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Elemental Associations of Coal:

A Study of the Organic and Inorganic

Association of Elements in Coal

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Data on the associations of elements in coal are summarized from the literature. Comparison of elemental analyses by different authors illustrate numerous inconsistencies. A summary of the literature showed zirconium, lanthanum, mercury, and silver are consistently classified as inorganic in origin; arsenic, cadmium, and manganese are generally inorganic; beryllium, germanium and antimony are usually regarded as organic in origin. Inconsistencies among authors in the organic/inorganic association of elements and in the use of different analytical techniques were investigated by a random variability test to determine the reliability of the conclusions concerning the organic or inorganic preferences of the various trace elements. The results of the random variability test on data presented in the literature suggest the statistical significance of the assignment to organic versus inorganic fractions. significant probabilities (p=.001-<.0001) were found for barium, vanadium, and silicon. The other elements tested were inconsistent and many of the random variability tests resulted in not significant probabilities (p>.05). Preferential sensitivity of analytical methods to detect elements in the inorganic rather than organic fraction or incomplete separation of organic/inorganic fractions account for inconsistencies in the organic/inorganic association of elements in coal.

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Acknowledgements

The author would like to express sincere gratitude to Dr. Kuellmer for his generous guidance and assistance during the course of this study. Also, a deep sense of gratitude is felt toward Frank Kottlowski, Frank Campbell and the New Mexico Bureau of Mines and Mineral Resources for their guidance, encouragement, and financial support throughout my work. Gratitude is felt toward Dr. Martha Mitchell for her guiding questions which have directed me to important information and resources. Thank you to Dr. Renault for his advice on the thesis organization. Guidance with the statistical analyses from Dr. Gutjhar is greatly appreciated. Special thanks to Deborah Teglia for her library assistance in obtaining research articles. The author would also like to thank Keith O'Brien for editing and proofing this manuscript. Finally, the author would like to thank Rick Homans for his unending patience and dedication throughout my graduate career.

Introduction

This study presents a review of the literature on the nature, origins, and associations of the elements of coal. Furthermore, it tests the consistency of the organic/inorganic association of elements in coal from the data presented in the literature. Random variability tests were utilized to investigate the significance of data presented by nine researchers.

A large number of researchers have studied the association of elements in coal. Much of the earlier work is difficult interpret because the inorganic constituents of coal were placed into a poorly-defined category called mineral matter. Mineral matter refers to all ash-forming constituents. Recent work has shown that not all of the inorganic material present in coal are found in mineral phases (Miller, 1977). This is especially true for the low-rank coal. Since the ash-forming constituents present in low-rank coals are associated with carboxyl groups and are the result of ion exchange processes with groundwater, Miller (1977) and Given and Spackman (1978) point out that minerals and inorganics must be considered Separately. The term mineral matter in the literature is more appropriately applied to the mineral and non-mineral ash-forming constituents of higher rank coal because the inorganic materials associated with higher rank coals are commonly in mineral phases.

The importance of whether an element is associated with the organic or inorganic portion of coal is four-fold. First, as pointed out by Lessing (1914) the amount of inorganic material in

coal is important to industry because it affects the yield of the carbonization products as well as the structure, strength and reactivity of the resultant coke (Jenkins and Walker,1978). Inorganic constituents (mineral phases) also undergo major changes which lead to clinker formation, fly ash, slagging and boiler tube corrosion (Ely and Bernhart,1963; Borio, Henzel, Ulmer, Wilson and Leonard (1968); Wett (1968 and 1969); Mitchell and Gluskoter (1976); and Nankervis and Furlong (1980). Also important to industry and the environment are the effluent and volatile elements which can make their way up the stack. Secondly, knowledge of elemental associations in coal is important for environmental reconstruction purposes. From this data the geologist can interpret source area, conditions during deposition, secondary or post-depositional changes, and location within the basin.

Methods of InVestigation

Concentrations of organically and inorganically associated elements have been studied in a number of ways with a wide variety of analytical methods. Due to differences in analytical techniques and presentation of results, no work has been done to compare conclusions of different authors. To compare the different studies, an organic fraction, inorganic fraction, and associated standard deviations were determined from the data of each researcher and each sample they studied. Where the authors did not state a standard deviation of their analytical data, acceptable values of the standard deviation were assigned according to the analytical technique used. For example, in emission spectrography, the most likely probable error is + or = 50% of the amount reported. The probable error (PE) is related to the standard deviation (s) by:

(a) PE=0.67449s

Data presented by each author was used in the following ways:

- 1) The concentration of the element in the organic (x) fraction and inorganic fraction (y) were determined. These are considered to be mean concentrations.
- 2) From equation (a) the standard deviation of the organic fraction (sx) and inorganic fraction (sy) were determined.
- 3) The difference of the means (m\$U1\$D-m\$U2\$D) was determined by:
- (b) x=y=msU1sD=msU2sD
- 4) The variance (SsD2sU) was determined by:
- (c) SSD2SU=SQRT((sx)sD2sU+(sy)sD2sU)

S\$D2\$U

- 5) From the above information a corresponding Z-value for a standard normal distribution was determined by:
- (d) msu1sD=msu2sD

2= --------

6) Finally a probability was determined for a two-sided distribution from (Table 4 Areas Under the Normal Curve) (Walpole and Myers, pp.513, 1978).

numbers are considered highly significant and scored with three asterisks in the appendices. If they fall in the range 0.001-0.01 they are considered very significant and scored with two asterisks in the appendices. A probability of 0.01-0.05 is significant and scored with one asterisk in the appendices. An insignificant probability value is >0.05 and no asterick is given. These probabilities were then compared among samples of the same authors and then between authors to see what consistencies existed with regard to organic or inorganic elements in coal.

Previous Work

A number of investigators have looked at the elemental associations of coal. One of the earliest studies of the organic and inorganic associations of coal was by Goldschmidt who in 1935 investigated trace elements in coal. He identified some elements which combined inorganically in coal and also identified metal-organic complexes. He attributed vanadium, molybdenum and nickel to these metal-organic complexes. Other investigators include Horton and Aubrey (1950) Inagaki(1951); Hashimoto(1953); Zubovic, Sheffey and Stadnichenko(1960 and 1961); Finkelman and Stanton (1978); and Raymond (1979). To determine organic and inorganic affinities of various elements in coals of varying ranks, these authors analyzed the various macerals representative of the pure coal substance. Other researchers who have studied the organic/inorganic associations of the elements of coal are Breger and Schopft (1955); Nicholls (1958); Bogdanov (1965); Razdorozhnyy(1968); Manskaya and Drozdova 1968); Szilagyi (1971) Gluskoter and Landahl (1973); Ruch, Gluskoter and Shimp (1974); Miller (1977); Gluskoter, Ruch, Miller, Cahill, Dreher and Kuhn (1977); and Kuhn, Fiene, Cahill, Gluskoter and Shimp (1980). Because this study involves a very extensive literature survey, explanations and more detailed descriptions of each author's work will be presented in the text of this paper.

Gluskoter et al (1977) found that elements organically associated in a sub-bituminous coal from Wyoming might be inorganically associated in a coal from the Appalachians. Nicholls (1968) also noticed this trait and attributed it to the variation in age between the different seams analyzed. This seems logical since different geological events occurred at different times and brought new suites of elements into the surface geochemical systems. Observations like these raise the guestion of what are the factors which affect the organic and inorganic associations of the elements in coal?

Some of the factors which investigators have attributed to the many differences are: 1) source material 2) stability of the various compounds which contain metals 3) age and rank 4) environment of deposition and 5) secondary or post-depositional changes.

Source material is composed of those elements entering the basin of deposition during peat formation. At this stage the system is open and extrabasinal material is carried in either in the form of mineral phases or as soluble ions and metallo-organic complexes. This material is brought into the peat-forming environment by groundwater, meteoric waters, or by aeolian forces. Allogenic, adventitious or detrital are terms which describe these inorganic species which have been brought into the basin during peat accumulation. Another definition of adventitious material is that which can be separated from the coal substance

(Edgecombe and Manning, 1952). The soluble ions which have been brought into this depositional environment may either precipitate and form authigenic minerals or they may be assimilated by the living plants through the root system and combine organically with the plant tissues (Sprunk and O'Donell, 1942). This may occur at three stages during the coal formation. The first, which has already been mentioned occurs during the life of the plants, second, during the decay of the plants, and third, during the mineralization of the coal.

In an attempt to use plants as indicators of source material for the organically associated elements in coal, many authors have published lists of elements believed to be associated with either a particular species of plant or plants in general. Such lists may be inconclusive when based on observations of present day plants for it is not certain if the elemental composition of modern day plants is identical to ancient coal-forming plants. Miller (1931) listed ten elements necessary for the growth of all plants. They are carbon, oxygen, hydrogen, nickel, phosporous, potassium, calcium, magnesium, sulfur and iron, copper and boron, manganese and probably zinc are also believed to be essential. Kuhn, Fiene, Cahill, Gluskoter and Shimp (1980) provide a table in their report comparing the mean concentrations of elements which they predict to be organically associated and the mean concentrations of these same elements in plant material. From this comparison they have determined that the elements which are highly concentrated in plants (iron, calcium, potassium, magnesium, manganese and phosphourous) are less concentrated in the organic portion of coal. They attributed this depletion to epigenesis prior to polymerization. Casagrande and Erchull (1976), in studying the Okefenokee peat-forming environments noted that when drought occurs water levels drop. This change allows increased microbial oxidation of the organic matter and release of metals which had formed a part of the living plants. This activity may account for the depletion of metals in coal when compared to plants.

Szalay (1957) found nitrogen, phosphorous, sulfur, clorine, florine, bromine, iodine, niobium, and selenium to be elements not adsorbed by organic substances since organic matter has a negative charge and only cations will be adsorbed. These elements generally occur in their anionic form and are therefore, not absorbed.

precipitation of authigenic minerals, plant assimilation, and organic compounds which may form, provide the stability necessary for metals to remain with the coal-forming substances throughout the coalification process. To study the associations of metals with organic materials, Zubovic (1966) says one must assume that organically associated elements "in geologically old carbonaceous materials are present in the most stable complex possible to survive through geologic time". Chelates and ring structures of metallo-organic complexes are known to be stable. Porphyrin chelates of metals are known to exist. These structures enable plant material to incorporate transition metals. For example porphyrin nuclei are structural units of chlorophyll and they retain Magnesium atoms by two ionic and two covalent bonds

(Manskaya and Drovdoza,1968). Schartz (1954) hypothesized the important role of chelate-fertilizer in the extraction of trace elements from minerals making them water soluble and available to plants. In this case, the metal ion forms the center of the complex ring structure. Zubovic, Stadnichenko, and Sheffey (1960) and Zubovic (1966) relate high ionic potential with degree of organic association. Metals with high ionic potential have high organic association in coal. Examples of metals of high ionic potential are beryllium, boron, germanium, titanium, gallium, aluminum and silicon. Zubovic (1966) states that when yttrium, gallium, lanthanum, beryllium, nickel, cobalt and zinc are bonded to organic material, they are held as chelated complexes.

Two other types of compounds can be formed by organic compounds and metals: a salt-like compound and a metallo-organic compound. The salt-like compound is formed by a metal substitution for a hydrogen of a carboxyl group. Many salts are soluble in water in a geologic sense. Metallo-organic compounds are formed when a metal bonds directly to a carbon of an organic radical (Krauskopf,1967). Martell and Calvin (1952) listed the organic compounds capable of forming internal complex compounds with metals: primary amines, secondary amines, tertiary amines, oximes, imines, thioesters, keto groups, thioketo groups, hydroxyl groups, and carboxyl groups.

The associations of elements may also be related to conditions under which the coal is being deposited. Razdorozhnyy (1968) related the irregular distribution of trace elements in coal described in the literature to changes in pH between the

coal beds and country rock. For example, the Donbas Coal Beds of Russia which are 50-65 cm thick have considerable variety in ph's between each bed. He also found that coals deposited in basins with little circulation of water are alkaline and those deposited in open basins accessible to sea water are strongly oxidized. He concludes alkaline coals are better concentrators of trace elements than acid coals.

Another topic on which many researchers have concentrated is the ability to discriminate between marine vs non-marine paleo-environments. A very recent study was conducted by Bailey (1981) who studied the differences between coals formed in marine-influenced and fluvial paleo-environments of the Lower Kittanning Coals. He concluded that fluvial samples are higher in copper, chromium, titanium, potassium, silicon, and aluminum, while marine-influenced samples are more concentrated in zinc, iron, pyritic sulfur and sulfate sulfur.

Variations in age and rank account for the differences in elemental associations. Lower rank coals differ from coals of higher rank in that they have higher oxygen contents. This oxygen is in the form of weakly acidic and reactive functional groups (Van Krevelan, 1961). The functional groups are involved in ion-exchange and chelation with metals. Lower rank coals are also known to have some humic acid present which serves as progenitors for coals of higher rank (Breger, 1955). Humic acids, though they are not contained in plants play an important role in the formation of the organic portion of peats and are capable of combining with certain elements. Uranium, vanadium, gallium,

molybdenum, nickel, and copper are examples of elements which are able to do this (Manskaya and Drovdoza, 1968). Manskaya and Drovdoza (1968) stressed the role of humic acids in mobilizing and trapping metal cations.

Behavior of elements associated with coal post-depositionally and the diagenetic changes which take place is not well understood. As rank increases there is a decrease in porosity, moisture content, and optical anisotropy increases (Stach, 1975). As the porosity amd moisture content decreases so does the ability for extrabasinal material to enter the coal except through fractures. Miller (1977), who studied the lignites from South Dakota, found elements that are organically associated in bituminous coals to be associated in the same way in lignites, but with the total content of a number of elements in lignite being greater than bituminous coal.

Brief descriptions of published work of a number of researchers who have investigated organic and inorganic associations of elements in coal is included. Analytical techniques, precision, type of coal analyzed and the results of the authors are summarized in Table 1.

Bogdanov (1965) collected over 15,000 samples of Russian bituminous coals, coal inclusions in country rocks, and country rocks for semiquantitative spectral analysis. From these analyses he grouped the elements into three catagories: those which form insoluble metallo-organic compounds with humic acids and are closely related to organic substances: Ge, T1, Sc, Cd, Mo, Sb, As, P, Pb, Zn; elements associated with terrigenous material are T1, Cr, Zr, Au, Y, Ce, La, W, Sn, Ni, and Ag; and the final group is variable in association: Fe, V, Cu, Ba, Sr, and Mn.

Breger, Duel and Rubenstein (1955) analyzed spectrographically a sample of lighte from the Mendenhill strip mine, Harding County, South Dakota. From their work they suggest that uranium is present in the organic portion of the coal and is held in the coal as an organo-uranium compound. Also, Ni, Co, Be, Mo, Ti, V, Cr and Sn are present in the demineralized lightte.

Dalton and Pringle (1962) studied the content of gallium in the Warwickshire Coalfield, Cannock Chase, Shropshire and North and South Staffordshire Seams, England. Associated roof and floor samples were also analyzed. Spectrographic analyses were conducted to determine concentrations. As a result of this

investigation, it was determined that gallium is variable in association and is present in the finely divided alumino-silicates intimately mixed with the coal. A small quantity was associated with the organic and inherent mineral matter of the coal.

Duck and Himus (1952) studied the mode of occurence of arsenic in commercial coal and coke samples. Age, rank, and names of the seams sampled have not been given in the article. Arsenic was determined by a modified Gutzeit Process on the coal as received and retained in the coal ash. They concluded that arsenic occurs in the coal as arsenopyrite and to some extent as an oxidation product of arsenopyrite.

