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Coal Quality Loss from Acquisition to Analysis--
A Preliminary Time Study

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INTRODUCTION AND PURPOSE

A coal core sample from the time of drilling and subsequent exposure to the atmosphere to the time of analysis undergoes various chemical and physical changes, such as oxidation, loss of calorific value, and slacking. The extent and rate of these changes are dependent on several interrelated factors ranging from core sample handling and packaging at the drill site, sample preparation for analysis at the laboratory, the time interval from sample acquisition to analysis, and excessive heating and drying at any point in the continuum.

Where possible, the purpose of this study is to: (a) identify and quantify the rate of change, the coal quality deterioration, and other changes to the coal composition; (b) verify the standards proposed for sample handling and packaging for analysis at the drill site; and (c) indicate areas where further research would be warranted.

GENERAL INFORMATION

Several basic criteria for this preliminary study were established as follows:

1. The samples would be acquired from several major coal beds of the Tongue River Member of the Tertiary Fort Union Formation within the Northern Powder River Basin.

2. They would be from areas of on-going coal resource assessment projects which include coal exploratory drilling and coring.

3. The coring, core sample describing, handling, and packaging would follow the proposed guidelines in Hobbs, 1979.

4. The core sample acquisition would not interfere with the individual project's primary purpose but the data acquired, all or in part, would complement other acquired data.

5. The samples would be forwarded to the analytical laboratory as soon as possible after core acquisition.

6. The laboratory, upon splitting each sample into the required fractions, would maintain the moisture level as near as possible to the original as-received value and exclude as much air as possible from each fraction package.

7. The laboratory would make the specified analysis and determinations upon the following standard time intervals: upon receipt at the laboratory, 15, 30, 60, 120, and 150 days thereafter from the "upon receipt" analysis plus whatever longer time period may be appropriate.

8. All procedures, analysis, and determinations would be per the appropriate ASTM (American Society for Testing and Materials) standard where such standards exist.

9. The results of the study would be applicable to similar subbituminous coals and lignites of the Powder River Basin.

These criteria were met.

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Geology

All samples were from the Tongue River Member of the Tertiary Fort Union Formation. For details of the geology see Olive (1957) and Bryson and Bass (1973).

Coal Beds Sampled

The coal beds sampled were:

Anderson-Canyon coal bed--The Anderson-Canyon coal bed of the study area has been correlated to the southeast with the thick Wyodak coal of the east-central Powder River Basin and can be traced to the east into the Recluse area and northeast into the Moorhead coal fields.

Pawnee coal bed--The Pawnee coal bed has been traced south to the Recluse area of northern Campbell County into the Moorhead/Birney-Broadus coal field, north and west into the Birney area.

Cache coal bed--The Cache coal bed has been traced south and southeast from the Recluse area and in the Moorhead/Birney-Broadus coal fields north towards Broadus and west into the Birney area.

The portion of the geophysical logs showing the sampled coal beds and intervals are in appendix A; core descriptions for the same intervals are in appendix B.

Drilling

The drill-hole locations, coal fields, coal beds, and intervals sampled are shown in table 1. The coal-field designation follows Olive (1953) for the Spotted Horse field and Bryson and Bass (1973) for the Moorhead field.

The drill holes in the Spotted Horse Field, 80AU15 and 80AU16, were twin core holes to the pilot holes 78-3 and 78-30 which were drilled in 1978 (Correia, 1978). The two holes in the Moorhead coal field were part of the 1980 portion of a coal exploratory project started in 1978 (Hardie, 1979).

Sampling Methods

The coal core handling and packaging procedure for all samples was standardized and closely controlled following the guidelines set forth by Hobbs (1979). Briefly, this procedure was: The coal core was removed from the core barrel as soon as it reached the surface. The core was washed completely and described by the well-site geologist. During this time it was never allowed to become dry. The coal sample was placed in a plastic bag (6 mil or 0.006 in. thick), sufficient water was added to maintain 100 percent humidity, and the plastic bag was tightly sealed after as much air as possible

Table 1.--Drill-hole locations, coal-bed intervals and intervals sampled

Sample and hole number	Coal field/location	Coal bed	Interval cored (ft)	Interval sampled (ft)	Remarks
80AU15	Spotted Horse Coal Field	Anderson-			78-3 1978 Pilot Hole
	SE 1/4 NE 1/4 Sec. 24	Canyon	703.5-752.0	716.0-727.0	
	T. 54 N., R. 77 W. Sheridan Co., Wyo.				
80AU16	Spotted Horse Coal Field	Anderson-	596.0-637.0	596.0-608.0	78-30 1978 Pilot Hole
	NW 1/4 SW 1/4 Sec. 5	Canyon		613.0-637.0	
	T. 54 N., R. 76 W.		598.0-639.0	598.0-610.0	
	Sheridan Co., Wyo.			615.0-639.0	
80MBE7 (P)	Moorhead Coal Field	Pawnee	27.0-57.3	27.0-57.3	Shallow, probably oxidized in part
	NE 1/4 SE 1/4 Sec. 35				
	T. 7 S., R. 48 E. Powder River County, Mont.				
80MBE7 (C)	....do.....	Cache	126.4-133.0	126.4-133.0	
80MBA2	Moorhead Coal Field	Cache	69.5-88.3	69.5-87.0	
	SE 1/4 SE 1/4 Sec. 25 T. 8 S., R. 50 E. Powder River County, Mont.				

was pressed out. This bag was placed in a second bag and it was likewise sealed. The samples were kept in a sheltered location until forwarded to the laboratory for analysis. The average time from coal core acquisition to delivery at the laboratory was about 4 1/2 days.

The laboratory maintained the same control standards throughout their work. This is evidenced in part by the as-received moisture level (with two exceptions) being above the equilibrium moisture.

All samples except 80AU15 include the entire coal bed sample. The sample from 80AU15 includes about 25 percent of the full thickness of the coal and is considered to be representative of the entire coal bed at this location.

RESULTS AND DISCUSSION

Analyses and Other Determinations

The laboratory analyses and determinations that were made on these samples are:

1. Proximate and ultimate analysis--as-received and dry (moisture-free) basis
2. Btu/lb (British thermal units per pound)
3. Sulfur content
4. Equilibrium moisture
5. Hardgrove Grindability Index (HGI) with the moisture level of determination
6. Apparent specific gravity at two moisture levels--as-received and a value less than as-received

These analyses and determinations were to be made at six standard time intervals; upon receipt at the laboratory, 15, 30, 60, 120, and 150 days thereafter. Additional analyses were made of sample 80AU15 at 268 days, sample 80AU16 at 284 days, and samples 80MBE7(P) (Pawnee), 80MBE7(C) (Cache), and 80MBA2 at 361 days from the time of receipt at the laboratory.

From the reported data, the following was calculated or determined:

Proximate and ultimate analysis	--as-received corrected to the equilibrium moisture basis
	--dry mineral matter free basis
Apparent rank	--moist mineral matter free Btu/lb ASTM-Parr formula 3
Apparent specific gravity	--specific gravity at equilibrium moisture and 0 percent moisture (dry basis)

The proximate and ultimate analyses are shown in table 2; the apparent rank data in table 3; Btu and oxygen change with time in table 4; the apparent specific gravity in table 5; and the Hardgrove Grindability Index data in table 6.

Coal Classification--Apparent Rank

The rank classifications of the coals were based on the moist (equilibrium moisture), mineral matter free Btu/lb determined by the Parr formula 3 in ASTM Standard D388-77 (1980). These data are shown in table 3. The term "apparent rank" was used instead of "rank" for the following reasons:

1. The sample distribution and quantity do not conform with Section 6.1 of ASTM Standard D388-77.

2. ASTM does not presently have standards developed for sample acquisition, handling, and areal density of coal core samples for rank classification.

The Pawnee coal, sample 80MBE7P, in all probability is altered partly by oxidation due to its shallow depth and circulating ground waters which is indicated by abundant gypsum rosettes and partly by the heat and gases from natural burning. This coal bed is burned at the outcrop a short distance to the south and east and in all probability this has affected the Pawnee coal at this location. Visual examination of the core did not show any anamolous zones; however, the analytical results do (table 2). For these reasons, the Pawnee coal was not ranked.

General

The Btu/lb and oxygen were plotted and evaluated by linear plots as well as a LRA (linear regression analysis) on a dmmf (dry, mineral matter free) basis; the apparent specific gravity on a dry basis. Each will be discussed separately.

Calorific Value

The Btu linear regression values by time period are shown in table 4a for 0-360 days and 4b for 0-150 days. These data suggest the Btu/lb loss is greatest during the first 150 days for samples 80AU15, 80AU16, and 80MBA2, then decreasing. The opposite seems to be the case for 80MBE7 (Pawnee and Cache). The plotted data are shown on figures 1a-1j.

The linear plot (time period to time period) indicates that the loss rate of Btu values for all samples is greatest at the onset and gradually reduces with time. These data confirm that the Btu loss of lower rank coal is at a higher rate than for higher rank coal.

Table 2.--Proximate and ultimate analysis

[Leaders (---) indicate no data]

Time--days	Proximate					Ultimate						
	H_2O	VM	FC	Ash	Btu/lb	H_2O	C	H	N	Cl	S	O
80AU15												
As-received												
0	27.03	31.11	38.16	3.70	9013	27.03	52.38	3.75	0.82	0.04	0.19	12.09
15	27.26	29.36	38.75	4.36	8909	27.26	51.30	3.61	.81	.01	.30	12.35
30	27.06	30.68	38.53	3.73	8958	27.06	51.69	3.66	.67	.00	.17	13.02
60	27.61	30.61	38.06	3.72	8884	27.61	52.17	3.58	.75	.05	.17	11.95
120	26.67	31.94	37.64	3.75	8959	26.67	52.15	3.61	.85	.04	.17	12.76
150	26.88	31.59	38.06	3.47	8841	26.88	52.19	3.68	.84	.00	.20	12.74
268	27.32	31.25	37.91	3.52	8826	27.32	51.82	3.63	.81	.01	.14	12.75
As-received corrected to equilibrium moisture												
0	25.52	31.75	38.95	3.78	9200	25.52	53.46	3.75	.84	.04	.19	12.34
15	26.04	30.13	39.40	4.43	9058	26.04	52.16	3.67	.82	.01	.31	12.56
30	25.87	31.18	39.16	3.79	9104	25.87	52.53	3.72	.68	.00	.17	13.24
60	26.30	31.16	38.75	3.79	9045	26.30	53.11	3.64	.76	.05	.17	12.18
120	27.43	31.61	37.25	3.71	8959	27.43	51.60	3.57	.84	.04	.17	12.64
150	26.10	31.93	38.47	3.51	8935	26.10	52.75	3.72	.85	.00	.20	12.88
268	26.00	31.82	38.60	3.52	8956	26.00	52.77	3.70	.82	.01	.14	12.98
Dry basis												
0	---	42.64	52.29	5.07	12352	---	71.78	5.14	1.13	.05	.26	16.57
15	---	40.73	53.27	6.00	12248	---	70.52	4.96	1.11	.01	.41	16.99
30	---	42.06	52.82	5.12	12281	---	70.87	5.02	.92	.00	.23	17.84
60	---	42.28	52.58	5.14	12273	---	72.07	4.95	1.03	.07	.24	16.50
120	---	43.45	51.34	5.11	12218	---	71.12	4.92	1.16	.05	.23	17.41
150	---	43.20	52.05	4.75	12091	---	71.38	5.03	1.15	.00	.27	17.42
268	---	43.00	52.16	4.84	12143	---	71.30	4.99	1.11	.02	.19	17.55
Moisture and ash free												
0	---	44.91	55.09	---	13012	---	75.61	5.41	1.19	.05	.27	17.46
15	---	43.33	56.67	---	13030	---	75.02	5.28	1.26	.01	.44	18.07
30	---	44.33	55.67	---	12944	---	74.69	5.29	.97	.00	.24	18.81
60	---	44.57	55.43	---	12938	---	75.97	5.22	1.09	.07	.26	17.39
120	---	45.90	54.10	---	12876	---	74.95	5.18	1.22	.05	.24	18.35
150	---	45.35	54.65	---	12694	---	74.95	5.28	1.21	.00	.28	18.29
268	---	45.19	54.81	---	12761	---	74.93	5.24	1.17	.02	.20	18.44

Table 2.--Proximate and ultimate analysis--Continued

Time--days	Proximate					Ultimate						
	H_2O	VM	FC	Ash	Btu/lb	H_2O	C	H	N	Cl	S	O
80AU16												
As-received												
0	28.33	30.45	36.78	4.44	8659	28.33	50.47	3.45	0.85	0.00	0.32	12.14
15	27.96	30.67	36.77	4.65	8697	27.96	50.70	3.44	.82	.04	.37	12.00
30	28.44	30.52	36.50	4.54	8599	28.44	50.22	3.55	.67	.01	.36	12.21
60	28.47	30.14	37.15	4.24	8544	28.47	50.15	3.38	.83	.04	.38	12.51
120	28.74	29.54	37.23	4.49	8512	28.74	50.21	3.34	.81	.01	.39	12.01
150	28.06	30.37	37.12	4.45	8517	28.06	50.67	3.23	.83	.01	.40	12.35
284	28.72	28.91	37.94	4.43	8442	28.72	49.80	3.26	.83	.01	.38	12.57
As-received corrected to equilibrium moisture												
0	26.51	31.22	37.71	4.55	8879	26.51	51.75	3.54	.87	.00	.33	12.45
15	26.63	31.19	37.45	4.74	8857	26.63	51.63	3.50	.84	.04	.40	12.22
30	26.83	31.21	37.32	4.54	8792	26.83	51.35	3.63	.69	.01	.37	12.48
60	26.87	30.81	37.98	4.33	8735	26.87	51.27	3.46	.85	.04	.39	12.79
120	27.43	30.08	37.91	4.57	8667	27.43	51.13	3.40	.82	.01	.40	12.23
150	27.30	30.69	37.51	4.50	8607	27.30	51.21	3.26	.84	.01	.40	12.48
284	27.70	29.32	38.48	4.49	8563	27.70	50.51	3.31	.84	.01	.39	12.75
Dry basis												
0	---	42.48	54.71	6.20	12082	---	70.42	4.81	1.19	.00	.45	16.93
15	---	42.91	54.55	6.46	12072	---	70.38	4.78	1.14	.06	.58	16.64
30	---	42.65	51.01	6.34	12016	---	70.18	5.30	.93	.01	.51	17.07
60	---	42.13	51.94	5.93	11945	---	70.11	5.02	1.23	.06	.53	17.49
120	---	41.45	52.25	6.30	11945	---	70.46	5.01	1.14	.01	.55	16.85
150	---	42.22	51.59	6.19	11839	---	70.44	4.79	1.24	.02	.56	17.14
284	---	40.56	53.23	6.21	11843	---	69.87	4.57	1.16	.02	.54	17.63
Moisture and ash free												
0	---	45.29	54.71	---	12880	---	75.07	5.13	1.27	.00	.48	18.05
15	---	45.45	54.55	---	12910	---	75.24	5.11	1.22	.06	.58	17.79
30	---	45.54	54.46	---	12830	---	74.99	5.30	.99	.01	.54	18.23
60	---	44.79	55.21	---	12700	---	74.53	5.02	1.23	.06	.56	18.59
120	---	44.24	55.76	---	12750	---	75.19	5.01	1.22	.01	.59	17.98
150	---	45.01	54.99	---	12620	---	75.09	4.79	1.24	.02	.60	18.27
284	---	43.25	56.75	---	12627	---	74.51	4.87	1.24	.02	.58	18.80

Table 2.--Proximate and ultimate analysis--Continued

Time--days	Proximate					Ultimate						
	H_2O	VM	FC	Ash	Btu/lb	H_2O	C	H	N	Cl	S	O
80MBE7 (Pawnee)												
As-received												
0	32.20	28.49	31.27	8.04	7306	32.20	42.84	3.32	0.89	0.00	0.10	12.61
15	33.01	27.63	32.28	7.08	7426	33.01	44.17	2.97	.87	.00	.48	11.42
30	31.89	28.27	32.55	7.29	7550	31.89	46.10	2.57	.86	.07	.58	10.64
60	32.69	27.24	32.83	7.24	7375	32.69	43.83	3.08	.72	.03	.53	11.88
120	32.68	27.27	32.95	7.10	7352	32.68	44.30	2.81	.81	.03	.52	11.75
150	32.73	27.88	32.32	7.07	7388	32.73	43.87	2.99	.77	.00	.54	12.03
361	31.94	28.21	32.66	7.42	7308	31.94	43.40	3.20	.76	.02	.50	13.11
As-received corrected to equilibrium moisture												
0	31.33	28.86	31.67	8.04	7454	31.33	43.39	3.36	.90	.00	.10	12.61
15	31.28	28.34	33.11	7.08	7617	31.28	45.31	3.05	.89	.00	.49	11.71
30	31.02	28.63	32.97	7.38	7646	31.02	46.69	2.60	.87	.07	.59	10.78
60	32.60	27.28	32.87	7.25	7385	32.60	43.89	3.08	.72	.03	.53	11.90
120	32.00	27.55	33.28	7.17	7426	32.00	44.74	2.84	.82	.03	.53	11.87
150	31.30	28.48	33.02	7.22	7548	31.30	40.82	3.06	.79	.00	.56	12.27
361	29.80	29.10	33.69	7.19	7538	29.80	44.76	3.20	.76	.02	.52	13.52
Dry basis												
0	---	42.02	46.12	11.86	10855	---	63.19	4.90	1.32	.00	.15	18.58
15	---	44.24	48.19	10.57	11085	---	65.94	4.43	1.30	.00	.72	17.04
30	---	41.50	47.80	10.70	11085	---	67.69	3.78	1.27	.11	.85	15.60
60	---	40.47	48.78	10.75	10957	---	65.11	4.57	1.07	.04	.79	17.67
120	---	40.51	48.95	10.54	10921	---	65.81	4.17	1.20	.06	.86	17.46
150	---	41.45	48.04	10.51	10983	---	65.22	4.45	1.15	.00	.81	17.86
361	---	41.45	47.98	10.57	10738	---	63.76	4.55	1.09	.03	.73	19.27
Moisture and ash free												
0	---	47.67	52.33	---	12316	---	71.69	5.56	1.50	.00	.17	21.08
15	---	46.11	53.89	---	12395	---	73.73	4.95	1.45	.00	.81	19.05
30	---	46.47	53.53	---	12413	---	75.80	4.23	1.42	.12	.95	17.47
60	---	45.34	54.66	---	12277	---	72.95	5.12	1.20	.04	.89	19.80
120	---	45.28	54.72	---	12208	---	73.56	4.66	1.34	.06	.86	19.52
150	---	46.32	53.68	---	12273	---	72.87	4.97	1.29	.00	.91	20.14
361	---	46.35	53.65	---	12007	---	71.30	5.09	1.22	.03	.82	21.55

Table 2.--Proximate and ultimate analysis--Continued

Time--days	Proximate					Ultimate						
	H_2O	VM	FC	Ash	Btu/lb	H_2O	C	H	N	Cl	S	O
80MBE7 (Cache)												
As-received												
0	31.82	27.48	33.87	7.23	7854	31.82	46.16	2.86	0.74	0.03	1.54	9.62
15	32.30	28.23	32.26	7.11	7727	32.30	44.73	3.18	.84	.00	1.48	10.36
30	31.85	27.70	33.19	7.26	7768	31.85	44.77	3.12	.88	.03	1.56	10.53
60	31.72	29.56	31.43	7.29	7716	31.72	44.98	3.07	.86	.05	1.60	10.43
120	31.12	28.34	33.29	7.25	7777	31.12	45.50	3.07	.85	.03	1.52	10.66
150	31.18	29.34	32.23	7.25	7740	31.18	45.28	3.14	.82	.01	1.49	10.83
361	30.04	30.85	31.85	7.26	7655	30.04	45.18	3.21	.87	.04	1.53	11.87
As-received corrected to equilibrium moisture												
0	30.71	27.93	34.01	7.35	7982	30.71	46.90	2.91	.75	.03	1.57	9.78
15	30.79	28.86	33.08	7.27	7900	30.79	45.73	3.25	.86	.00	1.51	10.59
30	31.07	28.02	33.57	7.34	7857	31.07	45.28	3.16	.89	.03	1.58	10.65
60	31.36	29.72	31.60	7.33	7756	31.36	45.21	3.09	.87	.05	1.61	10.49
120	30.80	28.47	33.44	7.28	7813	30.80	45.71	3.09	.85	.03	1.53	10.71
150	30.50	29.63	32.55	7.32	7817	30.50	45.74	3.17	.83	.01	1.51	10.92
361	28.20	31.66	32.69	7.45	7856	28.20	46.37	3.29	.89	.04	1.57	12.18
Dry basis												
0	---	40.30	49.10	10.60	11519	---	67.71	4.19	1.09	.05	2.26	14.10
15	---	41.70	47.80	10.50	11414	---	66.07	4.70	1.24	.00	2.18	15.31
30	---	40.65	48.69	10.66	11399	---	65.70	4.58	1.29	.05	2.29	15.43
60	---	43.29	46.03	10.68	11300	---	65.87	4.50	1.26	.07	2.34	15.28
120	---	41.15	48.33	10.52	11291	---	66.05	4.45	1.23	.05	2.20	15.50
150	---	42.63	46.83	10.54	11247	---	65.08	4.56	1.19	.02	2.17	15.72
361	---	44.09	45.53	10.38	10942	---	64.58	4.59	1.25	.06	2.19	16.95
Moisture and ash free												
0	---	45.08	54.92	---	12885	---	75.74	4.69	1.22	.06	2.53	15.77
15	---	46.59	53.41	---	12753	---	73.82	5.25	1.39	.00	2.44	17.11
30	---	45.50	54.50	---	12759	---	73.54	5.13	1.44	.06	2.56	17.27
60	---	48.47	51.53	---	12651	---	73.75	5.04	1.41	.08	2.62	17.11
120	---	45.98	54.02	---	12618	---	73.82	4.97	1.37	.06	2.46	17.32
150	---	47.65	52.35	---	12572	---	73.55	5.10	1.33	.02	2.43	17.57
361	---	49.20	50.80	---	12209	---	72.06	5.12	1.39	.07	2.44	18.91

