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Development and Evaluation of Deterministic Models for Predicting the Weight of Fouling Deposits from Coal Combustion

by

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PREFACE

The research summarized in this report was supported by the Coal Utilization Technology Division of the U.S. Department of Energy through Interagency Agreement No. DE AI22-88PC88901 to the U. S. Geological Survey.

We wish to thank Philip M. Goldberg, Contract Officer, for his cooperation and encouragement. We also acknowledge the help of Michael L. Jones and his staff at the University of North Dakota's Energy and Minerals Research Center for supplying the combustion database on which this research project was based. We also wish to thank Joseph T. O'Conner and Frank E. Senftle, both of the U.S. Geological Survey, for their many helpful comments on this report.

SUMMARY

Statistical models have been developed that quantitatively predict the weight of fouling deposits formed in the test combustor of the University of North Dakota Energy and Minerals Research Center (UNDEMRC). The models are based primarily on the major element composition of the coal ash and are consistent with the geochemical characteristics of elements.

The models were constructed from combustion test data and coal compositional analyses provided by UNDEMRC. Their original database contained the results of 632 combustion runs. By restricting our attention to lignites having all the requisite analytical data we reduced the database to 196 samples. These samples were divided into two subsets; MAIN containing 126 samples having wide geographic distribution and broad chemical composition range; B-STD containing 71 samples all from a single mine and having a restricted range of properties. Various statistical parameters were used to test the relationship between deposit weight and the coal compositional variables. The primary objectives were to develop quantitative predictive models and to gain insight into the chemical and physical interactions of the coal compositional variables during deposit formation.

The best R^2 (square of the multiple regression coefficient) obtained was 0.73 for the full MAIN subset and 0.43 for the full B-STD subset. By restricting the MAIN subset (e.g. high- and low-ash and low-sodium) we were able to develop models with substantially higher squared multiple regression coefficient values. For example, the model describing the deposit weight expected from the 53 samples having less than 5 weight percent sodium oxide has a squared multiple correlation coefficient of 0.98. The data also indicate that all samples having more than 20 weight percent ash and about 0.5 weight percent sodium will cause severe fouling problems.

No significant improvement could be made with the B-STD subset. This is attributed to the narrow range of ash yield and sodium contents in the B-STD subset.

There appears to be a saturation limit for sodium values in influencing deposit weight. Above about 5 weight percent sodium oxide, on a sulfate-free basis, there is little increase in deposit weight, even for samples with as much as 30 weight percent NA_2O. Perhaps at about 5 weight percent NA_2O the liquid binding phase has been saturated with sodium.

Our results indicate that, under controlled conditions (uniform combustor geometry and standardized run conditions), we can identify the coal compositional variables that most strongly

effect deposit formation. Data from this study indicate that the two most important compositional components promoting the buildup of sintered ash deposits are the ash yield and total alkalies ($Na_2O + K_2O$).

For systems in which there is a wide range of ash contents and chemical compositions, and for systems with little variation in sodium content, ash yield appears to be the dominant factor in influencing deposit formation. For systems with a narrow range of ash contents and chemical compositions, such as coal from a mine or prospect site, alkali content becomes the dominant controlling factor. Total alkalies are also the principal factor influencing deposit weight in low-sodium (<~5 weight percent) coals.

Our data indicate that calcium and magnesium are important contributors to the binding phase. Reports that calcium decreases deposit formation are likely due to misinterpretation of the negative correlation between calcium (and magnesium) and deposit weight. This negative correlation is a carryover of the strong negative correlation between calcium (and magnesium) and ash.

We introduce a new parameter: the Interaction Factor (IF). The IF is the difference between a coal quality variables correlation with ASHDRY and with DEPOWT. Strong positive IF

values (e.g. SIO2, AL2O3, TIO2) may indicate a physical contribution to deposit weight. The components with positive IF's are largely chemically inert and probably contribute to the deposit mass either in the form of altered minerals, such as quartz and rutile, or in the form of glassy particles. In contrast, sodium, calcium, magnesium, potassium, and perhaps phosphorous are chemically active ingredients helping to form the binding agent that holds the deposit together. These elements have strong negative IF values.

Our data does not indicate that any coal quality component retards fouling deposit formation. However, different modes of occurrence may render a component a less effective participant in deposit formation. The results of this study indicate that the ideal coal sample for minimizing deposit formation is low in ash and alkalies and has a low Si/Al ratio.

The practice of adding overburden material to high sodium coal to reduce the sodium concentration in the ash is of questionable value. Our data indicate that the higher ash content may more than compensate for any decrease in deposit weight due to the lower sodium content. Moreover,if sodium oxide is not reduced below 5 weight percent, no advantage can be gained. However, higher ash and lower sodium contents may yield a weaker, more easily removed deposit.

Other uses of predictive models such as those developed in this project include assessing the effect that modifications or blends will have on fouling performance and helping design modifications and blends that have desired fouling characteristics.

Additional refinement of the predictive models requires information on the modes of occurrence of the major elements, especially information on sulfur forms and mineralogy.

We suggest that the approach used in this study can be further refined to produce models that allow quantitative prediction of fouling deposit weight for any lignite combusted in the UNDEMRC test combustor. These models will allow us to better understand the interactions of the various coal compositional parameters. This, in turn, can lead to a more general model that could be applied to other boilers and to coals from other areas or coals of different rank.

Clearly, boiler geometry and operating conditions play a major role in influencing deposit formation. For this reason the models developed for the UNDEMRC test combustor probably cannot be applied directly to other combustor such as utility boilers.

It is our belief, however, that the chemical interactions taking place in the UNDEMRC test combustor are similar to, if not

identical to, the chemical reactions occurring in utility boilers. We also believe that the relative performance of the coals, as predicted by models based on UNDEMRC data, should be similar to the coals' performance in a utility boiler.

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INTRODUCTION

Background

In the formation of sintered ash (fouling) deposits the inorganic constituents from the fired coal are recombined in various glassy and crystalline phases (Reid, 1981, Bryers, 1979). Variations in the chemical and mineralogical composition of the coal should, therefore, be related to variations in the amount and binding strength of the sintered ash deposits.

One method of assessing the importance of coal compositional variations on the fouling deposits is to statistically evaluate the relation between compositional variables and deposit formation. Because little data exist on coal mineralogy or on binding strength we are limited to evaluating the influence of coal chemical composition on deposit weight.

There have been numerous attempts using chemical data to develop empirical formulas, models, or indices for predicting the tendency of a coal to form sintered ash deposits. Most of these attempts have sought a quick and dirty solution to the problem by focusing on generally one, but no more than a few compositional variables, to account for deposit formation. Examples of these indices appear in **table 1.** In general, these indices have met with limited application and success. Wall and others (1980) state "there may be very severe limitations to the applicability of 'fouling indices' based on elemental analysis or even ash

Table 1: **Common Fouling Indices**
(From: Vaninatti and Busch, 1982)

Index	Factors	Application*	Fouling Tendency			
			low	medium	high	severe
Fouling factor (R_f)	(Base/Acid)/ Na_2O	E	<0.20	0.20-0.50	0.50-1.00	>1.00
Fouling factor (R_f')	(Base/Acid) (water soluable Na_2O	E	<0.10	0.10-0.25	0.25-0.70	>0.70
Alkalis in coal	$\frac{(\%Ash)(Na_2O+(0.659*K_2O))}{100}$	E	<0.30	0.30-0.45	0.45-0.60	>0.60
Sodium in ash	% Na_2O	E	<0.50	0.50-1.00	1.00-2.50	>2.50
Sodium in ash	% Na_2O	W	<3.00		3.00-5.00	>5.00
ash sintering strength	P.S.I. at 1700°F		1000	1000-5000	5000-16000	>16000
Chlorine in coal	% Cl		<0.20	0.20-0.30	0.30-0.50	>0.50

* E = Eastern bituminous ash
W = Western lignitic ash

fusion observations..." They go on to say that fouling indices appeared applicable only to coal from a particular field.

Selle and others (1986) offers a comprehensive review of the attempts to develop predictive models for ash deposition. The reader is referred to this report for a thorough overview of the subject. There have been few reported attempts to use large databases containing complete chemical analyses of coal to develop predictive models. One such attempt by Gomez and others (1970) resulted in a rather cumbersome model for predicting the sodium content of lignite in a single mine site in North Dakota requiring 77 lines on four pages!

Recently Finkelman and Yeakel (1988) and Yeakel and Finkelman (1988) have proposed a statistical model for quantitatively predicting fouling deposit weight of lignites. The principle features are:

- The model is not entirely empirical, it is based, in part, on fundamental geochemical parameters.

- The model accounts for 84 percent of the variance of deposit weight for low-rank coals, .

- The model was based on test combustion runs from samples with a wide geographic range.

- The model indicated that variation in coal ash yield is the most important parameter in affecting deposit weight.

- The model indicated that sodium oxide content of the coal ash is a minor factor in controlling deposit weight.

A reliable model for the prediction of fouling deposit weight has several possible applications. Among these are:

- Enabling utilities to anticipate the relative fouling potential of candidate coals prior to or instead of combustion tests.

- Providing capability to minimize ash buildup through programs to modify feed coals by selective mining, by blending, or by the use of additives.

- Enabling data base searches (such as the U.S. Geological Survey's National Coal Resources Data System) for coals with desired fouling characteristics.

The model proposed by Yeakel and Finkelman (1988) could be used for these purposes. However, their model was based on only 44 samples and needed to be validated.

Therefore, the U.S. Geological Survey requested support from the U.S. Department of Energy (DOE) to use the University of North Dakota Energy and Mineral Research Center's (UNDEMRC) data to evaluate the relationships between coal quality variables and fouling deposit weight. One consequence of evaluating these relationships would be an assessment of the procedures used by Yeakel and Finkelman (1988) in generating their model.

DOE provided support for this project through Interagency Agreement No. DE AI22-88PC88901. This report documents the results of the research conducted under this agreement.

OBJECTIVES

The primary objective of this research was to develop a method for quantitatively predicting fouling deposit weight of lignites fired in the University of North Dakota Energy and Mineral Research Center test combustor. A second objective was to evaluate the method Yeakel and Finkelman (1988) used to develop their predictive model on a limited suite of data from UNDEMRC. A third objective was to apply the predictive method to compositional variations at a single mine site.

TASK 1 - Database Construction

The first task was to obtain the appropriate information on deposit formation and from this information develop databases from which the relationships were to be derived. The University of North Dakota Energy and Mineral Research Center (UNDEMRC) provided us with floppy disks (Lotus 123 format) containing the analytical and test combustion data on 632 coal samples. These data had been generated by UNDEMRC over the past 21 years on projects largely supported by the Department of Energy (DOE) through the Pittsburgh Energy Technology Center. Most of the data were collected when the UNDEMRC facility was under the auspices of the U.S. Department of Energy and was known as the Grand Forks Energy Technology Center (GFETC). This is the same database used by Yeakel and Finkelman (1988) to develop their model. A valuable feature of this database is that the test combustor conditions were kept constant for most runs. This feature allowed us to detect the influence of coal quality parameter variation on deposit weight. This was the principal concern of our study. The important influence of boiler geometry, run conditions, and additives on the formation of fouling deposits are outside the scope of this study.

The GFETC/UNDEMRC facility is a 75 lb/hr pulverived-coal pilot plant test furnace described in detail in Honea (1983). The combustion chamber is 30 in. in diameter, 8 ft. high and is refractory lined. Flue gas passes out of the furnace into a 10 in. square refractory lined duct. Located in the duct are three probe banks designed to simulate superheater and reheater surfaces in a combustion boiler. Our models attempt to predict the wieght of the deposits formed on these probe banks.

TASK 2 - Statistical Analysis

The Statistical Analysis System (SAS) was used for the data analysis. The procedures used included, UNIVARIATE, PLOT, CORR, STEPWISE, and REG (SAS, 1982a, 1982b, 1985, 1987). UNIVARIATE computes univariate statistics, and a test statistic for the hypothesis that the data have a normal distribution, PLOT graphs variables, CORR computes correlation coefficients between variables, STEPWISE computes a regression model using the stepwise procedure, where variables are added and also can be removed in a subsequent step if it no longer produces a significant F statistic, and REG fits least-square estimates to a linear regression model and provides a detailed analysis of the estimate and residuals.

We recognize the use of multivariate stepwise regression analysis as a powerful tool for generating deterministic models.

The usefulness of the models in providing a solution to the stated objective is tempered by limitations in our experience with rigorous statistical application. We are also aware of the abuses of multivariate stepwise regression (Box, 1966), and have stayed within the default limitations of the SAS programs. We appreciate the complexity of the formation of fouling deposits and acknowledge that we cannot know what the true deterministic model is. We have chosen to evaluate a model determined from chemical variables, data that are usually readily available as part of the rigorous analysis of a coal bed before and during mining. Our understanding of the formation of sintered ash deposits has been obtained through suitable application of multivariate regression analysis and the consideration of geochemical relationships.

TASK 3 - Data Analysis and Reporting

This document is the final report for this project. The report describes the methodology used, the results obtained, the conclusions derived from the study, and recommendations for future work.

TASK 1 - DATABASE CONSTRUCTION

Subset Construction

The North Dakota - U.S. Department of Energy database contains 632 samples. The selection of samples used in the deterministic analysis was based on those observations which satisfy the following general criteria:

- The coal rank is lignite;
- Information is available on Btu, all major elements in the coal, and deposit weight for the three probe banks;
- No additives were used during the combustion test.

One hundred ninety seven of the 632 samples satisfied these criteria. Seventy-one of the 197 were standard samples used to calibrate the reactor. For use in our deterministic analysis two data subsets were created. The first subset (MAIN) consisted of 126 samples having a wide range of chemical properties and broad geographic distribution. The second subset (B-STD) contained 71 samples used as a standard to periodically calibrate the combustion unit. These 71 samples are all from the Beulah coal bed, mined at one site. The average of the 71 B-STD samples are included in the MAIN subset as one of the 126 samples. Using the

two subsets (MAIN and B-STD) of the UNDEMRC data provided an opportunity to compare coal quality parameters that influence regional and local variations in fouling deposit weight. **Appendix 1** lists by sample subsets all of the data used in the formulation of the deterministic models.

Variables Considered

The dependent variable (DEPOWT) is the grams of deposit per million BTU calculated as:

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DEPOWT = (TOTDEPO / TOTLBS) * (10**6 / BTUDRY)
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where: TOTDEPO= weight (grams) of deposit on probe banks 1, 2, and 3.

TOTLBS = total weight (pounds) of coal put in the reactor.

BTUDRY = BTU (per lb by definition) on a moisture-free basis.

Yeakel and Finkelman (1988) recommended the use of deposit weight on a grams per million BTU basis. They reasoned that using a unit energy per input basis, such as DEPOWT, eliminates variations in coal feed rate and total weight of coal burned.

Independent variables used from the UNDEMRC data set included: the major element oxides normalized to a SO_3-free (SF) basis, ASHDRY which is the ash value on a dry-basis and BTUDRY which is the Btu, or heating value, per pound on a dry-basis. Other independent variables (derived variables) were calculated based on empirical parameters formulated from the major element oxide data (Winegartner, 1974). Other variables were cross products, quotients, and sums of major oxide chemistry including the following:

1) SIRATIO, silica ratio. The percent of SiO_2 in the ash when the ash composition is normalized to include only SiO_2, Fe_2O_3, CaO and MgO.
2) SULDRY, percent sulfur on a moisture-free basis
3) TOTBSF, total base, sulfur-free basis. The total base in coal ash is the sum of the percentages of Fe_2O_3, CaO, MgO, K_2O, and Na_2O normalized to include only SiO_2, Al_2O_3 and TiO_2, all oxides on a sulfur-free basis.
4) TOTASF, total acid, sulfur-free basis. The sum of the percentages SiO_2, Al_2O_3 and TiO_2 in the ash, normalized as in TOTBSF.
5) TOTALK, total alkali. The total alkali content of the coal ash is the sum of the percent K_2O determined on the ash, times .659 and percent Na_2O. The .659 is the ratio of the molecular weights of Na_2O/K_2O and thus the percent K_2O is converted to equivalent Na_2O.

6) TOTALKWC, total alkali, whole coal basis

7) ALKRATIO, alkali ratio, sulfur-free basis. Percent ash on a dry basis times TOTALK on a sulfur-free basis divided by the sum of percent CaO and MgO, also on a sulfur-free basis.

8) SIXFE, silicon times iron, both as oxides

9) ALXFE, aluminum times iron, both as oxides

10) CAXFE, calcium time iron, both as oxides

11) MGXFE, magnesium times iron, both as oxides

12) SIXAL, silicon times aluminum, both as oxides

13) SIXCA, silicon times calcium, both as oxides

14) CAXMG, calcium times magnesium, both as oxides

15) SIXK, silicon times potassium, both as oxides

16) ALXK, aluminum times potassium, both as oxides

17) FEXK, iron times potassium, both as oxides

18) CAXK, calcium times potassium, both as oxides

19) MGXK, magnesium times potassium, both as oxides

20) SI+AL, silicon plus aluminum, both as oxides

21) CA+MG, silicon plus magnesium, both as oxides

22) FE/CA, iron divided by calcium, both as oxides

23) SI/AL, silicon divided by aluminum, both as oxides

24) SI/ALSQ, silicon oxide divided by aluminum oxide squared

25) SIO2SQ, silicon oxide squared

26) AL2O3SQ, aluminum oxide squared

27) CAOSQ, calcium oxide squared

28) NA2OSQ, sodium oxide squared

29) MGOSQ, magnesium oxide squared

30) FE2O3SQ, iron oxide squared

31) P2O5SQ, phosphorus oxide squared

32) TIO2SQ, titanium oxide squared

33) K2OSQ, potassium oxide squared

TASK 2 - STATISTICAL ANALYSIS

MAIN Data Subset

The average, standard deviation, median, minimum, maximum, and determination of normality (W-test of Shapiro and Wilk, 1965) for each of the independent variables are listed in **table 2**. Only three variables have a normal distribution: 1) MGO, percent MgO; MGOSF, percent MgO sulfur-free; and 3) MGFE, percent MgO times percent Fe_2O_3. The variables which are not normally distributed were transformed by the log function and the determination for normality was calculated again. The log transformation did not 'normalize' any of the non-normal parameters.

Pearson product moment correlation coefficient were determined between the percent ash, dry basis (ASHDRY), and the grams of deposit weight per million Btu's (DEPOWT) and all of the other variables in the MAIN data set (**table 3**). thirty-one

variables are significantly (0.05 level) correlated with the deposit weight.

The model for determining the grams of deposit per million Btu (DEPOWT) for the MAIN subset as determined by stepwise regression (Draper and Smith, 1966; SAS Institute, Inc. 1982a, 1982b, 1885, 1987) is:

DEPOWT = 491 + 12.4 ***ASHDRY** - 7.0***CAOSF** + 11.1***NA2OSF** - 870***SIRATIO** + 0.25***SIXFE** + 0.45***SIXAL** + 15.2***ALXK** - 32.6***MGXK** - 230***FE/CA** - 0.86***AL2O3SQ** - 0.48***NA2OSQ**

The eleven variable model has a square of the multiple regression coefficient of 0.715. The full model is found in Appendix II, **Model 1.**

The variables are: **ASHDRY**, %ash on a dry basis; **CAOSF**, %CaO on a sulfur free basis; **NA2OSF**, %Na_2O on a sulfur free basis; **SIRATIO**, silica ratio; **SIXFE**, %SiO_2 times %Fe_2O_3; **SIXAL**, %SiO_2 times %Al_2O_3; **ALK**, %Al_2O_3 times %K_2O; ; **MGXK**, %MgO times %K_2O; **FE/CA**, %Fe_2O_3 divided by %CaO; **AL2O3SQ**, %Al_2O_3 squared; and **NA2OSQ**, %Na_2O squared.

If the independent variables are restricted to the primary variables, that is, major elements on a sulfur-free basis as well as variable numbers 1 through 7 (as listed above) the model

determined by stepwise regression for predicting the grams of deposit per million Btu (DEPOWT) is:

DEPOWT = - 191 + 5.8***ASHDRY** + 3.9***CAOSF** + 78.3***K2OSF** + 24.6***SULDRY** - 13.8***TOTALK** + 281***TOTALKWC**

The six variable model has a square of the multiple regression coefficient of 0.536. The full model is found in Appendix II, **Model 2.**

The variables are: **ASHDRY**; %ash on a dry basis; **CAOSF**, %CaO on a sulfur free basis;; **K2OSF**, %K_2O on a sulfur-free basis; **SULDRY**, % sulfur on a dry-basis; **TOTALK**, total alkalinity; and **TOTALKWC**, total alkalinity on a whole coal-basis.

B-STD Data Subset

The 71 standard samples (B-STD) provided an opportunity to develop a predictive model on a dataset from a single mine site. The samples are from the Beulah coal bed mined in North Dakota. The average, standard deviation, median, minimum, maximum, and determination of normality (W-test of Shaprio and Wilk, 1965) are listed in **table 4.** Twelve parameters have a normal distribution: 1) ASHDRY, percent ash, dry-basis; 2) SULDRY, percent sulfur, dry-basis; 3) INITDEF, initial deformation temperature (F^o); 4) TOTAL, sum of percent major oxides; 5) TOTDEPO, sum of grams

deposit weight; 6) TOTBSF, total base, sulfur-free basis; 7) TOTASF, total acid, sulfur-free basis; 8) BTOASF, total base divided by total acid, both sulfur-free; 9) SIAL, percent silica oxide times percent aluminum oxide; 10) SICA, percent silica oxide times percent calcium oxide; 11) SIPLSAL, percent silica oxide plus percent aluminum oxide; and 12) SQSIO2, percent silica oxide squared.

Pearson product moment correlation coefficient (r) were determined between the percent ash, dry basis (ASHDRY), and the grams of deposit weight per million Btu's (DEPOWT) and all of the other variables in the B-STD data subset that were used in the determination of the model (**table 5**). Twelve variables are significantly (0.05 level) correlated with the deposit weight. Only SULDRY (r= .44) is significantly and positively correlated with ASHDRY, the remaining eight variables are significant and negatively correlated.

The model for determining the grams of deposit per million Btu (DEPOWT) for the B-STD samples as determined by stepwise regression is:

DEPOWT = 242 - 69.8***P2O5SF** - 130***SULDRY** - 28.1***TOTALK** + 478***TOTALKWC**

The square of the multiple regression coefficient for the model is 0.393. The full model is found in Appendix II, **Model 3.**

If the independent variables are restricted to the primary variables the stepwise regression model for determining DEPOWT is:

DEPOWT =408 - 28.6***ASHDRY** - 59.3***P2O5SF** - 36.1***TOTALK** - 586***TOTALKWC**

The square of the multiple regression coefficient for the model is 0.392. The full model is found in Appendix II, **Model 4.**

Table 2: Univariate statistics for 126 MAIN subset samples. **MEAN**= average, **SD**= standard deviation, **MEDIAN**= median value, **MIN**= minimum value, **MAX**= maximum value, **W**= calculated W value. 1 is the highest possible W value and small values are significant, i.e. indicate non-normality., **Prob<W**= probability associated with the W value. Variables that have a normal distribution have the probabilities in bold type. Underlined variables are used in the determination of the model for predicting the grams of deposit per million Btu.

VARIABLE	MEAN	SD	MEDIAN	MIN	MAX	W	Prob<W
ASH	8.3	2.9	7.9	4.7	23.4	0.7586	0.0
percent ash							
ASHDRY	11.7	3.9	11.0	6.7	30.6	0.7989	0.0
percent ash, moisture-free basis							
SULFUR	0.81	0.53	0.68	0.18	3.05	0.8116	0.0
percent sulfur							
SULDRY	1.1	0.75	0.93	0.26	4.1	0.8242	0.0
percent sulfur, moisture-free basis							
BTU	7554	613	7581	5880	10120	0.9565	0.0030
heating value, Btu per pound							
BTUDRY	10571	474	10640	8398	11350	0.8562	0.0
heating value, Btu per pound, moisture-free basis							
INITDEF	2186	158	2135	1920	2700	0.9206	0.0001
initial temperature (F°) of deformation							

VARIABLE	MEAN	SD	MEDIAN	MIN	MAX	W	Prob<W
SIO2	26.2	10.0	24.8	11.6	73.1	0.8881	0.0001
SIO2SF	31.9	10.0	30.8	15.2	71.7	0.9315	0.0001
AL2O3	12.0	3.2	11.4	6.9	22.7	0.9170	0.0001
AL2O3SF	14.8	3.5	14.4	8.5	27.3	0.9449	0.0001
FE2O3	8.6	3.1	7.7	3.3	19.6	0.9281	0.0001
FE2O3SF	10.8	4.1	10.0	3.8	22.6	0.9303	0.0001
TIO2	0.46	0.26	0.4	0.1	1.5	0.7799	0.0
TIO2SF	0.56	0.30	0.5	0.1	1.8	0.8083	0.0
P2O5	0.32	0.24	0.2	0.1	1.2	0.8148	0.0
P2O5SF	0.39	0.31	0.3	0.1	1.6	0.8357	0.0
CAO	21.1	6.7	20.2	3.8	40.6	0.9168	0.0001
CAOSF	26.4	8.3	26.3	4.0	47.2	0.9644	0.0240
MGO	6.0	2.1	6.0	0.2	12.3	0.9835	**0.6639**
MGOSF	7.5	2.8	7.6	0.2	15.3	0.9804	**0.4852**
NA2O	5.6	4.7	5.0	0.2	26.8	0.8562	0.0
NA2OSF	7.0	5.7	6.6	0.2	32.8	0.8732	0.0
K2O	0.51	0.37	0.3	0.1	2.1	0.8066	0.0
K2OSF	0.63	0.42	0.4	0.1	2.4	0.8407	0.0
SO3	17.6	5.9	18.7	0.2	28.3	0.9623	0.0142
TOTAL	98.4	2.2	98.2	92.8	109	0.9550	0.0019
TOTDEPO	496	275	491	37	1608	0.9357	0.0001
DEPOWT	106	87.7	101	7.3	774	0.6813	0.0

Table 2: continued, all variables are used in the determination of the model.

VARIABLE	MEAN	SD	MEDIAN	MIN	MAX	W	Prob<W
SIRATIO	0.42	0.13	0.39	0.19	0.81	0.9500	0.0004
TOTBSF	52.3	12.1	53.6	16.9	75.8	0.9590	0.0059
TOTASF	47.3	12.1	45.8	24.1	82.9	0.9597	0.0072
BTOASF	1.2	0.60	1.2	0.20	3.1	0.9333	0.0001
TOTALK	6.0	4.7	5.7	0.27	27.0	0.8625	0.0
TOTALKWC	0.46	0.36	0.40	0.033	1.9	0.8703	0.0
ALKRATIO	11.0	3.0	11.0	2.2	19.0	0.9494	0.0004
SIXFE	220	125	195	75	870	0.6777	0.0
ALXFE	100	39.7	95.1	41.4	306	0.8423	0.0
CAXFE	177	70.8	181	36.9	344	0.9635	0.0193
MGXFE	49.7	21.0	52.0	2.3	105	0.9757	**0.2479**
SIXAL	331	190	261	86.2	919	0.8508	0.0
SIXCA	507	136	484	248	1043	0.9322	0.0001
CAXG	137	82.6	118	1.0	433	0.9039	0.0001
SIXK	15.2	16.8	8.4	2.7	100	0.6806	0.0
ALXK	6.3	5.6	4.3	0.89	33.8	0.7209	0.0
FEXK	4.4	3.7	3.1	0.42	29.1	0.7680	0.0
CAXK	9.8	5.2	8.1	1.0	21.7	0.9191	0.0001
MGXK	2.7	1.5	2.5	0.04	6.2	0.9348	0.0001
SI+AL	38.1	12.0	35.1	19.2	84.0	0.9260	0.0001
CA+MG	27.1	8.4	26.2	5.3	50.2	0.9393	0.0001
FE/CA	0.48	0.38	0.41	0.11	2.8	0.5873	0.0
SI/AL	2.2	0.75	2.0	1.2	6.7	0.7838	0.0
SI/ALSQ	5.4	5.1	4.0	1.3	45.0	0.5525	0.0
SIO2SQ	784	709	617	135	5344	0.6995	0.0
AL2O3SQ	154	88.5	131	47.6	515	0.8325	0.0
CAOSQ	491	323	410	14.4	1648	0.8048	0.0
NA2OSQ	53.8	99.2	24.5	0.04	718	0.5111	0.0
MGOSQ	40.2	25.7	35.4	0.04	151	0.9385	0.0001
FE2O3SQ	82.7	62.8	59.3	10.9	384	0.8148	0.0
P2O5SQ	0.16	0.25	0.04	0.01	1.4	0.6507	0.0
TIO2SQ	0.28	0.38	0.16	0.01	2.2	0.5812	0.0
K2OSQ	0.40	0.65	0.09	0.01	4.4	0.5788	0.0

Table 3: Significant, 95 percent, Pearson product-moment correlation coefficients (r) for ASHDRY and DEPOWT between all other variables in the MAIN data subset, N = 126. Values in parentheses are not significant.

	ASHDRY	DEPOWT
ASHDRY		0.3808
BTUDRY	-0.8546	-0.3830
SIO2SF	0.7991	0.2875
AL2O3SF	0.4025	(0.0237)
FE2O3SF	(0.0201)	(-0.0236)
TIO2SF	0.5633	(0.1120)
P2O5SF	(0.0095)	(0.0254)
CAOSF	-0.7265	-0.3630
MGOSF	-0.5753	-0.3851
NA2OSF	-0.3812	(0.1653)
K2OSF	0.3180	0.5662
INITDEF	-0.3038	-0.3349
SIRATIO	0.7545	0.3439
SULDRY	0.7235	0.2961
TOTBSF	-0.7980	-0.2500
TOTASF	0.7964	0.2487
BTOASF	-0.6726	-0.2234
TOTALK	-0.3510	0.1902
TOTALKWC		0.3803
ALKRATIO	-0.3119	0.2384
SIXFE	0.6789	
ALXFE	0.4016	
CAXFE	-0.5041	-0.2639
MGXFE	-0.4900	-0.3043
SIXAL	0.7488	0.2383
SIXCA		
CAXMG	-0.6011	-0.3691
SIXK	0.6028	0.6129
ALXK	0.5010	0.5887
FEXK	0.4423	0.4523
CAXK	-0.1826	0.2538
MGXK	-0.2069	
SI+AL	0.7770	0.2406
CA+MG	-0.7172	-0.3889
FE/CA	0.6937	
SI/AL	0.5242	0.1792
SI/ALSQ	0.5244	
SIO2SQ	0.7862	0.2332
AL2O3SQ	0.4625	
CAOSQ	-0.5840	-0.3222
NA2OSQ	-0.2319	
MGOSQ	-0.4848	-0.3823
FE2O3SQ	0.1795	

Table 3: Continued. Significant, 95 percent, Pearson product-moment correlation coefficients (r) for ASHDRY and DEPOWT

	ASHDRY	DEPOWT
P2O5SQ		
TIO2SQ	0.5606	
K2OSQ	0.4702	0.6462

Table 4: Univariate statistics for 71 B-STD subset samples. **MEAN**= average, **SD**= standard deviation, **MEDIAN**= median value, **MIN**= minimum value, **MAX**= maximum value, **W**= calculated W value. 1 is the highest possible W value and small values are significant, i.e. indicate non-normality., **Prob<W**= probability associated with the W value. Variables that have a normal distribution have their probabilities in bold type. Underlined variables are used in the determination of the model for predicting the grams of deposit per million Btu.

VARIABLE	MEAN	SD	MEDIAN	MIN	MAX	W	Prob<W
ASH	7.8	0.42	7.7	7.3	10.1	0.6807	0.0
percent ash							
ASHDRY	10.9	0.25	10.9	10.2	11.6	0.9664	**0.1591**
percent ash, moisture-free basis							
SULFUR	0.75	0.046	0.74	0.66	0.92	0.9012	0.0001
percent sulfur							
SULDRY	1.0	0.049	1.0	0.91	1.1	0.9792	**0.5922**
percent sulfur, moisture-free basis							
BTU	7590	364	7530	7210	9300	0.6611	0.0
heating value, Btu per pound							
BTUDRY	10539	117	10560	10060	10710	0.9133	0.0001
heating value, Btu per pound, moisture-free basis							
INITDEF	2180	69	2190	2030	2380	0.967	**0.1706**
initial temperature (F^{o}) of deformation							

VARIABLE	MEAN	SD	MEDIAN	MIN	MAX	W	Prob<W
SIO2	19.8	1.1	19.8	15.9	22.6	0.9539	0.0288
SIO2SF	25.5	1.2	25.6	20.3	28.1	0.9112	0.0001
AL2O3	11.1	0.56	11.1	10.1	14.3	0.8141	0.0001
AL2O3SF	14.4	0.63	14.4	13.5	18.3	0.7649	0.0001
FE2O3	10.1	1.2	9.9	9.0	18.7	0.5320	0.0
FE2O3SF	13.1	1.6	12.8	11.4	24.5	0.5482	0.0
TIO2	0.45	0.091	0.5	0.2	0.9	0.7812	0.0001
TIO2SF	0.56	0.11	0.6	0.3	1.1	0.8715	0.0001
P2O5	0.47	0.080	0.5	0.3	0.8	0.8305	0.0001
P2O5SF	0.60	0.12	0.6	0.4	1.1	0.8646	0.0001
CAO	21.4	1.2	21.2	18.8	27.3	0.7723	0.0001
CAOSF	27.6	1.6	27.3	24.2	36.1	0.7298	0.0
MGO	7.6	0.56	7.7	5.3	8.9	0.7873	0.0001
MGOSF	9.9	0.70	9.9	7.1	11.4	0.8098	0.0001
NA2O	6.1	1.1	6.4	0.6	7.7	0.6147	0.0
NA2OSF	7.9	1.5	8.3	0.8	9.5	0.5869	0.0
K2O	0.32	0.081	0.3	0.2	0.6	0.5736	0.0
K2OSF	0.42	0.092	0.4	0.3	0.8	0.5506	0.0
SO3	21.3	1.3	21.3	18.3	27.6	0.7863	0.0001
TOTAL	98.7	1.3	98.8	95.5	102.2	0.9793	**0.5963**
TOTDEPO	610	179	58	234	1142	0.9768	**0.4854**
DEPOWT	125	39	117	48	205	0.1017	0.0415

Table 4: continued, all variables are used in the determination of the model.

VARIABLE	MEAN	SD	MEDIAN	MIN	MAX	W	Prob<W
SIRATIO	0.34	0.017	0.34	0.28	0.38	0.9380	0.0024
TOTBSF	58.9	1.10	59	55.4	61.3	0.9790	**0.5820**
TOTASF	40.4	1.15	40.3	38	44	0.9808	**0.6669**
BTOASF	1.46	0.068	1.46	1.26	1.61	0.9857	**0.8642**
TOTALK	6.35	1.15	6.60	0.73	7.90	0.6251	0.0
TOTALKWC	0.50	0.10	0.51	0.058	0.75	0.7589	0.0001
ALKRATIO	13.1	0.93	13.3	8.55	14.3	0.6281	0.0
SIXFE	200	22.0	199	161	348	0.6758	0.0
ALXFE	113	12.4	111	94.6	198	0.6086	0.0
CAXFE	216	22.8	212	187	263	0.6910	0.0
MGXFE	77.1	7.56	77.8	48.2	107	0.9329	0.0011
SIXAL	220	17.7	222	180	280	0.9649	**0.1320**
SIXCA	422	31.0	422	340	521	0.9731	**0.3409**
CAXMG	163	15.4	162	111	203	0.9182	0.0001
SIXK	6.27	1.69	5.97	3.18	12.2	0.7142	0.0
ALXK	3.52	0.89	3.36	2.06	6.72	0.6699	0.0
FEXK	3.22	0.96	3.00	1.92	7.48	0.6833	0.0
CAXK	6.78	1.88	6.36	4.18	14.7	0.6124	0.0
MGXK	2.41	0.61	2.31	1.48	4.80	0.7059	0.0
SI+AL	30.9	1.32	31.0	27.5	35.0	0.9808	**0.6624**
CA+MG	29.0	1.32	28.9	25.1	34.7	0.8810	0.0001
FE/CA	0.48	0.070	0.46	0.36	0.96	0.6012	0.0
SI/AL	1.77	0.11	1.79	1.11	1.99	0.7482	0.0001
SI/ALSQ	3.16	0.35	3.20	1.23	3.96	0.8226	0.0001
SIO2SQ	392	43.8	392	253	511	0.9663	**0.1558**
AL2O3SQ	125	13.3	123	102	204	0.7635	0.0001
CAOSQ	458	52.5	449	353	724	0.7292	0.0
NA2OSQ	39.0	9.94	41.0	0.36	59.3	0.7979	0.0001
MGOSQ	58.6	7.98	59.3	28.1	79.2	0.8661	0.0001
FE2O3SQ	104	31.7	98.0	81.0	350	0.4113	0.0
P2O5SQ	0.23	0.082	0.25	0.09	0.64	0.7746	0.0001
TIO2SQ	0.21	0.094	0.25	0.04	0.81	0.6496	0.0
K2OSQ	0.11	0.067	0.09	0.04	0.36	0.4858	0.0

Table 5: Significant, 95 percent, Pearson product-moment correlation coefficients for ASHDRY and DEPOWT between all other variables in the B-STD data subset, number of samples= 71.

