(1)

AD-A224 831

NAME OF CONTRACTOR:	Paul M. Raccah
CONTRACT NUMBER:	DAAK 70-83-K-0047
EFFECTIVE DATE OF CONTRACT:	2/1/83
EXPIRATION DATE OF CONTRACT:	1/31/86
REPORTING PERIOD:	SIXTH QUARTER
PRINCIPAL INVESTIGATOR:	PAUL M. RACCAH
PHONE NUMBER:	(312) 996-3403

Growth on A Virus versus Growth on B Surfaces

THE VIEWS AND CONCLUSIONS CONTAINED IN THIS DOCUMENT ARE THOSE OF THE AUTHORS AND SHOULD NOT BE INTERPRETED AS NECESSARILY REPRESENTING THE OFFICIAL POLICIES, EITHER EXPRESSED OR IMPLIED, OF THE U. S. GOVERNMENT.

SIXTH QUARTER

The sixth quarter has been devoted to the study of 7 samples provided by Night Vision Laboratories (See Tables Attached). We have addressed the question of growth on A versus growth on B surfaces and found that the differences are clear. We intend to study this question more actively in the coming quarter. We have addressed as well the question of comparison between layers grown by LPE versus layers grown by VPE. Here again we have seen what we have reported before, namely, that VPE layers are graded in composition and we have now established that this grading is accompanied by extensive strains. In comparison layers grown by LPE are superior.

EER AND ASE DATA FROM THE UNIVERSITY OF ILLINOIS
FOR BOTH LIQUID AND VAPOR PHASE EPITAXIAL MCT FILMS
GROWN AT NIGHT VISION.

GROWTH FACES- A(111) WITH ONE VPE B(111) SAMPLE
GROWTH SUBSTRATE-CDTE

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PHYSICAL MEANING OF ΔE_1 and $\Delta\sigma^2$

$$\Delta E_1 = \Delta E_{cb} - \Delta E_{vb}$$

$\Delta E_1 > 0$ means $\Delta E_{cb} > \Delta E_{vb}$

$\Delta E_1 = 0$ means $\Delta E_{cb} = \Delta E_{vb}$

$\Delta E_1 < 0$ means $\Delta E_{cb} < \Delta E_{vb}$

TWO CAUSES FOR THE CONTRIBUTION

a - Piezoelectric effect in non-centrosymmetric materials.

b - Breakdown of symmetry induced by overlapping structural defects.

$\Delta\sigma^2$ is proportional to the density of polarizable defects is in first approximation related linearly to ΔE_1

E_1-transition energy,yields composition fraction(x value)
Γ-line width, related to crystal quality
θ-phase, related to type

LPE #051084(A)

DEPTH IN MICRONS	E_1 EER	E_1 ASE	X EER	Γ EER	θ EER	Δ_1	$\Delta\sigma_2$
0.0	2.341	2.449	0.267	0.098	4.198	-19.270	-10.115
1.375	2.404	2.397	0.331	0.114	4.394	-16.765	- 4.788
2.750	2.399	2.393	0.327	0.110	4.489	-13.142	- 4.392
4.125	2.390	2.395	0.318	0.101	4.321	-24.993	- 5.755
5.500	2.397	2.399	0.324	0.111	4.491	- 9.604	- 3.582
6.875	2.406	2.399	0.333	0.108	4.439	-12.232	- 2.506
8.250	2.437		0.363	0.129	4.894	2.392	- 4.039
9.625	2.544	2.519	0.458	0.189	5.977	4.005	- 0.771

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LPE #050784(A)

DEPTH IN MICRONS	E_1 EER	E_1 ASE	X EER	Γ EER	θ EER	Δ_1	$\Delta\sigma^2$
0.0	2.260	2.268	0.176	0.088	4.138	-25.166	- 9.760
1.35	2.378	2.366	0.306	0.109	4.546	- 8.889	- 3.223
2.70	2.370	2.366	0.297	0.110	4.484	-10.236	- 3.460
4.04	2.369	2.360	0.296	0.108	4.565	- 9.470	- 3.795
5.38	2.365	2.361	0.292	0.105	4.580	- 7.646	- 3.353
6.73	2.362	2.356	0.289	0.103	4.563	- 7.756	- 3.246
8.08	2.361	2.352	0.288	0.113	4.871	0.042	- 3.529
9.42	2.357	2.355	0.284	0.102	4.469	- 7.076	- 3.314
10.77	2.354	2.355	0.281	0.097	4.382	-11.906	- 3.490
12.12	2.359	2.361	0.286	0.099	4.377	-12.177	- 3.591
13.46	2.379	2.384	0.307	0.101	4.430	-15.780	- 3.784
14.81	2.419	2.461	0.345	0.113	4.550	-21.923	- 4.872
16.15	2.508		0.427	0.181	4.855	- 8.956	- 4.574
17.50			0.995				

LPE #031484(A)

DEPTH IN MICRONS	E· EER	ASE	X EER	Γ EER	θ EER	Δ_1	$\Delta\sigma^2$
0.0	2.212	2.230	0.115	0.098	4.136	- 8.196	- 4.490
1.35	2.358	2.352	0.285	0.114	4.569	- 8.443	- 3.272
2.70	2.353	2.351	0.279	0.106	4.383	- 7.251	- 2.656
4.05	2.351	2.349	0.278	0.111	4.531	- 5.938	- 2.285
5.40	2.355	2.355	0.282	0.107	4.439	- 7.653	- 2.543
6.75	2.360	2.353	0.287	0.108	4.451	- 7.704	- 2.776
8.10	2.366		0.293	0.106	4.387	- 8.231	- 2.686
9.45	2.397	2.383	0.325	0.108	4.368	-10.928	- 3.063
10.80	2.458	2.439	0.382	0.123	4.421	-13.524	- 2.778
12.15	2.570	2.544	0.480	0.215	4.611	-12.095	- 2.333
13.5			0.993				

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LPE # 031484(A

NV314A

DEPTH	X		E1		GAMMA		THETA		DE1	DSIGMA
	EER	ASE	EER	ASE	EER	ASE	EER	ASE		
0.0	0.115		2.212		0.098		4.136		-8.196	-4.49C
1.35	0.285		2.358		0.114		4.569		-8.443	-3.272
2.70	0.279		2.353		0.106		4.383		-7.251	-2.656
4.05	0.278		2.351		0.111		4.531		-5.938	-2.285
5.40	0.282		2.355		0.107		4.439		-7.653	-2.543
6.75	0.287		2.360		0.108		4.451		-7.704	-2.776
8.10	0.293		2.366		0.106		4.387		-8.231	-2.686
9.45	0.325		2.397		0.108		4.368		-10.928	-3.063
10.80	0.382		2.458		0.123		4.421		-13.524	-2.778
12.15	0.480		2.570		0.215		4.611		-12.095	-2.333
13.5	0.993									

VPE #042684(A)

DEPTH IN MICRONS	E_1 EER	ASE	X EER	Γ EER	θ EER	Δ_1	$\Delta\sigma 2$
0.0	2.330	2.324	0.256	0.115	4.382	- 8.351	- 6.624
0.53	2,336	2.332	0.262	0.084	3.771	-79.986	-16.852
1.05	2.338		0.264	0.103	4.238	-10.444	- 3.584
1.57	2.343	2.340	0.269	0.103	4.217	- 9.519	- 3.202
2.10	2.343	2.347	0.269	0.102	4.223	-10.482	- 3.276
2.63	2.349	2.347	0.276	0.105	4/183	-12.394	- 3.897
3.15	2.355	2.358	0.282	0.106	4.268	- 9.586	- 3.153
3.68	2.360	2.359	0.287	0.103	4.214	-10.539	- 3.205
4.21	2.364	2.360	0.291	0.099	4.146	-24.579	- 5.481
4.73	2.364	2.365	0.291	0.106	4.357	- 9.637	- 2.226
5.26	2.387	2.369	0.315	0.106	4.497	- 4.-15	- 2.705
5.78	2.372	2.372	0.299	0.110	4.300	- 9.545	- 2.42?
6.31	2.375	2.375	0.302	0.101	4.174	-16.254	- 3.649
6.84	2.382	2.381	0.310	0.108	4.216	-12.545	- 3.291
7.36	2.389	2.390	0.316	0.110	4.277	-11.563	- 2,409
7.89	2.404	2.404	0.331	0.105	4.240	-13.190	- 3.209
8.74	2.432	2.433	0.358	0.111	4.282	-13.287	- 2.959
9.58	2.445	2.440	0.370	0.110	4.308	-13.760	- 3.037
10.42	2.459	2.450	0.383	0.110	4.278	-16.170	- 3.333
11.26	2.469	2.461	0.393	0.113	4.247	-17.882	- 3.447
12.10	2.490	2.477	0.411	0.121	4.604	- 6.673	- 2.670
12.94	2.547	2.547	0.460	0.139	4.893	- 6.253	- 2.815
14.21	2.585		0.492	0.152	4.893	- 7.107	- 3.303
15.47	2.637	2.610	0.533	0.188	5.095	- 7.241	- 3.773
16.73		2.729					