Table 2.--Proximate and ultimate analysis--Continued

Time--days	Proximate					Ultimate						
	H_2O	VM	FC	Ash	Btu/lb	H_2O	C	H	N	Cl	S	O
80MBA2 (Cache)												
As-received												
0	34.56	28.42	31.03	5.99	7456	34.56	43.67	3.09	0.65	0.03	0.35	11.66
15	35.30	28.03	31.25	5.42	7371	35.30	43.54	2.96	.74	.00	.33	11.71
30	34.53	27.89	32.05	5.53	7444	34.53	44.98	2.82	.82	.05	.39	10.88
60	34.78	28.14	31.54	5.54	7410	34.78	43.98	3.02	.75	.06	.40	11.47
120	35.69	26.72	32.48	5.11	7200	35.69	43.66	2.76	.67	.05	.34	11.72
150	33.87	27.77	32.68	5.68	7321	33.87	44.11	3.00	.63	.01	.38	12.32
361	33.62	28.09	32.63	5.66	7217	33.62	43.64	3.03	.76	.05	.38	12.86
As-received corrected to equilibrium moisture												
0	33.63	28.42	31.03	5.99	7562	34.56	43.67	3.09	.65	.03	.35	11.66
15	33.52	28.03	31.25	5.42	7574	33.52	44.74	3.04	.76	.00	.34	12.03
30	34.16	28.05	32.23	5.56	7486	34.16	45.23	2.84	.82	.05	.39	10.94
60	34.48	28.07	31.67	5.57	7444	34.48	44.18	3.03	.75	.06	.40	11.52
120	34.20	27.34	33.23	5.23	7366	34.20	44.67	2.82	.69	.05	.35	11.99
150	33.20	28.05	33.01	5.74	7395	33.20	44.55	3.03	.64	.01	.38	12.44
361	30.30	29.48	34.28	5.94	7253	30.30	45.82	3.18	.80	.05	.40	13.50
Dry basis												
0	---	43.43	47.42	9.15	11394	---	66.74	4.72	1.00	.04	.54	17.81
15	---	43.32	48.30	8.38	11393	---	67.30	4.57	1.14	.00	.51	18.10
30	---	42.60	48.96	8.44	11370	---	68.70	4.30	1.26	.08	.59	16.63
60	---	43.14	48.37	8.49	11362	---	67.43	4.63	1.15	.09	.62	17.59
120	---	41.55	50.51	7.94	11195	---	67.89	4.66	1.04	.07	.53	18.24
150	---	42.00	49.41	8.59	11070	---	66.70	4.54	.95	.02	.57	18.63
361	---	42.32	53.74	8.52	10872	---	65.74	4.57	1.14	.07	.57	19.39
Moisture and ash free												
0	---	47.80	52.20	---	12541	---	73.46	5.20	1.10	.04	.59	19.60
15	---	47.28	52.72	---	12435	---	73.46	4.99	1.24	.00	.56	19.76
30	---	46.53	53.47	---	12418	---	75.03	4.70	1.38	.09	.64	18.16
60	---	47.14	52.86	---	12416	---	73.68	5.06	1.26	.10	.68	19.22
120	---	45.13	54.87	---	12161	---	73.75	4.66	1.13	.08	.58	19.81
150	---	45.95	54.05	---	12110	---	72.97	4.97	1.04	.02	.62	20.38
361	---	46.26	53.74	---	11885	---	71.86	5.00	1.25	.07	.62	21.20

Table 3.--Relationship of time, moist mineral matter free Btu/lb, and apparent rank

Hole number	Coal bed	Time interval (days)	Calorific value (Btu/lb)	Apparent rank
80AU15	Anderson-Canyon	0	9596	Subbituminous B
		15	9512	Do.
		30	9494	Subbituminous C
		60	9433	Do.
		120	9247	Do.
		150	9286	Do.
		268	9348	Do.
80AU16	Anderson-Canyon	0	9333	Subbituminous C
		15	9331	Do.
		30	9252	Do.
		60	9161	Do.
		120	9114	Do.
		150	9047	Do.
		284	9005	Do.
80MBE7	Pawnee	0	8168	Not ranked--
		15	8248	believed to be
		30	8298	partially
		60	8014	oxidized and
		120	8049	altered
		150	8143	
		361	8171	
80MBE7	Cache	0	8661	Subbituminous C
		15	8556	Do.
		30	8524	Do.
		60	8413	Do.
		120	8472	Do.
		150	8483	Do.
		361	8539	Do.
80MBA2	Cache	0	8084	Lignite A
		15	8043	Do.
		30	7953	Do.
		60	7916	Do.
		120	7794	Do.
		150	7875	Do.
		361	7747	Do.

Table 4.--Btu/lb and oxygen, (moisture-ash free basis) change with time--linear regression analysis; (a) 0- to 360-day time intervals, (b) 0- to 150-day time intervals

[Leaders (---) indicate no data]

Sample	Time interval (days)								Difference (0-360 and 0-150 days)	Coefficient determination (R2)	Change (in percent)	
	0	15	30	60	120	150	270	360			Total	Per day
a. 0- to 360-day time intervals												
Btu/lb												
80AU15	12997	12980	12963	12930	12862	12828	12693	12591	-406 Btu/lb	0.73	-3.1	-1.13 Btu/lb
80AU16	12852	12837	12822	12793	12734	12704	12588	12500	-351 Btu/lb	.70	-2.7	- .98 Btu/lb
80MBE7P	12375	12360	12346	12315	12255	12224	12103	12011	-364 Btu/lb	.86	-2.9	-1.01 Btu/lb
80MBE7C	12812	12787	12762	12711	12610	12559	12357	12205	-607 Btu/lb	.96	-4.7	-1.67 Btu/lb
80MBA2	12468	12442	12415	12361	12254	12200	11986	11825	-643 Btu/lb	.91	-5.2	-1.77 Btu/lb
Oxygen												
80AU15	17.92	17.95	17.98	18.05	18.18	18.24	18.50	18.70	+0.78 percent	.16	+ 4.4	+.002 percent
80AU16	18.02	18.06	18.09	18.16	18.31	18.38	18.66	18.88	+ .86 percent	.46	+ 4.5	+.002 percent
80MBE7P	19.17	19.26	19.35	19.53	19.89	20.07	20.79	21.33	+2.16 percent	.31	+11.3	+.006 percent
80MBE7C	16.61	16.71	16.81	17.00	17.39	17.59	18.37	18.95	+2.34 percent	.78	+11.1	+.007 percent
80MBA2	19.11	19.20	19.29	19.47	19.82	20.00	20.71	21.24	+2.13 percent	.79	+11.1	+.006 percent
b. 0- to 150-day time intervals												
Btu/lb												
80AU15	13046	13016	12986	12927	12807	12747	-----	-----	-299 Btu/lb	.85	-2.3	-1.99 Btu/lb
80AU16	12883	12859	12835	12786	12688	12639	-----	-----	-244 Btu/lb	.77	-1.9	-1.63 Btu/lb
80MBE7P	12371	12358	12344	12316	12261	12233	-----	-----	-138 Btu/lb	.51	-1.1	- .92 Btu/lb
80MBE7C	12816	12789	12763	12711	12603	12553	-----	-----	-263 Btu/lb	.85	-2.1	-1.75 Btu/lb
80MBA2	12519	12478	12437	12354	12188	12105	-----	-----	-414 Btu/lb	.95	-3.3	-2.76 Btu/lb
Oxygen												
80AU15	1789	17.93	1797	18.05	18.22	18.31	-----	-----	+ .42 percent	.10	+2.4	+.003 percent
80AU16	18.08	18.10	18.11	18.15	18.22	18.25	-----	-----	+ .17 percent	.06	+ .9	+.001 percent
80MBE7P	19.36	19.39	19.43	19.50	19.65	19.73	-----	-----	+ .37 percent	.02	+1.9	+.003 percent
80MBE7C	16.58	16.68	16.79	17.01	17.44	17.65	-----	-----	+1.07 percent	.46	+6.5	+.007 percent
80MBA2	19.07	19.17	19.27	19.47	19.87	20.07	-----	-----	+1.00 percent	.28	+5.2	+.007 percent

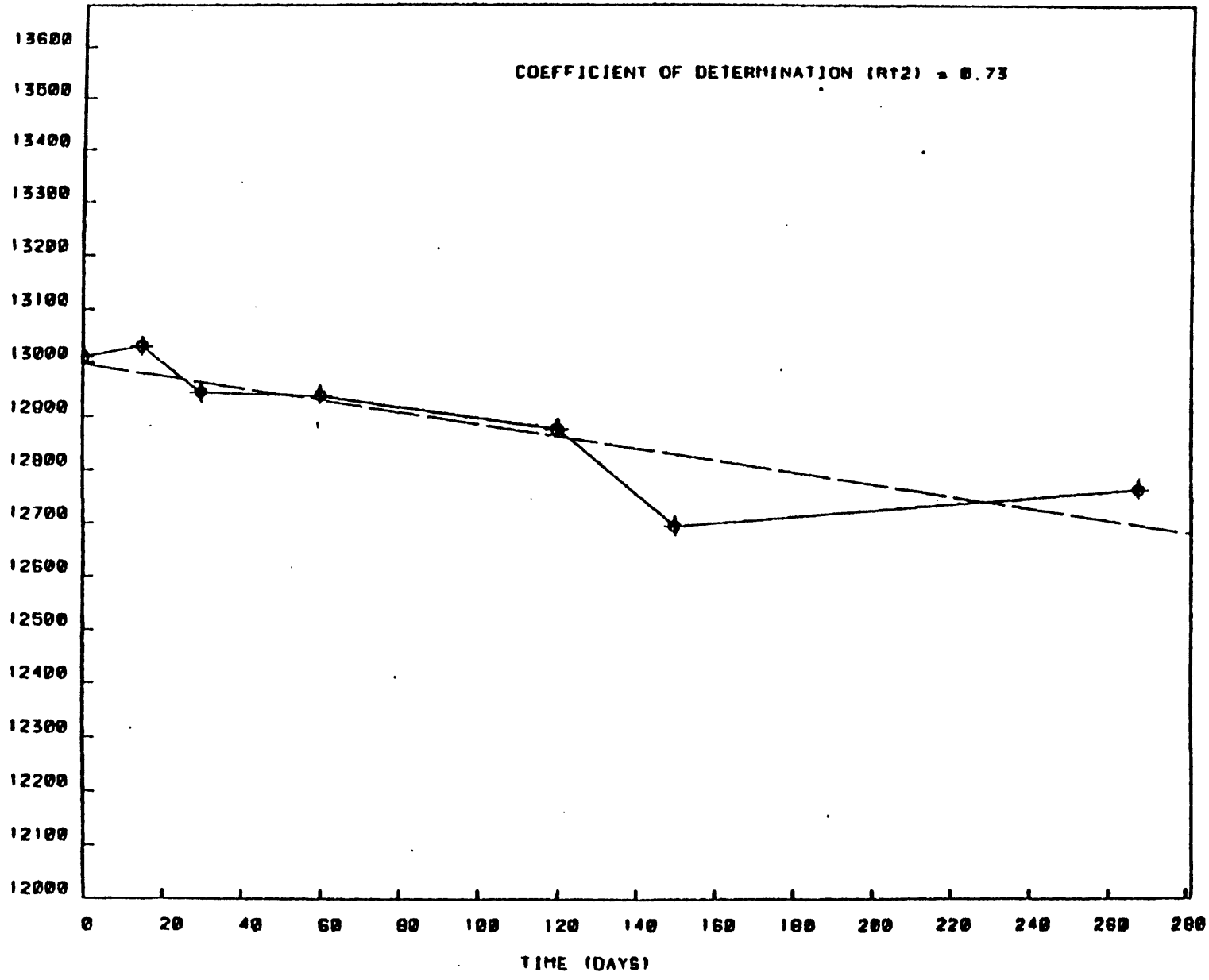

Figure 1. Btu/lb, moisture and mineral matter free basis, linear and linear regression plots. (a. 80AU15 0-268 days)

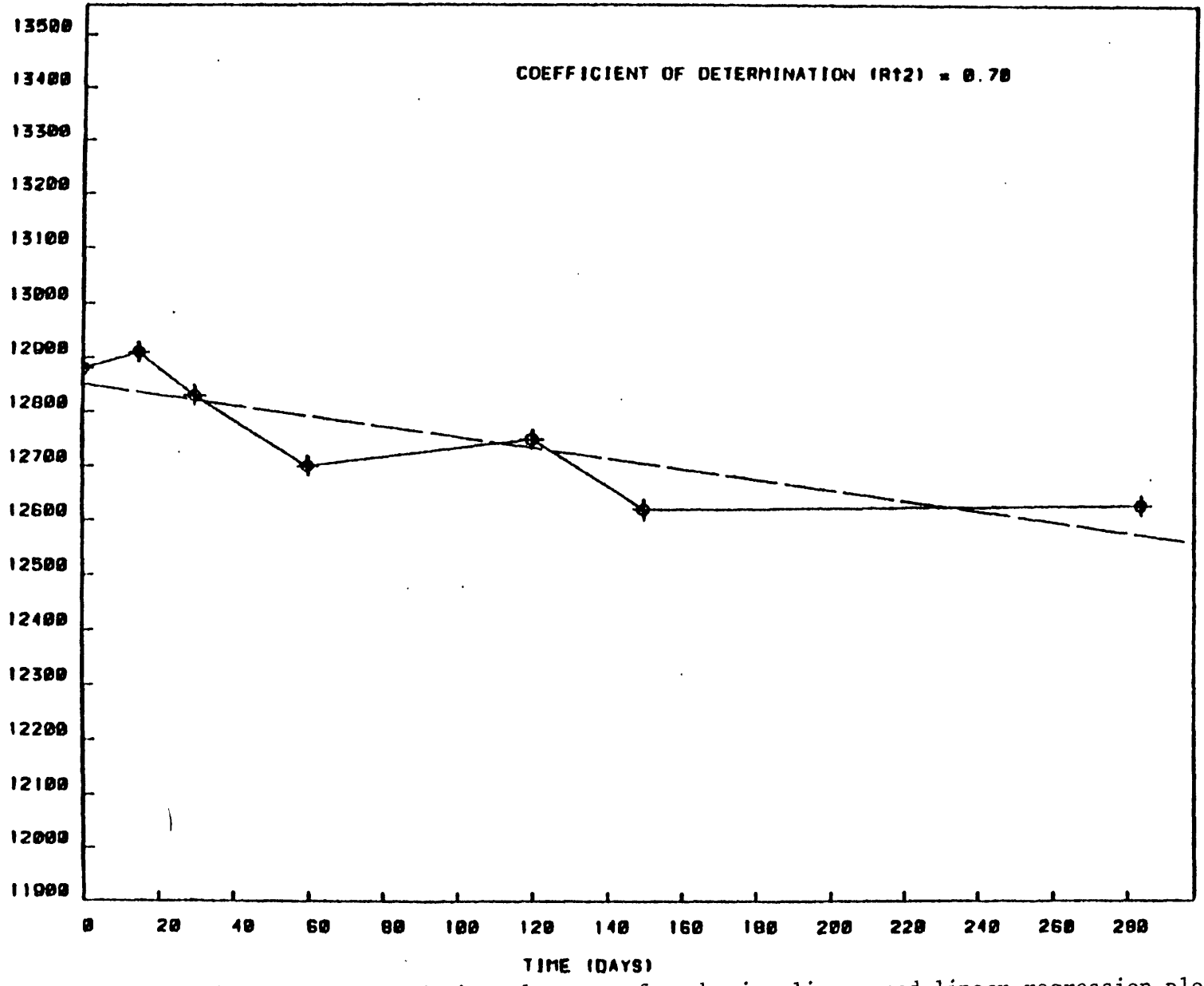

Figure 1. Btu/lb, moisture and mineral matter free basis, linear and linear regression plots. (b. 80AU16 (0-284 days)

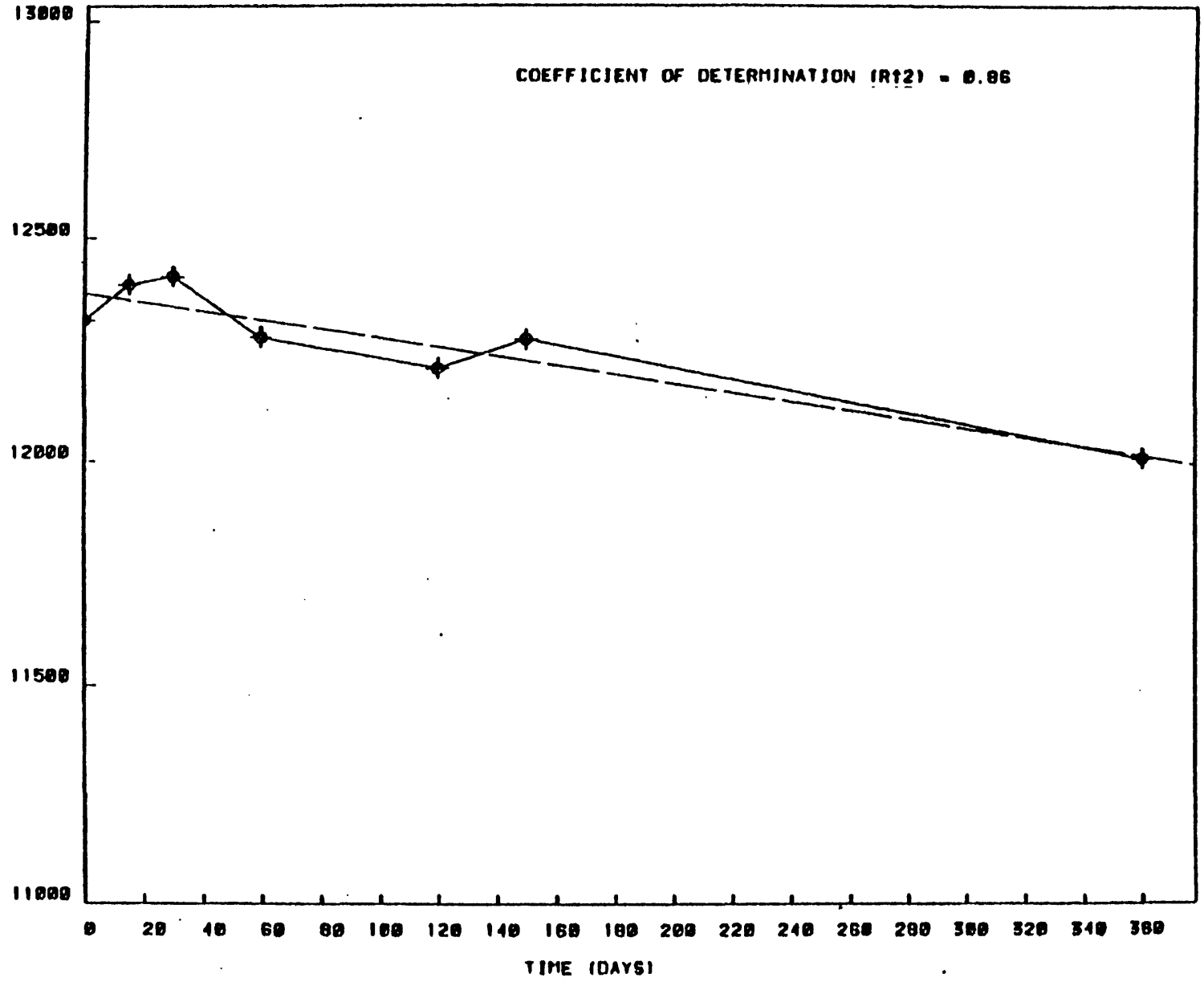

Figure 1. Btu/lb, moisture and mineral matter free basis, linear and linear regression plots. (c. 80MBE7P 0-360 days)