	ASHDRY	DEPOWT
BTUDRY		
SIO2SF		
AL2O3SF		
FE2O3SF		-0.2668
TIO2SF		
P2O5SF		-0.3898
CAOSF		
MGOSF		
NA2OSF		0.4434
K2OSF	-0.3639	
INITDEF		
SIRATIO		0.3264
SULDRY	0.4445	
TOTBSF		
TOTASF		
TOTALK		0.4527
TOTALKWC		0.5412
ALKRATIO		
SIXFE		
ALXFE		
CAXFE		-0.3285
MGXFE		-0.3030
SIXAL		0.2418
SIXCA		
CAXMG	-0.2370	
SIXK	-0.3307	
ALXK	-0.3734	
FEXK	-0.3162	
CAXK	-0.3543	
MGXK	-0.4110	
SI+AL		0.2400
CA+MG		
FE/CA		
SI/AL		
SI/ALSQ		
SIO2SQ		
AL2O3SQ		
CAOSQ		
NA2OSQ		0.4676
MGOSQ		
FE2O3SQ		
P2O5SQ		-0.3569
TIO2SQ		
K2OSQ	-0.3875	

TASK 3 - DATA ANALYSIS

In this section we evaluate the use of statistical methods to develop models for predicting fouling deposit weight based on coal quality variables. We accept as a working hypothesis that sintered ash deposits consist of two phases; a particulate phase consisting of unreacted minerals and glassy agglomerates; and a melt phase that acts as the glue to bind the deposit (see for example Honea and others, 1983). This hypothesis assumes that the ash forming components in coal (e.g. SiO_2, Al_2O_3, TiO_2, Fe_2O_3) contribute to the bulk of the sintered ash deposit while the alkalies (Na_2O, K_2O), alkaline earths (CaO, MgO), and sulfur interact to form the binding agent for the deposit. It is also likely that molten silicates act as a binding agent.

Selle and others (1986) correctly caution that "derived" indices or variables for predicting ash fusion or viscosity "should not be viewed as necessarily describing the underlying chemical and physical mechanisms of fouling..." (Selle and others, 1986, p.271). Although many "derived" factors are presented in the tables of this report the discussions will focus on the primary coal quality variables and the way these primary variables interact to form the sintered ash deposits.

Correlation Coefficients (r) - MAIN Subset

In **table 3** we present the Pearson product-moment correlation coefficients for ASHDRY, DEPOWT with other variables in the MAIN data subset. The correlation of the coal quality variables with ash are typical of low-rank coals. ASHDRY is very strongly correlated with SIO2SF (r= 0.80), as well as with AL2O3SF (r= 0.40), TIO2SF (r= 0.56), K2OSF (r= 0.32), and SULDRY (r= 0.72). These five components constitute almost 70 percent of the ash in U.S. coals (U.S. Geological Survey's National Coal Resources Data System). CAOSF (r= -0.73), MGOSF (r= -0.58), and NA2OSF (r= -0.38) all negatively correlate with ASHDRY. In low-rank coal these three elements commonly are associated with the organic phase and thus have a negative correlation with coal ash (Finkelman, 1981). We will see below how these relationships affect our ability to relate the concentration of an element in coal to its influence on deposit formation.

Of the primary coal quality variables K2OSF has the strongest positive correlation with DEPOWT (r= 0.57), in addition, K2OSF is the only variable having a stronger correlation with DEPOWT than with ASHDRY. ASHDRY (r= 0.38), SIO2SF (r= 0.29), and SULDRY (r= 0.30) are the only other primary variables with significant positive correlations with DEPOWT. MGOSF (r= -0.44) and CAOSF (r= -0.41) both have strong negative correlations with DEPOWT.

These data would appear to support the contention of Yeakel and Finkelman (1988) that Ca and Mg do not contribute to deposit formation but may be incorporated into the deposit as inert material. However, viewing the data from a slightly different perspective provides a very different picture. This new perspective indicates that both Ca and Mg are active participants in deposit formation.

Our hypothesis holds that the coal ash is the principle contributor to the bulk or mass of the sintered ash deposit. The correlation of a variable with ASHDRY is an indication of the variable's association with the coal ash. In contrast, the correlation of a variable with DEPOWT is an indication of the degree to which a variable contributed to the deposit. This contribution could be in the form of: 1) a physical contribution to the deposit mass. This would be especially true for the chemically inert elements such as Si and Al; 2) a chemical contribution to the binding phase. Relatively small amounts of flux-forming elements such as Na, K, Mg or Ca could make a significant contribution to the formation of the sintered ash deposit. These elements may have weak or negative correlations with the coal ash but still make a major contribution to the deposit formation.

By subtracting the DEPOWT correlation coefficient from the

ASHDRY correlation coefficient we derive a parameter that we call the Interaction Factor (IF). The IF may indicate whether the variable contributes to the bulk or to the binder. In **table 6** we have indicated the IF's for the primary variables. SIO2SF(+0.51), AL2O3SF (+0.38), and TIO2SF (+0.45) have high positive IF values, that is, they more strongly correlate with ASHDRY than with DEPOWT. A high positive IF is probably an indication of a primarilly physical contribution to deposit formation. NA2OSF (-0.55), CAOSF (-0.36), and MGOSF (-0.19) all have negative IF's derived from a stronger correlation with DEPOWT than with ASHDRY. These variables probably contributed to the formation of the sintered ash deposits primarily through the formation of the binder.

K2OSF correlates positively with ASHDRY but has a negative IF. This indicates that potassium's chemical contribution to the binder is more significant than its physical contribution to the bulk. This is not surprising as the mean value of K2OSF in the MAIN subset is only 0.63 weight percent.

The negative IF's for CAOSF and MGOSF indicated a strong chemical contribution to the sintered ash deposits. However, both variables are negatively correlated with DEPOWT. Can these apparently conflicting tendencies be reconciled? The answer lies in the relationship between these variables and the ash (ASHDRY) content of the coal. CAOSF and MGOSF (and to a lesser extent

NA2OSF) are negatively correlated with ASHDRY. Thus, in high ash coals which commonly lead to high DEPOWT values the Ca and Mg concentrations are generally low. Conversely in low ash coals which commonly generate low DEPOWT values the Ca and Mg concentrations are high. As there is a relatively strong correlation between ash (ASHDRY) and DEPOWT (r=0.38) the negative association of CAOSF and MGOSF with ASHDRY is carried over as a negative correlation of these variables with DEPOWT. However, the negative correlations of CAOSF and MGOSF with DEPOWT are ameliorated by the chemical contribution of these elements to the binder phase. Hence their correlation with DEPOWT is less negative than their correlation with ASHDRY. This results in a negative IF (**table 6**). Support for the contribution of Ca and Mg to the sintered ash deposits can be found in the analysis of any deposit in the UNDEMRC database. These deposits average over 20 weight percent CaO and about 5 weight percent MgO.

Perhaps this explanation accounts for the reports that fouling decreases with increased calcium content (Selle and others, 1986, p.276). The decrease in fouling would, of course, not be due to the increase in calcium content but to the decrease in ash content. It would also explain the absence of the anticipated decrease in fouling when calcium compounds are added to many coals prior to combustion (S. Benson, UNDEMRC, personal communication, 1988).

Table 6. INTERACTION FACTORS - MAIN SUBSET

Variable (SF)	IF
SIO2SF	+0.51
AL2O3SF	+0.38
FE2O3SF	+0.04
TIO2SF	+0.45
P2O5SF	-0.02
CAOSF	-0.36
MGOSF	-0.19
NA2OSF	-0.55
K2OSF	-0.25
SULDRY	+0.43

FE2O3SF and P2O5SF have IF's near zero, indicating roughly equal physical and chemical contributions to the sintered ash deposits. SULDRY has a large positive IF (+.43) indicating a strong physical contribution to deposit formation and a small chemical contribution. This result is somewhat surprising. It is, of course, abundantly clear that sulfur chemically interacts with Na, Ca, Mg, and K to form the sulfates that help bind the deposit. This perplexing situation (the positive IF) may be caused by the extremely strong positive correlation ($r = 0.75$) of SULDRY with ASHDRY in our data set. This strong positive correlation between sulfur and ash may be characteristic of non-marine depositional basins such as the Northern Great Plains from which most of the samples in our study are derived.

NA2OSF has a negative correlation with ASHDRY and a positive correlation with DEPOWT indicating predominant chemical

contributions. No variable has a positive correlation with ASHDRY and a negative correlation with DEPOWT. We interpret this to indicate the importance of coal ash in fouling deposit formation.

In our hypothesis we assume that during combustion most primary coal quality parameters interact to form the sintered ash deposits. No single variable dominates fouling deposit formation. This assumption is supported by the generally weak correlations of the coal quality variables with DEPOWT. K2OSF has the strongest correlation at 0.57 reflecting its contribution to both the bulk and the binder. ASHDRY and SULDRY are next with correlation coefficients of 0.38 and 0.30, respectively. NA2OSF is not significantly correlated with DEPOWT (r= 0.17), but as we have discussed, sodium plays a major role in deposit formation by contributing to the binding agent. CAOSF and MGOSF both have strong negative correlations with DEPOWT, a reflection of their very strong negative correlation with ASHDRY. The negative IF's for CAOSF and MGOSF indicate a significant contribution to the binding phase.

These observations are consistent with those of Yeakel and Finkelman (1988) who stated that "the fouling potential of a coal cannot be adequately evaluated by using one or two compositional variables. A multivariate approach is more apt to yield reliable

evaluations of fouling behavior." (Yeakel and Finkelman, 1988, p. 97).

Correlation Coefficients - B-STD Subset

Table 5 contains the Pearson product-moment correlation coefficients for ASHDRY and DEPOWT with other variables in the B-STD data subset. Because the range in ASHDRY values for this subset is only 1.3 weight percent versus a range of 23.9 for the MAIN subset few coal quality variables correlate with ASHDRY (**figures 1 and 2**). Only SULDRY (r= 0.44) and K2OSF (r= -0.36) have significant correlations with ASHDRY. Neither variable is significantly correlated with DEPOWT. The absence of significant correlations with ASHDRY precludes the application of the Interaction Factor to the B-STD subset.

Nevertheless, the B-STD subset provides us with a distinct advantage. In this subset an important variable (ASHDRY) is virtually held constant (range of only 1.3 weight percent). This allows us to get a clearer view of how some of the other variables interact to form the deposits.

In this subset only NA2OSF (r= 0.44) displays a positive correlation with DEPOWT. This behavior illustrates the significance of sodium in influencing fouling potential at a mine or prospect site where ash range would be restricted.

FE2O3SF (r= -0.27) and P2O5SF (r= -0.39) have significant negative correlations with DEPOWT. The significance of these negative correlations is uncertain at this time.

Plots

Scrutinizing plots of variables versus DEPOWT proved to be useful in elucidating the relationships. In **figure 3** we present the plot of NA2OSF vs. DEPOWT (r= 0.17) for the MAIN subset. Despite the low correlation coefficient there appears to be a trend of increasing DEPOWT with increasing NA2OSF for samples in the low sodium region (Na <~ 5 weight percent). For samples with more than 10 weight percent NA2OSF there is no increase in DEPOWT above 200, even for samples with over 30 weight percent NA2OSF. The B-STD subset has a much more restricted range of NA2OSF values, nevertheless, the trend observed (**figure 4**) is consistent with that of the MAIN subset.

We interpret this trend to indicate that below about 5 weight percent NA2OSF sodium pays a dominant role in the formation of sintered ash deposits. In samples with more than about 5 weight percent NA2OSF sodium is no longer the dominant variable controlling deposit weight. **In other words, there appears to be a saturation limit for NA2OSF values. Above this limit (~ 5 weight percent NA2OSF) the system is saturated and**

increases in sodium content will not cause increases in deposit weight. We stress the influence of sodium on deposit weight here; the higher sodium contents may however be influencing the hardness of the deposits. **Figures 3** and **4** indicate that the relationship between NA2OSF and DEPOWT might best be characterized by two models, one model for low sodium (<~ 5 weight percent NA2OSF) samples and another model for the high sodium samples.

The MAIN subset, therefore, was split along this boundary to form a low sodium group (NA2OSF: mean= 2.1 weight percent, standard deviation (std)= 1.4, N=53. DEPOWT: mean= 72.1, std= 72.2, N=53) and a high sodium group (NA2OSF: mean= 10.3, std= 5.0, N=73. DEPOWT: mean= 130, std= 90.3, N=73). For the low sodium samples we found a stepwise regression r^2 (square of the multiple regression coefficient) of 0.804 (Appendix II, **Model** 5). Using the maximum-r procedure the square of the multiple regression coefficient can be improved to **0.983** with 26 of 46 variables (Appendix II, **Model 6**). Using only 11 of the 24 primary variables the maximum-r square of the multiple regression coefficient is 0.628 (Appendix II, **Model 7**). The square of the multiple regression coefficient for the stepwise regression model for the low sodium samples using the primary variables is 0.425 (Appendix II, **Model** 8). For the high sodium samples the square of the multiple regression coefficient is 0.608 for the stepwise regression with all variables (Appendix II, **Model 9**) and the

maximum-r square of the multiple regression coefficient is 0.656 with only 8 of 46 variables in the model (Appendix II, **Model 10**). Using only primary variables, the stepwise square of the multiple regression coefficient is 0.656 (Appendix II, **Model 11**) and the maximum-r square of the multiple regression coefficient is 0.564 with only 4 of 24 variables (Appendix II, **Model 12**). The best stepwise model using the entire 126 sample MAIN subset had a square of the multiple regression coefficient of 0.715 (Appendix II, **Model 1**).

Subdividing the samples by NA2OSF content significantly improved our ability to predict the DEPOWT of the low sodium coals while not substantially diminishing our ability to predict DEPOWT for the high sodium coals. It may be possible to improve our predictive capability for the high sodium samples by further subdividing this group.

A complete listing of the regression equations can be found in Appendix II. The following table summarizes the above discussion of the various models are their respective the square of the multiple regression coefficient values:

		the square of the multiple regression coefficient (R^2)			
		STEPWISE REG.		MAXR REG.	
N	Data restrictions	All-var*	Primary*	All-var	Primary
126	No restrictions	0.715	0.536	0.734	0.566
53	NA2OSF <5	0.804	0.425	0.982	0.628
73	NA2OSF >=5	0.608	0.548	0.656	0.564
50	NA2OSF <5 & ASHDRY <22	0.856	0.736	0.978	0.796

* All-var = all 46 variables
* Primary = 24 primary variables.

In the above table we have also included statistics for the low-sodium group in which ASHDRY is constrained below 22 weight percent (Appendix II, **Models 13, 14, 15, and 16**). Eliminating the high ash samples improves the the square of the multiple regression coefficient for both the all-variable and primary variable stepwise models and for the maximum-r primary variable model. Also included are the maximum-r regression equations for the MAIN subset (Appendix II, **Models 17 and 18**).

Although the data are more sparse (6 observations) we found that all samples having more than 22 percent ASHDRY and greater than approximately 0.4 weight percent NA2OSF yielded DEPOWT of 233 or more. Coals with these high ash values show severe fouling behavior and do not require a detailed predictive model.

In examining the original UNDEMRC database of 632 samples we found 20 samples having ASHDRY values greater than 20 weight percent. Test combustion runs involving these 20 samples yielded

DEPOWT's greater than 279 except when the convective passes in the cumbustor had plugged and the combustion tests cut short.

It appears safe to assume that any coal having more than approximately 20 weight percent ash on a dry-basis and more than 0.5 sodium on a sulfur-free basis in the ash will cause severe fouling problems.

Predictive Models

The models derived from this study indicate that we can use statistical procedures to accurately predict fouling deposit weight for samples combusted at the UNDEMRC test combustor. This type of approach can generate models that can account for as much as 98 percent of the variance (i.e. low-sodium coals). Plots depicting predicted versus measured DEPOWT for selected models appear in **figures 5** to **14**.

For the 126 sample MAIN subset using primary variables we found a model that accounted for approximately 57 percent of the variance, compared to 84 percent of the variance in the model developed by Yeakel and Finkelman (1988) for a 44 sample dataset.

Our experience on this research project has taught us that predictive models are very sensitive to certain changes. These

include changes in the dataset, independent variables and statistical procedure.

Dataset. If samples (especially outlyers) are added or removed from consideration the independent variables in the model may change. This can be seen in the model produced by removing the three high ash samples from the low sodium model (see Appendix II, **Models 5-8**, n=53 versus **Models 13-16**, n=50).

Independent variables considered. A nearly infinite number of derived variables could be considered in model construction. The use of these derived variables could improve the the square of the multiple regression coefficient of the predictive model. However, many of these derived variables (e.g. the square of a primary variable) have no obvious physical significance and therefore tell us little about the chemical interactions involved in deposit formation.

The type and number of variables considered will be dictated by the objective of the modelling exercise. If the objective is to develop a model that is the most accurate predictor of deposit weight, then a large number of derived variables is called for. If the objective is to develop a model that reflects the chemical processes involved in deposit formation only primary variables should be considered.

Statistical procedures. PROC STEPWISE versus MAXR. The SAS procedure REG allows several types of regression modeling, two of which are stepwise and maximum-r. The stepwise procedure is forward stepping and allows for variables already in the model to be removed if they no longer contribute significantly to the model. The procedure estimates the parameters or coefficients and calculates their standard error. The type II sum of squares is used as the numerator on an F-test, testing the hypothesis at the default level of 0.1500 that the estimated parameter is zero. If no other variable can significantly enter the model the procedure is stopped. The maximum-r procedure is also forward stepping with removal and fits the best one variable model, the best two variable model, and so on. Variables are switched in and out of the model so that the square of the multiple regression coefficient is maximized. Variables continue to enter the model as long as the overall square of the multiple regression coefficient is improved. We have chosen to use as the 'best' maximum-r models those which have the largest number of significant estimated parameters (at the 0.1500 level). The 0.1500 level is conservative and well suited for the purpose of this study, understanding the relationship of chemical variables to the formation of fouling deposits.

Because of the sensitivity of the predictive models to changes in the databases or variables considered there can be no unique model for quantitatively predicting fouling deposit

weight. However, relatively simple models can be constructed that will accurately predict deposit weight for most samples. As we indicated in the previous section improved predictive capability can be obtained by dividing the data set into logical groupings such as high- and low-sodium samples or high- and low-ash samples.

Despite the models' sensitivity to change, certain primary variables consistently occur in the predictive models indicating that these variables play an important fundamental role in the formation of sintered ash deposits.

The stepwise regression procedure does not draw every variable into the model as does the maximum-r procedure. Looking at **Models 1 through 18** in appendix II we find that TOTALKWC is in 11 models, TOTALK occurs in 4 and ALKRATIO is in 7 models. ASHDRY appears in 9 models and NA2OSF appears in 4 models but is included as part of the calculation of TOTALK, TOTALKWC, and ALKRATIO. SQNA2O occurs in 5 models. K2OSF appears in 6 models in addition to inclusion in TOTALK, TOTALKWC, and ALKRATIO. SULDRY appears in 6 models as does INITDEF AL2O3SF, FE2O3SF, SQAL2O3. The variables which occur only once are CAMG, SIK, SIPLSAL, SIDBAL, and SQSIO2 and variables not in any model are SIO2SF and BTOASF. Note that silicon in various forms dominates these last groups. Clearly the alkali elements, sodium,

potassium, and ash yield are the most important variables influencing deposit formation in our dataset.

The model of Yeakel and Finkelman (1988) is as follows:

$$\log_{10}(DEPOWT) = 1.21 + 0.45*(\log_{10}(TIO2SF)) + 1.46*(\log_{10}(SULDRY)) + 0.38*(\log_{10}*(ASHDRY)) + 1.14*(\log_{10}(CAOSF/SULDRY)) + 0.63*(\log_{10}(ALKRATIO))$$

The reported square of the multiple regression coefficient for the above model is 0.84 (r= 0.92). We calculated the $\log_{10}$ transformed variables used in their equation from our datasets and calculated the correlation coefficient between the fouling deposit weight (FDW) calculated by their model and DEPOWT for all 126 samples of the MAIN subset, 53 low sodium samples of the MAIN subset and 71 samples of the B-STD subset. The correlation coefficients are:

Data subset	correlation r, DEPOWT vs FDW
MAIN, n=126	0.370 (significant at 0.0001)
MAIN, n= 53	0.372 (significant at 0.0060)
B-STD, n= 71	0.012 (not significant at 0.0500)

Although the Yeakel and Finkelman model accurately predicted the FDW for their 44 sample dataset, it's application to this broader dataset is limited.

In the B-STD subset we are dealing with a situation in which ash is essentially kept constant (range of ASHDRY is 1.3%). Total alkalies are then the most important quality variable. In the stepwise regression model (Appendix II, **Model 3**) TOTALK + TOTALKWC account for 87 percent of the variance (model the square of the multiple regression coefficient= 0.41). We can see a similar effect by focusing on a narrow range of NA2OSF values in the MAIN subset. We selected a range around the median, **figure 3**, with 8-10 percent NA2OSF. Twenty-one samples lie within this range. **Figure 15** depicts the relationship between ASHDRY and DEPOWT, the correlation coefficient is 0.78 (n= 21, significant at <0.01 level). This relation indicates that for a suite of samples with a moderate range of ash values (6.7-13.4) and a narrow range of sodium values, the ash yield is a reasonable predictor of fouling behavior. The importance of ash yield on deposit weight is seen in the fact that by holding ash relatively constant in the B-STD subset the best the square of the multiple regression coefficient we obtained are 0.41 and 0.39 for the stepwise regression (Appendix II, **Models 3** and **4**) and 0.41 and 0.39 for the maximum-r regression (Appendix II, **Models 19** and **20**). The implication is that the local-scale variation is small and therefore it would be difficult to generate a model for predicting fouling deposit weight at a mine or prospect site.

One reason for separating the B-STD data from the original

data was concern that these 71 samples from a single mine and having a narrow composition range would distort (bias) the picture derived from the other (125) samples from 19 locations in North Dakota, Montana, Texas, Alabama, and Canada. This was not the case, however. We ran our statistics on the combined MAIN-B-STD data set (196 samples). There was only slight changes in the correlation coefficients and IF values **(table 7)**. The deterministic models for the stepwise procedure with all of the variables and with the primary variables have the square of the multiple regression coefficient values of 0.660 and 0.500 respectively (Appendix II, **Models 21 and 22**).

Table 7: CORRELATION COEFFICIENTS AND INTERACTION FACTORS, COMBINED DATASETS, N=196.

r-values in parenthesis are not significant at the 0.05 level. Compare with tables 3 and 6.

Variable (SF)	r with DEPOWT	IF
ASHDRY	0.3415	NA
SIO2SF	0.2126	0.57
AL2O3SF	(0.0164)	+0.39
FE2O3SF	(-0.0037)	-0.02
TIO2SF	(0.1121)	+0.42
P2O5SF	(0.0362)	+0.07
CAOSF	-0.3365	-0.38
MGOSF	-0.2716	-0.29
NA2OSF	0.1896	-0.57
K2OSF	0.4743	-0.14
SULDRY	0.2658	+0.46

CONCLUSIONS

It is evident that the formation of sintered ash deposits is a complex process in which the major components of the coal ash interact with one another in an, as yet, undefined manner. Despite the complex nature of the chemical interactions, results from this study indicate that we can quantitatively predict the amount of sintered ash deposit forming in the UNDEMRC test combustor. Our study shows that the statistical approach first used by Yeakel and Finkelman (1988) is valid. For certain groups of data (i.e low-sodium lignites) models can be constructed that account for as much as 98 percent of the variance.

Models accounting for 60 to 70 percent of the variance of a 125 sample database can readily be constructed from a limited number of variables. Improved accuracy can be obtained by either adding derived independent variables or by dividing the database into smaller logical groupings, such as low-sodium coals. The first alternative can maximize the square of the multiple regression coeifficent of the predictive models. The second alternative can help to elucidate the role of various coal components in deposit formation.

Our results indicate that, under controlled conditions (uniform combustor geometry and standardized run conditions), we can identify the coal compositional variables that most strongly effect deposit formation. Data from this study indicate that the two most important compositional components promoting the buildup of sintered ash deposits are the ash yield and total alkalies (Na2O + K2O).

For systems in which there is a wide range of ash contents and chemical compositions, and for systems with little variation in sodium content, ash yield appears to be the dominant factor in influencing deposit formation. In such systems ash yield alone may be a reasonable predictor of fouling deposit weight. For systems with a narrow range of ash contents and chemical compositions, such as coal from a mine or prospect site, alkali content becomes the dominant controlling factor. Total alkalies are also the principle factor influencing deposit weight in low-sodium (<~5 weight percent) coals. Above the saturation value of about 5 weight percent, sodium content has little influence on deposit weight. Perhaps at about 5 weight percent NA2OSF the liquid binding phase has been saturated with sodium.

Our data indicate that calcium and magnesium are important contributors to the binding phase. The reports that calcium decreases deposit formation (see Selle and others, 1986) are likely due to misinterpretation of the negative correlation

between calcium (and magnesium) and deposit weight. This negative correlation is a carryover of the strong negative correlation between calcium (and magnesium) and ash, the most important contributor to deposit weight. This is seen in the fact that all coals in our dataset with greater than 20 percent ash, even with NA2OSF values as low as 0.5 weight percent, have severe fouling tendencies.

We introduce a new parameter designated the Interaction Factor (IF). The IF is the difference between a coal quality variables correlation with ASHDRY and with DEPOWT. We suggest that strong positive IF values (e.g. SIO2, AL2O3, TIO2) indicate a physical contribution to deposit weight. These components are largely chemically inert and probably contribute to the deposit mass either in the form of unreacted minerals, such as quartz and rutile, or in the form of glassy particles. In contrast, sodium, calcium, magnesium, potassium, and perhaps phosphorous are active ingredients helping to form the binding agent that holds the deposit together. These elements have strong negative IF values. The IF value of iron and sulfur are near zero and their role in deposit formation is still unclear. The validity of the IF values needs further testing.

Our data does not suggest that any coal quality component retards fouling deposit formation. However, different modes of occurrence may render a component a less effective participant in

deposit formation. The results of this study indicate that the ideal coal sample to minimize deposit formation has low ash and alkalies and has a low Si/Al ratio.

The practice of adding overburden material to high sodium coal to reduce the concentration of sodium in ash is of questionable value. Our data indicate that the higher ash content may more than compensate for any decrease in deposit weight due to the lower sodium content. Moreover, if NA2OSF is not reduced below 5 weight percent, no advantage can be gained. However, higher ash and lower sodium contents may yield a weaker, more easily removed deposit.

Other uses of these models include predicting the effect that modifications or blends will have on fouling performance and helping design modifications and blends that have desired fouling characteristics.

Implications

We suggest that the approach used in this study can be further refined to produce models that allow quantitative prediction of fouling deposit weight for any lignite combusted in the UNDEMRC test combustor. These models will allow us to better understand the interactions of the various coal compositional parameters. This, in turn, can lead to a more general model that

could be applied to other boilers and to coals from other areas or of different rank.

Clearly boiler geometry and operating conditions play a major role in influencing deposit formation. For this reason the models developed for the UNDEMRC test combustor probably cannot be applied directly to other combustors such as utility boilers.

It is our belief, however, that the chemical interactions taking place in the UNDEMRC test combustor are similar to, if not identical to, the chemical reactions occurring in utility boilers. We also believe that the relative performance of the coals, as predicted by models based on UNDEMRC data, should be similar to the coals' performance in a utility boiler.

Final Comment

Selle, and others (1986, p. 270) state "The science of coal combustion may some day allow valid assessments based on first principles, which with sufficient coal and ash property data could, in theory at least, predict concentrations and properties of gaseous, molten and solid phases in a boiler from knowledge of the chemical and mineral forms entering and the applicable temperature/time history. In practice, the state of the art is

far removed from that capability." We believe that this assessment capability is now at hand.

RECOMMENDATIONS FOR FUTURE WORK

The ultimate goal of our research is to develop a reliable model (or series of models) that can be used to accurately predict fouling deposit formation in utility boilers. In this section we suggest additional avenues for research that should bring us closer to this goal.

Further Refinements of Predictive Models

Additional refinement of predictive models may be achieved by further subdividing the sample populations. Examining the high and low concentration ranges for the variables may yield improved models as well as provide insights into the interaction of the variables during deposit formation.

It is likely that some of the variation in deposit weight is due to differences in modes of occurrence of the coal quality parameters, that is, differences in the chemical or physical form of the parameter. For example, sodium can be associated with the organic constituents or with the clays, or with other minerals. It is possible that these different forms of sodium may behave differently during combustion. Similarly, sulfur can occur in

sulfides, sulfates, or in the organic constituents; calcium can be organically complexed, or can occur in carbonates, sulfates, or silicates. Each of these chemical forms may react differently during the combustion process and thus account for some of the observed variation. We recommend that information on modes of occurrence of the coal quality parameters be obtained and incorporated into the predictive models, especially information on sulfur forms and bulk mineralogy.

One example of how mode of occurrence may influence fouling can be found in the samples with high (>2.4) Si/Al ratios (SIDBAL). Virtually all of these samples yield high DEPOWT for their ash and sodium contents. Ten of the 11 samples with DEPOWT values greater than 140 and having less than 20 weight percent ash and less than 10 weight percent NA2OSF, had Si/Al ratios greater than 2.4. High Si/Al is generally (though not exclusively) indicative of a high quartz content. Quartz, a chemically inert mineral that is generally no larger than a few microns in coal, may be swept out in the gas stream to quantitatively contribute to the mass of the fouling deposit.

We also recommend that data from samples for which the models do not successfully predict DEPOWT be carefully considered. Important insights can be gained from an understanding of the reasons for the exceptions to the models. For example, we found that one sample that did not obey our model

had been dried from 28 to 4 percent moisture. Perhaps drying lignites alters their fouling characteristics.

Testing the Models

The models should be tested by comparing predictive values to the results from tests being run at the UNDEMRC test combustor. Coal samples with extreme coal quality parameters should be combusted at UNDEMRC to test for the limits of applicability of these models.

The models should be used to predict the behavior of: a) modified samples, i.e. samples in which ash, sodium, or calcium has been added to modify the coals fouling behavior; b) blends of different coals combined to achieve a desired composition.

The models should be applied to coals of higher rank or different geographic locations. The models developed in this study are based on primary coal quality parameters or on derivatives of the primary parameters. Therefore, they should not be dependent on coal rank related parameters such as BTU or moisture contents.

Relating Results of Predictive Models to Behavior in Utility Boilers

The ultimate goal of this research effort is to develop the capability to accurately predict the fouling potential of a coal in a utility boiler. The variables used in our models are primary coal quality parameters. Therefore, these models should be applicable to utility boilers as well as to the UNDEMRC test combustor. However, differences in scale, boiler geometry, and run conditions may cause the DEPOWT values to vary substantially from the UNDEMRC data. Nevertheless, the relative performance of the coals should, theoretically, be similar. Therefore, these models may be able to predict relative fouling performance of lignites in utility boilers.

We recommend that fouling data be obtained from a utility that has combusted several of the coals included in our database. These data should be plugged into our predictive models to see if the models can be used for utility boilers.

Another approach would be to develop a utility model based on the methods used in this study. Appropriate records will have to be obtained from a utility that has combusted a variety of coals under similar conditions.

Other Recommendations

Throughout this report we have stressed that our predictive models address the weight of the sintered ash deposit. The

strength of the deposit is an equally important characteristic. We believe that if the appropriate data are available models, similar to those presented in this report, can be constructed to predict deposit strength. We therefore, recommend that a systematic collection of data on deposit strength be initiated and maintained.

We strongly recommend the use of 3-axis plots, such as the one used by Yeakel and Finkelman (1988; see Appendix I) to show the relationships between ash, sodium, and deposit weight. The 3-axis plots are excellent method of envisioning the relative influence of two variables on a third.

Polynomial multivariate regression may aid in formulating deterministic models. In **figure 16** we used a second order polynomial regression on the variables DEPOWT vs NA2OSF from the MAIN subset. The correlation coefficient improved significantly from 0.17 to 0.58 using a squared function. Other multivariate regression techniques using exponential and/or logarithmic functions should be evaluated for all the datasets.

The role of iron, sulfur, and phosphorous in deposit formation should be studied further.