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VPE #042584(A)

DEPTH IN MICRONS	E_1 EER	E_1 ASE	X EER	Γ EER	θ EER	Δ_1	$\Delta\sigma^2$
0.0	2.398	2.359	0.325	0.102	5.917	34.951	- 0.216
0.48	2.384	2.373	0.312	0.106	4.138	-15.045	- 3.586
0.95	2.399	2.377	0.326	0.113	4.492	- 6.171	- 3.056
1.43	2.405		0.332	0.104	4.245	-13.469	- 3.811
1.90	2.419	2.402	0.346	0.112	4.559	- 4.358	- 3.291
2.38	2.419	2.406	0.346	0.104	4.114	-20.869	- 5.194
2.85	2.424	2.410	0.351	0.104	4.213	-20.358	- 5.004
3.33	2.435	2.424	0.351	0.109	4.313	-13.119	- 3.632
3.81	2.440	2.430	0.365	0.106	4.160	-19.369	- 4.461
4.29	2.445	2.435	0.371	0.108	4.157	-21.594	- 4.590
4.76	2.478	2.444	0.400	0.124	4.632	- 2.587	- 3.193
5.24	2.459	2.447	0.383	0.107	4.073	-22.306	- 4.361
5.71	2.491	2.466	0.394	0.128	4.302	-33.463	- 5.395
6.19	2.487	2.474	0.409	0.160	4.757	- 6.959	- 1.207
6.67	2.502	2.498	0.422	0.122	4.214	-15.984	- 2.722
7.14	2.529	2.526	0.445	0.133	4.413	-18.058	- 2.571
7.90	2.539	2.534	0.454	0.107	4.033	-41.850	- 5.147
8.67	2.553	3.554	0.466	0.113	4.035	-33.686	- 3.889
9.43	2.572	2.577	0.482	0.123	4.127	-28.224	- 3.074
10.19	2.670	2.601	0.559	0.163	0.105	10.879	- 0.548
10.95	2.652	2.605	0.545	0.201	0.310	4.405	- 0.073
11.71	2.637	2.700	0.533	0.249	5.160	- 4.639	- 1.051
12.86	2.691	2.793	0.575	0.297	4.974	- 4.354	- 0.916
15.14	3.375		1.00	0.130	0.843	5.292	0.694

VPE #042584(B)

DEPTH IN MICRONS	E_1 EER	E_1 ASE	X EER	Γ EER	θ EER	Δ_1	$\Delta\sigma^2$
0.0	2.347	2.331	0.274	0.097	5.293	-57.775	4.892
0.48	2.351	2.330	0.278	0.125	5.177	-23.905	2.557
0.95	2.352	2.343	0.279	0.101	5.215	-32.016	3.309
1.43	2.362		0.289	0.102	5.174	-24.977	3.211
1.90	2.360	2.347	0.287	0.102	5.186	-29.196	3.392
2.38	2.367	2.354	0.294	0.102	5.136	-24.400	3.337
2.85	2.376		0.303	0.101	5.145	-25.937	3.568
3.33	2.378	2.362	0.306	0.102	5.175	-26.329	3.141
3.81	2.378	2.369	0.305	0.096	5.212	-29.958	3.187
4.29	2.394	2.377	0.321	0.105	5.176	-29.663	3.195
4.76	2.406	2.378	0.333	0.083	5.517	-77.702	6.705
5.24	2.401	2.378	0.328	0.102	5.180	-35.096	3.490
5.71	2.407	2.393	0.334	0.109	5.151	-29.246	3.003
6.19	2.418	2.401	0.345	0.106	5.125	-29.674	3.206
6.67	2.426	2.416	0.352	0.125	5.103	-28.216	2.732
7.14	2.423	2.420	0.350	0.112	5.027	-23.246	3.101
7.90	2.440	2.428	0.365	0.109	5.095	-25.279	3.779
8.67	2.450	2.437	0.377	0.116	5.041	-20.570	3.260
9.43	2.467	2.456	0.390	0.145	5.026	-18.006	1.730
10.19	2.479	2.469	0.402	0.131	4.989	-17.933	2.624
10.95	2.504	2.496	0.423	0.125	5.100	-24.235	3.138
11.17	2.590	2.581	0.496	0.160	5.311	-18.106	1.662
12.86	2.745	2.710	0.614	0.152	5.432	-29.389	2.949

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NIGHT VISION COMPARATIVE ANALYSIS OF NIGHT VISION (IR TRANSMISSION AND REFLECTANCE) AND UNIVERSITY OF ILLINOIS DATA (EER, ASE). ALL DATA WAS PLOTTED FOR VISUAL COMPARISON.

LPE ON A(111) CDTE

EER AND ASE E_1 TRANSITION ENERGIES AGREE WELL AND YIELD COMPOSITION FRACTIONS (X-VALUES) WHICH COMPARE TO IR TRANSMISSION DATA.

COMMENTS:

1. THE SURFACES OF ALL THREE SAMPLES ARE MERCURY RICH, AND COMPOSITION DEPTH PROFILES ARE NEARLY FLAT WITH A 4 MICRON INTERDIFFUSION WIDTH AT THE SUBSTRATE.

2. THE 20 MIN. LONGER GROWTH OF #050784(A) RELATIVE TO #051084(A) RESULTED IN A 6 MICRON THICKER LAYER WITH AN X VALUE REDUCED BY .02.