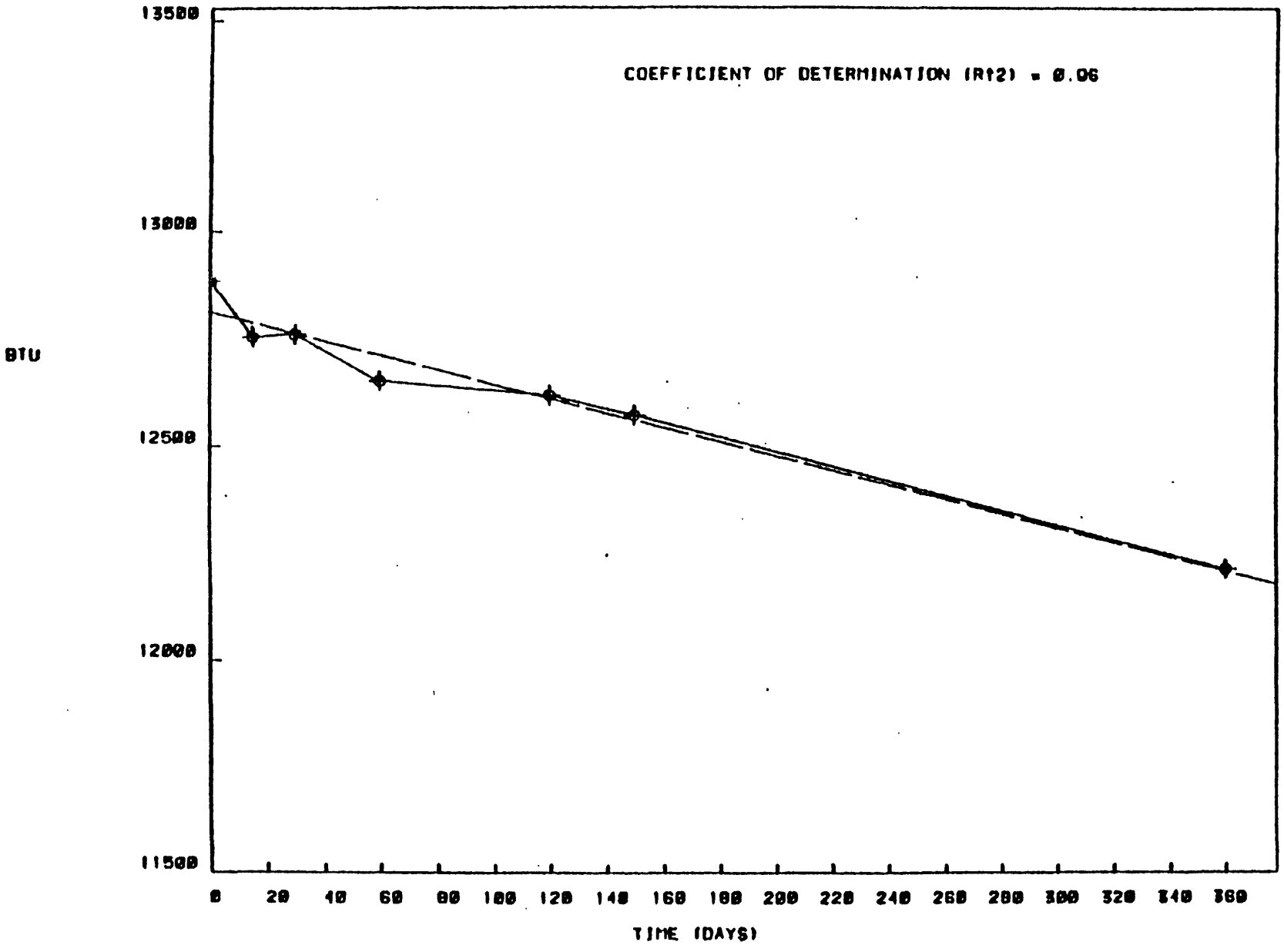

Figure 1. Btu/lb, moisture and mineral matter free basis, linear and linear regression plots (d. 80MBE7C 0-360 days)

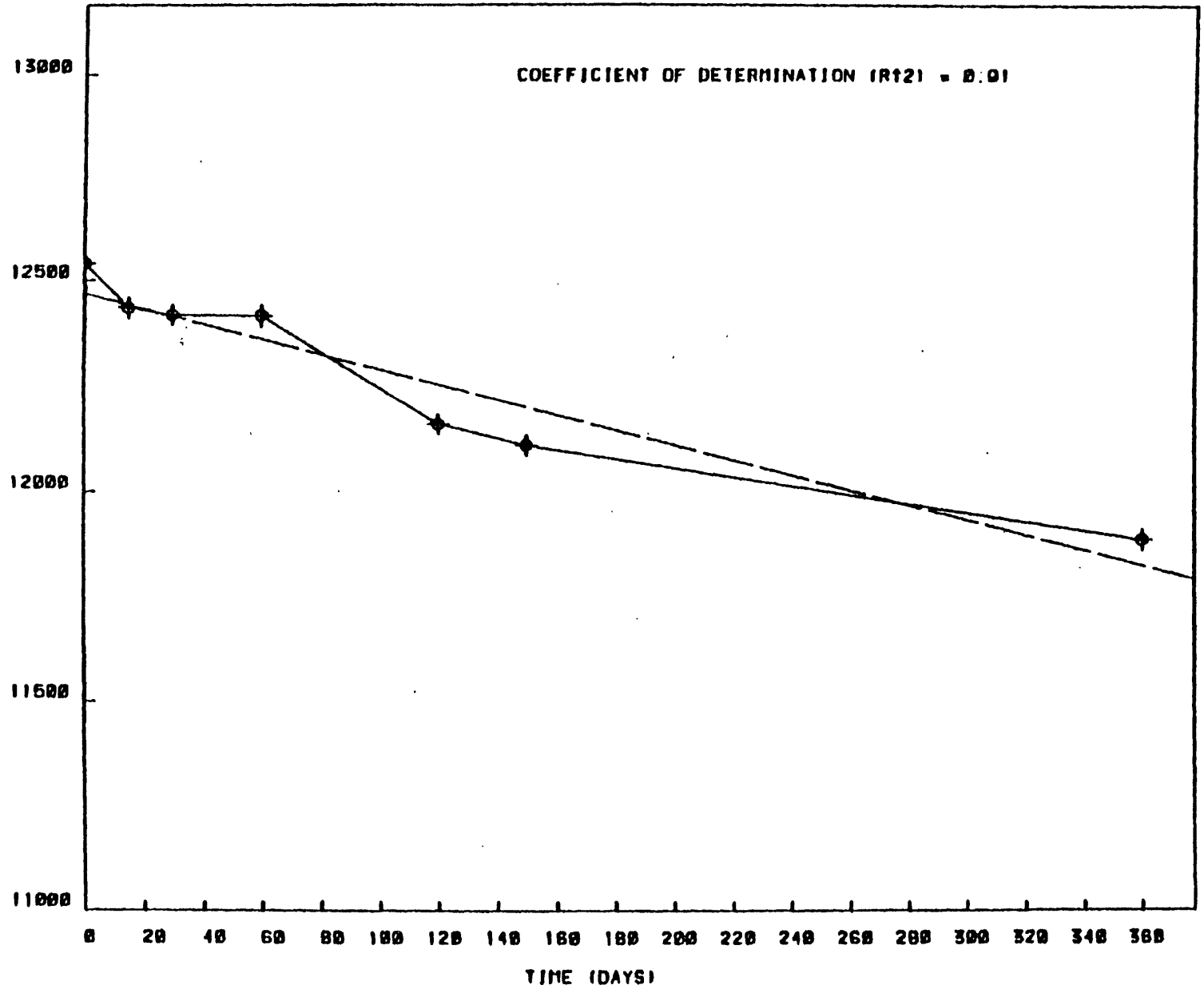

Figure 1. Btu/lb, moisture and mineral matter free basis, linear and linear regression plots. (e. 80MBA2 0-360 days)

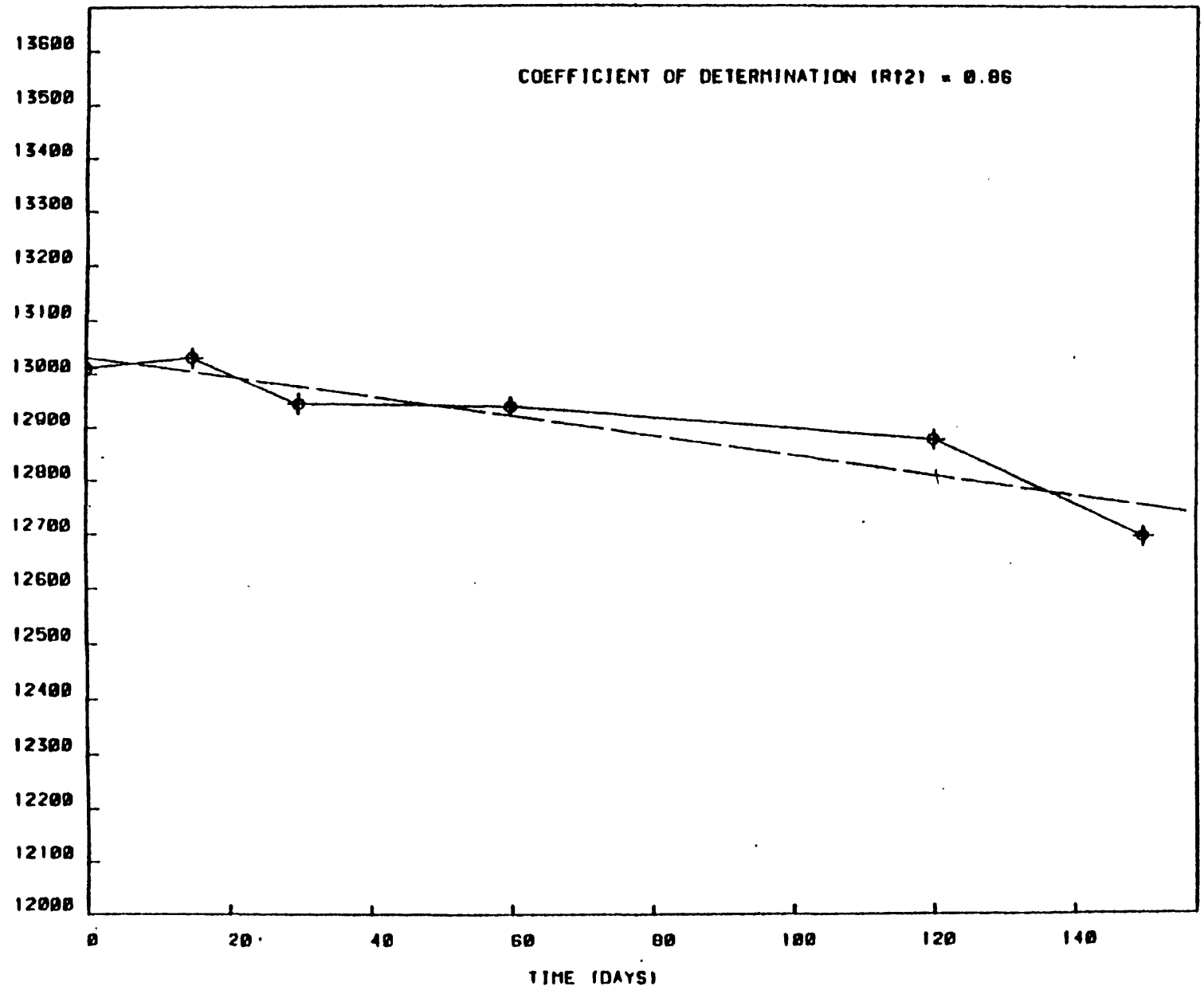

Figure 1. Btu/lb, moisture and mineral matter free basis, linear and linear regression plots. (f. 80AIII5 0-150 days)

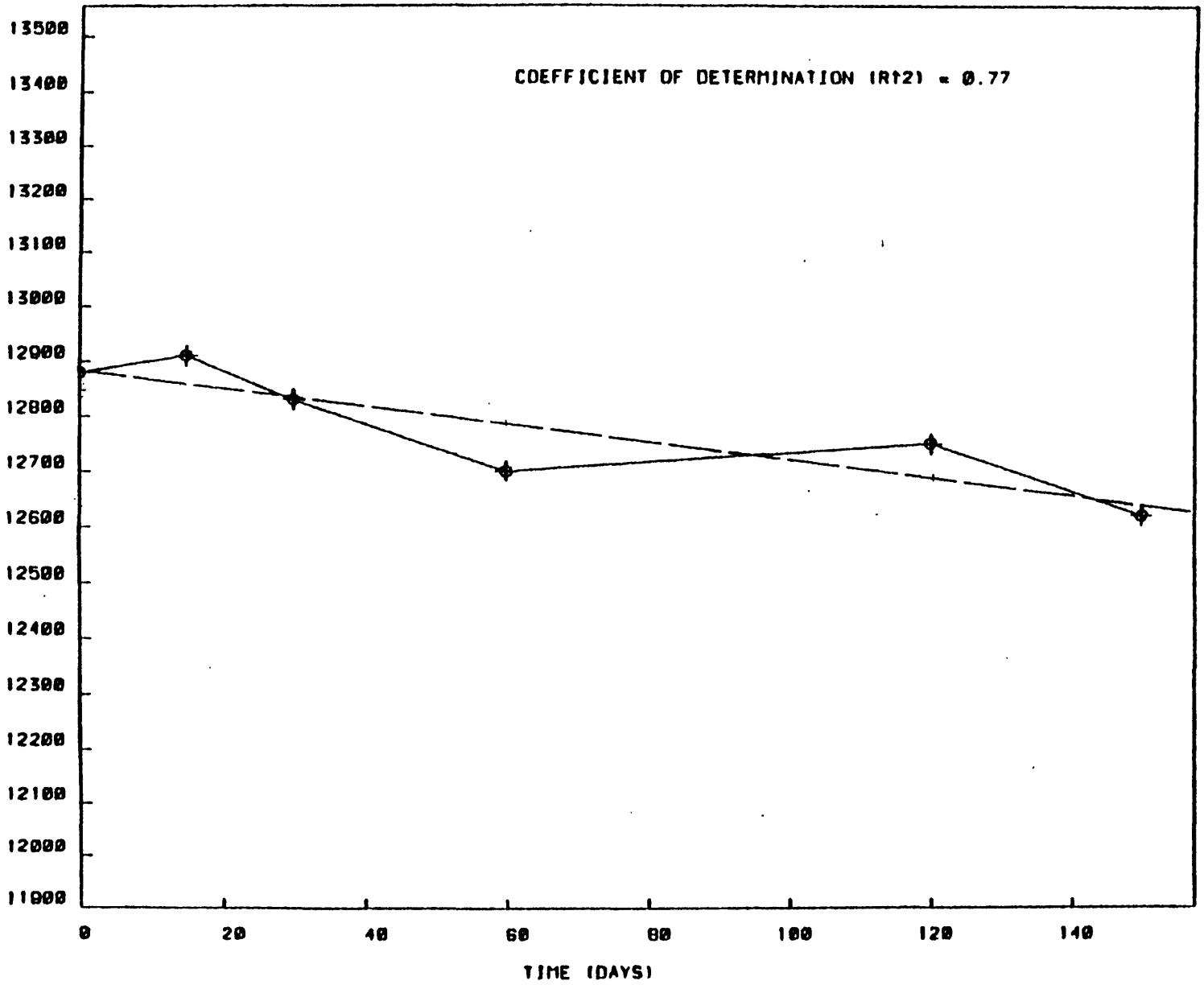

Figure 1. Btu/lb, moisture and mineral matter free basis, linear and linear regression plots. (g. 80AU16 0-150 days)

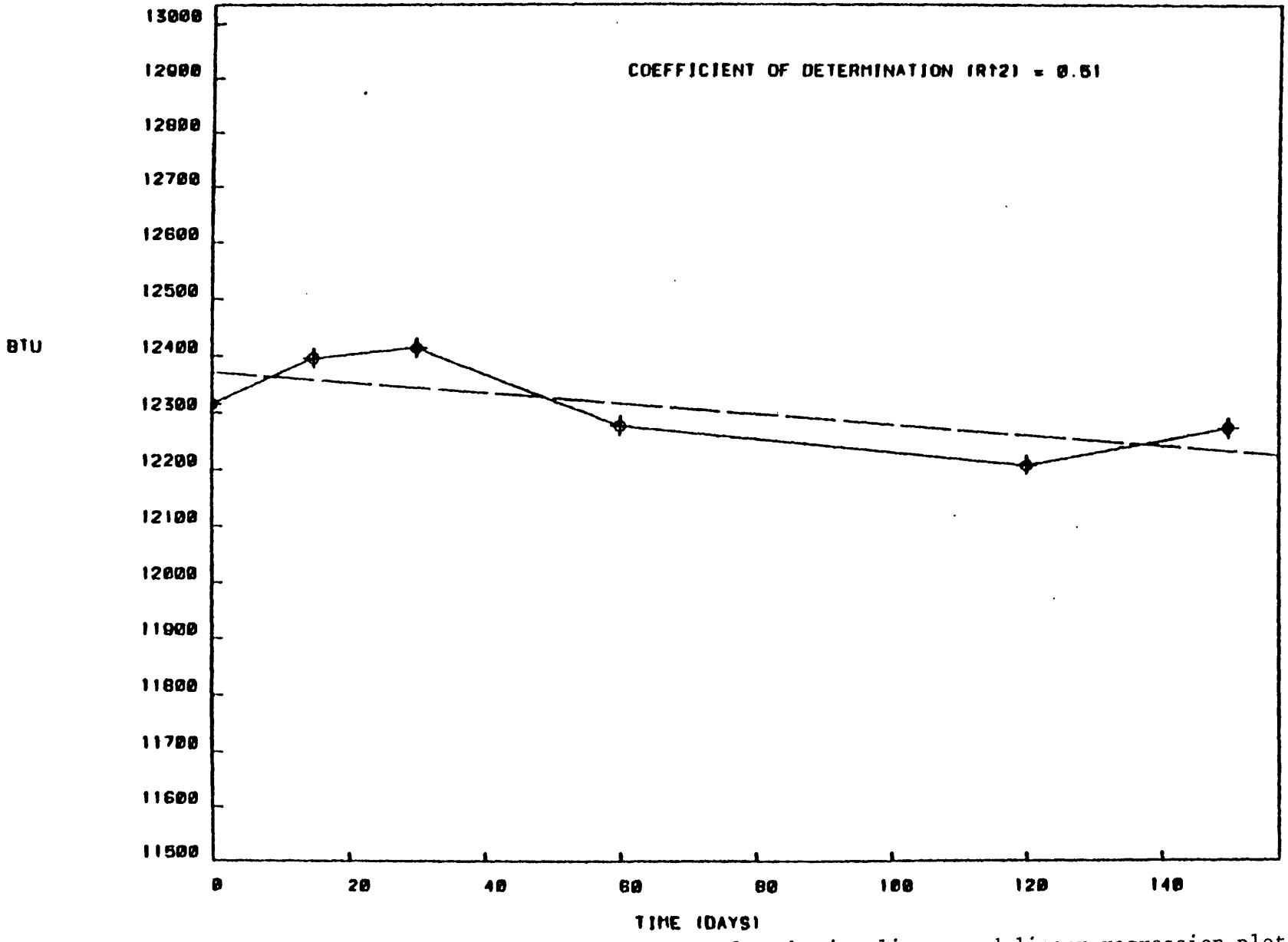

Figure 1. Btu/lb, moisture and mineral matter free basis, linear and linear regression plots. (h. 80MBE7P 0-150 days)

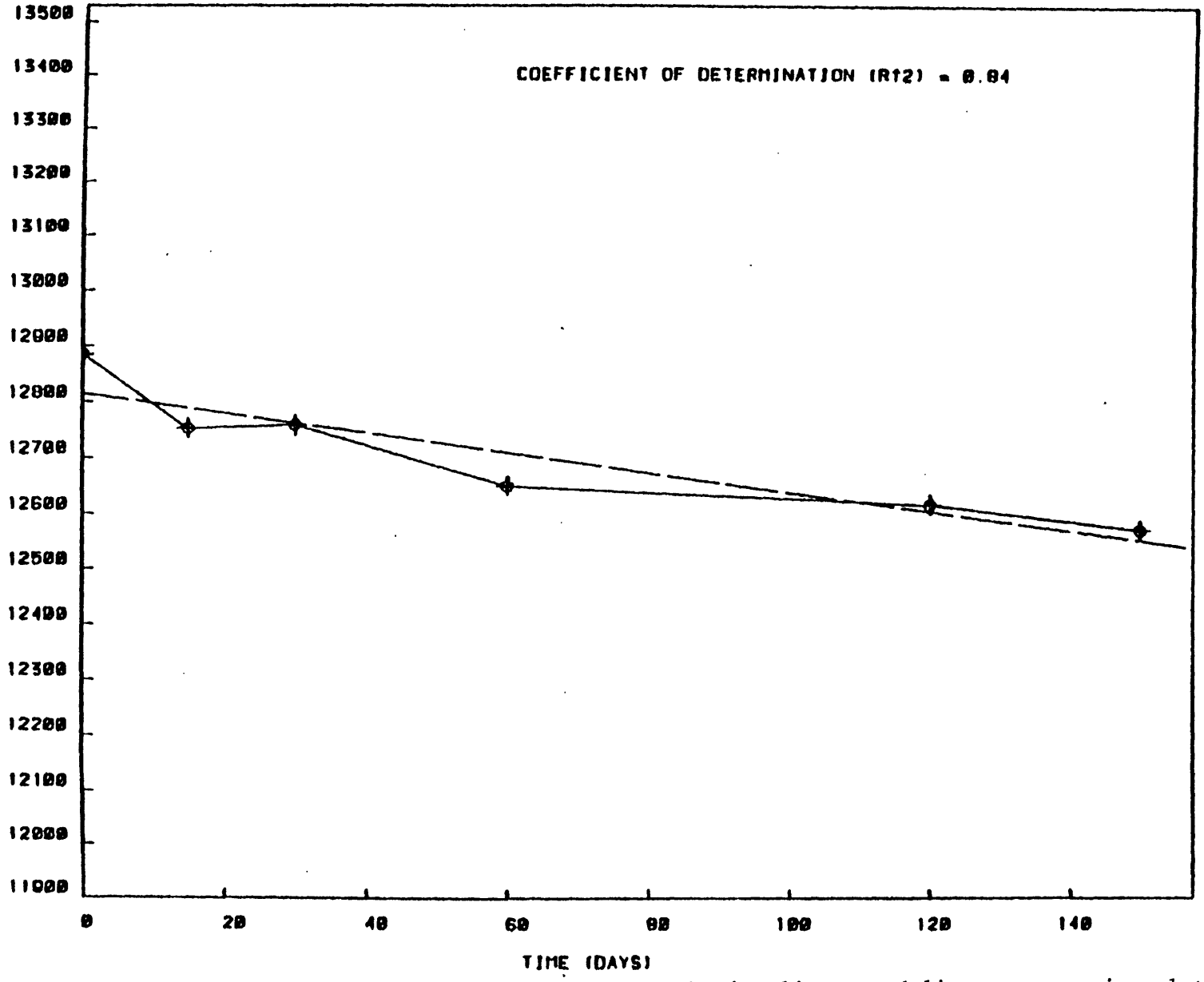

Figure 1. Btu/lb, moisture and mineral matter free basis, linear and linear regression plots. (i. 80MBE7C 0-150 days)