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Appendix I:

MAIN subset, data list

OBS	SPLNUM	SPLDESIG	RANK	STATE	ASHDRY	BTUDRY	SIO2SF	AL2O3SF	FE2O3SF
1	2	BN-1	LIGNITE	N.DAKOTA	9.64	11090	31.5	16.6	7.1
2	3	BN-1	LIGNITE	N.DAKOTA	9.63	11230	30.1	16.6	6.9
3	4	BN-1	LIGNITE	N.DAKOTA	10.47	10900	31.4	16.9	7.0
4	5	B-1	LIGNITE	N.DAKOTA	11.24	10490	21.5	16.7	22.6
5	6	B-2	LIGNITE	N.DAKOTA	11.05	10570	25.9	13.7	11.1
6	7	B-2	LIGNITE	N.DAKOTA	11.59	10800	25.1	13.1	14.8
7	8	B-1	LIGNITE	N.DAKOTA	12.55	10570	23.9	17.0	21.5
8	10	V-1	LIGNITE	N.DAKOTA	6.81	11010	15.2	8.5	8.1

OBS	TIO2SF	P2O5SF	CAOSF	MGOSF	NA2OSF	K2OSF	DEPOWT	SIRATIO	SULDRY	TOTBSF
1	0.4	0.4	18.3	4.9	20.3	0.5	112.270	0.50973	0.54932	51.1
2	0.4	0.5	19.0	4.8	21.3	0.4	73.110	0.49505	0.48818	52.4
3	0.5	0.4	19.3	4.7	19.5	0.5	111.402	0.50385	0.51853	51.0
4	0.4	0.3	29.0	7.0	2.2	0.3	60.893	0.26850	1.91338	61.1
5	0.4	0.4	26.1	9.8	12.2	0.4	158.509	0.35484	1.32975	59.6
6	0.4	0.1	24.6	9.1	12.1	0.7	117.957	0.34180	1.43791	61.3
7	0.4	0.1	28.3	7.2	1.4	0.3	51.555	0.29545	1.82458	58.7
8	0.4	0.2	45.7	11.9	9.7	0.4	37.447	0.18741	0.28563	75.8

OBS	TOTASF	BTOASF	TOTALK	TOTALKWC	ALKRATIO	SIXFE	ALXFE	CAXFE	MGXFE	SIXAL
1	48.5	1.05361	17.1636	1.44517	15.7671	154.58	81.42	89.68	24.19	361.56
2	47.1	1.11253	17.8977	1.55352	15.7293	142.50	78.66	90.06	22.80	345.00
3	48.8	1.04508	16.5636	1.37146	15.4572	151.96	81.78	93.38	22.62	369.42
4	38.6	1.58290	1.7318	0.15049	7.9293	255.84	198.44	344.40	83.64	188.76
5	40.0	1.49000	8.9977	0.73961	15.0767	149.60	79.20	151.20	56.80	185.13
6	38.6	1.58808	8.7294	0.77430	15.0181	180.25	93.73	176.13	64.89	159.25
7	41.3	1.42131	1.1318	0.10899	7.9085	256.88	182.40	304.00	77.52	202.80
8	24.1	3.14523	8.1977	0.39103	13.3847	83.75	46.90	252.59	65.66	87.50

OBS	SIXCA	CAXMG	SIXK	ALXK	FEXK	CAXK	MGXK	SI+AL	CA+MG	FE/CA	SI/AL
1	398.24	62.32	10.48	5.52	2.36	6.08	1.64	40.0	19.3	0.38816	1.89855
2	395.00	63.20	7.50	4.14	1.71	4.74	1.20	38.8	19.8	0.36076	1.81159
3	421.82	62.79	10.48	5.64	2.32	6.44	1.56	40.3	20.0	0.36025	1.85816
4	327.60	107.10	3.12	2.42	3.28	4.20	1.02	27.7	26.1	0.78095	1.28926
5	353.43	134.19	5.61	2.97	2.40	5.67	2.13	28.6	26.0	0.42328	1.88889
6	299.25	107.73	8.75	4.55	5.15	8.55	3.15	26.6	23.4	0.60234	1.92308
7	338.00	102.00	3.38	2.40	3.04	4.00	1.02	28.9	25.1	0.76000	1.40833
8	471.25	369.46	3.75	2.10	2.01	11.31	2.94	19.5	47.5	0.17772	1.78571

OBS	SI/ALSQ	SIO2SQ	AL2O3SQ	CAOSQ	NA2OSQ	MGOSQ	FE2O3SQ	P2O5SQ	TIO2SQ	K2OSQ
1	3.6045	686.44	190.44	231.04	285.61	16.81	34.81	0.09	0.09	0.16
2	3.2819	625.00	190.44	249.64	313.29	16.00	32.49	0.16	0.09	0.09
3	3.4527	686.44	198.81	259.21	265.69	15.21	33.64	0.09	0.16	0.16
4	1.6622	243.36	146.41	441.00	2.56	26.01	268.96	0.04	0.09	0.04
5	3.5679	349.69	98.01	357.21	77.44	50.41	64.00	0.09	0.09	0.09
6	3.6982	306.25	82.81	292.41	70.56	39.69	106.09	0.01	0.09	0.25
7	1.9834	285.61	144.00	400.00	1.00	26.01	231.04	0.01	0.09	0.04
8	3.1888	156.25	49.00	1421.29	64.00	96.04	44.89	0.04	0.09	0.09

OBS	SPLNUM	SPLDESIG	RANK	STATE	ASHDRY	BTUDRY	SIO2SF	AL2O3SF	FE2O3SF
9	11	V-2	LIGNITE	N.DAKOTA	11.69	10080	35.8	15.0	4.1
10	12	V-1	LIGNITE	N.DAKOTA	6.73	10790	16.1	9.9	7.2
11	13	V-2	LIGNITE	N.DAKOTA	12.19	9960	38.5	15.5	3.8
12	14	BN-2	LIGNITE	N.DAKOTA	8.73	11080	20.1	9.4	9.3
13	15	BN-1	LIGNITE	N.DAKOTA	9.97	10780	30.5	16.6	6.2
14	16	BN-3	LIGNITE	N.DAKOTA	9.48	11190	35.5	18.8	6.9
15	17	BN-3	LIGNITE	N.DAKOTA	9.94	11130	36.3	18.5	7.4
16	18	GH-1	LIGNITE	N.DAKOTA	8.32	10970	21.7	11.7	16.2

OBS	TIO2SF	P2O5SF	CAOSF	MGOSF	NA2OSF	K2OSF	DEPOWT	SIRATIO	SULDRY	TOTBSF
9	0.5	0.2	34.3	6.7	3.0	0.2	72.928	0.44236	0.27510	48.3
10	0.2	0.2	45.9	11.2	8.9	0.4	55.255	0.20059	0.30338	73.6
11	0.5	0.1	32.9	5.8	2.7	0.3	109.144	0.47539	0.29134	45.5
12	0.2	0.2	22.5	5.0	32.8	0.4	112.137	0.35269	0.48577	70.0
13	0.4	0.2	20.1	5.1	20.5	0.5	145.487	0.49343	0.49401	52.4
14	0.5	0.3	22.5	6.0	9.2	0.3	89.045	0.50000	0.52155	44.9
15	0.3	0.3	22.0	6.0	8.9	0.3	62.523	0.50722	0.57456	44.6
16	0.5	0.1	29.2	7.0	12.8	0.8	110.332	0.29273	0.93339	66.0

OBS	TOTASF	BTOASF	TOTALK	TOTALKWC	ALKRATIO	SIXFE	ALXFE	CAXFE	MGXFE	SIXAL
9	51.3	0.94152	2.9318	0.24920	7.7674	125.40	52.44	120.08	23.56	455.40
10	26.2	2.80916	7.7977	0.36337	12.5436	83.57	51.24	237.90	57.95	115.08
11	54.5	0.83486	2.5977	0.22834	6.8736	111.54	44.88	95.37	16.83	459.68
12	29.7	2.35690	26.9977	1.69815	17.8287	124.64	58.52	139.84	31.16	126.28
13	47.5	1.10316	17.9636	1.44966	15.4318	139.39	75.79	91.69	23.32	376.09
14	54.8	0.81934	8.2977	0.57337	9.9596	190.93	101.26	121.39	32.33	519.58
15	55.1	0.80944	7.8977	0.58759	10.1105	202.24	103.04	122.24	33.28	508.76
16	33.9	1.94690	9.8953	0.58185	10.7973	193.20	104.40	260.40	62.40	140.07

OBS	SIXCA	CAXMG	SIXK	ALXK	FEXK	CAXK	MGXK	SI+AL	CA+MG	FE/CA	SI/AL
9	1042.80	195.92	6.60	2.76	0.76	6.32	1.24	46.8	37.8	0.12025	2.39130
10	534.30	370.50	4.11	2.52	1.83	11.70	2.85	22.1	48.5	0.15641	1.63095
11	976.82	147.39	10.14	4.08	0.99	8.67	1.53	47.4	34.0	0.11419	2.48529
12	301.76	75.44	4.92	2.31	2.28	5.52	1.23	24.1	22.5	0.41304	2.12987
13	454.99	76.12	10.52	5.72	2.12	6.92	1.76	40.6	21.7	0.30636	1.83916
14	622.87	105.47	9.39	4.98	1.83	5.97	1.59	47.9	25.2	0.30653	1.88554
15	603.56	99.32	9.48	4.83	1.92	5.73	1.56	47.7	24.3	0.33508	1.96273
16	349.37	112.84	9.66	5.22	7.20	13.02	3.12	24.8	26.9	0.55300	1.85057

OBS	SI/ALSQ	SIO2SQ	AL2O3SQ	CAOSQ	NA2OSQ	MGOSQ	FE2O3SQ	P2O5SQ	TIO2SQ	K2OSQ
9	5.7183	1089.00	190.44	998.56	7.84	38.44	14.44	0.04	0.25	0.04
10	2.6600	187.69	70.56	1521.00	57.76	90.25	37.21	0.04	0.04	0.09
11	6.1767	1142.44	184.96	835.21	5.76	26.01	10.89	0.01	0.16	0.09
12	4.5363	268.96	59.29	338.56	718.24	16.81	57.76	0.04	0.04	0.09
13	3.3825	691.69	204.49	299.29	313.29	19.36	28.09	0.04	0.09	0.16
14	3.5553	979.69	275.56	396.01	65.61	28.09	37.21	0.09	0.16	0.09
15	3.8523	998.56	259.21	364.81	59.29	27.04	40.96	0.09	0.09	0.09
16	3.4246	259.21	75.69	470.89	90.25	27.04	144.00	0.01	0.16	0.36

OBS	SPLNUM	SPLDESIG	RANK	STATE	ASHDRY	BTUDRY	SIO2SF	AL2O3SF
17	19	GH-1	LIGNITE	N.DAKOTA	8.54	11020	21.0	11.5
18	20	GH-2	LIGNITE	N.DAKOTA	8.82	10840	25.6	12.0
19	21	GH-3	LIGNITE	N.DAKOTA	11.25	10490	40.9	14.2
20	22	GH-2	LIGNITE	N.DAKOTA	8.88	10810	27.2	11.8
21	23	GH-3	LIGNITE	N.DAKOTA	11.40	10550	42.3	14.5
22	24	BN-3	LIGNITE	N.DAKOTA	9.87	11010	37.2	18.5

OBS	FE2O3SF	TIO2SF	P2O5SF	CAOSF	MGOSF	NA2OSF	K2OSF	DEPOWT	SIRATIO
17	16.1	0.4	0.1	29.9	7.6	12.6	0.8	106.388	0.28154
18	10.3	0.4	0.1	31.4	7.7	11.9	0.7	113.913	0.34079
19	8.7	0.6	0.1	20.6	5.1	8.5	1.3	137.688	0.54286
20	9.4	0.4	0.1	30.7	7.3	12.4	0.7	112.781	0.36529
21	8.4	0.6	0.1	19.7	5.5	7.8	1.2	121.239	0.55760
22	6.9	0.5	0.3	21.4	6.1	8.9	0.3	129.003	0.52044

OBS	SULDRY	TOTBSF	TOTASF	BTOASF	TOTALK	TOTALKWC	ALKRATIO	SIXFE
17	0.94740	67.0	32.9	2.03647	9.5953	0.57956	11.3494	181.72
18	0.69573	62.0	38.0	1.63158	9.5294	0.59178	11.1722	158.40
19	0.83963	44.2	55.7	0.79354	7.8248	0.62911	10.2098	249.66
20	0.65722	60.5	39.4	1.53553	10.4953	0.63812	11.0201	167.96
21	0.87484	42.6	57.4	0.74216	7.3589	0.59460	10.4713	261.36
22	0.52666	43.6	56.2	0.77580	8.0977	0.60733	10.2960	201.91

OBS	ALXFE	CAXFE	MGXFE	SIXAL	SIXCA	CAXMG	SIXK	ALXK	FEXK	CAXK
17	99.12	258.42	66.08	129.36	337.26	122.64	9.24	5.04	7.08	13.14
18	74.40	194.40	48.00	184.14	481.14	145.80	9.90	4.65	4.00	12.15
19	86.87	125.56	31.39	406.98	588.24	73.96	37.62	13.09	8.03	18.92
20	72.96	189.24	44.84	212.16	550.29	146.91	13.26	5.76	4.56	14.94
21	89.28	121.68	33.84	450.12	613.47	79.43	36.30	12.40	7.20	16.90
22	100.04	115.90	32.94	542.84	628.90	102.60	9.93	4.92	1.83	5.70

OBS	MGXK	SI+AL	CA+MG	FE/CA	SI/AL	SI/ALSQ	SIO2SQ	AL2O3SQ
17	3.36	23.8	27.5	0.53881	1.83333	3.3611	237.16	70.56
18	3.00	29.1	30.3	0.32922	2.12903	4.5328	392.04	86.49
19	4.73	46.1	21.5	0.42442	2.87395	8.2596	1169.64	141.61
20	3.54	31.7	30.8	0.30522	2.30208	5.2996	488.41	92.16
21	4.70	48.7	21.6	0.42604	2.92742	8.5698	1317.69	153.76
22	1.62	49.5	24.4	0.32105	2.01829	4.0735	1095.61	268.96

OBS	CAOSQ	NA2OSQ	MGOSQ	FE2O3SQ	P2O5SQ	TIO2SQ	K2OSQ
17	479.61	84.64	31.36	139.24	0.01	0.09	0.36
18	590.49	84.64	36.00	64.00	0.01	0.09	0.25
19	295.84	50.41	18.49	53.29	0.01	0.25	1.21
20	620.01	102.01	34.81	57.76	0.01	0.09	0.36
21	285.61	44.89	22.09	51.84	0.01	0.25	1.00
22	361.00	62.41	29.16	37.21	0.09	0.16	0.09

OBS	SPLNUM	SPLDESIG	RANK	STATE	ASHDRY	BTUDRY	SIO2SF	AL2O3SF
23	25	S-1	LIGNITE	MONTANA	11.84	10570	28.2	16.8
24	26	S-1	LIGNITE	MONTANA	11.61	10440	26.2	16.7
25	27	S-2	LIGNITE	MONTANA	14.29	10300	41.2	22.7
26	28	S-2	LIGNITE	MONTANA	13.12	10370	39.3	24.3
27	29	B-3	LIGNITE	N.DAKOTA	10.78	10840	24.9	15.9
28	30	B-3	LIGNITE	N.DAKOTA	10.99	10820	24.8	16.1

OBS	FE2O3SF	TIO2SF	P2O5SF	CAOSF	MGOSF	NA2OSF	K2OSF	DEPOWT	SIRATIO
23	12.0	0.4	1.0	28.9	11.9	0.5	0.4	28.736	0.34873
24	13.7	0.4	1.1	29.1	12.1	0.4	0.4	29.163	0.32295
25	6.2	0.6	0.7	18.4	8.8	0.5	1.0	49.300	0.55255
26	6.1	0.8	0.7	19.2	8.0	0.5	0.9	39.631	0.54058
27	12.9	0.5	0.7	28.8	9.3	6.6	0.5	113.304	0.32801
28	12.6	0.4	0.7	29.3	9.3	6.3	0.5	109.261	0.32682

OBS	SULDRY	TOTBSF	TOTASF	BTOASF	TOTALK	TOTALKWC	ALKRATIO	SIXFE
23	1.08397	53.7	45.4	1.18282	0.5977	0.04638	12.2128	203.67
24	1.14437	55.7	43.3	1.28637	0.4977	0.03937	12.3648	202.91
25	0.83542	34.9	64.5	0.54109	0.9271	0.09512	9.7001	180.44
26	0.79627	34.7	64.4	0.53882	0.9271	0.08863	8.7470	173.16
27	1.37102	58.1	41.3	1.40678	5.1636	0.39346	11.8938	177.60
28	1.34280	58.0	41.3	1.40436	4.9636	0.35341	11.7866	171.12

OBS	ALXFE	CAXFE	MGXFE	SIXAL	SIXCA	CAXMG	SIXK	ALXK	FEXK	CAXK
23	120.90	208.32	85.56	284.70	490.56	206.08	6.57	3.90	2.79	6.72
24	129.78	225.57	93.73	248.22	431.43	199.29	5.91	3.78	3.09	6.57
25	99.32	80.60	38.48	662.77	537.85	114.70	27.76	15.28	4.16	12.40
26	107.12	84.76	35.36	685.98	542.79	110.84	26.64	16.48	4.16	13.04
27	113.28	205.44	66.24	218.30	395.90	147.66	7.40	4.72	3.84	8.56
28	110.67	201.81	64.17	218.96	399.28	149.73	7.36	4.76	3.72	8.68

OBS	MGXK	SI+AL	CA+MG	FE/CA	SI/AL	SI/ALSQ	SIO2SQ	AL2O3SQ
23	2.76	34.9	31.6	0.41518	1.68462	2.8379	479.61	169.00
24	2.73	32.3	31.0	0.47032	1.56349	2.4445	388.09	158.76
25	5.92	53.8	22.9	0.33548	1.81675	3.3006	1204.09	364.81
26	5.44	53.9	23.1	0.31902	1.61650	2.6131	1108.89	424.36
27	2.76	30.3	28.3	0.44860	1.56780	2.4580	342.25	139.24
28	2.76	30.3	28.6	0.42857	1.54622	2.3908	338.56	141.61

OBS	CAOSQ	NA2OSQ	MGOSQ	FE2O3SQ	P2O5SQ	TIO2SQ	K2OSQ
23	501.76	0.16	84.64	86.49	0.64	0.09	0.09
24	479.61	0.09	82.81	106.09	0.64	0.09	0.09
25	240.25	0.16	54.76	27.04	0.36	0.25	0.64
26	265.69	0.16	46.24	27.04	0.36	0.49	0.64
27	457.96	24.01	47.61	92.16	0.25	0.16	0.16
28	470.89	22.09	47.61	86.49	0.25	0.09	0.16

OBS	SPLNUM	SPLDESIG	RANK	STATE	ASHDRY	BTUDRY	SIO2SF	AL2O3SF
29	31	G-1	LIGNITE	N.DAKOTA	12.49	10610	29.4	17.3
30	32	G-1	LIGNITE	N.DAKOTA	12.30	10640	30.2	16.2
31	33	G-1	LIGNITE	N.DAKOTA	12.47	10630	32.6	17.3
32	34	STD-AVE	LIGNITE	N.DAKOTA	10.87	10539	25.5	14.4
33	35	BN-4	LIGNITE	N.DAKOTA	8.94	11010	34.4	17.3
34	37	BN-4	LIGNITE	N.DAKOTA	8.97	10980	33.9	16.9

OBS	FE2O3SF	TIO2SF	P2O5SF	CAOSF	MGOSF	NA2OSF	K2OSF	DEPOWT	SIRATIO
29	8.5	0.5	0.3	28.2	10.8	4.5	0.4	78.357	0.38235
30	8.3	0.5	0.3	28.7	11.1	4.4	0.3	112.228	0.38567
31	7.8	0.5	0.5	26.5	10.6	4.0	0.3	96.885	0.42079
32	13.1	0.6	0.6	27.6	9.9	7.9	0.4	106.878	0.33616
33	8.0	0.4	0.4	23.6	5.9	9.6	0.5	128.401	0.47791
34	8.2	0.5	0.2	23.5	6.0	10.1	0.6	108.154	0.47291

OBS	SULDRY	TOTBSF	TOTASF	BTOASF	TOTALK	TOTALKWC	ALKRATIO	SIXFE
29	1.51776	52.4	47.2	1.11017	3.5977	0.28709	12.9098	141.44
30	1.43905	52.8	46.9	1.12580	3.4318	0.29925	13.0704	140.12
31	1.38261	49.2	50.4	0.97619	3.2318	0.29442	12.5753	155.55
32	1.04196	58.9	40.5	1.45432	6.3977	0.50094	13.1152	199.98
33	0.51435	47.6	52.1	0.91363	8.4636	0.55944	9.6614	198.56
34	0.54223	48.4	51.3	0.94347	8.9294	0.59113	10.0061	201.60

OBS	ALXFE	CAXFE	MGXFE	SIXAL	SIXCA	CAXMG	SIXK	ALXK	FEXK	CAXK
29	83.20	135.68	51.84	287.30	468.52	171.72	6.63	3.90	1.92	6.36
30	75.02	133.30	51.46	273.46	485.90	178.45	4.52	2.42	1.24	4.30
31	82.35	126.27	50.63	344.25	527.85	171.81	5.10	2.70	1.22	4.14
32	112.11	216.14	76.76	219.78	423.72	162.64	5.94	3.33	3.03	6.42
33	99.96	136.68	34.00	429.24	586.92	100.50	11.68	5.88	2.72	8.04
34	100.80	140.00	35.70	414.72	576.00	102.00	14.40	7.20	3.50	10.00

OBS	MGXK	SI+AL	CA+MG	FE/CA	SI/AL	SI/ALSQ	SIO2SQ	AL2O3SQ
29	2.43	35.1	29.3	0.30189	1.70000	2.8900	488.41	169.00
30	1.66	34.7	29.8	0.28837	1.86777	3.4886	510.76	146.41
31	1.66	39.0	29.0	0.29469	1.88889	3.5679	650.25	182.25
32	2.28	30.9	29.0	0.47196	1.78378	3.1819	392.04	123.21
33	2.00	43.9	25.1	0.33831	1.98639	3.9458	852.64	216.09
34	2.55	43.2	25.1	0.35000	2.00000	4.0000	829.44	207.36

OBS	CAOSQ	NA2OSQ	MGOSQ	FE2O3SQ	P2O5SQ	TIO2SQ	K2OSQ
29	449.44	11.56	65.61	40.96	0.04	0.16	0.09
30	462.25	10.89	68.89	38.44	0.04	0.16	0.04
31	428.49	9.61	68.89	37.21	0.16	0.16	0.04
32	457.96	38.44	57.76	102.01	0.25	0.25	0.09
33	404.01	67.24	25.00	46.24	0.09	0.09	0.16
34	400.00	73.96	26.01	49.00	0.04	0.16	0.25

OBS	SPLNUM	SPLDESIG	RANK	STATE	ASHDRY	BTUDRY	SIO2SF	AL2O3SF
35	42	V-3	LIGNITE	N.DAKOTA	8.62	10690	23.2	11.9
36	50	BN-2	LIGNITE	N.DAKOTA	8.26	11080	20.4	10.7
37	69	V-3	LIGNITE	N.DAKOTA	9.08	10470	26.3	10.4
38	78	V-1	LIGNITE	N.DAKOTA	7.44	10770	15.5	9.5
39	79	V-2	LIGNITE	N.DAKOTA	10.34	10250	31.8	15.4
40	96	R-1	LIGNITE	TEXAS	17.89	10570	47.1	20.9

OBS	FE2O3SF	TIO2SF	P2O5SF	CAOSF	MGOSF	NA2OSF	K2OSF	DEPOWT	SIRATIO
35	7.1	0.5	0.6	43.9	10.8	1.6	0.4	40.505	0.27260
36	10.3	0.2	0.4	46.4	10.4	1.0	0.2	27.759	0.23301
37	7.6	0.4	0.4	42.9	10.2	1.5	0.4	38.670	0.30242
38	8.5	0.1	0.2	46.1	10.2	9.5	0.4	76.832	0.19296
39	5.0	0.7	0.1	36.1	7.5	3.3	0.2	84.192	0.39563
40	8.8	1.8	0.2	18.9	1.9	0.2	0.1	38.545	0.61429

OBS	SULDRY	TOTBSF	TOTASF	BTOASF	TOTALK	TOTALKWC	ALKRATIO	SIXFE
35	0.33468	63.8	35.6	1.79213	1.5977	0.09874	11.1659	121.39
36	0.48933	68.3	31.3	2.18211	0.9318	0.05665	10.6015	142.80
37	0.32084	62.6	37.1	1.68733	1.4977	0.09330	10.5733	146.25
38	0.31487	74.7	25.1	2.97610	7.8977	0.41068	11.7757	86.94
39	0.31391	52.1	47.9	1.08768	3.1318	0.23739	8.4830	133.40
40	1.89389	29.9	69.8	0.42837	0.2659	0.03417	2.1517	278.64

OBS	ALXFE	CAXFE	MGXFE	SIXAL	SIXCA	CAXMG	SIXK	ALXK	FEXK	CAXK
35	62.22	229.97	56.73	202.98	750.23	350.61	5.97	3.06	1.83	11.31
36	74.80	324.70	73.10	147.84	641.76	328.52	3.36	1.76	1.70	7.64
37	57.85	238.55	56.55	200.25	825.75	319.29	6.75	2.67	1.95	11.01
38	53.13	258.75	57.27	97.02	472.50	311.25	3.78	2.31	2.07	11.25
39	64.40	151.34	31.28	406.00	954.10	223.72	5.80	2.80	0.92	6.58
40	123.84	111.60	11.52	665.64	599.85	24.80	3.87	1.72	0.72	1.55

OBS	MGXK	SI+AL	CA+MG	FE/CA	SI/AL	SI/ALSQ	SIO2SQ	AL2O3SQ
35	2.79	30.1	47.0	0.16180	1.95098	3.8063	396.01	104.04
36	1.72	25.6	46.8	0.22251	1.90909	3.6446	282.24	77.44
37	2.61	31.4	45.4	0.17711	2.52809	6.3912	506.25	79.21
38	2.49	20.3	45.8	0.18400	1.63636	2.6777	158.76	59.29
39	1.36	43.0	39.7	0.13982	2.07143	4.2908	841.00	196.00
40	0.16	55.9	17.1	0.46452	2.25000	5.0625	1497.69	295.84

OBS	CAOSQ	NA2OSQ	MGOSQ	FE2O3SQ	P2O5SQ	TIO2SQ	K2OSQ
35	1421.29	1.96	86.49	37.21	0.25	0.16	0.09
36	1459.24	0.64	73.96	72.25	0.09	0.04	0.04
37	1346.89	1.69	75.69	42.25	0.09	0.09	0.09
38	1406.25	59.29	68.89	47.61	0.04	0.01	0.09
39	1082.41	9.00	46.24	21.16	0.01	0.36	0.04
40	240.25	0.04	2.56	51.84	0.04	2.25	0.01

OBS	SPLNUM	SPLDESIG	RANK	STATE	ASHDRY	BTUDRY	SIO2SF	AL2O3SF
41	97	R-1	LIGNITE	TEXAS	17.95	10510	46.2	21.3
42	98	Z-1	LIGNITE	N.DAKOTA	11.85	10780	26.2	15.4
43	99	Z-2	LIGNITE	N.DAKOTA	10.24	10980	24.1	11.8
44	100	Z-1	LIGNITE	N.DAKOTA	11.58	10810	24.5	14.4
45	102	GH-4	LIGNITE	N.DAKOTA	13.38	10440	43.5	11.4
46	103	GH-4	LIGNITE	N.DAKOTA	8.83	11090	21.9	10.1

OBS	FE2O3SF	TIO2SF	P2O5SF	CAOSF	MGOSF	NA2OSF	K2OSF	DEPOWT	SIRATIO
41	8.5	1.6	0.2	19.8	2.0	0.2	0.1	45.487	0.60345
42	11.1	0.4	1.0	28.5	7.7	9.4	0.4	257.404	0.35638
43	16.8	0.4	0.8	33.3	9.1	3.4	0.3	125.609	0.28908
44	11.9	0.4	0.9	29.3	8.1	10.0	0.4	160.913	0.33211
45	9.9	0.4	0.2	19.4	5.6	8.5	1.2	192.676	0.55488
46	14.0	0.4	0.3	30.5	7.7	14.6	0.6	142.899	0.29585

OBS	SULDRY	TOTBSF	TOTASF	BTOASF	TOTALK	TOTALKWC	ALKRATIO	SIXFE
41	1.82884	30.6	69.1	0.44284	0.2659	0.03419	2.2411	273.35
42	1.23978	57.1	42.0	1.35952	7.3977	0.64360	11.7180	170.85
43	1.44217	62.9	36.3	1.73278	2.5318	0.18507	10.2063	206.40
44	1.50570	59.7	39.3	1.51908	7.5977	0.64808	12.1564	159.28
45	0.84452	44.6	55.3	0.80651	7.7589	0.74951	12.0078	302.12
46	0.90195	67.4	32.4	2.08025	11.7294	0.71198	12.0413	186.39

OBS	ALXFE	CAXFE	MGXFE	SIXAL	SIXCA	CAXMG	SIXK	ALXK	FEXK	CAXK
41	126.38	117.15	12.07	685.30	635.25	28.05	3.85	1.78	0.71	1.65
42	100.30	186.15	50.15	237.18	440.19	129.21	6.03	3.54	2.55	6.57
43	100.80	285.60	78.00	144.48	409.36	154.70	3.44	1.68	2.40	4.76
44	93.28	190.08	52.80	191.86	390.96	129.60	5.43	3.18	2.64	6.48
45	78.85	134.46	39.01	345.80	589.68	76.14	36.40	9.50	8.30	16.20
46	86.11	259.42	65.40	135.09	406.98	142.80	8.55	3.95	5.45	11.90

OBS	MGXK	SI+AL	CA+MG	FE/CA	SI/AL	SI/ALSQ	SIO2SQ	AL2O3SQ
41	0.17	56.3	18.2	0.43030	2.16292	4.6782	1482.25	316.84
42	1.77	31.9	27.8	0.38813	1.70339	2.9015	404.01	139.24
43	1.30	25.6	30.3	0.50420	2.04762	4.1927	295.84	70.56
44	1.80	28.7	27.6	0.40741	1.70755	2.9157	327.61	112.36
45	4.70	45.9	20.9	0.51235	3.83158	14.6810	1324.96	90.25
46	3.00	25.0	29.8	0.45798	2.16456	4.6853	292.41	62.41

OBS	CAOSQ	NA2OSQ	MGOSQ	FE2O3SQ	P2O5SQ	TIO2SQ	K2OSQ
41	272.25	0.04	2.89	50.41	0.04	1.69	0.01
42	479.61	51.84	34.81	72.25	0.64	0.09	0.09
43	566.44	5.76	42.25	144.00	0.36	0.09	0.04
44	466.56	54.76	36.00	77.44	0.49	0.09	0.09
45	262.44	50.41	22.09	68.89	0.04	0.09	1.00
46	566.44	129.96	36.00	118.81	0.04	0.09	0.25

OBS	SPLNUM	SPLDESIG	RANK	STATE	ASHDRY	BTUDRY	SIO2SF	AL2O3SF
47	104	GH-5	LIGNITE	N.DAKOTA	9.10	10790	33.1	14.0
48	107	GH-5	LIGNITE	N.DAKOTA	8.99	10870	32.8	14.1
49	109	GH-4/GH-5	LIGNITE	N.DAKOTA	8.70	10980	28.8	12.5
50	110	Z-2	LIGNITE	N.DAKOTA	10.23	10990	24.0	12.1
51	111	GH-2/GH-3	LIGNITE	N.DAKOTA	10.40	10510	35.6	13.6
52	123	Z-3	LIGNITE	N.DAKOTA	9.84	10990	24.0	11.8

OBS	FE2O3SF	TIO2SF	P2O5SF	CAOSF	MGOSF	NA2OSF	K2OSF	DEPOWT	SIRATIO
47	6.4	0.3	0.1	26.3	7.3	11.5	1.0	181.079	0.45283
48	6.1	0.6	0.2	26.2	7.8	11.2	1.0	162.091	0.45000
49	9.0	0.5	0.3	27.4	9.4	11.1	0.9	68.199	0.38591
50	16.8	0.4	0.9	33.3	9.1	3.0	0.3	68.495	0.28889
51	9.2	0.5	0.1	23.6	6.1	10.2	1.1	114.754	0.47776
52	14.1	0.5	0.7	27.6	7.8	12.9	0.4	125.200	0.32675

OBS	SULDRY	TOTBSF	TOTASF	BTOASF	TOTALK	TOTALKWC	ALKRATIO	SIXFE
47	0.76170	52.5	47.4	1.10759	9.7271	0.65074	11.5071	134.64
48	0.71360	52.3	47.5	1.10105	9.7271	0.63713	11.8692	135.00
49	0.77552	57.8	41.8	1.38278	9.3612	0.57759	13.1128	165.60
50	1.38433	62.5	36.5	1.71233	2.2318	0.16002	10.0824	199.42
51	0.74095	50.2	49.7	1.01006	8.8930	0.64919	10.9144	217.50
52	0.96344	62.8	36.3	1.73003	9.9977	0.74583	12.4931	194.74

OBS	ALXFE	CAXFE	MGXFE	SIXAL	SIXCA	CAXMG	SIXK	ALXK	FEXK	CAXK
47	57.12	107.10	29.58	295.68	554.40	121.80	21.12	8.96	4.08	16.80
48	58.00	108.00	32.00	313.20	583.20	138.24	21.60	9.28	4.00	17.28
49	72.00	157.68	54.00	230.00	503.70	164.25	16.10	7.00	5.04	15.33
50	100.30	276.12	75.52	143.65	395.46	149.76	3.38	1.70	2.36	4.68
51	83.25	144.00	37.50	321.90	556.80	96.00	26.10	9.99	6.75	17.28
52	96.30	223.63	63.13	163.80	380.38	123.31	5.46	2.70	3.21	6.27

OBS	MGXK	SI+AL	CA+MG	FE/CA	SI/AL	SI/ALSQ	SIO2SQ	AL2O3SQ
47	4.64	37.6	26.8	0.24286	2.35714	5.5561	696.96	125.44
48	5.12	38.6	28.0	0.23148	2.32759	5.4177	729.00	134.56
49	5.25	33.0	29.4	0.32877	2.30000	5.2900	529.00	100.00
50	1.28	25.4	29.8	0.50427	1.98824	3.9531	285.61	72.25
51	4.50	40.1	24.2	0.39062	2.61261	6.8257	841.00	123.21
52	1.77	27.2	26.8	0.51196	2.02222	4.0894	331.24	81.00

OBS	CAOSQ	NA2OSQ	MGOSQ	FE2O3SQ	P2O5SQ	TIO2SQ	K2OSQ
47	441.00	84.64	33.64	26.01	0.01	0.04	0.64
48	466.56	84.64	40.96	25.00	0.04	0.25	0.64
49	479.61	79.21	56.25	51.84	0.04	0.16	0.49
50	547.56	4.41	40.96	139.24	0.36	0.09	0.04
51	368.64	68.89	25.00	56.25	0.01	0.16	0.81
52	436.81	96.04	34.81	114.49	0.25	0.16	0.09

OBS	SPLNUM	SPLDESIG	RANK	STATE	ASHDRY	BTUDRY	SIO2SF	AL2O3SF
53	124	Z-3	LIGNITE	N.DAKOTA	9.78	10810	23.6	11.8
54	126	V-1	LIGNITE	N.DAKOTA	7.05	10560	15.5	8.6
55	127	V-1	LIGNITE	N.DAKOTA	6.70	10710	15.3	9.7
56	137	M	LIGNITE	TEXAS	8.11	11350	31.9	17.8
57	138	M	LIGNITE	TEXAS	7.93	11330	31.3	17.6
58	139	B-1	LIGNITE	N.DAKOTA	12.15	10210	25.0	17.6

OBS	FE2O3SF	TIO2SF	P2O5SF	CAOSF	MGOSF	NA2OSF	K2OSF	DEPOWT	SIRATIO
53	14.2	0.5	0.7	28.8	6.7	13.1	0.4	95.831	0.32206
54	7.5	0.2	0.4	43.8	15.3	8.0	0.6	63.658	0.18939
55	7.6	0.2	0.1	47.2	11.1	8.4	0.3	38.739	0.18884
56	15.3	1.2	0.1	24.8	7.6	1.0	0.2	12.985	0.40094
57	14.2	1.3	0.1	26.3	7.7	1.0	0.3	14.122	0.39303
58	20.3	0.5	0.1	27.7	7.1	1.2	0.3	35.374	0.31208

OBS	SULDRY	TOTBSF	TOTASF	BTOASF	TOTALK	TOTALKWC	ALKRATIO	SIXFE
53	0.93042	63.2	35.9	1.76045	10.2977	0.76821	11.2381	197.29
54	0.29007	75.2	24.3	3.09465	6.7294	0.32705	16.6513	75.00
55	0.25803	74.6	25.2	2.96032	7.3977	0.34547	12.3204	85.80
56	0.76756	48.9	50.9	0.96071	0.9318	0.05218	7.9701	316.11
57	0.73402	49.5	50.2	0.98606	0.9318	0.05134	8.0611	280.24
58	1.77824	56.6	43.1	1.31323	1.0318	0.09585	7.7131	280.86

OBS	ALXFE	CAXFE	MGXFE	SIXAL	SIXCA	CAXMG	SIXK	ALXK	FEXK	CAXK
53	99.19	240.89	55.59	164.71	400.01	112.71	5.43	2.73	3.27	6.63
54	41.40	211.20	73.80	86.25	440.00	432.96	6.25	3.45	3.00	17.60
55	53.95	263.90	62.40	109.56	535.92	389.76	3.96	2.49	1.95	12.18
56	175.89	246.00	75.03	367.51	514.00	122.00	5.14	2.86	2.46	4.00
57	158.20	236.17	68.93	347.20	518.32	127.49	4.96	2.80	2.26	4.18
58	197.81	311.06	80.03	243.66	383.16	109.18	3.72	2.62	3.02	4.12

OBS	MGXK	SI+AL	CA+MG	FE/CA	SI/AL	SI/ALSQ	SIO2SQ	AL2O3SQ
53	1.53	27.2	27.2	0.49321	1.98901	3.9562	327.61	82.81
54	6.15	19.4	47.5	0.17045	1.81159	3.2819	156.25	47.61
55	2.88	21.5	50.2	0.16010	1.59036	2.5292	174.24	68.89
56	1.22	40.0	26.1	0.61500	1.79720	3.2299	660.49	204.49
57	1.22	38.8	27.0	0.54067	1.77143	3.1380	615.04	196.00
58	1.06	31.7	25.9	0.73301	1.41985	2.0160	345.96	171.61

OBS	CAOSQ	NA2OSQ	MGOSQ	FE2O3SQ	P2O5SQ	TIO2SQ	K2OSQ
53	488.41	102.01	26.01	118.81	0.25	0.16	0.09
54	1239.04	40.96	151.29	36.00	0.09	0.04	0.25
55	1648.36	51.84	92.16	42.25	0.01	0.04	0.09
56	400.00	0.64	37.21	151.29	0.01	1.00	0.04
57	436.81	0.64	37.21	127.69	0.01	1.00	0.04
58	424.36	0.81	28.09	228.01	0.01	0.16	0.04

OBS	SPLNUM	SPLDESIG	RANK	STATE	ASHDRY	BTUDRY	SIO2SF	AL2O3SF
59	142	B-3	LIGNITE	N.DAKOTA	9.83	10690	21.7	14.9
60	143	B-2	LIGNITE	N.DAKOTA	12.05	10350	26.7	12.6
61	144	B-2	LIGNITE	N.DAKOTA	12.52	10240	28.0	12.8
62	145	B-2/V-1	LIGNITE	N.DAKOTA	10.09	10410	23.5	11.5
63	146	S-2	LIGNITE	MONTANA	13.94	10010	42.3	22.9
64	147	S-1	LIGNITE	MONTANA	11.76	10220	27.4	16.4