Gluskoter and Lindahl (1973) studied the cadmium contents of twenty-three Illinois Coals. They hypothesized from their work that cadmium substitutes for zinc in sphalerite and in coal it is associated with the high specific gravity fraction or sink.

Gluskoter, Ruch, Miller, Cahill, Dreher, and Kuhn (1977) analyzed 172 whole coal samples, 40 of which were bench samples and 64 were washed coal samples. 114 of the samples were from the Illinois Basin. Five of the nine washed coal samples were also from the Illinois Basin. The other samples are from other areas in the United States. Ions were determined using a number of analytical techniques. In table J of their text is a summary of the techniques used for each element. From the washability studies they determined an index of organic affinity for the elements and catagorized them as: 1) organic 2)

intermediate-organic 3) intermediate-inorganic and 4) inorganic. They concluded that Ge, Be, B, and Sb were organically associated and Zn, Cd, Mn, As, Mo, Fe and inorganic.

Horton and Aubrey (1950) studied the distribution of minor elements in three samples of vitrain of different ranks from the Barnsley Seam of South Yorkshire, England. The samples were taken at 12 mile intervals. The vitrains were hand separated from the coal and ground so that they passed through a 100 Bs test-sieve. Microscopic examination followed to determine how pure the vitrains were. Thurcroft and Markham Main were found to be of high purity. Because a number of fusain bands were present in the Dalton Main Sample It was impossible to isolate the vitrains by hand. Horton and Aubrey (1950) then used float-sink separation methods. The different density fractions were then ashed and examined with a quartz spectrograph to determine the following minor elemental concentrations: Sb, Be, B, Cr, Co, Cu, Ga, Ge, Pb, Mn, Mo, Ni, P, Sn, Ti, V, Zn, and Zr. The coal was ashed at 400 degrees centigrade. The quantities of the elements present were estimated by a visual comparison of intensities of the samples as compared to a series of standards.

Based on graphic representation of the ideal variation in concentration for elements associated with 1)the organic portion (pure coal substance) 2)the inorganic portion (adventitious) and 3) variable association, Horton and Aubrey (1950) grouped the elements according to varying proportions contributed by each fraction. A scoring system was then created in which a value of one means that all of the element is contributed by the pure coal

substance; 3/4 implies that 3/4 of the element is contributed by the pure coal substance and 1/4 was contributed by the adventitious material. They determined that the number of elements interpreted to be associated with the organic or pure coal substance are variable between vitrains from the same seam. Although some generalities may be determined, Be, B, Ga, Ge, Ti and V all seem associated with the pure coal substance while, with the exception of Cu, none of the elements examined show evidence for association with the adventitious portion of the coal.

Inagaki (1968) made colorimetric determinations of Ga and Ge in Japanese lignites and Coals. He found that Ge may be more firmly retained in lignites than in coals. He also found that Ga is associated with the adventitious mineral matter.

The work of Kuhn, Fiene, Cahill, Gluskoter and Shimp (1980) includes data from the studies by Gluskoter et al (1977), Kuhn et al (1978) and Kuhn, Fiene and Harvey (1978). In the 1980 study by Kuhn et al (1980), 27 coals from the various regions of the United States-Eastern, Central, and Western-were investigated. The samples were subjected to gravity separations and chemical demineralization in order to achieve a more complete separation of the organic and mineral fractions of the coal since gravity separation "seldom if ever, results in a complete separation of mineral matter from the coal" (Kuhn et al, 1980). Elemental concentrations were then determined using a number of analytical techniques. These include: neutron activation, X-ray fluorescence, wavelength-dispersive, direct-reading optical

emission spectroscopy, prompt gamma-ray/neutron activation and X-ray fluorescence-energy dispersive. For the Illinois Coals: Br, Ge, Be, Sb, B, and organic Sulfur were found in the organic phase. Zn, As, Cd, Fe, and pyritic sulfur were consistently associated with the inorganic material. Zr, Hg, Pb, Hf and Mn were found to be inorganically associated and easility removed. Al, Si, Ti, Mo, K, P, Ga, Ca, Cr, Co, Ni, Cu, Mg and Se were variable in association.

South Dakota in his doctoral dissertation. His work indicates that Ca, Na, K, Sr, Ba, Mg, and Mn are present in an ion-exchangable form attached to organic acid groups. Chelated organic complexes contain Al, Ti, Be, and V. These chelated organo-metallic complexes are decomposable in dilute mineral acid. Because these cations are associated with carbonates as well this catagory is considered variable in association. Another group Si, Al, K, Mg, Zr, and Ti are present as detrital minerals. Miller concluded that "a surprisingly large number of elements in lignite owe their association to interactions with organic matter, and that the organic matter has had a profound influence in determining the distribution of many elements in the seam".

Nicholls (1968) compared a number of coal analyses and plotted the concentrations of various elements in coals against the ash content of the coal. Diagrams were presented depicting a number of such points for a single coal seam or group of coal seams in a single geographic area. These points were then

interpreted for degree of inorganic and organic association of elements. The seams used in the analysis were the Svea Seam, Spitzbergen (Butler, 1953), the Lloyd Cove Seam, Nova Scotia (Hawley, 1955), and the New South Wales Coalfield (Swaine, 1962). These seams differ in age. For example, the Svea Seam is of Cretaceous age and the Lloyd Cove Seam is of Upper Carboniferous age. Nicholls described elements as: associated with the organic portion: associated with the inorganic portion; variably associated; high concentration of element and associated with the inorganic portion; and high concentration of the element and associated with the organic portion of the coal, Nicholls (1968) determined B to be inorganically associated and Pb, Co, Cr, Ba, Sr and V to be inorganically associated. Ge, Ga, Ni, Mo, As, and Cu he found to be variable between the different seams. Ni and Cu were inorganically associated when their concentrations in the coal were high. This was also true of Ga and Ge which were organically associated when their concentrations were high in the coals. Nicholls accounts for the variability of some of the elements studied due to the differences in age of the different seams.

Razdorozhnyy (1968) studied the acidity of bituminous coals from the Bagansk area of the Donbas, U.S.S.R. and attempted to correlate fifteen elements with pH values and ash contents. A set of coal and enclosing rock samples (argillite and siltstone) were analyzed using heavy liquid separations. From his investigation, he found that Co, Ni and Be are found in the organic fraction, while Pb, V, Sn, Cr, and Ag are found in the

inorganic portion of the coals. Zn, Ga, Sc, Cu, Yb, Y and Mo are variable in association.

Ruch, Gluskoter and Shimp (1974) have determined elemental concentrations for 21 elements on four samples of coals from the Illinois Basin (Illinois, Indiana, and Western Kentucky). The seams studied include the Davis Member and the Dekoven Member of the Natton Formation, Colchester (No.2) and Herrin (No.6). From gravity separations, they determined an organic affinity index. Elemental concentrations were determined using a variety of analytical techniques including x-ray fluorescence, optical emission spectrometry, atomic absorption, neutron activation and ion-selective electrode analysis. From their data, they found that Ge, Be, and B have the greatest organic affinities and tended to be concentrated in the clean coal fractions. Hg, Zr, Zn, Cd, As, Pb, Mn, and Mo were concentrated in the mineral matter portion of the coal and have the least organic affinity. They found P, Ga, Ti, Sb and V to be variably associated but more closely allied to the elements with high organic affinities. A fourth group was identified as being variable, but as more closely related to the elements with inorganic associations. These elements are: Co, Ni, Cr, Se, and Cu.

Szilagyi (1971) also used spectrographic methods to determine the association of Mo, V, and Cr in coal samples from Hungary. A portion of his work includes the data of Szava (1966 and 1967) from two coal beds. The Mecsek Coals are of Liassic age (Lower Jurassic) and the Borsod Coals are Miocene. The Mecsek

Coals have high concentrations of Mo and the Borsod Coals are V and Cr-rich. The seams were sampled in intervals. The units of these intervals were not indicated. It is important to note that the sampling also included the carbonaceous shales between the coal layers as well as the shaly layers above and below the coal units. An ideal diagram of the expected relation between the metal concentration in the ash and organic material was determined. As a result of his analysis, Szilagyi found Mo to be organically associated. When Mo is found in low ash coals it is in higher concentrations than would be expected just from the accumulation of ash and organic plant material. Szilagyi attributed this to secondary Mo enrichment through the groundwater. Cr and V were not so clear cut in their distribution and are interpreted to be variably associated.

Valeska, Malan and Kessler(1967) studied trace elements of the Ostravakarvina Coal District of Czechoslovakia and determined that Ge, Be, P, B and V increase with decreasing ash and are associated with what they call the "inner ash" of the organic matter. Analytical methods used were not indicated.

Thallium in coal has been studied by Voskresenskaya (1968). He has established through quantitative spectographic analyses that thallium in a number of coal basins in the Soviet Union accumulates in sulfide inclusions, especially in pyrite and is therefore inorganically associated.

Zubovic, Sheffey and Stadnichenko (1960, 1961, and 1964) and Zubovic (1966, 1976) also studied the organic/inorganic association of elements in coal. Their analyses were conducted in

a manner similar to Horton and Aubrey (1950). Thirteen samples of coal were separated into float-sink fractions; two samples were separated into five fractions, and the third sample into three fractions. The samples originated from several different beds, the Minshall Seam, Indiana (member of the Tradewater Group), and Number 9, and Number 5, Kentucky (both members of the Carbondale Group). A diagram was used to present their data as those elements which are associated with the float and those associated with the sink. From this information, Zubovic et al (1960, 1961, and 1964) made a list of elements in order of decreasing association with organic matter: Ge, Ga, V, Be, Ti, B, Ni, Cr, Co, Y, Mo, Cu, Sn, Zn and La. The first six: Ge, Ga, V, Be, Ti and B are identical to the results of Horton and Aubrey (1950). Zubovic (1966) added that this series is related to the chelating properties of the metals. Table 1 is a summary of the various authors, analytical methods used, location of coal sampled, age, and rank of coal.

Table 1: Summary of Authors

Author	Analytical Method	Geographic Location	Rank & Age
Bogdanov (1965)	Spectral Methods	Russian Coal	nete station Arbeit station, agent station, agent station, agent vectors gaves their first vector
Breger, Duel and Rubenstein (1955)	Spectrographic Analysis Chemical extraction in 1 N HCl acid	Mendenhill, South Dakota	Lignite age not indicated
Dalton and Pringle (1962)	Spectral Methods Carbon tetrachloride and Carbon tetrachloride- benzene mix 1.32,1.40,1.59	Warwickshire, Cannock Chase, Shropshire, North and Sout Staffordshire	age not indicated
Duck and Himus (1952)	en again traditions affirmance, susceptive against assessment against account	ордин обина удаци этом, этом того того того того обина было обина обина обина обина обина обина обина обина об	Bituminous Coal and Coke age not indi- cated
Eskenazy (1977)	gyykanga-taba-katin-teritoska-novataine _{Jako} nsalla gova-hall enerchwan terrenan had atab ^{Jako} Apas SCH vaga san) भवान भारतम् व्यक्ति व्यक्ति ^{व्यक्} रियाच्या व्यक्ति स्वत्रात्त्र व्यक्ति व्यक्ति स्वत्रात्त्र स्वत्रात्त्र स्वत्र	awan awan awan amin'inanga wasa iliam' anananaan eron onga per
Gluskoter and Lindahl (1973)	Atomic Absorption Spectrophotometry	Illinois Coal	Bituminous Carbon- iferous
Ruch, Miller,	Atomic Absorption X-ray Fluorescence Neutron Activation Emmision Spectroscopy	Illinois Basin U.S. Coals	Bituminous Carbon- iferous
Horton and Aubrey (1950)	Spectral Methods	South Yorkshire Coals	Vitrains of various unspecifie ranks

Table 1: (Continued) Summary of Authors

is visigani mindar mindar drongs. Holless citizen, hidana diskultu antalak visitasi antalah selatan seritasi citizen.	atomic visitor seletivolene sutationales subscission separational total total total some select states and total	eler stand uppen detak elektronom svent sentet samer svent singer stand elektronom stande elektronom e	nder rations somete entries, adjuict solitille-reduces, solities, annotherings, episoes littlings, hadden
Author	Analytical Method	Geographic Location	Rank & Age
Inagaki (1968)	Colorimetric Analysis	Japanese Coals	Lignites and Coal of various unspecifie rank
Kuhn, Fiene, Cahill, Gluskoter and Shimp (1980)	Atomic Absorption X-ray Fluorescence Neutron Activation Emmision Spectroscopy	Illinois Coals	Various unspecifie ranks
Manskaya and Drozdova (1968)	Dilute alkali solution		Peat age not indicated
Miller (1977) and Miller and Given (1978)	от в применя в применя в под в применя в	त्रकार प्रकार विकास विकास विकास प्रकार विकास	Lignite age not indicated
Nicholls (1968)	Graphic Interpretation	Lloyd Cove, Nova Scotia Svea, Spitzbergen	Bituminous Pennsylvan ian
Otte (1953)	ususehmise sekit miste titistagan sakutetiin. Annustaka apanittiis asun saan zitehmise menetaan titis daan tito	and stated states within a state of the stat	स्थाः व्यवस्थाः वेशासाः विशेषाः प्रवृत्ताभाषाः , व्यवका तम्मा , व्यवस्थाः । विशेषाः , व्यवस्थाः । विशेषः ने भय
Razdorozhnyy (1968)	waar male Anni Saur (1975) agas salahidan aman man ahan salah salah sam agas han-dalah alapsaman (1976) agas Elifo adah ahan d	apan sagasi sagani kisiwa. Kililah Annin 7000 susaan Annin Anke-Anke Inspiri magasi 5000 a	www.malac. region allerin. John commits. Socials printil. Socials about videous amount orders first
Ruch, Gluskoter and Shimp (1974)	Atomic Absorption Optical Emmission Spectroscopy Neutron Activation X-ray Fluorescence Ion-Selective Electrode	Illinois	Bituminous Carbonif- erous

Table 1: (Continued) Summary of Authors

Author	Analytical Method	Geographic Location	Rank & Age
SZILagyi (1971)	Spectrographic Methods	Hungarian Coals	Unspecified rank Miocene
Valeska, Malan and Kessler (1967)	maderigen titten vinne aven av vinneger Jersenvinn, annsverligen avsik tillet avte avter reger titter av vinneger tillet v Anna state av vinnege	Ostava Ostava Karvina, Czech oslovakia	noon engar riiden. Arabiin elijät, taavaliitiisti, suuriiteenaa, saaga siigiti arabiin vali Taavaliin elijät oli
Voskres- enskaya (1968)	Quantitative Spectrography	Middle Asia; Donbas Basin, Karaganda and Moscow Coal Fields, Dnepr Basin, Transcarpathic Region, U.S.S	rank Jurassic Paleogene Neogene
Zubovic, Sheffey and Stadnichenko (1960,1961 and 1964) Zubovic (1966 and	а оценторы пото пото пото учентува, чентува, порежден чентора чентора чентува советнения выполнения по	Eastern Inter U,S,A, Coals	$\hat{\mathbb{L}} \odot \Gamma$ g

Table 2 provides a summary of the work previously discussed on elemental associations of coals. The various elements have been categorized as either organic, inorganic, or variable in their associations with coal. Other workers listed in Table 2 such as Manskaya and Drovdoza (1968) Otte (1953) and Eskenazy (1977) were added out of interest because they have studied mechanisms by which elements are combined with the organic fraction rather than determining with which fraction the elements are associated.