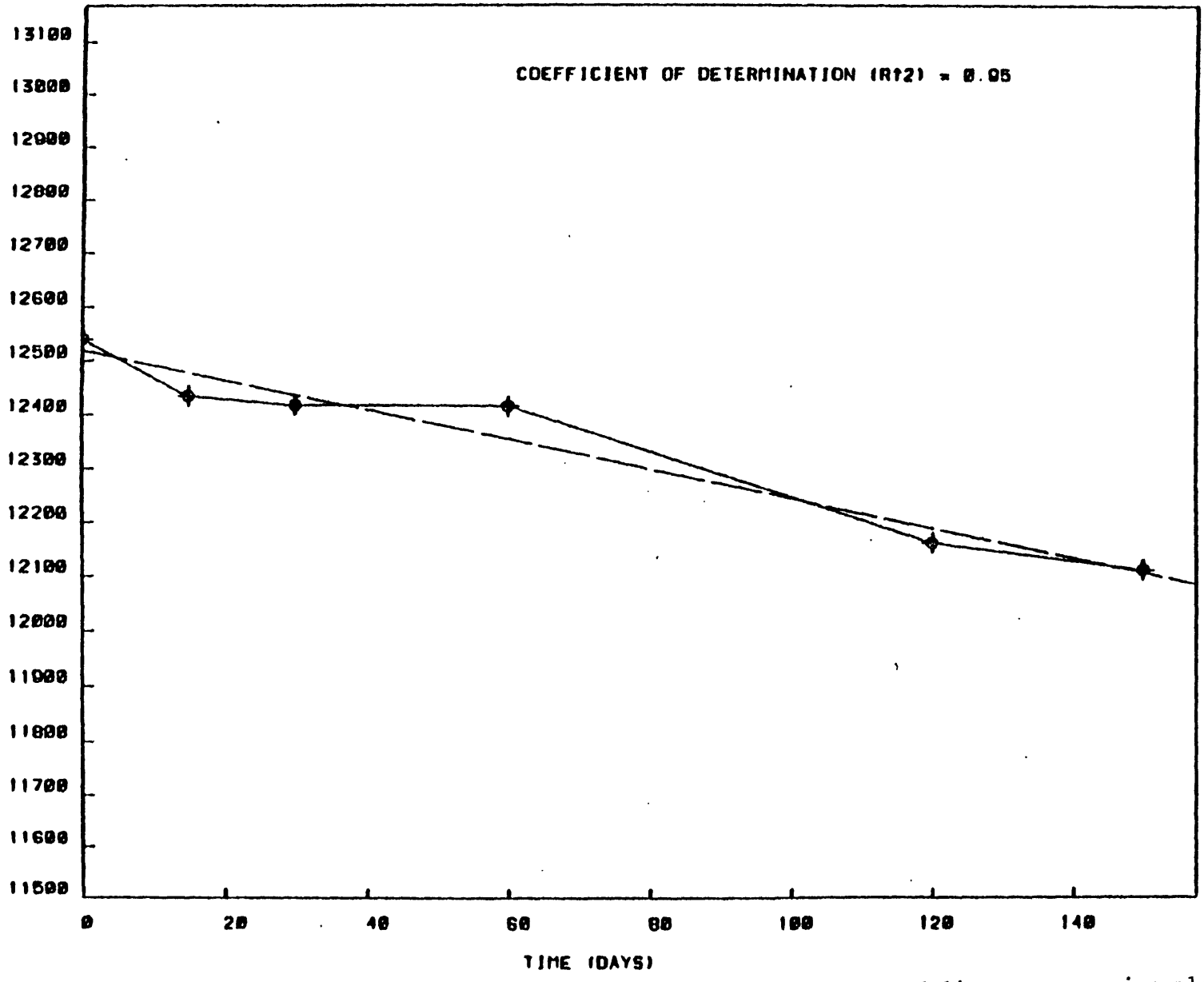

Figure 1. Btu/lb, moisture and mineral matter free basis, linear and linear regression plots. (j. 80MBA2 0-150 days)

Oxygen

Tables 4a and 4b also show the oxygen values over the same time period. All show an increase in oxygen over the time period. The data in table 4a show a higher, but as varied, coefficent of determination as that in table 4b, but overall the trend and approximate value of the oxygen gain has been established.

The plots are shown on figures 2a to 2j. The rise in oxygen values at the initial intervals for 80AU15, 80AU16, and 80MBE7C are probably the initial oxygen gain without the concurrent loss of volatile oxidation products (Berkowitz, 1979, p. 96). This is discussed further in the specific gravity section.

The oxygen values are compromised in part by the method used for the oxygen content determination. All the other constituents are added together and subtracted from 100 percent; this resulting value is the oxygen content. In actuality, this value may contain other constituents not detected and is subject to the sum of error of all other determinations.

Apparent Specific Gravity

The apparent specific gravity is shown on figures 3a-3e, together with a linear plot of the ash on a dry basis. The specific gravity shows a reasonable correlation to the ash content over the 150-day period; thereafter, all except 80AU15 show a rise in specific gravity without a corresponding increase of the ash content. This rise after 150 days, plus smaller variations prior to the 150-day interval, is probably attributable to increased oxygen content.

Table 5 shows the apparent specific gravity at four different moisture levels corresponding to the same time periods as shown on figures 3a-3e.

Hardgrove Grindability Index

The Hardgrove Grindability Indices generally decrease with lower moisture content and increasing time (table 6). An opposite result would be expected, the indices increasing with decreasing moisture. Further research is indicated.

A possible source of the anomalus results may be inherent in the preparation phase of the test method. When the coal is crushed and screened the more easily ground portion may have, with time, become more oxidized and therefore would not be retained on the lower mesh screen. Only the more resistant portion of the test sample(s) would be retained and therefore resulting in a lower grindability index. It is also possible that the coal-fine particles formed aggregates (Berkowitz, 1979, p. 92) after crushing and would not pass through the screen.

Table 5.--Apparent specific gravity at four moisture levels

[Leaders (---) indicate no data]

Hole No.	Time interval (days)	Determined (lab)				Calculated			
		Moisture (percent)	Apparent specific gravity (g/cm^3)	Moisture (percent)	Apparent specific gravity (g/cm^3)	Equilibrium moisture (percent)	Apparent specific gravity (g/cm^3)	Moisture (percent)	Apparent specific gravity (g/cm^3)
80AU15	0	24.87	1.30	27.03	1.29	25.52	1.30	0.00	1.42
	15	22.08	1.28	27.26	1.26	26.04	1.27	.00	1.37
	30	22.82	1.31	27.06	1.29	25.87	1.30	.00	1.42
	60	20.97	1.32	27.61	1.29	26.30	1.30	.00	1.41
	120	16.78	1.34	26.67	1.30	27.43	1.30	.00	1.41
	150	21.86	1.30	26.88	1.28	26.10	1.28	.00	1.38
	268	23.93	1.29	27.32	1.28	26.00	1.28	.00	1.38
80AU16	0	26.29	1.29	28.33	1.28	26.51	1.29	.00	1.39
	15	22.32	1.32	27.96	1.30	26.63	1.29	.00	1.40
	30	25.19	1.31	28.44	1.30	26.83	1.31	.00	1.39
	60	23.28	1.30	28.06	1.28	26.87	1.29	.00	1.39
	120	20.70	1.30	28.74	1.28	27.43	1.29	.00	1.40
	150	23.28	1.30	28.06	1.28	27.30	1.28	.00	1.39
	284	26.77	1.30	28.72	1.29	27.70	1.30	.00	1.41
80MBE7 (Pawnee)	0	29.09	1.31	32.20	1.30	31.33	1.30	.00	1.44
	15	28.96	1.32	33.01	1.30	31.28	1.31	.00	1.45
	30	26.02	1.34	31.89	1.31	31.02	1.32	.00	1.46
	60	26.15	1.35	32.69	1.32	32.06	1.32	.00	1.48
	120	27.00	1.31	32.68	1.29	32.00	1.29	.00	1.43
	150	29.17	1.31	32.73	1.29	31.30	1.30	.00	1.44
	361	27.75	1.35	31.94	1.33	29.20	1.34	.00	1.48
80MBE7 (Cache)	0	27.04	1.31	31.82	1.29	31.33	1.29	.00	1.43
	15	25.47	1.34	32.30	1.31	31.28	1.31	.00	1.46
	30	24.21	1.34	31.85	1.31	31.02	1.31	.00	1.45
	60	24.60	1.35	31.72	1.32	32.06	1.32	.00	1.47
	120	24.08	1.31	31.12	1.28	32.00	1.28	.00	1.41
	150	27.39	1.31	31.18	1.29	31.30	1.29	.00	1.42
	361	25.19	1.36	30.04	1.34	28.20	1.35	.00	1.48
80MBA2	0	30.35	1.31	34.56	1.29	33.63	1.29	.00	1.44
	15	31.64	1.31	35.30	1.29	33.52	1.30	.00	1.45
	30	30.04	131	34.53	1.29	34.16	1.29	.00	1.44
	60	28.71	1.32	34.78	1.29	34.48	1.29	.00	1.45
	120	29.31	1.30	35.69	1.27	34.20	1.28	.00	1.42
	150	29.21	1.29	33.87	1.27	33.20	1.27	.00	1.41
	361	28.04	1.34	33.62	1.31	30.30	1.33	.00	1.47

Table 6.--Hardgrove Grindability Index

Hole number	Coal bed	Time interval (days)	Index	Moisture level (percent)
80AU15	Anderson-Canyon	0	Not determined	
		15	54.2	22.04
		30	48.8	22.94
		60	47.8	20.52
		120	42.4	16.96
		150	44.2	21.91
		268	46.6	23.26
80AU16	Anderson-Canyon	0	59.2	23.90
		15	62.2	21.56
		30	56.6	25.35
		60	56.0	22.60
		120	57.0	20.43
		150	51.6	24.46
		284	51.6	25.22
80MBE7	Pawnee	0	52.0	29.66
		15	52.8	29.05
		30	42.0	27.01
		60	35.0	23.83
		120	38.0	24.81
		150	41.6	29.37
		361	40.2	28.23
80MBE7	Cache	0	44.0	26.99
		15	43.4	25.28
		30	40.0	24.63
		60	33.8	21.90
		120	36.8	24.26
		150	32.0	27.41
		361	34.0	25.62
80MBA2	Cache	0	48.2	38.87
		15	52.0	32.04
		30	46.0	31.21
		60	36.8	25.99
		120	37.0	30.04
		150	36.2	29.80
		361	40.2	23.00

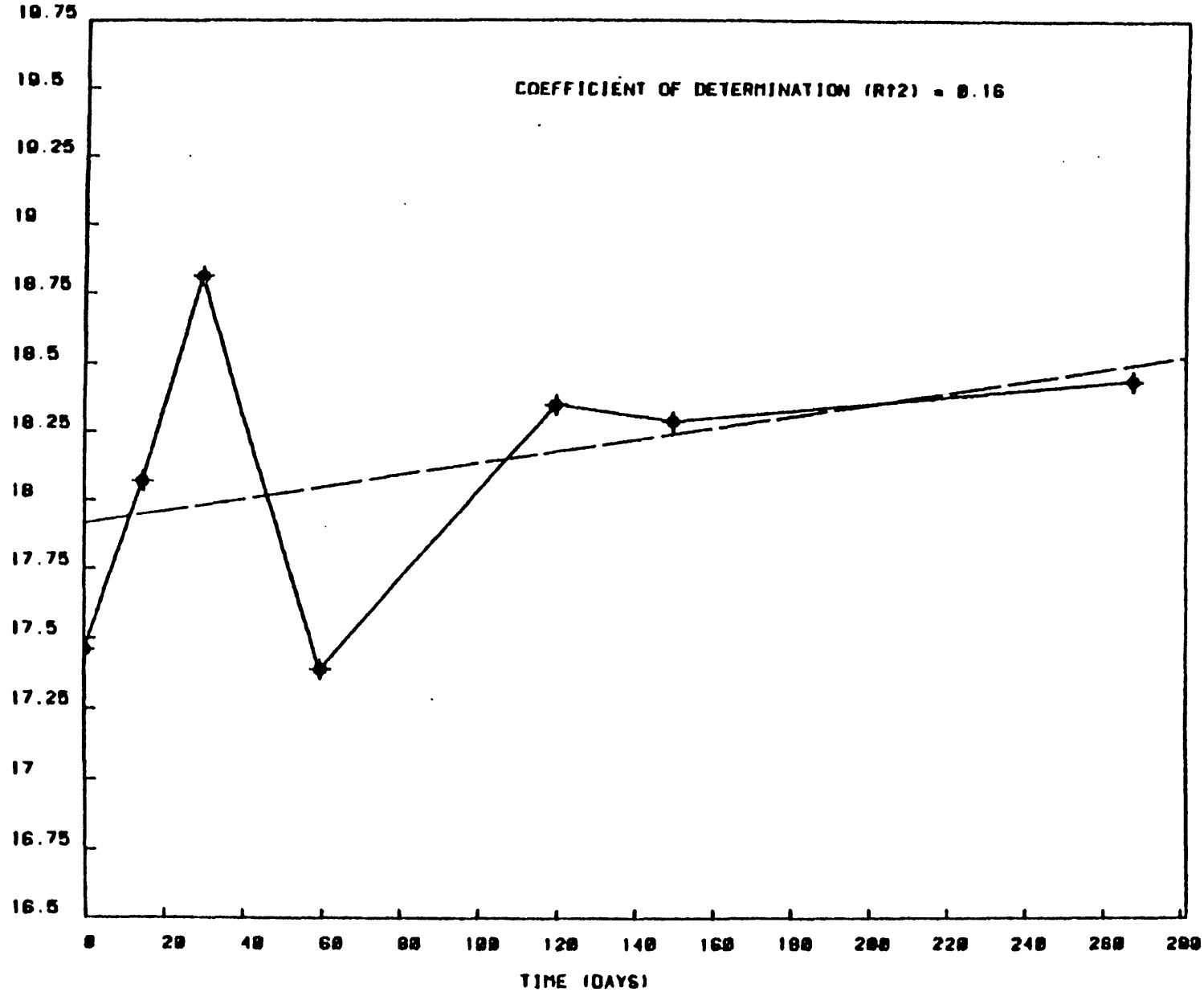

Figure 2. Oxygen (percent), moisture and mineral matter free basis, linear and linear regression analysis plots.
(a. 80AU15 0-268 days)

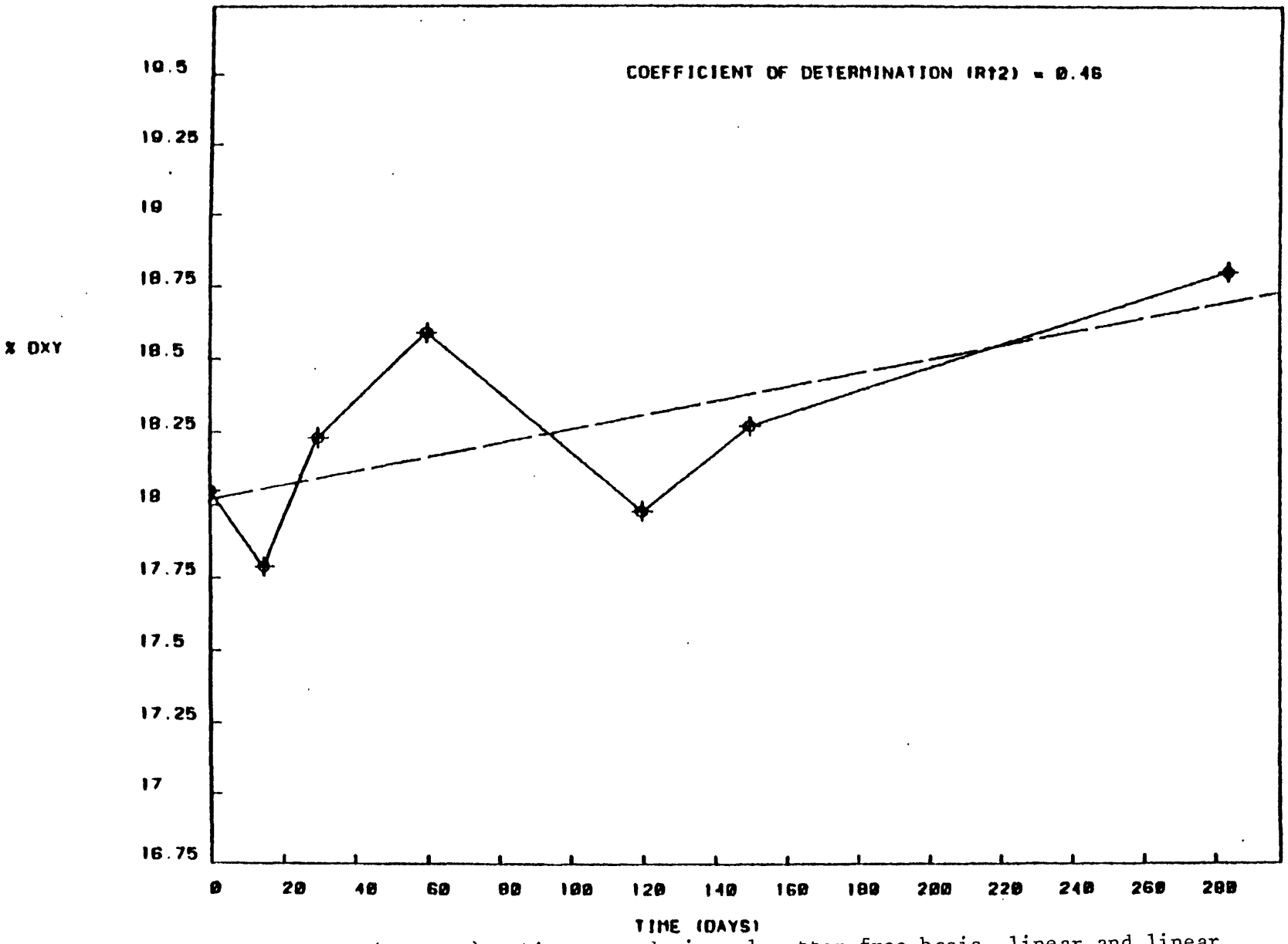

Figure 2. Oxygen (percent), moisture and mineral matter free basis, linear and linear regression analysis plots.
(b. 80AU16 0-284 days)