OBS	FE2O3SF	TIO2SF	P2O5SF	CAOSF	MGOSF	NA2OSF	K2OSF	DEPOWT	SIRATIO
59	13.1	0.3	0.7	31.7	9.5	7.6	0.4	102.619	0.28520
60	10.9	0.5	0.5	26.2	9.0	13.1	0.4	127.263	0.36691
61	12.8	0.5	0.3	24.1	8.4	12.5	0.4	141.482	0.38163
62	11.0	0.6	0.3	32.0	9.3	11.6	0.3	134.329	0.30976
63	5.8	0.6	0.6	18.6	7.4	0.6	1.1	25.823	0.57075
64	12.6	0.5	1.0	29.2	11.7	0.8	0.4	21.456	0.33874

OBS	SULDRY	TOTBSF	TOTASF	BTOASF	TOTALK	TOTALKWC	ALKRATIO	SIXFE
59	1.29653	62.3	36.9	1.68835	5.6977	0.40169	11.9385	151.68
60	1.22580	59.6	39.8	1.49749	10.1977	0.88210	15.1462	169.32
61	1.24059	58.2	41.3	1.40920	9.8977	0.88881	15.0307	213.84
62	0.82850	64.2	35.6	1.80337	9.2318	0.67484	13.0200	158.24
63	0.77316	33.5	65.8	0.50912	1.0930	0.11039	8.3930	175.91
64	1.04384	54.7	44.3	1.23476	0.7977	0.06294	12.1284	200.64

OBS	ALXFE	CAXFE	MGXFE	SIXAL	SIXCA	CAXMG	SIXK	ALXK	FEXK	CAXK
59	104.64	221.76	66.24	172.22	364.98	159.39	4.74	3.27	2.88	6.93
60	79.68	166.00	57.27	195.84	408.00	138.00	6.12	2.88	2.49	6.00
61	98.01	184.14	64.35	213.84	401.76	120.90	6.48	2.97	2.97	5.58
62	77.40	215.86	62.78	165.60	461.84	183.23	3.68	1.80	1.72	5.02
63	95.06	77.42	30.87	696.46	567.22	99.54	32.31	17.46	4.41	14.22
64	120.00	214.08	85.44	261.25	466.07	198.47	6.27	3.75	2.88	6.69

OBS	MGXK	SI+AL	CA+MG	FE/CA	SI/AL	SI/ALSQ	SIO2SQ	AL2O3SQ
59	2.07	26.7	30.0	0.41558	1.44954	2.1012	249.64	118.81
60	2.07	30.0	26.9	0.41500	2.12500	4.5156	416.16	92.16
61	1.95	31.5	25.1	0.53226	2.18182	4.7603	466.56	98.01
62	1.46	27.4	32.4	0.34263	2.04444	4.1798	338.56	81.00
63	5.67	55.3	22.1	0.31013	1.85052	3.4244	1288.81	376.36
64	2.67	33.4	31.2	0.43049	1.67200	2.7956	436.81	156.25

OBS	CAOSQ	NA2OSQ	MGOSQ	FE2O3SQ	P2O5SQ	TIO2SQ	K2OSQ
59	533.61	30.25	47.61	92.16	0.25	0.04	0.09
60	400.00	100.00	47.61	68.89	0.16	0.16	0.09
61	345.96	94.09	42.25	98.01	0.04	0.16	0.09
62	630.01	82.81	53.29	73.96	0.04	0.25	0.04
63	249.64	0.25	39.69	24.01	0.25	0.25	0.81
64	497.29	0.36	79.21	92.16	0.64	0.16	0.09

OBS	SPLNUM	SPLDESIG	RANK	STATE	ASHDRY	BTUDRY	SIO2SF	AL2O3SF
65	148	G-1	LIGNITE	N.DAKOTA	12.17	10470	31.0	16.1
66	155	BN-C	LIGNITE	N.DAKOTA	7.95	11050	23.5	14.0
67	156	BN-C	LIGNITE	N.DAKOTA	7.69	10940	22.7	14.1
68	157	BN-C	LIGNITE	N.DAKOTA	7.93	10970	22.9	13.9
69	158	PCA	LIGNITE	ALABAMA	15.49	10140	36.4	27.3
70	162	V-4	LIGNITE	N.DAKOTA	7.91	10900	28.0	12.4

OBS	FE2O3SF	TIO2SF	P2O5SF	CAOSF	MGOSF	NA2OSF	K2OSF	DEPOWT	SIRATIO
65	10.0	0.6	0.4	27.5	10.2	3.7	0.4	100.623	0.39329
66	13.6	0.4	0.1	34.4	11.1	2.5	0.4	43.997	0.28462
67	13.2	0.5	0.1	34.8	11.4	2.6	0.4	37.297	0.27656
68	14.3	0.2	0.6	34.5	10.8	2.2	0.4	44.652	0.27753
69	5.7	0.5	0.1	16.1	13.4	0.4	0.1	7.309	0.50943
70	7.2	0.3	0.2	37.7	9.1	4.5	0.6	55.064	0.34133

OBS	SULDRY	TOTBSF	TOTASF	BTOASF	TOTALK	TOTALKWC	ALKRATIO	SIXFE
65	1.50715	51.8	47.7	1.08595	3.2977	0.25854	11.9541	216.72
66	0.89336	62.0	37.9	1.63588	2.1977	0.12329	11.7387	197.95
67	0.84923	62.4	37.3	1.67292	2.1977	0.12131	12.0328	182.31
68	0.85315	62.2	37.0	1.68108	1.9977	0.11327	11.3663	223.02
69	4.01235	35.7	64.2	0.55607	0.3659	0.03304	13.8482	113.40
70	0.33908	59.1	40.7	1.45209	4.2294	0.22712	10.1271	150.04

OBS	ALXFE	CAXFE	MGXFE	SIXAL	SIXCA	CAXMG	SIXK	ALXK	FEXK	CAXK
65	112.56	192.36	71.40	345.72	590.82	194.65	7.74	4.02	2.52	6.87
66	117.70	289.97	93.09	203.50	501.35	235.77	5.55	3.30	3.21	8.13
67	113.30	279.13	91.67	194.70	479.67	241.19	5.31	3.30	3.09	8.13
68	135.70	336.30	105.02	217.35	538.65	253.65	5.67	3.45	3.54	8.55
69	84.84	49.98	41.58	545.40	321.30	117.81	2.70	2.02	0.42	1.19
70	66.34	202.12	48.98	258.94	788.92	257.54	12.10	5.35	3.10	16.30

OBS	MGXK	SI+AL	CA+MG	FE/CA	SI/AL	SI/ALSQ	SIO2SQ	AL2O3SQ
65	2.55	39.2	31.4	0.36681	1.92537	3.7071	665.64	179.56
66	2.61	29.5	35.8	0.39483	1.68182	2.8285	342.25	121.00
67	2.67	28.7	36.0	0.38007	1.60909	2.5892	313.29	121.00
68	2.67	30.4	37.4	0.41404	1.64348	2.7010	357.21	132.25
69	0.99	47.2	21.8	0.35294	1.33663	1.7866	729.00	408.04
70	3.95	34.9	40.5	0.19018	2.26168	5.1152	585.64	114.49

OBS	CAOSQ	NA2OSQ	MGOSQ	FE2O3SQ	P2O5SQ	TIO2SQ	K2OSQ
65	524.41	9.61	72.25	70.56	0.09	0.25	0.09
66	734.41	4.00	75.69	114.49	0.01	0.09	0.09
67	734.41	4.00	79.21	106.09	0.01	0.16	0.09
68	812.25	3.24	79.21	139.24	0.25	0.04	0.09
69	141.61	0.09	98.01	17.64	0.01	0.16	0.01
70	1062.76	15.21	62.41	38.44	0.04	0.09	0.25

OBS	SPLNUM	SPLDESIG	RANK	STATE	ASHDRY	BTUDRY	SIO2SF	AL2O3SF	FE2O3SF
71	163	V-4	LIGNITE	N.DAKOTA	8.71	10840	27.5	12.8	7.2
72	164	BN-1	LIGNITE	N.DAKOTA	10.23	10970	21.1	10.5	11.7
73	180	E-1	LIGNITE	SASKATCHEWAN	15.77	10010	41.7	25.6	5.7
74	181	E-2	LIGNITE	SASKATCHEWAN	16.02	9970	43.4	21.7	4.5
75	182	E-1/E-2	LIGNITE	SASKATCHEWAN	15.98	10060	42.9	23.5	5.2
76	183	GH-6	LIGNITE	N.DAKOTA	10.16	10760	32.6	10.4	13.7
77	184	GH-6	LIGNITE	N.DAKOTA	10.14	10740	33.5	10.7	13.7
78	189	V-5	LIGNITE	N.DAKOTA	8.31	10660	25.1	12.2	8.2

OBS	TIO2SF	P2O5SF	CAOSF	MGOSF	NA2OSF	K2OSF	DEPOWT	SIRATIO	SULDRY	TOTBSF
71	0.6	0.2	37.2	9.1	4.6	0.6	54.902	0.33965	0.37431	58.7
72	0.2	0.4	21.0	4.0	30.5	0.4	82.245	0.36475	0.45929	67.6
73	1.1	1.0	17.1	5.0	2.4	0.2	35.355	0.60000	1.07955	30.4
74	1.2	1.0	18.0	4.8	5.2	0.2	75.311	0.61371	0.60129	32.7
75	1.2	1.1	17.8	4.7	3.6	0.2	67.068	0.60726	0.73291	31.5
76	0.4	0.1	25.5	6.8	9.3	1.0	92.271	0.41498	0.89488	56.3
77	0.6	0.1	24.8	6.5	9.1	1.0	87.981	0.42628	0.88801	55.1
78	0.6	0.5	38.9	9.9	3.8	0.6	38.199	0.30551	0.41297	61.4

OBS	TOTASF	BTOASF	TOTALK	TOTALKWC	ALKRATIO	SIXFE	ALXFE	CAXFE	MGXFE	SIXAL
71	40.9	1.43521	4.2294	0.24615	10.2696	142.13	66.49	192.15	46.97	253.97
72	31.8	2.12579	25.8977	1.90348	18.9863	176.22	88.11	175.23	33.66	158.42
73	68.4	0.44444	2.2318	0.24795	7.3349	184.50	113.50	76.00	22.00	837.63
74	66.3	0.49321	4.8318	0.54068	9.5453	161.54	80.77	66.83	18.04	776.18
75	67.6	0.46598	3.3318	0.37782	8.0502	180.95	99.17	75.20	19.74	812.35
76	43.4	1.29724	8.1271	0.61847	10.7680	297.92	95.20	232.96	61.60	226.10
77	44.8	1.22991	7.7271	0.59112	10.4902	289.94	92.65	214.73	56.68	226.10
78	37.9	1.62005	3.4294	0.18622	10.7962	137.35	67.00	213.06	54.27	205.00

OBS	SIXCA	CAXMG	SIXK	ALXK	FEXK	CAXK	MGXK	SI+AL	CA+MG	FE/CA	SI/AL
71	733.95	242.55	11.65	5.45	3.05	15.75	3.85	34.2	39.2	0.19365	2.13761
72	315.06	60.18	5.34	2.67	2.97	5.31	1.02	26.7	21.1	0.55932	2.00000
73	560.88	66.88	7.38	4.54	1.00	3.04	0.88	59.6	19.6	0.32895	1.62555
74	642.22	71.72	7.88	3.94	0.82	3.26	0.88	59.1	20.7	0.25153	2.00000
75	616.00	67.20	7.70	4.22	0.94	3.20	0.84	59.6	20.2	0.29375	1.82464
76	553.28	114.40	21.28	6.80	8.96	16.64	4.40	35.1	26.3	0.53846	3.12941
77	524.02	102.44	21.28	6.80	8.72	15.76	4.16	35.1	24.9	0.55330	3.12941
78	651.90	257.58	10.25	5.00	3.35	15.90	4.05	30.5	39.9	0.21069	2.05000

OBS	SI/ALSQ	SIO2SQ	AL2O3SQ	CAOSQ	NA2OSQ	MGOSQ	FE2O3SQ	P2O5SQ	TIO2SQ	K2OSQ
71	4.5694	542.89	118.81	992.25	15.21	59.29	37.21	0.04	0.25	0.25
72	4.0000	316.84	79.21	313.29	660.49	11.56	98.01	0.09	0.04	0.09
73	2.6424	1361.61	515.29	231.04	4.41	19.36	25.00	0.81	1.00	0.04
74	4.0000	1552.36	388.09	265.69	22.09	19.36	16.81	0.81	1.21	0.04
75	3.3293	1482.25	445.21	256.00	10.24	17.64	22.09	1.00	1.21	0.04
76	9.7932	707.56	72.25	432.64	57.76	30.25	125.44	0.01	0.09	0.64
77	9.7932	707.56	72.25	388.09	51.84	27.04	118.81	0.01	0.25	0.64
78	4.2025	420.25	100.00	1011.24	9.61	65.61	44.89	0.16	0.25	0.25

OBS	SPLNUM	SPLDESIG	RANK	STATE	ASHDRY	BTUDRY	SIO2SF	AL2O3SF	FE2O3SF
79	205	G-2	LIGNITE	N.DAKOTA	11.83	10710	25.9	15.7	10.3
80	206	G-2	LIGNITE	N.DAKOTA	12.31	10730	26.5	15.0	10.1
81	207	G-3	LIGNITE	N.DAKOTA	12.70	10650	36.7	12.0	10.4
82	208	G-3	LIGNITE	N.DAKOTA	12.68	10710	35.9	12.7	10.0
83	210	G-4	LIGNITE	N.DAKOTA	8.59	10880	16.6	10.9	14.4
84	211	G-5	LIGNITE	N.DAKOTA	11.00	10660	23.7	17.5	9.2
85	212	G-6	LIGNITE	N.DAKOTA	13.41	10590	42.3	11.3	6.7
86	215	V-6	LIGNITE	N.DAKOTA	7.18	10720	21.9	10.0	7.7

OBS	TIO2SF	P2O5SF	CAOSF	MGOSF	NA2OSF	K2OSF	DEPOWT	SIRATIO	SULDRY	TOTBSF
79	0.7	0.1	30.5	9.9	6.5	0.4	111.611	0.33805	1.73329	57.6
80	0.3	0.3	30.6	10.1	6.6	0.4	98.096	0.34295	1.84635	57.8
81	0.5	0.3	29.0	10.4	0.5	0.1	34.008	0.42410	1.78600	50.4
82	0.5	0.1	29.7	10.2	0.7	0.3	29.770	0.41846	1.57406	50.9
83	0.3	0.3	39.1	13.0	4.6	0.6	50.320	0.19966	1.51232	71.7
84	0.3	0.3	32.3	10.9	5.3	0.4	74.819	0.31148	1.59974	58.1
85	0.6	0.4	26.4	9.3	2.7	0.3	68.941	0.49925	1.43571	45.4
86	0.5	0.2	37.9	9.5	11.6	0.6	74.338	0.28485	0.55734	67.3

OBS	TOTASF	BTOASF	TOTALK	TOTALKWC	ALKRATIO	SIXFE	ALXFE	CAXFE	MGXFE	SIXAL
79	42.3	1.36170	4.9977	0.37882	12.5234	145.16	88.16	171.00	55.48	221.56
80	41.8	1.38278	5.1977	0.40906	12.8611	155.54	87.78	179.41	59.29	230.28
81	49.2	1.02439	0.4659	0.03746	10.6478	208.67	68.53	164.78	59.29	241.19
82	49.1	1.03666	0.6318	0.05092	10.5833	206.72	72.96	171.00	58.52	261.12
83	27.8	2.57914	3.4636	0.19084	14.0975	117.16	76.76	275.73	91.91	88.16
84	41.5	1.40000	3.9977	0.26944	12.7947	112.86	83.16	153.78	52.14	215.46
85	54.2	0.83764	2.2318	0.19171	10.7719	176.49	47.17	110.24	38.69	296.37
86	32.4	2.07716	10.3294	0.53197	11.7725	124.08	56.76	214.50	53.46	161.68

OBS	SIXCA	CAXMG	SIXK	ALXK	FEXK	CAXK	MGXK	SI+AL	CA+MG	FE/CA	SI/AL
79	429.75	164.25	5.73	3.48	2.28	6.75	2.19	30.7	29.8	0.33778	1.64655
80	470.66	179.41	6.06	3.42	2.31	6.99	2.31	31.6	31.0	0.33047	1.77193
81	579.94	164.78	2.71	0.89	0.77	2.14	0.77	36.0	29.1	0.35981	3.04494
82	612.00	173.25	5.44	1.92	1.52	4.50	1.54	36.8	30.2	0.33778	2.83333
83	316.68	248.43	4.64	3.04	4.04	10.92	3.64	19.2	36.4	0.36996	1.52632
84	398.43	184.07	5.13	3.78	1.98	6.99	2.37	29.7	31.2	0.28326	1.35714
85	692.64	151.84	6.66	1.78	1.06	4.16	1.46	42.2	28.1	0.25481	3.74157
86	611.00	263.25	9.40	4.30	3.30	16.25	4.05	27.4	40.6	0.20308	2.18605

OBS	SI/ALSQ	SIO2SQ	AL2O3SQ	CAOSQ	NA2OSQ	MGOSQ	FE2O3SQ	P2O5SQ	TIO2SQ	K2OSQ
79	2.7111	364.81	134.56	506.25	23.04	53.29	57.76	0.01	0.25	0.09
80	3.1397	408.04	129.96	542.89	25.00	59.29	59.29	0.04	0.04	0.09
81	9.2717	734.41	79.21	457.96	0.16	59.29	59.29	0.04	0.16	0.01
82	8.0278	739.84	92.16	506.25	0.25	59.29	57.76	0.01	0.16	0.04
83	2.3296	134.56	57.76	745.29	10.24	82.81	102.01	0.04	0.04	0.16
84	1.8418	292.41	158.76	542.89	14.44	62.41	43.56	0.04	0.04	0.09
85	13.9994	1108.89	79.21	432.64	4.41	53.29	28.09	0.09	0.25	0.04
86	4.7788	353.44	73.96	1056.25	100.00	65.61	43.56	0.04	0.16	0.25

OBS	SPLNUM	SPLDESIG	RANK	STATE	ASHDRY	BTUDRY	SIO2SF	AL2O3SF	FE2O3SF
87	216	V-6	LIGNITE	N.DAKOTA	7.36	10740	22.2	11.1	7.1
88	217	G-1	LIGNITE	N.DAKOTA	12.01	10260	29.4	16.0	10.3
89	218	G-1	LIGNITE	N.DAKOTA	12.24	10220	31.5	16.1	11.1
90	229	B-4	LIGNITE	N.DAKOTA	10.34	10880	24.5	13.8	13.6
91	232	B-6	LIGNITE	N.DAKOTA	11.76	10610	23.7	14.2	15.3
92	233	B-6	LIGNITE	N.DAKOTA	11.46	10550	21.1	14.3	18.3
93	235	G-7	LIGNITE	N.DAKOTA	14.78	10300	42.7	14.8	7.0
94	236	B-7	LIGNITE	N.DAKOTA	9.76	10670	24.9	14.6	13.0

OBS	TIO2SF	P2O5SF	CAOSF	MGOSF	NA2OSF	K2OSF	DEPOWT	SIRATIO	SULDRY	TOTBSF
87	0.5	1.1	37.2	9.0	11.1	0.6	75.267	0.29467	0.47222	65.0
88	0.7	0.1	27.7	11.1	4.1	0.4	101.121	0.37479	1.52315	53.6
89	0.5	0.1	26.3	10.2	3.6	0.4	97.745	0.39831	1.42410	51.6
90	0.7	1.6	27.5	8.1	9.3	0.8	134.716	0.33215	1.25847	59.3
91	0.7	0.1	26.1	9.1	10.2	0.4	186.037	0.31957	1.53780	61.1
92	0.4	0.4	34.3	6.8	3.8	0.4	124.094	0.26224	1.53095	63.6
93	0.8	0.1	23.1	7.8	3.0	0.5	117.033	0.52978	1.56658	41.4
94	0.5	0.9	30.2	9.4	5.6	0.7	104.606	0.32124	0.97756	58.9

OBS	TOTASF	BTOASF	TOTALK	TOTALKWC	ALKRATIO	SIXFE	ALXFE	CAXFE	MGXFE	SIXAL
87	33.8	1.92308	9.7294	0.51566	11.2744	112.80	56.40	188.40	45.60	176.72
88	46.1	1.16269	3.2977	0.26282	12.9919	169.40	92.40	159.39	63.91	264.00
89	48.1	1.07277	2.8977	0.22660	11.9981	195.05	99.60	162.68	63.08	282.00
90	39.0	1.52051	7.4953	0.56065	11.7950	194.48	110.24	218.40	64.48	198.22
91	38.6	1.58290	7.8977	0.65235	13.8146	204.70	123.05	225.40	78.20	190.46
92	35.8	1.77654	2.8977	0.25181	8.1577	195.00	132.60	317.20	62.40	153.00
93	58.3	0.71012	2.6636	0.25650	9.9303	185.90	64.35	100.65	34.10	395.46
94	40.0	1.47250	4.5295	0.32114	11.3589	180.42	105.73	219.22	67.90	202.74

OBS	SIXCA	CAXMG	SIXK	ALXK	FEXK	CAXK	MGXK	SI+AL	CA+MG	FE/CA	SI/AL
87	590.32	238.64	9.40	4.70	3.00	15.70	3.80	28.2	39.0	0.19108	2.00000
88	455.40	171.81	6.60	3.60	2.31	6.21	2.49	34.0	29.0	0.37198	1.83333
89	460.60	148.96	7.05	3.60	2.49	5.88	2.28	35.5	27.2	0.42347	1.95833
90	392.70	130.20	11.22	6.36	6.24	12.60	3.72	29.3	27.2	0.49524	1.76415
91	348.88	133.28	5.34	3.21	3.45	5.88	2.04	28.5	26.4	0.58673	1.66355
92	366.00	117.12	4.50	3.06	3.90	7.32	1.44	25.2	29.2	0.53279	1.47059
93	618.54	113.46	13.52	4.68	2.20	7.32	2.48	45.5	24.5	0.30055	2.88889
94	420.36	158.20	9.30	5.45	4.85	11.30	3.50	29.5	29.6	0.42920	1.70642

OBS	SI/ALSQ	SIO2SQ	AL2O3SQ	CAOSQ	NA2OSQ	MGOSQ	FE2O3SQ	P2O5SQ	TIO2SQ	K2OSQ
87	4.0000	353.44	88.36	985.96	88.36	57.76	36.00	0.81	0.16	0.25
88	3.3611	484.00	144.00	428.49	9.61	68.89	59.29	0.01	0.25	0.09
89	3.8351	552.25	144.00	384.16	7.29	57.76	68.89	0.01	0.16	0.09
90	3.1122	349.69	112.36	441.00	50.41	38.44	108.16	1.44	0.25	0.36
91	2.7674	316.84	114.49	384.16	59.29	46.24	132.25	0.01	0.25	0.09
92	2.1626	225.00	104.04	595.36	7.29	23.04	169.00	0.09	0.09	0.09
93	8.3457	1142.44	136.89	334.89	5.76	38.44	30.25	0.01	0.36	0.16
94	2.9119	345.96	118.81	510.76	17.64	49.00	94.09	0.49	0.16	0.25

OBS	SPLNUM	SPLDESIG	RANK	STATE	ASHDRY	BTUDRY	SIO2SF	AL2O3SF	FE2O3SF
95	237	GH-7	LIGNITE	N.DAKOTA	11.13	10560	38.7	14.3	8.8
96	238	GH-8	LIGNITE	N.DAKOTA	12.24	10640	42.2	15.4	8.0
97	239	GH-8	LIGNITE	N.DAKOTA	12.43	10510	42.9	16.0	7.7
98	240	GH-8	LIGNITE	N.DAKOTA	12.26	10410	41.3	16.3	8.2
99	245	GH-9	LIGNITE	N.DAKOTA	10.66	10740	35.5	13.0	10.8
100	249	BN-5	LIGNITE	N.DAKOTA	10.72	11010	41.0	14.7	7.2
101	264	GH-10	LIGNITE	N.DAKOTA	9.93	10390	31.7	12.1	15.3
102	274	GH-10	LIGNITE	N.DAKOTA	10.17	10520	32.4	12.2	15.4

OBS	TIO2SF	P2O5SF	CAOSF	MGOSF	NA2OSF	K2OSF	DEPOWT	SIRATIO	SULDRY	TOTBSF
95	0.5	0.4	20.7	5.3	9.9	1.3	126.001	0.52581	0.58997	46.0
96	0.5	0.1	20.0	5.1	6.9	1.6	127.477	0.56032	0.97351	41.6
97	0.6	0.1	19.2	5.3	6.5	1.5	84.391	0.57098	0.92738	40.2
98	0.5	0.1	19.9	5.1	7.0	1.6	98.809	0.55429	0.95721	41.8
99	0.3	0.3	22.6	6.3	9.9	1.1	69.706	0.47176	0.85881	50.7
100	0.3	0.3	17.4	5.9	11.6	1.4	71.509	0.57323	0.60748	43.5
101	0.5	1.1	22.3	6.0	9.9	1.1	102.512	0.42097	0.81622	54.6
102	0.5	0.3	22.5	6.0	9.4	1.1	107.388	0.42419	0.84923	54.4

OBS	TOTASF	BTOASF	TOTALK	TOTALKWC	ALKRATIO	SIXFE	ALXFE	CAXFE	MGXFE	SIXAL
95	53.5	0.85981	9.0248	0.71567	11.0837	241.24	89.54	129.50	33.30	394.46
96	58.1	0.71601	6.6566	0.56914	9.9681	236.51	86.43	111.89	28.81	455.37
97	59.5	0.67563	6.3566	0.55366	10.1480	235.30	87.75	105.30	29.25	488.70
98	58.1	0.71945	6.6566	0.57979	10.0622	232.56	91.80	112.20	28.56	461.70
99	48.8	1.03893	9.2589	0.67775	11.3116	290.46	106.22	185.18	51.70	349.17
100	56.0	0.77679	11.0907	0.86064	13.6151	232.96	83.84	99.20	33.28	476.84
101	44.3	1.23251	8.4930	0.64122	10.7312	308.66	118.34	217.16	58.56	245.41
102	45.1	1.20621	8.1930	0.63824	10.5765	328.75	123.75	228.75	61.25	260.37

OBS	SIXCA	CAXMG	SIXK	ALXK	FEXK	CAXK	MGXK	SI+AL	CA+MG	FE/CA	SI/AL
95	570.50	78.75	35.86	13.31	8.14	19.25	4.95	44.7	22.0	0.42286	2.69421
96	589.51	71.81	45.89	16.77	8.71	21.71	5.59	48.2	21.0	0.40120	2.73643
97	586.44	72.90	47.06	17.55	8.45	21.06	5.85	49.7	20.7	0.40123	2.68148
98	564.30	69.30	44.46	17.55	8.84	21.45	5.46	47.7	20.7	0.41212	2.53333
99	608.73	108.35	30.90	11.30	9.40	19.70	5.50	42.2	25.2	0.47716	2.73451
100	564.20	80.60	43.68	15.72	7.68	18.60	6.24	49.5	20.7	0.41290	2.77863
101	450.34	85.44	22.77	8.73	10.98	16.02	4.32	35.0	22.6	0.68539	2.60825
102	481.29	89.67	23.67	8.91	11.25	16.47	4.41	36.2	23.2	0.68306	2.65657

OBS	SI/ALSQ	SIO2SQ	AL2O3SQ	CAOSQ	NA2OSQ	MGOSQ	FE2O3SQ	P2O5SQ	TIO2SQ	K2OSQ
95	7.2588	1062.76	146.41	306.25	68.89	20.25	54.76	0.09	0.16	1.21
96	7.4881	1246.09	166.41	278.89	33.64	18.49	44.89	0.01	0.16	1.69
97	7.1903	1310.44	182.25	262.44	30.25	20.25	42.25	0.01	0.25	1.69
98	6.4178	1169.64	182.25	272.25	33.64	17.64	46.24	0.01	0.16	1.69
99	7.4776	954.81	127.69	388.09	73.96	30.25	88.36	0.09	0.09	1.00
100	7.7208	1324.96	171.61	240.25	106.09	27.04	40.96	0.09	0.09	1.44
101	6.8030	640.09	94.09	316.84	62.41	23.04	148.84	0.81	0.16	0.81
102	7.0573	691.69	98.01	334.89	57.76	24.01	156.25	0.04	0.16	0.81

OBS	SPLNUM	SPLDESIG	RANK	STATE	ASHDRY	BTUDRY	SIO2SF	AL2O3SF	FE2O3SF
103	276	G-7	LIGNITE	N.DAKOTA	14.63	10360	40.4	14.9	8.4
104	277	G-8	LIGNITE	N.DAKOTA	12.55	10540	29.5	13.5	14.8
105	286	V-7	LIGNITE	N.DAKOTA	9.14	10920	32.3	15.3	6.4
106	298	BN-6	LIGNITE	N.DAKOTA	10.69	10940	38.3	16.6	7.3
107	302	GH-11	LIGNITE	N.DAKOTA	10.93	10640	34.7	11.8	14.3
108	323	SCA	LIGNITE	ALABAMA	20.25	9900	71.7	10.7	11.1
109	376	BY-1	LIGNITE	TEXAS	23.74	9470	55.7	18.5	7.4
110	393	GH-12	LIGNITE	N.DAKOTA	13.26	10295	46.9	15.1	6.6

OBS	TIO2SF	P2O5SF	CAOSF	MGOSF	NA2OSF	K2OSF	DEPOWT	SIRATIO	SULDRY	TOTBSF
103	0.9	0.1	23.7	8.4	2.8	0.4	145.672	0.49920	1.66252	43.7
104	0.1	0.5	27.8	9.7	3.7	0.3	103.696	0.36120	1.55848	56.3
105	0.2	0.1	34.7	8.7	1.2	0.9	31.260	0.39280	0.64720	51.9
106	0.4	0.1	18.4	5.2	12.8	0.7	140.670	0.55366	0.59701	44.4
107	0.4	0.1	24.1	6.0	7.4	1.0	109.797	0.43810	1.01844	52.8
108	0.5	0.2	5.0	0.2	0.4	0.2	8.195	0.81494	3.24823	16.9
109	1.0	0.1	13.0	2.0	1.0	1.1	480.988	0.71235	2.27090	24.5
110	0.8	0.2	17.6	4.1	7.2	1.3	280.797	0.62264	0.92357	36.8

OBS	TOTASF	BTOASF	TOTALK	TOTALKWC	ALKRATIO	SIXFE	ALXFE	CAXFE	MGXFE	SIXAL
103	56.2	0.77758	2.3977	0.22586	10.2912	202.80	74.75	118.95	42.25	358.80
104	43.1	1.30626	2.8318	0.23475	11.4596	233.28	106.92	219.24	76.68	213.84
105	47.8	1.08577	1.4612	0.09703	9.1723	136.24	65.00	146.64	36.92	327.50
106	55.3	0.80289	11.2953	0.89007	12.9045	201.50	87.42	96.72	27.28	458.25
107	46.9	1.12580	6.4271	0.51031	9.6550	314.64	107.16	218.88	54.72	259.44
108	82.9	0.20386	0.5318	0.08056	2.3538	826.03	123.17	57.63	2.26	796.79
109	75.2	0.32580	1.5589	0.22978	5.1499	367.50	122.50	86.10	13.30	918.75
110	62.8	0.58599	6.8248	0.67565	10.1700	221.76	71.68	83.44	19.60	506.88

OBS	SIXCA	CAXMG	SIXK	ALXK	FEXK	CAXK	MGXK	SI+AL	CA+MG	FE/CA	SI/AL
103	570.96	118.95	9.36	3.45	1.95	5.49	1.95	42.7	24.8	0.35519	2.71304
104	438.48	144.13	4.32	1.98	2.16	4.06	1.42	31.5	27.4	0.53202	2.18182
105	738.84	200.22	18.34	8.75	3.64	19.74	4.97	38.7	35.3	0.18440	2.09600
106	507.00	68.64	19.50	8.46	3.72	9.36	2.64	46.6	20.0	0.39744	2.30496
107	529.92	92.16	22.08	7.52	9.12	15.36	3.84	37.0	24.0	0.59375	2.93617
108	372.81	1.02	14.62	2.18	2.26	1.02	0.04	84.0	5.3	2.21569	6.70642
109	645.75	23.37	52.50	17.50	7.00	12.30	1.90	70.0	14.2	0.56911	3.00000
110	590.04	52.15	43.56	14.08	6.16	16.39	3.85	52.4	18.4	0.37584	3.09375

OBS	SI/ALSQ	SIO2SQ	AL2O3SQ	CAOSQ	NA2OSQ	MGOSQ	FE2O3SQ	P2O5SQ	TIO2SQ	K2OSQ
103	7.3606	973.44	132.25	334.89	4.84	42.25	42.25	0.01	0.49	0.09
104	4.7603	466.56	98.01	412.09	7.29	50.41	116.64	0.16	0.01	0.04
105	4.3932	686.44	156.25	795.24	1.00	50.41	27.04	0.01	0.04	0.49
106	5.3129	1056.25	198.81	243.36	118.81	19.36	38.44	0.01	0.09	0.36
107	8.6211	761.76	88.36	368.64	34.81	23.04	129.96	0.01	0.09	0.64
108	44.9761	5343.61	118.81	26.01	0.16	0.04	127.69	0.04	0.25	0.04
109	9.0000	2756.25	306.25	151.29	0.81	3.61	49.00	0.01	0.81	1.00
110	9.5713	1568.16	163.84	222.01	37.21	12.25	31.36	0.04	0.49	1.21

OBS	SPLNUM	SPLDESIG	RANK	STATE	ASHDRY	BTUDRY	SIO2SF	AL2O3SF	FE2O3SF
111	410	FC	LIGNITE	TEXAS	30.61	8547	68.5	13.0	10.1
112	413	RW	LIGNITE	N.DAKOTA	11.46	10421	38.6	15.2	6.0
113	421	HC	LIGNITE	TEXAS	10.49	11254	34.3	17.8	19.1
114	429	B-9	LIGNITE	N.DAKOTA	13.07	10452	35.3	14.2	14.3
115	431	B-9	LIGNITE	N.DAKOTA	13.57	10402	39.3	13.2	14.4
116	432	B-9	LIGNITE	N.DAKOTA	13.05	10475	37.8	13.4	14.5
117	441	Z-5	LIGNITE	N.DAKOTA	10.04	10506	28.7	12.7	15.0
118	442	Z-5	LIGNITE	N.DAKOTA	10.86	10054	30.7	13.1	15.2

OBS	TIO2SF	P2O5SF	CAOSF	MGOSF	NA2OSF	K2OSF	DEPOWT	SIRATIO	SULDRY	TOTBSF
111	1.3	0.1	4.0	1.7	0.2	0.9	17.293	0.81196	1.73675	16.9
112	0.7	0.7	23.1	6.2	8.4	1.1	176.356	0.52248	0.60411	44.8
113	1.4	0.6	21.1	4.1	1.0	0.4	44.902	0.43602	1.34439	45.7
114	0.6	0.5	20.9	5.9	6.8	1.3	237.800	0.46129	1.20879	49.2
115	0.6	0.5	19.9	5.5	5.2	1.2	121.206	0.49593	1.31707	46.2
116	0.6	0.5	20.7	6.0	5.1	1.2	170.850	0.47805	1.31324	47.5
117	0.6	0.5	23.5	6.8	11.4	0.6	117.941	0.38715	0.96004	57.3
118	0.6	0.5	23.8	6.2	9.1	0.6	119.379	0.40394	0.88532	54.9

OBS	TOTASF	BTOASF	TOTALK	TOTALKWC	ALKRATIO	SIXFE	ALXFE	CAXFE	MGXFE	SIXAL
111	82.8	0.20411	0.7930	0.18588	7.7692	632.44	120.28	36.86	15.52	808.48
112	54.5	0.82202	7.9589	0.67969	10.7269	175.24	69.16	105.04	28.08	448.21
113	53.5	0.85421	0.9977	0.07313	4.7282	425.04	220.22	261.80	50.82	394.68
114	50.1	0.98204	6.0589	0.57681	10.6882	319.20	128.82	189.24	53.58	316.40
115	53.1	0.87006	4.5930	0.44966	9.5852	341.60	115.36	173.60	48.16	314.15
116	51.8	0.91699	4.5930	0.43358	9.7138	332.22	117.52	181.93	53.11	305.76
117	42.0	1.36429	9.2294	0.71436	11.8394	260.91	115.83	214.11	62.01	220.77
118	44.4	1.23649	7.6295	0.59891	10.5328	300.12	128.10	233.02	61.00	258.30