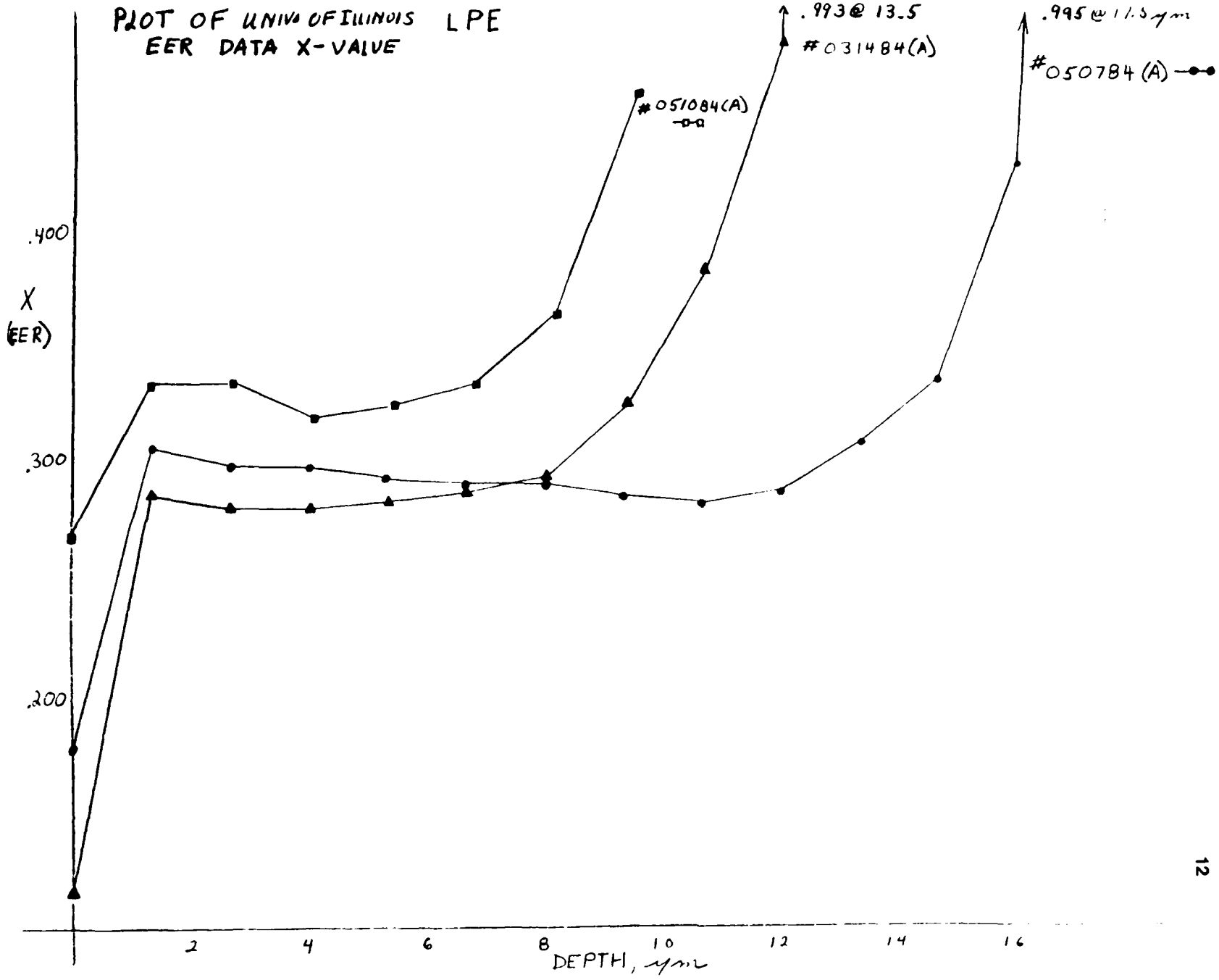
VPE ON A(111) AND B(111) CDTE

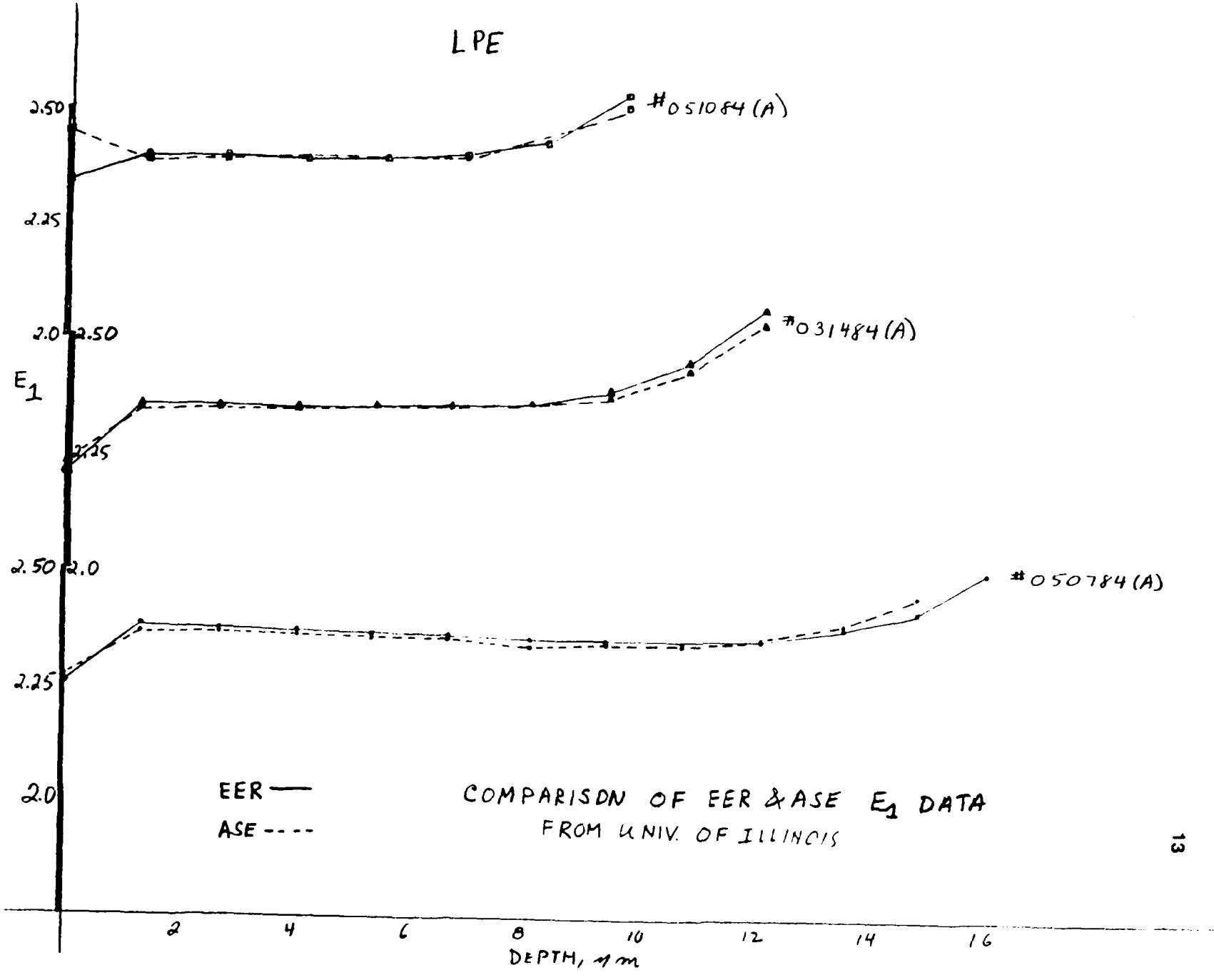
EER, ASE, AND REFLECTANCE E_1 TRANSITION DATA AGREE WELL EXCEPT FOR A CALIBRATION SHIFT OF THE REFLECTANCE DATA.

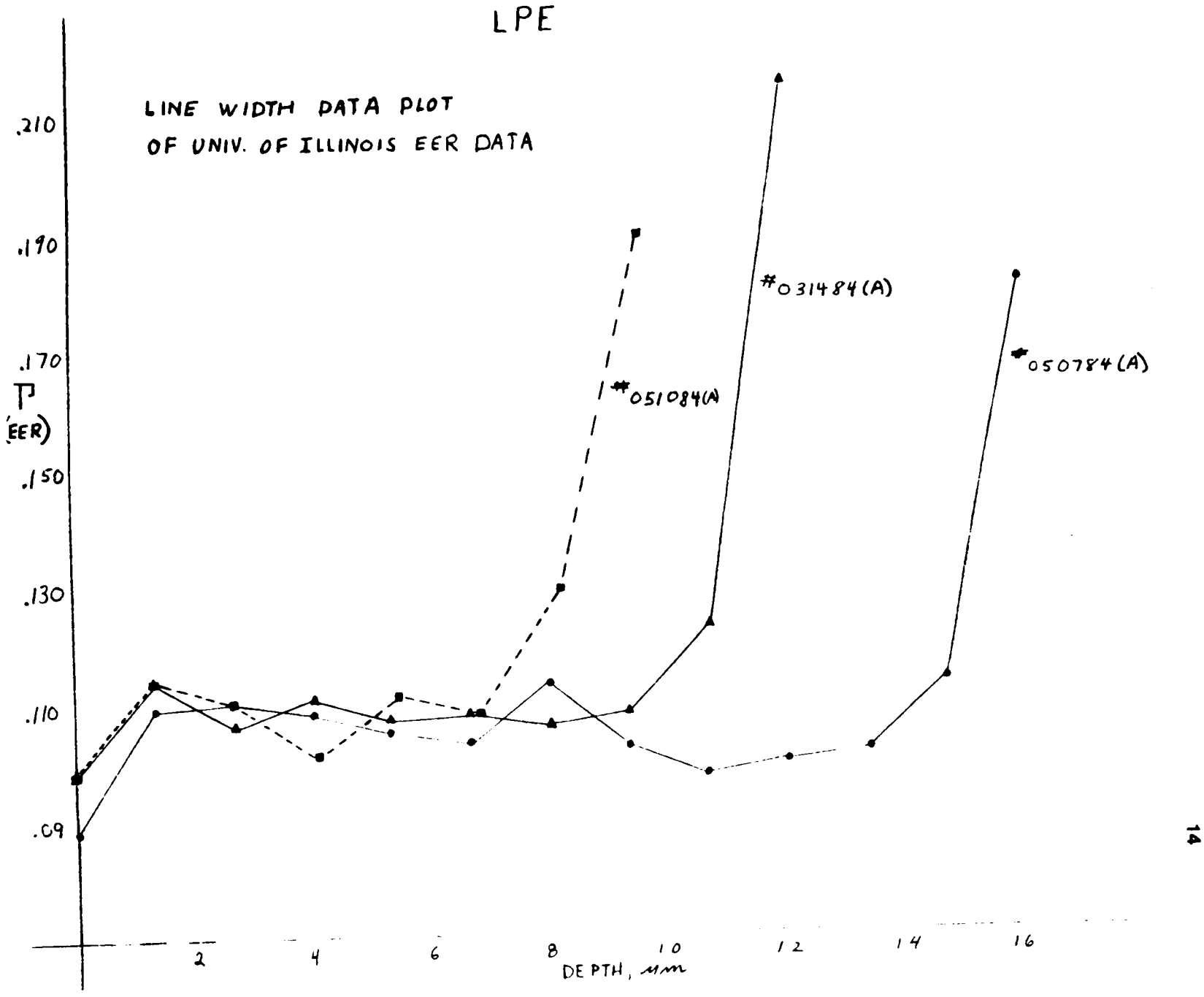
COMMENTS:

1. THE LAYERS ARE GRADED IN COMPOSITION (X-VALUE) YIELDING A SOFTER EDGE, RELATIVE TO THE LPE MATERIAL, IN THE IR TRANSMISSION DATA.

2. EER, ASE, AND IR TRANSMISSION CLEARLY SHOW THE EFFECTS OF GROWTH FACE FOR SAMPLES #042584(A) AND #042584(B).

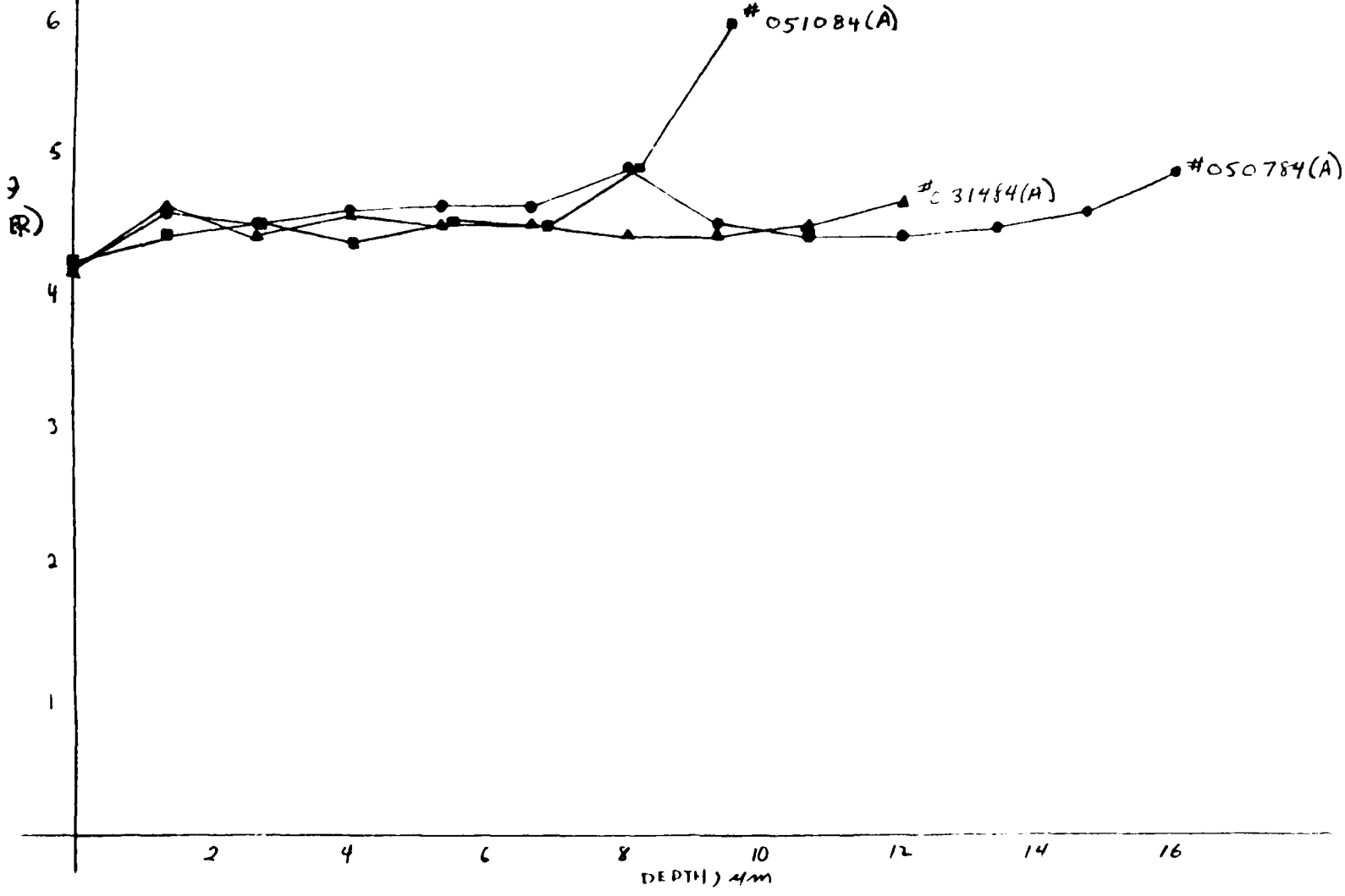

PLOT OF UNIV. OF ILLINOIS LPE
EER DATA X-VALUE
.993 @ 13.5
#031484(A)
.995 @ 11.5 mm
#050784(A)
#051084(A)
.400
X
(EER)
.300
.200
2
4
6
8
10
12
14
16
DEPTH, mm


LPE
#051084(A)
#031484(A)
#050784(A)
2.50
2.25
2.0
2.50
2.25
2.50
2.0
2.25
2.0
E_1
EER
ASE
COMPARISON OF EER & ASE E_1 DATA
FROM UNIV. OF ILLINOIS
2
4
6
8
10
12
14
16
DEPTH, μm


LPE
LINE WIDTH DATA PLOT
OF UNIV. OF ILLINOIS EER DATA
.210
.190
.170
Γ
(EER)
.150
.130
.110
.09
#051084(A)
#031484(A)
#050784(A)
2
4
6
8
10
12
14
16
DEPTH, mm