Associations of elements in coal are inconsistent. This may be due to a number of factors, many of which have already been mentioned: age, rank, source material, differences in diagenesis, secondary contamination by marine waters, differences in acidity of the coal, location within the basin of deposition, and differences in analytical technique.

Table 2: Summary of Organic and Inorganic Associations in Coal.

Page 25

ASSOCIATION AS				
Cd, Mo, Sb,				VARIABLE ASSOCIATION
and Rubenstein Be, Mo, Ti, (1955) V, Cr, Sn. Ga Ga Ga Ga Ga Ga Ga	Bogdanov (1965)	Cd,Mo,Sb, As,P,Pb,	Zr, Au, Y, Ce, La, W,	Fe,V,Cu, Ba,Sr,Mn.
and Pringle (1962) Duck and Himus (1952) Eskenazy (1977) Gluskoter and Lindah1 (1973) Gluskoter, Ruch, Miller, Sb As, Mo, Fe Cr, Se Cahill, Dreher	and Rubenstein I	Be, Mo, Ti,	The state of the s	a como vera todo a
and Himus As (1952)	and Pringle		ge again and a second a second and a second	Ga
Gluskoter Cd and Lindahl (1973) Gluskoter, Ge,Be,B, Sn,Cd,Mn, Co,Ni,C Ruch, Miller, Sb As,Mo,Fe Cr,Se Cahill, Dreher	and Himus		A 5	to come same da
and Lindahl (1973) Gluskoter, Ge,Be,B, Sn,Cd,Mn, Co,Ni,C Ruch, Miller, Sb As,Mo,Fe Cr,Se Cahill, Dreher	Eskenazy (1977)		W	es cause es
Ruch, Miller, Sb As, Mo, Fe Cr, Se Cahill,	and Lindahl		Cd	to come does age of
	Ruch, Miller, Cahill, Dreher			Co,Ni,Cu, Cr,Se
Horton and Be,B,Ge, P,Mn,Sn Aubrey (1950) Ti,V			P,Mn,Sn	EL COMP CENTRAL CONTRAL CONTRACTOR CONTRACTO
Inagaki (1968) Ge Ga	Inagaki (1968)	Ge	Ga	Se common se

Table 2: (Continued) Summary of Organic and Inorganic Associations in Coal.

Page 26

and agent apper consecution information before construction where more variety apper and a first construction $AUTHOR$	ORGANIC ASSOCIATION	INORGANIC ASSOCIATION OR O	VARIABLE ASSOCIATION
Kuhn, Fiene Cahill, Gluskoter, and Shimp (1980)	Br,Ge,Be,B Sb	Zn, As, Cd, Fe	Ti,Al,Ca Ga,Ni,P, Si
Manskaya and Drozdova (1968)	Ge	T cape	
Miller (1977) and Miller and Given (1978)	Na,K,Ca, Mg,Sr,Mn	Mo,Si,Al, K,Mg,Zr	Al,Ti,Be, V
Nicholls (1968)	В	Pb,Cr,Co, Ba,Sr,V	Ga,Ge,Ni, Mo,Cu
Otte (1953)	Be	8	
Razdorozhnyy (1968)	Ni,Co,Be,	Pb,V,Sn, Cr,Ag.	Zn,Ga,Sc, Cu,Yb,Y, Mo.
Ruch, Gluskoter, and Shimp (1974)	Ge,Be,B.	Hg,Zr,Zn, Cd,As,Pb, Mn,Mo.	P,Ga,Ti, Sb,V,Co, Ni,Cr,Se, Cu,
Szilagyi (1971)	Mo.	Stimute state	Cr,V.
Valeska, Malan, Kessler (1967)	Ge,Be,P, Be,V.	e de	9
Voskresenskaya (1968)			
Zubovic, Sheffey, and Stadnichenko (1960,1961 and 1964). Zubovic (1966 and 1976).	Ge,Be,Ga,B Ti,V, Ni,Cr,Co,	Zn,Sn La.	THE TABLE CASE CASE CASE CASE CASE CASE CASE CAS

From Table 2, it can be seen that Ge shows the greatest consistency in its association with the organic fraction of the coal. Only Nicholls (1968) believes Ge to be variable in its association. There is also agreement among Bogdanov (1965) and Zubovic et al (1960, 1961, 1964, 1966 and 1976) that Lanthanum is inorganic in its association, Bogdanov (1965) and Ruch et al (1974) place zirconium in the inorganic portion of the coal. Silver according to Bogdanov (1965) and Razdorozhnyy (1968) is inorganic. Tungsten is inorganic in its association (Bogdanov (1965) and Eskenazy (1977)). Mercury according to Ruch et al (1974) is inorganic. Gluskoter and Lindahl (1973), Kuhn et al (1980), Ruch et al (1974), and Gluskoter et al (1977) agree that cadmium is inorganic in association. Bogdanov's (1965) data is in disagreement. He concludes that cadmium is organic. Duck and Himus (1952), Gluskoter et al (1977), Kuhn et al (1980) and Ruch et al (1974) have all stated that arsenic is found in the inorganic portion of the coal. Bogdanov's (1965) results are different. According to him arsenic is organically associated. Lead, it is agreed, is inorganically associated by all the authors with the exception of Bogdanov. He has concluded that lead is organic. Manganese is also inorganically associated with the exception of Bogdanov who found it to be variable in association, and Miller (1977) and Miller and Given (1978) who found manganese to be organic.

All of the authors listed who have studied boron agree that it is organically associated. Vanadium is also organic in

its association (Breger et al (1955), Horton and Aubrey (1950), Valeska, Malan and Kessler (1967) and Zubovic et al (1960, 1961, 1964, 1966 and 1976)). Bogdanov (1965) found vanadium to be variable. Nicholls (1968) and Razdorozhnyy (1968) consider vanadium to be inorganically associated. Antimony is organic with the exception of Ruch et al (1974) who found antimony to be variable. Beryllium is organic according to most of the researchers except Bogdanov who believes it to be inorganic and Miller (1977) and Miller and Given (1978) who believe beryllium to be variable.

The other elements do not fall consistently into one category or another. For example, molybdenum is considered to be organic by Bogdanov (1965), Breger et al (1955), and Szilagyi (1971). Ruch et al (1974) and Gluskoter et al (1977) have found molybdenum to be inorganically associated. Kuhn et al (1980), Nicholls (1968), and Rasdorozhnyy (1968) have concluded that molybdenum is variable in association. Phosphorous, titanium, zinc, chromium, lead, vanadium, magnesium, tin, nickel, strontium, thallium, barium, and gallium are other examples of elements which are inconsistent in their associations.

Erom this information, the following summary can be made. Zr, La, Hg and Ag are consistently inorganically associated while Be, Ge, Sb and V are largely organically associated on the basis of data of all workers with no more than one exception. Boron is considered by all of the authors listed to be organic. There is agreement that As, Cd, and Mn are inorganically associated except for one author. Because of the disagreement between many

researchers a random variability test has been used to verify the extent to which the elemental associations are different. The random variability test determines the probability that the data represent two differing groups.

Statistical Analysis

The major difficulty when studying elemental associations is obtaining statistically valid samples. This is difficult because of the inability to completely separate the inorganic material from the organic material. Specific gravity techniques have been most widely used to separate the organic and inorganic fractions and is presently used by industry during coal cleaning. The specific gravity technique assumes that the organic portion has a low specific gravity, (<1.30), whereas density fractions more than 1.60 are largely mineral matter. This technique can separate the sample into some portions which are mineral rich and others which contain relatively pure coal, but separation is incomplete (Ruch, Gluskoter and Shimp (1981). Important in maximizing release of intimately associated minerals from the organic matter is the grain size of the coal. Fractionation of finely-ground coal is preferred to coarsely-ground coal (Miller, 1977).

Most of the authors studied have used specific gravity separations to divide the organic from the inorganic portion of the coal. Once the two fractions are separated, the authors determined the elemental concentrations by differing methods.

This difference in analysis produces differing precision so that a statistical analysis is necessary to compare the results of the various authors. A common statistical test has been used which compares the differences in concentration of an element between the organic and inorganic fractions and determines the likelihood is due to random selection of sample.

A number of assumptions have been made so that standard deviations, differences between means, variance of means, and probabilities could be determined. The following is a description of these assumptions for each publication used. The results of these statistical tests are presented in the Appendix of this text. This section will be followed by a series of tables which will provide a summary by element of the results of the tests on the published data.

Breger, Duel and Rubenstein's (1955) associations of elements in ashed float-sink separates were presented in the following ranges of percent: >10%, 10-1%, 1-0.1%,0.1-0.01%, 0.01-0.001%, and 0.001-0.0001%. Since they used semi-quantitative spectrographic analyses for the elements studied, a value of 3.2 was used because 3.2 is the geometric midpoint value between 1 to 10 on a logarithmic scale. Likewise, 0.32 was used for the 1 to 0.1 range, etc. Because emission spectrographic methods were used, + or = 50% was considered to be the probable error as was determined by Horton and Aubrey (1950).

The statistical test described on page 3 of this text was then used to determine the reliability of the elemental associations. Appendix 1 presents the results of Breger et al (1955).

Kuhn et al (1980) in their study of Illinois, Eastern and Western Coals have listed in their text (table 7 on page 31) the mean concentrations and retention percentages in mineral-matter-free coals. To apply the statistical test to Kuhn et al's (1980) numbers, mineral-matter-free numbers were assumed

to be the organic fraction, the raw coal minus the mineral-matter-free portion is considered inorganic. The error term for the organically associated elements are the probable error terms of the mineral-matter-free numbers. The probable error term for the inorganic portion is the sum of the errors of the two fractions.

Appendix 2 shows the results of these tests.

Ruch, Gluskoter and Shimp (1974) present the concentration of trace elements in the various specific gravity fractions in their text (table 10 on page 31). The 1.28 gravity fraction was considered organic and >1.60 was considered inorganic for the Davis Seam. In the Dekoven Seam 1.29 and >1.60 are organic and inorganic, respectively. In Colchester #2 and Herrin #6, 1.25 is organic and >1.60 is inorganic. Standard deviations for each of the elements studied were given in their text (table 6, page 19). Numbers are treated as described on page 3 of this text. The probabilities determined are shown in Appendix 3.

Appendix 4 shows the probabilities determined from the work of Horton and Aubrey (1950). Fraction #1 is considered organic and 4 is inorganic. These numbers were then treated as described on page 3.

The numbers from Dalton and Pringle's (1962) article (table 1, page 44 of their text) show gallium in ppm coal to be organic and gallium in the ash as inorganic. Because they use spectrographic methods to obtain the concentrations of the

element, a plus or minus 50 percent value is assumed to be the probable error term and a similar statistical treatment was used Appendix 5 presents the results.

Szilagyi (1971), who studied Mo, Cr, and V, presents his data in his text (table 1, page 1076). The parts per million (ppm) value of the elements in the coal and ash represent the organic and inorganic fractions, respectively. It is also assumed that because spectrographic data is presented plus or minus 50 percent represents the error value and the numbers have been treated similarly to Horton and Aubrey. Appendix 6 presents the results.

Duck and Himus (1952) studied arsenic using specific gravity methods (table 1, page 268; and tables 4 and 5, on page 270) on coal and coke samples. It was first necessary to convert AssU2SDOSU3SD values ppm to As ppm. In table 1, of their text arsenic in coal is assumed to be the organically associated arsenic while arsenic in the ash is inorganic. The error term is considered to be from 4 to 10 percent as stated by the author. The largest error, 10 percent, was used to determine the standard deviations. In tables 4 and 5 of their text for two of the samples float—sink tests are shown. Bi2 and Li. 1.283 is assumed to be the organic fraction and 1.517 the inorganic portion in Bi2. 1.374 is considered organic and 1.519 inorganic in Li. All of the data were treated similarly to the above mentioned authors. Appendix 7 presents the results.

Zubovic et al (1960) present their data graphically. In

order to determine numerical values for the organic and inorganic fractions, it was necessary to measure the concentrations from figure 41.1, (page B85) of their text representing percent recovered from float and sink. They state in their text that a procedure similar to Horton and Aubrey (1950) which implies spectographic methods were used. Therefore, the probable error was assumed similar, plus or minus 50 percent, and the data was treated in the same fashion as described on page 3. Appendix 8 presents the probabilities determined.

Miller (1977) presented his data in the appendix of his thesis. The numbers are presented as ppm values for different specific gravity fractions. He has also catagorized the various concentrations by type of chemical fraction. To determine probabilities on these numbers similar elements of each different treatment were added together for the float of the <1.40 liquid and the sink fraction of the >1.80 liquid. Standard deviations were determined from the precision of the techniques used. For the elements determined by atomic absorption a value of 5 percent (Lynn Branvold, personal communication) was used for Ca, Mg, Na, K, S, Ba, Mn, Ti, Al, Cu, Zn, and Fe. Emission spectroscopy was used by Miller to determine Cr, Yb, Ni, V, beryllium, Zr, Ce La, so that plus or minus 50 percent was used as a probable error for the statistical analysis in the same manner as used for Horton and Aubrey (1950). Appendix 9 presents the results.

Several of the researchers presented in Table 2 could not be treated statistically such as Inagaki (1968) because his work

was unobtainable at the time of this study. Razdorozhnyy's (1968) work was not tested because his data are presented as correlation coefficients. Gluskoter et al (1977) data were used in the Ruch et al (1980) article so a statistical analysis of both would be redundant. Voskresenskaya (1968) was also not used in this analysis. His data are presented in ranges which are to large to assume an average value. Eskenazy (1977) was added to Table 2 to provide a consensus of the relationship of tungsten to coal. His article does not present analytical data in a form which could be used. Gluskoter and Lindahl (1973) also did not present their data in a manner conducive to its use in this paper.

Tables 3 through 29 show the probability of the elements studied by the various authors may be classified as organic or inorganic on the basis of a significant enrichment in either the organic or inorganic fraction. The tables have been divided into organic and inorganic based on the abundance in each fraction. If the numbers were larger in one fraction than the other, for example the organic fraction, a star is placed in the organic side of the graph. All of the stars in the graphs represent one sample with the exception of Dalton and Pringle (1962), Szilagyi (1971) and Duck and Himus (1952) Whose stars represent an average of the probabilities of the samples studied.

From these tables the probability that an element may be assignied either to an organic or inorganic fraction shows wide scatter. analyses can be seen. Aluminum was not classified in Table 2 but is known to occur in Coal as allogenic and authigenic

clay minerals. Because of its association with mineral matter, aluminum is expected to be found in the inorganic fraction. This is the case for Kuhn et al (1980) and Ruch et al (1974) but not for Miller (1977) and Breger et al (1955) in Table 3. The statistical test for Miller (1977) has determined that his numbers are highly significant and are more highly concentrated in the organic fraction. Miller and Given (1978) note that the amount of aluminum in the acid soluble fraction is higher in the float than in the sink and that the rest of the aluminum is in acid insoluble form. From this they infer that some of the aluminum is chelated to organic matter.

Figure 1 shows the probability of aluminum in the organic and inorganic fractions plotted against concentration. Both the highly significant inorganic and highly significant organic portions of the graph have been divided in the same format as Table 3. The tick marks indicate highly significant, very significant an significant values. The tick marks in the not significant region indicates the seperation of inorganic and organic not significant probability region. Note that in Figure 1 the high concentrations of aluminum are associated with in inorganic fraction, whereas the low concentration is associated with the organics.