OBS	SIXCA	CAXMG	SIXK	ALXK	FEXK	CAXK	MGXK	SI+AL	CA+MG	FE/CA	SI/AL
111	247.76	6.08	58.68	11.16	8.73	3.42	1.44	77.6	5.4	2.55263	5.25806
112	680.74	109.08	33.70	13.30	5.20	20.20	5.40	47.0	25.6	0.25743	2.53383
113	469.20	56.10	8.28	4.29	4.62	5.10	0.99	41.9	20.3	0.90588	1.93007
114	464.80	78.02	28.00	11.30	11.40	16.60	4.70	39.3	21.3	0.68675	2.47788
115	472.75	66.65	27.45	9.27	10.08	13.95	3.87	40.8	19.8	0.72258	2.96117
116	473.34	75.67	26.46	9.36	10.17	14.49	4.23	39.8	20.8	0.70186	2.82692
117	408.09	96.99	11.15	4.95	5.85	9.15	2.65	32.2	23.6	0.63934	2.25253
118	469.86	95.50	12.30	5.25	6.10	9.55	2.50	35.1	24.1	0.63874	2.34286

OBS	SI/ALSQ	SIO2SQ	AL2O3SQ	CAOSQ	NA2OSQ	MGOSQ	FE2O3SQ	P2O5SQ	TIO2SQ	K2OSQ
111	27.6472	4251.04	153.76	14.44	0.04	2.56	94.09	0.01	1.44	0.81
112	6.4203	1135.69	176.89	408.04	53.29	29.16	27.04	0.36	0.36	1.00
113	3.7252	761.76	204.49	289.00	0.64	10.89	237.16	0.25	1.21	0.09
114	6.1399	784.00	127.69	275.56	29.16	22.09	129.96	0.16	0.25	1.00
115	8.7685	930.25	106.09	240.25	16.00	18.49	125.44	0.16	0.25	0.81
116	7.9915	864.36	108.16	259.21	16.00	22.09	127.69	0.16	0.25	0.81
117	5.0739	497.29	98.01	334.89	79.21	28.09	136.89	0.16	0.25	0.25
118	5.4890	605.16	110.25	364.81	53.29	25.00	148.84	0.16	0.25	0.25

OBS	SPLNUM	SPLDESIG	RANK	STATE	ASHDRY	BTUDRY	SIO2SF	AL2O3SF	FE2O3SF
119	443	Z-5	LIGNITE	N.DAKOTA	11.31	10105	31.4	13.2	15.4
120	458	CCA-1	LIGNITE	ALABAMA	20.59	9593	50.2	10.0	22.1
121	459	CCA-1	LIGNITE	ALABAMA	12.69	10689	23.9	20.7	20.0
122	461	CCA-2	LIGNITE	ALABAMA	27.57	8398	50.0	18.0	19.5
123	464	B-CPC	LIGNITE	N.DAKOTA	10.73	10713	22.3	14.9	12.2
124	525	B-10	LIGNITE	N.DAKOTA	17.24	10426	39.2	20.1	12.0
125	527	SM-1	LIGNITE	TEXAS	23.15	9007	53.7	18.3	8.0
126	532	SM-1	LIGNITE	TEXAS	22.60	9131	54.4	18.4	7.4

OBS	TIO2SF	P2O5SF	CAOSF	MGOSF	NA2OSF	K2OSF	DEPOWT	SIRATIO	SULDRY	TOTBSF
119	0.6	0.4	22.7	6.1	9.3	0.8	145.882	0.41569	0.90784	54.3
120	0.6	0.1	13.1	2.0	1.0	0.7	167.698	0.57364	3.88032	38.9
121	0.6	0.3	27.8	4.1	2.0	0.4	94.017	0.31481	3.01457	54.3
122	0.9	0.1	7.0	2.3	0.4	1.7	233.120	0.63438	4.12999	30.9
123	0.5	1.0	27.7	7.1	13.7	0.5	176.377	0.32213	1.41143	61.2
124	1.6	1.1	20.1	3.5	1.5	0.7	78.095	0.52366	2.56837	37.8
125	0.9	0.6	9.3	1.5	5.3	2.3	276.794	0.74086	3.24324	26.4
126	1.0	0.6	8.9	1.8	5.0	2.4	773.778	0.74961	2.97129	25.5

OBS	TOTASF	BTOASF	TOTALK	TOTALKWC	ALKRATIO	SIXFE	ALXFE	CAXFE	MGXFE	SIXAL
119	45.2	1.20133	7.7953	0.64078	10.9963	303.78	128.10	219.60	58.56	261.45
120	60.8	0.63980	1.2953	0.17111	4.2968	870.24	172.48	227.36	35.28	390.72
121	45.2	1.20133	1.7977	0.15819	5.1333	293.59	254.34	342.26	50.24	302.94
122	68.9	0.44848	1.4542	0.29608	8.2878	846.30	305.76	118.30	38.22	781.20
123	37.7	1.62334	10.2636	0.78003	12.5345	145.07	97.01	179.78	46.28	177.67
124	60.9	0.62069	1.6953	0.24582	5.1822	360.15	184.80	184.80	32.55	603.68
125	72.9	0.36214	5.9178	1.16581	18.4660	321.54	109.71	55.89	8.97	740.94
126	73.8	0.34553	5.7837	1.04685	18.5128	309.40	104.65	50.70	10.40	766.36

OBS	SIXCA	CAXMG	SIXK	ALXK	FEXK	CAXK	MGXK	SI+AL	CA+MG	FE/CA	SI/AL
119	448.20	86.40	14.94	6.30	7.32	10.80	2.88	35.4	22.8	0.67778	2.37143
120	515.04	20.88	26.64	5.28	11.76	6.96	1.08	53.2	13.4	1.68966	5.04545
121	407.66	69.76	5.61	4.86	4.71	6.54	0.96	34.9	25.0	0.72018	1.15432
122	302.25	13.65	74.40	26.88	29.12	10.40	3.36	63.3	8.6	2.80000	2.76786
123	329.26	105.04	6.52	4.36	3.56	8.08	2.08	27.2	25.4	0.44059	1.49541
124	603.68	54.56	20.58	10.56	6.30	10.56	1.86	51.9	20.7	0.59659	1.94886
125	377.46	10.53	93.20	31.80	13.80	16.20	2.60	62.5	9.4	0.85185	2.93082
126	371.28	12.48	99.96	33.81	13.65	16.38	3.36	63.7	9.4	0.83333	2.95652

OBS	SI/ALSQ	SIO2SQ	AL2O3SQ	CAOSQ	NA2OSQ	MGOSQ	FE2O3SQ	P2O5SQ	TIO2SQ	K2OSQ
119	5.6237	620.01	110.25	324.00	54.76	23.04	148.84	0.09	0.25	0.36
120	25.4566	1971.36	77.44	134.56	0.81	3.24	384.16	0.01	0.25	0.36
121	1.3325	349.69	262.44	475.24	2.56	10.24	246.49	0.04	0.25	0.09
122	7.6610	2162.25	282.24	42.25	0.16	4.41	331.24	0.01	0.64	2.56
123	2.2363	265.69	118.81	408.04	100.00	27.04	79.21	0.49	0.16	0.16
124	3.7981	1176.49	309.76	309.76	1.69	9.61	110.25	1.00	1.96	0.36
125	8.5897	2171.56	252.81	65.61	21.16	1.69	47.61	0.25	0.64	4.00
126	8.7410	2265.76	259.21	60.84	19.36	2.56	42.25	0.25	0.81	4.41

APPENDIX I, cont

BSTD subset, data list

OBS	SPLNUM	SPLDESIG	RANK	STATE	ASHDRY	BTUDRY	SIO2SF	AL2O3SF
1	34	B-STD-1	LIGNITE	N.DAKOTA	10.62	10430	25.2	14.9
2	36	B-STD-1	LIGNITE	N.DAKOTA	10.28	10400	25.2	14.8
3	38	B-STD-1	LIGNITE	N.DAKOTA	11.06	10650	24.0	14.5
4	40	B-STD-1	LIGNITE	N.DAKOTA	10.88	10650	24.4	14.5
5	43	B-STD-1	LIGNITE	N.DAKOTA	11.04	10670	25.3	14.4
6	44	B-STD-1	LIGNITE	N.DAKOTA	11.12	10590	25.2	13.7

OBS	FE2O3SF	TIO2SF	P2O5SF	CAOSF	MGOSF	NA2OSF	K2OSF	DEPOWT	SIRATIO
1	13.0	0.5	0.6	27.3	10.1	8.0	0.4	106.377	0.33333
2	12.8	0.4	0.7	27.2	10.3	8.3	0.4	140.359	0.33333
3	12.9	0.5	0.7	27.8	10.4	8.7	0.4	150.060	0.31930
4	13.7	0.5	0.7	33.3	10.7	1.9	0.4	62.619	0.29725
5	12.8	0.5	0.7	27.4	10.0	8.5	0.4	133.302	0.33450
6	12.8	0.5	0.8	36.1	9.8	0.8	0.3	47.890	0.30079

OBS	SITOAL	SULDRY	TOTBSF	TOTASF	BTOASF	TOTALK	TOTALKWC	ALKRATIO
1	1.69565	1.01053	58.8	40.6	1.44828	6.39767	0.48430	13.3146
2	1.70175	0.98177	59.0	40.4	1.46040	6.59767	0.48361	13.5365
3	1.65455	1.01677	60.2	39.0	1.54359	6.79767	0.56964	13.9661
4	1.68807	1.14302	60.0	39.4	1.52284	1.59767	0.12174	11.4069
5	1.75229	1.09640	59.1	40.2	1.47015	6.59767	0.51198	13.5310
6	1.83654	1.04939	59.8	39.4	1.51777	0.73178	0.05818	10.1073

OBS	SIXFE	ALXFE	CAXFE	MGXFE	SIXAL	SIXCA	CAXMG	SIXK	ALXK	FEXK
1	196.95	116.15	213.11	78.78	224.25	411.45	164.58	5.85	3.45	3.03
2	192.06	112.86	207.90	78.21	221.16	407.40	165.90	5.82	3.42	2.97
3	178.36	107.80	206.78	77.42	200.20	384.02	166.69	5.46	3.30	2.94
4	189.52	112.27	258.53	83.43	200.56	461.84	203.31	5.52	3.27	3.09
5	185.27	105.73	200.79	73.72	208.19	395.37	157.32	5.73	3.27	2.91
6	185.27	100.88	264.81	71.78	198.64	521.43	202.02	3.82	2.08	1.94

OBS	CAXK	MGXK	SI+AL	CA+MG	FE/CA	SI/AL	SI/ALSQ	SIO2SQ	AL2O3SQ
1	6.33	2.34	31.0	28.9	0.47867	1.69565	2.87524	380.25	132.25
2	6.30	2.37	30.8	28.9	0.47143	1.70175	2.89597	376.36	129.96
3	6.33	2.37	29.2	29.0	0.46445	1.65455	2.73752	331.24	121.00
4	7.53	2.43	29.3	33.2	0.41036	1.68807	2.84959	338.56	118.81
5	6.21	2.28	30.0	28.3	0.46860	1.75229	3.07053	364.81	118.81
6	5.46	1.48	29.5	34.7	0.35531	1.83654	3.37287	364.81	108.16

OBS	CAOSQ	NA2OSQ	MGOSQ	FE2O3SQ	P2O4SQ	TIO2SQ	K2OSQ
1	445.21	38.44	60.84	102.01	0.25	0.16	0.09
2	441.00	40.96	62.41	98.01	0.25	0.09	0.09
3	445.21	43.56	62.41	96.04	0.25	0.16	0.09
4	630.01	1.96	65.61	106.09	0.25	0.16	0.09
5	428.49	40.96	57.76	94.09	0.25	0.16	0.09
6	745.29	0.36	54.76	94.09	0.36	0.16	0.04

OBS	SPLNUM	SPLDESIG	RANK	STATE	ASHDRY	BTUDRY	SIO2SF	AL2O3SF
7	48	B-STD-1	LIGNITE	N.DAKOTA	10.82	10670	25.5	14.5
8	49	B-STD-1	LIGNITE	N.DAKOTA	10.74	10640	25.8	14.6
9	53	B-STD-1	LIGNITE	N.DAKOTA	10.92	10680	26.5	13.9
10	55	B-STD-1	LIGNITE	N.DAKOTA	10.81	10650	24.8	14.7
11	56	B-STD-1	LIGNITE	N.DAKOTA	11.56	10630	25.3	14.5
12	59	B-STD-1	LIGNITE	N.DAKOTA	11.03	10460	24.9	14.4

OBS	FE2O3SF	TIO2SF	P2O5SF	CAOSF	MGOSF	NA2OSF	K2OSF	DEPOWT	SIRATIO
7	12.9	0.7	0.7	27.1	9.8	8.6	0.4	90.179	0.33910
8	13.2	0.4	0.5	27.3	9.7	8.1	0.4	104.113	0.33907
9	12.5	0.5	0.5	27.3	10.0	8.4	0.4	122.469	0.34783
10	12.4	0.6	0.6	27.4	9.9	9.2	0.3	202.806	0.33333
11	13.1	0.5	0.5	27.0	9.4	9.2	0.4	204.999	0.33731
12	13.0	0.6	0.5	27.6	10.1	8.5	0.4	194.669	0.32997

OBS	SITOAL	SULDRY	TOTBSF	TOTASF	BTOASF	TOTALK	TOTALKWC	ALKRATIO
7	1.76577	1.13144	58.8	40.7	1.44472	6.79767	0.52682	13.3389
8	1.75893	1.03801	58.7	40.8	1.43873	6.39767	0.49006	12.9903
9	1.90826	1.04439	58.6	40.9	1.43276	6.79767	0.59684	13.4654
10	1.68696	1.07064	59.2	40.1	1.47631	7.33178	0.68039	13.6076
11	1.73684	1.04083	59.1	40.3	1.46650	7.39767	0.74790	13.4518
12	1.73451	1.02204	59.6	39.9	1.49373	6.89767	0.61803	13.6023

OBS	SIXFE	ALXFE	CAXFE	MGXFE	SIXAL	SIXCA	CAXMG	SIXK	ALXK	FEXK
7	194.04	109.89	205.92	74.25	217.56	407.68	156.00	5.88	3.33	2.97
8	198.97	113.12	211.09	74.74	220.64	411.73	154.66	5.91	3.36	3.03
9	203.84	106.82	209.72	76.44	226.72	445.12	166.92	6.24	3.27	2.94
10	188.18	111.55	207.58	74.69	223.10	415.16	164.78	3.88	2.30	1.94
11	203.94	117.42	218.36	76.22	225.72	419.76	156.88	5.94	3.42	3.09
12	199.92	115.26	221.34	80.58	221.48	425.32	171.43	5.88	3.39	3.06

OBS	CAXK	MGXK	SI+AL	CA+MG	FE/CA	SI/AL	SI/ALSQ	SIO2SQ	AL2O3SQ
7	6.24	2.25	30.7	28.3	0.47596	1.76577	3.11793	384.16	123.21
8	6.27	2.22	30.9	28.3	0.48325	1.75893	3.09383	388.09	125.44
9	6.42	2.34	31.7	29.2	0.45794	1.90826	3.64144	432.64	118.81
10	4.28	1.54	30.9	29.1	0.45327	1.68696	2.84582	376.36	132.25
11	6.36	2.22	31.2	28.6	0.48585	1.73684	3.01662	392.04	129.96
12	6.51	2.37	30.9	29.6	0.47005	1.73451	3.00854	384.16	127.69

OBS	CAOSQ	NA2OSQ	MGOSQ	FE2O3SQ	P2O4SQ	TIO2SQ	K2OSQ
7	432.64	43.56	56.25	98.01	0.25	0.25	0.09
8	436.81	38.44	54.76	102.01	0.16	0.09	0.09
9	457.96	43.56	60.84	96.04	0.16	0.16	0.09
10	457.96	51.84	59.29	94.09	0.25	0.25	0.04
11	449.44	51.84	54.76	106.09	0.16	0.16	0.09
12	470.89	44.89	62.41	104.04	0.16	0.25	0.09

OBS	SPLNUM	SPLDESIG	RANK	STATE	ASHDRY	BTUDRY	SIO2SF	AL2O3SF
13	62	B-STD-1	LIGNITE	N.DAKOTA	10.95	10640	26.2	14.4
14	63	B-STD-1	LIGNITE	N.DAKOTA	10.81	10560	25.8	14.9
15	64	B-STD-1	LIGNITE	N.DAKOTA	11.07	10550	26.7	14.6
16	67	B-STD-1	LIGNITE	N.DAKOTA	11.16	10650	25.6	14.4
17	71	B-STD-1	LIGNITE	N.DAKOTA	11.16	10610	26.2	14.7
18	72	B-STD-1	LIGNITE	N.DAKOTA	10.86	10570	26.3	14.8

OBS	FE2O3SF	TIO2SF	P2O5SF	CAOSF	MGOSF	NA2OSF	K2OSF	DEPOWT	SIRATIO
13	12.8	0.8	0.5	26.8	9.8	8.3	0.4	109.967	0.34622
14	12.6	0.6	0.5	27.1	9.8	8.3	0.4	146.313	0.34251
15	12.4	0.5	0.6	26.6	9.6	8.5	0.4	205.243	0.35506
16	13.3	0.7	0.7	27.1	9.5	8.4	0.4	151.393	0.33910
17	12.4	0.6	0.5	27.1	9.7	8.3	0.4	136.209	0.34760
18	12.3	0.6	0.5	26.8	9.7	8.5	0.4	146.969	0.35000

OBS	SITOAL	SULDRY	TOTBSF	TOTASF	BTOASF	TOTALK	TOTALKWC	ALKRATIO
13	1.82301	1.06104	58.1	41.4	1.40338	6.79767	0.54041	13.2989
14	1.73043	1.05148	58.2	41.3	1.40920	6.59767	0.52254	13.2160
15	1.83186	1.04109	57.5	41.8	1.37560	6.79767	0.54177	13.2471
16	1.78182	1.13952	58.7	40.7	1.44226	6.59767	0.52979	13.0677
17	1.78070	1.03903	57.9	41.5	1.39518	6.59767	0.52451	13.2266
18	1.78070	1.08116	57.7	41.7	1.38369	6.79767	0.52614	13.2512

OBS	SIXFE	ALXFE	CAXFE	MGXFE	SIXAL	SIXCA	CAXMG	SIXK	ALXK	FEXK
13	208.06	114.13	213.11	77.77	232.78	434.66	162.47	6.18	3.39	3.03
14	193.03	111.55	202.73	73.72	228.85	415.91	158.84	5.97	3.45	2.91
15	198.72	108.48	197.76	71.04	233.91	426.42	152.44	6.21	3.39	2.88
16	199.92	112.20	211.14	74.46	215.60	405.72	151.11	5.88	3.30	3.06
17	194.88	109.44	201.60	72.00	231.42	426.30	157.50	6.09	3.42	2.88
18	192.85	108.30	196.65	71.25	231.42	420.21	155.25	6.09	3.42	2.85

OBS	CAXK	MGXK	SI+AL	CA+MG	FE/CA	SI/AL	SI/ALSQ	SIO2SQ	AL2O3SQ
13	6.33	2.31	31.9	28.8	0.47867	1.82301	3.32336	424.36	127.69
14	6.27	2.28	31.4	28.5	0.46411	1.73043	2.99440	396.01	132.25
15	6.18	2.22	32.0	28.0	0.46602	1.83186	3.35571	428.49	127.69
16	6.21	2.19	30.6	28.0	0.49275	1.78182	3.17488	384.16	121.00
17	6.30	2.25	31.7	28.5	0.45714	1.78070	3.17090	412.09	129.96
18	6.21	2.25	31.7	28.2	0.45894	1.78070	3.17090	412.09	129.96

OBS	CAOSQ	NA2OSQ	MGOSQ	FE2O3SQ	P2O4SQ	TIO2SQ	K2OSQ
13	445.21	43.56	59.29	102.01	0.16	0.36	0.09
14	436.81	40.96	57.76	94.09	0.16	0.25	0.09
15	424.36	43.56	54.76	92.16	0.25	0.16	0.09
16	428.49	40.96	53.29	104.04	0.25	0.25	0.09
17	441.00	40.96	56.25	92.16	0.16	0.25	0.09
18	428.49	43.56	56.25	90.25	0.16	0.25	0.09

OBS	SPLNUM	SPLDESIG	RANK	STATE	ASHDRY	BTUDRY	SIO2SF	AL2O3SF
19	73	B-STD-1	LIGNITE	N.DAKOTA	10.75	10660	27.2	15.5
20	74	B-STD-1	LIGNITE	N.DAKOTA	10.74	10630	26.5	14.7
21	75	B-STD-1	LIGNITE	N.DAKOTA	10.47	10650	26.1	14.4
22	76	B-STD-1	LIGNITE	N.DAKOTA	10.96	10560	28.1	15.4
23	77	B-STD-1	LIGNITE	N.DAKOTA	10.94	10630	27.2	14.2
24	80	B-STD-1	LIGNITE	N.DAKOTA	10.82	10610	26.8	14.6

OBS	FE2O3SF	TIO2SF	P2O5SF	CAOSF	MGOSF	NA2OSF	K2OSF	DEPOWT	SIRATIO
19	11.6	0.6	0.6	26.5	9.4	8.2	0.4	124.296	0.36455
20	12.3	0.6	0.6	26.8	9.6	8.5	0.4	167.925	0.35185
21	12.0	0.6	0.5	27.3	9.8	8.9	0.4	164.430	0.34760
22	11.9	0.5	0.6	24.2	10.3	8.6	0.4	152.444	0.37667
23	12.2	0.5	0.5	26.9	9.8	8.4	0.4	140.494	0.35726
24	11.9	0.5	0.5	27.8	9.8	7.6	0.4	170.819	0.35108

OBS	SITOAL	SULDRY	TOTBSF	TOTASF	BTOASF	TOTALK	TOTALKWC	ALKRATIO
19	1.75806	1.01742	56.1	43.3	1.29561	6.79767	0.52410	12.8333
20	1.80172	1.07618	57.6	41.8	1.37799	6.89767	0.52284	13.1120
21	1.81250	0.99789	58.4	41.1	1.42092	7.09767	0.52878	13.3144
22	1.82258	1.05537	55.4	44.0	1.25909	7.09767	0.56781	14.3143
23	1.91071	1.02831	57.7	41.9	1.37709	6.79767	0.52818	13.3234
24	1.83478	0.97293	57.5	41.9	1.37232	6.19767	0.47536	12.8606

OBS	SIXFE	ALXFE	CAXFE	MGXFE	SIXAL	SIXCA	CAXMG	SIXK	ALXK	FEXK
19	202.74	115.32	197.16	69.75	270.32	462.16	159.00	6.54	3.72	2.79
20	202.73	112.52	205.64	73.72	242.44	443.08	161.12	6.27	3.48	2.91
21	188.79	104.16	197.16	70.68	227.36	430.36	161.12	6.09	3.36	2.79
22	216.96	119.04	187.20	79.68	280.24	440.70	161.85	6.78	3.72	2.88
23	205.44	107.52	203.52	73.92	239.68	453.68	163.24	6.42	3.36	2.88
24	198.34	108.10	205.86	72.38	242.65	462.09	168.63	6.33	3.45	2.82

OBS	CAXK	MGXK	SI+AL	CA+MG	FE/CA	SI/AL	SI/ALSQ	SIO2SQ	AL2O3SQ
19	6.36	2.25	34.2	28.7	0.43868	1.75806	3.09079	475.24	153.76
20	6.36	2.28	32.5	28.8	0.45755	1.80172	3.24621	436.81	134.56
21	6.36	2.28	31.5	28.8	0.43868	1.81250	3.28516	412.09	125.44
22	5.85	2.49	35.0	27.8	0.49231	1.82258	3.32180	510.76	153.76
23	6.36	2.31	32.6	28.9	0.45283	1.91071	3.65083	457.96	125.44
24	6.57	2.31	32.6	29.6	0.42922	1.83478	3.36643	445.21	132.25

OBS	CAOSQ	NA2OSQ	MGOSQ	FE2O3SQ	P2O4SQ	TIO2SQ	K2OSQ
19	449.44	43.56	56.25	86.49	0.25	0.25	0.09
20	449.44	44.89	57.76	94.09	0.25	0.25	0.09
21	449.44	47.61	57.76	86.49	0.16	0.25	0.09
22	380.25	47.61	68.89	92.16	0.25	0.16	0.09
23	449.44	43.56	59.29	92.16	0.16	0.16	0.09
24	479.61	36.00	59.29	88.36	0.16	0.16	0.09

OBS	SPLNUM	SPLDESIG	RANK	STATE	ASHDRY	BTUDRY	SIO2SF	AL2O3SF
25	87	B-STD-1	LIGNITE	N.DAKOTA	11.00	10690	25.6	15.0
26	88	B-STD-1	LIGNITE	N.DAKOTA	11.06	10630	26.0	14.7
27	89	B-STD-1	LIGNITE	N.DAKOTA	10.93	10670	26.0	14.6
28	90	B-STD-1	LIGNITE	N.DAKOTA	11.08	10560	27.0	14.8
29	113	B-STD-1	LIGNITE	N.DAKOTA	10.70	10480	25.7	14.4
30	114	B-STD-1	LIGNITE	N.DAKOTA	10.68	10490	25.2	13.7

OBS	FE2O3SF	TIO2SF	P2O5SF	CAOSF	MGOSF	NA2OSF	K2OSF	DEPOWT	SIRATIO
25	12.5	0.5	0.5	28.1	8.6	8.7	0.4	201.181	0.34215
26	12.3	0.5	0.5	27.2	9.8	8.6	0.4	170.857	0.34471
27	12.6	0.6	0.5	27.1	9.7	8.5	0.4	175.400	0.34530
28	12.0	0.4	0.5	27.0	9.4	8.5	0.4	128.051	0.35811
29	11.8	0.5	0.6	28.5	10.4	7.6	0.4	101.575	0.33611
30	12.2	0.6	0.6	28.8	11.4	7.1	0.4	189.833	0.32450

OBS	SITOAL	SULDRY	TOTBSF	TOTASF	BTOASF	TOTALK	TOTALKWC	ALKRATIO
25	1.70175	1.01488	58.3	41.1	1.41849	6.79767	0.53770	12.1089
26	1.77193	1.04661	58.3	41.2	1.41505	6.89767	0.54699	13.4041
27	1.78761	1.07616	58.3	41.2	1.41505	6.79767	0.53838	13.2345
28	1.82759	0.99324	57.3	42.2	1.35782	6.89767	0.55388	12.9963
29	1.78761	0.97224	58.7	40.6	1.44581	6.19767	0.47040	13.3523
30	1.83178	1.04573	59.9	39.5	1.51646	5.69767	0.43644	14.1307

OBS	SIXFE	ALXFE	CAXFE	MGXFE	SIXAL	SIXCA	CAXMG	SIXK	ALXK	FEXK
25	184.30	108.30	202.35	61.75	221.16	413.22	138.45	5.82	3.42	2.85
26	193.92	109.44	203.52	72.96	230.28	428.24	161.12	6.06	3.42	2.88
27	197.96	110.74	205.80	73.50	228.26	424.20	157.50	6.06	3.39	2.94
28	199.28	109.04	199.28	69.56	245.92	449.44	156.88	6.36	3.48	2.82
29	187.86	105.09	208.32	76.26	228.26	452.48	183.68	6.06	3.39	2.79
30	186.20	101.65	212.80	84.55	209.72	439.04	199.36	5.88	3.21	2.85

OBS	CAXK	MGXK	SI+AL	CA+MG	FE/CA	SI/AL	SI/ALSQ	SIO2SQ	AL2O3SQ
25	6.39	1.95	30.8	27.8	0.44601	1.70175	2.89597	376.36	129.96
26	6.36	2.28	31.6	28.8	0.45283	1.77193	3.13974	408.04	129.96
27	6.30	2.25	31.5	28.5	0.46667	1.78761	3.19555	408.04	127.69
28	6.36	2.22	32.8	28.6	0.44340	1.82759	3.34007	449.44	134.56
29	6.72	2.46	31.5	30.6	0.41518	1.78761	3.19555	408.04	127.69
30	6.72	2.67	30.3	31.3	0.42411	1.83178	3.35540	384.16	114.49

OBS	CAOSQ	NA2OSQ	MGOSQ	FE2O3SQ	P2O4SQ	TIO2SQ	K2OSQ
25	453.69	43.56	42.25	90.25	0.16	0.16	0.09
26	449.44	44.89	57.76	92.16	0.16	0.16	0.09
27	441.00	43.56	56.25	96.04	0.16	0.25	0.09
28	449.44	44.89	54.76	88.36	0.16	0.09	0.09
29	501.76	36.00	67.24	86.49	0.25	0.16	0.09
30	501.76	30.25	79.21	90.25	0.25	0.25	0.09

OBS	SPLNUM	SPLDESIG	RANK	STATE	ASHDRY	BTUDRY	SIO2SF	AL2O3SF
31	115	B-STD-1	LIGNITE	N.DAKOTA	10.65	10670	25.7	14.1
32	116	B-STD-1	LIGNITE	N.DAKOTA	10.50	10610	20.3	18.3
33	119	B-STD-1	LIGNITE	N.DAKOTA	10.84	10650	25.2	13.8
34	120	B-STD-1	LIGNITE	N.DAKOTA	10.78	10580	26.3	14.4
35	121	B-STD-1	LIGNITE	N.DAKOTA	10.91	10640	24.2	14.4
36	128	B-STD-1	LIGNITE	N.DAKOTA	10.24	10350	25.2	13.9

OBS	FE2O3SF	TIO2SF	P2O5SF	CAOSF	MGOSF	NA2OSF	K2OSF	DEPOWT	SIRATIO
31	12.6	0.5	0.4	27.5	10.0	8.7	0.3	97.979	0.33854
32	12.9	0.6	0.5	28.5	10.0	8.5	0.3	111.056	0.28342
33	14.2	0.5	0.5	27.1	9.9	8.3	0.3	109.626	0.33051
34	12.1	0.7	0.7	27.5	9.8	8.1	0.4	101.002	0.34768
35	12.8	0.5	0.7	28.5	10.3	8.0	0.5	121.276	0.31922
36	12.3	0.5	0.6	28.0	10.0	8.6	0.7	75.210	0.33443

OBS	SITOAL	SULDRY	TOTBSF	TOTASF	BTOASF	TOTALK	TOTALKWC	ALKRATIO
31	1.82243	0.97334	59.1	40.3	1.46650	6.73178	0.50825	13.4458
32	1.11189	1.07705	60.2	39.2	1.53571	6.73178	0.51162	13.2044
33	1.82243	1.08939	59.8	39.5	1.51392	6.53178	0.50687	13.2991
34	1.81982	1.00742	57.9	41.4	1.39855	6.39767	0.49262	13.0785
35	1.67593	1.02687	60.1	39.1	1.53708	6.26356	0.48543	13.4886
36	1.81250	0.95472	59.6	39.6	1.50505	7.29534	0.54788	13.3138

OBS	SIXFE	ALXFE	CAXFE	MGXFE	SIXAL	SIXCA	CAXMG	SIXK	ALXK	FEXK
31	187.20	102.72	200.64	72.96	208.65	407.55	158.84	3.90	2.14	1.92
32	160.59	144.43	225.23	78.78	227.37	354.57	173.94	3.18	2.86	2.02
33	214.50	117.70	229.90	83.60	208.65	407.55	158.84	3.90	2.14	2.20
34	187.86	103.23	196.23	69.75	224.22	426.22	158.25	6.06	3.33	2.79
35	173.76	103.68	204.48	73.92	195.48	385.53	164.01	7.24	4.32	3.84
36	200.97	110.88	222.75	79.20	227.36	456.75	180.00	12.18	6.72	5.94

OBS	CAXK	MGXK	SI+AL	CA+MG	FE/CA	SI/AL	SI/ALSQ	SIO2SQ	AL2O3SQ
31	4.18	1.52	30.2	28.5	0.45933	1.82243	3.32125	380.25	114.49
32	4.46	1.56	30.2	30.1	0.45291	1.11189	1.23630	252.81	204.49
33	4.18	1.52	30.2	28.5	0.52632	1.82243	3.32125	380.25	114.49
34	6.33	2.25	31.3	28.6	0.44076	1.81982	3.31174	408.04	123.21
35	8.52	3.08	28.9	29.0	0.45070	1.67593	2.80873	327.61	116.64
36	13.50	4.80	31.5	30.5	0.44000	1.81250	3.28516	412.09	125.44

OBS	CAOSQ	NA2OSQ	MGOSQ	FE2O3SQ	P2O4SQ	TIO2SQ	K2OSQ
31	436.81	43.56	57.76	92.16	0.09	0.16	0.04
32	497.29	43.56	60.84	102.01	0.16	0.25	0.04
33	436.81	40.96	57.76	121.00	0.16	0.16	0.04
34	445.21	38.44	56.25	86.49	0.25	0.25	0.09
35	453.69	36.00	59.29	92.16	0.25	0.16	0.16
36	506.25	47.61	64.00	98.01	0.25	0.16	0.36

OBS	SPLNUM	SPLDESIG	RANK	STATE	ASHDRY	BTUDRY	SIO2SF	AL2O3SF
37	129	B-STD-1	LIGNITE	N.DAKOTA	10.28	10350	24.8	13.7
38	130	B-STD-1	LIGNITE	N.DAKOTA	10.50	10380	25.7	13.9
39	131	B-STD-1	LIGNITE	N.DAKOTA	10.76	10430	25.2	13.9
40	132	B-STD-1	LIGNITE	N.DAKOTA	10.90	10590	25.5	14.3
41	133	B-STD-1	LIGNITE	N.DAKOTA	10.83	10460	25.3	14.0
42	134	B-STD-1	LIGNITE	N.DAKOTA	10.57	10550	24.8	14.1

OBS	FE2O3SF	TIO2SF	P2O5SF	CAOSF	MGOSF	NA2OSF	K2OSF	DEPOWT	SIRATIO
37	12.7	0.6	0.6	28.0	10.3	8.5	0.8	129.434	0.32712
38	12.2	0.6	0.6	27.7	9.8	8.5	0.8	167.296	0.34060
39	12.6	1.1	0.6	30.4	7.1	8.2	0.7	177.204	0.33443
40	13.0	0.5	0.8	27.2	10.0	8.1	0.5	140.762	0.33723
41	13.1	0.5	0.6	27.6	10.2	8.2	0.4	186.629	0.33221
42	13.5	0.6	0.6	27.6	10.1	8.2	0.4	116.387	0.32601

OBS	SITOAL	SULDRY	TOTBSF	TOTASF	BTOASF	TOTALK	TOTALKWC	ALKRATIO
37	1.80374	0.98121	60.3	39.1	1.54220	6.99534	0.52045	13.6143
38	1.84545	0.94070	59.0	40.2	1.46766	7.09534	0.54634	13.2219
39	1.81250	1.01480	59.0	40.2	1.46766	6.99534	0.53374	10.1656
40	1.78761	1.02817	58.8	40.3	1.45906	6.66356	0.51576	13.3780
41	1.80734	1.01138	59.5	39.8	1.49497	6.59767	0.50868	13.5210
42	1.75455	1.05997	59.8	39.5	1.51392	6.59767	0.50010	13.3413

OBS	SIXFE	ALXFE	CAXFE	MGXFE	SIXAL	SIXCA	CAXMG	SIXK	ALXK	FEXK
37	191.07	105.93	215.82	79.20	206.51	420.74	174.40	11.58	6.42	5.94
38	196.91	106.70	212.43	74.69	223.30	444.57	168.63	12.18	6.60	5.82
39	207.06	114.24	249.90	58.14	227.36	497.35	139.65	12.18	6.72	6.12
40	208.06	116.39	221.45	81.37	228.26	434.30	169.85	8.08	4.52	4.12
41	200.94	111.18	219.30	80.58	214.73	423.55	169.85	5.91	3.27	3.06
42	202.65	115.50	225.75	82.95	212.30	414.95	169.85	5.79	3.30	3.15

OBS	CAXK	MGXK	SI+AL	CA+MG	FE/CA	SI/AL	SI/ALSQ	SIO2SQ	AL2O3SQ
37	13.08	4.80	30.0	29.8	0.45413	1.80374	3.25347	372.49	114.49
38	13.14	4.62	31.3	29.6	0.44292	1.84545	3.40570	412.09	121.00
39	14.70	3.42	31.5	30.2	0.41633	1.81250	3.28516	412.09	125.44
40	8.60	3.16	31.5	29.4	0.47907	1.78761	3.19555	408.04	127.69
41	6.45	2.37	30.6	29.4	0.47442	1.80734	3.26648	388.09	118.81
42	6.45	2.37	30.3	29.4	0.48837	1.75455	3.07843	372.49	121.00

