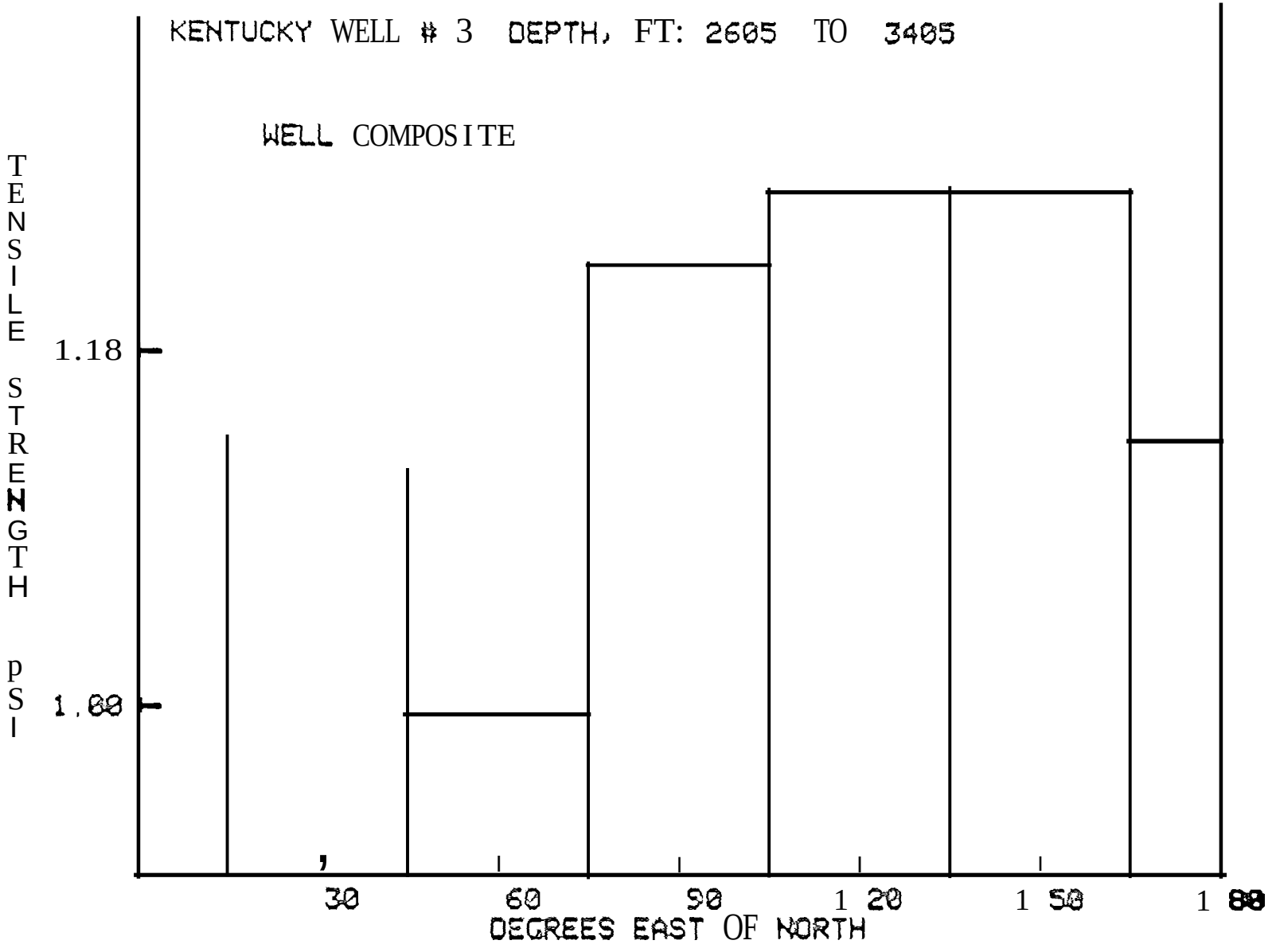

KENTUCKY WELL # 3 DEPTH, FT: 2605 TO 3405
WELL COMPOSITE
TENSILE STRENGTH PSI
1.18
1.00
30
60
90
120
150
180
DEGREES EAST OF NORTH

TABLE D-l

EGSP-Kentucky #3, Martin County

Depth in Feet	Density grlml
2,499.8	2.608
2,506.2	2.774
2,528.6	2.660
2,551.2	2.770
2,555.6	2.658
2,572.1	25.15

TABLE *D-2*

EGSP-Kentucky #3, Martin County

Directional Permeabilities in Microdarcys

Depth in Feet	Parallel to Ore Axis	Perpendicular to Core Axis
2,493.5	0.0376	0.627
2,499.8		0.16
2,506.2		0.35
2,541.8	0.101	2.60
2,555.6		1.75
2,570.1		10.03
2,572.1		0.02

TABLE D-3 Continued

Depth and direction.	P-Wave Velocity Vp(km/sec)	S-Wave Velocity VS(km/sec)	Poisson's Ratio *a*	Youngs Modulus E(gPa x 10^3)	Shear Modulus G(gPa x 10^3)	Bulk Density. ρ(g/cc)
2,630'						2.65
N60W	5.028	3.274	0.132	0.06432	0.02841	
N30W	5.042	3.320	0.117	0.06525	0.02920	
N	5.085	3.377	0.145	0.06516	0.02846	
N30E	5.092	3.282	0.145	0.06536	0.02855	
N60E	5.093	3.283	0.145	0.06538	0.02856	
E	5.060	3.280	0.138	0.06485	0.02850	
2,633'						2.65
N60W	5.090	3.243	0.158	0.06457	0.02787	
N30W	5.002	3.217	0.147	0.06292	0.02742	
N	4.930	3.212	0.131	0.06183	0.02733	
N30E	4.966	3.225	0.135	0.06258	0.02756	
N60E	4.986	3.234	0.137	0.06303	0.02772	
E	5.017	3.219	0.150	0.06317	0.02746	
2,805'						2.92
N60W	5.438	3.184	0.239	0.07336	0.02960	
N30W	5.410	3.185	0.235	0.07315	0.02962	
N	5.408	3.187	0.234	0.07320	0.02966	
N30E	5.424	3.184	0.237	0.07326	0.02961	
N60E	5.445	3.185	0.240	0.07343	0.02961	
E	5.444	3.182	0.241	0.07337	0.02957	

TABLE D-3 Continued

Depth and direction	P-Wave Velocity Vp(km!sec)	S-Wave Velocity VS(km!sec)	Poisson's Ratio σ	Youngs Modulus E(gPa x 10^3)	Shear Modulus G(gPa x 10^3)	Bulk Density p(g/cc)"
3,006'						2.54
N60W	4.647	2.908	0.178	0.05061	0.02148	
N30W	4.612	2.912	0.169	0.05034	0.02154	
N	4.607	2.906	0.170	0.05018	0.02145	
N30E	4.660	2.907	0.181	0.05073	0.02147	
N60E	4.662	2.912	0.180	0.05084	0.02154	
E	4.667	2,909	0.182	0.05082	0.02149	