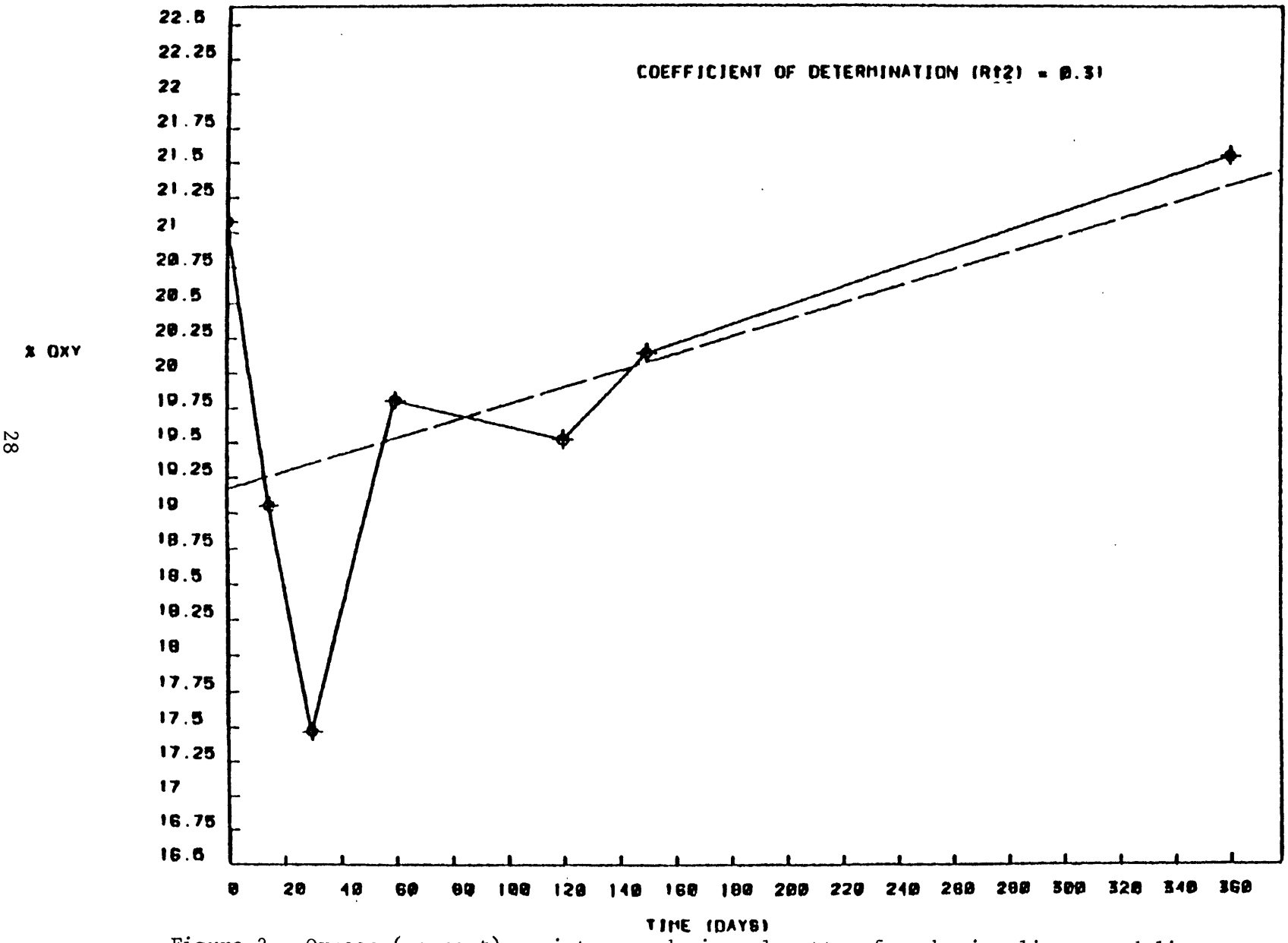

Figure 2. Oxygen (percent), moisture and mineral matter free basis, linear and linear regression analysis plots.
(c. 80MBE7P 0-360 days)

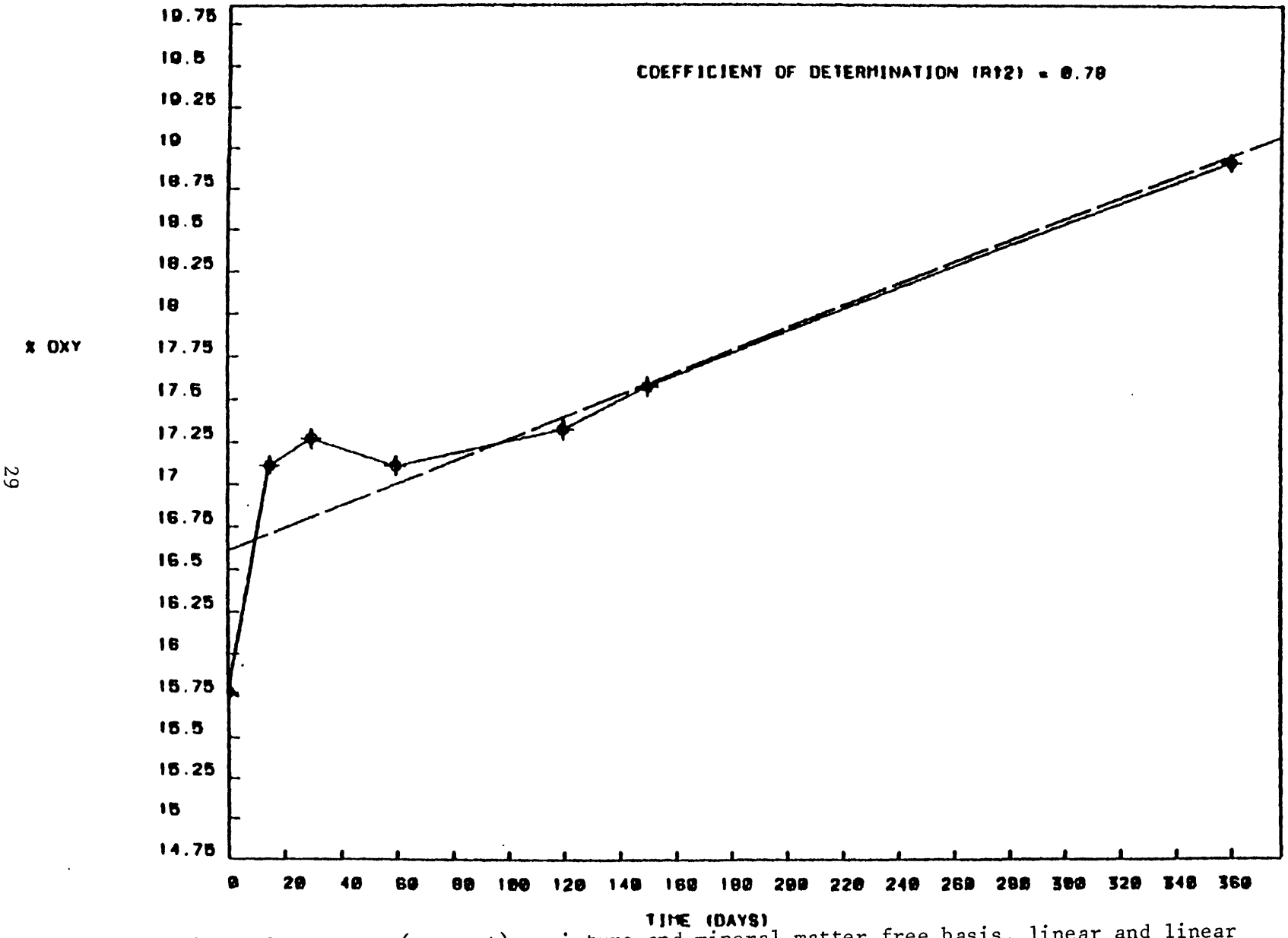

Figure 2. Oxygen (percent), moisture and mineral matter free basis, linear and linear regression analysis plots
(d. 80MBE7C 0-360 days)

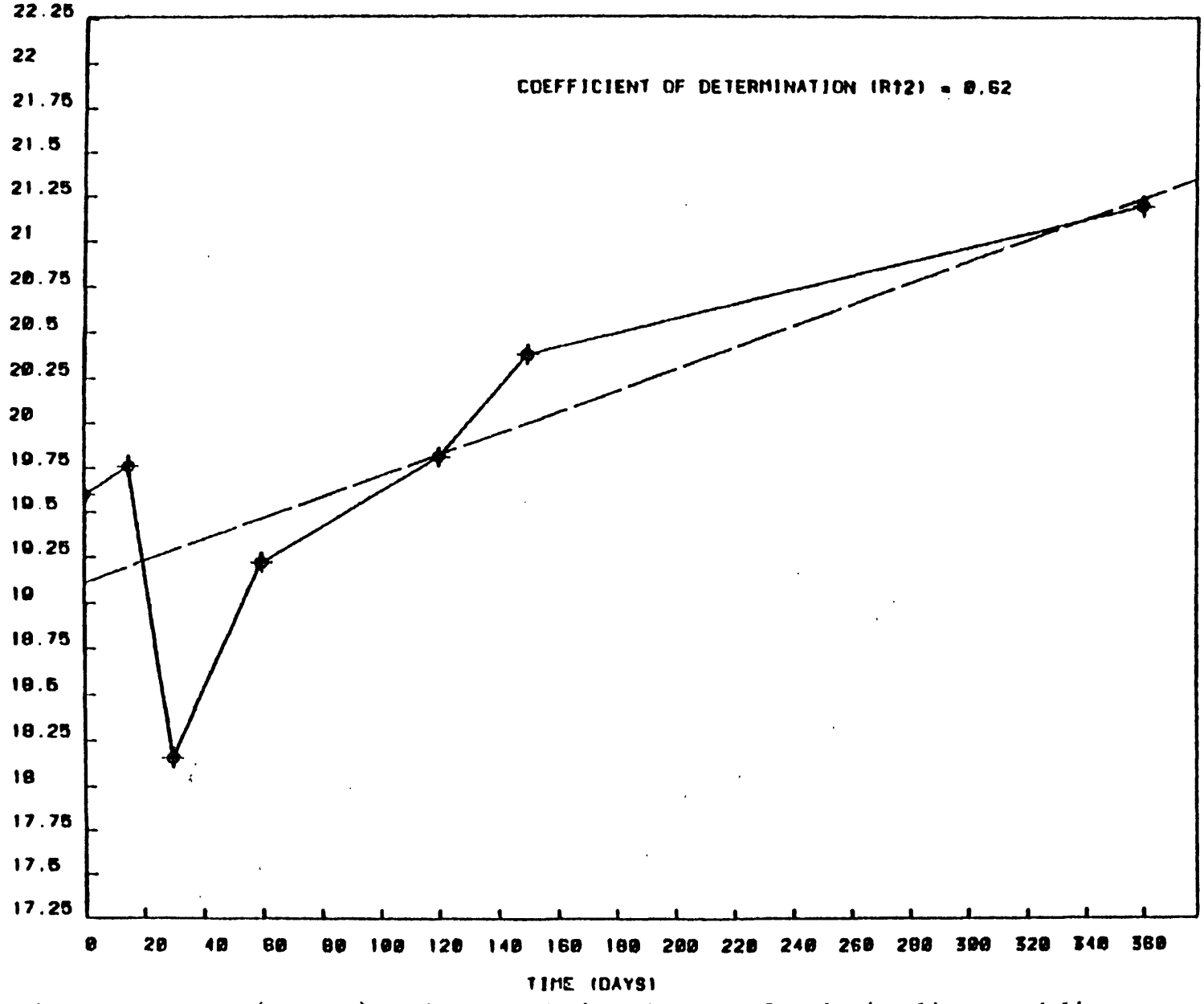

Figure 2. Oxygen (percent), moisture and mineral matter free basis, linear and linear regression analysis plots.
(e. 80MBA2 0-360 days)

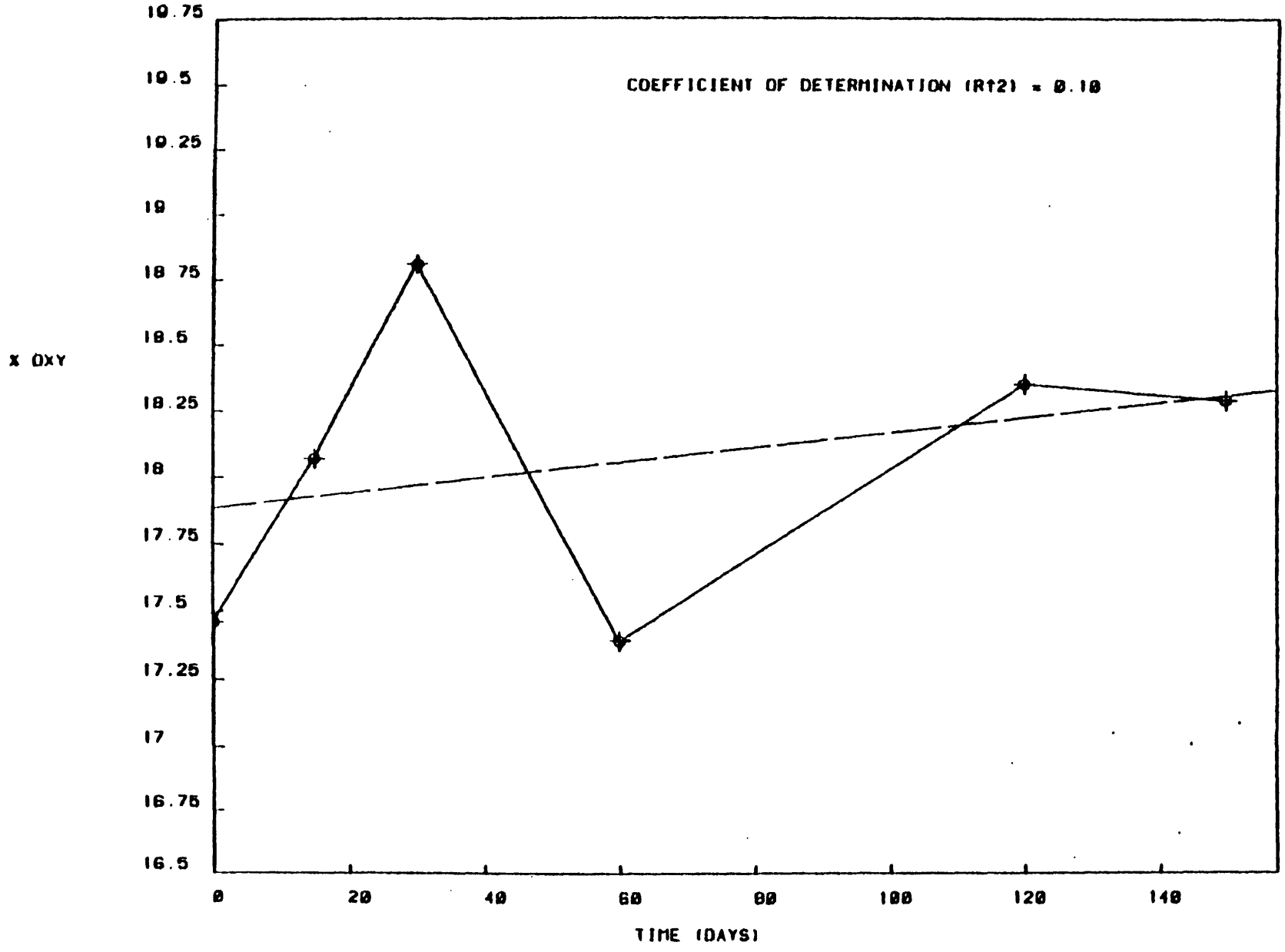

Figure 2. Oxygen (percent), moisture and mineral matter free basis, linear and linear regression analysis plots.
(f. 80AU15 0-150 days)

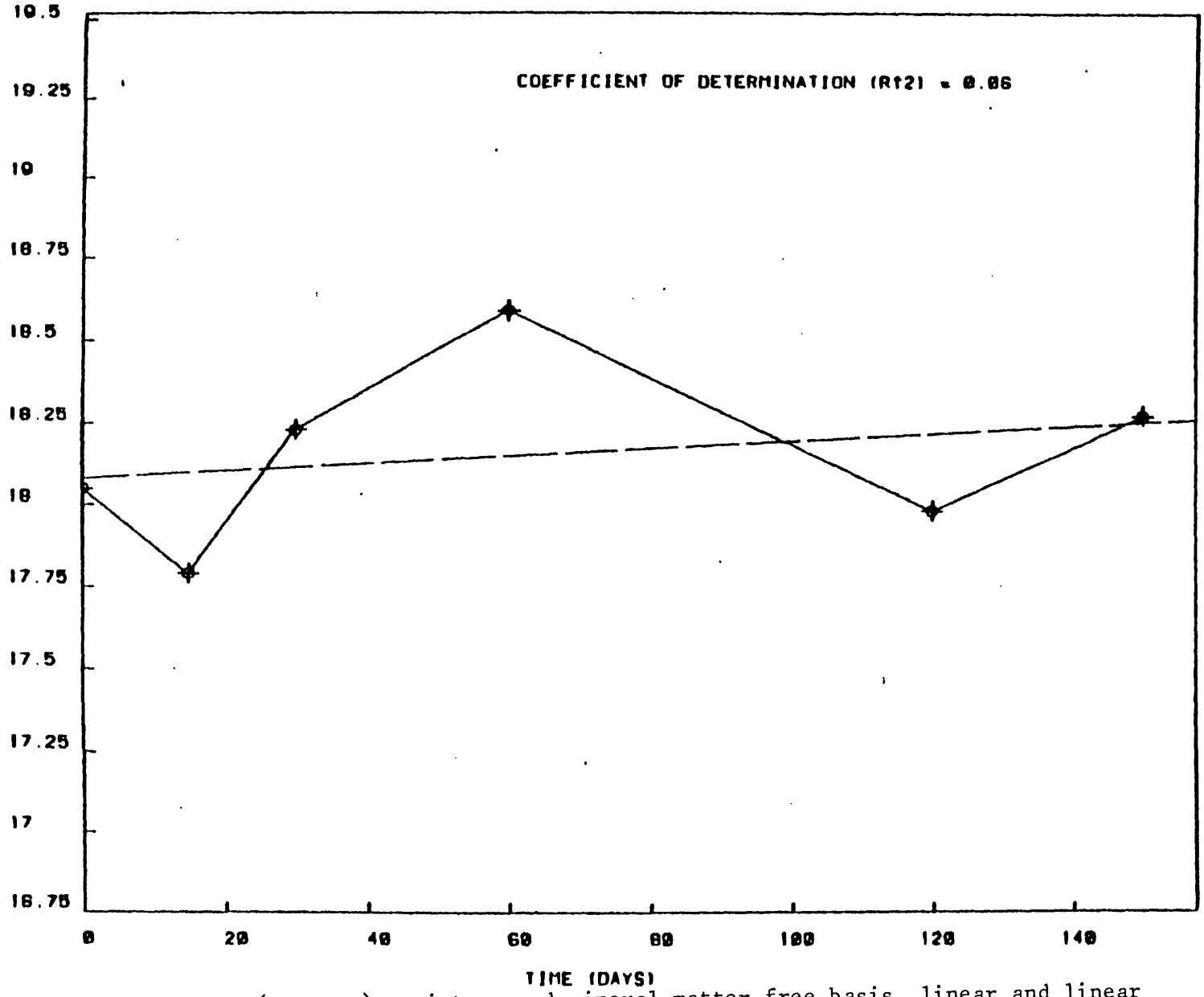

Figure 2. Oxygen (percent), moisture and mineral matter free basis, linear and linear regression analysis plots.
(g. 80AU16 0-150 days)

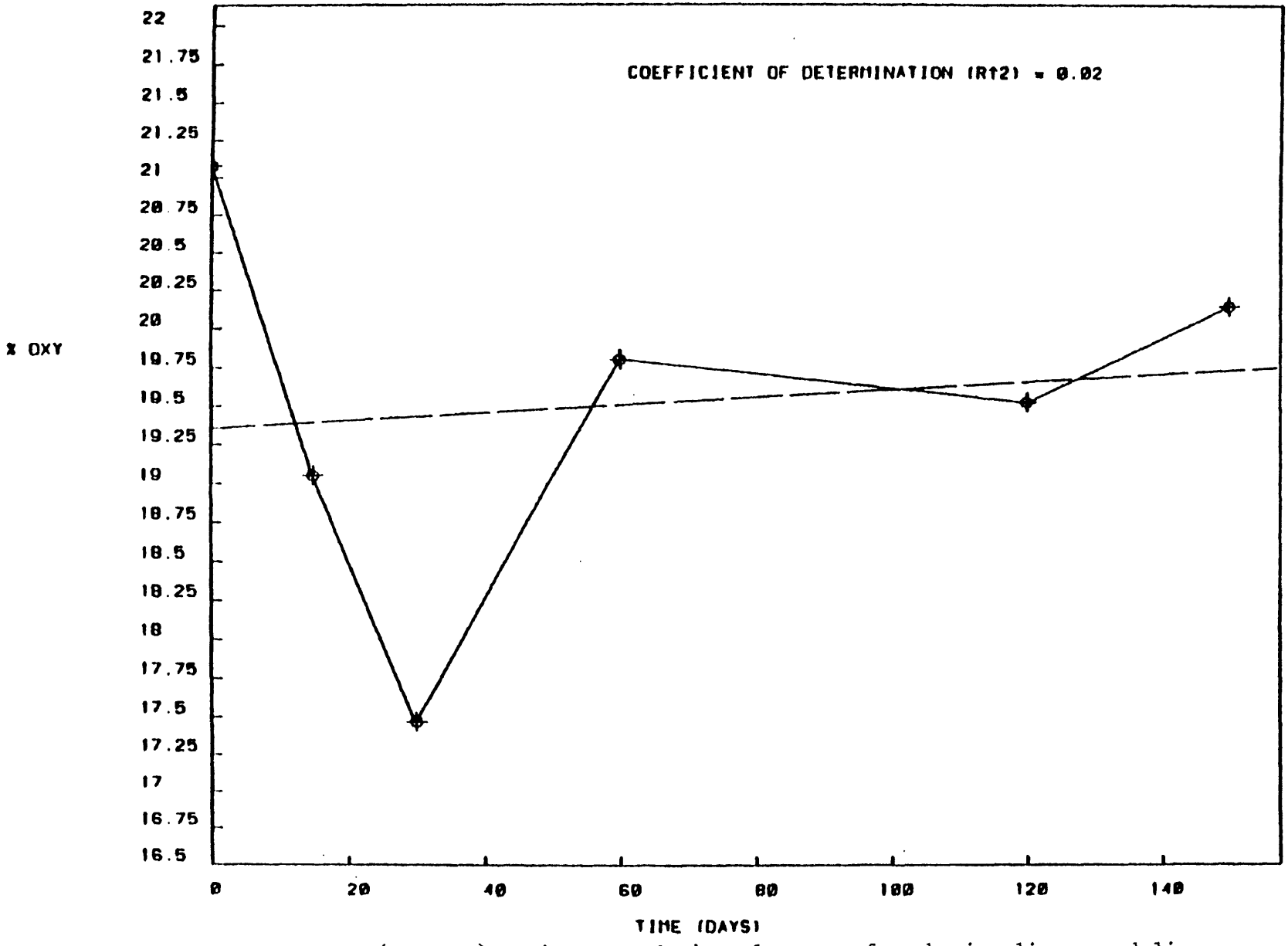

Figure 2. Oxygen (percent), moisture and mineral matter free basis, linear and linear regression analysis plots.
(h. 80MBE7P 0-150 days)