The results in Table 4 of the tests of arsenic are more consistent. Both Ruch et al (1974) and Duck et al (1952) have highly significant probabilities indicating arsenic in the inorganic fraction is not due to random selection of a homogeneous population. These results are in agreement with the

predictions of the authors summarized in Table 2. Arsenic is generally associated with sulfide minerals and is probably in solid solution with minerals such as pyrite and marcasite (Gluskoter et al, 1977). This is consistent with the results in Table 4. The arsenic values shown in figure 2 also show that low concentrations of arsenic are associated with the inorganic fraction.

Table 3

Aluminum

Organic	Not Significant	Inorganic
p<.0001 .001 .01	. 05	.01 .001 <.0001
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Toppes water devel accept final abbat from Pages	Principal Basin approximate association come. I intercheben non-time \$100 mins associated code: 5	Ruch et al
ু ব্যৱসাধ মার্যার মার	Princess America consultation from A techniques supervisors 2007 calls.	made I represent their spirit and I made along from maje same consistent expectation. I had introduce, was about expectation constitutes their maje.
The same paint assessment with trade areas a specific direct states areas area	officials.	(1977)
ange dan	*	let al (1955)

Table 4

Arsenic

Organic	Not	Significant		norganic	
p<.0001 .001		1 • 0 • 0 5	.01 .001	<.0001	
designs and the second about the second second second second second and second about second second second second	NAMES AND ADDRESS OF THE PARTY	AND THE PROPERTY AND TH	an reference folgowing supplement statistics of the state	MATERIA SERVICE, PROCESS, PROCESS, PROCESS, STOCKES, STOC	
- STEENEY	adjuster:	· · · · · · · · · · · · · · · · · · ·	January Company	Kuhn e	t al
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40.00E	8	See	officery.	IRuch e	t al
example:	900	# # # #	-#- 1	* I(1974)	
			action represents the second state of the second states and the second states are second states as the second states are secon	mplan referiik syyppii, taalaan, saryote rindian sarksi tandah anda tandah saksanayadan, syyben sarksi raadhisi	elik veriletilih elakir dalah
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100	_	4		Section streets sensor responsibilities trademiciantis	tales numeropian (matrix entres

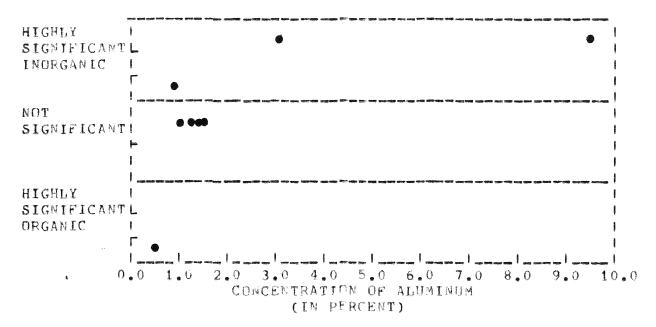


FIGURE 1

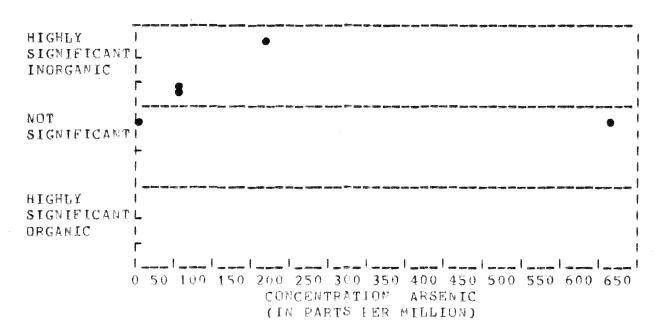


FIGURE 2

Boron, considered to be organically associated according to Table 2, displays no such distribution in Table 5. Only one of the samples of Kuhn et al (1980) shows a significant difference in the concentration of boron in the organic and inorganic fractions. Boron is suggested by Couch (1971) and Bohor and Gluskoter (1973) to be an indicator of paleosalinity. High concentrations (300 ppm) of boron (Fredrickson and Reynolds, 1960) indicate normal marine salinities. The difference in salinities may be the cause for the lack discrimination between organically and inorganically associated boron. Gluskoter et al (1977) found that boron is more highly concentrated in coal samples from the Illinois Basin Coal than from the Eastern and Western United States. This can be seen in Table 5. The work of Kuhn et al (1974) Which was originally presented in Gluskoter et al (1977) shows the Herrin #6 sample to be highly significant while the other values are not significant and represent samples from the Eastern and Western United States. According to the work of Kuhn et al (1980), boron is highly significant inorganically associated. Figure 3 shows no specific distribution for boron throughout the various concentration ranges. The probabilities are not significant and random selection was a factor in this elements distribution.

In Table 2 barium has been summarized as one of the elements which has an unclear association, possibly due to its ion-exchange character and similarity to calcium (Miller and Given, 1978). In Table 6, barium is consistently inorganically associated with a high likelihood, Barium is also inorganic at

various concentrations in figure 4.

Magnesium, strontium, manganese, sodium, and potassium are all predicted by Miller and Given (1978) to be in an ion-exchangeable form in low-rank coals. Elements that are organically associated in bituminous coals are associated in the same way as in lignites, but with greater ammounts of total content in lignites than in bituminous coal (Miller, 1977). This indicates that these elements are comparable between different ranks. Magnesium and strontium have inconsistent associations as indicated in Table 2. Manganese is more consistently regarded as inorganic with the exception of Bogdanov (1965) who considers manganese to be variable in its association. In Table 2 the authors do not list sodium and potassium except in 2 cases. Miller (1977) summarizes sodium as organic and Kuhn et al (1980) concludes that sodium is variable in association. Tables 7, 8, 9, 10, and 11 show the random variability tests for these elements. Both magnesium and strontium are inconsistent in their associations and in agreement with the predictions in Table 2. Magnesium and strontium probabilities are plottd against their concentration in figures 5 and 6. a low concentrations magnesium has no distinct distribution. From One analysis, strontium is shown to be organic in figure 6.

Magnesium shows highly significant probabilities for both organic and inorganic association. Manganese is consistently inorganic with several probabilities which are highly significant as predicted in Table 2. In figure 7, manganese is inorganic at low concentration ranges.

Sodium is inconsistent in Table 10. Only Miller's (1977) numbers are highly significantly organic. The data of Kuhn et al (1980) and Ruch et al (1974) have a marginal likelihood that they may be the result of enrichment in the inorganic fraction. Sodium, based on its probability versus concentration plot, shows a variable distribution between the organic and inorganic fractions (figure 8). Potassium, in figure 9, its inorganic throughout the entire concentration range.

The inconsistencies of magnesium, manganese, sodium, and potassium are likely to be related to the variable associations of these elements prior to coal deposition. Magnesium, manganese, sodium, and potassium are considered by Miller (1931) to be elements necessary for the growth of all plants. It is also known that MgO is always present in kaolinite and KsU2sDO and NasU2sDO are often present in kaolinite (Weaver and Pollard, 1975). Magnesium substitutes for aluminum in the octahedral sheets of smectites (Grim, 1968). Also, MgO, NasU2sDO, and KsU2sDO have also been identified in montmorillonite samples (Grim and Kulbücki, 1961). Magnesium may substitute for calcium in the calcite lattice and form dolomite. Manganese may substitute for iron in pyrite from a variety of different environments (Maclean and Shimazake, 1976; Raiswell and Plant, 1980; Keith and Degens, 1959; and Mitchell, 1968).

Boron

Organic	Not Significant	Inorganic
p<.0001 .001 .01	0.5 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	01 .001 <.0001
Managa salah sejaga telagi dajay reneri tercih serini, sajara serini telaga darih dajat selarih telagi dajah dengi telam reneri tercih. Managa salah sejaga telagi dajay reneri tercih serini, sajara serini telaga darih dajat selarih telaga dajah dajat selarih telaga dajah dajat selarih telaga dajat sel	**	
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	en e	
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Table 6

Barium

Organic	Not Significant	Inorgan	ic
p<.0001 .001 .01	assume an experimental constant and the second consta	.01 .001 <.0	001
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20 Marie 1997	94000	*	1(1977)
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name .		*	1(1980)
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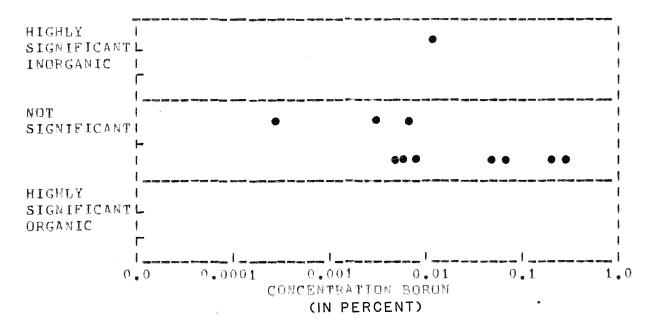


FIGURE 3

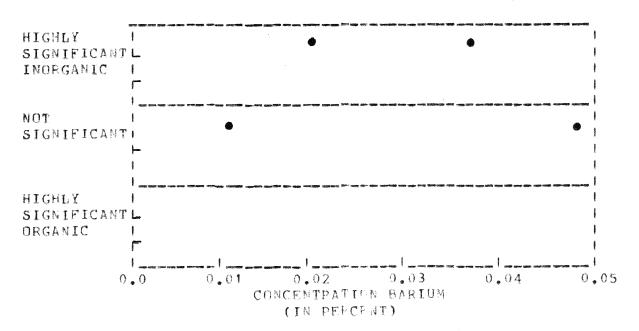


FIGURE 4

Table 7

Magnesium

Organic	Not Significant	Inorganic
p<.0001 .001 .01	100	01 .001 <.0001
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To the second se		Assistance that some east of the same and some that some east of the same and the s

Table 8

Strontium

Organic	Not	Significant	Inorg	anic
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p<.0001 .001	.01 .05	1.0 .05	.01 .001 <	.0001
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	-bunder-	100	- Statement - Stat	Kuhn et al
480	equiti-	**	90000	1(1980)
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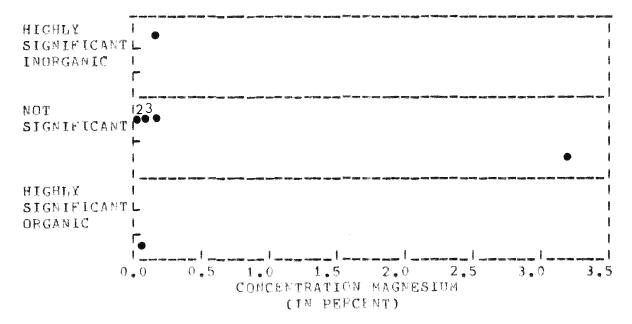


FIGURE 5

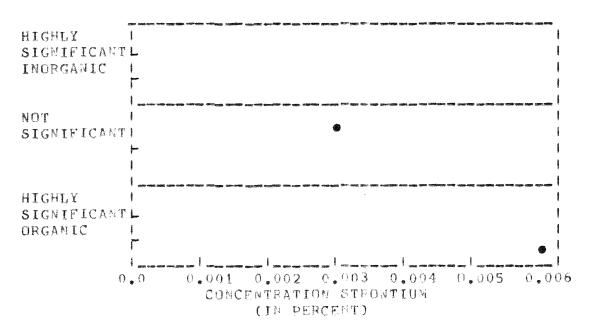


FIGURE 6

Although Nicholls (1968) agrees that strontium is variable in association in coal he mentions a relationship between strontium and carbonate content and describes some strontium to be adsorbed on clay minerals during the early stages of coal formation. But he concludes that the high strontium contents in coals is related to the introduction of post-depositional mineral matter. Strontium is also known to substitute for calcium in calcite (Mason and Berry, 1968). Strontium, summarized in Table 8 shows strontium to be inconsistent and attributable to random selection as predicted in Table 2.

Antimony in Table 2 is considered to be largely organically associated with the exception of the opinion of Ruch et al (1974). They found it to be variable in association. In Table 12 only the data of Horton and Aubrey (1950) show significant differences and they are organic in association. Antimony in figure 10 is organic in the higher concentration ranges.

Relative to the Earth's crust Coal is known to contain high concentrations of germanium. Ratinskii (1943, 1946) and Otte (1953) found germanium to concentrate in the vitrains which have undergone the most gelification. It is these humic acid gels which entrap and concentrate the Germanium brought in by aqueous solutions during the decomposition of the original plant material during the peat stage. Fischer (1960) suggested the following

conclusions which are related to the association of germanium in coal:

- 1)Coals high in vitrain content contain more germanium than those with low vitrain content.
- 2)Low-ash coals are richer in germanium than high-ash coals.
- 3)Coals of older age usually have lower germanium content than coals which are more recent.
- 4) Germanium is usually concentrated in the top and bottom portions of a coal seam.

In Table 2 germanium is considered organic in association by the authors listed with the exception of Nicholls who considers it to be variable. Table 13 shows Ruch's et al (1974) germanium values show a highly significant differentiation and the major amount is organic in association. The other numbers are not significant but concentrations of germanium in Horton et al (1950) and Breger et al (1955) indicate that concentrations were higher in the inorganic fraction than the organic fraction. Perhaps the scatter of germanium is related to variations such as suggested by Fischer (1960). Germanium shows an organic association at lower concentration ranges in figure 11.