OBS	CAOSQ	NA2OSQ	MGOSQ	FE2O3SQ	P2O4SQ	TIO2SQ	K2OSQ
37	475.24	43.56	64.00	98.01	0.25	0.25	0.36
38	479.61	44.89	59.29	94.09	0.25	0.25	0.36
39	600.25	43.56	32.49	104.04	0.25	0.81	0.36
40	462.25	40.96	62.41	106.09	0.36	0.16	0.16
41	462.25	40.96	62.41	104.04	0.25	0.16	0.09
42	462.25	40.96	62.41	110.25	0.25	0.25	0.09

OBS	SPLNUM	SPLDESIG	RANK	STATE	ASHDRY	BTUDRY	SIO2SF	AL2O3SF
43	135	B-STD-1	LIGNITE	N.DAKOTA	10.72	10560	26.5	14.1
44	136	B-STD-1	LIGNITE	N.DAKOTA	10.74	10570	25.7	14.6
45	160	B-STD-1	LIGNITE	N.DAKOTA	10.75	10560	25.8	13.5
46	161	B-STD-1	LIGNITE	N.DAKOTA	10.80	10270	28.0	14.1
47	168	B-STD-1	LIGNITE	N.DAKOTA	11.01	10520	25.0	14.1
48	169	B-STD-1	LIGNITE	N.DAKOTA	11.09	10430	25.7	15.2

OBS	FE2O3SF	TIO2SF	P2O5SF	CAOSF	MGOSF	NA2OSF	K2OSF	DEPOWT	SIRATIO
43	13.1	0.6	0.7	26.8	9.8	8.0	0.4	80.343	0.34804
44	13.4	0.5	0.5	27.1	9.7	8.1	0.4	117.190	0.33833
45	13.1	0.7	0.5	28.0	9.8	8.1	0.3	145.423	0.33618
46	11.4	0.6	0.5	26.4	9.3	9.1	0.5	158.793	0.37331
47	13.4	0.4	0.8	27.3	9.8	8.6	0.4	77.729	0.33108
48	12.2	0.7	0.5	27.4	9.8	8.1	0.4	68.381	0.34256

OBS	SITOAL	SULDRY	TOTBSF	TOTASF	BTOASF	TOTALK	TOTALKWC	ALKRATIO
43	1.88496	1.01810	58.1	41.2	1.41019	6.59767	0.50010	13.1054
44	1.76522	1.05101	58.7	40.8	1.43873	6.59767	0.50538	13.0146
45	1.91262	1.08696	59.3	40.0	1.48250	6.33178	0.47615	12.9857
46	1.99099	0.94352	56.7	42.7	1.32787	7.46356	0.61500	13.1575
47	1.76577	1.10807	59.5	39.5	1.50633	6.89767	0.52767	13.3747
48	1.69231	1.14515	57.9	41.6	1.39183	6.39767	0.49582	13.1851

OBS	SIXFE	ALXFE	CAXFE	MGXFE	SIXAL	SIXCA	CAXMG	SIXK	ALXK	FEXK
43	223.65	118.65	225.75	82.95	240.69	457.95	169.85	6.39	3.39	3.15
44	215.18	121.90	226.84	81.62	233.45	434.42	164.78	6.09	3.45	3.18
45	197.00	103.00	214.00	75.00	202.91	421.58	160.50	3.94	2.06	2.00
46	198.90	99.90	187.20	65.70	245.31	459.68	151.84	8.84	4.44	3.60
47	205.80	116.55	224.70	80.85	217.56	419.44	164.78	5.88	3.33	3.15
48	186.12	109.98	198.34	70.50	231.66	417.78	158.25	5.94	3.51	2.82

OBS	CAXK	MGXK	SI+AL	CA+MG	FE/CA	SI/AL	SI/ALSQ	SIO2SQ	AL2O3SQ
43	6.45	2.37	32.6	29.4	0.48837	1.88496	3.55306	453.69	127.69
44	6.42	2.31	31.8	29.1	0.49533	1.76522	3.11599	412.09	132.25
45	4.28	1.50	30.0	28.9	0.46729	1.91262	3.65812	388.09	106.09
46	8.32	2.92	33.2	28.1	0.43269	1.99099	3.96405	488.41	123.21
47	6.42	2.31	30.7	29.1	0.49065	1.76577	3.11793	384.16	123.21
48	6.33	2.25	31.5	28.6	0.44550	1.69231	2.86391	392.04	136.89

OBS	CAOSQ	NA2OSQ	MGOSQ	FE2O3SQ	P2O4SQ	TIO2SQ	K2OSQ
43	462.25	40.96	62.41	110.25	0.36	0.25	0.09
44	457.96	40.96	59.29	112.36	0.16	0.16	0.09
45	457.96	38.44	56.25	100.00	0.16	0.25	0.04
46	432.64	51.84	53.29	81.00	0.16	0.25	0.16
47	457.96	44.89	59.29	110.25	0.36	0.09	0.09
48	445.21	38.44	56.25	88.36	0.16	0.25	0.09

OBS	SPLNUM	SPLDESIG	RANK	STATE	ASHDRY	BTUDRY	SIO2SF	AL2O3SF
49	170	B-STD-1	LIGNITE	N.DAKOTA	11.16	10510	25.7	14.5
50	171	B-STD-1	LIGNITE	N.DAKOTA	11.13	10430	25.6	14.1
51	172	B-STD-1	LIGNITE	N.DAKOTA	11.17	10530	25.7	14.4
52	173	B-STD-1	LIGNITE	N.DAKOTA	10.94	10560	26.1	14.4
53	174	B-STD-1	LIGNITE	N.DAKOTA	10.96	10550	26.6	14.5
54	185	B-STD-1	LIGNITE	N.DAKOTA	10.98	10480	26.2	13.8

OBS	FE2O3SF	TIO2SF	P2O5SF	CAOSF	MGOSF	NA2OSF	K2OSF	DEPOWT	SIRATIO
49	13.2	0.5	0.6	27.4	10.0	7.5	0.4	77.398	0.33673
50	13.0	0.6	0.6	26.6	9.5	9.5	0.4	85.166	0.34267
51	12.6	0.4	0.7	30.7	7.3	7.9	0.4	96.462	0.33696
52	12.5	0.6	0.6	27.3	10.5	7.5	0.4	72.131	0.34179
53	12.3	0.6	0.6	27.3	9.9	7.8	0.4	75.450	0.34975
54	12.9	0.6	0.6	27.3	9.8	8.3	0.4	87.371	0.34338

OBS	SITOAL	SULDRY	TOTBSF	TOTASF	BTOASF	TOTALK	TOTALKWC	ALKRATIO
49	1.76786	1.14685	58.5	40.7	1.43735	5.99767	0.47861	13.1621
50	1.80870	0.99914	59.0	40.3	1.46402	7.89767	0.61602	13.5853
51	1.78846	0.99152	58.9	40.5	1.45432	5.89767	0.45825	10.2703
52	1.81982	1.08853	58.2	41.1	1.41606	5.99767	0.45222	13.6111
53	1.83929	1.04016	57.7	41.7	1.38369	6.19767	0.47040	13.1373
54	1.89815	1.03782	58.7	40.6	1.44581	6.69767	0.51773	13.2443

OBS	SIXFE	ALXFE	CAXFE	MGXFE	SIXAL	SIXCA	CAXMG	SIXK	ALXK	FEXK
49	201.96	114.24	215.22	78.54	221.76	417.78	162.47	5.94	3.36	3.06
50	220.48	121.90	228.96	81.62	239.20	449.28	166.32	6.24	3.45	3.18
51	169.26	94.64	202.02	48.23	193.44	412.92	117.66	5.58	3.12	2.73
52	195.94	107.67	204.67	78.57	224.22	426.22	170.91	6.06	3.33	2.91
53	195.70	106.40	200.45	73.15	230.72	434.66	162.47	6.18	3.36	2.85
54	207.05	109.08	216.14	77.77	221.40	438.70	164.78	6.15	3.24	3.03

OBS	CAXK	MGXK	SI+AL	CA+MG	FE/CA	SI/AL	SI/ALSQ	SIO2SQ	AL2O3SQ
49	6.33	2.31	31.0	28.8	0.48341	1.76786	3.12532	392.04	125.44
50	6.48	2.31	32.3	29.3	0.49074	1.80870	3.27138	432.64	132.25
51	6.66	1.59	29.0	27.5	0.40991	1.78846	3.19859	345.96	108.16
52	6.33	2.43	31.3	29.2	0.45972	1.81982	3.31174	408.04	123.21
53	6.33	2.31	31.8	28.8	0.45024	1.83929	3.38297	424.36	125.44
54	6.42	2.31	31.3	29.1	0.47196	1.89815	3.60297	420.25	116.64

OBS	CAOSQ	NA2OSQ	MGOSQ	FE2O3SQ	P2O4SQ	TIO2SQ	K2OSQ
49	445.21	33.64	59.29	104.04	0.25	0.16	0.09
50	466.56	59.29	59.29	112.36	0.25	0.25	0.09
51	492.84	32.49	28.09	82.81	0.25	0.09	0.09
52	445.21	33.64	65.61	94.09	0.25	0.25	0.09
53	445.21	36.00	59.29	90.25	0.25	0.25	0.09
54	457.96	42.25	59.29	102.01	0.25	0.25	0.09

OBS	SPLNUM	SPLDESIG	RANK	STATE	ASHDRY	BTUDRY	SIO2SF	AL2O3SF
55	186	B-STD-1	LIGNITE	N.DAKOTA	11.01	10520	25.7	13.7
56	187	B-STD-1	LIGNITE	N.DAKOTA	11.09	10500	25.1	14.0
57	188	B-STD-1	LIGNITE	N.DAKOTA	11.00	10600	24.8	14.1
58	190	B-STD-1	LIGNITE	N.DAKOTA	10.79	10380	24.3	14.0
59	192	B-STD-1	LIGNITE	N.DAKOTA	11.11	10430	25.9	13.8
60	193	B-STD-1	LIGNITE	N.DAKOTA	10.96	10440	22.7	14.7

OBS	FE2O3SF	TIO2SF	P2O5SF	CAOSF	MGOSF	NA2OSF	K2OSF	DEPOWT	SIRATIO
55	13.6	0.7	0.7	27.5	9.8	8.0	0.4	102.010	0.33560
56	14.1	0.6	0.8	27.3	9.9	7.9	0.4	108.990	0.32826
57	14.6	0.5	0.5	27.0	10.3	7.7	0.4	109.976	0.32292
58	13.8	0.7	0.7	27.5	10.8	7.7	0.4	83.982	0.31857
59	12.8	0.6	0.5	28.6	10.6	6.8	0.4	105.969	0.33224
60	13.2	0.7	0.7	29.5	11.3	6.9	0.4	104.990	0.29610

OBS	SITOAL	SULDRY	TOTBSF	TOTASF	BTOASF	TOTALK	TOTALKWC	ALKRATIO
55	1.87619	1.07743	59.3	40.1	1.47880	6.29767	0.48240	13.1084
56	1.79630	1.06136	59.6	39.7	1.50126	6.29767	0.48051	13.2163
57	1.75472	1.07821	60.0	39.4	1.52284	5.99767	0.45882	13.5444
58	1.73148	1.03597	60.2	39.0	1.54359	6.09767	0.45733	13.9246
59	1.87037	1.04727	59.2	40.3	1.46898	5.49767	0.43157	13.3439
60	1.54630	1.05917	61.3	38.1	1.60892	5.29767	0.41110	13.9615

OBS	SIXFE	ALXFE	CAXFE	MGXFE	SIXAL	SIXCA	CAXMG	SIXK	ALXK	FEXK
55	204.88	109.20	219.44	78.00	206.85	415.67	158.25	5.91	3.15	3.12
56	211.46	117.72	229.99	83.93	209.52	409.34	162.47	5.82	3.24	3.27
57	204.60	116.60	223.30	84.70	197.16	377.58	156.31	5.58	3.18	3.30
58	198.22	114.48	223.66	87.98	201.96	394.57	175.13	5.61	3.24	3.18
59	202.00	108.00	223.00	83.00	218.16	450.46	185.09	6.06	3.24	3.00
60	161.99	104.76	210.49	80.51	180.36	362.39	180.11	5.01	3.24	2.91

OBS	CAXK	MGXK	SI+AL	CA+MG	FE/CA	SI/AL	SI/ALSQ	SIO2SQ	AL2O3SQ
55	6.33	2.25	30.2	28.6	0.49289	1.87619	3.52009	388.09	110.25
56	6.33	2.31	30.2	28.8	0.51659	1.79630	3.22668	376.36	116.64
57	6.09	2.31	29.2	28.0	0.54187	1.75472	3.07903	345.96	112.36
58	6.33	2.49	29.5	29.4	0.50237	1.73148	2.99803	349.69	116.64
59	6.69	2.49	31.0	30.6	0.44843	1.87037	3.49829	408.04	116.64
60	6.51	2.49	27.5	30.0	0.44700	1.54630	2.39103	278.89	116.64

OBS	CAOSQ	NA2OSQ	MGOSQ	FE2O3SQ	P2O4SQ	TIO2SQ	K2OSQ
55	445.21	37.21	56.25	108.16	0.25	0.25	0.09
56	445.21	37.21	59.29	118.81	0.36	0.25	0.09
57	412.09	33.64	59.29	121.00	0.16	0.16	0.09
58	445.21	34.81	68.89	112.36	0.25	0.25	0.09
59	497.29	28.09	68.89	100.00	0.16	0.25	0.09
60	470.89	26.01	68.89	94.09	0.25	0.25	0.09

OBS	SPLNUM	SPLDESIG	RANK	STATE	ASHDRY	BTUDRY	SIO2SF	AL2O3SF
61	194	B-STD-1	LIGNITE	N.DAKOTA	10.66	10560	22.5	15.0
62	195	B-STD-1	LIGNITE	N.DAKOTA	11.40	10370	24.8	14.1
63	196	B-STD-1	LIGNITE	N.DAKOTA	10.99	10370	25.9	14.4
64	200	B-STD-1	LIGNITE	N.DAKOTA	10.86	10550	24.6	14.0
65	202	B-STD-1	LIGNITE	N.DAKOTA	10.90	10580	25.1	14.0
66	203	B-STD-1	LIGNITE	N.DAKOTA	10.22	10710	25.4	14.4

OBS	FE2O3SF	TIO2SF	P2O5SF	CAOSF	MGOSF	NA2OSF	K2OSF	DEPOWT	SIRATIO
61	13.3	0.5	0.7	29.0	10.8	7.8	0.4	93.920	0.29735
62	13.8	0.5	0.8	26.4	9.9	9.1	0.4	97.283	0.33099
63	13.4	0.6	0.8	27.4	10.2	6.9	0.4	93.604	0.33662
64	13.3	0.6	0.6	27.5	10.4	8.4	0.4	106.236	0.32487
65	14.4	0.7	0.5	27.5	9.9	7.4	0.4	135.736	0.32646
66	12.9	0.5	0.6	28.1	10.6	7.0	0.4	114.216	0.33002

OBS	SITOAL	SULDRY	TOTBSF	TOTASF	BTOASF	TOTALK	TOTALKWC	ALKRATIO
61	1.50000	1.01241	61.3	38.0	1.61316	5.99767	0.44863	13.7641
62	1.75701	1.06215	59.6	39.4	1.51269	7.09767	0.56355	13.9434
63	1.79825	1.01856	58.3	40.9	1.42543	5.69767	0.44841	13.0733
64	1.76147	1.00014	60.0	39.2	1.53061	6.69767	0.52376	13.8213
65	1.79245	1.07633	59.6	39.8	1.49749	5.79767	0.44642	12.9376
66	1.76106	0.98175	59.0	40.3	1.46402	5.69767	0.42106	13.2418

OBS	SIXFE	ALXFE	CAXFE	MGXFE	SIXAL	SIXCA	CAXMG	SIXK	ALXK	FEXK
61	166.32	110.88	214.83	80.19	188.16	364.56	175.77	5.04	3.36	2.97
62	197.40	112.35	210.00	78.75	201.16	376.00	150.00	5.64	3.21	3.15
63	217.30	120.84	230.02	85.86	233.70	444.85	175.77	6.15	3.42	3.18
64	199.68	113.36	222.56	84.24	209.28	410.88	173.34	5.76	3.27	3.12
65	207.10	115.54	226.72	81.75	201.40	395.20	156.00	5.70	3.18	3.27
66	200.99	114.13	222.20	83.83	224.87	437.80	182.60	5.97	3.39	3.03

OBS	CAXK	MGXK	SI+AL	CA+MG	FE/CA	SI/AL	SI/ALSQ	SIO2SQ	AL2O3SQ
61	6.51	2.43	28.0	29.8	0.45622	1.50000	2.25000	282.24	125.44
62	6.00	2.25	29.5	27.5	0.52500	1.75701	3.08708	353.44	114.49
63	6.51	2.43	31.9	29.8	0.48848	1.79825	3.23369	420.25	129.96
64	6.42	2.43	30.1	29.5	0.48598	1.76147	3.10277	368.64	118.81
65	6.24	2.25	29.6	28.3	0.52404	1.79245	3.21289	361.00	112.36
66	6.60	2.49	31.2	30.3	0.45909	1.76106	3.10134	396.01	127.69

OBS	CAOSQ	NA2OSQ	MGOSQ	FE2O3SQ	P2O4SQ	TIO2SQ	K2OSQ
61	470.89	33.64	65.61	98.01	0.25	0.16	0.09
62	400.00	47.61	56.25	110.25	0.36	0.16	0.09
63	470.89	30.25	65.61	112.36	0.36	0.25	0.09
64	457.96	42.25	65.61	108.16	0.25	0.25	0.09
65	432.64	31.36	56.25	118.81	0.16	0.25	0.09
66	484.00	30.25	68.89	102.01	0.25	0.16	0.09

OBS	SPLNUM	SPLDESIG	RANK	STATE	ASHDRY	BTUDRY	SIO2SF	AL2O3SF
67	204	B-STD-1	LIGNITE	N.DAKOTA	10.89	10510	24.7	13.5
68	221	B-STD-1	LIGNITE	N.DAKOTA	10.74	10420	26.3	14.6
69	223	B-STD-1	LIGNITE	N.DAKOTA	11.25	10440	24.5	13.7
70	247	B-STD-1	LIGNITE	N.DAKOTA	10.59	10060	24.4	13.9
71	300	B-STD-1	LIGNITE	N.DAKOTA	10.95	10670	26.2	14.2

OBS	FE2O3SF	TIO2SF	P2O5SF	CAOSF	MGOSF	NA2OSF	K2OSF	DEPOWT	SIRATIO
67	14.7	0.6	0.4	26.9	10.1	8.5	0.5	121.442	0.32387
68	14.1	0.7	0.7	25.5	10.0	7.4	0.5	102.783	0.34609
69	16.2	0.7	0.5	25.5	9.0	9.4	0.4	135.977	0.32613
70	24.5	0.3	1.1	25.4	7.5	2.2	0.5	69.858	0.29808
71	12.8	0.4	0.5	28.0	10.1	7.6	0.4	137.961	0.34003

OBS	SITOAL	SULDRY	TOTBSF	TOTASF	BTOASF	TOTALK	TOTALKWC	ALKRATIO
67	1.83019	1.07390	60.7	38.8	1.56443	6.96356	0.53689	13.6745
68	1.79279	1.05827	57.5	41.6	1.38221	5.86356	0.45794	13.2555
69	1.79208	1.08040	60.5	38.9	1.55527	7.09767	0.56923	13.2634
70	1.75472	0.91236	60.1	38.6	1.55699	1.96356	0.15041	8.5546
71	1.84545	1.01955	58.9	40.8	1.44363	6.09767	0.47806	13.1752

OBS	SIXFE	ALXFE	CAXFE	MGXFE	SIXAL	SIXCA	CAXMG	SIXK	ALXK	FEXK
67	223.10	121.90	242.65	90.85	205.64	409.34	166.69	7.76	4.24	4.60
68	212.93	118.77	206.51	81.32	220.89	384.07	146.68	7.96	4.44	4.28
69	217.20	121.20	225.60	79.20	182.81	340.28	124.08	5.43	3.03	3.60
70	347.82	198.22	362.78	106.59	197.16	360.84	110.58	7.44	4.24	7.48
71	200.97	108.90	214.83	77.22	223.30	440.51	169.26	6.09	3.30	2.97

OBS	CAXK	MGXK	SI+AL	CA+MG	FE/CA	SI/AL	SI/ALSQ	SIO2SQ	AL2O3SQ
67	8.44	3.16	30.0	29.0	0.54502	1.83019	3.34959	376.36	112.36
68	7.72	3.04	31.0	26.9	0.55440	1.79279	3.21411	396.01	123.21
69	5.64	1.98	28.2	25.4	0.63830	1.79208	3.21155	327.61	102.01
70	7.76	2.28	29.2	25.1	0.96392	1.75472	3.07903	345.96	112.36
71	6.51	2.34	31.3	29.5	0.45622	1.84545	3.40570	412.09	121.00

OBS	CAOSQ	NA2OSQ	MGOSQ	FE2O3SQ	P2O4SQ	TIO2SQ	K2OSQ
67	445.21	44.89	62.41	132.25	0.09	0.25	0.16
68	372.49	31.36	57.76	114.49	0.25	0.25	0.16
69	353.44	47.61	43.56	144.00	0.16	0.25	0.09
70	376.36	2.89	32.49	349.69	0.64	0.04	0.16
71	470.89	34.81	60.84	98.01	0.16	0.09	0.09

APPENDIX II

Statistical Models:

The following lists in order of their discussion in the report the regression models determined from the various datasets. The models were generated by the Statistical Analysis System (SAS), i.e. PROC REG STEPWISE or MAXR. In the case of the STEPWISE model, the 'best' model is the final step. For the MAXR, we have chosen the 'best' model as having all parameter estimates significant at at least the 0.1500 level.

The models are as follows:

MDL#	PG	Model of..
1)	115	MAIN dataset, all 126 observations, all 46 variables, stepwise regression.
2)	116	MAIN dataset, all 126 observations, 24 primary variables, stepwise regression.
3)	117	B-STD dataset, all 71 observations, all 46 variables, stepwise regression.
4)	118	B-STD data set, all 71 observations, 24 primary variables, stepwise regression.
5)	119	MAIN dataset, 53 observations with NA2OSF <5 weight percent, all 46 variables, stepwise regression.
6)	120	MAIN dataset, 53 observation with NA2OSF <5 weight percent, all 46 variables, maximum-r stepwise regression.
7)	121	MAIN dataset, 53 observation with NA2OSF <5 weight percent, 24 primary variables, maximum-r stepwise regression.
8)	122	MAIN dataset, 53 observations with NA2OSF <5 weight percent, 24 primary variables, stepwise regression.
9)	123	MAIN dataset, 73 observations with NA2OSF >=5 weight percent, all 46 variables, stepwise regression.
10)	124	MAIN dataset, 73 observations with NA2OSF >=5 weight percent, 24 primary variables, stepwise regression.
11)	125	MAIN dataset, 73 observations with NA2OSF >=5 weight percent, all 46 variables, maximum-r stepwise regression.
12)	126	MAIN dataset, 73 observations with NA2OSF >=5 weight percent, 24 primary variables, maximum-r stepwise regression.
13)	127	MAIN dataset, 50 observations with NA2OSF <5 weight percent and ASHDRY <22 weight percent, all 46 variables, stepwise regression.
14)	128	MAIN dataset, 50 observations with NA2OSF <5 weight percent and ASHDRY <22 weight percent, 24 primary variables, stepwise regression.
15)	129	MAIN dataset, 50 observations with NA2OSF <5 weight percent and ASHDRY <22 weight percent, all 46 variables, maximum-r stepwise regression.

MDL#	PG	Model of..
16)	130	MAIN dataset, 50 observations with NA2OSF <5 weight percent and ASHDRY <22 weight percent, 24 primary variables, maximum-r stepwise regression.
17)	131	MAIN dataset, 126 observations, all 46 variables, maximum-r stepwise regression.
18)	132	MAIN dataset, 126 observation, 24 primary variables, maximum-r stepwise regression.
19)	133	B-STD dataset, 71 observations, all 46 variables, maximum-r stepwise regression.
20)	134	B-STD dataset, 71 observations, 24 primary variables, maximum-r stepwise regression.
21)	135	Combined datasets (MAIN and B-STD), 196 observations, all 46 variables, stepwise regression.
22)	136	Combined datasets (MAIN and B-STD), 196 observations, 24 primary variables, stepwise regression.

1) MAIN dataset, all 126 observations, all 46 variables, stepwise regression.

R-square = 0.71472490 C(p) = 0.61681704

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	11	687054.803	62459.527	25.96	0.0001
Error	114	274230.862	2405.533		
Total	125	961285.666			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	490.833	169.954	20063.800	8.34	0.0046
ASHDRY	12.380	3.098	38412.345	15.97	0.0001
CAOSF	-7.024	2.524	18623.578	7.74	0.0063
NA2OSF	11.145	2.283	57301.453	23.82	0.0001
SIRATIO	-870.469	257.968	27389.670	11.39	0.0010
SIFE	0.253	0.114	11749.584	4.88	0.0291
SIAL	0.446	0.197	12308.911	5.12	0.0256
ALK	15.171	1.598	216785.893	90.12	0.0001
MGK	-32.572	5.273	91769.101	38.15	0.0001
FEDBCA	-230.165	39.646	81073.996	33.70	0.0001
SQAL2O3	-0.855	0.238	31038.017	12.90	0.0005
SQNA2O	-0.486	0.106	49888.062	20.74	0.0001

All variables in the model are significant at the 0.1500 level.

No other variable met the 0.1500 significance level for entry into the model.

2) MAIN dataset, all 126 observations, 24 primary variables, stepwise regression.

R-square = 0.53565139 C(p) = 5.09574373

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	6	514914.007	85819.001	22.88	0.0001
Error	119	446371.658	3751.022		
Total	125	961285.666			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	-190.639	63.044	34298.534	9.14	0.0031
ASHDRY	5.790	2.985	14109.947	3.76	0.0548
CAOSF	3.906	1.165	42119.529	11.23	0.0011
K2OSF	78.311	15.320	98007.146	26.13	0.0001
SULDRY	24.583	10.943	18927.910	5.05	0.0265
TOTALK	-13.764	4.933	29203.838	7.79	0.0061
TOTALKWC	281.422	64.037	72442.669	19.31	0.0001

All variables in the model are significant at the 0.1500 level.

No other variable met the 0.1500 significance level for entry into the model.

3) B-STD dataset, all 71 observations, all 46 variables, stepwise regression.

R-square = 0.40762083 C(p) = -5.20752227

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	4	42415.002	10603.750	11.35	0.0001
Error	66	61640.040	933.940		
Total	70	104055.043			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	545.628	205.447	6587.341	7.05	0.0099
ASHDRY	-37.097	17.345	4272.146	4.57	0.0362
TOTALK	-39.012	12.431	9197.528	9.85	0.0025
TOTALKWC	631.312	144.551	17813.962	19.07	0.0001
MGFE	-1.095	0.516	4205.194	4.50	0.0376

All variables in the model are significant at the 0.1500 level.

No other variable met the 0.1500 significance level for entry into the model.

4) B-STD data set, all 71 observations, 24 primary variables, stepwise regression.

R-square = 0.39236577 C(p) = -3.62321417

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	4	40827.636	10206.909	10.65	0.0001
Error	66	63227.406	957.991		
Total	70	104055.043			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	408.132	191.642	4344.896	4.54	0.0369
ASHDRY	-28.561	17.243	2628.345	2.74	0.1024
P2O5SF	-59.286	35.864	2617.829	2.73	0.1031
TOTALK	-36.097	12.463	8035.556	8.39	0.0051
TOTALKWC	586.039	146.657	15296.947	15.97	0.0002

All variables in the model are significant at the 0.1500 level.

No other variable met the 0.1500 significance level for entry into the model.

5) MAIN dataset, 53 observations with NA2OSF <5 weight percent, all 46 variables, stepwise regression.

R-square = 0.80408097 C(p) =261.63033314

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	6	217774.760	36295.793	31.47	0.0001
Error	46	53062.093	1153.523		
Total	52	270836.854			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	78.611	20.767	16528.059	14.33	0.0004
K2OSF	401.451	40.170	115207.740	99.87	0.0001
TOTALKWC	165.208	58.323	9255.567	8.02	0.0068
SIFE	0.208	0.080	7709.803	6.68	0.0130
MGK	-74.916	8.492	89775.830	77.83	0.0001
FEDBCA	-162.811	24.833	49581.777	42.98	0.0001
SQTIO2	-44.749	10.586	20610.106	17.87	0.0001

All variables in the model are significant at the 0.1500 level.

No other variable met the 0.1500 significance level for entry into the model.

6) MAIN dataset, 53 observation with NA2OSF <5 weight percent, all 46 variables, maximum-r stepwise regression.

R-square = 0.98277955 C(p) = 27.42412462

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	26	266172.922	10237.420	57.07	0.0001
Error	26	4663.931	179.381		
Total	52	270836.854			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	-1501.054	680.316	873.271	4.87	0.0364
BTUDRY	0.023	0.011	704.570	3.93	0.0582
AL2O3SF	-75.135	25.594	1545.924	8.62	0.0069
P2O5SF	66.741	15.595	3285.207	18.31	0.0002
CAOSF	18.019	6.483	1385.532	7.72	0.0100
NA2OSF	72.094	14.786	4264.273	23.77	0.0001
INITDEF	0.089	0.046	676.645	3.77	0.0630
SIRATIO	-13614.709	1733.451	11065.529	61.69	0.0001
TOTASF	154.413	24.029	7407.511	41.29	0.0001
TOTALKWC	585.414	111.005	4989.005	27.81	0.0001
SIFE	0.459	0.126	2360.271	13.16	0.0012
ALFE	-0.914	0.265	2128.818	11.87	0.0020
CAFE	-0.505	0.263	659.365	3.68	0.0663
MGFE	3.814	0.998	2615.237	14.58	0.0007
SICA	-0.322	0.155	768.279	4.28	0.0486
FEK	16.526	3.053	5255.716	29.30	0.0001
CAPLSMG	-68.939	13.028	5022.505	28.00	0.0001
FEDBCA	-528.280	42.617	27563.831	153.66	0.0001
SIDBAL	541.802	100.167	5248.184	29.26	0.0001
SQSIDBAL	-84.023	10.622	11223.610	62.57	0.0001
SQSIO2	0.237	0.050	3974.332	22.16	0.0001
SQAL2O3	0.857	0.340	1138.818	6.35	0.0182
SQCAO	1.046	0.187	5573.105	31.07	0.0001
SQNA2O	-5.954	2.251	1253.986	6.99	0.0137
SQMGO	2.448	0.701	2184.685	12.18	0.0017
SQFE2O3	0.812	0.343	1004.344	5.60	0.0257
SQTIO2	-108.103	14.812	9554.647	53.26	0.0001

The above model is the best 26-variable model found.

All variables in the model are significant at the 0.1500 level.

7) MAIN dataset, 53 observation with NA2OSF <5 weight percent, 24 primary variables, maximum-r stepwise regression.

R-square = 0.62824080 C(p) = 5.57726120

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	11	170150.761	15468.251	6.30	0.0001
Error	41	100686.092	2455.758		
Total	52	270836.854			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	-3659.344	1260.725	20689.550	8.42	0.0059
ASHDRY	16.775	5.934	19623.690	7.99	0.0072
BTUDRY	0.045	0.030	5344.247	2.18	0.1478
AL2O3SF	13.096	6.276	10690.668	4.35	0.0432
FE2O3SF	36.594	13.917	16978.307	6.91	0.0120
P2O5SF	-45.282	22.911	9592.096	3.91	0.0549
CAOSF	32.315	12.597	16159.111	6.58	0.0141
MGOSF	98.193	25.187	37323.157	15.20	0.0004
K2OSF	103.470	28.812	31670.621	12.90	0.0009
SIRATIO	2700.159	1102.899	14719.482	5.99	0.0187
TOTALKWC	1036.865	194.305	69929.585	28.48	0.0001
ALKRATIO	-62.577	18.818	27154.788	11.06	0.0019

The above model is the best 11-variable model found.

All variables in the model are significant at the 0.1500 level.

8) MAIN dataset, 53 observations with NA2OSF <5 weight percent, 24 primary variables, stepwise regression.

R-square = 0.42542515 C(p) = 8.44111126

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	3	115220.808	38406.936	12.09	0.0001
Error	49	155616.045	3175.837		
Total	52	270836.854			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	-44.752	21.073	14322.591	4.51	0.0388
K2OSF	70.578	26.794	22034.736	6.94	0.0113
SULDRY	21.035	8.635	18842.296	5.93	0.0185
TOTALKWC	343.435	88.500	47825.230	15.06	0.0003

All variables in the model are significant at the 0.1500 level.

No other variable met the 0.1500 significance level for entry into the model.

9) MAIN dataset, 73 observations with NA2OSF >=5 weight percent, all 46 variables, stepwise regression.

R-square = 0.60798221 C(p) =-17.13051179

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	3	357118.552	119039.517	35.67	0.0001
Error	69	230264.676	3337.169		
Total	72	587383.229			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	125.640	31.022	54737.283	16.40	0.0001
SULDRY	30.497	19.365	8276.807	2.48	0.1199
CAK	-6.452	2.046	33160.844	9.94	0.0024
SQK2O	95.187	16.678	108701.873	32.57	0.0001

All variables in the model are significant at the 0.1500 level.

No other variable met the 0.1500 significance level for entry into the model.

10) MAIN dataset, 73 observations with NA2OSF >=5 weight percent, 24 primary variables, stepwise regression.

R-square = 0.54752406 C(p) = 3.97043526

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	3	321606.451	107202.150	27.83	0.0001
Error	69	265776.777	3851.837		
Total	72	587383.229			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	-178.363	44.934	60691.667	15.76	0.0002
ASHDRY	18.056	3.631	95245.320	24.73	0.0001
K2OSF	42.231	21.115	15407.094	4.00	0.0494
ALKRATIO	6.736	3.403	15092.911	3.92	0.0518

All variables in the model are significant at the 0.1500 level.

No other variable met the 0.1500 significance level for entry into the model.

11) MAIN dataset, 73 observations with NA2OSF >=5 weight percent, all 46 variables, maximum-r stepwise regression.

R-square = 0.65645210 C(p) =-13.04919413

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	8	385588.952	48198.619	15.29	0.0001
Error	64	201794.276	3153.035		
Total	72	587383.229			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	256.179	155.398	8568.892	2.72	0.1041
AL2O3SF	28.029	12.216	16598.370	5.26	0.0251
FE2O3SF	-27.526	19.195	6484.314	2.06	0.1564
ALKRATIO	-4.701	4.987	2801.575	0.89	0.3494
CAK	-11.942	3.408	38719.477	12.28	0.0008
SQAL2O3	-1.834	0.674	23289.689	7.39	0.0084
SQFE2O3	1.632	1.350	4605.237	1.46	0.2313
SQTIO2	124.968	56.082	15655.817	4.97	0.0294
SQK2O	129.158	21.500	113786.963	36.09	0.0001

The above model is the best 8-variable model found.

All variables in the model are significant at the 0.1500 level.

12) MAIN dataset, 73 observations with NA2OSF >=5 weight percent, 24 primary variables, maximum-r stepwise regression.

R-square = 0.56384178 C(p) = 3.48314202

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	4	331191.207	82797.801	21.98	0.0001
Error	68	256192.022	3767.529		
Total	72	587383.229			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	-150.376	48.946	35561.758	9.44	0.0031
TIO2SF	126.789	48.421	25831.020	6.86	0.0109
K2OSF	61.658	18.423	42199.080	11.20	0.0013
SULDRY	55.780	17.979	36263.426	9.63	0.0028
ALKRATIO	9.713	3.485	29254.590	7.76	0.0069

The above model is the best 4-variable model found.

All variables in the model are significant at the 0.1500 level.

13) MAIN dataset, 50 observations with NA2OSF <5 weight percent and ASHDRY <22 weight percent, all 46 variables, stepwise regression.