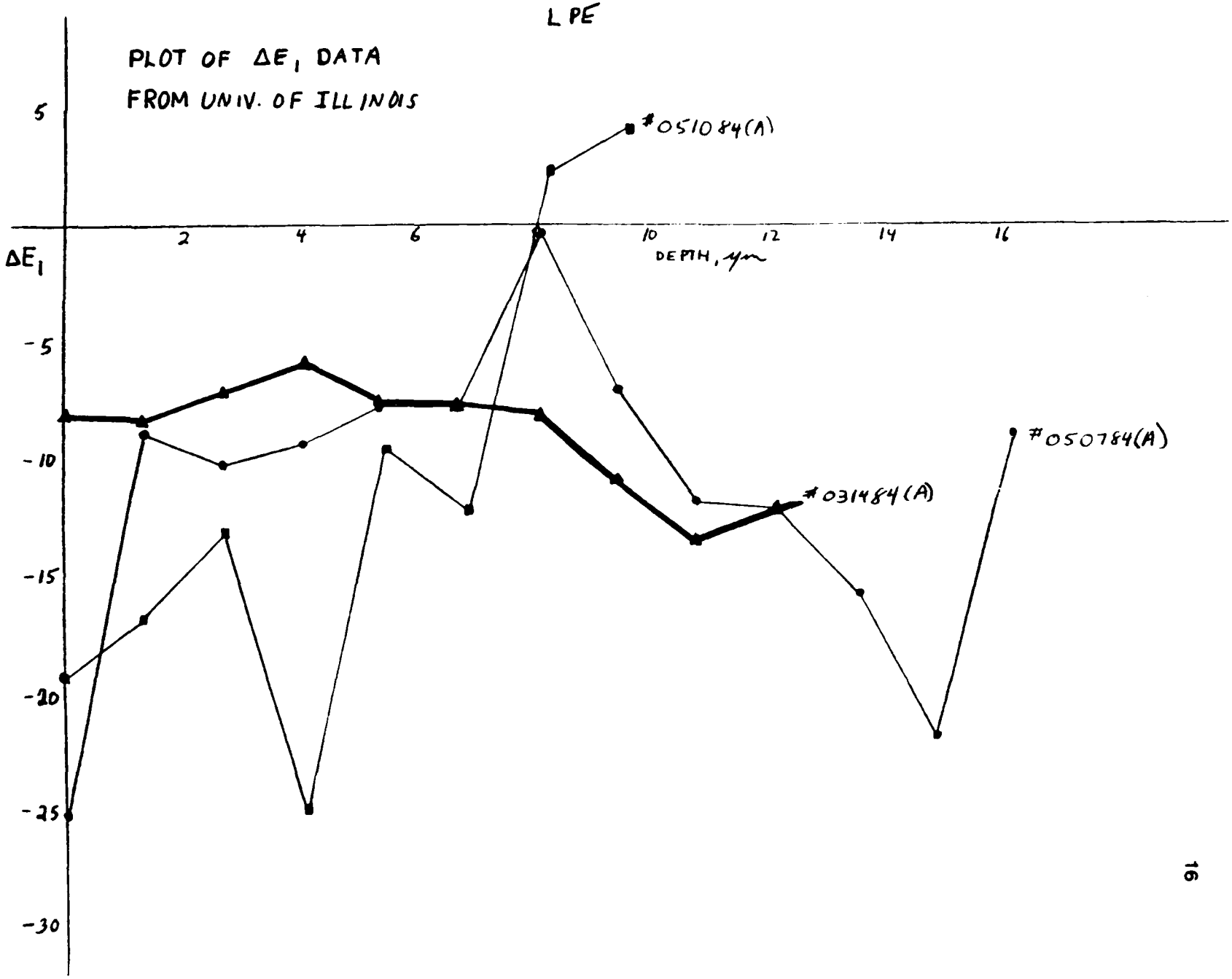
LPE

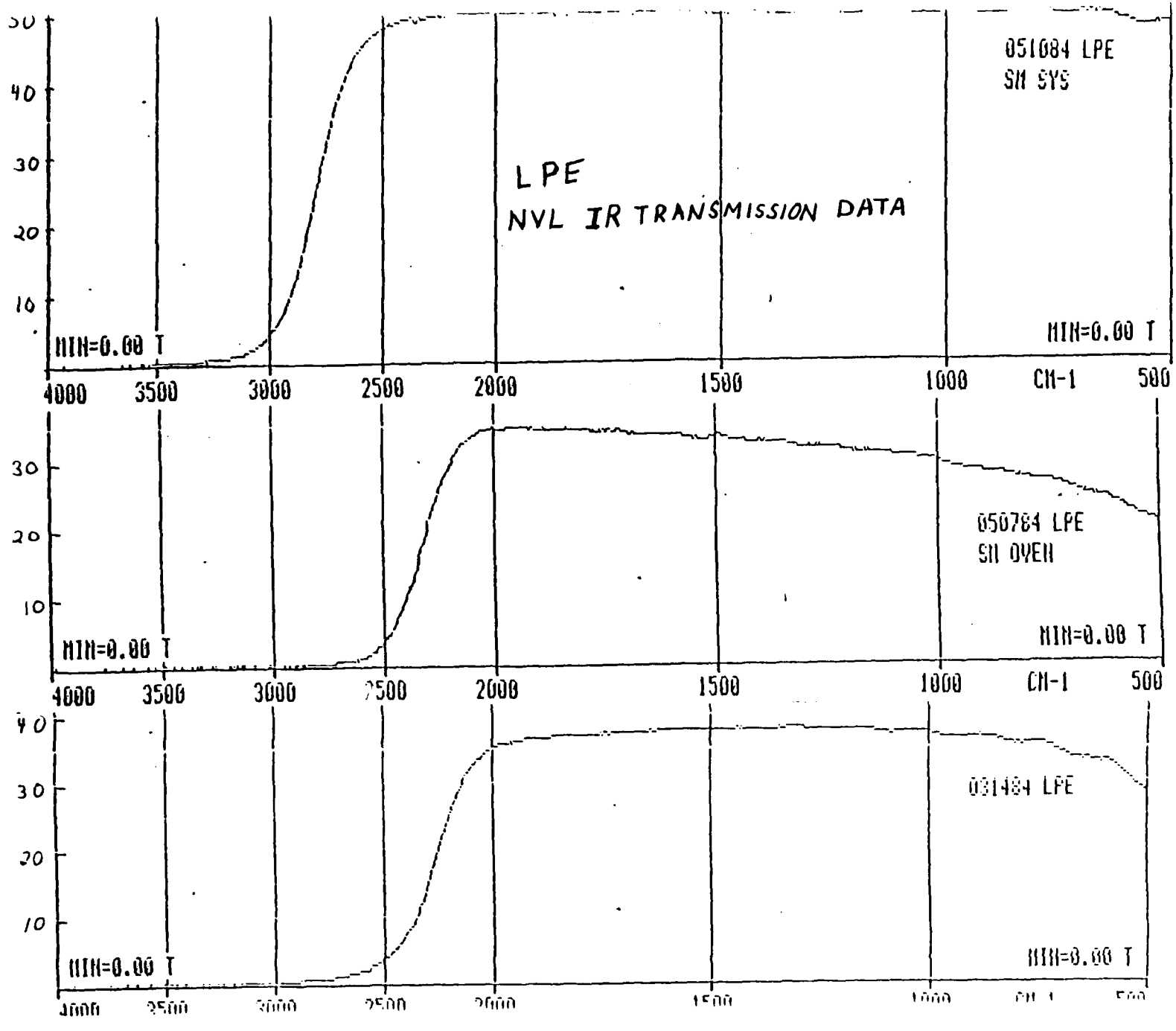
PLOT OF θ DATA
FROM UNIV. OF ILLINOIS

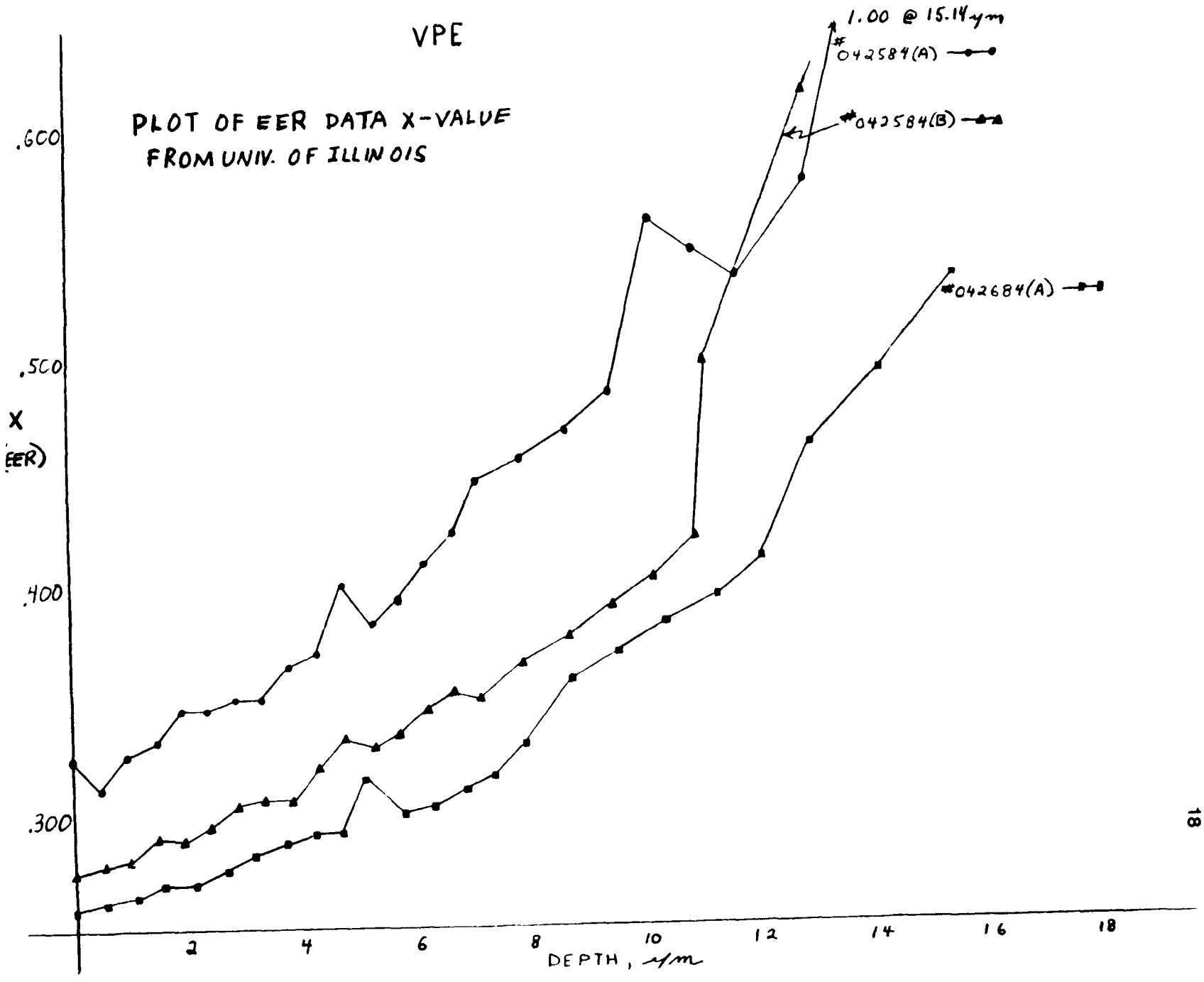


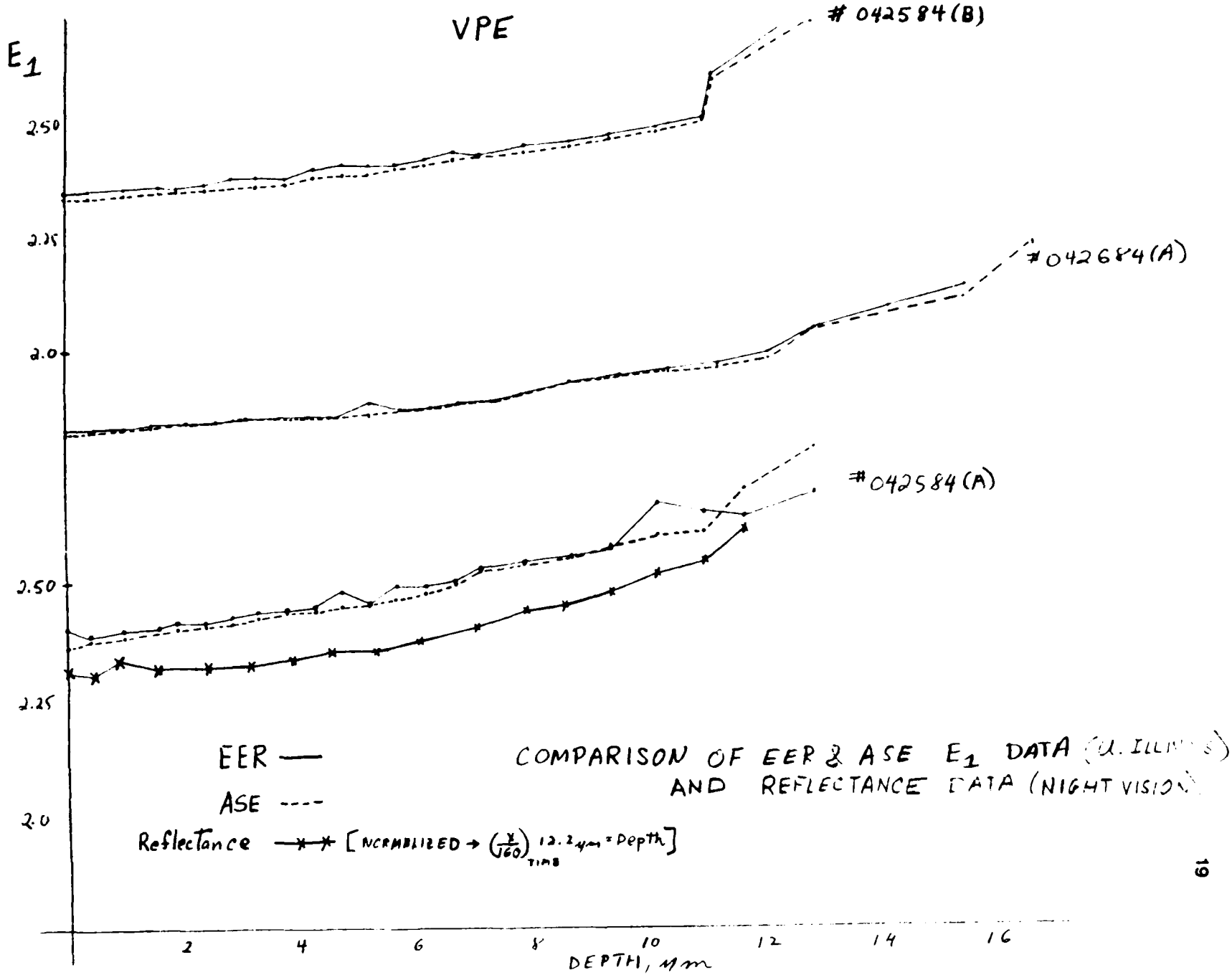
LPE

PLOT OF ΔE_1 DATA
FROM UNIV. OF ILLINOIS

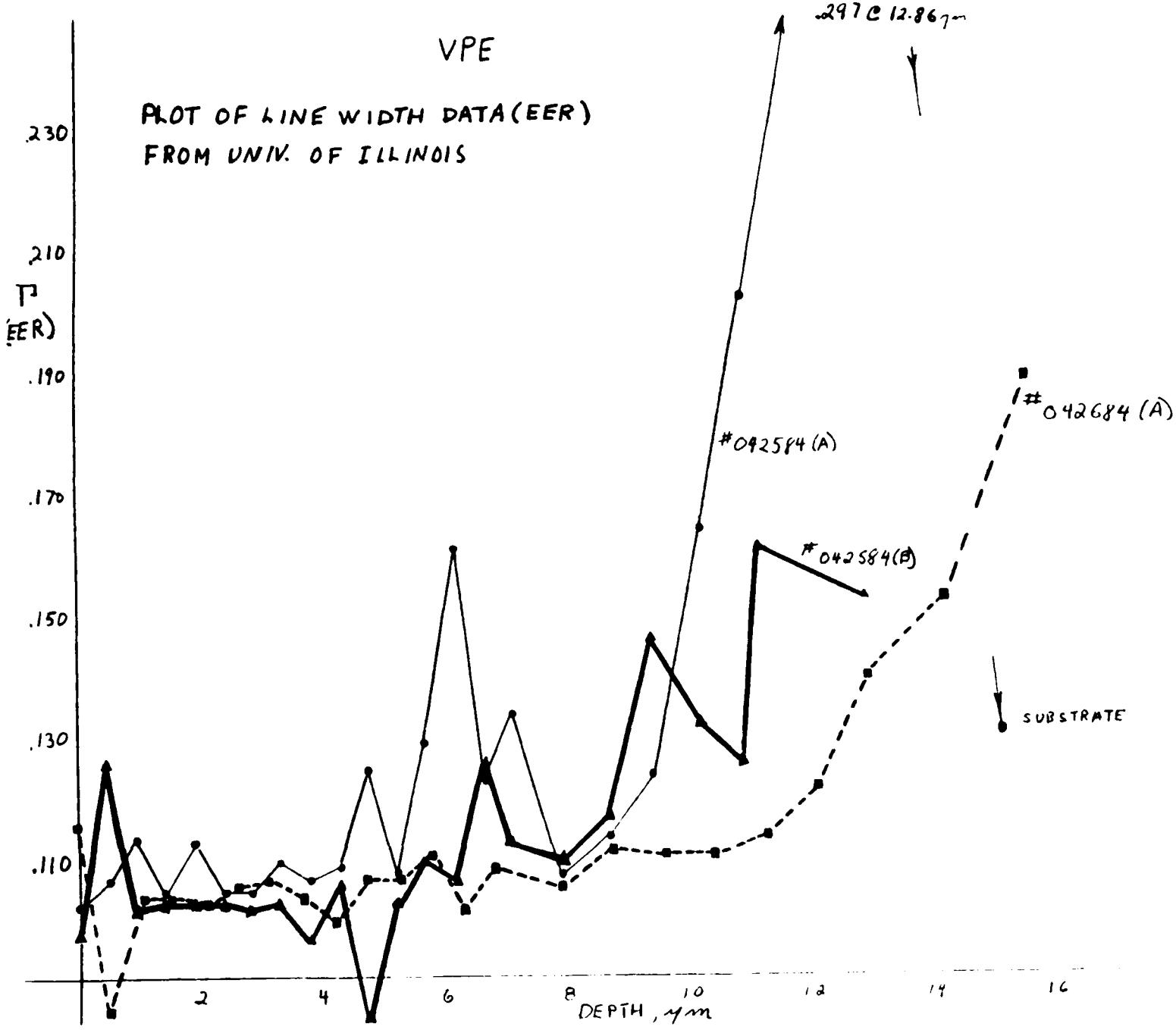



LPE
NVL IR TRANSMISSION DATA
051084 LPE