Table 9

Manganese

Organic	Not Significant	Inorganic
p<.0001 .001 .01	.05 1.00 .05	01 .001 <.0001
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4 specification dated have 1998 Tollar revier 2000.	STATE AND THE STATE AND THE STATE AND STATE AN	
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Table 10

Sodium

ı	Organic		Λ	ot Sig	nifican	er Co		Inorganic	
	p<.0001 .	,001			• 0)1 .00	<.000	4
	managa nagadi sasana. Helenik nagaga manafi. Safeta tarada kadinis mil adalah sasana sasana sasana sasana sasana sasana sasana sasana adalah sasana sasana sasana sasana sasana sasana adalah sasana sasana sasana sasana sasana sasana sasana sasana adalah sasana	region appears for several regions. Several regions regions for	ange-neede dictrictorianismi Virinti- _{manage} .	THE PROPERTY AND PARTY AND	necesia mentretanna susua carae mini manna B	Age and a second	erier (1905) - productive principal (1905) - productive principal (1905)		Kuhn et al
	THE THE PARTY STATES AND THE PARTY STATES AND THE PARTY STATES.	Appropriate States States Section - Section -			Source design. Assessments - White design.	sinni apalantai nom assa	- 1907/1911 11/1000 - 444/64 - 1910/01, 1919/16		Ruch et al
	Angusta anguse retente unaque revisto e especialmente supuara	appear administrative referred streams	Andrews Control Control Species		Anticologies essent takes 100 cm excess	parties, recognisistics delicas appear	epopperusperi HAPIS gynga tempa		M111er (1977)
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	makes sender to over against threat. Moreover before	THE PARTY MADE STORE THEM	AND DESCRIPTION OF SHAPE SHAPE	AND MARKET SERVICES ASSOCIATED	A CALLE AND	Marie Minnesona sous Minnes	CALL WITH SAID WAS TANK	THE COURSE SHALL THE	THE RESIDENCE AND PARTY OF THE PROPERTY OF THE

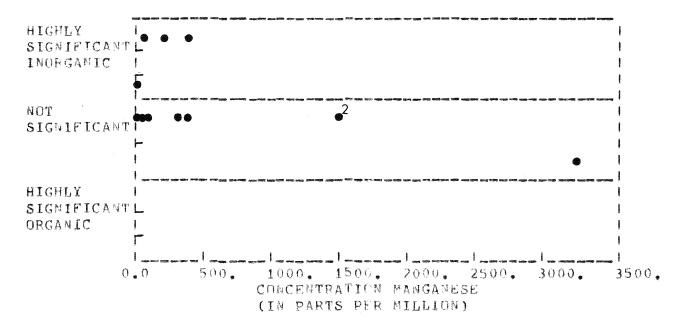


FIGURE 7

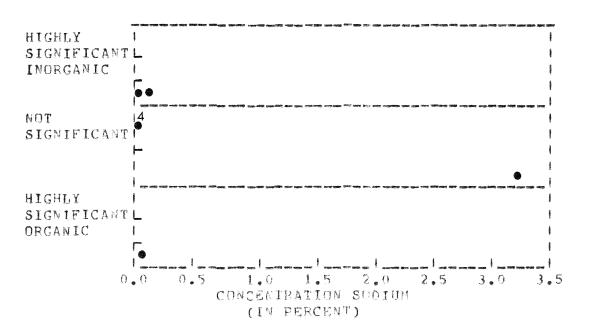


FIGURE 8

Table 11

Potassium

Organic	Not Significant	Inorganic
p<.0001 .001 .01	$_{\circ}$ 0.5 $_{\circ}$ 0.5 $_{\circ}$ 0.1	.001 <.0001
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Table 12

Antimony

Organic	Not Significant	Inorganic
p<.0001 .001 .01	, 0.5 1 , 0 , 0.5	.01 .001 <.0001
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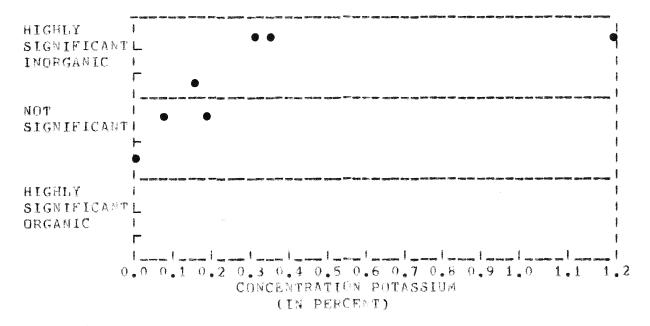


FIGURE 9

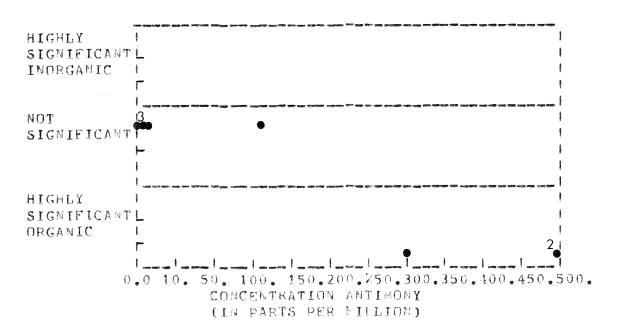


FIGURE 10

Beryllium is another element considered to be organically associated. In Table 2 this is evident except for Bogdanov who considers it to be inorganic. Otte (1953) found beryllium to be concentrated chiefly in vitrains and clarains. Stadnichenko, Zubovic, and Sheffey (1961) found the beryllium content from the ash of vitrains to be higher than its content in the ash of the whole coal. They also determined that the amount of beryllium in coal is unrelated to the rank and age of the coal. Beryllium content is related to the source of the various rocks that may have contributed to the coal deposit, and position in the basin. Because of its chemical properties, beryllium can be transported to the site of deposition and become incorporated into the coal syngenetically rather than post-depositionally. Beryllium has also been correlated with ash content. Jedwals (1960) found that coals with high beryllium content generally have low Beryllium is known to form beryllium-organic complexes and combines with oxygen as the donor element (Martell and Calvin, 1952). Stadichenko et al (1961) hypothesizes the presence of organic beryllium to be the result of plant accumulation or due to fixation by adsorption onto colloidal organic particles in the swamp or by beryllium-organic complexes with the decomposed plant tissues.

The probability of beryllium in Table 14 concentrating significantly with either the organic or inorganic fractions is low. This indicates that the results are due to random selection and that the tests for beryllium are the results of unknown

factors. The probability vs concentration plot of beryllium is shown in figure 12.

Nickel as it has been summarized in Table 2 is inconsistent in its association in coal. This inconsistency is reflected in Table 15. Although the results of 3 authors in Table 15 indicate that nickel is inorganic and 2 authors in Table 15 indicate that there is a higher concentration of nickel in the organic portion of the coal, only the work of Ruch et al (1974) has highly significant differences in magnitude indicating that nickel is inorganic in association. Possible reasons for the conflicting evaluations may be the association of nickel with mineral matter as well as a necessary nutrient for plant life. Nickel has been described to be associated with the smectites and may substitute for aluminum in the octahedral sheet (Grim, 1968). Nickel is also known to substitute for iron in pyrite (Maclean and Shimazake, 1976; Mitchell, 1968; and Raisdell and Plant, 1980). Nickel is also found in other sulfide minerals such as millerite and linnaeite. Miller (1931) listed nickel among those elements necessary for plant life. Thus, nickel is contributed by both inorganic and organic sources and may indicate that nickel cannot be attributed to any one fraction of the coal. Figure 13 shows that nickel is inorganically associated at approximately the 0.05 percent concentration range.

Table 13

Germanium

Organic		26 harris	ot Sig	nificant	io-		Inorganic	
p<.0001 .	.001			. 0		1 .00	<.000	eggatorije.
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- MORROW MINEROL THAT'S MANUFACTURE AND ADDRESS ASSESSED.	STOREN - PAULANT, Spicarett still rister i STORAGE	anne Aborinsie, Strettgagge		August States grants update 2775 bases	Species species and district reside	STATEMENT OF THE SECOND AND A		Zubovic let al (1960)
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SMINISTER PROPERTY PROPERTY AND	अञ्चलकः जनसम्बद्धः बहुद्धावाः संभोगवदे स्टानकः			Source and a street recovery of the seasons		sentananist herriti menga salam	ानानारे १४२००२ राजवाने अञ्चलक त्रांतारे उत्तराक व्यवस्था	Breger let al (1955)
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Table 14

Beryllium

Organic	Not Significant	Inorganic	
p<,0001 .001 .01	, 0.5	.01 .001 <.0001	
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Apple states design productional references where.	Total managing and managing and a solve date date date date date date date dat		ich et al 1974)
September States and assess define description where the september of the	Total Annual Control State Control Con		ubovic t al (1960)
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- gaper depth colors region rates in conversion to the color region rates rates and the color rates are color rates are color rates and the color rates are color	A STATE OF THE PROPERTY OF THE STATE OF THE		reger t al (1955)
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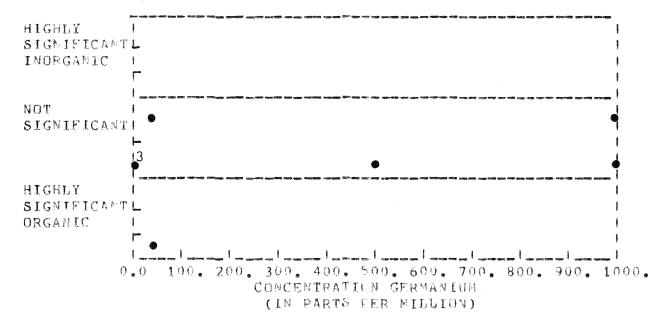


FIGURE 11

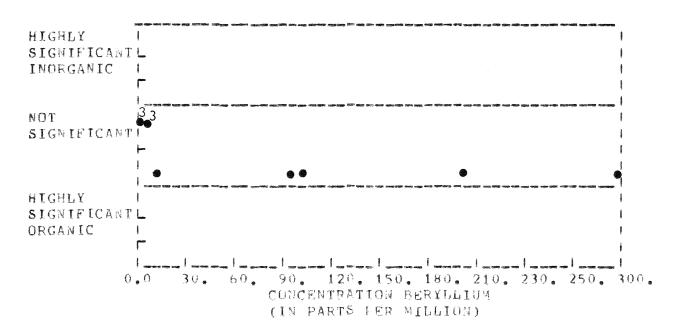


FIGURE 12

Table 15

Nickel

Organic	Not Significant	Inorganic
p<.0001 .001 .01	• 05 1 • 0 • 05	.01 .001 <.0001
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Total series soon cone fine main more repair.	State appointment consistent space of report appointment of the space	
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Table 16

Calcium

Organic	Not Significant	Inorganic
p<.0001 .001 .01	05 1,0 ,0 ,05 ,0	.001 <.0001
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Makes stress needs notice three deeps stress and stress needs notice needs notice and needs need		2005-000 2006 2006 2006 2006 2006 2006 2006
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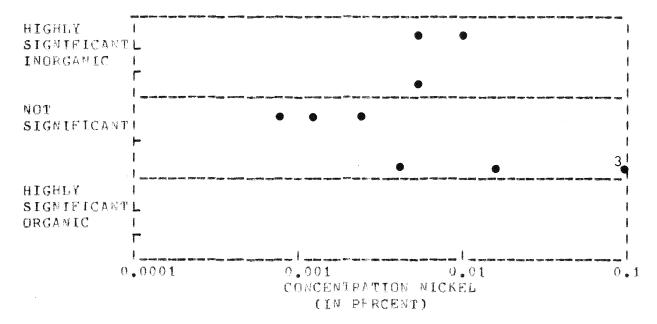


FIGURE 13

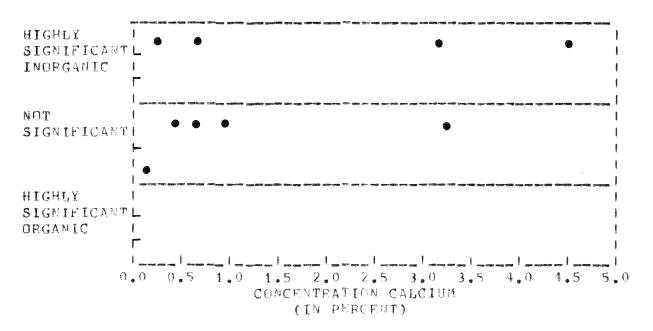


FIGURE 14

Calcium is another element similar to nickel in that it is both important as an organic as well as an inorganic substance. Miller (1931) and Kuhn et al (1980) attribute calcium to be necessary for the growth of all plants. Calcium is also present in carbonate minerals. The carbonates are very important mineral constituents in coal because they are the next most abundant after the clay minerals (Stach, 1975). In Table 2, only Miller (1977) concludes that calcium is organic in association. Other authors listed in Table 2 make no conclusions. In the case of Kuhn et al (1980) and Ruch et al (1974), calcium is highly significantly inorganic as shown in Table 16. Calcium, is highly significantly organic determined by analysis of Miller's (1977) work. Figure 14 supports calcium as an inorganicallyy associated element at various concentration ranges.

This split in the association of calcium reflects the known association of calcium with both the organic and inorganic portions of the coal. Carbonates can form authigenetically in the pre-burial stage of coal formation (Miller, 1977) and epigenetically as inferred by their location in cleavage, joint and fracture planes (Marshall, 1955).

Vanadium in Table 2 is inconsistent in association. Miller (1977) accounts for the presence of a small portion of vanadium in the sink fraction as present in clay minerals. The majority of the vanadium he reports to be organically held by chelation or ion exchange. Table 17 shows consistent agreement between 3 of the authors. Their numbers are highly significant and suggest an inorganic association. From these results it may

be possible to state that vanadium is commonly inorganically associated. it may well reflect the influence of marine waters. Figure 15 shows that vanadium is inorganic at low concentration ranges.

Most of the authors in Table 2 agree that gallium is variable in association. Only Inagaki (1968) has found this element to be inorganic. The random variability test in Table 18 reinforces this variability in the analysis of the data of Ruch et al (1974). In their probabilities, there is a highly significant inorganically associated gallium value as well as an insignificant organic value. The other tests show a similar insignificant differentiation. Goldschmidt (1954) determined that because of gallium's ionic radius and ionic charge it could enter the silicate lattice and substitute for aluminum in aluminosilicates. Gallium, studied by Dalton and Pringle (1962), is often similar to germanium as there is a tendency for it to concentrate near the roof and floor of coal seams. Dalton and Pringle (1962) use Headlee and Hunter's (1951) explanation that this localization is the result of percolating water and capillary action from above and below, respectively. Gallium is associated with the aluminosilicates which are intimately mixed with the coal and derived from Mineral matter absorbed by the coal forming plants (Dalton and Pringle, 1962). Gallium, as shown in figure 16, is inorganic at low concentration values.

Table 17

Vanadium

Organic	Not Significant	Inorganic
p<.0001 .001 .01	.05 1.0 .05	.001 <.0001
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Mentioner from page New Seria class fame and series seen seen seen seen seen seen seen s	TOTAL PARTY TOTAL PARTY STORM AND ADDRESS OF THE PARTY STORM AND ADDRESS OF THE PARTY STORM AND ADDRESS OF THE PARTY STORM ADDRES	when these ratios 1 and the transform that the transformation in the same same same 1 and 2 an
Appendix storm storm storm total treat the story of the s	A TOTAL TRANSPORTED TRANSPORTE	(1977)

Table 18

Gallium

Organic	Not Significant	Inorganic
p<.0001 .001 .01	.05 1.0 .05	.01 .001 <.0001
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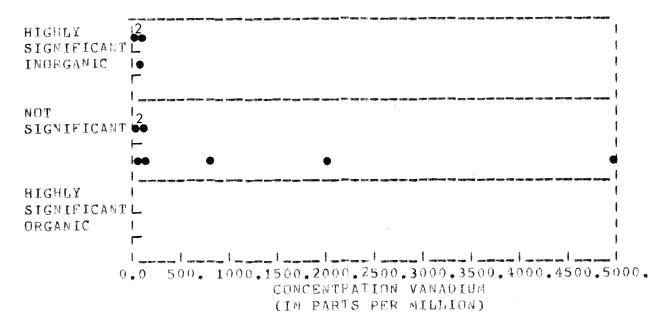


FIGURE 15

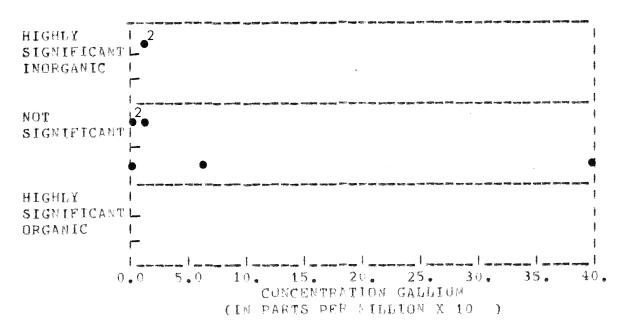


FIGURE 16

analysis, silicon was analyzed for the various authors who have presented data relating silicon's association in coal. Silicon is the major contribution to the inorganic or mineral matter portion of the coal and is found in all of the silicate minerals associated with coal. A small amount of silicon is also associated with the organic portion of coal as inherent mineral matter. Since the greater quantity is associated with the mineral matter, sink float tests should show silicon to be inorganic in association. Table 19 shows highly significant and very significant inorganically associated probabilities for two of the authors tested. The other probabilities, although they are not significant, are also inorganic in their distribution. Silicon is inorganic throughout the entire concentration range (figure 17).

inconsistent in its association. The results of Table 20 show highly significant probabilities for both organic and inorganic association in the coals tested. The data of Ruch et al (1974) shows a very significant probability that titanium is inorganically associated. The results of the other authors are not significant. Miller and Given (1978) as a result of their work believe titanium to be associated with the organic matter rather than the mineral phases based on their acid solubility tests. Organo-titanium complexes in coals have even been suggested (Zubovic et al. 1960; and Given et al. 1975). Titanium is also known to be associated in such minerals as rutile,

anatase, brookite, ilmenite, and sphene. High concentrations of heavy minerals probably produce a concentration of titanium with the inorganic fraction whereas the acid-solubility testing of Miller and Given suggests normal titanium would be organic. Titanium has no characteristic distribution based on the probability versus concentration plot shown in figure 18.