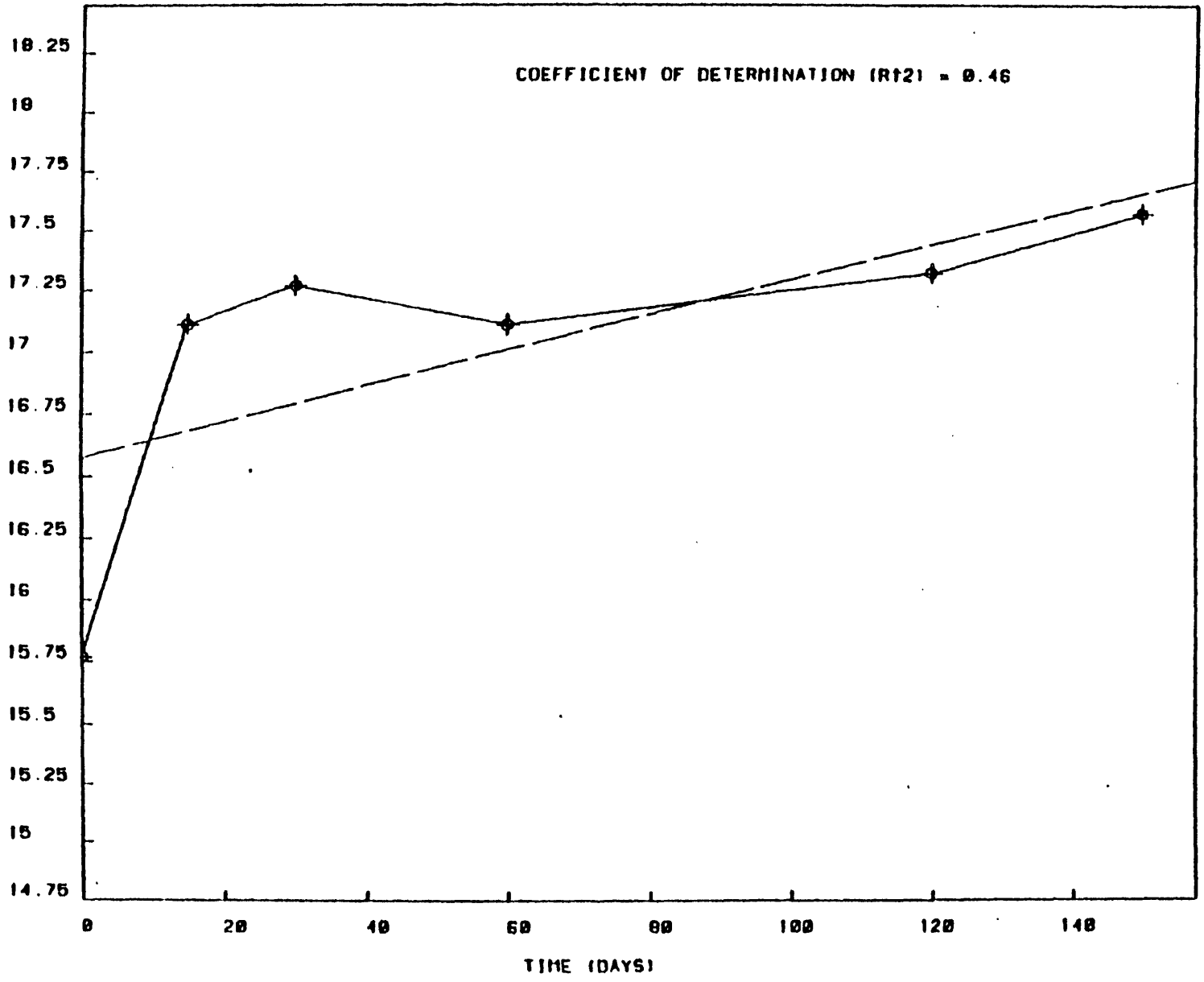

Figure 2. Oxygen (percent), moisture and mineral matter free basis, linear and linear regression analysis plots.
(i. 80MBE7C 0-150 days)

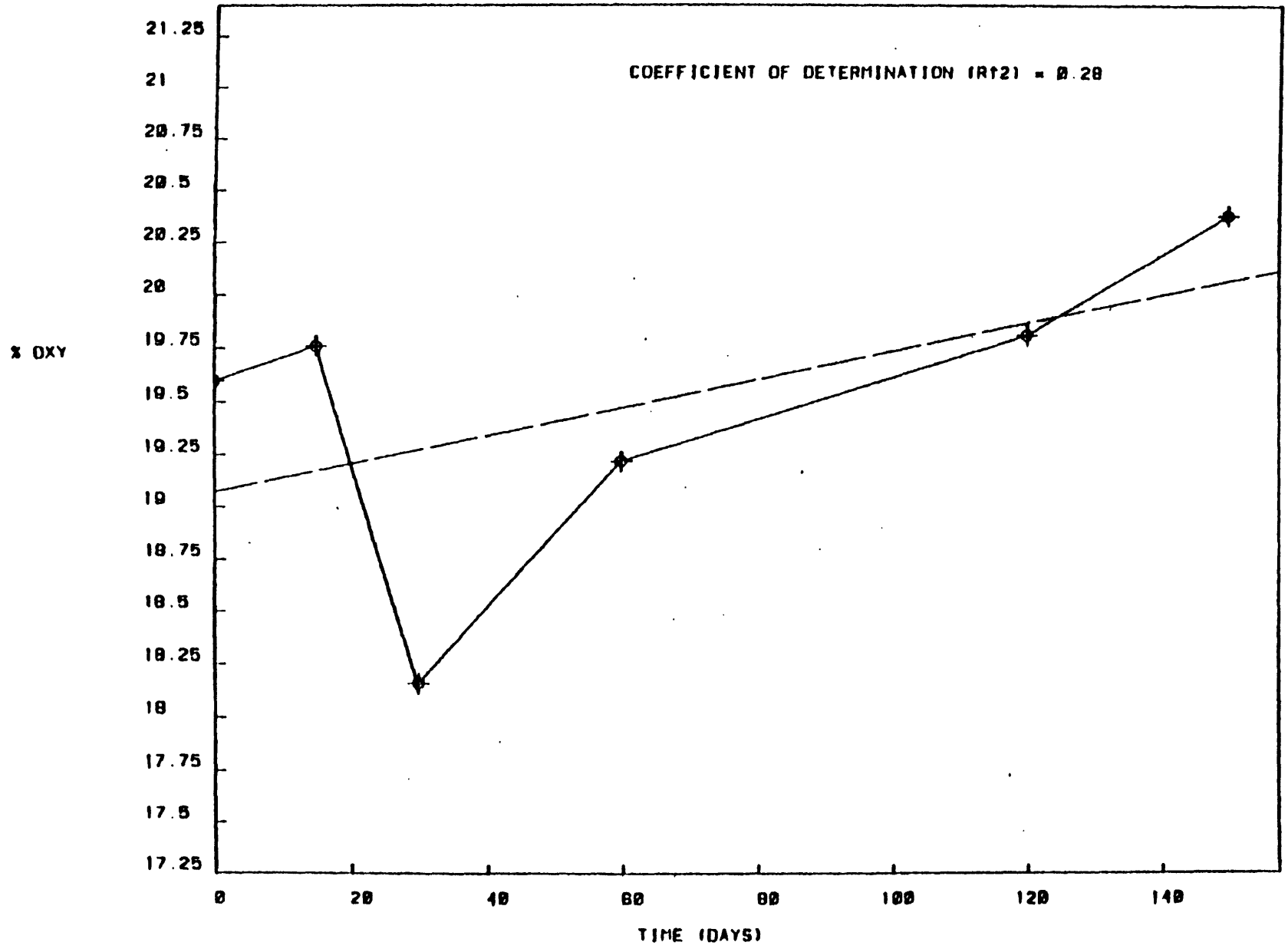

Figure 2. Oxygen (percent), moisture and mineral matter free basis, linear and linear regression analysis plots.
(j. 80MBA2 0-150 days)

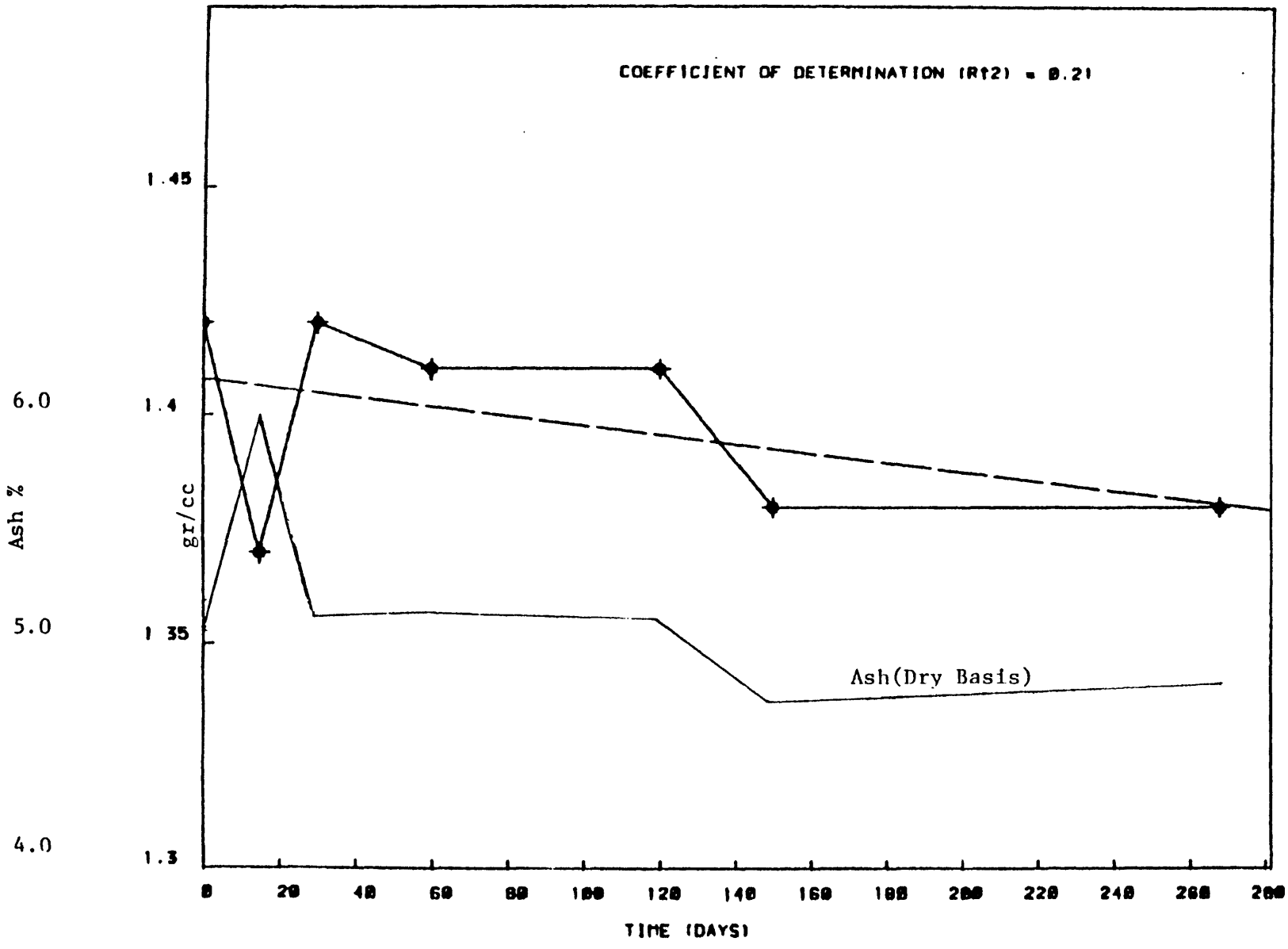

Figure 3. Apparent specific gravity (g/cm^3) at dry base, (0 percent moisture) with ash content (dry basis).

(a. 80AU15 0-268 days)

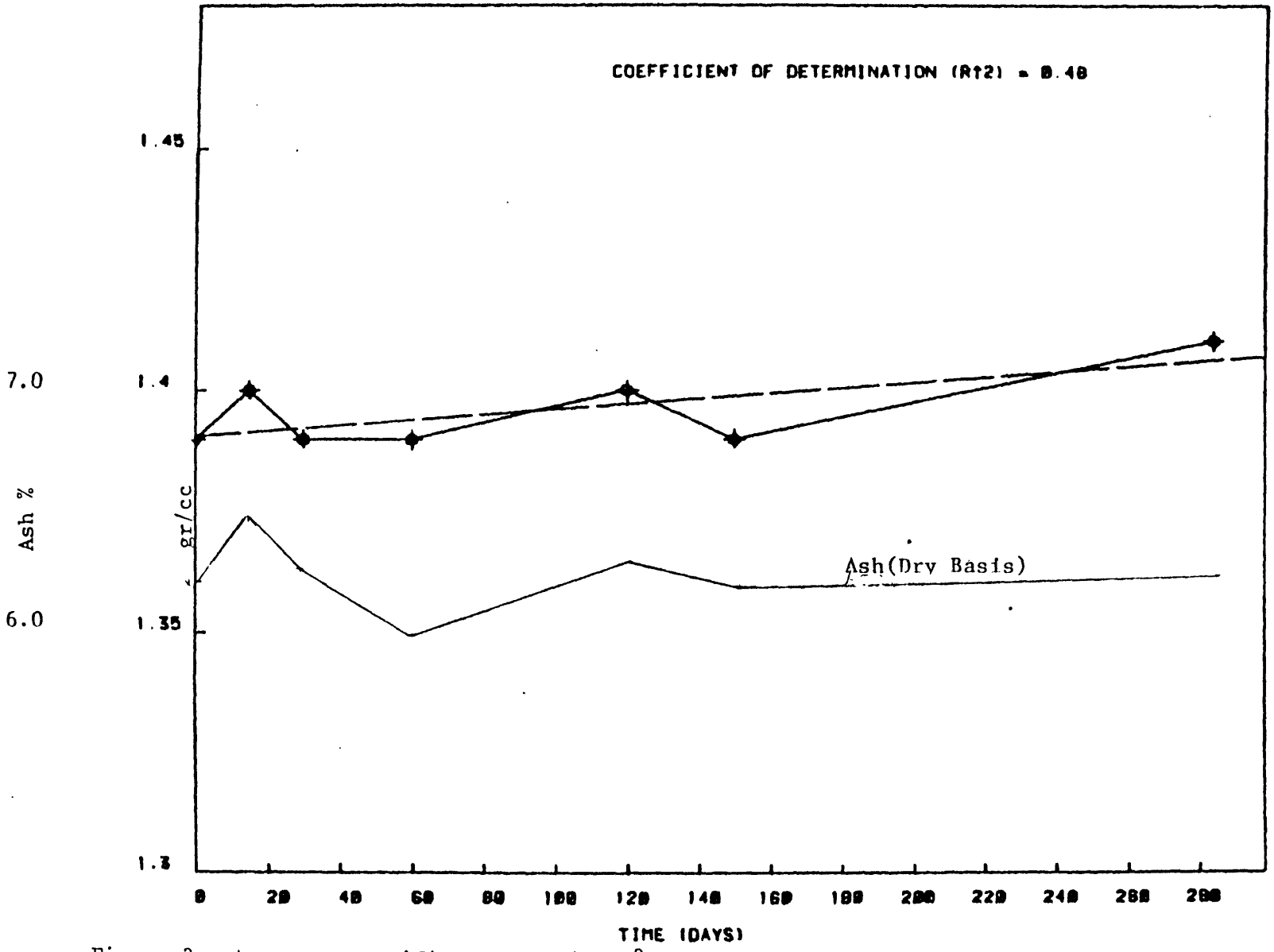

Figure 3. Apparent specific gravity (g/cm^3) at dry base, (0 percent moisture) with ash content (dry basis).

(b. 80AU16 0-284 days)

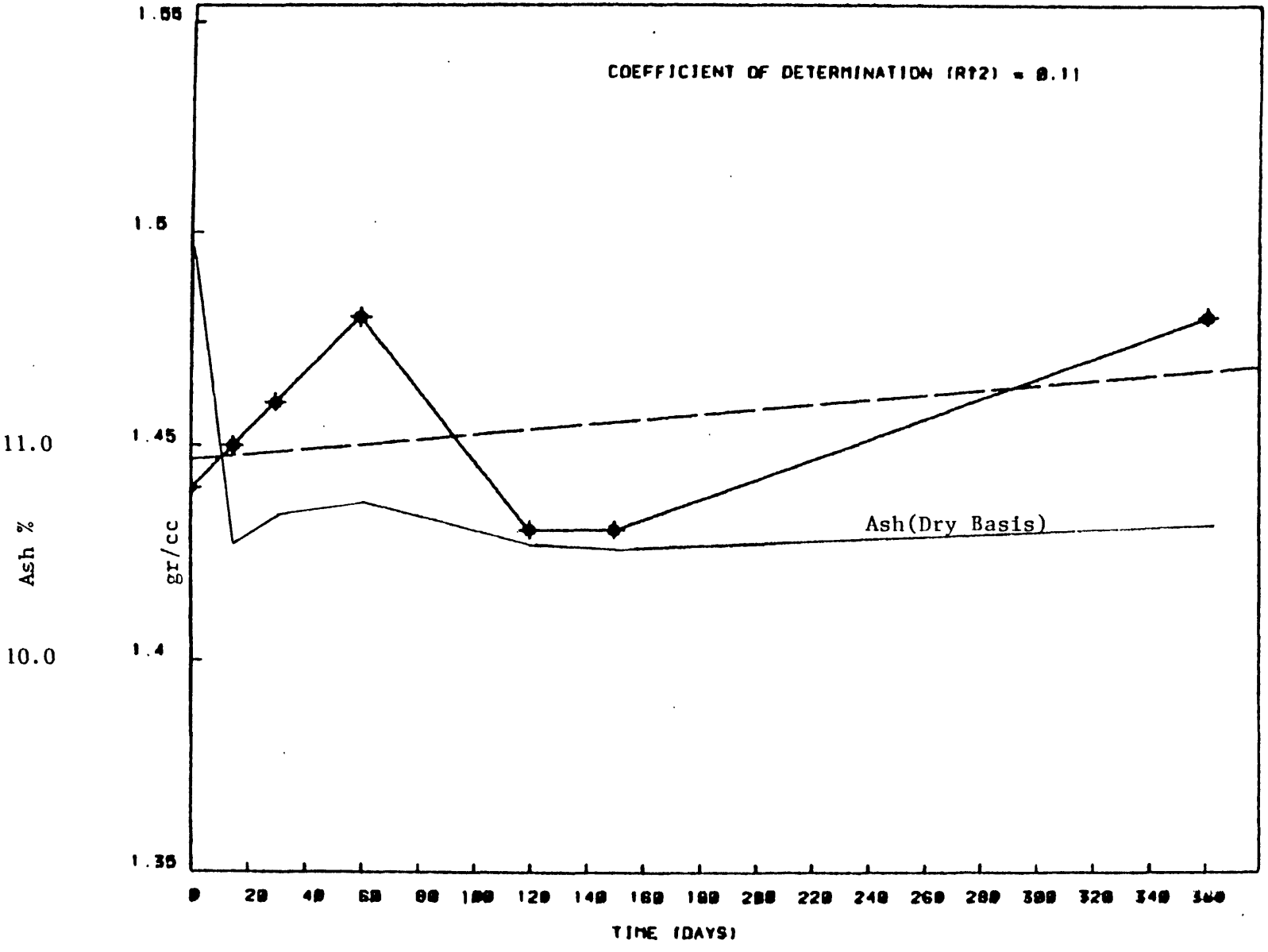

Figure 3. Apparent specific gravity (g/cm^3) at dry base,(0 percent moisture) with ash content (dry basis).