SM SYS
MIN=0.00 T
MIN=0.00 T
4000 3500 3000 2500 2000 1500 1000 CM-1 500
050784 LPE
SM OVEN
MIN=0.00 T
MIN=0.00 T
4000 3500 3000 2500 2000 1500 1000 CM-1 500
031484 LPE
MIN=0.00 T
MIN=0.00 T


VPE
PLOT OF EER DATA X-VALUE
FROM UNIV. OF ILLINOIS
1.00 @ 15.14 ym
#042584(A)
#042584(B)
#042684(A)
.600
.500
.400
.300
X
(EER)
2
4
6
8
10
12
14
16
18
DEPTH, ym

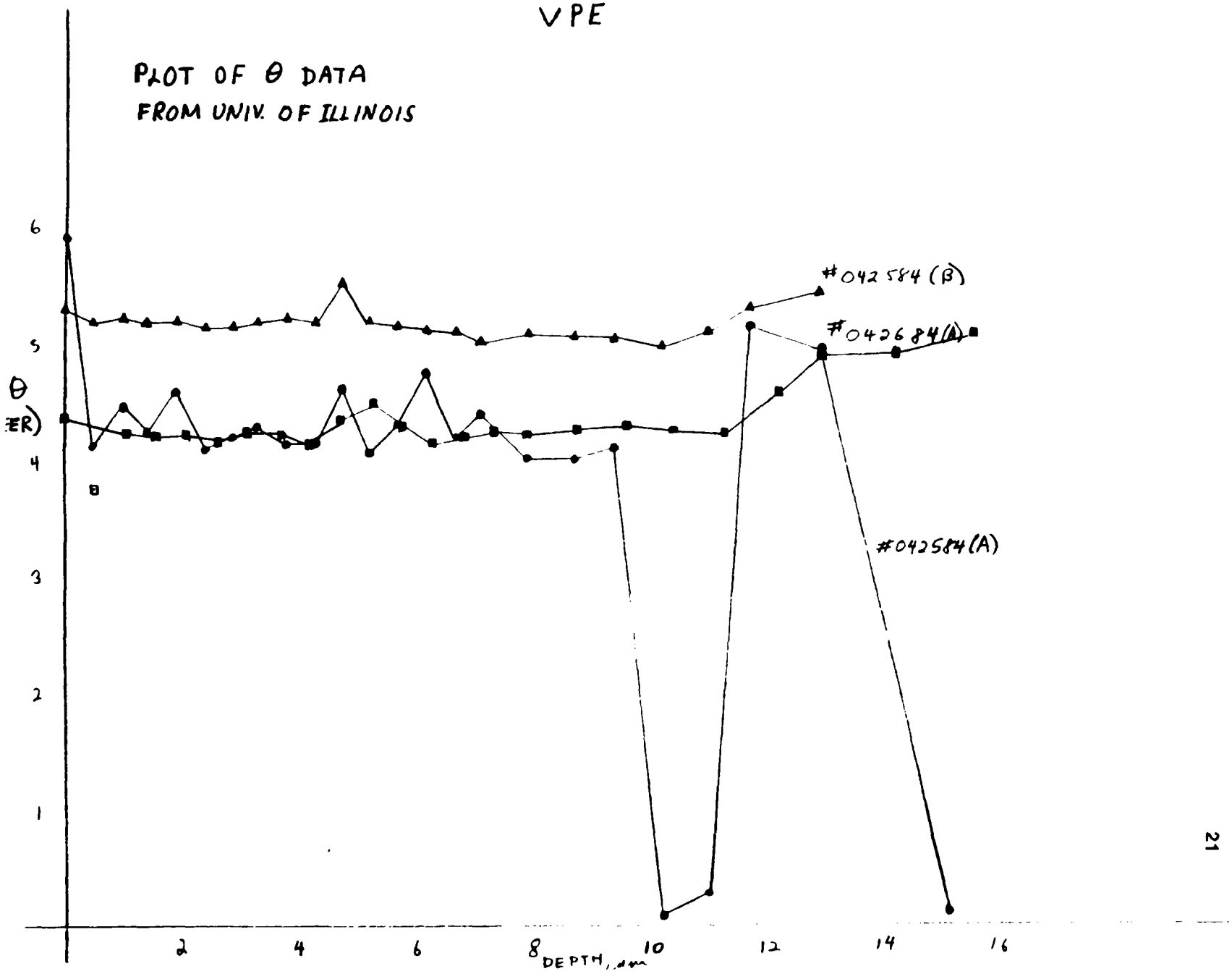


COMPARISON OF EER & ASE E_1 DATA (U. ILLINOIS) AND REFLECTANCE DATA (NIGHT VISION)


VPE
PLOT OF LINE WIDTH DATA (EER)
FROM UNIV. OF ILLINOIS
.297 @ 12.867 μm
#042584 (A)
#042584 (B)
#042684 (A)
SUBSTRATE
.230
.210
.190
.170
.150
.130
.110
Γ²
(EER)
2
4
6
8
10
12
14
16
DEPTH, μm