Gluskoter et al (1977) suggest that selenium may be inherited from plants which have concentrated it in the original coal swamp. Selenium was one of the elements used by Mitchell (1968) to distinguish between marine pyrite, magmatic/hydrothermal, and fresh-water pyrites. He noted that among other elements selenium was higher in concentration in marine pyrite than fresh-water pyrites. Table 2 describes selenium as variable in association, while Table 21 shows the probability of selenium being inorganicis highly significant. The results of these tests indicate that selenium may be inorganic in association rather than variable. Selenium as shown in figure 19 is inorganic at higher concentration values.

In Table 2 molybdenum is inconsistent in its distribution between the different coal fractions. In Table 22, although there is variability, analyses of several authors indicates molybdenum a highly significant level is inorganic in association. The data of Horton et al (1950) and Breger et al (1968) indicate an organic association but their data are not significantly different. Nicholls (1968) hypothesizes that molybdenum may be associated with sulfide minerals of coal seams and adds that some molybdenum which is found in the light fractions may be the result of post-burial sorption similar to germanium. Korolev (1955) investigated the

Page 65

Table 19

Silicon

Organic	Not Significan	Ino	rganic
p<.0001 .001 .01	. 0.5 1 , 0	05 .01 .001	<.0001
AND			Kuhn et al * (1980)
The state and th		TO THE PROPERTY AND ASSESSED ASSESSEDA ASSESSED ASSESSED ASSESSED ASSESSED ASSESSED ASSESSED ASSESSEDA	and taken states states relativistics.
Dis est	Magnetic Section 1		Ruch et al ** (1974)
Somethings their appealations department stage. He show states about batter about them.	TOTAL SECURITION OF SECURITION AND SECURITION OF SECU	A STATE OF THE PROPERTY OF T	FBLGGEL THE CONTRACT NATIONAL PROPERTY OF THE CONTRACT NATIONAL PROPERTY
HAMRI TORRIC REPORT REQUESTIONS COORDINATES COORDINATE	Applications of the control of the c	Makes white after the control of the	let al (1955)

Table 20

Titanium

Organic	Not Significant	Inorganic	
p<.0001 .001 .01	05 1.0 .05	.01 .001 <.0001	
dames space which support from the control states which support from the control states and control states a	The state of the s		Kuhn et al (1980)
September States Service Service Service Conference Service Conference Service Conference Service Conference Service Conference Service Conference Service Service Conference Service Service Conference Service Service Service Conference Service Se	্র টার্কার স্থান্তরাক্রিক ক্রান্তর্ভালিক ব্যবহার ক্রান্তর্ভালিক ব্যবহার স্থান পর্বাহার ক্রান্তর্ভালিক ব্যবহার ক্রান্ত্র্ভালিক ব্যবহার ক্রান্তর্ভালিক ব্যবহার ক্রান্তর্ভালিক ব্যবহার ক্রান্ত্র্ভালিক ব্যবহার ক্রান্তর্ভালিক ব্যবহার ক্রান্তর্ভালিক ব্যবহার ক্রান্তর্ভালিক ব্যবহার ক্রান্ত্র্ভালিক ব্যবহার ক্রান্ত্র্ত্ত্বালিক ব্যবহার		Ruch et al (1974)
AND THE THE PROPERTY PROPERTY AND PROPERTY A	ne de la constitue de la const		Zubovic et al (1960)
THE CONTRACT OF THE CONTRACT O	ns to state woundard topic form of distribution and about \$1000 model in the state of the state		Horton let al (1950)
Home was date ages ages ages ages ages ages ages age	and the state of t		
PROPERTY STATES WEREAUTHER SECURITIONS WHERE A SHARE WHICH HAVE HAVE HAVE THE SECURITIES SECURITIES.	and antifer associated appropriate com-	association none essenti super-note Antida stores serve super-note Antida stores serve supe	Breger let al (1955)
TABLES TABLES TO THE PROPERTY CONTINUES AND THE TABLES AND THE TAB	Total reference residence con program of the progra		The first time took after the second of the

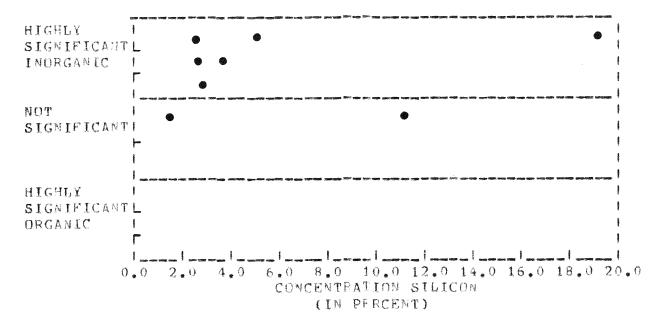


FIGURE 17

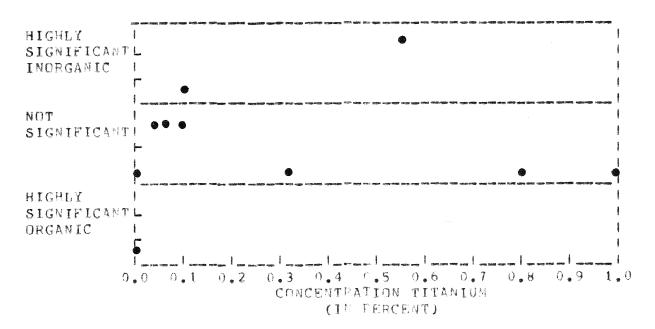


FIGURE 18

Table 21

Selenium

Organic	Not Signifi	cant	Inorganic	
p<.0001 .001 .01	. 05		.000 <.000	All responses
NUMBER HAND AND PROPERTY OF THE PROPERTY AND AND A SERVICE AND A SERVICE AND	SPECTAGORY.	Control State States - States	a Marian salaga salada sanaan sistaan Salaga Alabah salada salada salada, salada sepilah salada dibibi -	projet
AZERVO		NAME OF THE PARTY	mediate-	lKuhn et al
	1 44	*	Manager	1(1980)
The same applications in the same of the same and the sam		name November 1 was common new many 1 manufacture		A THE RESIDENCE AND A SECURE AND A SECURE ASSESSMENT AS
determine the second se	addition.	Application of the second of t	y	IRuch et al
- SAMO-	1 1	Approx.	* **	1(1974)
AND ASSESSMENT STORY AND ADDRESS OF THE PERSON AND ADDRESS ASSESSMENT ADDRESS	THE RESIDENCE OF THE PROPERTY AND ADDRESS OF THE PARTY AND ADDRESS OF T	AND THE PARTY NAMED IN COLUMN TWO PARTY IS NOT THE OWNER.	I seed with their seed. A see seed their seed them to the seed their seed of	

Table 22

Molybdenum

Organic	Not Significant	Inorganic	
p<.0001 .001 .01	0.5 1.0 .0 .0 .0 .0 .0 .0 .0 .0 .0 .0 .0 .0 .	5 .01 .001 <.0001	
TRANSPORTED AND AND THE STATE OF THE STATE O	and solid solidings restrictes one solid security decisions good over a		Kuhn et al (1980)
3. And the second bullet have force wide minds about 3 colors are second about about 2000 and 1000 force which we have	TO THE PERSON NAMED AND THE PERSON OF T		Ruch et al (1974)
SEMPLEMENT MINOR ANGESTED STEERING STORE ST	SERVICE CONTRACTOR STATE SALES STATE CONTRACTOR STATE SALES		Szilagyi (1971)
yanga saper Maria saper Rasia saper Alama cerea saper a saper arism'n copica Rasia saper all'arism'n appear all'arism'n copica Rasia saper all'arism'n appear all'arism'n copica Rasia saper all'arism'n copica Rasia saper	The state of the s		Zubovic et al (1960)
ক্ষ্যক মন্ত্ৰায় হাজনা ব্যক্ত নাবাৰ বিশ্বস্থা নাপৰা প্ৰথম নাপৰা প্ৰথম নাপৰা			Horton et al (1950)
	Total Annual Relativistic Colors Total Annual Print	TOTAL SHARE COMM MATER TOTAL STATE SHARE MATER AND A COMM CASE COMM MATER TOTAL ASSESSMENT ASSESSME	Breger et al (1955)
The second section of the second section of the second section of the second se		AND CONTROL CO	

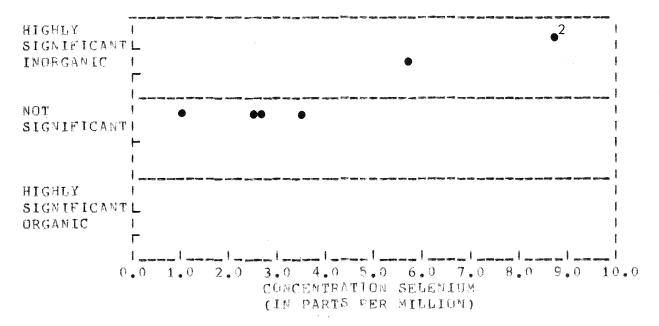


FIGURE 19

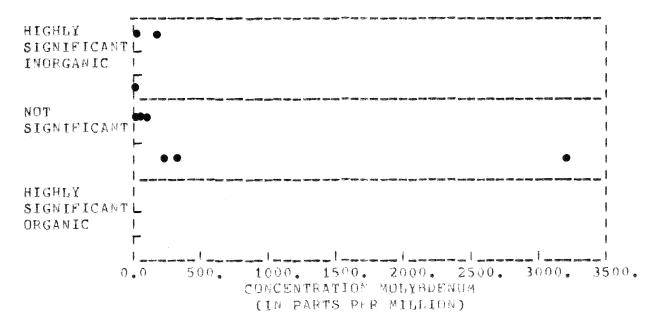


FIGURE 20

irregular accumulation of molybdenum in coals and concluded that in a coal where molybdenum is not directly bonded by organic matter its accumulation depends to a great extent on the intensity of the reduction process. The results in Table 23 are consistent. Even though molybdenum is often considered variable in association, the results in Table 22 indicate that the molybdenum in the coals studied by these authors is fairly consistently associated with the inorganic fraction.

Zirconium in Table 2 is summarized as inorganic in its association in coal. Table 23 shows the random variability test of zirconium data. The data show no significant and there appear to be no criteria with which to determine the association of zirconium. Zubovic (1966) explains that because of the ionic potential of zirconium it is largely associated with the mineral phases in coal as the heavy mineral zircon or isomorphically in clays (Mackowsky, 1968). Miller (1977) has found zirconium to exhibit a strong organic affinity in lignite. Zirconium forms stable complexes with carboxyl acid groups (Cotton and Wilkenson, 1966). Although zirconium is described as being inorganic in association in Table 2, the data in Table 23 do not support this interpretation. Figure 21 shows the probability versus concentration plot of Zircinium. No trend is apparent from this figure.

In Table 2 all authors agree that copper is variable in association while zinc is inconsistent in its association. Table 24, showing the probabilities of copper's association with either fraction, also differ. The probabilities of Ruch et al (1974) indicate that the copper data tested show highly significant

Appendix 2: (Continued)

KUHN, FIENE, CAHILL, GLUSKOTER AND SHIMP ILLINOIS, EASTERN AND WESTERN COALS [IN PERCENT]

at Melatina. Louiscus Vallatina en este: Incomen consider.	entage version meteor common appare memor e conseque memors aques società e mese	a me an and an an	HEAVY FRACTION	Z- VALUE	TWO-SIDED PROBABILITY
ELEMEN	SEAM	(X)	(Y)	(Z)	(P)
	FASTERN	10.00093	10.0038	-0.0056	.9920
V)10.00065	-77	-0.688	.4966
Ÿ.		10.00023		-3.426	.0006***
W	EASTERN	10.000026	10,000031	-0.0406	9680
W	HERRIN(#6) •	*	e e e e e e e e e e e e e e e e e e e	4689
W	WESTERN	9999	apper		柳椒
Yb	EASTERN	10.000019	10.000039	-0,5456	.5892
Yb	HERRIN(#6)10.000013	10.000045	1 -0.85	.3954
Yb	WESTERN	10,000011	0.000028	-0.47	.6384
Z.n	EASTERN	e treves - P zerani filozofi, popularinario popularitifici ministra migro. 3965	The state and other date filter was accommon to the state of the state	Tables Active Process States Active Active Active States States Active States States Active States States Active States S	provide annua repaire desper africas industrianis industrianis. Super contra annual annual contra annual an
Zn	HERRIN(#6	·) [· ·	***
Zn	WESTERN	280	Marie Marie	***	***
erwinin pasa, Minin pasak bengeranan	wingles abstract contents adjusts another language through sension remains 200000-1444	N TOTAL BEAUTY AND ASSESSMENT MANY AND ASSESSMENT ASSES	The same processing the same are stored as a second		After Many Ages Areas Herry Description (Section 1994) Action (Section 1994)

Appendix 3:

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HANNEL MARRIES - STEPPE ARREST		ILIGHT FRACTION	HEAVY FRACTION	Z *** VALUE	TWO-SIDED PROBABILITY
ELE	SEAM MENT	(X)	(X)	(Z)	(P)
A1 A1 A1 A1	COLCHESTER(#2) DAVIS MEMBER DEKOVEN HERRIN(#6)	0.26%	3.05% 1.39% 1.50% 9.50%	-5.332 -1.834 -1.854 -17.372	<.0001*** .0672 .0644 <.0001***
As As As	COLCHESTER (#2) DAVIS MEMBER DEKOVEN HERRIN (#6)	0.7	630.0 58.00 181.0	1 6 0 3 2 2 25 1 6 6 4 9 1 2 1 3 1	. 1096
B B B	COLCHESTER(#2) DAVIS MEMBER DEKOVEN HERRIN(#6)	70.0 1 29.0 1 35.0 1 90.0	42.0 80.0 80.0	0.541	.5824
Be Be Be	COLCHESTER (#2) DAVIS MEMBER DEKOVEN HERRIN (#6)	2 • 6 1 2 • 8 1 7 • 0 1 2 • 3	7 • 0 1 3 • 2 1 7 • 1	-0.014 0.852 -0.085 -0.766	. 9920 . 3954 . 3954 . 4412
Ca Ca Ca Ca	COLCHESTER(#2) DAVIS MEMBER DEKOVEN HERRIN(#6)	0.078	4.53% 0.41% 0.03% 3.20%		<.0001*** .7794 .8258 .0001***
Cd Cd Cd	COLCHESTER(#2) DAVIS MEMBER DEKOVEN HERRIN(#6)	0 * 1 0 * 1 1 0 * 1 1 0 * 2		=38.13 =16.98 =0.195 =2.278	<.0001*** <.0001*** .8494 .0232*
60 C0 C0	COLCHESTER(#2) DAVIS MEMBER DEKOVEN HERRIN(#6)	5 • 0 1 2 • 0 1 12 • 0 2 • 0	18.0 19.00 19.0 19.0	-0.262 -0.736 -0.859	. 7948 . 4654 . 3844 . 0358*
Cr Cr Cr	COLCHESTER(#2) DAVIS MEMBER DEKOVEN HERRIN(#6)	4.0 7.0 1 15.0	7 No. 1020 N	-4.019 -1.32 -2.741 -5.955	<.0001*** .1868 .0062** <.0001***
alice alone paper belon	a-vantes salahin kelebi selebih sebah salahin selebih kelebih terana basah selebih selebih dilakir (inker adalah salahir salahir	STATEMENT SERVICES SE	many appropriate With many first stem encountries.	- NAMES AND PARTY OF THE PARTY	