R-square = 0.85585380 C(p) = 24.95357905

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	10	59386.375	5938.637	23.16	0.0001
Error	39	10002.082	256.463		
Total	49	69388.458			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	38.816	55.398	125.910	0.49	0.4877
ASHDRY	5.603	1.451	3824.348	14.91	0.0004
P2O5SF	45.944	22.545	1065.085	4.15	0.0484
INITDEF	-0.036	0.019	876.936	3.42	0.0720
TOTALKWC	415.664	61.353	11771.713	45.90	0.0001
SICA	0.023	0.015	588.680	2.30	0.1378
FEK	4.300	1.429	2322.127	9.05	0.0046
SQSIDBAL	-1.818	0.578	2535.137	9.88	0.0032
SQAL2O3	-0.167	0.033	6367.635	24.83	0.0001
SQNA2O	-3.302	1.301	1650.725	6.44	0.0153
SQP2O5	-89.876	30.915	2167.493	8.45	0.0060

All variables in the model are significant at the 0.1500 level.

No other variable met the 0.1500 significance level for entry into the model.

14) MAIN dataset, 50 observations with NA2OSF <5 weight percent and ASHDRY <22 weight percent, 24 primary variables, stepwise regression.

R-square = 0.73591239 C(p) = 8.04378240

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	5	51063.826	10212.765	24.52	0.0001
Error	44	18324.632	416.468		
Total	49	69388.458			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	512.473	109.744	9081.473	21.81	0.0001
BTUDRY	-0.022	0.008	2916.019	7.00	0.0113
AL2O3SF	-3.481	0.849	6998.319	16.80	0.0002
FE2O3SF	1.430	0.638	2093.005	5.03	0.0301
INITDEF	-0.097	0.022	8028.027	19.28	0.0001
TOTALKWC	271.054	34.658	25472.355	61.16	0.0001

All variables in the model are significant at the 0.1500 level.

No other variable met the 0.1500 significance level for entry into the model.

15) MAIN dataset, 50 observations with NA2OSF <5 weight percent and ASHDRY <22 weight percent, all 46 variables, maximum-r stepwise regression.

R-square = 0.97799205 C(p) = 14.08484654

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	27	67861.360	2513.383	36.21	0.0001
Error	22	1527.097	69.413		
Total	49	69388.458			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	-898.151	1204.690	38.582	0.56	0.4638
BTUDRY	0.031	0.008	960.232	13.83	0.0012
AL2O3SF	-79.897	16.717	1585.510	22.84	0.0001
FE2O3SF	-41.834	7.192	2348.647	33.84	0.0001
INITDEF	-0.057	0.026	327.622	4.72	0.0409
SIRATIO	-5441.171	1422.652	1015.386	14.63	0.0009
SULDRY	17.678	7.514	384.201	5.53	0.0280
TOTBSF	20.168	12.047	194.513	2.80	0.1083
TOTASF	108.932	17.100	2816.740	40.58	0.0001
TOTALKWC	1391.829	115.246	10124.287	145.85	0.0001
ALKRATIO	-55.250	6.542	4949.701	71.31	0.0001
ALFE	-0.393	0.204	256.837	3.70	0.0674
MGFE	5.280	0.771	3254.870	46.89	0.0001
SICA	0.362	0.124	586.500	8.45	0.0082
CAMG	-1.156	0.390	608.617	8.77	0.0072
ALK	-2.921	1.909	162.509	2.34	0.1402
CAK	-9.568	2.402	1101.434	15.87	0.0006
MGK	52.130	10.348	1761.296	25.37	0.0001
SIPLSAL	-42.446	5.057	4888.794	70.43	0.0001
CAPLSMG	-34.421	16.500	302.084	4.35	0.0488
FEDBCA	412.048	83.856	1675.961	24.14	0.0001
SQSIDBAL	-8.537	2.833	630.33	9.08	0.0064
SQAL2O3	1.898	0.309	2614.072	37.66	0.0001
SQCAO	0.649	0.183	874.153	12.59	0.0018
SQNA2O	-5.173	1.154	1394.416	20.09	0.0002
SQMGO	4.159	0.909	1451.618	20.91	0.0001
SQP2O5	58.323	16.050	916.563	13.20	0.0015
SQTIO2	-81.309	13.726	2435.561	35.09	0.0001

The above model is the best 27-variable model found.

All variables in the model are significant at the 0.1500 level.

16) MAIN dataset, 50 observations with NA2OSF <5 weight percent and ASHDRY <22 weight percent, 24 primary variables, stepwise regression.

R-square = 0.79638858 C(p) = 3.49973353

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	8	55260.176	6907.522	20.05	0.0001
Error	41	14128.282	344.592		
Total	49	69388.458			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	219.889	76.238	2866.559	8.32	0.0062
ASHDRY	6.181	1.603	5120.107	14.86	0.0004
AL2O3SF	-3.250	0.810	5545.385	16.09	0.0002
FE2O3SF	1.434	0.634	1762.023	5.11	0.0291
TIO2SF	-20.044	11.526	1042.050	3.02	0.0895
MGOSF	31.609	10.453	3150.625	9.14	0.0043
INITDEF	-0.101	0.023	6320.217	18.34	0.0001
TOTALKWC	487.846	74.540	14760.033	42.83	0.0001
ALKRATIO	-31.379	10.261	3222.432	9.35	0.0039

The above model is the best 8-variable model found.

All variables in the model are significant at the 0.1500 level.

17) MAIN dataset, 126 observations, all 46 variables, maximum-r stepwise regression.

R-square = 0.73402484 C(p) = -0.32559960

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	14	705607.560	50400.540	21.88	0.0001
Error	111	255678.105	2303.406		
Total	125	961285.666			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	658.046	210.470	22516.564	9.78	0.0023
ASHDRY	10.022	3.600	17846.440	7.75	0.0063
TIO2SF	116.480	55.937	9987.765	4.34	0.0396
NA2OSF	9.865	2.389	39256.029	17.04	0.0001
SIRATIO	-1338.432	296.154	47046.610	20.42	0.0001
SIFE	0.441	0.137	23722.512	10.30	0.0017
CAFE	-0.345	0.224	5459.189	2.37	0.1265
SIAL	0.600	0.190	22896.532	9.94	0.0021
SIK	5.418	0.666	152342.101	66.14	0.0001
MGK	-27.533	5.368	60588.514	26.30	0.0001
CAPLSMG	-7.392	2.057	29737.069	12.91	0.0005
FEDBCA	-272.976	41.424	100024.240	43.42	0.0001
SQAL2O3	-0.658	0.210	22488.511	9.76	0.0023
SQNA2O	-0.377	0.108	28073.579	12.19	0.0007
SQTIO2	-114.860	45.100	14939.719	6.49	0.0122

The above model is the best 14-variable model found.

All variables in the model are significant at the 0.1500 level.

18) MAIN dataset, 126 observation, 24 primary variables, maximum-r stepwise regression.

R-square = 0.56598492 C(p) = 3.44647543

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	9	544073.193	60452.577	16.81	0.0001
Error	116	417212.472	3596.659		
Total	125	961285.666			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	168.832	104.897	9317.125	2.59	0.1102
FE2O3SF	-87.098	19.336	72975.242	20.29	0.0001
CAOSF	-77.192	18.986	59452.291	16.53	0.0001
MGOSF	-109.230	18.243	128936.096	35.85	0.0001
NA2OSF	-49.442	17.177	29795.767	8.28	0.0048
INITDEF	-0.100	0.052	12965.945	3.60	0.0601
SULDRY	37.423	12.093	34443.777	9.58	0.0025
TOTBSF	82.633	18.878	68907.679	19.16	0.0001
TOTALK	-46.233	17.347	25546.430	7.10	0.0088
ALKRATIO	19.035	4.216	73291.178	20.38	0.0001

The above model is the best 9-variable model found.

All variables in the model are significant at the 0.1500 level.

19) B-STD dataset, 71 observations, all 46 variables, maximum-r stepwise regression.

R-square = 0.40762083 C(p) = -5.20752227

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	4	42415.002	10603.750	11.35	0.0001
Error	66	61640.040	933.940		
Total	70	104055.043			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	545.628	205.447	6587.341	7.05	0.0099
ASHDRY	-37.097	17.345	4272.146	4.57	0.0362
TOTALK	-39.012	12.431	9197.528	9.85	0.0025
TOTALKWC	631.312	144.551	17813.962	19.07	0.0001
MGFE	-1.095	0.516	4205.194	4.50	0.0376

The above model is the best 4-variable model found.
All variables in the model are significant at the 0.1500 level.

20) B-STD dataset, 71 observations, 24 primary variables, maximum-r stepwise regression.

R-square = 0.39515311 C(p) = -3.88641376

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	4	41117.674	10279.418	10.78	0.0001
Error	66	62937.368	953.596		
Total	70	104055.043			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	-497.149	340.481	2033.063	2.13	0.1490
BTUDRY	0.069	0.034	3758.632	3.94	0.0513
SULDRY	-175.940	82.775	4308.139	4.52	0.0373
TOTALK	-25.226	10.847	5157.116	5.41	0.0231
TOTALKWC	472.389	125.916	13421.420	14.07	0.0004

The above model is the best 4-variable model found.

All variables in the model are significant at the 0.1500 level.

21) Combined datasets (MAIN and B-STD), 196 observations, all 46 variables, stepwise regression.

R-square = 0.67750735 C(p) = 3.87571521

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	14	732762.694	52340.192	27.16	0.0001
Error	181	348794.117	1927.039		
Total	195	1081556.812			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	688.932	186.026	26429.756	13.72	0.0003
ASHDRY	14.264	2.522	61621.552	31.98	0.0001
FE2O3SF	-11.334	5.280	8879.610	4.61	0.0332
NA2OSF	16.347	1.770	164220.836	85.22	0.0001
BTOASF	-127.540	29.964	34912.689	18.12	0.0001
SIFE	0.535	0.160	21480.757	11.15	0.0010
ALK	14.312	1.654	144281.736	74.87	0.0001
MGK	-27.067	5.081	54673.936	28.37	0.0001
SIPLSAL	-21.776	4.098	54411.257	28.24	0.0001
FEDBCA	-327.020	42.051	116542.941	60.48	0.0001
SQSIDBAL	-12.650	3.831	21003.751	10.90	0.0012
SQSIO2	0.319	0.065	46513.019	24.14	0.0001
SQNA2O	-0.537	0.091	67253.221	34.90	0.0001
SQMGO	0.778	0.282	14644.082	7.60	0.0064
SQFE2O3	1.053	0.346	17825.416	9.25	0.0027

All variables in the model are significant at the 0.1500 level.

22) Combined datasets (MAIN and B-STD), 196 observations, 24 primary variables, stepwise regression.

R-square = 0.50028622 C(p) = 2.53802944

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	8	541087.965	67635.995	23.40	0.0001
Error	187	540468.846	2890.207		
Total	195	1081556.812			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	166.487	153.134	3416.221	1.18	0.2783
BTUDRY	-0.026	0.013	10391.096	3.60	0.0595
TIO2SF	34.039	19.649	8673.911	3.00	0.0849
CAOSF	3.137	0.957	31026.187	10.73	0.0013
NA2OSF	22.509	9.417	16510.649	5.71	0.0178
K2OSF	79.342	15.380	76917.968	26.61	0.0001
SULDRY	23.143	9.303	17884.520	6.19	0.0137
TOTALK	-44.344	12.093	38857.272	13.44	0.0003
TOTALKWC	330.969	53.084	112351.071	38.87	0.0001

All variables in the model are significant at the 0.1500 level.

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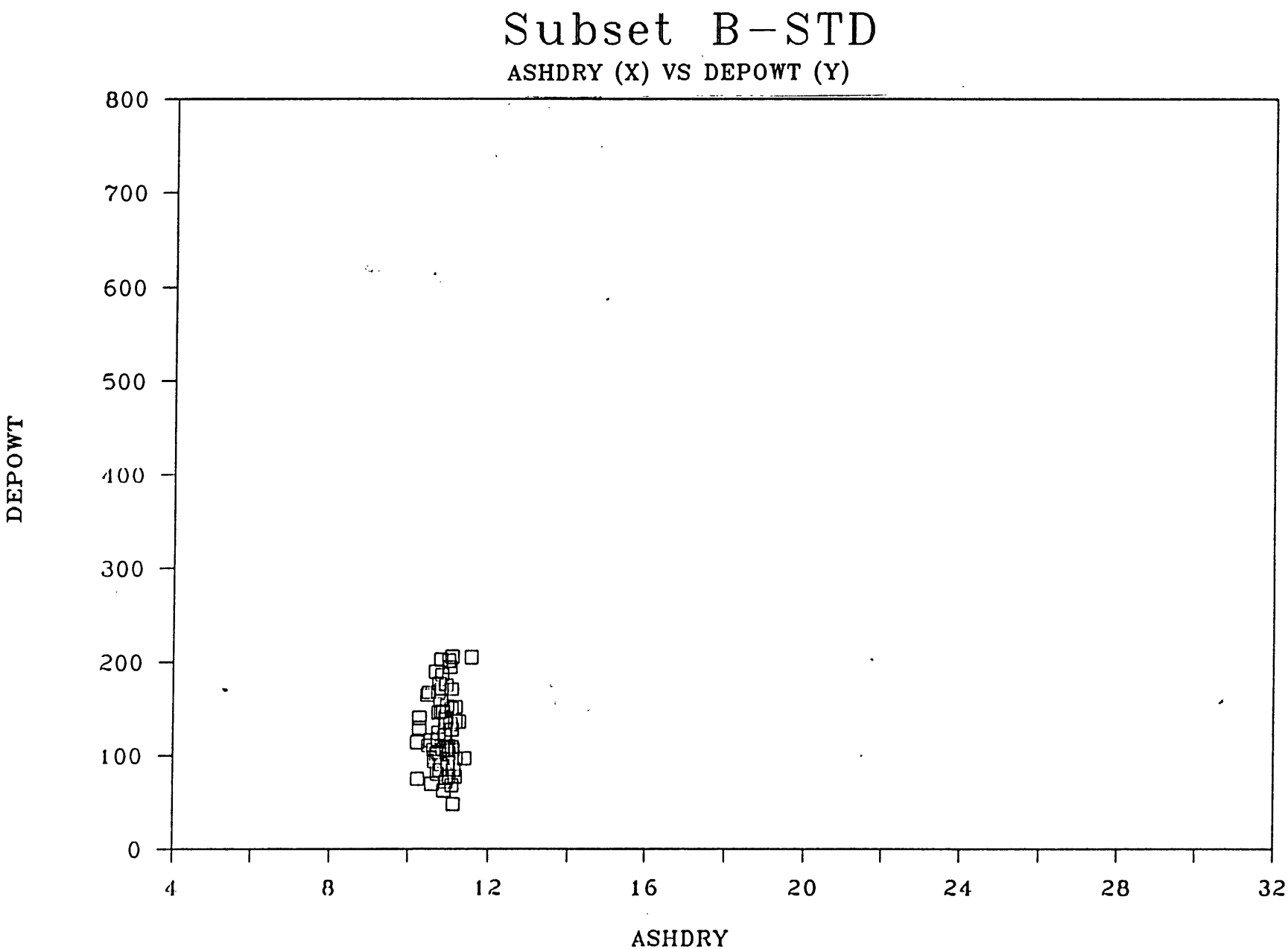

Figure 1: Subset B-STD, ASHDRY versus DEPOWT

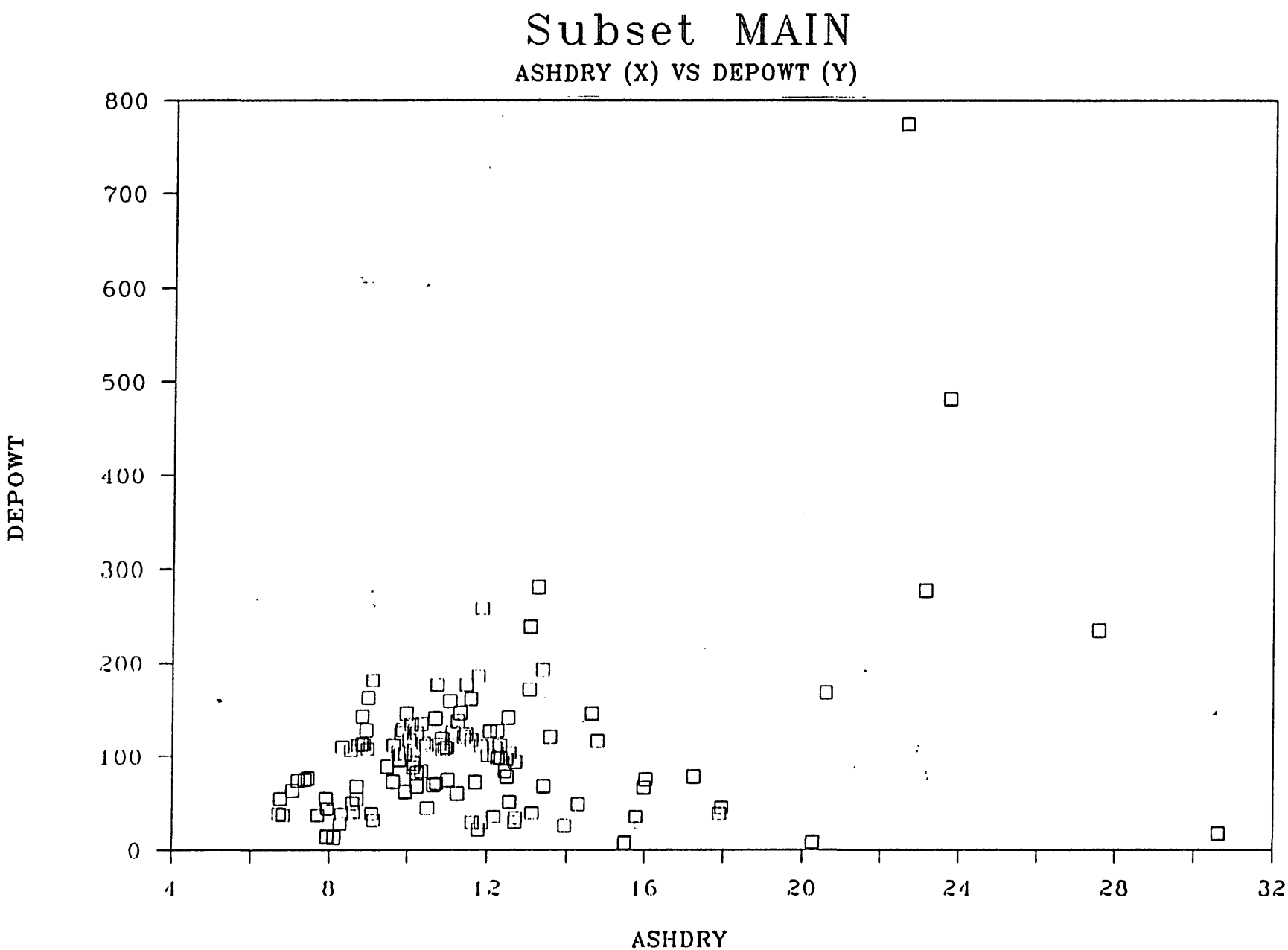

Figure 2: Subset MAIN, ASHDRY versus DEPOWT

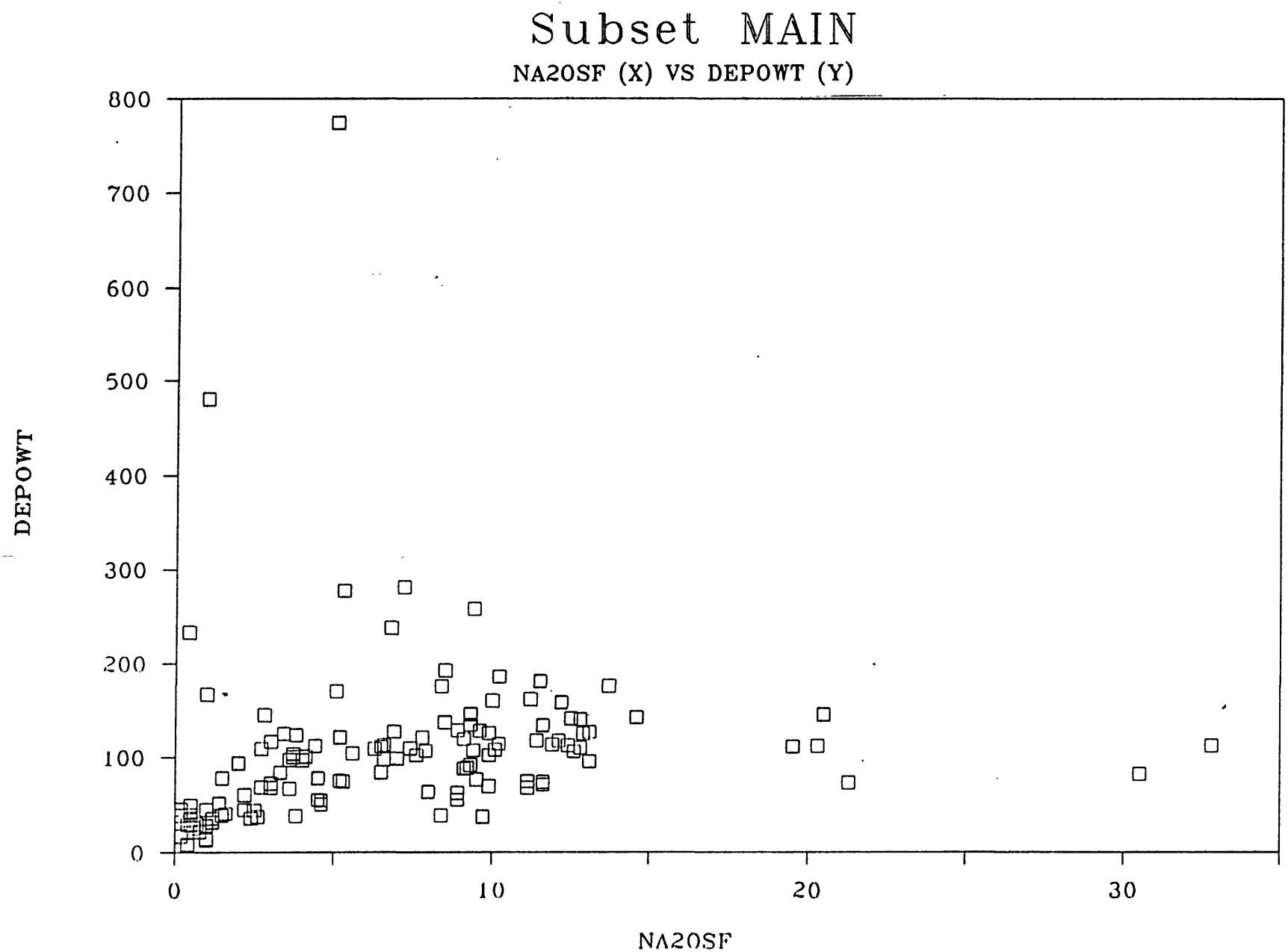

Figure 3: Subset MAIN, NA2OSF versus DEPOWT

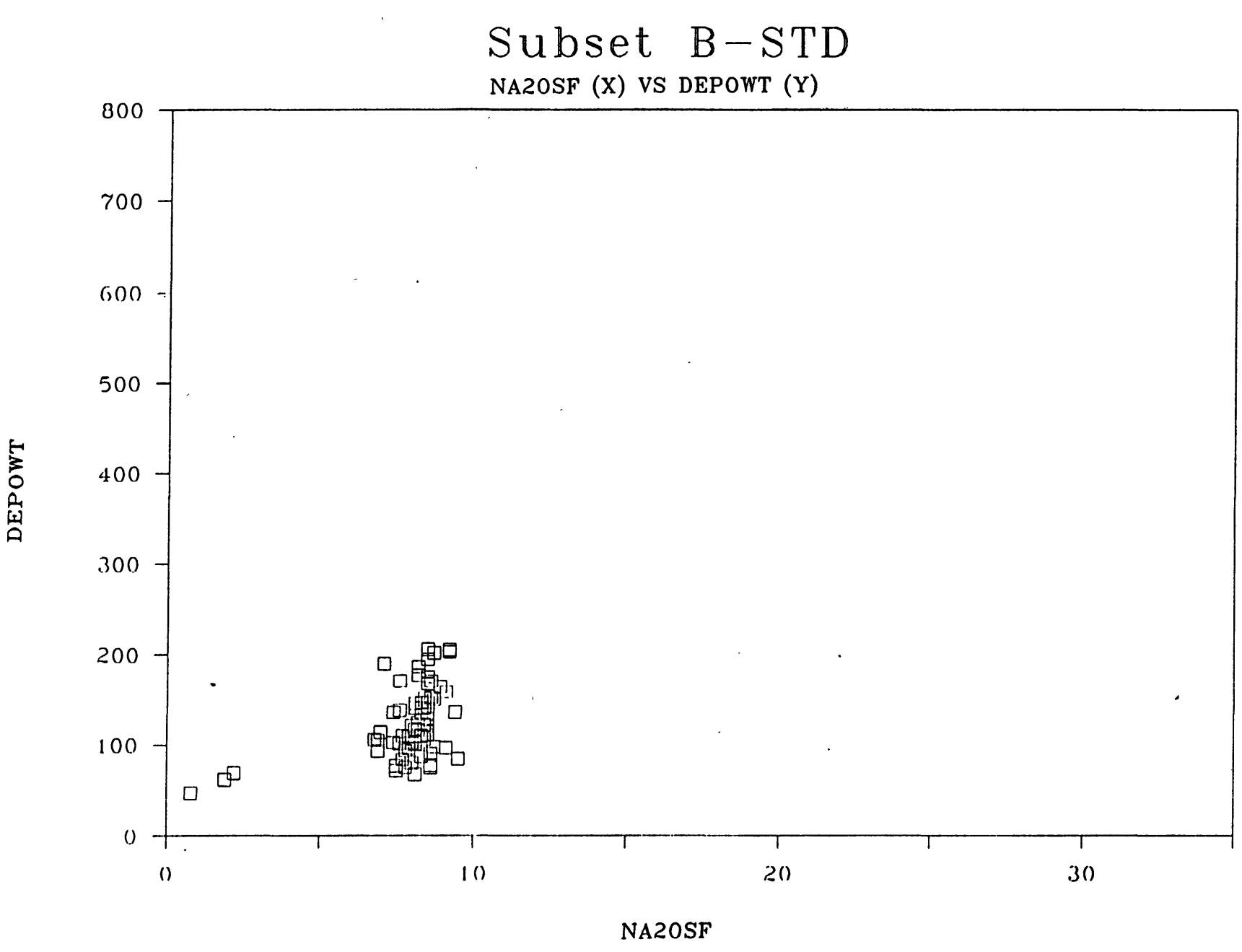

Figure 4: Subset B-STD, NA2OSF versus DEPOWT

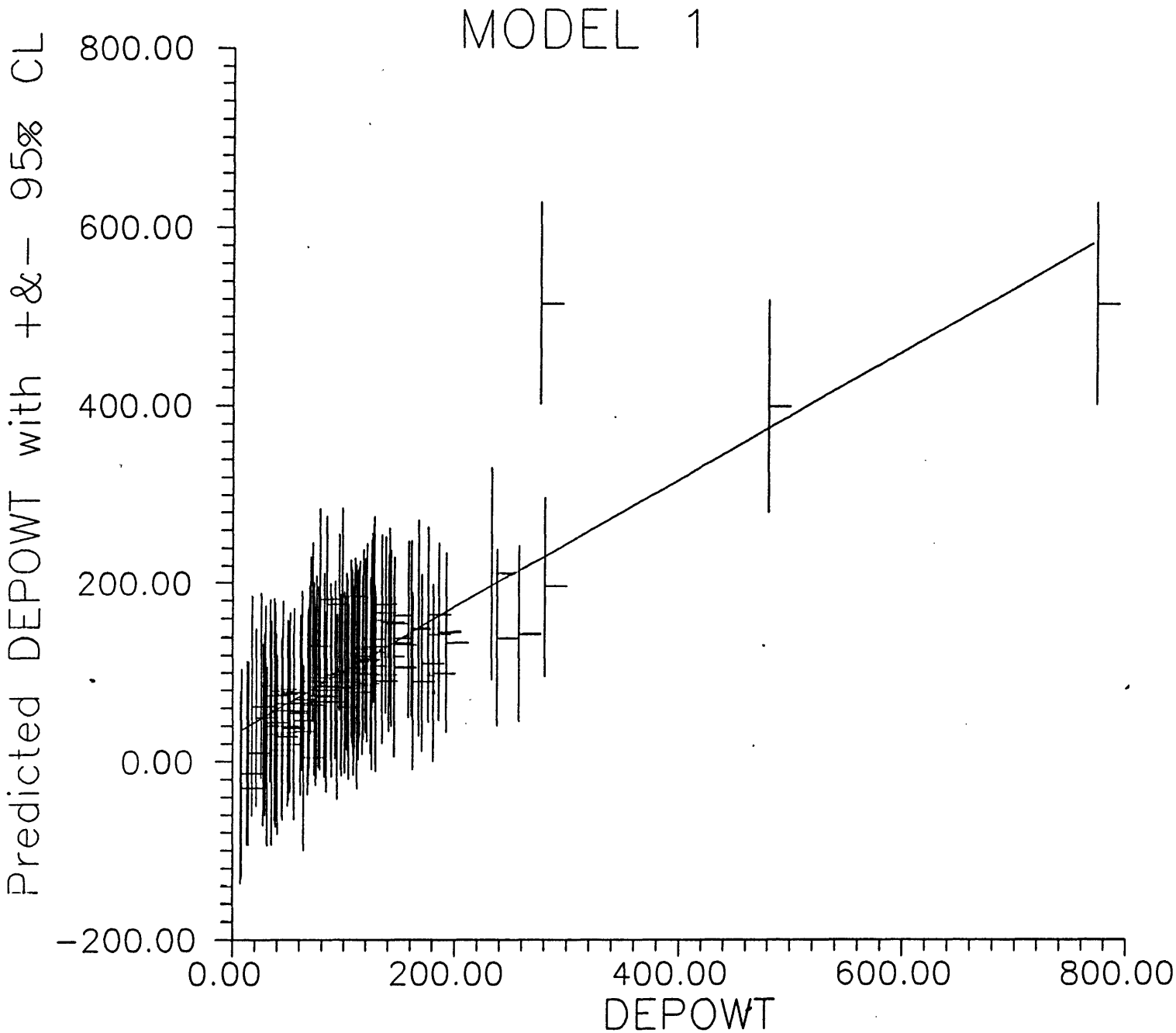

Figure 5: Model 1, DEPOWT versus predicted DEPOWT with upper and lower 95% confidence limits.

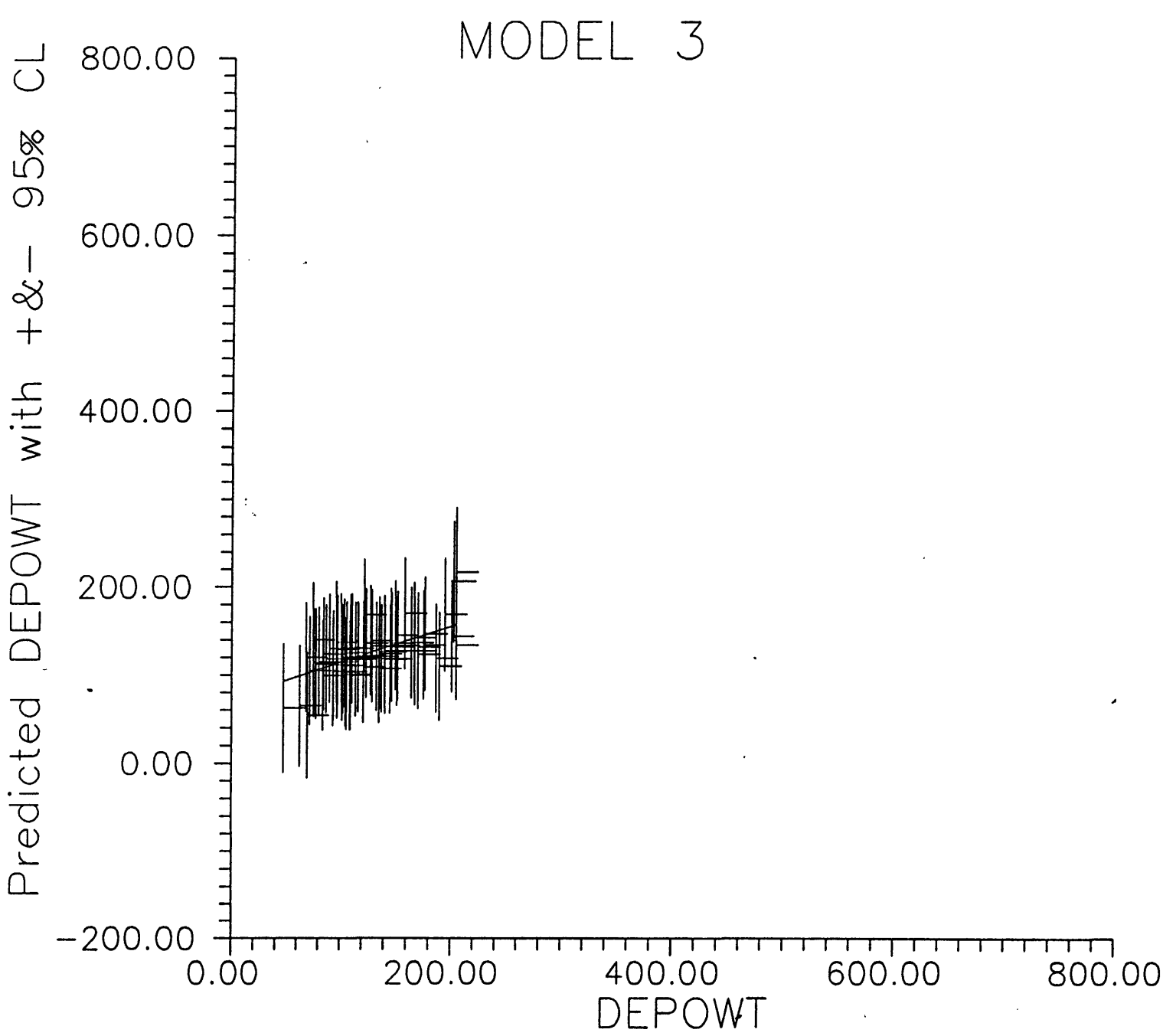

Figure 6: Model 3, DEPOWT versus predicted DEPOWT with upper and lower 95% confidence limits.

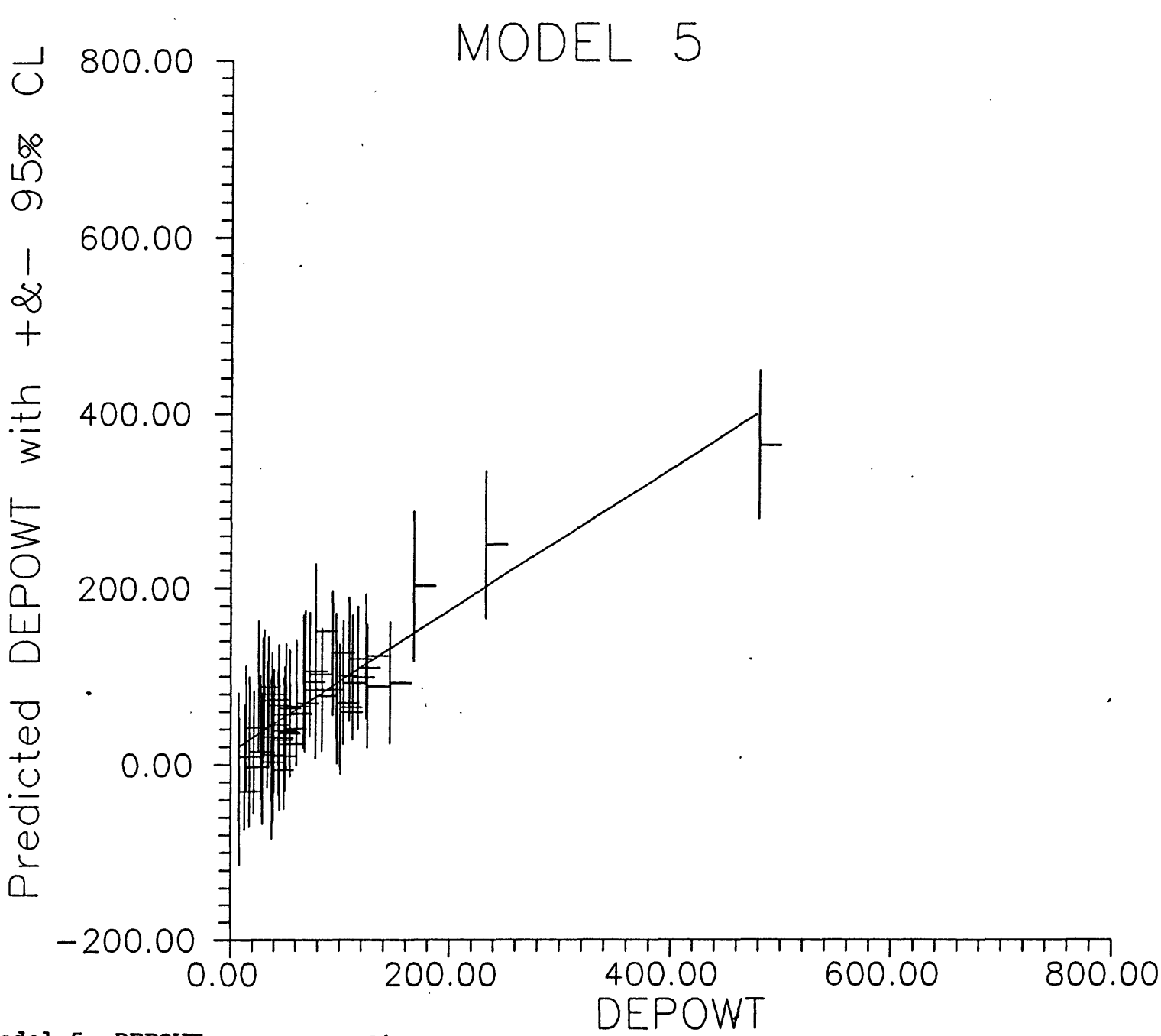

Figure 7: Model 5, DEPOWT versus predicted DEPOWT with upper and lower 95% confidence limits.