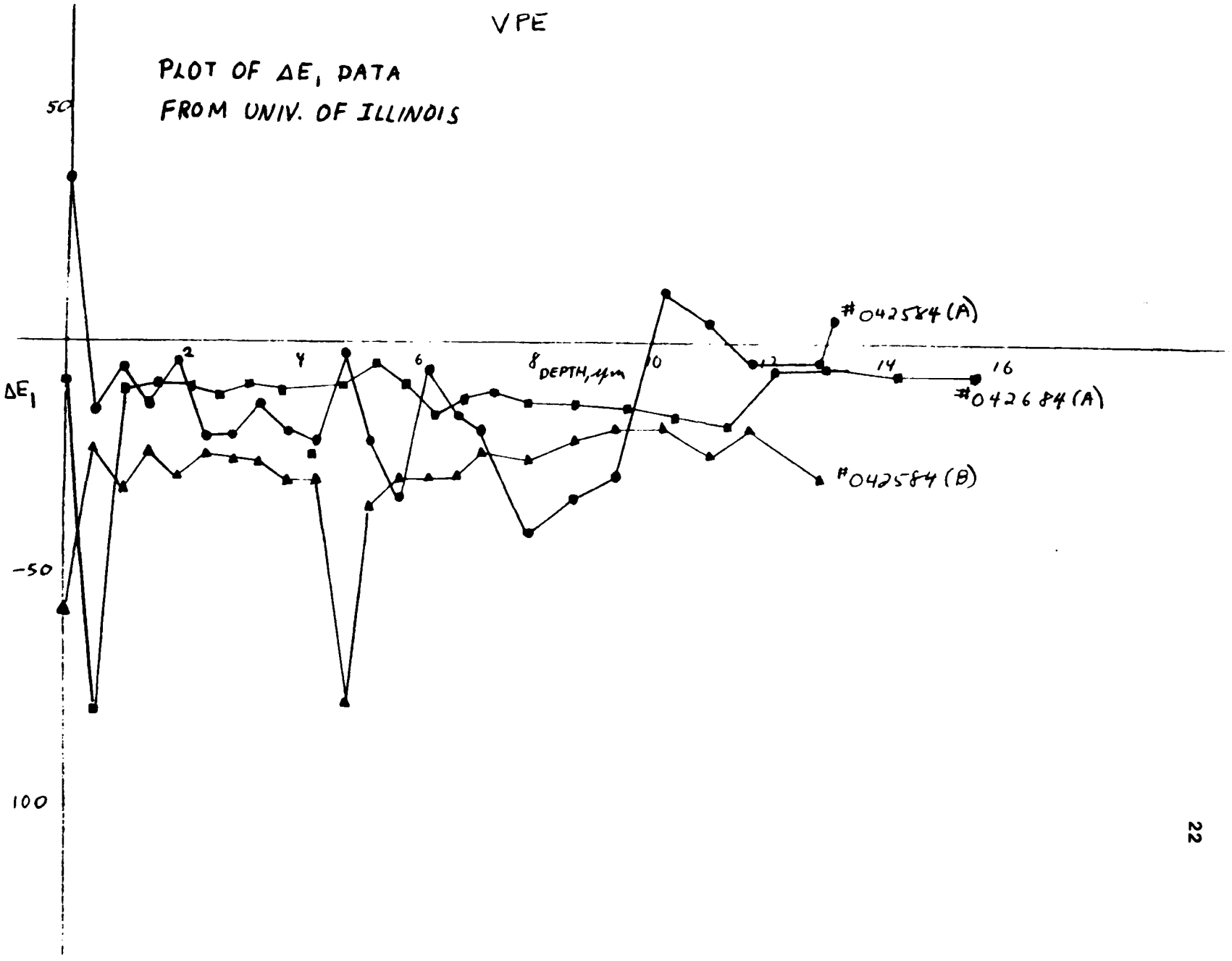
VPE

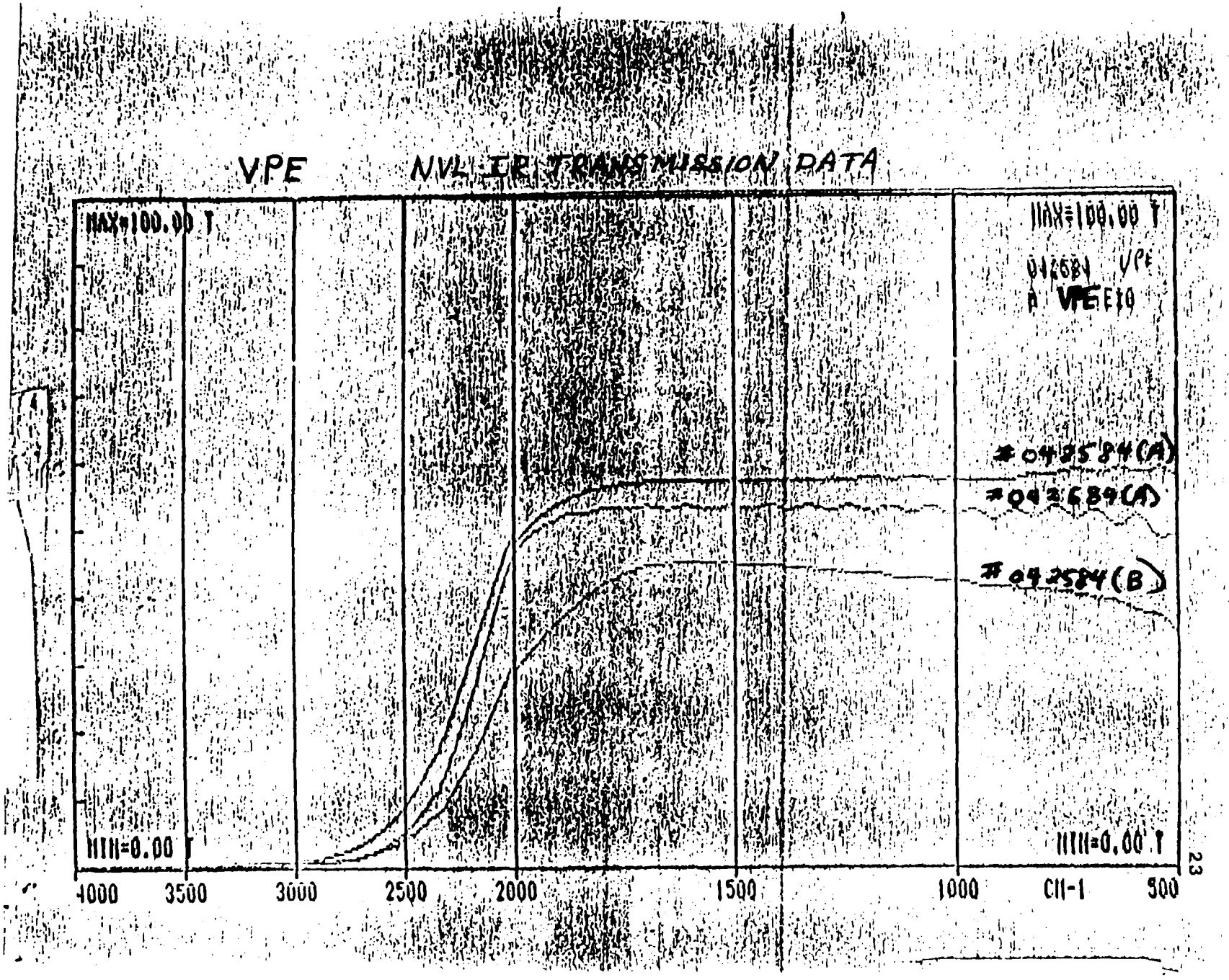
PLOT OF θ DATA
FROM UNIV. OF ILLINOIS



VPE

PLOT OF ΔE_1 DATA
FROM UNIV. OF ILLINOIS




VPE NVL IR TRANSMISSION DATA
MAX=100.00 T
MIN=0.00 T
MAX=100.00 T
042684 VPE
VPE E10
#042584(A)
#042689(A)
#042584(B)
MIN=0.00 T
4000
3500
3000
2500
2000
1500
1000
CM-1
500
23

NVL DATA

Normalization of Reflectomer Data VPE # 042584(A)

$\frac{x_t}{160_{time}}(12.2_{4m}) = depth$

E_1	x_{time}	Depth	
2.307		0.00	not normalized
2.299		.05	not normalized
2.330		.09	not normalized
2.309	20.92	1.60	
2.314	32.00	2.44	
2.319	41.85	3.19	
2.330	51.69	3.94	
2.342	60.31	4.60	
2.348	70.15	5.35	
2.372	80.00	6.10	
2.401	92.31	7.04	
2.433	103.38	7.88	
2.443	112.49	8.58	
2.473	123.08	9.38	
2.519	134.15	10.23	
2.546	144.00	10.98	
2.614	153.85	11.73	