(c. 80MBE7P 0-360 days)

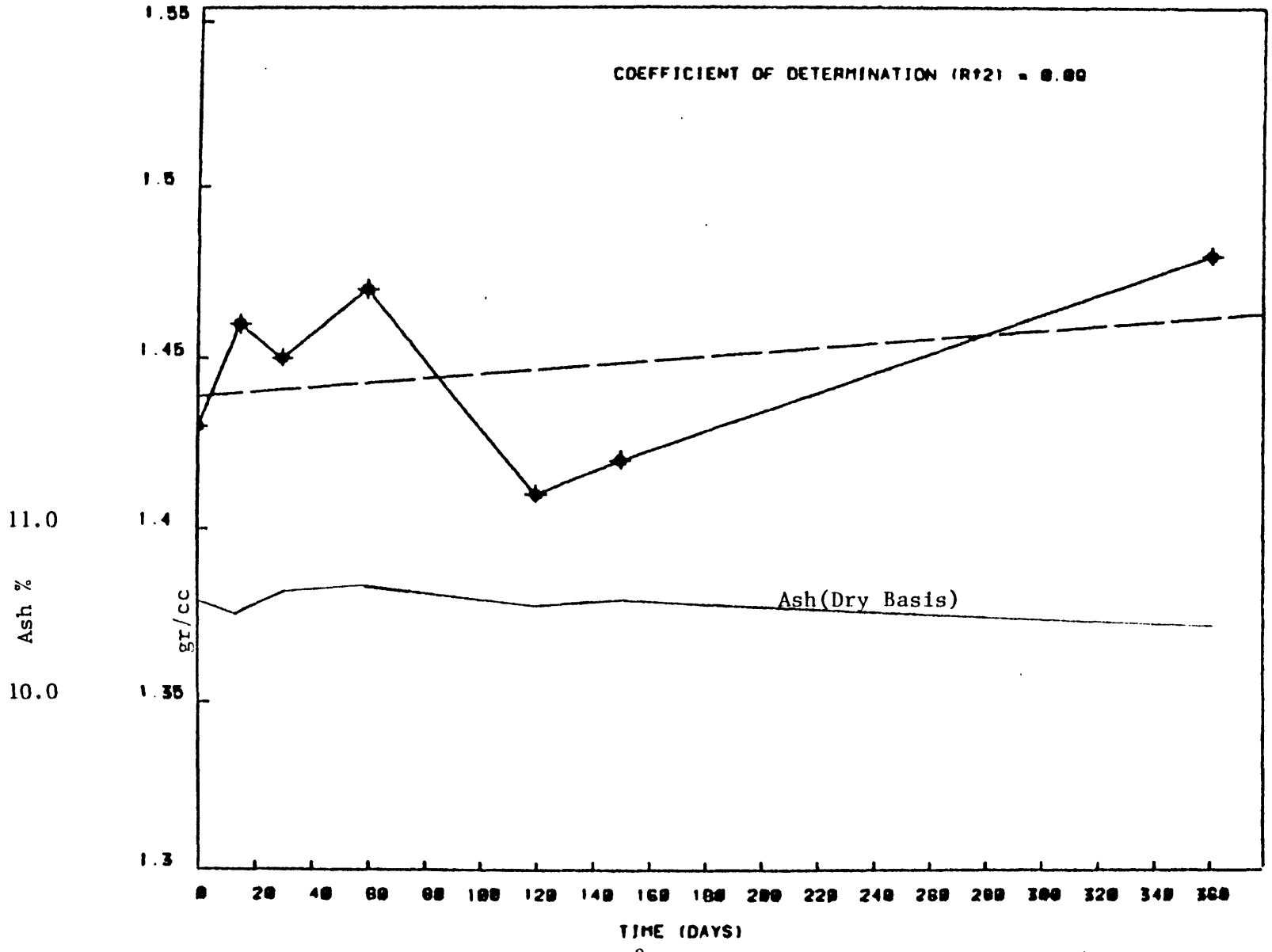

Figure 3. Apparent specific gravity (g/cm^3) at dry base, (0 percent moisture) with ash content (dry basis).

(d. 80_MBE7C 0-360 days)

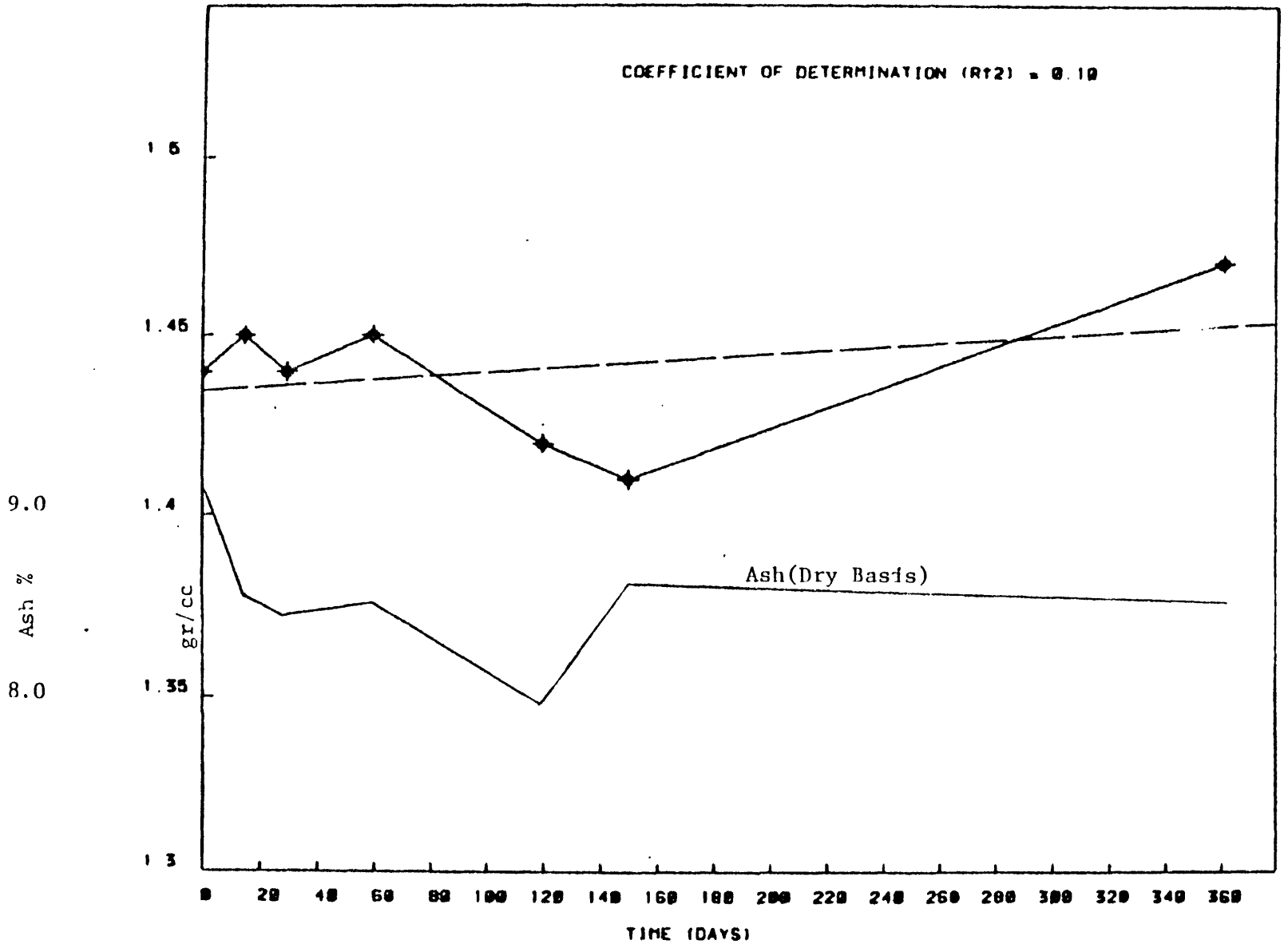

Figure 3. Apparent specific gravity (g/cm^3) at dry base, (0 percent moisture) with ash content (dry basis).

(e. 80MBA2 0-360 days)

RESEARCH RECOMMENDED

The results of this preliminary study indicate several areas that need further study. These are:

1. The simultaneous studies of two or more standardized sampling, handling, and packaging procedures. For example, split the sample into two or more fractions and evaluate one under the standards used herein. The other sample, under less stringent standards allowing drying to a degree and having access to free oxygen (air).

2. In addition to the standard proximate and ultimate analysis, simultaneously conduct detailed geochemical and other chemical analyses. This would more accurately identify the chemical changes taking place.

3. Correlate the analyses.

4. Make concurrent petrographic, palynological, and/or vitrinite reflectance studies.

5. Devise a methodology for more complete mixing of the coal samples at the drill site and, subsequently, in the laboratory. This mixing and subsequent sampling should minimize the exposure of the coal to heat, drying, and possible oxidation.

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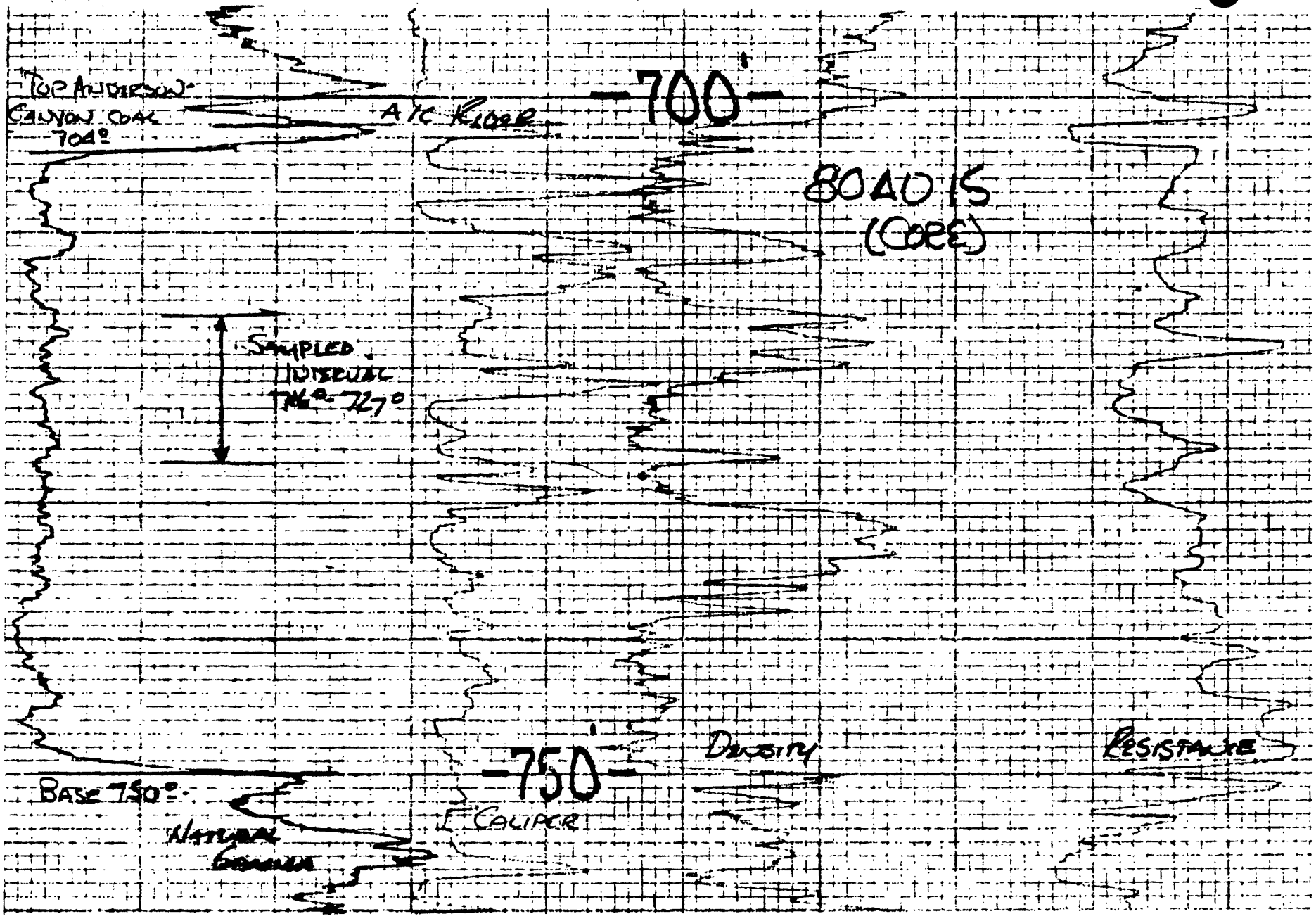
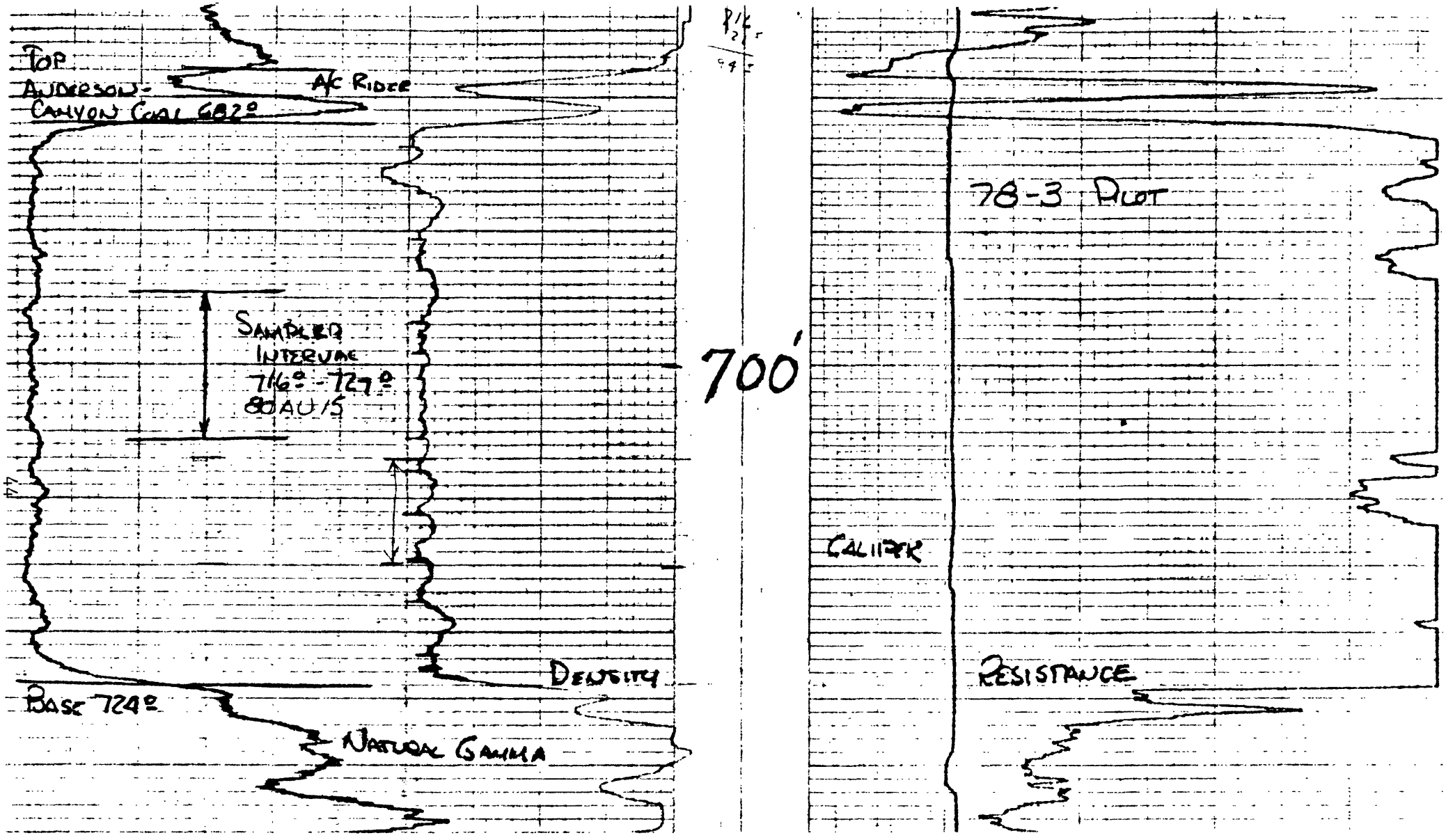
Appendix A

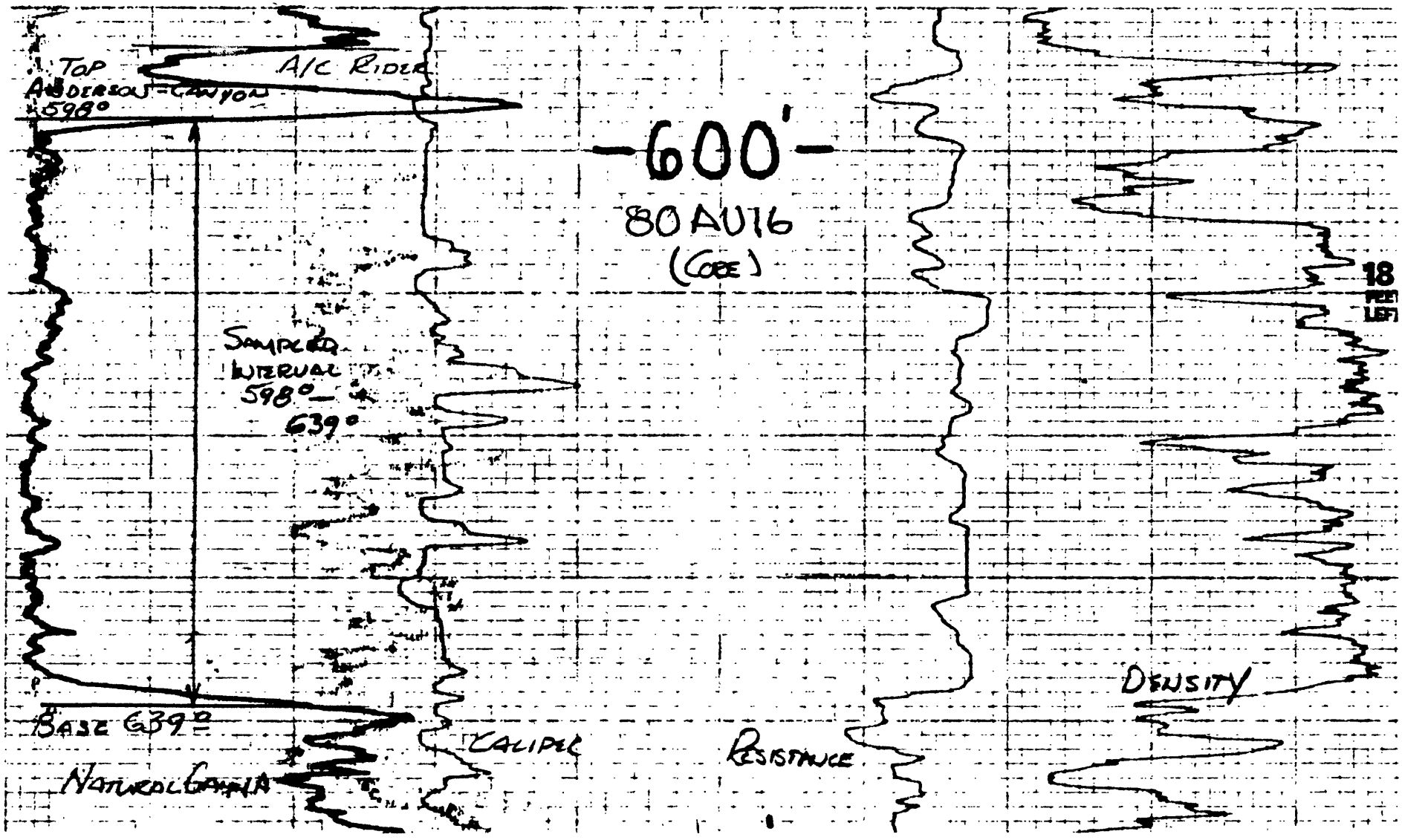
Geophysical Logs of the Sampled Coal



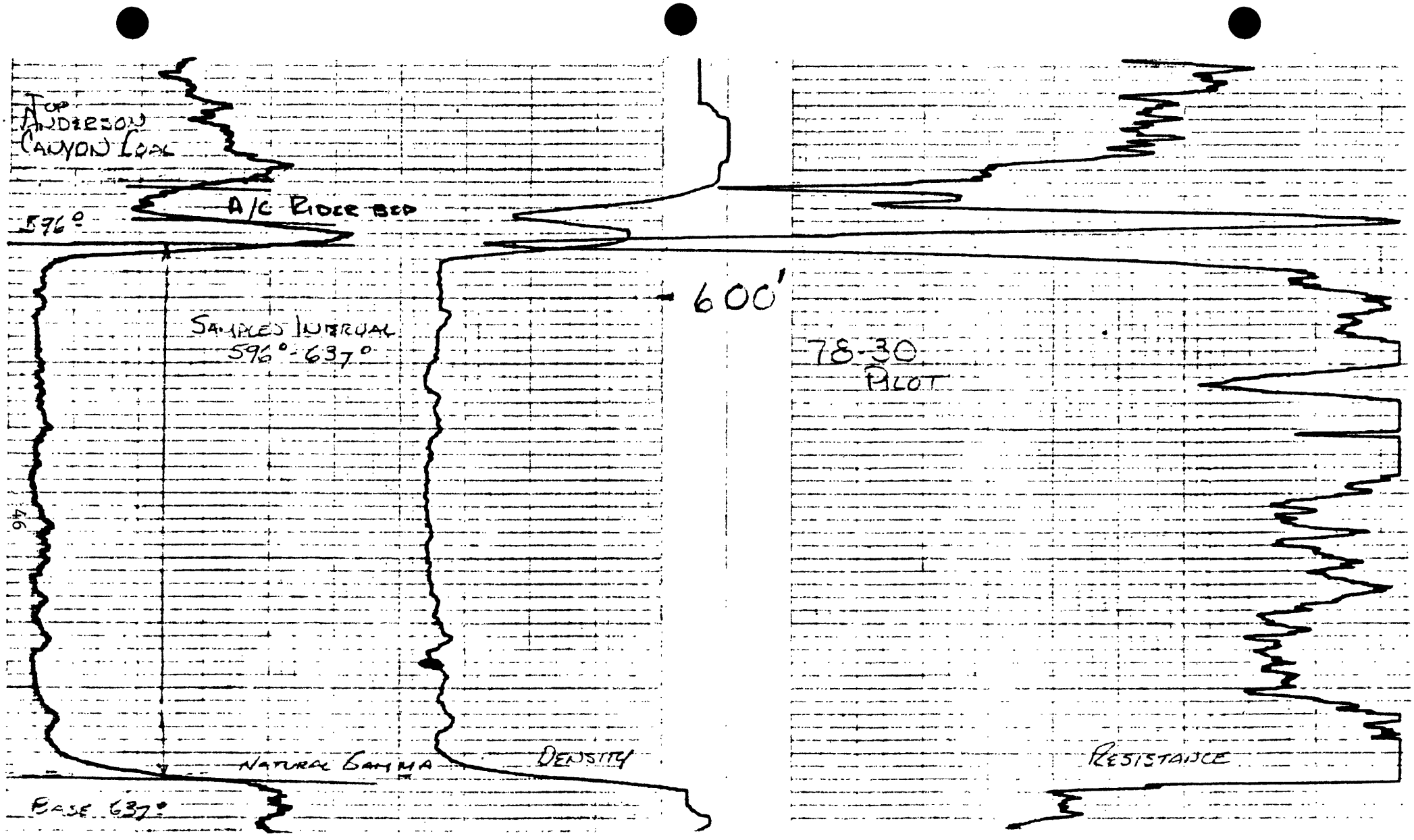
80AU15 Core Hole: Portion of Geophysical Log Showing Anderson-Canyon Coal & Sample Interval