Appendix 3: (Continued)

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100000 400000 -50000 -60000	olgania ilikulek abunya 1949a		LIGHT	HEAVY FRACTION	Z* VALUE	TWO-SIDED PROBABILITY
Appen valger as	ELE	SEAM	(X)	(Y)	(Z)	(P)
- HEEDEN - ARRESTON	Cu Cu Cu	COLCHESTER(#2) DAVIS MEMBER DEKOVEN HERRIN(#6)	17.00 4.0 7.0 5.0	1 1 4 0 • 0 6 5 • 0 1 7 • 0 6 5 • 0	= 13.22 = 1.46 = 1.042 = 6.257	<.0001*** .1444 .2984 <.0001***
commence outside	Fe Fe Fe	COLCHESTER(#2) DAVIS MEMBER DEKOVEN HERRIN(#6)	1.19% 0.51% 0.85% 0.54%		-19.938 -25.485 -5.766 -9.302	<.0001*** <.0001*** <.0001*** <.0001***
-	Ga Ga Ga Ga	COLCHESTER(#2) DAVIS MEMBER HERRIN(#6) DEKOVEN	2 • 4 1 • 1 2 • 1 3 • 7	13 · 0 12 · 0 12 · 0 3 · 1	-3.897 -0.411 -6.796 0.4119	<.0001*** .6818 <.0001*** .6818
	Ge Ge Ge	COLCHESTER(#2) DAVIS MEMBER DEKOVEN HERRIN(#6)	31.0 9.0 10.0 15.0	10.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0	2.483 0.499 0.3995 1.398	<.0001*** .6170 .6892 .1646
-estate - ration	K K K K	COLCHESTER(#2) DAVIS MEMBER DEKOVEN HERRIN(#6)	0.05% 0.06% 0.08% 0.06%	0.07%	-5.480 -0.177 -4.065	<.0001*** .4325 <.0001*** <.0001***
estate estate.	Mg Mg Mg Mg	COLCHESTER(#2) DAVIS MEMBER DEKOVEN HERRIN(#6)	0.001%	0.170%	-0.318 -5.303 -0.247 -0.954	.7566 <.0001*** .8026 .3422
anagar.	Mn Mn Mn Mn	COLCHESTER (#2) DAVIS MEMBER DEKOVEN HERRIN (#6)	8.0	1209.0 1365.0 1 26.00 1365.0	-4.839 -1.259 -0.310 -6.177	<pre>.0001*** .2112 .7566 <.0001***</pre>
origina mediate	Mo Mo Mo	COLCHESTER (#2) DAVIS MEMBER DEKOVEN HERRIN (#6)	2.0	1111.0 128.0 135.0 128.0	-0.798 -7.345 -16.432 -2.863	. 4296 <.0001*** <.0001***
F .0000	- majori- statistic school-stati	the states which when states when states when sales have been supply to the states sales.	TOTAL PROPERTY AND	To the contract of the contrac	The state of the s	The same design which each make the same representative appropriate their same interviews

Appendix 3: (Continued)

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		FRACTION	FRACTION	VALUE I	PROBABILIT
	SEAM	4889		Special Specia	
ELEME	WT	(X)	(Y)	(Z)	(P)
make white properties where	THE REST WAS ABOUT THE WAY WHEN THE WAY THE WA	Marchael Marchael State State State	THE RESIDENCE PARTY SHAPE SHAPE AND ARREST AND ARREST	The same series and same some same series and	THESE STATES STATES STATES SECTION STATES, SALES STATES, SALES STATES STATES STATES STATES STATES SALES STATES STATES SALES STATES SALES STATES SALES
		- Salarin			
Na C	OLCHESTER (#2)			-0.212	.8336
Na D	AVIS MEMBER	0.010%		-0.176	.8650
	EKOVEN	0.0108		-	. ###
Na H	ERRIN(#6)	0.020%	0.140%	-2.121	.0348*
N1 C	OLCHESTER (#2)	16.0	116.0	-8.774	<.0001***
	AVIS MEMBER		77.0	-2.420 I	.0156*
	EKOVEN	1 18.0	38.0	-1.308 I	.1902
	ERRIN(#6)	9.0	77.0	-4.448	<.0001***
		MARKETON AND THE REST TO SERVE THE PARTY NAMED			TARKE Annual parties income better accomplished report about the consequence about the other
P C	OLCHESTER(#2)	1 21.0	14.0	22,913	<.0001***
9 0	AVIS MEMBER	1 13.0	****	999 999	***
9 D	EKOVEN	81.0	1167.0	100	***
P H	ERRIN(#6)	No.		1000 1000 1000 1000 1000 1000 1000 100	柳
Pb C	OLCHESTER(#2)	81.0	753.0	1 = 1 4 . 5 7	<.0001***
	AVIS MEMBER			-14.99	<.0001***
	EKOVEN			I-13.314 I	<.0001***
	ERRIN(#6)		1530.0	I -7.957 I	<.0001***
	MENTER HARRIN SERVICE ARRIVER PROTECT FRANCE FRANCE FRANCE SERVICE SER	SUPERIOR AND PROPERTY AND PARTY AND PARTY.	Marine was discoursed from the same of the same and the s	NAMES AND POST OFFICE ADDRESS AND PARTY AND PARTY ADDRESS AND PART	
Sb C	OLCHESTER (#2)	1 3.9	1110.0	~0,00	.1000
Sb D	AVIS MEMBER	1 0.3	4.2	I -0.3486 I	.7338
5b D	EKOVEN	1 0.6	0.8	- 0.0996	.9204
Sb H	ERRIN(#6)	1.2	4.2	-1.494	.1336
se C	OLCHESTER(#2)	0.8	1 3.5	· ~0.753	, 4532
40	AVIS MEMBER	1.6	8.8	I =3.649 I	<.0001***
Apr. 100	EKOVEN	2.1	5.8	-2.813	.0050**
des	ERRIN(#6)	1 1.1	8.8	I -5.854 I	<.0001***
and these was seen to be	riching annun artist service annun annun artista santa santa artista annu artista santa annun annun santa santa	Transmission appropriately appropriately appropriately	STATE AND ADDRESS OF THE PARTY AND ADDRESS		and place and positive to the state of the same and another same and
Si C	OLCHESTER (#2)	0.49%	5.31%	1 -5.497	<.0001***
Si D	AVIS MEMBER		3.62%		.0012**
	EKOVEN		2.63%		.0348*
Si H	ERRIN(#6)	0.59%	19.35%	1-21.395	<.0001***
ri C	OLCHESTER(#2)	0.032	0.10%	* 2 . 475	.0124*
	AVIS MEMBER		0.04%		
other other					
Ti D	EKOVEN	1 0.04%	1 0.04%	§ 990 §	38PA

Appendix 3: (Continued)

			Market .		
Automatical Automa		a color and affection of	HEAVY FRACTION	Z- I VALUE	TWO-SIDED PROBABILITY
ELE	SEAM	(X)	(Y)	(Z)	(P) 1
Transport Andrews of Married Application of the Control of the Con	nina internation unua siren muun arien ausei emusi kenti ausei mate internation muun.	AND THE PROPERTY AND THE PARTY	men operande (***) dans tier den men eine	MANUAL CONTRACTOR OF THE PARTY AND ASSESS OF THE PARTY ASSESS OF THE PARTY AND ASSESS OF THE PARTY ASSESS OF THE PARTY ASSESSED.	TO STATE THE THE PROPERTY OF T
l v	COLCHESTER (#2)	8.0	46.0	-3.168	.0016**
ĺV	DAVIS MEMBER	1 13.0	72.0	-0.7904	.4296
IV	DEKOVEN	3.0	58.0	-3.344	.0008***
l V	HERRIN(#6)	16.0	72.0	-3.404	.0032**
DROF HAVE BUILD LODGE	antan sahari panjan mbalan manan manan tahani, sangga keriki, kantan menga agami. Mitan madan Afriki	AND THE PERSON NAMED AND THE PERSON NAMED IN	MATERIAL MATERIAL MATERIAL AND A SERVICE AND ADDRESS OF THE PARTY AND A	MARGON STORM STANDS AND ASSESS MARGON STREET, RESPECT STANDS	NOTIFIC STREET, WHERE WE ARE PROPERTY STREET, STREET, STREET, STREET, STREET, STREET, STREET, STREET, STREET,
I Zn	COLCHESTER (#2)	13.0	132140.0	1-42.84	<.0001***
Zn	DAVIS MEMBER	1 31.0	3128.0	-2.352	.0188*
1 Zn	DEKOVEN	1 54.0	429.0	-0.353	.7264
l Zn	HERRIN(#6)	7.0	3128.0	1 -2.943	,0032**
Jacobs Hallon - Million Sanger 7	tical depot transfe some system there is never makes where these souther makes about the second transfer.	STATE OF THE PARTY NAMED IN COLUMN 2 IN COLUMN 2	when approprie their man their man approprie	Manager strong recommends coming supply recommends recommend	THE PROPERTY OF THE PROPERTY O
1 Zr	COLCHESTER(#2)	1.0	14.0	1 -0.219	.8336
IZr.	DAVIS MEMBER	1.0	32.0	-0.207	,8336
Zr	DEKOVEN	2.0	19.0	-0.207	.8414
1 Zr	HERRIN(#6)	1 1.0	32.0	-0.3779	.7040
TOWNS VALUE AND	THE RESIDENCE AND MAD WAS SHOWN THE THE THE THE SAME AND SHOW THE SAME		NESTE STATES SERVICE PROPERTY SERVICE SERVICE SERVICES SERVICES	THE PERSON NAMED AND PARTY AND PARTY AND PARTY AND PARTY AND PARTY.	

Appendix 4:

HORTON AND AUBREY(1950) BRITISH COALS (IN PERCENT)

		ILIGHT FRACTION	HEAVY FRACTION	Z- ! VALUE !	TWO-SIDED PROBABILITY
ELEA	SEAM	(X)	(Y)	(Z) !	(P)
	DALTON MAIN MARKHAM MAIN THURCROFT	0.07	0 , 0 2 0 , 3 0 , 0 2	0.925 0.3228 0.986	atte suus seen passimen meroten anatunat siguinen, nosa tehti sinosi $\begin{smallmatrix}&3524\\&6456\\&63222\end{smallmatrix}$
Be Be Be	DALTON MAIN MARKHAM MAIN THURCROFT	0.01	0.006	0.751 1 0.2699 1 0.1977	4 4 6 8 • 7 8 7 2 • 3 9 5 4
Co Co	DALTON MAIN MARKHAM MAIN THURCROFT	0.05	0 n 0 3 0 n 0 5 0 n 0 5	0.462	. 6456
Cr Cr Cr	DALTON MAIN MARKHAM MAIN THURCROFT	0.04	0 • 0 2 0 • 0 2 0 • 2	0.604 0.603	, the report report of the transfer transfers the content content of the transfer t
Cu Cu Cu	DALTON MAIN MARKHAM MAIN THURCROFT	0.1	0 • 0 7 0 • 15 0 • 2	0.653	6 5 1 5 6 6 7 8 7 2 6 7 8 7 2
Ga Ga Ga	DALTON MAIN MARKHAM MAIN THURCROFT	0.01	0 . 0 1 0 . 0 1 0 . 0 3	0.375	and the second representation and the second control of the second representation of 7.114 , 4296 , 7872
Ge Ge Ge	DALTON MAIN MARKHAM MAIN THURCROFT	0.05	0.08	0.089	and one can represent the control of the control o
Mr. Mr. Mr.	DALTON MAIN MARKHAM MAIN THURCROFT	0.08	0.15	[-0.556 -0.374 -0.866	$^{\circ}$ 5 7 5 4 $^{\circ}$ 7 1 1 4 $^{\circ}$ 3 8 4 4
Mo Mo Mo	DALTON MAIN MARKHAM MAIN THURCROFT	0.03	0 • 0 1 0 • 0 1 0 • 0 2	0.603 0.854 0.066	. 5486 . 3954
	DALTON MAIN MARKHAM MAIN THURCROFT	0 • 1	0 . 0 7 0 . 0 5 0 . 4	0.331	• 7 4 1 4 • 5 4 1 8 • 8 3 3 6
P P P	DALTON MAIN MARKHAM MAIN THURCROFT	0 a 1	400	m 0 , 9 9	and special color control in the color co

Appendix 4: (Continued)

HORTON AND AUBREY(1950) BRITISH COALS [IN PERCENT]

end. Defend states are not transfer and transfer states are not to the state of the states are not to the stat		HE.AVY FRACTION	Z- VALUE	TWO-SIDED PROBABILITY
SEAM ELEMENT) (X)	(Y)		(P)
Pb DALTON MAI Pb MARKHAM MA Pb THURCROFT		**	0.5014	.6170 .5486
Sb DALTON MAI Sb MARKHAM MA Sb THURCROFT		*	= 8 , 63 = 6 , 367 0 , 464	<.0001*** <.0001*** .6456
Sn DALTON MAI Sn MARKHAM MA Sn THURCROFT		0.008	0.211 0.752 -1.06	. 8336 . 4532 . 2892
TI DALTON MAI TI MARKHAM MA TI THURCROFT	The second secon	0 . 3 1 . 0 0 . 5	1 .059	and once there is no contract an extent executive processes when the execution $\begin{array}{cccccccccccccccccccccccccccccccccccc$
V DALTON MAI V MARKHAM MA V THURCROFT	70	ерга, дома цино 2000 авана 2000 авана система анад инерга. О " О 4 О " 1 О " 5	0.6059	*5486 *5418 •4296
Zn DALTON MAI Zn MARKHAM MA Zn THURCROFT		0.0499	= 0,604 = 0,017 = 0,331	, 5486
Zr DALTON MAI Zr MARKHAM MA Zr THURCROFT	* *	0 , 0 9 9 0 , 0 4 0 , 1	1 .06	that were supported information assumed consistent qualified over $\begin{array}{cccccccccccccccccccccccccccccccccccc$

Appendix 5:

DALTON AND PRINCLE(1962) GALLIUM WARWICKSHIRE COALS [IN PARTS PER MILLION]