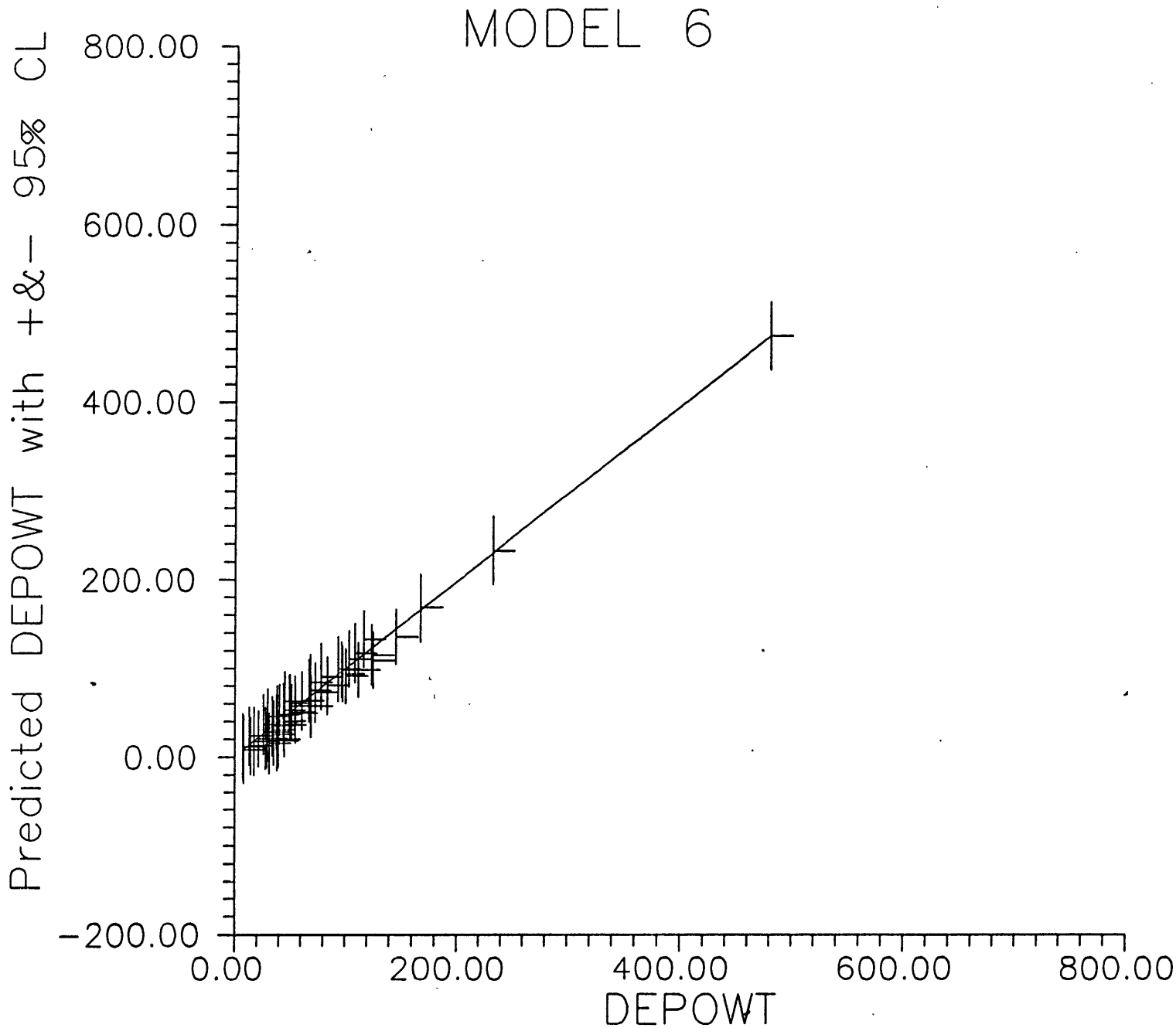

Figure 8: Model 6, DEPOWT versus predicted DEPOWT with upper and lower 95% confidence limits.

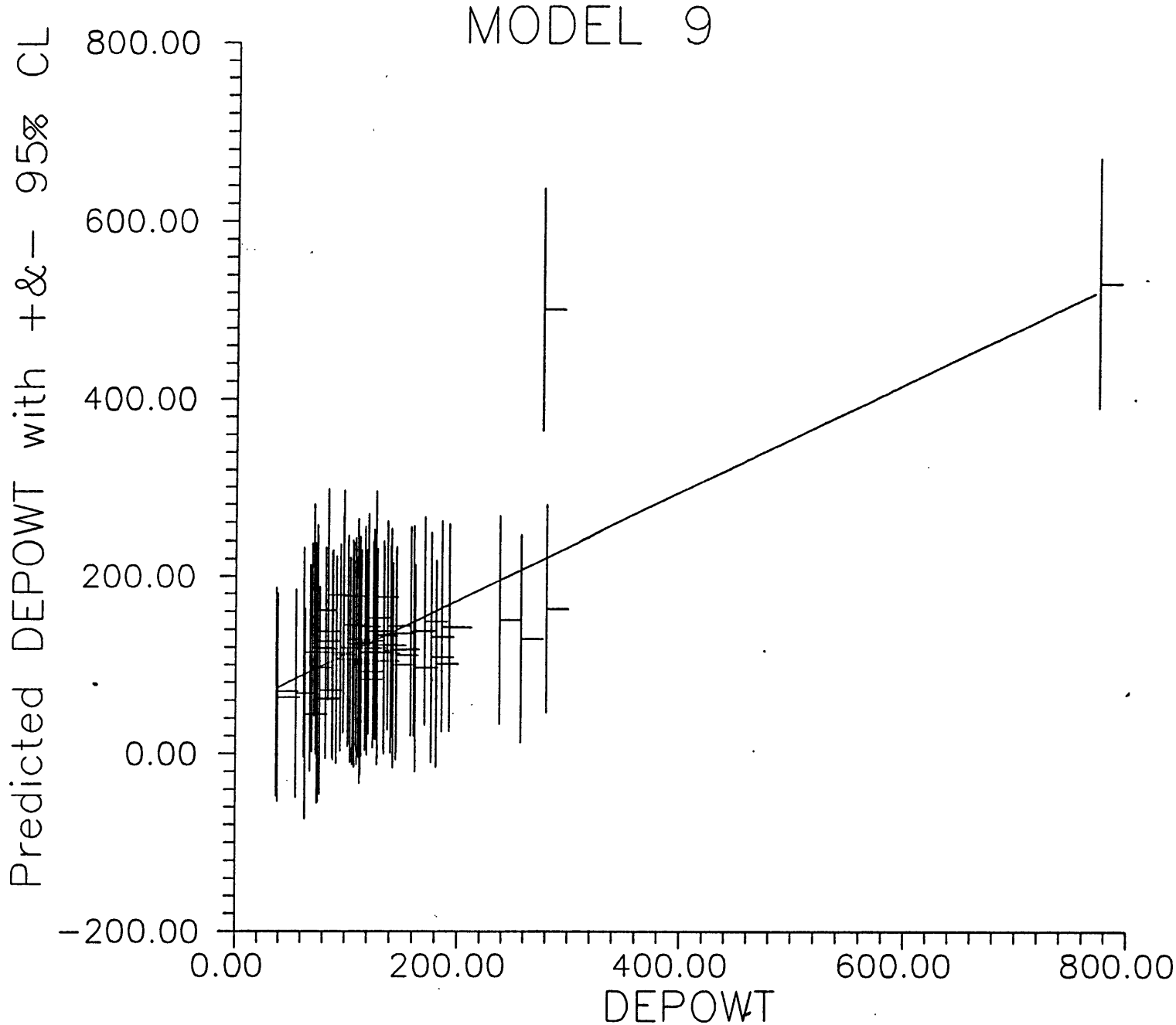

Figure 9: Model 9, DEPOWT versus predicted DEPOWT with upper and lower 95% confidence limits.

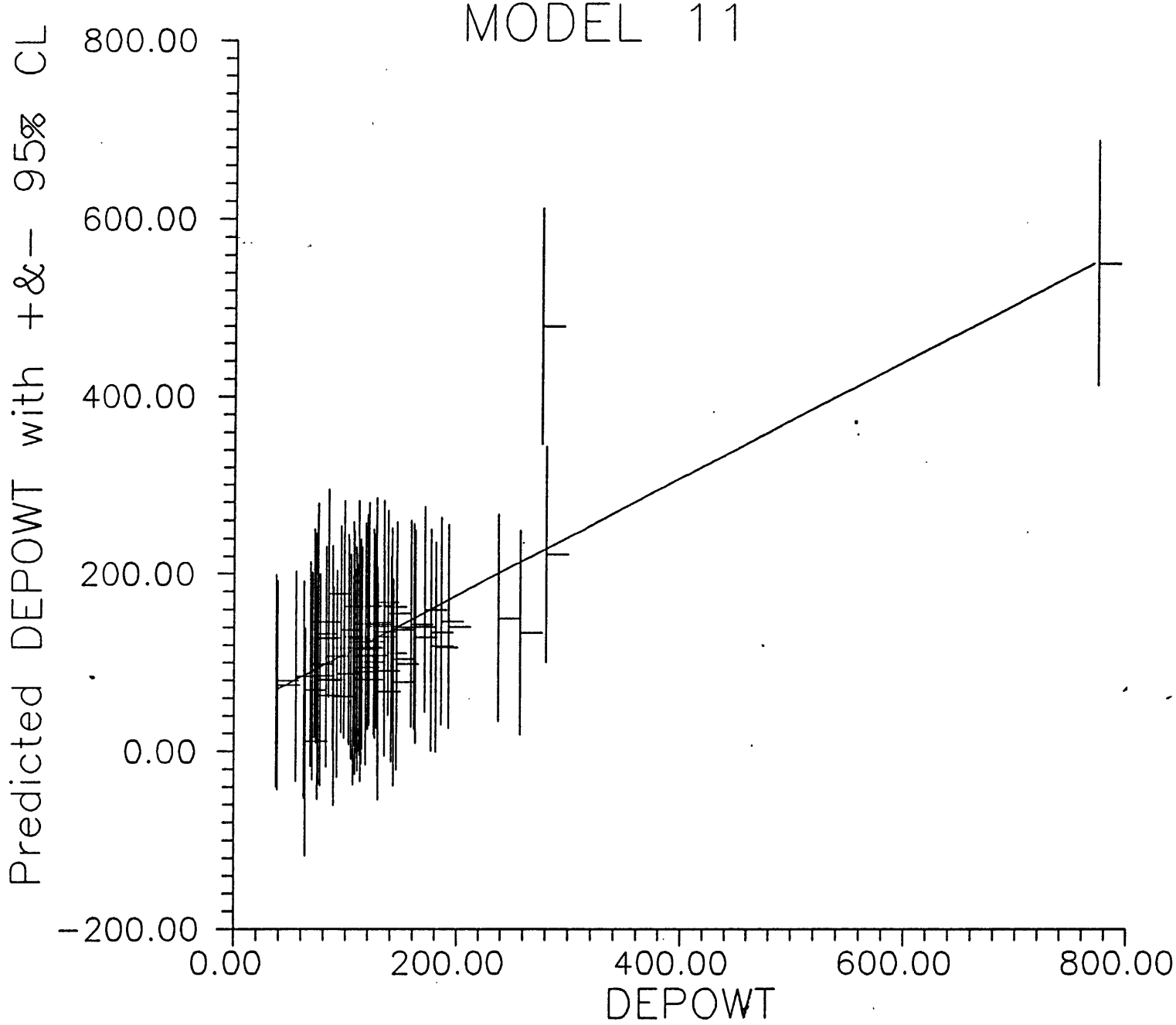

Figure 10: **Model 11, DEPOWT versus predicted DEPOWT with upper and lower 95% confidence limits.**

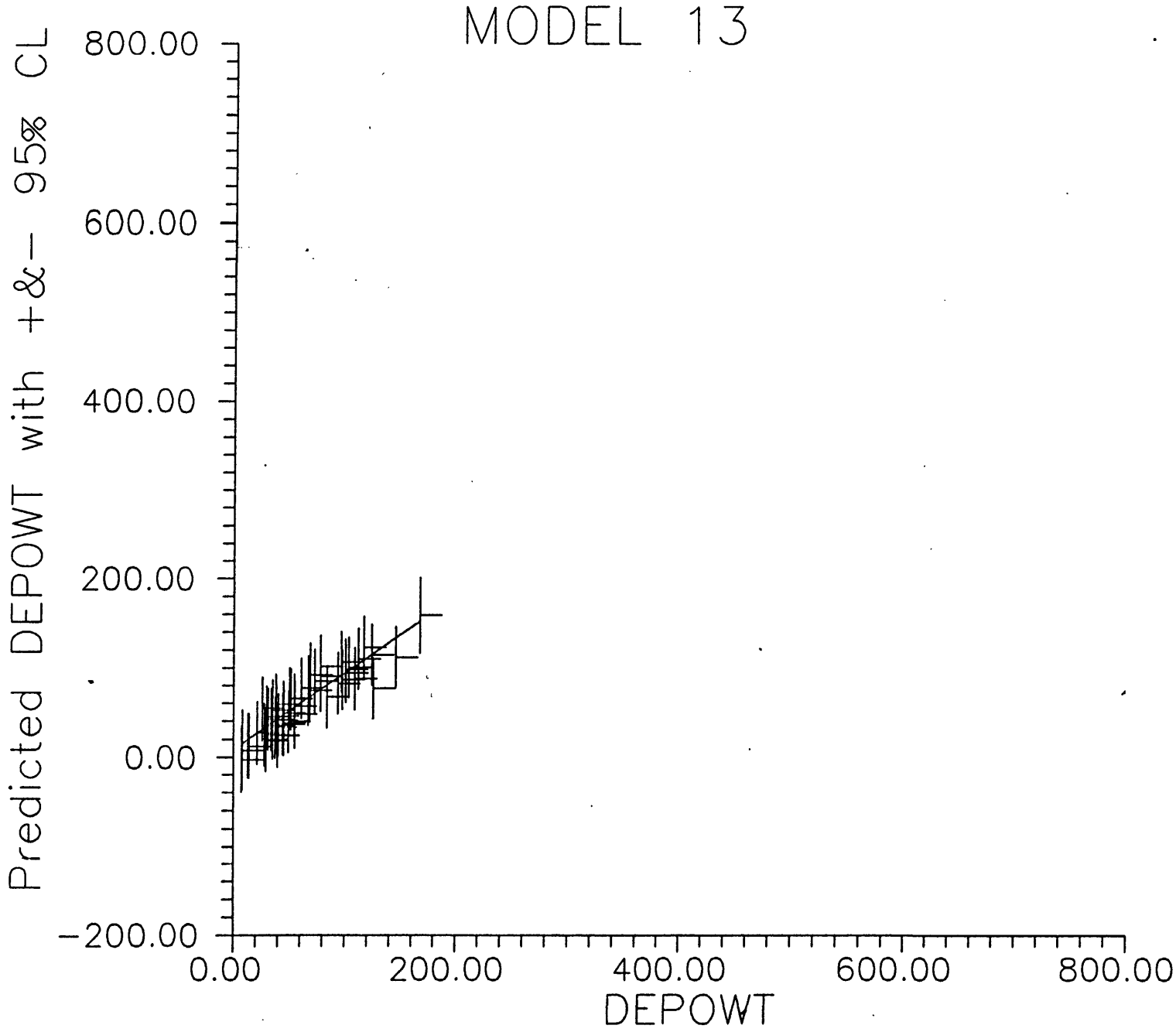

Figure 11: **Model 13, DEPOWT versus predicted DEPOWT with upper and lower 95% confidence limits.**

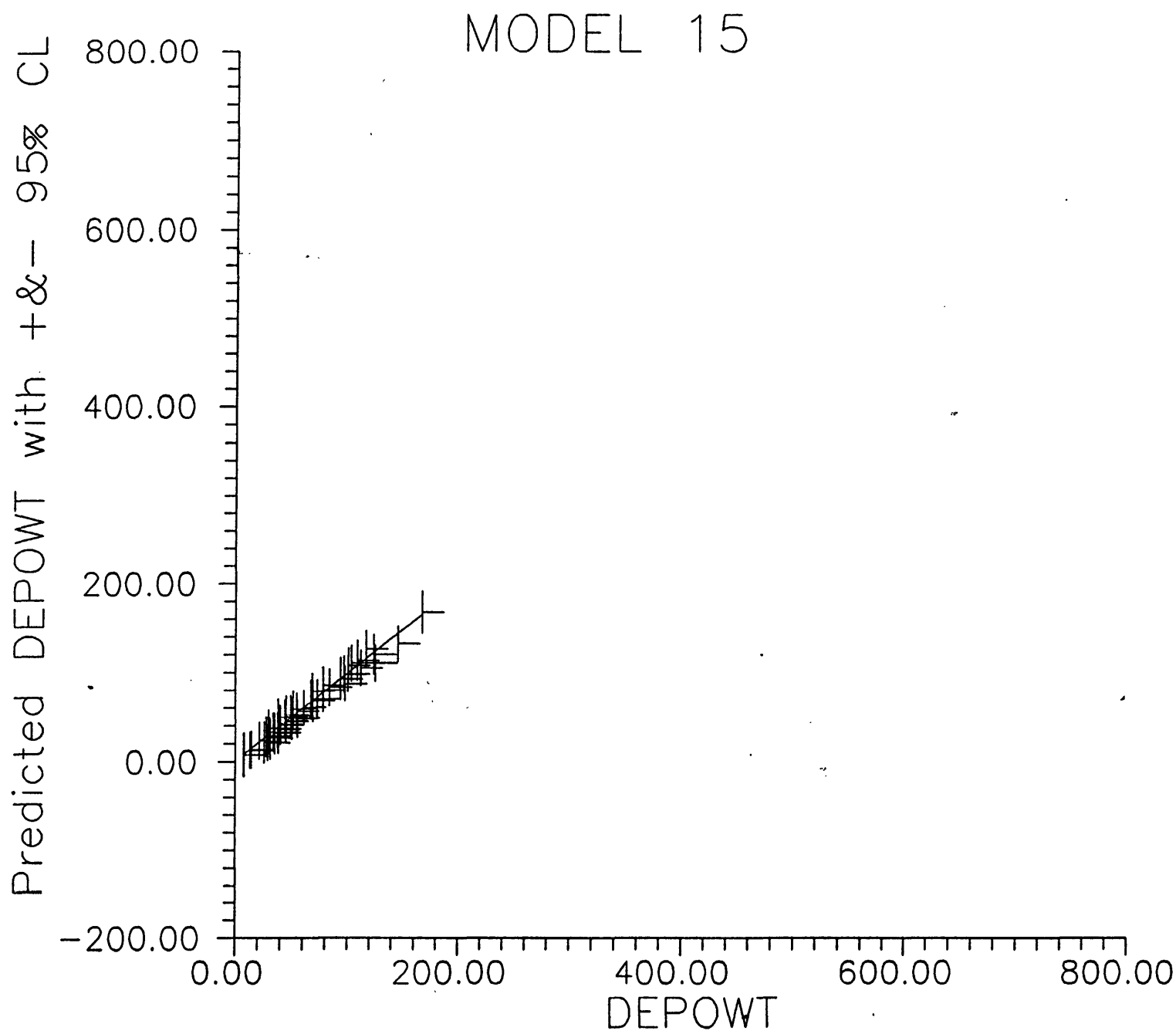

Figure 12: **Model 15, DEPOWT versus predicted DEPOWT with upper and lower 95% confidence limits.**

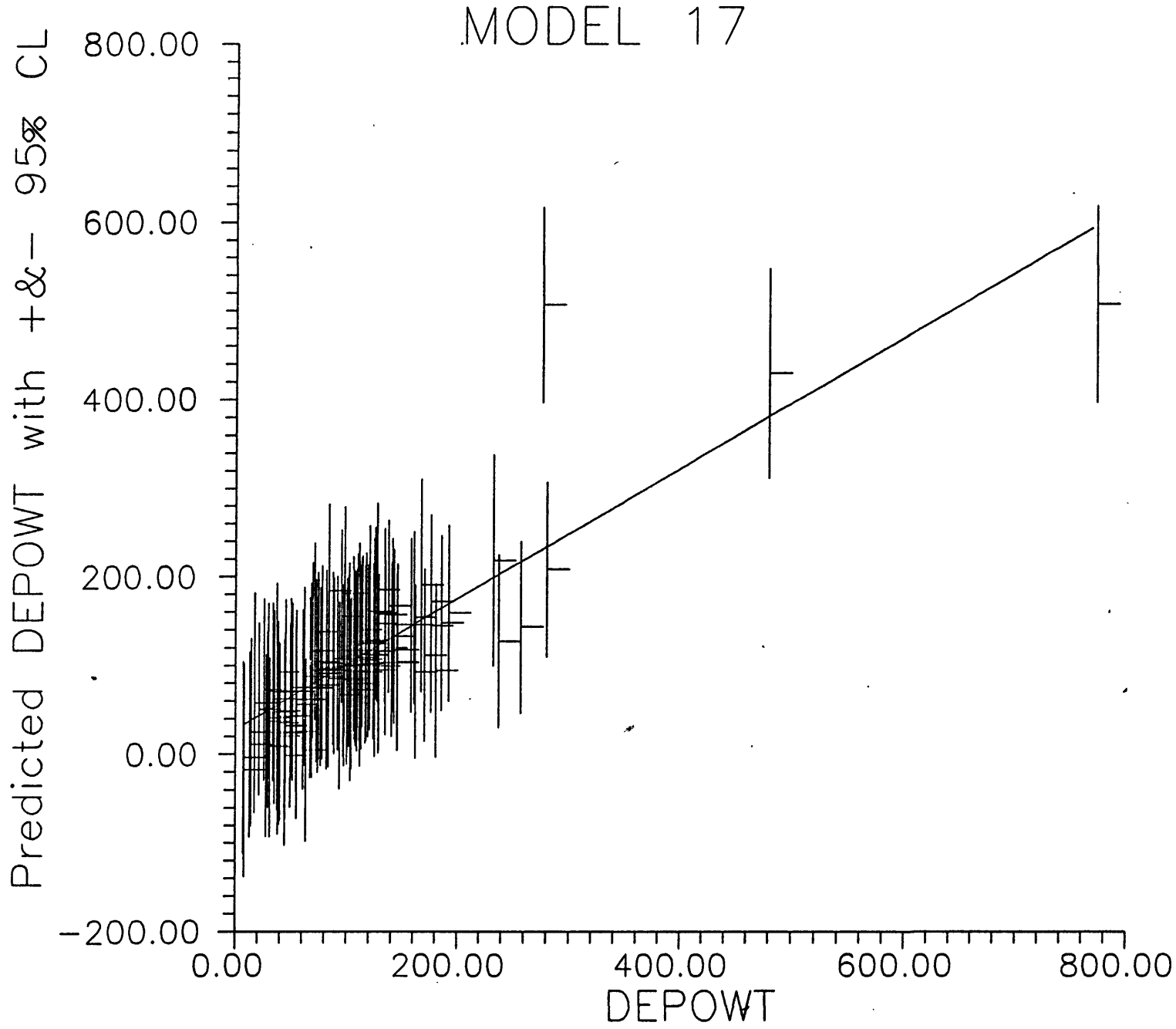

Figure 13: **Model 17, DEPOWT versus predicted DEPOWT with upper and lower 95% confidence limits.**

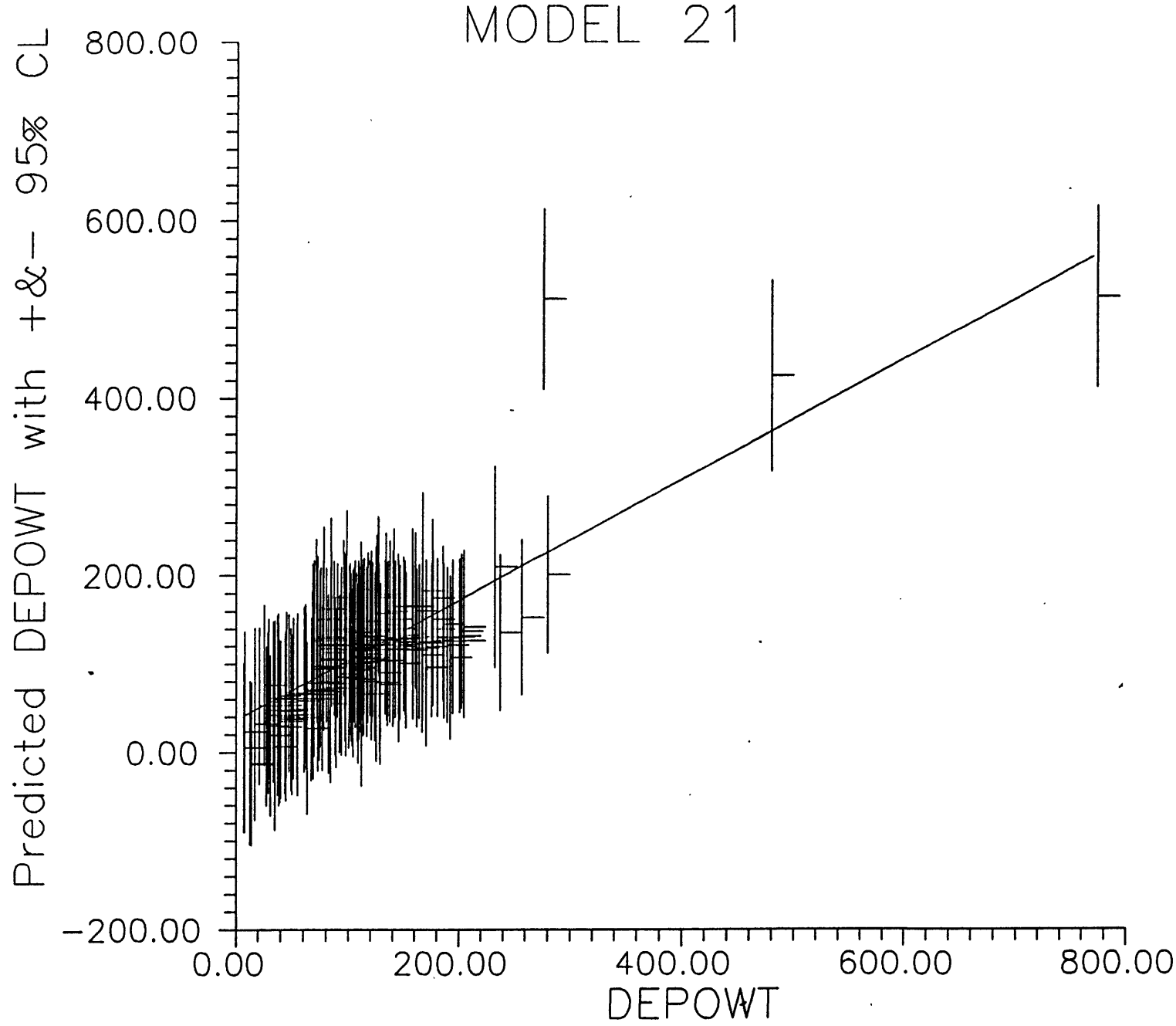

Figure 14: **Model 21, DEPOWT versus predicted DEPOWT with upper and lower 95% confidence limits.**

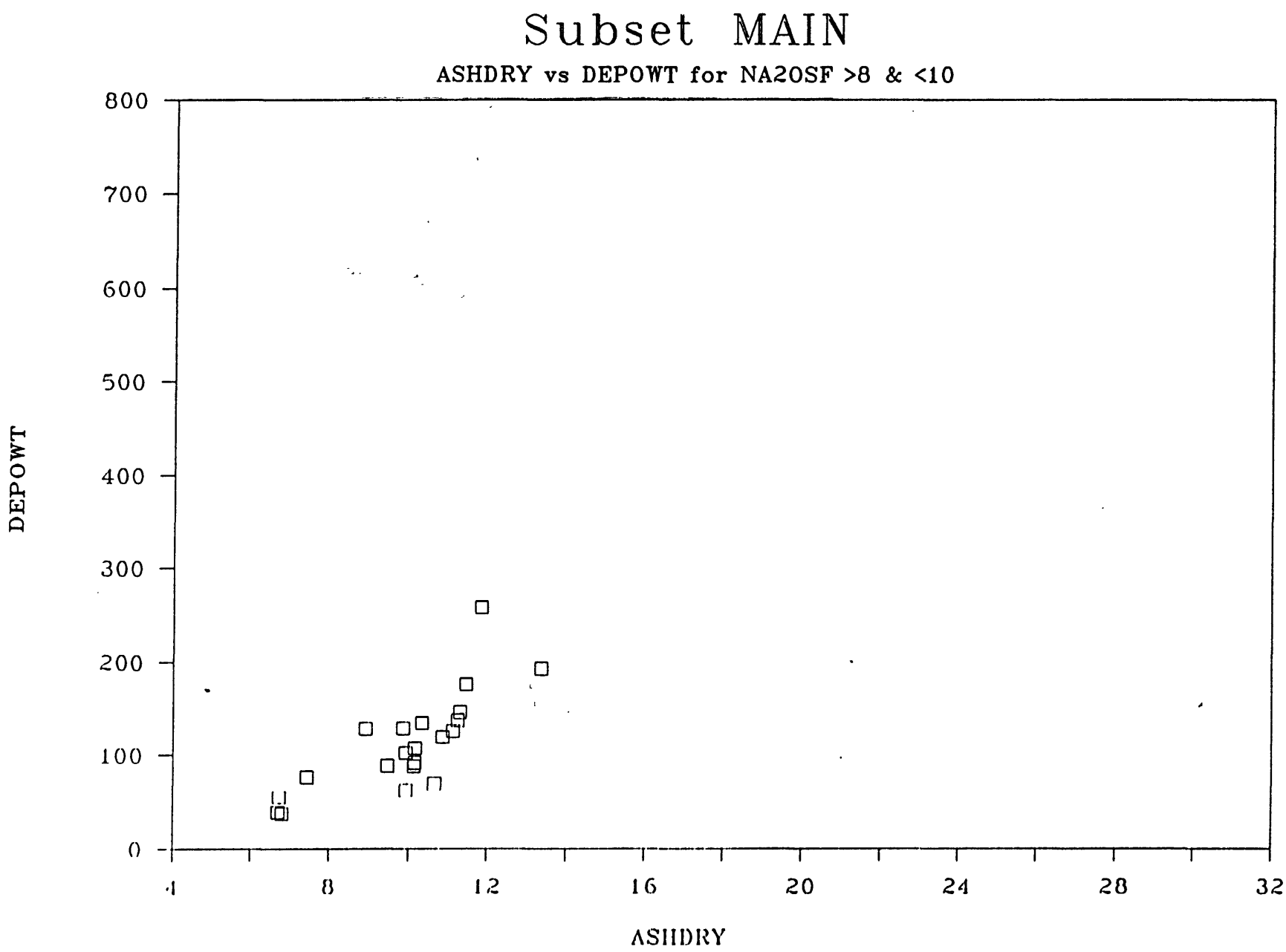

Figure 15: Subset MAIN, ASHDRY versus DEPOWT for NA2OSF >8 and <10 weight percent.

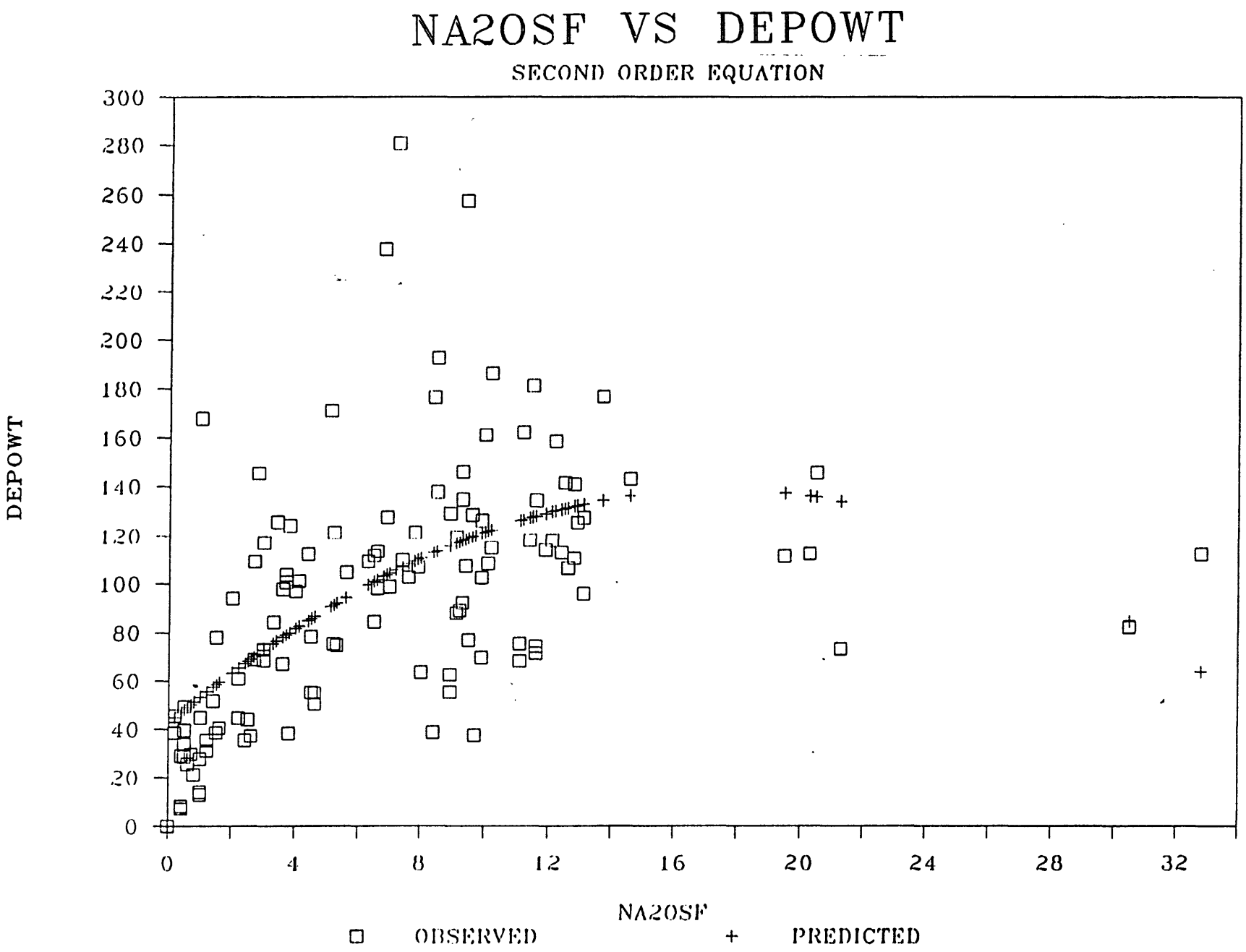

Figure 16: **Subset MAIN, NA2OSF versus DEPOWT showing second order relationship for NA2OSF with DEPOWT.**