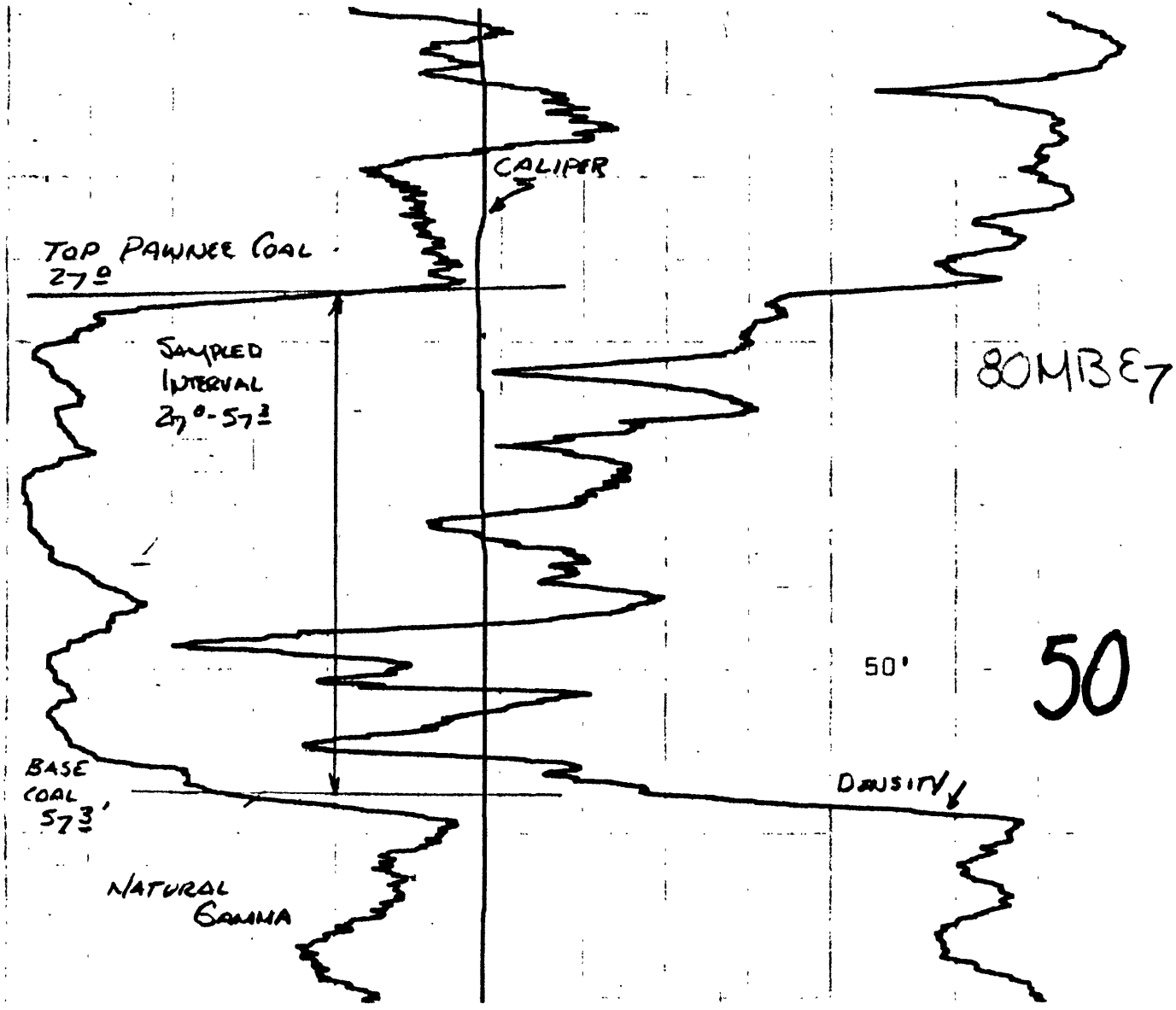
78-3 Pilot Hole For 80AU15: Portion of Geophysical Log Showing Anderson-Canyon Coal & Sample Interval



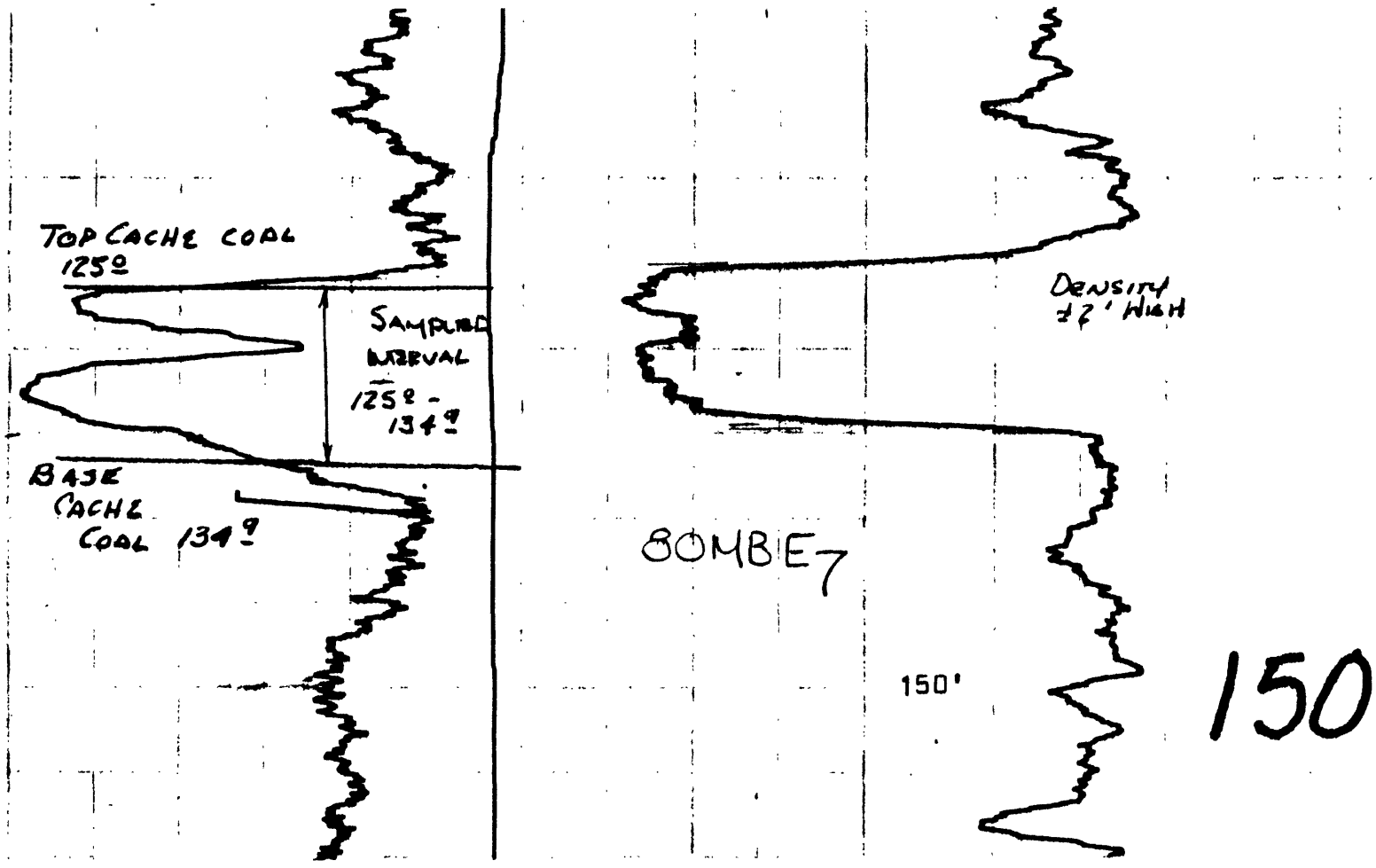
80AU16 Core Hole: Portion of Geophysical Log Showing Anderson-Canyon Coal & Sample Interval



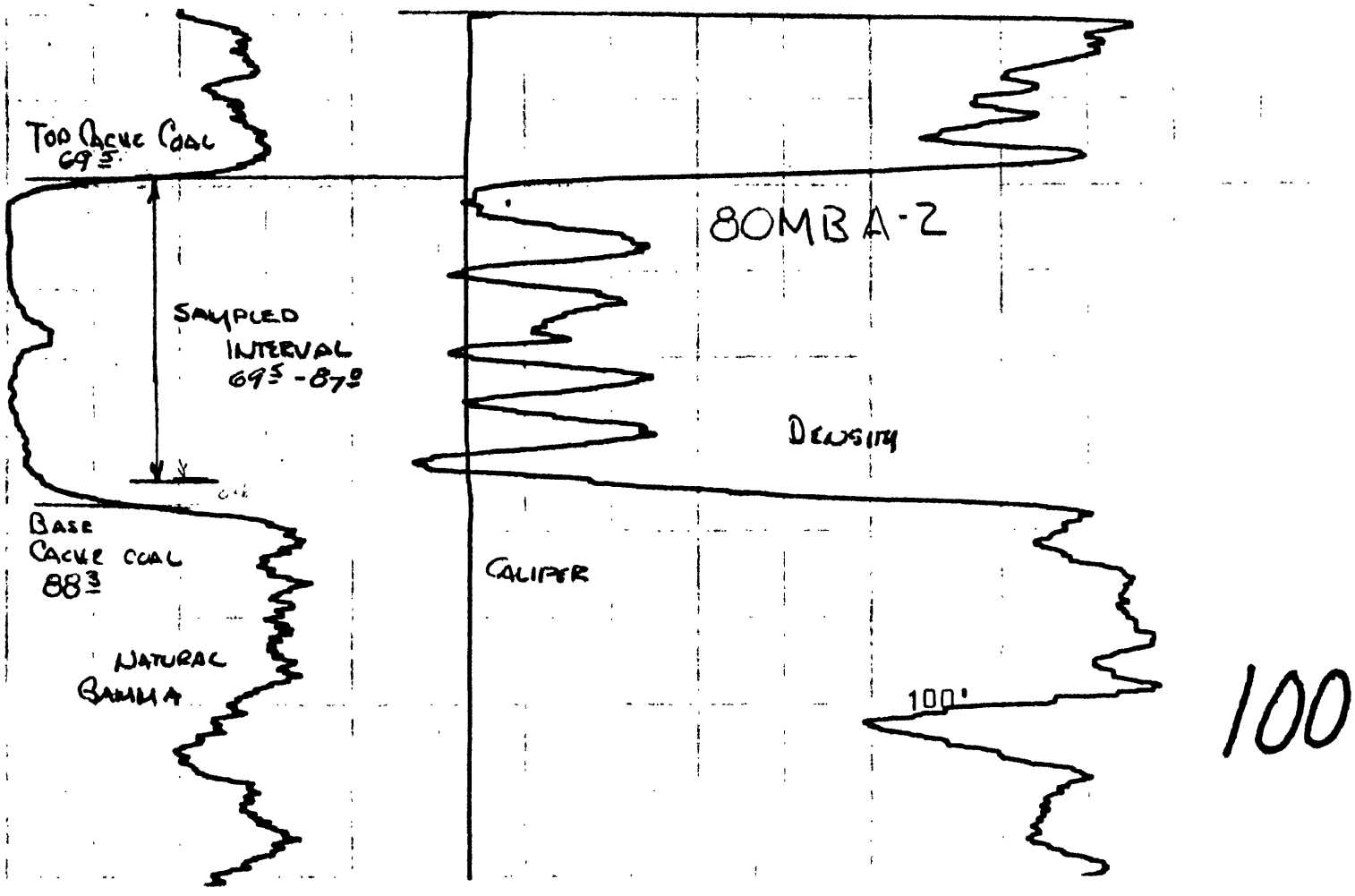
78-30 Pilot Hole (1978) for 80AU16: Portion of Geophysical Log Showing Anderson-Canyon Coal & Sample Interval



80MBE7 Portion of Geophysical Log Showing Pawnee Coal & Sample Interval



80MBE7 Portion of Geophysical Log Showing Cache Coal & Sample Interval



80MBA2 Portion of Geophysical Log Showing Cache Coal & Sample Interval

Appendix B

Core Description Logs of the Sampled Coal

U.S. Geological Survey
Branch of Coal Resources

Project: Arvada-Ucross 1980

Hole No.: 80 AU 15 Geologist: Maureen McPhillips

Type log: Lithologic Elev.: 3800′ Total depth: 1000′

Location: SE 1/4 NE 1/4 Sec.: 24 T. 54 N. N. R. 77 W.

Nearest town: Arvada County: Sheridan State: Wyo. Quad.: Arvada NE

Drilled by: El Dorado Exploration, Inc.

Driller(s): Ed Potter

Drill: Porta-drill TK-1 Date start: 8/13/80 Complete: 8/18/80

Non-core intervals and size hole:

Cored intervals and size: Core Description 690.4-762.3′

Remarks: Other logs include natural gamma, caliper, density, and resistivity run by Digilog, Inc.: 0-1000′. Drill cuttings and core description.

From	To (in feet)	Length	Log Description
690.4	694.9	4.5	Sandstone, medium-light-gray to medium-gray, very fine grained, thin coaly stringers throughout; interbedded with siltstone, brown-gray
694.9	695.2	0.3	Shale, brown-gray, carbonaceous
695.2	700.0	4.8	Shale, brown-black, carbonaceous
700.0	701.9	1.9	Coal, black, dull, bony
701.9	703.5	1.6	Shale, brown-gray, carbonaceous
703.5	703.8	0.3	Coal, black, bony, dull with silky bands, abundant thin pyrite streaks
703.8	706.1	2.3	Coal, black, silky with dull bands, some bony, some gypsum, some resin
706.1	719.7	13.6	Coal, black, silky with dull bands, scattered gypsum rosettes, shiny patches at 709.7 and 715.1 ft, bony at 712.5 ft

From	To (in feet)	Length	Log Description
719.7	732.3	12.6	Coal, black, silky with dull bands, abundant scattered gypsum rosettes
732.3	745.8	13.5	Coal, black, silky with dull bands, scattered gypsum rosettes, slightly bony at top in dull bands
745.8	747.8	2.0	Coal, black, dull with silky bands, some resin, trace gypsum rosettes
747.8	750.9	3.1	Shale, brown-black, carbonaceous, thin coal stringers, scattered pyrite nodules
750.9	752.1	1.2	Coal, black, dull with shiny streaks to silky, some resin, bony, shaley in places, some pyrite nodules, very bony from 751 ft to bottom
752.1	762.3	10.2	Shale, brown-black to brown-gray, carbonaceous, coaly stringers and thin streaks throughout

U.S. Geological Survey
Branch of Coal Resources

Project: Arvada-Ucross 1980

Hole No.: 80 AU 16 Geologist: Connie Barnes

Type log: Lithologic Elev.: 3830′ Total depth: 1000′

Location: C NW 1/4 SW 1/4 Sec.: 5 T. 54 N. R. 76 W.

Nearest town: Arvada County: Sheridan State: Wyo. Quad.: Arvada NE

Drilled by: El Dorado Exploration, Inc.

Driller(s): Ed Potter

Drill: Porta-drill TK-1 Date start: 7/29/80 Complete: 7/31/80

Non-core intervals and size hole:

Cored intervals and size: Core Description 588.2-638.0′

Remarks: Other logs run include natural gamma, caliper, density, and resistivity run by Digilog, Inc.; 0-1000′. Drill cuttings and core description

From	To (in feet)	Length	Log Description
588.2	589.6	1.4	Claystone, brown, trace carbonaceous plant remnants
589.6	592.5	2.9	Shale, dark-brown-gray, fissle to coarsely fissle; abundant carbonaceous material
592.5	592.8	0.3	Siltstone, brown-gray, poorly cemented
592.8	596.0	3.2	Coal, black, silky and dull-banded, shaley at bottom
596.0	598.0	2.0	Shale, dark-brown-gray, fissile; abundant carbonaceous material
598.0	615.0	19.0	Coal, black, silky and dull-banded disseminated pyrite stringers, blocky fracture, bleeding gas, trace gypsum
615.0	622.3	7.3	Coal, black, silky, conchoidal to blocky fracture, trace scattered gypsum, bleeding gas
622.3	630.0	8.3	Coal, black, silky and dull-banded, bony, blocky fracture, bleeding gas

From	To (in feet)	Length	Log Description
630.0	634.2	4.2	Coal, black, silky with dull bands, trace clay filling plant imprints, bony, rare gypsum, very finely disseminated pyrite, bleeding gas
634.2	635.5	1.3	Coal, black, silky, banded, conchoidal fracture, very finely disseminated pyrite
635.5	638.0	2.5	Coal, black, silky and dull-banded, blocky fracture, very finely disseminated pyrite

U.S. Geological Survey
Branch of Coal Resources

Project: Moorhead-Broadus

Hole No.: 80 MB-E7 Geologist: Maureen McPhillips

Type log: Core description Elev.: 3490′ Total depth: 655′

Location: NE 1/4 SE 1/4 Sec.: 35 T. 7 S. R. 48 E.

Nearest town: Broadus County: Powder River State: Mont. Quad.: Bloom Creek

Drilled by: U.S. Geological Survey

Driller(s): Steve Grant

Drill: Porta-drill 524 Date start: 9/13/80 Complete: 9/14/80

Non-core intervals and size hole:

Cored intervals and size: 25.8-60.0′; 120.0-137.5′

Remarks:

From	To (in feet)	Length	Log Description
25.8	27.0	1.2	Shale, medium-dark-gray, thin carbonaceous streaks with interbedded sandstone, medium light gray, very fine grained, silty, with thin coal streaks
27.0	30.0	3.0	Coal, black, silky, hard; abundant pyrite nodules (micro)
30.0	42.6	12.6	Coal, black, dull to silky; very abundant pyrite (nodules and bands)
42.6	56.6	14.0	Coal, black, dull to silky-banded; abundant pyrite nodules (micro); abundant gypsum rosettes
56.6	57.2	0.6	Coal, black, dull to silky-banded; abundant pyrite nodules (micro); abundant gypsum rosettes
57.2	60.0	2.8	Siltstone, medium-light-gray

Hole No. 80 MB-E7 Page 2 of 2

From	To (in feet)	Length	Log Description
120.0	122.3	2.3	Siltstone, medium-gray to medium-dark-gray, thin carbonaceous streaks
122.3	126.4	4.1	Claystone, medium-light-gray to medium-gray
126.4	133.0	6.6	Coal, black, dull with silky bands to silky with dull bands, shiny at 127.1-127.3 ft; abundant gypsum rosettes from 127.1-133.0 ft; abundant micropyrite nodules from 127.1-133.0 ft; bony near bottom, resin
133.0	136.3	3.3	Coal, black, silky with dull bands; abundant micropyrite nodules and gypsum rosettes
136.3	137.5	0.2	Siltstone, medium-gray, sandy, with thin carbonaceous streaks

U.S. Geological Survey
Branch of Coal Resources

Project: Moorhead Broadus

Hole No.: 80 MB-A-2 and 80 MB-A-2C Geologist: Frank Spencer

Type log: Cuttings and core Elev.: 3800′ (Topo) Total depth: 235′

Location: SE 1/4 SE 1/4 Sec.: 25 T. 8 S. N. R. 50 E.

Nearest town: Broadus County: Powder River State: Mont. Quad.: Bay Horse

Drilled by: U.S. Geological Survey

Driller(s): Arthur Clark

Drill: Gardner-Denver Date start: 9/15/80 Complete: 9/15/80

Non-core intervals and size hole:

Cored intervals and size: 68.4-88.5 4 1/2" x 3" (3" core)

Remarks: Casing at 20′. Geophysical logs--natural gamma, density, and caliper. Drilled to 120′ - 120± ABS casing run - for Frank Senftle - Reston, geophysical logging research and development.

From	To (in feet)	Length	Log Description
68.4	69.3	0.9	Siltstone, light- to medium-gray
69.3	69.5	0.2	Carbonaceous shale with thin coal streaks
69.5	75.5	6.0	Coal, hard, minor pyrite
75.5	82.2	6.7	Coal, hard, minor pyrite
82.2	88.3	6.1	Coal, hard, 0.3 ft vertical fracture coated with pyrite at base
88.3	88.5	0.2	Siltstone, light- to medium-gray