	LIGHT	2 to 200ms 1 to 100	Z- I	TWO-SIDED
when there was the co	IFRACTION	FRACTION	VALUE !	PROBABILITY
SEAM	1 - 232 5	- 37 %	(2)	
ELEMENT	(X)	(Y) !	(2)	(P)
WARWICKSHIRE	The supposition and suppositio	AND THE PROPERTY AND PARTY	THE PARTY CONTROL TO STATE AND ASSESSED TO STATE	arben denne versus samen samen versus denne denne denne denne semen denne denne denne denne denne denne denne
COALFIELD	augustes.		Andidato:	
UPPER SEAMS	6 1	27	-1.024	, 3078
OI K. FTAA PREDEZIAN	6 1	41	-1.139 I	.2542
	5 1	30	-1.108	.2714
		3 4	1.00	***
TWO YARDS	4	125	-1.305	.1936
BARE	3	42	-1.249	.2112
RYDER	4	53	-1.243	.2150
ELL	4	7.0	-1.269	.2076
NINE FEET	9 1	204	-1.288	.2006
HIGH MAIN	11 1	282	-1.295 I	.1970
SMITHY	3 1	35	-1.229	.2224
FLEET AND THIN	4 1	41	-1.211	
TRENCHER	5 1	85	-1.267	.2262
DEER RIDER	14		-1.115	.2670
DOUBLE	5		-1.274	.2040
TOP BENCH	9 1	96	-1.217	.2262
BENCH	4 1	70	-1.269	.2040
STANHOPE	7	109	-1.259	.2112
Transact depote papers from these sectors capes from the capes process papers review depote these sectors from the	Principality representation property approximation makes proper	Appears, supply region of the same appears appear appears appe		appear to the second se
All the second control of the second	Addition of the second of the		in addition	
COALFIELD	deliner d		- department	
PARK	The second secon	55	*1,273	• 2040
DEEP	5 1	49	-1.205 I	.2302
YARD	11	168	-1.257 I	.2176
A PARA		St. S.J. S.J.		A Go B I SI
SHROPSHIRE	- Section - Sect		Manye	
COALFIELD	ANDONE A		estata 4	
TOP COAL		19 A	*1.311	. 1902
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NORTH STAFFSHIRE	8000 A		and	
COALFIELD	NO. 1986	3	New Year	
		report communication (MEPH-LORGE SCIENT) pages acceptances.	Toward major instructions rating course recent values become	entire course super-sistem enterior similaritants incominated becomes super-sistem make
SPENCROFT	2.	20	-1,207	,2302

Appendix 5: (Continued)

DALTON AND PRINGLE(1962) GALLIUM WARWICKSHIRE COALS [IN PARTS PER MILLION]

ARREST STATE AND STATE ARREST STATE ARREST STATE ARREST STATE STATE STATE STATE ARREST ARREST STATE STATE STATE	e spiece simplification. Summitted any country and extension of the second and extension of	repriests the second galaxy appearance at the second secon	men pagga, forder tridet overe ment passa algoric soppic allert et	era rijum iesasi iesas esima iesas iesas asentintis maneritaina meseritaina meseritas. Esiste iesas territori
Reamen	ILIGHT	I HEAVY	1 Z=	TWO-SIDED !
depose	IFRACTION	FRACTION	I VALUE	PROBABILITY
I SEAM	Malaret	distribu	dilition-	revare:
ELEMENT	1 (X)	(Y)	(Z)	(P)
- Selation regions (1997) symmyty from the 1997 November of American symmetry and the symmetry content of American States (1997) and the symmetry content of Am	THE PERSON NAMED AND POST OFFICE ADDRESS OF THE PERSON NAMED ADDRESS OF THE PERSON NAM	The second secon	Annal contact department region where these contact enters	APPART ANDREA ANDREA STRANG STRANG STRANG STRANG STRANG STRANG STRANG PACKAGE ANDREAS STRANG
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I SOUTH STAFFSHIRE	description of the second of t	Management	- supplies -	and
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The state of the s			Mark their constitutes and with their lives posses.	$\frac{d}{dt} = \frac{d}{dt} \left(\frac{d}{dt} + \frac{d}{dt} \right) \left(\frac{d}{dt} + \frac{d}{dt}$
ITHICK	8	1 136	1 -1.267	.2040
I BROOCH	2	66	1 -1.307	.1902
I FLYING REED	3	60	1 -1.279	.2006
Applicate injuries: comment: alaborate initiality. All all controls initiality initiality initiality initiality initiality initiality. Initiality initiality initiality initiality initiality initiality initiality.	T CHICAGO AND THE PROPERTY AND	THE RESIDENCE WAS ARREST TO SELECT THE RESIDENCE THE PARTY OF THE PARTY THE	. AND PARTY AND PARTY PARTY TOTAL STATE ST	Transfer consider statutes - content contents - descriptional Association in the content of the

Appendix 6:

SZILAGYI(1971) HUNGARIAN COALS [IN PPM]

	ILIGHT FRACTION		Z-! Value !	TWO-SIDED PROBABILITY
SEAM	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	2 1/2:20 0 W (312 4	* **********	
CLEMENT	(X)	(Y)	(Z)	(P)
region como remine service como como remine entre entre entre como como como remine entre como como como como como como como com	The second secon	NORMAL DAVING MARCH. STATES AND AND ASSESSMENT ASSESSME	THE THE PERSON STATES AND ADDRESS AND ADDR	rialistik antario teraturi serjana teraturi saterpolitistiksi beraturi 1986, barporintario capaca 1986 otap
MECSEK SEAM	2000		*	
DEPTH	- State of the sta	9	l ,	
T. N.	Market Control of the	and the second s		
SEAM				
0-10	1 13 1	166	-3,911	<.0001***
10-20	1 29 1	182	-4.584	<.0001***
20-30	34	131	-4.705	<.0001***
30-40	30 1	88	-3,668	<.0001***
40-50	1 50 1	112	-3.299	<.0012**
50-60	32	60	-1.788	.0734
60-70	1 37 1	57	-0.766	.5028
70-80	1 33 1	45	-0.304	.7642
80-90	4000	19	-0.400	.6892
Mo	98889	300	vanage.	
BORSOD SEAM	depen- saz		880	•
0-10	4	52	-1,409 I	.1586
10-20	6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6	53	-4.603	<.0001***
20-30	9 1	38	-5.687	<.0001***
30-40	denni man	32	-3.320	.0010**
40-50	1 12 1	26	-2.599	.0094
50-60	1 10 1	18	-1.372	.1706
60-70	6 1	9	-2.121	.0340*
70-80		7	-1.414	.1586
80-90	7 1	8	-0.141	.8886
V	to states			
MECSEK SEAM	rections during		oaan aan	
0-10	26	327	-6.000 i	<.0001***
10-20	4	338	-6.518 I	<.0001***
20-30	83	324	-7.582	<.0001***
30-40	1 128 1	370	-7.151	<.0001***
40-50	1 183 1	411	-4.244	<.0001***
50-60	213	398	-3.726	<.0001***
60-70	1 192	297	-2.067	.0384*
70-80	1 283 1	382	-1.367	.1706
80-90	1 293 1	356	-0,693	.5902

Appendix 6: (Continued)

SZILAGYI(1971) HUNGARIAN COALS [IN PPM]

400		HEAVY FRACTION		TWO-SIDED PROBABILITY
SEAM ELEMENT	(X)	(Y) I	(Z)	(P)
names some appear fillion. Affilit filmes energi skryps kloset, soviet strate, strate, strate some strate filme. D	TOTAL PROPERTY SECOND AND ASSESSMENT AND ASSESSMENT ASS	anger enterprese filter stem total again parecents.	Judges spirites installerational named subservations sough finance.	and the second section of the
V	apples.	rabon.	97800	
BORSOD SEAM			9,000	
0-10	9	120	*1.787	.0734
10-20	33 1	219	-2.619 I	.0088*
20-30	1 49 1	199	-4.869	<.0001***
30-40	1 68 1	196	-5.059	<.0001***
40-50	1 112 1	250	-4.470	<.0001***
50-60	1 142 1	252	-2.824	.0048**
60-70	I 228 I	349	-2.260	.0238*
70-80	1 218 1	293	-1.543	.1236
80-90	206	242	-1.057	,2892
Cr	90 ORBINO	9000	9000	
MECSEK SEAM	400000 visit 400	90°	600s set	
0-10		157	-4,953	<.0001***
10-20	1 24 1	153	-5.301	<.0001***
20-30	1 43 1	167	-4.605 I	<.0001***
30-40	1 54 1	157	-6.514	<.0001***
40-50	1 106 l	237	-4.434	<.0001***
50-60	1 117 1	219	-3.302	,0010**
60-70	1 110 1	170	-2.844	.0046*
70-80	1 108	146	-0.900	,3682
80-90	1 133 1	162	-0.783	. 4354
Cr	n		9	
BORSOD SEAM	- sagnino - ping		0.00000	
0-10	no entre A	60	-1.746	.0802
10-20	1 18	120	-2.968 I	.0030**
20-30	1 24 1	97	-4.702	<.0001***
30-40	1 42 1	120	-3.852	<.0001***
40=50	1 62 1	140	=3.556	<.0001***
50-60	97 1	172	-1.515	.1286
60-70	1 108	165	-2.536	.0114*
70-80	1 103 1	139	-1.935	.0536
80-90	85	100	-0.571	.5686

Appendix 7

DUCK AND HIMUS AS IN COAL [IN PPM]

DEPTH	LLIGHT	HEAVY	Z. **	TWO-SIDED
Joseph Joseph	IFRACTIONI	FRACTION	VALUE	PROBABILITY
SEAM		e de la companya de l		
	1 (X) 1	(Y) ((Z)	(P)
AND THE PROPERTY WINDOWN WARREST FROM THE PROPERTY WARREST STATE OF THE PROPERTY OF THE PROPER	AND THE PERSON NAMED IN COLUMN TWO IS NOT THE OWNER.	design companying 1889 many 2007 many again males	manage country restrict country system, consequently cons	
	1	9400		
A1	1 1.97 1	126.48	-6.6397	<.0001***
A 2		34.46	-6.6656	<.0001***
AC1		46.20	-6.6197	<.0001***
AC2		43.17	-6.6510	<.0001***
SB1	1 1.68		-5.8937	<.0001***
SB2	1 0.616 1		=6.4035	<.0001***
SB3	1 1.82	257.5	-6.6970	<.0001***
B1	1 3.55 1		-6,1472	<.0001***
B2	1 0.238 1	9.47	-6.5731	<.0001***
B 3		10.98	-6.4354	<.0001***
B 7	1 0.826 1	12,49	-6.2855	<.0001***
88	1 16.69 1	643.78	-6.5678	<.0001***
B9	1 0.797 1	12,97	-6.6588	<.0001***
B10		ples.	***	***
B11	1 10.63 I	331.36	-6.5248	<.0001***
B12	1 1.50 1	488.52	-6.7244	<.0001***
B13	1 1.26 1	68.92	-6.6207	<.0001***
B14	1 2.16 1	231.00	-6.6815	<.0001***
B15	0.349	50.37	-6.6982	<.0001***
B16		20.45	-5.8905	<.0001***
L1	1 0.774 1	46,95	-6.6328	<.0001***
L2		69,30	-6.1289	<,0001***
B12FS		170.41	-6.7011	<.0001***
LIFS	1 0.757 1	75.74	-6.6826	<.0001***

Appendix 8:

ZUBOVIC, STADNICHENKO AND SHEFFEY(1960)
[IN PERCENT]

These affects about the second second states and second sec	II.I	management announcement announcement of	I HEAV	()	na en	e sele con sele son sele con sele TV (s	70-SIDED	. 4
	1 50 00	With the Wall	FRACT		VALUE		OBABILITY	10000
SEAM	gassey		40000	all a		SAMPLE		codevi
ELEMENT	***	(X)	(Y)	- Man	(Z)	9000	(P)	dustr
Berger (Specific Specific Spec		AND THE PERSON NAMED AND ADDRESS OF	THE RESERVE ASSESSMENT THE TAX STREET THE	TOP MONEY APPROXIMENT	THE PARTY PARTY STATES AND ADDRESS AND ADDRESS AND	SECTION SHOULD FROM HERE THE	n static spile alternation statement where apply apply as the court of	, #
B	dalury	74.2	26.6	5	0.815	4	.4180	- delay-
1 Be	MAGRADI	94.0	7.2	2 1	1.24	See	.2150	steate.
ICo	94000	39.5	60.5	> 4	-0.392	-944400	.6966	and the same of
ICr	1000	41.9	1 58.1		-0.305	August	.7642	100000
I C u	- seedo-	33.8	66.1	9000	-0.589		.5552	-
l Ga	49400-	58.6	1 42.7	7 1	0.296	900	.7718	Mary .
l Ge	organical control of the control of	65.3	37.1	1	0.506	·	.6170	8
Mo	40000	38.7	1 61.3	3 1	-0.421	1	.3744	-
N 1	coderect	45.9	54.0) [-0.154	99999	.8808	-
171	yeqtiqe;	62.0	1 38.	7 1	0.430	9	.6672	- 80
1 V	B	59.2	41.5	9 1	0.321	dayane.	.7490	1000
a X	**************************************	51.3	1 49.3	1 5	0.039	8	.9680	100
1Zn	194	22.6	96.8	3 1	-1.01	400	.3174	TOTAL
Material sussess. Hereby, sussess frames. Window hereby, sussess status of strongs hereby, sussess, whether deletes he	me moreone desp.	owners with the second country to the second	THE SHARE SHARE SHARE AND ADDRESS OF	C-result survey parent.	NAMES AND POST OFFICE AND POST OF THE PARTY AND PARTY.	NAME AND ADDRESS OF TAXABLE PARTY.	an suspensions about the propositions where suggest an included	the state of

Appendix 9:

MILLER (1977) LIGNITE [IN PARTS PER MILLION]

	7 TOWN TOWN THAT IS NOT UPON TO	I HEAVY		TWO-SIDED
	IFRACTION	FRACTION	VALUE	PROBABILITY
SEAM		- Address	•	
	(X)	(Y)	(Z)	(P)
SAGENY INSTALL BANGER MANUAL BANGER TO SAGENY CANNOT ANNOUNCE TO SAGENY CONTROL MANUAL TO SAGENY	The state of the same and the same of the	The state of the state and the	STATES AND A STATE SECUL STATE SECUL SECUL AND A SECUL SECUL	THE WALL PROPER SECURIC SECURIC SECURIC SECURICAL SECURICA SECURICA SECURICA SECURICA SECURICAL SECURICA SECURICA SE
	and	49.00cm		September :
A	1 552.42	289.38	5.69	<.0001***
Ba	1 17,62	375.13	-12.841	
Be	1 13.4	1.3	1.216	.2262
Ca	12787.88	897.41	8.707	<.0001***
Ce	81.0	70.0	0.139	.8886
Cr	1 110.0	26.0	1.00	.3174
Cu	1 13.02	1 2.27	10,97	<.0001***
Fe	1 457.3	2506.7	-10.851	<.0001***
K	1 59.93	48.89	1.927	.0536
La	1 26.0	1 20.0	0.246	.8026
Ma	1 743.0		12.487	<.0001***
Mn	1 7.31	49.33	-11.357	<.0001***
Na	1 734.11	51.2	12.518	<.0001***
N 1	1 62.0	35.0	0.511	.6110
Sr	1 58.49	1 15.72	9.541	<.0001***
71	1 43.58	1 14.69	8.483	<.0001***
V	1 96.0		0.917	
Yb	1 17.0		0.823	
Zn	1 12.981	0.07		
Zr	1266.0	1 83.0	0.886	.2788

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